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Manager of
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September 21, 2007

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

Subject: **Docket Nos. 50-361 and 50-362**
Response to Request for Additional Information Regarding
Third Ten-Year Inservice Inspection (ISI) Interval
Relief Request ISI-3-27
San Onofre Nuclear Generating Station, Units 2 and 3

References: (1) Letter from A. E. Scherer (SCE) to Document Control Desk (NRC), dated February 21, 2007, Subject: Docket Nos. 50-361 and 50-362, Third Ten-Year Inservice Inspection (ISI) Interval Relief Request, ISI-3-27 Use of Structural Weld Overlay and Associated Alternative Repair Techniques, San Onofre Nuclear Generating Station, Units 2 and 3.

(2) Letter from N. Kalyanam (NRC) to R. M. Rosenblum (SCE), dated September 13 2007, Subject: San Onofre Nuclear Generating Station, Units 2 and 3 – Request for Additional Information – Relief Request ISI-3-27, Use of Structural Weld Overlay and Associated Alternative Repair Techniques (TAC Nos. MD4580 and MD4581)

Dear Sir or Madam:

By letter dated February 21, 2007 (Reference 1), Southern California Edison (SCE) submitted the Relief Request ISI-3-27, which requests approval for repair/replacement activities related to the performance of structural weld overlay repairs at San Onofre Nuclear Generating Station (SONGS) Units 2 and 3.

By letter dated September 13, 2007 (Reference 2), SCE received questions from the U. S. Nuclear Regulatory Commission (NRC) staff reviewers. The answers to these questions are provided as an enclosure to this letter.

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Should you have any questions, please contact Ms. Linda T. Conklin at (949) 368-9443.

Sincerely,

Enclosure:

cc: E. E. Collins, Jr., Regional Administrator, NRC Region IV
N. Kalyanam, NRC Project Manager, San Onofre Units 2 and 3
C. C. Osterholtz, NRC Senior Resident Inspector, San Onofre Units 2 and 3

Enclosure

Response to NRC Request for Additional Information
Regarding Relief Request ISI-3-27

NRC Questions and SCE Responses

1. Most recent industry experience involves the hot cracking of nickel Alloy 52M weld overlay deposits on stainless steel (SS) base materials with higher levels of sulfur in the austenitic SS base metal. The application of a low sulfur stainless steel weld build-up or barrier layer stopping just short of the dissimilar metal weld (Alloy 82/182) is a method used to avoid this hot cracking phenomenon.

   (a) Discuss whether you have considered the potential of hot cracking and if you have plans to incorporate the use of a barrier weld layer prior to welding of the full structural overlay.

   SCE Response:

   Southern California Edison (SCE) and Welding Services, Inc (WSI) performed an extensive investigation, including a full-scale mockup, into the cause of cracking that was observed in the pressurizer end surge line weld overlay on San Onofre Nuclear Generating Station (SONGS) Unit 3. This investigation concluded that hot cracking, also referred to as solidification cracking, had caused the observed 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 overlay weld.

   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 Structural Weld Overlays (SWOLs) covered by 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.

(b) As part of your analysis to use a barrier weld layer please include in your discussion meeting the Chromium (Cr) content outlined in Attachment 2 of Relief Request (RR) ISI-3-27, the transition point from barrier layer into dissimilar metal weld, filler metal to be used for barrier layer, mock-up testing performed and whether or not the barrier layer will be considered part of the structural weld overlay (SWOL).

SCE Response:

As part of the investigation and mockup described above, an analysis of the Chromium 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. These measurements are provided in the table below.

As can be seen in this table, the Chromium content of the Alloy 52M weld deposit layer adjacent to the stainless steel buffer weld layer is expected to meet Pressurized Water Stress Corrosion Cracking (PWSCC) resistance criteria of at least (24%) Chromium. The expected Chromium content of Alloy 52M weld metal applied over the PWSCC susceptible Alloy 600/82/182 components is provided in Attachment 2 to Relief Request ISI-3-27. It can be expected that the Chromium content of the Alloy 52M weld deposit at the transition point between the barrier layer and the dissimilar metal (DM) weld will also meet PWSCC resistance criteria.

The proposed weld overlay 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.

Chromium Content of the first A52M 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 SS safe-end	26.9%	27.2%	27.3%	26.7%
SS 316 surge line pipe	27.1%	26.9%	26.8%	26.5%

(c) Discuss the basis if you should choose not to utilize the barrier layer.

SCE Response:

N/A. SCE currently plans to use a buffer layer.

2. Section 4.0 of ISI-3-27 on page 4 of 14.

Provide material specification for the SS similar metal (SM) welds designated to be incorporated as part of the full SWOL planned at San Onofre Nuclear Generating Station, Units 2 and 3.

SCE Response:

The filler material used in the stainless steel similar metal welds (SMS) was E308L. The general requirements including chemical composition, mechanical properties, test procedures, manufacture methods, and welding applications are governed under the ASME Code Section II, Part C, SFA-5.4 Specification.

3. Section 4.0, page 5 of 14

(a) Confirm that a flaw of 10 percent (%) thickness of the pipe base metal wall will be analyzed for crack growth in the base metal.

(b) Will a flaw of the same size (i.e., 10% of the weld overlay thickness) be assumed in the SWOL and analyzed for crack growth in the SWOL.

SCE Response:

An initial flaw size of 10% of the original wall thickness is required to be postulated if no flaws were detected in the DM weld. SCE has conservatively chosen to evaluate initial flaw sizes of 25%, 50% and 75% of the original wall thickness. The crack growth calculation, which evaluated both PWSCC and fatigue, showed stable flaws even under these conservative assumptions.

Crack growth analyses do not assume a flaw in the SWOL. Code Case N-504-2, Criteria I requires that Non-Destructive Examination (NDE) inspection be performed on the weld overlay and the outer 25% of the original weld after the weld overlay is completed. Alloy 52M weld overlay materials are known to be highly resistant to PWSCC, and the industry experience has indicated no cracks were ever recorded in the weld overlay applications either in Boiling Water Reactors or Pressurized Water Reactors. Should a crack be initiated in the interior diameter (ID) of the DM weld it is not likely to grow based on the above mentioned calculation. In addition, if any crack grows beyond 75% of the original wall thickness, it will be detected by future examination of the overlaid joint.

4. Section 4.0, page 6 of 14 and continued on page 7 of 14 states the requirements for qualification and performance of ultrasonic testing (UT) examination of base metal on the DM and SM welds; however, it does not state requirements for the surface examination of this base metal. Provide acceptance criteria and discuss your repair strategy if the base material inspection results identify indications exceeding the acceptance criteria.

   SCE Response:

   Surface examination will be performed as required per Code Case N-504-2, "Alternative Rules for Repair of Classes 1, 2, and 3 Austenitic Stainless Steel Piping" as mentioned below.

   Prior to deposition of the weld reinforcement, the surface to be repaired shall be examined by the liquid penetrant method. Indications greater than 1/16 inch are unacceptable and shall be prepared for weld reinforcement in accordance with (1) or (2) below;

   (1) Unacceptable indications shall be excavated to the extent necessary to create a cavity that can be repaired using qualified welding procedures.

   (2) One or more layers of weld overlay shall be applied to seal unacceptable indications in the area to be repaired without excavation. The thickness of these layers shall not be included in meeting weld reinforcement design thickness requirements.

   If the preparation of (1) or (2) above is required, the area where the weld reinforcement is to be deposited, including any local repair or initial weld overlay layers, shall be examined by the liquid penetrant method, and shall contain no indication greater than 1/16 inch prior to application of the structural layers of the weld overlay.

5. Section 4.0, on page 6 of 14 and continued on page 7 of 14 you identified cast SS base material components. You state, ". . .Southern California Electric (SCE) will perform the qualified Appendix VIII, Supplement 10, as modified by the Performance Demonstration Inspection (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 Code of Federal Regulations (CFR) 50.55a(g)(6)(ii)(C)." In these cases SCE will perform UT examination from the cast austenitic SS side in accordance with ASME Section XI, Appendix III.

(a) Discuss the technical acceptability of the proposed UT examination for detecting flaws in the cast SS with PDI qualified representative mockups, examination procedures and personnel not demonstrated for cast materials, with or without the SWOL installed.

(b) Since UT examination is not qualified to detect flaws in cast SS material regardless of the SWOL, discuss how crack growth calculation will be performed in terms of the initial flaw size. A conservative approach would be to assume a 100 percent through-wall flaw existing in the original base metal/weld in the crack growth calculation even if UT examination is performed of the base metal prior to SWOL installation.

SCE Response:

As stated in part (b) of the NRC's question, the Ultrasonic Test (UT) examination is not currently qualified to detect flaws in cast stainless steel material. As described in the response to part (c) of this question (see below), SCE is working with the industry to demonstrate that this UT technique has the ability to detect flaws in cast stainless steel material.

As suggested in part (b) of the NRC's question, the SWOL sizing calculation takes no credit for the original pipe. The calculation assumed that there is a 360 degree, 100% original pipe wall thickness crack size, (i.e., SWOL is a full structural replacement). Additionally, as explained in the response to Question #3, the Elastic Fracture Mechanics analysis showed no crack propagation will be experienced due to service with an initial crack size of up to 75% of original wall thickness.

(c) Clarify the following statement, ". . .SCE will perform a UT examination using the best available technique for the pre-service and inservice inspections for these welds."

SCE Response:

SCE received a similar question from the NRC as part of the review of ISI-3-18. ISI-3-18 was a request for relief to perform SWOLs on pressurizer spray and safety valve line nozzles on SONGS Unit 2. In response to the NRC question (letter from A. E. Scherer to Document Control Desk dated March 16, 2007), SCE stated that the best available technique would be used for the pre-service and inservice inspections for these welds and committed to work with the industry to demonstrate within 2 cycles of operation (i.e., by 2010) that this UT technique has the ability to detect flaws in cast stainless steel material.

An excerpt from SCE's response to the NRC question regarding ISI-3-18 is provided below:

> "Because the three safety nozzle safe ends are cast austenitic material, a qualified UT technique to examine the weld overlay plus 25% of the base material under the overlay does not exist.
>
> SCE is using the best available UT technique to perform the pre-service and inservice inspections, and will work with the industry to demonstrate this UT technique has the ability to detect flaws in the cast material. SCE proposes to complete this demonstration within the next two cycles of operation (approximately 4-years).
>
> To meet this commitment SCE will coordinate with the [Electric Power Research Institute] EPRI NDE Center in developing techniques and a qualification process to address this examination. The EPRI NDE Center is responsible for administering the Performance Demonstration Initiative (PDI) program. The PDI program is an industry-funded program that was established to provide a uniformed approach to meeting Appendix VIII qualification issues. It is expected that EPRI will work closely with the PDI Steering Committee in developing the most appropriate qualification plan, which will address flaw making, mock-up design and acceptance criteria needed to demonstrate the techniques.
>
> This after-the-fact demonstration is an appropriate approach, because 1) the weld overlay is a full structural overlay that does not take any credit for the original weld, 2) the material used in the weld overlay is Alloy 52M, which is resistant to PWSCC due to the composition and especially its Cr content..."

Based in part on the response described above, NRC verbal approval of ISI-3-18 was granted on March 23, 2006. NRC written approval of ISI-3-18 was issued on December 14, 2006.

6. Section 4.0, on page 8 of 14 states, "The most appropriate technique to detect surface cracking [hydrogen introduced during temper bead weld process] is the surface examination technique that SCE will perform on the overlay and the adjacent base material in a band at least 1.5 times the thickness of the base material on either side of the overlay. 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 [heat affected zone] HAZ immediately adjacent to the weld." ". . .it would not be possible with current technology to UT inspect 100% 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." Discuss further whether hydrogen induced cracking is a surface phenomenon exclusively and whether this condition can occur undetected in the region you will surface inspect, but not UT inspect.

SCE Response:

Heat Affected Zone (HAZ) hydrogen exposure would occur during installation of the first layer. This layer, because it is the only layer in direct contact with the base metal contaminants and since it is the only layer that directly contacts the HAZ, is considered to have the greatest potential contribution to hydrogen cracking. For the second and third (tempering) weld layers, the likelihood of additional hydrogen introduction is negligible.

The microstructure at the toe of the temperbead SWOL in the P-3 weld HAZ (at the outside diameter surface where tempering is somewhat limited) may encounter hardness to reach a lower threshold level for hydrogen cracking in the component. Even in the very unlikely case that cracking was to occur, it would not be structurally significant.

There have been more than 20 temperbead weld overlays applied to nuclear power plant low alloy steel nozzles and more than 100 temperbead repairs to other low alloy steel components over the years. To date no hydrogen induced cracking has been reported at the outcome of ambient temperature temper bead welding application performed with the Gas-Tungsten Arc Welding process.

7. Section 4.0, of RR ISI-3-27 on page 8 of 14 states, "Acceptance of UT indications in weld overlay repairs using Section XI acceptance criteria has been approved by the Nuclear Regulatory Commission in past weld overlay applications (e.g. References 1, 2)."

   (a) Provide the specific subarticle of the ASME Code Section XI that the acceptance criteria will be based on to disposition indications in the SWOL.

SCE Response:

NRC Regulatory Guide 1.147 revision 14, August 2005, conditionally accepted Code Case N-504-2, "Alternative Rules for Repair of Classes 1, 2, and 3 Austenitic Stainless Steel Piping, Section XI, Division 1," with the condition that the provisions of Section XI, Nonmandatory Appendix Q, "Weld Overlay Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping weldments," must also be met. Appendix Q, Article Q-4000, "Examination and Inspection," requires that the ultrasonic examination results comply with the acceptance criteria of preservice examination standards of Table IWB-3514-2 for Planar flaws. Laminar flaws shall meet acceptance standards of Table IWB-3514-3.

(b) Discuss how the indications will be dispositioned if the indications do not satisfy the acceptance criteria.

SCE Response:

Any indications that do not satisfy the acceptance criteria mentioned above shall be repaired to comply with acceptance standards in Article Q-4000.

(c) Discuss the disposition of an indication in the SWOL if that indication is attributed to primary water stress corrosion cracking.

SCE Response:

Any indication in the SWOL due to PWSCC will be an extension of flaw equal to 100% through the original wall that makes the indication greater than 75% of the overall thickness. Any such flaw would be required to be repaired in accordance with ASME Code, Section XI, Table IWB-3641-1 through IWB-3641-4.