October 19, 2006

Mr. Mark B. Bezilla
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 NO. 1 - EVALUATION OF REQUEST FOR RELIEF RE: FULL STRUCTURAL WELD OVERLAY (TAC NO. MD0683)

Dear Mr. Bezilla:

By letter to the U.S. Nuclear Regulatory Commission (NRC) dated March 29, 2006, as supplemented by letters dated March 31 and May 22, 2006, FirstEnergy Nuclear Operating Company (FENOC) submitted a request for approval of the proposed alternatives from certain American Society of Mechanical Engineers (ASME) *Boiler and Pressure Vessel Code* (Code), Section XI inservice inspection requirements for the third 10-year interval, which began on September 21, 2000, and will end on September 20, 2012, for Davis Besse Nuclear Power Station, Unit No. 1. Modifcations to ASME Code Case N-504-2, “Alternative Rules for Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping, Section XI, Division 1” and Appendix VIII, Supplement 11, “Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds,” to the 1995 Edition through the 1996 Addenda of ASME Code, Section XI were submitted specifically for the purpose of performing a full structural weld reinforcement (weld overlay) on reactor coolant pump 1-1 inlet cold-leg drain nozzle-to-elbow weld RC-40-CCA-18-1-FW2-2½.

On April 5, 2006, FENOC requested, and the NRC staff authorized, verbal relief to Davis-Besse under Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.55a(a)(3)(i), to perform the full structural weld overlay repair. The verbal authorization was provided before returning the plant to service from refueling outage 14.

Based on its review, the NRC staff concludes that the ASME Code Case N-504-2 modifications proposed in relief request (RR)-A29 provide an acceptable level of quality and safety, and are therefore, authorized pursuant to 10 CFR 50.55a(a)(3)(i) for the remaining service life of the weld. In addition, the NRC staff concludes that the alternatives to Appendix VIII, Supplement 11 to the 1995 Edition through the 1996 Addenda of ASME Code, Section XI will provide an acceptable level of quality and safety and are, therefore, authorized pursuant to 10 CFR 50.55a(a)(3)(i) for the remainder of the third 10-year interval. Additionally, all other ASME Code, Section XI requirements for which relief was not specifically requested and approved in RR-A29 remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

Sincerely,

/RA signed by J.Williams for/

Daniel S. Collins, Chief
Plant Licensing Branch III-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-346

Enclosure:
Safety Evaluation

cc w/encl: See next page

provide an acceptable level of quality and safety and are, therefore, authorized pursuant to 10 CFR 50.55a(a)(3)(i) for the remainder of the third 10-year interval. Additionally, all other ASME Code, Section XI requirements for which relief was not specifically requested and approved in RR-A29 remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO THIRD 10-YEAR INSERVICE INSPECTION INTERVAL

RELIEF REQUEST RR-A29

FIRSTENERGY NUCLEAR OPERATING COMPANY

DAVIS-BESSE NUCLEAR POWER STATION, UNIT NO. 1

DOCKET NO. 50-346

1.0 INTRODUCTION

By letter to the U.S. Nuclear Regulatory Commission (NRC, the Commission) dated March 29, 2006 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML060900374), as supplemented by letters dated March 31 (ADAMS Accession No. ML060940424) and May 22, 2006 (ADAMS Accession No. ML061440282), FirstEnergy Nuclear Operating Company (FENOC, the licensee), proposed modifications/alternatives under relief request (RR)-A29, for Davis-Besse Nuclear Power Station, Unit No. 1 (Davis-Besse), to the repair requirements of the American Society of Mechanical Engineers *Boiler and Pressure Vessel Code* (ASME Code) Code Case N-504-2, "Alternative Rules for Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping, Section XI, Division 1" (N-504-2), and Appendix VIII, Supplement 11, "Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds," to the 1995 Edition through the 1996 Addenda of ASME Code, Section XI.

During refueling outage (RFO)-14, an axial indication in the Alloy 182 filler (butter) material of reactor coolant pump (RCP) 1-1 inlet cold-leg drain nozzle-to-elbow weld RC-40-CCA-18-1-FW2-2½ was discovered during augmented ultrasonic testing (UT) examinations. Since there is no qualified procedure for sizing indications in dissimilar metal welds and the indication is in the material susceptible to primary water stress-corrosion cracking (PWSCC), the licensee proposed repairing the area containing the indication using a full weld reinforcement (weld overlay). Pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.55a(a)(3)(i), an alternative would be used to perform the full structural weld overlay repair on the subject weld to mitigate any potential PWSCC.

On March 28, 2006, the NRC staff and the licensee participated in a telephone conference call to discuss the weld overlay repair issue. During the call, the licensee committed to the NRC staff to document the technical basis on why the N-504-2 calculations would not be supplied to the NRC before startup of Davis-Besse from RFO-14. This commitment was addressed by letter to the NRC dated March 31, 2006. In addition, during the call, the licensee committed to sending the NRC a letter to address residual stresses, flaw growth and increased loading due to shrinkage as a result of the repair and paragraphs g(1) through g(3) of N-504-2. The

March 31, 2006, letter noted that due to schedule constraints, the licensee proposed to complete the evaluations required under paragraphs g(1) through g(3) of N-504-2 30 days from restart of RFO-14. The technical justifications are listed in Section 3.4 of this safety evaluation (SE). Additionally, the March 31, 2006, letter stated that the licensee would provide the NRC staff with a summary of the evaluations within 30 days of restart. This summary was provided to the NRC by letter dated May 22, 2006.

On April 5, 2006, the licensee requested, and the NRC staff authorized, verbal relief to Davis-Besse under 10 CFR 50.55a(a)(3)(i), to perform the full structural weld overlay repair. The verbal authorization was provided before returning the plant to service from the RFO. The licensee's extent of condition review included, in addition to the normal outage scope of four welds, a UT examination of a fifth dissimilar metal weld on a high-pressure injection line and a review of construction records of other dissimilar metal welds. No issues were identified.

2.0 REGULATORY EVALUATION

Pursuant to 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) will meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in the ASME Code, Section XI, "Rules for Inservice Inspection (ISI) of Nuclear Power Plant Components," and addenda that become effective subsequent to editions specified in 10 CFR 50.55a(g)(2) and 50.55a(g)(3) 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. The ISI Code of record for Davis-Besse for the third 10-year ISI interval, which began on September 21, 2000, and will end on September 20, 2012, is the 1995 Edition through the 1996 Addenda.

In accordance with 10 CFR 50.55a(g)(6)(ii)(C)(1), the implementation of Supplements 1 through 8, 10, and 11 of Appendix VIII to Section XI, 1995 Edition with the 1996 Addenda of the ASME Code, was required on a phased schedule ending on November 22, 2002. ASME Code Section XI, Appendix VIII, Supplement 11 was required to be implemented by November 22, 2001. Additionally, 10 CFR 50.55a(g)(6)(ii)(C)(2) requires licensees implementing the 1989 Edition and earlier editions and addenda of Subsection IWA-2232, "Ultrasonic Examination," of Section XI, Division 1, of the ASME Code to implement the 1995 Edition with the 1996 Addenda of Appendix VIII and the supplements to Appendix VIII of Section XI, Division 1, of the ASME Code.

Pursuant to 10 CFR 50.55a(g)(4)(iv), inservice examination of components and system pressure tests may meet the requirements set forth in subsequent editions and addenda of the ASME Code that are incorporated by reference in 10 CFR 50.55a(b), subject to the limitations and modifications listed therein, and subject to Commission approval. Portions of editions or addenda may be used provided that all related requirements of the respective editions and addenda are met.

Pursuant to 10 CFR 50.55a(a)(3) proposed alternatives to the requirements of 10 CFR 50.55a(c), (d), (e), (f), (g), and (h) or portions thereof may be used when authorized by the Director of the Office of Nuclear Reactor Regulation if the licensee demonstrates that: (i) the proposed alternatives would 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 licensee submitted RR-A29, pursuant to 10 CFR 50.55a(a)(3)(i), which proposed alternatives to the implementation of the ASME Code, Section XI, Appendix VIII, and modifications to N-504-2, for the deposition of a full structural weld overlay, as a repair, for the remaining service life as defined under N-504-2, paragraph g(2).

3.0 TECHNICAL EVALUATION

3.1 Applicable ASME Code Requirements

Per Subsection IWA-4120, “Applicability,” repairs shall be performed in accordance with the licensee’s design specification and the original Construction Code. Later editions and addenda of the Construction Code or of ASME Code, Section III, either in their entirety or portions thereof, and ASME Code Cases may be used. Therefore, the 1995 Edition through the 1996 Addenda of the ASME Code applies to this request. Additionally, ASME Code, Section XI, Article IWA-4000, “Repair/Replacement Activities,” Appendix VIII, Supplement 11, which is required to be implemented per 10 CFR 50.55a(g)(6)(ii)(C), N-504-2, with conditions as specified in Regulatory Guide (RG) 1.147, Revision 14, “Inservice Inspection Code Case Acceptability ASME Section XI, Division 1,” is also applicable.

3.2 N-504-2 Requirements for which Relief is Requested

In the March 29, 2006, submittal, Table 1, “Modifications to Code Case N504-2 and Corresponding Nonmandatory Appendix Q Requirements,” the licensee requested relief from the weld overlay requirements from the following paragraphs to ASME Code Case N-504-2 pursuant to 10 CFR 50.55a(a)(3)(i):

The reply mentioned in N-504-2 states, “It is the opinion of the [ASME] Committee that, in lieu of the requirements of [Subsection] IWA-4120 in Editions and Addenda up to and including the 1989 Edition with the 1990 Addenda, in [Subsection] IWA-4170 [Inspection](b) in the 1989 Edition with the 1991 Addenda up to and including the 1995 Edition, and in [Subsection] IWA-4410 [General Requirements] in the 1995 Edition with the 1995 Addenda and later Editions and Addenda, defect in austenitic stainless steel piping may be reduced to a flaw of acceptable size in accordance with [Subsection] IWB-3640 [Evaluation Procedures and Acceptance Criteria for Austenitic Piping] from the 1983 Edition with the Winter 1985 Addenda, or later Editions and Addenda, by deposition of weld reinforcement (weld overlay) on the outside surface of the pipe, provided the following requirements are met. [Essentially the same as the Scope of [Nonmandatory] Appendix Q [Weld Overlay Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping Weldments.]]”

Paragraph (b) states, “Reinforcement weld metal shall be low carbon (0.035%, max.) austenitic stainless steel applied 360° around the circumference of the pipe, and shall be deposited in accordance with a qualified welding procedure specification identified in the Repair Program. [Same as Q-2000(a)]”

Paragraph (e) states, “The weld reinforcement shall consist of a minimum of two weld layers having as-deposited delta ferrite [delta ferrite is a crystal structure in the metal and, for weld overlay, the delta ferrite content in the metal needs to be in a specific range to minimize cracking] content of at least 7.5 FN [Ferrite Number]. The first layer of weld metal with delta ferrite content of least 7.5 FN shall constitute the first layer of the weld reinforcement design thickness. Alternatively, first layers of at least 5 FN may be acceptable based on evaluation. [Same as Appendix Q]”

3.3 Licensee’s Proposed Modifications to N-504-2

The licensee proposed in Table 1 of its March 29, 2006, request, to use N-504-2 for the weld overlay repairs to the ferritic (P1) and nickel alloy (F43/P43) base material as well as the austenitic stainless steel (P8) base material. In Table 1, the licensee included the following modifications to N-504-2 for a full structural weld overlay repair of an axial indication of the weld RC-40-CCA-18-1-FW2-2½:

- Use of N-504-2 as an alternative.
- In lieu of an austenitic stainless steel filler material, the reinforcement weld metal will be a nickel alloy.
- FN measurements will not be performed for weld overlay repairs made of Alloy 52/52M/52MS weld metal.

In addition to the above modifications, in its supplemental letter dated March 31, 2006, the licensee indicated that due to schedule constraints, it had planned to perform the evaluations required under paragraphs g(1) through g(3) of N-504-2 after the weld overlay repair implementation. Subsequently, the licensee completed the evaluations and sent the summary of the analysis to the NRC staff by letter dated May 22, 2006.

3.4 Licensee’s Basis for Relief from N-504-2

Pursuant to 10 CFR 50.55a(a)(3)(i), the licensee stated the following in its March 29, 2006, request:

> Code Case N-504-2 is accepted for use along with Nonmandatory Appendix Q in the current NRC Regulatory Guide 1.147, Rev. 14. For the weld overlay of the identified weld at the DBNPS [Davis-Besse], the base material will be ferritic material (P1) with existing nickel alloy weld metal (F43/P43) to which an austenitic stainless steel (P8) elbow is welded. Industry operational experience has shown that PWSCC in Alloy 82/182 will blunt at the interface with stainless steel base metal, ferritic base metal, or Alloy 52/52M/52MS weld metal. The 360° structural weld overlay will control growth in any PWSCC crack and maintain weld integrity. The weld overlay will induce compressive stress in the weld, thus impeding growth of any reasonably shallow cracks. Furthermore, the overlay will be sized to meet all structural requirements independent of the existing weld.
>
> Paragraph (b), “The weld metal used may be ERNiCrFe-7A (Alloy 52M/MS, UNS

N06054) or ERNiCrFe-7 (Alloy 52, UNS N06052). This weld metal is assigned F43 by ASME per Code Case 2142-2 [F-Number Grouping for Ni-Cr-Fe Filler Metals Section XI (applicable to all Sections, including Section III, Division 1, and Section XI)]. The requirements of ASME Code, Section III, NB-2400 [Welding Material] will be applied to all filler material. The chromium content of Alloy 52M/MS is 28-31.5%, identical to that of Alloy 52. The main difference in Alloy 52 vs. Alloy 52M/MS is a higher Niobium content (0.5 - 1 %). The difference in chemical composition between Alloy 52 and Alloy 52M/MS improves the weld-ability of the material and pins the grain boundaries thus preventing separation between the grains and hot tearing during weld puddle solidification. These filler materials were selected for their improved resistance to PWSCC. Alloys 52 and 52M/MS contain about 30% chromium that imparts excellent corrosion resistance. The existing Alloy 82/182 weld and the Alloy 52M/52MS overlay are nickel based and have ductile properties and toughness similar to austenitic stainless steel piping welds at pressurized water reactor operating temperature. These filler materials are suitable for welding over the ferritic nozzle, Alloy 82/182 weld and the austenitic stainless steel elbow."

Paragraph (e), "Welds of Alloy 52/52M/52MS are 100% austenitic and contain no delta ferrite due to the high nickel composition (approximately 60% nickel)."

Under paragraph g(1) of N-504-2, the licensee stated in its March 31, 2006, letter that it complies with the recording requirements in Subsection IWA-1400, "Owner Responsibilities," item (p), and that the flaw has been recorded in the component's non-destructive examination (NDE) record.

Under paragraph g(2) of N-504-2, four issues were discussed by the licensee:

1. Consideration of Residual Stresses and Other Applied Loads

   It has been shown in several studies (both experimentally and analytically) that the residual stresses resulting from application of a weld overlay repair with water backing, plus the operating stresses due to other applied loads, are compressive in the inner portion of the component and thereby mitigate future crack growth into the overlay. This has been demonstrated for nozzle-to-safe end welds of various sizes in recent projects for several plants considering an initial weld repair that results in significant through-wall tensile residual stresses. The presence of post-weld overlay compressive residual stresses in the inner portion of the component mitigates propagation into the overlay. The welding parameters that will be used during the overlay application are very similar to what have been used in previous industry projects in which favorable residual stresses have been demonstrated, and therefore, it is expected that similar results will be obtained for the component at Davis-Besse. The compressive stresses introduce a negative mean stress which minimizes fatigue crack growth.

2. Potential for Flaw Growth

   The overlay is designed as a standard overlay (full structural) assuming a 360-degree flaw through the original pipe wall. As such, no credit is taken for any of the original pipe wall. The overlay material is Alloy 52 (or Alloy 52M or Alloy 52MS), which is very resistant to stress-corrosion cracking, and as such, flaw growth into the overlay by this mechanism is not expected. As explained above, the presence of compressive residual stresses on the inside of the component after the overlay application also mitigates stress-corrosion cracking and minimizes fatigue crack growth into the overlay. Compared with other components such as spray nozzles, the transients associated with the drain nozzle at Davis-Besse are much less severe, and therefore, no significant fatigue crack growth is expected.

3. Demonstration that Requirements of Subsection IWB-3640 [Evaluation Procedures and Acceptance Criteria for Austenitic Piping] Will Be Satisfied

   The overlay was sized in accordance with the requirements of Subsection IWB-3640, and since no crack growth is expected into the overlay, the requirements of Subsection IWB-3640 will be satisfied.

4. Structural Credit of Shielded Arc Weld (SAW) or Shielded Metal Arc Weld (SMAW) Weldment

   Since the overlay is designed as a standard overlay (full structural) and applied with the gas tungsten arc weld (GTAW) process, no structural credit was taken for the underlying weld and base material or for SAW or SMAW weld metal in the overlay. Therefore, the evaluations per Tables IWB-3641-5, “Service Level A and B Loadings,” and IWB-3641-6, “Service Level C and D Loadings,” do not apply to this overlay design.

Under paragraph g(3) of N-504-2, two issues were discussed by the licensee:

1. Increase in Load Due to Weld Overlay

   The application of the overlay introduces at most 10 pounds of additional weight to the piping system. The effect of this added weight is not expected to change the stresses on the system by any significant amount. This added mass is also not expected to change the dynamic characteristics of the piping system. Even though the overlay increases the thermal gradient slightly, this is compensated for by the added thickness of the overlay which reduces the thermal stresses. Note that this section of piping is normally insulated, which minimizes the thermal gradient.

2. Weld Overlay Shrinkage and Shrinkage Stresses

   The application of the weld overlay will result in a small amount of axial shrinkage. For a 2.5-inch nominal pipe size nozzle-to-elbow weld, this shrinkage will typically be on the order of 0.125 inches. The resulting shrinkage stress is expected to be very small (less than 0.5 kilo-pounds per square inch (ksi)). This was confirmed prior to restart. The effect of this axial shrinkage is to impose sustained (non-cyclic) secondary stresses on the system. ASME Code, Section III does not require evaluation of non-cyclic secondary stress, and as such, shrinkage stresses are not considered in the ASME Code, Section III load combinations. However, the shrinkage stresses are considered in flaw evaluations of other welds in the system. Since there are no other flaw evaluations in the system, this is not an issue. The licensee will perform system inspections of the affected portions of the piping after the overlay implementation to ensure that system restraints, supports and snubbers have not exceeded their design tolerances resulting from weld shrinkage associated with the overlay repair. Due to the relatively small size of the overlay and associated shrinkage, the affected portions of the piping will be in the vicinity of the overlay. ASME Code safety margins in the short term are established by the full structural nature of the weld overlay. The additional analyses discussed above are only required to establish the long-term life of the weld overlay, which is expected to equal or exceed the remaining life of the plant.

The licensee indicated during a telephone conference call on March 28, 2006, that after completion of the weld overlay, the resultant shrinkages will be determined from the as-welded measurements. The results of this determination were documented by letter dated May 22, 2006, where the licensee provided the NRC staff with a summary of the analysis demonstrating all of the above points. The following summarizes the calculation packages that were prepared to document the design and analysis of the Davis-Besse RCP 1-1 inlet cold-leg drain line nozzle-to-elbow weld overlay:

- For the weld overlay sizing of the RCP-1-1 cold-leg drain nozzle, the licensee evaluated in Calculation DB-06Q-301, Revision 2, "Weld Overlay Sizing for RCS-1-1 Cold Leg Drain Nozzle," the required size (thickness and length) for a full structural (standard) overlay repair based on plant-specific nozzle geometry and loadings, and N-504-2. The licensee determined that the minimum required thickness and length of the overlay meets the structural integrity and inspection requirements of N-504-2 and Nonmandatory Appendix Q.

- The licensee developed in Calculation DB-06Q-302, Revision 1, "Finite Element Models of the Davis-Besse Reactor Coolant Cold Leg Letdown Nozzle with Weld Overlay Repair," finite element models of the overlaid drain nozzle configuration, based upon the design provided in Calculation DB-06Q-301. The models were used in subsequent calculations to calculate stresses. Finite element models were required for use in calculating mechanical, thermal and residual stresses.

- The licensee analyzed in Calculation DB-06Q-303, Revision 1, "Thermal and Mechanical Stress Analyses of Cold Leg Letdown Nozzle with Weld Overlay Repair," the finite element models for design-bases loading conditions, and produced stress results for use in ASME Code, Section III stress and fatigue evaluations and, ASME Code Section XI crack growth evaluations. Design-bases loads were applied to finite element models and stresses calculated for those loading conditions.

- The licensee performed in Calculation DB-06Q-304, Revision 1, "Reactor Coolant System (RCS) Cold Leg Letdown Line Nozzle Weld Overlay Repair," an ASME Code, Section III, Class 1 evaluation for the repaired configuration by comparing primary and secondary stress intensities calculated in Calculation DB-06Q-303 to appropriate Section III acceptance criteria and performed a fatigue evaluation in accordance with Section III criteria. The required evaluations were performed and all ASME Code stress and fatigue acceptance criteria were met.

- The licensee determined in Calculation DB-06Q-305, Revision 1, "RCS Letdown Nozzle Weld Shrinkage Analysis," that the maximum stresses developed in the reactor coolant drain and letdown piping system due to the effects of the observed weld shrinkage associated with the weld overlay repair. The licensee determined that piping system stresses resulting from the measured axial shrinkage associated with the weld overlay repair were small compared to the load carrying capability of the system.

- The licensee analyzed in Calculation DB-06Q-306, Revision 1, “Residual Stress Evaluation of the Davis Besse Unit 1 Reactor Coolant Cold Leg Drain Nozzle with Weld Overlay Repair Using Design Dimensions,” the finite element model for weld residual stresses resulting from the initial butt weld and a postulated repair, as well as for the application of the weld overlay. The licensee determined that the weld residual stresses at and near the inside surface of the PWSCC susceptible material were reversed from tensile to compressive after application of the weld overlay.

- The licensee addressed in Calculation DB-06Q-307, Revision 0, “Predicting Fatigue Crack Growth for the Davis-Besse RCP 1-1 Cold Leg Drain Nozzle with Design Weld Overlay,” the potential crack growth due to both stress corrosion and fatigue utilizing initial (or postulated) crack geometry, and the stress fields generator in Calculations DB-06Q-303 and DB-06Q-306. The licensee determined that crack growth was not considered to be a significant factor affecting the weld overlay design based on compressive stresses present in the nozzle weld due to the presence of the overlay.

- The licensee provided in Calculation SIR-06-148, Revision 0, “Weld Overlay Design Analysis for Reactor Coolant Pump 1-1 Inlet Cold Leg Drain Nozzle-to-Elbow Weld at Davis-Besse Nuclear Power Station,” a summary of the technical basis and the supporting design and analyses of the cold-leg drain nozzle overlay, as provided in the applicable calculation packages. The licensee determined that all design requirements of N-504-2 were met by the design overlay.

Subsequent to RFO-14, on April 18, 2006, the licensee completed system inspections of the affected portions of the piping to ensure that system restraints, supports and snubbers had not exceeded their design tolerances resulting from weld shrinkage associated with the overlay repair. The results of this walkdown were documented on Commitment Close-Out Extension Form No. A21831. Similarly, a confirmation of the resulting axial shrinkage stresses was performed on April 18, 2006, as documented on Commitment Close-Out Extension Form No. A21830.

3.5 Staff Evaluation of Modifications to N-504-2

Per Subsection IWA-4120, in editions and addenda up to and including the 1989 Edition through the 1990 Addenda of the ASME Code, repairs shall be performed in accordance with the owner’s [licensee’s] design specification and the original Construction Code of the component or system. Later editions and addenda of the Construction Code, or of ASME Code, Section III, either in their entirety or portions thereof, and Code Cases may be used. In addition to the above requirements, defects shall be removed or reduced in size in accordance with Subsection IWA-4300, “Design.” Alternatively, the component may be evaluated and accepted in accordance with the design rules of either the Construction Code, or ASME Code, Section III, when the Construction Code was not Section III. N-504-2 is being used by the licensee to perform a full structural weld overlay, as a repair, over an axial indication in the Alloy 182 butter material of the weld RC-40-CCA-18-1-FW2-2½. N-504-2 was conditionally approved by the NRC staff for use under RG 1.147. Therefore, the use of N-504-2 as an alternative to the mandatory ASME Code repair provisions is acceptable to the NRC staff, provided that the licensee complies with all conditions and provisions of the Code Case.

The first proposed modification to the N-504-2 provisions involved the use of a nickel-based alloy weld material, rather than the low-carbon austenitic stainless steel. The licensee stated that Paragraph (b) of N-504-2 requires that the reinforcement weld material shall be low-carbon (0.035 percent maximum) austenitic stainless steel. In lieu of the stainless steel weld material, Alloy 52/52M/52MS, a consumable welding wire highly resistant to PWSCC, was proposed for the overlay weld material. The NRC staff notes that the use of Alloy 52/52M/52MS material is consistent with weld filler material used to perform similar weld overlays at operating boiling-water reactor (BWR) facilities. The NRC staff concludes, therefore, that the proposed use of weld material for the full structural overlays provides an acceptable level of quality and safety and is, therefore, acceptable.

The second proposed modification to the N-504-2 provisions involved Paragraph (e) of N-504-2 which requires as-deposited delta ferrite measurements of at least 7.5 FN for the weld reinforcement. The licensee proposed that delta ferrite measurements will not be performed for this overlay because the deposited Alloy 52/52M/52MS material is 100-percent austenitic and contains no delta ferrite due to the high nickel composition (approximately 60-percent nickel). N-504-2 allows the use of weld overlay repair by deposition of weld reinforcement on the outside surface of the pipe in lieu of mechanically reducing the defect to an acceptable flaw size. However, N-504-2 is only applicable to weld overlay repair of austenitic stainless steel piping. Therefore, the material requirements regarding the carbon content limitation (0.035-percent maximum) and the delta ferrite content of at least 7.5 FN, as delineated in N-504-2, paragraphs (b) and (e), apply to austenitic stainless steel weld overlay materials. These requirements are not applicable to Alloy 52/52M/52MS, a nickel-based material which the licensee will use for the weld overlays.

The NRC staff notes that the licensee is performing a full structural overlay on dissimilar metal welds made of Alloy 182 material. For material compatibility in welding, the NRC staff considers that Alloy 52/52M/52MS is a better choice of filler material than austenitic stainless steel material for this weld joint configuration. Alloy 52/52M/52MS contains about 30 percent chromium which would provide excellent resistance to PWSCC in the reactor coolant environment. This material is identified as F-No. 43 Grouping for Ni-Cr-Fe, classification UNS N06052 Filler Metal and has been previously approved by the NRC staff for similar applications. Therefore, the licensee’s proposed use of Alloy 52/52M/52MS for the weld overlays as a modification to the requirements of N-504-2, paragraphs (b) and (e) is acceptable as it will provide an acceptable level of quality and safety.

In its supplemental letter dated March 31, 2006, the licensee indicated that due to schedule constraints, it planned to perform the evaluations required under paragraphs g(1) through g(3) of N-504-2 after the weld overlay repair implementation. The licensee committed to complete these items within 30 days of plant startup. Paragraphs (g)(1) through (g)(3) of N-504-2 specify recording criteria and requires that the stress evaluation shall take into consideration the residual stresses produced by the weld overlay. Specific acceptance criteria for the stresses will be in accordance with the Construction Code.

Paragraph g(1) of N-504-2 requires a licensee to record regions in components where flaws or relevant conditions, exceeding the acceptance standards, have been evaluated by analysis to allow continuous operation. In its supplemental letter dated March 31, 2006, the licensee indicated that the axial indication in the subject weld complies with the recording requirements of Subsection IWA-1400(p). The NRC staff concludes that paragraph g(1) of N-504-2 is satisfied, therefore relief from this requirement is not necessary.

Paragraph g(2) of N-504-2 requires that for repaired welds, the evaluation shall consider residual stresses produced by the weld overlay in addition to other applied loads on the system. The evaluation shall demonstrate that the requirements of Subsection IWB-3640 from the 1983 Edition through the Winter 1985 Addenda, or later editions and addenda, are satisfied for the design life of the repair, considering flaw growth due to fatigue and the mechanism believed to have caused the flaw. The methodology consists of performing a flaw evaluation to determine whether the calculated maximum flaw dimensions of a detected flaw exceed the allowable flaw size for a specified evaluation period. Both fatigue and stress-corrosion cracking (i.e., PWSCC) mechanisms are to be considered for both normal operating conditions and emergency and faulted conditions.

Paragraph g(3) of N-504-2 requires an evaluation of other welds and components in the system considering the potential increases in loading, including shrinkage effects due to all the weld overlays in the system. It also requires the identification and recording of the magnitude and location of the maximum shrinkage stress developed. In its supplemental letter dated March 31, 2006, the licensee indicated that the size of the overlay will increase the weight on the system by 10 pounds. Also, the small size of the overlay (approximately 24 square inches) will result in a small amount of shrinkage (on the order of 0.125 inch) which could produce a stress of approximately 0.5 ksi.

For Alloy 52/52M/52MS welds, the NRC staff considers stresses below 20 ksi a conservative limit for the residual stresses, which is significantly lower than the 39 ksi yield of the weld material. Based on the small surface area and low projected residual shrinkage stresses from the application of the full structural overlay, the NRC staff concludes that there is reasonable assurance that the structural integrity of the adjoining welds to the repaired area will be maintained. Based on the discussion above, the NRC staff concludes that the licensee's modification to complete the calculations under paragraphs g(2) through g(3) of N-504-2, within 30 days after startup will provide an acceptable level of quality and safety.

On April 5, 2006, the licensee requested, and the NRC staff authorized, verbal relief to the licensee under 10 CFR 50.55a(a)(3)(i). The granting of relief for post-startup performance of the calculations under N-504-2 paragraphs g(2) and g(3) is a one-time relief under 10 CFR 50.55a(a)(3)(i) for Davis-Besse and not to be considered a precedent for the licensee (and other licensees) to follow. The NRC staff's expectation is that calculations associated with paragraphs g(2) and g(3) will be completed by all licensees before startup which includes an assessment of the impact on adjoining welds. A thorough assessment of the stresses and weight addition, particularly in large volume overlays, is warranted to assure continued structural integrity of the piping system.

The licensee completed RFO-14 on April 27, 2006, and by letter dated May 22, 2006, provided the NRC staff with summary of the analyses performed in support of the repair in accordance with N-504-2. This summary is documented in Section 3.4 of this SE. The NRC staff reviewed the summary and concluded that all of the overlay design requirements of N-504-2 provided an acceptable level of safety.

3.6 Code Requirements for which Relief is Requested From ASME Code, Section XI, Appendix VIII, Supplement 11

In Table 2, "Alternatives to Appendix VIII, Supplement 11," of its March 29, 2006, letter, pursuant to 10 CFR 50.55a(a)(3)(i), the licensee requested relief from the weld overlay requirements in the following paragraphs to ASME Code, Section XI, Appendix VIII, Supplement 11 (the NRC staff did not consider Paragraphs 1.1(e)(2), 1.1(e)(2)(a)(2), 1.1(e)(2)(b)(2), 1.1(e)(2)(b)(3), 1.1(f)(1), 1.1(f)(3), 1.1(f)(4), 2.0, 2.1, 2.2(d), and 3.2(a) listed in Table 2 of the licensee's March 29, 2006, request to be alternatives to ASME Code, Section XI, Appendix VIII, Supplement 11):

Paragraph 1.1(b) states, "The specimen set shall consist of at least three specimens having different nominal pipe diameters and overlay thicknesses. They shall include the minimum and maximum nominal pipe diameters for which the examination procedure is applicable. Pipe diameters within a range of 0.9 to 1.5 times a nominal diameter shall be considered equivalent. If the procedure is applicable to pipe diameters of 24 in. or larger, the specimen set must include at least one specimen 24 in. or larger but need not include the maximum diameter. The specimen set must include at least one specimen with overlay thickness within -0.1 in. to +0.25 in. of the maximum nominal overlay thickness for which the procedure is applicable."

Paragraph 1.1(d)(1) states that for all base metal flaws, "All flaws must be cracks in or near the ~[approximate] butt weld heat-affected zone, open to the inside surface, and extending at least 75% through the base metal wall. Flaws may extend 100% through the base metal and into the overlay material; in this case, intentional overlay fabrication flaws shall not interfere with ultrasonic detection or characterization of the cracking. Specimens containing IGSCC [inter-granular stress corrosion cracking] shall be used when available."

Paragraph 1.1(e)(1) states, "At least 20% but not less than 40% of the flaws shall be oriented within +/-20° of the pipe axial direction. The remainder shall be oriented circumferentially. Flaws shall not be open to any surface to which the candidate has physical or visual access. The rules of [Subsection] IWA-3300 [Flaw Characterization] shall be used to determine whether closely spaced flaws should be treated as single or multiple flaws."

Paragraph 1.1(e)(2)(a)(1) states, "A base grading unit shall include at least 3 in. of the length of the overlaid weld. The base grading unit includes the outer 25% of the overlaid weld and base metal on both sides. The base grading unit shall not include the inner 75% of the overlaid weld and base metal overlay material, or base metal to-overlay interface."

Paragraph 1.1(e)(2)(a)(3) states, "When a base grading unit is designed to be unflawed, at least 1 in. of unflawed overlaid weld and base metal shall exist on either side of the base grading unit. The segment of weld length used in one base grading unit shall not be used in another base grading unit. Base grading units need not be uniformly spaced around the specimen."

Paragraph 1.1(e)(2)(b)(1) states, “An overlay grading unit shall include the overlay material and the base metal-to-overlay interface of at least 6 in^2. The overlay grading unit shall be rectangular, with minimum dimensions of 2 in.”

Paragraph 2.3 states, “For the depth sizing test, 80% of the flaws shall be sized at a specific location on the surface of the specimen identified to the candidate. For the remaining flaws, the regions of each specimen containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the maximum depth of the flaw in each region.”

Paragraph 3.1 states, “Examination procedures, equipment, and personnel are qualified for detection when the results of the performance demonstration satisfy the acceptance criteria of Table VIII-S2-1 for both detection and false calls. The criteria shall be satisfied separately by the demonstration results for base grading units and for overlay grading units.”

Paragraph 3.2(b) states, “All extensions of base metal cracking into the overlay material by at least 0.1 in. are reported as being intrusions into the overlay material.”

3.7 Licensee’s Proposed Alternatives to ASME Code, Section XI, Appendix VIII, Supplement 11

In lieu of the requirements of ASME Code, Section XI, 1995 Edition through the 1996 Addenda, Appendix VIII, Supplement 11, the Performance Demonstration Initiative (PDI) program, as described in of the licensee’s request dated March 29, 2006, shall be used. The duration of the relief is for the remainder of the third 10-year ISI interval. The PDI program proposed alternatives to the following paragraphs of Supplement 11 requirements (the NRC staff did not consider Paragraphs 1.1(e)(2), 1.1(e)(2)(a)(2), 1.1(e)(2)(b)(2), 1.1(e)(2)(b)(3), 1.1(f)(1), 1.1(f)(3), 1.1(f)(4), 2.0, 2.1, 2.2(d), and 3.2(a) listed in Table 2 of the licensee’s March 29, 2006, letter, to be alternatives to ASME Code, Section XI, Appendix VIII, Supplement 11):

- Paragraph 1.1(b) states, “The specimen set shall include specimens with overlays not thicker than 0.1 in. more than the minimum thickness, nor thinner than 0.25 in. of the maximum nominal overlay thickness for which the examination procedure is applicable.”

- Paragraph 1.1(d)(1) states, “[All flaws] must be [cracks] in or. . . intentional overlay fabrication flaws shall not interfere with ultrasonic detection or characterization of the base metal flaws. Specimens containing inter-granular stress corrosion cracking shall be used when available. At least 70% of the flaws in the detection and sizing tests shall be cracks and the remainder shall be alternative flaws. Alternative flaw mechanisms, if used, shall provide crack-like reflective characteristics and shall be limited by the following:
(a) The use of alternative flaws shall be limited to when the implantation of cracks produces spurious reflectors that are uncharacteristic of actual flaws.
(b) Flaws shall be semi elliptical with a tip width of less than or equal to 0.002 inches.”

- Paragraph 1.1(e)(1) states, “At least 20% but less than 40% of the base metal flaws shall be oriented within +/-20° of the pipe axial direction. The remainder shall be oriented circumferentially. Flaws shall not be open to any surface to which the candidate has physical or visual access.”

- Paragraph 1.1(e)(2)(a)(1) states, “A base metal grading unit includes the overlay material and the outer 25% of the original overlaid weld. The base metal grading unit shall extend circumferentially for at least 1 in. and shall start at the weld centerline and be wide enough in the axial direction to encompass one half of the original weld crown and a minimum of 0.50" of the adjacent base material.”

- Paragraph 1.1(e)(2)(a)(3) states, “Sufficient unflawed overlaid weld and base metal shall exist on all sides of the grading unit to preclude interfering reflections from adjacent flaws. Modified to require sufficient unflawed overlaid weld and base metal to exist on all sides of the grading unit to preclude interfering reflections from adjacent flaws, rather than the 1 inch requirement.”

- Paragraph 1.1(e)(2)(b)(1) states, “An overlay fabrication grading unit shall include the overlay material and the base metal-to-overlay interface for a length of at least 1 in. Modified to require sufficient unflawed overlaid weld and base metal to exist on all sides of the grading unit to preclude interfering reflections from adjacent flaws, rather than the 1-inch requirement.”

- Paragraph 2.3 states, “(a) The depth sizing test may be conducted separately or in conjunction with the detection test. (b) When the depth sizing test is conducted in conjunction with the detection test and the detected flaws do not satisfy the requirements of 1.1(f), additional specimens shall be provided to the candidate. The regions containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the maximum depth of the flaw in each region. (c) For a separate depth sizing test, the regions of each specimen containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the maximum depth of the flaw in each region.”

- Paragraph 3.1 states, “Examination procedures are qualified for detection when:
  (a) All flaws within the scope of the procedure are detected and the results of the performance demonstration satisfy the acceptance criteria of Table VIII-S2-1 for false calls.
  (b) At least one successful personnel demonstration has been performed meeting the acceptance criteria defined in (c).
  (c) Examination equipment and personnel are qualified for detection when the results of the performance demonstration satisfy the acceptance criteria of Table Vlll-S2-1 for both detection and false calls.
  (d) The criteria in (b) and (c) shall be satisfied separately by the demonstration results for base metal grading units and for overlay fabrication grading units.”

- Paragraph 3.2(b) states, “This requirement is omitted.”

3.8 Licensee’s Basis for Relief from ASME Code, Section XI, Appendix VIII, Supplement 11

The following paragraphs, which correspond to the paragraphs listed in ASME Code, Section XI, Appendix VIII, Supplement II, are direct quotes from the bases listed in Table 2 of the licensee’s submittal dated March 27, 2006. The licensee omitted the bases for alternatives proposed for Paragraphs 1.1(e)(2), 1.1(e)(2)(a)(2), 1.1(e)(2)(a)(3), 1.1(e)(2)(b)(1), 1.1(e)(2)(b)(3), 1.1(f)(1), 1.1(f)(3), 1.1(f)(4), 2.0, 2.1, 2.2(d), 2.3, 3.1, and 3.2(a) (the alternative and associated basis for Paragraph 1.1(e)(2)(b)(2) was not considered by the NRC staff):

- Paragraph 1.1(b) states, “To avoid confusion, the overlay thickness tolerance contained in the last sentence was reworded and the phrase “and the remainder shall be alternative flaws” was added to the next to last sentence in paragraph 1.1(d)(1).”

- Paragraph 1.1(d)(1) states, “This paragraph requires that all base metal flaws be cracks. Implanting a crack requires excavation of the base material on at least one side of the flaw. While this may be satisfactory for ferritic materials, it does not produce a useable axial flaw in austenitic materials because the [ultrasonic] sound beam, which normally passes only through base material, must now travel through weld material on at least one side, producing an unrealistic flaw response. To resolve this issue, the PDI program revised this paragraph to allow use of alternative flaw mechanisms under controlled conditions. For example, alternative flaws shall be limited to when implantation of cracks precludes obtaining an effective ultrasonic response, flaws shall be semi elliptical with a tip width of less than or equal to 0.002 inches, and at least 70% of the flaws in the detection and sizing test shall be cracks and the remainder shall be alternative flaws. To avoid confusion, the overlay thickness tolerance contained in paragraph 1.1(b) last sentence, was reworded and the phrase “and the remainder shall be alternative flaws” was added to the next to last sentence. Paragraph 1.1(d)(1) includes the statement that intentional overlay fabrication flaws shall not interfere with ultrasonic detection or characterization of the base metal flaws.”

- Paragraph 1.1(e)(1) states, “The requirement for axially oriented overlay fabrication flaws was excluded from the PDI Program as an improbable scenario. Weld overlays are typically applied using automated GTAW techniques with the filler metal applied in a circumferential direction. Because resultant fabrication induced discontinuities would also be expected to have major dimensions oriented in the circumferential direction axial overlay fabrication flaws are unrealistic. The requirement for using [Subsection] IWA-3300 for proximity flaw evaluation was excluded, instead indications will be sized based on their individual merits.”

- Paragraph 1.1(e)(2)(a)(1) states, “The phrase “and base metal on both sides,” was inadvertently included in the description of a base metal grading unit. The PDI program intentionally excludes this requirement because some of the qualification samples include flaws on both sides of the weld. To avoid confusion several instances of the term “cracks” or “cracking” were changed to the term “flaws” because of the use of alternative Flaw mechanisms .... ”

- Paragraph 3.2(b) states, “The requirement for reporting all extensions of cracking into the overlay is omitted from the PDI Program because it is redundant to the RMS calculations performed in paragraph 3.2(c) and its presence adds confusion and ambiguity to depth sizing as required by paragraph 3.2(c). This also makes the weld overlay program consistent with the supplement 2 depth sizing criteria.”

3.9 Staff Evaluation of Alternatives to ASME Code, Section XI, Appendix VIII, Supplement 11

The U.S. nuclear utilities created the PDI to implement performance demonstration requirements contained in ASME Code, Section XI, Appendix VIII, Supplement 11. To this end, PDI has developed a program for qualifying equipment, procedures, and personnel in accordance with the UT examining criteria of ASME Code, Section XI, Appendix VIII, Supplement 11. Prior to the ASME Code, Section XI, Appendix VIII, Supplement 11, EPRI was maintaining a performance demonstration program for weld overlay qualification under the Tri-party Agreement, instead of having two programs with similar objectives, the NRC staff recognized the PDI program for weld overlay qualifications as an acceptable alternative to the Tri-party Agreement. The PDI program does not fully comport with the existing requirements of ASME Code, Section XI, Appendix VIII, Supplement 11.

The NRC staff did not consider Paragraphs 1.1(e)(2), 1.1(e)(2)(a)(2), 1.1(e)(2)(b)(2), 1.1(e)(2)(b)(3), 1.1(f)(1), 1.1(f)(3), 1.1(f)(4), 2.0, 2.1, 2.2(d), and 3.2(a) listed in Table 2 of the licensee's March 29, 2006, letter, to be alternatives to ASME Code, Section XI, Appendix VIII, Supplement 11. However, the NRC staff addressed applicable differences between the PDI and Supplement 11 paragraphs. These applicable differences are discussed below.

Paragraph 1.1(b) of Supplement 11 states limitations to the maximum thickness for which a procedure may be qualified. The ASME Code states, "The specimen set must include at least one specimen with overlay thickness within -0.10-inch to +0.25-inch of the maximum nominal overlay thickness for which the procedure is applicable." The ASME Code requirement addresses the specimen thickness tolerance for a single specimen set, but is confusing when multiple specimen sets are used. The PDI proposed alternative states "the specimen set shall include specimens with overlay not thicker than 0.10-inch more than the minimum thickness, nor thinner than 0.25-inch of the maximum nominal overlay thickness for which the examination procedure is applicable." The proposed alternative provides clarification on the application of the tolerance. The tolerance is unchanged for a single specimen set, however, it clarifies the tolerance for multiple specimen sets by providing tolerances for both the minimum and maximum thicknesses. The proposed wording eliminates confusion while maintaining the intent of the overlay thickness tolerance. Therefore, the NRC staff finds this PDI program revision acceptable.

Paragraph 1.1(d)(1) requires that all base metal flaws be cracks. The PDI determined that certain ASME Code, Section XI, Appendix VIII, Supplement 11 requirements pertaining to location and size of cracks would be extremely difficult to achieve. For example, flaw implantation requires excavating a volume of base material to allow a pre-cracked coupon to be welded into this area. This process would add weld material to an area of the specimens that typically consists of only base material, and could potentially make UT examination more difficult and not representative of actual field conditions. In an effort to satisfy the requirements, the PDI developed a process for fabricating flaws that exhibit crack-like reflective characteristics. Instead of all flaws being cracks as required by Paragraph 1.1(d)(1), the PDI weld overlay performance demonstrations contain at least 70-percent cracks with the remainder being fabricated flaws exhibiting crack-like reflective characteristics. The fabricated flaws are semi-elliptical with tip widths of less than 0.002 inches. The licensee provided further information describing a revision to the PDI program alternative to clarify when real cracks, as opposed to fabricated flaws, will be used; "Flaws shall be limited to the cases where implantation of cracks produces spurious reflectors that are uncharacteristic of actual flaws." The NRC staff has reviewed the flaw fabrication process, compared the reflective characteristics between actual cracks and PDI-fabricated flaws, and found the fabricated flaws acceptable for this application.

Paragraph 1.1(e)(1) requires that at least 20 percent but not less than 40 percent of the flaws shall be oriented within ± 20 degrees of the axial direction [of the piping test specimen]. Flaws contained in the original base metal heat-affected zone satisfy this requirement, however, the PDI excludes axial fabrication flaws in the weld overlay material. The PDI has concluded that axial flaws in the overlay material are improbable because the overlay filler material is applied in the circumferential direction (parallel to the girth weld), therefore fabrication anomalies would also be expected to have major dimensions in the circumferential direction. The NRC staff finds this approach to implantation of fabrication flaws to be reasonable and, therefore, the PDI's application of flaws oriented in the axial direction, is acceptable.

Paragraph 1.1(e)(1) also requires that Subsection IWA-3300 shall be used to determine whether closely spaced flaws should be treated as single or multiple flaws. The PDI treats each flaw as an individual flaw and not as part of a system of closely spaced flaws. The PDI controls the flaws going into a test specimen set such that the flaws are free of interfering reflections from adjacent flaws. In some cases, this permits flaws to be spaced closer than what is allowed for classification as a multiple set of flaws by IWA-3300, thus potentially making the performance demonstration more challenging. The NRC staff concludes that the PDI's application for closely spaced flaws is acceptable.

Paragraph 1.1(e)(2)(a)(1) requires that a base grading unit shall include at least 3 inches of the length of the overlaid weld, and the base grading unit includes the outer 25 percent of the overlaid weld and base metal on both sides. The PDI program reduced the criteria to 1 inch of the length of the overlaid weld and eliminated from the grading unit, the need to include both sides of the weld. The proposed change permits the PDI program to continue using test specimens from the existing weld overlay program which have flaws on both sides of the welds. These test specimens have been used successfully for testing the proficiency of personnel for over 16 years. The weld overlay qualification is designed to be a near-side [relative to the weld] examination, and it is improbable that a candidate would detect a flaw on the opposite side of the weld due to the sound attenuation and redirection caused by the weld micro-structure. However, the presence of flaws on both sides of the original weld (outside the PDI grading unit) may actually provide a more challenging examination, as candidates must determine the relevancy of these flaws, if detected. Therefore, the NRC staff concludes that the PDI's use of the 1 inch length of the overlaid weld base grading unit and elimination from the grading unit, the need to include both sides of the weld, as described in the revised PDI program alternative, is acceptable.

Paragraph 1.1(e)(2)(a)(3) requires that for unflawed base grading units, at least 1 inch of unflawed overlaid weld and base metal shall exist on either side of the base grading unit. This requirement minimizes the number of false identifications of extraneous reflectors. The PDI program stipulates that unflawed overlaid weld and base metal exists on all sides of the grading unit and that flawed grading units must be free of interfering reflections from adjacent flaws which addresses the same concerns as the ASME Code. The NRC staff concludes that the PDI's application of the variable flaw-free area adjacent to the grading unit is acceptable.

Paragraph 1.1(e)(2)(b)(1) requires that an overlay grading unit shall include the overlay material and a base metal-to-overlay interface of at least 6 square inches. The overlay grading unit shall be rectangular, with minimum dimensions of 2 inches. The PDI program reduces the base metal-to-overlay interface to at least 1 inch (in lieu of a minimum of 2 inches) and eliminates the minimum rectangular dimension. This criterion is necessary to allow use of existing examination specimens that were fabricated in order to meet in order to meet the Tri-Party Agreement. This criterion may be more challenging than the ASME Code because of the variability associated with the shape of the grading unit. The NRC staff concludes that the PDI's application of the grading unit is acceptable.

Paragraph 2.3 states that, for depth sizing tests, 80 percent of the flaws shall be sized at a specific location on the surface of the specimen identified to the candidate. This requires detection and sizing tests to be separate. The PDI revised the weld overlay program to allow sizing to be conducted either in conjunction with, or separately from, the flaw detection test. If performed in conjunction with detection, and the detected flaws do not meet the ASME Code, Section XI, Appendix VIII, Supplement 11 range criteria, additional specimens will be presented to the candidate with the regions containing flaws identified. Each candidate will be required to determine the maximum depth of flaw in each region. For separate sizing tests, the regions of interest will also be identified and the maximum depth and length of each flaw in the region will similarly be determined. In addition, the PDI stated that grading units are not applicable to sizing tests, and that each sizing region will be large enough to contain the target flaw, but small enough that candidates will not attempt to size a different flaw. The above clarification provides a basis for implementing sizing tests in a systematic, consistent manner that meets the intent of ASME Code, Section XI, Appendix VIII, Supplement 11. As such, this is acceptable to the NRC staff.

Paragraphs 3.1 and 3.2 of ASME Code, Section XI, Appendix VIII, Supplement 11 state that procedures, equipment and personnel [as a complete UT system] are qualified for detection or sizing of flaws, as applicable, when certain criteria are met. The PDI program allows procedure qualification to be performed separately from personnel and equipment qualification. Historical data indicate, if UT detection or sizing procedures are thoroughly tested, that the personnel and equipment using those procedures have a higher probability of successfully passing a qualification test. In an effort to increase this passing rate, the PDI has elected to perform procedure qualifications separately in order to assess and modify essential variables that may affect overall system capabilities. For a procedure to be qualified, the PDI program requires three times as many flaws to be detected (or sized) as shown in ASME Code, Section XI, Appendix VIII, Supplement 11 for the entire UT system. The personnel and equipment are still required to meet ASME Code, Section XI, Appendix VIII, Supplement 11. Therefore, the NRC staff concludes that the PDI program exceeds ASME Code requirements for personnel, procedures, and equipment qualification and is acceptable.

Paragraph 3.2(b) requires that all extensions of base metal cracking into the overlay material by at least 0.1 inch are reported as being intrusions into the overlay material. The PDI program omits this criterion because of the difficulty in actually fabricating a flaw with a 0.1 inch minimum extension into the overlay, while still knowing the true state of the flaw dimensions. However, the PDI program requires that cracks be depth-sized to the tolerance of 0.125 inch as specified in the ASME Code. Since the ASME Code tolerance is close to the 0.1 inch value of Paragraph 3.2(b), any crack extending beyond 0.1 inch into the overlay material would be identified as such from the characterized dimensions. The reporting of an extension in the overlay material is redundant for performance demonstration testing because of the flaw sizing tolerance. Therefore, the NRC staff concludes that the PDI's omission of highlighting a crack extending beyond 0.1 inch into the overlay material is acceptable.

4.0 CONCLUSION

Based on the discussion above, the NRC staff concludes that the modifications to N-504-2 proposed in RR-A29, for the full structural overlay repair of weld RC-40-CCA-18-1-FW2-2½ at Davis-Besse, will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff authorizes the proposed alternatives for the remaining service life of the subject weld.

Regarding the licensee's proposed alternatives to ASME Code, Section XI, Appendix VIII, Supplement 11 and the use of the PDI program in lieu of Supplement 11, the NRC staff did not consider Paragraphs 1.1(e)(2), 1.1(e)(2)(a)(2), 1.1(e)(2)(b)(2), 1.1(e)(2)(b)(3), 1.1(f)(1), 1.1(f)(3), 1.1(f)(4), 2.0, 2.1, 2.2(d), and 3.2(a) to be alternatives to ASME Code, Section XI, Appendix VIII, Supplement 11.

Based on the discussion above, the NRC staff concludes that the alternatives to ASME Code, Section XI, Appendix VIII, Supplement 11, will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff authorizes the proposed alternatives for the remainder of the third 10-year ISI interval.

All other ASME Code, Section XI requirements for which relief was not specifically requested and approved in RR-A29 remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

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Date: October 19, 2006

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