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Douglas R. Bauder
Site Vice President & Station Manager
San Onofre Nuclear Generating Station

10 CFR 50.73(a)(2)(ii)(A)
10 CFR 50.73(a)(2)(v)(C)

May 10, 2012

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

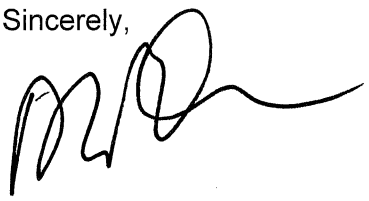
Subject: **Docket No. 50-362**
LER 2012-002-00, Unit 3 Steam Generator Tube Degradation Indicated by Failed In-Situ Pressure Testing
San Onofre Nuclear Generating Station (SONGS), Unit 3

Dear Sir or Madam:

Attached is Licensee Event Report (LER) 2012-002-00, which is being submitted in accordance with 10 CFR 50.73(a)(2)(ii)(A) and 10 CFR 50.73(a)(2)(v)(C).

This letter does not contain any commitments. If you have any questions regarding the attached report, please call Lee Kelly at 949-368-6657.

Sincerely,



Attachment: LER 2012-002-00

cc: E.E. Collins, Regional Administrator, NRC Region IV
R. Hall, NRC Project Manager, SONGS Units 2 and 3
G.G. Warnick, NRC Senior Resident Inspector, SONGS Units 2 and 3

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NRC FORM 366 (10-2010) U.S. NUCLEAR REGULATORY COMMISSION

APPROVED BY OMB: NO. 3150-0104 EXPIRES: 10/31/2013

Estimated burden per response to comply with this mandatory collection request: 80 hours. Reported lessons learned are incorporated into the licensing process and fed back to industry. Send comments regarding burden estimate to the FOIA/Privacy Section (T-5 F53), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by internet e-mail to infocollects.resource@nrc.gov, and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202, (3150-0104), Office of Management and Budget, Washington, DC 20503. If a means used to impose an information collection does not display a currently valid OMB control number, the NRC may not conduct or sponsor, and a person is not required to respond to, the information collection.

LICENSEE EVENT REPORT (LER)

1. FACILITY NAME	2. DOCKET NUMBER	3. PAGE
San Onofre Nuclear Generating Station (SONGS) Unit 3	05000362	1 of 7

4. TITLE

Unit 3 Steam Generator Tube Degradation Indicated by Failed In-Situ Pressure Testing

5. EVENT DATE			6. LER NUMBER			7. REPORT DATE			8. OTHER FACILITIES INVOLVED	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REV NO.	MONTH	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
									N/A	N/A
03	14	2012	2012-002-00			05	14	2012	FACILITY NAME: N/A	DOCKET NUMBER: N/A

9. OPERATING MODE

5

10. POWER LEVEL

0%

11. THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR§: *(Check all that apply)*

☐ 20.2201(b)	☐ 20.2203(a)(3)(i)	☐ 50.73(a)(2)(i)(C)	☐ 50.73(a)(2)(vii)
☐ 20.2201(d)	☐ 20.2203(a)(3)(ii)	☒ 50.73(a)(2)(ii)(A)	☐ 50.73(a)(2)(viii)(A)
☐ 20.2203(a)(1)	☐ 20.2203(a)(4)	☐ 50.73(a)(2)(ii)(B)	☐ 50.73(a)(2)(viii)(B)
☐ 20.2203(a)(2)(i)	☐ 50.36(c)(1)(i)(A)	☐ 50.73(a)(2)(iii)	☐ 50.73(a)(2)(ix)(A)
☐ 20.2203(a)(2)(ii)	☐ 50.36(c)(1)(ii)(A)	☐ 50.73(a)(2)(iv)(A)	☐ 50.73(a)(2)(x)
☐ 20.2203(a)(2)(iii)	☐ 50.36(c)(2)	☐ 50.73(a)(2)(v)(A)	☐ 73.71(a)(4)
☐ 20.2203(a)(2)(iv)	☐ 50.46(a)(3)(ii)	☐ 50.73(a)(2)(v)(B)	☐ 73.71(a)(5)
☐ 20.2203(a)(2)(v)	☐ 50.73(a)(2)(i)(A)	☒ 50.73(a)(2)(v)(C)	☐ OTHER
☐ 20.2203(a)(2)(vi)	☐ 50.73(a)(2)(i)(B)	☐ 50.73(a)(2)(v)(D)	Specify in Abstract below or in NRC Form 366A

12. LICENSEE CONTACT FOR THIS LER

NAME	TELEPHONE NUMBER (Include Area Code)
Douglas R. Bauder, Site Vice President and Station Manager	949-368-9275

13. COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT

CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX	CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX
B	SG	TBG	M380	Y			N/A		

14. SUPPLEMENTAL REPORT EXPECTED

☐ YES *(If yes, complete 15. EXPECTED SUBMISSION DATE)* ☒ NO

15. EXPECTED SUBMISSION DATE

MONTH	DAY	YEAR

ABSTRACT *(Limit to 1400 spaces, i.e., approximately 15 single-spaced typewritten lines)*

On 03/14/2012 at 1120 PDT, SONGS Unit 3 was in Mode 5 (cold shutdown), when the first of eight Steam Generator (SG) tubes failed in-situ pressure testing. A SG tube is considered degraded and is reportable if it does not meet the tube integrity performance criteria stated in the SG Program (Technical Specification 5.5.2.11), as indicated by a failed in-situ test. In addition, the degraded condition was considered a safety system functional failure; i.e., potential failure to isolate radioactive fission products in the primary coolant from the secondary system as part of the reactor coolant pressure boundary.

The first tube that failed was the tube with a through-wall leak that resulted in the Unit 3 shutdown from full power on 01/31/2012. Following the shutdown, extensive inspection, testing, and analysis of SG tube integrity in both Unit 3 SGs commenced, with a total of eight tubes failing in-situ testing in SG 3E088 as follows: on 03/14/12, three tubes did not meet the accident induced leakage performance criteria (exceeded 0.5 gpm at maximum pressure achieved during test); and on 03/15/12 and 03/16/12, a total of five tubes did not meet the structural integrity performance criteria (failed three-times normal pressure conditions). The postulated post-accident onsite and offsite doses were well below allowable limits.

At the time of this event, Unit 2 was in a refueling outage. Planned inspection of 100 percent of the Unit 2 SG tubes was performed, with one tube requiring in-situ testing. This tube met the performance criteria.

A. REPORTABLE OCCURRENCE

On March 14-16, 2012, in-situ pressure testing identified that eight Unit 3 Steam Generator (SG) 3E088 tubes [SG] did not meet the target performance criteria in accordance with Technical Specification (TS) 5.5.2.11 for tube integrity, which requires a 60-day written report pursuant to 10 CFR 50.73(a)(2)(ii)(A) - a condition that resulted in a principal safety barrier being seriously degraded (i.e., serious SG tube degradation). In addition, the degraded condition is considered a safety system functional failure (i.e., potential failure to isolate radioactive fission products in the primary coolant from the secondary system as part of the reactor coolant pressure boundary), which is reportable under 10 CFR 50.73(a)(2)(v)(C) - a condition that could have prevented the fulfillment of the safety function needed to control the release of radioactivity.

Within 8 hours of the in-situ testing failures, telephone notifications were made to the NRC Emergency Notification System (ENS) as required by 10 CFR 50.72(b)(3)(ii)(A).

B. INITIAL CONDITIONS

SONGS Unit 3 was in Mode 5 (cold shutdown) at the time of discovery of the degraded condition of the eight SG 3E088 tubes during in-situ pressure testing on March 14 -16, 2012. The plant had been shutdown since January 31, 2012, due to a SG 3E088 tube leak, and was undergoing extensive SG tube inspection and testing at the time of the event.

SONGS had installed new SGs in both Units 2 and 3 during the previous refueling outages for each unit. The replacement SGs were manufactured by Mitsubishi Heavy Industries and the original SGs were supplied by Combustion Engineering. The new Unit 3 SGs were placed into service during plant startup in February 2011. Unit 3 had operated for approximately eleven months prior to shutdown on January 31, 2012. At the time of the event, Unit 2 was in its first refueling outage since SG replacement, and was undergoing 100 percent SG tube inspection in accordance with the SG Program.

C. BACKGROUND INFORMATION

SONGS Units 2 and 3 are two-loop Combustion Engineering (CE) Pressurized Water Reactors (PWRs); each unit contains two SGs. The originally installed CE SGs were replaced during the previous refueling outages with new SGs designed and manufactured by Mitsubishi Heavy Industries (MHI). The replacement SGs incorporate thermally treated Inconel Alloy 690 (I-690) tubing which has demonstrated through laboratory testing and industry experience, superior resistance to stress corrosion cracking as compared with the I-600 tubing used in the original SGs.

There are 9727 tubes within each SG, in 142 rows and 177 columns, in a triangular pitch arrangement. The tube bundle u-bend region is supported by a floating Anti-Vibration Bar (AVB) structure consisting of six sets of V-shaped AVBs between each tube row. The AVBs are equipped with two end caps, and each end cap is welded to a retaining bar. The retaining bars with AVBs attached are supported by twenty four retainer bars that lock the assembly to the tubes. Thirteen bridges run perpendicular to the retaining bars

and the retainer bars, and hold the entire assembly together. The AVB structure is not attached to any other SG component, other than the tubes.

The Reactor Coolant System (RCS) circulates primary system water in a closed cycle, removing heat from the reactor core and internals and transferring it to the secondary side main steam system. The SGs provide the interface between the RCS and the main steam system. Reactor coolant is separated from the secondary system fluid by the steam generator tubes and tube sheet, making the RCS a closed system and forming a barrier to the release of radioactive materials from the core. The secondary side systems also circulate water in a closed cycle transferring the waste heat from the condenser to the circulating water system. However, the secondary side is not a totally closed system and presents several potential release paths to the environment in the event of a primary to secondary leak. Detection of primary to secondary coolant leakage is accomplished primarily by independent radiation monitoring systems including the Condenser Air Removal System monitors. TS 3.4.13 provides RCS operational leakage limits and required actions applicable in Modes 1 through 4.

The SG tubes have a number of important safety functions. As noted above, the SG tubes are an integral part of the Reactor Coolant Pressure Boundary (RCPB) and, as such, are relied on to maintain primary system pressure and inventory. The SG tubes isolate the radioactive fission products in the primary coolant from the secondary system. In addition, as part of the RCPB, the SG tubes act as the heat transfer surface that transfers heat from the primary system to the secondary system.

SG tube integrity means that the tubes are capable of performing their intended RCPB safety function consistent with the licensing basis, including applicable regulatory requirements. SG tubing is subject to a variety of degradation mechanisms related to corrosion phenomena, along with other mechanically induced phenomena such as denting and wear. These degradation mechanisms can impair tube integrity if they are not managed effectively. TS 5.5.2.11, Steam Generator (SG) Program, requires a program be established and implemented to ensure that SG tube integrity is maintained. Tube integrity is maintained when the SG performance criteria described in TS 5.5.2.11 are met. These SG performance criteria provide reasonable assurance of maintaining tube integrity at normal and accident conditions. The three SG performance criteria are summarized below.

1. Structural integrity performance criterion: All in-service steam generator tubes shall retain structural integrity over the full range of normal operating conditions (including startup, operation in the power range, hot standby, and cool down and all anticipated transients included in the design specification) and Design Basis Accidents (DBAs). This includes retaining a safety factor of 3.0 against burst (i.e., the gross structural failure of the tube wall) under normal steady state full power operation primary to secondary pressure differential and a safety factor of 1.4 against burst applied to the design basis accident primary to secondary pressure differentials.

2. Accident induced leakage performance criterion: The primary to secondary accident induced leakage rate for any DBA, other than a SG tube rupture, shall not exceed the leakage rate assumed in the accident analysis in terms of total leakage rate for all SGs and leakage rate for an individual SG. Main Steam Line Break (MSLB) is the limiting DBA. Leakage is not to exceed 0.5 gpm per SG and 1 gpm through both SGs.

3. The operational leakage performance criterion provides an observable indication of SG tube conditions during plant operation and is specified in TS Limiting Condition for Operation (LCO) 3.4.13, RCS Operational Leakage. This LCO is applicable in Modes 1-4 and states RCS operational leakage shall be limited to: (a) no pressure boundary leakage; (b) 1 gpm unidentified leakage; (c) 10 gpm identified leakage; and (d) 150 gallons per day (gpd) primary to secondary leakage through any one SG.

TS 3.4.17 provides SG tube integrity requirements associated with SG tubes satisfying the tube repair criteria for plugging in accordance with the SG Program in TS 5.5.2.11. The SG Program contains provisions for condition monitoring, inspection, repair, and requires 100% inspection of tubes during the first refueling following SG replacement.

D. DESCRIPTION OF OCCURRENCE

On January 31, 2012, SONGS Unit 3 was in Mode 1 operating at 100 percent power, when a high radiation alarm from the condenser air ejector monitor indicated a tube leak in SG 3E088. A rapid power reduction was commenced when the primary to secondary leak rate was determined to be greater than 75 gallons per day (gpd) with an increasing rate of leakage exceeding 30 gpd per hour. The reactor was manually tripped from 35 percent power, and placed in a stable cold shutdown condition in Mode 5. TS LCO 3.4.13 for RCS operational leakage (150 gpd) was not exceeded. Small, monitored radioactive releases to the environment occurred, well below allowable limits. Unit 3 LER 2012-001 reported the manual reactor trip due to the SG tube leak.

Subsequent to the reactor cooldown, extensive inspection, testing, and analysis of SG tube integrity commenced in both Unit 3 SGs. The work scope included the following activities: bobbin probe and rotating probe examinations using eddy current testing, secondary and primary side visual examinations, and in-situ testing. The location of the leaking tube which resulted in the Unit 3 shutdown was determined to be within the u-bend portion of the tube bundle, in the tube freespan area. The tube degradation which resulted in the leak was caused by flow-induced tube vibration and associated tube-to-tube wear (TTW). TTW is not a common wear mechanism. Other degradation mechanisms were identified during the inspections including anti-vibration bar (AVB) wear, tube support plate (TSP) wear, and retainer bar (RB) wear. The most severe TSP wear occurred in the same region as the TTW; i.e., a discrete centralized region of the tube bundle in higher row tubes within the u-bend region.

This was the first inspection of the Unit 3 SG tubes; performed after approximately eleven months of operation following SG replacement. With the exception of TTW, the potential for mechanical wear to develop at the various locations within the SGs was recognized prior to the examination, although the severity of the wear was not anticipated. All SG tubes with flaws meeting the SG Program plugging criteria of TS 5.5.2.11.c are required to be plugged and removed from service prior to plant startup. In accordance with TS 5.7.2.c, detailed results of the Unit 3 inspections and testing will be included in the Special Report required to be submitted to NRC within 180 days of entry into Mode 4 following completion of testing.

In-situ pressure testing was performed on a total of 129 tubes in Unit 3 SG 3E088 and SG 3E089 in March 2012. The pressure tests were performed in accordance with approved procedures using EPRI guidelines. The testing detected leaks in eight tubes in SG 3E088 as identified in the table below. The failure location for all eight tubes was in the u-bend portion of the tube bundle in the tube freespan area. The failure mechanism was TTW. The first tube listed in the table (location 106-78) was the tube with the through-wall leak which resulted in the Unit 3 shutdown on January 31, 2012. No leaks were detected in the remaining 121 tubes tested in SG 3E088 and SG 3E089. The three performance criteria are described in Section C above, as defined in TS 5.5.2.11.b. For the eight tubes indicating leakage, three tubes did not meet the accident induced leakage performance criterion and five tubes did not meet the structural integrity performance criterion. All tubes met the operational leakage performance criterion of TS LCO 3.4.13.

SONGS Unit 3 SG 3E088 In-Situ Pressure Tests With Tube Leakage			
Test Date, Time	Tube Location (row-column)	Maximum Test Pressure Achieved (see Note 1)	Target Performance Criteria Not Met (see Note 2)
03/14/12, 1120PDT	106-78	2874 psig	Accident Induced Leakage
03/14/12, 1249PDT	102-78	3268 psig	Accident Induced Leakage
03/14/12, 1425PDT	104-78	3180 psig	Accident Induced Leakage
03/15/12, 1109PDT	100-80	4732 psig	Structural Integrity
03/15/12, 1437PDT	107-77	5160 psig	Structural Integrity
03/15/12, 1604PDT	101-81	4889 psig	Structural Integrity
03/15/12, 1734PDT	98-80	4886 psig	Structural Integrity
03/16/12, 1216PDT	99-81	5026 psig	Structural Integrity

Note 1
Target Test Pressures: (Calculated)
Normal Operating Differential Pressure (NODP) = 1850 psig
Main Steam Line Break (MSLB) Pressure = 3200 psig
Structural Integrity Limit (3 x NODP) = 5250 psig

Note 2
Target Performance Criteria:
Structural Integrity - no leakage indicated at 3 x NODP test pressure
Accident Induced Leakage - leak rate < 0.5 gpm at MSLB test pressure
Operational Leakage - TS LCO 3.4.13

E. APPARENT CAUSE

A cause evaluation is being conducted to understand the wear mechanism leading to the degraded SG tube condition and to determine the cause of the wear. The mechanistic cause of degradation of the eight tubes in the Unit 3 u-bend region was determined to be localized severe TTW and TSP wear due to fluid elastic instability (FEI). The direct cause of the FEI was the combination of high steam velocity, high void fraction (low damping), and less than expected AVB-to-tube contact forces. Investigation is ongoing to determine the root cause as to why the condition exists (e.g., design, manufacturing, installation, operational issues).

Two Unit 2 tubes in the u-bend region indicated minor TTW; however, the performance criteria were met and no tube degradation was identified.

F. CORRECTIVE ACTIONS

Immediate/Interim Actions

Both units remain shutdown, and all tubes in all SGs have been inspected. Any tube that satisfies the SG Program repair criteria will be removed from service by plugging. Preventative plugging and stabilization of specific tubes potentially susceptible to degradation is also planned. Startup of either unit is contingent on completion of actions in response to the NRC Confirmatory Action Letter (CAL), dated March 27, 2012, and subsequent NRC review of required actions.

Long Term Corrective Actions

Long term actions will be documented in the Root Cause Evaluation and in the response to the NRC CAL. Actions may include operational restrictions (e.g., reduced power operations) and increased SG tube inspection frequency (e.g., mid-cycle inspection outage).

G. SAFETY ASSESSMENT

There was no actual safety significance relative to the as-found degraded condition of the Unit 3 SG tubes, and both units remain shutdown. The Unit 3 shutdown on January 31, 2012, due to a SG tube leak, resulted in small, monitored radioactive releases to the environment, well below allowable limits. The potential safety significance of the degraded condition of the Unit 3 SG tubes is discussed below.

The SONGS Updated Final Safety Analysis Report (UFSAR) Section 15.10.1.3.1.2 presents the current licensing basis steam line break post-trip return-to-power (post-trip SLB) event. The post-trip SLB RCS activity concentration limits are equivalent to 1.0 microcuries/gram Dose Equivalent Iodine-131 (DEI) and 725 microcuries/gram Dose Equivalent Xenon-133 (DEX). The post-trip SLB also considers an accident-induced (concurrent) iodine spiking factor of 500. The post-trip SLB is evaluated at the TS 5.5.2.11.b.2 limit for primary-to-secondary SG tube leakage of 0.5 gpm into the affected SG and 0.5 gpm into the unaffected SG. UFSAR Section 15.10.1.3.1.2 concludes that the post-trip SLB event Exclusion Area Boundary (EAB), Low Population Zone (LPZ), and Control Room (CR) doses are each less than 0.1 Rem Total Effective Dose Equivalent (TEDE).

The January 25, 2012, RCS chemistry sample (the most recent sample prior to the January 31, 2012 tube leak/manual reactor trip) was evaluated and determined to be equivalent to RCS activity concentrations of 3.4E-04 microcuries/gram DEI and 0.325 microcuries/gram DEX. These actual RCS activity concentrations are a factor of at least 2230 times less severe than the concentrations modeled in the post-trip SLB dose presented in the UFSAR. It is estimated that had the post-trip SLB occurred, then the actual primary-to-secondary leakage rate through the ruptured (affected) SG tubes would be no more than 1500 gpm. Based on the actual plant RCS chemistry data, the accident-induced iodine spiking factor of 500, and the estimated SG tube rupture leakage rate, the calculated dose would have been at least 32 percent lower than the dose consequences reported in the UFSAR for the post-trip SLB event with a

concurrent iodine spike. The postulated post-trip SLB with tube rupture and concurrent iodine spike EAB, LPZ, and CR doses would be less than 0.068 Rem TEDE, which is well below the post-trip SLB CR limit of 5 Rem TEDE, and the EAB and LPZ limit of 2.5 Rem TEDE.

H. ADDITIONAL INFORMATION

SONGS had not previously experienced in-situ pressure testing failures in the SGs currently installed in Units 2 and 3.

The Unit 3 shutdown on January 31, 2012, due to the SG 3E088 tube leak, was reported in Unit 3 LER 2012-001.