Edward R. Pigott
Site Vice President
McGuire Nuclear Station

Duke Energy
MG01VP | 12700 Hagers Ferry Road
Huntersville, NC 28078

o: 980.875.4111
Edward.Pigott@duke-energy.com

Serial: RA-22-0101
March 24, 2022

10 CFR 50.4
10 CFR 50.36(c)(5)

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

MCGUIRE NUCLEAR STATION, UNIT NO.2
DOCKET NO. 50-370 / RENEWED LICENSE NUMBER NPF-17

SUBJECT: McGuire Nuclear Station Unit 2, End of Cycle 27 (M2R27) Steam Generator Tube Inspection Report

Ladies and Gentlemen:

In accordance with McGuire Nuclear Station (MNS) Technical Specification 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 MNS Unit 2, Refueling Outage 27 (M2R27). 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 Mr. Lee Grzeck, Nuclear Fleet Licensing Manager (Acting), at 980-373-1530.

Sincerely,

Edward R. Pigott
Site Vice President
McGuire Nuclear Station

Enclosure:
Steam Generator Tube Inspection Summary Report, McGuire Unit 2, M2R27 (Fall Refueling Outage 2021)

cc: (with enclosure)

J. Klos, NRC Project Manager, NRR
L. Dudes, NRC Regional Administrator, Region II
A. Hutto, NRC Senior Resident Inspector

U.S. Nuclear Regulatory Commission
Serial: RA-22-0101
Enclosure

RA-22-0101

Enclosure
Steam Generator Tube Inspection Summary Report, McGuire Unit 2, M2R27 (Fall Refueling Outage 2021)

McGuire 2 EOC-27 Steam Generator Tube Inspection Report

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

Background

McGuire Nuclear Station 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 McGuire RSG's are Model CFR80, manufactured by Babcock and Wilcox Canada and were replaced at EOC 11 in 1997. 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.

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. Figure 1 provides a visual representation of the of the SG's.

McGuire has a feedwater equalization header that also functions as a foreign object trapping device by its design.

No deviations have been taken from industry guidelines.

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

McGuire 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.*

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 2A SG only*
- *Visual inspection of the steam drum in 2A SG only*
    - *Laser metrology of selected secondary separator bottom plates*

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. Twenty-five (25) of these indications were newly reported. The deepest of fanbar wear indication was 29% TW. The average growth rate was near zero. The largest 95th percentile growth rate among all SG is 0.7%TW/EFPY. There were sixteen (16) indications of lattice grid (LG) wear reported. Four (4) of these indications were newly reported. The deepest of lattice grid wear indication was 11% TW. The average growth rate for lattice grid wear was near zero. The maximum growth rate for repeat indications was 0.78%TW/EFPY. There were two (2) indications of foreign object (FO) wear reported. Both were historical and showed no growth. The two FO wear indications were reported as HNC.

The complete listing for indications greater than or equal to 20%TW is attached.

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 17.62, EOC-25 was 19.01, EOC-26 was 20.44 and EOC-27 was 21.84. The last inspection was at EOC-24.

As of EOC-27, the McGuire Unit 2 steam generators had operated 20.64 EFPY since the first in-service inspection after replacement. In total, the McGuire Unit 2 steam generators had operated 21.84 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 11%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 15%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)	*41.3*	*29*
FB Wear Maximum Depth (New)	*39.0*	*14*
LG Wear Maximum Depth (Repeat)	*28.6*	*11*
LG Wear Maximum Depth (New)	*35.9*	*11*
FO Wear Maximum Depth	*<54.3*	*15*

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 [or repaired] during the inspection outage.

There were no tubes plugged during the EOC-27 inspection outage.

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	*47.4*	*52*	*1.6*	*7.3*
LG Wear	*30*	*54.3*	*1.6*	*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 [or repaired] to date, and the effective plugging percentage in each SG.

Steam Generator[1]	*2A*	*2B*	*2C*	*2D*	*Total*
Prior to EOC-27	*26*	*8*	*18*	*10*	*62*
EOC-27	*0*	*0*	*0*	*0*	*0*
Total	*26*	*8*	*18*	*10*	*62*
% Plugged/Effective Plugging (%)	*0.39*	*0.12*	*0.27*	*0.15*	*0.23*

1= There are 6633 tubes per steam generator

f. The results of any SG secondary side inspections.

During FOSAR, a total of 28 metal objects were found with 18 removed. All foreign objects that were not removed have a technical evaluation demonstrating that tube integrity will be met through the next scheduled inspection at EOC31. There was no wear associated with any foreign object.

An examination of the upper-most (9^{th}) lattice grid support was performed in 2A SG. The examination was performed via an inspection port above the 9^{th} lattice grid and included several inner bundle passes and a drop-down inspection to the top of the 5^{th} 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 relatively minor in the regions examined.

Visual examinations were also performed in the 2A 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 FAC susceptibility of the materials in these components and a history of FAC in the secondary separators. In addition to the visual examinations, laser metrology was performed to trend the remaining thickness of the secondary separator bottom plates.

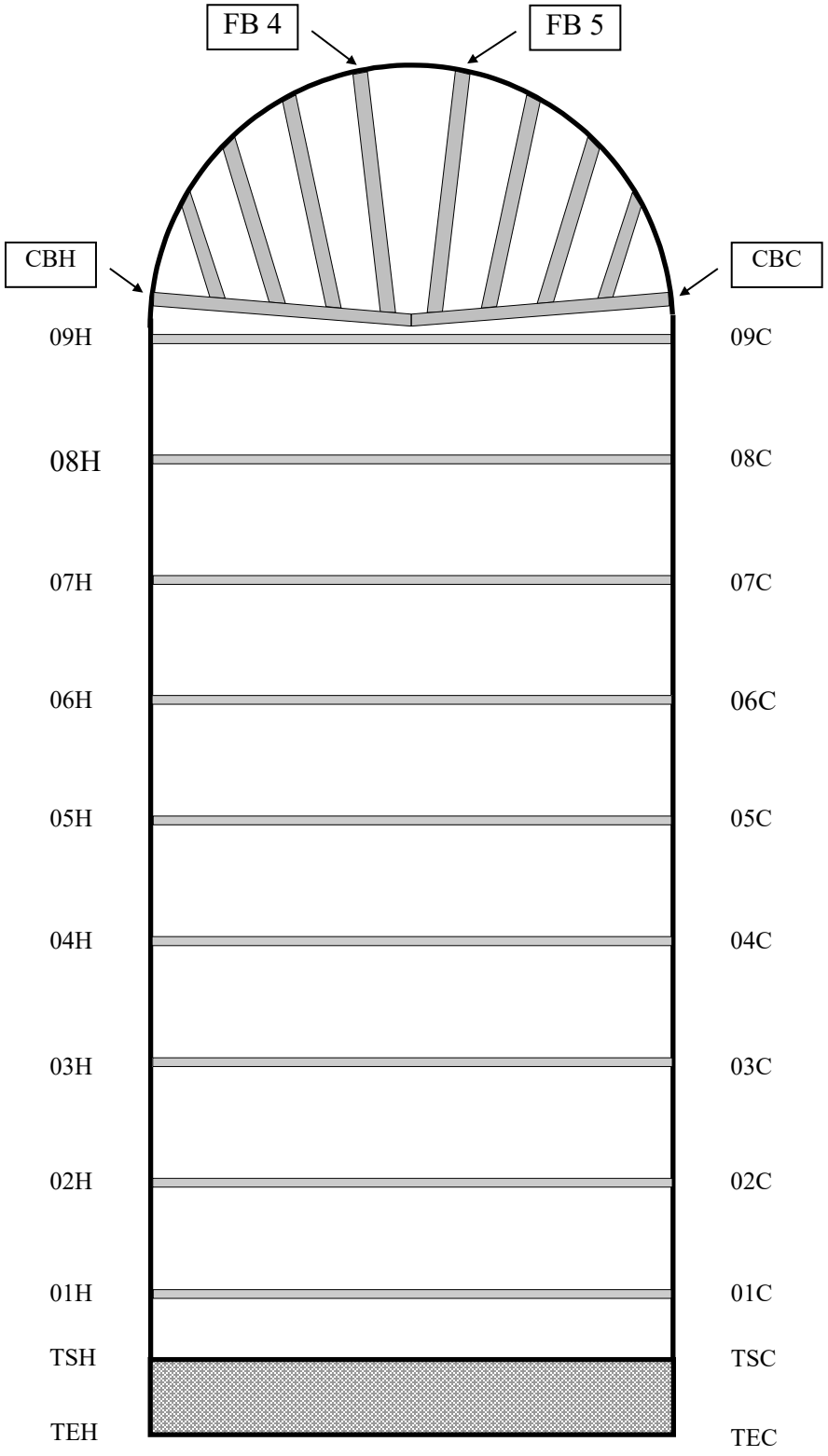
These examinations confirmed that secondary separator skimmer wall FAC is continuing. A total of 59 separators were identified with throughwall degradation as compared with 43 during the EOC-25 outage. It appears that portions of the skimmer wall are flaking off and migrating to the tube bundle at the secondary face of the tubesheet. Secondary separator bottom plate FAC is continuing although no throughwall penetration was identified. The maximum material loss was measured to be approximately 95% as compared with 48% (returned to service) at the EOC-25 outage. In addition, five stiffener plates in two primary separator curved arms were identified as degraded by FAC; a condition not previously observed in the SGs.

Sludge lancing removed various materials, comprised mostly of gasket material, sludge flakes, graphite pieces, thin metallic strips, and a few pieces of wires, springs and metal shavings and weld slag/splatter and approximately 162.5 pounds of sludge. The thin metallic strips found in each SG had a unique scalloped surface on one side consistent with flow accelerated corrosion (FAC) that is suspected of being secondary moisture separator material and are evaluated as not expecting to cause wear that would exceed the structural limit over the next 4 cycles (5.85 EFPY).

Sludge Lancing removed 162.5 pounds of sludge total with 42 pounds removed form 2A SG, 25 pounds removed from the 2B SG, 42.5 pounds removed from the 2C SG and 53 pounds removed from the 2D SG.

Approximately 7800 pounds of iron are contained in the four steam generators by iron transport.

Figure 1 - CFR80 Elevation Map



CFR 80

Tube Information:

No. of Tubes	6633
Material:	Inconel 690
Nominal Dia.:	0.688”
Nominal Wall:	0.040”

Tube Support Information

Type:	Lattice
Material:	Ferritic SS

Fan Bar (FB)

Material:	Ferritic SS

Collector Bar (CB)

Material:	Ferritic SS

List of indications greater than or equal to 20%TW

McGuire 2, EOC-27

INSPDATE	ROW	COL	VOLTS	DEG	IND	PER	CHN	LOCN	INCH1	INCH2	BEGT	ENDT	PDIA	PTYPE	CAL	L	IDX	UTIL1	UTIL2	UTIL3
2021/09/01	111	70	.85	276	PCT	26	P5	FB5	.65		TEC	TEH	.560	ZBAHS	12	H	293	WAR		
2021/09/01	111	70	.60	91	PCT	21	P5	FB6	1.68		TEC	TEH	.560	ZBAHS	12	H	293	WAR		
2021/09/01	86	73	.69	269	PCT	23	P5	FB5	-1.01		TEC	TEH	.560	ZBAHS	8	H	176	WAR		
2021/09/01	117	76	.57	292	PCT	20	P5	FB3	.95		TEC	TEH	.560	ZBAHS	8	H	124	WAR		
2021/09/01	117	76	.78	280	PCT	25	P5	FB5	-1.20		TEC	TEH	.560	ZBAHS	8	H	124	WAR		
2021/09/01	115	78	.57	98	PCT	20	P5	FB6	-1.54		TEC	TEH	.560	ZBAHS	9	H	73	WAR		
INSPDATE	ROW	COL	VOLTS	DEG	IND	PER	CHN	LOCN	INCH1	INCH2	BEGT	ENDT	PDIA	PTYPE	CAL	L	IDX	UTIL1	UTIL2	UTIL3

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

INSPDATE	ROW	COL	VOLTS	DEG	IND	PER	CHN	LOCN	INCH1	INCH2	BEGT	ENDT	PDIA	PTYPE	CAL	L	IDX	UTIL1	UTIL2	UTIL3
2021/09/01	80	67	.73	91	PCT	24	P5	FB5	1.22		TEC	TEH	.560	ZBAHS	21	H	30	WAR		
INSPDATE	ROW	COL	VOLTS	DEG	IND	PER	CHN	LOCN	INCH1	INCH2	BEGT	ENDT	PDIA	PTYPE	CAL	L	IDX	UTIL1	UTIL2	UTIL3

INSPDATE	ROW	COL	VOLTS	DEG	IND	PER	CHN	LOCN	INCH1	INCH2	BEGT	ENDT	PDIA	PTYPE	CAL	L	IDX	UTIL1	UTIL2	UTIL3
2021/09/01	108	69	.98	269	PCT	29	P5	FB4	1.33		TEC	TEH	.560	ZBAHS	5	H	296	WAR		
INSPDATE	ROW	COL	VOLTS	DEG	IND	PER	CHN	LOCN	INCH1	INCH2	BEGT	ENDT	PDIA	PTYPE	CAL	L	IDX	UTIL1	UTIL2	UTIL3