# Public Meeting with the Nuclear Regulatory Commission

## Technical Meeting – Non-Proprietary

### February 27, 2013

# Southern California Edison Commitment

We operate San Onofre Nuclear Generating Station (SONGS) safely and reliably to the highest standards to protect the health and safety of the public and our employees

We will not restart either Unit 2 or Unit 3 until we and the Nuclear Regulatory Commission (NRC) are satisfied it is safe to do

# Purpose of Today's Meeting

- Overview of Southern California Edison's (SCE) October 3, 2012 response to the Confirmatory Action Letter (CAL)
- Discussion of SCE's responses to Request for Additional Information (RAIs) 1 through 32
- Review SCE's plans for responding to draft RAIs 33-67

# SCE Response to Confirmatory Action Letter

# Conservative Actions to Improve Safety Margin

- Power Reduction to 70%
  - Significantly reduces fluid velocities: less energy causing tubes to vibrate
  - Significantly reduces void fraction: better damping
  - Prevents Fluid Elastic Instability (FEI)
- Preventive Plugging of Tubes
  - Tubes most susceptible to FEI at 100% power
  - Eliminates possibility of tube leakage
- Short Operating Interval
  - Five month window is significantly shorter than analysis allows
  - 100% tube inspection during mid-cycle outage

# Discussion of SCE's Responses to the NRC's Requests for Additional Information (RAIs) 1- 32

# RAI 32 - Compliance with Technical Specification 5.5.2.11

**NRC RAI:**

- *Provide clarity on how structural integrity in Technical Specification (TS) 5.5.2.11.b.1 is met for operation up to the Rated Thermal Power (RTP)*

*(or)*

- *Provide an Operational Assessment (OA) for Tube to Tube wear (TTW) at 100 % RTP*

# SCE Response to RAI 32
# Compliance with TS Requirements

- TS 5.5.2.11 uses the term “normal full power” not RTP
- Formal commitment in CAL response to limit power redefines our licensing basis “normal full power” to 70%
- OAs demonstrate Steam Generator (SG) tube performance criteria are met at 70%
- TS 5.5.2.11 is satisfied

# SCE Response to RAI 32
# OA for 100% RTP

- As requested in the RAI, an OA at 100% RTP will be provided to NRC
- This OA will be performed using accepted industry guidelines
- AREVA and Westinghouse (WEC) TTW OA analyses provide the basis for operation at 70% power
  - These OAs demonstrate that substantial margin to the onset of Fluid Elastic Instability (FEI) exists at 70% power

# SCE Response to RAI 32
# Actions after Return to Service

- Power will be limited to 70 % unless approval from NRC is obtained to raise power
- Initial operating period will be 150 days followed by mid-cycle SG inspection outage

# SCE Response to RAI 32
# Actions after Return to Service

- SCE will perform SG tube inspections in accordance with TS 5.5.2.11 and Section 8.3 of the Return to Service Report (RTSR)
- Additional indications of TTW due to FEI will be addressed with the NRC prior to restart

# SCE Response to RAI 32
# Actions after Return to Service

- OAs will determine subsequent operating intervals and power levels
- This approach will be used until long-term operational limits including power level are determined

# RAI 2 – Intertek OA Tube-To-Tube (TTW) Growth Rates

## NRC RAI:

*"The Operational Assessment in Attachment 6, Appendix C (Reference 4), pages 3-2 and 4-12, appears to state that tube-to-tube wear (TTW) growth rates are based on the maximum TTW depths observed in Unit 3 at EOC 16 divided by the first Unit 3 operating period (0.926 years at power). Provide justification for the conservatism of this assumption…"*

## Response:

- Explained why the determination of TTW growth rates was based on 0.926 years at 100% power in conjunction with a set of conservative assumptions to provide a conservative wear rate model for Unit 2
- Provided discussion of how the Unit 3 wear rates were benchmarked and the justification for this approach
- Computed TTW growth rates based on non-zero initiation time

# RAI 3 – Intertek OA Definition of Wear Index

## NRC RAI:

*"Regarding Reference 4, describe the sensitivity of the results in Figure 5-4 to the definition of "wear index." If alternate definitions significantly affect the results, what is the justification for the definition being used?"*

## Response:

- Discussed the approaches to the wear index that were examined:
  - Tube wear at Anti-Vibration Bars (AVBs) versus TTW
  - Tube wear at Tube Support Plates (TSPs) versus TTW
  - Tube wear at AVBs and TSPs treated as independent parameters
  - Tube wear as the summation of AVB and TSP
- Provided the evaluation of each approach and the justification for the wear index used in the OA

# RAI 4 – Intertek OA Wear Index Definition

## NRC RAI:

*"Regarding Reference 4, does the definition of "wear index" include summing the depths of 2-sided wear flaws at a given AVB intersection? If not, explain why SCE's approach is conservative."*

## Response:

- Explained the wear index is based on bobbin
- Discussed how the wear index is correlated to the presence or absence of TTW and its application in the OA model
- Explained the change in wear index depends on the AVB/TSP growth rates which are traditionally based on bobbin data
- Provided the justification for the bobbin-based wear index used in the OA

# RAI 18 - Vibration Loose Parts Monitoring System and RAI 19 - Smart Signal

## NRC Question:

1. *In the response to RAI 18, SCE implies that by upgrading the Vibration and Loose Parts Monitoring System (VLPMS) they will be able to evaluate historical acoustic signal data for events that would "help with the understanding of the causes of unexpected tube wear." For this statement to prove true, this implies that they believe that the VLPMS will indeed be capable of detecting events that are indicative of tube-to-tube contact. SCE states that a backward looking evaluation of the VLPMS alarms received for both Unit 3 and Unit 2 prior to their shut down failed to identify any correlation with tube vibration or tube-to-tube contact. SCE's response did not provide any basis for stating why they believe that by upgrading the VLPMS as described they will be able to detect events that are indicative of tube vibration or tube-to-tube contact, nor how this will provide a backward-looking tool to help with the understanding of the causes of unexpected tube wear. Similarly, the response to RAI 19, does not appear to provide a basis for stating how the GE Smart Signal analysis tool will be used to enable the analysis of the data from the VLPMS to conclude that noise events are indicative of tube-to-tube or tube-to-AVB contact.*

# RAI 18 - Vibration Loose Parts Monitoring System and RAI 19 - Smart Signal

## NRC Question:

2. *It is not clear what SCE's long-term game plan is for ensuring safe operation for Unit 2, and how the enhanced VLPMS performance fits into this plan. What specific data will be collected by the VLPMS, how will that data be correlated to specific tube wear mechanisms and locations, and how will the information be communicated to the NRC staff in a form that provides reasonable assurance of safe operation for any future cycles for Unit 2?*

# RAI 18 - Vibration Loose Parts Monitoring System and RAI 19 - Smart Signal

- SCE's long-term plan for ensuring safe operation of Unit 2 is summarized in our response to RAI 32
- SCE is not asserting or implying that the upgraded VLPMS will be able to detect TTW. SCE's plan is to record data on the VLPMS system during operation and to analyze that data during the next mid-cycle inspection. The analysis will include a comparison with the results of the SG inspection. As indicated in SCE's response to RAI 19, GE Smart Signal technology will also be used in that analysis
- As indicated in the SCE response to RAI 18 "The upgraded VLPMS will be used as a backward looking analysis tool in subsequent inspection outages should unexpected wear be discovered. The upgraded VLPMS will enable SCE to evaluate historical SG secondary side acoustic signal data for events ***which may help*** with the understanding of the causes of unexpected tube wear...the VLPMS is not designed to detect tube to tube contact..."

# Discussion of SCE's Response Plans to the NRC Requests for Additional Information (RAIs) 33 - 67

# RAI 35 – AREVA OA Upper Bound Contact Force Clarifications

## NRC RAI:

*Reference 1, Section 7.3, page 98 of 129: The "upper bound contact forces" shown in Figure 7-2 are average values. Clarify whether these "average values" are averages of the upper bound contact forces for each tube in the bundle at each AVB. Why is it acceptable that the calculated upper bound contact force prevents motion for only 97.7 percent of the force spectrum from turbulence? Finally, why has only turbulence excitation been considered in the development of these upper bound contact forces?*

## Response Plan:

- The values shown in Figure 7-2 are the averages of the upper values for 5 tubes in the area of high susceptibility to instability
- Small gaps with no contact force have been shown to provide effective support
- The upper bound contact forces are applicable when there is only one effective support for the tube; this special case was found to have little impact on probability results. Logically, support effectiveness depends on both contact force and gap

# RAI 55 – AREVA OA Anti-Vibration Bar Wear Clarifications

## NRC RAI:

*In Reference 2, page 107 of 129, second to last paragraph, did total gap also include wear of the anti-vibration bars (AVBs) themselves? If not, explain why the approach is conservative. If so, how was wear of the AVBs determined? (This question is a follow-up on RAI No. 26 from the NRC's December 26, 2012, letter).*

## Response Plan:

- Wear at tube to AVB intersections was included in the MHI calculations of gaps and contact forces. Both wear of the tube and wear of the AVB was included. Based on MHI wear test data, the wear volume of the AVB is one half of the corresponding wear volume of the tube. Increased gaps due to wear were added to the contact force quarter model input in addition to the random selection of gaps from the manufacturing gap distributions
- The sizes of wear induced gaps were based on eddy current inspection data for the worst case steam generators, Unit 2 SG 89 and Unit 3 SG 89. The wear gaps in the contact force model were placed at the same locations as found in the eddy current inspection. (continued on next slide)

# RAI 55 – AREVA OA Anti-Vibration Bar Wear Clarifications

**Response Plan (continued):**

- The wear level at any given location was adjusted for different time periods using the assumption that the work rate at that location was constant over time. Thus the wear volume loss rate is constant over time at a given location. The wear volume loss rate at different locations is calculated from the eddy current inspection wear depth and the total operating time

- For Unit 2, the wear volume loss rates after restart of 70% power are conservatively assumed to be the same as observed at 100% power

# RAIs 37 and 56 – AREVA OA Additional Discussion of Benchmarking and Sensitivity of Probability of FEI Results

## NRC RAI 37:

*Reference 1, Section 8.0, page 107 of 129, and Figure 8-3 indicate that Unit 2 can be operated for 8 months after BOC 17 before exceeding the 5% probability limit. What is the sensitivity of this estimate to a higher assumed value of median contact force for support effectiveness?*

## NRC RAI 56:

*For Reference 2, Figure 8-3, provide an assessment of the robustness of the Figure 8-3 predictions of the probability of instability versus time in terms of how well it accommodates uncertainty in these predictions for purposes of ensuring acceptable tube integrity margins during the planned 5-month inspection interval for Unit 2. Robustness refers in part to accommodating increases or decreases in the rate at which instability increases with time and the calculated value of the probability of instability at the beginning of cycle (BOC) 16 for Units 2 and 3 and BOC 17 for Unit 2. Robustness also considers the time interval between onset of instability and the loss of acceptable tube integrity margins.*

# RAIs 37 and 56 – AREVA OA

## Response Plan:

- The examination of the sensitivity of input parameters to probability of instability calculations must be examined in concert with one another and always in the context of the observed stability behavior of SONGS Unit 2 and Unit 3. Results of detailed sensitivity analyses are available and will be submitted in our response
- At 100% power the SONGS steam generators are outside of the envelope for past successful performance relative to in-plane Fluid Elastic Instability (FEI)
- At 70% power the SONGS steam generators are well inside of the envelope for past successful performance relative to in-plane FEI

# RAI 38 – Loading Condition and Influence by Hydrodynamic Pressure

## NRC RAI:

*In Reference 1, p. 8-3 (308 of 474), Section 3.2), "Loading conditions," please explain how ATHOS output is being converted to hydrodynamic pressure. The NRC staff is not aware that this quantity is a direct output of the ATHOS code. Please show a derivation of this parameter, explain how it is computed for the purposes of data reduction and display, and explain its technical significance.*

## Response Plan:

- Provide the equation used to calculate hydrodynamic pressure from ATHOS output
- Discuss the influence of the hydrodynamic pressure on the behavior of U-bend region of tube bundle

# RAI 39 – Definition of Homogeneous Void Fraction β

## NRC RAI:

*In Reference 2, p. 36, Bottom of page, the term β is not defined. Please define the parameter, and explain (1) how it is formulated, and (2) how it is related to the ATHOS computed nodal void fraction*

## Response Plan:

- Explain the definitions of homogeneous void fraction β and ATHOS computed nodal void fraction α
- Explain the relationship between β and α

# RAI 40 – Liquid Film Condition for Plugged Tubes

## NRC RAI:

*In Reference 2, p. 40, it is stated that "…plugged tubes are assumed to be in wet condition despite the void fraction." Please explain why this assumption is used, and provide information to justify that it is appropriate (i.e., valid, conservative, or insignificant) for the purposes of the relevant analyses.*

## Response Plan:

- Explain the basis for the assumption that plugged tubes (no heat flux) are assumed to be in a wet condition
- Demonstrate that the results are not sensitive to the assumption

# RAI 42 – Screened Tubes Were Plugged

## NRC RAI:

*In Reference 3, p. 4 (4 of 62), SCE does not conclusively state which screened tubes were actually plugged. Please discuss the threshold and implementation of the criteria (with exceptions) and provide or refer to a list of confirmed plugged tubes in Unit 2.*

## Response Plan:

- All tubes meeting the screening criteria from Reference 3 were plugged
- Provide discussion of the threshold and implementation of the criteria
  - Reference 3, Section 4, “Screening Level Selection”
  - Reference 3, Section 5, “Screening Results of Unit 2 Steam Generators,” contains maps and lists of the screened tubes
- Provide listing of confirmed plugged tubes in Unit 2

# RAI 43 – Fluid Force to Calculate Active Condition at AVB Supports

## NRC RAI:

*In Reference 4, p. 15, Section 6.3, "Assumption," Item (1) "Fluid force," please explain the basis for the statement, "The turbulent excitation force is evaluated and fluid force caused by FEI is not taken into account…" It is not clear how the turbulent excitation force is used to determine when the friction force is adequate to assume that there is no in-plane motion at the subject AVB intersection. Please clarify the statement, "When the friction force due to contact force is smaller than the turbulent excitation force at an AVB support point, a tube can slide in the in-plane direction.*

## Response Plan:

- Provide additional details of the reason why turbulence excitation force is used to determine support effectiveness
- Provide additional details and clarify the sentence cited in the RAI

# RAI 44 – Consideration of Small Amplitude Vibration on Required Contact Force

## NRC RAI:

*In Reference 4, p. 15, Section 6.3, "Assumption," Item (1) "Fluid force," it is assumed there is no in-plane motion if the stability ratio (SR) is less than 1.0. How has MHI accounted for the potential that in-plane tube motion may occur at a SR less than 1.0 and how is the analysis result affected if a smaller value is used for this threshold?*

## Response Plan:

- Explain the basis of method used in the response to RAI 43 (combined response will be provided for RAI 43 and 44)
- Discuss that SR criteria do not affect contact force

# RAI 45 – Intertek OA
# Effect of Power Reduction

## NRC RAI:

*In Reference 5, p. 4-12 (38 of 66), Section 4.7, "Effect of Power Reduction," the probability of initiation (POI) is based on a calculation of dynamic pressure. Please provide the location in the U-bend selected to compute the parameter and provide justification for selection for this application. It is not clear that dynamic pressure is a key parameter for correlation of the TTW damage patterns experienced at SONGS.*

## Response Plan:

- Explain the reason for using dynamic pressure and the source of the value used in the POI model
- Discuss the independent verification and comparison with tube instability ratio calculations shown in Figure 4-14 of Reference 5

# RAI 46 – Westinghouse OA Use of Beta of 5.0

## NRC RAI:

*In Reference 6, p. 15 of 131, please provide justification for selection of β=5.0 for the threshold value of the fluid elastic instability constant, and explain why it is a conservative selection for this application, considering the T/H conditions and size of the SONGS replacement SGs.*

## Response Plan:

- Section 4.2.5.2 of Reference 7 contains specific details regarding the selection of the values of Beta (Connor's coefficient) used in the analysis
- Additional test data will be provided to demonstrate conservatism used in the selection of Beta

# RAI 53 – Intertek OA TTW Growth Model Regression

## NRC RAI:

*In Reference 1, Section 4.6.2, "[Tube-to-Tube (TTW)] Growth Model," was the regression fit slope and intercept uncertainty modeled (e.g., as was done for the burst pressure versus voltage model in NRC Generic Letter 95-05)? If not, why is this conservative? Was the data scatter about the regression fit modeled as normally distributed? If so, provide justification for the adequacy of this assumption (i.e., normal distribution) to fully capture the upper tail of the distribution as shown in Figure 4-12 on page 4-25.*

## Response Plan:

- Explain the regression model variables in the OA
- Discuss the regression analysis and basis for the normally-distributed error of estimate for the TTW growth model
- Provide justification for the approach

# RAI 54 – Intertek OA TTW Growth Rate Figures

## NRC RAI:

*In Reference 1, Figures 4-11 and 4-13, the maximum depths in Figure 4-11 have been divided by the Unit 3 cycle length of 0.926 years to yield the growth rates in Figure 4-13. The staff understands that Figure 4-13 should be simply a scaled version of Figure 4-11. Please explain why some of the data in Figure 4-11 are not shown in Figure 4-13; for example, the three flaws shown in Figure 4-11 with maximum depths ranging from 89 to 100% (AREVA resized).*

## Response Plan:

- Discuss the derivation of Figure 4-13 and how the wear rate is computed in the OA algorithm
- Increase the range of the wear rate axis to show the data above the 100% through wall per years at power

# RAI 57 – Tube Support Plate Hole Location

## NRC RAI:

*In Reference 3, Appendix 9, Table 6.2-1, why is tube support plate (TSP) hole mis-location not included in the table headings? If not accounted for in the analysis, explain why the approach is conservative. If used in the analysis, provide an updated table that includes the TSP hole mis-location parameter.*

## Response Plan:

- TSP hole mis-location was considered in the analysis
- Provide an updated table including the TSP hole mis-location

# RAI 58 – Input Parameters for Contact Force Calculation (Random or Functional)

## NRC RAI:

*In Reference 3, Appendix 9, Table 6.2-1, which parameters are sampled randomly at each tube/AVB intersection? Why is this appropriate in lieu of assuming a functional relationship for each given parameter from tube to tube in a given column of tubes? For parameters (e.g., AVB twist) assumed to follow a functional relationship from tube to tube in the same column, provide the basis for the assumed relationship. For AVB twist, how does the assumed relationship relate to Figure 6.2-2?*

## Response Plan:

- Explain which parameters were randomly treated and which parameters have functional relationships
- Explain the process used to obtain the relationship shown in Figure 6.2-2

# RAI 59 – AVB Dimensional Inputs

## NRC RAI:

*In Reference 3, Appendix 9, Attachment 9-1; define the statistical distributions which were actually sampled for Unit 2 and Unit 3. What is the technical justification for the assumed distributions compared to the actual distribution of the data?*

## Response Plan:

- The data in Reference 3, Appendix 9, Attachment 9-1 are the results of verification testing prior to the application of AVB press load change
- Provide the justification for the assumed distributions

# RAI 60 – Additional Figures on Displacements Along Columns

## NRC RAI:

*In Reference 3, Appendix 9, Figures 7.2-3 and 7.2-5 apply to Unit 3. Please provide similar figures for Unit 2.*

## Response Plan:

- Provide similar figures for Unit 2

# RAI 61 – Ding Indication Plotting Differences

## NRC RAI:

*Reference 3, Appendix 9, Attachment 9-3, Figure 4.1.2-3. Discuss the pedigree of the data in this figure and how it differs from Reference 2, Figure 6-19 and 6-20. Please explain the differences between the Reference 3 versus the Reference 2 figures for dings exceeding 0.5 volts?*

## Response:

- The two figures are based on the same data. In Reference 3, the figure excluded free span ding signals and included TSP ding signals
- Reference 2 included free span ding signals but did not include TSP ding signals

# RAI 62 – AREVA OA Impact of Best Estimate Stability Ratio Values

## NRC RAI:

In Reference 2, Figure 8-3, the staff understands that the stability ratio (SR) in the context of Figure 8-3 is a 95% upper bound estimate, both for the last operating period for both Units 2 and 3 and for the next operating period for Unit 2. Why wasn't a best estimate SR used for benchmarking the probability of SR>1 at the conclusion of the last operating period for both Units 2 and 3? (Benchmarking refers to selecting a contact force criterion for effective AVB support such as to produce probabilities of SR>1 at the end of the last operating period consistent with what was actually observed.) How would a best estimate SR have affected the curves presented for the last operating period? Discuss whether the use of a 95% upper bound estimate for benchmarking purposes essentially negates the conservatism of using 95% upper bound SR estimates for future operation of Unit 2?

## Response Plan:

- The question is understood and a thorough response will be provided

# RAI 63 - Tube-to-AVB Gaps at Outer Tubes

## NRC RAI:

*In Reference 3, Page 66, the last sentence on this page states, "Therefore, the difference of the contact forces between Unit-2 and Unit-3 is caused by the difference of the manufacturing dimensional tolerances other than the outer-most tube-to-AVB gaps." Explain the basis for this conclusion in light of the omission of the measured tube-to-AVB gaps at the outer tubes as a boundary condition in the contact force model described in Appendix 9 of Reference 3.*

## Response Plan:

- Provide the basis for excluding the measured tube-to-AVB gaps at the outer tubes as a boundary condition in the contact force model. Explain that calculation results indicate the influence of outer-most gaps do not affect the contact forces inside the bundle where in-plane FEI was observed

# RAI 64 – Anti-Vibration Bar Twist Factor

## NRC RAI:

*In Reference 3, Appendix 9, page 9-6 (355 of 474), it is stated, "Especially for AVB twist, AVB twist factor in consideration of torsion stiffness is defined as a decrease function of distance from AVB bending peak, because the more contact points leave from AVB nose, the less AVB torsion stiffness is." Please clarify the meaning of this sentence by answering the following questions: What is the "AVB twist factor?" What is meant by "AVB twist factor in consideration of torsion stiffness?" What parameter is decreasing as a function of distance from the AVB nose, AVB twist or AVB torsional stiffness? Why does torsional stiffness vary as function of distance from the AVB nose? Describe the specific variation of torsional stiffness with distance from nose function that was used in the analysis. How was this variation determined?*

## Response Plan:

- Provide additional information of the AVB twist factor addressing each of the RAI's questions

# RAI 65 – Anti-Vibration Bar Twist Factor

## NRC RAI:

*In Reference 3, Appendix 9, Figure 6.2.2 shows AVB twist factor as a function of distance from AVB nose tip. Is this the function that was used in the contact force analysis? For all AVBs? If not, what twist factor functions were used for the other AVBs? How were these twist factor functions determined? Explain the relationship between twist factors shown in this figure versus those shown in Table 6.2-1.*

## Response Plan:

- Provide more detailed explanation of AVB twist factor. (RAIs 64 through 66 are related questions, a combined response will be provided)

# RAI 66 – Anti-Vibration Bar Twist Factor

## NRC RAI:

*In Reference 3, Appendix 9, page 9-6 (355 of 474) it is also stated, "In AVB nose area, the factor is always 1, because increased twist from nose tip and decreased stiffness from nose tip cancel each other." Please provide a detailed clarification of this sentence. The staff further notes that "twist" and "stiffness" have different units. How can they cancel each other out?*

## Response Plan:

- Provide additional information on AVB twist factor

# RAI 67 – Tuning of Contact Force Model

## NRC RAI:

*Reference 3, Appendix 9, Attachment 9-3; describe in detail any "tuning" of the contact force model that was performed to replicate the ding signals observed during pre-service inspection.*

## Response Plan:

- Provide detailed description of factors used to match the Eddy Current Testing inspection "ding" signals
- RAIs 67 and 59 are related questions, a combined response will be provided

# There is no timeline on safety