February 6, 2008

Mr. Jack S. Keenan
Senior Vice President and
Chief Nuclear Officer
Pacific Gas and Electric Company
Diablo Canyon Power Plant
P.O. Box 770000
San Francisco, CA 94177-0001

SUBJECT: DIABLO CANYON POWER PLANT, UNIT NO. 2 - APPROVAL OF RELIEF REQUEST REP-1 U2, REVISION 1, FOR THE APPLICATION OF WELD OVERLAY ON DISSIMILAR METAL WELDS OF PRESSURIZER NOZZLES (TAC NO. MD4974)

Dear Mr. Keenan:

By letter dated March 28, 2007, Pacific Gas and Electric Company (PG&E, the licensee) requested U.S. Nuclear Regulatory Commission (NRC) approval for inservice inspection (ISI) program Relief Request (RR) REP-1 U2, at Diablo Canyon Power Plant, Unit No. 2 (DCPP Unit 2). RR REP1-U2 requests the use of alternatives to the requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, repair/replacement program to install preemptive full structural weld overlays (SWOLs). The SWOLs mitigate the potential for primary water stress-corrosion cracking of dissimilar metal welds (DMWs) of the pressurizer nozzles. As part of the installation, similar metal welds adjacent to the DMWs will also be covered with SWOLs. The weld overlays are planned to be installed during DCPP Unit 2's 14th refueling outage (2R14), currently scheduled to begin February 4, 2008. The proposed alterative will be applied for the duration of up to and including the last outage of the current third 10-year ISI interval.

By letter dated October 22, 2007, the licensee responded to the NRC staff's request for additional information and also submitted a revised RR REP-1 U2, Revision 1. By letter dated November 29, 2007, the licensee provided further clarifications to the ISI requirements of the weld overlay.

The NRC staff has completed its review of the subject relief request. Based on the enclosed safety evaluation, the NRC staff has determined that the proposed alternatives in RR REP-1 U2, Revision 1, 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 the RR REP-1 U2, Revision 1, for the weld overlay of the dissimilar and similar metal welds of the pressurizer relief valve, safety valve, spray valve, and surge line nozzles for the third 10-year ISI interval at the DCPP Unit 2. The ISI requirements for the weld overlays for the fourth and later ISI intervals will be addressed in the ISI program plans for those intervals and will be based on regulatory requirements in effect at that time. 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.

If you have any questions regarding the safety evaluation, please contact Alan B. Wang at (301) 415-1445.

Sincerely,

/RA/

Thomas G. Hiltz, Chief
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-323

Enclosure: Safety Evaluation

cc w/encl: See next page

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.

If you have any questions regarding the safety evaluation, please contact Alan B. Wang at (301) 415-1445.

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cc w/encl: See next page

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ADAMS Accession No. ML080110001 NRR-028 (*) SE input memo

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REQUEST FOR RELIEF FROM THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS BOILER AND PRESSURE VESSEL CODE, SECTION XI, INSERVICE INSPECTION PROGRAM

PACIFIC GAS AND ELECTRIC COMPANY

DIABLO CANYON POWER PLANT, UNIT NO. 2

DOCKET NO. 50-323

1.0 INTRODUCTION

By letter dated March 28, 2007 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML070990060), Pacific Gas and Electric Company (PG&E, the licensee) requested U.S. Nuclear Regulatory Commission (NRC) approval for inservice inspection (ISI) program Relief Request (RR) REP-1 U2 at Diablo Canyon Power Plant, Unit No. 2 (DCPP Unit 2). This request for relief contains alternative requirements for the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI repair/replacement program to install preemptive full structural weld overlays (SWOLs) to mitigate the potential for primary water stress-corrosion cracking (PWSCC) of dissimilar metal welds (DMW) of pressurizer nozzles. As part of the installation, similar metal welds adjacent to the DMW will also be covered with the weld overlay. The weld overlays will be installed during the DCPP Unit 2 14th refueling outage (2R14) currently scheduled to begin February 4, 2008.

By letter dated October 22, 2007 (ADAMS Accession No. ML073040029), the licensee responded to the NRC staff's request for additional information and also submitted a revised RR, REP-1 U2, Revision 1. By letter dated November 29, 2007 (ADAMS Accession No. ML073460045), the licensee provided clarification to the ISI requirements of the weld overlay.

A DMW is defined as a weld that joins two pieces of metal that are not of the same material. In the proposed alternative, the DMW weld joins the ferritic pressurizer nozzle to the austenitic stainless steel safe end. The DMW 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 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) paragraph 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) must meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in the ASME Code, Section XI, "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)(i) or (ii), 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 licensee stated that the ASME Code of record for the current 10-year ISI interval is Section XI, 2001 Edition, including Addenda through 2003 for the Repair/Replacement and ISI Program. ASME Code Section XI, 2001 Edition, no Addenda, Appendix VIII, Supplement 11, as implemented by the Performance Demonstration Initiative (PDI) Program, is used for ultrasonic examination qualification for SWOLs.

3.0 PROPOSED RR REP-1 U2, REVISION 1

3.1 Components Affected

Code components associated with this request are high safety significant Class 1 DMWs with Alloy 82/182 weld metal in the pressurizer nozzle-to-safe end connection. There are six DMWs that are scheduled to have preemptive full SWOLs applied. In addition, the SWOLs will extend across the six adjacent stainless steel pipe-to-safe end similar metal welds. The welds are identified as follows:

a) Weld No. WIB-439SE Safe End-to-Surge Nozzle Weld and adjacent Pipe-to-Safe End Weld No. WIB-438 (Line Identifier 2-*-16-14SPL)

b) Weld No. WIB-369SE Safe End-to-8010A Safety Nozzle Weld and adjacent Pipe-to-Safe End Weld No. WIB-369 (Line Identifier 2-S6-729-6)

c) Weld No. WIB-423SE Safe End-to-8010B Safety Nozzle Weld and adjacent Pipe-to-Safe End Weld No. WIB-423 (Line Identifier 2-S6-728-6)

d) Weld No. WIB-359SE Safe End-to-8010C Safety Nozzle Weld and adjacent Pipe-to-Safe End Weld No. WIB-359 (Line Identifier 2-S6-727-6)

e) Weld No. WIB-380SE Safe End-to-Relief Nozzle Weld and adjacent Pipe-to-Safe End Weld No. WIB-380 (Line Identifier 2-S6-730-6)

f) Weld No. WIB-345SE Safe End-to-Spray Nozzle Weld and adjacent Pipe-to-Safe End Weld No. WIB-345 (Line Identifier 2-S6-15-4SPL)

Pressurizer nozzles are made of low-alloy steel SA-508, Class 2 (P-No. 3, Group No. 3). Safe end-to-nozzle welds and buttering are made of Alloy 82/182 (F-No. 43). Safe ends are made of wrought stainless steel SA-182, Grade F316L (P-No. 8). Attached pipe is wrought seamless stainless steel SA-376, Type 316 (P-No. 8) and the associated welds are stainless steel (A-No. 8).

3.2 Applicable Code Edition and Addenda

For the third 10-year ISI interval, the ASME Code of record is Section Xl, 2001 Edition, including Addenda through 2003 for the current 10-year ISI interval and the Repair/Replacement and ISI Program. ASME Code, Section Xl, 2001 Edition, no Addenda, Appendix VIII, Supplement 11, as implemented by the PDI Program, is used for ultrasonic examination qualification for SWOLs.

3.3 Applicable Code Requirement

The applicable code requirement for which relief is requested is ASME Code, Section XI, 2001 Edition, including Addenda through 2003, IWA-4410 and IWA-4611, and ASME Code, Section Xl, 2001 Edition, no Addenda, Appendix VIII, Supplement 11.

IWA-4410 requires, in part, that “Welding, brazing, defect removal,...and installation shall be performed in accordance with this Subarticle."

IWA-4611.1 (a) requires, in part, that defects be removed in accordance with IWA-4422.1. A defect is considered removed when it has been reduced to an acceptable size.

IWA-4611.2(a) requires, in part, that after final processing, the affected surfaces, including surfaces of cavities prepared for welding, shall be examined by the magnetic particle or liquid penetrant method to ensure that the indication has been reduced to an acceptable size in accordance with IWB-3500.

Appendix VIII provides requirements for performance demonstration for ultrasonic examination systems. Supplement 11 provides qualification requirements for full structural overlaid wrought austenitic piping welds.

3.4 Proposed Alternative and Basis

The proposed alternative, RR REP-1 U2, Revision 1, is contained in Enclosure 2 of the licensee’s October 22, 2007, submittal. Attachment 1 of Enclosure 2 of the October 22, 2007, submittal, contains the alternative requirements for implementing the six scheduled SWOLs for Alloy 82/182 safe end-to-nozzle welds of the pressurizer and its adjacent stainless steel pipe-to-safe end welds. Appendix 1 of Enclosure 2 of the October 22, 2007, submittal contains requirements for ambient temperature temper bead welding.

This proposed alternative is the result of industry experience with weld overlay modifications for potential or known flaws caused by PWSCC, and directly applies to the Alloy 52 or 52M weld material that is primarily being used for these SWOLs. The ultrasonic examination of the completed SWOLs will be accomplished with personnel and procedures qualified in accordance with ASME Code, Section XI, 2001 Edition, no Addenda, Appendix VIII, Supplement 11, as implemented by the PDI program.

3.4.1 SWOL Design

The licensee stated that the SWOLs satisfy all the structural design requirements of the pipe, as specified in the alternative requirements in Attachment 1 of the October 22, 2007, submittal. The SWOLs will completely cover the existing Alloy 82/182 weld and will extend onto the ferritic nozzle and austenitic stainless steel material on each end of the weld, including the adjacent pipe-to-safe end weld. The SWOLs extend around the entire circumference of the nozzle. Alloy 52M and 52 filler metals are compatible with all the wrought base materials and the DMWs and similar metal welds that will be covered by the SWOL.

The SWOLs will be designed as full structural overlays to repair the assumed worst-case flaw in accordance with the alternative requirements in the relief request. The design analyses for the preemptive SWOLs will be available at the plant for NRC review at the beginning of the DCPP Unit 2 refueling outage 2R14.

3.4.2 Welding

The licensee stated that the welding will be performed in accordance with the alternative requirements in Attachment 1, Enclosure 2 of the October 22, 2007, submittal using a remotely controlled machine gas tungsten arc welding (GTAW) process and the ambient temperature temper bead method with ERNiCrFe-7A (Alloy 52M) weld metal. The licensee will apply manual GTAW, using ERNiCrFe-7 (Alloy 52) or Alloy 52M, if local repairs of weld defects are necessary or additional weld metal is required locally to form the final SWOL contour in locations at least 3/16 inches away from the low-alloy steel nozzles.

The licensee stated that recent industry experience from weld overlay activities using ERNiCrFe-7A (Alloy 52M) and ERNiCrFe-7 (Alloy 52) reveals a potential for flaws in the first layer deposited on the austenitic stainless steel portions (safe ends and pipe) of the assemblies.

The flaw characteristics observed in the first layer are indicative of hot cracking. This phenomenon has not been observed on the ferritic steel or ENiCrFe-3 (Alloy 182) DMW portions of the assemblies when Alloy 52M is used for the first layer.

The licensee further stated that studies have determined that this problem may occur when using Alloy 52M filler metal on austenitic stainless steel materials with high sulfur content. Limited tests and evaluations recently performed have concluded that welding with Alloy 52M on stainless steel base material with 0.020 weight (wt)% sulfur results in cracking. Conversely, welding on stainless steel base materials with less than 0.010 wt% has resulted in no cracking.

The licensee stated that DCPP Unit 2 material composition records indicate that the possibility of hot cracking due to the influence of sulfur in existing base materials cannot be ruled out. In order to minimize the occurrence of hot cracking, the licensee will apply one or more barrier

layers to all stainless steel items prior to Alloy 52M overlay. The barrier layer(s) will be based on ER309L for the stainless steel base and weld metal, and Alloy 82 for the DMW fusion zone and adjacent stainless steel heat-affected zone (HAZ). The licensee will not credit the barrier layer in the structural analysis or in the crack-growth analysis.

3.4.3 Examination

The licensee stated that the current configuration of the existing DMWs does not permit an ASME Code, Section XI, Appendix VIII Supplement 10 ultrasonic examination to obtain greater than 90 percent coverage of the required examination volume. Therefore, none of the welds will receive a pre-weld overlay ultrasonic examination.

All overlay examinations will meet the requirements of the alternative requirements in Attachment 1 of the October 22, 2007, submittal. The ultrasonic examination qualification will be in accordance with ASME Code, Section XI, 2001 Edition, no Addenda, Appendix VIII, Supplement 11, as implemented by the PDI Program.

The licensee will perform ultrasonic and surface examinations of the completed temper bead portion of the SWOLs no sooner than 48 hours after completion of the third temper bead layer as specified in paragraphs 3(a)(2) and 3(a)(3), Attachment 1 of the October 22, 2007, submittal.

The 48-hour delay provides time for delayed hydrogen cracking occurrence. The proposed alternative requires the machine or automatic GTAW process to be used for temper bead welding thereby eliminating the use of welding processes requiring flux for arc shielding.

The licensee stated that the machine GTAW temper bead process is inherently free of hydrogen. The GTAW process relies on a bare welding electrode and bare wire filler metal with no flux to absorb moisture. An inert gas blanket provides shielding for the weld and surrounding metal, which protects the region during welding from the atmosphere and the moisture it may contain and typically produces porosity-free welds. In accordance with the weld procedure qualification, welding grade argon is used for the inert gas blanket. To further reduce the likelihood of any hydrogen effects, specific controls will be used to ensure the base metal, shielding gas, welding electrodes, filler metal and weld region are free of all sources of hydrogen.

In addition, the use of the machine GTAW temper bead process provides precise control of heat input, bead placement, bead size, and contour. The very precise control over these factors afforded by the machine GTAW process provides effective tempering of the nozzle ferritic steel HAZ resulting in achievement of lower hardness and tempered martensite. This further reduces susceptibility to hydrogen-induced cracking. Additional information regarding the 48-hour hold time is discussed in a later section of this safety evaluation.

3.5 Duration of the Proposed Request

The licensee requested that the alternative requirements of this request be applied to installation of weld overlays for the duration of the current third 10-year ISI interval. Overlay ISI requirements are applicable for the expected life of the overlay, which is 20 years beyond the current license expiration date of August 26, 2025.

4.0 NRC STAFF EVALUATION

Although RR REP-1 U2, Revision 1, is based on Code Case N-740-1 of the ASME Code, Section XI, the NRC staff has not endorsed Code Case N-740-1 and has not used it to evaluate RR REP-1 U2, Revision 1. The NRC staff has endorsed Code Case N-504-3, "Alternative Rules for Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping Section XI, Division 1." The NRC staff has also endorsed Code Case N-638-1, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique Section XI, Division 1." In accordance with RG 1.147, Revision 15, 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 Code Case N-504-3 is used. These three NRC-approved documents are relevant to SWOLs. Therefore, to evaluate RR REP-1 U2, Revision 1, the NRC staff has used Code Cases N-504-3 and N-638-1, and Appendix Q to the ASME Code, Section XI.

4.1 General Requirements

Section 1, Attachment 1 to Enclosure 2, of the October 22, 2007, submittal provides the general requirements for the overlay design, which are consistent with the requirements of Code Case N-504-3 and/or Appendix Q of the ASME Code, Section XI, with the following exceptions.

Code Case N-504-3 and Appendix Q of the ASME Code, Section XI, are only applicable to P-No. 8 austenitic stainless steel and not to nickel-alloy steel. However, paragraph 1.0(a) of Attachment 1, Enclosure 2 of the October 22, 2007, submittal proposes the weld overlay be applied to nickel-alloy 82/182 welds (F-No. 43) joining low-alloy steel (P-No. 3) to wrought stainless steel (P-No. 8) materials. It is also applicable to austenitic stainless steel welds joining wrought stainless steel (P-No. 8) materials. The NRC staff finds this exception acceptable because the proposed alternative is specifically prepared to address the repair of nickel-based Alloy 82/182 welds based on welding procedure qualifications.

During recent DMW overlay activities, where use of ERNiCrFe-7A (Alloy 52M) and ERNiCrFe-7 (Alloy 52) has been used for the filler metal, flaws in the first layer have occurred in the portion of the overlay deposited on the austenitic stainless steel safe ends and pipes in some cases. The flaw characteristics observed are indicative of hot cracking. This phenomenon has not been observed when welding Alloy 52M on the ferritic steel or ENiCrFe-3 (Alloy 182) DMW portions of the assemblies. Further studies have determined that this problem may occur when using Alloy 52M filler metal on austenitic stainless steel materials with high sulfur content.

Recent limited tests and evaluations have concluded that welding with Alloy 52M on stainless steel base material with 0.020 weight (wt)% sulfur results in cracking while welding on stainless steel base materials with less than 0.010 wt% have resulted in no cracking. To reduce the susceptibility of hot cracking occurrence due to welding Alloy 52M on the stainless steel base materials with high sulfur, the licensee selected ER309L as the preferred filler metal to provide a barrier layer between the Alloy 52M and the high-sulfur stainless steel base material. This filler metal is compatible with the base material and promotes primary weld metal solidification as ferrite rather than austenite. The ferrite is more accommodating of residual elements therein and in the underlying base material, thereby significantly reducing the susceptibility to hot cracking. ER309L is also compatible with the Alloy 52M subsequently welded thereon. However, the barrier layer will necessarily consist of ERNiCr-3 (Alloy 82) being used locally at the interface between the Alloy 182 DMW and the stainless steel item. ER309L welding on

Alloy 182 may result in cracking of the ER309L weld. Welding on high-sulfur stainless steel with Alloy 82 has not been a concern relevant to hot cracking occurrences.

The licensee fabricated a mockup assembly to evaluate the interactive effects, such as hot cracking and lack of fusion, between the Alloy 182 DMW, the stainless steel base material, the ER309L and Alloy 82 barrier layer, and the subsequent Alloy 52M weld overlay. The mockup assembly consisted of a stainless steel pipe (0.020 wt% sulfur) with an Alloy 182 groove weld performed therein. The barrier layer and overlay were welded in the same sequence as performed in the field (barrier layer ER309L and Alloy 82 and then two layers of Alloy 52M overlay). The barrier layer and overlay welding parameters used in the mockup were similar to those used in the field; however, slightly reduced wire-feed rates were used for conservatism.

The licensee performed penetrant testing (PT) and ultrasonic testing (UT) on the final mockup including high-sulfur stainless steel base material, Alloy 182 groove weld, ER309L barrier layer, Alloy 82 barrier layer, and Alloy 52M overlay. The licensee did not detect any recordable indications.

The licensee performed metallographic examination for any type of discontinuity, flaw or other anomaly on eight specimens that were removed in approximate 45-degree circumferential increments around the pipe. The licensee reported that final metallography of all the specimens has shown no conditions causing concern.

The licensee stated that the barrier layer welding will be performed in accordance with ASME Code Section IX-qualified welding procedure specification(s). The barrier layer will use ER309L on the stainless steel and Alloy 82 on the stainless steel near the DMW to stainless steel fusion zone only. The licensee will not assume structural credit of the barrier layer in determining the required minimum overlay thickness. This is conservative because the total weld overlay thickness will be greater. The licensee will perform the necessary surface examination on the barrier layer and its volume will be included in the final UT of the overlay. Based on these measures, the NRC staff finds that the design and welding requirements for the barrier layer are acceptable.

4.2 Crack-Growth Considerations and Design

Section 2 of Attachment 1, Enclosure 2 of the October 22, 2007, submittal provides the requirements for the overlay design and the crack-growth calculation, which are consistent with the requirements of Code Case N-504-3 and/or Appendix Q of the ASME Code, Section XI, with the following exceptions and specific requirements.

Paragraph (f) of Code Case N-504-3 and paragraph Q-3000 of Appendix Q require certain flaw sizes to be assumed in the weld overlay design and crack-growth calculation. Paragraph 2(a)(1) of Attachment 1, Enclosure 2 of the October 22, 2007, submittal requires that the initial flaw size for crack growth shall be based on the postulated flaw because the licensee will not ultrasonically examine the weld prior to weld overlay installation. Paragraph 2(a)(2) of the relief request requires that a circumferential flaw and an axial flaw originating from the inside diameter with a depth of 75 percent through-wall be assumed. The length of the circumferential flaw is assumed to be 360 degrees in circumferential extent. The length of the axial flaw is assumed to be 1.5 inches or the combined width of the weld plus buttering, whichever is greater. Crack growth, including both stress corrosion and fatigue-crack growth, will be evaluated in the

materials in accordance with subarticle IWB-3640 of the ASME Code, Section XI. Paragraph 2(a) requires that if the flaw is at or near the boundary of two different materials, evaluation of flaw growth in both materials is required.

Paragraph 2(a) Attachment 1, Enclosure 2 of the October 22, 2007, submittal requires that the size of all flaws detected or postulated in the original weldment be projected to the end of the expected life of the overlay. In its response to the NRC staff RAI, as shown in Enclosure 1 of the October 22, 2007, submittal, the licensee clarified that the expected life of the overlay is 20 years beyond the current license expiration date of August 26, 2025.

The licensee clarified further that the overlay thickness is designed based on the life of 20 years beyond the current license expiration date of August 26, 2025. The NRC staff finds this to be acceptable.

The NRC staff finds that the requirements for the weld overlay design and crack-growth calculations in RR REP-1 U2, Revision 1, are either consistent with or conservative with respect to the requirements of Code Case N-504-3 and/or Appendix Q to the ASME Code, Section XI, and, therefore, are acceptable.

4.3 Examination and Inspection

Section 3 of Attachment 1, Enclosure 2 of the October 22, 2007, submittal provides requirements for acceptance, preservice, and inservice examinations of the installed weld overlay, which are consistent with the requirements of Code Case N-504-3 and/or Appendix Q of the ASME Code, Section XI, with the following noted exceptions.

Acceptance Examination

Paragraph 4.0(b) of Code Case N-638-1 requires that the ultrasonic examination be conducted 48 hours after the completed weld overlay is cooled to ambient temperature. The purpose of the 48-hour hold is to allow sufficient time for hydrogen cracking to occur (if it is to occur) after welding such that the weld overlay could be repaired prior to it being placed in service.

However, paragraph 3.0(a)(2) of Attachment 1, Enclosure 2 of the October 22, 2007, submittal proposes that the ultrasonic examination be conducted 48 hours after completing the third temper bead layer of the weld overlay when ambient temperature temper bead welding is used. This proposal will allow the weld to be examined earlier than is required by Code Case N-638-1.

The NRC staff's concern with the proposal is the potential for hydrogen cracking or cold cracking resulting from welding. The NRC staff identified four potential contributors to cracking. They are changes in the microstructure of the base metal, sources for hydrogen introduction, tensile stress and temperature, and diffusivity and solubility of hydrogen in the P-3 material (i.e., pressurizer nozzles).

As its reference, the licensee cited Electric Power Research Institute (EPRI) report 1013558, "Repair and Replacement Applications Center: Temperbead Welding Applications 48-Hour Hold Requirements for Ambient Temperature Temperbead Welding" (ADAMS Accession No. ML070670060). The data in the EPRI report is based on testing performed on SA-508, Class 2 low-alloy ferritic steels, which is the material of the DCPP Unit 2 pressurizer nozzles.

After evaluating all of 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 [nondestructive examination] 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 …" EPRI also notes that over 20 weld overlays and 100 repairs have been performed using temper bead techniques on low-alloy steel components over the last 20 years. During this time, there has never been an indication of hydrogen cracking by the NDEs performed after the 48-hour hold or by subsequent ISIs.

An ASME Technical Basis Paper (ADAMS Accession No. ML070790679) to support the proposed revision to the 48-hour hold time requirement indicates that the introduction of hydrogen to the ferritic HAZ is limited to the first weld layer because this is the only weld layer that makes contact with the ferritic base material. The Technical Basis Paper states that while the potential for the introduction of hydrogen to the ferritic HAZ is negligible during subsequent weld layers, these layers provide a heat source that accelerates the dissipation of hydrogen from the ferritic HAZ in nonwater-backed applications. The Technical Basis Paper concludes that there is sufficient delay time to facilitate the detection of potential hydrogen cracking when NDE is performed 48 hours after completion of the third weld layer.

Furthermore, the solubility of hydrogen in austenitic weld materials such as Alloy 52M is much higher than that of ferritic materials while the diffusivity of hydrogen in austenitic materials is lower than that of ferritic materials. As a result, hydrogen in the ferritic HAZ tends to diffuse into the austenitic weld metal, which has a much higher solubility for hydrogen. This diffusion process is enhanced by heat supplied in subsequent weld layers.

Based on this information, the licensee proposed to revise the 48-hour hold time from the current requirement of performing NDE 48 hours after the finished weld overlay reaches ambient temperature to the revised requirement of performing NDE 48 hours after the third temper bead weld layer is completed.

The NRC staff finds that it is not necessary to wait until 48 hours after the completed overlay has reached ambient temperature because any delayed hydrogen cracking, were it to occur, is expected to occur within the 48 hours following completion of the third temper bead weld layer. Therefore, the NRC staff concludes that NDE of the weld overlay 48 hours after completion of the third temper bead weld layer is acceptable.

The acceptance standards in paragraph 3(a)(3) of Attachment 1, Enclosure 2 of the October 22, 2007, submittal are identical to paragraph Q-4100(c)(1) of the ASME Code, Section XI, Appendix Q, except that paragraph 3(a)(3) includes the additional limitation that the total laminar flaw shall not exceed 10 percent of the weld surface area and that no linear dimension of the laminar flaw area exceeds 3.0 inches or 10 percent of the nominal pipe circumference, whichever is greater. Paragraph 3(a)(3)(c) also limits the flaw size in the uninspectable volume of the overlay underneath the laminar flaws. The NRC staff finds that the proposed limitations on laminar flaws provide additional assurance to the weld overlay structural integrity. Therefore, the NRC staff finds that the proposed use of paragraph 3(a)(3) is acceptable.

The ASME Code, Section XI, Appendix Q, paragraph Q-4100(c)(4), requires radiographic examinations. However, paragraph 3 of Attachment 1, Enclosure 2 of the October 22, 2007, submittal proposes PDI UT examination in lieu of the radiographic examination. The licensee stated that the PDI UT examination is considered more sensitive for detection of defects, either from fabrication or service-induced, than either ASME Code Section III radiographic or ultrasonic methods. Furthermore, construction type flaws have been included in the PDI qualification sample sets for evaluating procedures and personnel. The NRC staff agrees with the licensee that the PDI UT examination is more sensitive for detecting defects than the radiographic examination. Therefore, the NRC staff finds that the PDI UT examination is acceptable for weld overlay installation in lieu of the radiographic examination.

Preservice Examination

The acceptance standards for preservice examination in paragraph 3(b)(2) of Attachment 1, Enclosure 2 of the October 22, 2007, submittal are identical to paragraph Q-4200(b) except paragraph 3(b)(2) includes the following requirement: "In applying the acceptance standards, wall thickness, tw, shall be the thickness of the weld overlay." This provision is to clarify that the nominal wall thickness of Table IWB-3514-2 shall be considered the thickness of the weld overlay. The acceptance standards in Table IWB-3514-2 were originally written for the welds identified in IWB-2500. Because IWB-2500 does not address weld overlays, this clarification was provided to avoid any potential confusion. The NRC staff finds that the use of wall thickness, tw, of the weld overlay in the acceptance standards of IWB-3514-2 is conservative and, therefore, is acceptable.

Paragraph 3(b)(3) requires that planar flaws detected in the outer 25 percent of the underlying weld or base material thickness be evaluated in accordance with the ASME Code, Section XI, IWB-3640. In the October 22, 2007, submittal, the licensee responded to the NRC staff's RAI (questions 8 and 12) that inside surface-connected planar flaws of 75 percent through-wall will be assumed for the flaw growth evaluations. Other flaws detected in the ISI examination volume will be evaluated in combination with these original postulated flaw(s). In addition, the licensee stated that if the initial 75 percent through-wall thickness flaw grows through the remaining original wall thickness, flaw growth into the overlay is assumed to occur. The NRC staff finds the licensee's crack-growth calculation assumption is acceptable because the licensee will add the flaw depth detected in the ISI examination volume to the postulated 75 percent through-wall flaw in the crack-growth evaluations.

Inservice Examination

Paragraph 3(c) of Attachment 1, Enclosure 2 of the October 22, 2007, requires that the ISI requirements of ASME Code, Section XI, Appendix Q, Subarticle Q-4300, apply for the life of the weld overlays. The NRC staff questioned which edition of the ASME Code, Section XI will be used. In the November 29, 2007, letter, the licensee clarified that the 2004 Edition, including 2005 Addenda, Section XI, Appendix Q Subarticle Q-4300 (including Q-4310) shall be used to examine the weld overlays for the third 10-year ISI interval. The licensee clarified further that the ISI requirements for the weld overlays for the fourth and later ISI intervals shall be those incorporated by reference in 10 CFR 50.55a in effect at that time. The NRC staff finds that Appendices Q-4300 and Q-4310 of the 2004 Edition including 2005 Addenda, as limited by the licensee as discussed below, are acceptable to be used to inspect the weld overlays.

Paragraph 3(c)(2) of Attachment 1, Enclosure 2 of the October 22, 2007, submittal proposes that flaws due to stress-corrosion cracking in the weld overlay that exceed the inservice examination acceptance standards of Table IWB-3514-2 shall not be accepted. Paragraph Q-4300(c) of Appendix Q to the ASME Code, Section XI, does not have this requirement. The NRC staff finds the proposed requirement is more conservative than Appendix Q because it limits the size and thus reduces the number of PWSCC flaws in the weld overlay. Therefore, the NRC staff concludes that the use of paragraph 3(c)(2) is acceptable.

4.4 Ambient Temperature Temper Bead Welding

Appendix 1, Enclosure 2 of the October 22, 2007, submittal specifies requirements for the ambient temperature temper bead welding, which are consistent with requirements of Code Case N-638-1 with the following exceptions.

- Code Case N-638-1, paragraph 1.0(a) limits the maximum area of an individual weld covering ferritic base metal to 100 square inches. Paragraph 1.0(b) of Appendix 1, Enclosure 2 of the October 22, 2007, submittal proposes to limit the maximum area of an individual weld covering ferritic base metal to 500 square inches. The proposed 500-square-inch weld area is addressed in EPRI Report 1014351, "Repair and Replacement Applications Center: Topical Report Supporting Expedited NRC Review of Code Cases for Dissimilar Metal Weld Overlay Repairs, December 2006," and the presentation slides entitled, "Bases for 500 Square Inch Weld Overlay Over Ferritic Material," was provided to the NRC staff in a public meeting held on January 10, 2007 (ADAMS Accession No. ML070470565). The industry provided results of finite element analysis demonstrating that the stresses of a nozzle with the 500-square-inch weld area will not adversely affect the integrity of the pressurizer nozzle. Based on a review of the information provided, the NRC staff finds that the proposed 500-square-inch weld area limit over the ferritic base metal is acceptable.

- Code Case N-638-1, paragraph 1.0(a) requires that the depth of the weld not be greater than one-half of the ferritic base metal thickness. Paragraph 2.1(b) requires that the pressurized environment be duplicated in the procedure qualification test assembly. Paragraph 2.1(c) requires that the effects of irradiation on the properties of the materials be considered. Paragraph 2.1(h) requires the performance of Charpy V-notch testing of the ferritic weld metal of the procedure qualification test coupon. Paragraph 3.0(c) requires the deposition and removal of at least one weld reinforcement layer for “similar materials” (i.e., ferritic materials). None of these Code Case N-638-1 requirements is included in RR REP-1 U2, Revision 1, because they are not applicable to the proposed weld overlay.

- Code Case N-638-1, paragraph 2.1(j) specifies acceptance criteria for Charpy V-notch tests of the HAZ and requires that the average value of the three HAZ impact tests be equal to or greater than the average value of the three unaffected base metal tests. Paragraph 2.1(g), Appendix 1, Enclosure 2 of the October 22, 2007, submittal proposes that the acceptance criteria for Charpy V-notch testing of the HAZ be based on average lateral expansion values. Paragraph 2.1(g) of the relief request clarifies the intent of paragraph 2.1(j) of Code Case N-638-1

(i.e., the average lateral expansion) and aligns its Charpy V-notch acceptance criteria with that of ASME Code, Section III, NB-4330, Impact Test Requirements, ASME Code, Section XI, IWA-4620, Temperbead Welding of Similar Materials, and ASME Code, Section XI, IWA-4630, Temperbead Welding of Dissimilar Materials. Therefore, the NRC staff finds the proposed use of paragraph 2.1(g) of Appendix 1, Enclosure 2 of the October 22, 2007, submittal is acceptable.

- Code Case N-638-1, paragraph 3.0 does not require monitoring of welding interpass temperatures. However, paragraph 3.0(e) of Appendix 1, Enclosure 2 of the October 22, 2007, submittal requires that the interpass temperature be measured using devices such as pyrometers, temperature indicating crayons, or thermocouples. If it is impractical to measure the interpass temperature by the direct method due to situations where the weldment area is not accessible, such as internal bore welding or when there are extenuating radiological concerns, the interpass temperature may be based on heat-flow calculations or on a test coupon. The NRC staff finds that the proposed interpass temperature measurements are an improvement to Code Case N-638-1 to monitor the proper heat input during welding and, therefore, are acceptable.

4.5 PDI Program

The U.S. nuclear utilities created the PDI program to implement performance demonstration requirements contained in Appendix VIII of the ASME Code, Section XI. To this end, EPRI 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, as discussed 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. The PDI representatives presented the differences between Supplement 11 and the PDI program 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 between the PDI program and Supplement 11 as shown in Enclosure 3 of the October 22, 2007, submittal. The NRC staff concludes that the justifications for the differences are acceptable and the PDI program provides an acceptable level of quality and safety. Therefore, the proposed PDI program is acceptable for use in lieu of Supplement 11 of Appendix VIII to the ASME Code, Section XI.

The NRC staff finds that the requirements of RR REP-1 U2, Revision 1, are consistent with the provisions of Code Cases N-504-3 and N-638-1 and Appendix Q of the ASME Code, Section XI, and the exceptions are acceptable based on the justification provided by the licensee.

4.6 Licensee Future Actions

In its submittals, the licensee has committed to do the following as part of the relief request:

1) The licensee will have the design analyses for the preemptive SWOLs at the plant for NRC review at the beginning of the DCPP Unit 2 refueling outage 2R14.

2) The licensee will submit a report with details of the examination results of the SWOLs on the DCPP Unit 2 pressurizer spray, relief, safety and surge nozzle safe-ends to the NRC within 60 days after completion of the final installation ultrasonic examination. The results will include description(s) of any weld repairs to the weld overlay material and/or base material and the reason(s) for the weld repair(s).

3) The ISI requirements of ASME Code, 2004 Edition, including 2005 Addenda, Section XI, Appendix Q, Subarticle Q-4300 (including Q-4310), shall apply for the third 10-year ISI interval for the weld overlay examination, with the exception that flaws detected in the overlay that are due to stress-corrosion cracking that exceed the standards of Table IWB-3514-2 are not allowed. The ISI requirements for the weld overlays for the fourth and later ISI intervals shall be those incorporated by reference in 10 CFR 50.55a in effect at that time.

5.0 CONCLUSION

The NRC staff has reviewed the licensee's submittal and determined that RR REP-1 U2, Revision 1, will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff authorizes the use of the RR REP-1 U2, Revision 1, for the weld overlay of the dissimilar and similar metal welds of the pressurizer relief valve, safety valve, spray valve, and surge line nozzles for the third 10-year ISI interval at the DCPP Unit 2. The ISI requirements for the weld overlays for the fourth and later ISI intervals will be addressed in the ISI program plans for those intervals and will be based on regulatory requirements in effect at that time. 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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