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U. S. Nuclear Regulatory Commission
Document Control Desk
Washington, D. C. 20555

Subject: **Docket No. 50-362**
Report of Inservice Inspection of Steam Generator Tubes,
Cycle 13 Additional Information
San Onofre Nuclear Generating Station, Unit 3

Reference: Letter from D. E. Nunn (SCE) to Document Control Desk dated October 25, 2004, Subject: Special Report: Inservice Inspection of Steam Generator Tubes, Cycle 13

Dear Sir or Madam:

By the referenced letter, Southern California Edison (SCE) submitted the reports required by Technical Specification 5.7.2.c of the inservice inspection of steam generator tubes at San Onofre Nuclear Generating Station Unit 3. Subsequently, NRC staff requested certain additional clarifying information. The requested information is provided in the enclosure.

If you have any questions or would like additional information concerning this subject, please contact Mr. Jack Rainsberry at (949) 368-7420.

Sincerely,

Enclosure

cc: B. S. Mallett, Regional Administrator, NRC Region IV
B. M. Pham, NRC Project Manager, San Onofre Units 2, and 3
C. C. Osterholtz, NRC Senior Resident Inspector, San Onofre Units 2 & 3

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REQUEST FOR ADDITIONAL INFORMATION
RELATED TO THE REVIEW OF THE
STEAM GENERATOR INSERVICE INSPECTION REPORT
SAN ONOFRE NUCLEAR GENERATING STATION, UNIT 3
CYCLE 13
DOCKET NO.: 50-362

By letter dated October 25, 2004 (ML043020275), Southern California Edison, the licensee for San Onofre Nuclear Generating Station (SONGS) Unit 3, submitted its special report on the inservice inspection of steam generator tubes for cycle 13.

The staff requests the licensee to address the following request for additional information.

1. **Tables 1 and 2 summarize the inspection scope of steam generators (SG) E-088 and E-089 for SONGS Unit 3 Cycle 13 (U3C13) outage. The third inspection scope item in these tables indicates that the cold leg top-of-tubesheet (CL TTS) was inspected with the +Point probe.**

The staff requests the licensee to discuss the scope of the CL TTS inspections including the basis for the length of tube inspected (e.g., to 16 inches below the expansion transition).

<u>Southern California Edison (SCE) Response</u>

<u>Summary</u>

The scope of the CL TTS inspections was 100% of the tubes in each steam generator. The length inspected was CL TTS + 1 inch to whichever of the following was lowest: CL TTS – 1 inch or CL TTS – {(the absolute (non-negative) Bottom of the Expansion Transition (BET) measurement) plus (the NDE Axial Position Uncertainty in Reference 1)}. For example, if the BET location was CL TTS – 0.8 inches, and the NDE Axial Position Uncertainty was 0.3 inches, then the lower end of the length of tubing inspected was CL TTS – 1.1 inches. The purpose of addressing BET location and uncertainty was to fully inspect expansion transitions and unexpanded tubing that may be below the CL TTS.

<u>Discussion</u>

The 100% inspection scope in each steam generator consisted of an initial inspection of 29% of the tubes and a scope expansion to include the balance of the tubes. The scope expansion resulted from the finding of a single indication in one tube in one of the steam generators. The scope and the length inspected are further discussed in the following paragraphs.

Existing information in the Special Report Tables 1 and 2, provide only summary information. More detail on the scope of the CL TTS inspections was provided (i.e., 2 paragraphs of text) on Page 1 of 11, in the section titled "Inspection Scope Expansion."

Scope of the planned CL TTS inspection (prior to the expansion), including length basis

A Plus Point probe sampling inspection of approximately 29% of the tubes in both of the 2 steam generators was intended to detect potential degradation mechanisms of:

- Axial or circumferential Outside Diameter Initiated Stress Corrosion Cracking (ODSCC)

  The key point in this being a potential degradation mechanism was circumferential ODSCC industry experience in the original Millstone Unit 2 Combustion Engineering designed steam generators. Although there was not industry experience indicating corresponding Primary Water Stress Corrosion Cracking (PWSCC) at the time of this inspection, the rotating plus point probe technique is also capable of detecting PWSCC.

- Axial or circumferential Primary Water Stress Corrosion Cracking (PWSCC)

  This was limited to the top-of-tubesheet in 64 tubes (total for both steam generators) that are adjacent to a Combustion Engineering manufacturing aid called a "tie rod." A tie rod is attached to the top-of-tubesheet in a location where a hole was not drilled for a tube. The tie rod passes through each eggcrate tube support level, and guided/facilitated assembly of the eggcrate tube supports. The seven tie rod locations (7 on the hot leg side and 7 on the cold leg side) are symmetrically distributed. This symmetry is illustrated in the Special Report, in Appendix 1, Page 4 of 4, where 5 of the 7 locations are obvious as untubed locations, while 2 of the 7 locations are less apparent due to the grid line aids for Row and Column number identification. San Onofre experience and industry experience in the original Millstone Unit 2 Combustion Engineering designed steam generators indicates that the carbon steel tie rod can be susceptible to denting, which can affect adjacent tubes. The bobbin probe monitors well for denting at tube supports above the top-of-tubesheet, but not at the top-of-tubesheet. Thus, 100% of the tubes (a total of 64 tubes for both steam generators) in this denting-susceptible area at the top-of-tubesheet were examined with a rotating plus point probe.

- Volumetric OD indications slightly above the top-of-tubesheet (in the region where bobbin probe detection can be degraded by the interfering variables of conductivity changes and geometry changes)

  The tubes on the periphery of the tubing bundle (including the center blowdown lane) have the highest susceptibility to volumetric OD indications from wear with loose parts. Thus, 100% of the tubes in this highest susceptibility area for loose parts were examined with a rotating plus point probe.

The length of the tube to be inspected was strongly influenced by the location of the 3 potential degradation mechanisms described above. SCE's understanding of industry experience was that no confirmed cracking has been detected in explosively expanded tubing within the cold leg tubesheet. This industry experience, and favorable SONGS experience of lack of Inside Diameter (ID) indications in rotating plus point probe testing of CL TTS locations (that should have higher stress levels because of the expansion transition) led to a limited rotating plus point probe inspection of explosively expanded tubing within the tubesheet.

<u>Basis of the planned CL TTS inspection, prior to the expansion (for the length of the tube inspected)</u>

The region for rotating plus point probe inspection for the 3 potential degradation mechanisms described above is:

- CL TTS + 1 inch to whichever of the following was lowest: CL TTS – 1 inch or CL TTS – {(the absolute (non-negative) Bottom of the Expansion Transition (BET) measurement) plus (the NDE Axial Position Uncertainty in Reference 1)}. For example, if the BET location was CL TTS – 0.8 inches, and the NDE Axial Position Uncertainty was 0.3 inches, then the lower end of the length of tubing inspected was CL TTS – 1.1 inches. The purpose of addressing BET location and uncertainty was to fully inspect expansion transitions and unexpanded tubing that may be below the CL TTS.

<u>Scope of the CL TTS inspection expansion, including length basis</u>

The expansion was prompted by detection of one circumferentially oriented OD indication at the top-of-tubesheet in one steam generator. In the planned inspection scope, and the expansion scope there were no other OD indications, and there were NO Inside Diameter (ID) indications.

There are two key points in the inspection expansion basis:

1. The specific response was for the detected, circumferentially oriented OD *indication*, (not ID)

2. In the San Onofre Unit 3 design, the tubes are explosively expanded into the full length of the tubesheet. The purpose of this design is to close the crevice between the tube and tubesheet, to preclude ODSCC. Industry experience indicates this design is successful in this regard. Further, San Onofre has systematically measured Bottom of Expansion Transition (BET) locations, and removed from service those tubes for which eddy current does not show evidence of the expansion. Thus, the top-of-tubesheet was the susceptible region for ODSCC, not the full length of the tubing within the tubesheet.

Expansion Basis (Number of Steam Generators and Number of Tubes):

- SCE expanded the inspection to 100% of the tubes in both steam generators (even though one steam generator had no indications in the approximately 29% planned inspection, and no indications in the expansion to 100%).

Expansion Basis (for the length of the tube inspected):

- Location: Tubing Expansion Transition

- Degradation Mechanism: Axially or circumferentially oriented OD indications
- Technique: Rotating plus point probe

This was the length of the tube inspected:

- CL TTS + 1 inch to whichever of the following was lowest: CL TTS – 1 inch or CL TTS – {(the absolute (non-negative) Bottom of the Expansion Transition (BET) measurement) plus (the NDE Axial Position Uncertainty in Reference 1)}. The purpose of addressing BET location and uncertainty was to fully inspect expansion transitions and unexpanded tubing that may be below the CL TTS.

This response is for the San Onofre Unit 3 Cycle 13 inspection, which was based on industry experience that was available during that inspection. Consistent with industry guidelines, the San Onofre Units 2 and 3 Degradation Assessment and associated inspection planning will be updated prior to the next planned inspection – currently the Cycle 14 refueling outage. This update will include relevant industry experience.

2. **Table 3 lists the non-destructive examination (NDE) techniques utilized for each degradation mechanism for the U3C13 outage.**

   The staff requests the licensee to discuss why cracking in the free span portion of the tubes is not listed as a degradation mechanism for this outage considering that axial cracks in the free span were detected in five tubes during the cycle 12 outage.

<u>SCE Response</u>

Table 3 could have been more clearly titled to read "List of Nondestructive Examination (NDE) Techniques Utilized for Each Degradation Mechanism Found During the U3C13 Refueling Outage." Cracking in the free span portion of the tubes was detected during the Cycle 12 outage. Cracking in the free span portion of the tubes was not detected (i.e., not found) during the Cycle 13 outage and, thus was not applicable to Table 3.

The staff also requests the licensee to list all other potential degradation mechanisms considered during this outage and not listed in Table 3, and confirm that the location of these potential degradation mechanisms were inspected with techniques capable of identifying these forms of degradation.

<u>SCE Response</u>

This is provided in the following table. An additional note to the table is that the Probe Type for Characterization for one plug type ("rolled") may also include Plus Point.

OTHER POTENTIAL DEGRADATION MECHANISMS CONSIDERED DURING THIS OUTAGE AND NOT LISTED IN TABLE 3

Indication Orientation/Location	Probe Type for Detection	Probe Type for Characteri-zation	Location Inspected with Techniques Capable of Identifying This Degradation
Axially oriented ID indications at the top of the hot leg tubesheet	Plus Point	Plus Point	Yes
Axially oriented OD indications at the top of the hot or cold leg tubesheet	Plus Point	Plus Point	Yes
Axially oriented ID indications and Circumferentially oriented ID indications in Low-Row U-bends	Plus Point	Plus Point	Yes
Axially oriented OD indications in the tubing free span and undented tube supports	Bobbin	Plus Point	Yes
Axially oriented ID indications at slightly dented tube supports (dents <2volts)	Bobbin	Plus Point	Yes
Axially oriented ID indications and Axially oriented OD indications at dented tube supports (dents ≥2 volts)	Plus Point	Plus Point	Yes
Axially oriented ID indications and Circumferentially oriented ID indications in explosively expanded tubing within the hot leg tubesheet	Plus Point	Plus Point	Yes
OD pitting in or above the sludge pile	Bobbin	Plus Point	Yes
Circumferentially oriented ID indications and Circumferentially oriented OD indications at dented tube supports (dents ≥2 volts)	Plus Point	Plus Point	Yes
Axially oriented OD indications at dings in tubing freespan (dings <4 volts)	Bobbin	Plus Point	Yes
Axially oriented OD indications, Circumferentially oriented OD indications, and Axially oriented ID indications at dings in tubing freespan (dings ≥4 volts)	Plus Point	Plus Point	Yes
Circumferentially oriented OD indications associated with another CE designed unit's tube support configuration (SONGS configuration is different)	Plus Point	Plus Point	Yes
Axially oriented ID indications and Circumferentially oriented ID indications at the top of the hot and cold leg tubesheet	Plus Point	Plus Point	Yes
Tube Plug Degradation	Visual	Visual	Yes
Axially oriented OD indications in Low-Row U-Bends	Plus Point	Plus Point	Yes
Circumferentially oriented ID indications at the Flanks of Tubing Bends and Axially oriented ID indications in similar Tubing Bends	Plus Point	Plus Point	Yes
Impingement	Bobbin	Plus Point	Yes
Cold Leg Thinning at tube supports	Bobbin	Plus Point	Yes

3. **Table 4 lists the number of tubes repaired and the active degradation mechanisms found during the U3C13 refueling outage. Category 7 in the table refers to tubes with apparent loose part wear (not an active degradation mechanism). Category 8 in the table refers to tubes with miscellaneous volumetric indications (not an active degradation mechanism).**

   With respect to Category 7, the staff requests the licensee to confirm that the loose part has been removed or to discuss the analysis performed to conclude that this is not an active degradation mechanism.

<u>SCE Response</u>

The loose part was removed in 1990. The degradation was not removed from service during that inspection because it's size was significantly less than the Technical Specification plugging limit. The degradation was not detected on a recurring basis in later inspections because of its small size.

Since the mid-1990s San Onofre has changed to a practice of "remove from service upon degradation detection" for such volumetric degradation that is not due to wear of tubing at a tube support.

This degradation was detected during the 2004 inspection. Under current San Onofre practice it was "removed from service upon degradation detection."

Two recent data analysis innovations likely increased the detectability of this degradation in the 2004 inspection:

1. Incorporation of industry experience from a different site regarding a bobbin probe data analysis practice associated with a September 2002 primary-to-secondary leak that led to a shutdown. Incorporation of this industry experience results in data analysts reporting indications with a phase angle that is outside of the range of phase angles that are indicative of degradation in the calibration standard (i.e., less than 0% on the calibration curve).

2. Computerized Data Screening (CDS) of bobbin probe data (as a "third party analysis" in addition to 2 independent parties performing full manual analysis). This exceeds the industry guidance in Reference 2 (that would only require the 2 independent parties performing full manual analysis). The purpose of the CDS "third party" analysis is to attempt to increase data analysis consistency and reliability beyond that possible with the 2 independent parties performing full manual analysis.

With respect to Category 8, the staff requests the licensee to provide more details on the miscellaneous indications found (e.g., location, sizes, possible causes).

<u>SCE Response</u>

A single Category 8 indication was found. It consisted of one volumetric indication in Row 78 Column 60 in steam generator E-089. Requested detail is provided below.

Indication Type	Single Volumetric Indication
Initiation Locale	On the outside diameter of the tube
Plus Point Voltage	0.51 volts
Location	DBH + 2.76 inches (This is 0.76 inches above the upper edge of the tube support.)
Measured Length	0.39 inches
Measured Depth	26% of tube wall thickness

This indication was detected by the bobbin probe. It was subsequently confirmed and characterized with a plus point rotating probe. Historical eddy current bobbin probe data for this location was compared. The indication was first apparent in 1995. <u>The following trend illustrates that this is not an active degradation mechanism:</u>

1985	no detectable degradation	
1993	no detectable degradation	
1993-1995	change	
1995-1997	little apparent change	
1997-2004	no apparent change	(Note that in 1997 the secondary side of all steam generator tubing was chemically cleaned.)

This indication is considered similar to other industry volumetric indication experience in large steam generators, with tubes installed within the tubesheet in a "triangular pitch" pattern.

One postulated cause for such an indication is wear of this tube against an adjacent tube. Rotating pancake coil data indicated this tube to be in closer-than-normal proximity to the adjacent tube, which would be consistent with this postulated cause. Note that all adjacent tubes were inspected with both a bobbin probe and a rotating plus point probe to provide assurance that there is no associated degradation in this vicinity.

<u>References</u>

1. Final Paragraph in Section 7.4, NDE Axial Position Uncertainty, in Westinghouse Proprietary Class 2 Report Number WCAP-16208-P, Revision 0, titled: NDE Inspection Length for CE Steam Generator Tubesheet Region Explosive Expansions, dated October 2004. Note that the U. S. Nuclear Regulatory Commission Staff has this Proprietary Document, that was provided on Docket No. 50-389 as an Enclosure (1) to Letter from W. Jefferson (Florida Power and Light Company) to the Document Control Desk (U. S. Nuclear Regulatory Commission) dated November 8, 2004; Subject: St. Lucie Unit 2, Docket No. 50-389, Proposed License Amendment, Define the Depth of the Required Tube Inspections and Clarify the Plugging Criteria Within the Tubesheet Region of the Original Steam Generators (ADAMS Accession Number ML043150403).

2. Pressurized Water Reactor Steam Generator Examination Guidelines: Revision 6, Requirements, Electric Power Research Institute, Final Report Number 1003138, October 2002.