AREVA NP Inc.

Engineering Information Record

Document No.: 51 - 9198783 - 000

Watts Bar WBN1C11 SG Inspection 180-Day Report

Watts Bar WBN1C11 SG Inspection 180-Day Report

Safety Related? ☒ YES ☐ NO

Does this document establish design or technical requirements? ☐ YES ☒ NO

Does this document contain assumptions requiring verification? ☐ YES ☒ NO

Does this document contain Customer Required Format? ☐ YES ☒ NO

Signature Block

Name and Title/Discipline	Signature	P/LP, R/LR, A-CRF, A	Date	Pages/Sections Prepared/Reviewed/ Approved or Comments
Victor Newman Principal Engineer	[signature]	P	4/1/13	All
David C. Ingram Technical Consultant	D Curt Ingram	R	4/11/13	All
James P. Campbell Technical Manager, C&S Engineering	James P. Campbell	A	4/11/13	All

Note: P/LP designates Preparer (P), Lead Preparer (LP)
R/LR designates Reviewer (R), Lead Reviewer (LR)
A-CRF designates Project Manager Approver of Customer Requested Format (A-CRF)
A designates Approver/RTM – Verification of Reviewer Independence

Record of Revision

Revision No.	Pages/Sections/ Paragraphs Changed	Brief Description / Change Authorization
000	All	Original Release

Table of Contents

Page

List of Tables

List of Figures

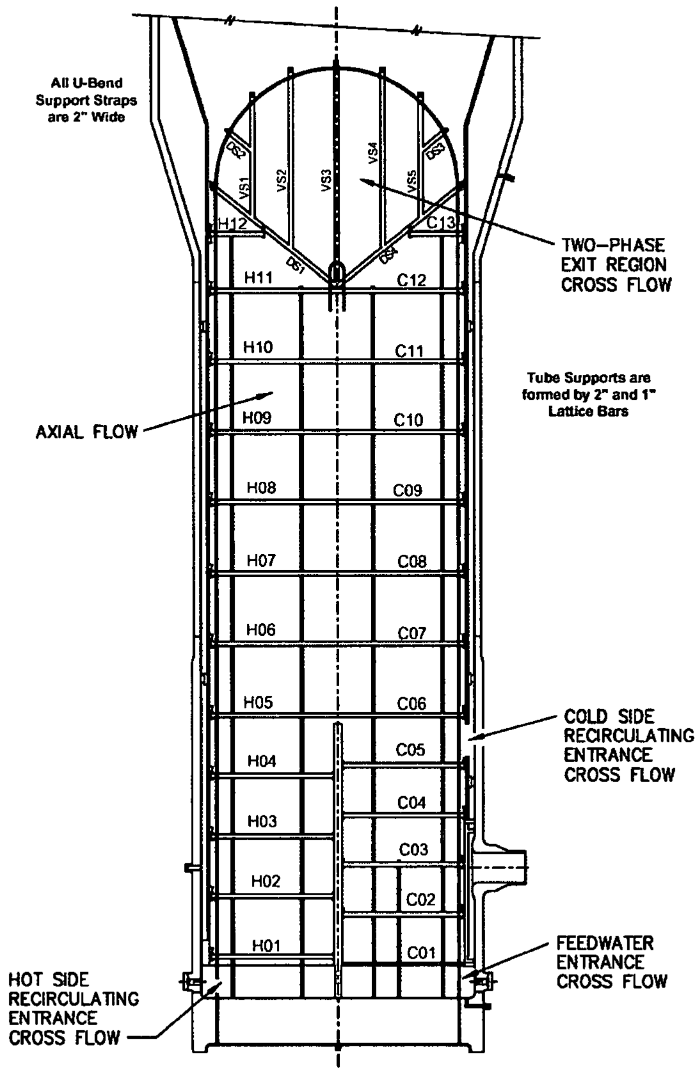
1.0 INTRODUCTION

During the Watts Bar Unit 1 (WBN1) Fall 2012 refueling outage (designated as 1C11), inspections of all four WBN1 steam generators (SGs) were performed. These inspections included eddy current inspections of the SG tubing as well as primary and secondary side visual inspections. This report documents the "Watts Bar 1C11 SG Inspection 180-Day Report" as required by the WBN1 Technical Specifications.

Commercial operation of the original steam generators began in 1996. Operation of the replacement steam generators (RSG) Westinghouse/Model 68AXP SG design began following the Unit 1 Cycle 7 refueling outage in 2006 when the SGs were replaced. The steam generators operated 1.184 EFPY in their first cycle after replacement which was the end of Cycle 8. An ISI (the first) was performed during that refueling outage. Cycle 11 is the second ISI of the replacement SGs (No inspections were performed in Cycles 9 or 10). The steam generators have operated a total of 5.254 EFPY since their replacement in the fall of 2006. They have operated 4.070 EFPY since the previous ISI.

Figure 1-1 below provides the arrangement of the tube support structures for the WBN1 SGs.

Figure 1-1: Tube Support Arrangement for Watts Bar-1 Steam Generators



Note: VS = Vertical Strap, DS = Diagonal Strap
Horizontal supports are a lattice grid design (ATSG)

2.0 180-DAY STEAM GENERATOR TUBE INSPECTION REPORT

In accordance with WBN1 Technical Specification 5.7.2.12, "Steam Generator Program", and Technical Specification 5.9.9, "Steam Generator Tube Inspection Report", this report documents the scope and results of the 1C11 SG inspections.

There are eight specific reporting requirements (labeled "a" through "h" below). Each reporting requirement is followed with the required information based on the inspections performed during the 1C11 outage.

a. The Scope of the Inspections Performed on Each SG

The 1C11 outage bobbin coil inspection was initially planned for 52.6% of the in-service tubes. The bobbin inspection included all tubes with prior indications of degradation. Subsequent scope expansions to bound wear and foreign objects resulted in a final inspection of 57.8% of in-service tubes.
In addition to the bobbin coil inspections, 5186 array coil inspections were also performed. The array coil exams were aimed at detection of foreign objects and foreign object wear near the top of the tubesheet and support wear up to the C06 cold leg support (see Figure 1-1). Expansions were conducted to encompass wear and loose parts. Expansions in some areas were performed with array probe to have the benefit of enhanced PLP detection.

Table 2-1: Eddy Current Inspection Scope

BOBBIN

S/G		Exam		Tests Analyzed and Completed
		Planned	Expanded	
1-1	Full Length rows 5+	2577	247	2824
	H/L candycane rows 1-4	132	0	132
	C/L straight rows 1-4	132	0	132
1-2	Full Length rows 5+	2637	305	2942
	H/L candycane rows 1-4	132	0	132
	C/L straight rows 1-4	132	74	206
1-3	Full Length rows 5+	2522	259	2781
	H/L candycane rows 1-4	132	0	132
	C/L straight rows 1-4	132	0	132
1-4	Full Length rows 5+	2538	237	2775
	H/L candycane rows 1-4	132	0	132
	C/L straight rows 1-4	132	7	139
TOTAL		**11330**	**1129**	**12459**

Table 2-1: Eddy Current Inspection Scope (continued)

Array Top of Tubesheet

S/G		Planned Exams	Expanded Exams	Tests Analyzed and Completed
1-1	HL = H01-HTE	607	0	607
	CL = C01-CTE/C08-CTE	607	44	651
1-2	HL = H01-HTE	607	0	607
	CL = C01-CTE/C08-CTE/ VS2-CTE	607	51	658
1-3	HL = H01-HTE	605	0	605
	CL = C01-CTE/C08-CTE	605	48	653
1-4	HL = H01-HTE	608	0	608
	CL = C01-CTE/C08-CTE	608	189	797
TOTAL		**4854**	**332**	**5186**

+Point Special Interest and historical preplan RPC

S/G		Locations to Inspect	Tests Analyzed and Completed
1-1	Hot Leg SI	54	54
	Cold Leg SI	1	1
	U-bend SI	4	4
1-2	Hot Leg SI	17	17
	Cold Leg SI	3	3
	U-Bend SI	5	5
1-3	Hot Leg SI	12	12
	Cold Leg SI	6	6
	U-Bend SI	1	1
1-4	Hot Leg SI	10	10
	Cold Leg SI	5	5
	U-Bend SI	0	0
TOTAL		**118**	**118**

All Scopes Summary

S/G	Tests Analyzed and Completed
1-1	4405
1-2	4570
1-3	4322
1-4	4466
TOTAL	**17763**

Visual Inspection Results

In addition to the eddy current inspections, visual inspections were also performed on both the primary and secondary sides. Primary side inspections included all previously installed plugs, the bowl cladding, and the divider plate. The plug inspections showed no anomalies indicative of improper installation or in-

service degradation. The inspections of the bowl cladding and the divider plate showed no visual evidence of degradation of the cladding, divider plate, or divider plate welds.

Secondary side visual inspections were performed on the steam drums in SGs 12 and 13 to investigate the structural integrity of the steam drum components. There were no anomalies reported in either steam drum. The visual to the extent possible included the perforated riser pipes, steam dryers, drains, drain cups, auxiliary feed water nozzle and sprayers, transmitter penetrations, hardware screws and nuts between the separators, upper dryers, and the Marmon clamp. All components were covered evenly with $^{1}/_{16}$" of magnetite. Steam drum inspections in SGs 11 and 14 were not inspected due to schedule and ALARA considerations.

Secondary side visual inspections were also performed at the top of the tubesheet in all SGs for the detection of foreign objects and for determining the effectiveness of water lancing. The cleanliness inspection at the top of the tubesheet resulted in additional sludge lancing. In bundle visuals were also performed by inserting the probe down several columns in each SG.

SG 4 was the only SG where foreign material was identified on the tubesheet. There were three pieces of wire identified. The pieces of wire appeared to be TIG wire. One retrieved from the cold leg annulus not identified by eddy current was 3¾" x $^{3}/_{64}$". Another piece retrieved, identified by eddy current, was 2¾" x $^{3}/_{64}$". Per analysis guidelines, once the foreign object was removed and the signal was confirmed to no longer be present, the PLP records (it was seen on two adjacent tubes) were permanently removed from the ECT database. The third piece, not identified by eddy current, was 3" x $^{3}/_{64}$". It could not be retrieved after two attempts. It appeared to be held in place due to the smaller gap between the tube and a stay rod (stay rods have a larger diameter than the tubes). The inability to retrieve the loose part resulted in the affected tubes bounding the loose part being plugged and stabilized. The PLP identification and disposition for tube plugging and stabilization is documented in AREVA CR 2012-7370.

One other indication in SG 4 identified by eddy current was examined visually. There was no appearance of a loose part. It was removed from the database.

The feedwater distribution boxes in each SG were inspected for the presence of foreign objects. These boxes have 0.29" diameter holes that serve to restrict foreign material of subsequent size from entering the steam generators. A number of foreign objects were removed from the boxes. SG 4 had the largest amount of material where 35 small objects were removed. Some of the objects appeared to be Furmanite.

PLP indications were recorded in SG 14 tubes 1-60, 1-62, and 1-64 but were attributed to the presence of water lancing equipment in the SG at the time of the ECT exam.

b. Active Degradation Mechanisms Found

Volumetric wear was the only degradation mechanism detected during the 1C11 inspection. All of the wear indications detected were located at support structures either in the U-bend at vertical or diagonal straps or in the lattice structure of the Advanced Tube Support Grids (ATSG). No wear indications attributable to foreign objects were reported. Table 2-2 below shows the number of indications reported during the 1C11 inspection.

Table 2-2: Number of Indications Detected for Each Degradation Mechanism

	Location of Wear Indication	SG11		SG12		SG13		SG14		Total	
		Tubes	Ind	Tubes	Ind	Tubes	Ind	Tubes	Ind	Tubes	Ind
Detected	U-bend support	0	0	2	3	3	3	2	2	7	8
	Tube Support Grid	6	6	13	20	14	19	18	27	51	72
Plugged	U-bend support	0	0	0	0	0	0	0	0	0	0
	Tube Support Grid	1	1	3	6	4	9	6	15	14	31
Returned to Service	U-bend support	0	0	2	3	3	3	2	2	7	8
	Tube Support Grid	5	5	10	14	10	10	12	12	37	41

Note: All tubes with a wear indication of 15% or greater were plugged. Some of the tubes had multiple indications of wear which varied in size (see Table 2-4). All pluggable degradation was related to cold leg support wear.

c. Nondestructive Examination (NDE) Techniques Used for Each Degradation Mechanism

Table 2-3 below provides the NDE techniques that were used for the detection of each degradation mechanism that was considered as existing or potential for the 1C11 inspection.

Table 2-3: NDE Techniques Used for Each Degradation Mechanism

Degradation Mechanism	Detection Technique
U-Bend / Vertical Strap Wear	Bobbin
Horizontal / Tube Support Grid Wear	Bobbin
Tube-to-Tube Wear	Bobbin
Foreign Object Wear	Bobbin / Array

In addition to the detection techniques shown in the above table, +Point™ probes were also used for confirmation, characterization, and length sizing of wear indications at the vertical straps and horizontal grid supports.

d. Location, Orientation (if Linear), and Measured Sizes (if Available) of Service Induced Indications

Table 2-4 below provides a listing of all service-induced indications reported during the 1C11 inspection including the estimated depths from the bobbin coil. If length sizing was available, this information is also provided as reported from the +Point™ inspections.

Table 2-4: Service-Induced Indications

SG	ROW	COL	IND	%TW	LOCATION	Inch	VOLTS	Circ extent	Ax extent	Characterization	Disposition
11	7	92	TWD	9	C04	0.93	0.31			ATSG Wear	
11	9	104	TWD	12	H07	-0.87	0.39			ATSG Wear	
11	29	124	TWD	13	C06	0.77	0.44			ATSG Wear	
11	37	122	TWD	26	C05	0.84	1.26	0.53	0.54	ATSG Wear	Plugged
11	89	96	TWD	11	C03	-0.92	0.35			ATSG Wear	
11	105	64	TWD	11	C05	-0.88	0.36			ATSG Wear	
12	22	123	TWD	9	C03	0.84	0.3			ATSG Wear	
12	24	123	TWD	11	C03	0.84	0.39			ATSG Wear	Plugged
12	24	123	TWD	17	C07	-0.88	0.72			ATSG Wear	Plugged
12	28	119	TWD	8	C06	-0.82	0.26			ATSG Wear	
12	30	123	TWD	12	C05	-0.89	0.38			ATSG Wear	
12	30	123	TWD	8	C06	-0.84	0.23			ATSG Wear	
12	30	123	TWD	14	C06	0.84	0.48			ATSG Wear	
12	30	123	TWD	13	C07	-0.86	0.44			ATSG Wear	
12	31	122	TWD	24	C06	-0.82	1.15	0.28	0.45	ATSG Wear	Plugged
12	31	122	TWD	25	C07	-0.85	1.18	0.15	0.24	ATSG Wear	Plugged
12	31	122	TWD	11	C08	-0.83	0.4			ATSG Wear	Plugged
12	62	113	TWD	12	C07	-0.99	0.37			ATSG Wear	
12	85	100	TWD	8	C06	-0.88	0.28			ATSG Wear	
12	87	98	TWD	10	C03	-0.87	0.28			ATSG Wear	
12	87	98	TWD	13	C06	-0.88	0.41			ATSG Wear	
12	88	95	TWD	14	C03	-1.01	0.49			ATSG Wear	
12	89	94	TWD	8	C03	-0.93	0.21			ATSG Wear	
12	90	93	TWD	28	C06	-0.98	1.21	0.28	0.45	ATSG Wear	Plugged
12	91	58	TWD	8	VS2	0.8	0.22			U Bend Support Wear	
12	91	94	TWD	8	C03	-0.89	0.22			ATSG Wear	
12	100	63	TWD	12	VS2	-0.75	0.37			U Bend Support Wear	
12	100	63	TWD	7	VS2	0.55	0.2			U Bend Support Wear	
12	105	66	TWD	9	C03	0.84	0.27			ATSG Wear	
13	15	4	TWD	8	C06	-0.9	0.22			ATSG Wear	
13	19	2	TWD	11	C04	-0.86	0.38			ATSG Wear	
13	23	124	TWD	12	C06	0.88	0.46			ATSG Wear	
13	61	114	TWD	5	C06	0.82	0.21			ATSG Wear	
13	86	29	TWD	21	C03	-0.95	0.77	0.61	0.53	ATSG Wear	Plugged
13	86	29	TWD	9	C03	0.81	0.24			ATSG Wear	Plugged

Table 2-4: Service-Induced Indications

SG	ROW	COL	IND	%TW	LOCATION	Inch	VOLTS	Circ extent	Ax extent	Characterization	Disposition
13	86	97	TWD	12	C02	-0.83	0.48			ATSG Wear	
13	86	99	TWD	8	C04	0.89	0.29			ATSG Wear	
13	87	96	TWD	24	C03	-0.87	1.11	0.49	0.49	ATSG Wear	Plugged
13	87	98	TWD	26	C02	-0.82	1.41	0.54	0.56	ATSG Wear	Plugged
13	87	98	TWD	18	C04	-0.87	0.8			ATSG Wear	Plugged
13	87	98	TWD	17	C04	0.79	0.73			ATSG Wear	Plugged
13	87	98	TWD	26	C05	0.79	1.4	0.56	0.58	ATSG Wear	Plugged
13	88	95	TWD	21	C03	-0.77	0.64	0.49	0.53	ATSG Wear	Plugged
13	88	95	TWD	32	C03	0.84	1.48	0.51	0.5	ATSG Wear	Plugged
13	89	96	TWD	8	C03	-0.82	0.28			ATSG Wear	
13	92	35	TWD	10	C03	-0.95	0.3			ATSG Wear	
13	92	91	TWD	8	C05	-0.96	0.17			ATSG Wear	
13	97	42	TWD	9	C04	0.78	0.34			ATSG Wear	
13	98	71	TWD	9	VS4	0.82	0.22			U Bend Support Wear	
13	100	55	TWD	8	VS2	-0.85	0.29			U Bend Support Wear	
13	101	58	TWD	12	DS2	-0.86	0.4			U Bend Support Wear	
14	13	78	TWD	11	C10	0.72	0.39			ATSG Wear	
14	23	124	TWD	11	C06	-0.82	0.38			ATSG Wear	
14	27	124	TWD	11	C03	-0.85	0.38			ATSG Wear	
14	35	122	TWD	9	C03	0.9	0.3			ATSG Wear	
14	49	110	TWD	8	C12	-0.91	0.25			ATSG Wear	
14	53	118	TWD	8	C02	-0.8	0.26			ATSG Wear	
14	63	114	TWD	11	C06	-0.98	0.4			ATSG Wear	
14	84	99	TWD	18	C03	0.82	0.74			ATSG Wear	Plugged
14	85	100	TWD	8	C04	-0.84	0.26			ATSG Wear	
14	86	99	TWD	25	C04	-0.98	1.24	0.48	0.51	ATSG Wear	Plugged
14	86	99	TWD	10	C06	-0.94	0.35			ATSG Wear	Plugged
14	89	96	TWD	10	C03	-0.84	0.31			ATSG Wear	
14	90	95	TWD	14	C03	0.68	0.52			ATSG Wear	Plugged
14	90	95	TWD	10	C04	-0.95	0.33			ATSG Wear	Plugged
14	90	95	TWD	28	C06	-0.94	1.56	0.68	0.54	ATSG Wear	Plugged
14	90	95	TWD	8	C06	0.81	0.26			ATSG Wear	Plugged
14	90	95	TWD	8	C08	-1.07	0.28			ATSG Wear	Plugged
14	91	94	TWD	9	C03	0.82	0.31			ATSG Wear	
14	92	35	TWD	19	C03	-1.06	0.8			ATSG Wear	Plugged
14	92	81	TWD	8	VS2	0.9	0.3			U Bend Support Wear	

Table 2-4: Service-Induced Indications

SG	ROW	COL	IND	%TW	LOCATION	Inch	VOLTS	Circ extent	Ax extent	Characterization	Disposition
14	93	36	TWD	11	C05	0.85	0.35			ATSG Wear	
14	93	70	TWD	10	VS2	0.88	0.29			U Bend Support Wear	
14	97	40	TWD	15	C03	-0.84	0.56			ATSG Wear	Plugged
14	97	40	TWD	8	C04	0.85	0.26			ATSG Wear	Plugged
14	97	40	TWD	9	C05	0.82	0.27			ATSG Wear	Plugged
14	97	40	TWD	8	C06	-0.82	0.26			ATSG Wear	Plugged
14	97	86	TWD	9	C03	0.85	0.39			ATSG Wear	
14	100	45	TWD	10	C03	-0.95	0.35			ATSG Wear	Plugged
14	100	45	TWD	19	C05	-0.96	0.78			ATSG Wear	Plugged

e. Number of Tubes Plugged During the Inspection Outage for Each Active Degradation Mechanism

Table 2-5 below provides the numbers of tubes plugged for each degradation mechanism detected.

Table 2-5: Number of Tubes Plugged for Each Degradation Mechanism

SG	ATSG Wear (preventative)	Foreign Object	Total
11	1	0	1
12	3	0	3
13	4	0	4
14	6	*6	12

* No tube degradation was identified with the foreign object. Tubes were plugged and stabilized to bound the loose part.

f. Total Number and Percentage of Tubes Plugged to Date

Table 2-6: Total Number and Percentage of Tubes Plugged to Date

Inspection	SG 11	SG 12	SG 13	SG 14	Total
Prior to service	0	1	0	1	2
1C8 2008	2	1	3	1	7
1C11 2012	1	3	4	12	20
Total	3	5	7	14	29
Percent	0.06%	0.1%	0.14%	0.27%	0.14%

g. The Results of Condition Monitoring, Including the Results of Tube Pulls and In-Situ Testing

Tube Integrity

As required by the WBN1 Steam Generator Program, a condition monitoring (CM) assessment was performed [1]. The only tube degradation detected during the 1C11 inspection was wear at support structures (U bend supports and ATSGs). The deepest indication had an estimated depth of 32%TW from the bobbin coil exam. This indication was located at an ATSG. The maximum NDE length of any ATSG wear flaw was 0.68". The CM limit for a flaw of this length is approximately 55% TWD. This CM limit includes uncertainties for material properties, NDE depth sizing, and the burst pressure relationship. Since the deepest flaw has an NDE depth less than the CM limit, the structural integrity performance criterion was met for the operating period prior to 1C11.

Since wear indications will leak and burst at essentially the same pressure, accident-induced leakage integrity at a much lower accident pressure differential is also demonstrated. Operational leakage integrity was demonstrated by the absence of any detectable primary-to-secondary leakage during the operating period prior to 1C11.

Since tube integrity was demonstrated analytically, in-situ pressure testing was not required nor performed during the 1C11 outage. Likewise, no tube pulls were planned nor performed during 1C11.

h. The Effective Plugging Percentage for All Plugging in Each SG

There are no sleeves installed in the WBN1 SGs. Therefore, the effective plugging percentage is the same as the plugging percentage shown in Table 2-6.

3.0 REFERENCES

1. AREVA Document 51-9196412-000 "Watts Bar Unit 1 Condition Monitoring for 1C11 and Final Operational Assessment for Cycles 12, 13, and 14"