Ameren MISSOURI

Callaway Plant

October 11, 2016

ULNRC-06332

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

Ladies and Gentlemen:

DOCKET NUMBER 50-483
CALLAWAY PLANT UNIT 1
UNION ELECTRIC CO.
FACILITY OPERATING LICENSE NPF-30
RESULTS OF STEAM GENERATOR TUBE IN-SERVICE INSPECTION

In accordance with Callaway Plant Technical Specification 5.6.10, the enclosed report provides the results of the most recent steam generator tube in-service inspection performed at Callaway Plant. This report documents that the steam generator tube integrity performance criteria have been met for operating cycles 19, 20, and 21, and also demonstrates that there is reasonable assurance that the performance criteria will be met for the upcoming 3-cycle operating period, consisting of cycles 22, 23, and 24.

This letter does not contain new commitments.

Sincerely,

Barry L. Cox,
Senior Director Nuclear Operations

DRB

Enclosure: Callaway Energy Center Steam Generator Tube Inspection Report

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1.0 PURPOSE

The purpose of this report is to document that the Callaway Unit-1 steam generator tube integrity performance criteria have been met for operating cycles 19, 20, and 21 (November 2011 to April 2016 of 3.975 EFPY duration) and to also demonstrate that there is reasonable assurance that the performance criteria will be met for the upcoming 3-cycle operating period, consisting of cycles 22, 23, and 24, not to exceed 4.25 EFPY.

2.0 REPORTING REQUIREMENTS

Technical Specification 5.6.10 requires that "A report shall be submitted within 180 days after initial entry into MODE 4 following completion of an inspection performed in accordance with Specification 5.5.9, "Steam Generator (SG) Program." The report shall include:

a. The scope of inspections performed on each steam generator;

b. Degradation mechanisms found;

c. Nondestructive examination techniques utilized for each degradation mechanism;

d. Location, orientation (if linear), and measured size (if available) of service induced indications;

e. Number of tubes plugged during the inspection outage for each degradation mechanism;

f. The number and percentage of tubes plugged to date, and the effective plugging percentage in each steam generator; and

g. The results of condition monitoring, including the results of tube pulls and in-situ testing.

3.0 SUMMARY

The steam generator tube in-service inspections were completed by AREVA during the Refuel 21 outage. An in-service inspection was performed on all four steam generators, primary and secondary side. The scope of inspections performed is described in the following inspection report. The service related degradation mechanisms identified by eddy current inspection (primary side) were 543 AVB (anti-vibration bar) wear indications and 131 TSP (tube support plate) wear indications in total from all four steam

generators. Callaway's plugging limit was set at 30% TW (through wall), conservatively, to maintain tube integrity for cycle 22, 23 and 24. In total, 25 tubes were removed from service due to AVB wear. TSP wear had no impact on RF-21 tube plugging. This equates to a total of 0.230% of tubes, from all four steam generators removed from service to date.

Table 1
Callaway Tube Cumulative Plugging Status

Outage	SGA	SGB	SGC	SGD	Total
Pre-Service	1	0	0	0	1
1R15	0	0	0	0	0
1R18	10	6	12	1	29
1R21	9	0	14	2	25
Total Tubes Plugged	20	6	26	3	55
Total Tubes	5872	5872	5872	5872	23488
Total Percentage	0.341%	0.102%	0.443%	0.051%	0.230%
Limit (%)	10.0%	10.0%	10.0%	10.0%	10.0%

Sludge Lancing (secondary side) was performed on all 4 steam generators. A combined total of 25.5 pounds of sludge was collected by AREVA. The steam generator tubes and the top of tubesheet were clean, with exception of a small sludge pile located near the center of each steam generator's top of tubesheet.

Steam Drum (secondary side) inspections were performed on only two steam generators, SG-A and SG-D. No loose parts (foreign material) or loose hardware was detected in either steam generator. Finally, the Condition Monitoring Report concluded that the Callaway steam generator tubes satisfied the structural integrity performance criterion, accident induced leakage criterion and operational leakage criterion.

4.0 INSPECTION REPORT

The Callaway Plant was shut down on April 2, 2016 for its 21st refueling outage. During the refueling outage an in-service inspection was performed on all four steam generators. The inspection scope was as follows:

- **Eddy current Bobbin probe examinations (All 4 SGs):**
  - 100% of all in-service tubes, full length tube-end to tube-end

- **Eddy current X-probe examinations (All 4 SGs):**
  - Tubesheet periphery, 3-tubes deep

- All cold leg tubes identified as having non-nominal tubesheet drilled hole diameters
- 20% of hot leg tubes identified with sludge from the 1R18 sludge analysis in all four SGs.
- All 1R21 Bobbin Distorted Support Signal with Indication (DSI) indications (i.e., TSP wear) in the Hot Leg of SGA and SGB

- **Special interest examinations:**
  - All AVB wear with a depth ≥ 28%TW
  - All new AVB indications with a depth ≥14%TW
  - All AVB indications with a growth >14%TW over the past three cycles
  - Select tubes for AVB wear
  - All 1R21 Bobbin DSI indications

- **Secondary Side Inspections:**
  - Top of Tubesheet (TTS) water lancing in all four SGs
    - Pre-lancing quick-look visual inspection in SG C and SG D
  - Foreign Object Search and Retrieval (FOSAR) performed in all four SG
    - Hot leg and cold leg TTS annulus area (post-lancing) looking in-bundle at the periphery tubes
    - No-tube lane (post-lancing)
    - Inner bundle passes in the hot leg TTS sludge pile region (post-lancing)
  - Visual inspections of steam drums in SG-A and SG-D
    - Inspections included the loose part trapping screen, the riser barrels, the feedring and J-nozzles 1, 2, 3, 4, 29, and 30

- **Visual Examinations**
  - As-found and as-left visual examinations of primary channel heads (both Hot Leg and Cold Leg)
  - NSAL 12-1 (and IN 2013-20) primary bowl inspections in all four SGs (both Hot Leg and Cold Leg)
  - Visual inspections of all plugs installed in the Callaway SGs both prior and during 1R21
  - EVT-1 on SG-A primary nozzle inner radius. The area of interest consisted of all accessible surfaces of the nozzle inside radius section.

4.1 Primary Side Inspection

The bobbin probe (ETSS 96004.1) is used for depth sizing AVB wear. The +Point (ETSS 96910.1) is used for depth and length sizing of TSP wear and providing extent and length sizing of AVB wear.

4.1.1 Eddy Current Inspections

Table 2
RF21 Eddy Current Inspection Scope Summary

Scope Description				SG A				SG B			
Exam Description	Leg	Probe	Extent	Planned	Acquired	Resolved	% Complete Resolved	Planned	Acquired	Resolved	% Complete Resolved
Bobbin Exams											
Full Length Rows>=6	HOT	610HS	TECTEH	5525	5525	5525	100.00%	5530	5530	5530	100.00%
H/L CandyCane Rows 2-5	HOT	610HS	08CTEH	270	270	270	100.00%	270	270	270	100.00%
H/L CandyCane Row 1	HOT	610HS	08CTEH	66	66	66	100.00%	66	66	66	100.00%
C/L Straight R1-5	COLD	610HS	08CTEC	336	336	336	100.00%	336	336	336	100.00%
Array Exams											
H/L Array	HOT	610XP	01HTEH	965	965	965	100.00%	965	965	965	100.00%
H/L Array - Sludge Pile sample	HOT	610XP	01HTEH	22	22	22	100.00%	21	21	21	100.00%
C/L Array	COLD	610XP	01CTEC	Scope Cancelled				Scope Cancelled			
C/L Array - TS Drill Signals	COLD	610XP	01CTEC	7	7	7	100.00%	N/A	N/A	N/A	N/A
Special Interest Array/+ Point	BOTH	610XP	Various								
Hot Leg Indications	HOT	610XP	Various	52	52	52	100.00%	35	35	35	100.00%
Cold Leg Indications	COLD	610XP	Various	26	26	26	100.00%	7	7	7	100.00%
U-Bend Indications	BOTH	610XP	Various	35	35	35	100.00%	17	17	17	100.00%
Total - All Exams				**7304**	**7304**	**7304**	**100.00%**	**7247**	**7247**	**7247**	**100.00%**

Scope Description				SG C				SG D			
Exam Description	Leg	Probe	Extent	Planned	Acquired	Resolved	% Complete Resolved	Planned	Acquired	Resolved	% Complete Resolved
Bobbin Exams											
Full Length Rows>=6	HOT	610HS	TECTEH	5524	5524	5524	100.00%	5535	5535	5535	100.00%
H/L CandyCane Rows 2-5	HOT	610HS	08CTEH	270	270	270	100.00%	270	270	270	100.00%
H/L CandyCane Row 1	HOT	610HS	08CTEH	66	66	66	100.00%	66	66	66	100.00%
C/L Straight R1-5	COLD	610HS	08CTEC	336	336	336	100.00%	336	336	336	100.00%
Array Exams											
H/L Array	HOT	610XP	01HTEH	965	965	965	100.00%	965	965	965	100.00%
H/L Array - Sludge Pile sample	HOT	610XP	01HTEH	28	28	28	100.00%	19	19	19	100.00%
C/L Array	COLD	610XP	01CTEC	Scope Cancelled				Scope Cancelled			
C/L Array - TS Drill Signals	COLD	610XP	01CTEC	N/A	N/A	N/A	N/A	3	3	3	100.00%
Special Interest Array/+ Point											
Hot Leg Indications	HOT	610XP	Various	12	12	12	100.00%	7	7	7	100.00%
Cold Leg Indications	COLD	610XP	Various	9	9	9	100.00%	3	3	3	100.00%
U-Bend Indications	BOTH	610XP	Various	44	44	44	100.00%	19	19	19	100.00%
Total - All Exams				**7254**	**7254**	**7254**	**100.00%**	**7223**	**7223**	**7223**	**100.00%**

Table 3
RF21 Summary of Wear Indications (Tubes | Indications)

	SG A		SG B		SG C		SG D		Total	
Detected										
AVB	72	160	47	97	106	240	22	46	247	543
TSP	41	56	23	29	19	30	9	16	92	131
Total	111[1]	216	70	126	124[2]	270	30[3]	62	335[1][2][3]	674
Plugged										
AVB	9	40	0	0	14	56	2	8	25	104
TSP	1	1	0	0	0	0	0	0	1	1
Total	9[1]	41	0	0	14	56	2	8	25[1]	105
Returned to Service										
AVB	63	120	47	97	92	184	20	38	222	439
TSP	40	55	23	29	19	30	9	16	91	130
Total	102[1]	175	70	126	110[2]	214	28[3]	54	310[1][2][3]	569

NOTES:
1) SGA Tubes 110-66 and 111-73 have both AVB and TSP wear. Tube 111-73 was plugged for AVB wear.
2) SGC Tube 110-72 has both AVB and TSP wear.
3) SGD Tube 88-72 has both AVB and TSP wear.

Callaway plugged 25 tubes due to AVB wear during refuel 21. The total number of tubes repaired to date is 55 (1 plugged during manufacturing). This is 0.230% total tubes plugged to date.

Table 4
RF21 Summary of AVB Wear Bobbin Indications

SG	Number of Indications		New and Repeat Depths (%TW)			Growth Rate of Repeats (%TW/EFPY)		
	New	Repeat	Average	Upper 95th	Maximum	Average	Upper 95th	Maximum
A	35	125	15.2	29.1	33.0	1.2	2.8	3.3
B	18	79	14.1	26.0	30.0	0.7	2.0	3.0
C	39	201	15.2	32.0	37.0	1.1	3.0	6.3
D	7	39	14.1	33.8	38.0	0.9	3.0	3.8
All SGs	99	444	14.9	30.9	38.0	1.1	3.0	6.3

AVB wear was reported in each of the four steam generators. A total of 543 AVB wear indications were detected. The maximum reported AVB wear depth was 38%TW.

Table 5
RF21 Summary of TSP Wear Indications

SG	Number of Indications		New and Repeat Depths (%TW)			Growth Rate of Repeats (%TW/EFPY)		
	New	Repeat	Average	Upper 95th	Maximum	Average	Upper 95th	Maximum
A	43	13	7.27	11	17.00	0.66	1.61	1.76
B	20	9	10.59	15	16.00	1.17	1.66	1.76
C	22	8	9.87	14	16.00	0.69	1.42	1.51
D	13	3	5.38	8	11.00	0.17	0.25	0.25
All SGs	98	33	8.37	14	17.00	0.76	1.61	1.76

TSP wear was reported in each of the four steam generators. A total of 131 TSP wear indications were detected. The maximum reported TSP wear depth was 17%TW.

4.1.2 Primary Side Visual Examination

Remote visual examinations of the primary channel heads in each steam generator were performed to the NSAL 12-1 requirements. No degradation of the cladding, welds, or structures was identified within the channel heads, and no foreign objects were identified. SG-A primary nozzle inside radius inspection did not identify any indications. No plug deficiencies were identified.

4.2 Secondary Side Inspections

The planned FOSAR (annulus, no-tube lane, and inner bundle passes) examinations were performed in each of the four SGs following water lancing. No foreign objects were detected. Visual inspections of the steam drums in SG-A and SG-D were performed as planned.

4.2.1 Steam Drum Inspections

Secondary side inspections were performed in the steam drums of SG-A and SG-D. No loose parts or loose hardware was detected in either SG.

4.2.2 Sludge Lancing

Sludge Lancing was performed on all 4 steam generators. A combined total of 25.5 pounds of sludge was collected by AREVA. The steam generator tubes and the top of tubesheet were clean, with exception of a small sludge pile located near the center of each steam generator's top of tubesheet.

Table 6
RF21 Sludge Lancing Results

	SGA	SGB	SGC	SGD	TOTAL
Sludge Removed (lbs)	6	3	10.5	6	25.5

4.3 Condition Monitoring

The Condition Monitoring report concluded that the Callaway steam generator tubes satisfied the structural integrity performance, accident-induced leakage and operational leakage performance criteria in accordance with Technical Specifications 5.5.9, 3.4.13 and 3.4.17. Callaway did not perform any tube pulls or in-situ testing.