September 17, 2007

Mr. Peter P. Sena III
Site Vice President
FirstEnergy Nuclear Operating Company
Beaver Valley Power Station
Mail Stop A-BV-SEB1
P.O. Box 4, Route 168
Shippingport, PA 15077

SUBJECT: BEAVER VALLEY POWER STATION, UNIT NO. 1 - RELIEF REQUEST NO. BV1-PZR-01 REGARDING WELD OVERLAY REPAIRS ON PRESSURIZER NOZZLE WELDS (TAC NO. MD4828)

Dear Mr. Sena:

By letter dated March 8, 2007, as supplemented by letter dated May 31, 2007, FirstEnergy Nuclear Operating Company (the licensee), requested approval of an alternative to the inservice inspection (ISI) interval requirements of the 1989 Edition of the American Society of Mechanical Engineers and Pressure Vessel Code (ASME Code), Section XI, for weld repairs. Additionally, the licensee requested approval of an alternative to the requirements of Supplement 11 of Appendix VIII of the 1995 Edition, including 1996 Addenda of ASME Code, Section XI, for nondestructive examination of weld overlays.

The Nuclear Regulatory Commission (NRC) staff has concluded that modifications to the requirements of ASME Code Cases N-504-2 and N-638-1, proposed in Relief Request No. BV1-PZR-01, will provide an acceptable level of quality and safety. Therefore, pursuant to Section 50.55a(a)(3)(i) of Part 50 to Title 10 of the *Code of Federal Regulations* (10 CFR), the NRC staff authorizes the proposed alternative for the remaining third ISI interval (ending April 2, 2008).

The NRC staff has concluded that the alternative to ASME Code, 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 authorized the proposed alternative for the remaining third ISI interval (ending April 2, 2008).

All other requirements of the ASME Code, Section XI for which relief has not been specifically requested remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

Sincerely,

/RA/

Mark G. Kowal, Chief
Plant Licensing Branch I-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-334

Enclosure:
As stated

cc w/encl: See next page

All other requirements of the ASME Code, Section XI for which relief has not been specifically requested remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

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cc w/encl: See next page

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ACCESSION NUMBER: ML072050488 *Input received. No substantive changes made.

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REGARDING THE INSERVICE INSPECTION INTERVAL

FOR RELIEF REQUEST NO. BV1-PZR-01

FIRSTENERGY NUCLEAR OPERATING COMPANY

FIRSTENERGY NUCLEAR GENERATION CORP.

BEAVER VALLEY POWER STATION, UNIT NO. 1

DOCKET NO. 50-334

1.0 INTRODUCTION

By letter dated March 8, 2007, Agencywide Document Access and Management System (ADAMS) Accession number ML070720511, as supplemented by letter dated May 31, 2007 (ADAMS Accession number ML071520522), FirstEnergy Nuclear Operating Company (the licensee), proposed an alternative for Beaver Valley Power Station, Unit No. 1 (BVPS-1), to the weld repair requirements of the American Society of Mechanical Engineers and Pressure Vessel Code (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 ASME Code Case N-638-1, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique, Section XI, Division 1." Additionally, the licensee proposed an alternative to Appendix VIII, Supplement 11 to the 1995 Edition including 1996 Addenda of the ASME Code, Section XI. The proposed approach would be used to perform full structural preemptive weld overlays (PWOLs) on pressurizer spray, safety, and relief nozzle safe end to nozzle dissimilar metal welds and weld overlays for the elbow to safe end welds. The subject welds were fabricated using Alloy 82/182 weld material to join the pressurizer nozzles and the safe ends. This weld material has a propensity for primary water stress-corrosion cracking (PWSCC) in the fleet. The licensee intends to mitigate the effects of cracking on subject welds by applying full structural PWOLs prior to the onset of PWSCC.

By letter dated May 31, 2007, the licensee submitted a revised copy of Relief Request No. BV1-PZR-01. The revised relief request addressed the following two concerns: (1) application of a butter layer of austenitic stainless steel filler metal on the austenitic stainless steel base material and (2) allowing the nondestructive examination (NDE) of the weld overlay after the 48-hour hold time starting from the completion of the third temperbead weld layer.

2.0 REGULATORY EVALUATION

Pursuant to Section 50.55a(g)(4) of Part 50 to Title 10 of the *Code of Federal Regulations* (10 CFR), ASME Code Class 1, 2, and 3 components (including supports) will meet the requirements, except the design and access provisions and the pre-service examination

requirements, set forth in the ASME Code, Section XI, "Rules for Inservice Inspection (ISI) of Nuclear Power Plant Components," to the extent practical within the limitations of design, geometry, and materials of construction of the components. 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) twelve months prior to the start of the 120-month interval, subject to the limitations and modifications listed therein. The ISI ASME Code of record for BVPS-1 is the 1989 Edition of the ASME Code with no Addenda for its third ISI interval.

In accordance with 10 CFR 50.55a(g)(6)(ii)(C)(1), the implementation of Supplements 1, 2, 3, and 8 of Appendix VIII to Section XI, 1995 Edition with the 1996 Addenda of the ASME Code, was required on a phased schedule ending on May 22, 2000. Supplement 10 was required to be implemented by November 22, 2002. 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 of paragraph IWA-2232 of Section XI of the ASME Code to implement the 1995 Edition with the 1996 Addenda of Appendix VIII and supplements to Appendix VIII of Section XI of the ASME Code.

Pursuant to 10 CFR 50.55a(g)(4)(iv), ISI items 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 and addenda may be used provided that related requirements of the respective editions and addenda are met.

Pursuant to 10 CFR 50.55a(a)(3), alternatives to requirements may be authorized by the Nuclear Regulatory Commission (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 licensee submitted the subject relief request, pursuant to 10 CFR 50.55a(a)(3)(i), which proposed an alternative to the implementation of the ASME Code, Section XI, Appendix VIII, Supplement 11, and modified implementation of N-638-1, and N-504-2, for the deposition of PWOLs for the remaining service life of the components including the period of extended operation.

3.0 TECHNICAL EVALUATION

3.1 ASME Code Components Affected

Component Numbers: 1RC-TK-1 (Pressurizer Vessel)

Nozzle	Nozzle-to-Safe End Weld ID	Safe End-to-Pipe Weld ID
Safety "A"	RC-97-1-E-01	RC-97-1-F-01
Safety "B"	RC-98-1-E-02	RC-98-1-F-01
Safety "C"	RC-99-1-E-03	RC-99-1-F-01
Relief	RC-104-1-E-01	RC-104-1-F-01
Spray	RC-72-E-01	RC-72-7-F-09

Code Class:	Class 1
Examination Categories:	B-F
Item Number:	B5.40

The BVPS-1 pressurizer surge nozzle-to-safe end weld is stainless steel and is not within the scope of this request.

3.2 Applicable Code Edition and Addenda

- The Code of Construction for pressurizer vessel is the ASME Code, Section III, 1965 Edition through Winter 1966 Addenda.

- The Code of Construction for Reactor Coolant System (RCS) Piping is American National Standards Institute (ANSI) B31.1, 1967 Edition through Summer 1971 Addenda.

- The Code for ISI and Repair/Replacement programs is the ASME Code, Section XI, 1989 Edition, No addenda.

- The Code for the ultrasonic examination is the ASME Code, Section XI, 1995 Edition, 1996 Addenda, Appendix VIII, Supplement 11 (as required by 10 CFR 50.55a(g)(6)(ii)(C)).

3.3 Applicable Code Requirements: (As stated)

Article IWA-4000 of ASME Section XI contains requirements for welded repairs performed on ASME components. The specific Code requirements for which use of the proposed alternative is being requested are as follows:

ASME Section XI, IWA-4120(a) states that “Repairs shall be performed in accordance with the Owner's Design Specification and the original Construction Code of the component or system.”

ASME Section XI, IWA-4310 states that “Defects shall be removed or reduced in size in accordance with this Article.”

ASME Section XI, IWA-4533(b) states that “Thermocouples and recording instruments shall be used to monitor the preheat and interpass requirements and the 450 °F to 550 °F heat treatment. Thermocouples may be attached by welding or by mechanical methods.”

ASME Section XI, Appendix VIII, Supplement 11 (1995 Edition, 1996 Addenda) contains nondestructive examination requirements for structural weld overlays and is required to be implemented by 10CFR50.55a(g)(6)(ii)(C).

The applicable requirements of the Construction Code required by ASME Section XI, IWA-4120(a) for which use of the proposed alternative is being requested are as follows:

ASME Section III, Subsection N-528 states that “Unacceptable defects...shall be removed by mechanical means or by thermal gouging processes...” and that “The post-weld heat-treating rules in N-532 shall apply to all weld repairs.”

ASME Section III, Subsection N-532.1 states that “... all welded pressure vessels or pressure vessel parts shall be given a postweld heat treatment at a temperature not less than specified in table N-532.”

3.4 Proposed Alternative to ASME Code, Section XI, IWA-4120(a), IWA-4310, and ASME Code, Section III, Subsection N-528

The licensee proposed to use a PWOL for each Alloy 82/182 nozzle-to-safe end weld of the pressurizer safety, relief, and spray nozzle. ASME Code Case N-504-2 allows a flaw to be reduced to an acceptable size through the deposition of weld reinforcement (weld overlay) on the outside surface of the pipe without flaw removal. In this case, the existence of (or lack of) any flaws are not known due to the inability to perform a qualified ultrasonic examination prior to application of the overlays. As such, assumptions are required to be made as to the size and location of flaws which may be present in the original dissimilar metal weld, as discussed below.

The licensee will design weld overlays consistent with the requirements of ASME Code Case N-504-2, "Alternative Rules for Repair of Classes 1, 2, and 3 Austenitic Stainless Steel Piping," with modifications. The weld overlay will extend around the full circumference of the nozzle-to-safe end weld location as required by Code Case N-504-2. The licensee will calculate the specific thickness and length of the overlay according to the guidance provided in Code Case N-504-2.

The design of each overlay will assume that a 360° circumferential through-wall flaw is present in the original Alloy 82/182 weld. The licensee will evaluate fatigue crack growth for the dissimilar metal butt welds to demonstrate that the weld overlay thickness is sized adequately to satisfy the requirements in the flaw evaluation procedures of IWB-3640 of ASME Code, Section XI. The initial flaw size assumed in the fatigue crack growth calculations will be consistent with the post-overlay ultrasonic examination requirements (i.e., a minimum of the outer 25% of the original Alloy 82/182 weld will be inspectable post-overlay). If the crack growth analysis shows that fatigue crack growth will not cause a flaw to exceed the allowable flaw size for the normal ASME Code, Section XI inspection interval, the licensee will use existing Code interval for subsequent ISI. If the crack growth analysis shows that the assumed crack will grow to the allowable flaw size, the licensee will establish an ISI interval based on the crack growth analysis. The licensee will perform pre-service inspections in accordance with Code Case N-504-2, Nonmandatory Appendix Q, Subarticle Q-4200, and ASME Section XI, 1995 Edition, 1996 Addenda, Appendix VIII, Supplement 11, as modified by this request.

Prior to entry into Mode 4, the licensee will perform flaw evaluations and shrinkage stress effects analyses to demonstrate that the overlays meet the design and structural requirements of Code Case N-504-2.

Recent industry experience has shown that Alloy 52M weld metal is sensitivity to certain impurities, such as sulfur, when deposited onto austenitic stainless steel base material. Therefore, a butter layer of austenitic stainless steel filler metal may be applied across the austenitic stainless steel base material prior to installing the overlay.

If appropriate, the licensee will apply a weld butter to the base metal with the gas tungsten arc welding (GTAW) process using an austenitic stainless steel weld filler metal that has chemical, mechanical, and metallurgical properties that are equivalent (or similar) to those of the austenitic stainless steel base materials. Austenitic stainless steel filler metals are specifically manufactured for joining, building up, overlaying, or buttering austenitic stainless steel base materials. The welding procedure for applying the austenitic stainless steel butter layer will be qualified in accordance with ASME Code, Section IX for the applicable base materials, filler metals, and welding variables. The stainless steel butter layer will not be deposited onto the existing Alloy 82/182 weld or carbon steel base material of the nozzle. The stainless steel butter will only be applied onto austenitic stainless steel base materials with sulfur, phosphorus, and silicon contents that could affect the soundness of the initial Alloy 52M weld layer.

The licensee stated that the application of the austenitic stainless steel weld metal (butter layer) is not expected to adversely impact the application of the Alloy 52M overlay. From a welding perspective, Alloy 52M weld metal can be deposited over austenitic stainless steel weld metal just as easily as it can be deposited over an austenitic stainless steel base material. The welding procedure that will be used to apply the Alloy 52M weld overlay onto the austenitic stainless steel base materials and butter layer has been qualified in accordance with ASME Code, Section IX and Code Case N-504-2. The licensee used mockups and test coupons to validate the process for the applications to be encountered at BVPS-1. In the tests, a stainless steel butter layer was applied to the stainless steel base material prior to deposition of the Alloy 52 weld metal. The thickness of the butter layer will be typical of that used for structural weld overlay layers (0.060 to 0.100-inch), with specific welding parameters as defined during the aforementioned welding procedure qualification and mock-up programs.

According to the licensee, because the coefficients of thermal expansion for the austenitic weld metal and base material are essentially the same, the differential thermal expansion between Alloy 52M weld metal (of the overlay) and stainless steel base material versus that of the Alloy 52M weld metal (of the overlay) and stainless steel weld metal (of the butter layer) will also be essentially the same. Therefore, the deposition of an austenitic stainless steel butter layer onto an austenitic stainless steel base material prior to deposition of the Alloy 52M weld overlay will have no adverse affect on weld shrinkage. Nonetheless, if the stainless steel butter layer is applied, the effect of the butter layer on the weld overlay will be reconciled in the weld overlay design and residual stress analyses.

The licensee clarified that if an austenitic stainless steel butter layer is used as described, it will not be included in or credited to the structural weld overlay design thickness. Additionally, the austenitic stainless steel butter layer will not adversely affect the ability to ultrasonically examine the weld overlay or the base metal.

The licensee will not perform ultrasonic examination of the subject welds prior to weld overlay installation due to the short length of the safe end between the Alloy 82/182 nozzle-to-safe end weld and the stainless steel safe end-to-pipe weld. However, the licensee will perform post-installation ultrasonic examination of the subject overlay and outer 25% of the original Alloy 82/182 weld and base metal to ensure that the inspected volume of the overlay and base material supports the conditions analyzed in the design and analysis of the overlays. The licensee will also perform bare metal visual examinations for leakage in accordance with BVPS-1 commitments to NRC Bulletin 2004-01 prior to application of the overlays. These examinations meet the requirements of the applicable Codes, as modified by this request.

3.5 Proposed Alternative to ASME Code, Section XI, IWA-4120(a) and ASME Code, Section III, Subsection N-532

Application of the structural weld overlays will require welding to the carbon steel nozzle material. The Code of Construction does not permit welding to the carbon steel nozzle without pre-heat or post-weld heat treatment. In lieu of these requirements, the licensee will use ASME Code Case N-638-1, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique," with modifications.

The ambient temperature temper bead welding technique of Code Case N-638-1 permits applications of the structural weld overlay without the need for elevated preheat or post-weld heat treatment required by ASME Code, Section III. Welding will commence when the base materials exhibit a minimum preheat of 50 °F. The interpass temperature, during weld installation, will not be permitted to exceed a maximum value of 350 °F. During the welding, heat input will be precisely controlled to conform to the welding procedure specification. The licensee will implement the above proposed alternative during the 1R18 refueling outage (fall 2007).

3.6 Proposed Alternative to ASME Code, Section XI, IWA-4533(b)

Subarticle IWA-4533(b) requires that in-process thermocouples and recording instruments be attached by welding or mechanical means. In lieu of attached thermocouples and recording instruments, the licensee will monitor process temperatures with non-attached devices, such as contact pyrometers, which will enable manual recording of process temperatures. The licensee will implement the above proposed alternative during the 1R18 Refueling Outage (fall 2007).

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

The licensee stated that Appendix VIII of ASME Code, Section XI, cannot be used for NDE of a structural weld overlay repair. The proposed alternative is to use the Performance Demonstration Initiative (PDI) program. The proposed alternative (i.e., the PDI program) will allow closer spacing of flaws provided they do not interfere with detection or discrimination. The specimens used to date for qualification to the Tri-party (NRC, Boiling-Water Reactor Owner's Group (BWROG), and Electric Power Research Institute (EPRI)) agreement have a flaw population density greater than allowed by current ASME Code requirements. These samples have been used successfully for all previous qualifications under the Tri-party agreement program. To facilitate their use and provide continuity from the Tri-party agreement program to Supplement 11, the PDI program has merged the Tri-party test specimens into their weld overlay program. The licensee will implement the above proposed alternative during the third ISI interval which ends on April 2, 2008.

3.8 Ultrasonic Examination Report

The licensee stated:

Within 14 days of completion of the last ultrasonic examination of the 1R18 refueling outage, the following information will be submitted in a report that summarizes the examination results of the pressurizer spray nozzle, relief nozzle, and three safety nozzle weld overlays for safe end-to-pipe and nozzle-to-safe end locations implemented during the 1R18 refueling outage:

- A listing of all indications detected[1],
- 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[2].

In addition, the licensee will discuss any repairs made to the overlay material and/or base metal and the reason for the repair.

3.9 Duration Of The Proposed Alternatives

The licensee requested the use of the proposed alternatives for the BVPS-1, third ISI interval (ending April 2, 2008). The resulting repairs are requested for the design life of the repairs, as determined by the required evaluation in Paragraph (g) of Code Case N-504-2 and the corresponding requirements in Nonmandatory Appendix Q.

The licensee will add the installed weld overlay to the BVPS-1 ISI Plan in accordance with Subarticle Q-4300 of Nonmandatory Appendix Q for at least one inservice examination to be completed within the next two refueling outages.

4.0 STAFF EVALUATION

In lieu of satisfying the requirements of the ASME Code, Section XI, as stated in Section 3.3 above, the licensee proposed to use alternative which were developed from Code Case N-504-2 and N-638-1. The NRC staff focused its evaluation of the proposed alternative:

4.1 Staff Evaluation of Proposed Modification to ASME Code Case N-504-2

The NRC staff notes that Code Case N-504-2 is applicable for repair of austenitic stainless steel piping. The licensee proposed to modify Code Case N-504-2 to apply the code case for

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[1]The recording criteria of the ultrasonic examination procedure to be used for the examination of the [BVPS-1] pressurizer overlays (PDI-UT-8) 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]Ultrasonic examination procedure PDI-UT-8, 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.

the repair of the ferritic (P-No. 1) nozzle material and nickel alloy (F-No. 43/P-No. 43) weld material, in addition to austenitic stainless steel base (P-No. 8, safe end and pipe) and weld materials. The licensee stated that Code Case N-504-2 is accepted for use in the current NRC Regulatory Guide (RG) 1.147, Revision 14, and has been used extensively in BWR primary system piping. Code Case N-504-2 has also been applied to pressurized water reactor (PWR) applications, with modifications, for the weld overlay repair of dissimilar metal welds. Industry operating experience has shown that PWSCC in Alloy 82/182 will arrest at the interface with stainless steel base metal, ferritic base metal, or Alloy 52/52M/152 weld metal. The 360° full structural weld overlay will control growth in any PWSCC crack and maintain weld integrity. The weld overlay will also induce compressive stress in the weld, thus potentially impeding growth of any reasonably shallow cracks. Furthermore, the overlay will be sized to meet all structural requirements without considering the existing 82/182 weld.

Paragraph (b) of Code Case N-504-2 requires that reinforcement weld metal be low carbon (maximum 0.035%) austenitic stainless steel. The modification to N-504-2 was in lieu of the low carbon stainless steel weld metal, the licensee proposed to use a nickel alloy, ERNiCrFe-7A (Alloy 52M, UNS N06054) or ERNiCrFe-7 (Alloy 52, UNS N06052). The licensee stated further that this weld metal is assigned F43 per ASME Code Case 2142-2. The requirements of ASME Code, Section III, NB-2400 will be applied to all filler material. The chromium content of Alloys 52, 52M, and 152 is 28% to 31.5%. Alloy 52M contains higher Niobium content (0.5% to 1%) than Alloy 52, which improves the weldability of the material and pins the grain boundaries, thus preventing separation between the grains and hot tearing during weld puddle solidification.

The licensee clarified that these filler materials are selected for their improved resistance to PWSCC. Alloys 52, 52M, and 152 all contain about 30% chromium (roughly twice that of Alloy 82/182), imparting corrosion resistance. The existing Alloy 82/182 weld and the Alloy 52/52M overlay are austenitic and have ductile properties and toughness similar to austenitic stainless steel piping welds at PWR operating temperature. Furthermore, these filler materials are suitable for welding over the ferritic nozzle, Alloy 82/182 weld, and the austenitic stainless steel pipe, welds, and safe ends. The NRC staff notes that use of 52/52M/152 material is consistent with weld filler material used to perform similar weld overlays at operating BWR facilities. EPRI has performed studies in qualifying weld overlays for application in BWRs, and in these applications, the studies have not identified any issues associated with shrinkage stress or weld contraction stresses. The similarities of design between BWR nozzles and the full structural weld PWOLs in the licensee's relief request provide reasonable assurance that there is a correlation in the performance of weld shrinkage and weld contraction stresses in the subject weld. The NRC staff concludes that the proposed use of Alloy 52/52M/152 weld material for the full structural PWOLs provides an acceptable level of quality and safety, and therefore, is acceptable.

Paragraph (e) of Code Case N-504-2 requires that the weld reinforcement consist of a minimum of two weld layers having as-deposited delta ferrite content of at least 7.5 FN. In lieu of the requirements of paragraph (e), the licensee will not measure the delta ferrite (FN) when using Alloy 52/52M/152 weld metal because Alloy 52/52M/152 contains no delta ferrite due to the high nickel content. The Alloy 52/52M filler material selected for these repairs is fully austenitic and is, therefore, exempt from delta ferrite content requirements. Alternatively, deposited chromium content provides a suitable alternate basis for first layer deposit acceptance in PWSCC-resistant structural weld overlays. The licensee stated that Code Case

N-504-2 does not identify first-layer acceptance criteria for fully austenitic deposits. However, ASME Code Case N-740 (and its accompanying technical justification) identifies 24% chromium as an acceptable measure of first-layer deposit acceptability in PWR applications. The licensee stated further that for structural weld overlay repairs, verification of first layer acceptability will be accomplished using Code Case N-740 methodology. To accomplish this, first layer overlay deposit chemistry will be verified either by field chemistry measurements or by prior mockup demonstration using comparable welding parameters. When first-layer surface chemistry meets or exceeds 24% chromium, this initial layer may be credited toward the structural overlay deposit thickness. When first-layer surface chemistry chromium is less than 24% chromium, the first layer will be considered sacrificial and will not be credited toward the structural overlay deposit thickness.

The NRC staff has not approved Code Case N-740 for weld overlays. However, the NRC staff has approved modifications to Code Case N-740 for pressurizer nozzle weld overlays at certain nuclear plants. The NRC staff finds that installation of the sacrificial layer is acceptable because the licensee and industry have performed mock-up tests to show that the sacrificial layer will minimize cracking of the weld overlay.

Paragraph (h) of Code Case N-504-2 requires that the completed repair be pressure tested in accordance with IWA-5000. Paragraph (h) requires further that if the flaw penetrated the original pressure boundary prior to welding, or if any evidence of the flaw penetrating the pressure boundary is observed during the welding operation, a system hydrostatic test shall be performed in accordance with IWA-5000. If the system pressure boundary has not been penetrated, a system leakage, inservice, or functional test shall be performed in accordance with IWA-5000.

In lieu of the hydrostatic test of Paragraph (h), the licensee proposed that if a flaw or evidence of a flaw penetrating the pressure boundary is observed, a system pressure test and an ultrasonic examination will be performed in accordance with the third interval ISI Program and Code Case N-416-2. The licensee stated that if no flaws penetrated the pressure boundary prior to welding, a system pressure test will be performed in accordance with paragraph (h), and the use of Code Case N-416-2 would not be required.

The NRC staff notes that Code Case N-416-3 is the latest N-416 approved for use in RG 1.147, Revision 14 and that RG. 1.147 does not prohibit the use of Code Case N-416-2. The NRC staff reviewed the differences between N-416-3 and N-416-2 and noted no significant changes in the requirements between the two ASME Code Cases.

Code Case N-416-2 requires that NDE shall be performed in accordance with the methods and acceptance criteria of the applicable subsection of the 1992 Edition of Section III. The acceptance criteria in Section III does not allow the presence of cracks, regardless of length, and are geared more toward construction type welds. The licensee's use of the post-repair NDE requirements of Code Case N-504-2 utilizing the appropriate PDI procedure is acceptable. The specimen sets for PDI qualification for weld overlay examinations include construction type flaws. Therefore, use of PDI qualified personnel and procedures for the examination of the weld overlay will result in the reliable detection of construction type flaws and meets the intent of compliance with the applicable subsection of the 1992 Edition of Section III. The NRC staff finds the use of Code Case N-416-2 as an alternative to paragraph (h) of Code Case N-504-2 is acceptable because Code Case N-416-2 requires a combination of an ultrasonic examination and system pressure test to assure the structural integrity of the weld overlay.

4.2 Staff Evaluation of Proposed Modification to ASME Code Case N-638-1

Paragraph 1.0(d) of Code Case N-648-1 requires that prior to welding the area to be welded and a band around the area of at least 1-1/2 times the component thickness or 5 inches, whichever is less, be at least 50 °F. Paragraph 4.0(b) of Code Case N-638-1 requires that the final weld surface and the band around the area defined in paragraph 1.0(d) be examined using a surface and ultrasonic methods when the completed weld has been at ambient temperature for at least 48 hours. The ultrasonic examination shall be in accordance with Appendix I of the 1989 Edition with the 1989 Addenda and later editions and addenda of the ASME Code, Section XI.

In lieu of the above, the licensee proposed to perform a surface examination of a band at least 0.50-inch outward from the toe of the weld overlay around the entire circumference of the nozzle and pipe in accordance with paragraph Q-4100(b) of Appendix Q to the ASME Code, Section XI. The licensee will also perform ultrasonic examinations in accordance with N-504-2 and Appendix Q.

The licensee stated that with respect to the weld overlay process on pressurizer nozzle dissimilar metal welds, the ASME Code Case N-638-1 defined band and examination volume would encompass the nozzle base metal volume below the outer diameter nozzle tapered surface and a part of the nozzle outer diameter blend region. Being that the inner diameter of the nozzle cannot be reasonably accessed, these outer diameter surfaces must be used as the ultrasonic test probe scanning surface. The outer diameter surfaces does not permit meaningful coverage of the examination volume due to non-coupling of the ultrasonic test probes over the surface; obstructions causing this non-coupling include the edge of the weld overlay, the transition between the outside diameter nozzle taper and the nozzle outer blend area, and the nozzle outer blend area.

The licensee stated that Appendix I of ASME Code, Section XI, 1998 Edition through the 2000 Addenda requires that the ultrasonic examination be conducted in accordance with ASME Code, Section V, Article 4 and all supplements of Appendix I except Supplement 9 – Scan Angles. The most applicable examination requirements fall under Article 4 T-440 Vessel Examinations. These requirements include straight beam scanning for laminar and planar reflectors and angle beam scanning for planar reflectors. The straight beam scanning is not likely to detect any delayed hydrogen cracking due to mis-orientation of the cracking with respect to the beam and to the anticipated near surface location of such cracking. Essentially the straight beam is a repeat of the nozzle material examination required by the Construction Code. The angle beam examinations will be largely impacted by the outer diameter surface configuration. To maximize angle beam examination coverage will entail a series of special transducers to be applied even though the most effective angle beam transducers would be those configured to detect near surface breaking planar reflectors. However, the most effective nondestructive method for detection of near surface breaking planar reflectors is not a volumetric method but a surface examination method.

The licensee stated further that the Section III criteria required by the condition imposed in RG 1.147 for the generic use of Code Case N-638-1 address concerns relating to deep cavity base material repairs that are not applicable to its use in weld overlay applications. Acceptance criteria of ASME Code, Section XI Code Case N-504-2 and Nonmandatory Appendix Q in lieu

of those of NB-5330 of ASME Code, Section III are the most appropriate for weld overlay applications of Code Case N-638-1 and provide an acceptable level of quality and safety.

Code Case N-638-1 applies to any type of welding in which a temper bead technique is employed and is not specifically written for a weld overlay repair. For a weld overlay, any base material cracking would take place in the heat affected zone directly below the weld overlay or in the underlying Alloy 82/182 weld deposit and not in the required band of material out beyond the overlay. Therefore, any cracking that occurs would be identified by the ultrasonic examination of the weld overlay in accordance with N-504-2 and Nonmandatory Appendix Q. The acceptance criteria required by Code Case N-504-2 and Nonmandatory Appendix Q are specifically tailored to the design and application of structural weld overlays to ensure that the overlay and underlying piping are capable of performing their design function, as specified in the design requirements of the code case and corresponding Appendix.

According to the licensee, ASME Code, Section XI pre-service acceptance standards, as specified in Appendix Q, are the appropriate standards for pre-service ultrasonic examinations of weld overlay repairs to nuclear plant components. These standards are consistent with the highly sensitive examination procedures being used, which are qualified in accordance with ASME Code, Section XI, Appendix VIII, Supplement 11, as implemented via the PDI. The post-repair inspection volume includes the full thickness of the weld overlay plus 25% of the underlying base metal/weldment thickness. The specimen sets for PDI qualification of weld overlay examinations include construction type flaws in the overlays in addition to simulated service flaws in the underlying base metal and weldment. Therefore, use of PDI-qualified personnel and procedures will result in the reliable detection of construction type flaws.

The ASME Code, Section XI flaw acceptance standards are based on fracture mechanics principles that evaluate the potential effect of flaw indications on the safe operation of a component. ASME Code, Section III ultrasonic standards, on the other hand, are derived from radiographic standards in earlier construction codes and tend to be workmanship-based, addressing flaws occurring in the original construction process that are likely to be detected by radiography. ASME Code, Section III acceptance criteria do not allow the presence of any cracks or crack-like indications, regardless of their size, and are geared more toward construction-type welds. Many indications that are detectable by PDI qualified ultrasonic techniques, and thus require evaluation, would not be detected by the radiographic examinations required by the original construction code or Section III. It is, therefore, not reasonable, nor technically logical, to reject such indications based on workmanship-based standards when found by much more sensitive examination techniques that are not required by the construction codes.

The Section XI pre-service examination standards were developed for the above stated reasons, and consider the materials in which the flaw indications are detected, the orientation and size of the indications, and ultimately their potential structural impact on the component. They are the logical choice for evaluation of potential flaw indications in post-overlay examinations, in which unnecessary repairs to the overlay would result in additional personnel radiation exposure without a compensating increase in safety and quality, and could potentially degrade the effectiveness of the overlays by affecting the favorable residual stress field they could produce.

The NRC staff finds that in lieu of paragraphs 1.0(b) and 4.0(b) of Code Case N-638-1, the licensee proposed surface and ultrasonic examinations of the weld overlay in accordance with Code Case N-504-2 and Appendix Q to the ASME Code, Section XI will verify the structural integrity of the weld overlays, and, therefore, are acceptable.

Paragraph 4.0(b) of Code Case N-638-1 requires that the final weld surface and the band around the area defined in paragraph 1.0(d) be examined using surface and ultrasonic methods when the completed weld has been at ambient temperature for at least 48 hours. The licensee proposes that the 48-hour hold period will begin after completion of the third temperbead weld layer in lieu of at ambient temperature.

The licensee stated that this 48-hour hold is specified to allow sufficient time for hydrogen cracking to occur (if it is to occur) in the heat affected zone (HAZ) of ferritic materials prior to performing final NDE. However, based on extensive research and industry experience, EPRI has provided a technical basis for starting the 48-hour hold after completing the third temperbead weld layer rather than waiting for the weld overlay to cool to ambient temperature. Weld layers beyond the third layer are not designed to provide tempering to the ferritic HAZ when performing ambient temperature temperbead welding. EPRI has documented their technical basis in Technical Report 1013558, “Temper Bead Welding Applications - 48 Hour Hold Requirements for Ambient Temperature Temper Bead Welding,” (ADAMS Accession No. ML070670060). Although the technical data provided by EPRI in their report is based on testing performed on SA - 508, Class 2, low alloy steels and other P-Number 3, Group 3 materials, the conclusions are bounding and applicable to P-Number 1 materials such as SA-216, Grade WCC, which have a lower carbon equivalent and lower hardenability. The BVPS-1 pressurizer nozzles are manufactured from SA-216, Grade WCC carbon steel.

According to the licensee, after evaluating the issues relevant to hydrogen cracking such as microstructure of susceptible materials, availability of hydrogen, applied stresses, temperature, and diffusivity and solubility of hydrogen in steels, EPRI concluded that there appears to be no technical basis for waiting 48 hours after cooling to ambient temperature before beginning the NDE of the completed weld. There should be no hydrogen present, and even if it were present, the temper bead welded component should be very tolerant of the moisture. The EPRI report also notes that over 20 weld overlays and 100 repairs have been performed using temper bead techniques on low alloy steel components over the last 20 years. During this time, there has never been an indication of hydrogen cracking by the NDE performed after the 48-hour hold or by subsequent ISI.

In addition, the licensee stated that the ASME Code, Section XI Committee published a White Paper to support the 48-hour hold time alternative (ADAMS Accession No. ML070790679). The ASME White Paper points out that introducing hydrogen to the ferritic HAZ is primarily limited to the first weld layer since this is the only weld layer that makes contact with the ferritic base material. While the potential for introducing hydrogen to the ferritic HAZ is negligible during subsequent weld layers, these layers provide a heat source that accelerates the dissipation of hydrogen from the ferritic HAZ in non-water backed applications. Furthermore, the solubility of hydrogen in austenitic materials such as Alloy 52M is much higher than that of ferritic materials while the diffusivity of hydrogen in austenitic materials is lower than that of ferritic materials. As a result, hydrogen in the ferritic HAZ tends to diffuse into the austenitic weld metal which has a much higher solubility for hydrogen. This diffusion process is enhanced by heat supplied in subsequent weld layers. The ASME White Paper concludes that there is

sufficient delay time to facilitate detecting potential hydrogen cracking when NDE is performed 48 hours after completing the third weld layer. The NRC staff finds that the licensee has provided sufficient technical basis to demonstrate that performing NDE after the 48-hour hold time, starting from the third temperbead overlay layer will not cause hydrogen cracking in the weld overlay. Therefore, it is acceptable that the proposed 48-hour hold time will begin after completion of the third weld layer.

4.3 Staff Evaluation of Proposed Alternatives to Supplement 11 of Appendix VIII to Section XI

The U.S. nuclear utilities created the PDI program to implement performance demonstration requirements contained 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 Appendix VIII, Supplement 11. Prior to the Supplement 11 program, EPRI was maintaining a performance demonstration program (the precursor to the PDI program) for weld overlay qualification under the Tri-party Agreement with the NRC, BWR Owner's Group, and EPRI, in the NRC letter dated July 3, 1984 (ADAMS Accession No. 8407090122). 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 does not fully comport with the existing requirements of Supplement 11. 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 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.

4.0 CONCLUSION

Based on the discussion above, the NRC staff concludes that the alternative, which is modifications to ASME Code Cases N-504-2 and N-638-1, 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 alternative for the remaining third ISI interval (ending April 2, 2008).

Based on the discussion above, the NRC staff concludes that the alternative 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 staff authorized the proposed alternative for the remaining third ISI interval (ending April 2, 2008).

All other requirements of the ASME Code, Section XI for which relief has not been specifically requested remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

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Date: September 17, 2007