December 13, 2007

Mr. Richard M. Rosenblum
Senior Vice President and Chief Nuclear Officer
Southern California Edison Company
San Onofre Nuclear Generating Station
P.O. Box 128
San Clemente, CA 92674-0128

SUBJECT: SAN ONOFRE NUCLEAR GENERATING STATION, UNIT 2 AND UNIT 3 - RE: REQUEST APPROVAL TO USE ALTERNATIVES TO THE REQUIREMENTS OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS CODE, SECTION XI, IWA-4000, FOR REPAIR/REPLACEMENT ACTIVITIES RELATED TO THE PERFORMANCE OF STRUCTURAL WELD OVERLAYS (TAC NOS. MD4580 AND MD4581)

Dear Mr. Rosenblum:

By letter dated February 21, 2007, as supplemented by letter dated September 21, 2007, Southern California Edison Company (SCE, the licensee) submitted Relief Request (RR) ISI-3-27 to use alternatives to the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code), Section XI, 1995 Edition through 1996 Addenda, IWA-4000, for repair/replacement activities related to the performance of structural weld overlays at San Onofre Nuclear Generating Station, Units 2 and 3 for the third 10-year inservice inspection (ISI) interval.

ISI-3-27 requests relief from the requirements of the ASME Code pursuant to paragraph 50.55a(a)(3)(i) of Title 10 of the *Code of Federal Regulations* (10 CFR). Modifications to ASME Code Cases N-504-2 and N-638-1, and Supplement 11, to the 1995 Edition including 1996 Addenda of the ASME Code, Section XI, were submitted specifically for the purpose of performing preemptive full structural weld overlays on pressurizer surge nozzle safe-ends and their adjoining welds. The relief request is for the remainder of the third 10-year ISI program interval which began on August 18, 2003, and ends on August 17, 2013.

The NRC staff has completed its review of this submittal and concludes that the ISI program relief request ISI-3-27 provides an acceptable level of quality and safety. The NRC staff authorizes the alternatives proposed by SCE in accordance with 10 CFR 50.55a(a)(3)(i), for the remainder of the third 10-year ISI program interval. 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.

The staff's safety evaluation is enclosed. If you have any questions, please contact N. Kalyanam, Project Manager, at 301-415-1480.

Sincerely,

/RA/

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

Docket Nos. 50-361 and 50-362

Enclosure: Safety Evaluation

cc w/encl: See next page

The staff's safety evaluation is enclosed. If you have any questions, please contact N. Kalyanam, Project Manager, at 301-415-1480.

Sincerely,

/RA/

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

Docket Nos. 50-361 and 50-362

Enclosure: Safety Evaluation

cc w/encl: See next page

DISTRIBUTION:

PUBLIC	RidsNrrDorlLpl4	RidsRgn4MailCenter
LPLIV r/f	RidsNrrLAJBurkhardt	DPelton, EDO RIV
RidsAcrsAcnwMailCenter	RidsNrrPMNKalyanam	DTarantino, NRR/DCI/CPNB
RidsNrrDciCpnb	RidsOgcRp	

ADAMS Accession No.: ML0733250004 *No comments major changes from Staff SE

OFFICE	NRR/LPL4/PM	NRR/LPL4/LA	DCI/CPNB*	OGC	NRR/LPL4/BC
NAME	NKalyanam	JBurkhardt	TChan	RVHolmes, NLO	THiltz
DATE	12/3/07	11/30/07	11/6/07	12/11/07	12/13/07

OFFICIAL RECORD COPY

San Onofre Nuclear Generating Station
Units 2 and 3

cc:
Douglas K. Porter, Esquire
Southern California Edison Company
2244 Walnut Grove Avenue
Rosemead, CA 91770

Dr. David Spath, Chief
Division of Drinking Water and
Environmental Management
California Dept. of Health Services
850 Marina Parkway, Bldg P, 2nd Floor
Richmond, CA 94804

Chairman, Board of Supervisors
County of San Diego
1600 Pacific Highway, Room 335
San Diego, CA 92101

Mark L. Parsons
Deputy City Attorney
City of Riverside
3900 Main Street
Riverside, CA 92522

Mr. Gary L. Nolff
Assistant General Manager - Resources
Riverside Public Utilities
City of Riverside, California
3901 Orange Street
Riverside, CA 92501

Regional Administrator, Region IV
U.S. Nuclear Regulatory Commission
611 Ryan Plaza Drive, Suite 400
Arlington, TX 76011-8064

Mr. Michael L. De Marco
San Diego Gas & Electric Company
8315 Century Park Ct. CP21G
San Diego, CA 92123-1548

Resident Inspector
San Onofre Nuclear Generating Station
c/o U.S. Nuclear Regulatory Commission
Post Office Box 4329
San Clemente, CA 92674

Mayor
City of San Clemente
100 Avenida Presidio
San Clemente, CA 92672

Mr. James T. Reilly
Southern California Edison Company
San Onofre Nuclear Generating Station
P.O. Box 128
San Clemente, CA 92674-0128

Mr. James D. Boyd
California State Liaison Officer
Vice Chair and Commissioner
California Energy Commission
1516 Ninth Street, MS 31
Sacramento, CA 95814

Mr. Gary Butner
Acting Branch Chief
Department of Public Health Services
Radiologic Health Branch
MS 7610, P.O. Box 997414
Sacramento, CA 95899-7414

Mr. Ross T. Ridenoure
Vice President and Site Manager
Southern California Edison Company
San Onofre Nuclear Generating Station
P.O. Box 128
San Clemente, CA 92674-0128

Mr. A. Edward Scherer
Director, Nuclear Regulatory Affairs
Southern California Edison Company
San Onofre Nuclear Generating Station
P.O. Box 128
San Clemente, CA 92674-0128

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELIEF REQUEST ISI-3-27 FULL STRUCTURAL WELD OVERLAY

AND ALTERNATIVE REPAIR TECHNIQUES

SOUTHERN CALIFORNIA EDISON

SAN ONOFRE NUCLEAR GENERATING STATION, UNITS 2 AND 3

DOCKET NUMBERS 50-361 and 50-362

1.0 INTRODUCTION

By letter to the U.S. Nuclear Regulatory Commission (NRC), dated February 21, 2007 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML070570433), and request for additional information (RAI) response dated September 21, 2007 (ADAMS Accession No. ML072680843), Southern California Edison (SCE), proposed alternatives under Relief Request (RR) ISI-3-27, for San Onofre Nuclear Generating Station, Units 2 and 3 (SONGS 2 and 3), to the repair requirements of American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME), Section XI. SCE's alternative repair includes Code Case N-504-2, "Alternative Rules for Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping, Section XI, Division 1," Code Case N-638-1, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW [Gas Tungsten-Arc Welding] Temper Bead Technique," and ASME Code, Section XI, Appendix VIII, Supplement 11, "Qualification Requirements for Full Structural Overlaid Wrought Austenitic Piping Welds," in lieu of the requirements of the 1995 Edition through the 1996 Addenda of ASME Code (1995A96 Edition), Section XI. The alternatives would be used to perform full structural weld overlays (SWOL) on reactor coolant system (RCS) surge, drain, and shutdown cooling nozzle safe ends.

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. The ASME Code of record for the current third 10-year ISI interval at SONGS 2 and 3 is the 1995A96 Edition, Section XI. Pursuant to 10 CFR 50.55a(a)(3), alternatives to requirements may be authorized by the NRC if the licensee demonstrates that: (i) the proposed alternatives provide an acceptable level of quality and safety, or (ii) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

SCE submitted RR ISI-3-27, dated February 21, 2007, pursuant to 10 CFR 50.55a(a)(3)(i), which proposed alternatives to the implementation of the ASME Code, Section XI, IWA-4000, and Appendix VIII, Supplement 11. SCE's alternative is based on Code Cases N-504-2 and N–638-1, with modifications, for the deposition of full SWOL and the performance demonstration initiative (PDI) program implementation of Appendix VIII.

3.0 TECHNICAL EVALUATION

3.1 Code Requirements

The following lists the code requirements for which SCE is requesting relief:

1. The 1995A96 Edition of the ASME Code, Section XI, Article IWA-4610(a), "Repair/Replacement Activities."

2. The 1995A96 Edition of the ASME Code, Section XI, Appendix VIII, Supplement 11, "Performance Demonstration for Ultrasonic Examination Systems."

3.2 System/Components for which the Alternative is Requested

The components for which RR 3-ISI-27 applies are RCS nozzle-to-safe end dissimilar metal welds (DMW) and adjacent safe end-to-piping similar metal welds (SMW). In addition, the components are high safety significant (HSS), ASME Code Class 1. The examination category is B-J for risk-informed (RI) piping examinations. The three DMW and SMW welds scheduled for full SWOL at SONGS 2 and 3 are listed as follows:

Apply Full SWOL on Three HSS, Class 1 Nozzle-to-Safe End DMW Extending Across the Adjacent Safe End-to-Pipe SMW.				
Location	**INSERVICE INSPECTION (ISI) DESIGNATION NUMBER**			
	Nozzle-to-Safe End DMW Units 2 and 3	**Code Item No.**	**Safe End-to-Pipe SMW Units 2 and 3**	**Code Item No.**
Hot Leg Surge Line	02-006-010/03-006-010*	B9.11	02-016-016/03-016-016**	B9.11
Hot Leg Drain	02-006-011/03-006-011*	B9.21	02-030-001/03-030-010**	B9.21
Shutdown Cooling Line	02-007-009/03-007-009*	B9.11	02-021-001/03-021-010**	B9.11

NOTES: *Welds susceptible to primary water stress-corrosion cracking (PWSCC) and Thermal Fatigue.
**Welds susceptible to Thermal Fatigue.

Apply Full SWOL on Three HSS, Class 1 Nozzle-to-Safe End DMW Extending Across the Adjacent Safe End-to-Pipe SMW.		
DMW Location(1)	**Nozzle Material Specification**(2)	**Safe End Material Specification**(3)
Hot Leg Surge Line	SA-105 GR II	SA-351 GR CF8M
Hot Leg Drain		SA-182 F316
Shutdown Cooling Line		SA-351 GR CF8M
SMW Location(4)	**Pipe Material Specification**(5)	
Hot Leg Surge Line	SA 376 Grade TP316	
Hot Leg Drain		
Shutdown Cooling Line	SA-403 Grade WP316	

(1) Safe end-to-nozzle weld and buttering = Alloy 82/182, Inconel (F-43)
(2) Surge line nozzle, Drain nozzle, Shutdown Cooling line nozzle = Forging, Carbon Steel (P-1, Group 2)
(3) Surge line safe end and Shutdown Cooling line safe end (Cast), Drain safe end (Forging) = Stainless Steel (P-8, Group 1)
(4) Safe end-to-pipe weld = Alloy E308L, Stainless Steel (A-8)
(5) Surge line pipe and Drain pipe (Wrought Seamless), Shutdown Cooling line pipe (Wrought Seamless or Welded) = Stainless Steel (P-8, Group 1)

3.3 Reason for Request

Currently, there are no comprehensive criteria for a licensee to apply a SWOL repair to a DMW that is constructed of Alloy 82/182 weld material, which is susceptible to PWSCC. Although the ASME Code, Section XI, 1995A96 Edition, IWA-4000 is used for the SONGS 2 and 3 repair/replacement program, it does not have the needed requirements for this type of repair. Also, the latest NRC-approved ASME Code does not have the needed requirements for this type of repair. Repair/replacement activities associated with a SWOL repair of this type are required to address the materials, welding parameters, as low as reasonably achievable (ALARA) concerns, operational constraints, examination techniques, and procedure requirements.

3.4 Proposed Alternative and Basis

3.4.1 Full Structural Weld Overlay Design Criteria

An SWOL repair is proposed for the DMW and extends across the adjacent SMW identified in Section 3.2 above. In addition, material specifications are provided in the Section 3.2 table above. The overlay will be designed as a full SWOL in accordance with ASME Code, Section XI, Code Case N-504-2 and Nonmandatory Appendix Q which is a condition to using the code case. The temper bead welding technique will be implemented in accordance with ASME Code, Section XI, Code Case N-638-1 for that portion of the overlay applied over the ferritic base material for which the Construction Code requires post-weld heat treatment (PWHT). Temperature monitoring requirements contained within Code Case N-638-1 will be performed using contact pyrometers in lieu of thermocouples required by IWA-4610(a) of the ASME Code, Section XI, 1995A96 Edition.

Additionally, the SWOL will be sized as a full SWOL designed to satisfy the ASME Code, Section III, requirements without crediting the existing pipe. SCE assumes the crack depth for weld overlay (WOL) sizing is equal to the original wall thickness (t original pipe). To meet the general Section XI requirement that no flaw of depth greater than 75 percent through-wall is acceptable, this requires:

$$\text{Crack depth} / (t_{\text{original pipe}} + t_{WOL}) = 0.75,\ t_{WOL} = 1/3 \text{ original pipe wall thickness.}$$

SCE also considers the piping loads in the WOL sizing. The final size of each WOL will be the larger of these two calculations. The planned full SWOL is designed to be more conservative than a "t optimized" WOL that assumes a crack depth equivalent to 75 percent of the original wall thickness only.

SCE stated that crack-growth calculations will be performed to determine the time for any observed flaw indications to grow to the overlay design basis in the structural sizing calculations (through-wall flaw) due to fatigue and stress-corrosion crack growth. These calculations will use as an initial flaw size the flaw depth detected by nondestructive examination (NDE) (if any) prior to the weld overlay. If no flaws are detected, the initial flaw size will be assumed to be 10 percent of the original wall thickness, based on a conservative estimate of the detection threshold for the NDE.

SCE stated that this SWOL (weld reinforcement) will completely cover the existing Alloy 82/182 weld metal and will extend onto the ferritic and austenitic stainless steel material on each end of the weld. To avoid stress risers, the weld material is extended and tapered across the pipe and nozzle side. The end slope is required to be no steeper than 45 degrees to minimize stress concentration.

SCE stated sufficient overlay length is provided to allow for adequate transfer of axial loads between the pipe and the SWOL. Therefore, the length of the actual SWOL will exceed the minimum length required by ASME Code Case N-504-2 and Section XI, Nonmandatory Appendix Q, for load redistribution and inspection purposes.

SCE stated that inspection requirements are a controlling factor in the SWOL repair design. The length of the SWOL must be sufficient for inspection of an area that is one-half inch beyond the required repair length and the outer 25 percent of the original wall thickness. It should be noted that the length of the SWOL may be extended and blended into the low-alloy steel nozzles outer diameter taper to permit ultrasonic (UT) inspection of the weld and minimize stress concentration on the nozzle outer diameter. Since generally the outside diameter of the nozzle is larger than that of the safe end, the SWOL thickness on the safe end will be increased to allow a smooth transition surface for UT inspection. Therefore, the final SWOL length and thickness after taking into consideration the UT inspection requirements will exceed the length required for a SWOL repair in accordance with the ASME Code Case N-504-2 and Section XI, Nonmandatory Appendix Q.

SCE stated that the combination of deposition of PWSCC-resistant weld reinforcement on the outside surface of the DMW, with favorable axial and hoop residual compressive stress produced on the inside diameter due to shrinkage will result in acceptable assurance for

long-term crack mitigation. In addition, ISI is facilitated because of the enhanced ability to inspect the joint.

3.4.2 Code Case N-504-2(g) Flaw Evaluations and Shrinkage Stress Effects Analyses

SCE will complete flaw evaluations and shrinkage stress effect evaluations prior to returning SONGS 2 and 3 to service from their respective Cycle 15 refueling outage. The evaluation records will be maintained on site and available for NRC review at any time.

3.4.3 Pre-Weld Overlay NDE

SCE will perform NDE to meet the requirements of Appendix VIII, Supplement 10, as modified by the PDI Program. However, because the material of the hot-leg surge line safe end and the shutdown cooling line safe end is cast austenitic stainless steel, SCE will perform the qualified Appendix VIll, Supplement 11, as modified by the PDI Program UT exam, on the Alloy 82/182 welds from the nozzle side, which is ferritic steel. Appendix VIII, Supplement 9, "Qualification Requirements for Cast Austenitic Piping Welds," is in the course of preparation and is not required by 10 CFR 50.55a(g)(6)(ii)(c). Therefore, to meet the RI-ISI UT examination requirement of the hot-leg surge line and shutdown cooling line nozzles, SCE will perform UT examination from the cast austenitic stainless steel side in accordance with ASME Code, Section XI, Appendix III. Additionally, the UT examination of the stainless steel SMW adjacent to the hot-leg surge line and shutdown cooling line nozzles will be performed in accordance with ASME Code, Section XI, Appendix III, from the cast austenitic stainless steel side and Appendix VIII, Supplement 2, as modified by the PDI Program UT exam, from the austenitic stainless steel side.

3.4.4 Post Weld Overlay NDE

The examinations of the completed full SWOL and heat affected zone (HAZ) beneath the weld overlay will be performed in accordance with the requirements of Code Case N-504-2 and Nonmandatory Appendix Q, including the flaw acceptance standards specified in Article Q-4000. These inspections and associated acceptance standards provide assurance that the weld and adjoining base material are fully capable of performing their intended function. Thus, SCE will meet the condition specified in the NRC Regulatory Guide (RG) 1.147 for the use of ASME Code Case N-504-2. The following discussion is provided to clarify how SCE will comply with the condition specified in RG 1.147.

ASME Code, Section XI, preservice acceptance standards, as specified in Nonmandatory Appendix Q, are the appropriate standards for preservice UT examinations of weld overlay repairs to nuclear plant components. These standards are consistent with the highly sensitive UT examination procedures being used, which are qualified in accordance with ASME Code, Section XI, Appendix VIII, Supplement 11, as implemented via the Electric Power Research Institute (EPRI) PDI. The post-repair inspection volume includes the full thickness of the SWOL plus 25 percent of the underlying base metal/weldment thickness. The specimen sets for PDI qualification of SWOL examinations include construction type flaws in the underlying base metal and weldment. Therefore, use of PDI-qualified personnel and procedures will result in the reliable detection of construction type flaws.

The ASME Code, Section XI, flaw acceptance standards are based on fracture mechanics principles that evaluate the potential effect of flaw indications on the safe operation of a component. ASME Code, Section III, UT standards, on the other hand, are derived from radiographic (RT) standards in earlier construction codes and tend to be workmanship-based, addressing flaws occurring in the original construction process that are likely to be detected by radiography. The ASME Code, Section III, acceptance criteria do not allow the presence of any cracks or crack like indications, regardless of their size, and are geared more towards construction-type welds. Many indications that are detectable by PDI qualified UT techniques, and thus require evaluation, would not be detected by the RT examinations required by the original construction Code or ASME Code, Section III. The ASME Code, Section XI, preservice examination standards were developed for exactly the above-stated reasons, and consider the materials in which the flaw indications are detected, the orientation and size of the indications, and ultimately their potential structural impact on the component. They are the logical choice for evaluation of potential flaw indications in post-overlay examinations, in which unnecessary repairs to the SWOL would result in additional personnel radiation exposure without a compensating increase in safety and quality, and could potentially degrade the effectiveness of the SWOL by affecting the favorable residual stress field that they produce.

Acceptance of UT indications in SWOL repairs using ASME Code, Section XI, acceptance criteria has been approved by NRC in prior SWOL applications.

Qualification requirements for full SWOL wrought austenitic piping welds, (i.e., ASME Code, Section XI, Appendix VIII, Supplement 11, as modified by the PDI Program) are not currently qualified for cast austenitic stainless steel. The hot-leg surge line and shutdown cooling line nozzle safe end are cast austenitic stainless steel. For 25 percent of the underlying cast austenitic stainless steel of the SWOL, CE will perform a UT examination using the best available technique for the preservice and inservice inspections for these welds. This is consistent with information provided to support previously approved RRs ISI-3-18 and ISI-3-24.

ASME Code Case N-638-1 addresses the use of the temper bead welding technique including those welds made in deep cavities in ferritic material. In the case of SWOLs to be applied at SONGS 2 and 3, this technique will be used to apply a non-ferritic overlay to the P3 ferritic nozzle base material adjacent to the DMW. The PDI-qualified UT examination procedure is designed and qualified to examine the entire volume of the SWOL as well as the region of the P3 material containing the weld HAZ and a volume of unaffected base material beyond the HAZ. In addition to verifying the soundness of the weld, a purpose of these examinations is to assure that delayed cracking that may be caused by hydrogen introduced during the temper bead welding process is not present. In the unlikely event that this type of cracking does occur, it would be initiated on the surface on which the welding is actually performed or in the HAZ immediately adjacent to the weld. The most appropriate technique to detect surface cracking is the surface examination technique that SCE will perform on the SWOL and the adjacent base material in a band at least 1.5 times the thickness of the base material on either side of the SWOL. The maximum achievable inspection volume is 100 percent of the volume susceptible to weld-induced flaws. While it would be possible to extend the examination volume to a larger extent on either side of the SWOL, it would not be possible with current technology to UT inspect 100 percent of the volume within 1.5 times the thickness of the base material because of geometric considerations. Inspection of an increased volume would result in increased dose to inspection personnel without a compensating increase in safety or quality because there is

no plausible mechanism for formation of new flaws or propagation of existing flaws in the region. The SWOL volume is small relative to the volume of the underlying pipe and does not present the same concerns as those related to welds in deep cavities contemplated by the requirements of ASME Code Case N-638-1. Therefore, the examinations tailored for SWOL inspection and required by ASME Code Case N-504-2 and Nonmandatory Appendix Q, as modified in the request for relief, provide full assurance that the weld and adjoining base material are fully capable of performing their intended function.

3.4.5 Post Weld Overlay NDE Report

A report that summarizes the results of the examinations will be submitted to the NRC within 14 days of completion of the final UT examination. The report will include the following details as applicable:

1. A listing of indications detected. (The recording criteria of the UT examination procedure to be used for the examination of the SONGS RCS SWOL will require that all indications, regardless of amplitude, be investigated to the extent necessary to provide accurate characterization, identity, and location. Additionally, the procedure requires that all indications, regardless of amplitude, that cannot be clearly attributed to the geometry of the overlay configuration be considered flaw indications.)

2. The disposition of all indications using the standards of ASME Code, Section XI, IWB-3514-2 and/or IWB-3514-3 criteria.

3. If possible, the type and nature of the indications. (The UT examination procedure requires that all suspected flaw indications are to be plotted on a cross sectional drawing of the weld and that the plots should accurately identify the specific origin of the reflector.)

4. A discussion of any repairs to the overlay material and/or base metal and the reason for the repair.

Comprehensive criteria of the SWOL when used with the ASME Code, Section XI, 1995A96 Edition, Article IWA-4000, provide a comprehensive package of proposed detailed criteria with requirements, proposed alternatives, methodologies, modifications, and the bases for these differences, to support this RR. SONGS 2 and 3 SWOL repair of a piping weld with Alloy 82/182 weld material will be performed as a repair/replacement activity in accordance with IWA-4000 of the 1995A96 Edition, of ASME Code, Section XI, with the exception of the requirements in IWA-4610(a).

In lieu of the weld-attached thermocouple requirements and recording instruments in IWA-4610(a), contact pyrometers and manual recording of the process temperatures will be used at SONGS 2 and 3. These contact pyrometers will be calibrated in accordance with the measuring and test equipment program and will be capable of monitoring the process temperatures from 50 degrees Fahrenheit (°F) minimum preheat temperature to 350 °F maximum interpass temperature. Additionally, the methodology of ASME Code Case N-504-2, as modified, will be used. The UT examination of the completed SWOL will be accomplished in

accordance with ASME Code, Section XI, 1995A96 Edition, Appendix VIII, Supplement 11, with the alternatives used to comply with the PDI Program.

The temper bead weld technique requirements in accordance with ASME Code Case N-638-1 will be applied to the ferritic nozzle base material with modifications. ASME Code Case N-638-1 specifies a limit of 100 square inches for a temper bead weld. Approval to exceed this limit will be needed for the hot-leg surge line and the shutdown cooling line nozzles. The intent of the code case is clarified to limit the area of an individual weld over the ferritic material. EPRI Technical Report 1003616, "Additional Evaluations to Extend Repair Limits for Pressure Vessels and Nozzles," March 2004, provides justification for a maximum area of 500 square inches. The hot-leg surge line and shutdown cooling line nozzle weld area can be assumed to not exceed 300 square inches. SCE is anticipating the SWOL on ISI Designation Nos. 02-006-010, 03-006-010, 02-007-009, and 03-007-009 will exceed 100 square inches. The SWOL on 02-006-011 and 03-006-011 will not exceed 100 square inches. Any applicable requirements not addressed will be met as described in ASME Code, Section XI, 95A96Edition, IWA-4000, Appendix VIII, Supplement 11, and Code Cases N-504-2 and N-638-1. ASME Code Case N-504-2 is approved for use with austenitic stainless steel material in NRC RG 1.147, Revision 14, August 2005, provided it is used with Nonmandatory Appendix Q, of ASME Code, Section XI, 2005 Addenda. Table 1 of RR ISI-3-27 provide SCE's proposed modifications for SWOL repair of nickel-based and ferritic materials due to the specific construction of the SONGS 2 and 3 DMW. Therefore, SCE intends to follow the methodology of Code Case N-504-2, except as modified within RR ISI-3-27, Table 1.

3.5 Duration of Proposed Relief Request

This request will be applied for the remainder of the current SONGS 2 and 3 third 10-year ISI interval that started on August 18, 2003. Once these SWOLs are installed, they will remain in place for the design life of the repair that is defined by the evaluation required in paragraph (g) of ASME Code Case N-504-2 and corresponding requirements in Nonmandatory Appendix Q.

The SWOLs are also subject to the satisfactory examination requirements of Article Q-4000 for ISI. Those requirements include adding any installed SWOL repairs into the SONGS 2 and 3 ISI plan per ASME Code, Subarticle Q-4300, for at least one inservice examination to be completed within the next two refueling cycles.

3.6 Sacrificial Layer Not Attributed as Part of the SWOL

SCE and Welding Services, Inc. performed an extensive investigation, including a full-scale mockup, into the cause of cracking that was observed in the pressurizer-end surge line SWOL on SONGS 3. This investigation concluded that hot cracking, also referred to as solidification cracking, was observed as causing the cracks. The investigation, along with industry data and experience, also demonstrated that the hot cracking phenomena is strongly influenced by welding heat input and base material impurity levels. The study concluded that the risk of developing hot cracking due to base material impurities could be mitigated by employing a stainless steel weld buffer layer between the base metal and the Alloy 52M overlay. These "buffer welds" are more resistant to hot cracking induced by base material impurities, and result in surface impurity levels that are within the tolerance levels of Alloy 52M for the subsequent SWOL.

The study also demonstrated that successful Alloy 52M overlay welds can be achieved on base materials having low impurity (sulphur/phosphorous) levels with weld procedure modifications alone. However, impurity levels on the surfaces of fabricated components may differ from the bulk chemical analyses to a degree that can be significant relative to hot cracking in Alloy 52M. As a result, hot cracking can still develop in overlay welds where the bulk underlying base material impurities are moderately within success limits.

Based on the uncertainty in establishing impurity thresholds for successful Alloy 52M weld overlays, SCE currently plans to employ a stainless steel buffer layer of Alloy ER308L, or an equivalent, over appropriate base materials in the SWOL covered by RR ISI-3-27. SCE would only consider appropriate base materials in the SWOL covered by RR ISI-3-27. SCE would only consider omitting buffer layers in these applications if industry experience clearly shows it to be unnecessary (i.e., clear criteria for impurity levels have been established) prior to implementation.

As part of the investigation and mockup described above, an analysis of the chromium (Cr) content of the initial Alloy 52M weld deposit over a single buffer layer of ER308L filler material was performed. Measurements were made at four circumferentially distributed locations surrounding each of the three (base) materials where the buffer layer is planned to be used.

The table below lists the Cr content of the Alloy 52M weld deposit layer adjacent to the stainless steel buffer weld layer is expected to meet PWSCC-resistance criteria of at least 24 percent Cr. The expected Cr content of Alloy 52M weld metal applied over the PWSCC-susceptible Alloy 600/Alloy 82/182 components is provided in Attachment 2 to RR ISI-3-27. It can be expected that the Cr content of the Alloy 52M weld deposit at the transition point between the barrier layer and the DMW will also meet PWSCC-resistance criteria. The proposed SWOL design does not take structural credit for the buffer weld layer. It also does not take credit for the first layer of Alloy 52M weld deposit that is deposited over PWSCC susceptible, nickel-based materials.

Table - Chromium Content of the First Alloy 52M Weld Layer

Base Material under the Alloy 52M and Er308l Buffer	0 Degrees	90 Degrees	180 Degrees	270 Degrees
Low Alloy CS Nozzle	24.2%	25.9%	25.4%	25.3%
Cast Stainless Steel Safe-end	26.9%	27.2%	27.3%	26.7%
Stainless Steel 316 Surge Line Pipe	27.1%	26.9%	26.8%	26.5%

4.0 STAFF EVALUATION

4.1 Proposed Alternatives

The staff evaluated the proposed alternatives of RR ISI-3-27 and the RAI response dated September 21, 2007, which proposes to perform a SWOL repair of dissimilar metal piping welds on Alloy 82/182 weld material and adjacent components to be used at SONGS 2 and 3.

SWOL repair will be performed as a repair/replacement activity in accordance with the ASME Code, 95A96Edition, Section XI, IWA-4000, with alternatives.

The basis for SCE's proposed alternatives is provided in Tables 1, 2, and 3 of RR ISI-3-27. The staff's evaluation of the proposed alternatives and related modifications to ASME Code, Section XI of IWA-4000, ASME Code Case N-504-2, ASME Code Case N-638-1 and Appendix VIII, Supplement 11, are discussed further as follows.

4.1.1 Modifications to Code Case N-504-2

SCE proposed modifications to the alternative ASME Code, Section XI, Code Case N-504-2 as shown below.

Code Case N-504-2 allows repair by deposition of weld reinforcement (weld overlay) on the outside surface of austenitic stainless steel pipe in lieu of mechanically reducing a defect to an acceptable flaw size. Code Case N-504-2 is accepted for use together with Nonmandatory Appendix Q (i.e., a conditional requirement of Code Case N-504-2) in accordance with the current NRC RG 1.147, Revision 14. The materials identified for SWOL at SONGS 2 and 3, are the ferritic nozzle base material (P-1) with existing nickel Alloy 82/182 weld metal (F-43/P-43) attaching an austenitic stainless steel (P-8) safe end using stainless steel weld metal (A-8) to attach a wrought or cast stainless steel pipe (P-8). Industry operational experience has shown that PWSCC in Alloy 82/182 will blunt at the interface with stainless steel base metal, ferritic base metal, or Alloy 52/52M weld metal. A 360 degree SWOL will be utilized to control growth in any PWSCC and to maintain the DMW integrity. The SWOL will induce compressive stress in the weld and will hold back or inhibit growth of any realistically shallow cracks. Furthermore, the SWOL will be sized to meet all structural requirements independent of the existing DMW.

Paragraphs (b) and (e) of the subject code case require the austenitic stainless steel weld overlay material to contain a carbon content limited to 0.035 percent maximum and to contain a delta ferrite content of at least 7.5 ferrite number (FN), respectively. The carbon content limitation of 0.035 percent is intended to ensure resistance to intergranular stress-corrosion cracking (IGSCC). The minimum ferrite content of at least 7.5 FN is expected to prevent weld solidification cracking and to provide enough retained ferrite in the weld to provide increased resistance to stress-corrosion cracking. These requirements are not applicable to nickel-based materials Alloy 52 or Alloy 52M. Therefore, SCE proposes to use nickel-based Alloy 52/52M in place of austenitic stainless steel filler material for the SWOL repair. SCE states that the weld metal used may be ERNiCrFe-7 (Alloy 52, UNSN06052) or ERNiCrFe-7A (Alloy 52M, UNSN06054) is assigned F43 by ASME Code Case 2142-2. ERNiCrFe-7 and ERNiCrFe-7A are listed in ASME Code, Section II, Part C, and are assigned an F-number grouping of F-43 in ASME Code, Section IX. SCE stated that the requirements of ASME Code, Section III, NB-2400 will be applied to all filler material. These filler materials were selected for their enhanced resistance to PWSCC. SCE states the Cr content of Alloy 52 and Alloy 52M is identical at 28 to 31.5 percent providing superior corrosion resistance. Alloy 52M will be used for the full SWOL. SCE states Alloy 52M contains a higher niobium content (0.5 to 1 percent), which acts as a stabilizer providing resistance to intergranular corrosion and that the Alloy 52M chemistry acts to pin grain boundaries inhibiting separation between grains and hot tearing during weld puddle solidification. Also, the difference in composition improves weldability.

Moreover, Alloy 52M exhibits ductile properties and toughness similar to austenitic stainless steel piping welds at pressurized-water reactor operating temperature. SCE states that these filler materials are suitable for welding over the ferritic nozzle, the Alloy 82/182 weld, and the adjacent austenitic stainless steel safe end-to-pipe welds and components.

For material compatibility in welding, the staff considers Alloy 52M to be an improved choice of filler metal over that of austenitic stainless steel filler metal for this weld joint configuration. Use of a stainless steel filler metal would result in a very low FN due to dilution of nickel from the existing Alloy 82/182 DMW. As a result, the weld would be highly susceptible to weld-solidification cracking. Alloy 52M is fully austenitic and does not rely on primary solidification as ferrite to resist cracking. Therefore, the resulting weld will not contain ferrite. SCE stated that delta ferrite (FN) measurements will not be performed for SWOL repairs made of Alloy 52M weld metal as Alloy 52M is 100 percent austenitic and contains no delta ferrite due to the high nickel composition (approximately 60 percent nickel).

Furthermore, SCE stated that a stainless steel buffer/barrier layer of Alloy ER308L, or equivalent, will be utilized over the appropriate base materials due to the uncertainty in establishing impurity thresholds for successful Alloy 52M SWOL. SCE also stated that the proposed SWOL design does not take structural credit for the buffer weld layer.

The staff has determined, based on the justifications presented above, SCE's proposed alternative to use ASME Code Case N-504-2, with modifications, for SWOL repair at SONGS 2 and 3 will produce a permanent repair weld and promote reasonable assurance of structural integrity. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the staff finds that the proposed preceding alternative with modifications to be acceptable.

4.1.2 Modifications to Code Case N-638-1

SCE proposed the following modifications to the alternative ASME Code, Section XI, Code Case N-638-1 as shown below.

SCE requests to increase the maximum allowable finished weld surface area above the current allowable Code Case N-638-1 requirement. Section 1.0(a) of Code Case N-638-1 states, "[t]he maximum area of an individual weld based on the finished surface shall be 100 in^2 [square inches], and the depth of the weld shall not be greater than one half of the ferritic base metal thickness." SCE stated that the maximum area of an individual weld based on the finished surface over the ferritic material will not exceed 300 in^2 and that the depth of the SWOL configuration shall not be greater than one half of the ferritic base metal thickness. SCE stated the maximum area of the SWOL for the surge line and shutdown cooling line nozzles will exceed 100 square inches over the ferritic material. SCE cited EPRI Technical Report 1003616 as justification for exceeding the Code Case N-638-1 maximum requirement. The staff cites additional justification as provided in EPRI Report 1014351, "Repair and Replacement Applications Center: Topical Report Supporting Expedited NRC Review of Code Cases for DMW Overlay Repairs, December 2006," and "Bases for 500 Sq. In. Weld Overlay over Ferritic Material," provided to the staff at the January 10, 2007, public meeting (ADAMS Accession No. ML070470565). Therefore, the staff concludes that SCE's request to exceed the required maximum 100 square inch area of an individual weld, but not to exceed 300 square inches is acceptable based on the various technical reports provided above suggesting that a finished

area of up to 500 square inches can be achieved without a negative consequence to compressive residual stress.

Code Case N-638-1, Section 1.0(a), refers to a depth of preparation for a repair weld that will be implemented using the temper bead weld process described within the code case. The staff believes depth of preparation is not applicable to the SWOL design because the overlay requires no preparation other than surface cleanup prior to application. The staff also believes that the one-half thickness limit was included in the code case as a conservative measure to assure sufficient material existed to support weld shrinkage stresses generated by the constraint of a deep cavity in a component. Code Case N-638-1 was not written for overlay design applications and is not specific enough to be used without modification for this type application. Therefore, the staff concludes the depth of preparation is not applicable to this SWOL repair based on the preceding discussion.

The condition listed in RG 1.147 must be met when using Code Case N-638-1. The condition requires that UT volumetric examinations be performed with personnel and procedures qualified for the repaired volume and qualified by demonstration using representative samples which contain construction-type flaws. UT examination shall be performed in accordance with the acceptance criteria of ASME Code, Section III, NB-5330 of the 1998 Edition through 2000 Addenda and applies to all flaws identified within the repaired volume. Code Case N-638-1, Section 4.0(b) requires the final weld surface and the band around the area defined in Section 1.0(d) to be examined using surface and UT examination methods when the completed weld has been at ambient temperature for at least 48 hours. SCE states that only the required surface liquid penetrant examination will be performed in accordance with Code Case N-638-1. SCE states that the UT examination will be performed in accordance with Code Case N-504-2 and Nonmandatory Appendix Q following the application of the SWOL repair addressed in RR ISI-3-27. SCE states that a meaningful UT examination is impossible to perform on the required band of base material because of existing nozzle configurations and that Code Case N-638-1 applies to any type of welding where a temper bead technique is to be employed and is not specifically written for a SWOL repair. SCE states it is believed that for this type of repair that any major base material cracking would take place in the HAZ directly below the SWOL or in the underlying Alloy 82/182 weld deposit and not in the required band of material out beyond the overlay. SCE assumes that if this cracking were to occur, it would be identified by the UT examination of the SWOL and not performing the required base material UT examination should be considered acceptable. SCE states the proposed inspection will provide equal or better assurance of the soundness of repaired volume, the SWOL and surrounding material. The staff finds SCE's proposed modification to perform UT examination of the SWOL in accordance with Code Case N-504-2 and Nonmandatory Appendix Q is acceptable because compliance with the specified Code Case N-638-1-required UT examination area is not directly applicable due to configuration which would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

SCE stated that qualification requirements for full structural overlaid wrought austenitic piping welds (i.e., ASME Code, Section XI, Appendix VIII, Supplement 11, as modified by the PDI Program), are not currently qualified for cast austenitic stainless steel. The hot-leg surge line and shutdown cooling line nozzle safe end are cast austenitic stainless steel at SONGS 2 and 3. SCE will perform a UT examination using the best available technique for the preservice and inservice inspections for these welds on the 25 percent of the underlying cast austenitic

stainless steel of the SWOL. SCE stated that the best available technique would be used for the preservice and inservice inspections for these welds and committed to work with the industry to demonstrate within two cycles of operation (i.e., by 2010) that this UT technique has the ability to detect flaws in cast stainless steel material. The staff believes the best available technique to meet UT examination will be performed using existing PDI-qualified personnel and procedures qualified to wrought stainless steel. SCE cited in a previous obligation (letter dated December 14, 2006, ADAMS Accession No. ML063110322) with the NRC staff that in order to meet the above commitment, SCE will coordinate with the EPRI NDE Center in developing techniques and a qualification process to address this examination. SCE states that preheat and interpass temperatures for the SWOL will be measured using a temporarily attached or contact pyrometer in lieu of thermocouples. SCE stated that the placement of welded thermocouples for monitoring weld interpass temperature is not beneficial based on dose savings due to the repair area radiation dose rate. SCE also states that readout of the temperature may be local using a manual method or remotely monitored by the operator. SCE will monitor interpass temperature at each repair location for the first three layers as follows: 1) the interpass temperature measurements will be taken every three to five passes on the first repair location and 2) interpass temperature measurements will be taken every six to ten passes for the subsequent layers following the first three layers. SCE states that the heat input from layers beyond the third layer will not have a metallurgical affect on the low-alloy steel HAZ and the proposed technique is faster and does not compromise collection of required data. As a result, welded thermocouples are not planned for use to monitor interpass temperature during welding and the proposed technique provides equivalent data to that obtained from weld attached thermocouples. The staff agrees that UT examination of cast austenitic stainless steel using the best available technique for the preservice and inservice inspections is acceptable based on SCE's previous commitment stated above. In addition, based on the impracticality of using thermocouples and the hardship of added exposure, use of contact pyrometers as a means to monitor temperature is acceptable.

The staff has determined based on the justifications presented above that SCE's proposed alternative to use ASME Code Case N-638-1 ambient temperature temper bead process with modifications in lieu of the ASME Code-required temper bead process, PWHT, elevated preheat and post-weld soak will produce a permanent repair weld of acceptable quality. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the staff finds the proposed alternative with modifications to be acceptable.

4.1.3 Appendix VIII, Supplement 11, Modifications

SCE proposed modifications to the alternative ASME Code, Section XI, Appendix VIII, Supplement 11, as shown below.

SCE stated that ASME Code, Section XI, Appendix VIII, Supplement 11 cannot be used for NDE of an SWOL repair and relief is requested to allow closer spacing of flaws, provided the flaws do not interfere with detection or discrimination of other discontinuities. SCE also stated that the specimens used for qualification to the Tri-party (NRC/BWROG [Boiling Water Reactor Owners Group]/EPRI) Agreement have a flaw population density greater than allowed by current ASME Code requirements and that the samples have been used successfully for all previous qualifications under the Tri-party Agreement program. The PDI Program has merged the Tri-party test specimens into their SWOL program to facilitate their use and provide

continuity from the Tri-party Agreement program to ASME Code, Section XI, Appendix VIII, Supplement 11. A detailed description of SCE's alternative to ASME Code, Section XI, Appendix VIII, Supplement 11, is located in Table 2 of RR ISI-3-27.

The U.S. nuclear utilities created the PDI Program to implement performance demonstration requirements contained in Section XI, Appendix VIII, of the ASME Code. Moreover, the PDI Program is designed for qualifying equipment, procedures, and personnel to examine weld overlays in accordance with the UT criteria of Appendix VIII, Supplement 11. Preceding the Supplement 11 program, EPRI maintained a performance demonstration program for weld overlay qualification under the Tri-party Agreement[1]. In lieu of having two programs with similar objectives, the NRC staff recognized the PDI Program[2] for weld overlay qualifications as an acceptable alternative to the Tri-party Agreement.

The PDI Program is routinely assessed by the staff for consistency with the current ASME Code and proposed changes. The PDI Program does not fully comport with the existing requirements of Supplement 11. PDI presented the differences at public meetings in which the NRC participated[3,4]. The differences involve flaw location within test specimens and fabricated flaw tolerances. The changes in flaw location permitted using test specimens from the Tri-party Agreement and the changes in fabricated flaw tolerances provide UT acoustic responses similar to responses associated with IGSCC. The differences between the PDI Program and Supplement 11 are presented in Table 2, "Alternatives to Appendix VIII, Supplement 11," of RR ISI-3-27.

The NRC staff concludes that the proposed alternatives provide an acceptable level of quality and safety based on evaluation of SCE's proposed PDI Program identified in Table 2 of RR ISI-3-27.

---

1 NRC Letter from William H. Bateman to Michael Bratton, "Weld Overlay Performance Demonstration Administered by PDI as an Alternative for Generic Letter 88-01 Recommendations," January 15, 2002 (ADAMS Accession No. ML020160532).

2 NRC 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).

3 NRC 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).

4 NRC 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).

5.0 CONCLUSION

The staff has evaluated and determined that the proposed alternatives with modifications to the requirements listed in Section 3.1, RR ISI-3-27 as supplemented by letter dated September 21, 2007, will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the staff authorizes the use of the proposed alternatives for the full SWOL repair and inspection of the reactor coolant and shutdown cooling system DMW, identified in SCE's RR ISI-3-27 for the remainder of the third 10-year ISI intervals at SONGS 2 and 3.

All other ASME Code, Section XI requirements for which relief was not specifically requested and approved in RR ISI-3-27 and RAI response dated September 21, 2007, remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

Principal Contributor: D. Tarantino

Date: December 13, 2007