

LICENSEE EVENT REPORT (LER)

(See reverse for required number of digits/characters for each block)

FACILITY NAME (1) South Texas, Unit 2		DOCKET NUMBER (2) 05000 499	PAGE (3) 1 of 7
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TITLE (4)
Steam Generator 2C Classified as Category C-3

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
10	24	1999	1999	007	00	11	3	1999	FACILITY NAME	05000
									FACILITY NAME	05000

OPERATING MODE (9) Defuel	THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more) (11)									
	20.2201(b)			20.2203(a)(2)(v)			50.73(a)(2)(i)		50.73(a)(2)(viii)	
POWER LEVEL (10) 0	20.2203(a)(1)			20.2203(a)(3)(i)			X 50.73(a)(2)(ii)		50.73(a)(2)(x)	
	20.2203(a)(2)(i)			20.2203(a)(3)(ii)			50.73(a)(2)(iii)		73.71	
20.2203(a)(2)(ii)			20.2203(a)(4)			50.73(a)(2)(iv)		OTHER		
20.2203(a)(2)(iii)			50.36(c)(1)			50.73(a)(2)(v)		Specify in Abstract below or in NRC Form 366A		
20.2203(a)(2)(iv)			50.36(c)(2)			50.73(a)(2)(vii)				

LICENSEE CONTACT FOR THIS LER (12)

NAME Scott M. Head - Licensing Supervisor	TELEPHONE NUMBER (Include Area Code) (361) 972-7136
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COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS	CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS

SUPPLEMENTAL REPORT EXPECTED (14)				EXPECTED SUBMISSION DATE (15)			MONTH	DAY	YEAR
YES (If yes, complete EXPECTED SUBMISSION DATE).				X NO					

ABSTRACT (Limit to 1400 spaces, i.e., approximately 15 single-spaced typewritten lines) (16)

On October 24, 1999, South Texas Project Unit 2 Steam Generator 2C eddy current inspection results for the end-of-cycle 7 (2RE07) inspection fell into Category C-3 per STP Technical Specification Surveillance Requirement 4.4.5.2. The NRC was notified within four hours pursuant to 10CFR50.72(b)(2) and Technical Specification Table 4.4-2. In most cases, the area of degradation is the tube-to-tube support plate intersections. The cause of the damage, as indicated by the eddy current data (supported by tube pull results from tubes with similar indications at the previous inspection of this unit) is outer diameter stress corrosion cracking (ODSCC). Eddy current inspections were conducted on 100% of in-service tube-to-tube support plate intersections on all four Unit 2 steam generators.

As a result of these inspections, a total of 187 steam generator tubes were plugged in the four Unit 2 steam generators. Of these, 162 were plugged due to detected defects, while 25 others were preventively plugged due to the existence of alloy properties preventing eddy current inspection in areas most susceptible to degradation. Of the 162 defective tubes, 152 were plugged due to the detection of distorted support plate indications with bobbin voltage in excess of 1.0 Volts that were subsequently confirmed by plus point inspection. The cause is summarized as the selection of tube material and the design of the tube-to-tube support plate intersection locations. A contributing factor is the high Reactor Coolant System hot leg temperature.

All defective tubes identified during the current refueling outage have been plugged. South Texas will evaluate submitting a license amendment for application of the 3-Volt voltage-based repair criteria to Unit 2.

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I. DESCRIPTION OF EVENT

South Texas conducted eddy current testing on all four steam generators during the seventh refueling outage of Unit 2 (2RE07). On October 24, 1999, with the reactor in the defueled condition, South Texas Project Unit 2 Steam Generator 2C eddy current inspection results for the end-of-cycle 7 (2RE07) inspection fell into Category C-3. Ultimately, a total of 50 defective tubes out of a sample population of 4677 were identified in Steam Generator 2C. Inspection results for the other three Unit 2 steam generators were classified C-2, as shown in Table 1 at the end of this report.

Eddy Current Examinations Performed

The basic eddy current examination scope for this outage was inspection of all inservice tubes in all four steam generators by the bobbin coil probe from tube end to tube end (except for the U-bend portion of tubes in rows 1 and 2, where a 20% sample using the plus point probe was performed). All bobbin indications which were non-quantifiable and could not be traced back to the baseline inspection data and all distorted indications at support plate intersections with bobbin voltage over 1 Volt were also examined by the plus point probe. Additional sample inspections of various special interest areas (e.g., the hot leg expansion transition) were performed using the plus point probe.

II. EVENT SIGNIFICANCE

Examination Results

No circumferential cracks were found in this inspection. Identified degradation consisted primarily of axial indications at the hot leg tube-to-tube support plate intersections. Eddy current data for these indications is consistent with data from tubes pulled during the previous inspection of this unit, where destructive examination has proven such cracking to be the result of outer diameter stress corrosion cracking in the tube support plate crevice region (see References 1 and 2). These indications are similarly consistent with the destructive examination results of tubes pulled at other plants (including South Texas Unit 1) to understand similar eddy current indications. In addition, nine axial indications were confirmed at "ding" locations. As used here, a "ding" means minor damage to the tube in the free span region. Most dings were introduced during the manufacturing processes and are apparent in baseline data. Also, one volumetric indication was classified as defective. The inspection results are summarized in Table 1. In-situ pressure testing was not necessary for any indications found during this inspection.

When the results were found to fall in Category C-3, no sample expansion was necessary because the first sample included 100% of the in-service tube-to-tube support plate intersections. (No indications were identified in the Row one and two U-bend Plus Point inspection.)

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Unit 2 Steam Generator Design/Operating History

Relevant background information includes the following:

- Age of Unit 2 steam generators at 2RE07: 7.64 effective full-power years
- Length of preceding cycle (Cycle 7): 342.5 effective full-power days
- Tube to tubesheet design: hydraulic expansion
- Previous outage (2RE06) inspection results: 52 tubes plugged
- Tube support plate design: Drilled-hole stainless steel
- Tube material: Alloy 600 mill annealed (except for 15 Alloy 600 thermally treated tubes in SG 2D)
- Shot peening: hot leg after first cycle, cold leg after second cycle
- U-bend heat treatment performed on Row 1 and Row 2 tubes prior to initial operation.

During Cycle 7 (November 1998 - October 1999), Unit 2 experienced consistently low (less than one gallon per day) primary-to-secondary leak rates calculated using equilibrium primary and secondary tritium concentrations.

Steam generator water chemistry during this cycle was consistent with current industry guidelines.

2RE07 Condition Monitoring & Operational Assessment

Distorted Support Plate Indications

The number of defective tubes found during this inspection that resulted in the C-3 classification in steam generator 2C occurred from a population of axial indications located at tube-to-tube support plate intersections. In evaluating the axial indications found at support plate crevices the following is of note:

- No axial indications extended outside of the tube support plates.
- No primary water stress corrosion cracking was found at any of these support plate locations or at any other locations.
- No circumferential indications were found at the tube-to-tube support plate intersections or at any other location.
- No distorted indications were observed at Flow Distribution Baffle intersections.
- The largest distorted support plate signal found in the inspection was 4.83 Volts (bobbin), which is below the Unit 2 voltage-based repair criteria structural limit.

The bobbin results for outer diameter stress corrosion cracking axial indications at tube support plate intersections are being evaluated to the analysis guidelines of Generic Letter 95-05. The End-of-Next Cycle Estimated Main Steam Line Break Leak Rate will be projected for the limiting steam generator and will be

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confirmed to be less than the leakage limit of 15.4 gpm. The Conditional Burst Probability will also be projected, and will be confirmed to be less than the Conditional Burst Probability Limit of 1×10^{-2} . As required for STP implementation of the voltage-based repair criteria, these calculations will be completed prior to outage completion. Also, the 90 day voltage-based repair criteria report will be submitted within 90 days following breaker closure at the end of 2RE07 as previously committed in conjunction with the implementation of the voltage-based repair criteria for Unit 2.

Other Degradation Mechanisms:

No new degradation mechanisms were identified in this inspection. During this inspection, the first occurrence of freespan cracking at dings on the hot leg side was observed (this degradation mechanism has been previously reported only on the cold leg side in Unit 2). A preliminary tube integrity assessment will be completed prior to outage completion, to confirm that performance criteria per NEI 97-06 were met, and to confirm that operation may proceed during the upcoming Cycle 8 without exceeding the NEI 97-06 performance criteria at the end of Cycle 8.

III. EVENT ANALYSIS

A Category C-3 inspection result per STP Technical Specification Surveillance Requirement 4.4.5.2 is reportable pursuant to 10CFR50.72(b)(2) per Technical Specification Table 4.4-2. Furthermore, per Technical Specification 4.4.5.5c, a Special Report is required to be submitted within 30 days and prior to resumption of plant operation. This event is therefore being reported accordingly. This report addresses both the Special Report requirement as well as the Licensee Event Report requirement. The health and safety of the public was not affected.

IV. CAUSE OF EVENT

152 of the 162 defective tubes plugged in 2RE07 were the result of outside diameter stress corrosion cracking at tube-to-tube support plate intersections. This tube degradation mechanism is well known to the industry (as documented in the EPRI Steam Generator Reference Book, Chapter 12) for plants employing drilled-hole tube support plates and Alloy 600 mill annealed tubes, and has been addressed in NRC Generic Letter 95-05. Outer diameter stress corrosion cracking at tube support plate intersections is the result of tube susceptibility to stress corrosion cracking in the tube support plate crevice environment as confirmed by tube pulls at South Texas Units 1 and 2 as well as at other plants. This stress corrosion cracking has been demonstrated to be a temperature-related corrosion process such that the higher the hot leg temperature, the more rapid the corrosion progression. The 2RE07 inspection results are consistent with this understanding of the outer diameter stress corrosion cracking at tube support plate corrosion phenomenon in that the lower hot leg tube support plate intersections contain the majority of the axial indications found.

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The root causes of outer diameter stress corrosion cracking at tube-to-tube support plate intersections is summarized as the selection of tube material (Alloy 600 mill annealed) and the design of the tube-to-tube support plate intersection locations (crevices resulting from drilled holes). A contributing factor is the high Reactor Coolant System hot leg temperature design values.

V. GENERIC IMPLICATIONS:

The Outside Diameter Stress Corrosion Cracking (ODSCC) phenomenon has been observed previously at the South Texas Project. All eight Model E Steam Generators in service at STP Units 1 and 2 are susceptible to this form of degradation.

VI. CORRECTIVE ACTIONS

The following actions were proactively implemented in Unit 2 prior to 2RE07 due to awareness of the possible advent of significant steam generator tube degradation:

- a. South Texas reduced the Unit 2 hot leg temperature from an initial average hot leg temperature of ~624°F to an average T_{hot} value of ~620°F at the start of Cycle 5 in 1995.
- b. South Texas has undertaken steps to help mitigate steam generator tube corrosion. Plant design was upgraded during construction to:
 - Add a full flow feedwater deaerator for dissolved oxygen control
 - Add cation condensate polishers in addition to the full flow mixed bed condensate polishers
 - Double the capacity of the steam generator blowdown system to 1% of main steam flow
 - Remove copper components from the secondary system
 - Use all volatile treatment
- c. N-16 radiation monitors were added to provide continuous indication of individual steam generator primary-to-secondary leakage.
- d. South Texas performed the necessary analysis and increased the steam generator plugging limit from 5% to 10%.
- e. As a result of the previous C-3 result in 2RE05 (see Additional Information), implementation of the voltage-based repair criteria was requested for STP Unit 2 and was approved by the NRC for implementation at 2RE06. This action has been successful in preventing the unnecessary plugging of many tubes in 2RE06 and 2RE07, permitting safe operation of the Model E Steam Generators until they can be replaced as currently planned at 2RE09.

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As a result of this event, the following actions have been or will be taken:

1. All defective tubes were plugged in accordance with Technical Specification requirements.
2. South Texas will evaluate submitting a license amendment for application of the 3-volt voltage-based repair criteria to Unit 2.

VII. ADDITIONAL INFORMATION

There has been one previous similar event at South Texas Project. At the 2RE05 inspection, STP Unit 2 inspection results were C-3 in all four steam generators. This event was documented in LER 97-002, Reference 3, closed by Reference 4. Corrective actions taken for the previous event would not have prevented this event.

References:

1. Letter from S. E. Thomas to U. S. Nuclear Regulatory Commission, Document Control Desk, ST-NOC-AE-000405, dated January 19, 1999, "2RE06 Steam Generator Tube Voltage-Based Repair Criteria 90-Day Report"
2. Letter from Thomas W. Alexion to William T. Cottle, dated 9/22/99, "South Texas Project, Unit 2 – Review of Steam Generator Inspection 90-Day Report" (STP-assigned correspondence number ST-AE-NOC-000514)
3. Letter from D. O. Wohleber to U. S. Nuclear Regulatory Commission, Document Control Desk, ST-HL-AE-5603, dated 3/13/97, "Licensee Event Report 97-002 Regarding Steam Generators Classified as Category C-3"
4. Letter from Arthur T. Howell to William T. Cottle, dated 8/31/98, "NRC Inspection Report 50-498/98-14; 50-499/98-14" (STP-assigned correspondence number ST-AE-NOC-000225)

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TABLE 1
UNIT 2 STEAM GENERATOR 2RE07 INSPECTION RESULTS

	SG 2A	SG 2B	SG 2C	SG 2D	TOTAL
Total No. of Tubes	4,864	4,864	4,864	4,864	19,456
Number of Tubes Previously Plugged	165	193	187	189	734
Total No. of Tubes Inspected (100%)	4,699	4,671	4,677	4,675	18,722
# Defective Tubes - TSP Indications	31	36	47	38	152
# Defective Tubes - Axial Ind. at "Dings"	2	1	2	4	9
# Defective Tubes - Volumetric Ind.	0	0	1	0	1
Total Number of Defective Tubes	33	37	50	42	162
% Defective	0.70%	0.79%	1.07%	0.90%	0.87%
Inspection Category	C-2	C-2	C-3	C-2	N/A
Preventative Plugging	11	2	12	0	25
Total Plugged in 2RE07	44	39	62	42	187
Total Plugging to Date	209	232	249	231	921
Total % Plugged to Date*	4.3%	4.8%	5.1%	4.7%	4.73%

* South Texas design basis plugging limit is 10%.