UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

January 29, 2010

Mr. Barry S. Allen
Site Vice President
FirstEnergy Nuclear Operating Company
Davis-Besse Nuclear Power Station
Mail Stop A-DB-3080
5501 North State Route 2
Oak Harbor, OH 43449-9760

SUBJECT: DAVIS-BESSE NUCLEAR POWER STATION, UNIT 1 - RELIEF REQUEST RR-A32 FOR THE APPLICATION OF FULL STRUCTURAL WELD OVERLAYS ON DISSIMILAR METAL WELDS OF REACTOR COOLANT PIPING (TAC NO. ME0478)

Dear Mr. Allen:

By letter to the U.S. Nuclear Regulatory Commission (NRC) dated January 30, 2009 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML090350070), as supplemented by letters dated July 13, 2009 (ADAMS Accession No. ML091950627), November 23, 2009 (ADAMS Accession No. ML093360333), and December 15, 2009 (ADAMS Accession No. ML100040016), the FirstEnergy Nuclear Operating Company (FENOC or the licensee) submitted a request to the NRC for the use of alternatives to certain American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section XI requirements at Davis-Besse Nuclear Power Station, Unit 1.

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(a)(3)(i), the licensee requested to use the proposed alternative on the basis that the alternative provides an acceptable level of quality and safety. The licensee requested NRC staff review and approval of Relief Request RR-A32 to allow the installation of optimized weld overlays (OWOLs) on the dissimilar metal welds (DMW) at the reactor coolant pump discharge nozzles at the Davis-Besse Nuclear Power Station (DBNPS).

The licensee revised the original RR-A32 dated January 30, 2009, based on the NRC staff request for additional information (ADAMS Accession No. ML091530151). Therefore, RR-A32 in the November 23, 2009, letter, with the additional requirements submitted in an electronic mail dated December 15, 2009, is the latest version upon which this safety evaluation is based.

On the basis of its review, the NRC staff has determined that Relief Request RR-A32, dated January 30, 2009 (ADAMS Accession No. ML090350070), as supplemented by letters dated July 13, 2009 (ADAMS Accession No. ML091950627), and November 23, 2009 (ADAMS Accession No. ML093360333) will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff authorizes the use of Relief Request RR-A32, for the OWOLs on the DMW at the reactor coolant pump discharge nozzles at the DBNPS. The subject relief request is authorized for the third 10-year inservice inspection interval which commenced on September 21, 2000, and will end on September 20, 2012.

If you have any questions, please contact the Davis-Besse Project Manager, Mr. Stephen Sands, at 301-415-3154.

Sincerely,

for

Stephen J. Campbell, Chief
Plant Licensing Branch III-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-346

Enclosure:
As stated

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELIEF REQUEST (RR)-A32

OPTIMIZED WELD OVERLAYS OF

REACTOR COOLANT PUMP DISCHARGE NOZZLES

DAVIS-BESSE NUCLEAR POWER STATION

FIRSTENERGY NUCLEAR OPERATING COMPANY

DOCKET NO. 50-346

## 1.0 INTRODUCTION

By letter dated January 30, 2009 (Agencywide Documents and Access Management System, (ADAMS) Accession No. ML090350070), the FirstEnergy Nuclear Operating Company (the licensee), requested U.S. Nuclear Regulatory Commission (NRC) staff review and approval of RR-A32 to allow the installation of optimized weld overlays (OWOLs) on the dissimilar metal welds (DMWs) of the reactor coolant pump discharge nozzles at the Davis-Besse Nuclear Power Station (DBNPS). The proposed RR is an alternative to the requirements of American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, "Rules for Inservice Inspection (ISI) of Nuclear Power Plant Components."

By letters dated July 13, 2009 (ADAMS Accession No. ML091950627), and November 23, 2009 (ADAMS Accession No. ML093360333), the licensee responded to the NRC staff's request for additional information and updated RR-A32. By an electronic mail dated December 15, 2009 (ADAMS Accession No. ML100040016), the licensee added in Section A2.3 of RR-A32 a requirement for examination expansion if indications are detected in any one of the overlaid DMWs during inservice inspections.

In the November 23, 2009, submittal, the licensee also requested to apply full structural weld overlays (FSWOL) on the DMWs of the reactor coolant pump discharge nozzles as presented in RR-A33 (ADAMS Accession No. ML100080573). The licensee will inspect the DMWs of the reactor coolant pump discharge nozzles prior to installing the weld overlays. If there are no indications in, or indication depth equal to or less than 50 percent of the pipe thickness (initiated from the inside surface of the pipe), the licensee will install the OWOLs. If the indication depth exceeds 50 percent of the pipe wall thickness, a FSWOL will be installed at the reactor coolant pump discharge nozzle. A FSWOL has more weld layers than an OWOL.

The licensee revised the original RR-A32 dated January 30, 2009, based on the NRC staff request for additional information (ADAMS Accession No. ML091530151). Therefore, RR-A32 in the November 23, 2009, letter, with the additional requirements submitted in an electronic mail dated December 15, 2009, is the latest version upon which this safety evaluation is based.

A DMW is defined as a weld that joins two pieces of metals that are not of the same material. The DMW itself is made of nickel-based Alloy 82/182 material. The industry has experienced degradation of the Alloy 82/182 weld material which is susceptible to primary water stress-corrosion cracking (PWSCC) in a pressurized-water reactor (PWR) environment. For the proposed alternative, the weld overlay is a process by which a weld metal that is less susceptible to PWSCC is deposited on the outside surface of the Alloy 82/182 welds to form a new pressure boundary.

## 2.0 REGULATORY EVALUATION

Pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Section 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 the ASME Code, Section XI, to the extent practical within the limitations of design, geometry, and materials of construction of the components. The regulations 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.

The ASME Code of record for the third 10-year ISI interval at the DBNPS is the 1995 Edition through the 1996 Addenda of the ASME Code, Section XI.

## 3.0 TECHNICAL EVALUATION

### 3.1 Proposed RR-A32

#### 3.1.1 Components Affected

| Weld Identification | Description | Size | Material |
|---|---|---|---|
| RC-MK-B-59-1-SW143B | Reactor coolant pump 1-1 Discharge Piping | Nominal 28-inch Inside Diameter (ID) | Stainless steel Pipe/Alloy 82-182 weld/carbon steel elbow |
| RC-MK-B-44-1-SW69B | Reactor coolant pump 1-2 Discharge Piping | Nominal 28-inch ID | Stainless steel pipe/Alloy 82-182 weld/carbon steel elbow |

| | | | |
|---|---|---|---|
| RC-MK-B-61-1-SW69A | Reactor coolant pump 2-1 Discharge Piping | Nominal 28-inch ID | Stainless steel pipe/Alloy 82-182 weld/carbon steel elbow |
| RC-MK-B-56-1-SW143A | Reactor coolant pump 2-2 Discharge Piping | Nominal 28-inch ID | Stainless steel pipe/Alloy 82-182 weld/carbon steel elbow |

Stainless Steel Pipe - A-376 Type 316 (P-8)
Carbon Steel Elbow - A 516 Grade 70 (P-1) 24 degree elbow internally clad with SA 240-304L (stainless steel)

3.1.2 Applicable Code Edition and Addenda

The ASME Code, Section XI, 1995 Edition through 1996 Addenda.

3.1.3 Applicable Code Requirement

IWA-4410(a) of ASME Code, Section XI states: "Repair/replacement activities shall be performed in accordance with the Owner's Requirements and the original Construction Code of the component or system, except as provided in IWA-4410(b), (c), and (d)."

IWA-4410(b) of ASME Code, Section XI states in part: "Later Editions and Addenda of the Construction Code, or a later different Construction Code, either in its entirety or portions thereof, and Code Cases may be used, provided the substitution is as listed in IWA-4221(b)."

IWA-4410(c) of ASME Code, Section XI states: "Alternatively, the applicable requirements of IWA-4600 may be used for welding and the applicable requirements of IWA-4700 may be used for heat exchanger tube plugging and sleeving."

ASME Code, Section XI, Appendix VIII, Supplement 11 provides requirements for the qualification requirements for the ultrasonic examination of Overlaid Wrought Austenitic Piping Welds.

3.1.4 Reason for Request

Dissimilar metal welds containing nickel welding alloys 82 and 182 have experienced PWSCC in components operating at PWR reactor temperatures. The licensee proposes to mitigate the PWSCC susceptibility of the DBNPS reactor coolant pump outlet DMWs by installing an OWOL. The licensee may apply an OWOL to the DMWs for flaws that meet the size and location criteria detailed in Attachment 2, "Requirements Applicable to Davis-Besse Nozzle Weld Overlays," Section A2.2, "Design and Analysis Requirements," of RR-A32.

Currently, there are no generically-accepted criteria for a licensee to apply an OWOL to Alloy 82/182 weld material. The edition and addenda of ASME Code, Section XI applicable to the DBNPS does not contain requirements for weld overlays. Dissimilar metal weld overlays have been applied to components at the DBNPS using the modified requirements of ASME Code Cases N-504-2, "Alternative Rules for Repair of Class 1, 2 and 3 Austenitic Stainless Steel Piping" and N-638-1, "Similar and Dissimilar Metal Welding Using Ambient Temperature

Machine GTAW Temper Bead Technique." However, since ASME Code Case N-504 (and its later versions) is written specifically for stainless steel pipe-to-pipe weld FSWOLs, and ASME N-638-1 contains unnecessary restrictions and requirements, an alternative is being proposed. This request describes the requirements the licensee proposes to design and install OWOLs on reactor coolant pump discharge nozzle DMWs.

3.1.5 Proposed Alternative and Basis for Use

The licensee proposes the use of an alternative based in part on the methodology contained in ASME Code Case N-740-2, "Full Structural Dissimilar Metal Weld Overlay for Repair or Mitigation of Class 1, 2, and 3 Items Section XI, Division 1." ASME Code, Section XI, Appendix VIII, "Performance Demonstration for Ultrasonic Examination Systems", Supplement 11 specifies requirements for performance demonstration of ultrasonic examination procedures, equipment, and personnel used to detect and size flaws in FSWOLs of wrought austenitic piping welds. Appendix VIII does not explicitly address OWOL applications. A proposed alternative is requested to allow use of the Performance Demonstration Initiative (PDI) program implementation of Appendix VIII for qualification of ultrasonic examinations used to detect and size flaws in the preemptive structural weld overlays of this request. Appendix VIII, Supplement 11 requires further qualification and modification for OWOL applications. The proposed modifications to Appendix VIII, Supplement 11 for use on OWOLs are detailed in Attachment 5, "Proposed Alternative to ASME Code Section XI Appendix VIII for Compatibility with the Performance Demonstration Initiative Program," of
RR-A32.

Materials Reliability Program (MRP) Report, MRP-169, published by Electric Power Research Institute (EPRI) provides the basis and requirements for OWOL design (Reference 1). The licensee proposes to use the alternative requirements for design, analysis and preservice and inservice inspection of preemptive weld overlays enumerated in MRP-169 as stated in Attachment 1, "Background and Technical Basis for Davis-Besse Reactor Coolant Pump Dissimilar Metal Weld Overlays," and Attachment 2 of RR-A32. Weld overlay materials, surface preparation, welding requirements, pressure testing, and acceptance examination shall be performed in accordance with Attachment 2 and Attachment 3, "Temper Bead Welding Requirements," of RR-32, which are based on the methodology contained in ASME Code Case

N-740-2. ASME Code Case N-740-2 has been approved recently by the ASME Code Committee to specifically address FSWOL on nickel alloy DMWs. ASME Code Case N-740-2 also incorporates the latest approved versions of ASME Code Case N-638-1. However, ASME Code Case N-740-2 has not yet been accepted by the NRC in Regulatory Guide 1.147, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division I." ASME Code Case N-504-3, "Alternative Rules for Repair of Classes 1, 2, and 3 Austenitic Stainless Steel Piping, Section XI, Division 1," has been conditionally accepted in Revision 15 of Regulatory Guide 1.147 with the condition that the provisions of ASME Code, Section XI, Nonmandatory Appendix Q, "Weld Overlay Repair of Class 1, 2 and 3 Austenitic Stainless Steel Piping Weldments," must be met.

The licensee stated that the weld overlay provides an acceptable method for preventing PWSCC and for reducing defects that may be observed in these welds to an acceptable size. The use of weld overlay filler metals that are less susceptible to PWSCC (for example, Alloy 52/52M), weld overlay procedures that create compressive residual stress profiles in the original weld, and post overlay preservice and inservice inspection requirements provide assurance that

structural integrity is maintained for the life of the plant. The weld overlays shall also meet the applicable stress limits from the ASME Code, Section III. Crack growth evaluations for PWSCC and fatigue of as-found (or conservatively postulated) flaws shall demonstrate that structural integrity is maintained.

Rupture of the large primary loop piping at the DBNPS has been eliminated as the structural design basis. The effects of the weld overlay application on the leak-before-break analysis have been evaluated to show the effects do not invalidate the conclusions of the existing design basis.

The licensee plans to perform a pre-overlay ultrasonic examination of the subject DMWs. The licensee may apply an OWOL to the DMWs for flaws that meet the size and location criteria of RR-A32. The requirements for the OWOL design and analyses are based upon MRP-169. Optimized weld overlay implementation requirements are detailed in Attachments 2 and 3 of RR-A32. The requirements of ASME Code Cases N-504-3 and N-638-1, as modified by ASME Code, Section XI, Appendix Q, are compared to the requirements proposed in Attachment 4, "Comparision of ASME Code Case N-504-3 and Appendix Q of ASME Code Section XI with the Proposed Alternative of Attachments 1, 2 and 3 for Weld Overlay," of the RR. Nondestructive examination (NDE) qualification requirements are detailed in Attachment 5.

Any indications discovered during the pre-overlay ultrasonic examination that are not inside and surface connected, will be evaluated in accordance with the requirements of ASME Code, Section XI, and if required, repaired in accordance with IWA-4000, "Repair/Replacement Activities."

3.1.6 Duration of Proposed Alternative

The provisions of this alternative are applicable to the DBNPS third 10-year inservice inspection interval which commenced on September 21, 2000, and will end on September 20, 2012. The weld overlays installed in accordance with the provisions of this alternative shall remain in place for the design life of the repair as described in Attachments 1, 2, 3 and 5 of the RR.

3.2 NRC Staff Evaluation

The NRC staff has approved Code Case N-504-3, "Alternative Rules for Repair of Class 1, 2 and 3 Austenitic Stainless Steel Piping Section XI, Division 1," in Regulatory Guide 1.147, Revision 15. ASME Code, Section XI, Appendix Q, shall be used when Code Case N-504-3 is used as stated in Regulatory Guide 1.147. The NRC staff has also approved ASME Code Case N-638-1. The NRC staff used the requirements of ASME Code Cases N-504-3, N-638-1, and Appendix Q to evaluate RR-A32.

The NRC staff notes that the pipe wall thickness and DMW wall thickness discussed in this safety evaluation are the same thickness and are the original weld thickness, not the weld thickness after the weld overlay installation.

3.2.1 General Requirements

General requirements of the OWOL design in Section A2.1, "Materials and Welding Requirements," Attachment 2 to RR-A32 include material specification and the applicable base metal (i.e., carbon steel, stainless steel, and Alloy 82/182) and weld overlay filler metal (i.e.,

Alloy 52M), and the chromium content of the weld overlay deposits. The NRC staff finds that the proposed requirements are consistent with the intent of the general requirements of Code Case N-504-3 and Appendix Q of the ASME Code, Section XI. Therefore, the NRC staff finds that Section A2.1 of RR-A32 is acceptable.

3.2.2 Design and Analysis Requirements

Section A2.2, Attachment 2 to Relief Request RR-A32 provides the requirements for the overlay design and the crack growth calculation. The OWOL design uses the outer 25 percent of the original DMW as part of its structural basis and its design concept exceeds the intent of ASME Code Case N-504-3 and Appendix Q to the ASME Code, Section XI.

3.2.3 The Flaw Size for Overlay Design

The NRC staff understands that ultrasonic testing (UT) has not been qualified to examine axial flaws in the overlaid DMW that are located in the inner 50 percent region of the pipe wall thickness. The NRC staff asked the licensee to clarify additional design requirements to compensate for the UT limitation of axial flaws. In the November 23, 2009, letter, the licensee clarified that the additional design requirement specified to address axial flaw UT limitations assumes a 100 percent through-wall flaw as the design basis axial flaw (i.e., the OWOL must meet ASME Code, Section XI, Appendix C required structural factor (safety margin) requirements in the presence of such a flaw). The post-OWOL preservice and inservice ultrasonic inspection procedure is qualified via the PDI program to detect and size axial flaws in the outer 25 percent of the original component wall through the weld overlay. For conservatism, a 75 percent through-wall flaw is assumed as the initial axial flaw size for crack growth evaluations that demonstrate such an initial flaw will not grow to reach the overlay design basis (i.e., grow to 100 percent through-wall) during the design life of the OWOL, or by the next scheduled inservice inspection. The licensee concluded that for all weld overlay designs, the added 100 percent through-wall design basis for the axial flaw allows a 25 percent buffer zone for potential crack growth, which is detectable by qualified preservice and inservice UT inspection procedures.

The NRC staff finds that the revised Section A2.2 in RR-A32, dated November 23, 2009, provides appropriate requirements to address the design of the OWOL for the postulated axial flaws.

3.2.4 Flaw Size Assumption

The OWOL has less thickness than the FSWOL. The OWOL is unable, by itself, to satisfy structural integrity design requirements because the design requires a portion of the underlying DMW material, which is susceptible to cracking, to remain intact and carry a portion of the load. In order to understand potential limitations of OWOLs, the NRC staff has considered the possibility that either the OWOL design or installation process may not perform as expected, or a large pre-existing crack may be missed by NDE, and a crack grows in the original DMW after the OWOL is applied. During initial phases of crack growth, bending and residual stress variations and metallurgical inhomogeneity could lead to uneven growth. However, once a portion of a surface crack grows deep enough to encounter the less susceptible PWSCC overlay material, it would stop growing in the depth direction at that azimuthal location. Other segments of the crack could continue to grow deeper until they also reach the overlay interface. This could continue until the remaining uncracked ligament of original DMW is insufficient to

adequately reinforce the OWOL material, at which point the overlaid DMW may fail without prior leakage during a design basis event.

The OWOL material, because it is less susceptible to PWSCC, can result in small circumferential cracks in the original DMW growing deep around the entire circumference, in which case the OWOL may become unable to withstand its design loading. In light of this possibility, the NRC staff asked the licensee to explain why application of an OWOL to a DMW is an appropriate mitigation method, and why its application will not invalidate previously NRC-approved leak-before-break analysis.

In the November 23, 2009, letter, the licensee responded that the combination of residual stress and crack growth analyses performed as part of the OWOL design process, plus process controls during in-plant weld overlay application, provide a high level of assurance that the residual stress improvements predicted for an OWOL will be present. For flaws of the type hypothesized by the NRC staff, the probability of detection is nearly 100 percent. The licensee analyzed the overlaid DWM with the OWOL, assuming two cases: (a) a 75 percent through-wall, 360 degree circumferential flaw in the DMW, and (b) a 100 percent through-wall, 360 degree circumferential flaw in the DMW.

The licensee stated that from a historical perspective, over 30 years of weld overlay operating experience in boiling-water reactors (BWRs), and more recently in PWRs, has demonstrated the benefits of weld overlays on crack growth mitigation. Hundreds of weld overlays have been subjected to multiple inservice inspections during this time period. There are no industry documented cases of existing circumferential cracks under a weld overlay extending in length.

The table below shows the licensee's calculated structural factors (SF) for the overlaid DMW. Column 2 shows the calculated SFs for the design basis flaw. Column 3 shows the calculated SFs that were derived from combining by weighted average of the SFs for the membrane stress and bending stress.

| **1** | **2** | **3** |
|---|---|---|
| **Service Level** | **SF for Design Basis Flaw** | **SF for NRC suggested flaw** |
| Level A | 7.2 | 3.33 |
| Level B | 4.72 | 2.18 |
| Level C | 3.58 | 1.66 |

The NRC understands that the OWOL design intent is to create stress fields such that PWSCC flaw growth is significantly diminished as demonstrated through flaw growth calculations, the outer 50 percent of the original DMW wall thickness will be examined after application of the OWOL, and that the weld will be subject to periodic ISI examinations on the order of once every 10 years. However, uncertainty exists in the calculation of stress fields and crack growth. There is always a potential for flaws to be missed during examinations, although the probability may be small. To address these concerns, the NRC has requested an evaluation of the OWOL, assuming a condition of a circumferential flaw exists 100 percent through the original DMW thickness and 360 degrees around the weld. The NRC acknowledges that there are several defenses to prevent this condition and accepts a reduction in ASME Code allowable safety margin for this beyond-design condition. The NRC also acknowledges that the Level D service condition is not applicable because with the assumption that a loss-of-coolant accident (LOCA) has already occurred, the integrity of the primary reactor coolant system has already been

compromised and further degradation would be in consequential. Therefore, the structural factors in the table below are appropriate for this special condition.

| | ASME Section XI SF | | NRC's Special Condition SF | |
|---|---|---|---|---|
| **Service Level** | **Membrane Stress** | **Bending Stress** | **Membrane Stress** | **Bending Stress** |
| Level A-Normal Operation | 2.7 | 2.3 | 2.4 | 2.0 |
| Level B-Normal + OBE | 2.4 | 2.0 | 1.8 | 1.6 |
| Level C-Normal + SSE | 1.8 | 1.6 | 1.3 | 1.4 |
| Level D-Normal +SEE + LOCA | 1.3 | 1.4 | NA | NA |

As shown above, the OWOL with the design basis flaw (the 75 percent through-wall flaw) satisfies the allowable structural factors of the ASME Code, Section XI, Appendix C. For the NRC staff-recommended 100 percent through-wall circumferential flaw, the OWOL design satisfies only the ASME Code allowable structural factors for Service Level A. The licensee's calculated structural factors for the NRC staff-recommended flaw achieved substantial percentage of the Code-allowable structural factors for Service Levels B and C.

The NRC staff believes that the probability of an overlaid DMW with a 100 percent through-wall flaw and an OWOL, experiencing an earthquake and rupturing is relatively low. The licensee will inspect each overlaid DMW with the OWOL once during a 10-year inspection interval, which will identify such a large flaw with a high probability of detection. If a crack is detected in an overlaid DMW, the licensee would take appropriate action. The NRC staff finds that the probability of an overlaid DMW containing a 100 percent through wall circumferential flaw during a 10 year inspection interval is low. Also, the licensee has demonstrated by crack growth/residual stress calculation, that the crack growth will be reduced significantly by the improvement in the residual stresses due to the OWOL. The NRC staff finds that the licensee has demonstrated, based on its structural factor calculation, inspection requirements, and the crack growth calculation, that the overlaid DMW with the OWOL provides reasonable assurance of structural integrity. The licensee's calculated structural factors for the NRC staff-recommended flaw meet the NRC staff's special condition structural factors and is, therefore, acceptable.

3.2.5 Criteria for OWOL Application

The proposed OWOL will be applied if the depth of an inside-surface connected flaw in the DMW is less than 50 percent through the pipe wall thickness. If the flaw depth is greater than 50 percent through pipe wall thickness, a FSWOL will be installed. The NRC staff noted that the proposed criterion did not address a flaw that is not connected to the inside surface (i.e., embedded flaws). The NRC staff has identified the following scenarios that may require either OWOL or FSWOL application: (1) if the pre-installation inspection detected an embedded flaw (i.e., not connected to inside surface of the pipe) that is 50 percent through the wall thickness, i.e, a portion of the flaw is located in the outer 50 percent region and a portion of the flaw is located in the inner 50 percent region of the pipe wall thickness, (2) if the embedded flaw is less than 50 percent through-wall and a portion is located in the outer 50 percent region of the pipe wall thickness, (3) if the embedded flaw is less than 50 percent through-wall and is located in the inner 50 percent region of the pipe wall thickness, and (4) if a flaw is initiated from the outside surface of the DMW regardless of the flaw depth.

In the July 13, 2009, letter, the licensee responded that, in general, embedded flaws will be evaluated in accordance with the rules of the ASME Code, Section XI. Unacceptable flaws will be repaired in accordance with the requirements of IWA-4000. Either an OWOL, as described in RR-A32, or a FSWOL, as described in RR-A33, may be used, provided the embedded flaw is bound by the design assumptions made in the applicable overlay (OWOL or FSWOL) design. The licensee provided the following responses for each scenario.

(1) If an embedded 50 percent through-wall flaw is detected inside the DMW during the pre-installation inspection, i.e., a portion of the flaw is located in the outer 50 percent region and a portion of the flaw is located in the inner 50 percent region of the pipe wall thickness, a flaw evaluation will be performed to the requirements of IWA-3300 "Flaw Characterization," and IWB-3640, "Evaluation Procedures and Acceptance Criteria for Flaws in Austenitic and Ferritic Piping," of ASME Code, Section XI. If the flaw is found acceptable for the operating period, an OWOL may be applied. If the flaw is judged to be unacceptable, a FSWOL will be applied.

(2) If the embedded flaw is less than 50 percent through-wall and is located in the outer 50 percent region of the pipe wall thickness, an IWA-3000 analysis and an IWB-3640 analysis will be performed. If the flaw is acceptable for continued operation, an OWOL may be applied. If the flaw is judged to be unacceptable, a FSWOL will be applied.

(3) If the embedded flaw is less than 50 percent through-wall and is located in the inner 50 percent region of the pipe wall thickness, an OWOL may be applied.

(4) If flaws connected to the outside surface are either removed, reduced in size, or weld repaired and the flaw is bound by the design assumptions made in the [optimized weld] overlay design, an OWOL may be applied.

For the embedded flaw in cases (1) through (3), the NRC staff finds that if a flaw is accepted by ASME Code, Section XI, IWB-3600, "Analytical Evaluation of Flaws," the flaw may remain in service without repair. However, the licensee plans to repair the DMW with an OWOL which is more conservative than the ASME Code requirement. The NRC staff finds this strategy acceptable. For Case (4), the NRC staff finds that if an outside-surface connected flaw is detected, the licensee will remove the flaw, reduce the flaw in size, or repair the flaw with an OWOL. This is acceptable because the strategy is either consistent or exceed the requirements of the ASME Code, Section XI.

The licensee incorporated the above scenarios in "Structural Sizing" of Section A2.2, Attachment 2 to RR-A32, which requires that for circumferential flaws that are not greater than 50 percent through-wall, but that extended into the outer 50 percent of the original DMW thickness, an FSWOL will be installed. For axial flaws that are not greater than 75 percent through-wall, but extend into the outer 25 percent of the original DMW thickness, an FSWOL will be installed. The flaws discussed in the "Structural Sizing" section of Section A2.2 apply to surface-connected and embedded flaws. The NRC staff finds that Section A2.2 of RR-A32 provides adequate decision criteria for the OWOL application based on flaw location and sizing.

3.2.6 Crack Growth Calculations

Section A2.2, of the original RR-A32 dated January 30, 2009, states that "....An analysis of fatigue and PWSCC growth must demonstrate that any growth shall not impair the ASME Code,

Section XI acceptance criteria for the OWOL at the end of the inspection interval.... "The NRC staff asked the licensee to (a) clarify whether the growth calculation is for the flaw growth in the DMW, in the OWOL, or in both, and (b) clarify the specific ASME Code, Section XI acceptance criteria. In the July 13, 2009, letter, the licensee responded that the PWSCC growth calculation is for the Alloy 82/182 dissimilar metal weld. As noted in Section A2.2, 'Structural Sizing', the weld overlay must meet the IWB-3640 rules for allowable flaw sizes in austenitic piping. The 1995 Edition through the 1996 Addenda is applicable to DBNPS. The NRC staff has confirmed that the licensee has revised Section A2.2 of RR-A32 to clarify the crack growth calculations.

3.2.7 Residual Stress Analysis

Section A1.2, Attachment 1 of RR-A32 discusses the improvement in residual stresses of the DMW following the OWOL installation. The NRC staff asked the licensee to clarify whether the residual stress analysis performed for the generic OWOL in MRP-169 is applicable to the DMWs in the subject nozzles in RR-A32. In the July 13, 2009 letter, the licensee responded that Section A1.2 provides the methodology for residual stress improvement as described in MRP-169, Revision 1. As noted in Section 2 of Attachment 2 to RR-A32, a joint-specific residual stress analysis was performed for the DBNPS reactor coolant pump (RCP) discharge piping OWOL geometry. As a result, the MRP-169 models were not used to bound the DBNPS DMW residual stresses. The NRC staff finds it acceptable that the licensee performed plant-specific residual stresses for the affected component.

Section A2.2, states that thermal boundary conditions (wet or dry) will be considered in the residual stress analyses. The NRC staff asked the licensee to discuss whether water will be present inside the pipe when the OWOL is installed at DBNPS. In the July 13, 2009, letter, the licensee responded that the piping may be in either the water-backed or dry condition. The residual stress analysis assumed the piping was dry.

Subsequently, the NRC staff questioned whether the residual stresses analyzed for the dry piping condition would bound the residual stresses for the water-backed pipe condition and whether the procedure qualification report for overlay welding considers the cooling rate of the water, compared to no water in the pipe for the field installation, to minimize the potential of base metal embrittlement. The NRC staff's concern is that martensite may be formed which would cause embrittlement during temper bead welding.

In the November 23, 2009, letter, the licensee responded that for the OWOL locations (reactor coolant pump discharge nozzles), the same welding procedure is used with either water-backed or dry pipe conditions. For these locations, water-backed or dry pipe conditions are not critical inputs. Residual stress and base metal embrittlement analyses have determined that the OWOL can be performed either wet or dry.

The licensee stated that dry, empty pipe conditions provide less heat removal (heat sink) capacity than do wet, water backed pipe conditions. The residual stress benefit produced by a weld overlay is greater in the inner portion of the component when the welding is performed while water backed. The weld residual stress calculation assumes a dry, empty pipe condition since it results in reduced residual stress, which is bounding, and results in higher calculated crack growth, which is conservative.

The licensee stated further that, with regard to base metal embrittlement and martensite formation (which is cool-down rate dependent), the dry, empty pipe condition with less heat

removal (heat sink) capabilities is less limiting than the wet, water-backed pipe condition and will minimize the potential of base metal embrittlement and martensite formation due to less rapid cooling rates. However, the temper bead welding process performed under wet, water-backed conditions has been shown to be effective in addressing base metal embrittlement and martensite formation as presented in EPRI Report NP-7085-D, "Inconel Weld-Overlay Repair for Low-Alloy Steel Nozzle to Safe-End Joint," January 1991. In addition, the procedure qualification and performance qualification requirements described in RR-A32, Attachment 3, are identical to ASME Code Case N-740 (earlier version of ASME Code Case N-740-2), Appendix I. This code case has been the basis for numerous temper bead weld overlay applications. Therefore, the OWOL can be applied to a pipe when the inside of the pipe is either wet or dry. Appendix I to Code Case N-740 provides requirements for ambient temperature temper beading welding. Appendix I is similar to ASME Code Case N-638-1, which the NRC staff has approved with conditions in Regulatory Guide 1.147, Revision 15. However, the NRC staff has not approved Code Case N-740.

The NRC staff finds that the licensee has addressed adequately the NRC staff's concerns regarding welding on a dry/wet pipe, and the impact of the welding on residual stresses and metal embrittlement.

The licensee stated that the residual stress analysis assumes a conservative pre-overlay residual stress condition from the weld repair during construction. The NRC staff asked the licensee to provide the depth of the postulated flaw for the inside surface weld repair during construction that is assumed in the residual stress analysis and to discuss whether the repair depth of the postulated flaw bounds the worst weld repair in the field. In the July 13, 2009, letter, the licensee stated that a 25 percent wall-thickness inside diameter repair was assumed in the residual stress analysis. The licensee has evaluated a postulated repair of an inside diameter-connected flaw of a depth of 25 percent and 50 percent wall thickness for thick walled large diameter nozzles, which showed that the repair depth does not have a significant influence on post weld-overlay residual stress distributions. The licensee responded that the reactor coolant pump discharge piping DMW was a shop weld. Shop weld records, including weld repair history and repair depth, are not available on site. As such, the residual stress analysis assumed a 25 percent through-wall flaw that is connected to the inside diameter to bound any recorded repairs.

The NRC staff believes that a pre-service repair of a 50 percent through-wall flaw should be assumed in the residual stress calculations. The NRC staff, with the assistance from Battelle Memorial Institute (Battelle), performed an independent analysis of residual stresses assuming a pre-service repair of a 25 percent and 50 percent through-wall flaw. The NRC staff found that there is not much difference in inside diameter axial stresses in the DMW between the 25 percent and 50 percent flaws. However, the NRC staff found that there are some differences in axial stresses from inside to outside surface of the DMW along the wall thickness between the two flaw repairs. The differences in the axial stresses may not affect the overall structural integrity of the overlaid DMW. The NRC staff is currently discussing with the industry, the issue of the 25 percent compared to a 50 percent through-wall flaw repair. As for Davis-Besse, the NRC staff is satisfied based on the results of the Battelle Memorial Institute evaluation of a 50 percent through-wall repair on the residual stress calculations.

The NRC staff asked the licensee to discuss whether the same welding sequences, heat input, interpass cooling temperatures, number of weld heads, and weld head travel directions for the original dissimilar butt weld fabrication and overlay installations will be included in the finite

element model to analyze the residual stresses. In the July 13, 2009, letter, the licensee responded that the residual stress analyses include the heat efficiency factor associated with the actual welding process, thermal boundary conditions (wet or dry), weld progression direction, and interpass temperature limits to be employed during the actual overlay welding process.

RR-A32, Section A2.2, Item (1) states that "...The resulting residual stresses on the inside surface over the entire length of primary water stress-corrosion cracking (PWSCC) susceptible material under the optimized weld overlay shall be less than or equal to 10,000 pounds per square inch tensile..." ASME Code, Section XI, Code Case N-770 has established that as part of an effective stress improvement mitigation technique, a compressive stress state is required on the wetted surface of all susceptible material used in DMW applications. The NRC staff has not yet approved Code Case N-770; however, a compressive stress state at the inside surface of the pipe is consistent with the NRC staff position and was developed, in part, due to the uncertainties in precise finite element stress modeling of the wetted surface of DMWs. Further, the NRC staff position was not established to define a stress level at which crack initiation could not occur, but rather to provide a conservative stress value as a basis for reasonable assurance of structural integrity for a stress improved DMW. The NRC staff asked the licensee to provide additional basis, including supporting data, analyses, and operational experience to support allowing a wetted surface stress threshold of 10 kilopounds per square inch (ksi).

In the November 23, 2009, letter, the licensee responded that MRP-169 establishes the following criteria for acceptability of weld overlay residual stresses:

1. Acceptable residual stresses for purposes of satisfying these criteria are those which, after application of the weld overlay, are compressive on the inside surface of the nozzle, over the entire length of PWSCC susceptible material on the inside surface, at operating temperature, but prior to applying operating pressure and loads. After application of operating pressure and loads, the resulting inside surface stresses must be less than 10,000 pounds per square inch (psi) tensile.

2. A separate PWSCC crack growth criterion must also be satisfied to demonstrate the acceptability of the post-weld overlay residual stress distribution. This criterion requires that any cracks detected in the pre- or post-overlay inspections, or postulated undetected cracks that are not within the applicable weld overlay examination volumes in the PWSCC susceptible material, would not grow by PWSCC and fatigue to the point that they would violate the overlay design basis (75 percent through-wall of the original DMW thickness for OWOLs or 100 percent through-wall of the original DMW thickness for FSWOLs). Since there is no generally accepted PWSCC crack growth threshold for Alloy 82/182 weld metals, satisfying this criterion generally requires that the crack tip stress intensity factor due to residual stresses, operating pressure and sustained, steady-state loads, be compressive up to the greater of the maximum flaw size detected (either pre- or post-overlay) or the maximum flaw size in PWSCC susceptible material that could be missed by the applicable inspections.

The licensee stated that the above combination of inside diameter surface stress and crack growth criteria, in conjunction with required post-overlay inspections, provides preemptive mitigation against initiating new PWSCC cracks after application of the weld overlay. Further, it provides assurance that initiation of new cracks and/or propagation of pre-existing cracks would not violate the overlay design basis.

The licensee stated further that the 10,000 psi tensile stress limit is consistent with (but conservative to) the limit of 20,000 psi which was used to establish the required examination volume for Alloy 600 reactor pressure vessel top head nozzles. The reduction from 20,000 psi to 10,000 psi is conservative and sufficient to address potential differences between the PWSCC susceptibility of Alloy 600 and its weld metals (Alloys 82 and 182). Industry data exists to support the threshold concept for PWSCC initiation in Alloy 600 and its weld metals Alloy 82, 132 and 182. This data includes temperature and impurity concentration in the coolant and stress limits, below which the initiation of stress-corrosion cracking is difficult and essentially of no engineering significance. A similar stress limit for Alloy 600 base metal has also been defined.

According to the licensee, two types of tests of PWSCC initiation in Alloy 182 weld metal exhibited no failures at stress levels less than 58,000 psi. Based upon the data, it was concluded that Alloy 182 is susceptible to stress-corrosion cracking in PWRs primary water only if the applied stress exceeds the yield stress.

Data from pressurized cylinder experiments reveal a relationship between hoop stress and time to leakage and establishes a threshold stress limit near 58,000 psi for PWSCC initiation in Alloy 182. Samples tested at stress levels down to approximately 47,000 psi revealed crack growth rates slow enough (0.0012 inch/year) to be of little engineering significance. The 10,000 psi limit is 18 to 22 percent of the minimum measured stresses at which PWSCC initiation has been observed in Alloy 132 and 182 weld metals in the laboratory experiments. Therefore, this limit ensures a low probability of initiating new PWSCC cracks after weld overlay application with significant margin to allow for uncertainties that may occur in attempting to precisely model the magnitude of tensile stress on the wetted surface of inservice DMWs.

The MRP-169 residual stress acceptance criteria imposes not just a crack initiation limit based on inside surface stress, but also a criteria to preclude both crack initiation and crack growth. A separate PWSCC crack growth criterion must be satisfied to demonstrate the acceptability of the post-overlay residual stress distribution, not just for observed cracks, but for conservatively postulated cracks that might escape detection. Specifically, the design must demonstrate that any cracks in PWSCC-susceptible material that are outside the pre- and post-overlay examination volumes will not grow to the point that they would violate the overlay design basis.

The NRC staff believes that PWSCC initiation is a function of stress level, material chemistry, water chemistry, and material surface conditions. Therefore, stress alone cannot be used to limit crack initiation, but can be used to demonstrate a low probability of crack initiation. The NRC staff believes that the residual stresses at the inside surface of the DMW should be less than zero psi so that the inside surface region of the DMW would be truly in a compressive state to prevent crack initiation and minimize crack growth. However, the licensee has performed a crack growth/residual stress calculation and demonstrated that crack growth should be sufficiently low to support a 10-year inspection frequency before any crack could grow to an unacceptable size. RR-32 requires a crack growth calculation and examination of every overlaid DMW once every 10 years. These two actions would monitor any crack initiation and growth in the DMW to minimize any catastrophic failures. The NRC staff finds that the licensee has adequately addressed the technical basis for the 10,000 psi criterion as a limit for the residual stresses.

Battelle, under a contract to the NRC, performed an independent analysis to evaluate the effect of the OWOL on the DMW in a RCP discharge nozzle and compared the results to the DBNPS analysis. Battelle calculated the welding residual stresses in the overlaid DMW using plant-specific data from the DBNPS letter, dated July 13, 2009, which included drawings, material properties of the RCP nozzles and associated welds, and the welding process of the weld overlay at the DBNPS. Battelle used finite element method and DBNPS plant data to model the overlaid DMW with OWOL, assuming no repair, and a 25 percent and 50 percent through-wall, inside diameter, pre-service repair. The licensee does not have the complete fabrication history of the subject DMW. Therefore, Battelle performed a sensitivity study to document the impact on the OWOL for several repair conditions.

The Battelle analysis shows that the OWOL is predicted to reduce the inside diameter axial stresses to compressive stresses in the DMW area. The OWOL will also reduce high inside diameter tensile hoop stresses to uniformly compressive hoop stresses. The Battelle analysis verifies the licensee's statements that the weld overlay will produce similar residual stresses at the inside diameter region of the pipe to mitigate crack initiation and growth.

In contrast to the licensee's results, the Battelle analysis shows a better axial stress improvement in the overlaid DMW area than the licensee's results. This result implies that the licensee is more conservative in its analysis. This could also imply that Battelle's analysis (methodology, assumptions, and data input) is different than the licensee's analysis. In general, the NRC staff finds that Battelle's stress analysis has confirmed the adequacy of the licensee's stress analysis. The NRC staff has not found any significant discrepancies in the licensee's stress analysis that would lead to question its validity.

3.2.8 Examination Requirements

Section A2.3, "Examination Requirements," Attachment 2 to RR-A32 provides requirements for acceptance, preservice, and inservice examinations of the overlaid DMWs. The NRC staff finds that the proposed requirements are either consistent with or exceed the requirements of ASME Code Case N-504-3 and Appendix Q of the ASME Code, Section XI. The specific issues are discussed below.

Section A2.2 of the original RR-A32, dated January 30, 2009, states that the detection of 50 percent through-wall axial flaws in the DMW after OWOL installation has not yet been qualified and the current UT technology does not provide reliable results for the examination of the cast austenitic stainless steel (CASS) material from which the RCP nozzles are fabricated. In the July 13, 2009, letter, the licensee clarified that an OWOL will not be applied to the reactor coolant pump inlet DMW which contain CASS material. The RCP discharge DMW does not contain CASS material and is designed to permit ultrasonic examination of the required volume shown in Figure A2-2 of RR-A32 and approximately 100 percent coverage of the examination volume is expected. The licensee revised the original RR-A32. The NRC staff confirmed that the OWOL design in the revised RR-A32 dated November 23, 2009, is not applicable to RCP inlet (suction) nozzles.

The licensee also revised examination requirements in Section A2.3 of original RR-A32, dated January 30, 2009, to include the requirements of ASME Code Case N-770 for preservice and inservice inspection of welds mitigated with stress improvement. The NRC staff has not yet approved ASME Code Case N-770. However, the NRC staff is incorporating ASME Code Case N-770 in 10 CFR 50.55a as part of the current rulemaking to incorporate the 2005 edition

through 2008 addenda of the ASME Code. Once the final rule for 10 CFR 50.55a is issued, licensees will need to examine the overlaid DMWs in accordance with ASME Code Case N-770 and associated conditions imposed as required in 10 CFR 50.55a. The licensee stated that it recognizes that ASME Code Case N-770 is subject to 10 CFR 50.55a rulemaking by the NRC and future inservice examinations of the overlaid DMWs at DBNPS will be performed in accordance with the rulemaking.

Inservice Examination Item (5) of Section A2.3 of RR-A32 requires that "...If a planar circumferential flaw is detected in the outer 50 percent of the base material thickness or if a planar axial flaw is detected in the outer 25 percent of the base material thickness, it shall meet the design analysis requirements of A2.2..." The NRC staff asked the licensee to explain the design analysis requirements of A2.2 of RR-A32. For example, explain how a planar flaw that occurs in the outer 50 percent of the base metal meets the design analysis requirements of A2.2. The NRC staff also asked the licensee to clarify whether the subject planar flaw is a subsurface flaw or an inside-surface connected flaw. In the November 23, 2009, letter, the licensee responded that the circumferential planar flaw design basis is 75 percent through-wall and fully circumferential. The PDI qualification provides assurance that a planar flaw that is 50 percent through-wall will be detected. If a circumferential flaw is detected within the inspection interval that is greater than 50 percent through-wall and less than 75 percent through-wall, it will be evaluated using the methodology of the ASME Code, Section XI, IWB-3640. The next operating interval
(before an examination will be performed for the overlaid DMW) will be established based upon the results of that evaluation.

The licensee stated that the same approach will be used for a detected axial planar flaw that is greater than 75 percent through-wall. The flaw will be evaluated using the methodology of the ASME Code, Section XI, IWB-3640. The next operating interval will be established based upon the results of that analysis. The licensee will determine whether the flaw is a surface or subsurface at the time of the inspection.

The NRC staff finds that the detected flaws will be evaluated in accordance with ASME Code, Section XI, IWB-3640 and the license has clarified the requirements in Inservice Examination Item (5) of Section A2.3 of RR-A32.

Section A1.3, "Inspectability Considerations," of RR-A32 states that a flaw in the DMW extending into the outer 25 percent of the pipe wall would violate the design basis of the OWOL. The NRC staff asked the licensee that (1) after the OWOL is installed, if a flaw is detected in the outer 25 percent region of the DMW wall thickness during the inservice inspection, discuss how the flaw will be dispositioned prior to plant restart because any flaw remaining in the outer 25 percent region of the DMW wall thickness would violate the design basis, and (2) before the OWOL is installed, if a flaw is detected in the outer 25 percent region of the DMW wall during pre-installation inspection, discuss how the flaw will be dispositioned prior to overlay installation and discuss whether OWOL or FSWOL will be applied in this situation. In the July 13, 2009, letter, the licensee responded that if an inside connected flaw is discovered in the outer 25 percent of the DMW base material during inservice inspection, the flaw will be evaluated against the overlay design basis to determine if the weld is acceptable for continued service. If not, repair or replacement activities will be performed in accordance with IWA-4000. The license also stated that f an inside connected flaw is discovered in the outer 25 percent of the DMW during pre-overlay ultrasonic examination, either the flaw will be reduced to an acceptable size in accordance with IWA-4000 and/or a FSWOL will be applied.

The NRC staff finds it acceptable that the licensee's criteria for disposition flaws in the outer 25 percent of the DMW wall thickness will be based on the ASME Code, Section XI, IWA-4000.

The NRC staff noted that Section A2.3 of RR-A32 does not contain requirements for examination expansion for the cases when a flaw is detected, or an existing flaw grows into the OWOL, or has an unexpected growth. By an electronic mail dated December 15, 2009, the licensee incorporated the following requirements for inspection expansion in Section A2.3.

> *"Additional Examinations.* If inservice examinations reveal a defect, 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 defects are found in the second sample, 50 percent of the total population of weld overlay examination volumes shall be examined prior to return to service. If additional defects are found, the entire remaining population of weld overlay examination volumes shall be examined prior to return to service."

The NRC staff finds the above requirements for the additional examinations are acceptable because the population of the overlaid DMWs examinations will be expanded when inservice examinations reveal a defect, planar flaw growth into the weld overlay design thickness, or axial flaw growth beyond the specified examination volume.

### 3.2.9 Ambient Temperature Temper Bead Welding

Section A3-1, Attachment 3 to RR-A32 provides requirements for the ambient temperature temper bead welding which follow the requirements of ASME Code Case N-638-1 with a few modifications. The modifications are discussed below.

Paragraph A3-1(b) of RR-A32, dated November 23, 2009, states that the maximum area of the weld overlay based on the finished surface over the ferritic base material may be greater than 600 square inches, but less than 700 square inches. ASME Code Case N-638-1 permits only 100 square inches over the ferritic base material. The NRC staff asked the licensee to justify the 700-square-inch surface area. In the letter dated November 23, 2009, the licensee submitted a finite element sensitivity analysis similar to that performed by the EPRI Technical Report 1011898, "RRAC Code Justification for the 100 Square Inch Temper Bead Weld Repair Limitation," and EPRI Report 1014351, "Repair and Replacement Applications Center: Topical Report Supporting Expedited NRC Review of Code Cases for Dissimilar Metal Weld Overlay Repairs, December 2006." The licensee's sensitivity analysis (Enclosure Q, ADAMS Accession No. ML093360332 of the November 23, 2009, letter), modeled temper bead weld overlay areas of 500, 750, and 1000 square inches in order to bound the 700 square-inch value. The analysis demonstrates favorable residual stress distribution on the inside surface of the pipe with minimal radial shrinkage and distortion, and reveals that increasing the weld overlay coverage areas improves the residual stress on the inside surface of the pipe.

The NRC staff noted that the model in the industry's stress analysis for the 500 square-inch area is based on a straight pipe. However, a pipe elbow exists at the RCP discharge nozzles. An elbow may present different stress distribution and there is a potential for stress risers with the overlay material on the elbow. The NRC staff asked the licensee to provide the basis of how the stress analysis is applicable to the elbows in the subject piping. In the July 13, 2009,

letter, the licensee responded that the residual stress and radial displacement is determined at the DMW using a computer model with the same component geometry as the weld overlay application. The elbow configuration and the cladding are modeled. The residual stress and radial displacement is evaluated comparing the pre-weld overlay component to the post-weld overlay component. The areas the model examines includes the DMW and surface area deposited over the carbon steel for at least two selected different area coverages on the carbon steel. The residual stress analysis uses the same component geometry as the ferritic base material to which the ambient temper bead process is to be applied. The residual stress is shown to be beneficial for the increased overlay size, both length and thickness, and the radial displacement is shown to be insignificant with a negligible difference as a result of increased overlay length or thickness. The NRC staff finds that the licensee included the elbow in its welding residual stress analysis; therefore, the modeling of the analysis is acceptable.

The subject carbon steel elbow at DBNPS has a stainless steel cladding. The NRC staff asked the licensee whether the current stress analysis contains stainless steel cladding on the inside of the pipe. In the July 13, 2009, letter, the licensee confirmed that the residual stress analysis includes the stainless steel cladding on the ferritic components.

The NRC staff finds that the 700 square-inch weld area on ferritic material is acceptable. The NRC staff finds that Section A3-1, Attachment 3 to RR-A32 satisfies ASME Code Case N-638-1 and, therefore, is acceptable.

3.2.10 Performance Demonstration Initiative Program

The U.S. nuclear utilities created the PDI Program to implement performance demonstration requirements contained in Supplement 11 in Appendix VIII of Section XI of the ASME Code. To this end, the PDI program has developed a program for qualifying equipment, procedures, and personnel in accordance with the UT criteria of 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, in the NRC letter dated July 3, 1984 (not publically available). 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 in Appendix VIII of Section XI of the ASME Code. PDI presented the differences 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 L. 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 PDI program provides an acceptable level of quality and safety.

The licensee identified and evaluated the differences between the PDI program and Supplement 11 in Attachment 5 of RR-A32. The NRC evaluated the differences and associated justifications.

Paragraph 1.1(d)(1) of Supplement 11 in Appendix VIII of Section XI of the ASME Code requires that all cracks must extend at least 75 percent through-wall from the inside surface of the pipe and may extend to 100 percent through the base metal. RR-A32 requires flaws to extend at least 50 percent through-wall from the inside surface. However, RR-A32, Attachment 1, page 1, states that NDE qualification for axial flaws shall be done to the current requirements from Supplement 11 for a 75 percent through-wall flaw. The NRC staff asked the licensee to clarify the discrepancy regarding the UT qualification for the axial flaw size between requirements in Attachment 1 and Attachment 5 of RR-A32. In the July 13, 2009, letter, the licensee responded that RR-A32 Attachment 1 and Figure A2-2 requires axial flaws in the outer 25 percent of the base material and circumferential flaws in the outer 50 percent of the base material be detected by the ultrasonic examination. The proposed alternative to paragraph 1.1(d)(1) of Supplement 11 was revised to decrease the flaw size used in PDI qualifications from 75 percent to 50 percent through-wall from the inside surface. This change increases the qualified examination depth and will ensure that the ultrasonic examination procedure is qualified to detect circumferential flaws in the outer 50 percent of the base material. There is no change in the qualification to detect axial flaws as the original PDI qualification required flaws be at least 75 percent through-wall from the inside surface.

The NRC staff finds that the revised flaw size in the proposed alternative to paragraph 1.1(d)(1) of Supplement 11 in Attachment 5, RR-A32 is acceptable because the revised flaw size is consistent with the design criteria.

The NRC staff noted that the proposed alternative is silent on the requirements for the representative mockups, base materials, weld material, weld butter, and overlay material that will be used for the performance demonstration test specimens. The NRC staff asked the licensee to provide the requirements for the representative mockups, base material, and overlay material for the performance demonstration test specimens. In the July 13, 2009, letter, the licensee responded that examination of OWOLs is an extension of the existing ASME Code, Section XI, Appendix VIII, Supplement 11, PDI Program for the examination of FSWOLs. The only difference is that the qualified examination depth has been extended from the outer 25 percent of the base material for FSWOLs to the outer 50 percent of the base material for OWOLs. Existing PDI protocol for mockups and the qualification of the ultrasonic procedures for field use has not changed from previously approved requirements for FSWOLs. The licensee stated further that the proposed alternative to ASME Code, Section XI, Appendix VIII, Supplement 11, will interrogate the outer 50 percent of the base material for circumferential flaws and the outer 25 percent of the base material for axial flaws. The NRC staff and its contractor, Pacific Northwest National Laboratory, reviewed the PDI qualification protocols for detecting circumferential flaws in the outer 50 percent at the EPRI NDE Center in Charlottesville, North Carolina, in February 2009. The NRC staff notes that the PDI program for examining the axial flaws in the OWOL is the same as that of the FSWOL which has been qualified. The NRC staff finds that the PDI program is acceptable to examine the overlaid DMWs with the OWOL design.

The NRC staff concludes that the justifications for the proposed alternative (i.e., the PDI program) to the ASME Code, Section XI, Appendix VIII, supplement 11 are reasonable and the proposed PDI program provides an acceptable level of quality and reliability. Therefore, the proposed PDI program is acceptable.

3.2.11 Analyses and Verifications

In Section 5, "Proposed Alternative and Basis for Use," of RR-A32, the licensee stated that the following list of analyses and verifications are performed subject to the specific design, analysis, and inspection requirements that have been defined in this relief request.

1. Nozzle specific stress analyses have been performed to establish a residual stress profile in the nozzle. Inside diameter weld repairs assumed in these analyses effectively bound any actual weld repairs that may have occurred in the nozzles. The analysis simulates application of the weld overlays to determine the final residual stress profile. Post weld overlay residual stresses at normal operating conditions result in a stress state on the inside surface of each component that ensures further crack initiation due to PWSCC is highly unlikely.

2. Fracture mechanics analyses have been performed to predict crack growth. Crack growth due to PWSCC and fatigue crack growth in the original dissimilar metal weld were evaluated. The crack growth analyses consider design loads and transients, plus the post weld overlay through-wall residual stress distributions, and demonstrate that the assumed cracks do not grow beyond the design bases for the weld overlays for the time period until the next scheduled inservice inspection. The crack growth analyses determine the time period for the assumed cracks to grow to the design basis for the weld overlays.

3. The analyses demonstrate that the application of the weld overlays do not impact the conclusions of the existing nozzle stress reports. ASME Code, Section III stress and fatigue criteria are met for the regions of the overlays remote from observed (or assumed) cracks.

4. The original leak-before-break calculations have been updated with an evaluation demonstrating that due to the efficacy of the overlay PWSCC mitigation, concerns for original weld susceptibility to cracking has been resolved. The effects of the mitigation on the leak-before-break analysis demonstrate the effects of application of weld overlays do not invalidate the conclusions of the existing design basis. By letter dated September 28, 2009, the licensee submitted the updated leak-before-break analysis as part of a license amendment request which currently is under NRC review.

5. Shrinkage shall be measured during the overlay application. Shrinkage stresses arising from the weld overlays at other locations in the piping systems shall be demonstrated to not have an adverse effect on the systems. Clearances of affected supports and restraints shall be checked after the overlay repair, and shall be reset within the design ranges as required.

6. The total added weight on the piping systems due to the overlays shall be evaluated for potential impact on piping system stresses and dynamic characteristics.

7. The as-built dimension of the weld overlays shall be measured and evaluated to demonstrate that they equal or exceed the minimum design dimensions of the overlays.

The licensee submitted the summaries of the analyses listed in Items one through four above in the November 23, 2009, letter. Items five though seven will be performed following installation of the weld overlays and results shall be included in the design modification package closure documents. This information shall be available to the NRC resident or regional inspectors for review.

The licensee stated that the following information will be submitted to the NRC within 14 days of completion of the final ultrasonic examination of the overlaid DMWs.

1. A listing of indications detected will be submitted. The recording criteria of the ultrasonic examination procedure to be used for the examination of the DBNPS overlays requires that all indications, regardless of amplitude, be investigated to the extent necessary to provide accurate characterization, identity, and location. Additionally, the procedure requires that all indications, regardless of amplitude, that cannot be clearly attributed to the geometry of the overlay configuration be considered flaw indications.

2. The disposition of all indications using the standards of ASME Code, Section XI, IWB-3514-2 and/or IWB-3514-3 criteria and, if possible, the type and nature of the indications will be submitted. The ultrasonic examination procedure requires that all suspected flaw indications are to be plotted on a cross sectional drawing of the weld and that the plots should accurately identify the specific origin of the reflector.

3. Any repairs to the overlay material and/or base metal will be discussed and the reason for the repair.

The NRC staff finds that the analyses and inspection results that the licensee has committed to submit and/or make available for NRC staff review will provide reasonable assurance that the design and inspection of the OWOL are within the ASME Code requirements. Therefore, the proposed analyses and submittal of the inspection results are acceptable.

The NRC staff finds that the requirements of RR-A32 dated November 23, 2009, as supplemented on December 15, 2009, are either consistent with or exceed the intent of the provisions of Code Cases N-504-3, N-638-1, and Appendix Q of the ASME Code, Section XI. Therefore, the proposed alternative is acceptable.

## 4.0 CONCLUSION

On the basis of its review, the NRC staff has determined that RR-A32, dated November 23, 2009, with additional requirements provided on December 15, 2009, will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff authorizes the use of RR-A32, dated November 23, 2009, as supplemented on December 15, 2009, for the OWOL of the DMWs of the RCP discharge nozzles at the DBNPS. RR-32 is authorized for the third 10-year inservice inspection interval which commenced on September 21, 2000, and will end on September 20, 2012.

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.

## 5.0 REFERENCES

1. EPRI Materials Reliability Program: Technical Basis for Preemptive Weld Overlays for Alloy 82/182 Butt Welds in PWRs (MRP-169), Rev. 1, EPRI, Palo Alto, CA and Structural Integrity Associates, Inc., San Jose, CA; June 2008, 1016602, (ADAMS Accession No. ML082610254).

Principal Contributor: JTsao, NRR

Date: January 29, 2010

If you have any questions, please contact the Davis-Besse Project Manager, Mr. Stephen Sands, at 301-415-3154.

Sincerely,

***/RA by CGratton for/***

Stephen J. Campbell, Chief
Plant Licensing Branch III-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-346

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