TVA

Tennessee Valley Authority, 1101 Market Street, Chattanooga, Tennessee 37402-2801

December 6, 2006

10 CFR 50.55a

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555-0001

Gentlemen:

In the Matter of	)	Docket Nos. 50-327
Tennessee Valley Authority	)	50-328
		50-390

SEQUOYAH NUCLEAR PLANT (SQN) UNITS 1 AND 2 AND WATTS BAR NUCLEAR PLANT (WBN) UNIT 1 - AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME) BOILER AND PRESSURE VESSEL CODE, SECTION XI - REACTOR PRESSURE VESSEL HEAD (RPVH) PENETRATION TUBE REMOTE INNER-DIAMETER TEMPER BEAD (IDTB) REPAIR - GENERIC REQUEST FOR RELIEF G-RR-2

Pursuant to 10 CFR 50.55a(a)(3)(i), TVA requests NRC approval of alternative repair methods for the repair or replacement of RPVH penetration tube welds and J-groove welds in the event that inservice examination results are determined unacceptable. TVA plans to perform the required ultrasonic and visual examinations during the next refueling outages at SQN Units 1 and 2 and WBN Unit 1 in accordance with NRC Order EA-03-009, "Issuance of First Revised NRC Order (EA-03-009) Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors," dated February 20, 2004. The applicable refueling outages are scheduled as follows: Ongoing SQN Unit 2 outage, SQN Unit 1 (fall 2007), and WBN Unit 1 (spring 2008).

<u>Status of Inservice Inspection (ISI) Programs</u>
Both SQN units are in the first period of the third 10-year ISI Program intervals. Since June 1, 2006, SQN performs repairs and replacements in accordance with the ASME Boiler and Pressure Vessel Code Section XI (ASME XI), 2001 Edition through the 2003 Addenda (2001A03 Code).

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Watts Bar Unit 1 is in the third period of the first 10-year ISI Program interval. WBN currently uses the 1989 Edition of ASME XI, but intends to transition to the 2001A03 Code on May 27, 2007, at the start of their next 10-year ISI Program interval.

TVA requests approval of this relief request on a routine review schedule. It is not anticipated that scheduled examinations during the ongoing SQN Unit 2 refueling outage will reveal unacceptable indications because SQN Unit 2 has operated at relatively low susceptibility temperatures in the upper RPVH areas in comparison to the industry. Thus, it is unlikely that SQN Unit 2 will need to use the alternative repair methods requested by this relief request.

Enclosure 1 provides Generic Request for Relief G-RR-2. Enclosure 2 provides a list of new commitments made by this letter. If you have any questions, please contact Rob Brown at (423) 751-7228.

Sincerely,

Russell R. Thompson

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ENCLOSURE 1

SEQUOYAH NUCLEAR PLANT (SQN) UNITS 1 AND 2
WATTS BAR NUCLEAR PLANT (WBN) UNIT 1

AMERICAN SOCIETY OF MECHANICAL ENGINEERS BOILER AND PRESSURE VESSEL CODE, SECTION XI - REACTOR PRESSURE VESSEL HEAD (RPVH) PENETRATION TUBE REMOTE INNER-DIAMETER TEMPER BEAD (IDTB) REPAIR - GENERIC REQUEST FOR RELIEF G-RR-2

EXECUTIVE SUMMARY

Pursuant to 10 CFR 50.55a(a)(3)(i), TVA requests approval for the contingent use of alternatives to the requirements of ASME XI, 2001 Edition with the 2003 Addenda, Article IWA-4000. This request seeks approval to use an alternative repair or replacement process related to the performance of ambient temperature temper bead weld techniques on the RPVH penetration tubes and J-groove welds in the event unacceptable indications are discovered during examination. These examinations are to be performed in accordance with the directives of NRC Order EA-03-009," Issuance of First Revised NRC Order (EA-03-009) Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors," dated February 20, 2004. In the event that unacceptable indications are identified, repairs or replacements of the RPVH penetration tubes or the associated J-groove weld areas may be necessary.

TVA proposes to use repair methodologies that result in the establishment of a new pressure boundary at the individual penetration tubes and J-groove welds. TVA proposes the combined use of certain provisions of ASME XI Code Cases, and ASME III provisions, with some minor changes, in order to achieve high quality weld repair techniques. These repairs would remove the existing J-groove welds from the pressure boundary and restore long-term stability to the penetration tube areas within the wall thickness of the RPVH assembly. This process reduces the susceptibility of penetration tube weld degradation from primary water stress corrosion cracking (PWSCC). This request for relief is similar to three prior NRC-approved relief requests noted in Section VIII of this enclosure. TVA proposes to use the provisions of ASME Code Case N-638-1, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine Gas Tungsten-Arc Welding (GTAW) Temper Bead Technique, ASME XI, Division 1," for potential IDTB repairs at SQN and WBN with some minor modifications to the process, as shown in this enclosure.

The successful use of these techniques and approved alternatives, at other utilities, have demonstrated that the IDTB process provides an acceptable level of quality and safety in accordance with the requirements of 10 CFR 50.55a(a)(3)(i).

TVA requests approval of this on a routine schedule. This is because of the low likelihood that examinations will reveal unacceptable indications or flaws due to low operating temperatures in the upper RPVH areas at SQN and WBN units. TVA plans to examine the RPVH penetration tubes and associated J-groove welds during the ongoing

SQN Unit 2 outage, the SQN Unit 1 fall 2007 outage, and the WBN Unit 1 spring 2008 outage.

I. SYSTEM/COMPONENT(S) FOR WHICH RELIEF IS REQUESTED:

The components that will receive J-groove weld and nozzle penetration tube examinations include the SQN Units 1 and 2, and the WBN Unit 1 RPVH assemblies in the Alloy 600 J-groove weld areas for the CRDM penetration tubes, the head adapter plug nozzles, the incore thermocouple instrumentation (ICI) penetration tubes, the head vent (HV) pipe penetration tubes, and the capped unused upper-head injection auxiliary head adapter (UHI) penetration tubes (SQN units only). The breakdown for the specific plant/unit components is as follows.

SQN Unit 1 includes 83 RPVH penetration tubes and the associated partial-penetration J-groove welds comprised of the following:

- 57 CRDM Nozzles with Thermal Sleeves
- 8 Part Length CRDM Nozzles
- 7 Dummy Cans with Head Adapter Plug Nozzles
- 6 Incore Instrument Thermocouple Column Nozzles
- 4 Upper-Head Injection (UHI) Auxiliary Head Adapter Nozzles
- 1 RPVH Vent Pipe Nozzle

SQN Unit 2 includes 83 RPVH penetration tubes and associated partial-penetration J-groove welds comprised of the following:

- 57 CRDM Nozzles with Thermal Sleeves
- 8 Part Length CRDM Nozzles
- 8 Dummy Cans with Head Adapter Plug Nozzles
- 5 Incore Instrument Thermocouple Column Nozzles
- 4 UHI Auxiliary Head Adapter Nozzles
- 1 RPVH vent pipe nozzle

WBN Unit 1 includes 79 RPVH penetration tubes and associated partial-penetration J-groove welds comprised of the following:

- 57 CRDM Nozzles with Thermal Sleeves
- 8 Part Length CRDM Nozzles
- 8 Dummy Cans with Head Adapter Plug Nozzles
- 5 Incore Instrument Thermocouple Column Nozzles
- 1 RPVH Vent Pipe Nozzle

II. CODE REQUIREMENTS:

The following table lists the current applicable ISI Program 10-year intervals per plant unit, the ASME XI ISI Code-of-Record (COR) (Code Edition, or Edition with Addenda), the ISI/Nondestructive Examination (NDE) Program COR for the repair examinations, the ASME XI Repairs and Replacements COR, and the ASME III COR to be used for the design of the IDTB repairs.

Plant/Unit	ISI Program Interval/ Period	ISI Program Code	Plant/Unit NDE Code	R&R Code	IDTB Design Code (ASME III)
SQN / 1	3rd / 1st	2001A03	2001A03	2001A03	2001A03
SQN / 2	3rd / 1st	2001A03	2001A03	2001A03	2001A03
WBN / 1	1st / 3rd; 2nd / 1st as of 5/27/07	2001A03 as of 5/27/07	2001A03*	2001A03 as of 5/27/07	2001A03

* NOTE: TVA recently received permission to update applicable ISI/NDE procedures to meet the 2001A03 Code. Watts Bar Unit 1 is currently in the third period of the first 10-year interval and plans to transition to the second 10-year interval on May 27, 2007, with the ASME XI Programs written to meet the 2001A03 Code.

In accordance with the ASME XI, 2001A03 Code requirements (see IWA-4220); repair and replacement activities must meet the owner's requirements and the construction codes applicable during original item construction. Accordingly, consideration was given to the respective units' original COR in the IDTB designs and the development of the individual repairs and replacements plans and associated installation of the RPVH repair activities. The original plant component fabrication and installation COR are:

Plant / Unit - Original Design COR

	SQN Unit 1	SQN Unit 2	WBN Unit 1
RPVH Assembly	ASME III, 1968 Edition with Code Case 1401	ASME III, 1968 Edition	ASME III, 1971W71
CRDM Penetration Tube	ASME III, 1968 Edition with Code Case 1401	ASME III, 1968 Edition	ASME III, 1971W72
Incore Instrument and Thermocouple Tube	ASME III, 1968 Edition with Code Case 1401	ASME III, 1968 Edition	ASME III, 1971W72

Alternatively, the given unit specific repair and replacements plan may meet all or portions of the requirements of different Editions and Addenda of the Construction Code, or ASME III when the Construction Code was not ASME III, provided the Code to be used for the activities is reconciled with the owner's requirements, in accordance with the reconciliation requirements of IWA-4200 of the ASME XI, 2001A03 Code.

Along with the IWA-4000 repairs and replacements requirements, the ASME Code allows the use of approved alternatives in the ASME XI Code Case N-638-1. However, NRC Regulatory Guide (RG) 1.147, "Inservice Inspection Code Case Acceptability, ASME XI, Division 1," Revision 14, also imposes additional limitations of the use of this

Code Case. TVA has incorporated consideration of these limitations into the proposed IDTB repair processes.

III. CODE REQUIREMENTS FROM WHICH RELIEF IS REQUESTED:

TVA is requesting relief from meeting the Construction COR during the performance of these IDTB repairs/modifications. TVA is requesting relief from meeting the requirements of ASME XI, 2001A03 Code, Article IWA-4000. Paragraph IWA-4220 requires that repair/replacements performed on Code Class boundary components, at a minimum, meet the design, fabrication, and installation requirements of the original applicable Construction Code. For SQN, for the proposed repairs to the RPVH penetrations, paragraph N-528 of the 1968 Edition of ASME III (i.e., the original Construction COR for the RPV) requires repairs to be post weld heat treated (PWHT) in accordance with paragraph N-532. For WBN, for the proposed repairs to the RPVH penetrations, paragraph NB-2539 of the 1971W71 Edition of ASME III requires repairs to be PWHT in accordance with paragraph NB-4640. In addition to the major aspects of the repair/replacement processes described above, proposed alternatives to the minor process requirements, such as the monitoring of interpass temperatures with the use of installed thermocouples, are addressed with this request.

Certain aspects of the pre-weld and post-weld repair NDE requirements and flaw characterization requirements cannot be practically met. Specifically, TVA is also requesting relief from meeting certain requirements of ASME XI, IWA-3300(b), IWB-3142.4, IWB-3420, and IWB-3612 of the 2001A03 Code.

- IWA-3300(b) contains a requirement for flaw characterization.
- IWB-3142.4 allows for analytical evaluation to demonstrate that a component is acceptable for continued service.
- IWB-3142.4 also requires that components found acceptable for continued service by analytical evaluation be subjected to successive examination.
- IWB-3420 requires the characterization of flaws in accordance with the rules of IWA-3300.
- IWB-3612(a) requires that, for normal conditions, the ratio of the maximum applied stress intensity factor (K_I) to the available fracture toughness based on crack arrest (K_{Ia}) for the corresponding crack tip temperature be less than $1/\sqrt{10}$.
- IWB-3612(b) requires that, for emergency and faulted conditions, the ratio of the maximum applied stress intensity factor (K_I) to the available fracture toughness based on crack initiation (K_{Ic}) for the corresponding crack tip temperature be less than $1/\sqrt{2}$.

IV. BASIS FOR RELIEF:

The PWHT requirements set forth, as indicated above, are unreasonable and impractical to attain under field conditions on a RPVH. In addition to possible distortion of the RPVH, significant personnel dose would be expended to set up and remove the PWHT equipment. Because of the risk of damage to the RPVH material properties or dimensions and the additional dose that would be required, it is not practical to apply the PWHT requirements of paragraph NB-4620 of the ASME III, 2001A03 Code to the

RPVH, nor the elevated temperature preheat and post weld soak required by the alternative temper bead method offered by ASME XI, IWA-4600. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), TVA requests relief to use an ambient temperature temper bead welding method of repair as an alternative to the requirements delineated above.

In addition, if inspection of the RPVH nozzle penetrations reveals flaws affecting the J-groove attachment welds, it may be unreasonable to characterize these flaws by NDE and it may be unreasonable to perform any successive examinations of these flaws. The original nozzle to RPVH weld configuration is difficult to ultrasonic test (UT) examine due to the compound curvature and fillet weld radius. The configuration is not conducive to UT due to the configuration and dissimilar metal interface between the repair/replacement weld and the low alloy steel RPVH. Furthermore, due to limited accessibility from the RPVH outer surface and the proximity of adjacent nozzle penetrations, it is unreasonable to scan from this surface on the RPVH base material to detect flaws in the vicinity of the original J-groove welds. These conditions preclude ultrasonic coupling and control of the sound beam in order to perform flaw sizing with reasonable confidence in the measured flaw dimension. Therefore, TVA is also requesting relief from meeting specific requirements of ASME XI, Article IWA-4000 governing this repair/replacement and the associated paragraphs of IWA-3300(b), IWB-3142.4, IWB-3420, and IWB-3612.

V. PROPOSED ALTERNATIVES:

For application of the IDTB repairs, an automatic or machine gas tungsten-arc welding (GTAW) ambient temperature temper bead welding technique will be implemented in accordance with ASME XI Code Case N-638-1, with certain exceptions. For the SQN and WBN Units, automatic or machine GTAW is allowed in accordance with the provisions of the ASME 2001A03 Code, Paragraphs IWA-4633.2(a) through (e). However, Code Case N-638-1 is also appropriate to be used with the 2001A03 Code in order to allow the qualification and use of the ambient temper bead weld technique. Use of N-638-1 for the IDTB repairs/modifications, as it is proposed in this request, is compatible with the ASME XI, 2001A03 Code provisions in Paragraph IWA-4623.2. Attachment 1 to this enclosure provides a listing of the basic process steps involved in the IDTB repair/replacement activities. Figures 1 and 2 in Attachment 1 are sketches of the approximate end configurations for the incore instrument tube and the CDRM nozzle configurations, respectively. Configuration sketches of the head vent line and the upper head injection auxiliary head adapter nozzle configurations will be provided if repairs/replacements of those nozzles, or their associated J-groove welds, are required. The following proposed alternative subsections provide a detailed description of the proposed alternative design (see Subsection V - I), welding and examination (see Subsection V - II), and the flaw characterization (see Subsection V - III) processes and provide a comparison of the applicable code requirements to proposed alternative processes.

V. (I) ALTERNATIVE REPAIR/REPLACEMENT DESIGN AND FABRICATION CONSIDERATIONS:

TVA requests relief to use an ambient temperature temper bead method of repair as an alternative to the requirements of the 2001A03 Code version of ASME III, NB-3300, NB-4453, NB-4622, NB-5245, and NB-5330. Approval is also requested to use filler materials, ERNiCrFe-7A (Alloy 52M, UNS06054), or ERNiCrFe-7 (Alloy 52, UNS06052), which are endorsed by Code Case 2142-2, "F-Number Grouping for Ni-Cr-Fe Filler Metals Section IX (Applicable to all Sections, including Section III, Division 1, and Section XI)," for the weld repair. Code Case N-638-1, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique, Section XI, Division 1," which has been approved in Regulatory Guide 1.147, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1," Revision 14, has also been used as a template for this application. As an alternative to these code case requirements, the requirements of the alternative welding process qualification paragraphs shown below will be used. Repairs to the RPVH nozzle penetration J-groove attachment welds, which are required when a 1/8-inch or less non-ferritic weld deposit exists above the original fusion line, will be made in accordance with the requirements of IWA-4000, of the ASME XI, 2001A03 Code. The requirements of paragraphs NB-4622, NB-3300, NB-4453, and NB-5245, of ASME III, 2001A03 Code, and QW-256 of the latest edition of ASME IX are also applicable to the potential RPVH penetration tube and J-groove weld repairs. Alternatives to these requirements will be used in accordance with the requirements of the alternative welding process described below. Specifically, alternatives are being proposed for the following ASME III, ASME IX, and ASME XI requirements:

1. NB-4622.1 establishes the requirement for PWHT of welds including repair welds. In lieu of these requirements, TVA proposes to utilize a temper bead weld procedure, which would preclude the need for PWHT.

2. NB-4622.2 establishes requirements for time at temperature recording of the PWHT and their availability for review by the inspector. This does not apply because the proposed alternative does not involve PWHT.

3. NB-4622.3 addresses the definition of nominal thickness as it pertains to time at temperature for PWHT. This is not applicable because the proposed alternative does not involve PWHT.

4. NB-4622.4 establishes the holding times at temperature for PWHT. This is not applicable because the proposed alternative does not involve PWHT.

5. NB-4622.5 establishes PWHT requirements when different P-number materials are joined. This is not applicable because the proposed alternative does not involve PWHT.

6. NB-4622.6 establishes PWHT requirements for nonpressure retaining parts. This is not applicable because the potential repairs in question will be to pressure retaining parts. Furthermore, the proposed alternative does not involve PWHT.

7. NB-4622.7 establishes exemptions from mandatory PWHT requirements. NB-4622.7 (a) through (f) are not applicable in this case because they pertain to conditions that do not exist for the proposed repairs. NB-4622.7 (g) addresses exemptions to weld repairs to dissimilar metal welds if the requirements of subparagraph NB-4622.11 are met. This does not apply because the ambient temperature temper bead repair is being proposed as an alternative to the requirements of NB-4622.11.

8. NB-4622.8 establishes exemptions from PWHT for nozzle to component welds and branch connections to run piping welds. NB-4622.8(a) establishes criteria for exemption of PWHT for partial penetration welds. This is not applicable to the proposed repairs because the criteria involve buttering layers at least 1/4-inch thick, which will not exist for the welds in question. NB-4622.8(b) also does not apply because it addresses full penetration welds and the welds in question are partial penetration welds.

9. NB-4622.9 establishes alternative PWHT requirements for temper bead repairs to P-No. 1 and P-No. 3 base materials and A-Nos. 1, 2, 10, or 11 filler metals. This paragraph does not apply because the proposed repairs will involve F-No. 43 filler metals. Thus, use of ASME XI Code Case N-638-1 is needed.

10. NB-4622.10 establishes requirements for repair welding to cladding after PWHT. This paragraph does not apply because the proposed repair alternative does not involve repairs to cladding.

11. NB-4622.11 addresses temper bead weld repair to dissimilar metal welds or buttering and would apply to the proposed repairs as follows:

    a. NB-4622.11 (a) requires surface examination prior to repair in accordance with NB-5000. The proposed alternative will include surface examination prior to repair consistent with NB-5000.

    b. NB-4622.11 (b) contains requirements for the maximum extent of repair including a requirement that the depth of excavation in the non-ferritic material for defect removal does not exceed 1/8-inch in the fusion line between the non-ferritic and ferritic base metal, or up to 3/8-inch if the defect penetrates into the ferritic material. The proposed alternative will include the same limitations on the maximum extent of repair.

    c. NB-4622.11 (c) addresses the repair welding procedure and welder qualification in accordance with ASME IX and the additional requirements of Article NB-4000. The proposed alternative will satisfy these requirements, except for the stipulations of paragraph QW-256 of ASME IX, as explained in the justification below. In addition, NB-4622.11(c) requires that the welding procedure specification include the following requirements:

        1) NB-4622.11 (c)(1) requires the area to be welded to be suitably prepared for welding in accordance with the written procedure to be used for the repair. The proposed alternative will satisfy this requirement.

        2) NB-4622.11 (c)(2) requires the use of the shielded metal-arc welding (SMAW) process with covered electrodes meeting either the A-No. 8 or F-No. 43 classification. The proposed alternative uses GTAW with bare electrodes and bare filler metal meeting the F-No. 43 classification.

        3) NB-4622.11 (c)(3) addresses requirements for covered electrodes pertaining to hermetically sealed containers or storage in heated ovens. These requirements do not apply because the proposed alternative uses

bare filler metal that does not require storage in heated ovens because the bare filler metal will not pick up moisture from the atmosphere as covered electrodes might.

4) NB-4622.11 (c)(4) addresses requirements for storage of covered electrodes during repair welding. These requirements do not apply because the proposed alternative utilizes bare filler metal, which does not require any special storage conditions to prevent the pick up of moisture from the atmosphere.

5) NB-4622.11 (c)(5) requires preheat of the weld area and 1-1/2 times the component thickness or 5-inch band, whichever is less, to a minimum temperature of 350°F prior to and during repair welding, and a maximum interpass temperature of 450°F. It also requires that thermocouples and recording instruments be used to monitor the metal temperature during welding. The proposed ambient temperature temper bead alternative does not require an elevated temperature preheat. Interpass temperature measurements cannot be accomplished due to inaccessibility in the weld region on the inner surfaces of the penetration tube area. However, the maximum interpass temperatures were verified based on the mockup results and analytical calculations using the maximum permitted welding procedure specifications (WPS) heat inputs, etc. The maximum interpass temperature used during the welding of the procedure qualification record (PQR) test assembly was less than 150°F, as specified in paragraph 2.1(e) of ASME Code Case N-638-1 for the first three layers. With the use of N-638-1, paragraph 2.1(e) takes precedence over the requirements of QW-256 and QW-406.3 in the latest version of ASME IX.

6) NB-4622.11 (c)(6) establishes requirements for electrode diameters for the first, second, and subsequent layers of the repair weld and requires removal of the weld bead crown before deposition of the second layer. Because the proposed alternative uses machine GTAW, the requirement to remove the weld crown of the first layer is unnecessary and the proposed alternative (i.e., with use of N-638-1) does not include this requirement.

7) NB-4622.11 (c)(7) requires the preheated area to be heated from 450°F to 550°F for four hours after a minimum of 3/16-inch of weld metal has been deposited. The proposed alternative (use of N-638-1) does not require this heat treatment because the use of the extremely low hydrogen GTAW temper bead procedure does not require the elevated temperature for hydrogen bake out.

8) NB-4622.11 (c)(8) requires welding subsequent to the hydrogen bake out of NB-4622.11 (c)(7) be done with a minimum preheat of 100°F and maximum interpass temperature of 350°F. The proposed alternative (Code Case N-638-1) limits the interpass temperature to 350°F (maximum) and requires the area to be welded to at least 50°F prior to GTAW welding. This approach has been demonstrated, through the weld procedure qualification process, to be adequate to produce tough and sound welds.

12. NB-4622.11(d)(1) requires a liquid penetrant (PT) examination after the hydrogen bake out described in NB-4622.11 (c)(7). The proposed alternative does not require the hydrogen bake out because it is unnecessary for the extremely low hydrogen GTAW temper bead process. Therefore, the PT examination will be performed as part of the final examination process.

13. NB-4622.11(d)(2) requires PT and radiographic (RT) examinations of the repair welds and the preheated band after a minimum time of 48 hours at ambient temperature. NB-4622.11(d)(2) also requires ultrasonic examination, if practical. The proposed alternative includes the requirement to inspect after a minimum of 48 hours at ambient temperature. Because the proposed repair welds are of a configuration that cannot be radiographed (due to limitations on access for source and film placement and the likelihood of unacceptable geometric unsharpness and film density), the proposed alternative final inspection will be by PT and UT examination in accordance with the proposed alternative use of Code Case N-638-1. These examinations will be performed after the 48 hours at ambient temperature waiting period.

14. NB-4622.11 (d)(4) requires that all NDE be in accordance with NB-5000. The proposed alternative will comply with NB-5000, except that the progressive PT examination required by NB-5245 will not be performed. In lieu of the progressive PT examination, the proposed alternative will use PT and UT examination of the final weld in accordance with the proposed alternative use of Code Case N-638-1. The volumetric examination coupled with surface examination will provide a high level of confidence that the proposed welds are sound.

15. NB-4622.11 (e) establishes the requirements for documentation of the weld repairs in accordance with NB-4130. The proposed alternative will comply with this requirement.

16. NB-4622.11 (f) establishes requirements for the procedure qualification test plate relative to the P-Number and group number and the PWHT of the materials to be welded. The proposed alternative meets and exceeds those requirements except that the root width and included angle of the cavity are stipulated to be no greater than the minimum specified for the repair.

17. NB-4622.11 (g) establishes requirements for welder performance qualification relating to physical obstructions that might impair the welder's ability to make sound repairs, which is pertinent to the SMAW manual welding process. The proposed alternative involves a machine GTAW process and requires welding operators be qualified in accordance with ASME IX. The use of a machine process eliminates any concern about obstructions, which might interfere with the welder's abilities, because all such obstructions will have to be eliminated to accommodate the welding machine.

18. NB-4453.4 (a) requires examination of the repair welds in accordance with the requirements for the original weld. The welds being made in accordance with the proposed alternatives will be partial penetration welds as described by NB-4244(d) and will meet the weld design requirements of NB-3352.4 (d). For these

partial penetration welds, paragraph NB-5245 requires a progressive surface liquid penetrate test (PT) or magnetic particle test (MT)) at the lesser of one-half the maximum weld thickness or 1/2-inch, as well as on the finished weld. For the proposed alternative with the use of Code Case N-638-1, the repair weld will be examined by a PT and UT examination no sooner than 48 hours after the weld has cooled to ambient temperature in lieu of the progressive surface exams required by NB-5245. The volumetric examination coupled with surface examination will provide a high level of confidence that the proposed welds are sound.

19. NB-5331 (b) does not allow any cracks, lack of fusion, or incomplete penetration regardless of length. As a result of the welding process, a linear indication often occurs at the intersection of the RPVH, the nozzle, and the first intersecting weld bead (triple point). The proposed alternative will allow this triple point indication to remain. Justification for this artifact of the welding process is discussed in paragraphs 12 and 14 in Section VI below.

20. QW-256/QW-406.3, of ASME IX, requires that the maximum interpass temperature during procedure qualification be no more than 100°F below that used for actual welding. Per the alternative welding process discussed below, the maximum interpass temperature during welding is specified to be 350°F maximum. The maximum interpass temperature during the procedure qualification was less than 150°F. The alternative to the NB-4622 requirements being proposed involves the use of an ambient temperature temper bead welding technique that avoids the necessity of traditional PWHT, preheat and post weld heat soaks. The welding technique described below is similar to the requirements of Code Case N-638-1. The proposed welding technique differs from that described in Sections 1.0 through 4.0 of Code Case N-638-1 as follows:

    a) N-638-1, paragraph 2.1 (b) requires consideration be given to the effects of welding in a pressurized environment. This requirement is not applicable because the welding will not occur in a pressurized environment.

    b) N-638-1, paragraph 2.1 (c) requires consideration be given to the effects of irradiation on the properties of materials in the core belt line region. This requirement is not applicable because the welding will be on the RPVH, not in the belt line region.

    c) N-638-1, paragraph 2.1 (h) specifies Charpy V notch requirements for ferritic weld material of the procedure qualification. The filler material is F-No. 43, which is not ferritic; therefore, this requirement does not apply.

    d) N-638-1, paragraph 2.1 (j) requires the average values of the three heat affected zones (HAZ) impact tests be equal or greater than average values for the unaffected base material tests. During the Charpy impact testing portion of the IDTB qualification process, the reference temperature (RT_{NDT}) was determined to be -30°F. In accordance with NB-2331, at RT_{NDT} + 60°F temperature (+30°F), the average of the HAZ absorbed energy Charpy impact tests was greater than the average of the unaffected base material. However, the average of the mils lateral expansion for the HAZ was less than the average values for the unaffected base material. Additional Charpy

V-notch tests were conducted on the HAZ material as permitted by NB-4335.2 to determine an additive temperature to the RT_{NDT} temperature. The average mils lateral expansion for the HAZ at +35°F was equivalent to the unaffected base material at +30°F. These test results require an adjustment temperature of +5°F to the RT_{NDT} temperature for base material on which welding is performed (i.e., RT_{NDT} +5°F).

e) N-638-1, paragraph 3.0 (c) requires a layer of weld reinforcement be applied and then machined to a flush surface. This requirement is not applicable because the welding will join dissimilar metals with non-ferritic weld filler metal.

f) N-638-1, paragraph 3.0 (d) specifies that the maximum interpass temperature for field applications shall be 350°F regardless of the interpass temperature during qualification. N-638-1, paragraph 2.1 (e) specifies that the maximum interpass temperature for the first three layers of the test assembly shall be 150°F. QW-256 specifies maximum interpass temperature as a supplementary essential variable that must be held within 100°F above that used during procedure qualification. Also see Section VI, Justification for Granting Relief, Paragraph No. 6 of this enclosure for additional discussion on the variations to the requirements of QW-256.

g) N-638-1, paragraph 3.0 (e) requires care be taken to ensure that the weld region is free of all potential sources of hydrogen. As described below, the proposed alternative temper bead procedure utilizes a welding process that is inherently free of hydrogen.

h) N-638-1, paragraph 4.0(b) requires the final weld surface and band around the area defined in paragraph 1.0 (d) to be examined using surface and UT methods. The purpose for the examination of the band is to assure all flaws associated with the weld repair area have been removed or addressed. However, the band around the area defined in paragraph 1.0(d) cannot be examined due to the physical configuration of the partial penetration weld. The final examination of the new weld and immediate surrounding area within the bore will be sufficient to verify that defects have not been induced in the low alloy steel RPVH material due to the welding process. Figure 1 of Attachment 1 to this enclosure shows the approximate area for PT and UT for the penetration repairs. UT will be performed by scanning from the inner diameter (ID) surface of the weld. The UT is qualified to detect flaws in the repair weld and base metal interface in the repair region, to the maximum practical extent. UT acceptance criteria will be in accordance with NB-5330. The extent of the examination is consistent with the construction code requirements.

The preheated band as specified in paragraph 4.0(b) of N-638-1 includes an annular area extending 5 inches around the penetration bore on the inside surface of the RPVH. The purpose for the examination of the band is to ensure all flaws associated with the weld repair area have been removed or addressed since these flaws may be associated with the original flaw and may have been overlooked. In this case, the repair welding is performed remotely using the known flaw(s) as a location from which to start the welding.

It is unreasonable to examine the band required by N-638-1, paragraph 4.0(b) due to the head configuration and interference from adjacent nozzles, as well as the configuration of the partial penetration welds. The proposed alternative examination area includes the weld and adjacent base material to be examined by PT and UT methods in the regions shown in Figure 1 of Attachment 1.

Scanning is performed from the inside surface of the new weld, the adjacent portion of the original nozzle, and the top of the new lower nozzle. The volume of interest for UT extends from at least 1 inch above and below the new weld into the RPVH low alloy steel base material to at least 1/4-inch depth. The PT area includes the weld surface and extends upward on the original nozzle inside surface to include the rolled expansion area including the rolled transition area (approximately 2.7 inches on the CRDM nozzles and approximately 3.1 inches on the ICI nozzles) and at least 1/2-inch below the new weld on the lower nozzle inside surface.

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

i) N-638-1, paragraph 4.0 (c) requires areas which had weld-attached thermocouples to be ground and examined using a surface examination. This requirement will be met if thermocouples are used. Thermocouples are not currently planned to be used. Contact pyrometers will be used to monitor interpass temperatures.

j) N-638-1, paragraph 4.0 (e) requires UT acceptance criteria to be in accordance with IWB-3000. However, for this configuration, there are no acceptance criteria in IWB-3000 that directly apply. Therefore, the proposed welding technique requires UT acceptance criteria in accordance with NB-5330, which is consistent with the original construction code requirements and generally more restrictive than ASME XI standards because the NB-5330 standards do not permit many common welding flaws such as lack of fusion, incomplete penetration, or cracks, regardless of length. ASME XI, IWB-3000 standards allow acceptance of these types of fabrication indications based on dimensioned flaw boundaries.

V. (II) ALTERNATIVE WELDING PROCESS CONSIDERATIONS:

TVA has contracted with Framatome Advanced Nuclear Products (FANP/AREVA) to provide for the performance of the RPVH penetration tube and J-Groove weld examinations and to perform any needed repairs/replacements.

During the performance of the IDTB repair/modification in accordance with N-638-1, monitoring of the weld preheat and interpass temperatures is required to meet the requirements of Article IWA-4000 of the Repair and Replacement Program (i.e., IWA-4610(a) of the ASME XI, 2001A03 Code). The IWA-4000 requirements stipulate that the temperatures are to be monitored with the use of thermocouples. In lieu of the thermocouples, contact pyrometers and manual records of the temperatures will be used to document the monitoring of these temperatures in order to preclude the need of attaching the thermocouples, thereby reducing the amount of personnel radiation exposure. The pyrometers will be calibrated in accordance with TVA's, or the contractor's, Measuring and Test Equipment Program and will be capable of monitoring at least the required process temperature range from the minimum preheat temperatures of 50°F to the maximum interpass temperatures of 350°F. In addition to the requirements of N-638-1 (with its modifications), and in accordance with the provisions of ASME IX, Code Case 2142-2, the welding metal to be used as the filler wire will be either ERNiCrFe-7A (Alloy 52M, UNS06054), or ERNiCrFe-7 (Alloy 52, UNS06052). Use of these weld filler materials is supported by ASME Code Case 2142-2, "F-Number Grouping for Ni-Cr-Fe Filler Metals ASME IX (Applicable to all Sections, including ASME III, Division 1, and ASME XI)," which was approved for use with ASME IX on August 7, 2003.

TVA plans to perform RPVH, CRDM, and ICI, HV penetration, and the upper head injection auxiliary adapter (SQN only) nozzle penetration repairs by welding the RPVH (P-No.3 base material) and the RPVH nozzle penetrations (P-No.43 base material) with filler material F-No.43, as shown herein and described above. The general repair outline is shown in Attachment 1.

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 non-ferritic weld to ferritic base material on which 1/8-inch or less of non-ferritic weld deposit exists above the original fusion line.

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

(d) Prior to welding, the area to be welded and a band around the area of at least 1 ½ 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) Peening will not be used.

2.0 Welding Qualifications

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

2.1 Procedure Qualification

(a) The ferritic steel base material for the welding procedure qualification is P-No. 3, Group No.3, which is the same P-Number and group number as the low alloy steel closure head base material to be welded. The ferritic base material will be post weld heat treated to at least the time and temperature that was applied to the materials being welded. The other base material is P-No. 43. The filler metal is F-No. 43.

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

(c) The maximum interpass temperature for the first 3 layers of the test assembly will be 150°F.

(d) The ferritic steel P-No. 3, Group No.3 base material 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 configuration will be prepared in accordance with the specifications supplied by the RPVH IDTB process repair/replacement services vendor.

(e) 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 (f) below, but shall be in the base metal.

(f) Charpy V-notch tests of the ferritic HAZ will be performed at the same temperature as the base metal test of subparagraph (e) 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-sized 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.

(g) The average values of the three HAZ impact tests shall be equal to or greater than the average values of the three unaffected base material tests.

2.2 Performance Qualification

Welding operators will be qualified in accordance with ASME IX.

3.0 Welding Procedure Requirements

The welding procedure will include the following requirements:

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

(b) Dissimilar metal welds will be made using F-No. 43 weld metal (QW-432) for P-No. 43 to P-No. 3 weld joints.

(c) The ferritic steel area to be welded will be buttered with a deposit of at least 3 layers to achieve at least 1/8-inch overlay thickness, with the heat input for each layer controlled to within ±10 percent 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 material to ensure that the HAZ and ferritic weld metal are tempered. Subsequent layers will be deposited with a heat input not exceeding that used for layers beyond the third layer in the procedure qualification.

(d) The maximum interpass temperature for field applications will be 350°F regardless of the interpass temperature during qualification. The new weld is inaccessible for mounting thermocouples near the weld. Therefore, thermocouples will not be used to monitor interpass temperature. Preheat temperature will be monitored using contact pyrometer(s) and/or thermocouple(s), on accessible areas of the closure head external surface(s).

(e) Particular care will be given to ensure that the weld region is free of all potential sources of hydrogen. The surface to be welded, filler metal, and shielding gas will be suitably controlled as specified in the welding process control documents.

4.0 Examination

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

(b) The final weld surface and adjacent HAZ will be examined using surface and ultrasonic methods when the completed weld has been at an ambient temperature for at least 48 hours.

The purpose for the examination of the band is to assure all flaws associated with the weld repair area have been removed or addressed. However, the band around the area defined in paragraph 1.0(d) cannot be examined due to the physical configuration of the partial penetration weld. The final examinations of the new weld repair and immediate surrounding area within the band will be sufficient to verify that defects have not been induced in the low alloy steel reactor vessel head material due to the welding process. Figure 1 of Attachment 1 indicates the approximate area for PT and UT examination for the nozzle penetration repairs. UT will be performed by scanning from the ID surface of the weld and adjacent portion of the nozzle bore. The UT is qualified to detect flaws in the repair weld and base metal interface in the repair region, to the maximum extent practical. The examination extent is consistent with the Construction Code requirements.

(c) NDE personnel will be qualified in accordance with IWA-2300 of the ASME XI, 2001A03 Code.

(d) For the Construction Code required examinations, the surface examination acceptance criteria will be in accordance with NB-5350 of the ASME III, 2001A03 Code. Ultrasonic examination acceptance criteria will be in accordance with NB-5330.

5.0 Documentation

Repairs/replacements in accordance with this request will be documented on Form NIS-2.

V. (III) ALTERNATIVE FLAW CHARACTERIZATION CONSIDERATIONS:

In accordance with the directives of NRC Order EA-03-009, TVA plans to perform examinations of the CRDM penetration tubes and associated RPVH J-groove welds. In the event that unacceptable indications are found during these examinations, repairs or replacements of the CRDM penetration tubes and/or the associated J-groove weld areas may be performed as described above. As part of this process, it may be necessary to allow indications to remain in place in the original J-groove weld areas which have been removed from the pressure boundary function. In accordance with the basic ASME XI requirements, characterization of any such flaws has to be performed.

The applicable code requirement for the RPVH penetration tube repair/replacement is ASME XI, 2001A03 Code. In accordance with this code, the inservice examination of the RPVH is performed during the normal VT-2 visual examinations conducted as part of the Class 1 system/component pressure tests. Evidence of leakage found during the VT-2 examination will precipitate evaluation and investigations into the source of the leakage. Thus, paragraphs IWA-3300, IWB-3142.4, and IWB-3420 would be applicable to any flaws identified as the result of inservice examinations such as the VT-2 visual examination. IWB-3612 provides acceptance criteria for the analytical evaluation of flaws that, in the case of this analytical analysis, are assumed to exist in the remnant of the J-groove weld material. Specifically:

1. IWA-3300(b) contains a requirement for flaw characterization.

2. IWB-3142.4 allows for analytical evaluation to demonstrate that a component is acceptable for continued service. It also requires that components found acceptable for continued service by analytical evaluation be subsequently examined in accordance with IWB-2420(b) and (c).

3. IWB-3420 requires the characterization of flaws in accordance with the rules of IWA-3300.

4. IWB-3612 provides acceptance criteria based upon applied stress intensity factors.

The above sections would require characterization of a flaw existing in the remnant of the J-groove weld that would be left on the RPVH if a penetration tube nozzle must be partially removed.

If inspection of the RPVH nozzle penetrations reveals flaws affecting the J-groove attachment welds, exact characterization of these flaws by NDE is unobtainable. Therefore, the full assurance that the future performance of any successive examinations in accordance with the requirements of the code is also unobtainable because of the inability to properly compare the two sets of results. The original nozzle to RPVH weld configurations are difficult to ultrasonically examine due to the compound curvature and fillet radius. The configuration is not conducive to UT due to the configuration and dissimilar metal interface between the NiCrFe weld and the low alloy steel RPVH. Furthermore, due to limited accessibility from the RPVH outer surface and the proximity of adjacent nozzle penetrations, it is not possible to perform a code required scan from the outer surface on the RPVH base material to detect flaws in the vicinity of the original welds. These conditions preclude ultrasonic coupling and control of the sound beam in order to perform flaw sizing which results in reasonable confidence of the accuracy of the measured flaw dimensions. Therefore, TVA is requesting relief from ASME XI, IWA-3300(b), IWB-3142.4, IWB-3420, and IWB-3612 pursuant to 10 CFR 50.55a(a)(3)(i), because the alternative proposed below provides an acceptable level of quality and safety.

The alternative requirements are:

1. IWA-3300(b) contains a requirement for flaw characterization. In lieu of this requirement, a conservative worst-case flaw shall be assumed to exist in this weld that extends from the weld surface to the RPVH low alloy steel base material interface. Appropriate fatigue crack growth analyses have been performed based on that flaw to establish the minimum remaining service life of the RPVH.

2. IWB-3142.4 allows for analytical evaluation to demonstrate that a component is acceptable for continued service. It also requires that components found acceptable for continued service by analytical evaluation be subject to successive examination. Analytical evaluation of the worst-case flaw referred to above has been performed to demonstrate the acceptability of continued operation. However, because of the impracticality of performing any subsequent inspection that would be able to characterize any remaining flaw, successive examination will not be performed.

3. Paragraph IWB-3420 requires the characterization of flaws in accordance with the rules of IWA-3300. As previously stated, a conservative worst-case flaw shall be assumed to exist and appropriate fatigue crack growth analyses have been performed based on that flaw.

4. Paragraph IWB-3612(a) requires that, for normal conditions, the ratio of the maximum applied stress intensity factor (K_I) and the available fracture toughness based on crack arrest (K_{Ia}) for the corresponding crack tip temperature be less than $1/\sqrt{10}$. Based on a determination that the flaw failure mechanism is ductile tearing, TVA proposes to consider the use of elastic plastic fracture mechanics (EPFM) and two different safety factors for primary and secondary loads, in keeping with industry practice. To evaluate flaw stability, TVA proposes to use safety factors of 3 on primary (pressure) stresses and 1.0 on secondary stresses (residual plus thermal) for flaw stability under ductile tearing for the normal and upset conditions. The crack driving force will be calculated using safety factors of 1.5 and 1.0 for primary and secondary stresses, respectively. For EPFM analysis of faulted conditions, safety factors of 1.5 and 1.0 will be used for flaw stability assessments and factors of 1.25 and 1.0 for evaluations of crack driving force. These safety factors will be applied for both the CRDM and the ICI penetration tube configuration analysis.

VI. JUSTIFICATION FOR GRANTING RELIEF:

This request generally addresses the SQN and WBN RPVHs and CRDM Penetration Tubes, the Head Adapter Plug Nozzles, the ICI Penetration Tubes, the HV Pipe Penetration Tubes, and the Capped Unused UHI Auxiliary Head Adapter Penetration Tubes (SQN units only). The probability of occurrence of cracks in the SQN and WBN RPVH penetrations and J-groove welds is unlikely. The SQN and WBN RVPH operating temperatures place these TVA units in the 5 least susceptible units for potential crack initiation in the RPVH Alloy 600 J-groove welds. Therefore, the FANP analytical evaluations, performed for support of TVA activities, currently only addresses the CRDM and ICI penetration tube configurations because these areas are the most probable areas (based upon the number of these penetrations) where J-groove indication would be found.

TVA will provide NRC with FANP's non-proprietary summary report with initial supporting analyses in the event that the required examinations of RPVH penetration tubes and J-groove welds reveal indications that require repair. FANP's bounding analysis will be reviewed for the impact of indications found to determine if there is a need to revise the supporting analyses. In the event that the FANP bounding analyses require revision, TVA will submit the revised summary report once it becomes available.

The features of the alternative repair technique, with the use of Code Case N-638-1, that make it applicable and acceptable for the potential repairs are described below:

1) The proposed alternative will require the use of an automatic or machine GTAW temper bead technique without the specified preheat or post weld heat treatment of the Construction Code. The proposed alternative will include the requirements of paragraphs 1.0 through 5.0 of ASME V - II, above. The alternative will be used to make welds of P-No. 43 (nozzle material) to P-No. 3 (RPVH material) using F-No. 43 filler material. The FANP weld qualification process subjected the mock-up sample ferritic base material to a post-weld heat treatment (PWHT) at 1150°F for a period of 66 hours. This PWHT was within the limits of SQN or WBN ferritic base materials in the RPVH.

2) The use of a GTAW ambient temperature temper bead welding technique to avoid the need for post weld heat treatment is based on research that has been performed by Electric Power Research Institute (EPRI), Report GC-111050, "Ambient Temperature Preheat for Machine GTAW Temper Bead Applications," dated November 1998. The research demonstrates that carefully controlled heat input and bead placement allow subsequent welding passes to relieve stress and temper the HAZ of the base material and preceding weld passes. Data presented in Tables 4-1 and 4-2 of the report show the results of procedure qualifications performed with 300°F preheats and 500°F post-heats, as well as with no preheat and post-heat. From that data, it is clear that equivalent toughness is achieved in base metal and HAZ in both cases. The ambient temperature temper bead process has been shown effective by research, successful procedure qualifications, and many successful repairs performed since the technique was developed.

3) The NB-4622.11 (c)(2) temper bead procedure requires the use of the SMAW welding process with covered electrodes. Low hydrogen electrodes, which are required by NB-4622.11, may be a source of hydrogen unless very stringent electrode baking and storage procedures are followed. The only shielding of the molten weld puddle and surrounding metal from moisture in the atmosphere (a source of hydrogen) is the evolution of gases from the flux and the slag that forms from the flux and covers the molten weld metal. As a consequence of the possibility for contamination of the weld with hydrogen, NB-4622 temper bead procedures require preheat and post weld hydrogen bake-out. However, the proposed alternative temper bead procedure utilizes a welding process that is inherently free of hydrogen.

4) Final examination of the repair welds would be by PT and UT and would not be conducted until at least 48 hours after the weld had returned to ambient temperature following the completion of welding. Given the 3/8-inch limit on repair depth in the ferritic material, the delay before final examination would provide ample time for any hydrogen that did inadvertently dissolve in the ferritic material to diffuse into the atmosphere or into the non-ferritic weld material, which has a higher solubility for hydrogen and is much less prone to hydrogen embrittlement cracking. Thus, in the unlikely event that hydrogen induced cracking did occur, it would be detected by the 48-hour delay in examination.

5) Results of procedure qualification work undertaken to date indicate that the ambient temper bead process produces sound and tough welds. Typical tensile test results have shown ductile type breaks in the weld metal.

6) The P-No. 43 to P-No. 3 welding procedure specifies a maximum interpass temperature of 350°F. The welding procedure was qualified with an interpass temperature less than 150°F. Per QW-256 of ASME IX, an increase greater than 100°F is a supplementary essential variable. The procedure qualification requirements recommended in Code Case N-638-1 impose a 150°F maximum interpass temperature during the welding of the procedure qualification. This requirement restricts base metal heating during qualification that could produce slower cooling rates that are not achievable during field applications. However, this requirement does not apply to field applications, as a 350°F maximum interpass temperature is a requirement in Section 3.0 of Code Case N-638-1. The higher interpass temperature is permitted because it would only result in slower cooling rates which could be helpful in producing more ductile transformation products in the HAZ. FANP has qualified the machine GTAW of P-No. 3, low alloy steel base materials, to P-No. 43, nickel alloy base materials, with the ambient temperature temper bead weld technique in accordance with the rules of ASME Code Case N-638-1. The qualifications were performed on the same P-No. 3, Group No. 3 base material as proposed for the penetration repairs, using the same filler material, with similar low heat input controls as will be used in the repairs. Also, the qualifications did not include a post weld heat soak. Based on FANP prior welding procedure qualification test data using machine GTAW ambient temperature temper bead welding, quality temper bead welds can be achieved with 50°F minimum preheat and no post weld heat soak.

7) As discussed previously, NB-5245 requires progressive surface examination of the proposed partial penetration welds while the alternative requires final PT and UT, which will provide added assurance of sound welds. The original Construction Code required progressive PT in lieu of volumetric examination because volumetric examination is not possible for the conventional partial penetration weld configurations in this area. In this case, the weld is suitable for UT and a final PT can be performed. The final examination of the new weld repair and immediate surrounding area within the band will be sufficient to verify that defects have not been induced in the low alloy steel RPVH material due to the welding process. Figure 1 of Attachment 1 to this enclosure shows the approximate areas for PT and UT for the nozzle penetration repairs. UT will be performed by scanning from the ID surface of the weld. The UT is qualified to detect flaws in the repair weld and base metal interface in the repair region, to the maximum practical extent. UT acceptance criteria will be in accordance with

NB-5330 (with exception to NB-5331 (b) for the triple point anomaly). The extent of examination is consistent with the Construction Code requirements.

8) The RPVH preheat temperature will be essentially the same as the reactor building ambient temperature during power operation. Therefore, RPVH preheat temperature monitoring in the weld region and the use of thermocouples is unnecessary and would result in additional personnel dose associated with thermocouple placement and removal. Consequently, preheat temperature verification by use of a contact pyrometer on accessible areas of the RPVH is sufficient. In lieu of using thermocouples for interpass temperature measurements, calculations show that the maximum interpass temperature will not be exceeded. These calculations are based on a maximum allowable welding heat input, weld bead placement, travel speed, and conservative preheat temperature assumptions. The calculation supports the conclusion that using the maximum heat input through the third layer of the weld, the interpass temperature returns to near ambient temperature. Heat input beyond the third layer will not have a metallurgical effect on the low alloy steel HAZ.

   A welding mockup on the full size Midland RPVH, which is similar to the TVA RPVH, was used to demonstrate the welding technique described herein. During the mockup, thermocouples were placed to monitor the temperature of the closure head during welding. Thermocouples were placed on the outside surface of the RPVH within a 5-inch band surrounding the CRDM nozzle. Three other thermocouples were placed on the RPVH inside surface. One of the 3 thermocouples was placed 1-1/2 inches from the CRDM nozzle penetration, on the lower hillside. The other inside surface thermocouples was placed at the edge of the 5-inch band surrounding the CRDM nozzle, one on the lower hillside, the second on the upper hillside. During the mockup, all thermocouples fluctuated less than 15°F throughout the welding cycle. Therefore, for ambient temperature conditions used for this repair, maintenance of the 350°F maximum interpass temperature will not be a concern.

9) UT will be performed in lieu of RT due to the repair weld configuration. Meaningful RT cannot be performed. The weld configuration and geometry of the penetration in the RPVH provide an obstruction for the X-ray path and interpretation would be very difficult. UT will be substituted for the RT and qualified to evaluate defects in the repair weld and at the base metal interface. This examination method is considered adequate and superior to RT for the RPVH penetration tube geometry. The new structural weld is sized like a coaxial cylinder partial penetration weld. ASME III construction rules require progressive PT of partial penetration welds. The ASME III original requirements for progressive PT were in lieu of volumetric examination. Volumetric examination is not practical for the conventional partial penetration weld configurations. In this case, the weld is suitable for UT and a final surface PT will be performed.

10) The extent of PT examination is consistent with the Construction Code requirements. The final modification configuration and surrounding ferritic steel area affected by the welding is either inaccessible or extremely difficult to access. PT of the accessible ferritic steel bore will be performed after removal by boring of the lower end of the existing CRDM nozzle prior to welding.

11) The J-groove weld has a high tensile stress state due to welding residual stresses that could promote PWSCC initiation. Removal of the nozzle will impart some additional cold work and tensile stress on the newly machined ID surface of the J-groove weld. The effect of the machining and cold work is not expected to adversely affect the susceptibility of the J-groove weld to PWSCC since it is already in a highly stressed state and has a high susceptibility. After the IDTB repair, the original J-groove weld no longer serves its original function and an EPFM analysis was performed which justified an assumed radial planar flaw in the J-groove weld that initially extends to the RPVH ferritic steel fusion zone and then propagates into the RPVH via fatigue crack growth.

12) A potential artifact of the temper bead weld repair is an anomaly in the weld at the triple point. Fracture mechanics analyses were performed by FANP to evaluate a postulated 0.100-inch semi-circular flaw extending 360 degrees around the circumference at the triple point locations where the Alloy 600 original nozzle or Alloy 690 replacement nozzle, the Alloy 52/52M weld, and the low alloy steel head meet. The postulated 0.100-inch flaw is assumed to propagate, via fatigue crack growth, in each of the two directions on the uphill and downhill sides of the nozzle. Flaw acceptance is based on the ASME XI, 2001A03 Code criteria for limit load (IWB-3644).

The results of the analyses for the nozzles demonstrate that a 0.100-inch weld anomaly is acceptable for a 40-year design life of the ID temper bead weld repair for both the CRDM and ICI nozzles.

13) The potential corrosion concerns of the RPVH low alloy steel include: general, galvanic, crevice, stress corrosion cracking (SCC), and hydrogen embrittlement. Galvanic corrosion, crevice corrosion, SCC, and hydrogen embrittlement of the RPVH low alloy steel are not significant concerns based on previous operational experience with low alloy steel exposed to primary coolant. The general corrosion rate for the RPVH low alloy steel, under the anticipated exposure conditions, is 0.0032 inch/year. This corrosion rate is based on an 18-month operating cycle followed by a 2-month refueling cycle.

14) Detailed stress and fatigue analyses of the IDTB CRDM/ICI nozzle weld repair were performed. The analysis demonstrated that the IDTB CRDM/ICI weld repair design meets the stress and fatigue requirements set by ASME III, 2001A03 Code Edition and Addenda. Conservative fatigue analyses conclude that the maximum cumulative fatigue usage factor for 40 years of operation is 0.336 for the CRDM weld repair and the Alloy 690 replacement nozzle and 0.263 for the ICI weld repair and Alloy 690 replacement nozzle. The maximum allowed ASME Code fatigue usage factor is 1.0. The fatigue analyses included the normal and upset operating transients (tabulated below) plus 200 cycles of the Operating Basis Earthquake (OBE) for SQN and WBN.

The life expectancy of the IDTB CRDM/ICI weld repair was also evaluated with respect to the PWSCC concerns of the remaining Alloy 600 CRDM nozzle portion affected by the IDTB weld repair. The Alloy 690 replacement nozzle and Alloy 52/52M IDTB weld are not considered susceptible to PWSCC. The life expectancy of the IDTB weld repair relative to PWSCC is conservatively estimated at 2.7 effective full power years (EFPY) with a non-abrasive water jet machining (AWJM) remediated IDTB weld for repair of a CRDM nozzle, or an ICI nozzle. The PWSCC life was based on the EPRI MRP-55 PWSCC crack growth model. The PWSCC propagation path was conservatively assumed to follow the highest hoop tensile stress. The crack tip stress intensity factor was calculated for each increment of crack growth.

Transient	Operating Condition	Cycles in 40 Years
Heat Up and Cool Down at 100°F Per Hour	Normal	200
Plant Loading and Unloading at 5 percent Full Power/Minute		3000
Step Load Increase/Decrease at 10 percent of Full Power		2000
Large Step Decrease in Load		200
Turbine Roll Test		10
Hydrostatic Test before Startup at 3125 psia		5
Hydrostatic Pressure Test at 2485 psig		50
Loss of Load	Upset	80
Loss of Power		40
Loss of Flow		80
Reactor Trip from Full Power		400
Reactor Coolant Pipe Break (assumed)	Faulted	1
Steam Pipe Break (assumed)		1

The results of the triple point flaw analyses demonstrates that a 0.100-inch weld anomaly is acceptable for 40 years of operation following the CRDM/ICI nozzle IDTB weld repair considering the transient frequencies listed in the above table.

Significant design margins have been demonstrated for all flaw propagation paths considered in the analysis. Flaw acceptance is based on the ASME XI, 2001A03 Code criteria for limit load (IWB-3644). Fatigue crack growth is minimal along each flaw propagation path with the maximum calculated final flaw size being only 0.1003-inch for both the CRDM nozzle and the ICI nozzle. For the CRDM nozzle IDTB weld repairs and the ICI thermocouple guide column nozzle weld repairs, the minimum limit load margins are 3.21, compared to the required safety factor of 2.7, in accordance with IWB-3644 of the ASME XI, 2001A03 Code.

Fracture mechanics evaluations were performed by FANP to determine if degraded J-groove weld material could remain in the reactor vessel closure head, with no examination to size any flaws that might remain following repairs. The remaining non-chamfered J-groove welds in the CRDM nozzles, after the IDTB repair, are analyzed by postulating an initial radial crack in the Alloy 82/182 J-groove weld and butter and evaluating fatigue crack growth into the low alloy steel head. Since a potential flaw in the J-groove weld can not be sized by currently available NDE techniques, it was assumed that the "as-left" condition of the remaining J-groove weld include degraded or cracked weld material extending through the entire J-groove weld and Alloy 82/182 butter material. It was further postulated that the "as-left" flaw propagates into the head by fatigue crack growth under cyclic loading conditions.

Crack stress intensity factors for initial "as-left" flaws were first determined using 3-dimensional finite element analysis and applying both residual and operating stresses for each of the 10 analyzed transients. Crack size was incremented based on the fatigue crack growth model given in ASME XI, Subarticle A-4300. For each increment of crack growth, stress intensity factors were increased by the square root of the ratio of flaw sizes. This is a conservative approximation since both the residual stresses and the thermal gradient stresses decrease in the direction of crack propagation. Flaw growth into the reactor head was calculated to be 0.309-inch on the uphill side and 0.102-inch on the downhill side for ten years of operation.

Evaluation of crack stress intensity factor, including pressure, thermal and residual stress effects, for the final maximum flaw size using the acceptance criteria of IWB-3612 indicates insufficient available fracture toughness to provide the specified margins under all conditions. Therefore, based on a determination that ductile tearing is the failure mechanism for the final flaw under the conditions being evaluated, EPFM was utilized to evaluate the final flaw sizes after 10 years of crack growth for all propagation paths. At operating and low temperature conditions, a J-integral/tearing modulus (J-T) diagram was used to evaluate flaw stability with safety factors of 3.0 on primary pressure stresses and 1.0 secondary (residual plus thermal) stresses. The crack driving force was checked against the J-integral/resistance (J-R) curve at an assumed crack extension of 0.1-inch using safety factors of 1.5 and 1.0 for primary and secondary stresses, respectively. At controlling faulted conditions, flaw stability was evaluated with safety factors of 1.5 on primary stress and 1.0 on secondary stress. Crack driving force was also checked against the J-R curve at an assumed crack extension of 0.1-inch under faulted conditions using safety factors of 1.25 and 1.0 for primary and secondary stresses, respectively. For the final flaw size on both the uphill and downhill sides under all operating, low temperature and faulted conditions with the above safety factors incorporated, the applied tearing modulus remains less than the material tearing modulus and the applied J-integral remains less than the material J-integral at the 0.1-inch crack extension.

The above discussion provides the basis for the subject relief request (G-RR-2). This alternative provides an acceptable level of quality and safety as needed and appropriate for the final configuration of the RPVH penetration nozzles. The acceptable level of quality and safety is obtained without the removal of existing flaws in the remaining original J-groove weld material and without performing flaw characterization as required by ASME XI, 2001A03 Code, paragraphs IWA-3300 (b), IWB-3142.4, IWB-3420, and IWB-3612.

Based on the information presented, and pursuant to 10 CFR 50.55a(a)(3)(i), TVA requests approval for the use of the above proposed alternative RPVH penetration tube and J-groove weld repair/replacement activities at SQN Units 1 and 2 and WBN Unit 1.

VII. IMPLEMENTATION SCHEDULE:

TVA requests approval of the subject relief for use during the remainder of the current 10-year ISI Program intervals as indicated in the table above. In the case of WBN, TVA also plans to apply the provisions of this request during the 2nd 10-year ISI Program interval that is scheduled to start May 27, 2007. Once the J-groove weld repairs are made or modifications are installed, they will remain in place for the design life of the repair that is defined in accordance with the evaluation requirements.

VIII. PRECEDENTS:

NRC has granted approval for several industry relief requests for similar IDTB repair/replacement processes. These relief requests and associated safety evaluation reports (SERs) were used to develop Relief Request No. G-RR-2. The 3 most recent ones are listed below:

1) Millstone Power Station Unit 2, Docket No. 50-336; SER dated October 2, 2002 [ML022280126]

2) Arkansas Nuclear One, Units 1 and 2, and Waterford Steam Electric Station, Unit 3, Docket Nos. 50-313, 50-368, and 50-382; SER dated April 16, 2003 [ML031060501]

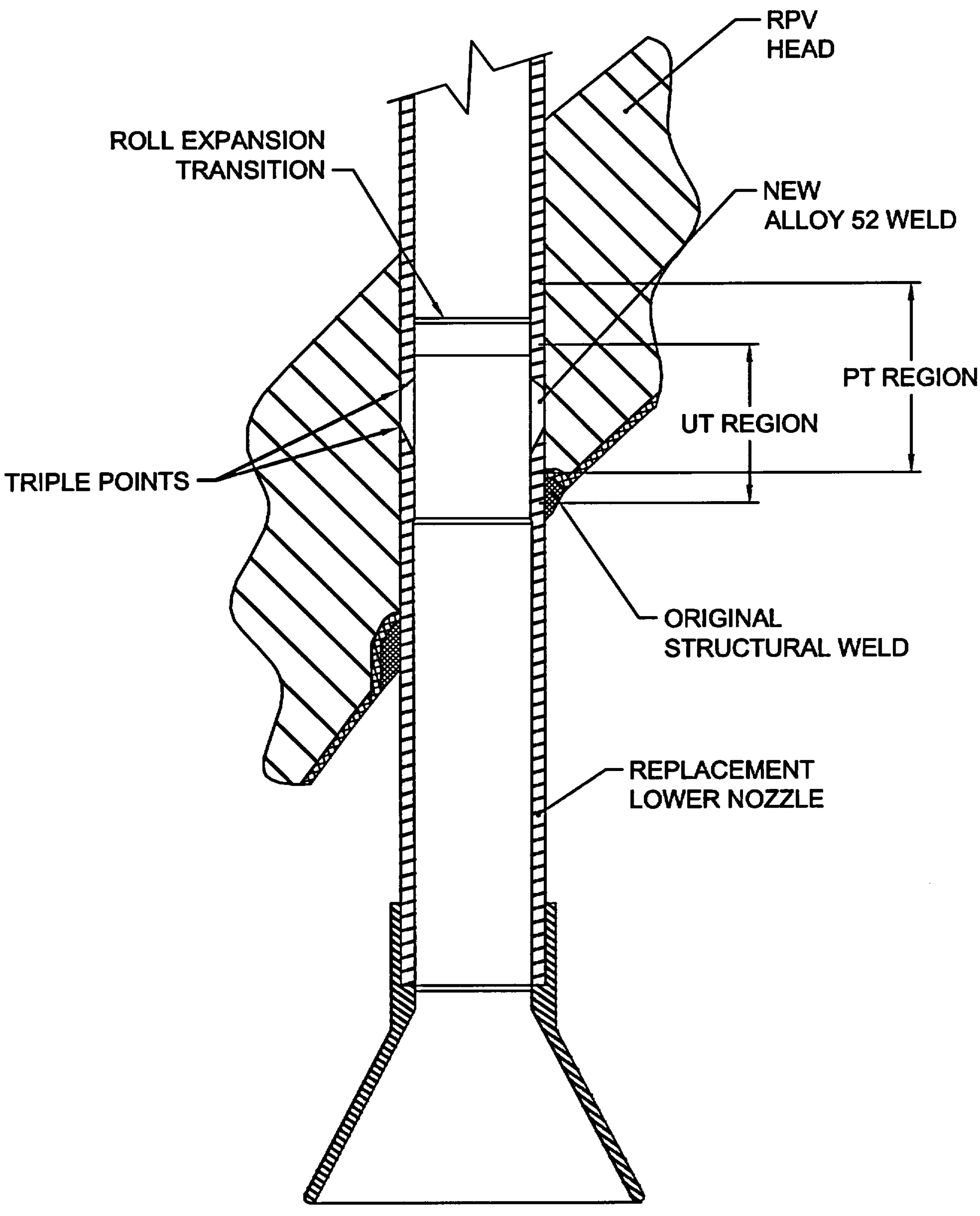
3) Palisades Nuclear Plant, Docket No. 50-255; SER dated April 3, 2006 [ML0607900610]

ATTACHMENT 1 (TO ENCLOSURE 1)

ALTERNATE REPAIR TECHNIQUE
DISSIMILAR METAL WELDS USING AMBIENT TEMPERATURE MACHINE
GTAW TEMPER BEAD TECHNIQUE

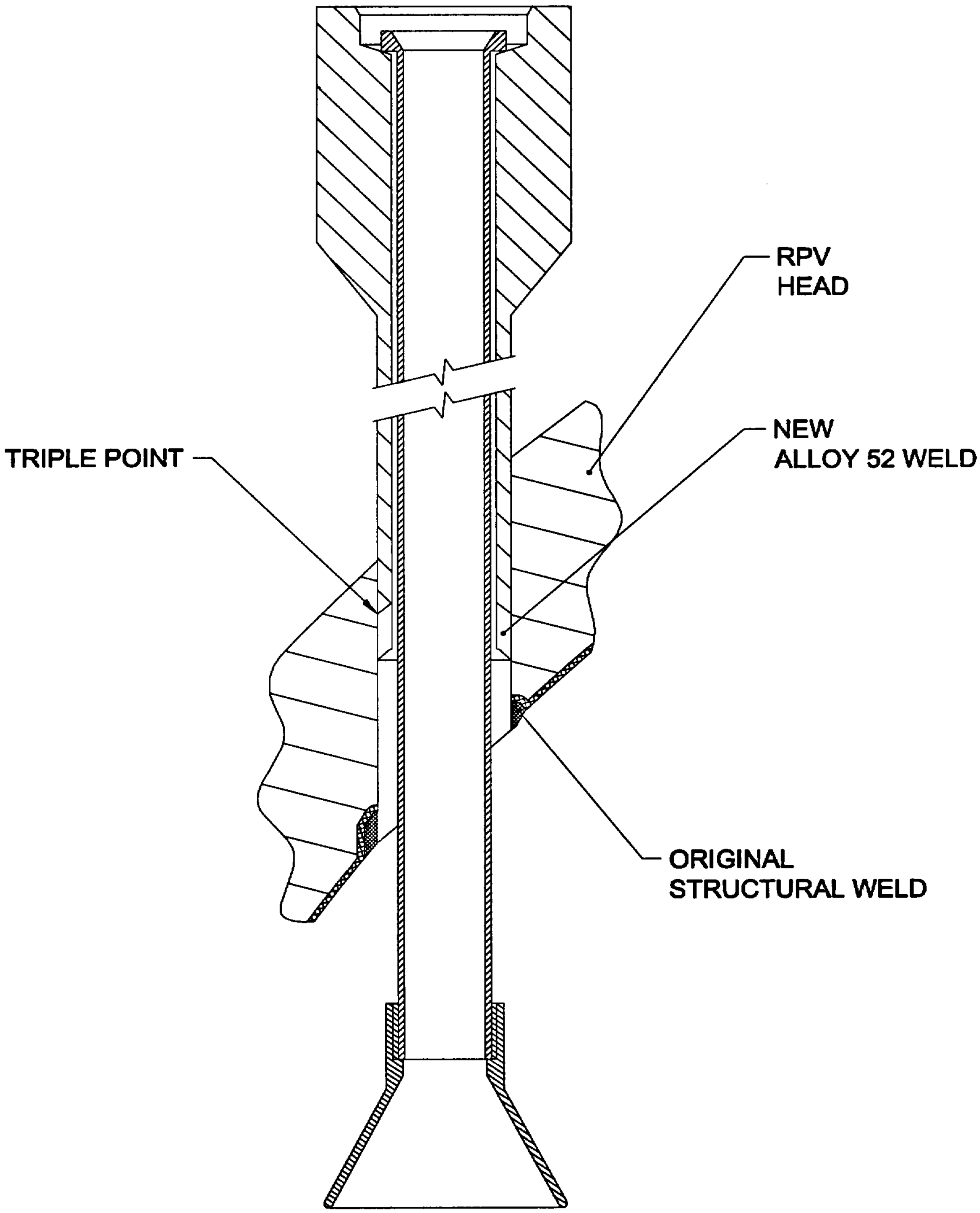
As a contingency, TVA has plans to perform Reactor Pressure Vessel Head (RPVH), Control Rod Drive Mechanisms (CRDM), and Incore Instrumentation (ICI) Nozzle Penetration repairs by welding the RPVH (P-No.3) base material and the Nozzle Penetrations (P-No.43) base material with filler material F-No.43, as shown in Figures 1 and 2 (following pages). A typical process outline is listed below. The process outline is similar for the CRDM and ICI nozzles, except as noted.

a. Perform Ultrasonic Test (UT) of weld repair area.
b. Cut tube grid structure adjoining the target nozzle and surrounding CRDMs. (nozzle only).
c. Cut the nozzle and remove the nozzle extension nearest to the underside of the reactor head.
d. Roll expand nozzle body.
e. Clean the bore.
f. Bore the lower nozzle outside diameter that is slightly oversized up to the location of the repair weld. The lower portion of the remaining nozzle is beveled suitable for welding.
g. Machine the replacement lower nozzle diameter and length.
h. Grind the original J-groove weld, if required to allow a proper fit for the replacement penetration tube (ICI only).
i. Clean the weld preparation area.
j. Pressure Test (PT) the weld preparation and exposed low alloy steel base material.
k. Clean PT consumables from weld prep and dry nozzle and crevice using a heating element.
l. Insert new replacement lower nozzle and weld using the ambient temperature temper bead machine gas tungsten arc welding (GTAW) process.
m. Weld cool down then 48-hour hold.
n. Machine new weld inside diameter (ID). This may be performed during the 48-hour hold.
o. UT the weld after 48-hour hold.
p. PT the weld and roll expanded portion of nozzle, including the roll transition region.
q. Install the new extension assembly and tube grid structure for CRDM locations.
r. Position and weld the new tube grid structure and the fillet weld new extension assembly to the lower nozzle and grid structure (CRDM nozzle only) and intermittent fillet weld extension to lower nozzle (ICI nozzle only).
s. Visually inspect the new welds.
t. Dimensionally inspect the location of the new nozzle extension assembly. The positioning tool shall perform a free path check for nozzles (CRDM only).
u. Perform final cleaning and visual inspection of each nozzle.



INCORE INSTRUMENT
(THERMOCOUPLE) NOZZLE

FIGURE 1



CRDM NOZZLE

FIGURE 2

ENCLOSURE 2

LIST OF COMMITMENTS

1. TVA will provide NRC with FANP's non-proprietary summary report with initial supporting analyses in the event that the required examinations of RPVH penetration tubes and J-groove welds reveal indications that require repair. This summary report would be submitted prior to unit restart for the associated outage.

2. FANP's bounding analysis will be reviewed for the impact of any indications found to determine if there is a need to revise the supporting analyses. In the event that the FANP bounding analyses requires revision, TVA will submit the revised summary report in conjunction with item 1 above, as needed.