December 20, 2007

Mr. Mark B. Bezilla
Site Vice President
FirstEnergy Nuclear Operating Company
Davis-Besse Nuclear Power Station
Mail Stop A-DB-3080
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Oak Harbor, OH 43449-9760

SUBJECT: DAVIS-BESSE NUCLEAR POWER STATION, UNIT NO. 1 - RELIEF REQUEST FOR ALTERNATIVE NO. A30, REVISION 2, FOR APPLICATION OF STRUCTURAL WELD OVERLAY ON DISSIMILAR METAL WELDS OF PRESSURIZER NOZZLES AND HOT LEG BRANCH CONNECTIONS (TAC NO. MD4452)

Dear Mr. Bezilla:

By letter dated February 15, 2007, as supplemented by letters dated June 28, September 28, and November 19, 2007, FirstEnergy Nuclear Operating Company (the licensee) submitted Relief Request (RR) No. A30, Revision 2, which requested relief to allow the installation of structural weld overlays on the dissimilar metal welds of pressurizer nozzles and hot leg branch connections at the Davis-Besse Nuclear Power Station, Unit No. 1 (DBNPS). The proposed RR is an alternative to the requirements of American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section XI.

The Nuclear Regulatory Commission (NRC) staff has reviewed the licensee's submittal and determined that RR-A30, will provide an acceptable level of quality and safety. Therefore, pursuant to paragraph 50.55a(a)(3)(i) of Title 10 of the *Code of Federal Regulations*, the NRC staff authorizes the use of RR-A30, Revision 2, for the installation of structural weld overlays on the dissimilar metal welds of the pressurizer nozzles and hot leg branch connections at DBNPS. The effective period of the proposed alternative is for the life of the component. Once a structural overlay is installed it will remain in place for the life of the repair.

The NRC staff's safety evaluation is enclosed. This completes the NRC staff's review under TAC No. MD4452. If you have any questions concerning this matter, please call Thomas Wengert of my staff at 301-415-4037.

Sincerely,

/RA/

Russell Gibbs, Chief
Plant Licensing Branch III-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-346

Enclosure: Safety Evaluation

cc w/encl: See next page

The NRC staff's safety evaluation is enclosed. This completes the NRC staff's review under TAC No. MD4452. If you have any questions concerning this matter, please call Thomas Wengert of my staff at 301-415-4037.

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO RELIEF REQUEST NO. A30, REVISION 2 STRUCTURAL WELD

OVERLAY OF PRESSURIZER NOZZLES AND HOT LEG BRANCH CONNECTIONS

FIRSTENERGY NUCLEAR GENERATION CORP.

FIRSTENERGY NUCLEAR OPERATING COMPANY

DAVIS BESSE NUCLEAR POWER STATION, UNIT NO. 1

DOCKET NO. 50-346

1.0 INTRODUCTION

By letter dated February 15, 2007 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML071020195), as supplemented by letters dated June 28 (ADAMS Accession No. ML071840039), September 28 (ADAMS Accession No. ML072750034), and November 19, 2007 (ADAMS Accession No. ML073300013), the FirstEnergy Nuclear Operating Company (the licensee) requested the U.S. Nuclear Regulatory Commission (NRC) staff's review and approval of Relief Request (RR) No. A30, Revision 2, to allow the installation of structural weld overlays on the dissimilar metal welds of pressurizer nozzles and hot leg branch connections, at Davis-Besse Nuclear Power Station, Unit No. 1 (DBNPS). The proposed RR is an alternative to the requirements of American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI.

A dissimilar metal weld is defined as a weld that joins two pieces of metals that are not of the same material. In the proposed alternative, the dissimilar metal weld joins the ferritic pressurizer nozzle to the austenitic stainless steel safe end. The dissimilar metal weld itself is made of nickel-based Alloy 82/182 material. A similar metal weld joins two pieces of metals that are of the same material. In this alternative, the similar metal weld joins the stainless steel safe end to the stainless steel piping. The similar metal weld itself is made of stainless steel weld material.

The industry has experienced degradation of the Alloy 82/182 weld material, which is susceptible to primary water stress-corrosion cracking (PWSCC) in the pressurized water reactor environment. For the proposed alternative, the weld overlay is a process by which a PWSCC-resistant weld metal is deposited on the outside surface of the Alloy 82/182 welds to form a new pressure boundary.

2.0 REGULATORY EVALUATION

Pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) must meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in the

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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), 12 months prior to the start of the 120-month interval, subject to the limitations and modifications listed therein.

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

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

3.0 PROPOSED RR-A30, REVISION 2

3.1 Components Affected

The following welds are affected by the RR:

1. Weld RC-PZR-WP-91-W/X-3" [inches] W/X Axis, Pressurizer Relief Nozzle to Safe End Weld (MK 124 to MK 125).

2. Weld RC-PZR-WP-91-Y/Z-3" [inches] Y/Z Axis, Pressurizer Relief Nozzle to Safe End Weld (MK 124 to MK 125).

3. Weld RC-PZR-WP-91-Z/W-2½" [inches] X/W Axis, Pressurizer Relief Nozzle to Safe End Weld (MK 31 to MK 32).

4. Weld RC-30-CCA-8-1-FW10-2½" [inches], Pressurizer Relief Nozzle Safe End to Pipe Weld. This weld is a similar metal weld which will be affected by the overlay applied to weld RC-PZR-WP-91-Z/W.

5. Weld RC-PZR-WP-102-4" [inches], Pressurizer Spray Nozzle to Safe End Weld (MK 9 to MK 45).

6. Weld RC-MK-A-90-FW56-4" [inches], Pipe to Pressurizer Spray Nozzle Safe End Weld (MK 90 to MK 45).

7. Weld RC-PZR-WP-23-10" [inches], Pressurizer Surge Nozzle to Safe End Weld (MK 8 to MK 37).

8. Weld RC-MK-A-82-FW54-10" [inches], Hot Leg Branch Connection to Surge Piping Weld (MK 25 to MK 140).

9. Weld DH-33A-CCA-4-1-FW1-12" [inches], Hot Leg Branch Connection to Decay Heat Piping Elbow Weld.

3.2 Applicable Code Edition and Addenda

The applicable code is the 1995 edition through the 1996 Addenda of the ASME Code, Section XI.

3.3 Applicable Code Requirements

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

IWA-4410(b) of ASME Code, Section XI states: “Later Editions and Addenda of the Construction Code, or a later different Construction Code, either in its entirety or portions thereof, and Code Cases may be used, provided the substitution is as listed in IWA-4221(b). Filler material requirements shall be reconciled as required, in accordance with IWA-4224.”

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

Section XI, Appendix VIII, Supplement 11 provides qualification requirements for the ultrasonic examination of full structural overlaid wrought austenitic piping welds.

3.4 Proposed Alternative and Basis

Pursuant to 10 CFR 50.55a(a)(3)(i), the licensee proposes, as an alternative to the ASME Code requirements stated above, the use of the proposed overlay alternative described in Tables 2 and 3 of RR-A30, Revision 2, for the full structural weld overlays for the dissimilar metal welds listed above.

The licensee will apply a full-structural Alloy 52/52M overlay to each of the dissimilar metal Alloy 82/182 safe-end welds identified above. In lieu of using the existing IWA-4000 repair procedures in the 1995 Edition through the 1996 Addenda of the ASME Code, Section XI, the licensee proposes to use the alternative requirements contained in Tables 2 and 3 of RR-A30, Revision 2 for the design, fabrication, pressure testing, and examination of the weld overlay repairs. The weld overlay will provide an acceptable methodology for preventing future PWSCC and for reducing any defects that may be contained in these welds to an acceptable size by increasing the wall thickness through the deposition of the weld overlays. The use of weld overlay filler materials that are resistant to PWSCC (Alloy 52/52M), weld overlay procedures that create compressive residual stress profiles in the original weld, and post overlay preservice and inservice inspections provides assurance that the structural integrity of these welds will be maintained for the life of the plant. The applicable stress limits from ASME Section III are applicable to the weld overlays. Crack growth evaluations for PWSCC and fatigue of any as-found (or conservatively postulated) flaws demonstrate that structural integrity of the welds will be maintained.

Experience at one plant has shown that Alloy 52M can be susceptible to hot cracking when excessive concentrations of surface impurities, such as sulfides, silicates or phosphates, exist in the underlying stainless steel piping or safe-end. If high levels of impurities are discovered in the nozzle welds to be overlaid, the licensee intends to apply a 308L stainless steel buffer layer over the stainless steel piping or safe-end. The buffer layer would be installed using a machine Gas Tungsten Arc Welding process and installed up to, but not touching, the dissimilar metal butt weld joining the safe-end to the low alloy steel nozzle. Stainless steel weld deposits have been shown to be substantially more resistant to hot cracking resulting from impurity effects than austenitic nickel-based filler materials, such as Alloy 52M.

After dye penetrant surface examination of the buffer layer, the first Alloy 52M weld overlay layer would be deposited, using proven and demonstrated overlay welding parameters, over the buffer layer and continuing over the dissimilar metal weldment and the low alloy steel nozzle material. Individual qualifications would be used for the stainless steel buffer layer and the Alloy 52M weld overlay, and a mockup would be prepared to validate the entire process for the range of configurations that may be used. If the austenitic stainless steel buffer layer is installed, the buffer layer would not be included in the structural weld overlay thickness, and the effect of the buffer layer would be reconciled in the weld overlay design and residual stress analyses. The thickness of the buffer layer would be typical of that used for structural weld overlay layers (0.080 to 0.100 inches), with specific welding parameters to be defined during the aforementioned procedure qualification and mockup programs.

3.4.1 The Structural Weld Overlay Assembly

The fundamental design basis for full structural overlays is to maintain the original safety margins, with no credit taken for the underlying PWSCC susceptible weldments. The assumed design basis flaw for the purpose of structural sizing of the overlays is 360-degree in circumferential extent and 100 percent through the original wall thickness of the dissimilar metal welds. For the crack growth analyses, initial flaw sizes will be assumed based upon Performance Demonstration Initiative (PDI) qualified inspection of the overlay at the conclusion of the weld overlay process, including the outer 25 percent of the original weld or susceptible base material. Initial flaw sizes will be discussed in detail in Section 4.0 of this safety evaluation.

The licensee will perform following analyses and verifications:

1. Nozzle specific stress analyses will be performed to establish a residual stress profile in the nozzle. Inside diameter (ID) weld repairs will be assumed in these analyses to effectively bound any actual weld repairs that may have occurred in the nozzles. The analysis will then simulate application of the weld overlays to determine the final residual stress profile. Post weld overlay residual stresses at normal operating conditions will be shown to result in beneficial compressive stresses on the inside surface of the components, assuring that further crack initiation due to PWSCC is highly unlikely.

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

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

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

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

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

Summaries of the results of the analyses listed in Items 1 through 3 above will be submitted to the NRC prior to entry into Mode 4 following completion of the repairs. Items 4 though 6 are performed following the repairs and results will be included in the design modification package closure documents.

As a part of the design of the weld overlay, the weld length, surface finish, and flatness are specified to allow qualified ASME Code, Section XI, Appendix VIII ultrasonic (UT) examinations, as implemented through the PDI program, of the weld overlay and the required volume of the base material and original weld. The examinations will provide adequate assurance of structural integrity for the following reasons:

- The UT examinations are performed in accordance with ASME Section XI, Appendix VIII, Supplement 11, as implemented by the PDI program. These examinations are considered to be more sensitive for detection of defects, either from fabrication or service induced, than either ASME Code, Section III radiographic (RT) or UT methods. Further, fabrication flaws have been included in the PDI qualification sample sets for evaluating UT procedures and personnel. The PDI Program alternatives to Appendix VIII Supplement 11 and their basis are shown in Table 4 of the RR.

- ASME Code, Section XI includes specific acceptance criteria and evaluation methodology to be utilized with the results from these more sensitive examinations. The licensee considered the materials in which the flaw indications are detected, the orientation and size of the indications, and ultimately their potential structural effects on the component. The acceptance criteria include allowable flaw indication tables for planar flaws (Table IWB-3514-2) and for laminar flaws (Table WB-3514-3) of the ASME Code, Section XI.

- A laminar flaw is defined in ASME Code, Section XI as a flaw oriented within 10 degrees of a plane parallel to the surface of the component (IWA-3360). This definition is applicable to welds and weld overlays as well as base materials. The standard imposed for evaluating laminar flaws in ASME Code, Section XI is more restrictive than the ASME Code, Section III standard for evaluating laminations. The ASME Section XI laminar flaw standards, Table IWB-3514-3, are supplemented in Table 2 of the RR such that the laminar flaw shall not exceed 10 percent of the weld overlay surface area and no linear dimension of the laminar flaw shall exceed 3 inches. For weld overlay areas where examination is precluded by the presence of the flaw, it is required to postulate the area as being cracked.

- Any planar flaws found during either the weld overlay acceptance or preservice examinations are required to meet the preservice standards of Table IWB-3514-2 of the ASME Code, Section XI. In applying the planar flaw standards, the thickness of the component will be defined as the thickness of the weld overlay.

- The NRC staff-imposed conditions on Code Case N-638-1 in NRC Regulatory Guide (RG) 1.147, Revision 14, regarding ultrasonic examination and the use of acceptance criteria based on NB-5330 of the ASME Section III, will not be applied by the licensee during these repairs. ASME Code Case N-638-1 was not prepared specifically for weld overlay applications. Instead, ASME Code Case N-638-1 (and the temperbead welding techniques in IWA-4600) was written to address repair welds where a defect is excavated and the resulting cavity is filled using a temperbead technique. An excavated cavity configuration differs significantly from the weld overlay configuration. Tables 2 and 3 of the relief request provide more appropriate examinations and acceptance criteria than the ASME Code Case N-638-1 condition.

  Conversely, the imposition of ASME Code, Section III acceptance standards to weld overlays is inconsistent with years of NRC precedence. Weld overlays for repair of cracks in piping are not addressed by ASME Code, Section III. ASME Code, Section III utilizes nondestructive examination (NDE) procedures and techniques with flaw detection capabilities that are within the practical limits of workmanship standards for welds. These standards are most applicable to volumetric examinations conducted using the RT method. RT of weld overlays is not practical because of the presence of radioactive material in the reactor coolant system and water in the piping. The ASME Section III acceptance standards are written for a range of fabrication flaws, including lack of fusion, incomplete penetration, cracking, slag inclusions, porosity, and concavity.

  However, experience and fracture mechanics have demonstrated that many of the flaws that would be rejected using the ASME Code, Section III acceptance standards do not have a significant effect on the structural integrity of the component. The ASME Code, Section XI acceptance standards are appropriate for the evaluation of potential flaw indications in post-overlay examinations, avoiding unnecessary repairs to the overlays that would result in additional personnel radiation exposure without a compensating increase in safety and quality. Additionally, the unnecessary repairs could potentially degrade the effectiveness of the overlays by affecting the favorable residual stress field that is produced. The ASME Section XI acceptance standards are consistent with previous criteria approved by the NRC for weld overlay installations.

The licensee has committed to submit to the NRC the following information within 14 days of completion of the final UT of the overlaid welds: (1) a discussion of any repairs to the overlay material and/or base metal and the reason for the repair. (2) a listing of indications detected. The recording criteria of the UT procedure to be used for the examination of the weld overlays requires that all indications, regardless of amplitude, be investigated to the extent necessary to provide accurate characterization, identity, and location. Additionally, the procedure requires that all indications, regardless of amplitude, that cannot be clearly attributed to the geometry of the overlay configuration be considered flaw indications. (3) the disposition of all indications using the acceptance 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. The UT procedure requires that all suspected flaw indications are to be plotted on a cross-sectional drawing of the weld and that the plots should accurately identify the specific origin of the reflector.

3.4.2 Duration of the Proposed Request

The licensee stated that this alternative repair is requested for the life of the component. Once a structural overlay is installed it will remain in place for the life of the repair. The ASME Code Case N-740 methodology as modified in Tables 2 and 3 of RR-A-30, Revision 2, is proposed as the basis for the repairs.

4.0 NRC STAFF EVALUATION

Although RR-A30, Revision 2, is based on ASME Code Case N-740, the NRC staff has not endorsed ASME Code Case N-740 and cannot use ASME Code Code N-740 to evaluate the proposed RR. However, the NRC staff has endorsed ASME Code Case N-504-2, “Alternative Rules for Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping Section XI, Division 1.” In accordance with RG 1.147, Revision 14, the ASME Code, Section XI, Appendix Q, “Weld Overlay Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping Weldments,” shall be used when ASME Code Case N-504-2 is used. The NRC staff has also endorsed ASME Code Case N-638-1, “Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW [gas tungsten arc welding] Temper Bead Technique Section XI, Division 1.” The NRC staff used the requirements of ASME Code Cases N-504-2, N-638-1, and Appendix Q to evaluate RR-A30, Revision 2.

4.1 General Requirements

The general requirements of the weld overlay design in Section 1 of Table 2 of RR-A30, Revision 2, are consistent with the general requirements of ASME Code Case N-504-2 and Appendix Q of the ASME Code, Section XI. The requirements include certain material specification and surface condition of the applicable base metal (i.e., carbon steel, stainless steel, and Alloy 82/182) and weld overlay filler metal (i.e., Alloy 52M), and the chromium content of the weld overlay deposits. However, the NRC staff raised two issues regarding the design of the weld overlay as follows.

The weld overlay will be applied to the dissimilar metal welds joining the pressurizer nozzles to the relief valve flanges (e.g. Weld RC-PZR-FW22). The NRC staff raised the concern that the weld shrinkage from the weld overlay on the valve flange may distort the flange or exert unanalyzed forces on the flange bolting. By letter dated September 28, 2007, the licensee responded that each of the two pressurizer safety valves has a tee with rupture discs attached to the valve discharge. The tee is drained to the pressurizer quench tank via flexible tubing. There is no hard pipe connection to the valve discharge. If actuated, these valves discharge directly to the containment atmosphere. As there is no hard pipe connection to the valve discharge, distortion or movement of the flange as a result of welding will not affect the fit up of these valves or exert any abnormal stresses on the flange connections. The licensee intends to remove the two pressurizer safety valves from the nozzle flanges prior to weld overlay installation. The NRC staff finds that weld overlay will not affect the valve flanges because the valves will be removed prior to weld overlay installation.

By letter dated August 16, 2007, the NRC staff informed the licensee that the practice of applying a new weld overlay over the top of an existing weld overlay that has been in service is not acceptable because the material properties of the weld overlay may change with more than one weld overlay application. In addition, the licensee has not analyzed the stress distribution in the base metal resulting from multiple weld overlays and its impact on the structural integrity of the pipe. By letter dated September 28, 2007, the licensee stated that it will not apply a new weld overlay over an existing weld overlay. Therefore, the NRC staff finds the licensee's response acceptable.

4.2 Crack Growth Considerations and Design

Section 2 of Table 2 of RR-A30, Revision 2, provides the requirements for the overlay design and the crack growth calculation. The majority of the proposed requirements are consistent with the requirements of Code Case N-504-2 and/or Appendix Q of the ASME Code, Section XI. However, some proposed requirements deviated from N-504-2 and Appendix Q and are discussed below.

Table 2, paragraph 2(a), of RR-A30, Revision 2, states that the flaw characterization and evaluation requirements shall be based on the as-found flaw. The NRC staff has concerns about this requirement because the licensee stated that it will not perform ultrasonic testing (UT) of the subject welds prior to installing the weld overlay. The condition of the inner 75 percent of the base metal or original weld may not be known after the installation of the weld overlay because UT is not qualified to inspect the inner 75 percent of the base metal or the original weld wall thickness once the weld overlay is installed. Because of the UT limitation, the NRC staff questions the basis of the assumed flaw size that would be modeled in the crack growth calculation if a flaw existed in the original weld, which was not inspected prior to overlay installation. Also, the flaw in the base metal, if it exists, may be squeezed tightly by the compressive stresses produced by the weld overlay, such that post-installation UT will be unable to detect it. The NRC staff asked the licensee to discuss the flaw size that will be used in the flaw characterization and evaluation. By letter dated September 28, 2007, the licensee clarified that the pre-outage crack growth analyses consider a 360 degree circumferential flaw that is 75 percent through-wall, and an axial flaw that is 75 percent through-wall. If the preservice examinations detect cracking in the outer 25 percent of the original weld metal, then an additional crack growth analysis is performed that considers the same 75 percent through-wall flaw assumptions stated above plus any flaws detected in the outer 25 percent of the original weld metal.

The NRC staff finds that by adding the detected flaw size and postulated 75 percent through-wall flaw, the licensee assumes a conservative flaw size in its crack growth calculation, and therefore, is acceptable.

Paragraph 2(b)(6) of Table 2 of the original RR allows planar flaws in the weld overlay to be accepted by IWB-3640 of the ASME Code, Section XI. This is contrary to the NRC staff position that flaws detected in the weld overlay, during preservice or acceptance examination, need to satisfy the requirements of IWB-3500, not IWB-3640 because the acceptance criteria of IWB-3600 are not as conservative as the acceptance criteria of IWB-3500. By letter dated September 28, 2007, the licensee responded that it intends to repair or accept, in accordance with IWB-3500, any flaws detected in the weld overlay material and has revised Paragraph 2(b)(6) accordingly.

In Section 5 of RR-A30, Revision 2, and as discussed above, the licensee states that the inside diameter weld repairs will be assumed in the nozzle stress analyses to bound any actual weld repairs that may have occurred in the nozzles. The NRC staff asked the licensee to explain how the assumption of inside diameter weld repairs will bound the outside diameter overlay repairs in terms of stresses. By letter dated September 28, 2007, the licensee responded that Electric Power Research Institute (EPRI) studies have been performed for cases of weld repairs of dissimilar metal butt welds. Results of these studies show that maximum hoop stresses typically exceed maximum axial stresses and that a weld repair to the ID surface after completing the main weld significantly increases both the axial and hoop stresses on the ID surface. EPRI states that the primary purpose of preemptive weld overlays is to modify the as-welded residual stresses to provide compressive stresses on the inside surface of the nozzle to inhibit crack growth or initiation. To adequately demonstrate the favorable residual stress effects of a weld overlay, EPRI started with a highly unfavorable, pre-overlay residual stress condition such as that which would result from an ID surface weld repair. As an outside surface weld overlay repair will place the inside surface in compression, the licensee believed that outside surface weld repairs will perform in a similar fashion, and an inside surface repair will be bounding. The NRC staff finds that the licensee’s modeling of an inside diameter weld repair to obtain conservative residual stresses is acceptable.

4.3 Examination and Inspection

Section 3 of Table 2 of RR-A30, Revision 2, provides requirements for acceptance, preservice, and inservice examinations of the installed weld overlay. The majority of the proposed requirements are consistent with the requirements of ASME Code Case N-504-2 and Appendix Q of the ASME Code, Section XI. The deviations are discussed below.

Paragraphs 3(a)(2) and 3(a)(3) of the relief request require that if ambient temperature temper bead welding is used, the liquid penetrant examination and ultrasonic examination will commence 48 hours after completing the third layer of the weld overlay. The proposed 48-hour hold time deviates from that of ASME Code Case N-638-1. ASME Code Case N-638-1 specifies that prior to performing NDE, a 48-hour hold time is required after the weld overlay cools to ambient temperature, not after completing the third weld layer. 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 of the ferritic materials prior to performing the final NDE. However, the licensee stated that based on extensive research and industry experience, EPRI has provided a technical basis for starting the 48-hour hold after completing the third temper bead weld layer rather than waiting for the weld overlay to cool to ambient temperature. This technical basis is documented in EPRI Report 1013558, *Temper Bead Welding Applications – 48-hour Hold Requirements for Ambient Temperature Temper Bead Welding*. 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 the 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 over the last 20 years. During this time, there has never been an indication of hydrogen cracking by the nondestructive examination performed after the 48-hour hold or by subsequent inservice inspection. The NRC staff has reviewed the information provided and finds that starting the 48-hour hold time following the completion of the third temper bead weld layer is acceptable because hydrogen cracking should not be a concern for the temper bead welding.

Paragraph 3(b)2 of the RR specifies that, if a flaw is detected in the outer 25 percent of the base metal (or original weld) during the pre-service examination, the actual flaw size would be used for the crack growth evaluation. As discussion above with regard to Table 2, paragraph 2(a), of the RR, the NRC staff's position is that this flaw size is not conservative for the crack growth calculation when the original weld is not examined prior to weld overlay installation, considering the UT limitation. By letter dated September 28, 2007, the licensee responded that it does not intend to solely use the as-found flaw size for characterization and evaluation. Instead, the pre-outage crack growth analyses consider a 360-degree circumferential flaw that is 75 percent through-wall, and an axial flaw that is 75 percent through-wall. If the preservice examinations detect cracking in the outer 25 percent of the original weld metal, then an additional crack growth analysis is performed that considers the same 75 percent through-wall flaw assumptions stated above plus any flaws detected in the outer 25 percent of the original weld metal. The NRC staff finds that by adding the detected flaw size to the postulated 75 percent through-wall flaw, the licensee assumes a conservative flaw size in its crack growth calculation and therefore, is acceptable.

Regarding Paragraph 3(c)3 of Table 2 of the original relief request, the NRC staff does not agree that the use of IWB-3600 to accept overlay flaws that are caused by primary water stress corrosion cracking (PWSCC) is appropriate because the growth rate of PWSCC can be rapid, which would challenge the integrity of the weld. The NRC staff's position is that any PWSCC flaws in the weld overlay that are rejected by Table IWB-3514-2 per Paragraph 3(c)3 need to be removed. By letter dated November 19, 2007, the licensee responded that it intends to repair or accept in accordance with the requirements of IWB-3500 any flaws in the weld overlay material which are characterized as PWSCC. The licensee has revised paragraph 3(c)3 accordingly. Therefore, the NRC staff finds that the revision is acceptable.

4.4 Ambient Temperature Temper Bead Welding

Table 3 of RR-A30, Revision 2, provides requirements for the ambient temperature temper bead welding which follow the requirements of ASME Code Case N-638-1 with a few modifications. The modifications are discussed below.

Paragraph I-1(b) of Table 3 of RR-A30, Revision 2, states that the maximum area of the weld overlay based on the finished surface over the ferritic base material shall be 300 square inches. ASME Code Case N-638-1 allows only 100 square inches over the ferritic base material. The NRC staff asked the licensee to justify the 300-square-inch surface area. In Section 5 of RR-A30, Revision 2, the licensee stated that EPRI Technical Report 1011898, *RRAC Code Justification for the 100 Square Inch Temper Bead Weld Repair Limitation*, November 2005, describes the technical justification for allowing increased overlay areas up to 500 square inches. This report notes that the original limit of 100 square inches in ASME Code Case N-638-1 was arbitrary. It cites evaluations of a 12-inch diameter feedwater nozzle weld overlay to demonstrate adequate tempering of the weld heat affected zone, residual stress evaluations demonstrating acceptable residual stresses in weld overlays ranging from 100 to 500 square inches, and service history in which weld repairs exceeding 100 square inches were NRC approved and applied to dissimilar metal weld nozzles in several boiling-water reactors (BWRs) and pressurized water reactors. Some of the cited repairs are greater than 15 years old, and have been inspected several times with no evidence of any continued degradation.

The licensee stated that the above theoretical arguments and empirical data have been verified in practice by extensive field experience with temper bead weld overlays, with ferritic material coverage ranging from 16 square inches up to and including 325 square inches. Dissimilar metal weld overlays, and weld overlays with ferritic material coverage in 100 square inch range have been in service 5 to 15 years. Several overlays have been applied with ferritic material coverage significantly greater than 100 square inches. RRs for these large overlays have been previously approved. These overlays have been examined with qualified techniques, and there is no known industry experience to date in which these overlays have shown any signs of new cracking or growth in existing cracks. Based on a review of the information provided, the NRC staff finds that the 300-square-inch weld area limit over the ferritic base metal is acceptable because the licensee has provided information demonstrating that the stresses of a nozzle with the 300-square-inch weld area will not adversely affect the integrity of the pressurizer nozzle.

By letters dated September 28 and November 19, 2007, the licensee has revised Paragraph 3(e) and 3(e)(1) regarding interpass temperature measurements. The preheat and interpass temperatures are measured using a contact pyrometer in accordance with Paragraph 3(e)(1). Contact pyrometers are calibrated in accordance with approved calibration and control program documents. If it is impractical to use contact pyrometers to measure interpass temperature due to situations where the weldment area is not accessible, such as internal bore welding or when there are extenuating radiological concerns, paragraph 3(e)(3) may be used. The licensee stated that it does not intend to use the method described in paragraph 3(e)(2) to determine interpass temperature. The NRC staff finds that the licensee proposed interpass temperature measurement in paragraphs 3(e) and 3(e)(1) is acceptable because it is consistent with the NRC staff position.

4.5 Performance Demonstration Initiative Program

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 is routinely assessed by the NRC staff for consistency with the current ASME Code and proposed changes. The PDI program does not fully comport with the existing requirements of Supplement 11. 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.

The NRC staff evaluated the differences identified in the PDI program with Supplement 11 in Table 4 of RR-A30, Revision 2 and associated justification for the differences. The NRC staff concludes that the justifications for the differences are reasonable and the PDI program provides an acceptable level of quality and safety. Therefore, the proposed PDI program to Supplement 11 is acceptable.

The NRC staff finds that the requirements of RR-A30, Revision 2, are consistent with the intent of the provisions of ASME Code Cases N-504-2 and N-638-1 and Appendix Q of the ASME Code, Section XI. Therefore, the proposed alternative is acceptable.

5.0 CONCLUSION

The NRC staff has reviewed the licensee's submittal and determined that RR-A30, Revision 2, will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff authorizes the use of RR-A30, Revision 2, for the weld overlay of the dissimilar metal welds of the pressurizer relief valve, spray valve, and surge line nozzles, and hot leg branch connections at the DBNPS.

The effective period of the proposed alternative is for the life of the component. Once a structural overlay is installed it will remain in place for the life of the repair.

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

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