June 18, 2008

Vice President, Operations
Arkansas Nuclear One
Entergy Operations, Inc.
1448 S.R. 333
Russellville, AR 72802

SUBJECT: ARKANSAS NUCLEAR ONE, UNIT NO. 1 - APPROVAL OF RELIEF REQUEST ANO1-R&R-011 TO USE A PROPOSED ALTERNATIVE TO THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS BOILER AND PRESSURE VESSEL CODE REQUIREMENTS FOR WELD OVERLAY REPAIRS (TAC NO. MD6958)

Dear Sir or Madam:

By letter dated October 8, 2007, as supplemented by letter dated February 26, 2008, Entergy Operations, Inc. (Entergy, the licensee), submitted Request for Alternative ANO1-R&R-011 seeking relief from the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code at the Arkansas Nuclear One, Unit 1. Relief request ANO1-R&R-011 is applicable to the structural weld overlay of the dissimilar metal weld of the hot leg nozzle to decay heat piping.

By letter dated February 26, 2008, the licensee responded to the NRC staff's request for additional information and provided a revised Request for Alternative ANO1-R&R-011.

The NRC staff has completed its review of the subject relief request. Based on the enclosed safety evaluation (SE), the NRC staff has determined that the proposed Request for Alternative ANO1-R&R-011, will provide an acceptable level of quality and safety. Therefore, pursuant to paragraph 50.55a(a)(3)(i) of Title 10 of the *Code of Federal Regulations*, the NRC staff authorizes the use of Request for Alternative ANO1-R&R-011 at ANO-1 for the fourth 10-year ISI interval which began on May 31, 2008, and ends on May 31, 2017. However, prior to the fall 2008 refueling outage, ANO-1 will have begun its fourth 10-year ISI interval and the code of record will be updated to the 2001 Edition/2003 Addenda of the ASME Code, Section XI for repair/replacement activities and the 2001 Edition of ASME Code, Section XI for performance demonstration of the ultrasonic examination. Therefore, this request is based on the 2001 Edition through 2003 Addenda of the ASME Code.

If you have any questions regarding the SE, please contact Alan B. Wang at (301) 415-1445.

Sincerely,

/RA/

Thomas G. Hiltz, Chief
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-313

Enclosure: Safety Evaluation

cc w/encl: See next page

If you have any questions regarding the SE, please contact Alan B. Wang at (301) 415-1445.

Sincerely,

/RA/

Thomas G. Hiltz, Chief
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-313

Enclosure: Safety Evaluation

cc w/encl: See next page

DISTRIBUTION:

| | | |
|---|---|---|
| PUBLIC | RidsNrrDorlLpl4 | RidsRgn4MailCenter |
| LPLIV R/F | RidsNrrLAGLappert | CNove, NRR/DCI/CPNB |
| RidsAcrsAcnw&mMailCenter | RidsNrrPMAWang | JAdams, EDO RIV |
| RidsNrrDciCpnb | RidsOgcRp | |

**ADAMS Accession No.: ML081130173** *SE Input Memo, **NLO w/comments

| OFFICE | NRR/LPL4/PM | NRR/LPL4/LA | DCI/CPNB/BC | OGC | NRR/LPL4/BC | NRR/PL4/PM |
|---|---|---|---|---|---|---|
| NAME | AWang | GLappert | TChan* | RVHolmes** | THiltz | AWang |
| DATE | 6/4/08 | 6/4/08 | 4/3/08 | 6/5/08 | 6/18/08 | 6/18/08 |

cc:
Senior Vice President
Entergy Nuclear Operations
P.O. Box 31995
Jackson, MS 39286-1995

Vice President, Oversight
Entergy Nuclear Operations
P.O. Box 31995
Jackson, MS 39286-1995

Senior Manager, Nuclear Safety
& Licensing
Entergy Nuclear Operations
P.O. Box 31995
Jackson, MS 39286-1995

Senior Vice President
& Chief Operating Officer
Entergy Operations, Inc.
P.O. Box 31995
Jackson, MS 39286-1995

Associate General Counsel
Entergy Nuclear Operations
P.O. Box 31995
Jackson, MS 39286-1995

Manager, Licensing
Entergy Operations, Inc.
Arkansas Nuclear One
1448 SR 333
Russellville, AR 72802

Section Chief, Division of Health
Radiation Control Section
Arkansas Department of Health and
Human Services
4815 West Markham Street, Slot 30
Little Rock, AR 72205-3867

Section Chief, Division of Health
Emergency Management Section
Arkansas Department of Health and
Human Services
4815 West Markham Street, Slot 30
Little Rock, AR 72205-3867

Pope County Judge
Pope County Courthouse
100 W. Main Street
Russellville, AR 72801

Senior Resident Inspector
U.S. Nuclear Regulatory Commission
P.O. Box 310
London, AR 72847

Regional Administrator, Region IV
U.S. Nuclear Regulatory Commission
612 E. Lamar Blvd., Suite 400
Arlington, TX 76011-4125

# SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

# REQUEST ALTERNATIVE ANO1-R&R-011 FOR RELIEF FROM THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS BOILER AND PRESSURE VESSEL CODE, SECTION XI,

# ENTERGY OPERATIONS, INC.,

# INSERVICE INSPECTION PROGRAM

# ARKANSAS NUCLEAR ONE, UNIT NO. 1

# DOCKET NO. 50-313

## 1.0 INTRODUCTION

By letter dated October 8, 2007 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML072910042), with supplement dated February 26, 2008 (ADAMS Accession No. ML080590385), Entergy Operations, Inc. (Entergy, the licensee), submitted Request for Alternative ANO1-R&R-011 seeking relief from the requirements of American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, Subsection IWA-4000 for mitigating primary water stress corrosion cracking (PWSCC) on a dissimilar metal weld (DMW) of the "A" hot leg nozzle to decay heat piping using the full structural weld overlay for Arkansas Nuclear One, Unit No. 1 (ANO-1). This request is based on ASME Code Case N-740, "Dissimilar Metal Weld Overlay for Repair of Class 1, 2, and 3 Items Section XI, Division 1."

In the February 26, 2008, letter, the licensee responded to the US Nuclear Regulatory Commission (NRC) staff's request for additional information and revised Request for Alternative ANO1-R&R-011. The NRC staff evaluated the proposed alternative in the October 8, 2007 and February 26, 2008 letters. However, this safety evaluation is based upon the Request for Alternative ANO1-R&R-011 dated February 26, 2008.

The licensee states that this request is based on a prior request, Request for Alternative ANO1-R&R-010 – Proposed Alternative to ASME Code Requirements for Weld Overlay Repairs (ADAMS Accession No. ML070850915), which was approved by the NRC on April 6, 2007. Additionally, Request for Alternative ANO1-R&R-011 is similar to Request for Alternative ANO2-R&R-005 at Arkansas Nuclear One, Unit No. 2 (ANO-2) which was approved by the NRC on March 17, 2008 (ADAMS Accession No. ML080660082).

A DMW is defined as a weld that joins two pieces of different type of metals. In the proposed alternative, the dissimilar metal weld joins the ferritic (i.e., carbon steel) hot leg nozzle to austenitic stainless steel piping. The DMW itself is made of nickel-based Alloy 82/182. The proposed weld overlay repair is a process by which weld filler metal, that is resistant to stress corrosion cracking, is deposited on the outside surface of the degraded pipe including the original pipe weld.

## 2.0 REGULATORY REQUIREMENTS

Pursuant to Title 10 of the Code of Federal Regulations (10 CFR), paragraph 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) must meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in Section XI of the ASME Code and Addenda, "Rules for Inservice Inspection (ISI) of Nuclear Power Plant Components," to the extent practical within the limitations of design, geometry, and materials of construction of the components. 10 CFR 50.55(g)(4)(ii) and (iv) require that inservice examination of components and system pressure tests conducted during the first 10-year interval and subsequent intervals comply with the requirements in the latest edition and addenda of Section XI of the ASME Code incorporated by reference in 10 CFR 50.55a(b) 12 months prior to the start of the 120-month interval, subject to the limitations and modifications listed therein.

Pursuant to 10 CFR 50.55a(a)(3) alternatives to requirements may be authorized by the NRC if the licensee demonstrates that: (i) the proposed alternatives provide an acceptable level of quality and safety, or (ii) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

This request is applicable to the weld overlay activities scheduled for the fall 2008 refueling outage (1R21) at ANO-1. As of the submittal date of this request, ANO-1 is in the final period of its third 10-year Inservice Inspection (ISI) interval. This request is applicable to the weld overlay activities scheduled in the fall 2008 outage at ANO-01. Because the fourth 10 year inservice inspection would begin on May 31, 2008, the licensee requested that the NRC use the 2001 Edition/2003 addendum of ASME Code, Section XI (2001/2003 Code) for its review. The Commission has incorporated the 2001/2003 Code into its regulations (10 CFR 50.55a(b)) and used it review this request.

## 3.0 LICENSEE'S PROPOSED ALTERNATIVE

### 3.1 ASME Code Components Affected

This request for alternative is specific to the "A" hot leg nozzle to decay heat piping DMW. The carbon steel (P-No.1) hot leg nozzle is welded to an austenitic stainless steel (P-No. 8) elbow. The weld joining the nozzle to elbow is an 82/182 DMW (see attachment 1 of Request for Alternative ANO1-R&R-011 for additional details). The full structural weld overlay will be applied by deposition of Alloy 52M (ERNiCrFe-7A) weld metal on the outside surface of the DMW and adjacent base metal.

### 3.2 Code Requirements

The ASME Code, Section XI, Subsections IWA-4411 and IWA-4520(a) require that repair/replacement activities be performed and examined in accordance with the Owner's Requirements and the original Construction Code of the component or system. Alternatively, Subsections IWA-4411(a) and (b) allow use of later Editions/Addenda of the Construction Code (or a later different Construction Code such as ASME Section III) and revised Owner Requirements.

Subsections IWA-4411(e) and IWA-4600(b) provide alternative welding methods when the requirements of Subsection IWA-4411 cannot be met.

Subsection IWA-4530(a) requires the performance of preservice examinations based on Subsection IWB-2200 for Class 1 components.

Table IWB-2500, Category B-J, prescribes inservice inspection requirements for Class 1 butt welds in piping.

Appendix VIII, Supplement 11 of ASME Code, Section XI specifies performance demonstration requirements for ultrasonic examination of weld overlays.

3.3 Licensee's Reason for Requesting an Alternative

PWSCC of Alloy 600 components and welds has become a growing concern in the nuclear industry over the past decade. In particular, DMW made with Nickel Alloy 82 and 182 weld metal exposed to elevated operating temperatures are believed to pose a heightened propensity to PWSCC. Due to this concern, Entergy has concluded that the application of a preemptive full structural weld overlay for the "A" reactor coolant system (RCS) hot leg connection to the decay heat piping DMW is the most appropriate course of action to ensure continued RCS pressure boundary integrity and enhance performance of future inspections.

Structural weld overlays have been used for several years on piping of both boiling water reactors (BWRs) and pressurized water reactors (PWRs) to arrest the growth of existing flaws while establishing a new structural pressure boundary. Notwithstanding the above, no evidence of PWSCC has been found in the "A" hot leg to decay heat piping DMW. However, PWSCC is difficult to detect except when the inspection is performed in accordance with the rigorous requirements of ASME Code, Section XI, Appendix VIII. The subject DMW has been evaluated and does not meet the surface or geometric requirements of Appendix VIII. Therefore, inspection of this weld cannot be performed to Appendix VIII requirements without modifying the weld geometry or configuration.

Effective May 31, 2008, ANO-1 will begin performing repair/replacement activities in accordance with the 2001 Edition through 2003 Addenda of ASME Code, Section XI, except as described in ASME Code, Section XI, 2001 edition to be used for Appendix VIII, "Performance Demonstration for Ultrasonic Examination Systems." This edition of ASME Code, Section XI does not include requirements for application of a preemptive, full structural weld overlay. Moreover, preemptive full structural weld overlay requirements are not presently included in any Edition/Addenda of ASME Code, Section XI (including Code Cases) approved by NRC.

Weld overlays have been applied as repairs to other plants in accordance with ASME Code Cases N-504-2 and N-638-1, which are "conditionally accepted" for use in Regulatory Guide (RG) 1.147. Application of these code cases to nozzle DMWs requires a series of relief requests since Code Case N-504-2 was written specifically for stainless steel pipe-to-pipe welds and Code Case N-638-1 contains some restrictions and requirements that are not applicable to weld overlays. Code Case N-740 has been approved by the ASME Code Committee to specifically address weld overlays on DMWs. Code Case N-740 also incorporates changes to the latest approved version of Code Case N-638 (i.e., N-638-3). However, Code Case N-740 does not specifically address preemptive weld overlays and has not yet been accepted by the NRC in RG 1.147.

3.4 Licensee's Proposed Alternative

Pursuant to 10 CFR 50.55a(a)(3)(i), the licensee proposes the following alternatives to the Code requirements specified above. The proposed alternatives are applicable to the DMW joining the decay heat piping to the "A" hot leg nozzle.

The licensee will install a preemptive full structural weld overlay in accordance with the proposed alternatives specified in Attachments 2 and 3 to Request for Alternative ANO1-R&R-011 dated February 26, 2008. These alternatives are based on the methodology of ASME Code, Section XI, Code Case N-740. The alternative to design, fabrication, examination, pressure testing, and ISI of preemptive full structural weld overlays is described in Attachment 2 of the February 26, 2008 submittal. The alternative to ambient temperature temper bead welding is described in Attachment 3 of the February 26, 2008 submittal. The Attachment 3 alternative will be applied to the DMW identified above as an alternative to post-weld heat treatment requirements of ASME Code, Section III. The licensee will perform ultrasonic examinations of the proposed preemptive full structural weld overlays in accordance with Appendix VIII, Supplement 11 of the 2001 Edition through 2003 Addenda of the ASME Code, Section XI except as modified by the Performance Demonstration Initiative (PDI) Program. The proposed PDI alternatives to Appendix VIII, Supplement 11 are specified in Attachment 6 of the February 26, 2008, submittal.

3.5 Duration of the Alternative

ANO1-R&R-011 is applicable for the fourth 10-year ISI inspection interval at ANO-1 which begins on May 31, 2008 and ends on May 31, 2017.

4.0 NRC STAFF EVALUATION

Attachment 2 to Request for Alternative to ANO1-R&R-011 contains requirements for the design and nondestructive examination (NDE) of the weld overlay. Attachment 3 to Request for Alternative ANO1-R&R-011 contains requirements for the ambient temperature temper bead welding technique. The proposed methodology and associated requirements for the weld overlay are similar to Code Case N-740, "Dissimilar Metal Weld Overlay for Repair of Class 1, 2, and 3 Items Section XI, Division 1" of the ASME Code, Section XI. Code Case N-740 combines the requirements in Code Case N-504-3, "Alternative Rules for Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping Section XI, Division 1," and N-638-1, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW [gas tungsten arc welding] Temper Bead Technique Section XI, Division 1." The NRC staff has endorsed Code Cases N-504-3 and N-638-1 in RG 1.147, Revision 15, but not Code Case N-740. The licensee used the Code Case 504-2 methodology. Since the Licensee's submittal, the NRC has approved Code 504-3 methodology in Regulatory Guide 1.147, revision 15 (ADAMS Accession No. ML072070419). The Commission used Code 504-3 in its evaluation of this request as Revision 3 is the latest approved version of the Code Case. When using N-504-3, RG 1.147 requires that Appendix Q to the ASME Code, Section XI be used.

The licensee has satisfactorily addressed in ANO1-R&R-011 many of the technical issues related to the design, analysis, and examination of the weld overlay that the NRC staff raised in its safety evaluation for ANO-1 Relief Request ANO1-R&R-010 and for ANO-2 Relief Request ANO2-R&R-005. Therefore, the NRC staff only needed to evaluate the following technical issues that are plant specific to ANO-1.

4.1 General Requirements

Section 1.0, "General Requirements," of Attachment 2 to Request for Alternative ANO1-R&R-011 dated February 26, 2008 provides requirements for the specification of the carbon steel base metal and austenitic Nickel Alloy 52M weld overlay filler metal, surface condition of the base metal, and chromium content of the weld overlay deposits. The proposed alternative is consistent with N-504-3; N-638-1; Appendix Q to the ASME Code, Section XI; ANO-1-R&R-010 at ANO-1 and ANO2-R&R-005 at ANO-2 with the following exception as discussed below.

In the October 8, 2007 submittal, the licensee stated that it may apply a butter (transitional) layer of austenitic stainless steel filler metal across the austenitic stainless steel base metal. Paragraph (e) of Code Case N-504-2 requires specific delta ferrite content in the weld layer when austenitic stainless steel weld metal is used. The NRC staff asked the licensee to discuss whether paragraph (e) of Code Case N-504-2 is applicable to the butter layer if austenitic stainless steel filler metal is applied. In addition, the licensee was requested to identify the austenitic stainless steel weld filler metal and to provide the maximum and minimum delta ferrite content for the heat of austenitic stainless steel filler wire to be used, as stated on the Certified Material Test Report (CMTR).

In the February 26, 2008, letter, the licensee responded that Code Case N-504-2 provides rules for installing austenitic stainless steel weld overlays onto austenitic stainless steel materials (i.e. welds and base materials) as a means of reducing a defect to a flaw of acceptable size. Code Case N-504-2 was originally developed as a repair method for austenitic stainless steel welds subject to intergranular stress corrosion cracking (IGSCC) in BWR systems. While BWR austenitic stainless steels are susceptible to IGSCC, PWR systems are not. IGSCC can occur when the following three essential conditions exist simultaneously at a given location: (1) a susceptible microstructure (i.e. sensitized austenitic material), (2) tensile stress, and (3) a susceptible environment having a critical oxygen content. The essential conditions are interdependent such that critical levels for each essential condition will vary depending upon the strength of the other two. Should any of these conditions be removed, then IGSCC cannot occur.

Paragraph (e) of N-504-2 requires weld reinforcement layers to have a deposited delta ferrite content of at least 7.5 ferrite number (FN, also expressed in percentages). Alternatively, an as-deposited delta ferrite content of 5 FN may also be accepted provided this lower value is substantiated by evaluation. This delta ferrite requirement is applicable to stainless steel weld overlays that are subject to IGSCC. Weld metals containing even small additions of delta ferrite are less susceptible to sensitization, and thereby, more resistant to IGSCC. As noted in paragraph 2.1 of NUREG-0313, Revision 2, "…weld metal with low carbon and controlled ferrite (such as 308L with 7.5% minimum ferrite) is resistant to sensitization and IGSCC…" However, NUREG-0313 also considers austenitic stainless steels with 5% delta ferrite resistant to sensitization and IGSCC depending on carbon content and other possible factors. As an additional benefit, small additions of one to three percent delta ferrite in austenitic weld deposits reduce the tendency for hot cracking or fissuring especially when welds are highly restrained.

The licensee does not believe that the delta ferrite requirement of Code Case N-504-2, paragraph (e) is applicable to the austenitic stainless steel butter layer of Request ANO1-R&R-011 for the following reasons:

(a) IGSCC is a credible degradation mechanism for austenitic stainless steels in oxidizing BWR environments. However, there is no industry experience to suggest that IGSCC is a concern for PWRs. In general, adverse environmental conditions in PWRs are reducing environments (environments with little or no free oxygen) and are not conducive for IGSCC. Therefore, IGSCC is not a credible degradation mechanism for the ANO-1 weld overlay location.

(b) The austenitic stainless steel butter layer will not be included in the structural weld overlay thickness as defined in Attachment 2 to ANO1-R&R-011. The delta ferrite requirements of Code Case N-504-2, paragraph (e) only apply to the structural layers of a weld overlay. They do not apply to nonstructural weld layers. Conversely, paragraphs (c) and (d) of the code case do apply to nonstructural weld layers but clearly do not include any delta ferrite requirements. Therefore, if nonstructural layers for a weld overlay subject to IGSCC do not require delta ferrite testing, then a nonstructural stainless steel butter layer (for an Alloy 52M weld overlay) that is not subject to IGSCC certainly does not require delta ferrite testing.

For ANO-1, the stainless steel butter layers will be deposited with ER308L filler metal which has a maximum of 0.03% carbon. The use of low carbon filler metals greatly reduces the potential for sensitizing austenitic stainless steel weld deposits. The licensee stated that the ER308L filler metal it uses will have a delta ferrite content of between 5 and 15 FN as documented on the applicable CMTR. This delta ferrite content is consistent with Code Case N-504-2 and NUREG-0313, Revision 2. It is also consistent with ASME Section III and RG 1.44, *Control of the Use of Sensitized Stainless Steel.* According to NB-2433.2 of ASME Section III, all austenitic stainless steel filler metals must have a minimum delta ferrite of at least 5 FN as reported on the CMTR. RG 1.44, paragraphs C.4.b and C.5.a provide exceptions to recommended controls for materials subject to sensitization based on a delta ferrite content of 5 FN. Regarding hot cracking, a minimum delta ferrite of 5 FN provides more than adequate resistance to fissuring as noted in RG 1.31, *Control of Ferrite in Stainless Steel Weld Metal*.

The licensee stated further that the butter weld layer will be deposited with a welding procedure that has been qualified in accordance with the ASME Code, Section IX. Liquid penetrant (PT) examinations will be performed prior to and after deposition of the butter layer. The second PT examination is performed to ensure that the completed butter layer is free from cracks and other unacceptable indications prior to deposition of the Alloy 52M weld overlay.

The NRC staff agrees with the licensee that the minimum delta ferrite requirement of N-504-2, paragraph (e), which is unchanged in N-504-3, does not apply to the butter layer at ANO-1. The NRC staff finds that the licensee will deposit the butter layer on the pipe and perform examination in accordance with the requirements of the ASME Code and N-504-3. The NRC staff finds that the licensee has responded to the NRC staff concern satisfactorily.

4.2 Crack Growth Considerations and Design

Section 2.0, “Crack Growth Considerations and Design,” of Attachment 2 to Request for Alternative ANO1-R&R-011 dated February 26, 2008, provides the requirements for weld overlay design, design-basis flaw size, and crack-growth calculation. The crack-growth calculation assures that the growth of the crack in the base metal will be mitigated or minimized by the installation of the weld overlay. The Section 2.0 requirements are consistent with N-504-3; ANO-

1 Relief Request ANO1-R&R-010; ANO-2 Relief Request ANO2-R&R-005; and Appendix Q to the ASME Code, Section XI.

The licensee states that the design basis for full structural weld overlays is to maintain the original design margins with no credit taken for the underlying PWSCC-susceptible weldments. The assumed design-basis flaw for the purpose of sizing the weld overlays is 360º and 100% through the original wall thickness of the DMW. Regarding the crack-growth analysis for the preemptive full structural weld overlay, a flaw originating from the inside diameter with a depth of 75% and a circumference of 360º will be assumed. A 75% through-wall flaw is the largest flaw that could remain undetected in the base metal after weld overlay installation. A pre-service volumetric examination will be performed after application of the weld overlay using an ASME Section XI, Appendix VIII (as implemented through PDI) examination procedure.

Since the PDI procedure is not qualified to examine the lower (i.e. inner ) 75% of the pipe wall thickness, this examination will verify that there is no cracking in the upper (i.e. outer ) 25% of the original weld and base material wall thickness. At a minimum the licensee assumes a 75% though-wall crack to exist in the lower 75% of the pipe wall thickness for the crack growth anayses because the PDI procedure is not qualified to examine the lower 75% of the pipe wall thickness. If any crack-like flaws are identified in the upper 25% of the original weld or base material by the preservice examination, then the assumed flaw length for the crack growth analysis is the as-found flaw size in the upper 25% of the pipe wall thickness plus the postulated 75% through-wall flaw. Therefore, the licensee's crack growth anayses will bound any flaws found in the upper 25% since it lengthens the as-found flaw with an additional 75% of the pipe wall thickness. With regard to the weld overlay design, flaws are considered to be 100% through the original weld and no structural credit is taken for the weld. The NRC staff finds that the proposed flaw size for the crack growth calculation is conservative and, therefore, is acceptable.

As part of the weld overlay design, the licensee will perform the following analyses and verifications:

- Nozzle-specific stress analysis will be performed to establish a residual stress profile in each nozzle. Post-weld overlay residual stresses at normal operating conditions will be shown to result in beneficial compressive stresses on the inside surface of the components, assuring that further crack initiation due to PWSCC is highly unlikely.

- Fracture mechanics analyses will also be performed to predict crack growth for postulated flaws. Crack growth due to PWSCC and fatigue will be analyzed for the original DMW. The analyses will demonstrate that the postulated cracks will not grow beyond the design basis for the weld overlays.

- The analyses will demonstrate that applying the weld overlay does not impact the conclusions of the existing nozzle stress reports. The ASME Code, Section III stress and fatigue criteria will be met for regions of the overlays remote from assumed cracks.

- Shrinkage will be measured during the overlay application. Shrinkage stresses at other locations in the piping systems arising from weld overlays will be demonstrated not to have an adverse effect on the system. Clearances of

affected support and restraints will be checked after the overlay repair and will be reset within the design ranges as required.

- The total added weight on the piping systems due to the overlay will be evaluated for potential impact on piping system stresses and dynamic characteristics.

- The as-built dimensions of the weld overlay will be measured and evaluated to demonstrate that they meet or exceed the minimum design dimensions of the overlay.

The NRC staff finds that the licensee's proposed analyses and shrinkage measurements are consistent with paragraph (g) of Code Case N-504-3 and are, therefore, acceptable.

4.3 Examination and Inspection

Section 3, "Examination and Inspection," of Attachment 2 to Request for Alternative ANO1-R&R-011 dated February 26, 2008, provides requirements for the acceptance examination, pre-service examination, and inservice examination after the weld overlay is installed. The length, surface finish, and flatness requirements of the weld overlay are specified in the weld overlay design to provide for required examination volume of the weld overlay as shown in Figures 1 and 2 of Attachment 2.

4.3.1 Acceptance Examination

Section 3.0(a), "Acceptance Examination," of Attachment 2 to Request for Alternative ANO1-R&R-011 dated February 26, 2008, requires a surface and UT examination of an installed weld overlay. The NRC staff finds the requirements of the acceptance examination acceptable because they are consistent with N-504-3, Appendix Q to the ASME Code, Section XI and previous NRC approvals for ANO-1 Relief Request ANO1-R&R-010 and ANO-2 Relief Request ANO2-R&R-005.

4.3.2 Preservice Examination

Section 3.0(b), "Preservice Inspection," of Attachment 2 to Request for Alternative ANO1-R&R-011 dated February 26, 2008 requires an ultrasonic examination of the installed weld overlay and the upper (outer) 25% of the original pipe-wall thickness. The required examination volume is defined in Figure 2 of Attachment 2 to Request for Alternative ANO1-R&R-011. The NRC staff finds the requirements of the preservice examination acceptable because they are consistent with N-504-3, Appendix Q to the ASME Code, Section XI and previous NRC approvals ANO-1 Relief Request ANO1-R&R-010 and ANO-2 Relief Request ANO2-R&R-005.

4.3.3 Inservice Examination

Section 3.0(c) of Attachment 2 to Request for Alternative ANO1-R&R-011 dated February 26, 2008, requires inservice examination to be conducted ultrasonically and the examination volume is defined in Figure 2 of Attachment 2 to Request for Alternative ANO1-R&R-011. The NRC staff finds the requirements of the inservice examination acceptable because they are consistent with Appendix Q to the ASME Code, Section XI and previous NRC approvals ANO-1 Relief Request ANO1-R&R-010 and ANO-2 Relief Request ANO2-R&R-005.

4.4 Pressure Testing

Section 4, "Pressure Testing," of Attachment 2 to Request for Alternative ANO1-R&R-011 requires a system leakage test be performed in accordance with IWA-5000 after a weld overlay is installed. The NRC staff finds this requirement acceptable because it is consistent with paragraph (h) of Code Case N-504-3.

4.5 Documentation

Section 5, "Documentation," of Attachment 2 to Request for Alternative ANO1-R&R-011 requires that the use of the proposed alternative be documented on ASME Form NIS-2, "Owner's Report for Repairs or Replacements." The NRC staff finds this requirement acceptable because it is consistent with paragraph (m) of Code Case N-504-3.

4.6 Proposed Ambient Temperature Temperbead Technique

The requirements for the proposed ambient temperature temperbead welding are discussed in Attachment 3 to Request for Alternative ANO1-R&R-011 and are based on Code Case N-638-1 with the following exceptions. The requirements in Attachment 3 to ANO1-R&R-011 are consistent with N-638-1, ANO-1 Relief Request ANO1-R&R-010, and ANO-2 Relief Request ANO2-R&R-005 with one exception as discussed below.

Paragraph 1.0(a) of Code Case N-638-1 limits the maximum area of an individual weld to 100 square inches on the ferritic base material using temperbead welding. However, the proposed alternative allows the weld surface area up to 500 square inches on the ferritic base material. The licensee stated that the technical justification for allowing weld overlays on ferritic materials with surface areas up to 500 inches is provided in the White Paper supporting the changes in ASME Code Case N-638-3 and EPRI Report 1011898, "Justification for the Removal of the 100 Square Inch Temperbead Weld Repair Limitation" (Reference 1). The licensee stated that the ASME white paper notes that the original limit of 100 square inches in Code Case N-638-1 was arbitrary. The report cites evaluations of a 12-inch diameter nozzle weld overlay to demonstrate adequate tempering of the weld heat-affected zone, residual stress evaluations demonstrating acceptable residual stresses in weld overlays ranging from 100 to 500 square inches, and service history in which weld repairs exceeding 100 square inches were approved by NRC and applied to DMW nozzles in several boiling-water reactor and pressurized-water reactor applications. Some of the cited repairs are greater than 15 years old, and have been inspected several times with no evidence of any continued degradation. The above theoretical arguments and empirical data have been verified in practice by extensive field experience with temperbead weld overlays, with ferritic material coverage ranging from less than 10 square inches up to and including 325 square inches.

The licensee notes that the proposed 500 square inch weld area on the ferritic material has been addressed in EPRI Report 1014351, "Topical Report Supporting an Expedited NRC Review of the Content of the Code Case needed for Dissimilar Metal Weld Overlay Repairs, December 2006" (Reference 2). This report shows that the structural integrity of the ferritic material is not adversely affected by a 500 square inch weld overlay area. The technical basis

for the 500 square inch weld area was also presented in slides entitled, "Basis for 500 Square Inch Weld Overlay Over Ferritic Material," in a NRC-ASME public meeting held on January 10, 2007 (ADAMS Accession No. ML070470565). Based on EPRI Report 1014351, the NRC staff finds that the proposed 500 square inch weld area on the ferritic material is acceptable because the stress analysis presented in EPRI Report 1014351 shows that the structural integrity of ferritic material is not adversely affected by a 500 square inch weld overlay area.

4.7 Performance Demonstration Initiative Program

Appendix VIII, Supplement 11 of the 2001 Edition of ASME Code, Section XI, specifies requirements for performance demonstration of ultrasonic examination procedures, equipment, and personnel used to detect and size flaws in full structural overlays of wrought austenitic piping welds. The industry initiated the PDI Program as an alternative to satisfy the requirements of ASME Code, Section XI, Appendix VIII. To this end, EPRI has developed a program for qualifying equipment, procedures, and personnel in accordance with the UT criteria of Appendix VIII, Supplement 11. Prior to the Supplement 11 program, EPRI was maintaining a performance demonstration program (the precursor to the PDI program) for weld overlay qualification under the Tri-party Agreement with the NRC, BWR Owner's Group, and EPRI, as discussed in the NRC letter dated July 3, 1984 (ADAMS Accession No. ML8407090122). Later, the NRC staff recognized the EPRI PDI program for weld overlay qualifications as an acceptable alternative to the Tri-party Agreement in its letter dated January 15, 2002, to the PDI Chairman (ADAMS Accession No. ML020160532).

The PDI program is routinely assessed by the NRC staff for consistency with the current ASME Code and proposed changes. The PDI program does not fully comport with the existing requirements of Supplement 11. The PDI representatives presented the differences between Supplement 11 and the PDI program at public meetings in which the NRC participated (Memorandum from Donald G. Naujock to Terence Chan, "Summary of Public Meeting Held January 31 – February 2, 2002, with PDI Representatives," March 22, 2002 (ADAMS Accession No. ML010940402), and Memorandum from Donald G. Naujock to Terence Chan, "Summary of Public Meeting Held June 12 through June 14, 2001, with PDI Representatives," November 29, 2001, (ADAMS Accession No. ML013330156)). Based on the discussions at these public meetings, the NRC staff determined that the industry's PDI program provides an acceptable level of quality and safety.

The licensee proposed to use the PDI program as indicated in Attachment 6 to Request for Alternative ANO1-R&R-011 to satisfy the Appendix VIII, Supplement 11, qualification requirements. The PDI initiatives will be used for qualification of ultrasonic examinations to detect and size flaws in the preemptive full structural weld overlays of this request. The NRC staff evaluated the differences between the PDI program and Supplement 11 as shown in Attachment 6 to ANO1-R&R-011. The NRC staff concludes that the justifications for the differences are acceptable and the PDI program provides an acceptable level of quality and safety. Therefore, the proposed ANO-1 PDI program is acceptable for use in lieu of Supplement 11 of Appendix VIII to the ASME Code, Section XI.

4.8 Commitments

In Enclosure 3 of Request for Alternative ANO1-R&R-011 dated February 26, 2008, the licensee made the following commitments;

1. The licensee will submit the following information to the NRC within fourteen (14) days from completing the final ultrasonic examinations of the completed weld overlays:

   a. the weld overlay examination results including a listing of indications detected;

   b. the disposition of indications using the standards of ASME Code, Section XI, Subsection IWB-3514-2 and/or IWB-3514-3 criteria and, if possible, the type and nature of the indications; and

   c. a discussion of any repairs to the weld overlay material and/or base metal and the reason for the repairs.

2. The licensee will submit to the NRC a stress analysis summary demonstrating that the hot leg piping nozzle will perform its intended design function after weld overlay installation. The stress analysis report will include results showing that the requirements of NB-3200 and NB-3600 of the ASME Code, Section III, are satisfied. The stress analysis will also include results showing that the requirements of Subsection IWB-3000 of the ASME Code, Section XI, are satisfied. The results will show that the postulated crack including its growth in the nozzles will not adversely affect the integrity of the overlaid welds. This information will be submitted to the NRC prior to entry into Mode 4 following the ANO-1 refueling outage 1R21.

## 5.0 CONCLUSION

The NRC staff has reviewed the licensee's submittal and determined that Request for Alternative ANO1-R&R-011 dated February 26, 2008, will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55(a)(3)(i), the NRC staff authorizes the use of Request for Alternative ANO1-R&R-011 for the installation of full structural weld overlay on the dissimilar metal weld of the hot leg nozzles at ANO-1. The effective period of Request for Alternative ANO1-R&R-011 is the fourth 10-year ISI interval which began on May 31, 2008 and ends on May 31, 2017. All other ASME Code, Section XI requirements for which relief was not specifically requested and approved in this relief request remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

## 6.0 REFERENCES

1. "Justification for the Removal of the 100 Square Inch Temperbead Weld Repair Limitation," Electric Power Research Institute Report, 1011898.

2. "Topical Report Supporting an Expedited NRC Review of the Content of the Code Case needed for Dissimilar Metal Weld Overlay Repairs," Electric Power Research Institute Report, 1014351

Principal Contributor: C. Nove
Date: June 18, 2008