UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

January 2, 2018

Mr. Edward D. Halpin
Senior Vice President, Generation
and Chief Nuclear Officer
Pacific Gas and Electric Company
Diablo Canyon Power Plant
P.O. Box 56, Mail Code 104/6
Avila Beach, CA 93424

SUBJECT: DIABLO CANYON POWER PLANT, UNITS 1 AND 2 – RELIEF REQUEST REP-RHR-SWOL, REQUEST FOR APPROVAL OF ALTERNATIVE FOR APPLICATION OF FULL STRUCTURAL WELD OVERLAY (EPID L-2017-LLR-0092)

Dear Mr. Halpin:

By letter dated September 26, 2017 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17269A220), as supplemented by letter dated November 20, 2017 (ADAMS Accession No. ML17324B344), Pacific Gas and Electric Company (the licensee) requested relief from the requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, IWA-4000, at Diablo Canyon Power Plant (DCPP), Units 1 and 2. The licensee submitted Relief Request REP-RHR-SWOL for the U.S. Nuclear Regulatory Commission (NRC) review and approval to repair a degraded weld of residual heat removal (RHR) suction piping at each unit.

Specifically, the proposed alternative consists of the installation of a structural weld overlay (SWOL) that replaces the structural function of the existing weld containing flaw. The alternative is based on the methodology contained in ASME Code, Section XI, Code Case N-740-2, "Full Structural Dissimilar Metal Weld Overlay for Repair or Mitigation of Class 1, 2 and 3 Items." Pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) paragraph 50.55a(z)(1), the licensee requested to use the proposed alternative on the basis that the alternative provides an acceptable level of quality and safety.

The NRC staff reviewed the licensee's submittal and determined that the proposed alternative provides an acceptable level of quality and safety. Accordingly, the NRC staff concludes that the licensee has adequately addressed all of the regulatory requirements set forth in 10 CFR 50.55a(z)(1). Therefore, the NRC staff authorizes the use of Relief Request REP-RHR-SWOL for the fourth 10-year inservice inspection interval at the DCPP, Unit 1, which ends on November 2, 2024, and at the DCPP, Unit 2, which ends on August 26, 2025.

The NRC staff recognizes that the SWOL installed in accordance with the provisions of this alternative will remain in place until the expiration of the current operating license for both DCPP

units. The NRC staff notes that this authorization does not imply or infer the NRC approval of generic use of ASME Code, Section XI, Code Case N-740-2.

All other requirements in ASME Code, Section XI, 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, please contact the Senior Project Manager, Balwant K. Singal, at 301-415-3016 or via e-mail at Balwant.Singal@nrc.gov.

Sincerely,

Robert J. Pascarelli, Chief
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-275 and 50-323

Enclosure:
Safety Evaluation

cc: Listserv

UNITED STATES
NUCLEAR REGULATORY COMMISSION
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELIEF REQUEST REP-RHR-SWOL

APPLICATION OF FULL STRUCTURAL WELD OVERLAY

ON RESIDUAL HEAT REMOVAL PIPING

DIABLO CANYON POWER PLANT, UNITS 1 AND 2

PACIFIC GAS AND ELECTRIC COMPANY

DOCKET NOS. 50-275 AND 50-323

1.0 INTRODUCTION

By letter dated September 26, 2017 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17269A220), as supplemented by letter dated November 20, 2017 (ADAMS Accession No. ML17324B344), Pacific Gas and Electric Company (the licensee) requested relief from the requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," Article IWA-4000, "Repair/Replacement Activities," at Diablo Canyon Power Plant (DCPP), Units 1 and 2. The licensee submitted Relief Request REP-RHR-SWOL for the U.S. Nuclear Regulatory Commission (NRC) review and approval to repair a degraded weld of residual heat removal (RHR) suction piping at each unit.

Specifically, the proposed alternative consists of the installation of a structural weld overlay (SWOL) that replaces the structural function of the existing weld containing flaw. The alternative is based on the methodology contained in ASME Code, Section XI, Code Case N-740-2, "Full Structural Dissimilar Metal Weld Overlay for Repair or Mitigation of Class 1, 2 and 3 Items, Section XI, Division 1." Pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) paragraph 50.55a(z)(1), "Acceptable level of quality and safety," the licensee requested to use the proposed alternative on the basis that the alternative provides an acceptable level of quality and safety.

2.0 REGULATORY EVALUATION

Adherence to Section XI of the ASME Code is mandated by 10 CFR 50.55a(g)(4), "Inservice inspection standards requirement for operating plants," which states, in part, that ASME Code Class 1, Class 2, and Class 3 components will meet the requirements, except the design and access provisions and the pre-service examination requirements, set forth in the ASME Code, Section XI.

Paragraph 50.55a(z), "Alternatives to codes and standards requirements," of 10 CFR states that:

> Alternatives to the requirements of paragraphs (b) through (h) of [10 CFR 50.55a] or portions thereof may be used when authorized by the Director, Office of Nuclear Reactor Regulation, or Director, Office of New Reactors, as appropriate. A proposed alternative must be submitted and authorized prior to implementation. The applicant or licensee must demonstrate that:
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> (1) "Acceptable level of quality and safety." The proposed alternative would provide an acceptable level of quality and safety; or
>
> (2) "Hardship without a compensating increase in quality and safety." Compliance with the specified requirements of this section would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Based on the above, and subject to the following technical evaluation, the NRC staff finds that regulatory authority exists for the licensee to request the use of an alternative and the NRC to authorize the proposed alternative.

3.0 TECHNICAL EVALUATION

3.1 Components Affected

Unit	Weld Designator	Description	Nominal Size	Materials of Construction* (per ASME Code, Section II)
1	WIB-228	RHR Pipe-to-Elbow Weld	14 inch Class 1 pipe	Pipe: SA-376 TP316 Elbow: SA-403 TP316 Weld: SFA-5.9 ER308 SFA-5.4 E308
2	WIB-245	RHR Pipe-to-Elbow Weld	14 inch Class 1 pipe	Pipe: SA-376 TP316 Elbow: SA-403 TP316 Weld: SFA-5.9 ER308

*Definition of nominal weld and base metals are defined in the ASME Code, Section II, as referenced by the ASME Code, Section III.

3.2 Applicable Code Edition and Addenda

ASME Code of record for the current fourth 10-year inservice inspection (ISI) interval is Section XI, 2007 Edition with the 2008 Addenda. This Edition is also used for the Repair/Replacement Program.

3.3 Applicable Code Requirement

The provision of Article IWA-4000 and Mandatory Appendix VIII, "Performance Demonstration for Ultrasonic Examination Systems," Supplement 11, "Qualification Requirements for Full

Structural Overlaid Wrought Austenitic Piping Welds," of the ASME Code, Section XI, 2007 Edition with the 2008 Addenda, are applicable to the subject welds.

3.4 Reason for Proposed Alternative

In May 2016, the licensee identified a circumferentially oriented flaw in the DCPP, Unit 2 (Unit 2) RHR suction pipe at weld joint WIB-245 during the Unit 2 19th refueling outage. The pipe wall thickness at this location is 1.42 inches. The licensee identified the flaw by the ultrasonic examination conducted from the outside surface of the pipe and that its length on the inside diameter (ID) of the pipe was calculated to be 6.4 inches. The flaw is connected to the ID surface, with a through-wall (radial) depth of 0.34 inches and a remaining ligament between the deepest point of the flaw and the outside diameter (OD) of 1.08 inches. The licensee evaluated this flaw in accordance with the ASME Code, Section XI criteria, and reported that continued operation of Unit 2 for a period in excess of one additional operating cycle was shown to be acceptable. By letter dated May 18, 2017 (ADAMS Accession No. ML17138B138), the licensee submitted this flaw evaluation to the NRC as required by the ASME Code, Section XI, subparagraph IWB-3134(b).

Similarly, in April 2017, the licensee identified a circumferentially oriented flaw in the DCPP, Unit 1 RHR suction pipe at weld joint WIB-228 during the Unit 1 20th refueling outage. The pipe wall thickness at this location is 1.4 inches. The licensee identified the flaw by the ultrasonic examination conducted from the outside surface of the pipe and that its length on the ID of the pipe was calculated to be 4.8 inches. The flaw is connected to the ID surface, with a through-wall (radial) depth of 0.2 inches and a remaining ligament between the deepest point of the flaw and the OD of 1.20 inches. The licensee evaluated the flaw in accordance with the ASME Code, Section XI criteria, and reported that continued operation of Unit 1 for a period in excess of one additional operating cycle was shown to be acceptable. By letter dated August 17, 2017 (ADAMS Accession No. ML17229B617), the licensee submitted this flaw evaluation to the NRC as required by the ASME Code, Section XI, subparagraph IWB-3134(b).

The licensee stated that based on the ultrasonic examinations, the detected flaws in DCPP, Units 1 and 2 are located in the same quadrant relative to the direction of the downstream 90-degree elbow and are generally at the same angular position on the cross-section. This indicates that the cause of the flaw and its growth in both units is due to the same degradation mechanism. At the time of the discoveries, the licensee examined additional welds as part of the extent of condition inspection per the ASME Code, Section XI, IWB-2430, "Additional Examinations." The licensee did not identify additional indications during the extent of condition inspection.

The licensee reviewed the DCPP Unit 1 fabrication records for weld WIB-228 and found no evidence of inside diameter weld repair during construction. Similar review of the DCPP Unit 2 fabrication records for weld WIB-245 determined that the weld ID was subjected to surface grinding during construction, but there was no evidence of ID weld repair after the grinding. The licensee concluded that no ID weld repairs have been performed on either weld WIB-228 or WIB-245.

The licensee eliminated vibration as a possible cause based on the inspections results, which concluded that physical evidence indicative of excessive vibration was not present. The licensee conducted temperature monitoring for both units from plant startup through several days of full power operation using temporary thermocouples installed on the RHR piping. The recorded temperature data indicated that thermal stratification and temperature cycling are

present at the 45-degree elbow in both units. The licensee used the field temperature measurement data as input to its flaw growth evaluations. The flaw growth evaluations show that thermal fatigue is a major contributor to the overall flaw growth. The licensee has determined that the primary degradation mechanism is thermal fatigue, based on the data from temperature monitoring in both units and also based on its flaw evaluations.

In its letter dated November 20, 2017, the licensee stated that Electric Power Research Institute (EPRI) Report Material Reliability Program (MRP)-146, "Management of Thermal Fatigue in Normally Stagnant Non-Isolable Reactor Coolant System Branch Lines" (not publicly available, proprietary information), is applicable to the subject RHR piping. EPRI Report MRP-146, Revision 0, was issued in 2005. In 2007, the licensee implemented the requirements of MRP-146, Revision 0, under Nuclear Energy Institute (NEI) 03-08, "Guideline for the Management of Materials Issues" (ADAMS Accession No. ML032190048), protocol by performing an assessment of non-isolable normally stagnant branch lines in the reactor coolant system. The subject RHR piping was included in this assessment. The licensee screened out the subject RHR piping for thermal fatigue per MRP-146, Revision 1. The licensee stated that an MRP-146 supplemental examination of the subject RHR piping was also not required because the subject RHR piping was screened out. EPRI Report MRP-146, Revisions 1 and 2, were issued in June 2011 and September 2016, respectively, and the applicable screening criteria for the subject RHR piping has not been revised in these revisions. The licensee reported the operating experience from the DCPP, Unit 2, 19th refueling outage and the DCPP, Unit 1, 20th refueling outage to the EPRI MRP and industry members via conference calls in June 2016 and May 2017, respectively. The EPRI MRP industry members are evaluating the subject weld degradation for future industry guidance and actions. The licensee stated that it will implement any industry guidance and actions from EPRI, per NEI 03-08 and MRP-146 protocols.

To repair the flaws in the subject welds, the licensee decided on a full SWOL using Alloy 52M material in accordance with ASME Code Case N-740-2 with additional provisions. This option generates increased compressive stress to mitigate thermal fatigue flaw growth and is composed of corrosion resistant material (Alloy 52M), which will mitigate conservatively assumed stress corrosion cracking. This option also provides a thinner overlay, which does not require significant modification of adjacent structures, and requires the shortest amount of time in a radiation area for installation compared to the other viable options.

According to the licensee, weld overlays have been used for repair and mitigation of cracking of similar and dissimilar metal welds (DMWs) in pressurized-water reactors (PWRs) for many years. NRC Generic Letter 88-01, "NRC Position on IGSCC [Intergranular Stress Corrosion Cracking] in BWR [Boiling-Water Reactor] Austenitic Stainless Steel Piping" (ADAMS Accession No. ML031130463), including Supplement 1 (Legacy Library Accession No. 9201300217), approved the use of ASME Code, Section XI inspection procedures for determining the acceptability of installed weld overlays in BWR reactor coolant pressure boundary piping. In addition, the NRC has conditionally accepted ASME Code Case N-504-4, "Alternative Rules for Repair of Classes 1, 2, and 3 Austenitic Steel Piping Section XI, Division 1," in Regulatory Guide (RG) 1.147, Revision 17, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1" (ADAMS Accession No. ML13339A689). ASME Code Case N-504-4 was developed to codify the BWR weld overlay experience for similar metal welds using similar metal filler material. Code Case N-740-2 has since been developed and approved by ASME for use on DMWs using a stress corrosion cracking (SCC) resistant nickel-based filler metal. The NRC has not approved ASME Code Case N-740-2 for use as shown in NRC Regulatory Guide 1.193, Revision 4, "ASME Code Cases Not Approved for Use" (ADAMS Accession

No. ML13350A001), because of the following issues: (a) the definition of nominal weld and base material appear to be inconsistent with the provisions of the ASME Code, Section III, (b) Lack of detail for how to perform the flaw growth or design analysis, and (c) lack of additional details on the design of the overlays.

3.5 Proposed Alternative

In lieu of repairing or replacing the degraded welds in accordance with the ASME Code, Section XI, the licensee proposed to install a SWOL that replaces the structural function of the subject welds. The proposed alternative is based on the requirements of ASME Code Case N-740-2. The SWOL will be designed, installed and examined in accordance with Code Case N-740-2. The SWOL design is applicable for both DCPP units.

3.6 Basis for Use

The key issues related to general requirements, material specifications, crack growth analysis and design, installation, examinations and pressure testing of the proposed weld overlay are discussed below.

General Requirements

In its letter dated September 26, 2017, the licensee stated, in part, that: "The SWOL location [at DCPP, Unit 1 and Unit 2] is external to the reactor pressure vessel and not exposed to high fluence. The SWOL location is predicted to have thermal neutron ($E < 0.5$ eV [electron volt]) fluence less than 1×10^{17} neutrons per cm^2 [square centimeter] prior to welding, therefore no special welding requirements are necessary."

The licensee also stated that "the SWOL is not being installed on top of an existing weld overlay that has been in service.

Further, the licensee stated that ASME Code Case N-740-2 provides provisions for application of the SWOL on welds joining P-No. 8 (austenitic stainless steel) and P-No. 43 (nickel-based alloy, Inconel), and permits extension of the SWOL over an adjacent weld joining P-No. 8 to P-No. 8 materials, if necessary for ultrasonic examination. The proposed alternative is to install the SWOL on a weld joining P-No. 8 to P-No. 8 materials. In this situation, the Code Case permits the use of its specified filler metal applied to welds WIB-228 and WIB-245.

Code Case N-740-2 contains additional general requirements in addition to the above. The licensee did not take exceptions to those provisions that are not specifically discussed in the proposed relief request.

Material Specifications

The licensee stated that it will use SFA-5.14 ERNiCrFe-7A (Alloy 52M) as weld filler metal to deposit the SWOL on the subject welds. The licensee stated that the increased yield strength of the Alloy 52M filler metal, over the existing austenitic stainless steel weld and pipe, results in improved compressive weld residual stresses in the weldment and base metal, and thus mitigate potential flaw growth from thermal fatigue. The higher ultimate strength of the Alloy 52M filler metal over that of austenitic stainless steel, allows for reduced SWOL weld volumes, resulting in reduced welding times, and reduced radiological exposure. The licensee

stated that in addition, this weld filler material provides a superior resistance to SCC. This material property will mitigate flaw growth from potential SCC, if any.

The NRC's position in not approving Code Case N-740-2 was that the definition of the SWOL material was not clearly specified. The proposed alternative clearly defines the definition of nominal weld and base metals, the buffer layer material, and the SWOL filler material as follows:

The materials are defined in ASME Code, Section II and Section IX as referenced in ASME Code, Section III, Article NB-2000. In its letter dated September 26, 2017, the licensee summarized the definitions for nominal weld and base metals, buffer layer. and SWOL filler materials, as stated below:

> Definition of nominal weld and base metals: The affected components and the materials of construction of pipe, elbow and weld associated with the SWOL application are presented in [the Table in Section 3.1 of this SE]. The base metals are defined in ASME Code, Section IX, as P-No. 8. The filler metal for the existing joining weld is defined in ASME Code, Section IX, as A-8 filler metal.
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> Definition of buffer layer material: All filler metals used for the buffer layers will be specified and purchased in accordance with the ASME Code, Section II, Part C, and certified to the ASME Code Section III. One or more stainless steel buffer layer(s), using either SFA-5.9 ER308L, ER309L, or ER316L will be deposited over the stainless steel pipe components to reduce the potential for hot cracking of the Alloy 52M overlay deposit. The filler material used will meet the minimum material specification requirements for delta ferrite. The implementation of buffer layers is presented schematically in Figure 4 [of the relief request]. The thickness of the buffer layer(s) will not be credited as structural thickness in the design calculations.
>
> Definition of SWOL filler material: All filler metals used for the SWOL will be specified and purchased in accordance with the ASME Code, Section II, Part C, and certified to the ASME Code, Section III. The body of the SWOL will use SFA-5.14, ERNiCrFe-7A [(Alloy 52M)]. This material contains a specified minimum chromium (Cr) content of at least 28 percent. The Cr content of the first layer of deposited weld metal will be determined by chemical analysis of a representative coupon taken from a mockup that will be prepared in accordance with the welding procedure specification for the production weld, and shall demonstrate a minimum Cr content of at least 24 percent. The thickness of the first layer and subsequent layers will be credited toward the required SWOL thickness.

Crack Growth Analysis and Design

The licensee stated that the proposed analyses and verifications will meet or exceed the criteria specified in Code Case N-740-2 as discussed below.

The licensee will perform crack growth calculations as required by Code Case N-740-2 as part of a design package. The licensee will conduct qualified ultrasonic examinations prior to the installation of the weld overlay, and the flaw size will be measured, per Code Case N-740-2. However, flaw characterization and evaluation requirements will be based on a postulated flaw depth of 75 percent through of original wall-thickness for two postulated flaws: a postulated

axial flaw and a postulated circumferential flaw. For the postulated axial flaws, the axial flaw length shall be 1.5 inches. For the postulated circumferential flaw, the circumferential flaw length shall be assumed to be 360 degrees. The size of all flaws will be projected to the end of the design life of the overlay, which will be a minimum of 10 years, which exceeds the remaining operating license duration for each unit.

The licensee will evaluate the SWOL, with the postulated flaw, for all the design transients and the observed thermal cycling phenomena. Crack growth, considering the effects of two different flaw growth mechanisms: fatigue crack growth and SCC, will be evaluated in accordance with ASME Code, Section XI, IWB-3640. If the flaw is at or near the boundary of two different materials, evaluation of flaw growth in both materials will be evaluated.

The licensee stated that it will perform the following analyses and verifications, which will meet or exceed the criteria specified in Code Case N-740-2 or in the applicable alternatives that are proposed in this request.

1. The licensee will perform component specific stress analyses to establish a residual stress profile in the weld. The licensee has reviewed the fabrication records for welds WIB-228 and WIB-245 and found no evidence of ID repair by welding during the production of these welds. The licensee stated that the inside diameter weld repairs will be assumed in the residual stress analysis to conservatively bound any actual weld repairs that may have occurred during original construction. In its letter dated November 20, 2017, the licensee confirmed that its weld residual stress analysis does include a postulated inside diameter weld repair as recommended by paragraph 3, Section 3.2.2 of the NRC Safety Evaluation Report for EPRI Report MRP-169, Revision 1A, "Technical Basis for Preemptive Weld Overlays for Alloy 82/182 Butt Welds in PWRs (MRP-169)" (ADAMS Accession No. ML101660468). The NRC safety evaluation states, in part:

   > The residual stress analysis assumes a highly unfavorable, pre-overlay residual stress condition which would result from an inside diameter surface weld repair during construction.

   The residual stress 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, and under cyclic thermal conditions, will be shown to result in an improved stress state in the overlaid weld that reduces the probability for further crack propagation.

   In addition, the licensee will perform fracture mechanics analyses to predict crack growth in the weld to thermal fatigue and possible SCC. The crack growth analyses will consider all design loads and transients, the thermal stratification and cycling loads, plus the post-weld overlay through-wall residual stress distributions. The licensee will include a summary of the DCPP, Units 1 and 2 combined pertinent temperature data in the crack growth evaluation. The crack growth analyses will determine the time period for the postulated cracks to reach the allowable flaw size after installation of the weld overlay. The allowable flaw size will be determined in accordance with the ASME Code, Section XI, Appendix C for the SWOL geometry. This time period will meet or exceed the design requirement of the weld overlay (i.e., continued operation of both the units until the expiration of the current operating license).

2. The licensee will demonstrate, by analyses, that the application of the weld overlay does not affect the conclusions of the existing piping analysis reports. The analyses will also demonstrate that the ASME Code, Section III, stress and fatigue criteria, for both design loadings and the observed thermal cycling phenomena, are continued to be met for the subject piping.

3. The licensee will evaluate the weight of overlay to determine its impact on piping system stresses and dynamic characteristics.

4. The licensee will measure axial shrinkage before and after the weld overlay application. Shrinkage stresses arising from the weld overlays at other locations in the piping systems will be demonstrated to not 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 licensee will measure the as-built dimension of the weld overlays and evaluate to demonstrate that the as-built dimensions equal or exceed the minimum design dimensions of the overlays.

The ASME Code, Section XI, subparagraph IWB-3134(b) states:

> Analytical evaluation of examination results as required by IWB-3132.3 shall be submitted to the regulatory authority having jurisdiction at the plant site.

The licensee stated that in accordance with the requirements of paragraph IWB-3134, summaries of the analytical evaluation results associated with analysis discussed in Items 1, 2, and 3 above will be completed prior to the applicable outages and submitted to the NRC following installation of the weld overlays. The licensee stated that Items 4 and 5 above will be performed following installation of the weld overlays and results will be included in the design modification package closure documents. This information will be made available to NRC resident or field inspectors for review.

In its letter dated November 20, 2017, the licensee stated, in part, that:

> The proposed SWOLs are currently being designed to completely replace the structural element of the piping at the subject location. In addition, the SWOLs will impart compressive residual stresses in the remaining ligament of the subject piping, such that the flaw growth will be halted or curtailed significantly, and the integrity of the piping will be maintained. The design and flaw growth evaluations (which assume that the SWOLs are installed) are in progress. The licensee stated that the requirements for design and flaw growth evaluations that are specified in Code Case N-740-2 will be met.

The licensee further stated, in part, that it "has not calculated the maximum allowable flaw depth [at the time of the relief request submittal] because of the number of calculations and analysis iterations that would need to be performed. The design of the SWOL is based on a specific postulated flaw depth, consistent with the requirements of Code Case N-740-2. The postulated flaw depth is conservative when compared to the predicted flaw depth at the time of the SWOL installation. The licensee stated that the subject welds will be reexamined prior to the SWOL

installation to measure the flaw depth. The existing flaw depth is predicted to grow to approximately 0.6 inches at the end of the current operating cycle."

The licensee stated that the growth analyses of the existing flaws in the subject welds show that growth of flaw depth vs. time is non-linear. A real-time flaw growth rate cannot be determined with only two measurements (i.e., only two data points will be available at the time of the SWOL installation). The licensee explained that as a result, the measured flaw depth will be used to determine whether a modification to the SWOL design is warranted. The licensee stated that if the measured flaw depth obtained during the pre-overlay examination exceeds the predicted flaw depth prior to SWOL installation, it will re-perform the design calculations to ensure the designed SWOL will continue to mitigate the weld.

The licensee stated that it has not identified a specific flaw growth rate (or flaw depth upper bound) that would result in a modification to the SWOL design. However, if the SWOL design calculations are required to be re-performed as a result of a flaw growth rate exceeding the predication, the licensee will determine whether a modification to the SWOL design is warranted. The licensee will also evaluate if a change in the inspection schedule is appropriate in addition to those required per Code Case N-740-2, if the measured flaw depth exceeds the predicted flaw depth.

Installation

Prior to installing the weld overlay, the licensee will install a buffer layer on the subject welds/pipes. The purpose of the buffer layer is to reduce the probability of cracking when Alloy 52M filler metal is welded to the host pipe that has high sulfur content.

The licensee stated that during welding, the interpass temperature will be measured by direct measuring devices (e.g. thermocouples, pyrometers, temperature indicating crayons). However, the interpass temperature will be determined by heat flow calculations when it is impractical to use the direct measurement methods only if there are extenuating radiological conditions.

The licensee will use a Welding Procedure Specification (WPS), qualified for groove welding in accordance with the ASME Code, Section III, Article NB-4000, using Alloy 52M filler metal with a minimum chromium content of 28 percent, per Section 1.2, "General Overlay Requirements," of Code Case N-740-2. This WPS will also be qualified for deposition of the ER308L, ER309L, or ER316L filler metal to be used for the buffer layer.

The licensee's vendor will use machine gas tungsten arc welding (GTAW) for installation of the overlay. The weld processes to be used for any repairs of the existing pipe base metal surface or the SWOL during installation have not been proposed by the vendor at this time. The licensee stated that if the vendor desires to use additional welding processes (such as manual GTAW or shielded metal arc welding) for any work scope involved with installation of the SWOL, the licensee will inform the NRC senior resident or inspectors prior to use.

The licensee stated that the provisions of ASME Code Case N-740-2, Mandatory Appendix I (Temper Bead) are not required. Mandatory Appendix I is only applicable when the SWOL will be deposited on ferritic materials with impact properties sensitive to quenching and tempering. The P-No. 8 stainless steel materials in the proposed alternative have an austenitic microstructure, which excludes the need for temper bead welding.

Examinations

Pre-Overlay Examinations

The licensee stated that it will conduct qualified ultrasonic examinations prior to the installation of the weld overlay and will determine the flaw size, if detected. As discussed above, if the measured flaw depth exceeds the predicted flaw depth, the licensee will re-perform the design calculations to ensure the designed SWOL will continue to mitigate the weld.

Acceptance and Preservice Examinations

The licensee will perform the acceptance and preservice examinations of the weld overlay after installation and prior to service. The purpose of the acceptance examination is to ensure a quality overlay. The purpose of the preservice inspection is to locate and size any indications and to provide a baseline for future inservice examinations. These two examinations will be performed during the same time period.

As a part of the design, the SWOL length, surface finish, and flatness are specified to allow for post-installation, ultrasonic examinations, which must be qualified in accordance with the ASME Code, Section XI, Mandatory Appendix VIII, Supplement 11. The licensee will perform an ultrasonic examination of the weld overlay in accordance with Code Case N-740-2 and Code Case N-653-1, "Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds, Section XI, Division 1," with certain exceptions. As an alternative to satisfy the performance demonstration requirements of the ASME Code, Section XI, Mandatory Appendix VIII, Supplement 11, the licensee will implement a Performance Demonstration Initiative (PDI) Program in accordance with the EPRI Report 1026510, "Nondestructive Evaluation: Performance Demonstration Initiative (PDI) Comparison to ASME Section XI, Appendix VIII, 2007 Edition with 2008 Addenda, and 10 CFR 50.55a, Year 2011," November 2012 (publicly available at the EPRI website). The PDI qualification is contained in ASME Code Case N-653-1, which is approved in the Draft Revision 18 of RG 1.147. The licensee has demonstrated the acceptability of its PDI program to the requirements of ASME Code, Section XI, Mandatory Appendix VIII, Supplement 11, as shown in Attachment 1 to the enclosure of the relief request by letter dated September 26, 2017.

The licensee stated that the proposed examinations by PDI are considered more sensitive for detection of defects, either from fabrication or service-induced, than the radiography or ultrasonic testing methods in accordance with the ASME Code, Section III. Further, construction flaws are included in the PDI qualification sample sets for evaluating procedures and personnel.

The licensee will verify the results from the examinations using acceptance criteria and evaluation methodology specified in the ASME Code, Section XI. These criteria consider the materials in which the flaw indications are detected, the orientation and size of the indications, and ultimately their potential structural effects on the subject pipe. The licensee stated that any planar flaws found in the SWOL, during either the weld overlay acceptance or preservice examinations, are required to meet the preservice standards of the ASME Code, Section XI, Table IWB-3514-2, as supplemented in Code Case N-740-2. Any laminar flaws found in the SWOL during either the weld overlay acceptance or preservice examinations are required to meet the preservice standards of ASME Code, Section XI, Table IWB-3514-3, as supplemented in Code Case N-740-2.

The licensee stated that the ultrasonic examination will be performed to the maximum extent practicable, for axial and circumferential flaws, in accordance with Code Case N-740-2. Schematic representation of the required ultrasonic examination volume is shown in the revised Figure 5 in the licensee's letter dated November 20, 2017.

The licensee will provide the following information to the NRC resident or field inspectors for review within 14 days after the completion of the ultrasonic examination of the SWOL installation: (a) the acceptance examination results of the weld overlays, (b) the preservice inspection results of the weld overlays, and (c) a description of any repairs to the overlay material and/or base metal and the reason for repair.

Inservice Examinations

The licensee stated that subsequent ISIs will be conducted per the requirements of Section 3, "Examination," of the Code Case N-740-2 including paragraphs 3(c)(4), 3(c)(6) and 3(c)(7) for the current fourth inservice inspection (ISI) interval. The weld overlay examination will be added to the current fourth interval ISI plan. The licensee further stated that any indication propagating into the weld overlay material, either by thermal fatigue or SCC, will be considered unacceptable.

The schedule for ultrasonic examinations is as follows, as stated by the licensee in its letter dated November 20, 2017:

> Schedule for ultrasonic examinations of DCPP, Unit 2 weld WIB-245 SWOL, during upcoming refueling outages:
>
> - Unit 2 twentieth refueling outage (February 2018): [Perform] Acceptance examination and preservice examination after the SWOL is installed.
>
> - Unit 2 twenty-first refueling outage (2R21) (circa October 2019) or Unit 2 twenty-second refueling outage (2R22) (circa May 2021): [Perform] Inservice examination[1].
>
> - Unit 2 twenty-fourth refueling outage (circa October 2024): [Perform] Inservice examination per Code Case N-740-2 paragraph 3(c)(6) if required by 2R21 OR 2R22 examination result.
>
> - [Unit 2] End of license on August 26, 2025.
>
> Schedule for ultrasonic examinations of Unit 1 weld WIB-228 SWOL, during upcoming refueling outages:
>
> - Unit 1 twenty-first refueling outage (circa February 2019): [Perform] acceptance examination and preservice examination [after the SWOL is installed].

[1] The licensee noted that it will confirm the inservice examination and assign resources when the associated refueling outage schedule is finalized. This flexibility in inservice examination schedule is in accordance with Code Case N-740-2.

- Unit 1 twenty-second refueling outage (circa October 2020) OR Unit 1 twenty-third refueling outage (circa May 2022): [Perform] Inservice examination[2].

- [Unit 1] End of license on November 2, 2024.

Pressure Testing

The licensee does not take exception to Section 4, "Pressure Testing," of Code Case N-740-2, which requires that a system leakage test be performed in accordance with the ASME Code, Section XI, Article IWA-5000.

3.7 Duration of Proposed Alternative

The licensee proposed that the alternative be applicable to the fourth 10-year ISI intervals for Unit 1, which commenced on May 7, 2015, and will end on November 2, 2024 (end of operating license); and for Unit 2 which commenced on March 13, 2016, and will end August 26, 2025 (end of operating license). The SWOL installed in accordance with the provisions of this alternative will remain in place until the expiration of the current operating license of both units.

3.8 NRC Staff Evaluation

The NRC staff has not approved the use of Code Case N-740-2. However, the NRC has approved the use of Code Case N-504-4 and the 2007 Edition of the ASME Code, Section XI, Nonmandatory Appendix Q, "Weld Overlay Repair of Classes 1, 2, and 3 Austenitic Stainless Steel Piping Weldments." Both of these documents provide requirements for the weld overlay on stainless steel piping such as the subject RHR piping. The NRC staff evaluation of the proposed alternative in the areas of general requirements, material specifications, crack growth analysis and design, installation, examinations, and pressure testing is based on the requirements of Code Case N-504-4 and Nonmandatory Appendix Q

General Requirements

The NRC staff finds that the proposed alternative did not take exception to Section 1, General Requirement of Code Case N-740-2. The NRC staff notes that the general requirements of the proposed alternative satisfy the general requirements of Code Case N-504-4 and ASME Code, Section XI, Nonmandatory Appendix Q. Therefore, the general requirements of the proposed alternative are acceptable.

Material Specifications

The NRC staff finds that the proposed alternative will use nickel-based Alloy 52M for the weld overlay and stainless steel filler metal SFA-5.9 ER308L, ER309L, or ER316L for the buffer layer. The NRC staff notes that Code Case N-504-4 and the ASME Code, Section XI, Nonmandatory Appendix Q do not specify Alloy 52M as a weld filler metal. However, the NRC staff has approved the use of Alloy 52/52M for the weld overlay in relief requests for other nuclear power plants. Thus far, the operating experience of using these two weld metals in the

[2] The licensee noted that it will confirm the inservice examination and assign resources when the associated refueling outage schedule is finalized. This flexibility in inservice examination schedule is in accordance with Code Case N-740-2.

weld overlay installation has been acceptable. Therefore, the NRC staff finds that the weld material that will be used in the proposed alternative is acceptable.

Crack Growth Analysis and Design

The NRC staff finds that the crack growth analysis and design of the proposed alternative are consistent with the requirements of Code Case N-504-4 and the ASME Code, Section XI, Nonmandatory Appendix Q, Article Q-3000. The weld overlay thickness is designed based on assuming a 100 percent through-wall flaw in the axial and circumferential direction. The circumferential flaw is assumed to be 360 degrees and the axial flaw is assumed to be 1.5 inches, which covers the width of the existing weld. The licensee will also calculate the growth of a postulated flaw having a depth of 75 percent through wall in the subject welds to ensure that the weld overlay will maintain the structural integrity of the pipe at the end of operating license. The NRC staff notes that the design and analysis requirements in the proposed alternative either consistent or exceed the design and analysis requirements of Code Case N-504-4 and the ASME Code, Section XI, Nonmandatory Appendix Q, Article Q-3000.

The NRC staff finds acceptable that the licensee will either submit or make available for NRC staff review the design calculations and crack growth analyses.

Therefore, The NRC staff finds that the crack growth analysis and design requirements of the proposed alternative are acceptable.

Installation

The NRC staff finds acceptable that the licensee will install a buffer layer on the subject welds/pipes to minimize the probability of hot cracking when 52M filler metal is welded to a pipe that has high sulfur content.

The NRC staff finds that the licensee will follow the requirements of ASME Code, Section III, Article NB-4000, using Alloy 52M with a minimum Cr content of 28 percent, per Section 1.2, "General Overlay Requirements," of Code Case N-740-2. The licensee's vendor will use machine GTAW for installation of the overlay. The NRC staff finds acceptable that the weld overlay installation satisfies the ASME Code, Section III, Article NB-4000; Section XI, Nonmandatory Appendix Q; and Code Case N-504-4.

Examinations

The NRC staff finds that the licensee's PDI program is consistent with the PDI program that the NRC has previously approved for other licensees. Therefore, the NRC staff finds the PDI program in the proposed alternative is acceptable.

Pre-Overlay Examination

The NRC staff finds acceptable that, as a defense-in-depth measure, if the pre-overlay examination shows that the measured flaw depth exceeds the predicted flaw depth, the licensee will re-perform the design calculations to ensure the designed SWOL will continue to mitigate the weld. The NRC staff finds that the licensee's pre-overlay examination satisfies Code Case N-504-4 and the ASME Code, Section XI, Nonmandatory Appendix Q, and therefore, is acceptable.

Acceptance and Preservice Examinations

The NRC staff finds that the acceptance examination of the proposed alternative does not take exception to Code Case N-740-2. The NRC staff notes that in terms of acceptance examination, Code Case N-740-2 provides more requirements than that of the ASME Code, Section XI, Nonmandatory Appendix Q, Article Q-4100. The NRC staff finds that the acceptance examination, as required by the proposed alternative, satisfies Nonmandatory Appendix, Article Q-4100, and, therefore, is acceptable.

The NRC staff finds that the pre-service examination of the proposed alternative does not take exception to Code Case N-740-2. The NRC staff finds that the pre-service examination as required by the proposed alternative is consistent with the pre-service examination requirements of the Code Case N-504-4 and the ASME Code, Section XI, Nonmandatory Appendix, Article Q-4200, and, therefore, is acceptable.

Inservice Examination

The NRC staff finds that the proposed alternative will follow the inservice examination requirements of Code Case N-740-2 for the fourth ISI interval. Specifically, the licensee will perform an ultrasonic examination during the first or second refueling outage after overlay is installed. The NRC staff finds that the proposed in-service examination schedule is acceptable because it is consistent with the ASME Code, Section XI, Nonmandatory Appendix Q, Article Q-4300.

The licensee has assumed that the flaw degradation mechanism is thermal stratification and thermal cycling. The NRC staff notes that Alloy 52M weld material used in the weld overlay is not resistant to thermal fatigue; therefore, the existing flaw may propagate into the weld overlay. The licensee responded that any indication propagating into the weld overlay material, either by thermal fatigue or stress corrosion cracking, will be considered unacceptable. The NRC staff finds this condition is appropriate and, therefore, is acceptable.

The NRC staff finds that the in-service examination in the proposed alternative is consistent with the in-service examination of the Code Case N-504-4 and the ASME Code, Section XI, Nonmandatory Appendix Q, and therefore, is acceptable.

Pressure Testing

The licensee did not take exception to the system leakage test in Section 4 of Code Case N-740-2, (i.e., the licensee will perform pressure testing per the ASME Code, Section XI, Article IWA-5000). The NRC staff finds this is acceptable because it is either consistent or exceeds the pressure testing requirement of the ASME Code, Section XI, Nonmandatory Appendix Q, Article Q-4400.

In summary, the NRC concludes that the proposed alternative provides reasonable assurance of the structural integrity and leak tightness of the subject welds because the design, material specifications, crack growth analysis and design, installation, examinations and pressure testing of the proposed weld overlay satisfy Code Case N-504-4 and the ASME Code, Section XI, Nonmandatory Appendix Q.

4.0 CONCLUSION

As set forth above, the NRC staff determines that the proposed alternative provides an acceptable level of quality and safety. Accordingly, the NRC staff concludes that the licensee has adequately addressed all of the regulatory requirements set forth in 10 CFR 50.55a(z)(1). Therefore, the NRC staff authorizes the use of Relief Request REP-RHR-SWOL for the fourth 10-year ISI interval at the DCPP, Unit 1, which ends on November 2, 2024, and at the DCPP, Unit 2, which ends on August 26, 2025.

The NRC staff recognizes that the SWOL installed in accordance with the provisions of this alternative will remain in place until the expiration of the current operating license for both DCPP units.

The NRC staff notes that this authorization does not imply or infer the NRC approval of generic use of Code Case N-740-2.

All other requirements in ASME Code, Section XI, 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.

Principal Contributor: J. Tsao, NRR/DMLR/MPHB

Date: January 2, 2018

SUBJECT: DIABLO CANYON POWER PLANT, UNITS 1 AND 2 – RELIEF REQUEST REP-RHR-SWOL, REQUEST FOR APPROVAL OF ALTERNATIVE FOR APPLICATION OF FULL STRUCTURAL WELD OVERLAY (EPID L-2017-LLR-0092) DATED JANUARY 2, 2018

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