VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

March 13, 2007

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

Serial No. 06-1007A
NLOS /ETS
Docket Nos. 50-338/339
License Nos. NPF-4/7

VIRGINIA ELECTRIC AND POWER COMPANY (DOMINION)
NORTH ANNA POWER STATION UNIT 1 - CMP-022R1
NORTH ANNA POWER STATION UNIT 2 - CMP-023R1
SUPPLEMENTAL INFORMATION TO SUPPORT
USE OF WELD OVERLAYS AS AN ALTERNATIVE REPAIR TECHNIQUE

In a letter dated January 3, 2007 (Serial No. 06-1007), Dominion requested approval to use the proposed alternative to apply dissimilar metal weld overlays for repair/replacement activities. That request contained alternative requirements for the Inservice Inspection (ISI) program for scheduled full structural preemptive weld overlays (PWOLs) that are planned to mitigate the potential for primary water stress corrosion cracking (PWSCC) susceptibility at North Anna Units 1 and 2. Since that time, several issues associated with the application of the weld overlays have been identified by the NRC and industry experience. Based on several discussions with the NRC, this letter provides supplemental information to address those issues. Attachment 2 contains supplemented Relief Request CMP-022R1 for North Anna Unit 1 and Request CMP-023R1 for North Anna Unit 2. Enclosure 1 to Attachment 2 contains the supplemented proposed alternative, which addresses the NRC and industry issues.

The most recent industry experience involves the hot cracking of the 52M nickel alloy weld overlay on stainless steel base materials with higher levels of sulfur in the austenitic stainless steel base metal. Dominion plans to apply a weld build-up (barrier layer) of ER309L stainless steel weld metal for the majority of the length of the build-up. The final tie-in to the existing 82/182 nickel alloy weld is being performed with nickel alloy 82 weld metal. This barrier layer provides an improved base layer for application of the PWOL that has been demonstrated by mock up testing to significantly reduce the susceptibility to hot cracking of the first layer of the PWOL. This application of weld build-up is not part of the PWOL. The weld build up will be performed in accordance with the requirements of the North Anna Section XI Repair/Replacement program and ASME Section III. In a March 9, 2007 phone call to discuss the hot cracking concern, the NRC staff requested specific information regarding the application of the barrier layer. This information is provided in Attachment 1 to the letter.

PWOLs for mitigation of potential PWSCC susceptibility are scheduled for the North Anna Unit 2 spring 2007 and the North Anna Unit 1 fall 2007 refueling outages. No pre-weld overlay ultrasonic examinations are planned. This is part of the control and remediation plan for Alloy 82/182 dissimilar metal piping butt welds susceptible to potential PWSCC at North Anna Units 1 and 2.

Dominion continues to request review and approval of this request to support implementation of the alternative repair technique during the upcoming North Anna Unit 2 spring 2007 and North Anna Unit 1 fall 2007 refueling outages.

If you have any questions regarding this submittal, please contact Mr. Thomas Shaub at (804) 273-2763.

Very truly yours,

W R Matthews

William R. Matthews
Senior Vice President – Nuclear Operations

Attachment

1. Additional Information - Use Of A Barrier Layer To Mitigate Hot Cracking

2. Supplemented Alternative Request CMP-022R1 for Unit 1 and CMP-023R1 for Unit 2, Use of Weld Overlays as an Alternative Repair Technique with Enclosure 1

Commitments made in this letter:

None - Reporting will be completed in accordance with the Relief Requests.

cc: U.S. Nuclear Regulatory Commission
Region II
Sam Nunn Atlanta Federal Center
61 Forsyth Street, SW
Suite 23T85
Atlanta, Georgia 30303

Mr. J. E. Reasor, Jr.
Old Dominion Electric Cooperative
Innsbrook Corporate Center
4201 Dominion Blvd.
Suite 300
Glen Allen, Virginia 23060

Mr. J. T. Reece
NRC Senior Resident Inspector
North Anna Power Station

Mr. S. P. Lingam
NRC Project Manager
U. S. Nuclear Regulatory Commission
One White Flint North
11555 Rockville Pike
Mail Stop 8-H12
Rockville, Maryland 20852

Mr. R. E. Martin
NRC Project Manager
U. S. Nuclear Regulatory Commission
One White Flint North
11555 Rockville Pike
Mail Stop 8-H12
Rockville, Maryland 20852

Mr. M. M. Grace
Authorized Nuclear Insurance Inspector
North Anna Power Station

ATTACHMENT 1

ADDITIONAL INFORMATION
USE OF A BARRIER LAYER TO MITIGATE HOT CRACKING

NORTH ANNA POWER STATION UNITS 1 AND 2
VIRGINIA ELECTRIC AND POWER COMPANY (DOMINION)

ADDITIONAL INFORMATION
USE OF A BARRIER LAYER TO MITIGATE POTENTIAL HOT CRACKING

NRC Question

1. What is the stainless steel (SS) type for SS elbow base metal?

Dominion Response

The elbow material is type 316 stainless steel.

NRC Question

2. What is the SS filler material type for the elbow-safe/end (SE) weld?

Dominion Response

The weld filler material is type 316 stainless steel.

NRC Question

3. What does Dominion consider the difference in sulfur content between high and low sulfur content (What is too high and what maximum do we wish to achieve)?

Dominion Response

AREVA's testing has concluded that welding on 0.020 weight percent sulfur stainless steel results in cracking while welding on materials with less than 0.010 have resulted in no cracking issues. More testing would be necessary to conclude where a definitive cut off is in sulfur content for barrier layer welding. Therefore, AREVA will deposit a barrier layer on all stainless steels with sulfur content greater than 0.010 weight percent or where the sulfur content has not been determined with reasonable certainty.

NRC Question

4. If sulfur of the SS base metal may lead to cracking, when depositing the Alloy 52M filler metal, why isn't cracking expected on the carbon steel (low alloy steel nozzles)?

Dominion Response

Carbon steel is a low alloy steel which involves a different alloy system. In carbon steel, the addition of manganese ties up sulfur in manganese sulfide (MnS). MnS virtually eliminates the formation of low melting point iron sulfides that contribute to solidification cracking. To this date we have not seen this problem on low alloy steel welded with ERNiCrFe-7A (Inconel 52M).

NRC Question

5. How does Dominion expect to achieve a low sulfur content using Type 309 SS filler material when its sulfur content is similar to the Type 316L SS base metal?

Dominion Response

Weld filler material ER309L helps to promote primary solidification of the weld metal as ferrite instead of austenite. Also this approach has been fully qualified in an ASME Section IX structural welding procedure qualification. AREVA PQ7280 was qualified with ER309L material that had a sulfur content of 0.01 weight percent. PQ7280 is of special interest as it was performed on high sulfur austenitic stainless base material with a single layer of ER309L deposited in the bottom half of the groove and a single layer of E309L deposited in the top half of the groove. The groove was subsequently filled with ERNiCrFe-7A (Inconel 52M). The intent of this procedure qualification was to fully qualify the layer of ER309L between high sulfur stainless and ERNiCrFe-7A to ASME Section IX structural requirements. This 0.01 sulfur ER309L layer supported tensile tests that resulted in ultimate tensile strengths of 83 and 82.8 KSI with failures being of a ductile nature in the base material. Four transverse side bends were also performed with no indications.

In addition to the procedure qualification described above AREVA performed mockup testing (described in the response to question 11) using the same heat of filler metal as used for the PQ and planned for use at North Anna. The mockup results were also satisfactory.

NRC Question

6. Why is Dominion concerned with welding short of the A182 weld joint with SS Type 309 filler material (i.e., weld short of 182 weld joint only with 182 filler and then weld with 182 filler material)?

Dominion Response

Welding over the nickel based ENiCrFe-3 (Inconel 182) joint with an iron based ER309L electrode may cause cracking in the ER309L.

NRC Question

7. Is the difference between a structural and barrier layer the difference between welding to Section III construction code and welding to Code Case N-740, respectively?

Dominion Response

The phrase "structural weld layers" is not associated with ASME III. It is used as part of Code Case N-740 and Dominion's Enclosure 1 to indicate deposited PWOL material with sufficient Cr to prevent stress corrosion cracking. For PWR's, to mitigate/repair Inconel 82/182 weld deposit at least 24%Cr is required in the PWOL deposit. When applying the first layer of Inconel 52M PWOL over base metal with less than 24% Cr (austenitic stainless steel, Inconel 82/182) or almost no Cr (low alloy steel nozzle) the weld dilution from these materials may lower the first layer chemistry slightly below 24%. When this happens, the first layer cannot be credited as a structural layer (i.e., PWSCC resistant) and it is termed a "sacrificial layer" by Code Case N-740 and Enclosure 1. The second layer and all subsequent layers of Inconel 52M PWOL deposit exceed 24% so they are counted as structural weld layers.

The term "barrier layer" is not referenced in either Section III or Code Case N-740. It is a Dominion phrase used to describe a layer of weld metal buildup (approximately .065" thick) applied to the austenitic stainless steel pipe and safe end to reduce the amount of sulfur available for pick-up when applying the subsequent Inconel 52M PWOL. Dominion will apply this weld metal buildup utilizing ASME III as the Construction Code for the ASME XI repair/replacement activity. Final NDE of the barrier layer will utilize the methods and acceptance criteria of ASME III. The barrier layer will increase the pipe and safe end thickness and will not be utilized as part of the PWOL. The barrier layer uses filler materials expected to result in a first layer deposit analysis containing less than 24% Cr, so from a functional standpoint, it is similar to the sacrificial layer described in the paragraph above. That said, precedent exists (ASME Code Case N-504-2 and Section XI, Nonmandatory Appendix Q) that the low carbon austenitic stainless steel weld metal (with at least 7.5 ferrite number (FN) 1st layer deposit analysis or 5 FN/0.02%C 1st layer deposit analysis) would be sufficient to mitigate SCC of the underlying austenitic stainless steel base metal. An argument could be made that the barrier layer could be credited as a structural layer over the austenitic stainless steel base metal. Dominion has chosen to simplify this relief by not including the barrier layer as part of the PWOL, and not trying to take structural credit for the barrier layer as part of the PWOL.

Following application of the PWOL the barrier layer will be examined by PDI UT in accordance with Enclosure 1 as part of the outer 25% of the pipe wall.

NRC Question

8. Has or can Dominion run a Sulfur analysis on the SS to be sure there is not high levels of sulfur segregation?

Dominion Response

The segregation phenomenon is typically not surface oriented and usually occurs in the thickness of the bulk material for ASTM A-182 and A-403 materials and, as such, shouldn't be a large concern for an overlay type repair. The testing also might have little value unless the population of sample sites were quite large with little space in between sample sites. Dominion has decided to forgo testing and proactively apply the ER309L barrier layer to all the austenitic stainless steel base metals to be subsequently overlaid.

NRC Question

9. Can Dominion purchase ER309 filler with a reduced sulfur content to use as a partial barrier layer?

Dominion response

Lower sulfur material may be utilized. However, AREVA PQ7280 was qualified with ER309L material that had a sulfur content of 0.01 weight percent. Procedure qualification, PQ7280, is of special interest as it was performed on High Sulfur Stainless Base material with a single layer of ER309L deposited in the bottom half of the groove and a single layer of E309L deposited in the top half of the groove. The groove was subsequently filled with ERNiCrFe-7A (Inconel 52M). The intent of this procedure qualification was to fully qualify the layer of ER309L between high sulfur stainless and ERNiCrFe-7A to ASME Section IX structural requirements. This 0.01 sulfur ER309L layer supported tensile tests that resulted in ultimate tensile strengths of 83 and 82.8 KSI with failures being of a ductile nature in the base material. Four transverse side bends were also performed with no indications.

In addition to the procedure qualification described above AREVA NP performed mockup testing (described in the question 11 response) using the same heat of filler metal as used for the procedure qualification and planned for use at North Anna. The mockup results were also satisfactory.

NRC Question

10. Confirm that the welding of the first layer on the base metal (i.e., the barrier layer with 309 stainless steel, the piping and a short length of A182 filler metal at the dissimilar metal weld with Inconel 52 metal on the nozzle) will be qualified in accordance with ASME Section IX.

Dominion Response

The welding procedure for application of the ER309L barrier layer and ERNiCrFe-3 tie in to the original 182 weld satisfies all qualification requirements of ASME Sections III, IX, and XI. The AREVA supporting procedure qualifications are PQ7213, PQ7280 and PQ7281.

The welding procedure for application of the 52M PWOL also satisfies the qualification requirements of ASME Sections III, IX, and XI. For depositing the 52M PWOL over the ferritic nozzles the temper bead qualification requirements of Enclosure 1 are also met. The AREVA procedure qualifications supporting the 52M PWOL application are PQ7164, PQ7213, PQ7280 and PQ7281.

NRC Question

11. Could the mixture of 309SS, 182 and 52M filler material in the first layer cause any hot cracking or lack of fusion?

Dominion Response

AREVA has performed a mockup of this very scenario with excellent results. The mockup consisted of high sulfur stainless pipe (0.020 sulfur content) with an ENiCrFe-3 (Inconel 182) structural weld with filler materials ER309L (309L), ERNiCr-3 (Inconel 82) and ERNiCrFe-7A (Inconel 52M). The mockup was performed in accordance with established Welding Procedure Qualifications and Welding Procedure Specifications.

The "82" mockup has passed the following examinations with No Recordable Indications:

PT's performed on the:

- Base material
- ENiCrFe-3 Deposit
- ER309L Deposit
- ERNiCr-3 Deposit
- ERNiCrFe-7A Deposit

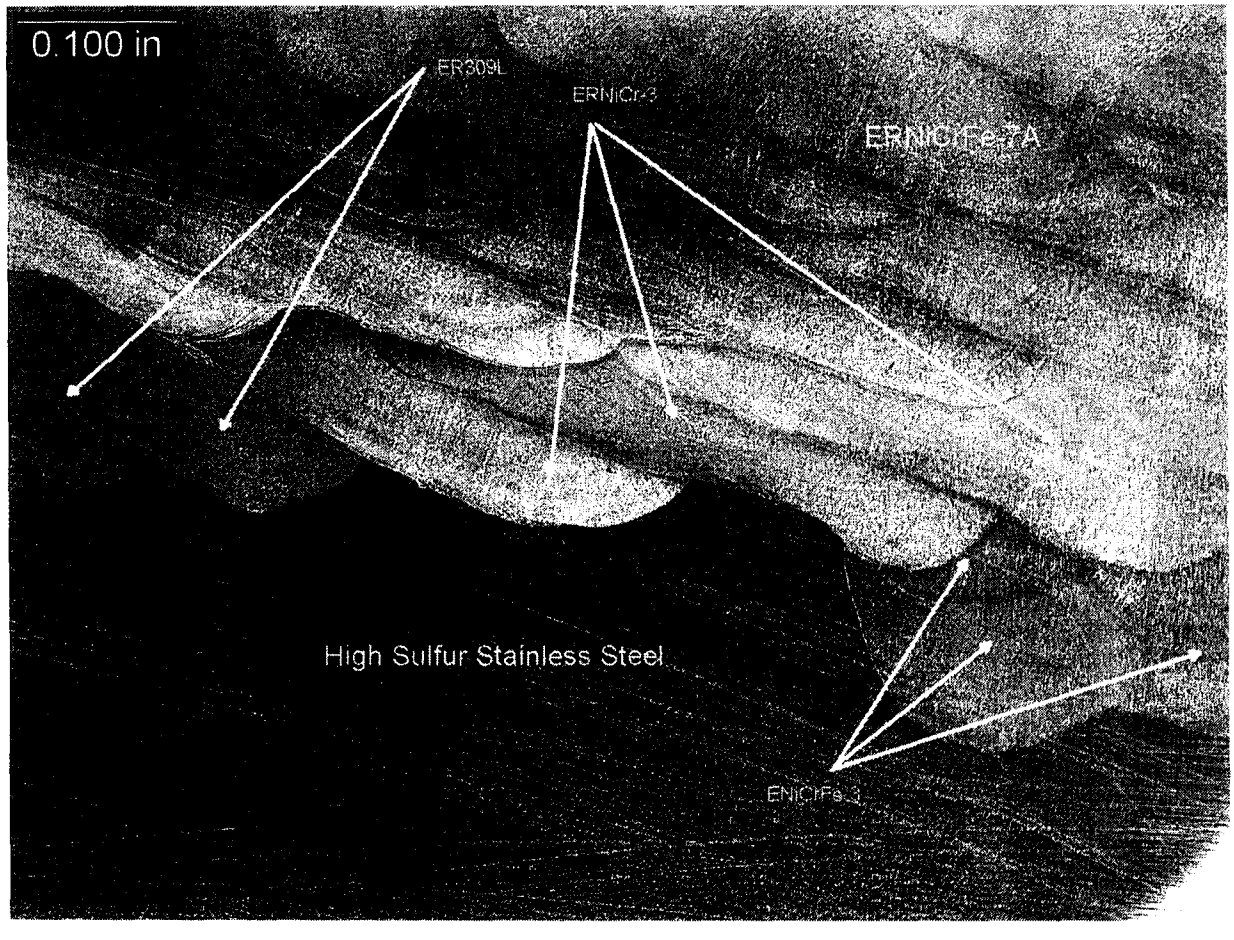
Limited Performance Demonstration Initiative (PDI) UT

- 0° Transducer with Full Coverage
- 45° Transducer with Full Coverage
- OD Creeper Transducer with Full Coverage
- 60° Transducer with limited coverage, (focal depth exceeded UT procedure allowable in places due to overlay thickness being insufficient. Only two layers of ERNiCrFe-7A were deposited.)

Initial metallographic of the mockup was performed looking for any type of discontinuity, anomalies, or flaws (single specimen with "rough" polish and etch). See Figure 1.

The "82" mockup is undergoing additional metallographic testing for a total of 8 specimens taken equidistance around the pipe being examined for any and all discontinuities, anomalies, and or flaws.

Figure 1: High Sulfur Stainless Pipe exhibiting ERNiCr-3 Deposit between ENiCrFe-3, ER309L, and ERNiCrFe-7A deposits.



ATTACHMENT 2

SUPPLEMENTED
ALTERNATIVE REQUEST CMP-022R1/023R1
USE OF WELD OVERLAYS AS AN ALTERNATIVE REPAIR TECHNIQUE

Revision Bars are included in the right margin
to identify changes from previous submittal.

NORTH ANNA POWER STATION UNITS 1 AND 2
VIRGINIA ELECTRIC AND POWER COMPANY (DOMINION)

ALTERNATIVE REQUESTS CMP-022R1/023R1
USE OF WELD OVERLAYS AS AN ALTERNATIVE REPAIR TECHNIQUE

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

- Alternative Provides Acceptable Level Of Quality And Safety -

1.0 REASON FOR THE REQUEST

Dissimilar metal welds, primarily consisting of Alloy 82/182 weld metal are frequently used in pressurized water reactor (PWR) construction to connect stainless steel pipe and safe ends to vessel nozzles, generally constructed of carbon or low alloy ferritic steel. These welds have shown a propensity for primary water stress corrosion cracking (PWSCC) degradation, especially in components subjected to higher operating temperatures, such as the pressurizer.

During the upcoming North Anna Unit 2 spring 2007 and North Anna Unit 1 fall 2007 refueling outages, six Class 1 dissimilar metal welds located on the pressurizer for each unit are currently scheduled to have full structural preemptive weld overlays (PWOLs) applied. Repair/replacement activities associated with PWOL repairs are required to address the materials, welding parameters, ALARA concerns, operational constraints, examination techniques and procedure requirements for repairs. Comprehensive and generic NRC approved criteria are, however, not currently available for application of PWOL repairs to dissimilar metal welds constructed of Alloy 82/182 weld material for mitigation of potential primary water stress corrosion cracking (PWSCC).

The welding will be performed using a remote machine gas tungsten-arc welding (GTAW) process and using the ambient-temperature temper bead method with ERNiCrFe-7A (Alloy 52M) weld metal. Manual GTAW, using ERNiCrFe-7 (Alloy 52) or Alloy 52M will be used if local repairs of weld defects are necessary or additional weld metal is required locally to form the final PWOL contour in locations at least 3/16 in. away from the low alloy steel nozzles.

2.0 CODE COMPONENTS FOR WHICH THE ALTERNATIVE IS REQUESTED

Code components associated with this request are the high safety significant (HSS) Class 1 dissimilar metal welds with Alloy 82/182 weld metal that are believed to be susceptible to PWSCC. There are six welds that are scheduled to have full structural PWOLs applied.

2.1 Category and System Details:

Code Class:	Class 1
System Welds:	Reactor Coolant System
Examination Categories:	R-A*

*Welds are included in the Risk-Informed Inservice Inspection Program

2.2 Component Descriptions:

The application of this alternative to apply PWOLs on the six potentially PWSCC susceptible safe end–to-pressurizer nozzle welds will also involve extending the weld overlay across the adjacent stainless steel pipe/fitting/elbow-to-safe end welds.

Unit 1:

1. Weld No. SW-51, 14-inch RCS Safe End Reducer-To-Surge Nozzle Weld and adjacent Pipe-to-Safe End Reducer Weld No. 39 (Pipe Identifier 14-RC-10-2501R-Q1)
2. Weld No. SW-30, 6-inch Safe End-to-Safety Nozzle-Weld and adjacent Elbow-to-Safe End Weld No. 21 (Pipe Identifier 6-RC-38-1502-Q1)
3. Weld No. SW-31, 6-inch Safe End-to-Safety Nozzle-Weld and adjacent Elbow-to-Safe End Weld No.17 (Pipe Identifier 6-RC-39-1502-Q1)
4. Weld No. SW-38, 6-inch Safe End-to-Safety Nozzle-Weld and adjacent Elbow-to-Safe End Weld No.25 (Pipe Identifier 6-RC-37-1502-Q1)
5. Weld No. SW-64, 6-inch Safe End-to-Relief Nozzle-Weld and adjacent 6X4 Concentric Reducer-to-Safe End Weld No. 30 (Pipe Identifier 4-RC-34-1502-Q1)
6. Weld No. SW-71, 4-inch Safe End-to-Spray Nozzle-Weld and adjacent Pipe-to-Safe End Weld No. 11 (Pipe Identifier 4-RC-15-1502-Q1)

Unit 2:

1. Weld No. SW-5, 14-inch RCS Safe End Reducer-To-Surge Nozzle Weld and adjacent Pipe-to-Safe End Reducer Weld No. 1 (Pipe Identifier 14-RC-410-2501R-Q1)
2. Weld No. SW-6, 6-inch Safe End-to-Safety Nozzle-Weld and adjacent Elbow-to-Safe End Weld No. 1 (Pipe Identifier 6-RC-437-1502-Q1)
3. Weld No. SW-9, 6-inch Safe End-to-Safety Nozzle-Weld and adjacent Elbow-to-Safe End Weld No. 1 (Pipe Identifier 6-RC-438-1502-Q1)
4. Weld No. SW-17, 6-inch Safe End-to-Safety Nozzle-Weld and adjacent Elbow-to-Safe End Weld No. 1 (Pipe Identifier 6-RC-439-1502-Q1)
5. Weld No. SW-40, 6-inch Safe End-to-Relief Nozzle-Weld and adjacent 6X4 Concentric Reducer-to-Safe End Weld No. 1 (Pipe Identifier 4-RC-434-1502-Q1)
6. Weld No. SW-62, 4-inch Safe End-to-Spray Nozzle-Weld and adjacent Pipe-to-Safe End Weld No. 42 (Pipe Identifier 4-RC-415-1502-Q1)

2.3 Component Materials:

1. Nozzles are (P-No. 3 Group No. 3) Low Alloy Steel SA-508 CL2
2. Safe End-to-Nozzle Weld and Buttering are Alloy 82/182 (F-No. 43)
3. Safe Ends are (P-No.8) Wrought Stainless Steel (SS) SA-182 GR F316L
4. Surge Line Pipe, Safety Line Elbows, Relief Line Reducer and Spray Line Pipe are (P-No. 8) Wrought Seamless SS and Welds are SS (A-No. 8)

3.0 CODE REQUIREMENTS FOR WHICH THE ALTERNATIVE IS REQUESTED

North Anna Unit 1 is currently in the third ten-year Inservice Inspection (ISI) interval (May 1, 1999 through April 30, 2009). The American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code of record for the current 10-year ISI interval is Section XI, 1989 Edition (Reference 1). This is also the version used for the Repair/Replacement Program.

North Anna Unit 2 is currently in the third ten-year Inservice Inspection (ISI) interval (December 14, 2001 through December 13, 2010). The American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code of record for the current 10-year ISI interval is Section XI, 1995 Edition, including Addenda through 1996 (Reference 2). This is also the version used for the Repair/Replacement Program.

IWA-4000 does not address all the necessary requirements for this type of repair. The Code requirements for which the relief is requested are contained in the following:

1. ASME Code Section XI, 1989 Edition for North Anna Unit 1 and 1995 Edition including Addenda through 1996 for North Anna Unit 2, IWA-4000.
2. ASME Code Section XI, 1989 Edition for North Anna Unit 1 and 1995 Edition including Addenda through 1996 for North Anna Unit 2, Appendix VIII, Supplement 11.

The alternative described in Section 4.0 is proposed to permit the implementation of PWOLs at North Anna Unit 1, as an alternative for the repair/replacement requirements of the ASME Code Section XI, 1989 Edition, IWA-4000 (Reference 1) and North Anna Unit 2, as an alternative for the repair/replacement requirements of the ASME Code Section XI, 1995 Edition, including Addenda through 1996, IWA-4000 (Reference 2).

The ultrasonic examination of the completed PWOLs will be accomplished in accordance with the ASME Code Section XI, 1989 Edition for North Anna Unit 1 and 1995 Edition including Addenda through 1996 for North Anna Unit 2, Appendix VIII, Supplement 11 (Reference 2) with the alternatives used for complying with the Performance Demonstration Initiative (PDI) Program. See Table 1.

4.0 PROPOSED ALTERNATIVES AND SUPPORTING INFORMATION

The mitigative weld overlay shall be applied by deposition of weld reinforcement (weld overlay) on the outside surface of the piping, component, or associated weld, including ferritic materials when necessary, provided the requirements as stated in Enclosure 1 are met. Enclosure 1, Alternative Requirements for Dissimilar Metal Welds, is submitted for NRC staff review in accordance with the provisions of 10 CFR 50.55a(a)(3)(i). This alternative is the result of the industry's experience with mitigative weld overlay repairs for flaws suspected or confirmed to be from PWSCC and for the first time directly applies to the Alloy 52 or 52M weld material that is primarily being used for these overlay repairs.

This proposed alternative is requested for implementing the six scheduled full structural PWOLs for the potentially PWSCC susceptible safe end-to-nozzle welds of the pressurizer. These PWOLs will include the adjacent stainless steel elbow/pipe/reducer-to-safe end welds. This request applies to each of the welds listed in Section 2.2, which are generically depicted in Figure 1.

A full structural PWOL (designed for the worst case flaw) will be applied in accordance with the requirements in Enclosure 1 with an ultrasonic examination following the application of the PWOL.

4.1 PWOL Assembly:

The ferritic materials of the nozzles are (P-No. 3 Group No. 3) material; the safe ends and pipe/elbow/reducers are wrought stainless steel (P-No. 8) material. The existing weld filler material is Alloy 82/182 (F-No. 43).

The ASME Committee has indicated that the inside diameter (ID) compressive stress levels remain essentially the same between 100 square inches and 500 square inches in relation to weld overlay applications. Enclosure 1 allows for installation of the PWOL using temper bead welding for up to 500 square inches over the ferritic material. The justification entitled, "Bases for 500 Sq. In. Weld Overlay Over Ferritic Material," was provided to the NRC staff in the January 10, 2007 meeting (ADAMS Accession No. ML070470565). Additional justification is provided in EPRI Report 1014351, "Repair and Replacement Applications Center: Topical Report Supporting Expedited NRC Review of Code Cases for Dissimilar Metal Weld Overlay Repairs, December 2006."

The full structural weld overlay satisfies all the structural design requirements of the pipe assuming no strength is contributed by the original safe end-to-nozzle welds or the elbow/pipe/reducer-to-safe end welds. The mitigative weld overlay is designed to meet structural requirements as if the original welds were removed. As shown in Figure 1, this structural weld overlay (weld reinforcement) will completely cover the existing Alloy 82/182 weld metal and will extend onto the ferritic and austenitic stainless steel material on each end of the weld, including the adjacent pipe/elbow/reducer-to-safe end weld. The weld overlay extends the full 360° around the nozzle.

The procedure qualification reports (PQRs) for qualification of the temperbead portion of the welds and for overlay of the buttered P3 nozzle material were performed using ERNiCrFe-7 (Alloy 52) or ERNiCrFe-7A (52M) filler metal. Both filler materials have 28.0 to 31.5% chromium (Cr), the same as the 52M filler metal that will be used for the production overlays.

Furthermore, paragraph 1(e) of Enclosure 1 states that "a diluted first 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 weld procedure specification (WPS) for the production weld." The PWOL vendor has prepared representative coupons taken from mockups prepared in accordance with the WPS (including use of 52M filler metal) for the production weld. Where the representative coupons provide a first layer Cr content less than 24%, the production weld overlay procedure will deposit a sacrificial layer of 52M filler metal over the material responsible for the excessive dilution. The sacrificial layer will not count as a structural layer of the PWOL, the layer covering the sacrificial layer will be the first layer credited as a structural PWOL layer. Where the representative coupons provide a first layer Cr content equal to or greater than 24% a sacrificial layer of 52M will not be used and the weld layer will count as a structural layer of the PWOL.

Thermocouples will be used to monitor welding preheat and interpass temperatures during application of the weld overlay. After completion of the overlay the thermocouples will be removed, the thermocouple attachment areas will be ground, and the ground areas will be subjected to a surface examination.

4.2 Weld Overlay Design:

The PWOLs will be designed as mitigative full structural overlays (assumed worst case flaw) in accordance with Enclosure 1, Section 2, therein. Crack growth calculations will be performed to demonstrate that the crack growth in the weld overlay or base metal is acceptable and that residual stress distribution in the weld overlay and original weld result in a favorable stress distribution. This is true for all nozzle structural mitigative weld overlay analyses except the portion of the ASME III analysis for the surge line weld overlay that addresses the insurge/outsurge transients. This portion of the analysis will be addressed with an engineering evaluation of insurge/outsurge transients that will use data from a DC Cook ASME Section III analysis that will qualify the design for seven heatups and cooldowns with thirty insurge/outsurge cycles. The Cook analysis is representative of the North Anna situation since the nozzles are very similar in configuration and the worst case transient severity is bounded (i.e., the Cook transient is considered more severe).

A weld shrinkage evaluation will be performed to insure the effect of weld shrinkage on other components or supports is acceptable. The evaluation will also address increased stiffness at the joint due to increased thickness in the localized area, increased weight due to the increased thickness in the localized area, and the impact on the piping due to thermal contraction caused by the weld cooling process. In addition to the weld shrinkage evaluation, mockup testing will be used to demonstrate piping movements as a result of the weld overlay application. After final installation of the pressurizer weld overlays, the actual shrinkage will be compared to the value assumed in the evaluation to insure consistency.

The North Anna pressurizer surge line nozzle-to-safe end and safe end-to-pipe welds are not included as part of the approved leak-before-break analysis.

4.3 Examinations:

The examinations will meet requirements of the alternative in Enclosure 1, excluding ultrasonic examination of the completed PWOL. The ultrasonic examination of the completed PWOL will be performed in accordance with ASME Code Section XI, 1989 Edition for North Anna Unit 1 and 1995 Edition including Addenda through 1996 for North Anna Unit 2, Appendix VIII, Supplement 11 with the alternatives used for complying with the PDI Program. See Table 1 of this attachment.

Ultrasonic examination requirements for the weld overlays are provided in Section 3 of Enclosure 1, which specifies that UT is to be performed in accordance with Section XI. Unlike ASME Section III requirements, the ASME Section XI UT examination is qualified based on performance demonstration for both personnel and procedures, and it has been proven to be capable for this application by that process. Therefore, in this application, UT in accordance with ASME Section XI requirements would be more appropriate than UT using ASME Section III requirements. Surface examination requirements of NB-5300 for the weld overlay and NB-2500 for the base material are required for this application.

The current configuration and geometric limitations of these welds does not permit an effective ultrasonic examination that will obtain the coverage (examination volume) as required by ASME Code Section XI, Appendix VIII, Supplement 10. As documented in our January 31, 2007 letter (Serial No. 07-0035), four of the six dissimilar welds on each unit have examination coverage estimates of significantly less than of the required examination volume (50%-65%). The remaining two dissimilar metal welds are estimated as capable of achieving approximately 75% to 80% of the required examination coverage. It is estimated that approximately 0.6 Rem per unit would be expended to perform the ultrasonic examinations for these two welds (for a total of 1.2 Rem). Since North Anna intends to apply full-structural overlays in accordance with Enclosure 1 which are designed for a worse case through-wall flaw that is 360 degrees in circumference, the dose received from examination of these welds would result in a hardship without a compensating increase in the level of quality and safety. Therefore, none of these welds will receive a pre-weld overlay ultrasonic examination. In addition, if welds are found with PWSCC or other unacceptable flaws during the post weld overlay ultrasonic examination, additional weld examination expansions will not be performed because there are no remaining similar trimetallic welds that are associated with the pressurizer environment that will not have been mitigated by application of the PWOL.

4.3.1 Required Activities:

The preliminary stress analysis required by the alternative will be performed prior to the outage for which the overlays are scheduled for installation and will be available on site for NRC review. The final stress analysis and the engineering evaluation of insurge/outsurge transients will be submitted to the NRC prior to entry into Mode 4. The final plastic/elastic analysis, which includes the engineering evaluation of insurge/outsurge transients for the surge line on Unit 2, will be completed and submitted to the NRC before the end of 2007.

If flaw growth in the weld overlay occurs and acceptance Standards of IWB-3514-2 cannot be met, a determination will be made to prove that the flaw is not PWSCC. If the cause is determined to be PWSCC or the cause of the flaw can not be determined, North Anna will repair the flaw and will not use IWB-3600, IWC-3600, or IWD-3600 to accept these types of flaws.

North Anna will provide: (1) the examination results of the weld overlays, and (2) a discussion of any repairs to the overlay material and/or base material and the reason for the repair within 14 days after the completion of the ultrasonic examination of weld overlay installations.

5.0 DURATION OF THE PROPOSED REQUEST

The alternative requirements of this request will be applied for the duration of up to and including the last outage of the current third 10-year ISI interval which includes inservice examination requirements of the alternative in Enclosure 1 for the six applied weld overlay locations for each unit identified Section 2.2.

6.0 REFERENCES

1. ASME Code, Section XI, 1989 Edition
2. ASME Code, Section XI, 1995 Edition, including Addenda through 1996

7.0 CONCLUSION

The proposed alternative has been developed to cover the most recent operating experience and NRC approved criteria that are associated with similar PWOL applications. Dominion considers that this alternative and the PDI Program provide an acceptable level of quality and safety, consistent with provisions of 10 CFR 50.55a(a)(3)(i).

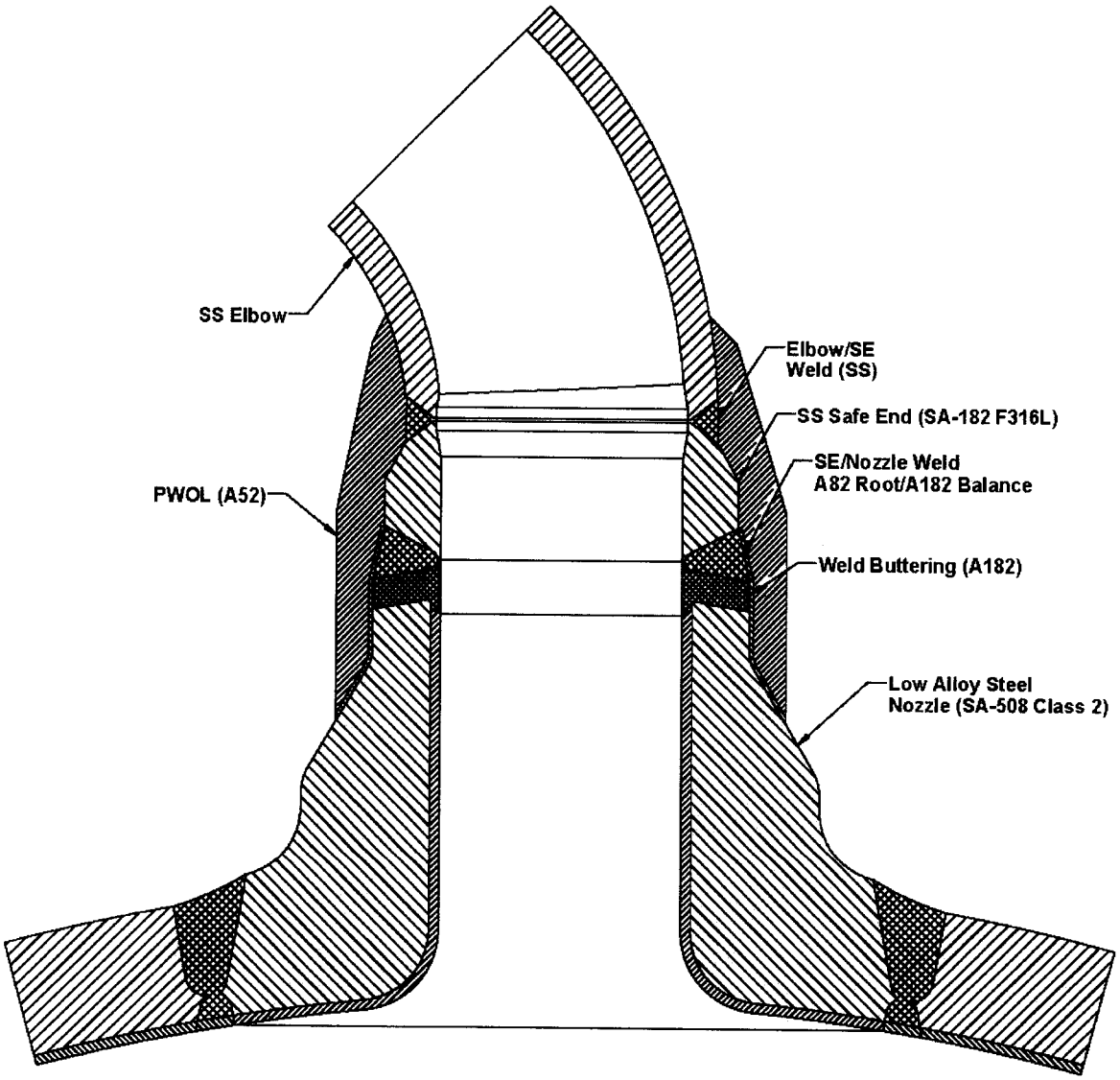


Figure 1 - Typical PWOL Configuration

TABLE 1
PDI Program Modifications to Appendix VIII Supplement 11

Appendix VIII, Supplement 11 – Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds	PDI Program: The Proposed Alternative to Supplement 11 Requirements
1.0 SPECIMEN REQUIREMENTS	
1.1 General The specimen set shall conform to the following 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 inches or larger, the specimen set must include at least one specimen 24 inches or larger, but need not include the maximum diameter. The specimen set must include at least one specimen with overlay thickness within -0.1 inches to +0.25 inches of the maximum nominal overlay thickness for which the procedure is applicable.	**Alternative:** (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 inches or larger, the specimen set must include at least one specimen 24 inches or larger, but need not include the maximum diameter. The specimen set shall include specimens with overlays not thicker than 0.1 inches more than the minimum thickness, nor thinner than 0.25 inches 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 and the phrase "and the remainder shall be alternative flaws" was added to the next to last sentence in paragraph 1.1 (d) (1).
(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	**Alternative:** (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% 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

Appendix VIII, Supplement 11 – Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds	PDI Program: The Proposed Alternative to Supplement 11 Requirements
cracking. Specimens containing IGSCC shall be used when available.	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 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)(1) 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 degrees of the pipe axial direction. The remainder shall be oriented circumferentially. Flaws shall not be open to any surface to	**Alternative:** (1) At least 20%, but less than 40%, of the base metal flaws shall be oriented within ±20 degrees 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.

Appendix VIII, Supplement 11 – Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds	PDI Program: The Proposed Alternative to Supplement 11 Requirements
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.	**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 GTA W 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 overlay grading units. Each specimen shall contain one or both types of grading units.	**Alternative:** (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)(1) A base grading unit shall include at least 3 inches 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.	**Alternative:** (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 inch 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 inch 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. 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. 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	**Alternative:** (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

Appendix VIII, Supplement 11 – Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds	PDI Program: The Proposed Alternative to Supplement 11 Requirements
the overlay metal within 1 inch of the crack location. This portion of the overlay material shall not be used as part of any overlay grading unit.	grading unit.
(a)(3) When a base grading unit is designed to be unflawed, at least 1 inch 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.	**Alternative:** (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:** 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 square inches. The overlay grading unit shall be rectangular, with minimum dimensions of 2 inches.	**Alternative:** (b)(l) An overlay fabrication grading unit shall include the overlay material and the base metal-to-overlay interface for a length of at least 1 inch. **Basis:** 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)(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 inch 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.	**Alternative:** (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:** (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	**Alternative:** (b)(3) Detection sets shall be selected

Appendix VIII, Supplement 11 – Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds	**PDI Program: The Proposed Alternative to Supplement 11 Requirements**
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.	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 flaws shall be overlay fabrication flaws. At least 40% of the flaws shall be cracks open to the inside surface.	**Alternative:** (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.
(3) Base metal cracking used for length sizing demonstrations shall be oriented circumferentially.	**Alternative:** (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 inch in the through-wall direction.	**Alternative:** (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	**Alternative:** 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.

Appendix VIII, Supplement 11 – Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds	PDI Program: The Proposed Alternative to Supplement 11 Requirements
after the performance demonstration is prohibited.	
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.	**Alternative:** 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.	**Alternative:** (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.	**Alternative:** (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.

Appendix VIII, Supplement 11 – Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds	PDI Program: The Proposed Alternative to Supplement 11 Requirements
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.	**Alternative:** Examination procedures are qualified for detection when: (a) 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. (b) At least one successful personnel demonstration has been performed meeting the acceptance criteria defined in (c). (c) 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. (d) The criteria in (b) and (c) shall be satisfied separately by the demonstration results for base metal grading units and for overlay fabrication grading units.
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.	**Alternative:** (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 inch are reported as being intrusions into the overlay material.	**Alternative:** 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.

ENCLOSURE 1
(of Attachment 2)

ALTERNATIVE REQUIREMENTS FOR DISSIMILAR METAL WELD OVERLAYS

NORTH ANNA NUCLEAR STATION UNITS 1 AND 2
VIRGINIA ELECTRIC AND POWER COMPANY

ALTERNATIVE REQUIREMENTS FOR DISSIMILAR METAL WELD OVERLAYS

In lieu of the requirements of IWA-4410 and IWA-4611, a defect in austenitic stainless steel or austenitic nickel alloy piping, components, or associated welds may be reduced to a flaw of acceptable size in accordance with IWB-3640 by addition of a repair weld overlay. Alternatively, if mitigation is performed, the weld overlay will be designed by assuming a worst case postulated flaw in accordance with IWB-3640. All Section XI references are to the 2004 Edition with the 2006 Addenda. For the use of these alternative requirements with other Editions and Addenda, refer to Table 1. The weld overlay shall be applied by deposition of weld reinforcement (weld overlay) on the outside surface of the piping, component, or associated weld, including ferritic materials when necessary, provided the following requirements are met.

1 GENERAL REQUIREMENTS

(a) A full-structural weld overlay shall be applied by deposition of weld reinforcement (weld overlay) on the outside surface of the low alloy steel nozzles (P-No. 3)-to-the safe end (P-No. 8 or 43), inclusive of the N06082 or W86182 weld that joins the two items. The design of the overlay may be extended to include the adjacent stainless steel-to-stainless steel welds (P-No. 8 to P-No. 8).

(b) These alternative requirements apply to dissimilar metal welds between P-No.8 or 43 and P-No.1, 3, 12A, 12B, or 12C[1] materials. These requirements also apply to dissimilar metal welds between P-No. 8 and P-No.43 materials joined with austenitic F-No.43 filler metal, and to welds between P–No. 8 and P-No. 8 materials as described in paragraph 1(a) above.

(c) Weld overlay filler metal shall be austenitic nickel alloy (28% Cr min., ERNiCrFe-7 or ERNiCrFe-7A) applied 360 degrees around the circumference of the item, and shall be deposited using a Welding Procedure Specification (WPS) for groove welding, qualified in accordance with the Construction Code and Owner's Requirements and identified in the Repair/Replacement Plan. As an alternative to the post weld heat treatment (PWHT) requirements of the Construction Code and Owner's requirements the following provisions may be applied.

(1) **INTENTIONALLY DELETED**

(2) Appendix I may be used for ambient-temperature temper bead welding.

(d) Prior to deposition of the weld overlay, the surface to be weld overlaid shall be examined by the liquid penetrant method. Indications larger than 1/16 in. (1.5 mm) shall be removed, reduced in size, or corrected in accordance with the following requirements.

(1) One or more layers of weld metal shall be applied to seal unacceptable indications in the area to be repaired with or without excavation. The thickness of these layers shall not be used in meeting weld reinforcement design thickness requirements. Peening the unacceptable indication prior to welding is permitted.

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[1] P-Nos. 12A, 12B, and 12C designations refer to specific material classifications originally identified in Section III and subsequently reclassified in a later Edition of Section IX.

(2) If repair of indications identified in 1(d) is required, the area where the weld overlay is to be deposited, including any local repairs or initial weld overlay layer, shall be examined by the liquid penetrant method. The area shall contain no indications greater than 1/16 in. (1.5 mm) prior to the application of the structural layers of the weld overlay.

(e) Weld overlay deposits 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 a Cr content of at least 28%. The first layer of weld metal deposited may not be credited toward the required thickness. Alternatively, for PWR applications, a diluted first 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. Alternatively, for BWR applications, a diluted first 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 20% 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.

(f) These alternative requirements are only for welding in applications predicted not to have exceeded thermal neutron fluence of 1 x 1017 (E< 0.5 eV) neutrons per cm2 prior to welding.

(g) A new weld overlay shall not be installed over the top of an existing weld overlay that has been in service.

2 CRACK GROWTH AND DESIGN

(a) Crack Growth

The size of all flaws detected or postulated in the original weldment shall be projected to the end of the expected life of the overlay. Crack growth due to both stress corrosion and fatigue shall be evaluated. Flaw characterization and evaluation shall be based on the ultrasonic examination results.

(1) For repair overlays, the initial flaw size for crack growth shall be based on the as-found flaw.

(2) For mitigative overlays, the initial postulated flaw size for crack growth shall be assumed consistent with the examinations performed, either pre or post overlay. The axial flaw length shall be set at 1.5 inches (38 mm) or the combined width of the weld plus buttering, whichever is greater. The circumferential flaw length shall be assumed to be 360 degrees.

(a) If an examination is performed prior to application of the overlay, which is qualified in accordance with Appendix VIII, Supplement 11 and no inside surface connected planar flaws are discovered, initial flaws (originated from the inside

surface of the weldment) equal to 10% of the original wall thickness shall be assumed in both the axial and circumferential directions.

(b) If no examination is performed prior to application of the overlay, initial flaws equal to at least 75% **(NORTH ANNA USES 100%)** through the original wall thickness shall be assumed, in both the axial and circumferential directions, consistent with the overlay inservice inspection volume in Fig. 2.

(c) There may be circumstances in which an overlay examination is performed using an ultrasonic examination procedure, which is qualified in accordance with Appendix VIII, Supplement 11 for depths greater than the outer 25% of the original wall thickness (Fig. 2). For such cases, initial flaw sizes may be assumed consistent with the depth to which the examination procedure is qualified.

(d) Any inside surface connected planar flaw found by the overlay preservice inspection of paragraph 3*(b)*, which exceed the depth of *(a)*, *(b)* or (c) above, shall be used as the initial flaw depth in determining the expected life of the overlay. Overlays meeting this condition shall be considered a repair.

***(b)* Structural Design and Sizing of the Overlay**

The design of the weld overlay shall satisfy the following using the assumptions and flaw characterization restrictions in 2(a). The following design analysis shall be completed in accordance with IWA-4311.

(1) The axial length and end slope of the weld overlay shall cover the weld and the heat affected zones on each side of the weld, and shall provide for load redistribution from the item into the weld overlay and back into the item without violating applicable stress limits of NB-3200, or the Construction Code. Any laminar flaws in the weld overlay shall be evaluated in the analysis to ensure that load redistribution complies with the above. These requirements will usually be satisfied if the weld overlay full thickness length extends axially beyond the projected flaw by at least $0.75\sqrt{Rt}$, where R is the outer radius of the item and t is the nominal wall thickness of the item.

(2) Unless specifically analyzed in accordance with 2(b)(1), the end transition slope of the overlay shall not exceed 30 degrees. A slope of not more than 1:3 is recommended.

(3) For determining the combined length of circumferentially-oriented flaws in the underlying base material or weld, multiple flaws shall be treated as one flaw of length equal to the sum of the lengths of the individual flaws characterized in accordance with IWA-3300.

(4) For circumferentially-oriented flaws in the underlying base material or weld, the flaws shall be assumed to be 100% through the original wall thickness of the item for the entire circumference of the item.

(5) For axial flaws in the underlying base material or weld, the flaws shall be assumed to be 100% through the original wall thickness of the item for the entire axial length of the flaw or combined flaws, as applicable for the entire circumference.

(6) For mitigative full structural overlays, the assumed flaw in the underlying base material or weld is to be based on the limiting case of the two below:

(a) 100% through wall for the entire circumference, or

(b) 100% through wall for 1.5 in. (38 mm) or the combined width of the weld plus buttering, whichever is greater, in the axial direction for the entire circumference.

(7) The overlay design thickness shall be based on the measured circumference, using only the weld overlay thickness conforming to the deposit analysis requirements of 1(e). The combined wall thickness at the weld overlay, **(INTENTIONALY DELETED)**, and the effects of any discontinuities (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, including the flaw size assumptions defined in *2(b)(4), (5),* or *(6)* above, shall be evaluated and shall meet the requirements of IWB-3640, IWC-3640 or IWD-3640 as applicable.

(8) The effects of any changes in applied loads, as a result of weld shrinkage from the entire overlay, on other items in the piping system (e.g., support loads and clearances, nozzle loads, changes in system flexibility and weight due to the weld overlay) shall be evaluated. Existing flaws (not in the weld overlay), previously accepted by analytical evaluation, shall be evaluated in accordance with IWB-3640, IWC-3640, or IWD-3640 as applicable.

3 EXAMINATION

In lieu of all other examination requirements, the examination requirements of this alternative shall be met. Nondestructive examination methods shall be in accordance with IWA-2200, except as specified herein. Nondestructive examination personnel shall be qualified in accordance with IWA-2300. Ultrasonic examination procedures and personnel shall be qualified in accordance with Appendix VIII, Supplement 11.

(a) Acceptance Examination

(1) The weld overlay shall have a surface finish of 250 micro-in. (6.3 micrometers) RMS or better and a flatness that is sufficient to allow for adequate examination in accordance with procedures qualified per Appendix VIII. The weld overlay shall be examined to verify acceptable configuration.

(2) The weld overlay and the adjacent base material for at least ½ in. (13 mm) from each side of the weld shall be examined using the liquid penetrant method. The weld overlay shall satisfy the surface examination acceptance criteria for welds of the Construction Code or NB-5300. The adjacent base metal shall satisfy the surface examination acceptance criteria for base material of the Construction Code or NB-2500. If ambient-temperature temper bead welding is used, the liquid penetrant examination shall be conducted at least 48 hours after the completed overlay has returned to ambient temperature.

The acceptance examination volume, A-B-C-D, in Fig.1(a) shall be ultrasonically examined to assure adequate fusion (i.e., adequate bond) with the base metal and to detect welding flaws, such as interbead lack of fusion, inclusions, or cracks. The interface C-D shown between the overlay and the weld includes the bond and the heat affected zone from the overlay. If ambient-temperature temper bead welding is used, the ultrasonic examination shall be conducted at least 48 hours after the completed overlay has returned to ambient temperature. Planar flaws detected in

the weld overlay acceptance examination shall meet the preservice examination standards of Table IWB-3514-2. In applying the acceptance standards to planar indications within the volume, E-F-G-H, in Fig. 1(b), the thickness "t1" shall be used as the nominal wall thickness in Table IWB-3514-2. For planar indications outside this examination volume, the nominal wall thickness shall be "t_2" as shown in Fig. 1(c), for volumes A-E-H-D and F-B-C-G.

Laminar flaws shall meet the following.

(a) Laminar flaws shall meet the acceptance standards of Table IWB-3514-3 with the additional limitation that the total laminar flaw shall not exceed 10% of the weld surface area and that no linear dimension of the laminar flaw area exceeds 3.0 in. (76 mm), or 10% of the nominal pipe circumference, whichever is greater.

(b) The reduction in coverage of the examination volume, A-B-C-D in Fig. 1(a) due to laminar flaws shall be less than 10%. The uninspectable volume is the volume in the weld overlay underneath the laminar flaws for which coverage cannot be achieved with angle beam examination.

(c) Any uninspectable volume in the weld overlay shall be assumed to contain the largest radial planar flaw that could exist within that volume. This assumed flaw shall meet the preservice examination standards of Table IWB-3514-2, with nominal wall thickness as defined above for planar flaws. Alternately, the assumed flaw shall be evaluated and meet the requirements of IWB-3640, IWC-3640, or IWD-3640 as applicable. Both axial and circumferential planar flaws shall be assumed.

(3) After completion of all welding activities, affected restraints, supports, and snubbers shall be VT-3 visually examined to verify that design tolerances are met.

***(b)* Preservice Inspection**

(1) The examination volume in Fig. 2 shall be ultrasonically examined. The angle beam shall be directed perpendicular and parallel to the piping axis, with scanning performed in four directions, to locate and size any cracks that might have propagated into the upper 25% of the base material or into the weld overlay.

(2) The preservice examination acceptance standards of Table IWB-3514-2 shall be met for the weld overlay. In applying the acceptance standards, wall thickness, t_w, shall be the thickness of the weld overlay. Cracks in the outer 25% of the base metal shall meet the design analysis requirements of 2 (b).

(3) The flaw evaluation rules of IWB-3640, IWC-3640 or, IWD-3640 shall not be applied to indications identified during preservice examination, which exceed the preservice examination standards of Table IWB-3514-2.

***(c)* Inservice Inspection**

(1) The weld overlay examination volume in Fig. 2 shall be added to the inspection plan and ultrasonically examined during the first or second refueling outage following application.

(2) Alternatively, for mitigative weld overlays, in which examinations are performed in accordance with 2(a)*(2)*(a), 3*(a)*, and 3*(b)*, and no inside surface connected planar

flaws are discovered, the overlay may be placed directly into the population to be examined in accordance with (c)*(5)* below.

(3) The weld overlay examination volume in Fig. 2 shall be ultrasonically examined to determine if any new or existing cracks have propagated into the upper 25% of the base material or into the overlay. The angle beam shall be directed perpendicular and parallel to the piping axis, with scanning performed in four directions.

(4) The inservice examination acceptance standards of Table IWB-3514-2 shall be met for the weld overlay. If the acceptance criteria of Table IWB-3514-2 cannot be met, the acceptance criteria of IWB-3600, IWC-3600, or IWD-3600 as applicable shall be met for the weld overlay. Cracks in the outer 25% of the base metal shall meet the design analysis requirements of Section 2*(b)*.

(5) Weld overlay examination volumes in Fig. 2 that show no indication of crack growth or new cracking shall be placed into a population to be examined on a sample basis. Twenty-five percent of this population shall be examined once every 10 years.

(6) If inservice examinations reveal crack growth, or new cracking, which meet the acceptance criteria of IWB-3514, IWB-3600, IWC-3600, or IWD-3600 the weld overlay examination volume shall be reexamined during the first or second refueling outage following discovery of the growth or new cracking.

(7) For weld overlay examination volumes with unacceptable indications according to 3*(c)(4)*, the weld overlay shall be removed, including the original defective weld, and the item shall be corrected by a repair/replacement activity in accordance with IWA-4000.

***(d)* Additional Examinations**

If inservice examinations reveal an unacceptable indication according to 3(c)(4), crack growth into the weld overlay design thickness, or axial crack growth beyond the specified examination volume, additional weld overlay examination volumes, equal to the number scheduled for the current inspection period, shall be examined prior to return to service. If additional unacceptable indications are found in the second sample, a total of 50% of the total population of weld overlay examination volumes shall be examined prior to operation. If additional unacceptable indications are found, the entire remaining population of weld overlay examination volumes shall be examined prior to return to service.

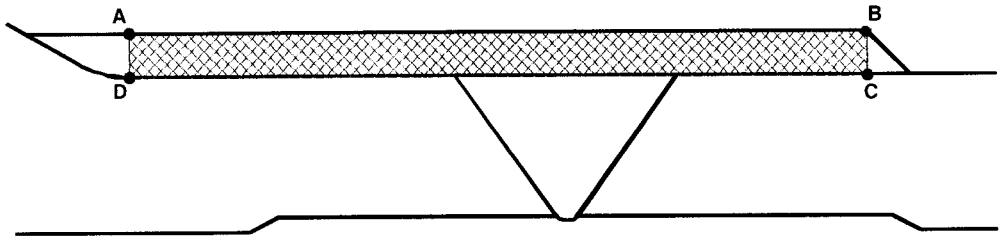
4 PRESSURE TESTING

A system leakage test shall be performed in accordance with IWA-5000.

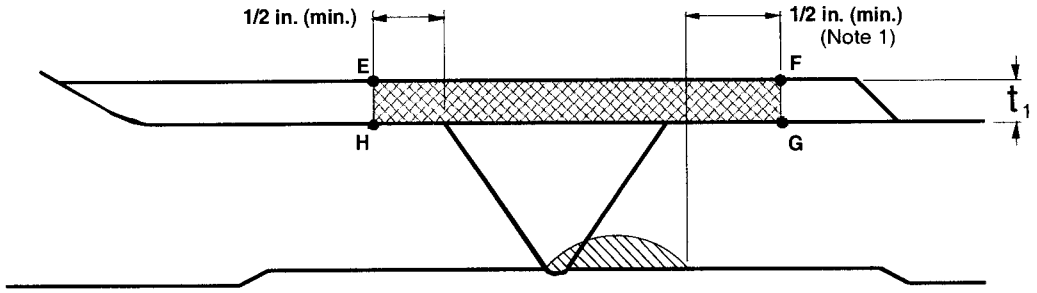
5 DOCUMENTATION

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

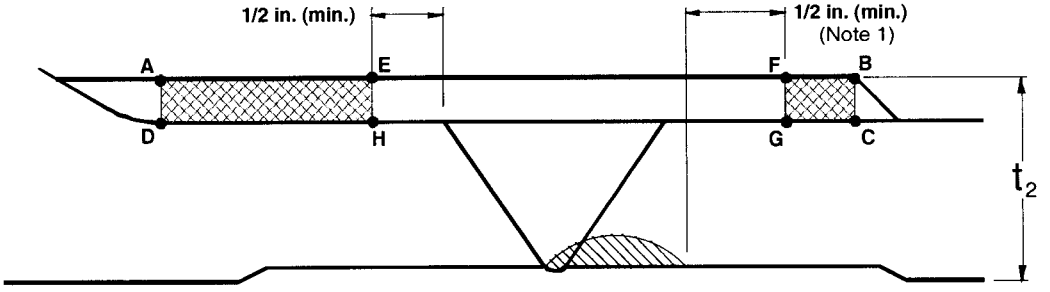
FIG. 1 ACCEPTANCE EXAMINATION VOLUME AND THICKNESS DEFINITIONS



a. Acceptance Examination Volume A-B-C-D



b. Thickness (t1) for Table IWB-3514-2



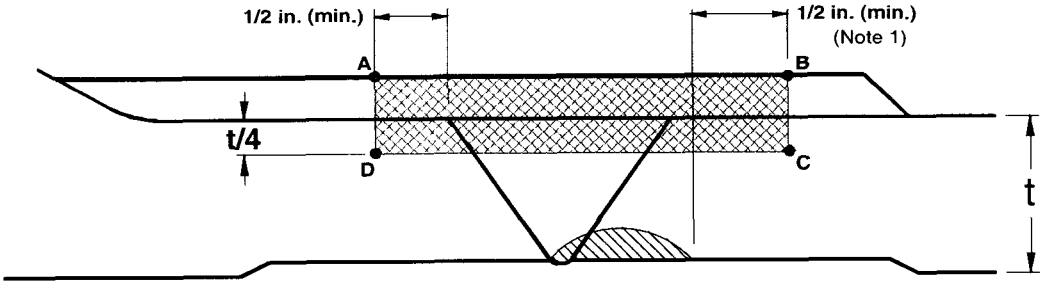
c. Thickness (t2) for Table IWB-3514-2

NOTES:

(1) For axial or circumferential flaws, the axial extent of the examination volume shall extend at least ½ in.(13mm) beyond the toes of the original weld.

(2) The weld includes the weld end butter, where applied.

FIG. 2 PRESERVICE AND INSERVICE EXAMINATION VOLUME



Examination Volume A-B-C-D

NOTES:

(1) For axial or circumferential flaws, the axial extent of the examination volume shall extend at least ½ in. (13mm) beyond the as-found flaw and at least ½ in. (13mm) beyond the toes of the original weld.

(2) The weld includes weld end butter, where applied.

MANDATORY APPENDIX I

AMBIENT-TEMPERATURE TEMPER BEAD WELDING

1 GENERAL REQUIREMENTS

(a) This appendix applies to dissimilar austenitic filler metal welds between P-No. 1, 3, 12A, 12B, and 12C1 materials and their associated welds and welds joining P-No. 8 or 43 materials to P-No. 1, 3, 12A, 12B, and 12C1 materials with the following limitation: This Appendix shall not be used to repair SA-302 Grade B material unless the material has been modified to include from 0.4% to 1.0% nickel, quenching and tempering, and application of a fine grain practice.

(b) The maximum area of an individual weld overlay based on the finished surface over the ferritic base material shall be 500 sq. in. (325,000 sq. mm).

(c) Repair/replacement activities on a dissimilar-metal weld in accordance with this Appendix are limited to those along the fusion line of a nonferritic weld to ferritic base material on which 1/8 in. (3 mm), or less of nonferritic weld deposit exists above the original fusion line.

(d) If a defect penetrates into the ferritic base material, repair of the base material, using a nonferritic weld filler material, may be performed in accordance with this Appendix, provided the depth of repair in the base material does not exceed 3/8 in. (10mm).

(e) Prior to welding, the area to be welded and a band around the area of at least 1-1/2 times the component thickness or 5 inches (130 mm), whichever is less, shall be at least 50°F (10°C).

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

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

2 WELDING QUALIFICATIONS

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

2.1 Procedure Qualification

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

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

(c) The maximum interpass temperature for the first three layers of the test assembly shall be 150°F (66°C).

(d) The test assembly cavity depth shall be at least 1 inch (25 mm). The test assembly thickness shall be at least twice the test assembly cavity depth. The test assembly shall be large enough to permit removal of the required test specimens. The test assembly dimensions surrounding the cavity shall be at least the test assembly thickness and at least 6 inches (150 mm). The qualification test plate shall be prepared in accordance with Fig. 1-1.

(e) Ferritic base material for the procedure qualification test shall meet the impact test requirements of the Construction Code and Owner's Requirements. If such requirements are not in the Construction Code and Owner's Requirements, the impact properties shall be determined by Charpy V-notch impact tests of the procedure qualification base material at or below the lowest service temperature of the item to be repaired. The location and orientation of the test specimens shall be similar to those required in 2.1(f) below, but shall be in the base metal.

(f) Charpy V-notch tests of the ferritic heat-affected zone (HAZ) shall be performed at the same temperature as the base metal test of 2.1(e) above. Number, location, and orientation of test specimens shall be as follows:

(1) The specimens shall be removed from a location as near as practical to a depth of one-half the thickness of the deposited weld metal. The coupons for HAZ impact specimens shall be taken transverse to the axis of the weld and etched to define the HAZ. The notch of the Charpy V-notch specimen shall be cut approximately normal to the material surface in such a manner as to include as much HAZ as possible in the resulting fracture. When the material thickness permits, the axis of a specimen shall be inclined to allow the root of the notch to be aligned parallel to the fusion line.

(2) If the test material is in the form of a plate or a forging, the axis of the weld shall be oriented parallel to the principal direction of rolling or forging.

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

(h) The average lateral expansion value of the three HAZ Charpy V-notch specimens shall be equal to or greater than the average lateral expansion value of the three unaffected base metal specimens. However, if the average lateral expansion value of the HAZ Charpy V-notch specimens is less than the average value for the unaffected base metal specimens and the procedure qualification meets all other requirements of this appendix, either of the following shall be performed:

(1) The welding procedure shall be requalified.

(2) **INTENTIONALLY DELETED**

2.2 Performance Qualification

Welding operators shall be qualified in accordance with Section IX.

3 WELDING PROCEDURE REQUIREMENTS

The welding procedure shall include the following requirements:

(a) The weld metal shall be deposited by the automatic or machine GTAW process.

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

(c) The area to be welded shall be buttered with a deposit of at least three layers to achieve at least 1/8 inch (3mm) overlay thickness with the heat input for each layer controlled to within ±10% of that used in the procedure qualification test. The heat input of the first three layers shall not exceed 45,000J/in. (1,800 kJ/mm) under any conditions. Particular care shall be taken in the placement of the weld layers of the austenitic overlay filler material at the toe of the overlay to ensure that the HAZ and ferritic base metal are tempered. Subsequent layers shall be deposited with a heat input not exceeding that used for layers beyond the third layer in the procedure qualification.

(d) The maximum interpass temperature for field applications shall be 350°F (180°C) for all weld layers regardless of the interpass temperature used during qualification. The interpass temperature limitation of QW-406.3 need not be applied.

(e) The interpass temperature shall be determined by:

(1) Temperature measurement (e.g. pyrometers, temperature-indicating crayons, thermocouples) during welding. When it is impractical to use interpass temperature measurements described in this paragraph due to situations where the weldment area is not accessible, such as internal bore welding or when there are extenuating radiological concerns, either paragraph 3(e)(2) or paragraph 3(e)(3) may be used.

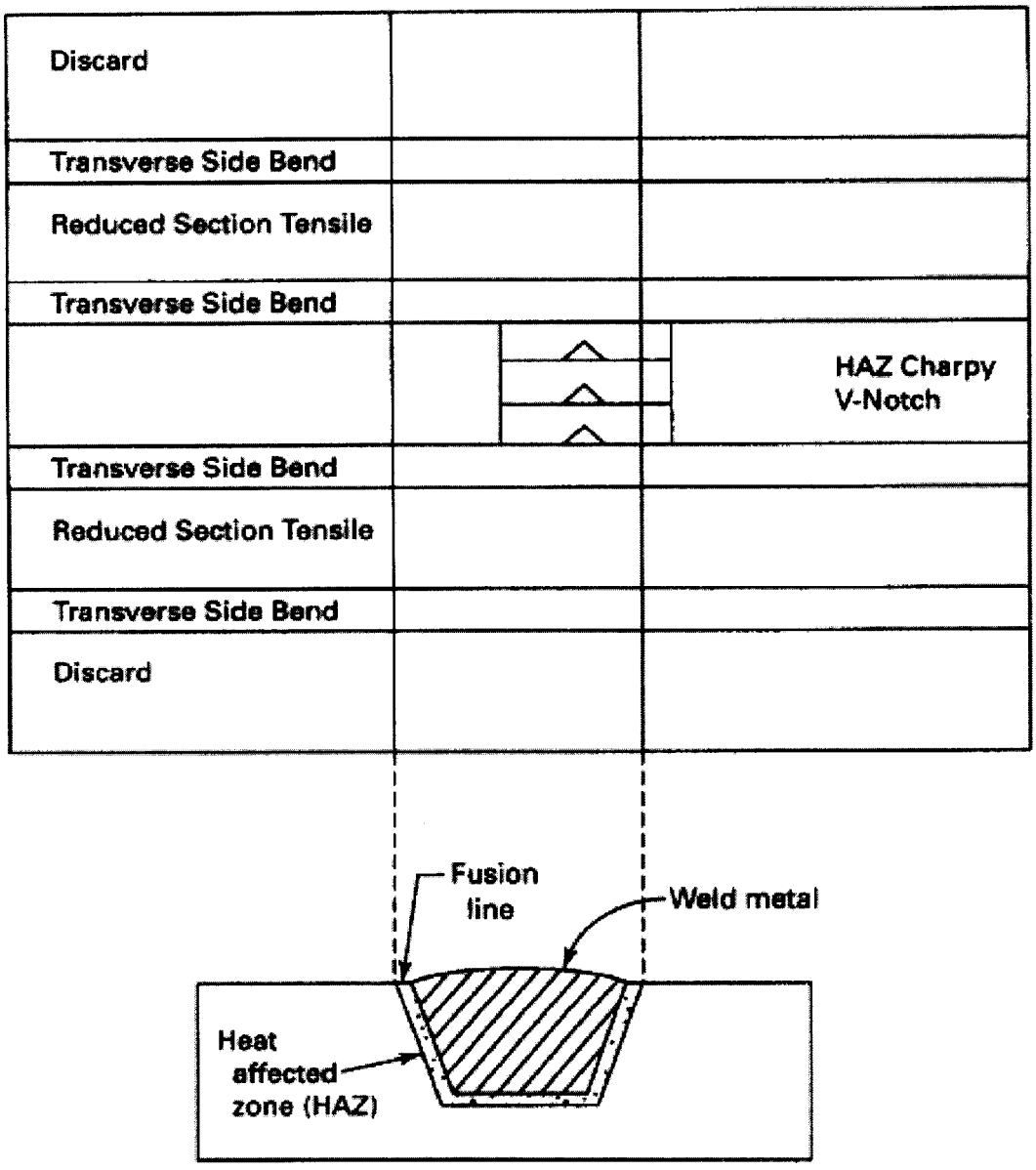
(2) Heat-flow calculations using the variables listed below as a minimum:

(i) welding heat input
(ii) initial base material temperature
(iii) configuration, thickness, and mass of the item being welded
(iv) thermal conductivity and diffusivity of the materials being welded
(v) arc time per weld pass and delay time between each pass
(vi) arc time to complete the weld

(3) Measurement of the maximum interpass temperature on a test coupon that is equal to or less than the thickness of the item to be welded. The maximum heat input of the welding procedure shall be used in the welding of the test coupon.

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

FIGURE. I-1 QUALIFICATION TEST PLATE



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

TABLE 1 REFERENCES FOR ALTERNATIVE EDITIONS AND ADDENDA OF SECTION XI

2001 Edition with 2003 Addenda through 2004 Edition with 2006Addenda	1995 Edition with 1996 Addenda through 2001 Edition with 2002 Addenda	1995 Edition with 1995 Addenda	1989 Edition with 1991 Addenda through 1995 Edition	1986 Edition with 1988 Addenda through 1989 Edition with 1990 Addenda
IWA-4000 Repair/Replacement Activities	IWA-4000	IWA-4000	IWA-4000	IWA-4000 & IWA-7000
IWA-4311 Configuration Changes	IWA -4311	IWA -4311	NA	NA
IWA-4410 Welding, Brazing, Metal Removal, and Installation – General Requirements	IWA 4410	IWA 4410	IWA 4170	IWA 4120
IWA-3300 Flaw Characterization	IWA-3300	IWA-3300	IWA-3300	IWA-3300
IWA-4611 Defect Removal	IWA-4611	IWA-4421 & IWA-4424	IWA-4170(b)	IWA-4120
IWB-3514 Standards for Category B-F	IWB-3514	IWB-3514	IWB-3514	IWB-3514
IWB/C/D –3600 Analytical Evaluation	IWB/C-3600	IWB/C-3600	IWB/C-3600	IWB/C-3600
IWB/C/D-3640 Evaluation Procedures	IWB/C-3640 or IWB/C-3650	IWB/C-3640 or IWB/C-3650	IWB/C-3640 or IWB/C–3650*	IWB/C–3640

*** Starting with the 1989 Edition with the 1989 Addenda**