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U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

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DOMINION NUCLEAR CONNECTICUT, INC.
MILLSTONE POWER STATION UNIT 2
END OF CYCLE 22 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 22 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. 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 degradation mechanism,
f. The number and percentage of tubes plugged to date, and the effective plugging percentage in each steam generator
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,

S. E. Scace
Site Vice President – Millstone Power Station

A001
NRR

Enclosures: (1)

Commitments made in this letter: None.

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Serial No. 14-265
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ENCLOSURE

END OF CYCLE 22
STEAM GENERATOR TUBE INSPECTION REPORT

MILLSTONE POWER STATION UNIT 2
DOMINION NUCLEAR CONNECTICUT, INC.

End of Cycle 22 Steam Generator Tube Inspection Report

The acronyms used in this report are defined in Attachment 1.

In accordance with MPS2 TS 6.9.1.9, DNC is submitting this 180-day report which describes the results of the EOC 22 SG examinations performed during MPS2 Refueling Outage 22. Based upon subsequent entry into Mode 4 on May 13, 2014, this report is required to be submitted by November 9, 2014.

Background:

MPS2 is a two loop Combustion Engineering pressurized water reactor with Babcock and Wilcox replacement SGs. Each SG is designed to contain 8,523 U-bend thermally treated Inconel 690 tubes. The tubing is nominally 0.750 inch outside diameter with a 0.0445 inch nominal wall thickness. The nominal hot leg temperature is 601°F.

Secondary side tube support structures include seven lattice grid supports on the vertical section of the tubes and twelve fan bar assemblies in the U-bend section of the tubes. All lattice grid supports are full supports. All tube supports were fabricated with 410-series stainless steel. Key MPS2 SG design parameters are summarized in Table 1.

The MPS2 SGs were replaced during Refueling Outage 11 (1992) and have accrued approximately 15.1 EFPYs of operation as of the EOC 22 (April 2014). Since the first sequential period begins after the first inservice inspection, programmatically, the SGs have accrued 13.8 EFPYs.

See Attachment 2, "Millstone Power Station Unit 2 Steam Generator Arrangement," for illustration of SG component locations.

Report:

TS 6.9.1.9 reporting requirements (in bold text) are provided below, followed by DNC's response:

A report shall be submitted within 180 days after the 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,

The MPS2 SG ECT conducted at the EOC 22 was completed on May 24, 2014. The examinations, personnel, and equipment conformed to the requirements of NEI 97-06, Steam Generator Program Guidelines; EPRI Pressurized Water Reactor Steam Generator Examination Guidelines, and Millstone Unit 2 TSs.

The EOC 22 ECT inspections are summarized in Table 2. In SG 2, 100% of the operational tubes (a total of 8,510 tubes) were inspected full length with bobbin probes while an augmented sample of 2,827 tube locations was inspected with MRPCs. No tube examinations were performed in SG 1.

The MRPC examinations included a 50% sample of the outer six rows of the hot and cold leg periphery and open tube lane at the top of tubesheet. The primary purpose of this examination was the detection of foreign objects or foreign object wear in the most susceptible regions of the SG. In addition, the MRPC examinations included both a pre-planned scope and a special interest emergent scope. The pre-planned scope included historical locations of interest, DNTs, DNGs, OXPs, BLGs, %TW indications, and a sample of NQH indications. The emergent scope included Refueling Outage 22 bobbin coil special interest locations such as NQIs, PLPs, and various hot leg and cold leg PLP bounding locations.

In addition to the ECT examinations, primary-side visual examinations were performed in both channel heads of SG 2. These visual examinations (as-found/as-left), revealed no degradation of the divider plates, divider plate retaining bars/welds, primary closure rings/welds, or cladding. Visual examinations performed on previously installed plugs identified no indications of plug degradation, leakage, or misplacement.

Secondary-side visual examinations were performed in SG 2 only. These examinations included:

- Post-sludge lancing visual examination of the top-of-tubesheet annulus and no-tube lane (no lancing was performed in SG 1) to assess as-left material condition and cleanliness, and to identify and remove any retrievable foreign objects using FOSAR.
- Visual investigation of accessible locations having eddy current indications potentially related to foreign objects, and removal of retrievable foreign objects.
- Steam drum visual inspections to evaluate the material condition and cleanliness of key components such as moisture separators, drain systems, and interior surfaces.

b. Degradation mechanisms found,

The tube examinations performed during Refueling Outage 22 in SG 2 identified fan bar wear and historical wear associated with foreign objects.

No degradation was detected during performance of the visual examinations.

c. Nondestructive examination techniques utilized for each degradation mechanism,

Table 3 identifies the inspection techniques used for each detected degradation mechanism.

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

A complete listing of the service induced indications, identified during Refueling Outage 22, is provided in Table 4.

Two fan bar wear indications were detected and sized during Refueling Outage 22 (see Table 4). The maximum depth of these indications was 15%TW and both indications had been reported during the previous examination in Refueling Outage 20. Neither flaw exhibited growth during the operating period from Refueling Outage 20 through Refueling Outage 22.

The remaining flaws listed in Table 4 were foreign object wear indications that had been identified during previous outage inspections and were confirmed to have no remaining adjacent foreign object. These flaws were re-examined during Refueling Outage 22. None of the flaws experienced growth during the operating period from Refueling Outage 20 through Refueling Outage 22.

Primary Side Foreign Object

Prompted by an obstruction of the bobbin probe within the tubesheet near the cold leg tube end, a visual examination of the inside of tube R49 C108 was performed. It was determined that the obstruction had been caused by a plastic object that had melted and adhered to the inside of the tube. The material was removed with a special extraction tool. The tube was then honed and swabbed to further clean the region. The tube was then examined with a +Point™ ECT probe. This testing confirmed that no tube degradation had occurred either during operation or as a result of the material removal activities. In addition, post-removal bobbin probe testing confirmed that no detectable residual material remained inside the tube.

The potential for more material of this type to have become lodged in other tubes was investigated. Within the unexpanded portion of the SG tubes, the clearance between the ECT bobbin probe OD (0.610") and the tube ID (0.661") is small enough such that any material in this part of the tube would have obstructed the probe. All inservice tubes in SG 2 were examined full length with the bobbin probe and no obstructions were found in this region of the tubes. Thus, it was concluded that no additional objects of this type were present in the unexpanded portion of the tubes.

Within the tubesheet region, the tube has a larger ID; therefore, an object of this type is less likely to be identified by probe obstruction. Although the first attempt to examine R49 C108 obstructed the 0.610" OD bobbin probe, follow-up bobbin (0.610") and array probe (0.560") exams were possible with the material in place. As the probe (bobbin or array) passed by the object, it was forced off-center, moving one side of the probe closer to the tube wall. This generated a distinctive signal normally associated with a significant geometric discontinuity. These examinations demonstrated that the presence of the object could be detected even though the non-conductive material itself was invisible to the ECT probes. Consequently, a RevospECT™ re-analysis of the ECT bobbin probe data from the hot leg and cold leg tubesheet region was performed in order to determine if any additional tubes had a signal similar to that caused by the foreign material in R49 C108. The re-analysis did not identify any additional indications. Thus, it was concluded that no other objects of this type were present in any other SG tubes.

Secondary Side Foreign Objects

A comprehensive program was implemented for detection of foreign objects and foreign object wear. This program consisted of planned examinations of known locations, a 50% +Point™ examination of the outer six tube deep periphery, a 100% bobbin coil examination, bounding examinations with +Point™, SSI of the top of tubesheet annulus and bundle periphery, and FOSAR, as required.

As shown in Table 4, there were 12 historical foreign object wear flaws in SG 2 and none of them indicated dimensional change when compared to the Refueling Outage 20 results. Various foreign objects were removed from SG 2 but no new foreign object wear indications were identified. No foreign objects with potential tube integrity significance are known to remain within SG 2.

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

No tubes were removed from service during Refueling Outage 22.

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

Table 5 provides the total number of tubes plugged and the percentages.

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 Refueling Outage 22.

Table 1: Key Design Parameters

Tubing Material	Inconel 690 thermally treated with post bend stress relief of U-bends Row 1-8
Number of tubes	8,523
Tube Size	0.750" OD, 0.0445" wall
Tube Pitch/Layout	1.00"/triangular pitch
Shortest Tube Radius	Row 3, 3.905" radius, Rows 1-3 are staggered
Outer Row Tube Radius	72.5"
Tubesheet Thickness	21.75"
Support Plates	Seven lattice grid support structures. Largest axial dimension is 3.15".
Anti-Vibration Bars	Twelve fan bars support all tube rows. Rows 1-5 contact F01 and F12 only. Higher rows have progressively more fan bar support structures. Largest fan bar width is 3.15".
Tubesheet Joint	Full hydraulic expansion

Table 2: MPS2 Refueling Outage 22 ECT Inspection Summary

	SG 1	SG 2	Total
Number of Installed Tubes	8,523	8,523	17,046
Number of Tubes Inservice Prior to Refueling Outage 22	8,503	8,510	17,013
Number of Tubes Inspected F/L w/Bobbin Probe**	N/A	8,510	8,510
Previously Plugged Tubes	19*	13	32
Number of Tubes Incomplete w/Bobbin Probe due to Obstruction	N/A	0	0
Number of Inspections w/MRPC (Total)	N/A	2,827	2,827
•Hot Leg Tubesheet Periphery (tubes)	N/A	1,250	1,250
•Hot Leg Previous Indications (locations)	N/A	49	49
•Hot Leg Special Interest (locations)	N/A	12	12
•Hot Leg TS Foreign Object Bounding (locations)***	N/A	140	140
•Cold Leg Tubesheet Periphery (tubes)	N/A	1,250	1,250
•Cold Leg Previous Indications (locations)	N/A	29	29
•Cold Leg Special Interest (locations)	N/A	9	9
•Cold Leg TS Foreign Object Bounding (locations)	N/A	31	31
•U-Bend Previous Indications (locations)	N/A	14	14
•U-Bend Special Interest (locations)	N/A	7	7
•Other Foreign Object Bounding (locations)	N/A	36	36
•Newly Developed Dents	N/A	0	0
Tubes with Max FB Wear ≥ 40 %	N/A	0	0
Tubes with Max FB Wear ≥20% but <40%	N/A	0	0
Tubes with Max FB Wear <20%	N/A	2	2
Tubes with Max SVI / VOL / WAR≥ 40 %	N/A	0	0
Tubes with Max SVI / VOL / WAR≥20% but <40%	N/A	10	10
Tubes with Max SVI / VOL / WAR<20%	N/A	2	2
Total Tubes Plugged as a Result of this Inspection	N/A	0	0

* One tubesheet location in SG 1 (R57 C156) was not drilled in the cold leg tubesheet. The hot leg hole for this tube was plugged with a welded plug.

** A number of tubes were examined in hot leg/cold leg segments to achieve full length coverage.

*** Includes post-part-removal re-examinations

Table 3: Degradation Mechanisms and Inspection Techniques

						Depth Sizing Parameters			
Degradation Mechanism(s)	Probe	EPRI ETSS	Demonstrated/ Extended Applicability	Detection	Sizing Applicability	Actual %TW vs. NDE %TW	Technique Uncertainty (Sy.x) %TW	Analyst Uncertainty %TW	Total Uncertainty @ 95/50 %TW
Fan bar wear and lattice support wear	Bobbin	96004.3 (Rev. 13)	Structures / None	All	CMOA	y = 0.97x + 2.5	3.10	1.55	5.67
Fan bar wear, lattice support wear and PLP wear (part present)	+Point™	96910.1 (Rev. 10)	All Structures and PLP Wear (Part present)	All	CM @ Structures and CM @ PLP	y = 1.01x + 4.30	6.68	3.34	12.3
Foreign object wear	Bobbin	27091.2 (Rev. 1)	PLP Wear / None	All	Information Only	N/A	N/A	N/A	N/A
	+Point™	27901.1 (Rev. 1)	Circ groove / None	All	CMOA Freespan (part not present)	y= 1.05x – 1.97	2.30	1.15	4.27
	+Point™	27902.1 (Rev. 1)	Axial groove / None	All	CMOA Freespan (part not present)	y= 0.98x + 1.89	2.32	1.16	4.25
	+Point™	27903.1 (Rev. 1)	Tapered football / None	All	CMOA Freespan (part not present)	y= 0.97x + 2.80	2.11	1.06	3.86
	+Point™	27904.1 (Rev. 1)	Tapered round hole / None	All	CMOA Freespan (part not present)	y= 1.00x + 0.48	1.99	1.00	3.66
	+Point™	27905.1 (Rev. 1)	Flat wear / None	All	CMOA Freespan (part not present)	y= 1.09x - 4.31	2.05	1.03	3.84
	+Point™	27906.1 (Rev. 1)	Tapered wear / None	All	CMOA Freespan (part not present)	y= 0.96x + 1.67	1.43	0.72	2.61
	+Point™	27907.1 (Rev. 1)	45° tapered wear / None	All	CMOA Freespan (part not present)	y= 1.05x - 2.10	2.59	1.30	4.81

Table 4: Service Induced Indications

SG	Row	Col	Location	ETSS	Axial Length (in)	Circ. Length (in)	Maximum Depth 2R22	Depth Reported Prior Outage	Initially Reported	Signal Present Prior to Current Outage?	Cause	Foreign Object Remaining?	In-Situ Tested?	Plugged & Stabilized?
2	28	5	01C-2.71"	27901.1	0.41	0.37	27 %TW	27 %TW (2R20)	2R15	Yes	Foreign Object Wear	No	No	No
2	29	4	01C-2.15"	27901.1	0.30	0.37	25 %TW	25 %TW (2R20)	2R18	Yes	Foreign Object Wear	No	No	No
2	37	120	F07-0.76"	96004.3	3.15" ¥	na	8 %TW	9 %TW (2R20)	2R15	Yes	Fan Bar Wear	na	No	No
2	44	5	01C-6.51"	27902.1	0.40	0.32	11 %TW	10 %TW (2R20)	2R20	Yes	Foreign Object Wear	No	No	No
2	59	10	01C-7.09"	27901.1	0.41	0.37	24 %TW	24 %TW (2R20)	2R15	Yes	Foreign Object Wear	No	No	No
2	98	143	TSH+8.73"	27903.1	0.30	0.32	20 %TW	25 %TW (2R20)	2R18	Yes	Foreign Object Wear	No	No	No
2	99	80	F06+1.30"	96004.3	3.15" ¥	na	15 %TW	15 %TW (2R20)	2R15	Yes	Fan Bar Wear	na	No	No
2	118	41	01H-12.17"	27902.1	0.36	0.32	12 %TW	10 %TW (2R20)	2R18	Yes	Foreign Object Wear	No	No	No
2	119	42	01H-11.63"	27903.1	0.35	0.37	24 %TW	28 %TW (2R20)	2R18	Yes	Foreign Object Wear	No	No	No
2	123	46	01H-6.50"	27903.1	0.35	0.32	22 %TW	26 %TW (2R20)	2R15	Yes	Foreign Object Wear	No	No	No
2	124	45	01H-4.90"	27903.1	0.30	0.32	26 %TW	31 %TW (2R20)	2R18	Yes	Foreign Object Wear	No	No	No
2	125	48	01H-5.04"	27903.1	0.35	0.37	32 %TW	36 %TW (2R20)	2R15	Yes	Foreign Object Wear	No	No	No
2	126	49	01H-4.36"	27903.1	0.40	0.37	34 %TW	38 %TW (2R20)	2R15	Yes	Foreign Object Wear	No	No	No
2	128	107	TSH-0.22"	27901.1	0.31	0.32	29 %TW	28 %TW (2R20)	2R20	Yes	Foreign Object Wear	No	No	No

¥ Conservative assumption

Table 5: Current Tube Plugging Status

	SG 1	SG 2
Tubes Plugged Prior to Refueling Outage 22	19	13
Tubes Plugged During Refueling Outage 22	0	0
Total Plugged Following Refueling Outage 22	19	13
Percentage Plugged	0.22	0.15
Overall Percentage Plugged	0.19	

Attachment 1
Acronyms

B&W	Babcock & Wilcox
BLG	Bulge
CHN	Channel
C	Column
CM	Condition Monitoring
CMOA	Condition Monitoring and Operational Assessment
COL	Column
DEG	Degrees
DEP	Deposit
DNC	Dominion Nuclear Connecticut, Inc.
DNG	Ding
DNT	Dent
ECT	Eddy Current Testing
EFPY	Effective Full Power Years
ELEV	Elevation
EOC	End of Cycle
EPRI	Electric Power Research Institute
ETSS	Examination Technique Specification Sheet
FB	Fan Bar
F/L	Full Length
FOSAR	Foreign Object Search and Retrieval
ID	Inner Diameter
IGA	Intergranular Attack
LPI	Loose Part Indication
MBM	Manufacturing Burnish Mark
MPS2	Millstone Power Station Unit 2
MRPC	Motorized Rotating Probe Coil
NDE	Non-Destructive Examination
NQH	Non-Quantifiable Historical Indication
NQI	Non-Quantifiable Indication
OD	Outer Diameter
OXP	Over Expansion
PCT	Percent Through-Wall
PLP	Possible Loose Part
POD	Probability of Detection
PTE	Partial Tubesheet Expansion
%TW	Percent Through-Wall
R	Row
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
TS	Technical Specification
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]