DUKE ENERGY®

Kevin M. Ellis
General Manager
Nuclear Regulatory Affairs, Policy &
Emergency Preparedness

Duke Energy
13225 Hagers Ferry Rd., MG011E
Huntersville, NC 28078

843.951.1329
Kevin.Ellis@duke-energy.com

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United States Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Catawba Nuclear Station, Unit No. 1
Docket No. 50-413 / Renewed License No. NPF-35

Subject: Catawba Nuclear Station Unit 1, End of Cycle 27 (C1R27) Steam Generator Tube Inspection Report

Ladies and Gentlemen:

In accordance with Catawba Nuclear Station (CNS) Technical Specifications 5.6.8, "Steam Generator Tube Inspection Report," Duke Energy Carolinas, LLC (Duke Energy) is providing the steam generator tube inspection summary report for the CNS, Unit No. 1, Refueling Outage 27 (C1R27). The report is provided as the Enclosure to this letter.

This submittal contains no regulatory commitments. Should you have any questions concerning this letter, or require additional information, please contact Ryan Treadway, Director – Nuclear Fleet Licensing, at 980-373-5873.

Sincerely,

Kevin M. Ellis
General Manager, Nuclear Regulatory Affairs, Policy & Emergency Preparedness

Enclosure:
Steam Generator Tube Inspection Summary Report, Catawba Unit 1, C1R27 (Spring Refueling Outage 2023)

NDE

cc: (w/ enclosure)

S. Williams, NRC Project Manager, NRR

L. Dudes, NRC Regional Administrator, Region II

D. Rivard, NRC Senior Resident Inspector, Catawba Nuclear Station

Enclosure

Steam Generator Tube Inspection Summary Report, Catawba Unit 1, C1R27 (Spring Refueling Outage 2023)

Catawba Unit 1 EOC-27 Steam Generator Tube Inspection Report

Pursuant to Catawba technical specification 5.6.8 and industry guidance the following information is provided:

Background

Catawba Nuclear Station Unit 1 utilizes a Recirculating Steam Generator (SG) design for primary to secondary heat transfer. There are four steam generators per unit, with reactor coolant flow divided among the four. The Catawba Unit 1 RSG's are Model CFR80, manufactured by Babcock and Wilcox Canada and were replaced at EOC 9 in 1996. Each steam generator has 6,633 tubes constructed of thermally treated Inconel Alloy 690 (I-690) with an outside diameter of 0.688 inches and nominal wall thickness of 0.040 inches. The tubes are hydraulically expanded full depth of the tubesheet, complete from the primary to secondary face, and flush seal welded at the primary face. There are 119 rows and 143 columns in the tube bundle for a total of 6,633 tubes.

On the secondary side, the tubes are supported using lattice grids and U-Bend restraints (commonly referred to as fanbars). There are 9 lattice grid tube support plates arranged vertically along the SG above the tubesheet. There are 8 fanbars per steam generator. They are arranged in a fan-shaped orientation, connected by connector bars. A visual representation of the SG's was provided in the McGuire Unit 2 Steam Generator Tube Inspection Report (Adams Accession Number is ML22088A236).

No deviations have been taken from industry guidelines.

The nominal T_{hot} is ~615 degrees Fahrenheit.

Catawba Unit 1 has implemented a measurement uncertainty uprate.

There has been no detectable primary to secondary leakage since the last inspection at EOC-24.

Report

a. The scope of inspections performed on each SG.

Bobbin Inspection

- Full length of 100% of the in-service tubes.

Array Inspection

- *100% of periphery tubes (5 tubes in from periphery) with array probe from top of tubesheet to the first support in both hot leg (TSH to 01H) and cold leg (TSC to 01C).*
- *Special interest inspections were also performed on selected indications.*
  - *100% of all bobbin I-codes, PRX, and PLP.*
  - *100% of new dent and new percent through wall calls*

Primary Visual Inspections

- *Previously installed plugs*
- *Bowl cladding inspections*

Secondary Side Inspections

- *Foreign object search and retrieval (FOSAR) of the tubesheet in all 4 steam generators*
- *Sludge Lancing*

- *Visual inspection of the upper most lattice grid in 1D SG only*
- *Visual inspection of the steam drum in 1D SG only*

b. The nondestructive examination techniques utilized for tubes with increased degradation susceptibility.

There are no tubes with increased degradation susceptibility.

c. For each degradation mechanism found:

1. The nondestructive examination techniques utilized.

The bobbin probe was utilized for the detection of wear at support structures, freespan locations and to size wear at support structures. The array probe was used to size the foreign object wear.

2. The location, orientation (if linear), measured size (if available), and voltage response for each indication. For tube wear at support structures less than 20 percent through-wall, only the total number of indications needs to be reported.

There were 350 indications of fanbar (FB) wear reported. Sixty-nine (69) of these indications were newly reported. The deepest of fanbar wear indication was 29% TW. There are 338 indications of fanbar (FB) wear less than 20%TW. The average growth rate was near zero. The largest 95th percentile growth rate among all SG is 0.72%TW/EFPY. There were six (6) indications of lattice grid (LG) wear reported, all of them are less than 20%TW. One (1) indication was newly reported. The deepest of lattice grid wear indications was 12% TW. The average growth rate for lattice grid wear was near zero. The maximum growth rate for repeat indications was 1.20%TW/EFPY. The growth rate of the new 10%TW indication is 1.19%TW/EFPY. There were eighteen (18) indications of presumed foreign object (FO) wear reported. The deepest of FO wear indication was 41% TW. All but two were historical and showed no growth. The two (2) new indications, both in 1C SG at TSH, had no loose part indication and visuals in the area confirmed no FO was present. One of the new indications in tube, 1C SG R104-C83, was plugged due to presumed foreign object wear greater than or equal to 40% TW and stabilized on the hot leg. The other new indication adjacent to the plugged tube had an 18% TW presumed foreign object wear indication. Two presumed foreign object wear indications in EOC-24 were reclassified as HNC in EOC-27.

Indications that can be traced back to the baseline due to manufacturing or material related properties and have exhibited no change in the bobbin signal are assigned a "historical no change" HNC bobbin code. Therefore, there are no service induced HNC indications to report.

3. A description of the condition monitoring assessment and results, including the margin to the tube integrity performance criteria and comparison with the margin predicted to exist at the inspection by the previous forward-looking tube integrity assessment.

The cumulative SG EFPY for EOC-24 was 20.21, EOC-25 was 21.58, EOC-26 was 22.93 and EOC-27 was 24.37. The last inspection was at EOC-24.

As of EOC-27, the Catawba Unit 1 steam generators had operated 23.25 EFPY since the first in-service inspection after replacement. In total, the Catawba Unit 1 steam generators had operated 24.37 EFPY since replacement.

Condition monitoring structural and leakage integrity were met for fanbar, lattice grid and foreign object wear.

An NDE maximum depth call of 49.1 %TW or less for fanbar wear is sufficient to demonstrate a minimum degraded tube burst pressure of 3ΔP, 4050 psi, at 0.95 probability with 50% confidence. The worst-case depth call for fanbar wear observed during the inspection was an NDE depth of 29%TW.

An NDE maximum depth call of 51.4 %TW or less for lattice grid wear is sufficient to demonstrate a minimum degraded tube burst pressure of 3ΔP, 4050 psi, at 0.95 probability with 50% confidence. The worst-case depth call for lattice grid wear observed during the inspection was an NDE depth of 12%TW.

An NDE maximum depth call of 51.9%TW or less for FO wear is sufficient to demonstrate a minimum degraded tube burst pressure of 3ΔP, 4050 psi, at 0.95 probability with 50% confidence. The worst case depth call for FO wear observed during the inspection was an NDE depth of 41%TW.

The table below shows the comparison with the margin predicted to exist at the inspection by the previous forward-looking tube integrity assessment to the current as found degradation

Degradation	***EOC-27 Projection (%TW)***	***EOC-27 As Found (%TW)***
FB Wear Maximum Depth (Repeat)	*46.5*	*29*
FB Wear Maximum Depth (New)	*44.3*	*14*
LG Wear Maximum Depth (Repeat)	*25.3*	*12*
LG Wear Maximum Depth (New)	*34.1*	*10*
FO Wear Maximum Depth (Repeat)	*No growth*	*27*
FO Wear Maximum Depth (New)	*<53.1*	*41*

No degradation was detected in the plug visual or bowl cladding inspections.

No in-situ tests or tube pulls were performed.

4. The number of tubes plugged during the inspection outage.

There was one (1) tube plugged in 1C SG during the EOC-27 inspection outage.

Steam Generator	***Row***	***Tube***	***Reason***	***Location***
1C	*104*	*83*	*FO wear @ 41%TW*	*TSH+0.15*

d. An analysis summary of the tube integrity conditions predicted to exist at the next scheduled inspection (the forward-looking tube integrity assessment) relative to the applicable performance criteria, including the analysis methodology, inputs, and results.

The operational assessment was determined deterministically for the worst-case flaw.

Degradation	*Maximum depth projected at next inspection (%TW)*	*OA Limit (%TW)*	*Growth rate (%TW/EFPY)*	*Projected EFPY*
FB Wear	*50.3*	*52*	*2.0*	*7.3*
LG Wear	*41.1*	*54.3*	*3.0*	*7.3*

For FO wear, since conditional monitoring was met and there is no mechanism for future growth then tube integrity is expected to be met at the next inspection.

e. The number and percentage of tubes plugged to date, and the effective plugging percentage in each SG.

Steam Generator[1]	*1A*	*1B*	*1C*	*1D*	*Total*
Prior to EOC-27	*8*	*0*	*24*	*17*	*49*
EOC-27	*0*	*0*	*1*	*0*	*1*
Total	*8*	*0*	*25*	*17*	*50*
% Plugged/Effective Plugging (%)	*0.12*	*0.00*	*0.38*	*0.26*	*0.19*

1= There are 6633 tubes per steam generator

f. The results of any SG secondary side inspections.

During FOSAR, a total of ninety-one (91) metallic objects were found with thirty-four (34) removed and fifty-seven (57) remaining in the steam generators. There were no indications of wear associated with any of these foreign objects. The parts remaining in the steam generators were evaluated and deemed acceptable for continued operation for the next five cycles.

A visual examination of the 7th lattice grid support was performed in 1D SG. The examination was performed above the 7th lattice grid and included several inner bundle passes and a drop-down inspection to the top of the 6th lattice grid. The purpose was to assess the material condition and cleanliness of this region of the SG. No evidence of degradation was identified. Deposit loading on the tube and structure surfaces, and within lattice openings was observed and prevented inspections from going through the entire bundle.

Visual examinations were also performed in the 1D SG steam drum to assess the material condition of the subcomponents in this region. The primary and secondary separators were of particular interest due to flow accelerated corrosion (FAC) susceptibility of the materials in these components and a history of FAC in the McGuire Unit 2 secondary separators.

The separators were last inspected in EOC24 and a comparison of 14 separator baseplates inspected at both EOC24 and EOC27 show no visible change in the erosion patterns on the baseplate in area and no visible perforations. This potentially indicates that the erosion on the baseplates has either stopped or is progressing at a negligible rate and is not expected to cause any performance issues or potential foreign objects. A slight difference in color of the deposit coating was observed for separators based on their location on the hot or cold leg side of the SG, with the cold leg separators having an orange color (likely hematite) compared to a gray color (likely magnetite) on the hot leg separators. The cause of this difference is unknown but is not expected to be a concern.

Inspections of the sidewalls of the separators did not identify any holes or signs of FAC, however, a couple of separators had a more "polished" texture of the magnetite buildup typical of most separators.

Additionally, the area around the longitudinal weld of several separators showed signs of erosion of the magnetite layer which aligns with operating experience of similar model SGs.

The inspections also included several primary separators, venturi nozzles, the weld along the secondary deck, and the hatch. No erosion or damage was observed at any of these locations.

Sludge Lancing removed 56 pounds of sludge total with 13 pounds removed from 1A SG, 15 pounds removed from the 1B SG, 14 pounds removed from the 1C SG, and 14 pounds removed from the 1D SG.

Approximately 4,671 pounds of iron are contained in the four steam generators by iron transport at cycle 27. Deposit mapping predicts there are 5,642 pounds total deposit in all four steam generators at the end of cycle 27.

List of tube wear at support structures indications greater than or equal to 20%TW

Catawba 1, EOC-27

SGID	ROW	COL	VOLTS	DEG	IND	PER	CHN	LOCN	INCH1	INCH2	UTIL1	UTIL2	CRLEN	CEG	CRWID	BEGT	ENDT	PDIA	PTYPE	CAL	L	IDX	UTIL3
SGID	ROW	COL	VOLTS	DEG	IND	PER	CHN	LOCN	INCH1	INCH2	UTIL1	UTIL2	CRLEN	CEG	CRWID	BEGT	ENDT	PDIA	PTYPE	CAL	L	IDX	UTIL3

SGID	ROW	COL	VOLTS	DEG	IND	PER	CHN	LOCN	INCH1	INCH2	UTIL1	UTIL2	CRLEN	CEG	CRWID	BEGT	ENDT	PDIA	PTYPE	CAL	L	IDX	UTIL3
B	97	70	.69	272	PCT	23	P5	FB5	-.82		WAR					TEC	TEH	.560	ZBAHS	15	H	49	

SGID	ROW	COL	VOLTS	DEG	IND	PER	CHN	LOCN	INCH1	INCH2	UTIL1	UTIL2	CRLEN	CEG	CRWID	BEGT	ENDT	PDIA	PTYPE	CAL	L	IDX	UTIL3
C	79	62	.55	256	PCT	20	P5	FB4	-1.24		WAR					TEC	TEH	.560	ZBAHS	16	H	135	
C	102	69	.56	69	PCT	20	P5	FB6	1.59		WAR					TEC	TEH	.560	ZBAHS	15	H	133	
C	83	76	.91	276	PCT	28	P5	FB5	-.80		WAR					TEC	TEH	.560	ZBAHS	12	H	47	
C	85	76	.86	254	PCT	27	P5	FB5	-1.11		WAR					TEC	TEH	.560	ZBAHS	10	H	135	
C	102	77	.59	87	PCT	20	P5	FB4	-.92		WAR					TEC	TEH	.560	ZBAHS	8	H	135	
C	97	78	.80	61	PCT	25	P5	FB6	-1.68		WAR					TEC	TEH	.560	ZBAHS	7	H	155	
C	97	86	.97	243	PCT	29	P5	FB6	-.77		WAR					TEC	TEH	.560	ZBAHS	7	H	126	
C	105	88	.57	250	PCT	20	P5	FB5	-.74		WAR					TEC	TEH	.560	ZBAHS	7	H	138	

SGID	ROW	COL	VOLTS	DEG	IND	PER	CHN	LOCN	INCH1	INCH2	UTIL1	UTIL2	CRLEN	CEG	CRWID	BEGT	ENDT	PDIA	PTYPE	CAL	L	IDX	UTIL3

SGID	ROW	COL	VOLTS	DEG	IND	PER	CHN	LOCN	INCH1	INCH2	UTIL1	UTIL2	CRLEN	CEG	CRWID	BEGT	ENDT	PDIA	PTYPE	CAL	L	IDX	UTIL3
D	97	68	.84	245	PCT	26	P5	FB5	-.73		WAR					TEC	TEH	.560	ZBAHS	18	H	143	
D	100	69	.58	64	PCT	20	P5	FB6	1.63		WAR					TEC	TEH	.560	ZBAHS	18	H	138	
D	53	76	.63	263	PCT	22	P5	FB4	1.84		WAR					TEC	TEH	.560	ZBAHS	25	H	79	

List of foreign object wear indications

Catawba 1, EOC-27

SGID	ROW	COL	VOLTS	DEG	IND	PER	CHN	LOCN	INCH1	INCH2	UTIL1	UTIL2	CRLEN	CEG	CRWID	BEGT	ENDT	PDIA	PTYPE	CAL	L	IDX	UTIL3
A	69	112	.93	60	PCT	19	207	07H	.35		17902.1		.14		.14	07H	TEH	.560	ZYAX2	44	H	413	

SGID	ROW	COL	VOLTS	DEG	IND	PER	CHN	LOCN	INCH1	INCH2	UTIL1	UTIL2	CRLEN	CEG	CRWID	BEGT	ENDT	PDIA	PTYPE	CAL	L	IDX	UTIL3
B	10	11	.22	129	PCT	12	203	TSH	.23		17902.1		.23		.14	01H	TEH	.560	ZYAX2	1	H	44	
B	73	18	.36	128	PCT	12	207	TSH	.13		17902.1		.20		.20	01H	TEH	.560	ZYAX2	1	H	349	
B	75	18	.66	111	PCT	16	207	TSH	.23		17902.1		.20		.20	01H	TEH	.560	ZYAX2	2	H	265	
B	72	19	.34	109	PCT	12	207	TSH	.18		17902.1		.20		.19	01H	TEH	.560	ZYAX2	1	H	342	
B	72	19	.29	111	PCT	11	207	TSH	.25		17902.1		.20		.20	01H	TEH	.560	ZYAX2	1	H	342	
B	106	103	.22	98	PCT	10	207	TSH	7.42		17902.1		.20		.14	01H	TEH	.560	ZYAX2	4	H	122	

SGID	ROW	COL	VOLTS	DEG	IND	PER	CHN	LOCN	INCH1	INCH2	UTIL1	UTIL2	CRLEN	CEG	CRWID	BEGT	ENDT	PDIA	PTYPE	CAL	L	IDX	UTIL3

SGID	ROW	COL	VOLTS	DEG	IND	PER	CHN	LOCN	INCH1	INCH2	UTIL1	UTIL2	CRLEN	CEG	CRWID	BEGT	ENDT	PDIA	PTYPE	CAL	L	IDX	UTIL3
C	46	7	.28	101	PCT	11	207	TSH	9.19		17902.1		.34		.20	01H	TEH	.560	ZYAX2	32	H	137	
C	104	37	.24	264	PCT	10	207	TSH	11.84		17902.1		.23		.20	01H	TEH	.560	ZYAX2	32	H	23	
C	3	66	.21	265	PCT	9	166	TSC	1.86		17902.1		.23		.27	01C	TEC	.560	ZYAX2	1	C	897	
C	2	67	.50	276	PCT	14	90	TSC	1.72		17902.1		.38		.27	01C	TEC	.560	ZYAX2	2	C	833	
C	1	70	.36	76	PCT	12	78	TSC	1.62		17902.1		.32		.41	01C	TEC	.560	ZYAX2	2	C	831	
C	103	82	.85	295	PCT	18	207	TSH	.16		17902.1		.20		.14	09C	TEH	.560	ZYAX2	33	H	27	
C	104	83	4.48	79	PCT	41	207	TSH	.15		17902.1		.18		.20	01H	TEH	.560	ZYAX2	36	H	17	
C	92	115	.20	84	PCT	9	207	TSC	17.76		17902.1		.29		.20	01C	TEC	.560	ZYAX2	2	C	370	
C	93	116	.21	283	PCT	9	207	TSC	15.84		17902.1		.27		.27	01C	TEC	.560	ZYAX2	2	C	369	

SGID	ROW	COL	VOLTS	DEG	IND	PER	CHN	LOCN	INCH1	INCH2	UTIL1	UTIL2	CRLEN	CEG	CRWID	BEGT	ENDT	PDIA	PTYPE	CAL	L	IDX	UTIL3
D	97	34	.47	125	PCT	14	207	TSC	.31		17902.1		.20		.20	01C	TEC	.560	ZYAX2	6	C	581	
D	99	34	1.84	66	PCT	27	207	TSC	.20		17902.1		.20		.20	01C	TEC	.560	ZYAX2	6	C	584	