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NL-02-104
IPN-02-061

U. S. Nuclear Regulatory Commission
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SUBJECT: Indian Point 2 and 3 Nuclear Power Plants
Docket Nos. 50-247 and 50-286
License Nos. DPR-26 and DPR-64
ASME Code Relief Requests to use
an Alternative to Temper Bead Welding Requirements
for Contingency Repairs on Reactor Vessel Head Penetration Nozzles

References:

1. ENO letter, M. Kansler to USNRC, dated July 1, 2002 (NL-02-094/IPN-02-053) regarding "ASME Code Relief Requests to Use Electrical Discharge Machining (EDM) for Contingency Repairs on Reactor Vessel Head Penetration Nozzles".

2. EOI letter to USNRC, dated March 4, 2002 (CNRO-2002-00008) regarding "Proposed Alternative to ASME Code Requirements for Weld Repairs" for ANO Units 1 and 2, and Waterford Unit 3.

3. EOI letter to USNRC, dated March 29, 2002 (CNRO-2002-00017) regarding "Proposed Alternative to ASME Code Requirements for Weld Repairs" for ANO Units 1 and 2, and Waterford Unit 3.

4. USNRC letter to EOI, dated March 28, 2002, "Request for Additional Information Regarding Proposed Alternatives to American Society of Mechanical Engineers Boiler and Pressure Vessel Code Requirements for Weld Repairs (TAC Nos. MB 4288, MB 4289, and MB 4286)"

5. USNRC letter to EOI, dated April 18, 2002, "Request for Additional Information Regarding Proposed Alternatives to American Society of Mechanical Engineers Boiler and Pressure Vessel Code Requirements for Weld Repairs (TAC Nos. MB 4288, MB 4289, and MB 4286)"

Dear Sir:

This letter transmits two identical requests for relief from ASME Section XI Code requirements. Relief Request RR 61 (Attachment I) is for Indian Point Nuclear Generating Unit No. 2 (IP2) and Relief Request RR 3-31 (Attachment II) is for Indian Point Nuclear Generating Unit No. 3 (IP3).

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Entergy Nuclear Operations, Inc. (ENO) proposes an alternative method to the temper bead welding requirements of ASME Section XI IWA-4300 and IWA-4500. These requests for relief are submitted pursuant to 10CFR50.55a(a)(3)(i). The proposed alternatives provide an acceptable level of quality and safety.

ENO will be performing reactor vessel head inspections during the upcoming refueling outages, in accordance with NRC Bulletins 2001-01 and 2002-01. The outage for IP2 is currently scheduled for October 2002 and the IP3 outage is currently scheduled for March 2003. The relief requests are appropriate as a contingency, in the event that the inspections identify the need for repairs. This is the second of three contingency relief requests associated with the reactor vessel head inspections. The first request was submitted by Reference 1 and ENO intends to submit the third relief request by August 23, 2002. ENO is requesting approval by September 30, 2002 to support the IP2 outage schedule.

Entergy Operations Inc. (EOI) has previously submitted a similar relief request (References 2 and 3) for ANO Units 1 and 2 and Waterford 3. The attached requests reflect the additional information in response to the NRC comments (References 4 and 5) on the EOI submittal.

There are no new commitments made in this letter. If you have any questions, please contact Ms. Charlene Faison at 914-272-3378.

Very truly yours,

Michael R. Kansler
Senior Vice President and
Chief Operating Officer

Attachments: I. Relief Request RR 61, Rev. 0 for Indian Point Generating Unit No. 2
II. Relief Request RR 3-31, Rev. 0 for Indian Point Generating Unit No. 3

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ATTACHMENT I TO NL-02-104 / IPN-02-061

INDIAN POINT NUCLEAR GENERATING UNIT NO. 2

THIRD TEN-YEAR INSERVICE INSPECTION INTERVAL PROGRAM PLAN

Relief Request RR 61, Revision 0 (IP2)

ENTERGY NUCLEAR OPERATIONS, INC.

INDIAN POINT NUCLEAR GENERATING UNIT NO. 2
DOCKET NO. 50-247
DPR-26

RELIEF REQUEST RR 61, Rev. 0

A. COMPONENT IDENTIFICATION

Code Class:	1
References:	Table IWB-2500-1, Category B-E
Examination Category:	B-E
Item Numbers:	B4.12, B4.13
Description:	Reactor Pressure Vessel (RPV) Head Penetration Nozzles

B. CODE REQUIREMENT

IWA-4120(a) of ASME Section XI, 1989 Edition states:

"Repairs 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 alternative requirements of IWA-4500 and the following may be used:

(1) IWB-4000 for Class 1 components

(2) IWC-4000 for Class 2 components

(3) IWD-4000 for Class 3 components

(4) IWE-4000 for Class MC components

(5) IWF-4000 for component supports."

IWA-4500 of ASME Section XI establishes alternative repair welding methods for performing temper bead welding.

IWA-4530 applies to dissimilar materials such as welds that join P-Number 8 or P-Number 43 material 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-No. 1, 3, 12A, 12B, or 12C material where the ferritic base material is within 1/8-inch of being exposed shall be made by welding in accordance with the provisions of Section III, without the specified post weld heat treatment, provided the requirements of IWA-4531 through IWA-4534 are met."

Half bead welding technique repairs of RPV head penetration nozzle J-welds are performed in accordance with IWA-4500, in particular IWA-4530 whenever the repair cavity is within 1/8-inch of the ferritic base materials of the RPV head. The requirements of IWA-4530 include:

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- The weld metal shall be deposited by the shielded metal-arc welding process (SMAW).
- A minimum preheat temperature of 300°F shall be maintained for at least 30 minutes before welding is started. Interpass temperature cannot exceed 400°F.
- The preheat temperature of 300°F shall be maintained until the exposed base metal is covered with at least 3/16" of weld metal.
- After at least 3/16" of weld metal has been deposited, the 3T band to be heat-treated shall be maintained in the range of 450°F to 550°F for 2 hours as a minimum.
- Preheat, interpass, and heat treatment temperatures shall be monitored using thermocouples and recording instruments.
- A liquid penetrant examination shall be performed in the area being repaired after the heat treatment is complete.
- The repair weld and preheated band shall be nondestructively examined after the completed weld has been at ambient temperature for 48 hours as a minimum.
- The nondestructive examination of the repaired region shall include radiography, if practical, ultrasonic examination, and liquid penetrant examination.
- Areas from which welded thermocouples have been removed shall be ground and examined by MT or PT methods.

C. RELIEF REQUESTED

In lieu of the SMAW-temper bead welding requirements of IWA-4500, and IWA-4530 of ASME Section XI, 1989 Edition, Entergy (ENO) proposes the alternatives as described below. These alternatives conform to ASME Code Case N-638. Specifically, ENO proposes to perform ambient temperature temper bead welding in accordance with Enclosure 1 of this relief request, "Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Welding Technique."

ENO has reviewed the proposed ambient temperature temper bead welding techniques of Enclosure 1 against the SMAW-temper bead welding requirements of IWA-4500, and IWA-4530. This review was performed to identify and to reconcile the differences between the proposed alternatives in Enclosure 1 and IWA-4500, and IWA-4530 requirements. Specifically, Entergy proposes these alternatives to the requirements of the following ASME Section XI subsections:

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1. **IWA-4530** specifies that repairs made to dissimilar materials identified in IWA-4530 may be performed without the specified post weld heat treatment of ASME Section III provided the requirements of IWA-4531 through IWA-4534 are met. As an alternative, ENO proposes to perform temper bead weld repairs using the ambient temperature temper bead welding technique described in Enclosure 1.

2. **IWA-4531(a) and (b)** specifies that the weld metal shall be deposited by the SMAW using F-No. 43 weld metal for P-No. 43 to P-No. 3 weld joints. The maximum bead width shall be three times the electrode core diameter. Also, the precautions of IWA-4521(b) shall be met. As an alternative, ENO proposes to use the Machine or Automatic GTAW welding process with F-No. 43 weld metal when performing ambient temperature temper bead welding in accordance with Enclosure 1.

3. **IWA-4533(a) and (d)** specifies that the cavity and area to be preheated to 300°F. This minimum temperature shall be maintained for at least 30 minutes before welding is started, during welding, and until starting the post weld heat treatment of 450°F to 550°F. The width of the band to be heat-treated shall be three times the thickness (3T) of the component to be welded, but need not exceed 10". The maximum interpass temperature shall be 400°F. The minimum preheat temperature for ferritic base material shall be 300°F, and shall be maintained until the exposed base metal is covered with at least 3/16" of weld metal. The preheat shall be maintained until the heat treatment specified in IWA-4533(b) is performed. For the balance of welding, the maximum interpass temperature shall be 350°F, and the minimum preheat shall be 60°F. After at least 3/16" of weld metal has been deposited, the 3T band shall be maintained in the range of 450°F to 550°F for 2 hours as a minimum. ENO proposes that 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 50°F for the GTAW welding 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-4533(b)** specifies that thermocouples and recording instruments shall be used to monitor process temperatures. As an alternative, ENO proposes to monitor preheat and interpass temperatures using an infrared thermometer.

5. **IWA-4533(b)** specifies that thermocouples shall be attached by either welding or mechanical methods. Because ENO will use an infrared thermometer to monitor preheat and interpass temperatures, thermocouples will not be used. Therefore, the thermocouple attachment requirements of IWA-4533(b) do not apply.

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6. **IWA-4533(c)** specifies that all areas of the ferritic base metal, exposed or not, shall be covered with one layer of weld deposit using 3/32" diameter electrodes. Approximately one-half the thickness of this layer shall be removed by grinding before depositing the second layer, and subsequent layers with 1/8" diameter electrodes. As an alternative, ENO 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.

7. **IWA-4534(b)** specifies the repair area and the 3T band as defined in IWA-4534(a) shall be nondestructively examined after the completed weld has been at ambient temperature for a period of 48 hours minimum. The nondestructive examination of the repair welded region shall include radiography, if practical, ultrasonic examination, and magnetic particle examination. As an alternative to the volumetric examination of IWA-4534(b), ENO proposes the following examination 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, 1989 Edition. Acceptance criteria shall be in accordance with NB-5350. Original fabrication records indicated that the J-welds, considered partial penetration welds, were only examined by the liquid penetrant method (References 13 and 14).

8. **IWA-4534(c)** specifies that areas from which weld attached thermocouples have been removed shall be ground and examined by the magnetic particle method or by the liquid penetrant method. Because ENO will use an infrared thermometer to monitor preheat and interpass temperatures, thermocouples will not be used. Therefore, the examination requirements of IWA-4534(c), for the areas from which weld attached thermocouples have been removed, do not apply.

These proposed alternatives are 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). All flaws in the J-weld will be removed prior to performing any temper bead weld repairs in accordance with this relief request.

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D. BASIS FOR RELIEF

IWA-4500, and IWA-4530 of ASME Section XI establish requirements for performing temper bead welding of "base materials" and "dissimilar materials". According to IWA-4531, the SMAW process shall be used. ENO proposes the Machine GTAW Welding process (Enclosure 1).

The IWA-4500, and IWA-4530 temper bead welding process is a time and person rem 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 post weld bake temperatures. Prior to heat-up, thermal insulation is also installed. Upon completion of repair welding (including the post weld bake), the insulation, heating blankets, studs, and thermocouples must be removed from the RPV head. Thermocouples and stud welds are removed by grinding. The ground areas are subsequently examined by the liquid penetrant or magnetic particle method. A significant reduction in person rem could be realized by utilizing an ambient temperature temper bead welding process. Because the ASME Code does not presently include rules for ambient temperature temper bead welding, ENO proposes the alternatives as described in Section C.

<u>Suitability of Proposed Ambient Temperature Temper Bead Welding Technique</u>

I. Evaluation of the Ambient Temperature Temper Bead Welding Technique

Research by the Electric Power Research Institute (EPRI) and other organizations on the use of an ambient temperature temper bead welding operation using the Machine GTAW welding process is documented in EPRI Report GC-111050 (Reference 12). According to the EPRI report, repair welds performed with an ambient temperature temper bead welding 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 Enclosure 1 on mechanical properties of repair welds, hydrogen cracking, and restraint cracking are addressed below:

1. MECHANICAL PROPERTIES

The principle 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

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

Section 2.1 of Enclosure 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 Enclosure 1 are identical to those in IWA-4512. Ambient temperature temper bead welding procedure specification WPS 3-43/52-TB MC-GTAW-N638 (Reference 15) was qualified in accordance with Enclosure 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 and therefore qualify the acceptability of use without a post weld bake. The mechanical testing results for the procedure qualification are summarized in Section D.III.

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 manifest by intergranular cracking of susceptible materials and normally occurs within 48 hours of welding.

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IWA-4500 establishes elevated preheat and post weld bake requirements. The elevated preheat temperature of 300°F increases the diffusion rate of hydrogen from the weld. The post weld bake 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 low hydrogen 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 welding process utilizes dry inert shielding gases that protect 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. 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 the Machine GTAW welding 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 Enclosure 1. Regarding this issue, EPRI Report GC-111050, Section 6.0 concluded the following:

"No preheat temperature or post weld bake above ambient temperature is required to achieve sound Machine GTAW temper bead weld repairs that have high toughness and ductility. This conclusion is based on the fact that the GTAW welding 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 post weld bake steps are necessary to remove hydrogen because the hydrogen is not present with the Machine GTAW welding 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 weld technique is designed to provide sufficient heat inventory so as to produce the desired tempering for high toughness. Because the Machine GTAW temper bead weld 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

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performed after the completed repair weld has been at ambient temperature for at least 48 hours as required in Section 4.0 of Enclosure 1.

In conclusion, no elevated preheat or post weld bake above ambient temperature is required to achieve sound and tough repair welds when performing ambient temperature temper bead welding technique using the Machine GTAW welding process. This conclusion is based upon strong evidence that hydrogen cracking will not occur with the GTAW welding 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:

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

1. According to **IWA-4530**, repairs may be performed to dissimilar base materials and welds without the specified post weld heat treatment of ASME Section III provided the requirements of IWA-4531 through IWA-4534 are met. The temper bead welding rules of IWA-4531 through IWA-4534 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 welding process, the IWA-4500 and IWA-4530 temper bead welding technique is based fundamentally on an elevated preheat temperature of 300°F, a maximum interpass temperature of 400°F, and a post weld bake of 450°F - 550°F. The proposed alternative of Attachment 3 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 welding technique of Enclosure 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 welding technique is evaluated in this section. The results of this evaluation demonstrate that the proposed ambient temperature temper bead welding technique provides an acceptable level of quality and safety.

2. According to **IWA-4531(a) and (b**) the weld metal shall be deposited by the SMAW using F-No. 43 weld metal for P-No. 3 to P-No. 43 weld joints. The maximum bead width shall be three times the electrode core diameter. Also, the precautions of IWA-4521(b) shall be met. Only the Machine or Automatic GTAW welding process

   with F-No. 43 weld metal can be used when performing ambient temperature temper bead welding in accordance with Enclosure 1. This is suitable because, the heat penetration of subsequent weld layers is carefully applied to produce overlapping thermal profiles that develop an acceptable degree of tempering in the underlying heat affected zone.

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3. According to **IWA-4533(a) and (d)** the cavity and area to be repaired shall be preheated to 300°F. This minimum temperature shall be maintained for at least 30 minutes before welding is started, during welding, and until starting the post weld heat treatment of 450°F to 550°F. The width of the band to be heat-treated shall be three times the thickness (3T) of the component to be welded, but need not exceed 10". The maximum interpass temperature shall be 400°F. The minimum preheat temperature for ferritic base material shall be 300°F, and shall be maintained until the exposed base metal is covered with at least 3/16" of weld metal. The preheat shall be maintained until the heat treatment specified in IWA-4533(b) is performed. For the balance of welding, the maximum interpass temperature shall be 350°F, and the minimum preheat shall be 60°F. ENO proposes that 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 50°F for the GTAW welding 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. This is suitable because, the heat penetration of subsequent weld layers is carefully applied to an acceptable degree of tempering in the underlying heat affected zone.

4. According to **IWA-4533(b)**, thermocouples and recording instruments shall be used to monitor the preheat and interpass requirements and the 450°F to 550°F heat treatment Thermocouples may be attached by welding or by mechanical methods. As an alternative to IWA-4533(b), ENO 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 Raytek Rayngen ST80 (or equivalent). The Raytek Rayngen 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 Rayngen 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,

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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.

5. According to **IWA-4533(c)**, all areas of the ferritic base metal, exposed or not, on which weld metal is to be deposited, shall be covered with a single layer of weld deposit using 3/32" diameter electrodes. Approximately one-half the thickness of this layer shall be removed by grinding before depositing the second layer. The second and subsequent layers shall be deposited with 1/8" diameter electrodes. The techniques described in this paragraph shall be duplicated in the procedure qualification. In the proposed alternative of Enclosure 1, the deposition and removal of a final reinforcement layer is not required. A final 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 using non-ferritic weld metal, a weld reinforcement layer is not required because non-ferritic weld metal does not require tempering. When performing a dissimilar material weld with a non-ferritic 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" 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 ENO recognizes that IWA-4533(c) does require the deposition and removal of a reinforcement layer on repair welds in dissimilar materials, ENO 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 ferritic base materials using a non-ferritic weld filler material are exempt from this requirement.

6. According to **IWA-4533(d)**, after at least 3/16" of weld metal has been deposited, the 3T band as defined in (a) above shall be maintained in the range of 450°F- to 550°F for 2 hours as a minimum. As an alternative, ENO proposes that an interpass temperature of 350°F may be used after depositing at least 1/8-inch of weld metal without a post weld bake. The proposed ambient temperature temper bead welding technique of Enclosure 1 is carefully designed and controlled such that successive weld beads supply the appropriate quantity of heat to the untempered heat-affected zone and 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 D.III. The suitability of an ambient temperature temper bead welding technique without a post weld bake is addressed in Section D.I.

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7. **IWA-4534(b)** specifies that the repair area and the 3T band as defined in IWA-4534(a) shall be nondestructively examined after the completed weld has been at ambient temperature for a period of 48 hours as a minimum. The nondestructive examination of the repaired region shall include radiography, if practical, ultrasonic examination, and liquid penetrant examination. As an alternative to the volumetric examinations of IWA-4534, ENO proposes the examinations of repair welds in RPV penetration nozzle J-welds described below. The suitability of the alternative examinations is addressed in Section D.IV.

   Repair welds will be progressively examined by the liquid penetrant method in accordance with NB-5245 of ASME Section III. Acceptance criteria shall be in accordance with NB-5350. Original fabrication records indicate that the J-welds, considered partial penetration welds, were only examined by the liquid penetrant method (References 13 and 14).

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

WPS 3-43/52-TB MC-GTAW-N638 (Reference 15) was qualified in accordance with Enclosure 1. The welding procedure qualification test assembly was 3" thick and consisted of SA-533, Type B, Class 1 (P-No. 3, Group 3) and SB-166, N06600 (P-No. 43) base materials. The reactor vessel shell was fabricated from SA-302, Grade B, Modified (with nickel) material. SA-533, Type B, Class1 material (chemical and mechanical properties, P-Number and Group Number) is equivalent to SA-302, Grade B, Modified material.

Prior to welding, the SA-533, Type 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-up) position using ERNiCrFe-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 C.

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

Tensile Test Results

Specimen No.	Tensile Specimen	Actual Tensile Strength	Failure
Test 1	0.506" Turned Specimen	86,600 psi	Ductile/Base
Test 2	0.505" Turned Specimen	84,500 psi	Ductile/Base
Test 3	0.509" Turned Specimen	82,400 psi	Fusion Line
Test 4	0.505" Turned Specimen	86,600 psi	Ductile/Base

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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, Type B, Class 1 "unaffected" base material was performed. Based upon drop weight testing of the SA-533, Type 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°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, Type 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°F	59.0	50.0	60.0
2	+10°F	51.0	43.0	50.0
3	+10°F	50.0	45.0	50.0
Average	+10°F	***53.3***	***46.0***	***53.3***

- Charpy V-notch testing of the SA-533, Type B, Class 1 heat affected zone was also performed at +10°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 welding process improved the heat affected zone properties. Test results are as follows:

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Charpy V-Notch Tests: Heat Affected Zone				
Specimen ID	Test Temperature	Absorbed Energy (ft-lbs)	Lateral Expansion(mils)	% Shear Fracture
1	+10°F	85.0	65.0	90.0
2	+10°F	136.0	64.0	75.0
3	+10°F	124.0	49.0	30.0
Average	+10°F	***115.0***	***59.3***	***65.0***

IV. Suitability of Alternative Nondestructive Examinations (NDE)

IWA-4534 of Section XI, 1989 specifies that the repaired region shall be examined by the radiographic method, and if practical, by the ultrasonic method. The NDE requirements of IWA-4534 were established based upon a temper bead weld repair to butt welds. Figures IWA-4532.1-1 and IWA-4532.2-1 in later code edition (Section XI, 1992) clearly indicate this. While the requirement to perform a radiographic examination, 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 penetration nozzle J-welds (see Figures 1 and 2).

Impracticality of Volumetric Examinations

Radiographic examination of weld repairs of RPV penetration nozzle J-welds are not practical. Meaningful radiographic examination cannot be performed because the weld configuration and geometry of the penetration in the head provide access limitations, thus making the performance of radiography and interpretation very difficult. Ultrasonic examination of the J-weld would also be impractical for the same reasons.

Suitability of Proposed Alternative

The partial penetration J-welds of the RPV penetration nozzles were designed and fabricated in accordance with ASME Section III 1965 Edition, 1966 Addenda, Section N-457(c) and Figure N-462.4(d). According to N-457(c), the Code required examination for these partial penetration J-welds is a progressive liquid penetrant examination performed in accordance with N-462.4(d)(1). A volumetric examination is not required. Therefore, as an alternative to radiographic and ultrasonic examinations, ENO proposes to perform a progressive liquid penetrant of the J-weld repair weld in accordance with N-462.4(d)(1) (equivalent to ASME Section III 1989 Edition, NB-5245). It should be noted that ASME Section III does not require volumetric examination of J-welds. According to N-457(c) (equivalent to ASME Section III 1989 Edition, NB-3352.4(d)(1) and NB-3337.3), "partial penetration welds used to connect nozzles shall meet the fabrication requirements of N-462.4(d) (equivalent to ASME Section III 1989 Edition, NB-4244(d) and shall be capable of being examined in accordance with N-462.4(d)(1)" (equivalent to ASME Section III 1989 Edition, NB-5245). N-462.4(d) (equivalent to ASME Section III

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1989 Edition, NB-4244(d)) establishes fabrication details for nozzles welded with partial penetration welds as shown in Figure N-462.4(d) (equivalent to ASME Section III 1989 Edition, Figures NB-4244(d)-1 and NB-4244(d)-2). According to N-462.4(d)(1) (equivalent to ASME Section III 1989 Edition, NB-5245), "Partial penetration welds, as permitted in N-457(c) (equivalent to ASME Section III 1989 Edition, NB-3352.4(d), and as shown in Figure N-462.4(d) (equivalent to ASME Section III 1989 Edition, 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 1/2 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."

E. PROPOSED ALTERNATIVE EXAMINATION

Pursuant to 10CFR50.55a(a)(3)(i), in lieu of the specific code requirements as prescribed in IWA-4500 and IWA-4530, ENO proposes to use the alternatives as summarized below. These proposed alternatives are described and discussed in greater detail in Section C of this relief request:

1. **IWA-4530** - ENO proposes to perform temper bead weld repairs using the ambient temperature temper bead welding technique described in Enclosure 1.

2. **IWA-4531(a) and (b)** - ENO proposes to use the Machine or Automatic GTAW welding process with F-No. 43 weld metal when performing ambient temperature temper bead welding in accordance with Enclosure 1.

3. **IWA-4533(a) and (d)** - ENO proposes that 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 50°F for the GTAW welding 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-4533(b)** - ENO proposes to monitor preheat and interpass temperatures using an infrared thermometer.

5. **IWA-4533(b)** - Since ENO will use an infrared thermometer to monitor preheat and interpass temperatures, thermocouples will not be used. Therefore, the thermocouple attachment requirements of IWA-4533(b) do not apply.

6. **IWA-4533(c)** - ENO 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

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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.

7. **IWA-4534(b)** – ENO proposes the following examinations for repair welds in RPV penetration nozzle J-welds as an alternative to the volumetric examination of IWA-4534(b):

   - Repair welds will be progressively examined by the liquid penetrant method in accordance with NB-5245 of ASME Section III, 1989 Edition. Acceptance criteria shall be in accordance with NB-5350.

8. **IWA-4534(c)** – Since ENO will use an infrared thermometer to monitor preheat and interpass temperatures, thermocouples will not be used. Therefore, the examination requirements of IWA-4534(c), for the areas from which weld attached thermocouples have been removed, do not apply.

F. JUSTIFICATION FOR RELIEF

ENO believes that compliance with the repair rules as stated in Reference 1 and as described in Section B 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).

G. PERIOD FOR WHICH RELIEF IS REQUESTED

Relief is requested for the reminder of the third inspection interval, through April 3, 2006.

H. ATTACHMENTS TO RELIEF

- Dissimilar metal Welding Using Ambient Temperature Machine GTAW Temper Bead Welding Technique (Enclosure 1).
- Code Case N-638

I. REFERENCE

1. ASME Section XI, 1989 Edition

2. ASME Section XI, 1992 Edition

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3. ASME Section III, 1965 Edition, Summer 1966 Addenda

4. ASME Section III, Subsection NB, 1989 Edition

5. ENO Letter, M. Kansler to USNRC dated August 31, 2001 (IPN-01-063) regarding thirty-day response to NRC Bulletin 2001-01.

6. ENO Letter, M. Kansler to USNRC dated September 24, 2001 (NL-01-113) regarding supplemental thirty-day response to NRC Bulletin 2001-01.

7. Consolidated Edison Letter, dated September 4, 2001 (NL-01-106) regarding thirty-day response to NRC Bulletin 2001-01.

8. ENO Letter, M. Kansler to USNRC (IPN-01-079/NL-01-133), dated November 13, 2001, Revised Vessel Head Penetration Inspection Plans, NRC Bulletin 2001-01, "Circumferential Cracking of Reactor Pressure Vessel Head Penetration Nozzles".

9. NRC Letter, P. D. Milano to M. Kansler, Bulletin 2001-01, dated April 8, 2002, "Circumferential Cracking of Reactor Pressure Vessel Head Penetration Nozzles", Responses for Indian Point Units 2 and 3.

10. ENO Letter, J. Herron to USNRC (NL-02-050/IPN-02-023), dated April 2, 2002, "Submittal of 15 Day response to NRC Bulletin 2002-01", for Indian Point Units 2 and 3.

11. ASME Section XI Code Case N-638, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique".

12. EPRI Report GC-111050, "Ambient Temperature Preheat for Machine GTAW Temper Bead Applications".

13. Analytical Report (Report Number 1110) for Indian Point Reactor Vessel-Unit No. 2, by Combustion Engineering, 1965.

14. Instruction Manual (C.E. Book No. 17765 / Drawing E 234-048-5, Fig. 8, Closure Head Assembly), Consolidated Edison Company, Indian Point Reactor Vessel No. 2, by Combustion Engineering, Inc.

15. PCI Energy Services Welding Procedure Specification WPS No. 3-43/52-TB MC-GTAW-N638, Revision 3, dated 03/21/02.

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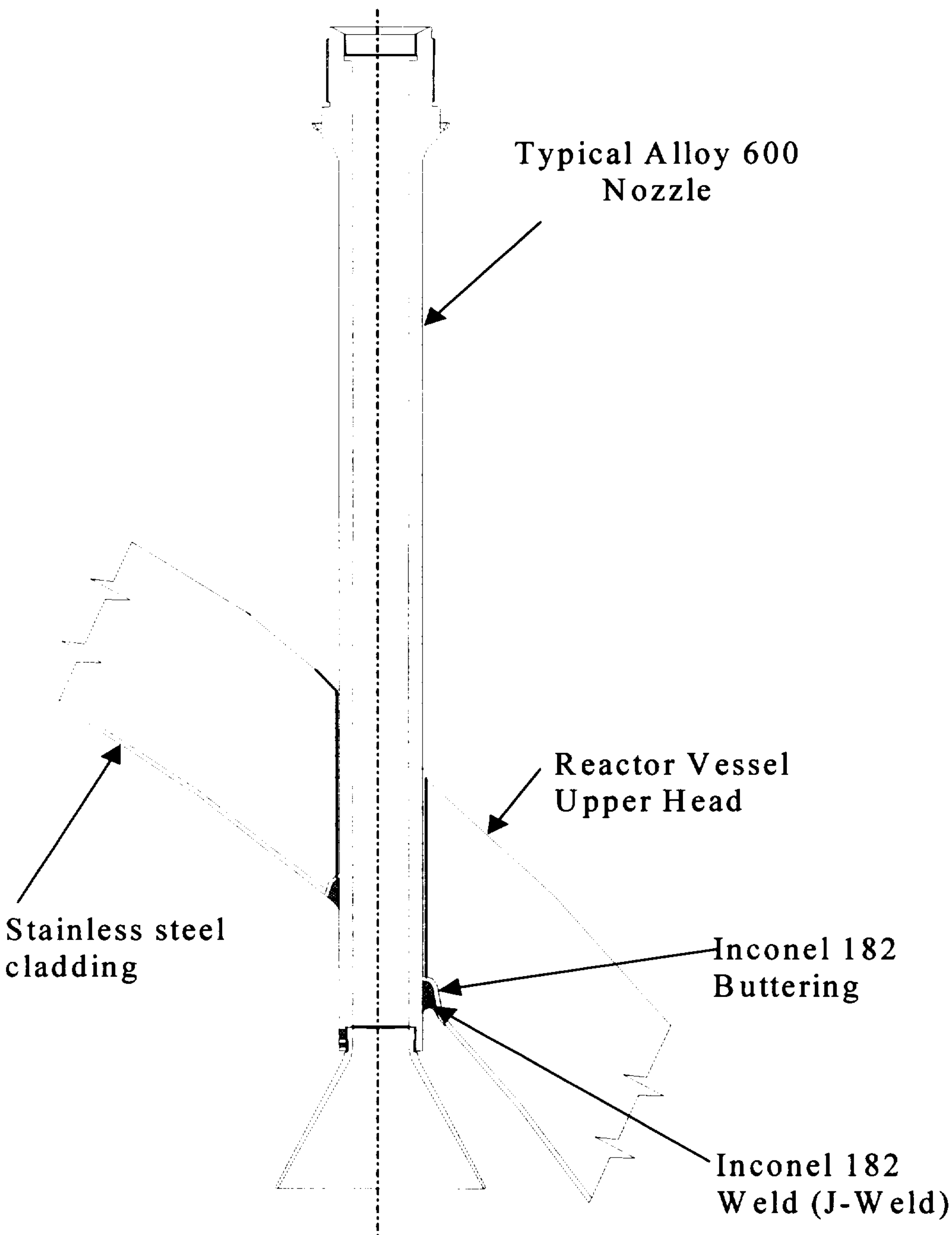

Typical RPV Penetration Nozzle

FIGURE 1

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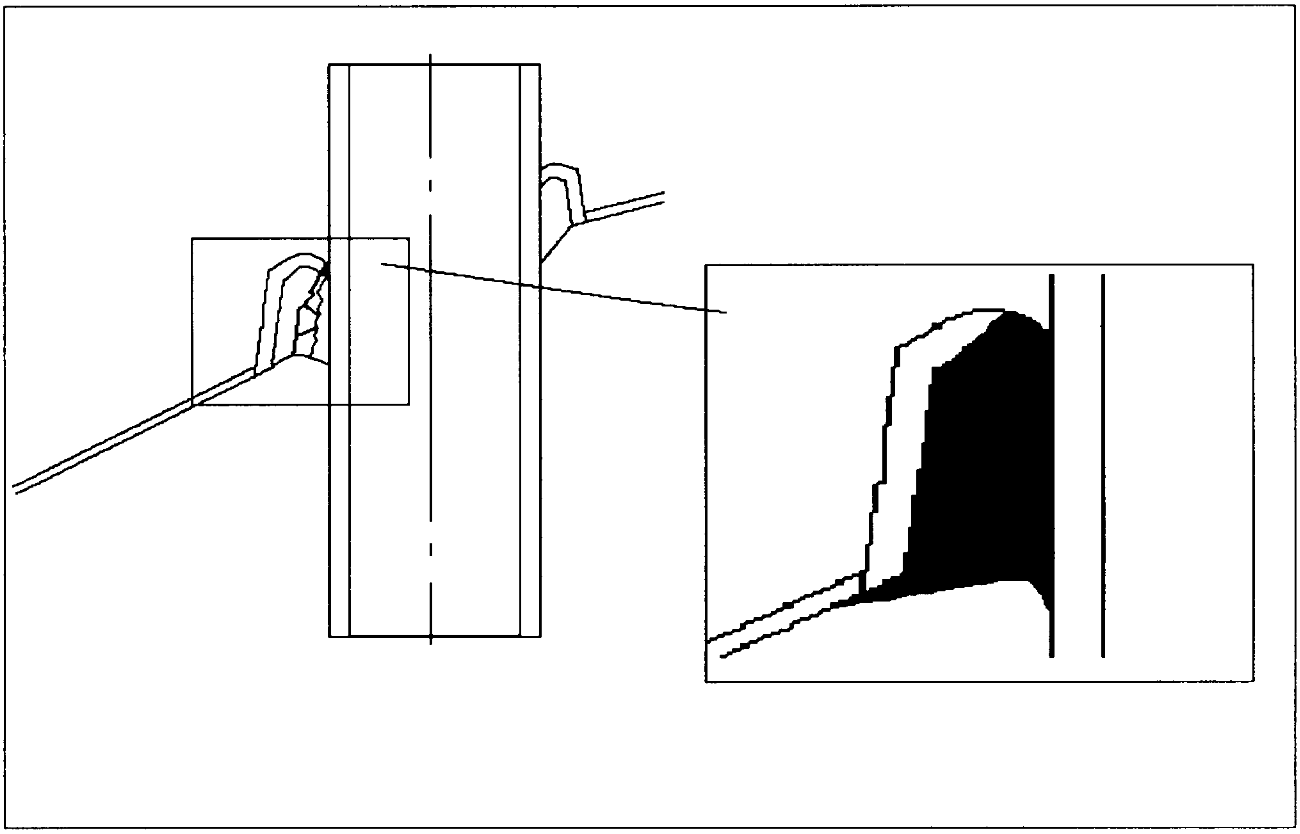

Example Repair of an RPV Penetration Nozzle J-Weld

FIGURE 2

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ENCLOSURE 1

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

ENCLOSURE 1
DISSIMILAR METAL WELDING USING AMBIENT TEMPERATURE MACHINE GTAW TEMPER BEAD WELDING 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 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. Repair/replacement activities on non-ferritic 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 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 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 Code 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 materials 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.

ENCLOSURE 1
DISSIMILAR METAL WELDING USING AMBIENT TEMPERATURE MACHINE GTAW TEMPER BEAD WELDING TECHNIQUE

(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" 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.

ENCLOSURE 1
DISSIMILAR METAL WELDING USING AMBIENT TEMPERATURE MACHINE GTAW TEMPER BEAD WELDING TECHNIQUE

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 welding 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 ± 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) The surfaces to be welded, filler metal, and shielding gas shall be suitably controlled and particular care given to ensure that the weld region is free of all potential sources of hydrogen.

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:

ENCLOSURE 1
DISSIMILAR METAL WELDING USING AMBIENT TEMPERATURE MACHINE GTAW TEMPER BEAD WELDING TECHNIQUE

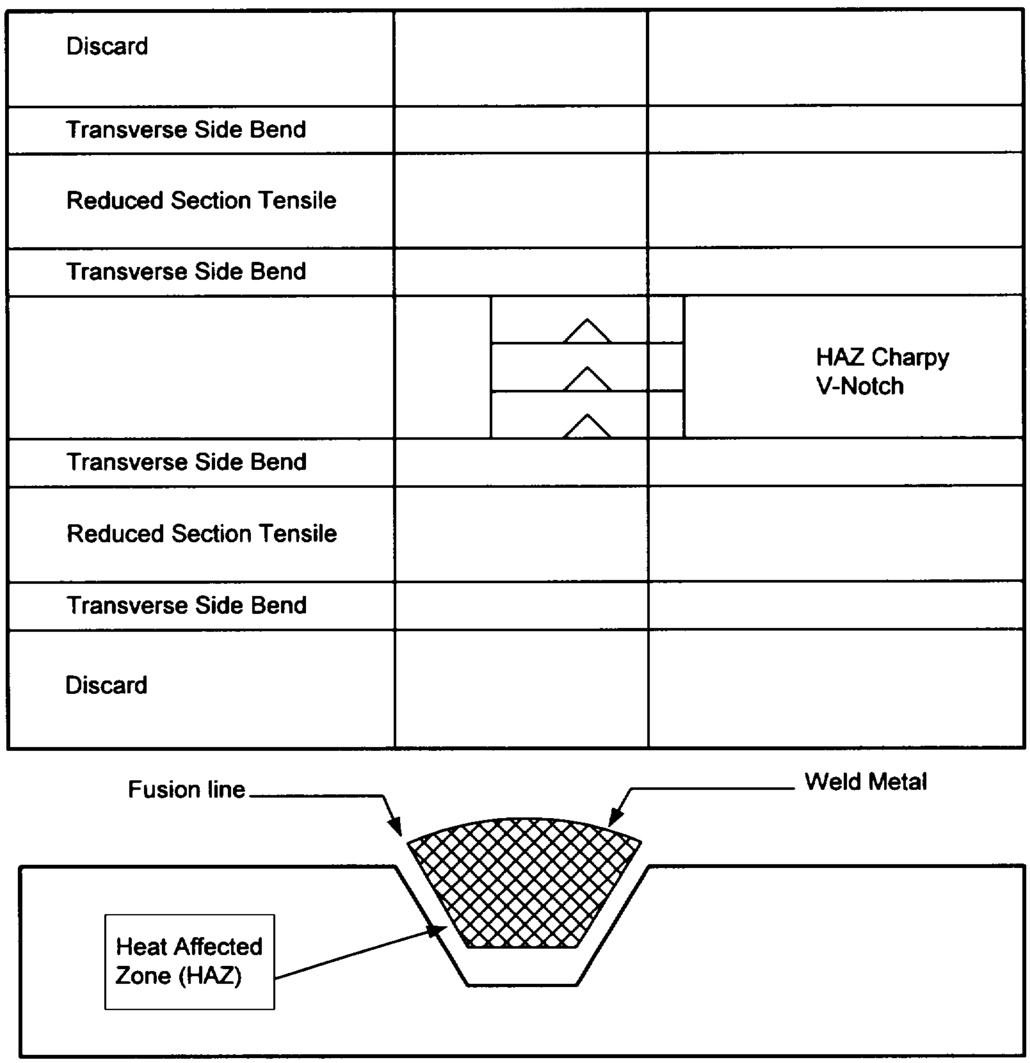
- Repair welds will be progressively examined by the liquid penetrant method in accordance with NB-5245 of ASME Section III. After the completed repair weld has been at ambient temperature for at least 48 hours, repair welds including the preheat band (1.5 times the component thickness or 5", whichever 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 this relief request (RR 61, 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.

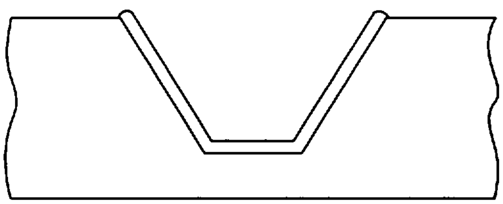
ENCLOSURE 1
DISSIMILAR METAL WELDING USING AMBIENT TEMPERATURE MACHINE GTAW TEMPER BEAD WELDING TECHNIQUE



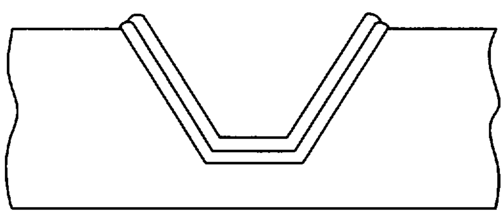
GENERAL NOTE: Base Metal Charpy impact specimens are not shown.

Figure 1 - QUALIFICATION TEST PLATE

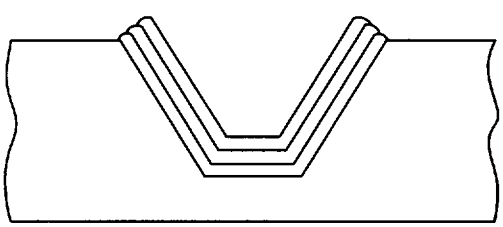
ENCLOSURE 1
DISSIMILAR METAL WELDING USING AMBIENT TEMPERATURE MACHINE GTAW TEMPER BEAD WELDING TECHNIQUE



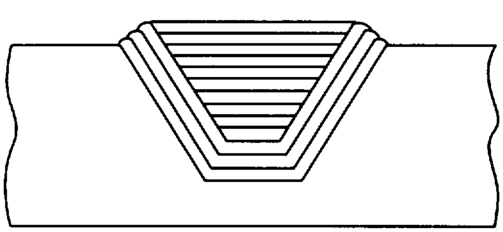
Step 1: Deposit layer one with first layer weld parameters used in qualification.



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



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



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

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

Figure 2 - AUTOMATIC OR MACHINE GTAW TEMPER BEAD WELDING

ATTACHMENT II TO NL-02-104 / IPN-02-061

INDIAN POINT NUCLEAR GENERATING UNIT NO. 3

THIRD TEN-YEAR INSERVICE INSPECTION INTERVAL PROGRAM PLAN

Relief Request RR 3-31, Revision 0 (IP3)

ENTERGY NUCLEAR OPERATIONS, INC.
INDIAN POINT NUCLEAR GENERATING UNIT NO. 3
DOCKET NO. 50-286
DPR-64

RELIEF REQUEST NUMBER RR 3-31, Rev. 0

A. COMPONENT IDENTIFICATION

Code Class:	1
References:	Table IWB-2500-1, Category B-E
Examination Category:	B-E
Item Numbers:	B4.12, B4.13
Description:	Reactor Pressure Vessel (RPV) Head Penetration Nozzles

B. CODE REQUIREMENT

IWA-4120(a) of ASME Section XI, 1989 Edition states:

"Repairs 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 alternative requirements of IWA-4500 and the following may be used:

(1) IWB-4000 for Class 1 components

(2) IWC-4000 for Class 2 components

(3) IWD-4000 for Class 3 components

(4) IWE-4000 for Class MC components

(5) IWF-4000 for component supports."

IWA-4500 of ASME Section XI establishes alternative repair welding methods for performing temper bead welding.

IWA-4530 applies to dissimilar materials such as welds that join P-Number 8 or P-Number 43 material 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-No. 1, 3, 12A, 12B, or 12C material where the ferritic base material is within 1/8-inch of being exposed shall be made by welding in accordance with the provisions of Section III, without the specified post weld heat treatment, provided the requirements of IWA-4531 through IWA-4534 are met."

Half bead welding technique 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. The requirements of IWA-4530 include:

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- The weld metal shall be deposited by the shielded metal-arc welding process (SMAW).
- A minimum preheat temperature of 300°F shall be maintained for at least 30 minutes before welding is started. Interpass temperature cannot exceed 400°F.
- The preheat temperature of 300°F shall be maintained until the exposed base metal is covered with at least 3/16" of weld metal.
- After at least 3/16" of weld metal has been deposited, the 3T band to be heat-treated shall be maintained in the range of 450°F to 550°F for 2 hours as a minimum.
- Preheat, interpass, and heat treatment temperatures shall be monitored using thermocouples and recording instruments.
- A liquid penetrant examination shall be performed in the area being repaired after the heat treatment is complete.
- The repair weld and preheated band shall be nondestructively examined after the completed weld has been at ambient temperature for 48 hours as a minimum.
- The nondestructive examination of the repaired region shall include radiography, if practical, ultrasonic examination, and liquid penetrant examination.
- Areas from which welded thermocouples have been removed shall be ground and examined by MT or PT methods.

C. RELIEF REQUESTED

In lieu of the SMAW-temper bead welding requirements of IWA-4500, and IWA-4530 of ASME Section XI, 1989 Edition, Entergy (ENO) proposes the alternatives as described below. These alternatives conform to ASME Code Case N-638. Specifically, ENO proposes to perform ambient temperature temper bead welding in accordance with Enclosure 1 of this relief request, "Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Welding Technique."

ENO has reviewed the proposed ambient temperature temper bead welding techniques of Enclosure 1 against the SMAW-temper bead welding requirements of IWA-4500, and IWA-4530. This review was performed to identify and to reconcile the differences between the proposed alternatives in Enclosure 1 and IWA-4500, and IWA-4530 requirements. Specifically, Entergy proposes these alternatives to the requirements of the following ASME Section XI subsections:

RELIEF REQUEST NUMBER RR 3-31, Rev. 0

1. **IWA-4530** specifies that repairs made to dissimilar materials identified in IWA-4530 may be performed without the specified post weld heat treatment of ASME Section III provided the requirements of IWA-4531 through IWA-4534 are met. As an alternative, ENO proposes to perform temper bead weld repairs using the ambient temperature temper bead welding technique described in Enclosure 1.

2. **IWA-4531(a) and (b)** specifies that the weld metal shall be deposited by the SMAW using F-No. 43 weld metal for P-No. 43 to P-No. 3 weld joints. The maximum bead width shall be three times the electrode core diameter. Also, the precautions of IWA-4521(b) shall be met. As an alternative, ENO proposes to use the Machine or Automatic GTAW welding process with F-No. 43 weld metal can be used when performing ambient temperature temper bead welding in accordance with Enclosure 1.

3. **IWA-4533(a) and (d)** specifies that the cavity and area to be preheated to 300°F. This minimum temperature shall be maintained for at least 30 minutes before welding is started, during welding, and until starting the post weld heat treatment of 450°F to 550°F. The width of the band to be heat-treated shall be three times the thickness (3T) of the component to be welded, but need not exceed 10". The maximum interpass temperature shall be 400°F. The minimum preheat temperature for ferritic base material shall be 300°F, and shall be maintained until the exposed base metal is covered with at least 3/16" of weld metal. The preheat shall be maintained until the heat treatment specified in IWA-4533(b) is performed. For the balance of welding, the maximum interpass temperature shall be 350°F, and the minimum preheat shall be 60°F. After at least 3/16" of weld metal has been deposited, the 3T band shall be maintained in the range of 450°F to 550°F for 2 hours as a minimum. ENO proposes that 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 50°F for the GTAW welding 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-4533(b)** specifies that thermocouples and recording instruments shall be used to monitor process temperatures. As an alternative, ENO proposes to monitor preheat and interpass temperatures using an infrared thermometer.

5. **IWA-4533(b)** specifies that thermocouples shall be attached by either welding or mechanical methods. Because ENO will use an infrared thermometer to monitor preheat and interpass temperatures, thermocouples will not be used. Therefore, the thermocouple attachment requirements of IWA-4533(b) do not apply.

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6. **IWA-4533(c)** specifies that all areas of the ferritic base metal, exposed or not, shall be covered with one layer of weld deposit using 3/32" diameter electrodes. Approximately one-half the thickness of this layer shall be removed by grinding before depositing the second layer, and subsequent layers with 1/8" diameter electrodes. As an alternative, ENO 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.

7. **IWA-4534(b)** specifies the repair area and the 3T band as defined in IWA-4534(a) shall be nondestructively examined after the completed weld has been at ambient temperature for a period of 48 hours minimum. The nondestructive examination of the repair welded region shall include radiography, if practical, ultrasonic examination, and magnetic particle examination. As an alternative to the volumetric examination of IWA-4534(b), ENO proposes the following examination 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, 1989 Edition. Acceptance criteria shall be in accordance with NB-5350. Original fabrication records indicated that the J-welds, considered partial penetration welds, were only examined by the liquid penetrant method (References 13, 14, and 15).

8. **IWA-4534(c)** specifies that areas from which weld attached thermocouples have been removed shall be ground and examined by the magnetic particle method or by the liquid penetrant method. Because ENO will use an infrared thermometer to monitor preheat and interpass temperatures, thermocouples will not be used. Therefore, the examination requirements of IWA-4534(c), for the areas from which weld attached thermocouples have been removed, do not apply..

These proposed alternatives are 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). All flaws in the J-weld will be removed prior to performing any temper bead weld repairs in accordance with this relief request.

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D. BASIS FOR RELIEF

IWA-4500, and IWA-4530 of ASME Section XI establish requirements for performing temper bead welding of "base materials" and "dissimilar materials". According to IWA-4531, the SMAW process shall be used. ENO proposes the Machine GTAW Welding process (Enclosure 1).

The IWA-4500, and IWA-4530 temper bead welding process is a time and person rem 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 post weld bake temperatures. Prior to heat-up, thermal insulation is also installed. Upon completion of repair welding (including the post weld bake), the insulation, heating blankets, studs, and thermocouples must be removed from the RPV head. Thermocouples and stud welds are removed by grinding. The ground areas are subsequently examined by the liquid penetrant or magnetic particle method. A significant reduction in person rem could be realized by utilizing an ambient temperature temper bead welding process. Because the ASME Code does not presently include rules for ambient temperature temper bead welding, ENO proposes the alternatives as described in Section C.

<u>Suitability of Proposed Ambient Temperature Temper Bead Welding Technique</u>

I. Evaluation of the Ambient Temperature Temper Bead Welding Technique

Research by the Electric Power Research Institute (EPRI) and other organizations on the use of an ambient temperature temper bead welding operation using the Machine GTAW welding process is documented in EPRI Report GC-111050 (Reference 12). According to the EPRI report, repair welds performed with an ambient temperature temper bead welding 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 Enclosure 1 on mechanical properties of repair welds, hydrogen cracking, and restraint cracking are addressed below:

1. MECHANICAL PROPERTIES

The principle 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

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

Section 2.1 of Enclosure 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 Enclosure 1 are identical to those in IWA-4512. Ambient temperature temper bead welding procedure specification WPS 3-43/52-TB MC-GTAW-N638 (Reference 16) was qualified in accordance with Enclosure 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 and therefore qualify the acceptability of use without a post weld bake. The mechanical testing results for the procedure qualification are summarized in Section D.III.

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 manifest by intergranular cracking of susceptible materials and normally occurs within 48 hours of welding.

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IWA-4500 establishes elevated preheat and post weld bake requirements. The elevated preheat temperature of 300°F increases the diffusion rate of hydrogen from the weld. The post weld bake 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 low hydrogen 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 welding process utilizes dry inert shielding gases that protect 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. 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 the Machine GTAW welding 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 Enclosure 1. Regarding this issue, EPRI Report GC-111050, Section 6.0 concluded the following:

"No preheat temperature or post weld bake above ambient temperature is required to achieve sound Machine GTAW temper bead weld repairs that have high toughness and ductility. This conclusion is based on the fact that the GTAW welding 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 post weld bake steps are necessary to remove hydrogen because the hydrogen is not present with the Machine GTAW welding 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 weld technique is designed to provide sufficient heat inventory so as to produce the desired tempering for high toughness. Because the Machine GTAW temper bead weld 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

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performed after the completed repair weld has been at ambient temperature for at least 48 hours as required in Section 4.0 of Enclosure 1.

In conclusion, no elevated preheat or post weld bake above ambient temperature is required to achieve sound and tough repair welds when performing ambient temperature temper bead welding technique using the Machine GTAW welding process. This conclusion is based upon strong evidence that hydrogen cracking will not occur with the GTAW welding 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:

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

1. According to **IWA-4530**, repairs may be performed to dissimilar base materials and welds without the specified post weld heat treatment of ASME Section III provided the requirements of IWA-4531 through IWA-4534 are met. The temper bead welding rules of IWA-4531 through IWA-4534 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 welding process, the IWA-4500 and IWA-4530 temper bead welding technique is based fundamentally on an elevated preheat temperature of 300°F, a maximum interpass temperature of 400°F, and a post weld bake of 450°F - 550°F. The proposed alternative of Attachment 3 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 welding technique of Enclosure 1 is an ambient temperature technique that only utilizes the GTAW-Machine or GTAW-Automatic process. The suitability of the proposed ambient temperature temper bead welding technique is evaluated in this section. The results of this evaluation demonstrate that the proposed ambient temperature temper bead welding technique provides an acceptable level of quality and safety.

2. According to **IWA-4531(a) and (b)** the weld metal shall be deposited by the SMAW using F-No. 43 weld metal for P-No. 3 to P-No. 43 weld joints. The maximum bead width shall be three times the electrode core diameter. Also, the precautions of IWA-4521(b) shall be met. Only the Machine or Automatic GTAW welding process

   with F-No. 43 weld metal can be used when performing ambient temperature temper bead welding in accordance with Enclosure 1. This is suitable because, the heat penetration of subsequent weld layers is carefully applied to produce overlapping thermal profiles that develop an acceptable degree of tempering in the underlying heat affected zone.

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3. According to **IWA-4533(a) and (d)** the cavity and area to be repaired shall be preheated to 300°F. This minimum temperature shall be maintained for at least 30 minutes before welding is started, during welding, and until starting the post weld heat treatment of 450°F to 550°F. The width of the band to be heat-treated shall be three times the thickness (3T) of the component to be welded, but need not exceed 10". The maximum interpass temperature shall be 400°F. The minimum preheat temperature for ferritic base material shall be 300°F, and shall be maintained until the exposed base metal is covered with at least 3/16" of weld metal. The preheat shall be maintained until the heat treatment specified in IWA-4533(b) is performed. For the balance of welding, the maximum interpass temperature shall be 350°F, and the minimum preheat shall be 60°F. ENO proposes that 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 50°F for the GTAW welding 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. This is suitable because, the heat penetration of subsequent weld layers is carefully applied to an acceptable degree of tempering in the underlying heat affected zone.

4. According to **IWA-4533(b)**, thermocouples and recording instruments shall be used to monitor the preheat and interpass requirements and the 450°F to 550°F heat treatment Thermocouples may be attached by welding or by mechanical methods. As an alternative to IWA-4533(b), ENO 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 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,

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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.

5. According to **IWA-4533(c)**, all areas of the ferritic base metal, exposed or not, on which weld metal is to be deposited, shall be covered with a single layer of weld deposit using 3/32" diameter electrodes. Approximately one-half the thickness of this layer shall be removed by grinding before depositing the second layer. The second and subsequent layers shall be deposited with 1/8" diameter electrodes. The techniques described in this paragraph shall be duplicated in the procedure qualification. In the proposed alternative of Enclosure 1, the deposition and removal of a final reinforcement layer is not required. A final 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 using non-ferritic weld metal, a weld reinforcement layer is not required because non-ferritic weld metal does not require tempering. When performing a dissimilar material weld with a non-ferritic 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" 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 ENO recognizes that IWA-4533(c) does require the deposition and removal of a reinforcement layer on repair welds in dissimilar materials, ENO 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 ferritic base materials using a non-ferritic weld filler material are exempt from this requirement.

6. According to **IWA-4533(d)**, after at least 3/16" of weld metal has been deposited, the 3T band as defined in (a) above shall be maintained in the range of 450°F- to 550°F for 2 hours as a minimum. As an alternative, ENO proposes that an interpass temperature of 350°F may be used after depositing at least 1/8-inch of weld metal without a post weld bake. The proposed ambient temperature temper bead welding technique of Enclosure 1 is carefully designed and controlled such that successive weld beads supply the appropriate quantity of heat to the untempered heat-affected zone and 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 D.III. The suitability of an ambient temperature temper bead welding technique without a post weld bake is addressed in Section D.I.

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7. **IWA-4534(b)** specifies that the repair area and the 3T band as defined in IWA-4534(a) shall be nondestructively examined after the completed weld has been at ambient temperature for a period of 48 hours as a minimum. The nondestructive examination of the repaired region shall include radiography, if practical, ultrasonic examination, and liquid penetrant examination. As an alternative to the volumetric examinations of IWA-4534, ENO proposes the examinations of repair welds in RPV penetration nozzle J-welds described below. The suitability of the alternative examinations is addressed in Section D.IV.

   Repair welds will be progressively examined by the liquid penetrant method in accordance with NB-5245 of ASME Section III. Acceptance criteria shall be in accordance with NB-5350. Original fabrication records indicate that the J-welds, considered partial penetration welds, were only examined by the liquid penetrant method (References 13, 14, and 15).

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

WPS 3-43/52-TB MC-GTAW-N638 (Reference 16) was qualified in accordance with Enclosure 1. The welding procedure qualification test assembly was 3" thick and consisted of SA-533, Type B, Class 1 (P-No. 3, Group 3) and SB-166, N06600 (P-No. 43) base materials. The reactor vessel shell was fabricated from SA-302, Grade B, Modified (with nickel) material. SA-533, Type B, Class1 material (chemical and mechanical properties, P-Number and Group Number) is equivalent to SA-302, Grade B, Modified material.

Prior to welding, the SA-533, Type 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-up) position using ERNiCrFe-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 C.

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

Tensile Test Results

Specimen No.	Tensile Specimen	Actual Tensile Strength	Failure
Test 1	0.506" Turned Specimen	86,600 psi	Ductile/Base
Test 2	0.505" Turned Specimen	84,500 psi	Ductile/Base
Test 3	0.509" Turned Specimen	82,400 psi	Fusion Line
Test 4	0.505" Turned Specimen	86,600 psi	Ductile/Base

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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, Type B, Class 1 "unaffected" base material was performed. Based upon drop weight testing of the SA-533, Type 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°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, Type 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°F	59.0	50.0	60.0
2	+10°F	51.0	43.0	50.0
3	+10°F	50.0	45.0	50.0
Average	+10°F	***53.3***	***46.0***	***53.3***

- Charpy V-notch testing of the SA-533, Type B, Class 1 heat affected zone was also performed at +10°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 welding process improved the heat affected zone properties. Test results are as follows:

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Charpy V-Notch Tests: Heat Affected Zone				
Specimen ID	Test Temperature	Absorbed Energy (ft-lbs)	Lateral Expansion(mils)	% Shear Fracture
1	+10°F	85.0	65.0	90.0
2	+10°F	136.0	64.0	75.0
3	+10°F	124.0	49.0	30.0
Average	+10°F	***115.0***	***59.3***	***65.0***

IV. Suitability of Alternative Nondestructive Examinations (NDE)

IWA-4534 of Section XI, 1989 specifies that the repaired region shall be examined by the radiographic method, and if practical, by the ultrasonic method. The NDE requirements of IWA-4534 were established based upon a temper bead weld repair to butt welds. Figures IWA-4532.1-1 and IWA-4532.2-1 in later code edition (Section XI, 1992) clearly indicate this. While the requirement to perform a radiographic examination, 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 penetration nozzle J-welds (see Figures 1 and 2).

Impracticality of Volumetric Examinations

Radiographic examination of weld repairs of RPV penetration nozzle J-welds are not practical. Meaningful radiographic examination cannot be performed because the weld configuration and geometry of the penetration in the head provide access limitations, thus making the performance of radiography and interpretation very difficult. Ultrasonic examination of the J-weld would also be impractical for the same reasons.

Suitability of Proposed Alternative

The partial penetration J-welds of the RPV penetration nozzles were designed and fabricated in accordance with ASME Section III 1965 Edition, 1966 Addenda, Section N-457(c) and Figure N-462.4(d). According to N-457(c), the Code required examination for these partial penetration J-welds is a progressive liquid penetrant examination performed in accordance with N-462.4(d)(1). A volumetric examination is not required. Therefore, as an alternative to radiographic and ultrasonic examinations, ENO proposes to perform a progressive liquid penetrant of the J-weld repair weld in accordance with N-462.4(d)(1) (equivalent to ASME Section III 1989 Edition, NB-5245). It should be noted that ASME Section III does not require volumetric examination of J-welds. According to N-457(c) (equivalent to ASME Section III 1989 Edition, NB-3352.4(d)(1) and NB-3337.3), "partial penetration welds used to connect nozzles shall meet the fabrication requirements of N-462.4(d) (equivalent to ASME Section III 1989 Edition, NB-4244(d) and shall be capable of being examined in accordance with N-462.4(d)(1)" (equivalent to ASME Section III 1989 Edition, NB-5245). N-462.4(d) (equivalent to ASME Section III

1989 Edition, NB-4244(d)) establishes fabrication details for nozzles welded with partial penetration welds as shown in Figure N-462.4(d) (equivalent to ASME Section III 1989 Edition, Figures NB-4244(d)-1 and NB-4244(d)-2). According to N-462.4(d)(1) (equivalent to ASME Section III 1989 Edition, NB-5245), "Partial_penetration welds, as permitted in N-457(c) (equivalent to ASME Section III 1989 Edition, NB-3352.4(d), and as shown in Figure N-462.4(d) (equivalent to ASME Section III 1989 Edition, 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 1/2 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."

E. PROPOSED ALTERNATIVE EXAMINATION

Pursuant to 10CFR50.55a(a)(3)(i), in lieu of the specific code requirements as prescribed in IWA-4500 and IWA-4530, ENO proposes to use the alternatives as summarized below. These proposed alternatives are described and discussed in greater detail in Section C of this relief request:

1. **IWA-4530** - ENO proposes to perform temper bead weld repairs using the ambient temperature temper bead welding technique described in Enclosure 1.

2. **IWA-4531(a) and (b)** - ENO proposes to use the Machine or Automatic GTAW welding process with F-No. 43 weld metal when performing ambient temperature temper bead welding in accordance with Enclosure 1.

3. **IWA-4533(a) and (d)** - ENO proposes that 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 50°F for the GTAW welding 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-4533(b)** - ENO proposes to monitor preheat and interpass temperatures using an infrared thermometer.

5. **IWA-4533(b)** - Since ENO will use an infrared thermometer to monitor preheat and interpass temperatures, thermocouples will not be used. Therefore, the thermocouple attachment requirements of IWA-4533(b) do not apply.

6. **IWA-4533(c)** - ENO 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

RELIEF REQUEST NUMBER RR 3-31, Rev. 0

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.

7. **IWA-4534(b)** – ENO proposes the following examinations for repair welds in RPV penetration nozzle J-welds as an alternative to the volumetric examination of IWA-4534(b):

    - Repair welds will be progressively examined by the liquid penetrant method in accordance with NB-5245 of ASME Section III, 1989 Edition. Acceptance criteria shall be in accordance with NB-5350.

8. **IWA-4534(c)** – Since ENO will use an infrared thermometer to monitor preheat and interpass temperatures, thermocouples will not be used. Therefore, the examination requirements of IWA-4534(c), for the areas from which weld attached thermocouples have been removed, do not apply.

F. JUSTIFICATION FOR RELIEF

ENO believes that compliance with the repair rules as stated in Reference 1 and as described in Section B 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).

G. PERIOD FOR WHICH RELIEF IS REQUESTED

Relief is requested for the reminder of the third inspection interval, through July 20, 2009.

H. ATTACHMENTS TO RELIEF

- Dissimilar metal Welding Using Ambient Temperature Machine GTAW Temper Bead Welding Technique (Enclosure 1).
- Code Case N-638

I. REFERENCE

1. ASME Section XI, 1989 Edition
2. ASME Section XI, 1992 Edition

RELIEF REQUEST NUMBER RR 3-31, Rev. 0

3. ASME Section III, 1965 Edition, Summer 1966 Addenda

4. ASME Section III, Subsection NB, 1989 Edition

5. ENO Letter, M. Kansler to USNRC dated August 31, 2001 (IPN-01-063) regarding thirty-day response to NRC Bulletin 2001-01.

6. ENO Letter, M. Kansler to USNRC dated September 24, 2001 (NL-01-113) regarding supplemental thirty-day response to NRC Bulletin 2001-01.

7. Consolidated Edison Letter, dated September 4, 2001 (NL-01-106) regarding thirty-day response to NRC Bulletin 2001-01.

8. ENO Letter, M. Kansler to USNRC (IPN-01-079/NL-01-133), dated November 13, 2001, Revised Vessel Head Penetration Inspection Plans, NRC Bulletin 2001-01, "Circumferential Cracking of Reactor Pressure Vessel Head Penetration Nozzles".

9. NRC Letter, P. D. Milano to M. Kansler, Bulletin 2001-01, dated April 8, 2002, "Circumferential Cracking of Reactor Pressure Vessel Head Penetration Nozzles", Responses for Indian Point Units 2 and 3.

10. ENO Letter, J. Herron to USNRC (NL-02-050/IPN-02-023), dated April 2, 2002, "Submittal of 15 Day response to NRC Bulletin 2002-01", for Indian Point Units 2 and 3.

11. ASME Section XI Code Case N-638, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique".

12. EPRI Report GC-111050, "Ambient Temperature Preheat for Machine GTAW Temper Bead Applications".

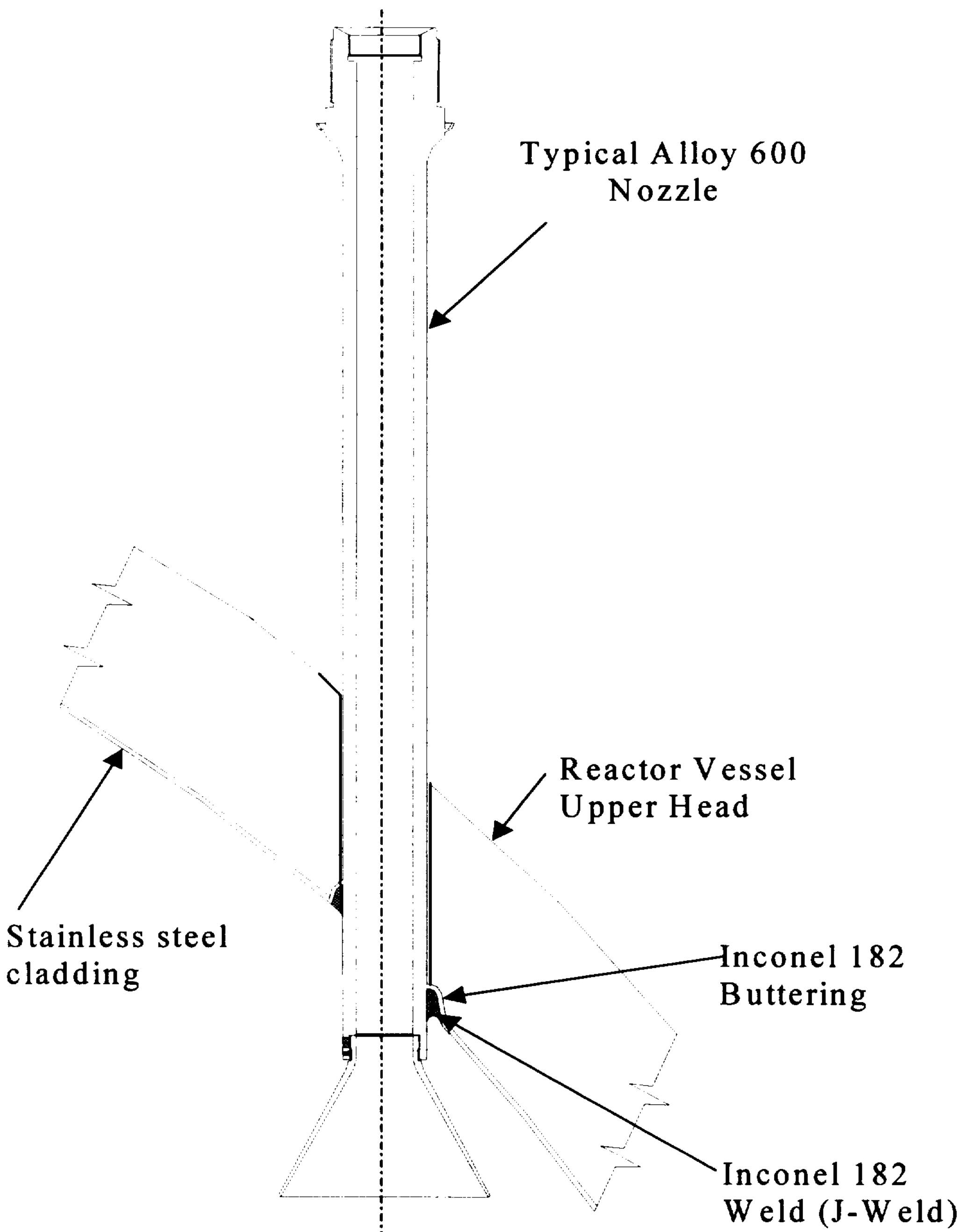
13. Analytical Report (Report Number 1122) for Indian Point Reactor Vessel-Unit No. 3, by Combustion Engineering, June 1969.

14. Instruction Manual (C.E. Book No. 3366/Drawing E 234-048-3, Fig. 8, Closure Head Assembly), Consolidated Edison Company, Indian Point Reactor Vessel No. 3, by Combustion Engineering, Inc.

15. Traveler 51242-011 Sequence 60-90 (Welding Procedure WA-3366-048-1), referenced in Report Number DEI-370, Strategic Plan CRDM Nozzle PWSCC, Indian Point Unit 3, March 1994.

16. PCI Energy Services Welding Procedure Specification WPS No. 3-43/52-TB MC-GTAW-N638, Revision 3, dated 03/21/02.

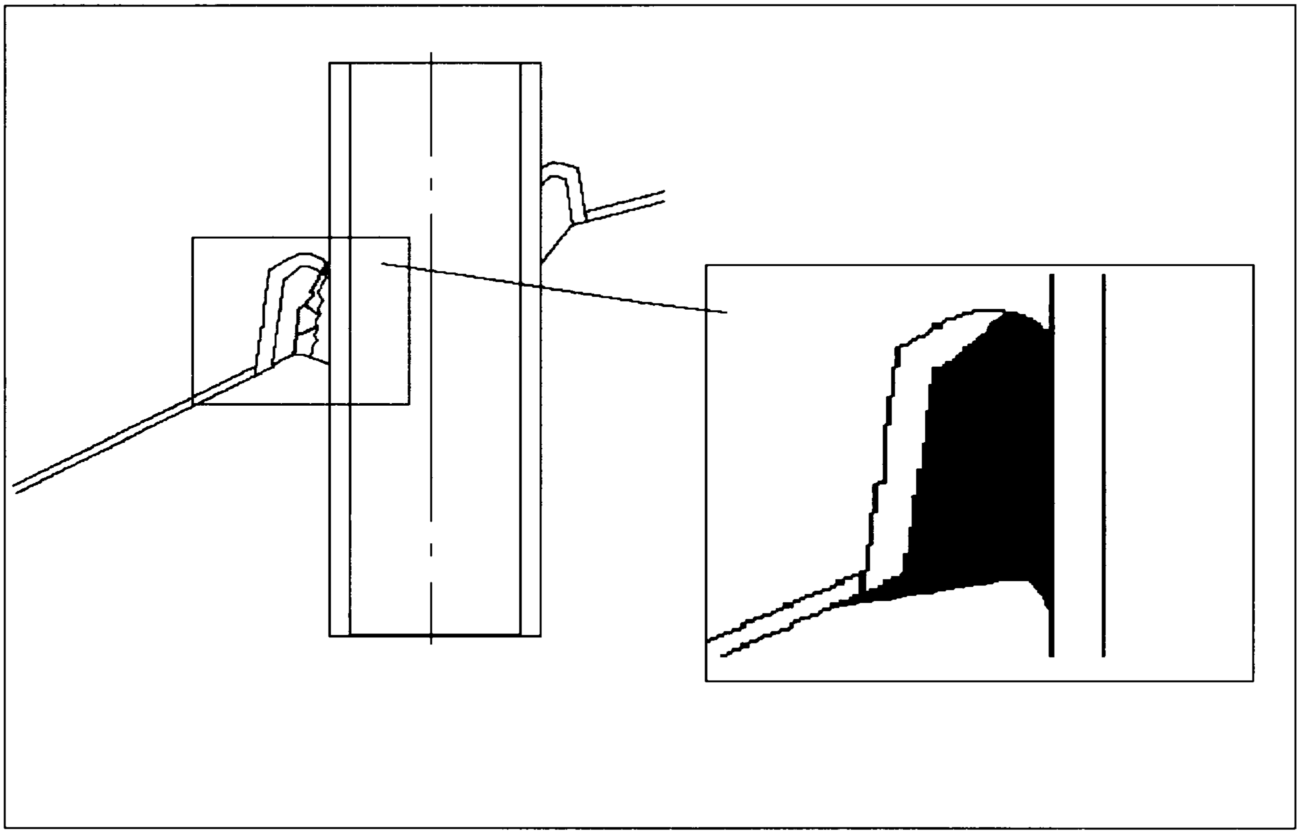
RELIEF REQUEST NUMBER RR 3-31, Rev. 0



Typical RPV Penetration Nozzle

FIGURE 1

RELIEF REQUEST NUMBER RR 3-31, Rev. 0



Example Repair of an RPV Penetration Nozzle J-Weld

FIGURE 2

RELIEF REQUEST NUMBER RR 3-31, Rev. 0

ENCLOSURE 1

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

ENCLOSURE 1
DISSIMILAR METAL WELDING USING AMBIENT TEMPERATURE MACHINE GTAW TEMPER BEAD WELDING 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 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. Repair/replacement activities on non-ferritic 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 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 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 Code 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 materials 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.

ENCLOSURE 1
DISSIMILAR METAL WELDING USING AMBIENT TEMPERATURE MACHINE GTAW TEMPER BEAD WELDING TECHNIQUE

(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" 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.

ENCLOSURE 1
DISSIMILAR METAL WELDING USING AMBIENT TEMPERATURE MACHINE GTAW TEMPER BEAD WELDING TECHNIQUE

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 welding 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 ± 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) The surfaces to be welded, filler metal, and shielding gas shall be suitably controlled and particular care given to ensure that the weld region is free of all potential sources of hydrogen.

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:

ENCLOSURE 1
DISSIMILAR METAL WELDING USING AMBIENT TEMPERATURE MACHINE GTAW TEMPER BEAD WELDING TECHNIQUE

- 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", 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.

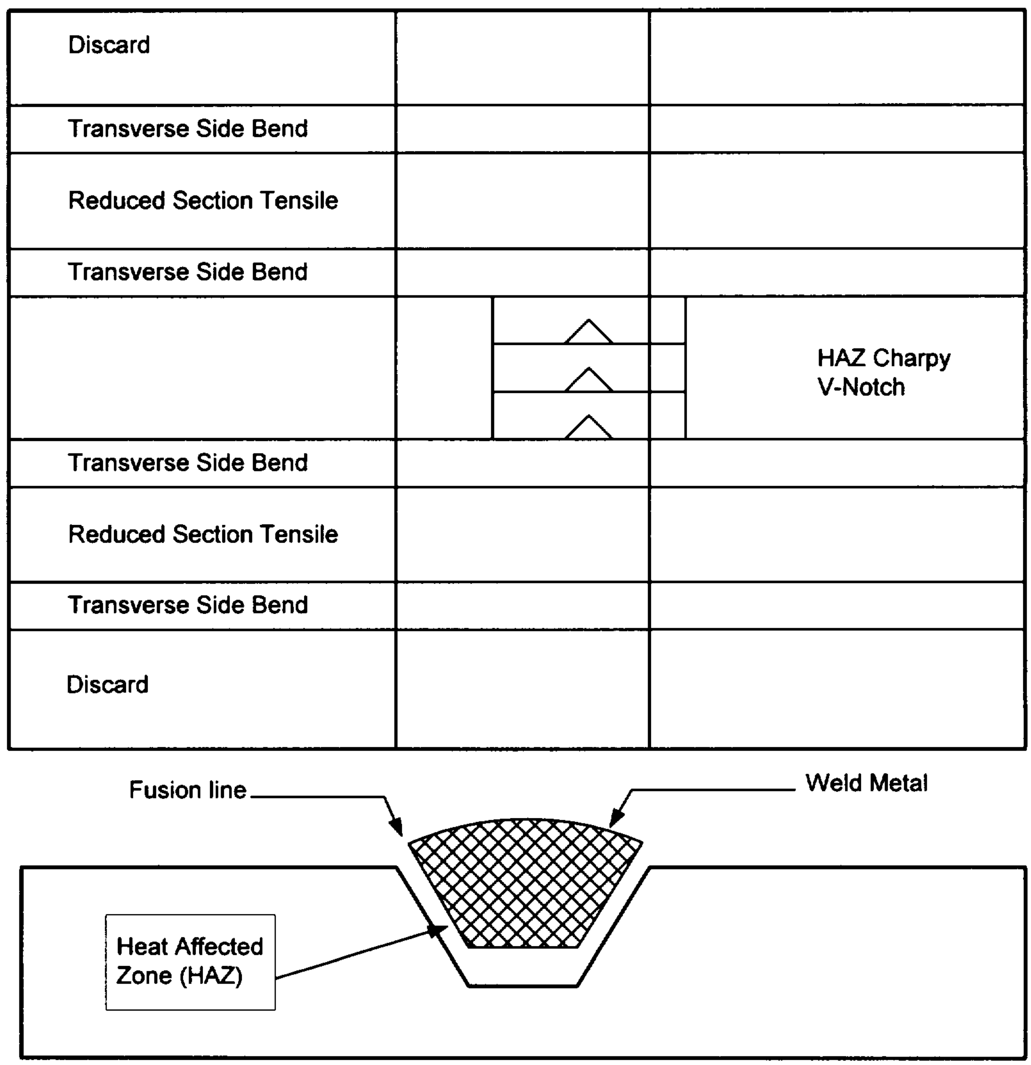
(c) NDE personnel performing liquid penetrant examination will be qualified and certified in accordance with NB-5500.

5.0 DOCUMENTATION

Use of this relief request (RR 3-31, 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.

Attachment II to
NL-02-104 / IPN-02-061
Docket No. 50-286
Indian Point Unit 3
3rd Interval
Inservice Inspection Plan

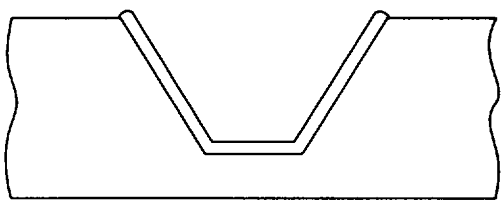
ENCLOSURE 1
DISSIMILAR METAL WELDING USING AMBIENT TEMPERATURE MACHINE GTAW TEMPER BEAD WELDING TECHNIQUE



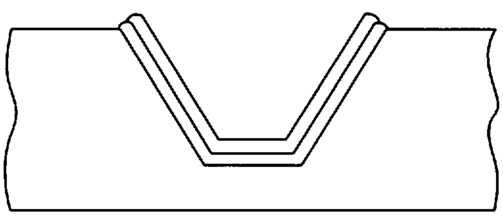
GENERAL NOTE: Base Metal Charpy impact specimens are not shown.

Figure 1 - QUALIFICATION TEST PLATE

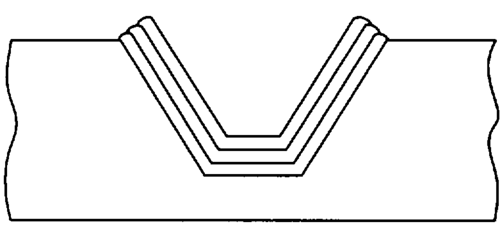
ENCLOSURE 1
DISSIMILAR METAL WELDING USING AMBIENT TEMPERATURE MACHINE GTAW TEMPER BEAD WELDING TECHNIQUE



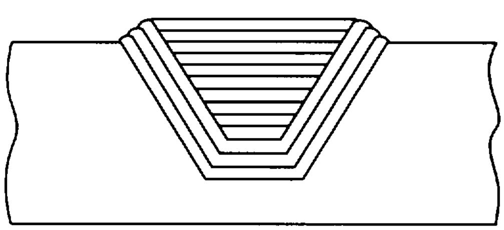
Step 1: Deposit layer one with first layer weld parameters used in qualification.



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



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



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

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

Figure 2 - AUTOMATIC OR MACHINE GTAW TEMPER BEAD WELDING

Approval Date: September 24, 1999

See Numeric Index for expiration and any reaffirmation dates.

Case N-638
Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique
Section XI, Division 1

Inquiry: May the automatic or machine GTAW temper bead technique be used without use of preheat or postweld heat treatment on Class 1 components?

Reply: It is the opinion of the Committee that repair to P-No. 1, 3, 12A, 12B, and 12C[1] *except SA-302 Grade B,* material and their associated welds and P-No. 8 or P-No. 43 material to P-Nos. 1, 3, 12A, 12B, and 12C[1] *except SA-302 Grade B,* material and may be made by the automatic or machine GTAW temper bead technique without the specified preheat or postweld heat treatment of the Construction Code, when it is impractical, for operational or radiological reasons, to drain the component, and without the nondestructive examination requirements of the Construction Code, provided the requirements of paras. 1.0 through 5.0, and all other requirements of IWA-4000[2], are met.

1.0 GENERAL REQUIREMENTS

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

(b) Repair/replacement activities on a dissimilar-metal weld in accordance with this Case are limited to those along the fusion line of a nonferritic weld to ferritic base material on which $^1/_8$ in., or less of nonferritic weld deposit exists above the original fusion line.

(c) If a defect penetrates into the ferritic base material, repair of the base material, using a nonferritic weld filler material, may be performed in accordance with this Case, provided the depth of repair in the base material does not exceed $^3/_8$ in.

(d) Prior to welding the area to be welded and a band around the area of at least $1^1/_2$ times the component thickness or 5 in., whichever is less shall be at least 50°F.

(e) Welding materials shall meet the Owner's Requirements and the Construction Code and Cases specified in the Repair/Replacement Plan. Welding materials shall be controlled so that they are identified as acceptable until consumed.

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

2.0 WELDING QUALIFICATIONS

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

2.1 Procedure Qualification

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

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

(c) Consideration shall 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 shall also apply to the test assembly materials for these applications.

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

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

(f) The test assembly cavity depth shall be at least one-half the depth of the weld to be installed during the repair/replacement activity and at least 1 in. The test assembly thickness shall be at least twice the test assembly cavity depth. The test assembly shall be large

[1] P-Nos. 12A, 12B, and 12C designations refer to specific material classifications originally identified in Section III and subsequently reclassified as P-No. 3 material in a later Edition of Section IX.

[2] IWA-4000 or IWA-7000, as applicable, in the 1989 Edition, with the 1990 Addenda, and earlier Editions and Addenda.

enough to permit removal of the required test specimens. The test assembly dimensions surrounding the cavity shall be at least the test assembly thickness and at least 6 in. The qualification test plate shall be prepared in accordance with Fig. 1.

(g) Ferritic base material for the procedure qualification test shall 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 (i) below, but shall be in the base metal.

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

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

(1) The specimens shall be removed from a location as near as practical to a depth of one-half the thickness of the deposited weld metal. The coupons for HAZ impact specimens shall be taken transverse to the axis of the weld and etched to define the HAZ. The notch of the Charpy V-notch specimen shall 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 shall 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 shall be oriented parallel to the principal direction of rolling or forging.

(3) The Charpy V-notch test shall be performed in accordance with SA-370. Specimens shall be in accordance with SA-370, Fig. 11, Type A. The test shall consist of a set of three full-size 10 mm × 10 mm specimens. The lateral expansion, percent shear, absorbed energy, test temperature, orientation and location of all test specimens shall be reported in the Procedure Qualification Record.

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

2.2 Performance Qualification

Welding operators shall be qualified in accordance with 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.

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

(c) The area to be welded shall be buttered with a deposit of at least three layers to achieve at least $\frac{1}{8}$ in., overlay thickness as shown in Fig. 2, Steps 1 through 3, with the heat input for each layer controlled to within ±10% of that used in the procedure qualification test. Particular care shall 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 shall be deposited with a heat input not exceeding that used for layers beyond the third layer in the procedure qualification. For similar-metal welding, the completed weld shall have at least one layer of weld reinforcement deposited. This reinforcement shall be removed by mechanical means, so that the finished surface is essentially flush with the surface surrounding the weld (Fig. 3).

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

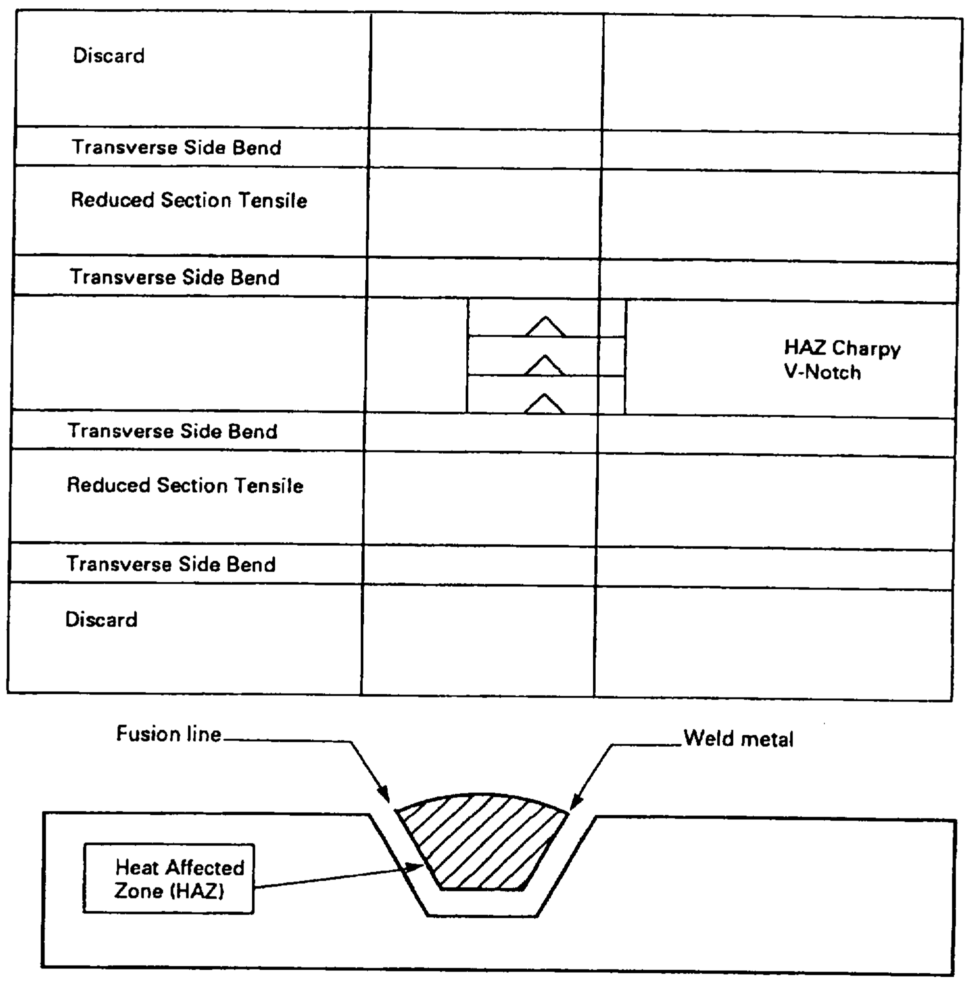
(e) Particular care shall be given to ensure that the weld region is free of all potential sources of hydrogen. The surfaces to be welded, filler metal, and shielding gas shall be suitably controlled.

4.0 EXAMINATION

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

(b) The final weld surface and the band around the area defined in para. 1.0(d) shall be examined using a surface and ultrasonic methods when the completed weld has been at ambient temperature for at least 48 hours. The ultrasonic examination shall be in accordance with Appendix I.[3]

[3] Refer to the 1989 Edition with the 1989 Addenda and later Editions and Addenda.



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

FIG. 1 QUALIFICATION TEST PLATE

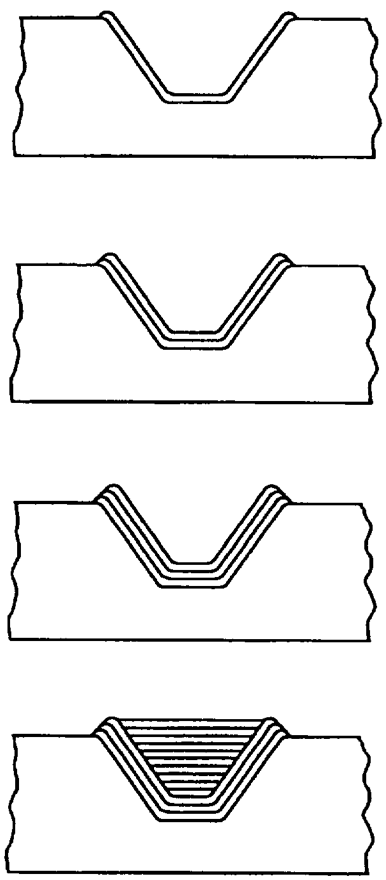
(c) Areas from which weld-attached thermocouples have been removed shall be ground and examined using a surface examination method.

(d) NDE personnel shall be qualified in accordance with IWA-2300.

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

5.0 DOCUMENTATION

Use of this Case shall be documented on Form NIS-2.



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

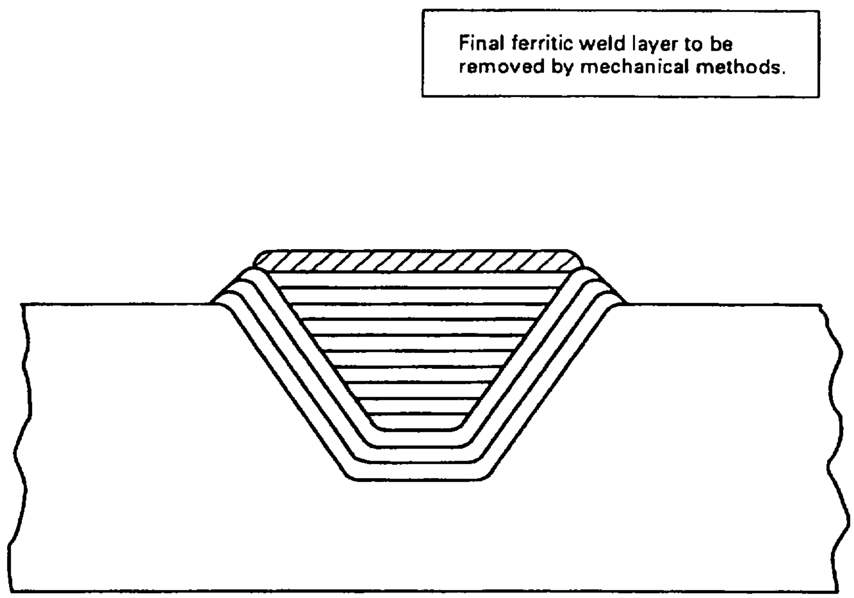
Step 2: Deposit layer two with second layer weld parameters used in qualification. NOTE: Particular care shall be taken in application of the second layer at the weld toe to ensure that the weld metal and HAZ of the base metal are tempered.

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

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

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

FIG. 2 AUTOMATIC OR MACHINE (GTAW) TEMPER BEAD WELDING



GENERAL NOTE: For ferritic filler metals the completed weld shall have at least one layer of weld reinforcement deposited. This reinforcement shall be removed by mechanical means, so that the finished surface of the weld is essentially flush with the surface of the component surrounding the repair.

FIG. 3 FINAL FERRITIC WELD LAYER