WOLF CREEK
NUCLEAR OPERATING CORPORATION

Terry J Garrett
Vice President, Engineering

August 4, 2006

ET 06-0031

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

Reference: Letter ET 06-0021, dated May 19, 2006, from T. J. Garrett, WCNOC, to USNRC

Subject: Docket 50-482: Wolf Creek Nuclear Operating Corporation's Response to Request for Additional Information Regarding 10 CFR 50.55a Request I3R-05 and Submittal of Revision 1 to 10 CFR 50.55a Request I3R-05

Gentlemen:

The Reference provided Wolf Creek Nuclear Operating Corporation (WCNOC) 10 CFR 50.55a Request I3R-05, which requested alternatives to the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (BPV) Code, Section XI for the installation and examination of full structural weld overlays for repairing/mitigating Pressurizer nozzle-to-safe end dissimilar metal (DM) and safe end-to-piping stainless steel (SS) butt welds.

On July 6, 2006, the Nuclear Regulatory Commission (NRC) Project Manager for WCNOC provided by electronic mail a request for additional information (RAI) regarding 10 CFR 50.55a (Relief) Request I3R-05.

The Attachment to this letter provides WCNOC's response to the RAI. It lists each NRC RAI question followed by WCNOC's response to each of those questions.

Enclosure I to this letter provides 10 CFR 50.55a Request I3R-05, Revision 1. Revision 1 to 10 CFR 50.55a Request I3R-05 incorporates the following changes (changes are denoted by revision bars in the right hand margin):

- In response to RAI question 7.0, Section 6.0 on page 7 was revised to change the duration of the proposed alternatives.
- On page 10, a new row was added to Table 2 for Code Case N-504-3, Paragraphs (c) and (d), to provide clarification of how WCNOC will address near surface indications found during pre-weld overlay ultrasonic (UT) examinations.
- In response to RAI question 5.0, Table 3 on pages 14 and 15 was revised to clarify the modification to paragraph 4.0(b) of Code Case N-638-1 and to revise the basis for the modification.

P.O. Box 411 / Burlington, KS 66839 / Phone: (620) 364-8831

A047

Enclosure II to this letter is a copy of an ASME White Paper concerning Code Case N-638 that was referenced in WCNOC's response to RAI question 4.0. It provides additional basis for justification of WCNOC's request

There are no commitments associated with this submittal. If you have any questions concerning this matter, please contact me at (620) 364-4084, or Mr. Kevin Moles at (620) 364-4126.

Very truly yours,

Terry J. Garrett

TJG/rlt

Attachment: Response to Request for Additional Information Regarding 10 CFR 50.55a Request I3R-05

Enclosure I: 10 CFR 50.55a Request I3R-05, Revision 1
Enclosure II: White Paper – Relaxation of the 100 Square Inch Size Limitation – Code Case N-638

cc: J. N. Donohew (NRC), w/a, w/e
W. B. Jones (NRC), w/a, w/e
B. S. Mallett (NRC), w/a, w/e
Senior Resident Inspector (NRC), w/a, w/e

Response to Request for Additional Information Regarding 10 CFR 50.55a Request I3R-05

1.0 Request for Additional Information:

In the submittal dated May 19, 2006, it is stated that a preemptive full structural weld overlay or a full structural overlay repair weld is proposed if a service related flaw is identified. It is also stated that the latest "NRC approved Code Case does not have the needed requirements for this type of overlay." Since the staff has not approved Code Case N-504-3 (N-504-3) for use, provide a more in-depth comparison in tabular format to show the differences between N-504-3 and N-504-2 with its corresponding alternative. The comparison should show why any significant differences between the two Code Cases will provide an acceptable level of quality and safety.

Wolf Creek Nuclear Operating Corporation (WCNOC) Response to 1.0:

Table A is attached, showing the differences between Cases N-504-2 and N-504-3. The text added or deleted has been underlined or crossed through to show the changes between N-504-2 and N-504-3. The important differences were described on page 3 of Request I3R-05 (enclosure to WCNOC letter ET 06-0021, dated May 19, 2006). As noted on page 3 of Request I3R-05, the changes incorporated into Case N-504-3 are consistent with Nonmandatory Appendix Q, which the NRC has required to be used with Case N-504-2. Therefore, the use of Case N-504-3 and Nonmandatory Appendix Q is consistent with provisions already approved by the NRC and provide an acceptable level of quality and safety.

2.0 Request for Additional Information:

Discuss in detail your strategy for expansion of examinations if an unacceptable flaw is found by NDE under a portion of the weld overlay that was not scheduled for an inservice examination that outage. This should include any adjoining stainless steel welds adjacent to the Alloy 82/182 welds.

WCNOC Response to 2.0:

All six of the Alloy 82/182 dissimilar metal (DM) butt welds on the Pressurizer are being examined in the upcoming Refuel 15 (RF15) refueling outage. These DM welds are classified as WCNOC augmented examinations in the WCNOC Inservice Inspection (ISI) Program, based on industry experience with Alloy 82/182 welds at higher temperature locations in the reactor coolant system. The six adjacent safe-end to piping stainless steel (SS) butt welds are also being examined in RF15 due to the installation of weld overlays on the DM welds. One of these SS welds (BB02-F008) is scheduled for examination per the ISI Program.

If unacceptable flaws are found during the examination of the Alloy 82/182 DM butt welds, no expansion of examination for the DM welds is necessary. This is due to the fact that 100% of the reactor coolant system Alloy 82/182 DM piping butt welds at Wolf Creek Generating Station (WCGS) would have been examined within 18 months. The other Alloy 82/182 DM piping butt welds are on the reactor vessel nozzles and were examined with acceptable results in the previous RF14 refueling outage.

Response to Request for Additional Information Regarding 10 CFR 50.55a Request I3R-05

The adjoining safe-end to piping SS butt welds are under the Risk Informed (RI) ISI program. BB02-F008 is scheduled for examination in RF15. If unacceptable service induced flaws are found in weld BB02-F008, per the RI-ISI methodology, the root cause of the unacceptable flaw will be determined through an engineering evaluation. This evaluation will include whether other elements in the segment or segments are subject to the same root cause conditions. Additional examinations will be performed on these elements up to the same number of elements required to be inspected on the segment or segments initially. If unacceptable flaws or relevant conditions are again found similar to the initial problem, the remaining elements identified as susceptible will be examined. No additional examinations will be performed if there are no additional elements identified as being susceptible to the same root cause conditions.

If flaws are found in any of the other 5 safe-end to piping SS butt welds, the condition will be entered into the WCNOC corrective action program for evaluation and corrective action.

3.0 <u>Request for Additional Information:</u>

Identify when the flaw evaluations and shrinkage stress effects analyses required under Code Case N-504-2(g), Items 2, and 3 (or corresponding requirements in N-504-3). Will be performed. If the evaluations are to be performed after placing the weld overlays into service, please provide justification why it is acceptable to not perform the calculations when placing these welded components into service pursuant to 10 CFR 50.55a(a)(3)(ii).

<u>WCNOC Response to 3.0:</u>

The design (which includes shrinkage assessment) and the flaw evaluations were described on pages 6 and 11 of Request I3R-05 (enclosure to WCNOC letter ET 06-0021, dated May 19, 2006).

The provisions of N-504-3 paragraphs (f) and (g) and Q-3000 in the 2005 Addenda of Section XI, along with the corrections to Q-3000 to be included in the 2006 Addenda of Section XI, define the design and flaw evaluations that will be performed. The evaluations will be performed before the weld overlays begin, to ensure that the overlays are in compliance with the requirements of the Code Case and Appendix Q. The shrinkage assessment and the fatigue crack growth assessment portions of the evaluation will not be fully completed before the pre-weld overlay examinations and the weld overlays are completed. A preliminary shrinkage assessment, using conservative shrinkage estimates based on past experience and shrinkage studies, will be included in an initial evaluation report. Shrinkage measurements will be taken after the overlays are completed and will be reconciled with the preliminary shrinkage assessment before the weld overlays are placed in service. Fatigue crack growth curves will be included in the initial evaluation report and will allow flaw sizes from the pre-weld overlay examinations to be quickly assessed before the weld overlays are placed in service. The final shrinkage assessment and fatigue crack growth assessments will be included in a final evaluation report after weld overlays are placed in service.

Response to Request for Additional Information Regarding 10 CFR 50.55a Request I3R-05

4.0 Request for Additional Information:

On page 14 of the submittal, it is indicated that the maximum area of the overlay over the ferritic nozzle material will be 300 in^2. Part of the basis for acceptability for Wolf Creek is an approval of the Susquehanna Steam Electric Station overlay. Identify the similarities and differences in design and stresses that apply to Wolf Creek as part of your basis for meeting an acceptable level of quality and safety.

WCNOC Response to 4.0:

The NRC acceptance of the Susquehanna relief request was not based on specific design and stresses but on the industry work demonstrating the acceptability of larger areas of ambient temperature temper bead welding. Because the basis was not specific to Susquehanna, WCNOC referred to that approval. Since the initial submittal of the WCNOC Request I3R-05, ASME has approved Case N-638-3, which increased the 100 square inch limitation to 500 square inches. The technical basis accompanying that Case revision provides an expanded basis for the change in area limitation. A copy of the technical basis, "White Paper – Relaxation of the 100 Square Inch Size Limitation – Code Case N-638" is included as Enclosure II to this letter to provide additional basis for justification of the WCNOC request. Additionally, in a June 28, 2006 letter to Calvert Cliffs, the NRC approved a relief request for weld overlays based on operational experience and the technical basis included in this same white paper.

Furthermore, it is noted that since the nozzle-to-safe-end welds and the weld overlays are fabricated from austenitic materials with inherent toughness, no cracking in the overlays is expected to occur due to the shrinkage associated with the weld overlay. With respect to the low alloy steel material in the nozzle, many temper bead weld overlays have been applied in the nuclear industry to these nozzle-to-safe end locations. In no instance has there been any reported cracking due to the weld overlay application. The stiffness and high toughness inherent in the low alloy steel nozzle is expected to protect against any cracking and limit any distortion that might occur in the nozzle. WCNOC will be measuring and evaluating the axial shrinkage in accordance with ASME Code Case N-504-3. Also, any cracking that might occur should be detected by the final non-destructive examination (NDE) of the weld overlay. Laboratory testing and field experience have been documented qualifying the temper bead weld overlay repair for nozzle-to-safe-end welds and these efforts and experience have demonstrated that the remedy provides a quality, sound repair that maintains structural integrity, thus demonstrating an acceptable level of quality and safety.

5.0 Request for Additional Information:

Apply the same rationale as stated in Question 4.0 above to expand the discussion why relief from NDE of the 1.5T area on either side of the weld overlay provides an acceptable level of quality and safety rather than Code Case N-638-2 and as the referenced Millstone request.

Response to Request for Additional Information Regarding 10 CFR 50.55a Request I3R-05

WCNOC Response to 5.0:

For clarification, it needs to be identified that Code Case N-638-1 is only being used for welding on and directly adjacent to the P-No. 3 ferritic nozzle materials, since only these locations require ambient temperature gas tungsten arc welding (GTAW) temper bead welding in lieu of the Code required post-weld heat treatment. Therefore, the N-638-1 ultrasonic (UT) examination of a band around the area to be welded of at least 1.5 times the component thickness or 5", whichever is less, is only required on the nozzle side of the weld overlay and does not apply to both sides of the weld overlay as indicated in the NRC request for additional information.

The following information is offered to further demonstrate the acceptability of not performing the UT examinations of the ferritic nozzle material band around the area to be welded of at least 1.5 times the component thickness or 5", which ever is less.

When the ambient temperature GTAW temper bead Code Case provisions were initially developed in 1997, little experience was available for ambient temperature GTAW temper bead welding. Although developmental testing indicated the acceptability of the process, conservative provisions were added to the Case because little actual field experience was available for welding without the temper bead pre-heat and post-bake temperature requirements. One such conservative provision was the requirement to examine a band around the area to be welded of at least 1.5 times the component thickness or 5", which ever is less, using surface and ultrasonic (UT) methods. The intent of these examinations was to ensure that the ferritic steel base material was not adversely affected as a result of the ambient temperature temper bead welding process. The adverse effect considered by ASME was the potential for delayed hydrogen cracking. Delayed hydrogen cracking is only a potential concern when welding on ferritic materials or using ferritic filler materials and is not a concern for welding on austenitic materials such as stainless steel safe-ends and stainless steel piping or using austenitic Alloy 52/52M filler materials. For austenitic weld overlays covered by the WCNOC Request, the concern is limited to the heat-affected zone in the P-No. 3 nozzle material at the weld overlay to nozzle interface.

For comparison, it is helpful to look at the requirements in IWA-4630 compared to those in Code Case N-638-1. IWA-4630, in ASME Section XI, 1998 Edition through the 2000 Addenda applicable to the WCNOC 3rd Interval, addresses repairs where a defect is excavated and the resulting cavity is welded using the dissimilar metal temper bead welding process. When using IWA-4630, a volumetric examination of the IWA-4610(a) preheated band is not required by IWA-4634 for dissimilar metal temper bead welding. IWA-4634 mandates a surface examination of this pre-heated band and of the weld itself. This surface examination of the pre-heated band was imposed because a surface examination assures that after welding the adjacent base material remains free of surface discontinuities and defects, including potential hydrogen cracking at the component surface in the heat-affected zone and base metal immediately adjacent to the welded cavity. IWA-4634 also mandates a UT examination of the deposited weld metal itself, but imposes no UT examination requirement for the pre-heated band. UT examination of the band was not considered necessary. Based on the experience

**Response to Request for Additional Information Regarding
10 CFR 50.55a Request I3R-05**

gained since the initial development of ambient temperature GTAW temper bead provisions, based on the experience with temper bead welding performed in accordance with IWA-4600 procedures, and based on a comparison of the examination differences in Code Case N-638-1 and IWA-4630, ASME began processing a revision to Code Case N-638-1 in 2004 to eliminate the examination of the adjacent base metal band and to require the welded excavation to be examined in accordance with the Construction Code. This revision was approved by the ASME consensus process and designated as Code Case N-638-2 but has not yet been approved for use by the NRC in Regulatory Guide 1.147.

Furthermore, Code Case N-638-1 and the temper bead welding techniques in IWA-4600 are written to address repair welds where a defect is excavated and the resulting cavity is filled using a temper bead technique. For IWA-4630 dissimilar metal temper bead welding in the 2000 Addenda, surface examination of an extended band around the weld is specified as described above. For Code Case N-638-1, the surface and volumetric examination of a band of equivalent size around the weld was imposed as a conservative measure as described above. However, an excavated cavity configuration differs significantly from the weld overlay configuration addressed in Code Case N-504-3 and Appendix Q. For an excavated cavity, the fusion line between the weld and the cavity is more critically oriented for hydrogen cracking than the fusion line between a weld overlay and the underlying base metal/original welds. For weld overlays, potential hydrogen cracking associated with the Pressurizer weld overlays would be limited to the heat-affected zone in the P-No. 3 nozzle material at the weld overlay to nozzle interface. Potential hydrogen cracking in the heat-affected zone at the toe of the weld overlay is best identified by a surface examination. Potential hydrogen cracking in the heat-affected zone in the weld overlay to nozzle interface under the weld overlay is best identified by a UT examination of the weld overlay. These potential causes of cracking are addressed by the WCNOC proposed modification to N-638-1, which examines the adjacent band and the weld with a surface examination, as required by N-638-1, and examines the weld overlay by UT examination in accordance with Case N-504-3, Appendix Q and demonstrated Performance Demonstration Initiative (PDI) UT procedures for examination of weld overlays, but eliminates the UT examination of the adjacent band.

Therefore, based on the above information, the WCNOC proposed modification to N-638-1 adequately examines the appropriate areas and volumes to address the potential types and locations of cracking, thereby assuring an acceptable level of quality and safety. The N-638-1 UT examination of the band outside of the weld overlay offers no additional benefit in terms of quality or safety.

In addition to the above justification, there are obstructions that limit performance of the N-638-1 UT examinations. Although this is not the basis for the WCNOC modification to N-638-1 to not perform the UT examination, it is provided for further information. In the following discussion, the UT (volumetric) examination requirement for the band is the entire base metal below the band surface. The UT inspection is to be conducted in accordance with Appendix I of the ASME Code Section XI.

Response to Request for Additional Information Regarding 10 CFR 50.55a Request I3R-05

With respect to the weld overlay process on Pressurizer nozzle dissimilar metal welds, the Code Case N-638-1 defined band and examination volume would encompass the nozzle base metal volume in the regions of the outside diameter (OD) nozzle tapered surface and, for some nozzles, a part of the nozzle larger cylindrical diameter. Such surfaces are not conducive for gaining full coverage of the examination volume due to non-coupling of the UT test probes over the surface. Obstructions causing this non-coupling include the edge of the weld overlay, the transition between the OD nozzle taper and the nozzle larger cylindrical diameter, and the nozzle outer blend area that transitions to the nozzle to shell weld.

Appendix I of the ASME Code Section XI, 1998 Edition through the 2000 Addenda requires that the UT examination be conducted in accordance with ASME Code Section V, Article 4 and all supplements of Appendix I except Supplement 9 – Scan Angles. The most applicable examination requirements fall under Article 4 T-440 Vessel Examinations. These requirements include straight beam scanning for laminar and planar reflectors and angle beam scanning for planar reflectors. Straight beam scanning is not the preferred technique for the detection of delayed hydrogen cracking due to the orientation of the postulated cracking with respect to the beam and to the anticipated near surface location of such cracking. The straight beam is essentially a repeat of the nozzle material examination required by the Construction Code. The angle beam examinations will be largely impacted by the outer diameter surface configuration. To maximize angle beam examination coverage would entail a series of special transducers to be applied even though the most effective angle beam transducers would be those configured to detect near surface breaking planar reflectors. However, the most effective NDE method for detection of near surface breaking planar reflectors is not with a volumetric method but with a surface examination method, as discussed above. Therefore, performing a limited UT examination of the adjacent nozzle ferritic material band provides no additional benefit in terms of quality and safety.

Based on the above information, the WCNOC proposed modification to Code Case N-638-1 adequately examines the appropriate areas and volumes to address the potential types and locations of cracking, thereby assuring an acceptable level of quality and safety. The Code Case N-638-1 UT examination of the band outside of the weld overlay offers no additional benefit in terms of quality or safety. Because the Code Case N-638-1 UT examination of the band outside of the weld overlay offers no additional benefit in terms of quality or safety, performing a UT examination of this band only serves to increase radiological dose for UT examiners.

6.0 Request for Additional Information:

The submittal requests that Code Case N-416-2 be used as an alternative to the hydrostatic testing requirement under IWA-5000. Is Code Case N-416-2 listed in your current inservice inspection (ISI) program plan?

**Response to Request for Additional Information Regarding
10 CFR 50.55a Request I3R-05**

WCNOC Response to 6.0:

The WCNOC Request does not request to use Code Case N-416-2. The modification to N-504-3 requested in the WCNOC Request is to use the provision of Section XI 1998 Edition through 2000 Addenda, specifically IWA-4540, that allows a system leakage test as an alternative to a hydrostatic test such as identified in Code Case N-504-3. The system leakage test is performed in accordance with IWA-5000.

The basis for this modification explained the history of why ASME eliminated hydrostatic tests for ISI inspections and that ASME provided similar relief from hydrostatic pressure tests for repair/replacements through the use of Code Case N-416-1. ASME incorporated Code Case N-416-1 into the 1999 Addenda of Section XI in IWA-4540. The current WCNOC 3rd Interval ISI and Repair/Replacement Programs use the 1998 Edition through the 2000 Addenda, which contains the incorporated provisions of Case N-416-1. Therefore, WCNOC has no need to use N-416-1 or N-416-2 as the provisions are already in the Code. The proposed WCNOC modification to Case N-504-3 simply notes that the provisions in Section XI will be used. Basis for this is further illustrated in that Nonmandatory Appendix Q, required by the NRC to be used along with Case N-504-2, does not take exception to the pressure test requirements of IWA-4540, thereby allowing the use of either a hydrostatic test or a system leakage test of IWA-4540.

7.0 Request for Additional Information:

It is stated in the submittal that the duration of the proposed alternative is for the design life of the affected components. The NRC staff agrees that the weld overlay(s) will remain in service indefinitely but the ISI requirements may change each 10-year interval. Based on this, discuss why the duration requested should not be revised accordingly since the relief request I3R-05 addresses both application of the weld overlay(s) and ISI requirements.

WCNOC Response to 7.0:

Paragraph 6.0 of the WCNOC Request I3R-05 has been revised (Reference I3R-05, Revision 1, included as Enclosure I to this letter) to request the duration for the installed weld overlays to be the design life of the affected components and the duration for the inservice examination requirements identified in the Request to be for the remaining duration of the WCNOC 3rd Interval ISI Program.

Response to Request for Additional Information Regarding 10 CFR 50.55a Request I3R-05

TABLE A
Comparison of Code Cases N-504-2 and N-504-3

Code Case N-504-2 (as shown in 2004 Edition of ASME Boiler and Pressure Vessel Code Cases: Nuclear Components)	**Changes Made in Code Case N-504-3** (as shown in 2004 Edition of ASME Boiler and Pressure Vessel Code Cases: Nuclear Components, Supplement 2)		**Comments**
In the Inquiry, line 6: …1995 Edition with the 1995 Edition and Addenda and later Editions and Addenda, defect may…	…Addenda, a defect may…	Inserted the word "a".	Editorial.
In the Reply, line 6: …including the 1995 Edition, and in…	…including the 1995 Edition, ~~and~~ in…	Deleted the word "and".	Editorial.
In the Reply, line 7: …the 1995 Addenda and later Editions and Addenda…	…the 1995 Addenda up to and including the 1996 Addenda, and in IWA-4420 in the 1995 Edition with 1997 Addenda and later Editions and Addenda…	Added the wording underlined.	The 1997 Addenda changed the requirements for defect removal and relocated the requirements from IWA-4410 to IWA-4420. When N-504-3 applicability was expanded to include the 1996 Addenda through the 2004 Edition, this additional wording was added.
In the Reply, line 7: …later Editions and Addenda, defect in…	…later Editions and Addenda, in IWA-4810(a) in the 1992 Edition with the 1994 Addenda through the 1995 Edition, and in IWA-4520(a) in the 1995 Edition with the 1995 Addenda and later Editions and Addenda, a defect in…	Added the wording underlined.	The Construction Code examination requirements in IWA-4810(a) and IWA-4520(a) were never meant to be applied to weld overlays because the Case identifies the examinations appropriate for weld overlays.
Foot note 1: …Repair Plan.	…Repair Plan or Repair/Replacement Plan, as applicable.	Added the wording underlined.	Editorial, recognizing the change in terminology in later Code Editions and Addenda.

Response to Request for Additional Information Regarding 10 CFR 50.55a Request I3R-05

Paragraph (b), last line: ...identified in the Repair/Replacement Program.	...identified in the Repair/Replacement Program. The submerged arc method shall not be used for weld overlay.	Added the wording underlined.	The submerged arc welding method was prohibited for use on weld overlays. This was added to address NRC comments during the ASME approval process.
Paragraph (f)(1), line 2: ...axial flaws greater then 1.5 in, in length, or more than 5 axial flaws...	...axial flaws equal to or greater then 1.5 in~~,~~ in length, or ~~more than~~ 5 or more axial flaws...	Changed wording as indicated.	This was revised to address the case where the flawed weld may have one axial flaw exactly 1.5 in. long, and exactly five axial flaws of any length.
Paragraph (g)(2), third line from the end: When structural credit is taken for SAW or SMAW weld metal in the original pipe weldment or the weld overlay,...	When structural credit is taken for SAW or SMAW weld metal in the original pipe weldment or SMAW weld metal in the weld overlay,...	Added the wording underlined.	Clarified that SAW could not be used for weld overlays. Clarification added to address an NRC comment during the ASME approval process.
Paragraph (g)(2), last line: ...requirements of Tables IWB-3641-5 and IWB-3641-6 shall apply.	...requirements of ~~Tables IWB-3641-5 and IWB-3641-6~~ IWB-3640 for SAW or SMAW welds, as applicable shall apply.	Changed wording as indicated.	The 1996 Addenda deleted Tables IWB-3641-5 and -6, and included the flaw evaluation requirements for SAW and SMAW weld metal in Tables IWB-3641-1 and -2. The 2002 Addenda then deleted these tables and incorporated their provisions into IWB-3640. The more general reference to IWB-3640 covers both the 1996 and 2002 changes.
Paragraph (i), line 7: The acceptance standards of Table IWB-3514-2 shall apply.	The acceptance standards of Table IWB-3514-2 shall apply for planar flaws. The acceptance standards of Table IWB-3514-3 shall apply for laminar flaws provided the reduction in coverage of the examination volume is less than 10%. The dimensions of the uninspectable	Added the wording underlined.	The laminar flaw acceptance criteria in paragraph (i) were revised to address an uninspectable volume below laminar flaws and the reduction in examination volume coverage due to laminar flaws. This was added to address NRC comments during the ASME approval process.

Response to Request for Additional Information Regarding 10 CFR 50.55a Request I3R-05

	volume are dependent on the coverage achieved with the angle beam examination. Additionally, any uninspectable volume in the weld overlay shall be assumed to contain the largest radial planar flaw that could exist within that volume. The assumed planar flaw shall meet the inservice examination acceptance standards of Table IWB-3514-2. Both axial and circumferential flaws shall be assumed. As an alternative to the assumed planar flaw, radiography in accordance with the Construction Code shall be used to examine the uninspectable volume of the weld overlay. The radiography acceptance criteria of the Construction Code shall apply.		
Paragraph (m): Use of this Case shall be documented on an NIS-2 form.	Use of this Case shall be documented on ~~an~~ Form NIS-2 ~~form~~.	Changed wording as indicated.	Editorial.

Wolf Creek Nuclear Operating Corporation
10 CFR 50.55a Request Number I3R-05, Revision 1

Proposed Alternative
In Accordance with 10 CFR 50.55a(a)(3)(i)

Alternative Provides Acceptable Level of Quality and Safety

1.0 ASME CODE COMPONENTS AFFECTED

Description:	Nozzle-to-safe end dissimilar metal (DM) Alloy 82/182 butt welds and safe end-to-piping stainless steel (SS) butt welds on the safety, relief, spray, and surge line connections to the Pressurizer
Code Class:	Class 1
Examination Categories:	R-A (risk informed designation for B-F and B-J categories)
Weld Numbers:	TBB03-2-W (4" spray nozzle-to-safe end weld) BB-04-F001 (4" spray safe end-to-piping weld) TBB03-3-A-W (6" safety "A" nozzle-to-safe end weld) BB-02-F001A (6" safety "A" safe end-to-piping weld) TBB03-3-B-W (6" safety "B" nozzle-to-safe end weld) BB-02-F005A (6" safety "B" safe end-to-piping weld) TBB03-3-C-W (6" safety "C" nozzle-to-safe end weld) BB-02-F006A (6" safety "C" safe end-to-piping weld) TBB03-4-W (6" relief nozzle-to-safe end weld) BB-02-F008 (6" relief safe end-to-piping weld) TBB03-1-W (14" surge nozzle-to-safe end weld) BB-01-F004B (14" surge safe end-to-piping weld)

2.0 APPLICABLE CODE EDITION AND ADDENDA

The following editions and addenda of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Sections III and XI, are used at Wolf Creek Generating Station (WCGS):

- ASME Section XI, 1998 Edition through the 2000 Addenda for the 3rd interval Inservice Inspection (ISI) and Repair/Replacement Programs
- ASME Section III, 1974 Edition through Summer 1974 Addenda [Original Code of Construction for Pressurizer]
- ASME Section III, 1974 Edition through Winter 1974 Addenda [Original Code of Construction for top of Pressurizer piping]
- ASME Section III, 1974 Edition through Summer 1975 Addenda [Original Code of Construction for bottom of Pressurizer piping]

3.0 APPLICABLE CODE REQUIREMENTS

IWA-4420 and IWA-4520(a) of ASME Section XI require repair/replacement activities to be performed and examined in accordance with the Owner's Requirements and the original Construction Code of the component or system. IWA-4430 and IWA-4600 provide for alternative welding methods when the requirements of IWA-4420 cannot be met. IWA-4530 requires a preservice examination to be performed in accordance with IWB-2200. Table IWB-2500-1 Categories B-F and B-J prescribe inservice examination requirements for Class 1 butt welds. Section XI Appendix VIII Supplement 11 specifies the performance demonstration requirements for ultrasonic examination of weld overlays.

4.0 REASON FOR REQUEST

Primary Water Stress Corrosion Cracking (PWSCC) of Alloy 600/82/182 components exposed to pressurized water reactor (PWR) primary coolant has become a growing concern in the nuclear industry over the past decade. In particular, base metal and weld metal components exposed to elevated temperatures, like the pressurizer, are believed to pose a heightened propensity to PWSCC.

Wolf Creek Nuclear Operating Corporation (WCNOC) has concluded that the application of either a full structural repair weld overlay or a preemptive full structural weld overlay to the Pressurizer nozzle DM welds is the most appropriate course of action to ensure reactor coolant system (RCS) pressure boundary integrity and improve future inspectability. The weld overlay of the DM nozzle-to-safe end weld will preclude future examination of the SS safe end-to-pipe weld due to the close proximity of the two welds. Therefore, each weld overlay will extend from the low alloy steel nozzle across both butt welds to the stainless steel pipe. WCNOC will perform examinations of the nozzle-to-safe end DM butt welds and the adjacent safe end-to-piping SS butt welds on the safety, relief, spray, and surge line connections to the Wolf Creek Pressurizer during the upcoming Refueling Outage 15 in October 2006 using Performance Demonstration Initiative (PDI) qualified procedures. If greater than or equal to 90% coverage of the original DM and SS welds is achieved with PDI qualified procedures and no PWSCC flaws or service related flaws are identified, a preemptive full structural weld overlay is proposed to be installed to mitigate the potential for future degradation. If greater than or equal to 90% coverage can not be obtained, or if PWSCC or service related flaws are identified, a full structural repair weld overlay is proposed to be installed to repair the degradation or the possibility of undetected degradation.

Structural weld overlays have been used for over 20 years for repair and mitigation of intergranular stress corrosion cracking in boiling water reactors and more recently for repair of PWSCC in pressurized water reactors. In some cases, full structural weld overlays have been used to reestablish structural integrity of DM butt welds containing through wall leaking flaws. Full structural weld overlays arrest existing flaws from propagating by favorable residual compressive stresses in the inner portions of the original susceptible welds, provide a PWSCC resistant material, and provide structural reinforcement that meets ASME Code Section XI margins even with existing cracks remaining in the original susceptible welds.

As discussed in this Request, there is no approved comprehensive criterion for WCNOC to apply a full structural nickel alloy weld overlay to a DM weld that is constructed of Alloy 82/182 weld material and is believed to be susceptible to or contains PWSCC degradation. Although the ASME Code, Section XI, 1998 Edition through 2000 Addenda Article IWA-4000 is used for the WCNOC Repair/Replacement Program, it does not have the needed requirements for this type of weld overlay repair/mitigation. The latest Nuclear Regulatory Commission (NRC) approved ASME Code also does not have the needed requirements for this type of weld overlay. ASME is in the process of preparing and approving a Code Case to provide the comprehensive provisions for this type of weld overlay but the Case has not yet been approved by ASME.

Section 3.0 of this Request identifies Code requirements that cannot be met or are not applicable when applying full structural nickel alloy weld overlays as described in this Request. Therefore, in lieu of IWA-4420 (and its referenced original Construction Code for the Pressurizer and attached piping), IWA-4430, IWA-4520(a), IWA-4530, IWA-4600, and the inservice examination requirements of Table IWB-2500-1, alternative requirements are requested for the installation and examination of full structural weld overlays for repairing/mitigating the DM welds and SS welds identified in section 1.0 of this Request. These alternative requirements use methodologies and requirements similar to those in ASME Code Cases N-504-3 and N-638-1. However, as described in section 5.0 of this Request, Cases N-504-3 and N-638-1 cannot be used without modifications.

The WCNOC risk-informed ISI Program prescribes inservice examination requirements for Class 1 butt welds that are used in lieu of the requirements of ASME Section XI Table IWB-2500-1. However, with this Request, the weld overlays installed on the welds identified in section 1.0 of this Request will be included in the WCNOC ISI Program Plan in place of the original DM and SS welds and will be examined as described in section 5.0 of this Request. The original DM and SS welds will be removed from the WCNOC risk-informed ISI Program.

Pursuant to 10CFR50.55a(a)(3)(i), alternatives are requested on the basis that the proposed alternatives will provide an acceptable level of quality and safety.

5.0 PROPOSED ALTERNATIVE AND BASIS FOR USE

A) Proposed Alternative For Application of Weld Overlays Using Modified Code Case N-504-3

A full structural repair weld overlay or a preemptive full structural weld overlay is proposed for each Pressurizer nozzle-to-safe end Alloy 82/182 butt weld. The weld overlay of the DM nozzle-to-safe end weld will preclude future examination of the SS safe end-to-pipe weld due to the close proximity of the two welds. Therefore, each weld overlay will extend from the low alloy steel nozzle across both butt welds to the stainless steel pipe. ASME Code Case N-504-3, "Alternative Rules for Repair of Classes 1, 2, and 3 Austenitic Stainless Steel Piping," allows a flaw to be reduced to an acceptable size through the deposition of weld reinforcement on the outside surface of the pipe without flaw removal. In this Request, an alternate application for nickel-based and low alloy steel materials is proposed due to the materials and configuration of the subject welds, and the lack of an approved Code Case for this application. As described in the following paragraphs, Code Case N-504-3 and Nonmandatory Appendix Q will be used along with the modifications detailed in Table 2.

Code Case N-504-3 is not listed in Regulatory Guide 1.147, Revision 14. However, Code Case N-504-2 is approved for use for austenitic stainless steel material in Regulatory Guide 1.147, Revision 14, with a condition that the provisions of Nonmandatory Appendix Q of the 2005 Addenda of ASME Section XI also must be met. According to the ASME Section XI Code Case Applicability Index, Code Case N-504-2 applicability does not apply to the ASME Section XI 2000 Addenda used for the WCNOC Repair/Replacement Program; therefore, Code Case N-504-3 is included in this request.

According to the ASME action that approved Case N-504-3, the following changes were made to Case N-504-2. N-504-2 was revised to correct references to IWA-4410 and Tables IWB-3641-5 and IWB-3641-6. The 1997 Addenda moved the defect removal rules from IWA-4410 to IWA-4420. The 1996 Addenda deleted Tables IWB-3641-5 and -6, and included the flaw evaluation requirements for submerged arc welding (SAW) and shielded metal arc welding (SMAW) weld metal in Tables IWB-3641-1 and -2. The 2002 Addenda then deleted these tables and incorporated their provisions into IWB-3640. In addition, the 1995 Addenda added a reference in IWA-4810(a) [which later became IWA-4520(a)] to Construction Code examination requirements that were never meant to be applied to these overlays. These revisions are all intended to make the Case usable with all Editions and Addenda of Section XI from the Summer 1978 Addenda through the 2004 Edition. The revision also clarifies which acceptance criteria of IWB-3514 apply to different kinds of flaws. Additionally, (f)(1) was revised to address the case where the flawed weld may have one axial flaw exactly 1.5 in. long, and exactly five axial flaws of any length. The laminar flaw acceptance criteria in paragraph (i) were revised to address an uninspectable volume below laminar flaws and the reduction in examination volume coverage due to laminar flaws. The submerged arc welding method was also prohibited for use on weld overlays. These changes incorporated into N-504-3 are consistent with Nonmandatory Appendix Q, which the NRC has required to be used with Case N-504-2. Therefore, the use of Case N-504-3 and Nonmandatory Appendix Q is consistent with provisions already approved by the NRC.

Table 1 identifies the materials of construction for the pressurizer nozzle-to-pipe assemblies within the scope of this Request. Figure 1 shows the generic configuration of the nozzle-to-pipe assemblies but does not reflect the actual external or internal surface profiles.

Figure 1: Generic Pressurizer Nozzle Configuration

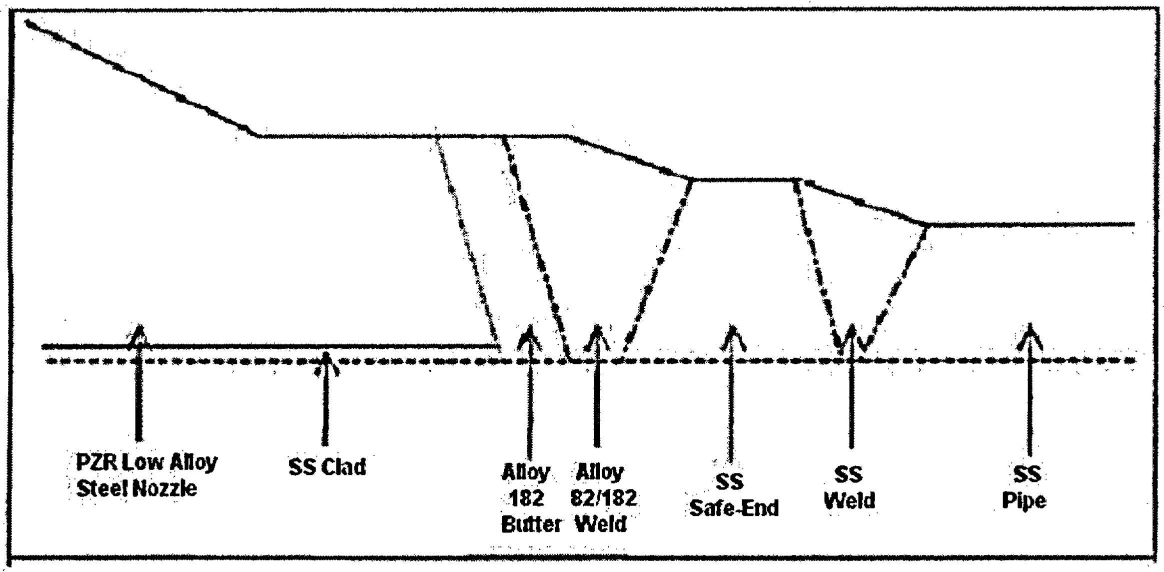


Table 1: WCGS Pressurizer Nozzle Material Identification

Nozzle Type	NPS	N-SE Weld ID[1] SE-P Weld ID[1]	Material Identification				
			Nozzle	N-SE Weld	Safe End	SE-P Weld	Pipe
Spray	4"	TBB03-2-W BB-04-F001	SA-508, Class 2a	DM Shop Weld (Alloy 82/182)	SA-182, Grade F-316L	SS Field Weld (ER308/E308)	Schedule 160, SA-312, Type 304S
Safety "A"	6"	TBB03-3-A-W BB-02-F001A	SA-508, Class 2a	DM Shop Weld (Alloy 82/182)	SA-182, Grade F-316L	SS Field Weld (ER308/E308 and ER308L for root inserts)	Schedule 160, SA-312, Type 304S
Safety "B"	6"	TBB03-3-B-W BB-02-F005A	SA-508, Class 2a	DM Shop Weld (Alloy 82/182)	SA-182, Grade F-316L	SS Field Weld (ER308/E308 and ER308L for root inserts)	Schedule 160, SA-312, Type 304S
Safety "C"	6"	TBB03-3-C-W BB-02-F006A	SA-508, Class 2a	DM Shop Weld (Alloy 82/182)	SA-182, Grade F-316L	SS Field Weld (ER308/E308 and ER308L for root inserts)	Schedule 160, SA-312, Type 304S
Relief	6"	TBB03-4-W BB-02-F008	SA-508, Class 2a	DM Shop Weld (Alloy 82/182)	SA-182, Grade F-316L	SS Field Weld (ER308/E308 and ER308L for root inserts)	Schedule 160, SA-312, Type 304S
Surge	14"	TBB03-1-W BB-01-F004B	SA-508, Class 2a	DM Shop Weld (Alloy 82/182)	SA-182, Grade F-316L	SS Field Weld (ER308/E308 with ER316 for repair)	Schedule 160, SA-376, Type 316S

Table 1 Footnote 1: N-SE refers to Nozzle-to-Safe End and SE-P refers to Safe End-to-Piping.

Each weld overlay will be designed consistent with the requirements of ASME Code Case N-504-3 and Nonmandatory Appendix Q, with the modifications noted in Table 2. The design of each overlay will assume that a 360° circumferential through-wall flaw is present in the original Alloy 82/182 weld and in the original SS weld. Each weld overlay will extend around the full circumference of the nozzle-to-piping weld locations as required by Code Case N-504-3. The specific thickness and length will be calculated according to the guidance provided in Code Case N-504-3 and Nonmandatory Appendix Q.

The determination of the life of the overlay will be based on the size of any indications in the region of the overlay. The existence of (or lack of) any flaws will be known or assumed due to the planned performance of qualified ultrasonic examinations prior to application of the overlays. As such, either the size and location of flaws will be known or assumptions are required to be made as to the size and location of flaws that may be present in the original dissimilar metal welds or original stainless steel welds. Fatigue crack growth evaluations will be performed for the dissimilar metal butt weld and the SS butt weld to demonstrate that the weld overlay thickness is sized adequately to satisfy the requirements in the flaw evaluation procedures of IWB-3640. The initial flaw size assumed in the fatigue crack growth calculations will be based on the pre-weld overlay UT examinations, and will be checked with the post-weld overlay UT examinations. If no service-related flaw is found, a flaw will be assumed with depth equal to the UT sensitivity. If the crack growth analysis shows that a flaw will not grow to the allowable flaw size for the normal ASME Code, Section XI inspection interval, then the existing Code interval will be used for subsequent in-service inspections. If the crack growth analysis shows that the assumed crack will grow to the allowable flaw size, then the in-service inspection interval will be established based on this time. The allowable flaw size will be that flaw size that meets the analytical requirements of Section XI, IWB-3640.

Preservice inspections and inservice inspections will be performed in accordance with Code Case N-504-3, Nonmandatory Appendix Q, Subarticles Q-4200 and Q-4300, and ASME Section XI, 1998 Edition through the 2000 Addenda, Appendix VIII, Supplement 11, with modifications noted in Tables 2 and 4. Details regarding the in-process, preservice, and inservice examinations that will be applied to the proposed weld overlays are shown in Table 5. These examinations meet all of the applicable Code and Code Case requirements as modified by this Request.

Section 3.0 of this Request identifies Code requirements that cannot be met or are not applicable when applying full structural nickel alloy weld overlays. The following explanation provides the basis for concluding that IWA-4420 and IWA-4520(a) are not applicable when using Case N-504-3 and Nonmandatory Appendix Q, as well as the basis for Case N-504-3 and Nonmandatory Appendix Q alternatives to IWA-4530, IWB-2200, and Table IWB-2500-1 categories B-F and B-J. As noted in the Reply paragraph of Code Case N-504-3, the provisions of N-504-3 are to be used in lieu of IWA-4420 and IWA-4520(a), which are the applicable Construction Code and examination paragraph references in the 2000 Addenda used for WCNOC's Repair/Replacement Program. Therefore, IWA-4420 and IWA-4520(a) are clearly not applicable to these weld overlay applications. The scope of Nonmandatory Appendix Q also states that the Appendix provides alternatives to the preservice examination requirements of IWA-4530 because the preservice examination requirements referenced by IWA-4530 do not have configurations applicable to weld overlays. Appendix Q provides specific preservice and inservice examination provisions applicable to weld overlay applications. Therefore, the Appendix Q specific provisions for weld overlays replace the preservice and inservice examination requirements of IWB-2200 and Tables IWB-2500-1 Categories B-F and B-J.

B) Proposed Alternative For Application of Ambient Temperature Machine Gas Tungsten Arc Welding (GTAW) Temper Bead Technique Using Modified Code Case N-638-1

Application of the structural weld overlays will require welding to the low alloy steel nozzle material. The ASME Section XI requirement to use ASME Section III for some repair/replacement requirements does not permit welding to the low alloy steel nozzle without pre-heat or post-weld heat treatment. In lieu of these ASME Section XI requirements, the requirements of ASME Code Case N-638-1, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique", will be met with the modifications detailed in Table 3. Code Case N-638-1 is conditionally approved for use in Regulatory Guide 1.147, Revision 14. The condition relates to the ultrasonic examination required by Case N-638-1. However, the modifications noted in Table 3 will perform the ultrasonic examinations of Code Case N-504-3 applicable to weld overlays, as noted in Tables 2 and 5, in lieu of the Code Case N-638-1 ultrasonic examination applicable to base metal/weld metal excavations and rewelding. Therefore, as discussed in Table 3, the NRC condition on use of N-638-1 is not applicable to this Request and will not be applied.

The Code Case N-638-1 ambient temperature temper bead welding technique permits application of the structural weld overlay without the need for elevated preheat or post-weld heat treatment required by ASME Section III. The technique has been qualified and will be performed using the methodology described in ASME Code Case N-638-1. Welding will commence when the base materials exhibit a minimum preheat of 50 degrees Fahrenheit. The maximum interpass temperature during weld overlay installation will be 350 degrees Fahrenheit. During the welding, heat input will be precisely controlled to conform to the welding procedure specification.

Section 3.0 of this Request identifies Code requirements that cannot be met or are not applicable when applying full structural nickel alloy weld overlays. The following explanation provides the basis for concluding that IWA-4430 and IWA-4600 are not applicable when using Case N-638-1. IWA-4430 allows the use of IWA-4600 when the Construction Code requirements of IWA-4420 cannot be met. However, IWA-4600 provides specific alternative welding methods that may be used and general requirements that apply to those specific alternative welding methods. Ambient temperature machine GTAW temper bead welding allowed by Case N-638-1 is not an alternative welding method identified in IWA-4600. Code Case N-638-1 provides the applicable requirements that apply to the use of this specific alternative welding method and IWA-4600 does not apply.

C) Proposed Alternatives to ASME Section XI, Appendix VIII, Supplement 11

ASME Section XI, 1998 Edition through 2000 Addenda, Appendix VIII, along with Appendix VIII Supplement 11, addresses the requirements for performance demonstration for ultrasonic examination procedures, equipment, and personnel used to detect and size flaws in full structural overlays of wrought austenitic piping welds. Appendix VIII Supplement 11 qualification requirements are modified by the proposed alternatives in the PDI program as indicated in Table 4 because the industry cannot meet the requirements of Appendix VIII, Supplement 11. Therefore, the PDI alternatives to Section XI, Appendix VIII, Supplement 11 as described in Table 4 will be used for qualification of ultrasonic examinations used to detect and size flaws in the full structural weld overlays of this Request.

6.0 DURATION OF THE PROPOSED ALTERNATIVE

The alternatives in this Request for the installed weld overlays are requested for the design life of the affected components. The duration for the inservice examination requirements identified in this Request are requested for the remaining duration of the WCNOC 3rd Interval ISI Program.

7.0 PRECEDENTS

Similar 50.55a Requests have been approved by the NRC as identified in the following letters:

1. Letter from Richard J. Laufer, NRC, to Christopher M. Crane, AmerGen, "Three Mile Island Nuclear Station, Unit 1 (TMI-1) Request for Relief from Flaw Removal, Heat Treatment, and Nondestructive Examination Requirements for the Third 10-year Inservice Inspection (ISI) Interval (TAC.No. MC1201)," Accession Number ML041670510, dated July 21, 2004.
2. Letter from Richard J. Laufer, NRC, to Bryce L. Shriver, PPL Susquehanna, "Susquehanna Steam Electric Station, Unit 1 - Relief from American Society of Mechanical Engineers, Boiler and Pressure Vessel Code (ASME Code), Section XI, Appendix VIII, Supplement 11, Requirements and Code Cases N-504-2 and N-638 Requirements (TAC Nos. MC2450, MC2451 and MC2594)," Accession Number ML051220568, dated June 22, 2005.
3. Letter from L. Raghavan, NRC, to Mano K. Nazar, I&M, "Donald C. Cook Nuclear Plant, Unit 1 - Alternative to Repair Requirements of Section XI of the American Society of Mechanical Engineers Code (TAC No. MC06751)," Accession Number ML051720006, dated June 27, 2005.
4. Letter from Richard J. Laufer, NRC, to George Vanderheyden, Calvert Cliffs, "Calvert Cliffs Nuclear Power Plant, Unit No. 2 - Relief Request for Use Weld Overlay and Associated Alternative Inspection Techniques (TAC Nos. MC6219 and MC6220)," Accession Number ML051930316, dated July 20, 2005.
5. Letter from Darrell J. Roberts, NRC, to David A. Christian, Dominion Nuclear Connecticut, Inc., "Millstone Power Station, Unit No. 3- Issuance of Relief from Code Requirements (TAC No. MC8609)," Accession Number ML053260012, dated January 20, 2006.

Table 2: Modifications to Code Case N-504-3 and Corresponding Nonmandatory Appendix Q Requirements

Code Case N-504-3 and Nonmandatory Appendix Q	Modification and Basis
Reply: It is the opinion of the Committee that, in lieu of the requirements of...IWA-4420 in the 1995 Edition with the 1997 Addenda and later Editions and Addenda...and in IWA-4520(a) in the 1995 Edition with the 1995 Addenda and later Editions and Addenda, a defect in austenitic stainless steel piping may be reduced to a flaw of acceptable size in accordance with IWB-3640 from the 1983 Edition with the Winter 1985 Addenda, or later Editions and Addenda, by deposition of weld reinforcement (weld overlay) on the outside surface of the pipe, provided the following requirements are met.	*Modification:* Code Case N-504-3 and Section XI Nonmandatory Appendix Q in the 2005 Addenda will be used for the application of Alloy 52/52M weld overlay of the ferritic (P-No. 3) nozzle material, nickel alloy (F-No. 43) weld material, and austenitic stainless steel (P-No. 8) safe end and pipe base material and (A-No. 8) weld materials, as modified herein. *Basis:* Industry operating experience has shown that PWSCC in Alloy 82/182 will arrest at the interface with stainless steel base metal, ferritic base metal, or Alloy 52/52M/152 weld metal. The 360° full structural weld overlay will control growth in any PWSCC crack and maintain weld integrity in both the Alloy 82/182 weld and the SS weld. The weld overlay will also induce inside diameter compressive stresses in the original welds, thus potentially impeding growth of any reasonably shallow cracks. Furthermore, the overlay will be sized to meet all structural requirements without considering the existing Alloy 82/182 and SS welds.
Paragraph (b): Reinforcement weld metal shall be low carbon (0.035% max.) austenitic stainless steel applied 360 deg. around the circumference of the pipe, and shall be deposited in accordance with a qualified welding procedure specification identified in the Repair Program [same as Section XI Nonmandatory Appendix Q, paragraph Q-2000(a)].	*Modification:* A nickel alloy filler material will be used in lieu of austenitic stainless steel filler material. *Basis:* The filler material used will be ERNiCrFe-7A (Alloy 52M, UNS N06054) or ERNiCrFe-7 (Alloy 52, UNS N06052). Repairs, if required, may use Alloy 52, Alloy 52M, or ENiCrFe-7 (Alloy 152, UNS W86152). Alloy 52 and Alloy 152 materials are listed in the ASME Code, Section II and Section IX as F-No. 43 and are acceptable for use under the ASME Code. Alloy 52M is assigned F-No. 43 by ASME per Code Case 2142-2. The requirements of ASME Section III, NB-2400 will continue to be applied to all filler material as required by ASME Section XI. The chromium content of Alloys 52/52M/152 is 28-31.5%. Alloy 52M contains higher Niobium content (0.5- 1 %), which improves the weldability of the material and pins the grain boundaries, thus preventing separation between the grains and hot tearing during weld puddle solidification.

Table 2: Modifications to Code Case N-504-3 and Corresponding Nonmandatory Appendix Q Requirements

Code Case N-504-3 and Nonmandatory Appendix Q	Modification and Basis
.	These filler materials are selected for their improved resistance to PWSCC. Alloys 52, 52M and 152 all contain about 30% chromium (roughly twice that of Alloy 82/182), imparting excellent corrosion resistance. The existing Alloy 82/182 welds and the Alloy 52/52M overlays are austenitic and have ductile properties and toughness similar to austenitic stainless steel piping welds at PWR operating temperature. Furthermore, these filler materials are suitable for welding over the ferritic nozzle, Alloy 82/182 weld, and the austenitic stainless steel pipe, welds, and safe ends.
Paragraph (c): Prior to deposition of the weld reinforcement, the surface to be repaired shall be examined by the liquid penetrant method. Indications greater than 1/16 in. are unacceptable and shall be prepared for weld reinforcement in accordance with (1) or (2) below: **(1)** Unacceptable indication shall be excavated to the extent necessary to create a cavity that can be repaired using qualified welding procedures. **(2)** One or more layers of weld overlay shall be applied to seal unacceptable indications in the area to be repaired without excavation. The thickness of these layers shall not be included in meeting weld reinforcement design thickness requirements. *Paragraph (d):* If the preparation of (c)(1) or (c)(2) above is required, the area where the weld reinforcement is to be deposited, including any local repairs or initial weld overlay layers, shall be examined by the liquid penetrant method, and shall contain no indications greater 1/16 in. prior to the application of the structural layers of the weld overlay.	*Modification:* In addition to the provisions in N-504-3 paragraphs (c) and (d), near-surface discontinuities identified by pre-weld overlay UT examinations may be prepared for weld overlay using provisions of (c) and will be examined using the provisions of (d). *Basis:* Code Case N-504-3 already specifies how to prepare the surface for weld overlay installation and addresses indications identified by surface examinations. This modification just expands these already acceptable provisions to near-surface discontinuities that may be identified in the pre-weld overlay UT examinations.
Paragraph (e): The weld reinforcement shall consist of a minimum of two weld layers having as-deposited delta ferrite content of at least 7.5 FN. The first layer of weld metal with delta ferrite content of least 7.5 FN shall constitute the first layer of the weld	*Modification:* Delta ferrite (FN) measurements will not be performed when using Alloy 52/52M/152 filler material. The weld overlay deposit shall meet the following requirements: The austenitic nickel alloy weld overlay shall consist of at least two weld layers deposited from a filler material with

Table 2: Modifications to Code Case N-504-3 and Corresponding Nonmandatory Appendix Q Requirements

Code Case N-504-3 and Nonmandatory Appendix Q	Modification and Basis
reinforcement design thickness. Alternatively, first layers of at least 5 FN may be acceptable based on evaluation [same as Q-2000(d)].	a Cr content of at least 28%. The first layer of weld metal deposited may not be credited toward the required thickness. Alternatively, a diluted layer may be credited toward the required thickness, provided the portion of the layer over the austenitic base material, austenitic filler material weld and the associated dilution zone from an adjacent ferritic base material contains at least 24% Cr and the Cr content of the deposited weld metal is determined by chemical analysis of the production weld or of a representative coupon taken from a mockup prepared in accordance with the WPS for the production weld. *Basis:* Welds composed of Alloy 52/52M/152 are 100% austenitic and contain no delta ferrite due to the high nickel (~60%) content. The Alloy 52/52M filler material selected for these weld overlays is fully austenitic and is, therefore, exempt from delta ferrite content requirements. Alternatively, deposit chromium content provides a suitable alternate basis for first layer deposit acceptance in PWSCC-resistant structural weld overlays. N-504-3 and Nonmandatory Appendix Q do not identify first-layer acceptance criteria for fully austenitic deposits, however, draft ASME Code Case N-740 (and its accompanying technical justification) identify 24% chromium as an acceptable measure of first-layer deposit acceptability in PWR applications. For structural weld overlays, verification of first-layer acceptability will be accomplished using the above modification. To accomplish this, first layer overlay deposit chemistry will be verified either by field chemistry measurements or by prior mockup demonstration using comparable welding parameters. When first-layer surface chemistry meets or exceeds 24% chromium, this initial layer will be credited toward structural overlay deposit thickness. If the first-layer surface chemistry chromium is less than 24% chromium, the first layer will be considered sacrificial and will not be credited toward structural overlay deposit thickness.
Paragraphs (f) and (g) and Q-3000 – Design Considerations	*Modifications:* The provisions of N-504-3 (f) and (g), Q-3000 in the 2005 Addenda of Section XI, and corrections to Q-3000 to be published in the 2006 Addenda of Section XI will be used.

Table 2: Modifications to Code Case N-504-3 and Corresponding Nonmandatory Appendix Q Requirements

Code Case N-504-3 and Nonmandatory Appendix Q	Modification and Basis
	Basis: ASME Code action BC 05-1530 approved a revision to Appendix Q, which will be published in the 2006 Addenda of ASME Section XI. The explanation for this revision notes that the action was correcting wording in Nonmandatory Appendix Q, which was first published in the 2005 Addenda. It was approved as part of BC03-1658 as the incorporation of Code Case N-504-2. However, some inadvertent consequences of changed wording during the incorporation of Case N-504-2 created problems in implementation. Therefore, two corrections were approved in the revision to Appendix Q to immediately fix the problems. The correction to Q-3000(b) was to delete the requirement for the design of the overlay to satisfy the requirements of the Construction Code and Owner's requirements. There was no similar wording in Code Case N-504-2. This wording was inappropriate because meeting the requirements of the Construction Code required the absence of cracks. However, the primary purpose of the Appendix and Code Case N-504-2 was to repair cracks with the external weld overlay. The appropriate requirements for maintaining Section III (i.e., the Construction Code) limits were properly transferred from Case N-504-2 into Q-3000(b)(1) in the initial issue of Appendix Q and the deletion in Q-3000(b) resolved the problem. Regarding the correction in Q-3000(b)(3), "overlay design thickness" is more appropriate than "pressure design", which is incorrect and was not used in Code Case N-504-2. Overlay design thickness is based on other loads in addition to pressure.
Paragraph *(h):* The completed repair shall be pressure tested in accordance with IWA-5000. If the flaw penetrated the original pressure boundary prior to welding, or if any evidence of the flaw penetrating the pressure boundary is observed during the welding operation, a system hydrostatic test shall be performed in accordance with IWA-5000. If the system pressure boundary has not been penetrated, a system leakage, inservice, or functional test shall be performed in accordance with IWA-5000.	*Modification:* In lieu of a hydrostatic test, a system leakage test will be performed in accordance with Section XI, IWA-5000 in the 2000 Addenda. *Basis:* A system hydrostatic test at 1.02 times Class 1 reactor coolant system operating pressure at normal operating temperature (as required by IWA-5000 and IWB-5000) is of no value. It provides no more assurance about the structural condition of the weld overlay than the system leakage test performed at Class 1 reactor coolant system operating pressure. ASME Section XI concluded this years ago and eliminated Class 1 system hydrostatic tests for inservice inspections starting in the 1993 Addenda.

Table 2: Modifications to Code Case N-504-3 and Corresponding Nonmandatory Appendix Q Requirements

Code Case N-504-3 and Nonmandatory Appendix Q	Modification and Basis
	ASME Section XI also issued Code Case N-416-1, which was accepted by the NRC, which substituted system leakage tests for system hydrostatic tests following repairs and replacements. ASME Section XI incorporated Code Case N-416-1 into IWA-4540 in the 1999 Addenda allowing a system leakage test to be used in lieu of a system hydrostatic test. A provision of the Code Case and the incorporation of the Case required examinations to be performed as required by ASME Section III because these examinations tell much more about the condition of the repair/replacement activity than any Section XI pressure test. However, the Section III examinations are not well suited to the weld overlay configuration. For the application of weld overlays, extensive surface and volumetric examinations of the weld overlay are required by Code Case N-504-3 and Nonmandatory Appendix Q, providing equivalent assurance of the quality of the overlay as the Section III examinations.

Table 3: Modifications to Code Case N-638-1

Code Case N-638-1	Modification and Basis
Paragraph 1.0(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.	*Modification:* The maximum area of a weld overlay over the ferritic nozzle material will be 300 sq. in. The one-half base metal thickness limitation applies only to excavations and repairs, and is not applicable to weld overlays covered by this 50.55a Request. *Basis:* The surge line nozzle weld overlay will require welding on more than 100 sq. in. of the surface of the low alloy steel surge nozzle base material. The weld overlays on the remaining nozzles each have less than 100 sq. in. of welding on the surface of the low alloy steel nozzle base material. Extensive experience exists in both boiling water reactor (BWR) and PWR weld overlays applied in excess of the 100 sq. in. limitation. Additionally, industry studies into the qualification of overlays in excess of 100 sq. in., have shown no issues with shrinkage stress, weld contraction stresses, etc. A weld overlay repair having 300 sq. in. surface area was recently approved by the NRC in a letter dated June 22, 2005 for Susquehanna Steam Electric Station. Weld shrinkage caused by application of the overlays will be measured and evaluated for any system impacts, as required by Code Case N-504-3, Paragraph (g)(3).
Paragraph 4.0(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.	*Modification:* In lieu of the ultrasonic examination requirement of paragraph 4.0(b), ultrasonic examinations of the final weld overlay will be performed in accordance with the requirements of Code Case N-504-3 and Nonmandatory Appendix Q as indicated in Table 5. *Basis:* When the ambient temperature GTAW temper bead Code Case provisions were initially developed in 1997, little experience was available for ambient temperature GTAW temper bead welding. Although developmental testing indicated the acceptability of the process, conservative provisions were added to the Case because little actual field experience was available for welding without the temper bead pre-heat and

Table 3: Modifications to Code Case N-638-1

	post-bake temperature requirements. One such conservative provision was the requirement to examine a band around the area to be welded of at least 1.5 times the component thickness or 5", which ever is less, using surface and ultrasonic (UT) methods. The intent of these examinations was to ensure that the ferritic steel base material was not adversely affected as a result of the ambient temperature temper bead welding process. The adverse effect considered by ASME was the potential for delayed hydrogen cracking. Delayed hydrogen cracking is only a potential concern when welding on ferritic materials or using ferritic filler materials and is not a concern for welding on austenitic materials such as stainless steel safe-ends and stainless steel piping or using austenitic Alloy 52/52M filler materials. For austenitic weld overlays covered by this Request, the concern is limited to the heat-affected zone in the P-No. 3 nozzle material at the weld overlay to nozzle interface. For comparison, it is helpful to look at the requirements in IWA-4630 compared to those in Code Case N-638-1. IWA-4630, in ASME Section XI, 1998 Edition through the 2000 Addenda applicable to the WCNOC 3rd Interval, addresses repairs where a defect is excavated and the resulting cavity is welded using the dissimilar metal temper bead welding process. When using IWA-4630, a volumetric examination of the IWA-4610(a) preheated band is not required by IWA-4634 for dissimilar metal temper bead welding. IWA-4634 mandates a surface examination of this pre-heated band and of the weld itself. This surface examination of the pre-heated band was imposed because a surface examination assures that after welding the adjacent base material remains free of surface discontinuities and defects, including potential hydrogen cracking at the component surface in the heat-affected zone and base metal immediately adjacent to the welded cavity. IWA-4634 also mandates a UT examination of the deposited weld metal itself, but imposes no UT examination requirement for the pre-heated band. UT examination of the band was not considered necessary. Based on the experience gained since the initial development of ambient temperature GTAW temper bead provisions, based on the experience with temper bead welding performed in accordance with IWA-4600 procedures, and based on

Table 3: Modifications to Code Case N-638-1

	a comparison of the examination differences in Code Case N-638-1 and IWA-4630, ASME began processing a revision to Code Case N-638-1 in 2004 to eliminate the examination of the adjacent base metal band and to require the welded excavation to be examined in accordance with the Construction Code. This revision was approved by the ASME consensus process and designated as Code Case N-638-2, but has not yet been approved for use by the NRC in Regulatory Guide 1.147. Furthermore, Code Case N-638-1 and the temper bead welding techniques in IWA-4600 are written to address repair welds where a defect is excavated and the resulting cavity is filled using a temper bead technique. For IWA-4630 dissimilar metal temper bead welding in the 2000 Addenda, surface examination of an extended band around the weld is specified as described above. For Code Case N-638-1, the surface and volumetric examination of a band of equivalent size around the weld was imposed as a conservative measure as described above. However, an excavated cavity configuration differs significantly from the weld overlay configuration addressed in Code Case N-504-3 and Appendix Q. For an excavated cavity, the fusion line between the weld and the cavity is more critically oriented for hydrogen cracking than the fusion line between a weld overlay and the underlying base metal/original welds. For weld overlays, potential hydrogen cracking associated with the Pressurizer weld overlays would be limited to the heat-affected zone in the P-No. 3 nozzle material at the weld overlay to nozzle interface. Potential hydrogen cracking in the heat-affected zone at the toe of the weld overlay is best identified by a surface examination. Potential hydrogen cracking in the heat-affected zone in the weld overlay to nozzle interface under the weld overlay is best identified by a UT examination of the weld overlay. These potential causes of cracking are addressed by the proposed modification to N-638-1, which examines the adjacent band and the weld with a surface examination, as required by N-638-1, and examines the weld overlay by UT examination in accordance with Code Case N-504-3, Appendix Q and demonstrated PDI UT procedures for examination of weld overlays, but eliminates the UT examination of the adjacent band. With this modification, the NRC Regulatory Guide 1.147, Revision 14,

Table 3: Modifications to Code Case N-638-1

	condition on use of N-638-1 is not applicable and will not be applied. Based on the above information, the proposed modification to Code Case N-638-1 adequately examines the appropriate areas and volumes to address the potential types and locations of cracking. The Code Case N-638-1 ultrasonic examination of the band outside of the weld overlay offers no additional benefit. Because the Code Case N-638-1 ultrasonic examination of the band outside of the weld overlay offers no additional benefit, performing an ultrasonic examination of this band only serves to increase radiological dose for UT examiners. In addition, it is noted that the NRC has previously granted relief on this specific issue at the Millstone Unit 3 in NRC letter dated Jan. 20, 2006 (reference 5 in Section 7 of this Request).
Paragraph 4.0(c): Use of weld-attached thermocouples and recording instruments is not clearly stated but may be implied. When weld-attached thermocouples are used, the area from which the thermocouples have been removed shall be ground and examined using a surface examination.	*Modification:* In lieu of weld-attached thermocouples and recording instruments, process temperatures will be monitored with non-attached devices, such as contact pyrometers, which will enable manual recording of process temperatures. Instruments used will be calibrated in accordance with approved calibration and control program requirements.

Modifications to ASME Section XI, Appendix VIII Supplement 11

Appendix VIII Supplement 11 of Section XI cannot be used for nondestructive examination (NDE) qualifications of a structural weld overlay repair. Relief is requested to use the PDI program implementation of Appendix VIII Supplement 11. A detailed comparison of Appendix VIII Supplement 11 and PDI requirements is summarized below in Table 4. The bases for the proposed alternatives to Supplement 11 are noted in Table 4 except as described in the following paragraph (for broader alternatives affecting several Supplement 11 paragraphs).

To avoid confusion several instances of the term "cracks" or "cracking" were changed to the term "flaws" because of the use of alternative flaw mechanisms. The PDI program revised paragraph 2.0 to allow the overlay fabrication and base metal flaw tests to be performed separately. The PDI program also allows closer spacing of flaws provided they don't interfere with detection or discrimination. The specimens used to date for qualification to the Tri-party NRC, Boiling Water Reactor Owners Group (BWROG) and Electric Power Research Institute (EPRI) agreement have a flaw population density greater than allowed by current Code requirements. These samples have been used successfully for all previous qualifications under the Tri-party agreement program. To facilitate their use and provide continuity from the Tri-party agreement program to Supplement 11, the PDI program has merged the Tri-party test specimens into their weld overlay program.

Table 4: Modifications to ASME Section XI, Appendix VIII Supplement 11

SUPPLEMENT 11 – QUALIFICATION REQUIREMENTS FOR FULL STRUCTURAL OVERLAID WROUGHT AUSTENITIC PIPING WELDS	PDI PROGRAM: Proposed Alternatives to Supplement 11 Requirements
1.1 SPECIMEN REQUIREMENTS	
(b) The specimen set shall consist of at least three specimens having different nominal pipe diameters and overlay thicknesses. They shall include the minimum and maximum nominal pipe diameters for which the examination procedure is applicable. Pipe diameters within a range of 0.9 to 1.5 times a nominal diameter shall be considered equivalent. If the procedure is applicable to pipe diameters of 24 in. or larger, the specimen set must include at least one specimen 24 in. or larger but need not include the maximum diameter. The specimen set must include at least one specimen with overlay thickness within -0.1 in. to +0.25 in. of the maximum nominal overlay thickness for which the procedure is applicable.	*(b)* The specimen set shall consist of at least three specimens having different nominal pipe diameters and overlay thicknesses. They shall include the minimum and maximum nominal pipe diameters for which the examination procedure is applicable. Pipe diameters within a range of 0.9 to 1.5 times a nominal diameter shall be considered equivalent. If the procedure is applicable to pipe diameters of 24 in. or larger, the specimen set must include at least one specimen 24 in. or larger but need not include the maximum diameter. The specimen set shall include specimens with overlays not thicker than 0.1 in. more than the minimum thickness, nor thinner than 0.25 in. of the maximum nominal overlay thickness for which the

Table 4: Modifications to ASME Section XI, Appendix VIII Supplement 11

SUPPLEMENT 11 – QUALIFICATION REQUIREMENTS FOR FULL STRUCTURAL OVERLAID WROUGHT AUSTENITIC PIPING WELDS	**PDI PROGRAM: Proposed Alternatives to Supplement 11 Requirements**
	examination procedure is applicable. *Basis:* To avoid confusion, the overlay thickness tolerance contained in the last sentence was reworded and the phrase "and the remainder shall be alternative flaws" was added to the next to last sentence in paragraph 1.1 (d)(l).
(d) Flaw Conditions	
(1) Base metal flaws. All flaws must be cracks in or near the butt weld heat-affected zone, open to the inside surface, and extending at least 75% through the base metal wall. Flaws may extend 100% through the base metal and into the overlay material; in this case, intentional overlay fabrication flaws shall not interfere with ultrasonic detection or characterization of the cracking. Specimens containing IGSCC shall be used when available.	(1) Base metal flaws. All flaws must be in or near the butt weld heat-affected zone, open to the inside surface, and extending at least 75% through the base metal wall. Intentional overlay fabrication flaws shall not interfere with ultrasonic detection or characterization of the base metal flaws. Specimens containing IGSCC shall be used when available. At least 70 percent of the flaws in the detection and sizing tests shall be cracks and the remainder shall be alternative flaws. Alternative flaw mechanisms, if used, shall provide crack-like reflective characteristics and shall be limited by the following: (a) The use of alternative flaws shall be limited to when the implantation of cracks produces spurious reflectors that are uncharacteristic of actual flaws. (b) Flaws shall be semi-elliptical with a tip width of less than or equal to 0.002 inches. *Basis:* This paragraph requires that all base metal flaws be cracks. Implanting a crack requires excavation of the base material on at least one side of the flaw. While this may be satisfactory for ferritic materials, it does not produce a useable axial flaw in austenitic materials because the sound beam, which normally passes only through base material, must now travel through weld material on at least one side, producing an unrealistic flaw response. To resolve this issue, the PDI program revised this paragraph to allow use of alternative flaw mechanisms under controlled conditions. For example, alternative flaws shall be limited to when implantation of

Table 4: Modifications to ASME Section XI, Appendix VIII Supplement 11

SUPPLEMENT 11 – QUALIFICATION REQUIREMENTS FOR FULL STRUCTURAL OVERLAID WROUGHT AUSTENITIC PIPING WELDS	PDI PROGRAM: Proposed Alternatives to Supplement 11 Requirements
	cracks precludes obtaining an effective ultrasonic response, flaws shall be semi elliptical with a tip width of less than or equal to 0.002 inches, and at least 70% of the flaws in the detection and sizing test shall be cracks and the remainder shall be alternative flaws. To avoid confusion, the overlay thickness tolerance contained in paragraph 1.1 (b) last sentence, was reworded and the phrase, "...and the remainder shall be alternative flaws." was added to the next to last sentence. Paragraph 1.1 (d)(l) includes the statement that intentional overlay fabrication flaws shall not interfere with ultrasonic detection or characterization of the base metal flaws.
(e) Detection Specimens	
(1) At least 20% but less than 40% of the flaws shall be oriented within ±20 deg. of the pipe axial direction. The remainder shall be oriented circumferentially. Flaws shall not be open to any surface to which the candidate has physical or visual access. The rules of IWA-3300 shall be used to determine whether closely spaced flaws should be treated as single or multiple flaws.	(1) At least 20% but less than 40% of the base metal flaws shall be oriented within ±20 deg. of the pipe axial direction. The remainder shall be oriented circumferentially. Flaws shall not be open to any surface to which the candidate has physical or visual access. *Basis:* The requirement for axially oriented overlay fabrication flaws was excluded from the PDI Program as an improbable scenario. Weld overlays are typically applied using automated GTAW techniques with the filler metal applied in a circumferential direction. Because resultant fabrication induced discontinuities would also be expected to have major dimensions oriented in the circumferential direction axial overlay fabrication flaws are unrealistic. The requirement for using IWA-3300 for proximity flaw evaluation was excluded, instead indications will be sized based on their individual merits.
(2) Specimens shall be divided into base and over-lay grading units.	(2) Specimens shall be divided into base metal and overlay

Table 4: Modifications to ASME Section XI, Appendix VIII Supplement 11

SUPPLEMENT 11 – QUALIFICATION REQUIREMENTS FOR FULL STRUCTURAL OVERLAID WROUGHT AUSTENITIC PIPING WELDS	PDI PROGRAM: Proposed Alternatives to Supplement 11 Requirements
Each specimen shall contain one or both types of grading units.	fabrication grading units. Each specimen shall contain one or both types of grading units. Flaws shall not interfere with ultrasonic detection or characterization of other flaws.
(a)(1) A base grading unit shall include at least 3 in. of the length of the overlaid weld. The base grading unit includes the outer 25% of the overlaid weld and base metal on both sides. The base grading unit shall not include the inner 75% of the overlaid weld and base metal overlay material, or base metal-to-overlay interface.	(a)(1) A base metal grading unit includes the overlay material and the outer 25% of the original overlaid weld. The base metal grading unit shall extend circumferentially for at least 1 in. and shall start at the weld centerline and be wide enough in the axial direction to encompass one half of the original weld crown and a minimum of 0.50" of the adjacent base material. *Basis:* The phrase, "and base metal on both sides," was inadvertently included in the description of a base metal grading unit. The PDI program intentionally excludes this requirement because some of the qualification samples include flaws on both sides of the weld. This paragraph was also modified to require that a base metal grading unit include at least 1 inch of the length of the overlaid weld, rather than 3 inches.
(a)(2) When base metal cracking penetrates into the overlay material, the base grading unit shall include the overlay metal within 1 in. of the crack location. This portion of the overlay material shall not be used as part of any overlay grading unit.	(a)(2) When base metal flaws penetrate into the overlay material, the base metal grading unit shall not be used as part of any overlay fabrication grading unit.
(a)(3) When a base grading unit is designed to be unflawed, at least 1 in. of unflawed overlaid weld and base metal shall exist on either side of the base grading unit. The segment of weld length used in one base grading unit shall not be used in another base grading unit. Base grading units need not be uniformly spaced around the specimen.	(a)(3) Sufficient unflawed overlaid weld and base metal shall exist on all sides of the grading unit to preclude interfering reflections from adjacent flaws. *Basis:* This paragraph was also modified to require sufficient unflawed overlaid weld and base metal to exist on all sides of the grading unit to preclude interfering reflections from adjacent flaws, rather than the 1 inch requirement.
(b)(l) An overlay grading unit shall include the overlay material and the base metal-to-overlay interface of at least 6 sq. in. The overlay	(b)(l) An overlay fabrication grading unit shall include the overlay material and the base metal-to-overlay interface for a length of at

Table 4: Modifications to ASME Section XI, Appendix VIII Supplement 11

SUPPLEMENT 11 – QUALIFICATION REQUIREMENTS FOR FULL STRUCTURAL OVERLAID WROUGHT AUSTENITIC PIPING WELDS	PDI PROGRAM: Proposed Alternatives to Supplement 11 Requirements
grading unit shall be rectangular, with minimum dimensions of 2 in.	least 1 inch. *Basis:* This paragraph was also modified to define an overlay fabrication grading unit as including the overlay material and the base metal-to-overlay interface for a length of at least 1 inch rather than the 6 inch^2 requirement.
(b)(2) An overlay grading unit designed to be unflawed shall be surrounded by unflawed overlay material and unflawed base metal-to-overlay interface for at least 1 in. around its entire perimeter. The specific area used in one overlay grading unit shall not be used in another overlay grading unit. Overlay grading units need not be spaced uniformly about the specimen.	(b)(2) Overlay fabrication grading units designed to be unflawed shall be separated by unflawed overlay material and unflawed base metal-to-overlay interface for at least 1 inch at both ends. Sufficient unflawed overlaid weld and base metal shall exist on both sides of the overlay fabrication grading unit to preclude interfering reflections from adjacent flaws. The specific area used in one overlay fabrication grading unit shall not be used in another overlay fabrication grading unit. Overlay fabrication grading units need not be spaced uniformly about the specimen. *Basis:* Paragraph 1.1 (e)(2)(b)(2) states that overlay fabrication grading units designed to be unflawed shall be separated by unflawed overlay material and unflawed base metal-to-overlay interface for at least 1 inch at both ends, rather than around its entire perimeter.
(b)(3) Detection sets shall be selected from Table VIII-S2-1. The minimum detection sample set is five flawed base grading units, ten unflawed base grading units, five flawed overlay grading units, and ten unflawed overlay grading units. For each type of grading unit, the set shall contain at least twice as many unflawed as flawed grading units.	(b)(3) Detection sets shall be selected from Table VIII-S2-1. The minimum detection sample set is five flawed base metal grading units, ten unflawed base metal grading units, five flawed overlay fabrication grading units, and ten unflawed overlay fabrication grading units. For each type of grading unit, the set shall contain at least twice as many unflawed as flawed grading units. For initial procedure qualification, detection sets shall include the equivalent of three personnel qualification sets. To qualify new values of essential variables, at least one personnel qualification set is required.
(f) Sizing Specimen	
(1) The minimum number of flaws shall be ten. At least 30% of the	(1) The minimum number of flaws shall be ten. At least 30% of the

Table 4: Modifications to ASME Section XI, Appendix VIII Supplement 11

SUPPLEMENT 11 – QUALIFICATION REQUIREMENTS FOR FULL STRUCTURAL OVERLAID WROUGHT AUSTENITIC PIPING WELDS	PDI PROGRAM: Proposed Alternatives to Supplement 11 Requirements
flaws shall be overlay fabrication flaws. At least 40% of the flaws shall be cracks open to the inside surface.	flaws shall be overlay fabrication flaws. At least 40% of the flaws shall be open to the inside surface. Sizing sets shall contain a distribution of flaw dimensions to assess sizing capabilities. For initial procedure qualification, sizing sets shall include the equivalent of three personnel qualification sets. To qualify new values of essential variables, at least one personnel qualification set is required.
(3) Base metal cracking used for length sizing demonstrations shall be oriented circumferentially.	(3) Base metal flaws used for length sizing demonstrations shall be oriented circumferentially.
(4) Depth sizing specimen sets shall include at least two distinct locations where cracking in the base metal extends into the overlay material by at least 0.1 in. in the through-wall direction.	(4) Depth sizing specimen sets shall include at least two distinct locations where a base metal flaw extends into the overlay material by at least 0.1 inch in the through-wall direction.
2.0 CONDUCT OF PERFORMANCE DEMONSTRATION	
The specimen inside surface and identification shall be concealed from the candidate. All examinations shall be completed prior to grading the results and presenting the results to the candidate. Divulgence of particular specimen results or candidate viewing of unmasked specimens after the performance demonstration is prohibited.	The specimen inside surface and identification shall be concealed from the candidate. All examinations shall be completed prior to grading the results and presenting the results to the candidate. Divulgence of particular specimen results or candidate viewing of unmasked specimens after the performance demonstration is prohibited. The overlay fabrication flaw test and the base metal flaw test may be performed separately.
2.1 Detection Test.	
Flawed and unflawed grading units shall be randomly mixed. Although the boundaries of specific grading units shall not be revealed to the candidate, the candidate shall be made aware of the type or types of grading units (base or overlay) that are present for each specimen.	Flawed and unflawed grading units shall be randomly mixed. Although the boundaries of specific grading units shall not be revealed to the candidate, the candidate shall be made aware of the type or types of grading units (base metal or overlay fabrication) that are present for each specimen.
2.2 Length Sizing Test	
(d) For flaws in base grading units, the candidate shall estimate the length of that part of the flaw that is in the outer 25% of the base wall thickness.	(d) For flaws in base metal grading units, the candidate shall estimate the length of that part of the flaw that is in the outer 25% of the base metal wall thickness.

Table 4: Modifications to ASME Section XI, Appendix VIII Supplement 11

SUPPLEMENT 11 – QUALIFICATION REQUIREMENTS FOR FULL STRUCTURAL OVERLAID WROUGHT AUSTENITIC PIPING WELDS	PDI PROGRAM: Proposed Alternatives to Supplement 11 Requirements
2.3 Depth Sizing Test.	
For the depth sizing test, 80% of the flaws shall be sized at a specific location on the surface of the specimen identified to the candidate. For the remaining flaws, the regions of each specimen containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the maximum depth of the flaw in each region.	(a) The depth sizing test may be conducted separately or in conjunction with the detection test. (b) When the depth sizing test is conducted in conjunction with the detection test and the detected flaws do not satisfy the requirements of 1.1(f), additional specimens shall be provided to the candidate. The regions containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the maximum depth of the flaw in each region. (c) For a separate depth sizing test, the regions of each specimen containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the maximum depth of the flaw in each region.
3.0 ACCEPTANCE CRITERIA	
3.1 Detection Acceptance Criteria.	
Examination procedures, equipment, and personnel are qualified for detection when the results of the performance demonstration satisfy the acceptance criteria of Table VIII-S2-1 for both detection and false calls. The criteria shall be satisfied separately by the demonstration results for base grading units and for overlay grading units.	(a)Examination procedures are qualified for detection when: 1) All flaws within the scope of the procedure are detected and the results of the performance demonstration satisfy the acceptance criteria of Table VIII-S2-1 for false calls. 2) At least one successful personnel demonstration has been performed meeting the acceptance criteria defined in (b). (b) Examination equipment and personnel are qualified for detection when the results of the performance demonstration satisfy the acceptance criteria of Table VIII-S2-1 for both detection and false calls. (c) The criteria in (a) and (b) shall be satisfied separately by the demonstration results for base metal grading units and for overlay fabrication grading units.

Table 4: Modifications to ASME Section XI, Appendix VIII Supplement 11

SUPPLEMENT 11 – QUALIFICATION REQUIREMENTS FOR FULL STRUCTURAL OVERLAID WROUGHT AUSTENITIC PIPING WELDS	**PDI PROGRAM: Proposed Alternatives to Supplement 11 Requirements**
	Basis: The PDI program allows procedure qualification to be performed separately from personnel and equipment qualification. Historical data indicate that, if ultrasonic detection or sizing procedures are thoroughly tested, personnel and equipment using those procedures have a higher probability of successfully passing a qualification test. In an effort to increase this passing rate, PDI has elected to perform procedure qualifications separately in order to assess and modify essential variables that may affect overall system capabilities. For a procedure to be qualified, the PDI program requires three times as many flaws to be detected (or sized) as shown in Supplement 11 for the entire ultrasonic system. The personnel and equipment are still required to meet Supplement 11.
3.2 Sizing Acceptance Criteria.	
(a) The RMS error of the flaw length measurements, as compared to the true flaw lengths, is less than or equal to 0.75 inch. The length of base metal cracking is measured at the 75% through-base-metal position.	(a) The RMS error of the flaw length measurements, as compared to the true flaw lengths, is less than or equal to 0.75 inch. The length of base metal flaws is measured at the 75% through-base-metal position.
(b) All extensions of base metal cracking into the overlay material by at least 0.1 in. are reported as being intrusions into the overlay material.	This requirement is omitted. *Basis:* The requirement for reporting all extensions of cracking into the overlay is omitted from the PDI Program because it is redundant to the RMS calculations performed in paragraph 3.2(c) and its presence adds confusion and ambiguity to depth sizing as required by paragraph 3.2(c). This also makes the weld overlay program consistent with the Supplement 2 depth sizing criteria.

Table 5: Weld Overlay Examination Requirements

IN-PROCESS EXAMINATIONS				
Examination Description	**Method**	**Technique**	**Reference**	**Acceptance Standards**
Safe end, welds, nozzle, and pipe pre-overlay surface preparation.	Surface	Liquid Penetrant	N-504-3 and Q-2000	N-504-3, Paragraph (c), Q-2000 (b)
Corrective layers of weld metal, if required, not associated with the structural weld overlay.	Surface	Liquid Penetrant	N-504-3 and Q-2000	N-504-3, Paragraph (d), Q-2000 (c)
Thickness measurements for verifying final deposited weld reinforcement.	Volumetric	UT-0°L	N-504-3 and Q-3000	Per weld overlay design requirements and Q-3000
COMPLETED WELD OVERLAY EXAMINATION and PRESERVICE EXAMINATION REQUIREMENTS				
Examination Description	**Method**	**Technique**	**Reference**	**Acceptance Standards**
Examination of the completed weld overlay and examination of a band around the entire circumference of the nozzle and pipe at least 1.5 times the nozzle end thickness outward from the toe of the weld overlay on the nozzle side and at least 0.50 inches outward from the toe of the weld overlay on the pipe side. For the portion of the weld overlay installed per Code Case N-638-1 and the band area on the nozzle side, this examination will occur at least 48 hrs. after the completed weld overlay has returned to ambient temperature.	Surface	Liquid Penetrant	N-504-3, N-638-1, and Q-4100	Q-4100 (b)
Completed weld overlay for complete bonding and minimum thickness and for detection of welding flaws. Examination for bonding and welding flaws in the portion of the weld overlay installed per Case N-638-1 will occur at least 48 hrs. after the completed weld overlay has returned to ambient temperature.	Volumetric	UT-0°L; UT angle beam per PDI-qualified procedures	N-504-3, N-638-1, Q-4100, and Appendix VIII	Thickness per weld overlay design requirements in Q-3000 and bonding and welding flaws per Q-4100(c)

Table 5: Weld Overlay Examination Requirements

Completed weld overlay and the outer 25 percent of the original DM weld thickness at least 0.5-inches beyond the toes of the original DM weld and butter and at least 0.5 inches beyond any as-found flaw. For N-638-1 welding, this examination will occur at least 48 hrs. after the completed weld overlay has returned to ambient temperature.	Volumetric	UT angle beam per PDI-qualified procedure	N-504-3, N-638-1, Q-4200, and Appendix VIII	N-504-3, Paragraph (i) and Q-4200
Completed weld overlay and the outer 25 percent of the original SS pipe weld thickness at least 0.5-inches beyond the toes of the original SS weld and at least 0.5 inches beyond any as-found flaw.	Volumetric	UT angle beam per PDI-qualified procedure	N-504-3, Q-4200, and Appendix VIII	N-504-3, Paragraph (i) and Q-4200
INSERVICE EXAMINATION REQUIREMENTS				
Examination Description	**Method**	**Technique**	**Reference**	**Acceptance Standards**
Full Structural Repair WOL: Weld overlay and outer 25 percent of the original DM weld thickness at least 0.5-inches beyond the toes of the original DM weld and butter, and at least 0.5 inches beyond any as-found flaw, will be examined within the next two refueling outages. Re-examination will be on a sampling basis in accordance with Q-4300(b) through (f) and Q-4310. These examinations will be added to the ISI Program Plan in accordance with IWB-2412(b)(1).	Volumetric	UT angle beam per PDI procedure	ASME Section XI Appendix VIII and Q-4300	Q-4300
Full Structural Repair WOL: Weld overlay and outer 25 percent of the original SS pipe weld thickness at least 0.5-inches beyond the toes of the original SS weld, and at least 0.5 inches beyond any as-found flaw, will be examined within the next two refueling outages. Re-examination will be on a	Volumetric	UT angle beam per PDI procedure	ASME Section XI Appendix VIII and Q-4300	Q-4300

Table 5: Weld Overlay Examination Requirements

sampling basis in accordance with Q-4300(b) through (f) and Q-4310. These examinations will be added to the ISI Program Plan in accordance with IWB-2412(b)(1).				
Preemptive Full Structural WOL: If greater than or equal to 90% coverage of the original DM weld is achieved with PDI qualified procedures and no PWSCC flaws are identified, the weld overlay and outer 25 percent of the original DM weld thickness at least 0.5-inches beyond the toes of the original DM weld and butter will be examined on a sampling basis in accordance with Q-4300(b) through (f) and Q-4310. These examinations and frequency of performance will be added to the ISI Program Plan in accordance with IWB-2412(b)(1).	Volumetric	UT angle beam per PDI procedure	ASME Section XI Appendix VIII and Q-4300 para. (b) through (f) and Q-4310	Q-4300(b) and (c)
Preemptive Full Structural WOL: If greater than or equal to 90% coverage of the original SS weld is achieved with PDI qualified procedures and no service related flaws are identified, the weld overlay and outer 25 percent of the original SS weld thickness at least 0.5-inches beyond the toes of the original SS weld will be examined on a sampling basis in accordance with Q-4300(b) through (f) and Q-4310. These examinations and frequency of performance will be added to the ISI Program Plan in accordance with IWB-2412(b)(1).	Volumetric	UT angle beam per PDI procedure	ASME Section XI Appendix VIII and Q-4300 para. (b) through (f) and Q-4310	Q-4300(b) and (c)

White Paper – Relaxation of the 100 Square Inch Size Limitation – Code Case N-638

Contains 20 Pages, 43.5 through 43.24

RRA 00-04, BC 04-1000, Revise Code Case N-638-2 to Address Limitations on Size of Repairs

White Paper-Relaxation of the 100 square inch Size Limitation-Code Case N-638

EXECUTIVE SUMMARY

The restriction on surface area size of 100 square inches for ambient temperature temper bead welding using the machine GTAW welding was arbitrarily established. The restriction was imposed to facilitate acceptance of the original code case. Dissimilar weld overlays have been approved by the NRC and in service on BWR piping since 1985. Many BWR dissimilar metal weld overlay applications have exceeded 100 square inches. In addition a dissimilar metal weld overlay over 100 square inches was installed, approved by the NRC and put in service at Three Mile Island Unit 1 (TMI-1) on a surge line to hot leg nozzle. In addition weld buttering for the reactor coolant pipe to the reactor vessel outlet nozzle weld repair at the VC Summer plant was performed using ambient temperature temper bead welding in accordance with N-638. The surface area that was buttered was about 140 square inches. Further ambient temperature temper bead welding per the case has been used for weld pads on pressurizers to replace heater sleeves. About 120 such pads were welded to the pressurizer lower heads to replace the heater sleeves at Calvert Cliffs with no adverse effects. The pads had a combined surface area greater than 1800 square inches

The results from both analytical and experimental programs discussed in the report show that the residual stress distributions for both cavity repairs and weld overlay repairs of 100 square inches and repairs up to 500 square inches are comparable. This includes comparison of the tensile stresses that result beyond the edges of the cavity type repairs in the base material and at the ends of weld overlay repairs. Thus up to 500 square in welds made in accordance with the requirements of Case N-638 have similar or better residual stress distributions to 100 square in welds and all welds meet the stress allowable requirements of Section III, the Construction Code or Owner's requirements as applicable. Further results from metallurgical evaluations and mechanical testing show that cooling of the heat affected zone is rapid enough to form a martensitic structure that is adequately tempered by the subsequent weld deposited layers.

Performance of the repairs over 100 square inches in service as well as the results of analyses and experimental results for repairs up to 500 square inches demonstrate that the repairs are acceptable and safe.

1) Background

The purpose of this action is to relax an arbitrary limitation that was included in N-638 to restrict the use of the ambient temperature bead welding to a surface area of less then 100 square inches and a depth of less then 50% through wall. Code Case N-432-1, which requires a preheat temperature of 300 F and a post weld soak in the 450 – 550 F for 2 hours. The same rules for temper bead welding by GTAW in IWA – 4630 require the same preheat and post weld soak requirement for temperature but a 2 hour hold is required for P-1 materials and a 4 hour hold for P-3 materials except restrictions on size and depth similar to those in N-638 are required.

It is not clear what the restriction on surface area for ambient temperature temper bead process was intended to address. The welding in N-638 is done using bare filler wire and welding grade shielding gases. The process is by its nature a low hydrogen process. Further diffusion of hydrogen is very rapid for low alloy steels. Nonetheless the post weld soaks in the Code and Code Case are intended as post hydrogen bake outs permitting NDE after the repair has returned to ambient temperature. N-638, since it does not impose the post bake, requires that a 48 - hour hold time prior to NDE be imposed to verify that the unlikely event of hydrogen induced cold cracking has not occurred. Further it should be pointed out that the post weld soak temperatures are too low to either temper the heat affected zone (HAZ) in the ferritic material or be an effective stress relief.

2) Technical Discussion

The temper bead weld process for excavated cavity and overlay repairs of ferritic and dissimilar metal welds using the automatic GTAW process have been performed at operating nuclear power plants for the past 20 years or longer. They have been performed by both welding at ambient temperature and with a pre-heat and post weld soak as discussed above. In no instance has hydrogen induced cracking occurred. Further qualification tests have demonstrated that fracture toughness of the heat affected zones are as high or higher than repairs using conventional welding and post weld stress relief heat treatments in accordandce with ASME code rules. Further all repairs meet the stress allowables of Section III, the Construction Code or Owner's requirements as applicable. Results from metallurgical evaluations and mechanical testing show that cooling of the HAZ is rapid enough to form a martensitic structure that is adequately tempered by the subsequent weld deposited layers.

a) *Older Qualification Programs*

EPRI conducted a program to evaluate weld overlay repairs of 12" BWR N-2 inlet nozzle to safe end weld joints (1) that was published in January 1991. As a part of the program a mockup of a nozzle to safe end weld was fabricated and destructive tested. The destructive testing included mechanical, hardness and Metallographic testing. The metallography and hardness demonstrated that the temper bead welding resulted in adequate tempering of the P-3 nozzle in the HAZ and reduced hardness in the HAZ to about 300 to 350 Knoop (about R_c 34 - 37) after three layers of weld had been deposited. In addition FEA analysis was performed to demonstrate that the residual stresses after the overlay were compressive on the ID in the region of the weld with the material susceptible to IGSCC. An overlay following the EPRI program was implemented at Vermont Yankee. Results of the qualification program and inspections are included in the report as well. The overlay has been in-service since the 1990's, been inspected several times and showed no evidence of degradation.

RRA 00-04, BC 04-1000, Revise Code Case N-638-2 to Address Limitations on Size of Repairs

EPRI conducted a program to provide a justification for extended overlay design life (2). While most of the program was intended to address overlay repairs for susceptible SS welds, the results of several test programs are included that show experimental results for ID residual stresses before and after application of a weld overlay. Further these programs were conducted on large diameter piping where the overlays would be far in excess of the 100 square inch limitation.

In one test (GPC/SI/WSI) two sections of 28" diameter pipe were welded together in a manner similar to that for the BWR main reactor coolant piping. A baffle was welded axially to divide the pipe segment into 2 halves. Axial and circumferential notches were ground in to the pipe near the girth weld. One half of the pipe ID was exposed to boiling $MgCl_2$ prior to applying the weld overlay. Extensive cracking was seen at the tip of each notch showing the presence of high residual tensile stresses at the notch tip. After weld overlay the other half of the pipe was exposed to boiling $MgCl_2$. No cracking occurred at the similar notch locations in the second half of the pipe showing the residual tensile stress at the notch tips changed from tensile to compressive following application of the overlay. This test confirmed the efficacy of the FEA.

In a second test (EPRI/J.A. Jones 24" mockup) a weld overlay was applied to the pipe and the residual stresses were determined experimentally and by FEA. The results of this residual stress and measurement project have shown that both axial and circumferential residual stresses are compressive at the pipe ID surface following a weld overlay of the thickness applied to the pipe. This also represents an experimental verification of FEA results for a large diameter reasonably thick wall pipe where the overlay would well exceed 100 square inches.

It should be noted that much of the weld shrinkage numerical methods as well the experimental verifications and failure analysis have been performed at government and not-for- profit laboratories (ANL, PNL and Battelle Columbus). Further details on the specific programs are found in the Reference Section in (1) and (2).

b) *More Recent Qualification Programs*

During the development of the code case to relax the limitation on the surface area for ambient temperature Working Group on Welding, after receiving comments from other Code Committees and the NRC, requested that supporting analyses be performed to determine if any significant changes in residual stresses occur if the repair exceeded 100 square inches. It is assumed that the focus on residual stresses was made because past programs have demonstrated that temper bead welding using automatic GTAW provides adequate tempering of the HAZ in P-1 and P-3 materials and does not degrade strength or fracture toughness. Further associated inspections have shown that hydrogen induced cracking has not been a problem with repairs produced by the automatic GTAW temper bead process. The metallurgical aspects discussed appear to be independent of the surface area of the repair but related to input qualified for the welding.

RRA 00-04, BC 04-1000, Revise Code Case N-638-2 to Address Limitations on Size of Repairs

EPRI sponsored analytical work (3) to evaluate the effects from increases in surface area beyond 100 square inches for both cavity and weld overlay repairs. Three cases were evaluated as a part of the program: a 100 square inch overlay on a nozzle was increased modestly and analyzed, a 500 square inch cavity repair was analyzed and three adjacent 100 square inch cavity repairs were analyzed.

In the first case a weld overlay that was applied to one of the 12 in. diameter Feedwater Nozzles of an operating BWR. The weld overlay was applied in order to restore the structural integrity of the flawed location assuming no credit for any remaining uncracked material in the original safe end. Due to the availability of the information from the utility and a finite element model, this geometry was selected for this initial phase of this work. These residual stress predictions were performed using the ANSYS Rev. 5.3 finite element program. The analysis consists of two parts: a thermal analysis and a stress analysis, to model the welding process in both thermal and mechanical respects. Two axisymmetric finite element models were created, one with a weld overlay of 100 in^2 (Figure 1), the other with the weld overlay extended on the nozzle side until it blends into the nozzle taper surface (Figure 2) (approximately 126 in^2). Figure 3 shows the residual stress on the pipe inside surface. These two figures show that the residual hoop stress is very similar, and in fact the hoop stress for the extended case is even more compressive. The axial stress is less compressive for the extended model, but still with significant compressive stress. This figure also shows that the main area of concern, on the edges of the repair, that stress caused by the 100 sq. in. repair and the larger repair are similar.

In summary results of this evaluation indicate that the combination of the extended overlay and geometric discontinuity of caused by the increased nozzle diameter on the outside surface modify the residual stress. This modified behavior is local to the end where the extension of the overlay was made and the presence of the geometric discontinuity. All other stresses remain essentially the same and the effectiveness of the overlay to provide structural reinforcement at the nozzle-to-safe end weld remains assured. Results of this evaluation indicate that the alternate extended overlay would have been an acceptable overlay from a structural integrity perspective.

In the second case the weld repair configuration selected for evaluation is a cavity of rectangular trough shape, along the longitudinal axis of the reactor vessel, with a depth equal to half of the vessel wall thickness. Two repair sizes, 100 in^2 and 500 in^2 are used. These are the projected areas on the inside surface of the vessel. The actual surface areas in the cavity are much larger, at 328 in^2 and 1894 in^2.

Comparison was made on different paths for the residual stress distribution between the two repair sizes. The stress contours for the two repairs are shown in Figures 4 through 9. In general, the residual stress distributions in the axial and hoop directions are very similar to each other for the two repair sizes. Within the weld repair area, the axial surface residual stress (S_z) for the smaller repair area is lower than the larger repair area. The hoop surface residual stress (S_y) for the smaller repair area is higher than the larger repair cavity. Outside the weld repair cavity, the residual stress for the larger repair area has lower residual stresses on the selected paths, both on the inside surface and through the wall of the reactor vessel.

It is shown that a larger weld repair area does not have a significant adverse effect on the weld residual stress. In some cases, the larger repair area is much more beneficial because of the lower tensile residual stress or higher compressive residual stress. Especially for the case of axial weld repair where an axial crack could exist, the hoop stress is more compressive or less tensile within the weld repair area and outside the repair area. The larger repair area could be less susceptible to the crack growth, due to either stress corrosion or fatigue.

The third case addresses the implementation of a 300 in^2 weld repair on a Reactor Pressure Vessel (RPV) vertical shell weld. The repair is implemented in 3 separate 100 in^2 repair, i.e., a 100 in^2 repair is simulated, then another 100 in^2 repair is simulated immediately adjacent to the first repair, followed by a third 100 in^2 repair immediately adjacent to the second repair. This case was selected to evaluate to ascertain the ramifications of repairs being performed sequentially to stay within the 100 in^2 limitations.

The final weld repair configuration selected for evaluation is a rectangular trough shape, with a depth equal to half of the vessel wall thickness. The final weld repair consists of three temperbead layers, and a weld out of the remaining cavity. Due to the complexity in the modeling, the temperbead layers are present only on the final weld repair volume outside surfaces, or boundaries, that are in contact with the base metal. The temperbead was not modeled in between the two adjacent weld repairs. Also, a half model of the weld repair is used in order to account for the effect of sequence in the weld repairs.

Due to the large volume of the repair cavity and the large number of bead passes, simplifying assumptions, as identified earlier, were used in the weld residual stress analyses. These assumptions should not have a significant impact on the conclusion since the evaluation is made on the comparison of residual stresses among the three individual weld repair areas using similar assumptions and parameters.

The stress contours for the single and three sequential repairs are shown in Figures 10 and 11. Comparison was made for the residual stress distribution on different paths after the completion of each 100 in^2 repair area. In general, each weld repair area induces a similar residual stress distribution within its repair area. In addition, the residual stress in the previously repaired area is reduced due to the subsequent adjacent repairs. This is due to the excavation of base metal in the subsequent weld repair volume that has a relaxation effect of residual stress in the previously repaired area. Also, the welding in the subsequent repair area has an effect similar to PWHT on the previously repair area.

Based on the comparison of the residual stress distributions for the sequential weld repairs, it can be concluded that a subsequent adjacent repair has an overall effect on reducing the residual stress distribution in the previously repair areas. Also, the residual stress in the last repaired area has a very similar residual stress magnitudes compared to an individual repair of 100 in^2.

RRA 00-04, BC 04-1000, Revise Code Case N-638-2 to Address Limitations on Size of Repairs

The current evaluation uses three 100 in^2 repair areas. But the discussions on these results and the conclusions could be applied to any number of weld repair areas in each with an area of 100 in^2.

As a part of a program to evaluate weld overlays as a measure to mitigate PWSCC (4), SI conducted an analysis to determine the residual stress profiles of a 33 in. OD PWR reactor coolant nozzle to a stainless steel pipe. A summary of the dimensions for the finite element mode is shown in Figure 12. The reduced thickness overlay modeled is 0.48 in. thick which is about ½ the thickness of a full structural overlay. The surface area of the overlay on the low alloy steel nozzle was 332 square in. The stress contours before and after the overlaying is shown in Figures 13 and 14. Please note that the overlay is shown in Figure 13 but is not active for analysis purposes since it does not exist at that time. Again it is quite apparent that tensile residual stresses at the ID in the weld location before overlaying become compressive after the overlay is applied. The inside surface axial and hoop stresses are shown in Figure 15. Note that the condition for the pre-WOL at 120 F shown in black curve with diamonds shows the high residual tensile stresses and the post-WOL leakage test curve at 120 F shown in the blue curve with diamonds show that all residual stresses in the weld are compressive where there is any PWSCC susceptible material. Other conditions for residual stresses for the hoop and axial directions are also shown. This evaluation as well as those shown above again demonstrates that acceptable residual stresses to mitigate PWSCC are induced by the shrinkage of the weld overlay. Also it demonstrates that these residual stresses are independent of the surface area of the repair and related to other parameters. The overlay could well have been extended an additional 2 in. up the nozzle to increase the surface area over 500 square in. with similar results for the 332 square in. case analyzed.

RRA 00-04, BC 04-1000, Revise Code Case N-638-2 to Address Limitations on Size of Repairs

c) Service History

Dissimilar metal overlays have been performed at some BWR units as long as 15 to 20 years ago. Several BWR units recently applied weld overlays to nozzle/safe-end locations and one PWR unit, Three Mile Island Unit 1 applied an overlay on a hot leg-to-surge line nozzle using temperbead welding procedures. Machine GTAW temperbead procedures were used to perform the repairs with the RPVs filled with water to avoid excessive radiation exposure to repair personnel. These BWR plants were Perry, Duane Arnold, Hope Creek, Nine Mile Point Unit 2 (NMP-2), Pilgrim, Susquehanna and two at Hope Creek. The Perry and Nine Mile Point Unit 2 overlays were applied to feedwater nozzles. Duane Arnold applied overlays to two recirculation inlet nozzles, and Hope Creek applied an overlay to a core spray nozzle and a recirculation inlet nozzle. All of these repairs were performed at ambient preheat temperatures except for the Hope Creek core spray nozzle overlay. Further several utilities have planned contingent repairs for nozzle welds that have Alloy 182 butter and Alloy182 filler. The code requirement limiting the application of temperbead procedures to 100 in^2 significantly influenced the design of some of the weld overlays. Further relief from the surface area limitation has been requested and approved by the NRC on a case basis for several of these repairs.

In addition weld buttering for the reactor recirculation pipe to the reactor vessel outlet nozzle weld repair at the VC Summer plant was performed using ambient temperature temper bead welding in accordance with N-638. The surface area that was buttered was about 140 square inches. Further ambient temperature temper bead welding per the case has been used for weld pads on pressurizers to replace heater sleeves. About 120 such pads were welded to the pressurizer lower heads to replace the heater sleeves at Calvert Cliffs with no adverse effects.

Service history with these overlays at dissimilar metal weldments has been excellent. Inspection methods that are qualified in accordance with PDI are available and have been used to conduct the examinations.

Further all repairs meet the stress allowables from Section III, the Construction Code or Owner's requirements as applicable. Further results from metallurgical evaluations and mechanical testing show that cooling of the heat affected zone is rapid enough to form a martensitic structure that is adequately tempered by the subsequent weld deposited layers.

3) Conclusions

The restriction on surface area for temper bead welding was arbitrary, is overly restrictive, leads to increased cost and dose for repairs and does not contribute to safety. There is no direct correlation of residual stresses either for cavity or overlay repairs done using temper bead welding. Cases have been analyzed up to 500 square in. that verify that residual stresses for cavity repairs are at an acceptable level and that residual stresses associated with weld overlay repairs remain compressive in the weld region for larger area repairs as well a for smaller area repairs. The implementing ASME Code and Code Case requirements assure that code stress limits and safety factors are maintained for overlay repairs regardless of size. Metallurgical, mechanical, and hardness testing results show that adequate tempering is achieved and that adequate fracture toughness and strength is maintained in the weld and heat affected zone. The restriction on surface area of repairs should be increased to 500 square in. based on the results of analyses and testing performed to date. The Code should provide an option to users to justify repairs beyond 500 square in. by additional analysis and evaluation.

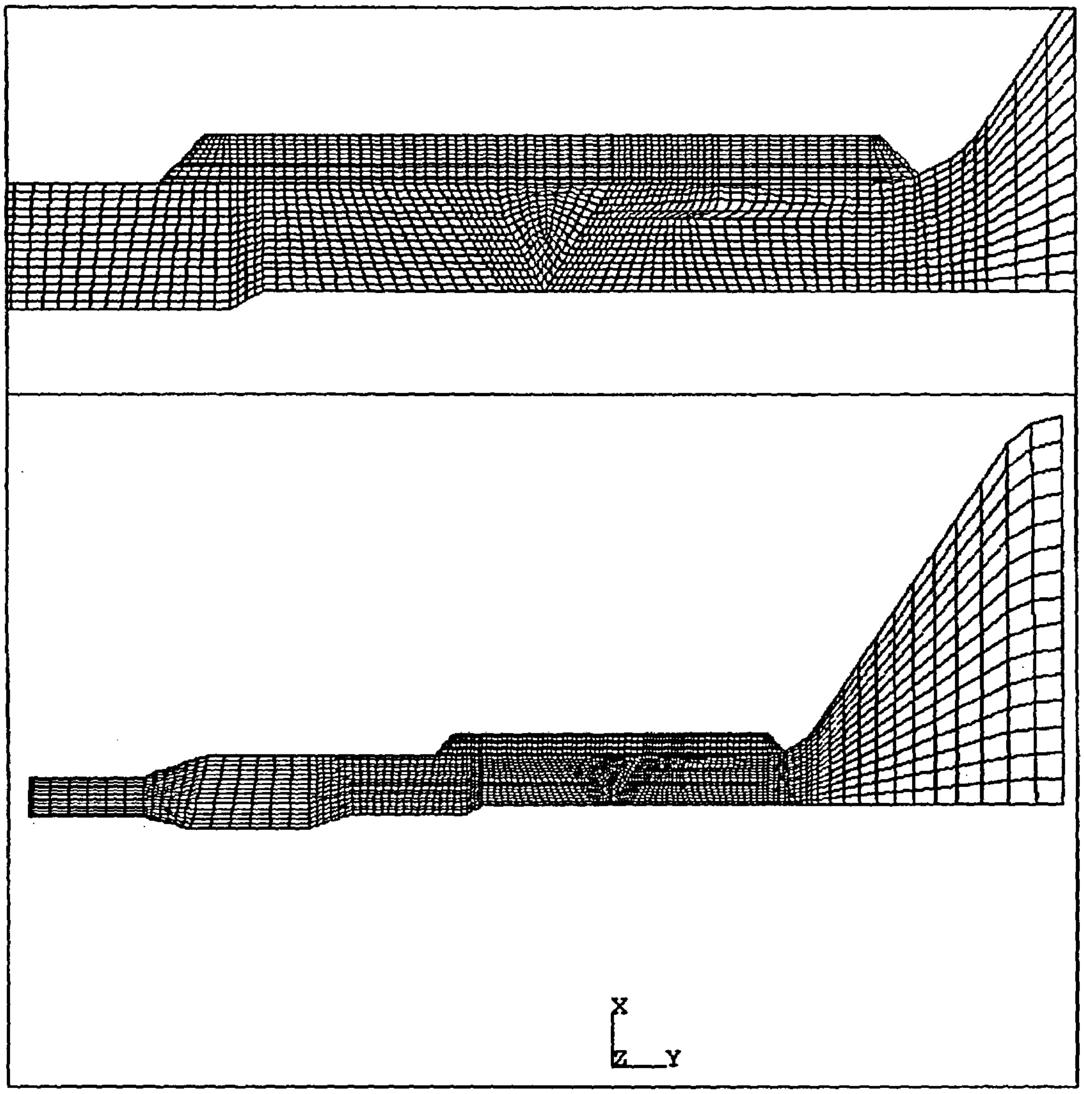


Figure 1. 100 in^2 Finite Element Model

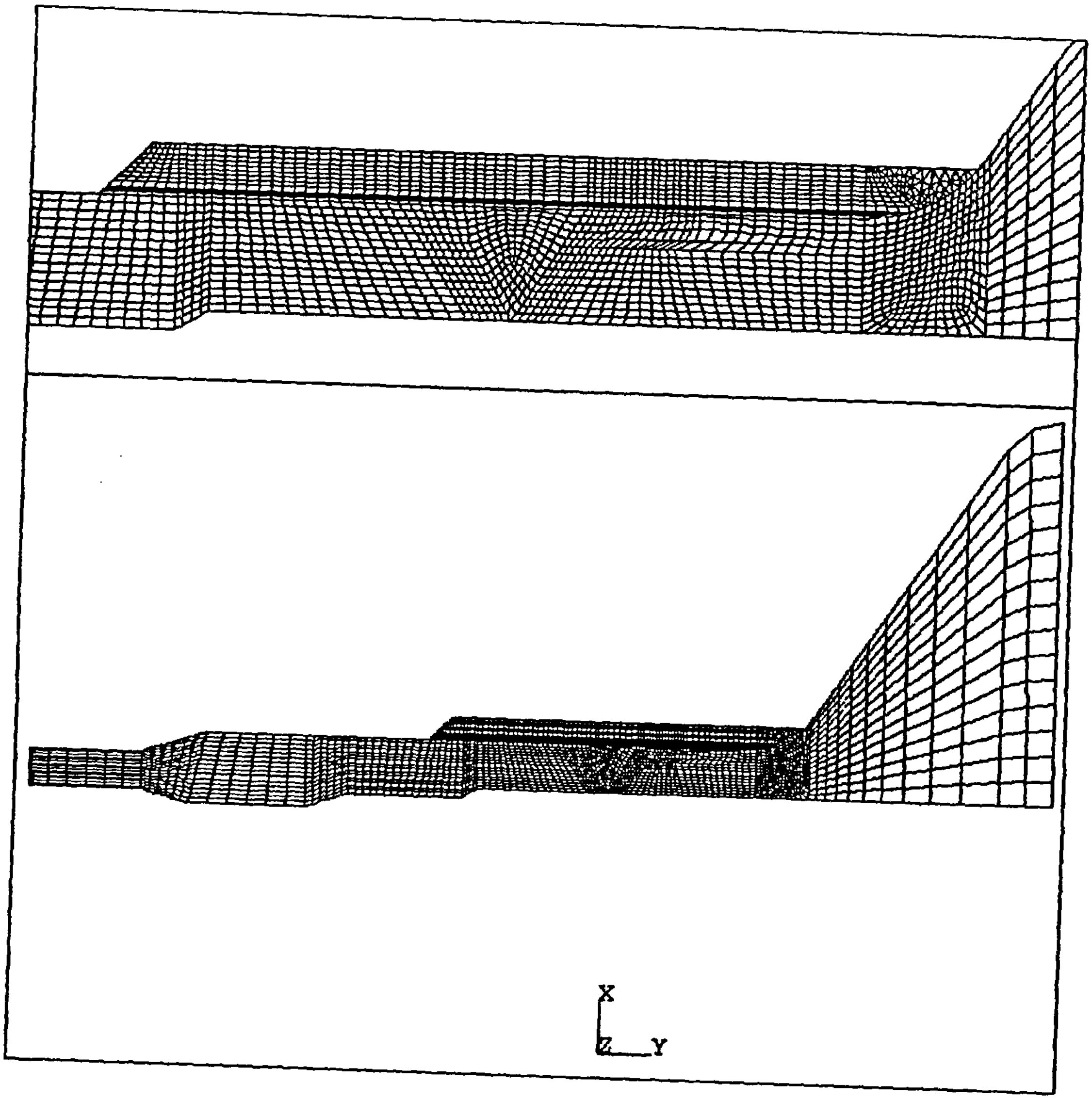
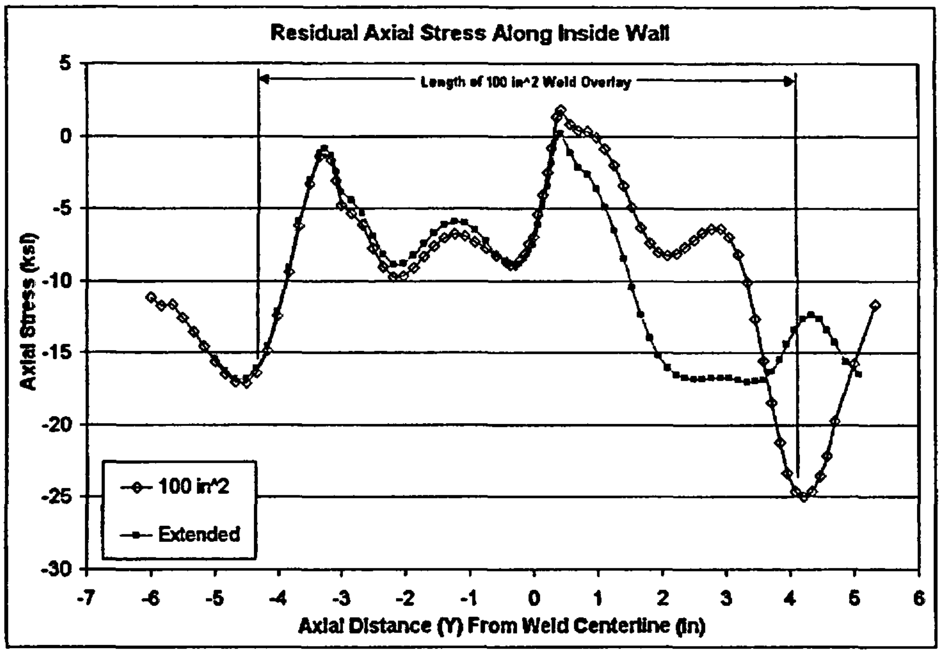


Figure 2. Extended (126 in^2) Overlay Finite Element Model



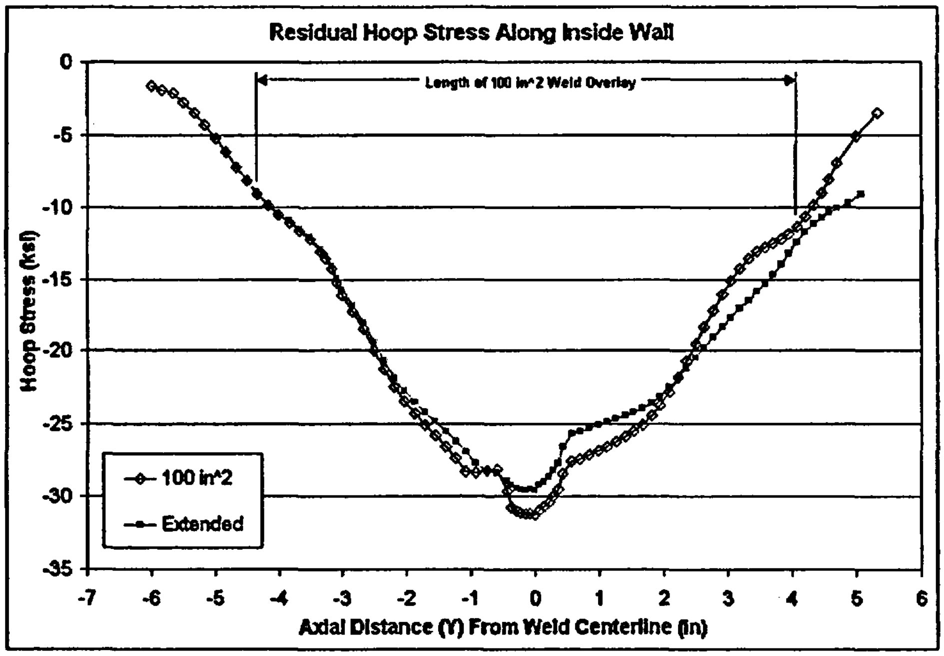


Figure 3. Residual Stresses Along Inside Wall of Pipe

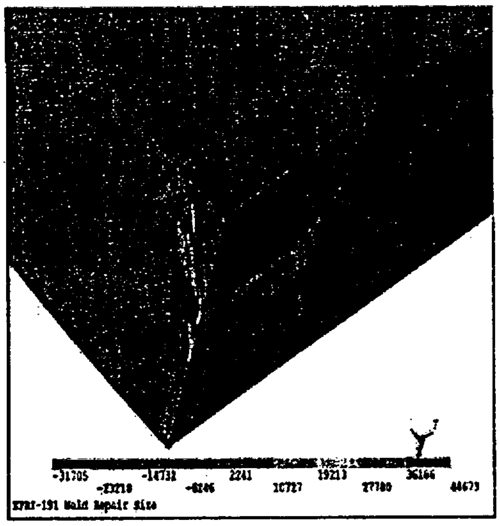


Figure 4 Stress Contour, Sx, at 50 °F After 100 in² Repair

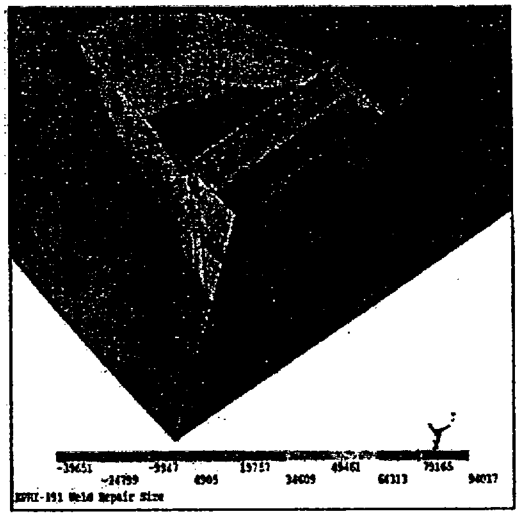


Figure 5 Stress Contour, Sy, at 50 °F After 100 in² Repair

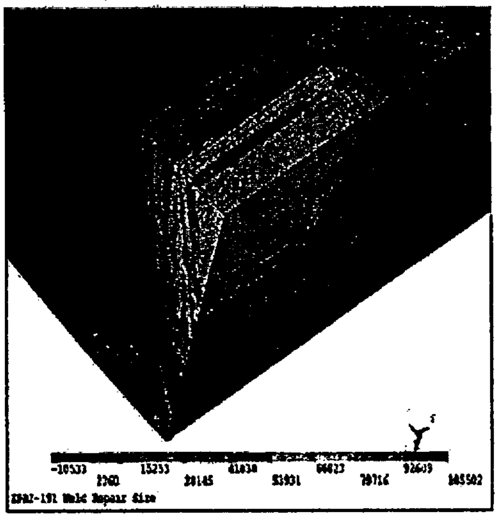


Figure 6 Stress Contour, Sz, at 50 °F After 100 in² Repair

RRA 00-04, BC 04-1000, Revise Code Case N-638-2 to Address Limitations on Size of Repairs

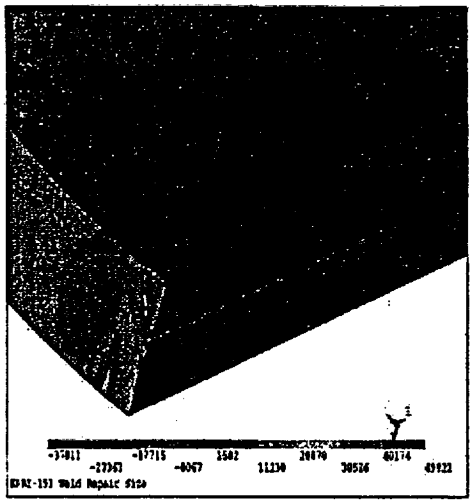


Figure 7 Stress Contour, Sx, at 50 °F After 500 in² Repair

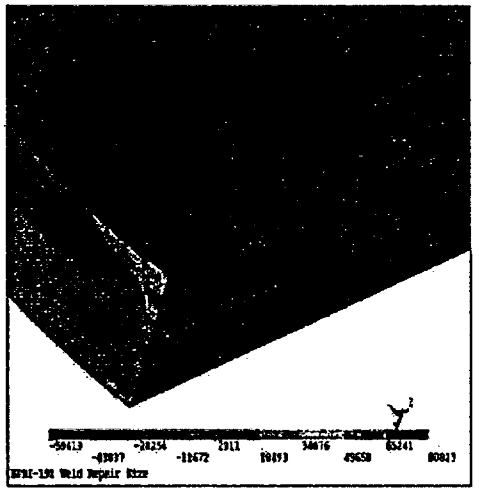


Figure 8 Stress Contour, Sy, at 50 °F After 500 in² Repair

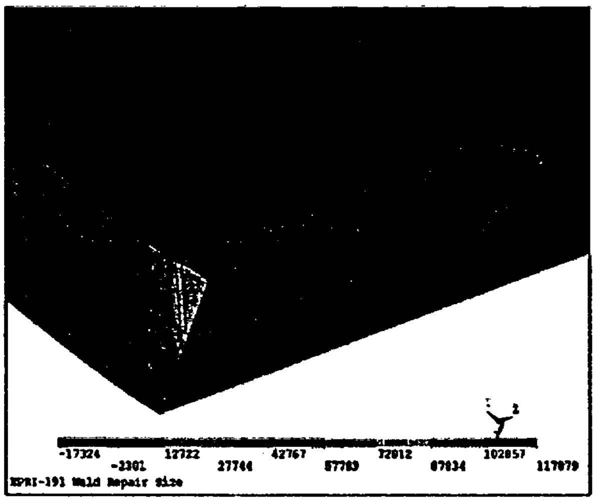
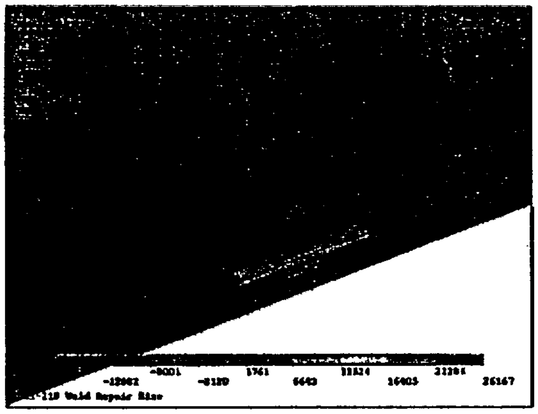
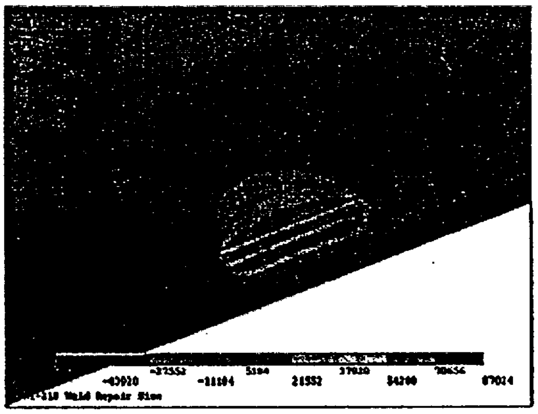


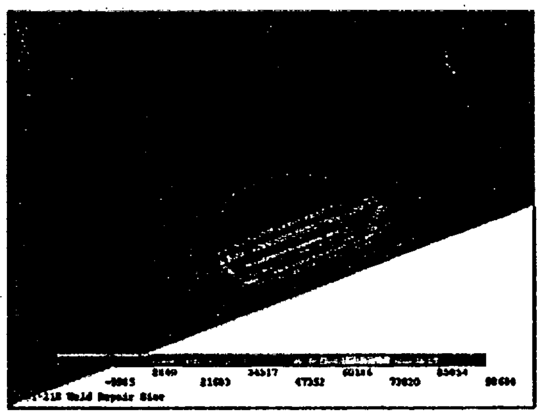
Figure 9 Stress Contour, Sz, at 50 °F After 500 in² Repair



a. Radial Stress (S_x)

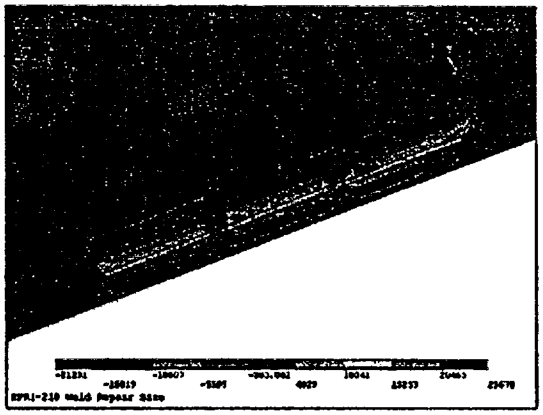


b. Hoop Stress (S_y)

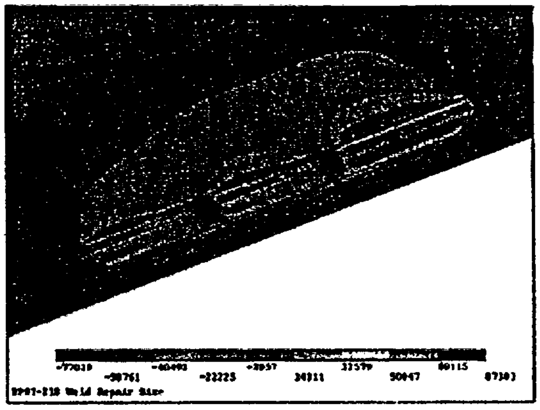


c. Axial Stress (S_z)

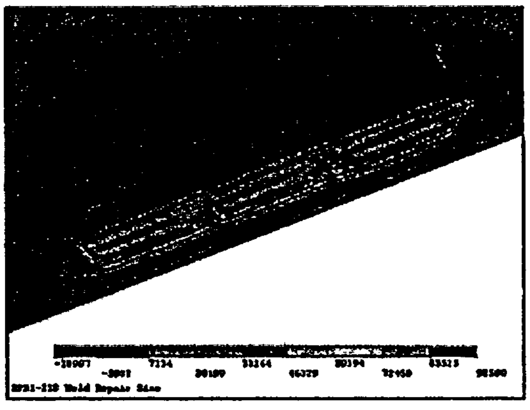
Fig.10 Stress Contour, at 70°F After 1st 100 in^2 Repair



a. Radial Stress (S_x)



b. Hoop Stress (S_y)



c. Axial Stress (S_z)

Fig. 11 Stress Contour, at 70 °F After 3rd 100 in^2 Repair

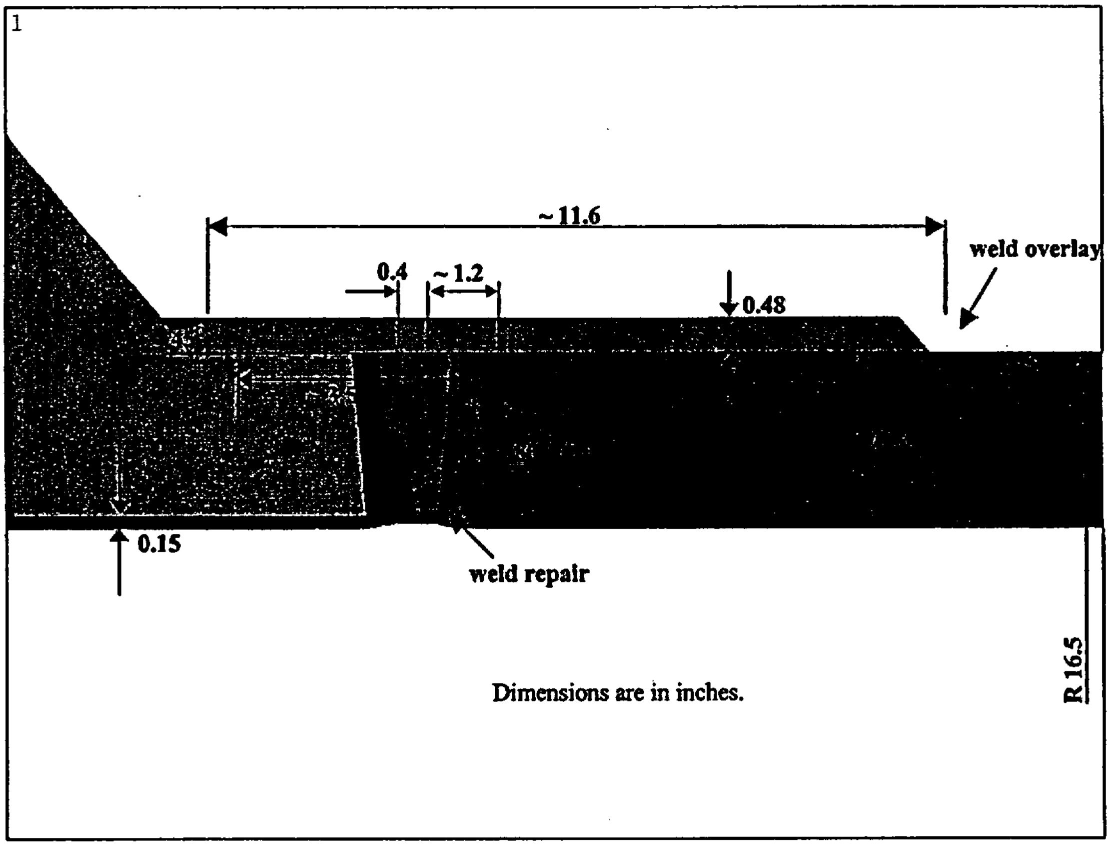
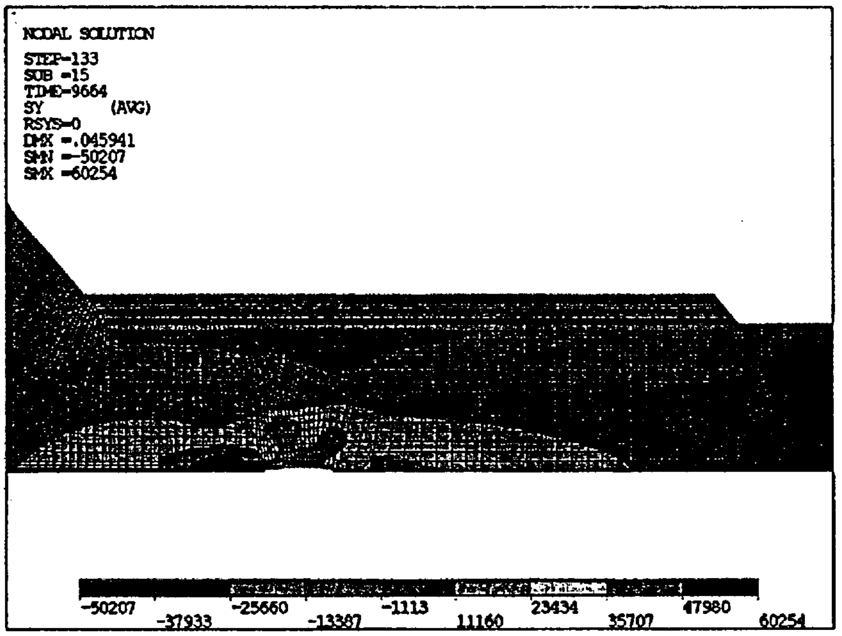
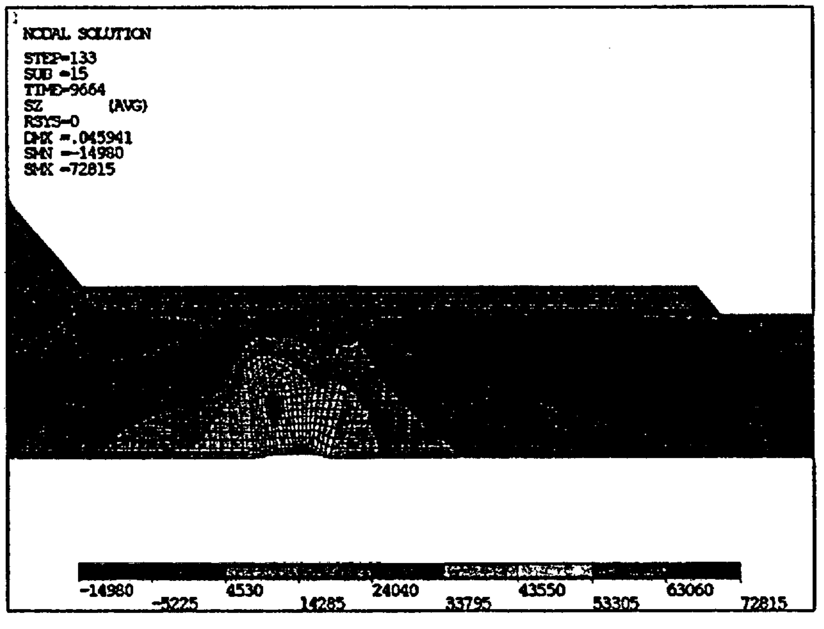


Fig. 12 Summary of Dimensions for the Weld Overlay Finite Element Model

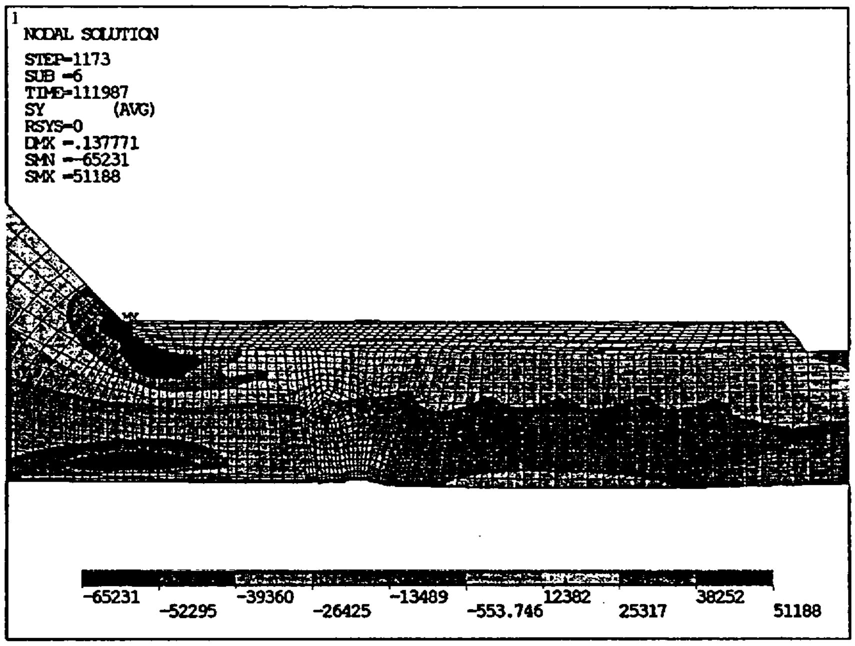


a. Axial

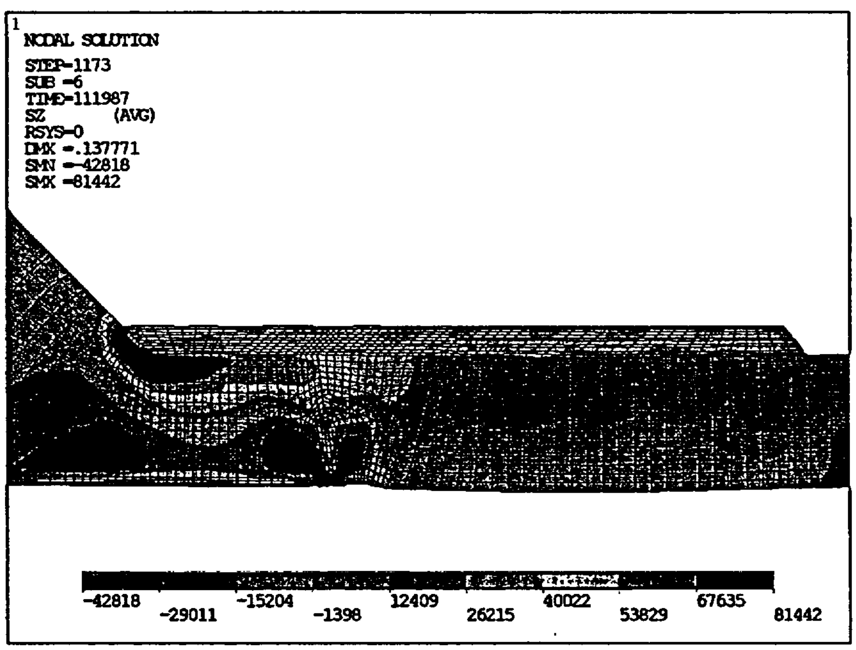


b. Hoop

Fig. 13 Pre-WOL Stress Contours, 70°

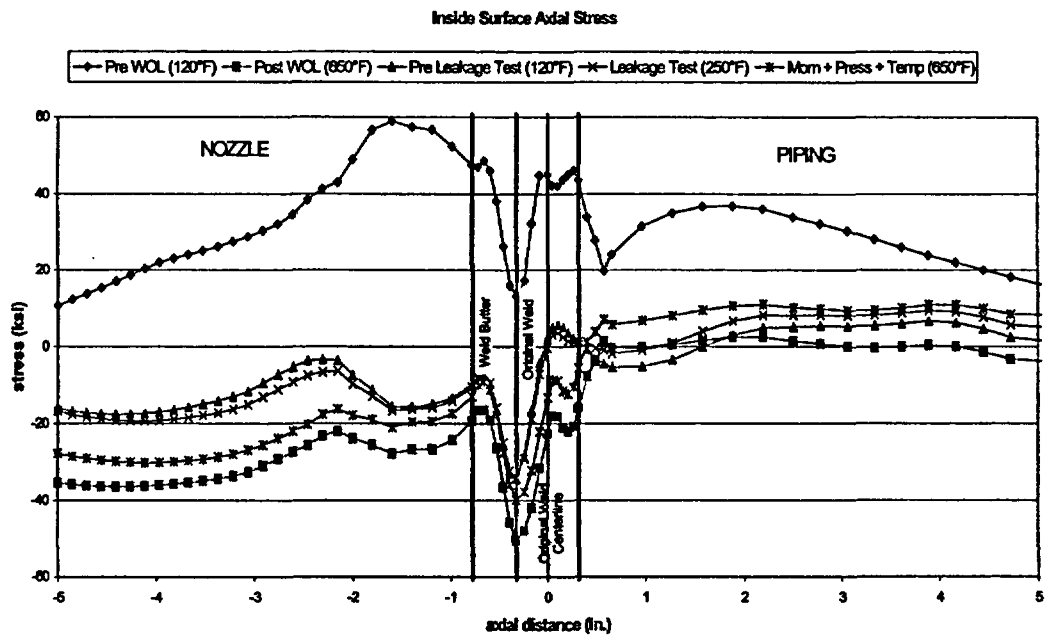


a. Axial



b. Hoop

Fig. 14 Post WOL Hoop Stress Contour, 70 F°



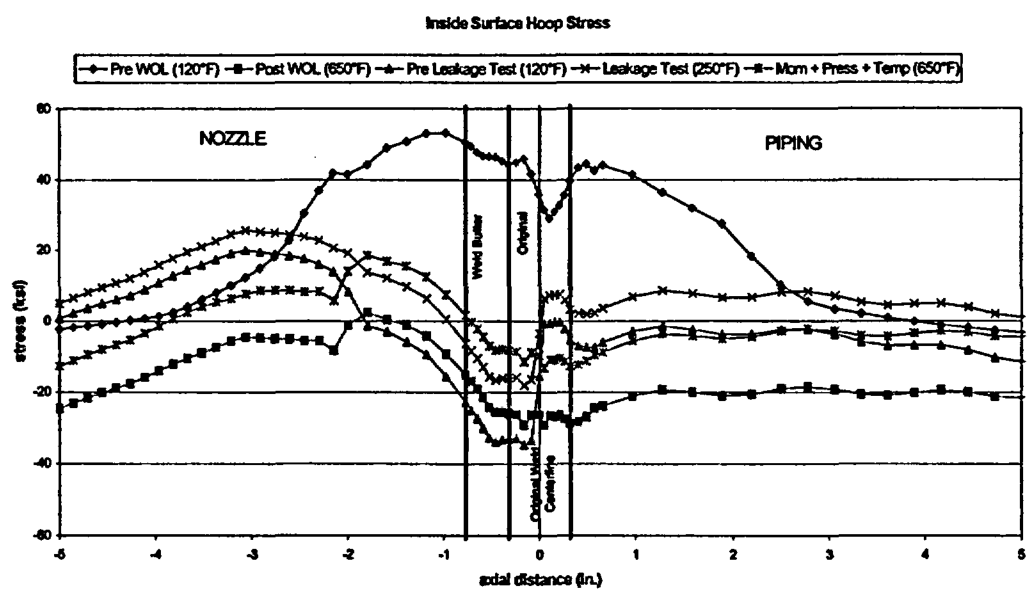


Fig. 15 Inside Surface Stresses at Different Conditions, 5 Layers, Long Overlay, Water Inside Pipe

RRA 00-04, BC 04-1000, Revise Code Case N-638-2 to Address Limitations on Size of Repairs

4) References

1. "Inconel Weld-Overlay Repair for Low-Alloy Steel Nozzle to Safe-End Joint", EPRI NP-7085-D, January 1991.
2. "Justification for Extended Weld-Overlay Design Life", EPRI-NP-7103-D, January 1991.
3. "Justification for the Removal of the 100 Square Inch Limitation for Ambient Temperature Temper Bead Welding on P-3 Material", EPRI-NP-XXXX, February 2005.
4. "Calculation Package, Preemptive Weld Overlay Residual Stress Analysis", DEV-03-3xx, Structural Integrity Associates, Inc., San Jose, CA, January 2005.