Enclosure 3
Technical Papers 2

Dated October 1, 2008

NEI/NRC Meeting

Technical Paper –Plant Application of Weld Onlay for Butt Weld Mitigation

Arkansas Core Flooding Nozzle Application

September 11, 2008

Arkansas Nuclear One Unit One (ANO-1) is planning to mitigate the susceptibility to PWSCC of the Dissimilar Metal (DM) butt welds on the reactor vessel Core Flooding nozzles (CFN) during the fall 2008 refueling outage by installing a weld onlay to the inside surface of the nozzle. The geometry of the ANO-1 Core Flooding nozzles and planned onlay weld are shown in Sketches CF-1, CF-2, CF-3 and Structural Integrity Associates Inc (SI) drawing ANO-52Q-02 attached.

Onlay Design

The geometry of the onlay must make a smooth transition from end to end, from the safe end to the existing cladding on the nozzle. The first layer of weld metal will be a type 308L stainless steel buffer, only on the existing stainless steel safe end and the stainless steel cladding on the nozzle, to prevent hot cracking which is possible if Alloy 52M is deposited directly onto the existing stainless steel. This buffer layer will be applied only to the existing stainless steel areas and will be stopped short of application to the existing Alloy 82 / 182. A layer of Alloy 82 will be applied directly to the existing Alloy 82 / 182 in between the interrupted pass of 308L stainless steel and the Alloy82 and 308L buffer layer will be blended to form a smooth first layer. Two Alloy 52M weld metal layers will be applied continuously over the 308L and Alloy 82 first layer. Subsequent layer(s) of 52M may be applied in order to provide material for machining and adequate thickness after surfacing, if needed. After welding, the surface of the weld will be machined to a relatively smooth condition (250 rms or better). The ends of the welds will be blended into the surrounding areas.

The design basis for the core flooding nozzles will not be compromised by this mitigation of the dissimilar metal welds. The addition of Alloy 52M weld material to the inside surface of each nozzle / safe end junction will have no adverse effect on the flow through these nozzles. The inside diameter of the completed onlay will be larger than the supply pipe inside diameter; therefore, the onlay will not be a limiting feature of the flow path. The structural qualification of the joint will not be adversely affected. No credit is taken for the strength of the onlay, which is considered as added cladding. Analysis of the effect that this additional cladding imposes on the existing material is required. The ASME Code (NB-3122.3) requires analysis for any cladding which exceeds 10 per cent of the component wall thickness. The design and installation of the onlay will meet all applicable Code requirements as discussed in Attachment A to this paper. In addition, ANO will impose additional requirements in excess of those contained in ASME Sections XI and III to ensure that the proposed weld onlays will provide a robust mitigation of the risk of PWSCC.

Onlay Design Basis

The initiation and propagation of PWSCC is contingent upon three conditions: 1) having reactor coolant (RC) in contact with Alloy 600 base material, Alloy 82 weld filler material, or Alloy 182 weld filler material; 2) high temperature; and 3) having tensile stress present in the material. If any one of the three conditions is removed, PWSCC will not initiate or propagate.

The weld onlay is designed to isolate the Dissimilar Metal Weld (DMW) from the reactor coolant and thereby eliminate PWSCC initiation and / or propagation. The DMW may be considered as mitigated for the purposes of establishing future examination requirements if the susceptible material is completely covered with an onlay of a PWSCC resistant material (stainless steel, or

a nickel based alloy containing a minimum of 24% chromium), and the onlay, DMW, and base material are acceptable in accordance with ASME Section XI.

The specific geometry of the ANO Unit One Core Flooding Nozzle onlay weld is shown on the Structural Integrity Associates Inc weld design drawing ANO-52Q-02.

The weld metal that will be used to make the buffer layer and the onlay, stainless steel and Alloy 52M, are both resistant to PWSCC. The susceptibility of materials to PWSCC, and the use of PWSCC resistant materials to isolate susceptible materials from the primary water environment as a mitigation method have been well documented in EPRI and vendor reports, and has been summarized in the white papers prepared for ASME Code Cases associated with Alloy 600.

The number of Alloy 52M layers to be applied for adequate mitigation is governed by the chromium content of the onlay material, the potential for undetected flaws, and the total thickness of the onlay. The chromium content dilution is discussed in detail later in this paper. The first layer and subsequent layers of Alloy 52M onlay will have adequate chromium content to be resistant to PWSCC because the welding process being applied has been shown to achieve the required content when welded over carbon steel, and there will be greater chromium content in the resulting weld deposit when welding over stainless steel or Alloy 82 than when welding over carbon steel. A minimum of two layers of Alloy 52M will be applied, and the final thickness of Alloy 52M will be at least 1/8 inch after machining. The requirement to have a minimum of two layers is based on the potential of having an undetected planar flaw in a single weld layer that could grow by fatigue. The addition of the second layer provides additional assurance that the onlay will provide a barrier isolating the susceptible material from the primary water environment. If required to obtain adequate thickness to allow smooth transition to the surrounding surfaces (blending), extra layers may be applied. This is acceptable as long as the heat input to the material is not excessive.

The existing cladding on the ferritic portion of the ANO-1 core flooding nozzles is greater than 1/8 inch thick. Because the onlay welding is greater than 1/8 inch from the ferritic base material, the onlay may be installed without having to use ambient temperature temper bead techniques.

There is the potential that PWSCC or other linear indications could be discovered in the existing cladding, DM weld, or the safe end. If such indications are identified prior to installation of the onlay mitigation, the indication could be removed completely, or the indication could be of a size (or could be reduced to a size) that could be left in place. Such a flaw would be covered by a repair weld or the onlay, and the resulting embedded flaw will be qualified under ASME Section XI Sub-Section IWB-3500 or IWB-3600 rules. The conditions for further PWSCC are mitigated by installation of the onlay, however, cyclic stresses may cause the discovered flaw to propagate. The potential fatigue crack growth of any such embedded flaw will be analyzed, and the length of time predicted for the embedded flaw to grow through the onlay or to an unacceptable size will be considered when establishing future re-inspection intervals.

If a pre-existing flaw cannot be qualified to allow leaving it in place as an embedded flaw, the flaw will be removed or reduced to an acceptable size (IWB-3500) by grinding out part or all of the material containing the flaw, and performing a small localized welded repair prior to performing the onlay weld. If such a welded repair involves welding within one eighth inch of the ferritic materials in the nozzle, the welding will be performed using ambient temperature temper bead (ATTB) techniques. If the requirements specified in ASME Code Case N-638-1, as conditionally approved in Regulatory Guide 1.147 Revision 15 can be met, the ATTB welding

will not require a Relief Request. It is recognized that there may be conditions that would make it either impractical to comply with ASME Code Case N-638-1 or desirable to use enhancements available in later revisions of ASME Code Case N-638, and if this becomes the case, a Relief Request will be required. Examples of some conditions that would require a relief request include 1) ATTB welding must be performed on an area that is greater than 100 square inches, 2) an excavation must be performed into the ferritic base material that is greater than 3/8 inch deep, or 3) ATTB welding must be performed over an existing flaw that will not meet the N-638-1 NDE acceptance criteria.

ASME Code Requirements

The applicable ASME Code requirements are discussed in detail in Attachment A to this paper.

Onlay Chromium Content Requirements

Alloy 600 materials including Alloys 82 (ERNiCr-3) and 182 (ENiCrFe-3) have demonstrated susceptibility to PWSCC. ERNiCr-3 and ENiCrFe-3 filler material have chromium contents of approximately 15% and 20%, respectively. ERNiCrFe-7A [Alloy 52M] which has a chromium content of approximately 30% is considered resistant to PWSCC. As noted in EPRI Technical Report MRP-115, chromium content has been shown to be the critical factor in assessing the resistance of nickel based alloys to PWSCC. This explains the resistance of Alloy 52M to PWSCC. Section 2.2 of this EPRI report states:

> The only well explored effect of the [chemical] differences among the weld alloys on PWSCC is the influence of chromium. Buisine, et al. evaluated the PWSCC resistance of nickel-based weld metals with various chromium contents ranging from about 15% to 30% chromium. Testing was performed in doped steam and primary water. Alloy 182, with about 14.5% chromium, was the most susceptible. Alloy 82 with 18-20% chromium took three or four times longer to crack. For chromium contents between 21 and 22%, no stress corrosion crack initiation was observed, as was also the case for Alloys 52 and 152 which have about 30% chromium. These results indicated that weld metals with 30% chromium were resistant to cracking, with a threshold for PWSCC resistance being between 22 and 30% chromium. This behavior is consistent with that of mill annealed wrought Ni-Cr-Fe base alloys. Tests by Yonezawa, et. al. evaluated the effect of chromium on the PWSCC susceptibility of wrought Ni-Cr-Fe alloys and showed that the susceptibility decreased as the chromium content increased from about 1% to over 15%. Extensive testing has shown that Alloy 690, with about 30% chromium, is very resistant to PWSCC. MRP-111 summarizes additional laboratory data collected by AREVA that support these conclusions regarding the importance of chromium content.

When employing an onlay (Alloy 52M, ~30% Cr), weld layers are applied until the surface exposed to the reactor coolant has sufficient chromium content to resist attack (greater than 24%). If applied over carbon steel or alloy steel, chromium dilution is more evident but chromium dilution is generally moot if the application is over existing austenitic stainless steel base material (this case type 316, ~17% Cr) or austenitic stainless steel cladding (this case ER308, ~21% Cr).

Report WSI-MW-CR1L-001, Rev 0, "Evaluation of Cr Content on First Layer of Weld Overlays for Top and Bottom Nozzles of Pressurizer" dated August 17, 2007 provided by Welding Services, Inc. addresses Cr content dilution in like-kind applications. This report documents that using WSI welding processes, operators, and welding equipment, deposition of Alloy 52M weld filler material on carbon steel base material yields surface Cr content consistently in excess of 24% in the first layer. The report further shows that in that combination, the Cr content on the weld surface is representative of the weld fusion material down to approximately 90% thickness. In other words, the weld fusion material is consistently high in Cr content. Carbon steel has virtually no Cr content. Therefore, when welding over austenitic stainless steel base material (which has significant Cr content), the Cr content of the resulting weld deposit will be greater than the 24% demonstrated in the WSI report. Considering that the stainless steel base materials in the core flooding nozzle application have relatively high Cr content (~17% and ~21%) it is clear that the resulting onlay Cr content will be greater than 24% (and the WSI report states the same conclusion). The safe ends of the subject core flooding nozzles are austenitic stainless steel and present no significant dilution challenge. The nozzles are alloy steel, but are covered with an austenitic stainless steel cladding and therefore present no significant dilution challenge either.

License Basis Document PAD / 50.59 Review

No changes to ANO-1 license basis documents and no unreviewed safety questions are created.

Implementation Process

The general implementation process steps are summarized below.

- Complete the ASME Section IX ISI examination of the DM welds
- Install nozzle dams in the core flooding nozzles from the reactor vessel side
- Dry the pipe interior and install FME barrier
- Install automated buffing machine into horizontal pipe
- Perform light buffing to remove surface oxides
- Remove automated buffing machine
- Record applicable dimensions prior to start of welding
- Install automated liquid penetrant machine into horizontal pipe
- Perform liquid penetrant examination
- Remove liquid penetrant machine
- Install automated weld machine into horizontal pipe
- Apply stainless steel buffer weld layer over existing stainless steel
- Remove automated weld machine from horizontal pipe

- Change wire and install automated weld machine into horizontal pipe
- Apply Alloy 82 bridge bead weld layer over DMW
- Remove automated weld machine from horizontal pipe
- If needed, install automated grinding machine into pipe and machine buffer layer to required thickness
- Install automated liquid penetrant machine into horizontal pipe
- Perform liquid penetrant examination
- Remove liquid penetrant machine
- Record dimensions
- Install automated weld machine into horizontal pipe
- Apply first layer of Alloy 52M weld onlay
- Remove weld machine
- Install automated liquid penetrant machine into horizontal pipe
- Perform liquid penetrant examination
- Remove liquid penetrant machine
- Record dimensions
- Install automated weld machine into horizontal pipe
- Apply second layer of Alloy 52M weld onlay
- Remove weld machine
- Install automated grinding machine into horizontal pipe
- Perform surfacing and blending to surrounding pipe surface
- Remove grinding machine
- Install automated liquid penetrant machine into horizontal pipe
- Perform liquid penetrant examination
- Remove liquid penetrant machine
- Install automated UT machine into horizontal pipe
- Perform UT for cladding acceptance (verify fusion of cladding and no cladding cracks)
- Remove UT machine
- Record dimensions
- Review examination results. If UT is not acceptable, rework onlay and re-examine
- Perform preservice ISI on CFN from the vessel side (wet) prior to re-installation of the core barrel

Non Destructive Examination

Ultrasonic examination (UT) and surface examination (PT) is used before, during, and after weld onlay material is deposited to ensure acceptable quality of the base material, acceptable fusion to the base material and acceptable quality of the deposited weld material.

The existing DM weld will be volumetrically examined by WesDyne using PDI qualified procedures and personnel as part of the ten year ISI examination prior to application of the onlay welding.

After removing the oxide layer on the inside surface of the nozzle/safe-end, the surface will be examined using a dye penetrant exam prior to installing the stainless steel buffer layer.

The first layer, and all subsequent layers of the onlay Alloy 52M weld material will receive a surface examination using a dye penetrant exam.

After the final layer of the onlay is complete, the onlay material will be volumetrically examined using ultrasonic examination methods to prove onlay filler material integrity and fusion with the base material. This construction UT process is not required to be PDI qualified.

After the nozzle dams have been removed and the core flooding piping has been filled, the DM welds will be volumetrically examined by WesDyne using PDI qualified procedures and personnel as part of the pre-service (PSI) ISI examination.

Based on prior work that has been performed by WesDyne on Reactor Vessel Main loop nozzles with an inlay applied, there is a strong indication that the existing Core Flooding nozzle examination procedure performed by WesDyne can be extended for the PSI examination of the core flooding nozzle base material with an onlay applied. The PSI UT examination process will be qualified for this onlay application by having WesDyne scan the onlay mockup using their Performance Demonstration Initiative (PDI) ultrasonic examination (UT) equipment, procedures, and personnel that are already qualified for inlays and then performing an equivalency evaluation. The onlay mockup (taken from the PWROG stock of mockups) was fabricated to duplicate the ANO core flooding nozzle with an onlay applied, and had flaws installed. The flaw shapes, sizes, orientations and locations were selected in accordance with recommendations from the EPRI NDE Center to ensure that the WesDyne PDI UT process is effective in finding and sizing flaws in the base material after the onlay is installed.

Specific acceptance criteria for these examinations is discussed in Attachment A to this paper.

1.0 General

The proposed weld onlays will comply with all applicable requirements of ASME Section XI and the Construction Code or ASME Section III as approved by the NRC in 10CFR50.55a. If ambient temperature temper bead welding is required, then the requirements of Code Case N-638-1 including the conditions of Regulatory Guide 1.147 must be met. If NRC requirements in 10CFR50.55a cannot be met, then a relief request would be required. In addition, ANO will impose additional requirements in excess of those contained in ASME Sections XI and III to ensure that the proposed weld onlays have the required robustness to resist PWSCC.

1.1 Nozzle Inside Diameter*: 12.25”

Material: A-508, Class 2 (P-3, Group 3)

1.2 Cladding Material: 308 Stainless Steel

Thickness: Nominal 3/16” (>1/8” min) after machining

1.3 Safe End Inside Diameter*: 12.25”

Material: SA-336, F8M

1.4 Dissimilar Metal Weld: Alloy 82/182

1.5 Attached Pipe: 14” NPS, Schedule 140 (1.25” nominal wall)

1.6 Applicable ASME Codes:

1.6.1 In-service Examination / Repair & Replacement Activities

ASME Section XI 2001 Edition / 2003 Addenda except that the 2001 Edition / No Addenda will be used for Appendix VIII, “Performance Demonstration for Ultrasonic Examination”

1.6.2 Construction Code applicable to Repair & Replacement Activities

ASME Section III, Subsection NB, 1989 Edition

1.6.3 RPV Code of Record

ASME Section III, Subsection NB, 1965 Edition / Summer 1967 Addenda

1.6.4 RCS Piping Code of Record

USAS B31.7, 1968 Edition, June 1968 Errata

2.0 ASME Section XI Requirements:

2.1 IWB-2500 ISI

Prior to installation of an onlay, an in-service inspection (ISI) of the Core Flooding Nozzle DMW's will be performed in accordance with IWB-2500. The ISI examination will include an Appendix VIII, PDI qualified UT examination.

The CFN mitigation at ANO will comply with these requirements using PDI qualified technique, procedures, equipment, and personnel during the 10 year ISI.

2.2 IWB-3131

A component with flaws detected by ISI is acceptable for continued service provided the flaws meet the acceptance standards of Table IWB-3410-1 (i.e. IWB-3500). Therefore, the UT acceptance standards for the Core Flooding Nozzle DMW's are based on IWB-3500. However, if a component weld contains a flaw that does not meet the acceptance standards of IWB-3500, the component may be corrected in accordance with either of the following:

2.2.1 IWB-3132.3

Acceptance by Analysis: The component may be accepted for continued service without the performance of a repair / replacement activity if an IWB-3600 analysis is performed and meets the acceptance criteria of IWB-3600.

If an IWB-3600 analysis is performed to accept flaws, then the area containing the flaw shall be subsequently re-examined in accordance with IWB-2420(b) and (c).

2.2.2 IWB-3132.2

Acceptance by Repair / Replacement Activity: The component may be corrected by a repair / replacement activity to the extent necessary to meet the acceptance standards of Table IWB-3410-1 (i.e. IWB-3500). In other words, after completion of the repair / replacement activity, flaws in a component must be eliminated or reduced to a size that meets the acceptance standards of IWB-3500 for the component to be acceptable for continued service.

If a repair / replacement activity is performed to correct the condition, then the "additional examination" requirements of IWB-2430 shall be met.

2.3 IWB-4422

IWB-4422 allows defects to be reduced to flaws of acceptable size and accepted.

2.3.1 IWA-4422.1(a)

Subsection IWA-4422.1(a) specifies that "a defect is considered removed when it has been reduced to an acceptable size" (as defined by IWX-3000). If the resulting section thickness of the defect removal area is less than its minimum design thickness, the component must be corrected by a repair / replacement activity (e.g. replace component or restore thickness by welding).

Alternatively, IWA-4422.1(b) allows an Owner to evaluate the "defect removal area and any remaining portion of the defect" using the "appropriate flaw analysis provisions of Section XI, or the design provisions of the Owner Requirements and either the Construction Code or Section III." Welding may be necessary to restore the defect removal area to design thickness requirements.

2.3.2 IWA-4422.2.2

Specifies NDE requirements for defect removal without welding and followed by welding not associated with temper bead welding. When defect removal is performed in accordance with IWA-4422.1, the NDE requirements of IWA-4422.2 shall be met as applicable.

ONLAY: Onlays will be installed as cladding, a <u>mitigative</u> repair / replacement activity – not a <u>corrective structural measure</u> to repair a defect. As such, onlays may be installed on DMW's under any of the following conditions:

(a) no ISI flaws,
(b) ISI flaws meet the acceptance standards of IWB-3500,
(c) ISI flaws meet acceptance criteria of IWB-3600, or
(d) ISI defects are reduced to a flaw of acceptable size based on acceptance criteria of IWB-3500.

2.4 IWA-4311

The design for installing the weld onlay and the effect of the change on the existing design report or analyses must be evaluated in accordance with IWA-4311. The use of design requirements from a later edition / addenda of the Construction Code or a different Construction Code (e.g. ASME Section III) will be evaluated in accordance with the design reconciliation provisions of IWA-4226.

2.5 IWA-4224

All replacement materials and new (i.e. different) materials, including weld filler metals, used in the weld onlays will be reconciled in accordance with IWA-4224.

2.6 IWA-4226

When design is performed to all or portions of the requirements of a later Edition or Addenda of the original Construction Code or a different Construction Code, then the design reconciliation requirements of IWA-4226 must be met.

2.7 IWA-4340

2.7.1 IWA-4340 addresses mitigation of defects by modification. In applying IWA-4340, an item or component may be modified to contain or isolate a defective area without removal of the defect provided:

2.7.1.1 The defect is characterized by NDE and evaluated to determine its cause and projected growth.

2.7.1.2 The modification provides for the structural integrity of the item such that it no longer relies on the defective area, including projected growth.

2.7.1.3 In lieu of preservice examination of the defective area, a plan for additional examinations to detect propagation and validate projected growth of the flaw beyond the limits of the modification.

2.7.2 The NRC has prohibited use of IWA-4340 in paragraph (b)(2)(xxv) of 10CFR50.55a. However, Entergy does not believe that the provisions of IWA-4340 apply to the proposed onlays for the following reasons:

2.7.2.1 IWA-4340 applies when a modification is performed to mitigate a defect. Contrary to this provision, onlays will not be installed on welds with defects as defined by ASME Section XI.

2.7.2.2 Contrary to IWA-4340(b), the installation of the onlay will neither negate nor replace the original DMW (i.e. “defective area”). While the DMW may contain a flaw, the flaw will meet the IWB-3500 or IWB-3600 acceptance standards. Therefore, the weld is not defective. Furthermore, the DMW will still be relied upon to ensure structural integrity of the system. The onlay is installed to provide a corrosion resistant barrier to mitigate the DMW from future PWSCC.

2.7.2.3 Contrary to IWA-4340(c), the DMW will be examined in accordance with the PSI requirements of IWA-4530. Furthermore, the DMW will continue to be inspected as required by IWB-2500 and IWB-3130.

2.8 IWA-4411

According to IWA-4411, welding shall be performed in accordance with the applicable Construction Code (ASME Section III) and Owner’s Requirements. Later editions / addenda of the Construction Code or a different Construction Code may be used provided the substitution is authorized by ASME Section XI. Revised Owner Requirements may also be used.

The installation of the weld onlay will comply with IWA-4411 as applicable. Since IWA-4411 refers to the applicable Construction Code for most welding applications, ASME Section III requirements that could apply to weld onlays will be met as discussed in Section 3.0 of this Attachment.

The provisions of IWA-4411(e) apply to temper bead welding. However, if temper bead welding is required, it will be performed in accordance with Code Case N-638-1. See Section 4.0 of this Attachment.

2.9 IWA-4440

Specifies administrative requirements applicable to the qualification of welding procedures and welders / welding operators in support of repair / replacement activities.

2.10 IWA-4460

Establishes requirements for metal removal processes. When metal removal is performed to support installation of the weld onlays, the metal removal processes will comply with IWA-4460. Based on the NRC prohibition in paragraph (b)(2)(xxiii) of 10CFR50.55a, Entergy will not use the provision of IWA-4461.4.2 for "evaluation of thermally cut surfaces".

2.11 IWA-4520

Specifies examination requirements for "welding or brazing areas and welded joints made for installation of items". According to IWA-4520, welding nondestructive examinations are to be performed "in accordance with the Construction Code identified in the Repair / Replacement Plan…" with some exceptions that are not applicable to the proposed onlays. However, if onlays are installed by ATTB welding, the NDE requirements of Code Case N-638-1 will apply. The applicability of IWA-4520 to weld onlays is summarized below:

2.11.1 Onlays will be examined in accordance with the applicable ASME Section III Construction Code provided ATTB welding is not required. Since onlays are essentially cladding, the onlays will be examined in accordance with the NDE requirements of NB-5000 applicable to cladding. See Section 3.0 of this Attachment for ASME Section III requirements.

2.11.2 If onlays must be installed using an ATTB process in accordance with Code Case N-638-1, the onlay will be examined in accordance with Code Case N-638-1. See Section 4.0 of this Attachment for Code Case N-638-1 requirements.

2.12 IWA-4530

Specifies preservice inspection requirements for items affected by a repair / replacement activity. "Preservice inspection shall be performed in accordance with IWB-2200… prior to return of the system to service." Following installation of the weld onlays, preservice inspections of the modified DMW's will be performed in accordance with IWA-4530.

2.13 IWA-4540(a)

Specifies pressure testing requirements for items affected by repair / replacement activities involving welding. IWA-4540(b) exempts cladding and welding activities that do not penetrate the pressure boundary from pressure testing. Therefore, if an onlay is installed without weld repairs to the base material, then a pressure test is not required.

3.0 ASME Section III Requirements:

3.1 NB-2121(f)

NB-2121(f) states that the requirements of NB-2000 for materials (NB-2400 for weld materials) apply to a corrosion resistant onlay (CRO) whenever the thickness of the onlay exceeds 10% of the base material thickness.

3.2 NB-2400

The combined thickness of the original cladding, buffer layer, and onlay cladding will exceed 10% of the base material thickness. Therefore, the weld metal used for the buffer layer and onlay must comply with NB-2000 (NB-2400).

3.3 NB-3122.1

NB-3122.1 states that “no structural strength shall be attributed to the cladding in satisfying NB-3221”.

3.4 NB-3122

NB-3122 states that “the presence of the cladding shall be considered with respect to both the thermal and stress analyses” of NB-3222.2 and NB-3222.4 whenever the cladding thickness exceeds 10% of the base material thickness.

The combined thickness of the original cladding, buffer, and onlay will exceed 10% of the base material thickness. Therefore, the thermal and stress analyses of NB-3222.2 / NB-3222.4 must be revised to consider the presence of the buffer and onlay.

3.5 NB-4121.3

NB-4121.3 states that pressure retaining materials shall be examined by a surface examination method in accordance with NB-2500 if the material removed from the item exceeds the lesser of 1/8” or 10% of the thickness of the item. This provision applies when pressure retaining items are machined during installation or fabrication for reasons other than defect removal.

The NDE provision of NB-4121.3 does not apply to the installation of the subject onlays. When these onlays are installed, no base material machining will be performed; only buffing to remove oxide layer or minor flaws as necessary for weld preparation. Therefore, NB-4121.3 does not apply.

3.6 NB-4300

NB-4300 specifies qualification requirements for welding qualifications. Welding procedure and performance qualifications for the ANO onlays will comply with these qualification requirements.

3.7 NB-4453.4

NB-4453.4 specifies NDE requirements for weld repairs of existing welds. According to NB-4453.4, repair welds shall be examined as required by the original weld, except that the repair weld may be examined by PT or MT when the defect was (a) originally detected by PT or MT and (b) the repair cavity does not exceed the lesser of 3/8" or 10% of the thickness.

NB-4453.4 does not apply to the subject onlays because they are installed as cladding and not a weld repair.

3.8 NB-5221

NB-5221 states that all circumferential butt welds shall require an RT and (PT or MT).

NB-5221 does not apply to the subject onlays since they are cladding, not groove welds. Therefore, the NDE requirements applicable to cladding will apply.

3.9 NB-5272

NB-5272 requires a PT for weld metal cladding. Since a nonstructural onlay is essentially cladding, a PT examination will be performed.

3.10 NB-5350

NB-5350 specifies acceptance criteria of PT examinations. The PT examination of the onlay will comply with this acceptance criteria.

4.0 Code Case N-638-1 Requirements:

Code Case N-638-1 [provisions for Ambient Temperature Temper Bead (ATTB)] will be used only if 1) the existing cladding thickness is reduced to ≤1/8" adjacent to the P-3 base material or 2) a weld repair of the DMW requires removal of existing buffer / butter to ≤1/8" thick adjacent to the P-3 base material.

The CFN mitigation at ANO will comply: if an ATTB is required, the onlay will be applied and examined in accordance with these requirements (Code Case N-638-1 or approved Relief Requests). If required, ATTB welding and subsequent examinations are to be performed by WSI / SI using qualified procedures, equipment, and personnel during the mitigation.

4.1 Code Case N-638-1 specifies ATTB welding requirements as an alternative to the IWA-4600 temper bead requirements applicable to similar and dissimilar metal welds. Code Case N-638-1 has been conditionally approved by the NRC in Regulatory Guide 1.147, Rev. 15 (latest revision of the Regulatory Guide). The applicability of Code Case N-638-1 to weld onlays is summarized below:

4.1.1 Code Case N-638-1 states in part that it is applicable to welds joining P-3 to P-8 materials and their "associated welds". Therefore, the ATTB welding requirements can be applied to onlays.

4.1.2 According to 1.0(b) of Code Case N-638-1, it is applicable whenever welding is performed on a ferritic base material subject to PWHT or within 1/8" of the fusion line of the ferritic base material.

4.1.3 A weld onlay can be installed without having to perform ATTB welding provided the existing cladding thickness is greater than 1/8" in thickness. According to 1.0(a), the finished surface of the onlay over the ferritic base materials shall not exceed 100 in^2. If the area of the onlay over the ferritic base material exceeds 100 in^2, a relief request will be required.

4.1.4 Paragraph 1.0(c) limits the depth of weld repair into the ferritic base material to 3/8" when using a nonferritic weld metal. If the excavation depth will exceed 3/8", a relief request would be required. If deep excavation is required, then conventional weld repair using like-kind material will be employed.

4.1.5 Section 2.0 specifies welding procedure and performance qualification requirements. Section 3.0 specifies additional welding procedure requirements. These requirements will be met if ambient temperature temper bead welding is performed.

4.2 Section 4.0 of Code Case N-638-1 specifies examination requirements for ATTB welding and are summarized below.

4.2.1 According to 4.0(a), surface examination (PT) must be performed on the onlay weld area prior to welding. Surface examination acceptance criteria must comply with NB-5350. NDE personnel shall be qualified in accordance with IWA-2300.

4.2.1.1 Surface examination acceptance criteria of NB-5350 are more restrictive than those of ASME Section XI. Therefore, an ISI indication that is acceptable under ASME Section XI may have to be reduced in size prior to welding to comply with the NDE requirements of Code Case N-638-1. If this is not possible, a relief request will be required.

4.2.2 According to 4.0(b), the final weld surface of the onlay and the 1.875" band around the onlay must be examined by surface (PT) and ultrasonic (UT) examination methods. This final NDE cannot be performed until "the completed weld has been at ambient temperature for at least 48 hours". Code Case N-638-1 requires the 48 hour hold to begin after completion of the final layer.

4.2.3 According to 4.0(b), a final PT examination of the completed onlay and preheat band (1.875" wide) around the onlay shall be performed. Surface examination acceptance criteria shall comply with NB-5350. NDE personnel shall be qualified in accordance with IWA-2300.

4.2.4 According to 4.0(b), a final UT examination of the completed onlay and preheat band (1.875" wide) around the onlay shall be performed. The UT shall comply with Appendix I of ASME Section XI. According to I-2220 of Appendix I, the UT examination for the onlay should be performed in accordance with ASME Section V, Article 4 as supplemented by Table I-2000. The following additional requirements will apply to performance of the UT examination:

4.2.4.1 According to 4.0(d), NDE personnel must also meet the qualification requirements of IWA-2300.

4.2.4.2 According to 4.0(e), the UT acceptance criteria shall comply with IWB-3000 (i.e. IWB-3500).

4.3 When using Code Case N-638-1, the following NRC conditions of Regulatory Guide 1.147, Rev. 15 have to be met.

4.3.1 Personnel and procedures shall be qualified for the repaired volume and qualified by demonstration using representative samples which contain construction type flaws.

4.3.2 Acceptance criteria of NB-5330 in the 1998 Edition / 2000 Addenda shall apply to all flaws identified within the repaired volume.

5.0 ANO Supplemental Requirements for Installing Weld Onlays

5.1 The thickness of the onlay over the exposed portion of the original DMW shall comply with the following:

5.1.1 The minimum thickness of the onlay shall be at least 1/8 in.

5.1.2 The minimum thickness of the onlay shall extend beyond both edges of the DMW fusion zones by at least ¼".

5.1.2.1 The location of the DMW fusion zones shall be determined using engineering methods based upon the physical location of the diametric steps within the nozzle and safe end. Locations are to be marked by WSI / SI using qualified procedures, demonstrated equipment, and qualified personnel during the mitigation.

5.2 To reduce the potential of hot cracking when applying an austenitic nickel alloy over P-8 base material, a buffer layer of austenitic filler material will be deposited over the austenitic stainless steel base material and cladding. The thickness of the buffer layer will be deposited using qualified procedures, equipment, and personnel, but it will not be credited to the design thickness of the onlay. The stainless steel filler material used in the buffer layer must have a delta ferrite content of 5-15 FN as reported on the CMTR.

5.3 The onlay shall consist of at least two (2) layers after final surface preparation and comply with the thickness requirements described above. Each layer shall have a chromium content of at least 24%. The first layer of weld metal deposited will be credited toward the required thickness provided the portion of the layer over the austenitic cladding, DMW, and ferritic base material contains at least 24% chromium. The chromium content of the deposited weld metal will be determined by chemical analysis of a coupon from a mockup representative of the materials on which the onlay will be deposited using the applicable production weld parameters and the same production weld metal classification. The weld filler metal used for the mockup shall have chromium content no greater than that to be used for the onlay. The results shall be documented.

5.3.1 Mock-up representative materials include materials whose chromium content is lower than that of the actual materials to be welded upon during production welding. WSI has demonstrated that the chromium content of the first layer will meet or exceed 24% using a single layer application over carbon steel. The chromium content increases with multiple layers.

5.4 Weld filler metal for the onlay shall be Alloy 52M, ERNiCrFe-7A, which has a minimum chromium content of 28% (30% nominally). The onlay will be applied by WSI using qualified procedures, equipment, and personnel.

5.5 The following NDE will be performed to install the onlays:

5.5.1 Prior to installing the weld onlay, a surface examination (PT) must be performed on the area to be welded plus 1/2 in. on each side of the weld area. NDE personnel and procedures shall comply with NB-5000. Acceptance criteria shall be in accordance with Section III, NB-5350.

5.5.2 After installing the stainless steel / Alloy 82 buffer layer, the weld surface shall be examined by PT as required by NB-5272 for weld metal cladding. NDE personnel and procedures shall comply with NB-5000. Acceptance criteria shall be in accordance with Section III, NB-5350 except that rounded indications with major dimension greater than 1/16 in. (1.5 mm) shall not be permitted. Per NB-5350, rounded indications 3/16" or less are acceptable.

5.5.3 After installing the first Alloy 52M onlay layer, the weld surface shall be examined by PT as required by NB-5272 for weld metal cladding. NDE personnel and procedures shall comply with NB-5000. Acceptance criteria shall be in accordance with Section III, NB-5350 except that rounded indications with major dimension greater than 1/16 in. (1.5 mm) shall not be permitted. Per NB-5350, rounded indications 3/16" or less are acceptable.

5.5.4 After installing each successive Alloy 52M onlay layer (except for the final Alloy 52M layer), the weld surface shall be examined by PT as required by NB-5272 for weld metal cladding. NDE personnel and procedures shall comply with NB-5000. Acceptance criteria shall be in accordance with Section III, NB-5350 except that rounded indications with major dimension greater than 1/16 in. (1.5 mm) shall not be permitted. Per NB-5350, rounded indications 3/16" or less are acceptable.

5.5.5 The completed weld onlay shall be examined as follows:

5.5.5.1 The final weld surface, plus 1/2 in. (13 mm) on each side of the onlay, shall be examined by PT as required by NB-5272 for weld metal cladding. NDE personnel and procedures shall comply with NB-5000. Acceptance criteria shall be in accordance with Section III, NB-5350 except that rounded indications with major dimension greater than 1/16 in. (1.5 mm) shall not be permitted. Per NB-5350, rounded indications 3/16" or less are acceptable.

5.5.5.2 The onlay volume including the fusion zone (and ferritic steel heat-affected zone, when temper bead welding is used) shall be ultrasonically examined. The UT examination procedure shall be in accordance with Section V, Article 4, using Cladding Technique One. Calibration blocks shall be in accordance with Fig. T-434.4.2.2. Examination personnel shall be qualified in accordance with the provisions of NB-5000. The acceptance criteria of Section III, NB-5330 shall apply.

6.0 ANO Supplemental Requirements PSI / ISI Requirements for Weld Onlays

6.1 As previously mentioned, an inservice examination of the DMWs will be performed in accordance with ASME Section XI, IWB-2500 and Appendix VIII.

6.2 Design of the onlay shall result in a configuration with greater than 90% coverage of the required preservice and in-service examination volume for each dissimilar metal weld and shall not cause a reduction in coverage of the required in-service examination volume for adjacent welds. In addition, the final surface of the onlay shall be suitable for examination.

6.3 The following UT demonstration requirements shall be met prior to installation of an onlay:

6.3.1 A mockup of the nozzle and onlay design is being examined by WesDyne to prove inspection capabilities and to qualify the PDI process for this configuration. The mockup onlay was applied by WSI using qualified procedures, equipment, and personnel to ensure qualification bases. The demonstration will verify that the volumetric examination detection, length sizing, through-wall sizing, and coverage capabilities for the DMW will not be adversely affected by the onlay.

6.3.2 The onlay mockup (taken from the PWROG stock of mockups) was fabricated to duplicate the ANO core flooding nozzle, had an onlay applied, and had flaws installed. The flaw shapes, sizes, orientations and locations were selected in accordance with recommendations from the EPRI NDE Center to ensure that the WesDyne PDI UT process is effective in finding and sizing flaws in the base material after the onlay is installed.

6.4 Preservice examinations shall be performed on DMW's with an onlay prior to return to service to determine that the onlay presents an acceptable barrier to prevent reactor coolant from contacting the Alloy 82 / 182 weld. Preservice examinations shall include the following:

6.4.1 PT examination shall be performed in accordance with IWA-2222. The acceptance standards of NB-5350 apply except that rounded indications with dimensions greater than 1/16 in. (1.5 mm) or 50% of the thickness of the onlay, whichever is smaller, are unacceptable. The inspection area beyond the onlay may comply with IWB-3514.

6.4.2 UT examination of the DMW with the installed onlay shall be performed in accordance with Appendix VIII of ASME Section XI. The UT examination shall comply with the acceptance standards of IWB-3514 or IWB-3600, as applicable. Planar flaws in the onlay shall comply with IWB-3500.

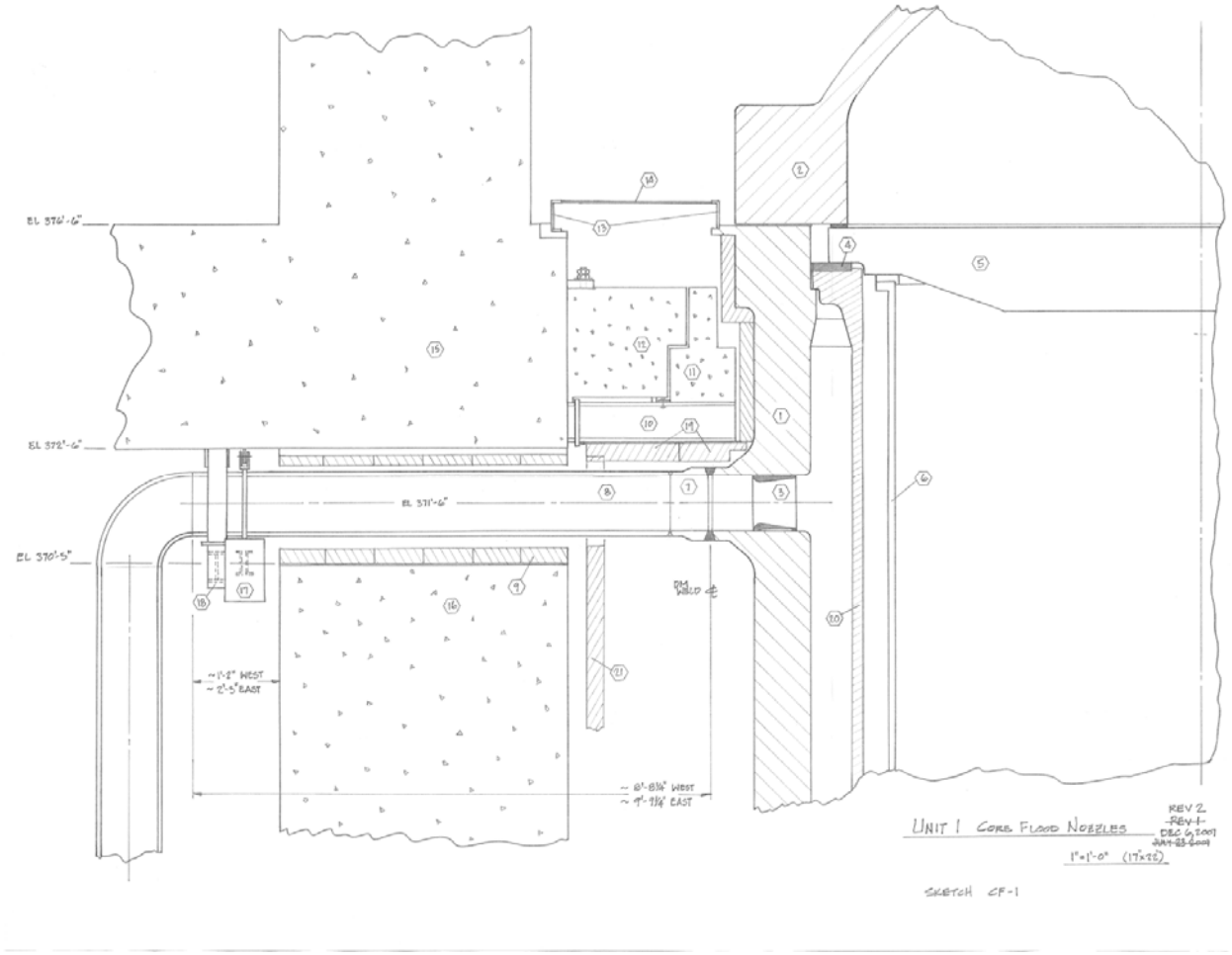
6.5 The following frequencies should be used for scheduling future ISI examinations:

6.5.1 UNCRACKED DMW: Perform a volumetric examination within 10 years following onlay installation, or within the design life of the onlay, whichever is shorter.

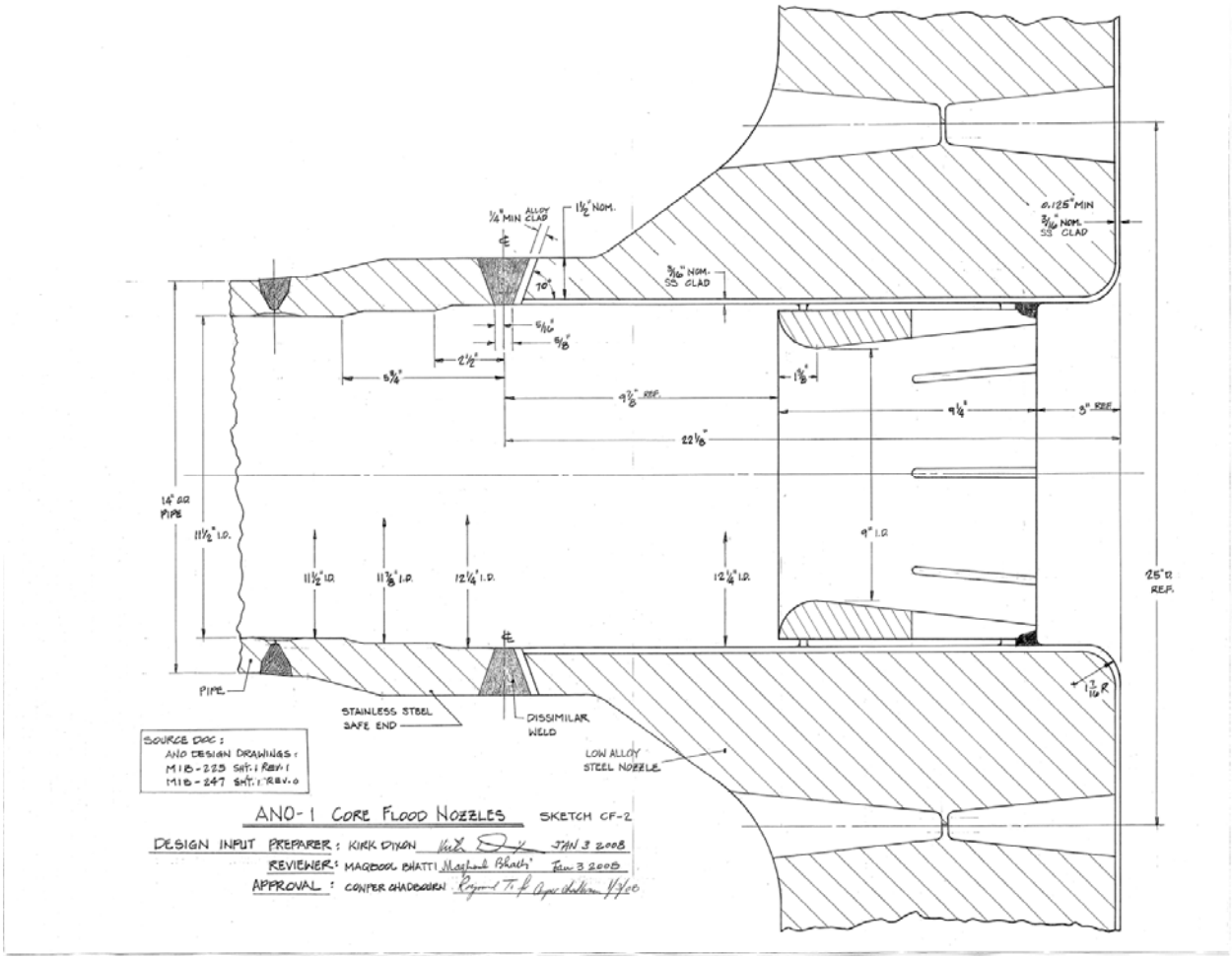
6.5.2 CRACKED DMW: Perform a volumetric examination once during the first or second refueling outage following application of the onlay. Examination volumes

that show no indication of new cracking shall be re-examined at the frequencies required by ASME Section XI.

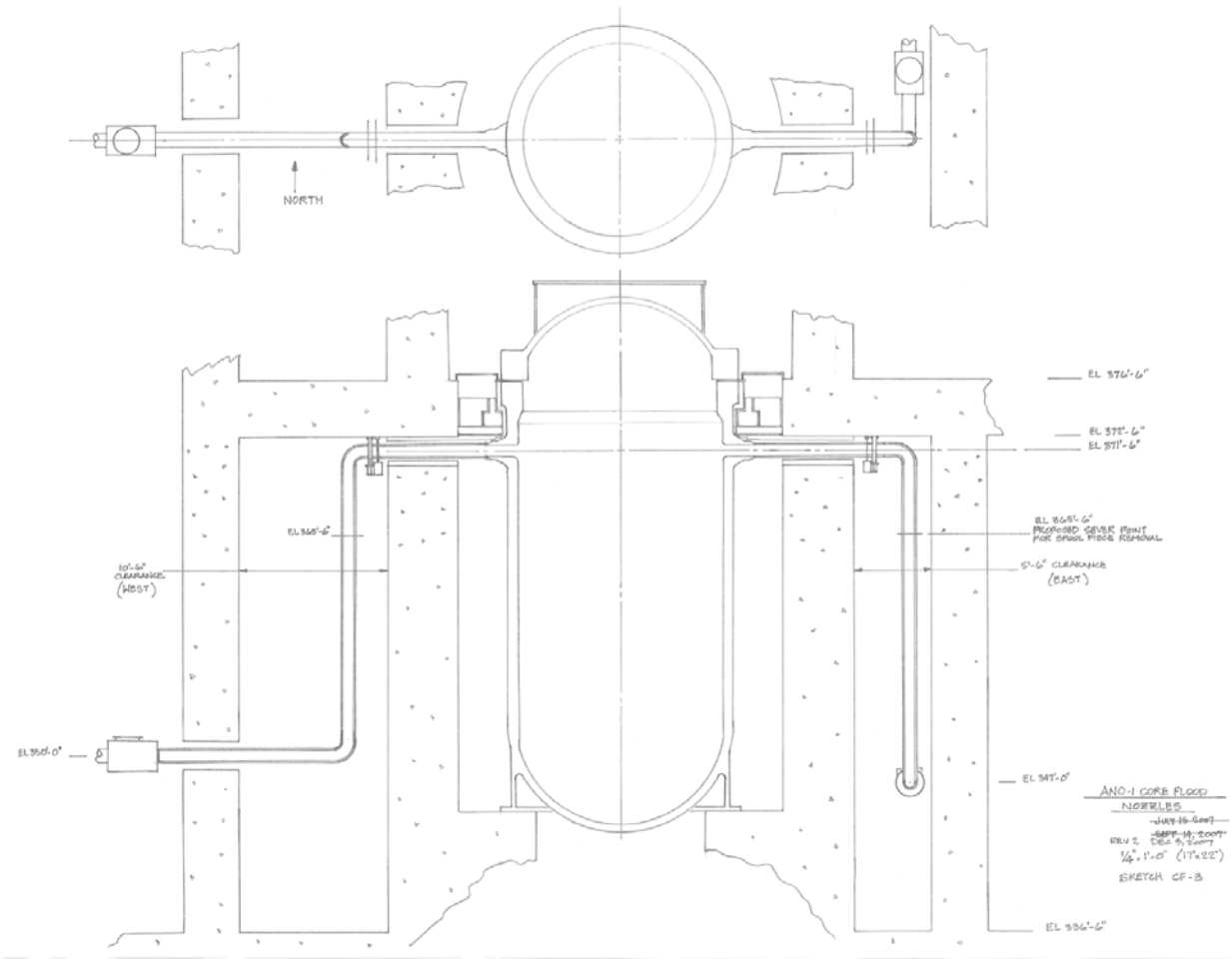
Attachment B
ANO Unit 1 Core Flooding Nozzle DM Butt Weld Mitigation
Sketch CF-1 (for information only-dimensions unverified)



Attachment C
ANO Unit 1 Core Flooding Nozzle DM Butt Weld Mitigation
Sketch CF-2



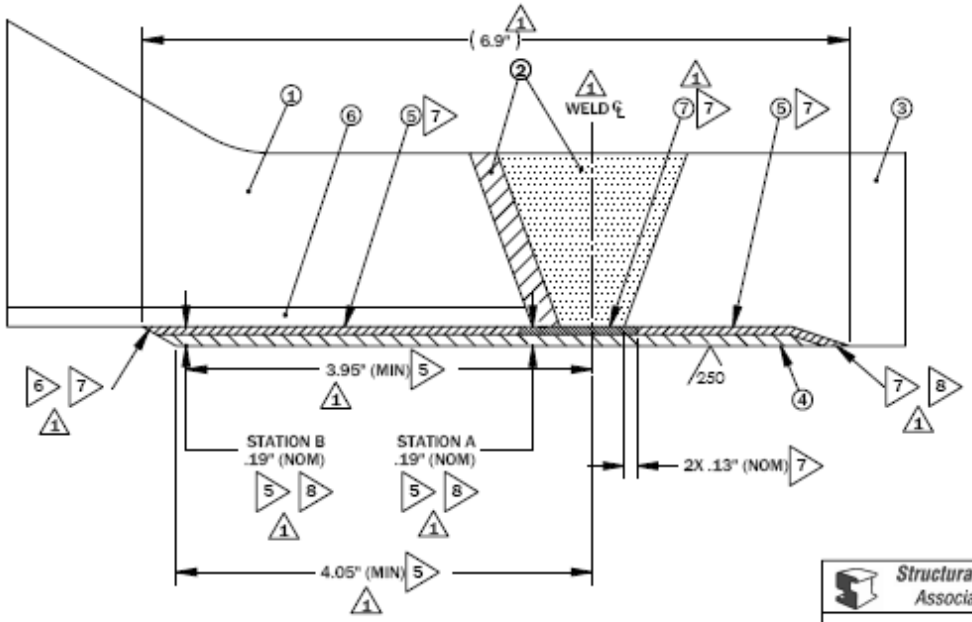
Attachment D
ANO Unit 1 Core Flooding Nozzle DM Butt Weld Mitigation
Sketch CF-3 (for information only-dimensions unverified)



Attachment E
ANO Unit 1 Core Flooding Nozzle DM Butt Weld Mitigation
Drawing ANO-52Q-02

NOTES:

1. COMPONENT SURFACE IS TO BE EXAMINED BY LIQUID PENETRANT METHOD AND DETERMINED TO BE ACCEPTABLE PRIOR TO ONLAY APPLICATION. THE SURFACE TO BE EXAMINED SHALL EXTEND BEYOND THE SURFACE TO BE ONLAYED BY ½". IN THE EVENT THAT THE ORIGINAL COMPONENT SURFACE IS FOUND UNACCEPTABLE, THE SURFACE SHALL BE PREPARED/REPAIRED AND REEXAMINED.
2. ONLAY FILLER METAL SHALL BE ASME, SECTION II, SFA-5.14, ERNiCrFe-7A (ALLOY 52M), CERTIFIED TO SECTION III SUBSECTION NB.
3. DESIGN THICKNESS INCLUDES NO ALLOWANCE FOR SURFACE CONDITIONING TO FACILITATE UT INSPECTION OF THE COMPLETED ONLAY. THE SURFACE OF THE ONLAY SHALL BE MECHANICALLY FINISHED AND HAVE A FINISH OF 250 RMS OR SMOOTHER. IN ADDITION THE SURFACE SHALL BE FLAT WITH NO OUT OF FLATNESS GREATER THAN 1/32" WITHIN ANY 1" DISTANCE.
4. DIMENSIONS APPLY TO ALL AZIMUTHS.
5. THE DIMENSION SHALL BE MEASURED AND RECORDED.
6. TRANSITION BETWEEN ONLAY AND NOZZLE CLADDING (PART 6) SHALL BE AS DEPOSITED AND SHALL HAVE AN INCLUDED ANGLE OF 135° OR GREATER.
7. A STAINLESS STEEL BUFFER LAYER (PART 5) SHALL BE INSTALLED. THE BUFFER LAYER TO CONSIST OF A SINGLE LAYER AND SHALL COVER THE NOZZLE CLADDING AND SAFE END UNDER THE ONLAY, WITHOUT CONTACTING THE DM WELD OR BUTTER (PART 2). THE BUFFER LAYER SHALL BE PLACED AS CLOSE AS PRACTICAL TO THE DM WELD/BUTTER FUSION LINE, BUT SHALL NOT TOUCH THE DM WELD/BUTTER. WELD FILLER METAL SHALL BE SFA-5.9, ER308L, CERTIFIED TO SECTION III, SUBSECTION NB. THE NOZZLE AND SAFE END BUFFER LAYERS SHALL BE CONNECTED USING USING A BRIDGE LAYER (PART 7). BRIDGE LAYER SHALL BE A SINGLE LAYER CONSISTING OF WELD FILLER METAL SFA-5.14, ERNiCr-3 (ALLOY 82), CERTIFIED TO SECTION III, SUBSECTION NB.
8. MACHINE ONLAY SURFACE INNER DIAMETER TO MATCH INNER DIAMETER OF SAFE END (PART 3) AS SHOWN. ONLAY SURFACE TO SAFE END TRANSITION SHALL BE GROUND SMOOTH TO PERMIT UT INSPECTION.



PARTS LIST		MATERIAL
1.	NOZZLE FORGING	A-508 CL. 2
2.	WELD/BUTTER	ALLOY 82/182
3.	SAFE END	SA-336 GR. F8M
4.	WELD ONLAY	ALLOY 52M
5.	BUFFER LAYER	ER308L
6.	CLADDING	ER308L
7.	BRIDGE LAYER	ALLOY 82

Structural Integrity Associates, Inc.

TITLE: RPV CORE FLOOD NOZZLE WELD ONLAY DESIGN

PLANT: ARKANSAS NUCLEAR ONE, UNIT 1

REV:	DRAWN BY:	ENGINEER:	REVIEWED BY:	APPROVED BY:
0	E.J. HOUSTON 1/10/08	N/A	R.A. MATTSON 1/10/08	S.W. SMITH 1/10/08
1	E.J. HOUSTON 7/26/08	N.A. FINNEY 7/26/08	R.A. MATTSON 7/26/08	S.W. SMITH 7/26/08

PROJECT NO. ANO-52Q
DRAWING NO. ANO-52Q-02
FILE NO. ANO-52Q-520
REVISION: 1 SCALE: NONE
NUCLEAR SAFETY RELATED Yes [X] No [ ]
SHEET: 1 OF 1

CONTAINS VENDOR PROPRIETARY INFORMATION