April 30, 2007

Mr. James H. Lash
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. 2 - RELIEF REQUEST NO. BV2-PZR-01 REGARDING WELD OVERLAY REPAIRS ON PRESSURIZER NOZZLE WELDS (TAC NO. MD1206)

Dear Mr. Lash:

By letter dated March 31, 2006, as supplemented by letters dated August 8, 2006, September 27, 2006, October 5, 2006, and February 14, 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.

On October 5, 2006, the Nuclear Regulatory Commission (NRC) staff granted, pursuant to Section 50.55a(a)(3)(i) of Part 50 to Title 10 of the *Code of Federal Regulations* (10 CFR 50.55a(a)(3)(i)), the temporary verbal authorization for the alternative ISI as described in Relief Request BV2-PZR-01. The NRC staff's final written authorization, including the results of the review, is now provided in the enclosed safety evaluation.

The 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. BV2-PZR-01, 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 service life of the subject welds.

The NRC staff has concluded that the alternatives to ASME 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 alternatives for the fall 2006 refueling outage.

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. 50-412

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.

Sincerely,

/RA/

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

Docket No. 50-412

Enclosure:
As stated

cc w/encl: See next page

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ACCESSION NUMBER: ML070590555 *Input received. No substantive changes made.

OFFICE	LPLI-1/PM	LPLI-1/LA	DCI/CFEB/BC	OGC	LPLI-1/BC
NAME	NMorgan	SLittle	TChan *	DRoth	MKowal
DATE	4/17/07	4/02/07	03/21/2007	3/24/07	4/30/07

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Beaver Valley Power Station, Unit Nos. 1 and 2

cc:

Gary R. Leidich
President and Chief Nuclear Officer
FirstEnergy Nuclear Operating Company
Mail Stop A-GO-19
76 South Main Street
Akron, OH 44308

Joseph J. Hagan
Senior Vice President of Operations
and Chief Operating Officer
FirstEnergy Nuclear Operating Company
Mail Stop A-GO-14
76 South Main Street
Akron, OH 44308

Danny L. Pace
Senior Vice President, Fleet Engineering
FirstEnergy Nuclear Operating Company
Mail Stop A-GO-14
76 South Main Street
Akron, OH 44308

Jeannie M. Rinckel
Vice President, Fleet Oversight
FirstEnergy Nuclear Operating Company
Mail Stop A-GO-14
76 South Main Street
Akron, OH 44308

David W. Jenkins, Attorney
FirstEnergy Corporation
Mail Stop A-GO-18
76 South Main Street
Akron, OH 44308

Manager, Fleet Licensing
FirstEnergy Nuclear Operating Company
Mail Stop A-GHE-115
395 Ghent Road
Akron, OH 44333

Ohio EPA-DERR
ATTN: Zack A. Clayton
P.O. Box 1049
Columbus, OH 43266-0149

James H. Lash
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

Director, Fleet Regulatory Affairs
FirstEnergy Nuclear Operating Company
Mail Stop A-GHE-315
395 Ghent Road
Akron, Ohio 44333

Manager, Site Regulatory Compliance
FirstEnergy Nuclear Operating Company
Beaver Valley Power Station
Mail Stop A-BV-A
P.O. Box 4, Route 168
Shippingport, PA 15077

Richard Anderson
Vice President, Nuclear Support
FirstEnergy Nuclear Operating Company
Mail Stop A-GO-14
Akron, Ohio 44308

Commissioner James R. Lewis
West Virginia Division of Labor
749-B, Building No. 6
Capitol Complex
Charleston, WV 25305

Director, Utilities Department
Public Utilities Commission
180 East Broad Street
Columbus, OH 43266-0573

Director, Pennsylvania Emergency
Management Agency
2605 Interstate Dr.
Harrisburg, PA 17110-9364

Beaver Valley Power Station, Unit Nos. 1 and 2 (continued)

cc:

Dr. Judith Johnsrud
Environmental Coalition on Nuclear Power
Sierra Club
433 Orlando Avenue
State College, PA 16803

Director
Bureau of Radiation Protection
Pennsylvania Department of
Environmental Protection
Rachel Carson State Office Building
P.O. Box 8469
Harrisburg, PA 17105-8469

Mayor of the Borough of Shippingport
P.O. Box 3
Shippingport, PA 15077

Regional Administrator, Region I
U.S. Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, PA 19406

Resident Inspector
U.S. Nuclear Regulatory Commission
P.O. Box 298
Shippingport, PA 15077

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REGARDING THE INSERVICE INSPECTION INTERVAL

FOR RELIEF REQUEST NO. BV2-PZR-01

FIRSTENERGY NUCLEAR OPERATING COMPANY

FIRSTENERGY NUCLEAR GENERATION CORP.

OHIO EDISON COMPANY

THE TOLEDO EDISON COMPANY

BEAVER VALLEY POWER STATION, UNIT NO. 2

DOCKET NO. 50-412

1.0 INTRODUCTION

By letter dated March 31, 2006, Agencywide Document Access and Management System (ADAMS) accession number ML060960393, as supplemented by letters dated August 8, 2006 (ADAMS accession number ML062220269), September 27, 2006 (ADAMS accession number ML062720121), October 5, 2006 (ADAMS accession number ML062830045), and February 14, 2007 (ADAMS accession number ML070460599), FirstEnergy Nuclear Operating Company (the licensee), proposed an alternative for Beaver Valley Power Station, Unit No. 2 (BVPS2), 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, relief and surge nozzle safe end to nozzle dissimilar metal welds and weld overlays for the elbow to safe end welds. The subject welds were fabricated using NiCrFe Alloy 82/182 weld material to butter the nozzle weld geometry ends and to weld the safe ends. This weld material has demonstrated a propensity for primary water stress-corrosion cracking (PWSCC) in the fleet. The licensee intends to mitigate the effects of cracking on specific BVPS2 welds by applying full structural PWOLs prior to the onset of PWSCC. This safety evaluation (SE) will be referring to the full structural configuration only for PWOLs.

Enclosure

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 BVPS2 is the 1989 Edition of the ASME Code with no Addenda for its second 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 Requirements for Code Case N-504-2:

Under the rules of IWA-4120, 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.

- N-638-1 and N-504-2, with conditions as specified in Regulatory Guide (RG) 1.147, Revision 14, and

- ASME Section XI, 1995 Edition including Addenda through 1996, Appendix VIII, Supplement 11, which is required to be implemented per 10 CFR 50.55a(g)(6)(ii)(c).

3.2 Licensee's Proposed Alternative to ASME Code Case N-504-2:

The licensee proposes using N-504-2 for full structural PWOLs for the subject components with the following modifications:

- Use of a nickel-based alloy weld material, Alloy 52/52M/152 rather than the low carbon (0.035% maximum) austenitic stainless steel.

- Relaxation from the requirement to perform delta ferrite measurements to meet the 7.5 Ferrite Number requirement of N-504-2. The Ferrite Number requirement cannot be met because the Alloy 52/52M/152 weld material is 100% austenitic and contains no delta ferrite.

- Performance of a system pressure test and an ultrasonic examination of the weld overlay using ASME Code Case N-416-1, "Alternative Pressure Test Requirement for Welded Repairs or Installation of Replacement Items by Welding, Class 1, 2, and 3 (N-416-1), versus the hydrostatic test requirement under N-504-2.

3.2.1 Licensee's Basis for Proposed Alternative to ASME Code Case N-504-2:

The weld overlay has been designed consistent with the requirements of N-504-2 with the specific thickness and length computed according to the guidance provided in the subject ASME Code Case. The chromium content of Alloys 52 and 52M is 28-31.5%. Alloy 52M contains higher Niobium content (0.5 - 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 also stated that these filler materials are selected for their improved resistance to PWSCC. Alloy 52, 52M and 152 all contain about 30% chromium (roughly twice that of Alloy 82/182), imparting excellent 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 pressurized-water reactor 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.

Paragraph (e) of N-504-2 requires as-deposited delta ferrite measurements of at least 7.5 Ferrite Number for the weld reinforcement. Delta ferrite measurements will not be performed for this overlay because the deposited Alloy 52/52M is 100% austenitic and contains no delta ferrite due to the high nickel composition (approximately 60% nickel). The filler material selected for these repairs is fully austenitic, and is therefore, exempt from delta ferrite content requirements.

Paragraph (h) of N-504-2 requires a system hydrostatic test of the completed repair if the flaw(s) penetrated the original pressure boundary or if there is any observed indication of the

flaw penetrating the pressure boundary during repair. In lieu of hydrostatic testing, a system pressure test and an ultrasonic examination of the weld overlay shall be performed in accordance with the second interval ISI Program and N-416-2. This modification is sufficient to demonstrate that the overlay is of adequate quality to ensure the pressure boundary integrity.

3.2.2 Staff Evaluation of Proposed Alternative to ASME Code Case N-504-2:

Under the rules of IWA-4120, in editions and addenda up to and including the 1989 Edition with the 1990 Addenda, repairs shall be performed in accordance with the Owner's Design Specification and the original Construction Code of the component or system. Later Editions and Addenda of the Construction Code, or of Section III, either in their entirety or portions thereof, and ASME Code Cases may be used. In addition to the above, defects shall be removed or reduced in size in accordance with IWA-4300. Alternatively, the component may be evaluated and accepted in accordance with the design rules of either the Construction Code, or Section III, when the Construction Code was not Section III. N-504-2 is being used by the licensee to perform PWOLs for pressurizer spray, safety, relief and surge nozzle safe end to nozzle dissimilar metal welds and PWOLs for the elbow to safe end welds. N-504-2 was conditionally approved by the NRC staff for use under RG 1.147, Revision 14, "Inservice Inspection ASME Code Case Acceptability, ASME Section XI, Division 1." 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 all conditions and provisions of the ASME Code Case are complied with.

The first proposed modification to the N-504-2 provisions involves 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% maximum) austenitic stainless steel. In lieu of the stainless steel weld material, Alloy 52/52M/152, a consumable welding wire highly resistant to PWSCC, was proposed for the overlay weld material. The NRC staff notes that the use of 52/52M/152 material is consistent with weld filler material used to perform similar weld overlays at operating boiling-water reactor (BWR) facilities. The Electric Power Research Institute (EPRI) has performed studies in qualifying weld overlays (full structural, design, and barrier 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 provide an acceptable level of quality and safety, and therefore, is 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 Ferrite Number for the weld reinforcement. The licensee proposed that delta ferrite measurements will not be performed for this overlay because the deposited Alloy 52/52M/152 material is 100% austenitic. 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 designed for weld overlay repair of austenitic stainless steel piping. Therefore, the material requirements regarding the carbon content limitation (0.035% maximum) and the delta ferrite content of at least 7.5 FN, as delineated in N-504-2, paragraphs

(b) and (e), apply only to austenitic stainless steel weld overlay materials to ensure its resistance to IGSCC. These requirements are not applicable to Alloy 52/52M/152, a nickel-based material which the licensee will use for the weld overlays.

The NRC staff notes that the licensee is performing full structural PWOLs on dissimilar metal welds made of Alloy 182 material. For material compatibility in welding, the NRC staff considers that Alloy 52/52M/152 is a better choice of filler material than austenitic stainless steel material for this weld joint configuration. Alloy 52/52M/152 contains about 30% 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/152 for the weld overlays as a modification to the requirements of N-504-2, paragraphs (b) and (e) will provide an acceptable level of quality and safety, and therefore, is acceptable.

The licensee's modification proposed to Paragraph (h) of N-504-2 is to perform a system pressure test and an ultrasonic examination of the weld overlay in accordance with the licensee's second interval ISI Program and N-416-2. N-416-3 was found to be acceptable in RG 1.147, Revision 14. In supplemental letter dated August 8, 2006, the licensee indicated that N-416-2 is the version currently listed in its third ISI Program. 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, only the scope of applicability was changed in N-416-3.

N-416-2 requires that nondestructive examination 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 do not allow the presence of cracks, regardless of length, and is geared more towards construction type welds. The licensee's use of the post-repair nondestructive examination requirements of N-504-2 utilizing the appropriate Performance Demonstration Initiative (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. Based on the discussion above, the NRC staff concludes that the modifications to N-504-2 will provide an acceptable level of quality and safety, and therefore, are acceptable.

3.3 Licensee's Proposed Alternative to ASME Code Case N-638-1:

The licensee proposes using N-638-1 for full structural PWOLs for the subject components with the following modifications:

- The maximum area of an individual weld, based on the finished surface over the ferritic material, may exceed 100 square inch, which is a modification to Paragraph 1.0(a).

- In supplemental letter dated August 8, 2006, the licensee modified the subject relief request to include for the application of the PWOLs, full UT of the 1.5T band will not be performed which is a modification to Paragraph 4.0(b).

3.3.1 Licensee's Basis for Proposed Alternative to ASME Code Case N-638-1:

The weld overlay area may exceed 100 square inch in some cases. The one-half base metal thickness limitation applies only to excavations and repairs, and is not applicable to the weld overlays described in this relief request. Extensive experience exists in both boiling water reactor (BWR) and pressurized water reactor (PWR) weld overlays applied in excess of the 100 square inch limitation. Additionally, industry studies into the qualification of overlays in excess of 100 square inch have shown no issues with shrinkage stress or weld contraction stresses. Weld shrinkage caused by application of the overlays will be measured and evaluated for any system impact, as required by ASME Code Case N-504-2, Paragraph (g)(3).

In lieu of the ultrasonic examination requirement of 1.5T, a surface examination of a band at least 0.50 inches outward from the toe of the weld overlay around the entire circumference of the nozzle and pipe will be performed. 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 to encompass the nozzle base metal volume below the outer diameter nozzle tapered surface and a part of the nozzle outer diameter blend region. The inner diameter of the nozzle cannot be reasonably accessed, and these outer diameter surfaces must be used as the ultrasonic test probe scanning surfaces. The outer diameter surfaces do 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 basis for not examining the full UT of the 1.5T band is that the existing nozzle configuration precludes complete coverage.

N-638-1 applies to any type of welding where a temper bead technique is to be employed and is not specifically written for a weld overlay repair. However, for a weld overlay any major base material cracking would take place in the Heat Affected Zone (HAZ) 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, if this cracking were to occur it would be identified by the ultrasonic examination of the weld overlay. This band is not in close proximity to the dissimilar metal (DM) weld and if flaws in the DM weld were to propagate, they would arrest at the interface with the ferritic base material or the Alloy 52/52M/152 weld metal and be contained in the volume of material that is subject to preservice examinations.

3.3.2 Staff Evaluation of Proposed Alternative to ASME Code Case N-638-1:

In the letter dated August 8, 2006, the licensee provided the following information with respect to the amount of overlay deposited on the ferritic portion of the dissimilar metal welds:

Safety A - 56 in^2
Safety B - 55 in^2
Safety C - 58 in^2
Relief - 57 in^2
Spray - 34 in^2
Surge - 128 in^2

As such, only one of the six weld overlays within the scope of this request (the surge nozzle) will exceed the 100 square inch overlay area limitation on the ferritic base material. Review of the surge nozzle weld overlay design drawings indicates that a best estimate weld overlay surface area of 128 square inches will be applied to the nozzle material.

The licensee is applying a 360-degree, full structural PWOL to reduce the susceptibility of the original weld to the initiation and growth of PWSCC and ultimately to maintain weld integrity. The full structural PWOL will fulfill all structural requirements, independent of the existing weld. Operational experience has also shown that PWSCC in Alloy 82/182 will blunt at the interface with stainless steel base metal, carbon steel base metal, or Alloy 52/152 weld metal, if cracking were to occur.

To eliminate the need for preheat and post-weld heat treatment under the Construction Code, the industry developed a temper bead welding technique which was published as N-638-1. The NRC recently conditionally accepted N-638-1 in RG 1.147, Revision 14. The temper bead technique carefully controls heat input and bead placement which allows subsequent welding passes to stress-relieve and temper the heat affected zones of the base material and preceding weld passes. The welding is performed with low hydrogen electrodes under a blanket of inert gas. The inert gas shields the molten metal from moisture and hydrogen. Therefore, the need for the preheat and post-weld heat treatment specified by the ASME Construction Code is not necessary to produce a sound weld using the temper bead process in N-638-1.

The licensee intends to follow the methodology of N-638-1, except paragraph 1.0(a) which requires the maximum area of an individual weld, based on the finished surface, be limited to 100 square inches, and the depth of the weld to exceed one-half of the ferritic base metal thickness. This condition is not being met because the design for the weld overlay covers an area slightly over 100 square inch, which exceeds the limitations of N-638-1. The licensee will perform an evaluation, as noted in Section 3.2.2 of this SE, to determine the effect of exceeding the 100-square inch area limitation for temper bead welding onto a low alloy steel nozzle. This evaluation will be conducted under the guidance of N-504-2.

The NRC staff notes that several similar weld overlays have been applied to BWR facilities (such as Nine Mile Point 2, Perry, and Duane Arnold) with similar geometry and overlay dimensions. EPRI has performed studies to qualify weld overlays for application in BWRs, and in these applications, the studies have not identified any issues with shrinkage stresses or weld contraction stresses. The BVPS2 weld overlay design is generally similar to the design applied in BWR feedwater, core spray, and recirculation nozzles. No clear basis has been documented by the ASME Code Working Group on Welding and Special Repair Processes (the group responsible for N-638-1) for the 100-square inch area limitation. Published literature shows that compressive stress remains on the inside surface near the weld, which supports mitigation of some degradation mechanisms, such as PWSCC. Thus, the residual stresses remain in compression on the inside surface of the weld as the nozzle overlay area increases. This supports mitigation of the degradation mechanism. Thus, increasing the overlay area is acceptable for this specific application, i.e., to support the mitigation of the PWSCC degradation mechanism and for enhancement of nondestructive examination of the geometries involved.

N-504-2, paragraphs (g)(2) and (g)(3) require consideration of the residual stresses produced by the weld overlay with other applied loads on the system. The evaluation of other welds and components in the system is to consider potential increases in loading, including shrinkage

effects, due to all weld overlays in the reactor coolant system. These welds and components are to meet the applicable stress limits of the Construction Code. The NRC staff considers this evaluation important in assuring that the reactor coolant system will not be adversely effected after PWOLs are deposited. In the letter dated August 8, 2006, the licensee stated that a flaw evaluation and shrinkage stress effects analyses will be performed prior to startup. The weld shrinkage effects on the attached piping and support systems will be assessed prior to the weld overlay based on estimated weld shrinkage. Confirmatory analyses based on actual weld shrinkage measurements after the weld overlay will be completed prior to plant startup. Based on the preceding discussions and the licensee's intention to complete the analyses required under N-504-2 g(2) and (3) prior to startup, the staff concludes that the modification to increase the PWOL beyond the 100 square inch maximum, will provide an acceptable level of quality and safety, and therefore, is acceptable.

The second modification requested by the licensee is that full ultrasonic testing (UT) of the 1.5T band will not be performed, which is required under Paragraph 4.0(b) of N-638-1. In the supplemental letter dated August 8, 2006, the licensee proposed an alternative to ASME Code Case N-638-1 and stated that ultrasonic examination will be performed. These examinations include ultrasonic examination of a minimum of the outer 25% and 0.5 inch axially of the nozzle base material beyond the DM weld. The issue of cracking and/or distortion of the weld and base metal were not specifically addressed in the ASME Code case development work. Since the weld overlays are fabricated from austenitic materials with inherent toughness, no cracking in the overlays is expected to occur due to the shrinkage associated with the weld overlay.

With respect to the ferritic portion of the overlays, many temper bead weld overlays have been applied in the nuclear industry to these nozzle to safe end locations. In no instance has there been any reported cracking due to the weld overlay application. The stiffness and high toughness inherent in the low alloy steel material is expected to protect against any cracking and limit any distortion that might occur in the low alloy steel material. In its supplemental letter dated August 8, 2006, the licensee stated that it will be measuring and evaluating axial shrinkage for impact on the materials and on the piping system after the weld overlay is deposited which is in accordance with the requirements of N-504-2. Also, any cracking which might occur should be detected by the final nondestructive examination (NDE) of the weld overlay which provides additional assurance of a defect free, structurally sound overlay. The assessment of the shrinkage stresses on the piping plus post weld NDE provides reasonable assurance that defect free welds will result in maintaining the structural integrity of the piping, and therefore, is acceptable to the NRC staff.

BVPS2 has requested relief from several requirements associated with weld overlay NDE requirements established in ASME Code Case N-638-1 and the conditions applied in RG 1.147 for Code Case N-638-1 and N-504-2. The requirements from which relief is requested are: (1) UT of the completed structural weld overlay (WOL) will be accomplished in accordance with ASME Code, Section XI, Appendix VIII, Supplement 11 modified to comply with the PDI, (2) the acceptance criteria stated in the applicable code cases in relation to the respective positions contained in RG 1.147, Rev. 14 will not be utilized. Use of 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 will be used, (3) an ultrasonic examination and surface examination of the band around the final weld surface that is at least 1.5 times the component thickness or 5 inches in width, as specified in Code Case N-638-1, will not be performed. As an alternative, the UT coverage area will be defined using Code Case N-504-2 and Appendix Q, Q-4100, and

a surface examination of a band at least 0.5 inch outward from the toe of the weld overlay around the entire circumference of the nozzle and pipe will be performed, and (4) the acceptance criteria of N-504-2, Paragraph (i) will be used for the weld overlay surface examination and the band 0.5 inch outward from the toe of the weld overlay around the entire circumference of the nozzle and pipe. Each of these requested deviations is evaluated below:

The use of ASME Code, Section XI, Appendix VIII, Supplement 11 modified to comply with the PDI is acceptable, in that the PDI methodology uses construction type flaws in the standards used to qualify equipment, procedures, and personnel. Therefore, the condition established in RG 1.147 for the use of Code Case N-638-1 is met.

ASME Code, Section III flaw acceptance standards are derived from the capability of radiography to detect and size flaws originating from the fabrication process used during new facility construction. The ASME Code, Section III acceptance criteria does not allow for the presence of any cracks or crack-like indications, regardless of their size, and are geared more towards volumetric flaws. The detection capability of radiography is a function of density differences such as 2% or greater changes in density. The density changes normally associated with cracks, depending on orientation, are much less than the detection capability of radiography. There is an inherent, unknown tolerance in the Section III acceptance criteria for radiography which encompasses tight cracks and densities below the detection capabilities of radiography. Flaws detected using radiography are not precise enough for applying Section XI crack growth analyses, as flaw depth cannot be measured with radiography. Section III radiography is not applicable for evaluating flaws for continued plant operations because of the difficulty associated with depth sizing flaws.

Using Code Case N-638-1, the temper bead weld is for filling a cavity in base metal which is inspectible in four directions. The licensee's application, however, is for structural weld overlay above the base metal, which results in a contour that is UT inspectible except for the edge taper where the overlay transitions to the nozzle surface and on the curvature of the nozzle. The proposed weld edge configuration has the same UT examination difficulties as are considered under ASME Code, Section XI, Appendix Q. Appendix Q only requires a surface examination of the tapered area of the weld overlay. In addition to verifying the soundness of the weld, a purpose of the ultrasonic examination is to assure that delayed cracking that may be caused by hydrogen introduced during the temper bead welding process or cracking in unannealed ferritic material are not present. In the unlikely event cracking does occur, it would be initiated on the surface on which the welding is actually performed or in the heat affected zone immediately adjacent to the weld. The most appropriate technique to detect surface cracking is the surface examination technique. Therefore, use of a surface examination in the area of the weld overlay taper and band beyond the toe of the overlay on the ferritic material is acceptable in that it provides an adequate level of safety and quality.

Using Code Case N-638-1, the temper bead weld is for filling a cavity in the base metal. The licensee's application, however, is for structural weld overlay above the base metal. Application of the weld overlay is through Gas Tungsten Arc Welding (GTAW). This results in a very small heat-affected-zone (HAZ), much less than may be created with a deep excavation using Code Case N-638-1. ASME Code, Section XI, Appendix Q requires a surface examination of the entire weld overlay surface to 0.5 inch beyond the overlay. Therefore, in the application of weld overlays, it is acceptable to reduce the area to be surface examined from 1.5 times the thickness of the component (or 5 inches, whichever is less) to a band 0.5 inch from the toe of the weld in that it provides an adequate level of safety and quality.

The licensee specifies, in Table 3 of the March 31, 2006, submittal, Code Case N-404-2, Paragraph (i) as the acceptance standard for examination of the completed weld overlay and 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. Paragraph (i) of Code Case N-504-2 states that a liquid penetrant examination shall be performed and the acceptance standards of Table IWB-3514-2 shall apply. RG 1.147 conditions Code Case N-504-2, stating the provisions of Section XI, Nonmandatory Appendix Q must also be met. Appendix Q, Q-4100(b) states the weld overlay shall satisfy the surface examination acceptance criteria for welds of the Construction Code or NB-5300, and the adjacent base metal shall satisfy the surface examination acceptance criteria for base material of NB-2500. The Construction Code, as listed in the March 31, 2006, submittal, is ASME Code, Section III. Therefore, use of Table IWB-3514-2 does not satisfy the Construction Code or NB-5300/NB-2500. This alternative does not provide an equivalent level of quality and safety and therefore, was not acceptable.

During a January 26, 2007, telecon, clarification was provided by the licensee on the use of the Construction Code surface examination acceptance criteria. The NRC staff indicated that there was a disparity between Table 3 and the written part of its March 31, 2006, submittal. The licensee indicated that the Construction Code acceptance criteria had in fact been used during the performance of the surface examinations and that there were no indications found by the surface examination. The licensee indicated that a correction to the submittal would be issued. The licensee corrected the disparity by supplemental letter dated February 14, 2007, which indicated that Construction Code acceptance criteria was used for the dye penetrant examinations. Based on the discussion above, the NRC staff concludes that the modifications to N-638-1 will provide an acceptable level of quality and safety, and therefore, is acceptable.

3.4 ASME Code Requirements for Proposed Alternatives to Supplement 11 of Appendix VIII to Section XI:

Pursuant to 10 CFR 50.55a(a)(3)(i), the licensee requested relief from the weld overlay requirements in the following paragraphs to Section XI, Appendix VIII, Supplement 11 (only those items considered by the NRC staff to be modifications to Appendix VIII Supplement 11 are listed in this safety evaluation):

Paragraph 1.1(b) limits the maximum thickness for which a procedure may be qualified. Also, the specimen set must include at least one specimen with overlay thickness within minus 0.10-inch to plus 0.25-inch of the maximum nominal overlay thickness for which the procedure is applicable.

Paragraph 1.1(d)(1) requires that all base metal flaws be cracks in or near the butt weld heat-affected zone, open to the inside surface, and extending at least 75 percent through the base metal wall.

Paragraph 1.1(e)(1) requires that at least 20% but not less than 40% of the flaws shall be oriented within ±20 degrees of the axial direction.

Paragraph 1.1(e)(1) also requires that the rules of IWA-3300 shall be used to determine whether closely spaced flaws should be treated as single or multiple flaws. Specimens shall be divided into base and overlay grading units with each specimen containing one or both types of grading units.

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 outer 25% of the overlaid weld and base metal on both sides.

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.

Paragraph 1.1(e)(2)(b)(1) requires that an overlay grading unit shall include the overlay material and the base metal-to-overlay interface of at least 6 square inches . The overlay grading unit shall be rectangular, with minimum dimensions of 2 inches.

Paragraph 3.1 requires examination procedures, equipment and personnel are qualified for detection when the results of the performance demonstration satisfy the acceptance criteria of Table VII-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) requires that 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.

3.4.1 Licensee's Proposed Alternatives to Supplement 11 of Appendix VIII to Section XI:

In lieu of the requirements of ASME Code, Section XI, 1995 edition, 1996 Addenda, Appendix VIII, Supplement 11, the PDI program as described in Table 4 of the licensee's August 8, 2006, submittal, shall be used.

3.4.2 Licensee's Basis for Proposed Alternatives to Supplement 11 of Appendix VIII to Section XI:

The ultrasonic examination of the completed preemptive weld overlays will be accomplished in accordance with ASME Code, Section XI, 1995 Edition with the 1996 Addenda, Appendix VIII, Supplement 11 with the modifications described in Table 4 of the submittal. These modifications were developed by the EPRI PDI program to implement the requirements of Appendix VIII. These EPRI Supplement 11 modifications have previously been approved for use by the NRC staff, as alternatives.

3.4.3 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). This NRC letter to EPRI defined a coordination plan for training and qualification activities of NDE personnel employed in performance of ultrasonic examination of piping weldments during ISI of BWR power plants. Instead of having two programs with similar

objectives, 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). As stated in the January 15, 2002, letter issued by the NRC, the purpose of the letter was to inform the PDI program that the PDI's performance demonstration program for weld overlays was an acceptable alternative to the performance demonstration recommendations of NRC Generic Letter (GL) 88-01, "NRC Position on IGSCC [Intragranular Stress-Corrosion Cracking] in BWR Austenitic Stainless Steel Piping," dated January 25, 1988.

Although the PDI program was developed during ISIs at BWR plants, it is applicable to weld overlay qualification for PWR plants, like BVPS2, because the weld overlays for BWRs are the same as weld overlays for PWRs.

Paragraph 1.1(b) of Supplement 11 states limitations to the maximum thickness for which a procedure may be qualified. The ASME Code states that: "The specimen set must include at least one specimen with overlay thickness within minus 0.10-inch to plus 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 that "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. PDI determined that certain 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 ultrasonic examination more difficult and not representative of actual field conditions. In an effort to satisfy the requirements, PDI developed a process for fabricating flaws that exhibit crack-like reflective characteristics. Instead of all flaws being treated as 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 inch. 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. The licensee stated, "Flaws shall be limited to the cases where implantation of cracks produces spurious reflectors that are uncharacteristic of actual flaws." The NRC 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 acceptable.

Paragraph 1.1(e)(1) requires that at least 20% but not less than 40% 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, PDI excludes

axial fabrication flaws in the weld overlay material. 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 finds this approach to implantation of fabrication flaws to be reasonable. Therefore, PDI's application of flaws oriented in the axial direction is acceptable.

Paragraph 1.1(e)(1) also requires that the rules of IWA-3300 shall be used to determine whether closely spaced flaws should be treated as single or multiple flaws. PDI treats each flaw as an individual flaw and not as part of a system of closely spaced flaws. 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. Hence, 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% 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 re-direction caused by the weld microstructure. 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, 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 is to minimize 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 ASME Code. Hence, 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. Hence, PDI's application of the grading unit is acceptable.

Paragraph 2.3 states that, for depth sizing tests, 80% 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. 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 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 will similarly be determined. In addition, 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 Supplement 11. As such, this method is acceptable to the NRC staff.

Paragraphs 3.1 and 3.2 of Supplement 11 state that procedures, equipment and personnel, as a complete ultrasonic 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 that, if ultrasonic detection or sizing procedures are thoroughly tested, personnel and equipment using those procedures have a higher probability of successfully passing a qualification test. In an effort to increase this passing rate, 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 Supplement 11 for the entire ultrasonic system. The personnel and equipment are still required to meet Supplement 11, therefore, the PDI program exceeds ASME Code requirements for personnel, procedures, and equipment qualification.

Paragraph 3.2(b) requires that all extensions of base metal cracking into the overlay material by at least 0.10 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 0.10 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 0.10 inch value of Paragraph 3.2(b), any crack extending beyond 0.10 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, PDI's omission of highlighting a crack extending beyond 0.10 inch into the overlay material is acceptable.

4.0 CONCLUSION

Based on the discussion above, the NRC staff concludes that the ASME Code Cases N-504-2 and N-638-1 alternatives 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 service life of the subject welds.

Based on the discussion above, the NRC staff concludes that the alternatives to ASME 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 fall 2006 refueling outage.

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.

Principal Contributor: T. Steingass

Date: April 30, 2007