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Dominion®

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U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
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DOMINION NUCLEAR CONNECTICUT, INC.
MILLSTONE POWER STATION UNIT 2
END OF CYCLE 18 STEAM GENERATOR TUBE INSPECTION REPORT

In accordance with the Millstone Power Station Unit 2 (MPS2) Technical Specification (TS), Section 6.9.1.9, Dominion Nuclear Connecticut, Inc., hereby submits, the End of Cycle (EOC) 18 Steam Generator Tube Inspection Report. The report is submitted within 180 days after initial entry into MODE 4 following completion of an inspection performed in accordance with TS 6.26, Steam Generator (SG) Program.

The report includes the following:

a. The scope of inspections performed on each SG,
b. Active degradation mechanisms found,
c. Nondestructive examination techniques utilized for each degradation mechanism,
d. Location, orientation (if linear), and measured sizes (if available) of service induced indications,
e. Number of tubes plugged during the inspection outage for each active degradation mechanism,
f. Total number and percentage of tubes plugged to date, and
g. The results of condition monitoring, including the results of tube pulls and in-situ testing.

If you have any questions or require additional information, please contact Mr. William D. Bartron at (860) 444-4301.

Sincerely,

A. J. Jordan
Site VP – Millstone

A047
NRR

Enclosures: (1)

Commitments made in this letter: None.

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ENCLOSURE

Millstone Power Station Unit 2

End of Cycle 18 Steam Generator Tube Inspection Report

MILLSTONE POWER STATION UNIT 2
DOMINION NUCLEAR CONNECTICUT, INC. (DNC)

End of Cycle 18 Steam Generator Tube Inspection Report

Millstone Power Station Unit 2 (MPS2) is a two loop Combustion Engineering (CE) pressurized water reactor (PWR) with Babcock and Wilcox (B&W) replacement Steam Generators (SGs). Each SG was designed to contain 8523 U-bend thermally treated Inconel 690 tubes. One hot leg tubesheet hole in SG 1 was plugged during construction and the opposing cold leg hole was not drilled, thus SG 1 has 8522 tubes. The tubing is nominally 0.750 inches outside diameter with a 0.0445 inch nominal wall thickness. During replacement SG fabrication, the tubes were installed using a two-step hydraulic expansion process over the full depth of the 21.06 inch thick tubesheet. The tubesheet was drilled on a triangular pitch with 1.0 inch spacing. There are 141 rows and 167 columns in each SG. To minimize small radius U-bends, tubes in rows 1 through 3 were installed using a staggered arrangement. This resulted in the termination of tubes at different locations between the hot and cold legs. For these rows, the tube identification follows the hot leg row/column naming convention. Secondary side tube support structures include seven lattice grid supports on the vertical section of the tubes and twelve fan bar assemblies on the U-bend section of the tubes. All lattice grid supports are full supports. SG replacement was completed in the fall of 1992 during MPS2's Refueling Outage 11 (2R11). The new SGs have accrued 9.762 Effective Full Power Years (EFPY) of operation as of the End of Cycle (EOC) 18 (April 2008). The 910 MW unit operates with a hot leg temperature of 601 degrees Fahrenheit.

The MPS2 SG eddy current testing (ECT) conducted at EOC 18 was completed on April 24, 2008. Initial entry into Mode 4 following completion of the inspections occurred on May 12, 2008. The examinations, personnel, and equipment conformed to the requirements of NEI 97-06, Rev. 2, Steam Generator Program Guidelines; EPRI Pressurized Water Reactor Steam Generator Examination Guidelines, Rev. 6; and MPS2 Technical Specifications (TSs).

In accordance with MPS2 TSs, a SG tube inspection report is required. TS Section 6.9.1.9 states:

> ***A report shall be submitted within 180 days after initial entry into MODE 4 following completion of an inspection performed in accordance with TS 6.26, Steam Generator (SG) Program. The report shall include:***
>
> ***a. The scope of inspections performed on each SG,***

For both SG 1 and SG 2, a 100% full length bobbin coil examination was scheduled to be performed on all tubes from the tube end of the hot leg (TEH) to the tube end of the cold leg (TEC). This was accomplished for the majority of the tubes. The remaining tubes were examined from 07C to TEH, 07C to TEC, 07H to TEH, or 07H to TEC to complete the full length bobbin inspection. See Attachment 1, "Acronyms," for explanation of acronyms. See Attachment 2, "Millstone Power Station Unit 2 Steam Generator Arrangement," for illustration of steam generator component locations.

For both SG1 and SG 2, the rotating pancake coil (RPC) examinations included a 140 tube sample of hot leg tubesheet expansion transitions (TSH +3"/-3") in the periphery area of each SG. In addition, a total of 1012 (438 in SG 1 and 574 in SG 2) locations were examined with RPC. These locations included 2R15 and 2R16 historical locations which consisted of previously reported bulges (BLG), dings (DNG), dents (DNT), non-quantifiable historical indications (NQH), partial tubesheet expansion (PTE), possible loose part (PLP), percent through-wall indications (%TW), and volumetric indications (VOL). These locations also included 2R18 bobbin coil special interest (SI) locations of ding (DNG), dent (DNT) distorted expansion indications (DEI), deposit (DEP), loose part indications (LPI), non-quantifiable indications (NQI), possible loose parts (PLP), various hot leg and cold leg bounding locations, and tubes that were observed with flex gasket material protruding from the tube ends. The inspection summary is documented in Table 1.

Table 1 - Millstone 2R18 ECT Summary

	SG 1	SG 2	Total
Number of Tubes (SG 1 and SG 2)	8,522	8,523	17,045
Number of Tubes Inspected F/L w/Bobbin Probe	8,522*	8,523*	17,045
Previously Plugged Tubes	0	0	0
Number of Tubes Incomplete w/Bobbin Probe due to Obstruction	0	0	0
Number of Inspections w/MRPC (Total)	578	714	1292
•Hot Leg Transitions - Original Scope (tubes)	140	140	280
•Hot Leg Transitions - Scope Expansion (tubes)	0	0	0
•Hot Leg Misc. Special Interest - Diagnostic Exams and from Previous History (locations)	75	92	167
•Cold Leg Transitions - Original Scope (tubes)	0	0	0
•Cold Leg Transitions - Scope Expansion (tubes)	0	0	0
•Cold Leg Misc. Special Interest - Diagnostic Exams and from Previous History (locations)	98	144	242
•U-Bends – Original Scope (locations)	0	0	0
•U-bend. Special Interest – Diagnostic Exams and from Previous History (locations)	51	97	148
•PLP / SVI Bounding Special Interest (locations)	214	241	455
Tubes with Max FB Wear ≥ 40 %	0	0	0
Tubes with Max FB Wear ≥20% but <40%	0	0	0
Tubes with Max FB Wear <20%	2	2	4
Tubes with Max SVI / VOL / WAR≥ 40 %	2	0	2
Tubes with Max SVI / VOL / WAR≥20% but <40%	2	10	12
Tubes with Max SVI / VOL / WAR<20%	3	1	4
Tubes Plugged as a result of SVI / VOL / WAR≥ 37 %	2	0	2
Tubes Plugged as a result of no qualified sizing	5	0	5
Tubes Plugged as a result of FB Wear ≥ 37 %	0	0	0
Tubes Plugged as a result of an Obstruction	0	0	0
Tubes Plugged on a discretionary basis (loose part wear with part not removed)	1	2	3
Total Tubes Plugged as a Result of this Inspection	8	2	10

*For 102 tubes in SG 1 and 260 tubes in SG 2, the bobbin exam was a combination of two examinations from opposite legs with overlap at the upper support structure.

b. Active degradation mechanisms found,

Two mechanical tube degradation mechanisms – fan bar wear and foreign object wear were identified during this examination. There was no evidence of any corrosion-related degradation.

c. Nondestructive examination techniques utilized for each degradation mechanism,

Table 2 identifies the examination techniques utilized for each identified degradation mechanism.

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

Table 3 identifies the service induced indications reported during the examination.

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

In SG 1, seven wear indications were reported. Five were located at the tubesheet interface and not in the freespan and were caused by a transient loose part. Since there was no qualified technique for sizing indications at this location, all five tubes were removed from service by plugging. Two additional indications were located above the cold leg secondary side tubesheet interface and were caused by loose part wear. The loose part that caused the wear could not be removed by Foreign Object Search and Retrieval (FOSAR). The maximum depth sizing for these two indications was 67% and 58%. Both tubes along with a third adjacent tube were removed from service by plugging and stabilization. These three tubes box the loose part that could not be removed.

In SG 2, a wear indication was located above the hot leg secondary side tubesheet interface and was caused by a loose part. The maximum depth sizing was 11% TW. The loose part, a piece of flexitallic gasket, was still present and could not be removed. The tube with the wear indication along with an adjacent tube also in contact with the foreign object, were both removed from service by plugging and stabilization.

f. Total number and percentage of tubes plugged to date, and

A total of eight tubes were plugged in SG 1 during this outage and none had been previously plugged. Eight of 8522 tubes or 0.094% of the tubes in SG 1 have been plugged to date. A total of two tubes were plugged in SG 2 during this outage and none had been previously plugged. Two of 8523 tubes or 0.024% of the tubes in SG 2 have been plugged to date.

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

No tubes were pulled and no in-situ pressure tests were performed. The condition monitoring assessment concluded that the structural integrity, operational leakage and accident induced leakage performance criteria were not exceeded during the operating interval preceding 2R18.

Table 2 – Degradation Mechanisms and Available Inspection Techniques

Degradation Mechanism	Location	Likelihood of Near-Term Initiation	Detection Technique, ETSS Number	Best Estimate Technique POD	Sizing Technique, ETSS Number	Tech. Sizing Correlation (r^2)	Tech. Sizing Regression Coef. (slope, intercept)	Technique, Personnel Sizing Std Err (%TW)	2R18 Sample Size
Wear	Tube to Tube Contact	Low	Bobbin, 96004.3	1.0 (>10%TW) 0.98 (>40%TW)	Bobbin, 96004.3	0.98	0.96, 2.92	3.52, 0.86	100%, full length bobbin in both SGs
			+Point, 96910.1	1.0 (>21%TW)	+Point, 96910.1	0.92	1.01, 4.3	6.68, NA	bobbin identified points of interest, +point / 0.115"
			0.115", 96911.1		0.115", 96911.1	0.92	1.22, 0.07	7.49, 3.22	exams in both SGs
Wear	Tube at Fan Bar (existing mechanism)	Medium	Bobbin, 96004.3	1.0 (>10%TW) 0.98 (>40%TW)	Bobbin, 96004.3	0.98	0.96, 2.92	3.52, 0.86	100%, full length bobbin in both SGs
			+Point, 96910.1	1.0 (>21%TW)	+Point, 96910.1	0.92	1.01, 4.3	6.68, NA	bobbin identified points of interest, +point / 0.115"
			0.115", 96911.1		0.115", 96911.1	0.92	1.22, 0.07	7.49, 3.22	exams in both SGs
Wear	Tube at Foreign Object (existing mechanism)	Medium	Bobbin, 96005.2	0.98 (>20%TW) 0.88 (>40%TW)	Bobbin, 96005.2	0.17	0.27, 28.42	13.36, 1.73	100%, full length bobbin in both SGs
			+Point, 96910.1	1.0 (>21%TW)	+Point, 96910.1	0.92	1.01, 4.3	6.68, NA	
			0.115", 96911.1		0.115", 96911.1	0.92	1.22, 0.07	7.49, 3.22	+point / 0.115" diagnostic exams
Pitting	Tube at Secondary Side Sludge/Deposits	Low	Bobbin, 96005.2	0.98 (>20%TW), 0.88 (>40%TW)	Bobbin, 96005.2	0.17	0.27, 28.42	13.36, 1.73	100%, full length in both SGs
Thinning	Tube at support structures	Low	Bobbin, 96001.1	0.96 (>20%TW), 0.98 (>40%TW)	Bobbin, 96001.1	0.74	0.97, -6.61	13.20, 0.89	100%, full length in both SGs
Impingement	Tube at support structures	Very Low	NA	NA	NA	NA	NA	NA	NA
IGA/SCC (OD) Volumetric/Axial	Tube Freespan, Non Dented Support Intersections, Sludge Regions	Very Low	Bobbin, 96008.1	1.0 (>20%TW), 0.89 (>40%TW)	Bobbin, 96008.1	0.55	0.74, 9.56	20.62, NA	100%, full length in both SGs
SCC (OD) Axial and/or circumferential	Tube Freespan, Dented and Non Dented Support Intersections, Sludge Regions, Expansion Transition	Very Low	+Point, 21409.1	1.0 (>35%TW), 0.98 (axial) 0.95 (circ)	+Point, 21409.1 (% degraded area)	0.15 (% degraded area)	0.33, 25.61 (% degraded area)	17.88, NA (% degraded area)	bobbin identified points of interest, +point exams in both SGs
SCC (OD) Circumferential	Freespan including Dent > 5.0 volt	Very Low	Bobbin, 24013.1	0.95 (>60%TW),	NA	NA	NA	NA	100%, full length bobbin in both SGs
SCC (OD)	Expansion Transition	Very Low	+Point, 21410.1	1.0 (>42%TW) 0.7 (<41%TW)	+Point, 21410.1	0.02	0.13, 60.1	24.50	bobbin identified points of interest, +point exams in both SGs
Volumetric	Freespan	Medium	+Point, 21998.1	1.0 (>10%TW)	+Point, 21998.1	0.88	1.02, 5.81	6.28	+point / 0.115" diagnostic exams

Table 2 – Degradation Mechanisms and Available Inspection Techniques (continued)

Degradation Mechanism	Location	Likelihood of Near-Term Initiation	Detection Technique, ETSS Number	Best Estimate Technique POD	Sizing Technique, ETSS Number	Tech. Sizing Correlation (r^2)	Tech. Sizing Regression Coef. (slope, intercept)	Technique, Personnel Sizing Std Err (%TW)	2R18 Sample Size
SCC (OD)	Dented Structural Supports	Very Low	+Point, 22401.1	1.0 (>53%TW)	+Point, 22401.1	0.02	1.3, 74.55	14.44	bobbin identified points of interest, +point exams in both SGs
			+Point, 22842.1	1.0 (44%TW)	+Point, 22842.1	0.56	0.52, 0.03	0.26	
SCC (ID) Circumferential	Tube Expansion Transition, Within Tubesheet , Dents, Near Seal Weld, Plugs	Very Low	+Point, 20510.1	0.96 (>30%TW)	+Point, 20510.1 (%degraded area)	0.77 (% degraded area)	0.82, 2.83 (% degraded area)	7.69 (% degraded area)	+Point diagnostic exams
			+Point, 96701.1	0.67(21-41%TW) 1.0 (>42%TW)	+Point 96701.1	0.85	0.84, 10.32	9.56	
SCC (ID) Axial	Tube Expansion Transition, Within Tubesheet, Dents, Tack Expansion, Plugs, <2.0v Dents at TSP / Freespan	Very Low	+Point, 20511.1	1.0 (>37%TW)	+Point, 20511.1 (%degraded area)	0.29 (% degraded area)	0.36, 18.91 (% degraded area)	7.60 (%degraded area)	+Point diagnostic exams
			Bobbin, 96012.1						
			+Point, 96703.1	1.0 (>17%TW)	+Point, 96703.1 (% degraded area)	0.83	0.90, 0,77	10.06	
					(Axial Length)	0.83	1.00, 0.13	0.28	
SCC (ID) Axial and/or circumferential	Low Row U-bends	Very Low	+Point, 96511.3	1.0 (>27%TW)	+Point, 96511.3	0.22	0.34, 31.96	17.61, NA	bobbin identified points of interest, +point exams in both SGs
PWSCC Axial	Dents	Very Low	+Point, 96703.1	1.0 (>10%TW)	+Point, 96703.1	0.98	0.90, 7.56	15.28	Bobbin identified points of interest
Wear (foreign object not present) (freespan)	Circumferential Groove	Medium	+Point, 27901.0	1.0 (>31%TW)	+Point, 27901.0	0.98	1.05, -1.97	2.30	Additional diagnostic wear techniques for loose part sizing
	Axial Groove		+Point, 27902.0	1.0 (>8%TW)	+Point, 27902.0	1.0	0.98, 1.89	2.32	
	Tapered Football		+Point, 27903.0	1.0 (>21%TW)	+Point, 27903.0	1.0	0.97, 2.80	2.11	
	Tapered Round Hole		+Point, 27904.0	1.0 (>32%TW)	+Point, 27904.0	0.98	1.00, 0.48	1.99	
	Flat Wear		+Point, 27905.0	1.0 (>7%TW)	+Point, 27905.0	1.0	1.09, -4.31	2.05	
	Tapered Wear		+Point, 27906.0	1.0 (>11%TW)	+Point, 27906.0	1.0	0.96, 1.67	1.43	
	45 deg. Tapered Wear		+Point, 27907.0	1.0 (>13%TW)	+Point, 27907.0	0.98	1.05, -2.10	2.59	
Corrosion Induced Tube Denting	Support Structures	Very Low	Bobbin, no specific ETSS	NA	NA	NA	NA	NA	100%, full length in both SGs
Plug Installation Deficiencies	Plug/Tube Interface	Low	Engineering review plug installation parameters and plug video after installation; Use to date of I-690 welded plugs.						SG 1

Table 3 – Service Induced Indications

SG 1

ROW	COL	VOLTS	DEG	PCT	CHN	LOCATION	ELEV_FROM
2	7	0.25	0	20	P5	TSH	-0.07
3	8	0.15	0	13	P5	TSH	-0.02
4	9	0.08	0	7	P5	TSH	-0.02
5	10	0.08	0	8	P5	TSH	-0.02
8	11	0.37	0	27	P5	TSH	0.09
40	155	0.37	115	11	P2	F06	-1.71
76	141	0.94	0	58	6	TSC	0.24
78	141	1.31	0	67	6	TSC	0.11
140	93	0.43	112	12	P2	F08	-0.54

SG 2

ROW	COL	VOLTS	DEG	PCT	CHN	LOCATION	ELEV_FROM
37	120	0.31	78	9	P2	F07	-0.7
28	5	0.25	0	29	6	01C	-2.59
29	4	0.19	0	25	6	01C	-1.86
40	81	0.17	79	30	6	TSH	0.12
59	10	0.16	0	23	6	01C	-6.8
98	143	0.11	0	26	6	TSH	8.51
99	80	0.43	76	11	P2	F06	1.31
118	41	0.15	0	11	6	TSH	12.43
119	42	0.17	80	29	6	TSH	12.78
123	46	0.13	64	27	6	TSH	17.61
124	45	0.20	75	31	6	TSH	19.23
125	48	0.3	81	37	6	TSH	19.38
126	49	0.34	93	39	6	TSH	19.82

Attachments

Attachment	Title
1	Acronyms
2	Millstone Power Station Unit 2 Steam Generator Arrangement

Attachment 1

Acronyms

B&W	Babcock & Wilcox
BLG	Bulge
CHN	Channel
COL	Column
DEG	Degrees
DEP	Deposit
DNG	Ding
DNT	Dent
ECT	Eddy Current Testing
EFPY	Effective Full Power Years
ELEV	Elevation
ETSS	Examination Technique Specification Sheet
FB	Fan Bar
F/L	Full Length
FOSAR	Foreign Object Search and Retrieval
IGA	Intergranular Attack
LPI	Loose Part Indication
MBM	Manufacturing Burnish Mark
MP 2	Millstone Unit 2
NQH	Non-Quantifiable Historical Indication
NQI	Non-Quantifiable Indication
OXP	Over Expansion
PCT	Percent Through-Wall
PLP	Possible Loose Part
POD	Probability of Detection
PTE	Partial Tubesheet Expansion
%TW	Percent Through-Wall
RPC	Rotating Pancake Coil
SCC	Stress Corrosion Cracking
SG 1	Steam Generator Number 1
SG 2	Steam Generator Number 2
SLG	Sludge
SSI	Secondary Side Inspection
SVI	Single Volumetric Indication
TEC	Tube End Cold-leg
TEH	Tube End Hot-leg
TSC	Top of Tube Sheet Cold-leg
TSH	Top of Tube Sheet Hot-leg
VOL	Volumetric Indication
WAR	Wear Indication

Attachment 2

Millstone Power Station Unit 2 Steam Generator Arrangement

[REDACTED]