November 06, 2010

NG-10-0559
10 CFR 50.55a(a)(3)(i)

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

Duane Arnold Energy Center
Docket No: 50-331
Op. License No: DPR-49

Alternative to ASME Section XI Requirements to Use Structural Weld Overlay Repairs as an Alternative Repair Technique at the Duane Arnold Energy Center

Reference: Letter to USNRC from G. Van Middlesworth, "Alternative to ASME Section XI Repair Requirements to use Code Case N-504-2 and N-638-1 for Weld Overlay Repairs at the Duane Arnold Energy Center" dated February 24, 2007 (NG-07-0176) (ML070660482)

Pursuant to 10 CFR 50.55a(a)(3)(i), NextEra Energy Duane Arnold, LLC (hereafter, NextEra Energy Duane Arnold) requests NRC authorization of an alternative to the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, Rules for Inservice Inspection of Nuclear Power Plant Components. The Duane Arnold Energy Center (DAEC) Inservice Inspection (ISI) Program complies with the requirements of the ASME Code Section XI, 2001 Edition with Addenda through 2003. This proposed alternative would permit the use of a full structural weld overlay repair for an indication identified in the N2A Recirculation Inlet Safe End to Safe End Extension Dissimilar Metal Weld (RRA-F002A). The DAEC is currently in its fourth ten-year ISI interval, which began on November 1, 2006 and will end concurrent with the DAEC Operating License on February 21, 2014. Consequently, the requested relief is for the remainder of the current ten-year interval. Enclosure 1 to this letter contains that request for relief.

During the current DAEC refueling outage (RFO22), weld inspections were being performed in accordance with the DAEC fourth ten-year interval ISI program. The original scope of examinations included three recirculation riser safe-end-to-safe-end extension welds (RRA-F002A, RRC-F002A, and RRE-F002A). These inspections identified a new indication in the RRA-F002A Recirculation Inlet Safe End to Safe End Extension Weld.

While the determination of the formal root cause is being tracked in the Corrective Action Program (CR00591178), the preliminary assessment is that the indication is due to Stress Corrosion Cracking (SCC). As part of extent of condition, in accordance with BWRVIP-75, three additional recirculation riser safe-end-to-safe-end extension (F002A) welds have been ultrasonically examined (RRF-F002A, RRG-F002A, and RRH-F002A). The preliminary assessment of these additional exams is that there are no indications requiring weld overlay repair.

10CFR50.55a(a)(3)(i) states that proposed alternatives may be used when authorized by the Director of the Office of Nuclear Reactor Regulation provided that the proposed alternatives provide an acceptable level of quality and safety. NextEra Energy Duane Arnold hereby requests NRC authorization to use an alternative repair technique to perform repair activities on the RRA-F002A Recirculation Inlet Safe End to Safe End Extension Weld as provided in the enclosure to this letter.

The enclosed relief request is similar to that previously submitted by FPL Energy Duane Arnold[1] in the referenced letter, "Alternative to ASME Section XI Repair Requirements to use Code Case N-504-2 and N-638-1 for Weld Overlay Repairs at the Duane Arnold Energy Center," which was approved by the Staff on June 12, 2007. (ML071110007)

In addition, the NextEra Energy Duane Arnold request is similar to other recent requests for dissimilar metal weld overlays, both Boiling Water Reactors (BWRs) (e.g., Pilgrim Nuclear Power Station – ML092370549) and Pressurized Water Reactors (PWRs) (e.g., Seabrook Station - ML081000008), with the noted exception that the NextEra Energy Duane Arnold request will not rely upon Code Case N-638-1. And while the enclosed request is not pre-emptive, many of the same requirements are common in the Staff's approval for the Materials Reliability Program (MRP) topical report (MRP-169), for full structural weld overlays (ML101660468).

NextEra Energy Duane Arnold requests verbal approval of this request prior to beginning the ASME Class I Leakage Test of the Reactor Pressure Vessel, currently scheduled for November 16, 2010.

This letter contains the following new commitments.

1) NextEra Energy Duane Arnold will perform an additional ultrasonic examination (UT) of the RRA-F002A weld prior to start-up from the current refuel outage (RFO22) following Mechanical Stress Improvement Process (MSIP), if performed, on the adjacent RRA-F002 weld.
2) NextEra Energy Duane Arnold will perform the required UT of the RRA-F002A/RRA-J003 weld overlay during the next refuel outage (RFO23), currently scheduled for fall of 2012, and this exam will include the RRA-F002 weld, if MSIP has been applied to that weld during RFO22.

Questions regarding this matter should be directed to Steve Catron, Licensing Manager, at (319) 851-7234.

Christopher R. Costanzo

Christopher R. Costanzo
Vice President, Duane Arnold Energy Center
NextEra Energy Duane Arnold, LLC

Enclosure

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[1] By License Amendment No. 275, the licensee name for the Duane Arnold Energy Center was legally changed from FPL Energy Duane Arnold, LLC to NextEra Energy Duane Arnold, LLC.

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Relief Request NDE-R014

1.0 Component Identification

Code Classes:	1
References:	ASME Code Section XI, 2001 Edition, including Addenda through 2003 ASME Section XI, Case N-504-4 NUREG-0313, Rev 2 Generic Letter 88-01 BWRVIP-75 DAEC Fourth Ten Year IS1 Plan – NRC Approved Relief Request NDE-R002, "Relief to use the PDI Program for Implementation of Appendix VIII, Supplement II requirements," (ML070090357)
Examination Category:	R-A
Item Number:	R1.16
Description:	Alternative Repair for the RRA-F002A Recirculation Inlet Safe End to Safe End Extension Weld
Component Numbers:	RRA-F002A Recirculation Inlet Safe End to Safe End Extension Weld and RRA-J003 Recirculation Safe End Extension to Pipe Weld

2.0 Applicable Code Edition and Addenda

ASME Code Section XI, 2001 Edition, including Addenda through 2003

3.0 Applicable Code Requirement

The applicable Code requirement for which relief is requested is ASME Code Section XI, 2001 Edition including Addenda through 2003, IWA-4410 and IWA-4611.

IWA-4410 states in part the following: “Welding, brazing, defect removal, metal removal by thermal methods, and installation shall be performed in accordance with the requirements of this Subarticle.”

IWA-4611(a) states in part the following: “Defects shall be removed in accordance with IWA-4422.1.”

4.0 Reason for Alternative

Dissimilar metal welds (DMWs), primarily consisting of Alloy 82/182 weld metal are frequently used in boiling water reactor (BWR) construction to connect stainless or Inconel safe ends to vessel and pipe nozzles, generally constructed of carbon or low alloy ferritic steel. These welds have shown a propensity for intergranular stress corrosion cracking (IGSCC) degradation in Boiling Water Reactor (BWR) environments.

This request is based on restoring the structural integrity of the RRA-F002A weld joint using technically sound welding practices and non-destructive examination (NDE), while limiting repair personnel exposure to the maximum extent practical. The following cited Code article identifies the actions that would be required if the repair were conducted in accordance with the Code without exception.

IWA-4421(a) requires defect removal in this case. The repair cavity would extend through wall since outer diameter (OD) removal would be required. Internal diameter (ID) removal of the indication would be impractical since it would require the removal of the thermal sleeve and jet pump riser from the reactor interior.

5.0 Proposed Alternative and Basis for Use

A full structural weld overlay repair is proposed for the safe-end-to-safe-end-extension weldment. The safe-end is Alloy 600 SB-166 austenitic nickel base Inconel forging (ASME Section II SB-166). The safe-end-extension is SA-336 Class F8 austenitic stainless steel forging (304 stainless steel). The full structural weld overlay will be extended beyond the safe end extension to stainless steel pipe weld to allow for ultrasonic examination of both of the welds, see Figure 1.

The weld overlay will be designed consistent with the requirements of NUREG-0313, Revision 2 (which was implemented by Generic Letter (GL) 88-01), the requirements specified in Attachment 1, and IWB-3640, ASME Section XI 2001 Edition, including Addenda through 2003 with Appendix C.

This proposed alternative (Attachment 1) is the result of industry's experience with weld overlay modifications for flaws suspected or confirmed to be caused by stress corrosion cracking and directly applies Alloy 52 or 52M weld material that is primarily being used for these weld overlays.

The ultrasonic examination of the completed overlay will be accomplished with personnel and procedures qualified in accordance with ASME Code, Section XI, 2001 Edition, for Appendix VIII, Supplement 11 (as approved by the NRC in Relief Request NDE-R002 (ML070090357)).

<u>Structural Weld Overlay Design</u>

The weld overlay satisfies all the structural design requirements of the pipe as specified in the Alternative Requirements shown in Attachment 1 for the original safe-end to safe-end extension welds. In particular, the design of the overlay will consider all the identified flaws, circumferential and axial, found during the initial UT examination. As shown in Figure 1, the weld overlay will completely cover the existing weld and will extend the Inconel safe-end and austenitic safe-end extension for the RRA-F002A. The weld overlay extends around the entire circumference from the vessel side of the safe end covering the safe-end extension and the safe end extension to stainless steel pipe weld and a distance onto the Type 304 stainless steel pipe, covering the RRA-J003 weldment. Alloy 52M filler metals are compatible with all the base materials and the dissimilar metal welds that will be covered by the overlay.

The weld overlay will be designed as one full structural overlay covering both welds, as illustrated in Figure 1. Postulated 100% through-wall flaws shall be assumed as specified in 2(b)(4) and (5), Attachment 1, for overlay length and thickness sizing per 2(b)(6) Attachment 1. Planar flaws detected during the acceptance examination will be characterized and flaw growth calculations performed using the flaw(s) detected plus the postulated 100% through-wall flaws.

NextEra Energy Duane Arnold would like to point out that a Mechanical Stress Improvement Process (MSIP) was originally scheduled to be applied to the adjacent nozzle to safe-end weld (RRA-F002) during RFO22 prior to the discovery of the indication in the safe-end-to-safe-end extension weld (RRA-F002A). NextEra Energy Duane Arnold believes that the MSIP application should proceed as planned. NextEra Energy Duane Arnold will discuss the effects of the applications of both processes on the safe-end welds in the as-left condition, both in the near-term (plant startup), as well as the longer term (future inspection intervals). Refer to Figure 2 for a drawing of the nozzle to safe-end area, including the safe-end extension. As can be seen from Figure 1, the weld overlay (WOL) will extend up onto the safe-end taper area. The MSIP equipment will be applying the compression on the safe-end area on the outboard (away from the Reactor Vessel N2 Nozzle) side of the RRA-F002 weld but will not extend to the safe-end taper down toward the safe-end extension. The two process areas will not physically overlap.

To confirm the proper sequence of application, NextEra Energy Duane Arnold consulted with the vendors of the individual processes and all parties agreed that the proper sequence is that the application of the WOL should precede the MSIP. This is because the post-WOL configuration is stiffer and mechanically reinforced, and thus, would be less prone to influence by the MSIP. A simplified evaluation is being conducted to ensure that the original MSIP application parameters were not adversely impacted by the additional stiffness of the WOL at the end of the safe-end. This gives confidence that the planned MSIP application will have the desired residual compressive stresses in the RRA-F002 area in the as-left condition. If the results of this simplified evaluation are not positive, NextEra Energy Duane Arnold may choose to postpone the MSIP application to a future RFO, so that more thorough evaluations can be performed to ensure the MSIP application has the desired result.

While there is some potential that the application of MSIP after the WOL may reduce the residual stresses at the site of the WOL, the WOL repair is expected to produce a region on the inner portion of the safe-end and safe-end extension that is compressive, retarding or arresting an existing crack in the affected material. Further, the WOL material is resistant to stress corrosion cracking (SCC). Thus, even if the MSIP application produced tensile stress in some portion of the WOL region, there remains a SCC resistant barrier over all susceptible material and all required structural margins are maintained. Also, the minimum required WOL thickness is determined considering the calculated fatigue crack growth (FCG) for a fully circumferential, through-wall flaw; such that, even if the post-WOL condition did not result in negative stress intensity factors at both the minimum and maximum load states considered for FCG (i.e., would give no FCG), the required structural margins at the repair location are preserved, independent of the as-left residual stress state. Because this is a full structural overlay, which was designed assuming a 100% through wall flaw, NextEra Energy Duane Arnold has confidence that the MSIP application will not create an environment that would negate the mitigation by the WOL repair.

In addition, UT exams are performed on their respective welds as part of each application. However, to provide additional assurance of the as-left condition, NextEra Energy Duane Arnold will also perform an additional UT exam of the RRA-F002A weld after the MSIP application (if performed), prior to startup from this refuel outage, to confirm the final as-left condition. By comparing this UT result with the exam performed after the WOL, but prior to the MSIP application, NextEra Energy Duane Arnold will gain important information on the effect (if any), of the MSIP process on the flaws under the overlay, notwithstanding the design assumption of the WOL of a 100% through wall flaw.

To confirm the long-term condition of the safe-end area, a complete residual stress analysis of the Nozzle, safe end, safe end extension, and attached recirculation pipe assembly will be performed in which the combined WOL repair and MSIP application will be modeled in the as-applied sequence. This final stress analysis report will provide the as-left stress distribution of the entire safe-end area, and include crack growth and fatigue assessments of the weld overlay repaired safe-end-to-safe-end extension joint. This analysis will provide NextEra Energy Duane Arnold the necessary information to properly classify these welds in the ISI program and to schedule future UT exams in accordance with BWRVIP-75. While BWRVIP-75 requires a follow-up exam to be performed anytime during the next three refuel outages, NextEra Energy Duane Arnold will perform that required UT exam of the weld overlay (RRA-F002A and RRA-J003 welds) during the next RFO (RFO23), currently scheduled for fall of 2012. In addition, NextEra Energy Duane Arnold will perform a UT exam of the RRA-F002 weld in RFO23 as well (assuming the MSIP is done during RFO22), even though BWRVIP-75 would not require this exam to be performed until RFO24 (scheduled for 2014).

The information from the final stress analysis report, and post-application UT examinations will be included in the Licensee Event Report (LER), or supplement thereto, that will be submitted after plant startup.

<u>Welding</u>

The welding will be performed in accordance with Attachment 1 using a machine gas tungsten-arc welding (GTAW) process for the RRA-F002A weld and adjacent RRA-J003 stainless steel weld with ERNiCrFe-7A (Alloy 52M) being used for the filler metal. In some instances of this process, flaws in the first layer have occurred in the portion of the overlay deposited on the austenitic stainless steel portions (safe ends, pipe etc.) of the assemblies.

The flaw characteristics previously observed above are indicative of hot cracking. This phenomenon has not been observed on austenitic stainless steel or Alloy 82/182 DMW portions of the assemblies when welding Alloy 52M thereon.

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Studies have determined that this problem may be exacerbated when using Alloy 52M filler metal on austenitic stainless steel materials with higher sulfur content and high levels of silicon, as in the case of cast austenitic stainless steel.

Extensive test and field experience from WSI indicate that hot cracking can be a concern when the sulfur and silicon content in the diluted weld puddle equals or exceeds 0.014%. The impurity hot cracking threshold level is a function of the composition of the base material, weld filler materials, and the welding parameters that are used because these two factors control the dilution of the solidified weld deposit. This suggests that a combined sulfur plus silicon content of the base material of approximately 0.046% will represent a threshold for hot cracking with the weld parameters WSI will use at Duane Arnold. Duane Arnold will use a barrier layer (buffer layer) on all stainless steel. The barrier layer will use ER308L on the stainless steel and will incorporate Alloy 82 on the stainless steel near the DMW to stainless steel fusion zone only.

The barrier layer will not be used in the structural analysis. The inside diameter of the portion of the overlay over the barrier layer will be the outside diameter of the barrier layer that is applied over the stainless steel material beneath the overlay. Since this barrier layer will not be considered as part of the structural overlay, a delta ferrite measurement is not required. See Attachment 2 for more information.

The Cr content of the 1st layer was verified by direct measurement of weld overlay deposits on ASTM A106 Grade B mockups. Welding was performed using a double up progression (starting at the bottom and welding upward to the top on each side) for 5G and 6G mockups and orbital progression for 2G mockups. The Cr content was measured at 90 degree intervals. All welding parameters were recorded and a 24% minimum Cr value, greater than that required in 1(e), Attachment 1 (20% minimum Cr for BWRs), was attained in all cases. The attainment of the minimum 24% Cr threshold level has been demonstrated many times on similar mockups using the same WSI welding parameters. The same heat of wire, or a wire heat with equal or greater chrome content than that used in qualification, will be used in situ for the first layer and the same welding parameters will be specified in the WPS as was used in the mockup for the first layer. It should be noted that the deposition of Alloy 52M over base material already having significant Cr content will result in a higher final deposited Cr content.

Examination

All examinations will meet the requirements of Attachment 1, excluding qualification of the ultrasonic examination for the completed overlay. The ultrasonic examination qualification will be in accordance with ASME Code Section XI, 2001 Edition (Reference 5), for Appendix VIII, Supplement 11 with the alternatives that are used in Relief Request NDE-R002.

The final ultrasonic examination report will be submitted to the NRC as part of the In-service Inspection (ISI) Report to be submitted after startup from the refuel outage, in accordance with IWA-6240. Any flaws detected that exceed the acceptance standards of Table IWB-3514-2 will be reported to the NRC as soon as possible. A discussion and reason for any overlay or base metal repairs will be provided.

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The ultrasonic examination requirements specified in NRC Regulatory Guide 1.147, Revision 16, as conditional acceptance of Code Case N-504-4 will be applied to these overlays. In doing so, UT of the overlays will be performed in accordance with Section XI, Appendix VIII, Supplement 11 qualified procedures and personnel as modified by Relief Request NDE-R002. Supplement 11 was prepared to be specifically applicable to weld overlays. The ultrasonic examination requirements in Section 3, Attachment 1, are similar to the ultrasonic examination requirements provided in Appendix Q which have been developed specifically for austenitic weld overlays. The UT examination to be performed, in conjunction with the surface examinations to be performed, as specified in Section 3 Attachment 1 are based on the latest industry experience and practice and are completely satisfactory for the weld overlay application.

Conclusion

The proposed alternative shown in Attachment 1 has been developed to cover the most recent operating experience and NRC approved criteria that are associated with similar overlay applications. Similar NRC approved requests have been used to produce acceptable weld overlays when applied to dissimilar metal welds with Alloy 82/182 weld material. Therefore, NextEra Energy considers the proposed alternative described in Attachment 1, with the inclusion of approved relief request NDE-R002, to provide an acceptable level of quality and safety, consistent with provision of 10CFR 50.55a(a)(3)(i).

Precedents

The proposed relief request is similar to that previously submitted by FPL Energy[2] submitted "Alternative to ASME Section XI Repair Requirements to use Code Case N-504-2 and N-638-1 for Weld Overlay Repairs at the Duane Arnold Energy Center" which was approved by the Staff on June 12, 2007. (ML071110007)

In addition, the NextEra Energy Duane Arnold request is similar to other recent requests for dissimilar metal weld overlays, both Boiling Water Reactors (BWRs) (e.g., Pilgrim Nuclear Power Station – ML092370549) and Pressurized Water Reactors (PWRs) (e.g., Seabrook Station - ML081000008), with the noted exception that the NextEra Energy Duane Arnold request will not rely upon Code Case N-638-1. And while the enclosed request is not pre-emptive, many of the same requirements are common in the Staff's approval for the Materials Reliability Program (MRP) topical report (MRP-169), for full structural weld overlays (ML101660468).

Duration of Proposed Alternative

The alternative requirements of this request will be applied for the duration of up to and including the last refuel outage of the current 4th 10-year ISI interval, which includes inservice examination requirements of Attachment 1 for any applied weld overlays. The 4th 10-year ISI Interval started on November 1, 2006 and ends February 21, 2014. Future inservice examination

[2] By License Amendment No. 275, the licensee name for the Duane Arnold Energy Center was legally changed from FPL Energy Duane Arnold, LLC to NextEra Energy Duane Arnold, LLC.

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of weld overlay at Duane Arnold beyond this inspection interval will be as required by the NRC in the regulations.

References

1. ASME Code, Section XI, 2001 Edition, including Addenda through 2003
2. Duane Arnold Relief Request NDE-R002 approved January 1, 2007
3. ASME Code, Section XI 2001 Edition, for Appendix VIII, Supplement 11 examinations as modified by 10CFR50.55a(b)(2)(xxiv).

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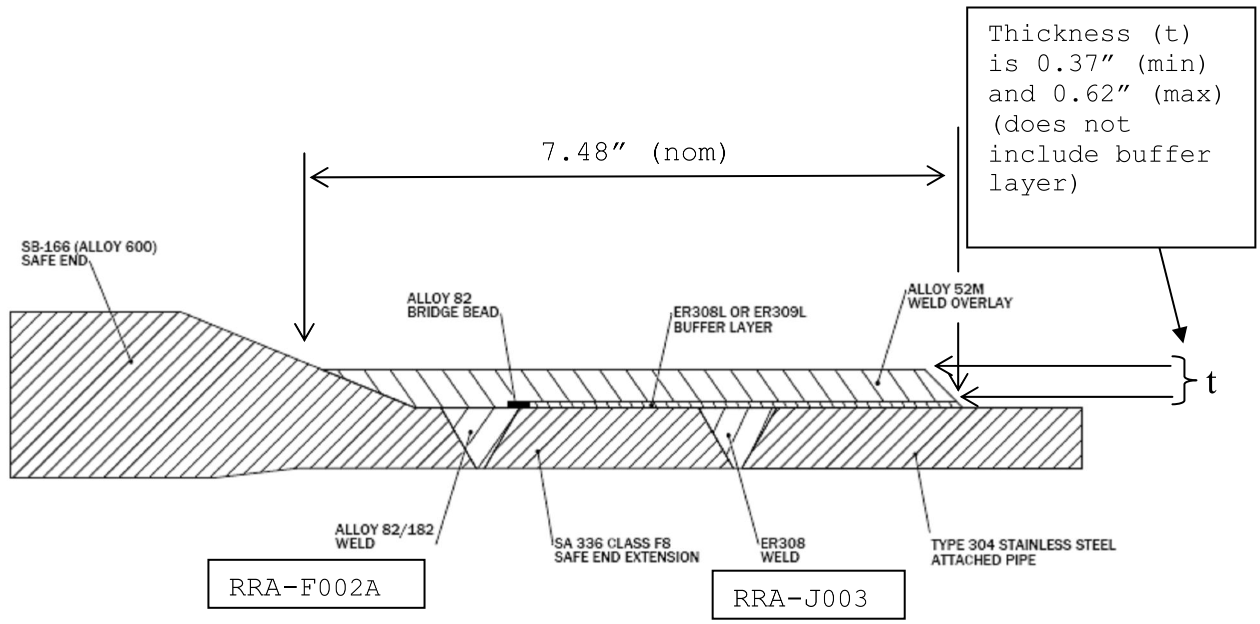

Figure 1.

Weld Overlay Repair for Safe End-to-Safe End Extension DMW (RRA-F002A) and Adjacent Stainless Steel Weld (RRA-J003).

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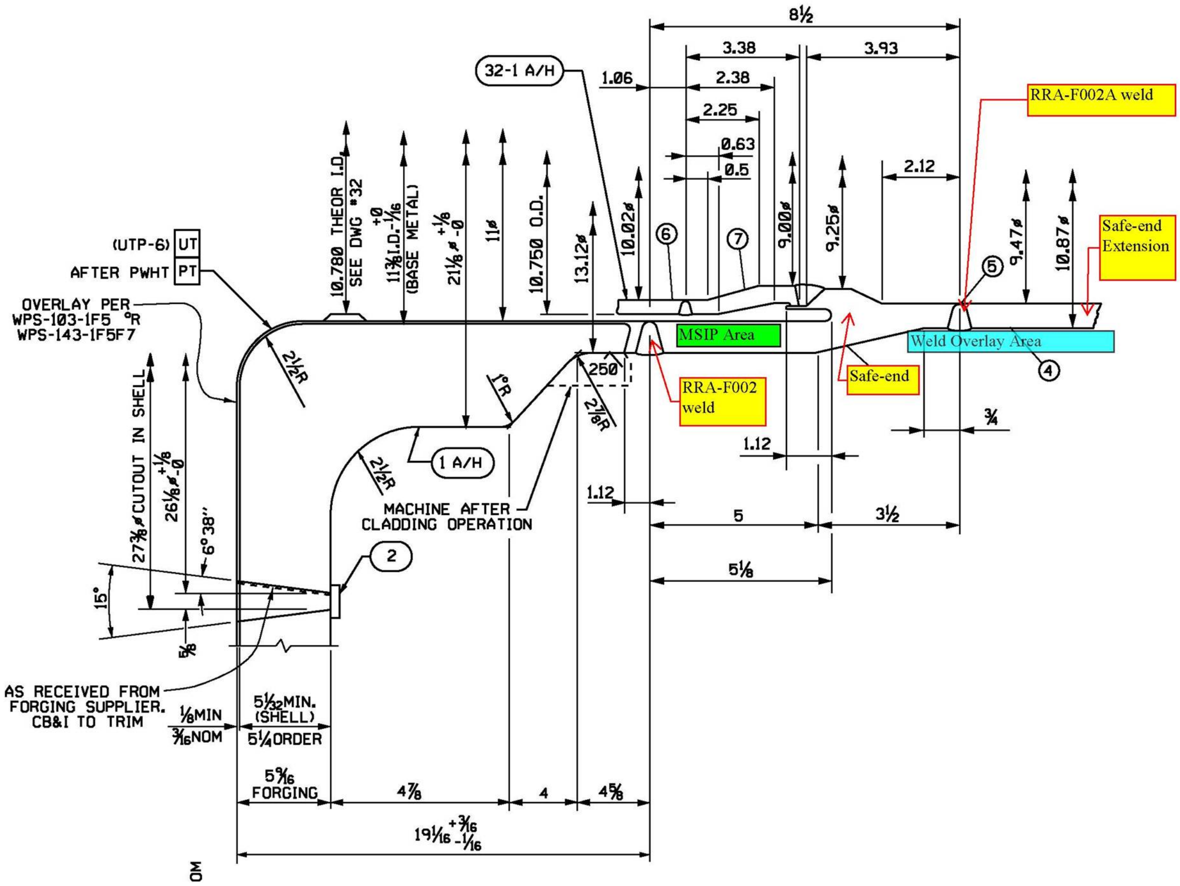

Figure 2.

“A” Recirculation N2 Nozzle, Safe End, and Safe End Extension Welds.

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Attachment 1
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 the addition of a repair weld overlay. The weld overlay shall be applied by deposition of weld reinforcement (weld overlay) on the outside surface of the piping, component, or associated weld, 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 circumferential welds in carbon steel (P-No. 1) to safe ends or piping components (P-No. 8 or 43), inclusive of the UNS N06082 or W86182 welds that join 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. This Attachment applies to dissimilar metal welds between P-No. 8 or 43 and P-Nos. 1, 3, 12A, 12B, or 12C[3] materials. Attachment 1 also applies 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 1A above.

1) Weld overlay filler metal shall be austenitic nickel alloy (28% Cr min., ERNiCrFe-7 or ERNiCrFe-7A) applied 360° around the circumference of the item, and 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.

C. Prior to deposition of the weld overlay, the surface to be weld overlaid shall be examined using the liquid penetrant method. Indications with major dimension greater than 1/16 in. (1.5 mm) shall be removed, reduced in size, or weld repaired 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.

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

D. Weld overlay deposits shall meet the following requirements: The austenitic nickel alloy weld overlay shall consist of at least two weld layers deposited using 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 BWR applications, a diluted layer may be credited toward the required thickness, provided the portion of the layer over the austenitic base material, austenitic filler material weld contain at least 20% Cr and the Cr content of the deposited weld metal is determined by chemical analysis taken from a mockup prepared in accordance with the WPS for the production weld.

E. 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 Calculation of Flaws in the Original Weld or Base Metal.

The size of all flaws postulated in the original weld or base metal shall be used to define the life of the overlay (defined as the end of the 40 year plant design life plus the 20 year license extension period). In no case shall the inspection interval be longer than the life of the overlay. The inspection interval shall be as specified in 3C. Crack growth in the original weld or base metal, due to both stress corrosion and fatigue, shall be evaluated. Flaw characterization and evaluation shall be based on the postulated flaw, if ultrasonic examination of the weld and base material is not performed.

(1) For repair overlays, the initial flaw size for crack growth in the original weld or base metal shall be based on the postulated flaw, if no pre-overlay ultrasonic examination is performed.
(2) For postulated flaws in the original weld or base metal, the axial flaw length shall be set at 1.5 in. (38 mm) or the combined width of the weld plus buttering, whichever is greater. The circumferential flaw length shall be assumed to be 360°.
(3) Flaw growth evaluations shall include the residual stress results to demonstrate that favorable stress distribution in the original weld has been performed.

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 2A. 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 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. 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 2B(1), the end transition taper of the overlay shall not exceed 30°. 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 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.
(6) The overlay design thickness shall be verified using only the weld overlay thickness conforming to the deposit analysis requirements of 1D. The combined wall thickness at the weld overlay and the effects of any discontinuities (e.g., another weld overlay or reinforcement for a branch connection) within a distance of $0.75\sqrt{(Rt)}$ from the toes of the weld overlay, including the flaw size assumptions defined in 2B(4) or (5) above, shall be evaluated and meet the requirements of IWB-3640.
(7) 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, and changes in system flexibility and weight due to the weld overlay) shall be evaluated. Existing flaws previously accepted by analytical evaluation shall be evaluated in accordance with IWB-3640, IWC-3640, or IWD-3640, as applicable. These evaluations shall meet the requirements of ASME Section III NB-3200 and NB-3600.

3 EXAMINATION

In lieu of all other examination requirements, the examination requirements herein shall be met for the life of the weld overlay. 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 and Relief Request NDE-R002.

A. Acceptance Examination

(1) The weld overlay shall have a surface finish of 250 micro-in. (6.3 micrometers) RMS or better and a contour that provides for ultrasonic examination in accordance with procedures qualified in accordance with Appendix VIII. The weld overlay shall be inspected 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. Surface examination shall be performed on weld attached thermocouple removal areas in accordance with NB-4435(b)(3). 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.
(3) The acceptance examination volume A-B-C-D in Fig. 1(a) plus the heat-affected zone beneath the fusion zone C-D 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.

Planar flaws detected in the weld overlay acceptance examination shall meet the pre-service 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 "t_1" 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 in the weld overlay 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 acceptance standards of Table IWB-3514-2, with nominal wall thickness as defined above for planar flaws. Both axial and circumferential planar flaws shall be assumed.

(4) 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. Pre-service 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 planar flaws 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.
(3) The flaw evaluation requirements rules of IWB-3640 shall not be applied to planar flaws identified during preservice examination that exceed the preservice examination acceptance 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. The weld overlay inspection interval shall not be greater than the life of the overlay defined in 2A above. The weld overlay shall be ultrasonically examined during the first or second refueling outage following application.
(2) The weld overlay examination volume in Fig. 2 shall be ultrasonically examined to determine if any new or existing planar flaws have propagated into the outer 25% of the base metal thickness or into the overlay. The angle beam shall be directed perpendicular and parallel to the piping axis, with scanning performed in four directions.
(3) The inservice examination acceptance standards of Table IWB-3514-2 shall be met for the weld overlay. If flaw growth in the weld overlay occurs and inservice examination acceptance standards of Table IWB-3514-2 cannot be met, a determination will be made to prove that the flaw is not SCC. If the cause is determined to be SCC or the cause of the flaw cannot be determined, the flaw shall be repaired and IWB-3600, IWC-3600, or IWD-3600 shall not be used to accept these types of flaws. Flaws due to stress corrosion cracking in the weld overlay that exceed the inservice examination acceptance standards of Table IWB-3514-2 shall not be accepted and will result in removal of the weld overlay and the item shall be repaired or replaced.
(4) Weld overlay examination volumes in Fig. 2 that show no indication of planar flaw growth or new planar flaws shall be placed into a population to be examined on a sample

basis, except as required by 3C(1). Twenty-five percent of this population shall be examined at least once during every 10 years.

(5) If inservice examinations reveal planar flaw growth, or new planar flaws that meet the inservice examination acceptance standards of IWB-3514 or acceptance criteria of IWB-3600, the weld overlay examination volume shall be reexamined during the first or second refueling outage following discovery of the growth or new planar flaws.

(6) For weld overlay examination volumes with unacceptable indications in accordance with 3C(3), 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 unacceptable indications according to 3C(3), planar flaw growth into the weld overlay design thickness, or axial flaw 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, 50% of the total population of weld overlay examination volumes shall be examined prior to return to service. 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 Attachment 1 shall be documented on Form NIS-2a (Ref. Code Case N-532-4).

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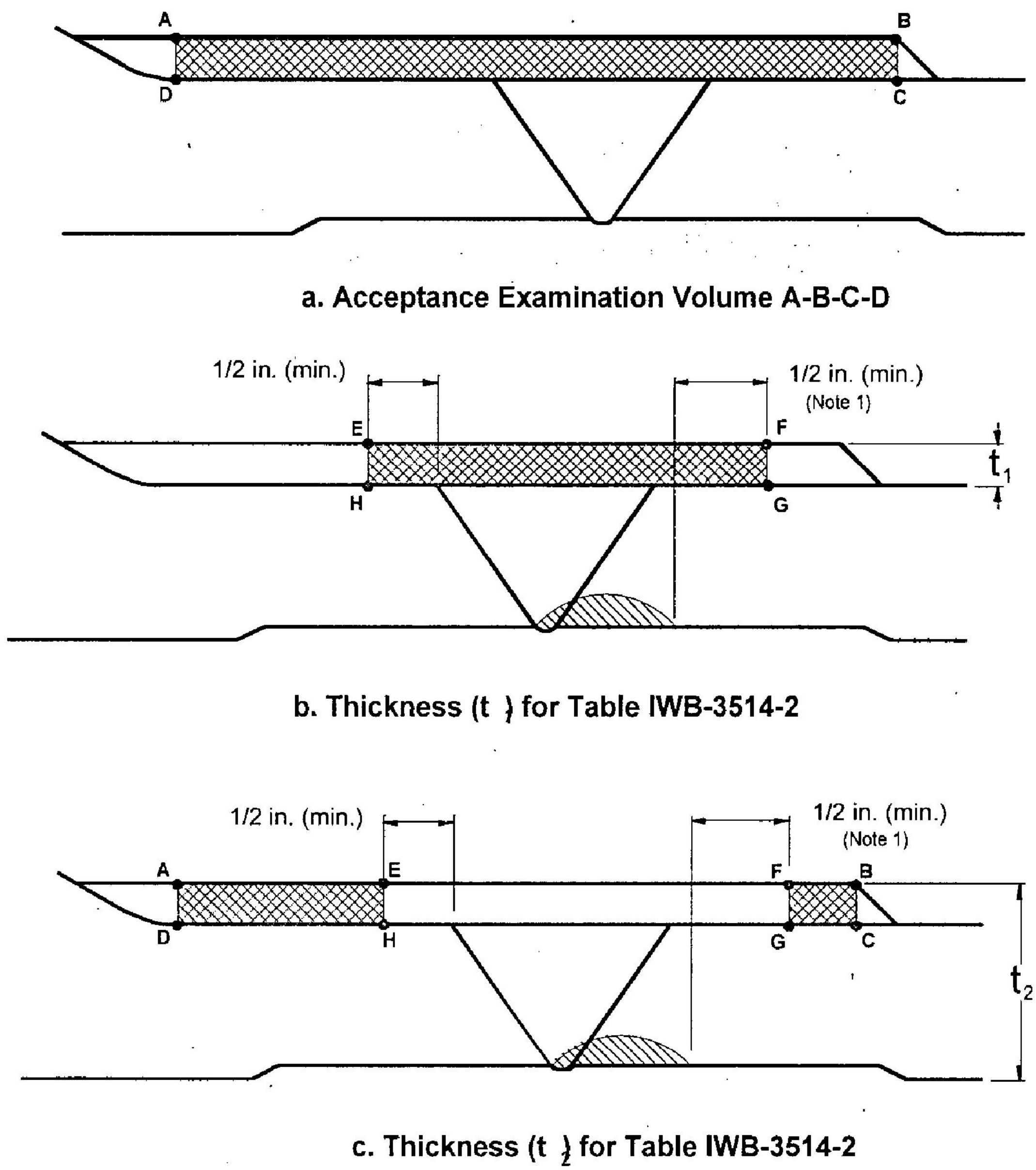

Fig. 1 Acceptance Examination Volume and Thickness Definitions

Notes:

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

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

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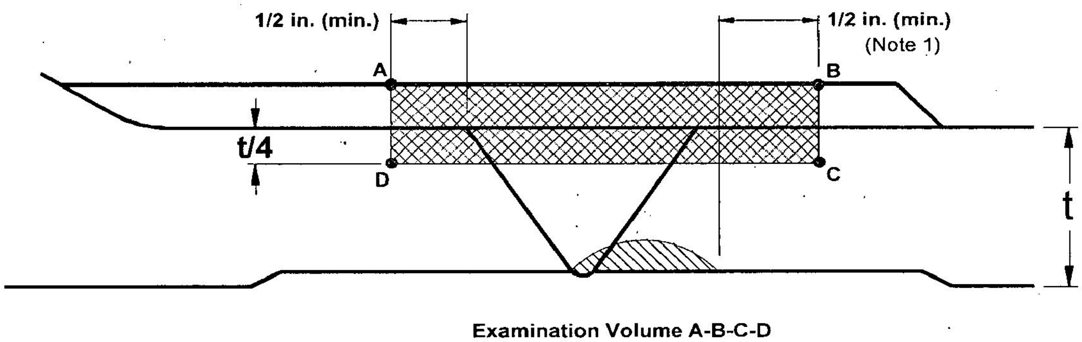

Fig. 2

Preservice and Inservice Examination Volume

Notes:

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

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

NextEra Energy Duane Arnold
FOURTH INSPECTION INTERVAL
RELIEF REQUEST NUMBER NDE-R014

ATTACHMENT 2

Barrier (Buffer) Layer to Prevent Hot Cracking in High Sulfur Stainless Steel

Background

During recent dissimilar metal weld (DMW) overlay activities, where use of ERNiCrFe-7A (Alloy 52M) and ERNiCrFe-7 (Alloy 52) has been used for the filler metal, flaws in the first layer have occurred in the portion of the overlay deposited on the austenitic stainless steel portions (safe ends, pipe, etc.) of the assemblies in some cases.

Discussion

The flaw characteristics observed above are indicative of hot cracking. This phenomenon has not been observed on the stainless steel or ENiCrFe-3 (Alloy 182) DMW portions of the assemblies when welding Alloy 52M thereon.

Further studies have determined that this problem may occur when using Alloy 52M filler metal on austenitic stainless steel materials with high sulfur content.

Extensive tests and field experience from WSI indicate that hot cracking can be a concern when the sulfur and silicon content in the diluted weld puddle equals or exceeds 0.014%. The impurity hot cracking threshold level is a function of both the composition of the weld filler materials and the welding parameters that are used because these two factors control the dilution of the solidified weld deposit. This suggests that a combined sulfur plus silicon content of the base material approximately 0.046% will represent a threshold for hot cracking with the weld parameters WSI will use at Duane Arnold.

To reduce the susceptibility of hot cracking occurrence due to welding Alloy 52M on the stainless steel base materials with high sulfur, WSI has selected ER308L filler metal as the preferred filler metals to provide a barrier (buffer) layer between the Alloy 52M and the high sulfur stainless steel base material. These filler metals are compatible with the base material and promote primary weld metal solidification as ferrite rather than austenite. The ferrite is more accommodating of residual elements therein and in the underlying base material thereby significantly reducing the susceptibility to hot cracking. These filler metals are also compatible with the Alloy 52M subsequently welded thereon. However, the barrier layer may consist of ERNiCr-3 (Alloy 82) being used locally at the interface between the Alloy 182 DMW and the stainless steel item. ER308L welding on Alloy 182 may result in cracking of the ER308L weld. Welding on high sulfur stainless steel with Alloy 82 has not been a concern relevant to hot cracking occurrence.

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WSI welded two mockups to evaluate the interactive effects, such as hot cracking and lack of fusion, between the Alloy 82/182 DMW, the stainless steel base material, the ER308L and the subsequent Alloy 52M weld overlay. One mockup assembly consisted of a stainless steel pipe (approximately 0.050 wt% sulfur and silicon combined) and an ASTM A106 Grade B pipe with an Alloy 82 groove weld joining them. The second mockup consisted of a stainless steel pipe joined to a cast stainless steel pipe with a stainless butt weld. The other end of the cast stainless steel pipe was joined to a P3 forging using an Alloy 82 groove weld.

For both mockups, the barrier layer and overlay were welded in the same sequence as performed in the field (barrier layer ER308L to within 1/8" of the joining DMW and then four or more layers of Alloy 52M overlay). The barrier layer and overlay welding parameters used in the mockup were similar to those used in the field and controlled the weld dilution by controlling the weld heat input and the Power Ratio.

The following examinations were performed on the final mockup:

- PT was performed on the base materials and joining groove welds
- PT was performed on the ER308L barrier layer
- PT was performed on the first layer of Alloy 52M overlay and on the final layer of the weld overlay
- PDI qualified Phased Array UT was performed on the completed mockup.

One recordable (not rejectable) planar UT indication of less than 0.200" in length was found on one of the mockups unrelated to the barrier layer. Subsequent metallographic examination found this likely to be porosity. Metallographic examination was conducted at EPRI searching for any type of discontinuity, flaw or other anomaly. All samples were removed from selected locations in both mockups and revealed no conditions of concern.

Conclusion

Duane Arnold will use the barrier layer on all the stainless steel items that equal or exceed the criteria prior to overlay. The barrier layer will use ER308L on the stainless steel and may use Alloy 82 on the stainless steel near the DMW to stainless steel fusion zone only.

Structural credit will not be assumed for the barrier layer in determining the required minimum overlay thickness since the alternative does not address the use of stainless steel filler metal.

The barrier layer welding will be performed in accordance with ASME Section IX qualified welding procedure specification(s). PT will be performed on the barrier layer surface and its volume will be included in the final UT of the overlay.