August 18, 1997

Mr. Dwight E. Nunn
Vice President
Southern California Edison Company
San Onofre Nuclear Generating Station
P. O. Box 128
San Clemente, California 92674-0128

SUBJECT: SAN ONOFRE NUCLEAR GENERATING STATION STEAM GENERATOR EGGCRATE DEGRADATION ISSUE

Dear Mr. Nunn:

Several meetings were held recently between Southern California Edison (SCE) and the NRC staff to discuss the adequacy of the degraded eggcrate supports in the San Onofre Nuclear Generating Station (SONGS) Unit 3 steam generators. These meetings occured on May 9, May 29, and June 11, 1997. The overall purpose of the meetings was to provide the NRC with an understanding of the cause, corrective actions, and the impact of the SONGS Unit 3 degraded eggcrate supports on continued plant operation. By letters dated April 30, May 16, May 26, and June 5, 1997, the licensee provided its justification for continued operation of SONGS Units 2 and 3.

SCE performed a 10 CFR 50.59 evaluation of the SONGS Unit 3 eggcrate tube supports in their present degraded condition, and concluded that no unreviewed safety question existed. The NRC has selected this 10 CFR 50.59 evaluation to review as part of its normal review process of licensee's 10 CFR 50.59 programs. On the basis of its review to date, the staff has not identified any deficiencies in the licensee's analysis of the adequacy of the eggcrate supports. The staff will provide its final assessment of this 10 CFR 50.59 evaluation in a future inspection report.

In support of its final assessment of this 10 CFR 50.59 evaluation, the staff has developed the attached list of questions. Please contact me at (301) 415-3062 if you wish to discuss these questions in more detail.

Sincerely,
Original Signed By
Mel B. Fields, Project Manager
Project Directorate IV-2
Division of Reactor Projects III/IV
Office of Nuclear Reactor Regulation

Docket Nos. 50-361
and 50-362

Enclosure: Eggcrate Evaluation Questions

cc w/encl: See next page

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SAN ONOFRE NUCLEAR GENERATING STATION

UNITS 2 AND 3

STEAM GENERATOR EGGCRATE QUESTIONS

Root Cause Evaluation Questions

1. It is Southern California Edison's (SCE's) position that the erosion corrosion of the eggcrate supports in Unit 3 was most likely the result of excessive steam generator tube and support deposits. What is SCE's hypothesis as to why excessive deposits developed in Unit 3 and not in Unit 2?

2. SCE performed secondary side visual inspections on both Unit 3 steam generators and one Unit 2 steam generator. For all four steam generators in the two units, discuss in general terms the extent of the degradation and compare the overall assessment of the degradation with the other indicators SCE used to determine the root cause. (Assume for this comparison similar results for both Unit 2 steam generators since only one was visually inspected.) These other indicators include (but are not limited to): amount of deposits removed after chemical cleaning; main steam pressure losses prior to chemical cleaning; number, severity and location of wear indications; steam quality and flow rate; and control of steam generator water level. Discuss how the comparison between the extent of the degradation and the qualitative indicators support or contradict the root cause.

3. Discuss the significance of the fact that the predicted deposit loadings for the Unit 2 steam generators were very close with actual values while the predicted deposit loadings for the Unit 3 steam generators were substantially lower than the actual values.

ATHOS Model Questions

1. In the June 11 presentation, SCE indicated secondary side fluid velocities in the tube bundle periphery could reach about 18 ft/sec which was on the "ragged edge" of erosion corrosion susceptibility.

   a) Confirm this velocity was predicted using ATHOS and assuming uniform tube surface fouling of 20 mils and eggcrate strip surface fouling of 20 mils on each side for all ten eggcrates.

   b) What velocities were predicted for the cold leg periphery, blowdown lanes, and stay cylinder regions? Discuss how the results support your root cause.

c) Explain the basis that the model of 20 mils uniform fouling on each steam generator tube and each eggcrate strip for all 10 eggcrates represents the conditions at the Unit 3 steam generators. What kind of physical measurements did SCE take to estimate the amount of tube and eggcrate support fouling in the Unit 3 steam generators? How does the amount of deposits removed from the Unit 3 steam generators fit with the ATHOS model? Does the amount of tube scale found during past tube pulls fit with the ATHOS model? Discuss how your visual examinations of the Unit 3 eggcrates confirmed blocked flow areas within the tube bundle.

2. SCE relied on ATHOS modeling to assist in the determination of the root cause and to evaluate the Cycle 9 fluid dynamic conditions experienced by the outer periphery tubes.

a) With the Unit 3 steam generators chemically cleaned, compare the current performance with the predicted performance shown in Tables 4-1 and 6-1 in Attachment D to Appendix D of SCE's June 5, 1997 letter. Discuss the significance of any discrepancies between actual and predicted steam generator performance values.

b) Explain what is meant by "calculated fouling thickness" in Table 6-1.

c) In the table on page 15 in Appendix E of the June 5 letter, why does the velocity "within tube bundle at the periphery (tubed)" increase from a clean condition to a 12 mils of fouling condition and then decrease upon further fouling of 20 mils?

3. The ATHOS code was used to calculated cross flow velocities to determine the stress values on the SG tubes. Explain how the actual variations in the thickness of eggcrates near the tube bundle pheriphery were accounted for in the calculation of the local velocity fields.

<u>Inspection Plan Questions</u>

1. Discuss the limitations of relying on remote visual inspections to assess the effectiveness of the corrective action. What is the basis for the conclusion that 10% additional thinning of the eggcrates will be detected at the mid-cycle or at the refueling inspection (this is the maximum tolerance SCE has for continued degradation)?

2. Is flow induced vibration always manifested through wear indications? Is there an increased likelihood of circumferentially oriented fatigue cracks in the peripheral tubes affected by loss of eggcrate support? Discuss the potential need to inspect the affected peripheral tubes with rotating pancake coil probes during routine eddy current inspections.

3. Discuss SCE's plans to monitor the number, severity and location of wear indications, given they were a manifestation of the root cause.

4. How much further eggcrate support degradation is considered to be within "operational norms" (p. 6-1 of the June 5 letter)? If continued eggcrate support degradation is expected, what are SCE's plans for future inspections to ensure the 10% additional thinning of the eggcrates will not be exceeded?

5. In what other ways will SCE assess the root cause and corrective actions? For example, what are SCE's plans to monitor iron transport, sludge lancing results, tube inspection results (wear and fatigue), visual inspection results, steam pressure losses, steam quality and velocity, etc.

6. Compare the specific locations and extent of the Unit 2 steam generator visual inspections with the areas of significant degradation found in the Unit 3 steam generators. In other words, demonstrate that the extent of the Unit 2 visual inspections encompassed areas of expected degradation. Is it possible that the visual inspections of the Unit 2 steam generator missed degraded eggcrates?

Flow-Induced Vibration Questions

With regard to the flow-induced vibration issue, SCE stated in its June 5, 1997 letter that (1) the bounding cases evaluated were those cases with multiple eggcrates uncredited, and (2) the tubes plugged or staked were those tubes with two or more consecutive eggcrates uncredited and having stability ratio greater than 0.64. SCE also stated that the cases where tubes were supported with alternate eggcrates uncredited were also investigated, and these cases were bounded by two or more consecutive eggcrates uncredited. The staff is requesting the following information regarding the licensee's evaluation:

1. Explain why the critical mode for bend region of the tube was considered only for tube rows (TR) 147 and 83 with higher modes, i.e., fn = 56.1 H_z for TR-147 and fn = 46.5 H_z for TR-83 respectively, while it was not assessed for other tubes with similar or different conditions, e.g., TR-111 and TR-93 with 8 and 9 eggcrates uncredited.

2. Provide results for the 5 most critical cases with alternate eggcrates uncredited, including the consideration of vulnerable higher modes of tube vibration.

3. The vibration phenomenon associated with the onset of the fluid-elastic instability is that multiple tubes in a tube row or a tube bank (surrounding multiple tubes having similar tube dynamic characteristics and similar flow field) will vibrate with large amplitudes. In view of this fluid-elastic instability phenomenon, confirm that all the vulnerable tubes with stability ratio greater than 0.64 are all plugged or staked.

4. Provide a detailed explanation of the relatively high gap flow velocities at tube rows TR-147 (216.6 in/sec) and TR-83 (320.7 in/sec) compared to other nearby tube row such as TR-145 (52.5 in/sec) in Table 6.5.1, Fluid-Elastic Instability Evaluation Summary. Confirm that similar high gap flow velocity fields as in the vicinities of TR-147 and TR-83 do not exist in other locations of the tube bank, or would not cause fluid-elastic instability for the surrounding tube rows.

<u>Design Basis Question</u>

1. With regard to the acceptance criteria, the analysis of record for the SG tubes referenced in the San Onofre Updated Final Safety Analysis Report, was based on the ASME Section III Subsection NB, 1971 Edition with Addenda through Summer 1971. This edition of the Code did not contain the faulted condition limits which the licensee has used in the current reevaluation of the SG tubes and eggcrates. (These limits are the same as those in Appendix F of the ASME Code editions after 1971.) SCE stated that these faulted stress limits were referenced in the original design specifications of the SG tubes. Provide the relevant portions of these design specifications which contain the faulted stress limits used in the current reevaluations of the SG tubes and other supporting structural elements. Also, provide pertinent documentation which identify how these original design specifications were referenced in the original approved design bases for the facility.