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

May 13, 2011

Mr. Peter T. Dietrich
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, UNITS 2 AND 3 - RELIEF REQUEST ISI-3-31, REQUEST FOR RELIEF FROM INSERVICE INSPECTION REQUIREMENTS FOR FLAW EVALUATION OF HIGH-ENERGY PIPING (TAC NOS. ME3961 AND ME3962)

Dear Mr. Dietrich:

By letter dated May 19, 2010 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML101440381), as supplemented by letters dated December 20, 2010, and March 16, 2011 (ADAMS Accession Nos. ML103550488 and ML110760485, respectively), Southern California Edison Company (the licensee) requested relief from the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, IWA-4000, "Repair/Replacement Activities," regarding the evaluation and disposition of flaws in specified high-energy piping at the San Onofre Nuclear Generating Station (SONGS), Units 2 and 3. As an alternative to IWA-4000, the licensee submitted Relief Request ISI-3-31 for Nuclear Regulatory Commission (NRC) review and approval, to allow the use of alternative evaluation criteria for temporary acceptance of flaws in certain sections of high-energy Class 2 and 3 Schedule 10S piping in the emergency core cooling system (ECCS). Relief Request ISI-3-31 is applicable to the third 10-year inservice inspection (ISI) interval, which began on August 18, 2003, and will end on August 17, 2013, for SONGS, Units 2 and 3.

The licensee's proposed alternative applies the requirements of the ASME Code, Section XI, and ASME Code Case N-513-2, "Evaluation Criteria for Temporary Acceptance of Flaws in Moderate Energy Class 2 or 3 Piping, Section XI, Division 1," with the exceptions of the Code Case maximum operating temperature limit of 200 degrees Fahrenheit and the nominal pipe size limit of 4 inches or greater. The licensee submitted Relief Request ISI-3-31 as a contingency in case flaws are found in Schedule 10S ECCS piping in situations where ASME Code Case N-513-2 cannot normally be applied.

The NRC staff has completed its review of the subject relief request and concludes that complying with the specified requirement would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. Accordingly, the NRC staff concludes that the licensee has adequately addressed all of the regulatory requirements set forth in paragraph 50.55a(a)(3)(ii) of Title 10 of the *Code of Federal Regulations* (10 CFR), and that the alternative provides reasonable assurance of structural integrity and leak tightness of the subject piping.

As discussed in the NRC staff's enclosed safety evaluation, the licensee's proposed alternative for the evaluation and disposition of flaws in the specified sections of ECCS piping is authorized for the remainder of the third 10-year ISI interval at SONGS, Units 2 and 3.

All other requirements of the ASME Code, Section XI, and Code Case N-513-2, for which relief was not specifically requested and approved remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

If you have any questions, please contact Randy Hall, at (301) 415-4032, or via e-mail, at randy.hall@nrc.gov.

Sincerely,

Michael T. Markley

Michael T. Markley, 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: Distribution via Listserv

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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

THIRD 10-YEAR INSERVICE INSPECTION (ISI) INTERVAL RELIEF REQUEST ISI-3-31

FLAW EVALUATION OF HIGH-ENERGY CLASS 2 AND 3 SCHEDULE 10S

EMERGENCY CORE COOLING SYSTEM PIPING

SAN ONOFRE NUCLEAR GENERATING STATION, UNITS 2 AND 3

SOUTHERN CALIFORNIA EDISON COMPANY

DOCKET NOS. 50-361 AND 50-362

1.0 INTRODUCTION

By letter dated May 19, 2010 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML101440381), Southern California Edison Company (the licensee) requested relief from the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, IWA-4000, "Repair/Replacement Activities," regarding high-energy Class 2 and 3 Schedule 10S piping in the emergency core cooling system (ECCS) at the San Onofre Nuclear Generating Station (SONGS) Units 2 and 3. As an alternative to IWA-4000, the licensee submitted Relief Request ISI-3-31 for Nuclear Regulatory Commission (NRC) review and approval, to allow the use of alternative evaluation criteria for temporary acceptance of flaws in the subject high-energy Class 2 and 3 ECCS Schedule 10S piping.

The proposed alternative in the relief request follows the requirements of the ASME Code, Section XI, and ASME Code Case N-513-2, "Evaluation Criteria for Temporary Acceptance of Flaws in Moderate Energy Class 2 or 3 Piping, Section XI, Division 1," with the exceptions of the maximum operating temperature limit of 200 degrees Fahrenheit (°F) and the nominal pipe size (NPS) limit of 4 inches or greater. The licensee submitted Relief Request ISI-3-31 as a contingency in case flaws are found in Schedule 10S ECCS piping in certain areas where Code Case N-513-2 cannot be applied.

By e-mail dated August 31, 2010, the NRC staff requested additional information (RAI) in support of the review of the relief request. By letter dated December 20, 2010 (ADAMS Accession No. ML103550488), the licensee responded to the staff's RAI.

By e-mail dated February 3, 2011, the NRC staff issued a second RAI requesting clarification of the licensee's response dated December 20, 2010. By letter dated March 16, 2011 (ADAMS Accession No. ML110760485), the licensee responded to the staff's follow-up RAI.

Enclosure

2.0 REGULATORY EVALUATION

Pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) paragraph 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) must meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in the ASME Code, Section XI, "Rules for Inservice Inspection (ISI) of Nuclear Power Plant Components," to the extent practical within the limitations of design, geometry, and materials of construction of the components. The regulations require that inservice examination of components and system pressure tests conducted during the first 10-year interval and subsequent intervals comply with the requirements in the latest edition and addenda of Section XI of the ASME Code, incorporated by reference in 10 CFR 50.55a(b), 12 months prior to the start of the 120-month interval, subject to the limitations and modifications listed therein.

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

The Code of record for the third 10-year ISI interval at SONGS, Units 2 and 3, is the 1995 Edition through 1996 Addenda of ASME Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components."

3.0 TECHNICAL EVALUATION

3.1 ASME Code Component(s) Affected

The 15 candidate ASME Class 2 and 3 Schedule 10S pipe sections are identified in Table 1 of Relief Request ISI-3-31. The pipe sections are part of the high-pressure safety injection lines, low-pressure safety injection lines, and containment spray lines of the ECCS in both units.

The pipe sections identified as items 1 through 11 in Table 1 of the relief request are ASME Code Class 2. The pipe sections in items 12 through 15 are ASME Code Class 3. The candidate pipe sections are fabricated with austenitic stainless steel.

In follow-up RAI Question 1(3), the NRC staff asked the licensee to discuss whether any candidate pipe section is located in a high radiation area such that daily walkdowns or monthly inspections cannot be performed. By letter dated March 16, 2011, the licensee responded that there are two short lengths of ECCS piping in the containment emergency sump (CES) that see high temperatures in a post-loss-of-coolant accident (LOCA) environment. They are identified as items 5 and 10 in Table 1 of the relief request. Item 5 is a 24-inch line, No. 1204ML003, located between valve HV9303 and the CES. Item 10 is a 24-inch line, No. 1204ML004, located between valve HV9302 and the CES. The portions of these lines that are inside containment lines are not accessible for inspection during normal plant operation. Therefore, the licensee has proposed to remove the portions of these lines that are inside containment from the scope of the relief request.

3.2 Applicable Code Edition and Addenda

The Code of record for the current (third) 10-year ISI interval is the ASME Code, Section XI, 1995 Edition, through the 1996 Addenda.

3.3 Applicable Code Requirement

For candidate Class 2 piping, the applicable Code requirements are the 1995 Edition through the 1996 Addenda of the ASME Code, Section XI, subparagraph IWC-3122.2 for disposition of flaws found through volumetric and surface examinations, and subparagraph IWC-3132.2 for disposition of flaws found through visual inspections.

For candidate Class 3 piping, the 1995 Edition through the 1996 Addenda of the ASME Code, Section XI, Article IWD-3000 applies.

The licensee notes that ASME Code, Section XI, article IWD-3000 refers to the rules of IWB-3000. Paragraph IWB-3133 and subparagraph IWB-3142.3 provide rules for Class 3 components analogous to those in subparagraphs IWC-3122.2 and IWC-3132.2 for Class 2 components.

The licensee stated that the maximum operating temperatures listed in Table 1 of the relief request were developed during initial plant design and construction. These are not design temperatures and they contain margin above the maximum operating temperature determined in the analyses of record.

3.4 Proposed Alternative and Basis for Use

The licensee proposed to apply the evaluation methodology, acceptance criteria, and required actions of Code Case N-513-2 to evaluate potential flaws in Schedule 10S ECCS piping to establish pipe integrity, with the exception that the maximum operating temperature for the candidate pipes during accident conditions will be either 225 °F or 275 °F instead of 200 °F, and that in one case, the NPS will be 2.5 inches instead of 4 inches or greater.

The licensee stated that should it discover unacceptable flaws in the sections of Schedule 10S ECCS piping that has maximum operating temperatures greater than 200 °F, the application of this proposed alternative will be as follows:

1. Perform Immediate Operability Determination based upon visual characterization of the indication and operating experience with the degradation mechanisms of this piping (stress-corrosion cracking or cyclic fatigue failure).

2. Perform Prompt Operability Determination (POD) based on non-destructive examination (NDE) of flaws and comparison of results to the allowable flaw sizes as described in calculation M-DSC-445 in the submittal dated May 19, 2010.

3. Implement follow-up actions as described in Code Case N-513-2.

4. Repair flaws in accordance with the schedule requirements of Code Case N-513-2.

3.5 <u>Basis for Acceptability of Proposed Alternative</u>

The licensee calculated the allowable through-wall flaw lengths for each of the affected pipes following the procedures of Code Case N-513-2 and the pipe flaw procedures of ASME Code, Section XI, Appendix C, for austenitic stainless steel piping. The licensee used the analytical evaluation methods of Appendix C, Article C-6320 for ductile fracture using elastic-plastic fracture mechanics (EPFM) criteria to derive allowable through-wall flaw lengths under upset and faulted loading conditions. The licensee stated that the EPFM method is appropriate to account for the possibility of having lower toughness weldments in the austenitic stainless steel pipe.

The licensee calculated allowable through-wall lengths based on maximum enveloping stresses obtained from piping stress analyses. For each of the pipe sections, the licensee presented the allowable through-wall circumferential flaw lengths in Table 2 and allowable through-wall axial flaw lengths in Table 3 of the relief request.

The maximum operating temperatures for the relevant piping lines range from 225 °F to 275 °F as listed in Table 1 of the relief request. The analyses of record show that following a large break loss-of-coolant accident (LBLOCA) or main steam line break, the ECCS piping initially draws water from the refueling water storage tank (RWST). The maximum RWST temperature is limited to 100 °F per Technical Specification Surveillance Requirement 3.5.4.1. Prior to depleting the RWST inventory, a recirculation actuation signal (RAS) is generated to initiate ECCS flow from the CES and terminate ECCS flow from the RWST.

The licensee stated that the only time that the candidate ECCS piping experiences temperatures above 200 °F is during post-RAS operation following an LBLOCA. The LBLOCA analyses show that the maximum post-RAS temperature in the CES is approximately 215 °F with replacement steam generators (RSGs), which were installed during the most recent refueling outages for both units. The CES experiences water temperatures above 200 °F for approximately 14 hours with the RSGs, for this scenario. Exposure to CES water provides the basis for the operating temperatures greater than 200 °F for the piping in question.

The licensee has previously discovered flaws on the candidate piping as the result of inside diameter (ID) and outside diameter (OD) stress-corrosion cracking or cyclic fatigue failure. These flaws have been smaller than the allowable flaw size specified in the relief request, and have not presented a challenge to structural integrity. The licensee believes that requiring a plant shutdown to perform an ASME Code repair of the affected piping, when compared to the application of Code Case N-513-2, does not provide a compensating increase in the level of quality and safety.

The licensee stated that Code Case N-513-2 invokes the analytical evaluation methods of the ASME Code, Section XI, Appendix C for the analysis of planar circumferential flaws. The limit load equations in Appendix C are generally applicable to all pipe sizes. The licensee noted that the equations for the Z-factors in Appendix C were developed for piping where NPS is greater than or equal to 4 inches, and caution must be used when extrapolating Z-factors to smaller pipe sizes. The Z-factor is a multiplier on applied pipe stress used in the allowable flaw evaluation to account for the possibility of low ductility weldments. The larger the pipe size, the higher the Z-factor becomes; and hence, a lower allowable flaw length will result. The licensee applied a Z-factor determined for a 4-inch NPS pipe in the case where the actual NPS was 2.5 inches. This analysis assumption is conservative in determining the allowable flaw length for the 2.5-inch NPS ECCS piping. The licensee stated that the restriction against using Appendix C methods for flaw evaluation in piping less than 4-inch NPS does not provide a compensating increase in the level of quality and safety under the conditions by which the calculations for allowable flaw length were performed.

3.6. Duration of Proposed Alternative

The licensee stated that the proposed alternative in the relief request will be applicable for the duration of the third 10-year ISI interval, which began on August 18, 2003, and will end on August 17, 2013 for both Units 2 and 3.

By letter dated December 20, 2010, in response to RAI Question 6(1), the licensee noted that for Unit 2, the duration for cycles 16 and 17 is from September 2009 to January 2012 and January 2012 to January 2014, respectively. For Unit 3, the duration for cycles 16 and 17 is from October 2010 to October 2012 and October 2012 to October 2014, respectively.

4.0 NRC STAFF EVALUATION

The currently approved version of the subject code case is N-513-3, as identified in NRC Regulatory Guide (RG) 1.147, Revision 16, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1," dated October 2010. As the licensee's relief request was submitted prior to the issuance of RG 1.147, Revision 16, Relief Request ISI-3-31 is based on the prior version of the code case, Code Case N-513-2. While the NRC staff evaluated this relief request using Code Case N-513-3, the staff notes that there is no significant difference between N-513-2 and N-513-3 as they apply to this request, and both versions are used interchangeably for the purposes of this safety evaluation.

The NRC staff concludes that, in general, the relief request is consistent with Code Case N-513-3, except that the relief request will be applied to certain pipe sections experiencing higher operating temperatures and one pipe section having a smaller NPS than Code Case N-513-3 would permit. The staff's assessment of the higher operating temperature issue is addressed in Section 4.1, Leakage Monitoring, of this safety evaluation. The issue regarding the application of Code Case N-513-3 to the smaller pipe size (less than 4-inch nominal diameter) is addressed in Section 4.2, Flaw Evaluation.

In addition, the NRC staff evaluated the relief request in the areas of applicability (i.e., how the relief request is applied), inspection, the degradation mechanism, and hardship.

4.1 Leakage Monitoring

Code Case N-513-3 permits limited leakage in Class 2 and 3 piping, provided that the licensee adheres to certain inspection and flaw evaluation requirements. Specifically, paragraph 1(d) of the code case specifies that,

> The provisions of this Case demonstrate the integrity of the item and not the consequences of leakage. It is the responsibility of the Owner to demonstrate system operability considering effects of leakage.

However, the hot steam/water exiting from the pipe crack may affect personnel safety and nearby safety-related components, and the leaking fluid may be radioactive. The NRC staff assessed the impact of leakage from piping experiencing higher operating temperatures in terms of personnel safety, effects on safety-related equipment, and how the leakage will be managed.

In RAI Question No. 7(1), the NRC staff asked how plant personnel are protected from potential hot steam/water exiting a pipe crack. By letter dated December 20, 2010, the licensee responded that leakage from through-wall flaws in Schedule 10S piping at temperatures exceeding 200 °F would only be expected following an RAS. There would be sufficient time following an accident initiation to evacuate personnel from areas near any known through-wall flaws. NRC staff requested further information on this issue.

By letter dated March 16, 2011, in response to follow-up RAI Question No. 4, the licensee explained further that no additional measures to contain or isolate any potential steam leaks are necessary based on estimations of the potential leak rates, velocities, and associated impingement forces. The licensee stated that the maximum allowable leak rate for any flaw based on contribution to control room dose consequences would be approximately 0.25 gallons per minute (gpm). As an example, applying an allowable leak rate of 0.25 gpm and using the computer program PICEP from the Electric Power Research Institute (EPRI), the licensee calculated a crack opening area of 3.72×10^{-5} ft^2 for a 24-inch Schedule 10S pipe (wall thickness of 0.25 inch) with internal pressure of 110 pounds per square inch (psi) and at a temperature of 225 °F. The calculated force from the resulting mass flow rate of 0.0331 pounds per second (lbs/sec) at a velocity of 15 ft/sec is 0.015 lbs (0.0331 x 15 / 32.2 = 0.015 lbs), which will not cause damage to adjacent equipment. Furthermore, no significant increase in the surrounding air temperature is expected due to the leaking water, based on the small amount of released mass (0.0331 lbs/sec) and the corresponding energy. Therefore, the licensee concluded that no damage to adjacent equipment is expected based on the mass rate and the velocity of the leaking fluid.

The licensee stated further that its leakage evaluation will be included in the POD on a case-by-case basis. The licensee explained that the only time there would be steam leakage through potential flaws in the affected piping is in post-accident conditions, following an RAS. As such, there would be sufficient time following an accident initiation to evacuate personnel from areas near any known through-wall flaw. Thus, the licensee concluded that there would be no effect on personnel safety from leakage through such flaws. The NRC staff concludes that the leakage from the allowable flaw sizes would be small and would be unlikely to affect nearby safety-related components or pose danger to plant personnel.

In RAI Question No. 7(2), the NRC staff asked the licensee to discuss the maximum leak rates from the allowable flaw sizes in Tables 2 and 3 of the relief request. By letter dated December 20, 2010, the licensee responded that leakage and any resulting dose from flaws in Schedule 10S piping would be addressed by the Operability Determination for the flaw in question, but would be outside the scope of Relief Request ISI-3-31. The licensee stated further that it is possible that a flaw evaluation based on Code Case N-513-2 could conclude that the affected piping is OPERABLE, but the overall Operability Determination would conclude that the piping is inoperable due to leakage concerns. The licensee intends to evaluate leak rates on a case-by-case basis in the event through-wall leakage is detected during normal plant operation. The licensee intends to use the EPRI PICEP program or alternate methods to compute the flow rates. The PICEP leak rate calculation method uses a two-phase fluid flow, taking into account pipe size, flaw orientation, and the internal pressure and fluid temperature for the limiting accident. The calculation of the flaw opening area will use EPFM methods taking into account the stress-strain properties of the pipe material. Such a leak rate evaluation will be used to support the POD.

The licensee has estimated flaw sizes corresponding to maximum potential leak rates in the affected piping. As an example, a flaw size estimate, assuming no existing ECCS leakage, based on a conservative leak rate limit of 0.25 gpm, shows that the through-wall flaw size for that leakage is about 2.5 inches long under the most restrictive conditions. The final allowable flaw length for any flaw to remain in service will be established based on the allowable length per Code Case N-513-3 (i.e., based on the relief request), or the case-specific calculated allowable length for leakage (i.e., as part of POD), whichever is the smaller.

The licensee stated that the projected leak rate would be computed for the specific flaw location, for the given loading conditions and geometry, following the same analysis methods that were used to establish the maximum flaw length based on allowable leakage. The calculated accident-induced leak rate will be compared to the accident leak rate limit for the pipe location under evaluation to determine flaw acceptance and operability. This flaw evaluation would be performed in the POD.

Per Code Case N-513-2, the licensee will monitor leakage from any potential flaw on a daily basis during plant operation to confirm leak rates are low, stable, and predictable. This will also ensure the flaw size will not exceed the allowable flaw length based on both the fracture mechanics and the leak rate calculations. Thus, any flaw allowed to remain in service is not expected to exceed the maximum allowable length during the postulated accident. Similarly, any non-leaking flaws are not expected to exceed the maximum allowable length based on similar considerations.

In RAI Question No. 7(3), the NRC staff noted that any leakage that results in a release of radionuclides may affect the calculated radioactive doses. By letter dated December 20, 2010, the licensee responded that accident dose analyses evaluate dose contributions from all sources, including engineered safety feature (ESF) leakage. The total dose resulting from a LOCA is calculated at the exclusion area boundary, the low population zone, and in the control room (CR). The limiting dose with respect to sensitivity to ESF leakage is the CR dose. ESF leakage of approximately 0.25 gpm has been estimated to result in a CR dose equal to the 5-rem total effective dose equivalent (TEDE) limit. Thus, the licensee stated that any leakage resulting from a potential flaw in the candidate pipes, when added to existing known leakage, must be limited to 0.25 gpm.

In follow-up RAI Question Nos. 6(1) and 6(2), the NRC staff questioned whether any of the allowable flaw sizes will result in leakage greater than 0.25 gpm and whether the affected pipe will be repaired at the time of discovery (i.e., a potential for a mid-cycle repair) if the leakage from a flaw exceeds 0.25 gpm. By letter dated March 16, 2011, the licensee responded that the allowable flaw sizes are based on the structural evaluation described in the code case. The POD will include an additional evaluation to calculate the allowable flaw size that causes a leak rate under post-LOCA conditions (considering a 120-day mission time) that would result in CR dose consequences exceeding the limits of 10 CFR Part 50, Appendix A General Design Criterion 19, "Control room" (approximately 0.25 gpm). The licensee stated that it is possible that an allowable flaw size calculated using the code case methods would be greater than an allowable flaw size calculated based on leakage considerations, particularly for large diameter pipes. The smaller of the two allowable flaw sizes will be used as the allowable flaw size in the POD. The licensee stated that the degraded pipe will be repaired or replaced if the observed or calculated leak rate exceeds 0.25 gpm.

In follow-up RAI Question Nos. 6(3) and 6(4), the NRC staff noted that the 0.25 gpm leakage criterion is not part of the proposed alternative requirement and questioned how the RCS leakage detection systems can detect and quantify a small leak rate of 0.25 gpm. By letter dated March 16, 2011, the licensee responded that although the leak rate acceptance criterion is not explicitly part of the proposed alternative, it is obligated to consider through-wall flaw leakage rates and associated dose consequences in the POD for any such flaws. The licensee stated that as a result, the final allowable flaw length for any flaw to remain in service will be the smaller of the allowable flaw size provided in Tables 2 and 3 of the relief request, or the flaw size that corresponds to a maximum leak rate of approximately 0.25 gpm, as determined in the POD.

The NRC staff concludes that the licensee has provided reasonable assurance that the leakage will be managed adequately because of the following: (1) the dose limit of 5-rem TEDE will restrict the leak rate from the candidate piping to 0.25 gpm, which will in turn restrict the flaw size in any pipe section allowed to remain in service; and (2) the licensee will perform a leakage calculation as part of the POD to derive the allowable flaw size. The smaller allowable flaw size, based on either the leakage calculation or the specified flaw size in Tables 2 and 3 of the relief request, will be used to disposition the detected flaw. The staff concludes that these dual allowable flaw size criteria will provide assurance that a leaking flaw remaining in service will not affect the structural integrity of the affected pipe and will not result in the radioactive dose limits being exceeded. In addition, the required daily walkdown will provide a more specific and accurate leakage reading than the remote leakage detection systems. The staff also concludes that the licensee will implement measures to protect plant personnel from leaking high-temperature steam or water. Based on the measures to limit and control leakage described by the licensee, the staff does not believe that the performance of safety-related piping systems will be significantly impacted as a result of potential flaws in the subject piping.

4.2 Flaw Evaluation

Code Case N-513-3, Section 3, invokes the flaw evaluation methods of the ASME Code, Section XI, Appendix C. The limit load equations in Appendix C, Section C-5000, are generally applicable to all pipe sizes. However, Section C-5000 invokes the Z-factor equation in Appendix C, Section C-6330. The Z-factor is a multiplier on applied pipe stress used in the allowable flaw evaluation to account for the possibility of low ductility weldments that are fabricated by shield metal arc welding (SMAW) or submerged arc welding (SAW) processes. The larger the pipe size, the higher the Z-factor becomes; and hence, a lower allowable flaw length will result. However, the Z-factor equation in Section C-6330 is developed for piping where NPS is greater than or equal to 4 inches. In the proposed alternative, the licensee applied a Z-factor determined for 4-inch NPS pipe for the case where the actual NPS is 2.5 inches.

The licensee applied the Appendix C method to calculate the allowable flaw size for the 2.5-inch pipe. The licensee's only deviation from Appendix C is on the use of the Z-factor. For that deviation, the licensee used a higher Z-factor than required. The staff concludes that the approach is conservative and that it is therefore acceptable that the licensee applied the Z-factor for a 4-inch NPS pipe to the NPS pipe of 2.5 inches.

In RAI Question No. 1, the NRC staff asked whether the maximum operating or design temperature was used in the flaw evaluation. By letter dated December 20, 2010, the licensee explained that the maximum operating temperatures in the pipe stress analysis of record may be different than the maximum operating temperatures in Table 1 of the relief request. The maximum operating temperatures provided in Table 1 were obtained from the Piping and Instrumentation Diagrams (P&ID), and represent the current maximum operating temperature for each of the lines listed in Table 1. Piping stress analyses for items 1 through 11 in Table 1 are based on an operating temperature of 225 °F, or a bounding value of 275 °F in some cases. The staff concludes that use of the higher temperature value is acceptable since it results in higher thermal stresses. Piping stress analyses for items 12 through 15 in Table 1 are based on an operating temperature of 275 °F. In addition, the licensee used a bounding temperature of 275 °F, regardless of the actual operating temperature, to obtain the yield and ultimate strength values for the pipe in the flaw evaluations.

Code Case N-513-2, paragraph 3(b), specifies the use of the operating pressure and temperature of interest for the piping system as inputs to the flaw evaluation. The licensee stated that maximum operating pressure and temperature, therefore, meets Code Case N-513-2, paragraph 3(b). ASME Code, Section XI, Appendix C, on which the analytical methods are based, also specifies that the flow stress for the pipe material is based on service temperature as stated in C-8200. The licensee contends that although design temperature is higher than operating temperature, use of maximum operating temperature is appropriate as permitted by N-513-2 and Appendix C. The NRC staff concludes that the licensee has used appropriate temperatures and pressures in calculating allowable flaw size in accordance with Code Case N-513-2 (and Code Case N-513-3).

Section 5.0 of the licensee's flaw evaluation (Calculation M-DSC-445) in the relief request states that the allowable circumferential flaw lengths were calculated based on the limit load and EPFM methods. However, the allowable axial flaw lengths were calculated using the limit load method only. The NRC staff notes that the limit load method is less conservative than EPFM method for the welds that are made using SAW and SMAW techniques. In RAI Question No. 8, the staff asked the licensee to explain why the allowable axial flaw lengths were not calculated using the EPFM method for the welds that were made using SAW and SMAW techniques.

By letter dated December 20, 2010, the licensee noted that pipe butt welds were fabricated by shop practice or in the field. Depending on fabrication procedures, tungsten inert gas (TIG), SMAW, or SAW processes may have been used. Circumferential flaws will initiate at pipe butt welds due to weld residual stress. Such flaws will be oriented predominately along the circumference of the weld. Therefore, both non-flux (TIG) and flux (SMAW and SAW) welds are included in the evaluation of circumferential flaws to cover these situations. Axial flaws, if found, will be oriented transverse to butt welds, or possibly along external attachment welds. The licensee asserted that in either case, the tips of axial flaws will be well contained in base metal so that wrought toughness properties of the wrought base pipe will be controlling, not the weldment. For this situation, fully plastic collapse will be the relevant failure mode and the limit load method of ASME Code, Section XI, Appendix C, will be applicable.

The NRC staff does not agree with the licensee that the tips of axial flaws will be contained in base metal. Operating experience has shown that there are cases where the tips of some axial flaws were contained within the weld and not in the base metal. However, the staff notes that all the allowable axial lengths in the relief request are longer than the width of the weld; therefore, it is acceptable that the material properties of the base metal, not the weld, were used to derive the allowable axial flaw length. Therefore, the staff concludes that the limit load method is acceptable for use in this case, in calculating the allowable flaw size for the subject pipes.

In RAI Question No. 9, the NRC staff noted that the licensee's flaw evaluation does not include loadings from the emergency condition. By letter dated December 20, 2010, the licensee explained that the design of the ECCS piping includes normal, upset, and faulted loading conditions. Section 3.9.3 of the Updated Final Safety Analysis Report (UFSAR) for SONGS states that no emergency condition has been identified to be more severe than the upset condition. Therefore, the faulted condition is the only postulated accident condition for the subject ECCS piping. This is also reflected in the piping design stress analysis where Equation 9 of the ASME Code, Section III, NC-3600 stress calculations for occasional loads were completed for upset and faulted conditions only. The staff accepts the licensee's rationale for not including the emergency condition in the flaw evaluation because the licensee did consider the upset and faulted conditions which cover the emergency condition.

The NRC staff questioned whether the allowable flaw sizes in the relief request could reach the critical crack size, at which point the structural integrity of the candidate pipes would be challenged. By letter dated March 16, 2011, in response to follow-up RAI Question No. 5, the licensee provided the critical crack size and the margin between the allowable and critical flaw size for each candidate pipe. The allowable flaw lengths are all shorter than the critical flaw lengths for each candidate pipe. The staff concludes that the calculated allowable flaw sizes satisfy the full structural factors on load for upset (Level B) and faulted (Level D) loading conditions specified in C-2620 of ASME Code, Section XI, Appendix C.

4.3 Applicability

The NRC staff questioned how the relief request will be applied to disposition flaws detected in the candidate pipes, for example, how the allowable flaw size will be used to disposition detected flaws and when a degraded pipe would be repaired/replaced. The staff identified the following issues.

In RAI Question No. 3, the NRC staff asked the licensee for clarification of the allowable flaw lengths in Tables 2 and 3 of the relief request and how the actual flaw growth will be monitored in the field. By letter dated December 20, 2010, the licensee responded that Tables 2 and 3 of Relief Request ISI-3-31 provide the allowable through-wall lengths of the final flaw size, not the initial flaw size.

In lieu of an explicit flaw growth analysis, the licensee will implement a monitoring plan based on a shortened inspection interval in combination with daily walkdowns to search for leaking flaws. The licensee will perform periodic inspections at no more than 30-day intervals, in order to determine the rate of growth of any identified flaws, and to establish the time at which any detected flaw would reach the allowable size. The licensee noted that this inspection interval is considered conservative because a very small flaw growth rate is expected under the operating conditions of the subject piping. Through-wall flaws will be observed by daily walkdowns to confirm that the analysis conditions remain valid and that flaw size stays within the allowable limit. Any through-wall leaking flaws will be marked so that the change in flaw length can be measured and the change in leak rate recorded.

The licensee stated further that flaws detected to date in ECCS piping at SONGS have been much smaller than the allowable flaw sizes. Furthermore, periodic examinations did not reveal any significant size increase in these flaws. Thus, the flaw growth monitoring plan described above provides assurance that any increase in flaw size will be determined in a timely fashion and the flaw will remain within the allowable limit. The NRC staff concurs that under the operating conditions of the subject piping, the flaw growth rate, given the licensee's plant specific history, is expected to be small and daily monitoring will address any flaw size and associated growth issues before flaws reach an unacceptable size.

By letter dated March 16, 2011, in response to follow-up RAI Question No. 1, the licensee clarified that the allowable through-wall flaw sizes in Tables 2 and 3 of the relief request are also applicable to partial through-wall flaws (e.g., embedded flaws). Based on the evaluation procedures of ASME Code, Section XI, Appendix C, the allowable through-wall flaw sizes in Tables 2 and 3 are bounding for part-through-wall flaws for a given flaw length and, therefore, are applicable to part-through-wall flaws.

Known flaws, including flaws that are open to the outside surface but have not penetrated the inside surface pipe wall will be inspected every 30 days using NDE techniques. The surface length of the part-through-wall flaws will be determined at each inspection to trend the flaw growth and to compare the measured lengths with the allowable through-wall lengths to justify continued operation.

According to the licensee, ECCS lines for which this relief request applies are located outside containment and would be accessible for daily or monthly inspections under Code

Case N-513-2. However, as discussed above, there are two short lengths of ECCS piping in the containment emergency sump that see a high temperature in a post-LOCA environment. These lines are not accessible during normal plant operation and, as such, the licensee has removed the portions of these lines that are inside containment from the scope of the relief request.

The licensee has walked down the ECCS lines outside containment as part of the extent of condition walkdowns performed in late 2009, and has performed subsequent walkdowns to monitor these lines for through-wall leaks. The ECCS lines outside containment are accessible and, therefore, could be monitored consistent with Code Case N-513-2 and this relief request.

The NRC staff concludes that the licensee's monitoring and inspection regimen described above is consistent with the inspection requirements of Code Case N-513-3 to monitor flaw growth and is acceptable. The staff notes that any pipe segments that are not accessible for periodic inspection will be excluded from the relief request as they would not meet the monitoring requirements of Code Case N-513-3.

In RAI Question No. 6(2), the NRC staff asked whether, upon detection of a flaw during a refueling outage, the licensee would repair/replace the degraded pipe during that refueling outage, or defer repair/replacement until the subsequent refueling outage. By letter dated December 20, 2010, the licensee responded that it intends to repair the degraded piping at the earliest opportunity commensurate with safety significance. The licensee will exercise its due diligence to identify leaks and repair them before restart, and is planning to inspect the candidate piping early in a scheduled outage, so that sufficient time would be available to make necessary repairs within that outage.

The licensee stated that it intends to repair or replace piping with flaws found during a refueling outage prior to the end of that outage, whenever it is reasonable to do so. Should a leak be detected after completing its initial inspections, the licensee would apply its Operability Determination process, which includes immediate operability and prompt operability determinations. The POD would be based, in part, on the flaw evaluation using the methods described in the proposed alternative. The licensee would evaluate the impact of the flaw and, using conservative decision-making, take appropriate action based on the flaw characterization, whether there is an active leak, and the overall impact on safe plant operation.

The licensee noted that it would only make mode changes and restart from an outage with a flaw remaining in service if operation in that condition did not violate the plant Technical Specifications or the Operating License. The flaw evaluation based on the proposed alternative would be the justification for operability and for not making the repairs during the refueling outage. If flaw growth is found to be at a greater rate than originally expected and operation for the duration of the operating cycle could not be justified, the licensee would initiate a mid-cycle repair.

In follow-up RAI Question No. 3, the NRC staff questioned how the licensee would determine an acceptable flaw growth rate. By letter dated March 16, 2011, the licensee explained that an unacceptable growth rate is one where the flaw length is projected to exceed the allowable flaw length before the next 30-day inspection required by Code Case N-513-2 or the next scheduled outage, whichever is less. If the detected flaw length upon discovery is the same size as the allowable flaw length, then the degraded pipe will be repaired or replaced. The licensee noted that the allowable flaw lengths provided in Tables 2 and 3 of the relief request were calculated conservatively based on the bounding stresses for each line. Therefore, using these allowable lengths to disposition flaws at any location in the piping system is conservative because pipe locations will experience lower stresses than the bounding stresses and the allowable flaw size at the lower stress location will be larger than the specified allowable size in the relief request.

The NRC staff concludes that the licensee has sufficiently clarified its methodology to address unacceptable flaw growth for leaking and non-leaking defects. The staff concludes that the licensee's methodology to evaluate the flaw and flaw growth based on allowable flaw size and inspections every 30 days provides reasonable assurance of structural integrity of the piping system.

The NRC staff observed that the allowable flaw size in the relief request applies to planar flaws only. In RAI Question No. 14, the staff asked the licensee whether the relief request would be applicable to non-planar flaws such as wall thinning flaws. By letter dated December 20, 2010, the licensee responded that the proposed alternative permits application of the methodology described in Code Case N-513-2 to evaluate planar flaws detected in the candidate ECCS pipe. Code Case N-513-2 does provide provisions where planar flaw analysis may be used to evaluate non-planar flaws under the requirements of paragraph 3(d)(1) or 3(f) of the code case. This will allow the use of the relief request to evaluate non-planar flaws, such as localized pitting, or intergranular attack, if such degradation is detected.

By letter dated March 16, 2011, in response to follow-up RAI Question No. 7, the licensee explained further that depending on the extent of localized degradation, a planar flaw evaluation may be used to assess non-planar degradation following the provisions of 3(d)(1) of Code Case N-513-2, which can be summarized as follows:

(A) When the width of wall thinning, W_m, that exceeds minimum wall thickness, $t_{min,}$ is less than or equal to 0.5 times $(R_o t)^{1/2}$, where R_o is the outside pipe radius and t is the wall thickness, the flaw can be classified as planar and evaluated in accordance with Appendix C. Figure 2 of Code Case N-513-2 specifies the above parameters.

(B) When the wall thinning does not meet the requirements of (A) above, the licensee will apply the provisions of paragraph 3(d) items (2), (3), or (4) of Code Case N-513-2.

(C) When there is through-wall penetration along a portion of the thinned wall, then the licensee will apply the provisions of paragraph 3(e) of Code Case N-513-2.

The NRC staff concludes that as long as the requirements of Code Case N-513-3 are satisfied, the licensee may use the relief request to disposition non-planar flaws.

4.4 Flaw Inspection

Although the licensee stated that it will follow the inspection requirements of Code Case N-513-2, the NRC staff questioned how the inspections will be conducted under various scenarios of pipe cracking and flaw growth.

In RAI Question No. 13, the NRC staff asked the licensee to discuss the NDE requirements for the flaws (e.g., monitoring of crack growth), and actions that will be taken if the actual crack growth exceeds the crack growth assumed in the flaw evaluation. By letter dated December 20, 2010, the licensee responded that the NDE requirements for flaws that remain in service will be as described in Code Case N-513-2, paragraph 2(e). Specifically, periodic inspections will be performed at no more than 30-day intervals. The licensee intends to use ultrasonic examinations at the flaw location or physical measurement to satisfy this requirement.

The licensee stated further that it will follow Code Case N-513-2 to determine if flaws are growing and to establish the time at which the detected flaw will reach the allowable size. In addition, for through-wall leaking flaws, leakage will be observed by daily walkdowns to confirm the analysis conditions used in the evaluation remain valid. The actions taken if actual crack growth exceeds that used in the flaw evaluation will be consistent with Code Case N-513-2. Specifically, a repair or replacement shall be performed no later than when the predicted flaw size from periodic inspection or flaw growth analysis exceeds the acceptance criteria, or the next scheduled outage, whichever occurs first. Code Case N-513-3, paragraph 2(e), requires, in part, that

> When a flaw growth analysis is used to establish the allowable time for temporary operation, periodic examination of no more than 90 day intervals shall be conducted to verify the flaw growth analysis predictions.

The NRC staff notes that the licensee is required to use the new flaw growth rate that is greater than originally predicted in determining whether the degraded pipe needs to be repaired or replaced. In addition, Code Case N-513-3, paragraph 2(g) requires that

> If examinations reveal flaw growth rate to be unacceptable, a repair or replacement shall be performed.

The NRC staff concludes that the licensee will perform the inspection per Code Case N-513-3 and that it will repair or replace the degraded pipe should the flaw growth or flaw size exceed the acceptance criteria prior to the next scheduled refueling outage.

In Section 5 of the relief request, the licensee stated that should it discover unacceptable flaws in candidate piping, it will prepare an immediate Operability Determination based upon visual characterization of the indication and operating experience with the degradation mechanisms of this piping (stress-corrosion cracking or cyclic fatigue failure). In RAI Question No. 4, the NRC staff asked whether the licensee will perform a volumetric examination following the initial visual examination.

By letter dated December 20, 2010, the licensee responded that volumetric examination of detected flaws in the candidate piping will be performed as part of the prompt operability determination process. The licensee clarified further that it intends to use ultrasonic testing as the primary method of characterizing flaws found in the candidate piping. In accordance with Code Case N-513-2, paragraph 2(a), this examination will be for the full pipe circumference at the flaw location. If ultrasonic testing is impractical due to geometry, obstructions, or other reasons, then physical measurement of the flaw will be performed.

In follow-up RAI Question No. 2(1), the NRC staff noted that the licensee did not consider eddy current testing (ECT) or penetrant testing if ultrasonic testing is impractical. By letter dated March 16, 2011, the licensee responded that surface examination by penetrant testing has been used on this type of pipe and will be used for the ECCS piping on a case-by-case basis where practical. The licensee stated that surface examination using ECT may also be used for ECCS piping on a case-by-case basis where practical. The staff concludes that it is acceptable that the licensee will consider penetrant testing or ECT if ultrasonic testing is impractical.

The NRC staff notes that the flaw length on the inside surface of the pipe may be longer than the outside surface of the pipe and the flaw may grow more at the inside surface than at the outside surface. In follow-up RAI Question No. 2(2), the staff asked the licensee how the physical measurement can detect the flaw growth of the through-wall flaw to ensure structural integrity of the degraded pipe. The licensee responded that Schedule 10S pipe is relatively thin. For example, the 24-inch pipe has a wall thickness of only 0.25 inches. The extent of an ID flaw length is not expected to significantly exceed the OD length before through-wall penetration and visible leakage occurs. Additionally, most observed degradation initiates on the OD surface so that OD flaw lengths are expected to be greater than ID lengths at time of discovery. An additional margin of 0.25 inches will be added to the measured OD flaw length prior to comparison to allowable flaw lengths to account for uncertainty on length sizing. The staff concludes it is acceptable that the licensee will add an additional 0.25 inches to the measured flaw length to account for measurement uncertainty.

In follow-up RAI Question No. 4, the NRC staff notes that it would be difficult to measure the flaw length accurately considering the presence of exiting hot steam/water. By letter dated March 16, 2011, the licensee responded that higher temperatures only occur following a LOCA. Flaw measurements can be accurately made and leakage safely monitored during normal inspection periods when the operating temperature is less than 200 °F. During a postulated accident, the time at which containment sump water temperatures exceed 200 °F will be less than 14 hours. At all other times, the affected piping is moderate energy (i.e., less than 200 °F). The licensee does not intend to perform inspections immediately following an accident until such time as accident recovery conditions allow for safe access to perform such inspections. The staff concludes it is acceptable that the licensee will examine the flaw when the leakage cools to an appropriate temperature to allow personnel access to obtain an accurate crack size.

4.5 Degradation Mechanism

According to the licensee, the flaws that have been discovered to date have resulted from stress-corrosion cracking or cyclic fatigue failure on both the piping ID and OD. The licensee stated that it is still developing long-term corrective action for the degradation of the Schedule 10S ECCS piping. To date, some piping has been replaced and further options under consideration include possible replacement of additional Schedule 10S piping, the application of weld overlays for affected welds, or other actions yet to be identified. While specific actions have not yet been finalized for all of the subject piping, the licensee intends to actively address the degradation of Schedule 10S piping rather than continuing to evaluate and repair individual flaws on an as-found basis.

The licensee has recognized that Relief Request ISI-3-31 will not address the long-term impact of stress-corrosion cracking on the subject piping and the licensee has indicated that it will develop a long-term solution to address this issue, which the NRC staff concludes is acceptable. NRC Information Notice 2011-04, "Contaminants and Stagnant Conditions Affecting Stress Corrosion Cracking in Stainless Steel Piping in Pressurized Water Reactors," provides additional information on stress-corrosion cracking that applies to the subject piping in SONGS, Units 2 and 3.

4.6 <u>Hardship</u>

The licensee noted that, based on SONGS operating experience, the flaws detected to date have been smaller than the allowable flaw size specified in the relief request, and have not presented a challenge to piping structural integrity. The licensee believes that requiring a plant shutdown to perform an ASME Code repair of the affected piping that may reach a maximum operating temperature of 275 °F, when compared to the 200 °F limit of Code Case N-513-2, does not provide a compensating increase in the level of quality and safety.

In addition, the licensee believes that the restriction in Code Case N-513-2 against using Appendix C methods for flaw evaluation in piping less than 4-inch NPS does not provide a compensating increase in the level of quality and safety under the conditions by which the calculations for allowable flaw length were performed. The licensee applied a Z-factor determined for a 4-inch NPS pipe in the case where the actual NPS was 2.5 inches. The licensee noted that this analysis assumption is conservative in determining the allowable flaw length for the 2.5-inch NPS ECCS piping. The NRC staff concludes that requiring the licensee to repair the flaws in the candidate piping would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

In addition to this hardship, the NRC staff concludes that Relief Request ISI-3-31 provides reasonable assurance that the structural integrity of the candidate pipe sections will be maintained because the relief request provides for adequate leakage monitoring, flaw inspection and allowable flaw sizes based on acceptable flaw evaluations.

5.0 <u>CONCLUSIONS</u>

On the basis of the information submitted, the NRC staff concludes that the licensee has provided sufficient information to support its argument that compliance with the specified requirement to perform an ASME Code repair of the candidate ECCS pipes, should they be degraded, would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. The NRC staff concludes that the licensee has demonstrated that the proposed alternative in Relief Request ISI-3-31 provides reasonable assurance that the subject ECCS pipes, if degraded, would still maintain their structural integrity until repair/replacement as specified in ASME Code Case N-513-3. Pursuant to 10 CFR 50.55a(a)(3)(ii), the NRC staff authorizes the use of Relief Request ISI-3-31 for SONGS, Units 2 and 3. Relief Request ISI-3-31 is hereby authorized for use for the third 10-year ISI interval, which ends on August 17, 2013, for SONGS, Units 2 and 3.

As discussed in Section 3.1 of this safety evaluation, the licensee has excluded from the relief request those sections of piping that are inside containment, for the piping identified in items 5 and 10 in Table 1 of the May, 19, 2010, letter. Therefore, the NRC's authorization for Relief Request ISI-3-31 does not apply to those sections of piping that are inside containment for the piping identified in items 5 and 10 in Table 1 of the relief request.

All other requirements in the ASME Code, Section XI, and Code Case N-513-3 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

Date: May 13, 2011

As discussed in the NRC staff's enclosed safety evaluation, the licensee's proposed alternative for the evaluation and disposition of flaws in the specified sections of ECCS piping is authorized for the remainder of the third 10-year ISI interval at SONGS, Units 2 and 3.

All other requirements of the ASME Code, Section XI, and Code Case N-513-2, for which relief was not specifically requested and approved remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

If you have any questions, please contact Randy Hall, at (301) 415-4032, or via e-mail, at randy.hall@nrc.gov.

Sincerely,

/RA/

Michael T. Markley, Chief
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-361 and 50-362

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