Union Electric
Callaway Plant

PO Box 620
Fulton, MO 65251

August 14, 2006
ULNRC-05292
10 CFR 50.55a

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Mail Stop P1-137
Washington, DC 20555-0001

Ladies and Gentlemen:

DOCKET NUMBER 50-483
UNION ELECTRIC COMPANY
CALLAWAY PLANT
10 CFR 50.55a REQUEST FOR RELIEF FROM
ASME SECTION XI REPAIR AND REPLACEMENT REQUIREMENTS:
PROPOSED ALTERNATIVES FOR APPLICATION
OF STRUCTURAL WELD OVERLAYS TO PRESSURIZER NOZZLE WELDS

Pursuant to 10 CFR 50.55a(a)(3), Union Electric Company (AmerenUE) hereby requests NRC approval of relief from applicable requirements of Section XI of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, as identified in the attached relief request. This request is for Callaway Plant's Repair/Replacement program, as established by the ASME Section XI Code, and involves utilization of an alternate approach to ASME Section XI requirements for a particular application.

Specifically, per the attached 10 CFR 50.55a (relief) request, AmerenUE proposes to implement alternative requirements in lieu of requirements contained in ASME Section XI IWA-4410 (and its referenced original Construction Code for the reactor coolant system pressurizer and attached piping at Callaway), IWA-4430, IWA-4520(a), IWA-4530, IWA-4600, and Table IWB-2500-1 (Examination Categories B-F and B-J), in order to provide for the installation and examination of full structural weld overlays for nozzle-to-safe end dissimilar metal and safe end-to-piping stainless steel butt welds associated with the pressurizer and connected piping. The overlays are a pre-emptive measure for addressing primary water stress corrosion cracking concerns that have been identified by the industry for welds associated with Alloy 600/82/182 components exposed to pressurized water reactor primary coolant. The proposed alternative requirements to be implemented have been determined to be appropriate for application and examination of the needed overlays, and will provide an acceptable level of quality and safety as required by 10 CFR 50.55a(a)(3)(i).

Supporting information and essential details, including justification, is provided in the attached relief request. With respect to this request, and as noted in Section 9.0, "Precedent," of the attached, the NRC has approved similar requests for other utilities.

The weld overlays addressed by the attached 10 CFR 50.55a request are to be installed during the next refueling outage for Callaway, i.e., Refuel 15 which is scheduled for March 2007. In order to plan and prepare for those activities sufficiently in advance of the outage, AmerenUE respectfully requests NRC review and approval of the attached relief request by January 31, 2007.

It may be noted that no new regulatory commitments have been made or identified pursuant to this letter and its attachments. Please contact me at 573-676-8659 or Dave Shafer at 314-554-3104 for any questions you may regarding these relief requests.

Sincerely,

Keith D. Young
Manager - Regulatory Affairs

TBE/jdg

Attachment: 10 CFR 50.55a Request for Application of
Overlays to Pressurizer Nozzle Welds

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Proposed Alternative
In Accordance with 10 CFR 50.55a(a)(3)(i)
--Alternative Provides Acceptable Level of Quality and Safety--

1.0 ASME Code Component(s) Affected

Nozzle-to-safe end dissimilar metal (DM) Alloy 82/182 butt welds and safe end-to-piping stainless steel (SS) butt welds on the Class 1 safety, relief, spray, and surge line connections to the pressurizer: Examination Categories: R-A (risk informed designation for B-F and B-J categories. (See Table 1 and Figure 3.)

TABLE 1: Pressurizer Nozzle Safe End Welds

RI Category	RI Item	Code Category	Code Item	Weld Description	Weld ID No.
R-A	R1.11-2	B-F	B5.40	14" surge nozzle-to-safe end	2-TBB-03-1-W
R-A	R1.20-4	B-F	B5.40	4" spray nozzle-to-safe end	2-TBB-03-2-W
R-A	R1.20-4	B-F	B5.40	6" safety "A" nozzle-to-safe end	2-TBB-03-3-A-W*
R-A	R1.20-4	B-F	B5.40	6" safety "B" nozzle-to-safe end	2-TBB-03-3-B-W
R-A	R1.20-4	B-F	B5.40	6" safety "C" nozzle-to-safe end	2-TBB-03-3-C-W
R-A	R1.20-4	B-F	B5.40	6" relief nozzle-to-safe end	2-TBB-03-4-W
R-A	R1.11-2	B-J	B9.11	14"surge nozzle safe end-to-piping	2-BB-01-F004B
R-A	R1.20-4	B-J	B9.11	6" safety nozzle safe end-to-piping	2-BB-02-F001*
R-A	R1.20-4	B-J	B9.11	6" safety nozzle safe end-to-piping	2-BB-02-F005
R-A	R1.20-4	B-J	B9.11	6" safety nozzle safe end-to-piping	2-BB-02-F006
R-A	R1.20-4	B-J	B9.11	6" relief nozzle safe end-to-piping	2-BB-02-F008*
R-A	R1.20-4	B-J	B9.11	4" spray nozzle safe end-to-piping	2-BB-04-F001
* Weld selected for examination under the Risk-Informed (RI) Program					

2.0 Applicable Code Edition and Addenda

ASME Section XI:

- 1998 Edition, with 2000 Addenda.

ASME Section III:

- 1974 Edition through Summer 1974 Addenda (Original Code of Construction for pressurizer).
- 1974 Edition through Winter 1974 Addenda (Original Code of Construction for top head pressurizer piping).
- 1974 Edition through Winter 1975 Addenda (Original Code of Construction for bottom head pressurizer piping).

3.0 Applicable Requirements and Provisions

3.1 Applicable ASME Code Requirements

IWA-4410 and IWA-4520(a) of ASME Section XI (Ref. 8.1) require repair/replacement activities to be performed in accordance with the Owner's Requirements and the original Construction Code for the affected component or system. IWA-4430 and IWA-4600 provide for alternative welding methods when the requirements of IWA-4410 cannot be met. IWA-4530 requires a preservice examination to be performed in accordance with IWB-2200. Table IWB-2500-1 prescribes inservice examination requirements for Class 1 butt welds, as applicable to Categories B-F and B-J.

Section XI Appendix VIII Supplement 11 (Ref. 8.2) specifies the performance demonstration requirements for ultrasonic examination of weld overlays (WOLs), including requirements for ultrasonic testing (UT) procedures, equipment, and personnel for UT of completed WOLs.

3.2 Applicable ASME Code Cases

ASME Code Case N-504-2 (Ref. 8.3) allows use of a WOL to enhance pipe integrity. This Code Case has been endorsed in Nuclear Regulatory Commission (NRC) Regulatory Guide (RG) 1.147, Revision 14 (Ref. 8.4), for generic use with the condition that the provisions of Section XI, Nonmandatory Appendix Q (Ref. 8.5) must also be met.

ASME Code Case N-638-1 (Ref. 8.6) describes the process for welding similar and dissimilar metals using ambient temperature machine gas tungsten arc weld (GTAW) temperbead method. This Code Case has been conditionally endorsed in NRC RG 1.147, Revision 14. However, based on other/additional modifications proposed for application of this Code Case, the conditions imposed on use of this Code Case as given in RG 1.147 are not applicable for the intended application.

As explained in Section 5 and associated Tables 2 and 3 of this relief request, Code Cases N-504-2 and N-638-1 cannot be used without certain provisions and/or modifications applied.

4.0 Reason for Request

Primary water stress corrosion cracking (PWSCC) of nickel alloy base materials and weld metals exposed to pressurized water reactor (PWR) primary coolant is a concern in the nuclear industry. In particular, alloy 82/182 welds exposed to elevated temperatures, like the Callaway Plant pressurizer dissimilar metal nozzle-to-safe end welds, are believed to pose a heightened propensity to PWSCC.

AmerenUE has concluded that the application of a full structural weld overlay (FSWOL) to the pressurizer nozzle DM welds is the most appropriate course of action for Callaway in order to ensure reactor coolant system (RCS) pressure

boundary integrity and improve future inspection capability. The FSWOL of the DM nozzle-to-safe end welds will preclude future examination of the SS safe end-to-pipe welds due to the close proximity of the two welds. Therefore, each FSWOL will extend from the low alloy ferritic steel nozzle across both butt welds to the SS pipe.

WOLs 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. FSWOLs arrest propagation of existing flaws (if present) by inducing favorable residual compressive stress in the susceptible portion of the original DM weld.

Electric Power Research Institute (EPRI) axial and circumferential scan coverage studies of the Callaway pressurizer nozzle weld geometries have shown that the resulting approved PDI Program examination scan coverage percentages do not meet the requirements of MRP-139 (Ref. 8.7) or ASME Section XI and are otherwise inadequate. EPRI also determined that if surface conditioning were applied to the pressurizer nozzle welds, the resulting PDI Program approved scan coverage percentages would still not meet the requirements of MRP-139 or ASME Section XI. As such, relevant circumferential and axial scan coverage could only be obtained through the use of a WOL. Because of the comparative dose and field activities associated with a WOL and a FSWOL, a FSWOL is most appropriate. However, while adequate examination by UT of the safe end welds prior to the FSWOL is not possible, if flaws are present, they will be mitigated by the FSWOL.

Currently, there is no approved comprehensive guidance or criteria to follow for applying a nickel alloy FSWOL to a DM weld that is constructed of Alloy 82/182 weld material and is believed to be susceptible to PWSCC. Therefore, pursuant to 10CFR50.55a(a)(3)(i), and in lieu of the noted IWA-4000 requirements, alternative requirements are requested for installation and examination of the FSWOL that are to be applied for repairing/mitigating the pressurizer nozzle-to-safe end DM welds. These alternative requirements use methodologies and requirements similar to those in ASME Code Cases N-504-2 and N-638-1, and are requested with certain provisions and/or modifications applied on the basis that the proposed alternatives will provide an acceptable level of quality and safety.

5.0 Proposed Alternatives and Basis for Use

AmerenUE proposes to apply a FSWOL for each of the identified pressurizer nozzle-to-safe end DM welds at Callaway using a high-chromium nickel alloy weld metal resistant to PWSCC. The FSWOL will extend around the full circumference of the existing nozzle safe end Alloy 82/182 welds, overlapping the neighboring sections of the low-alloy ferritic steel nozzle and SS piping. A typical FSWOL configuration to be applied is shown in Figure 1.

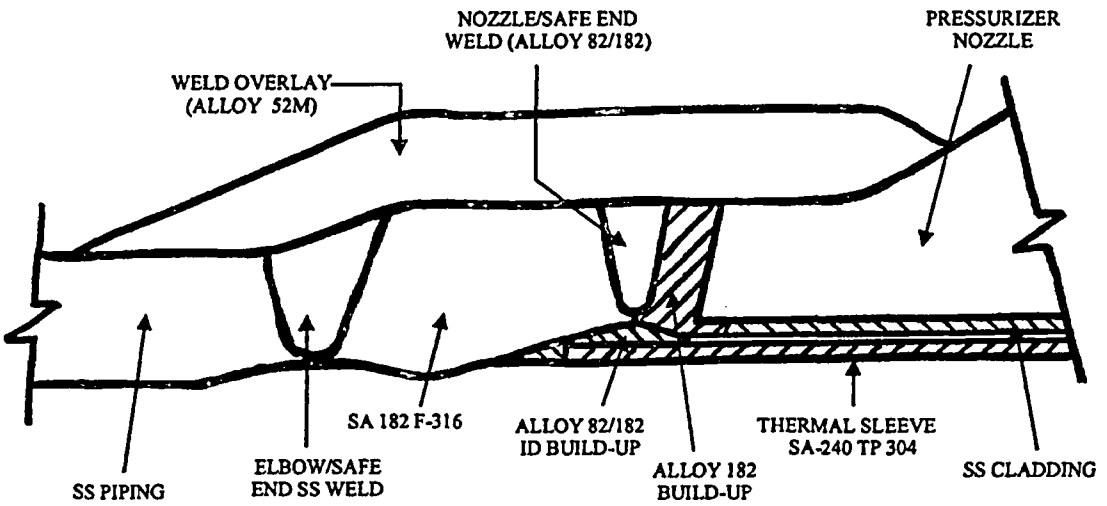

FIGURE 1: **General Configuration for Pressurizer Nozzle and Welds with Applied Full Structural Weld Overlay**

5.1 Code Case N-504-2 and Section XI, Nonmandatory Appendix Q

ASME Section XI Code Case N-504-2 allows a flaw in austenitic SS piping to be reduced to an acceptable size through the deposition of weld reinforcement on the outside surface of the pipe without flaw removal. The provisions of Section XI Nonmandatory Appendix Q are imposed by NRC RG 1.147, Revision 14, as a condition for acceptance of Code Case N-504-2.

For the design of each FSWOL it is conservatively assumed that a 360° circumferential through-wall flaw is present in the original Alloy 82/182 weld and in the original SS weld. Thus, each FSWOL will extend around the full circumference of the nozzle-to-piping weld locations as required by ASME Code Case N-504-2. The weld reinforcement material is to be Alloy 52M, or equivalent, and applied as a FSWOL to the existing austenitic SS safe ends, the low alloy ferritic steel nozzles, SS piping, and the Alloy 82/182 and austenitic SS weld material joining them.

The WOL will be designed as a FSWOL consistent with the requirements of ASME Code Case N-504-2 and Nonmandatory Appendix Q. The FSWOL design assumes there is no contribution to structural integrity from the original section of pipe. The FSWOL thickness and length will be designed according to the guidance provided in Code Case N-504-2.

Preservice and inservice inspections will be performed in accordance with Code Case N-504-2, Nonmandatory Appendix Q, Subarticles Q-4200 and Q-4300, and ASME Section XI, 1998 Edition through the 2000 Addenda, Appendix VIII, Supplement 11, with the modifications noted in Section 5.3 and Table 4 of this

relief request. These examinations will thus meet all of the applicable Code and Code Case requirements as modified by this request.

The design and repair methodologies of Code Case N-504-2 and provisions of Appendix Q will also be followed but with the modifications described in Table 2. The basis for each proposed modification is summarized in Table 2. Applicable requirements not listed in Table 2 will be met as described in Code Case N-504-2 and Appendix Q.

5.2 Code Case N-638-1

Application of the FSWOL requires welding on the low alloy ferritic steel nozzle material with Alloy 52M. Temperbead welding will be used for this purpose using the guidance of Code Case N-638-1. Code Case N-638-1 describes the process for welding similar and dissimilar metals using ambient temperature machine gas tungsten arc weld (GTAW) temperbead method. GTAW will be performed in accordance with Code Case N-638-1, with some modifications. As noted previously, Code Case N-638-1 was conditionally approved for generic use in NRC RG 1.147, Revision 14, and was developed for welding similar and dissimilar metals using ambient temperature machine GTAW temperbead technique. However, based on other/additional modifications proposed for application of this Code Case, the conditions imposed on use of this Code Case as given in RG 1.147 are not applicable for the intended application.

The methodology of Code Case N-638-1 will be followed for welding on ferritic material where the Construction Code requires post-weld heat treatment, with modifications. The proposed modifications to Code Case N-638-1 specifically address the draining requirement, weld area limit of 100 square inches, ultrasonic examination thickness, 48-hour post-weld hold criteria, and the use of non-attached temperature measuring devices for temperbead welding. These specific changes and the basis justifying each proposed modification to the methodologies specified in Code Case N-638-1 are addressed in Table 3. Applicable requirements not listed will be met as described in the Code Case.

5.3 ASME Section XI, Appendix VIII, Supplement 11

UT of the completed FSWOLs will be accomplished in accordance with ASME Section XI, Appendix VIII, Supplement 11, modified to comply with the Performance Demonstration Initiative (PDI), as described in Table 4. PDI has developed a program for qualifying equipment, procedures, and personnel for WOL examinations in accordance with the UT criteria of Appendix VIII, Supplement 11. Table 4 addresses the specific modifications made to the requirements of Appendix VIII, Supplement 11. The basis for each modification is provided as well.

ASME Section XI, Appendix VIII, Supplement 11 requires that all base metal flaws be cracks. As illustrated in Figure 2, 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 made revisions to allow use of alternative flaw mechanisms under controlled conditions. For example, alternative flaws shall be limited to cases when implantation of cracks precludes obtaining an effective ultrasonic response, flaws shall be semielliptical with a tip width of less than or equal to 0.002 inches, and at least 70 percent of the flaws in the detection and sizing test shall be cracks and the remainder shall be alternative flaws.

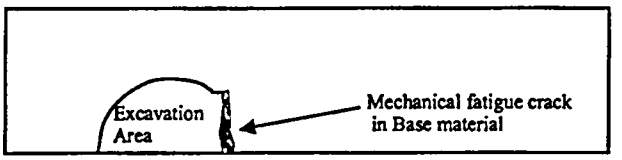

FIGURE 2: **Base Metal Crack Excavation Area**

ASME Section XI, Appendix VIII, Supplement 11 also requires that a base grading unit shall include at least 3 in. of the length of the overlaid weld (para. 1.1(e)(2)(a)(1)). The overlay grading unit shall include the overlay material (and) the base metal-to-overlay interface of at least 6 sq. in. In addition, the overlay grading unit shall be rectangular, with minimum dimensions of 2 in. (para. 1.1(e)(2)(b)(1)). All extensions of base metal cracking into the FSWOL material by at least 0.1 in. are to be reported as being intrusions into the FSWOL material (para. 3.2(b)).

Applicable requirements not listed or addressed in Table 4 will be met as described in ASME Section XI, Appendix VIII, Supplement 11.

6.0 Duration of Proposed Alternative

The alternatives in this Request are requested for the design life of the FSWOLs, as determined by the required evaluation in Paragraph (g) of Code Case N-504-2 and the corresponding requirements in Nonmandatory Appendix Q. Inservice Inspection (ISI) requirements beyond the current interval will be evaluated and established by the Callaway RI-ISI Plan.

7.0 Implementation

The FSWOLs will be installed during the Callaway Spring 2007 refueling outage as a preventive measure against flaw development in the dissimilar metal welds. NRC approval is requested by January 31, 2007 to support scheduling for completion of activities during the outage.

8.0 References

8.1 1995 Edition through 1996 Addenda, ASME Code, Section XI, IWA-4000

8.2 1995 Edition, ASME Code, Section XI, with the 1996 Addenda, Appendix VIII, "Performance Demonstration for Ultrasonic Examination Systems, Supplement 11"

8.3 ASME Code Case N-504-2, "Alternative Rules for Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping, Section XI, Division 1"

8.4 U.S Nuclear Regulatory Commission Regulatory Guide 1.147, Revision 14, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1," August 2004

8.5 ASME Code Section XI, 2005 Addenda, Nonmandatory Appendix Q, "Weld Overlay Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping Weldments"

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

8.7 Electric Power Research Institute Technical Report 1010087, "Materials Reliability Program: Primary System Piping Butt Weld Inspection and Evaluation Guidelines (MRP-139)," August 2005

8.8 Electric Power Research Institute Topical Report 1013036, "Topical Report Supporting an Expedited NRC Review of the Content of the Code Case needed for Dissimilar Metal Weld Overlay Repairs," January 2006

8.9 Electric Power Research Institute Technical Report 1003616, "Additional Evaluations to Expand Repair Limits for Pressure Vessels and Nozzles," March 2004

8.10 Electric Power Research Institute GC-111050, "Ambient Temperature Preheat for Machine GTAW Temperbead Applications," November 1998

9.0. Precedent

Similar 10 CFR 50.55a Requests have been approved by the NRC for other facilities, as identified below:

9.1 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.

9.2 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.

9.3 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.

9.4 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.

9.5 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 ASME Code Case N-504-2 and Nonmandatory Appendix Q

Current Requirements	Modification and Basis*
Code Case 504-2, Reply: It is the opinion of the Committee that, in lieu of the requirements of IWA-4120 in Editions and Addenda up to and including the 1989 Edition with the 1990 Addenda, in IWA-4170(b) in the 1989 Edition with the 1991 Addenda up to and including the 1995 Edition, and in IWA-4410 in the 1995 Edition with the 1995 Addenda and later Editions and Addenda, 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. *Appendix Q, Scope:* This Appendix provides an alternative to the requirements of IWA-4420, IWA-4520, IWA-4530, and IWA-4600 for making repairs to, and subsequent examination of Class 1, 2, and 3 austenitic stainless steel pipe weldments with stress corrosion cracking, by deposition of 452.1 weld reinforcement (weld overlay) on the outside surface of the pipe. After a weld overlay has been installed in accordance with this. Appendix, the inservice examinations identified in Q-4300 shall be performed as long as the repair remains part of the pressure boundary.	*Modification:* Permit Code Case N-504-2 and Section XI Nonmandatory Appendix Q for the installation of a nickel alloy FSWOL to mitigate the potential of PWSCC in Pressurizer nozzle-to-safe-end DM welds as modified herein. *Code Case 504-2, Reply:* It is the opinion of the Committee that Code Case N-504-2 and Section XI Nonmandatory Appendix Q, 2005 Addenda, may be used for the application of Alloy 52/52M full structural weld overlays of the ferritic (P-No. 3 Group 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, to mitigate the potential of PWSCC in nozzle-to-safe-end DM welds as modified herein. *Basis:* The FSWOL will be sized to meet all structural requirements without considering the structured component of the existing Alloy 82/182 and SS weldments. In addition, the FSWOL will induce inside diameter compressive stresses thus mitigating PWSCC initiation. Finally, industry operating experience has shown that propagation of PWSCC in Alloy 82/182 weld metal will arrest at the SS base metal, ferritic base metal, or Alloy 52/52M interface. The 360° FSWOL will thus control propagation of PWSCC and maintain joint integrity.
Code Case 504-2, 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. *Appendix Q, Q-2000 Paragraph (a):* 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 using a	*Modification:* Nickel alloy weld filler metal may be used in lieu of low carbon austenitic filler metal. *Code Case 504-2, Paragraph (b):* Reinforcement weld metal shall be a PWSCC resistant nickel alloy filler material applied 360 deg. around the circumference of the pipe, ... *Basis:* The FSWOL weld metal will be ERNiCrFe-7A (Alloy 52M, UNS N06054). Repairs, if required, may be ERNiCrFe-7A or ENiCrFe-7 (Alloy 152, UNS W86152). ERNiCrFe-7A and ENiCrFe-

* The "Modification and Basis" column includes the proposed modifications formatted for the specific Code Case requirements.

TABLE 2: Modifications to ASME Code Case N-504-2 and Nonmandatory Appendix Q

Current Requirements	Modification and Basis*
Welding Procedure Specification for groove welding, qualified in accordance with the Construction Code and Owner's Requirements and identified in the Repair/Replacement Plan.	7 are assigned F-No. 43 by ASME Section IX, 2006 Addenda. The requirements of ASME Section III, NB-2400 will be applied to all filler material as required by ASME Section XI. Alloys 52M and 152 contain about 30% Cr (roughly twice that of Alloy 82/182), imparting excellent PWSCC resistance. Alloy 52M and 152 are fully austenitic and have ductile properties and toughness similar to austenitic SS piping welds at PWR operating temperature. Furthermore, these filler materials are suitable for welding to the ferritic nozzle, Alloy 82/182 weld, and the austenitic SS pipe, welds, and safe end materials.
Code Case 504-2, 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 reinforcement design thickness. Alternatively, first layers of at least 5 FN may be acceptable based on evaluation [same as Q-2000(d)]. *Appendix Q, Q-2000 Paragraph (d):* The weld reinforcement shall consist of at least 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 at least 7.5 FN shall constitute the first layer of the weld reinforcement that may be credited toward the required thickness. Alternatively, first layers of at least 5 FN are acceptable, provided the carbon content of the deposited weld metal is determined by chemical analysis to be less than 0.02%.	*Modification:* Delta ferrite (FN) measurements will not be performed when using Alloy 52M/152 filler material. The FSWOL deposit shall instead meet the following requirements: *Code Case 504-2, Paragraph (e):* The austenitic nickel alloy weld overlay shall consist of at least two weld layers deposited from a filler material with a Cr content of at least 28%. The first layer of weld metal deposited may not be credited toward the required WOL structural design thickness. Alternatively, the as-deposited first layer may be credited toward the required structural design thickness, provided the diluted layer applied over the austenitic base material, austenitic weld metal and low alloy ferritic base material contains at least 24% Cr. The Cr content of the first layer may be determined by chemical analysis of the production weld or may be demonstrated by a representative coupon taken from a mockup prepared in accordance with the production welding procedure specification (WPS). The welding parameters demonstrated on the mockup to achieve 24% Cr on the first layer shall be used for the production weld first layer. *Basis:* Alloy 52M/152 weld metal is fully austenitic and contains no delta ferrite due to the high nickel (~60%) content. As-deposited delta

* The "Modification and Basis" column includes the proposed modifications formatted for the specific Code Case requirements.

TABLE 2: Modifications to ASME Code Case N-504-2 and Nonmandatory Appendix Q

Current Requirements	Modification and Basis*
	ferrite content is therefore not applicable for Alloy 52M/152 weld metal. Alloy 52M with as-deposited first layer chromium content greater than or equal to 24% provides acceptable PWSCC resistance. EPRI Topical Report 1013036, Appendix B, "White Paper-Effect of Chromium Content on Nickel-Base Allow SCC Resistance," (Ref. 8.8) shows that 24% Cr provides acceptable resistance to PWSCC in PWR applications. As-deposited first layer chemistry will be verified either by field chemistry measurements or by prior mockup demonstration using production WPS parameters. When first-layer chemistry meets or exceeds 24% Cr, this initial layer will be credited toward FSWOL design thickness. If the first-layer Cr is less than 24%, the first layer will be considered sacrificial and will not be credited toward FSWOL design thickness.
Code Case N-504-2 Paragraphs (f) and (g) *Appendix Q, Q-3000 Paragraph (b):* The design of the weld overlay shall satisfy the requirements of the Construction Code and Owner's Requirements in accordance with IWA-4221 and the following, using the assumptions and flaw characterization 452.3 restrictions in Q-3000(a). The design analysis required by Q-3000(b)(1) – (4) shall be completed in accordance with IWA-4311.	*Code Case 504-2, Modifications:* The provisions of N-504-2 (f) and (g), Q-3000 in the 2005 Addenda of Section XI, and corrections to Q-3000 published in the 2006 Addenda of Section XI will be used, with the following modifications: *Appendix Q, Q-3000 Paragraph (b):* The design of the weld overlay shall be in accordance with IWA-4221 and the following, using the assumptions and flaw characterization 452.3 restrictions in Q-3000(a). The design analysis required by Q-3000(b)(1) – (4) shall be completed in accordance with IWA-4311. *Appendix Q, Q-3000 Paragraph(b) (3):* The overlay design thickness of items meeting Q-3000(a)(2), (3), or (4) shall be based on the measured diameter, using the thickness of the weld overlay as restricted by Q-2000(d). The wall thickness at the weld overlay, any planar flaws in the weld overlay, and the effects of any discontinuity (e.g., another weld overlay or reinforcement for a branch connection) within a distance of $2.5\sqrt{Rt}$ from the toes of the weld overlay, shall be

* The "Modification and Basis" column includes the proposed modifications formatted for the specific Code Case requirements.

TABLE 2: Modifications to ASME Code Case N-504-2 and Nonmandatory Appendix Q

Current Requirements	Modification and Basis*
	evaluated and shall meet the requirements of IWB-3640, IWC-3640, or IWD-3640, as applicable. *Basis:* The 2005 Addenda of Section XI incorporated Code Case N-504-2 as Nonmandatory Appendix Q. Unfortunately, inadvertent consequences of modified wording caused problems with implementation. Appendix Q was revised in the 2006 Addenda to more accurately incorporate the provisions of Code Case N-504-2. A correction to Q-3000(b) deleted the requirement for the design of the WOL 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. A fundamental purpose of Code Case N-504-2 was to repair cracks (reduce to an acceptable size) by installation of a WOL. 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) in the 2006 Addenda of Appendix Q 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.
Code Case 504-2, 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	*Modification:* In lieu of a hydrostatic test, a system leakage test will be performed in accordance with Section XI, IWA-5000 of the 2000 Addenda. *Code Case 504-2, Paragraph (h):* The completed repair shall be pressure tested in accordance with IWA-5000. *Basis:* A system hydrostatic test at normal operating temperature and at 1.02 times the Class 1 reactor coolant system operating pressure (as

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TABLE 2: Modifications to ASME Code Case N-504-2 and Nonmandatory Appendix Q

Current Requirements	Modification and Basis*
performed in accordance with IWA-5000.	specified by IWA-5000 and IWB-5000) provides no more assurance of the structural condition of the WOL than a system leakage test performed at RCS operating pressure. The 1993 Addenda of ASME Section XI eliminated Class 1 system hydrostatic tests for inservice inspection. Furthermore, the 1999 Addenda of ASME Section XI, which is accepted in 10CFR50.55a, permits a system leakage test in lieu of a system hydrostatic test for all repair/replacement activities.

* The "Modification and Basis" column includes the proposed modifications formatted for the specific Code Case requirements.

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

Current Requirements	Modification and Basis*
Reply: It is the opinion of the Committee that repair to P-No. 1, 3, 12A, 12B, and 12C1, *except SA-302 Grade B,* material and their associated welds and welds joining P-No. 8 or P-No. 43 material to P-Nos. 1, 3, 12A, 12B, and 12C1, *except SA-302 Grade B,* material may be made by the automatic or machine GTAW temper bead technique without the specified preheat or postweld heat treatment of the Construction Code, when it is impractical to drain the component or impractical for radiological reasons. The nondestructive examination requirements of the Construction Code need not be met, provided the requirements of paragraph 1.0 through 5.0, and all other requirements of IWA-4002, are met.	*Modification:* Permit installation of the FSWOL with or without the Pressurizer and associated nozzle piping drained. *Reply:* It is the opinion of the Committee that repair to P-No. 1, 3, 12A, 12B, and 12C1, *except SA-302 Grade B,* material and their associated welds and welds joining P-No. 8 or P-No. 43 material to P-Nos. 1, 3, 12A, 12B, and 12C1, *except SA-302 Grade B,* material may be made by the automatic or machine GTAW temperbead technique without the specified preheat or postweld heat treatment of the Construction Code with or without draining the system or component. The nondestructive examination requirements . . . . *Basis:* It is not practical to fill the Pressurizer to a level that would provide water backing for the vapor space nozzles and associated piping (e.g., spray, relief, and safety nozzles). In addition, depending on plant refueling status the surge nozzle and associated piping may be drained for a brief period during FSWOL installation. Code Case N-638-1 requires 150°F interpass temperature for the first three layers and 350°F interpass temperature for all subsequent layers. The 150°F interpass on the first three layers provides adequate control to ensure tempered martensite with adequate toughness in the low alloy ferritic nozzle material, and the 350°F interpass for all subsequent layers ensures the SS weld and base material are not sensitized. The interpass temperature controls of N-638-1 are therefore adequate to ensure acceptable mechanical properties and structural integrity of the overlay weldment.
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 area of the low alloy ferritic nozzle base material covered by the FSWOL may exceed 100 sq. in. The one-half base metal thickness limitation applies to weld repair of base metal

* The "Modification and Basis" column includes the proposed modifications formatted for the specific Code Case requirements.

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

Current Requirements	Modification and Basis*
	excavations and is not applicable to FSWOLs. *Paragraph 1.0(a):* The maximum low alloy ferritic base material surface area covered by weld overlay shall be 500 sq. in. *Basis:* The requirements of N-638-1 are applied to the FSWOL material installed on the low-alloy ferritic nozzle base material. Depending upon the nozzle diameter and the axial extent of the FSWOL, the 100 sq. in. limit of surface covered by the FSWOL imposed by Code Case N-638-1 may be exceeded. In order for the FSWOL to satisfy structural requirements, additional weld material may be necessary in the axial direction on the low-alloy ferritic nozzle to facilitate the required post-overlay ultrasonic examination and/or to achieve an acceptable overlay blend transition into the nozzle. The maximum low-alloy ferritic base material covered by the FSWOL will be limited to 500 sq. in. Extensive experience exists in BWR and PWR WOL applications where the ferritic base material covered by WOL exceeded the 100 sq. in. limitation without any damaging or long-term detrimental effects. EPRI Technical Report 1003616, "Additional Evaluations to Expand Repair Limits for Pressure Vessels and Nozzles," (Ref 8.9) provides justification for WOL areas up to 500 sq. in. Finite element analyses of the ambient temperature temperbead repair process show that residual stresses are not detrimentally affected by increasing the allowable repair area. In fact, analyses show that in some cases increasing the allowable repair area improves the residual stress distribution in the weldment. ASME published Code Case N-638-3, which permits a repair area up to 500 sq. in., in Supplement 9 to the 2004 Edition of ASME Section XI. The Committee white paper basis for this N-638 revision indicates that the 100 sq. in. limitation was arbitrarily established and that repair

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

Current Requirements	Modification and Basis*
	areas of up to 500 sq. in. would have no adverse effect.
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 requirements of Paragraph 4.0(b), examination of the final FSWOL will be in accordance with the requirements of Code Case N-504-2 and Appendix Q, as modified in this relief request. The 48-hour hold time may start following completion of the third temperbead layer and is applied only to the FSWOL section that covers and/or adjoins the ferritic nozzle base material. *Paragraph 4.0(b):* The final weld overlay shall be examined in accordance with Code Case N-504-2 and Appendix Q, as modified. Examination of the weld overlay covering the ferritic base material and examination of the adjacent ferritic base material shall be performed no sooner than 48 hours after completion of the third temperbead layer over the ferritic base material. *Basis:* Examination of a band width 1.5 times the component thickness or 5 in., which ever is less, around the repair area after 48 hours at ambient temperature is for detection of delayed HAZ cracking that may occur due to inadvertent introduction of deleterious monatomic hydrogen into a hardened base metal HAZ microstructure that was not adequately tempered. The ferritic nozzle base material HAZ of the first Alloy 52M layer is the only region susceptible to potential hydrogen delayed cracking. The volume and area requiring examination by Code Case N-504-2 and Appendix Q are therefore adequate for detection of hydrogen delayed cracking that occurs in vicinity of the first layer HAZ and the excessive examination band region specified by Paragraph 4.0(b) is not necessary. Hydrogen contamination to deleterious levels from outside sources is unlikely when applying the ambient temperature temperbead machine

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

Current Requirements	Modification and Basis*
	GTAW process with the associated methodologies specified for welding control, cleanliness, and examination. As compared to flux type welding processes, machine GTAW with argon shielding is an inherently low-hydrogen process that provides optimum temperbead welding controls to ensure adequately tempered base metal HAZ with high fracture toughness. The low hydrogen and tempering characteristics of the machine GTAW process are well documented in EPRI GC-111050, "Ambient Temperature Preheat for Machine GTAW Temperbead Applications," (Ref. 8.10). Code Case N-504-2 and Appendix Q require liquid penetrant examination (PT) prior to installation of the FSWOL. Cleaning the base metal for PT provides assurance, in addition to typical welding process controls, that deleterious hydrogen from surface contamination is not introduced in the first layer of the FSWOL. The high affinity of fully austenitic Alloy 52M filler metal for monatomic hydrogen combined with a low diffusion coefficient keeps diffusion of deleterious hydrogen into the low alloy ferritic base material to negligible levels. Furthermore, only welding in contact with the low alloy ferritic base material has potential of introducing deleterious monatomic hydrogen into a hardened untempered HAZ region. Each successive temperbead layer has a decreasing propensity for introducing hydrogen into the ferritic base material due to increasing distance from the susceptible base metal HAZ. After three layers the temperbead process adequately tempers the martensite formed in the ferritic base material by the first layer. Adequate tempering by the third weld layer decreases the hardness and increases the fracture toughness in the potentially susceptible ferritic base material HAZ thus mitigating susceptibility to delayed hydrogen cracking.

* The "Modification and Basis" column includes the proposed modifications formatted for the specific Code Case requirements.

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

Current Requirements	Modification and Basis*
	Additionally, the interpass temperature controls of Code Case N-638-1 maintain the temperature near or at ambient temperature between the relatively short and infrequent localized welding heat cycles. N-638-1 requires a 150°F interpass temperature for the first three layers to ensure adequately high cooling rates to promote a base metal HAZ microstructure with high fracture toughness. A 350°F interpass temperature is required for the fourth and subsequent layers to protect against sensitization of the austenitic groove weld and austenitic base materials and to maintain an acceptable microstructure in the Alloy 52M overlay weld metal. The 150°F and 350°F interpass temperature controls maintain the ferritic base metal HAZ at relatively low temperatures, which effectively contributes to time at or near ambient temperature. For time during the welding process where temperatures are above ambient, the elevated temperatures are beneficial and enhance diffusion of hydrogen out of the ferritic base material HAZ. It is therefore, both reasonable and conservative, to include the temperbead welding time following completion of the third layer in the total 48-hour hold time required prior to performing final examination of the ferritic base material and of the FSWOL on the ferritic base material. In summary, the inherent low hydrogen nature of the prescribed ambient temperature temperbead machine GTAW process and methodology, the relatively low susceptibility of hydrogen induced cracking in ferritic base material HAZ when using nickel alloy filler metals, and performance of the Appendix Q and N-504-2 final examination (as modified) 48 hours after completion of the third layer over the ferritic base material provides substantial assurance against the potential for delayed hydrogen cracking in the ferritic base material HAZ. Additionally, ASME published Code Case N-638-3, which does not

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

Current Requirements	Modification and Basis*
	require examination of the band around the repair area, in Supplement 9 to the 2004 Edition of ASME Section XI. Also, the Boiler and Pressure Vessel Main Committee in August 2006 approved a revision to N-638-3 which permits start of the 48 hour hold following completion of the third temperbead layer (Reference ASME Code Committee tracking no. BC06-134).
Paragraph 4.0(c): Areas from which weld-attached thermocouples have been removed shall be ground and examined using a surface examination method.	*Modification:* Provide for use of non-attached temperature measuring devices. *Paragraph 4.0(c):* Process temperatures may be monitored with non-attached type 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. When weld-attached thermocouples are used, the local area where thermocouples were attached shall be ground and examined using a surface examination method. *Basis:* Use of non-attached temperature measuring devices is adequate for controlling and monitoring temperatures during ambient temperature temperbead machine GTAW.
NRC conditions for use of Code Case N-638-1 specified in Regulatory Guide 1.147	With the modifications described above, the NRC RG 1.147, Revision 14, conditions for use of N-638-1 are not applicable and therefore will not be applied.

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Modifications To Appendix VIII, Supplement 11

Appendix VIII Supplement 11 of Section XI cannot be used without modification for nondestructive examination (NDE) qualifications of a FSWOL. 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 Appendix VIII, Supplement 11

Current Requirements	Modification and Basis*
1.0 SPECIMEN REQUIREMENTS	
1.1 General. The specimen set shall conform to the following requirements.	No Change

* The "Modification and Basis" column includes the proposed modifications formatted for the specific Code Case requirements.

TABLE 4: Modifications To Appendix VIII, Supplement 11

Current Requirements	Modification and Basis*
Paragraph (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.	*Paragraph (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 examination procedure is applicable. *Basis:* To avoid confusion, the overlay thickness tolerance contained in the last sentence was reworded.
(d) Flaw Conditions	
Paragraph (d) (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.	*Paragraph (d) (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: *Paragraph (d) (1)* (a): The use of Alternative flaws shall be limited to when the implantation of cracks produces spurious reflectors that are uncharacteristic of actual flaws.

* The "Modification and Basis" column includes the proposed modifications formatted for the specific Code Case requirements.

TABLE 4: Modifications To Appendix VIII, Supplement 11

Current Requirements	Modification and Basis*
	Paragraph (d) (1) (b): Flaws shall be semielliptical 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 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.
(e) Detection Specimens	
Paragraph (e) (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.	*Paragraph (e) (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 FSWOL fabrication flaws was excluded from the PDI Program as an improbable scenario. WOLs 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

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TABLE 4: Modifications To Appendix VIII, Supplement 11

Current Requirements	Modification and Basis*
	FSWOL 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.
Paragraph (e) (2): Specimens shall be divided into base and over-lay grading units. Each specimen shall contain one or both types of grading units.	*Paragraph (e) (2):* Specimens shall be divided into base metal and overlay 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) Base Metal Grading unit	
Paragraph (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.	*Paragraph (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.
Paragraph (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.	*Paragraph (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.

* The "Modification and Basis" column includes the proposed modifications formatted for the specific Code Case requirements.

TABLE 4: Modifications To Appendix VIII, Supplement 11

Current Requirements	Modification and Basis*
Paragraph (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.	*Paragraph (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) Overlay Fabrication Grading Unit	
Paragraph (b) (1): An overlay grading unit shall include the overlay material and the base metal-to-overlay interface of at least 6 sq. in. The overlay grading unit shall be rectangular, with minimum dimensions of 2 in.	*Paragraph (b) (1):* An overlay fabrication grading unit shall include the overlay material and the base metal-to-overlay interface for a length of at least 1 in. *Basis:* This paragraph was also modified to define an overlay fabrication grading unit as including the FSWOL material and the base metal-to-overlay interface for a length of at least 1 inch rather than the 6 inch^2 requirement.
Paragraph (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.	*Paragraph (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 in. 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

* The "Modification and Basis" column includes the proposed modifications formatted for the specific Code Case requirements.

TABLE 4: Modifications To Appendix VIII, Supplement 11

Current Requirements	Modification and Basis*
	least 1 inch at both ends, rather than around its entire perimeter.
Paragraph (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.	*Paragraph (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	
Paragraph (f) (1): The minimum number of flaws shall be ten. At least 30% of the flaws shall be overlay fabrication flaws. At least 40% of the flaws shall be cracks open to the inside surface.	*Paragraph (f) (1):* The minimum number of flaws shall be ten. At least 30% of the 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.
Paragraph (f) (3): Base metal cracking used for length sizing demonstrations shall be oriented circumferentially.	*Paragraph (f) (3):* Base metal flaws used for length sizing demonstrations shall be oriented circumferentially.
Paragraph (f) (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.	*Paragraph (f) (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 in. in the through-wall direction.
2.0 CONDUCT OF PERFORMANCE DEMONSTRATION	

* The "Modification and Basis" column includes the proposed modifications formatted for the specific Code Case requirements.

TABLE 4: Modifications To Appendix VIII, Supplement 11

Current Requirements	Modification and Basis*
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	
Paragraph (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.	*Paragraph (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.
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.	*Paragraph (a):* The depth sizing test may be conducted separately or in conjunction with the detection test.
	Paragraph (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

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TABLE 4: Modifications To Appendix VIII, Supplement 11

Current Requirements	Modification and Basis*
	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.
	Paragraph (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.	*Paragraph (a):* Examination procedures are qualified for detection when;
	Paragraph (a) (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.
	Paragraph (a) (1) (a): At least one successful personnel demonstration has been performed meeting the acceptance criteria defined in (b).
	Paragraph (a) (1) (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.

* The "Modification and Basis" column includes the proposed modifications formatted for the specific Code Case requirements.

TABLE 4: Modifications To Appendix VIII, Supplement 11

Current Requirements	Modification and Basis*
	Paragraph (a) (1) (c): The criteria in (a), (b) shall be satisfied separately by the demonstration results for base metal grading units and for overlay fabrication grading units. *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.	
Paragraph (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.	*Paragraph (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.
Paragraph (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 FSWOL is omitted from the PDI Program because it is redundant to the root mean squared (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 FSWOL program consistent with the Supplement 2 depth sizing criteria.

* The "Modification and Basis" column includes the proposed modifications formatted for the specific Code Case requirements.

TABLE 4: Modifications To Appendix VIII, Supplement 11

Current Requirements	Modification and Basis*
Paragraph (c): The RMS error of the flaw depth measurements, as compared to the true flaw depths, is less than or equal to 0.125 in.	*Paragraph (b):* The RMS error of the flaw depth measurements, as compared to the true flaw depths, is less than or equal to 0.125 in. *Basis:* By omitting the Paragraph 3.2 (b) requirement, Paragraph 3.2 (c) is reformatted and becomes 3.2 (b).

* The "Modification and Basis" column includes the proposed modifications formatted for the specific Code Case requirements.

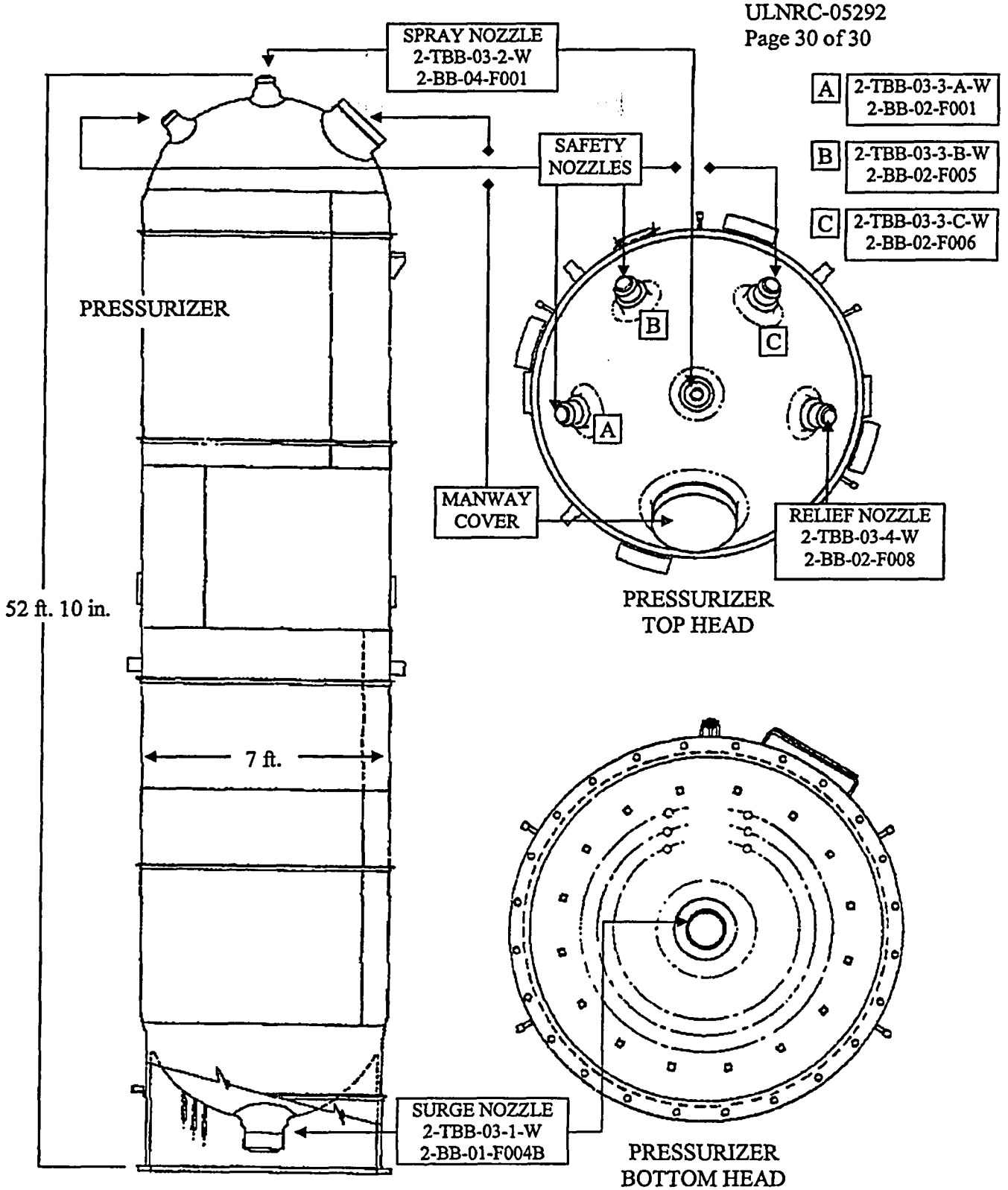

FIGURE 3: **General Callaway Pressurizer Configuration**