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PSEG
Nuclear LLC

Technical Specification 6.9.1.5

MAR 0 1 2007
LR-N07-0045

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Salem Nuclear Generating Station Units 1 and 2
Facility Operating License Nos. DPR-50 and 75
NRC Docket Nos. 50-272 and 50-311

Subject: 2006 Steam Generator Tube ISI Summary Report

PSEG Nuclear LLC (PSEG) submits this report in accordance with the requirements of Salem Units 1 and 2 Technical Specification (TS) 6.9.1.5 b. Specifically, TS 6.9.1.5 b. requires that the complete results of steam generator tube inservice inspections performed during the report period be reported to the Commission.

Attachment 1 to this letter contains PSEG report in accordance with Technical Specification 6.9.1.5.b

Should you have any questions regarding this transmittal, please contact E. H. Villar at (856) 339-5456.

Sincerely,

Thomas P. Joyce
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A047

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Attachment 1

2006 Steam Generator Tube ISI Summary Report

In the Fall of 2006, PSEG Nuclear conducted eddy current examinations on the Salem Unit 2 Steam Generators (SG) during the 15th Refueling Outage (2R15). Outage 2R15 is the last planned in-service inspection of the currently installed (Westinghouse Series 51) steam generators. Steam generator replacement is currently planned for the Spring 2008 outage (2R16). In-service inspections were not required or performed on the Salem Unit 1 Steam Generators during 2006.

Overview

Commercial operation began in October of 1981. Salem Unit 2 has four Westinghouse Model 51 series steam generators. Each steam generator contains 3388 NiCrFe alloy (Inconel ASME-SB-163) U-tubes with an outside diameter of 0.875 inches and a nominal wall thickness of 0.050 inches. The tube support structures consist of seven equally spaced 0.750 inch thick carbon steel support plates, which are drilled with 0.891 inch holes and two sets of anti-vibration bars (AVB) that are located in the U-bend region of the tubes. The AVB bars are made from 0.387 square inch cross-section straight length bar material (Nickel-Chromium iron Alloy 600, chrome plated subsequent to bending) that is bent to a vee form with a 5.00-inch radius at the apex. The tube sheet is 21 inches thick ASME-SA508 Class 2 steel forging with Inconel cladding on the primary side. The tube ends are rolled into the tube plate and welded to the tube plate cladding. All tubes are explosively expanded into the tube sheet holes (a.k.a. WEXTEX). The expansion includes the entire depth of the tube sheet for both the hot and cold leg sides.

Examinations Performed (Scope)

The eddy current examination scope performed during outage 2R15 met or exceeded Salem Unit 2 Technical Specification 3/4.4.6, "Steam Generators" Surveillance Requirements and NEI 97-06 SG Program requirements.

The final scope performed (including expansions) is outlined below:

- With the exception of those row 2 through 5 U-bends inspected under Rotating Coil inspection program, a full-length bobbin coil inspection was performed on 100% of the in-service tubes in each steam generator. These inspections provided a seamless tube-end to tube-end inspection (including bobbin and Rotating Coil probes). Note that all row 1 tubes were preventatively plugged during a previous outage.
- 100% Rotating Coil (+ Point) exam of the rows 2 through 10 U-bends (07C-07H or 07H – 07C) in each steam generator.

- 100% Rotating Coil (+ Point) exam of the Hot Leg (HL) WEXTEX Top of Tubesheet (TTS) transition regions in each steam generator at an extent of at least +3 inches above and -8 inches below the TTS.
- 100% Rotating Coil (+ Point) exam of the ≥ 1.0-volt dented HL Tube Support Plate (TSP) intersections at 01H, 02H and 03H and 20% of the ≥ 1.0-volt dented HL Tube Support Plate (TSP) intersections at 04H in 22, 23 and 24 steam generator. In 21 SG performed 100% Rotating Coil (+ Point) exam of the ≥ 1.0-volt dented HL Tube Support Plate intersections at 01H, 02H, 03H, 04H and 20% of the ≥ 1.0-volt dented HL Tube Support Plate (TSP) intersections at 05H.
- 20% (at a minimum) Rotating Coil (+Point) inspection of the > 5 volt dented TSP locations at 04H (05H for SG 21) to 07H, which included all >5 volt dented TSP locations at 04H (05H for SG 21) to 07H that were not inspected since 2R12. Note: The 04H (05H for SG 21) ≥1 volt 20% sample TSP inspections (mention previously) is conservatively NOT credited to meet the 04H (05H for SG 21) >5 volt 20% sample. A separate, non-overlapping population is selected at 04H (05H for SG 21) for the two separate scopes.
- 20% (at a minimum) Rotating Coil (+Point) inspection of the ≥2 volt Dings in each SG from TSH +0.5 inches to 07H + 2 inches which shall include all ≥2 volt Dings that were not inspected since 2R12. SG 24 was expanded to include 100% ≥5 volt Dings from TSH +05 inches to 07H, and SG 21, 22, and 23 included a minimum 20% inspection of all the ≥5 volt Dings (TSH +0.5 inches to 07H) with Rotating Coil (+Point).
- Rotating Coil (+ Point) examination of previous TSP ligament Indications identified from the 2R14 bobbin coil data and any newly identified TSP ligament indications identified during 2R15.
- 20% Rotating Coil (+ Point) of ≥ 2.0 volt U-bends Dings (07H to 07C) in each steam generator.
- 20% Rotating Coil (+Point) of ≥ 1.0 volt dented Anti-Vibration Bar (AVB's) locations in each steam generator.
- New AVB wear indications found during 2R15 were inspected with Rotating Coil (+ Point).
- New cold leg thinning indications found during 2R15 were inspected with Rotating Coil (+ Point).

Examination Results and Technical Specification Classification

Consistent with the requirements specified in NEI 97-06 Rev 2, the Unit 2 steam generators met the structural integrity, accident induced leakage and operational leakage performance criteria specified in site procedures ER-AP-420 "Steam Generator Management Program" and ER-AP-420-0051 " Conduct of Steam Generator Management Program Activities" for outage 2R15. Table 1 (see below) summarizes the number of tubes plugged in each steam generator by degradation mechanism. Areva designed Alloy 690 rolled plugs were used to remove these tubes from service.

The Technical Specification categorization of each steam generator is listed in the table below and takes into consideration both the Bobbin coil and Rotating Coil inspection results.

	21 SG	22 SG	23 SG	24 SG
Technical Specification Category	C-2	C-2	C-2	C-2

Table 1

SALEM UNIT 2 R15
Final Indication Summary

Location	Tube Degradation	Steam Generator				Total
		2-1	2-2	2-3	2-4	
TSP	Axial PWSCC	7	1		3[2]	8
	Circ PWSCC					
	Axial ODSCC	1			1	2
	Circ ODSCC	1				1
Tubesheet	Axial PWSCC	1	2		7	10
	Axial ODSCC				1	1
	Circ PWSCC	1				1
	Circ ODSCC			1		1
U-bends	Axial PWSCC					
	Circ PWSCC					
	Axial ODSCC					
High Row U-bends	AVB Wear >=40%	1	1	4[1]	2	4
Cold Leg Thinning	Thinning >=40% or SVI		1	1	3	5
Free Span	Axial ODSCC @ Dings				1	1
Total Indications		12	5	6	18	41

Final Tube Repair Summary

		Steam Generator				Total
		2-1	2-2	2-3	2-4	
Total Tubes with Indications (See Table Above)		12	5	5[1]	17[2]	39
Preventative (Tubes)	Loose Part		2		7	9
	Permeability Variation	2	3			5
	Ding Signal Above TSH	2				2
Total Tubes Plugged During 2R15		16	10	5	24	55

Notes:

1) Tube 32-45 in SG23 contained two AVB wear indications >=40% throughwall.
2) Tube 20-64 in SG24 contained two axial PWSCC indications at the 01H intersection.

Degradation in the WEXTEX & TTS Transition Zone

The WEXTEX transition is the region of the tube where the tube transitions from the expanded tube diameter to the nominal tube diameter and is typically located near the top of the tubesheet. The bottom of the WEXTEX transition (BWT) is the first point of contact between the tube and the tubesheet. In this region, both Primary Water Stress Corrosion Cracking (PWSCC) and Outside Diameter Stress Corrosion Cracking (ODSCC) have been observed with PWSCC being the prominent damage mechanism at Salem Unit 2.

There were a total of 13 detected indications in the WEXTEX & TTS Transition Zone inspections performed in all four steam generators. A total of 10 PWSCC Axial indications, affecting 10 tubes, were identified in the hot leg WEXTEX region. In addition, one PWSCC circumferential indication, one ODSCC circumferential indication, and one ODSCC Axial indication were also detected in the WEXTEX & TTS Transition Zone (also see Table 2 below). It should be noted that all in-service tubes received the minimum +Point inspection extent of TSH +3 inches to TSH -8 inches, and all tubes were verified for inspection depth greater than or equal to the W* Distance as defined in Salem Unit 2 TS (Amendment 256).

All indications were physically located below the TTS, as shown in Table 2. Structural performance criterion for indications below the TTS are met based on the fact that the tubesheet prevents burst. All tubes identified with this degradation were plugged.

Leakage calculations for the indications in the WEXTEX expansion are performed in accordance with Salem Unit 2 Tech Specs (Amendment 256) requirements, and are summarized as follows:

Each SG is assessed for Main Steam Line Break (MSLB) leakage individually, and the SG with the most calculated leakage is conservatively assigned (assumed) as the affected SG. Calculating of the Condition Monitoring (CM) and the Operational Assessment (OA) leakage for each SG is in accordance with the following (LCR S05-07 {Amendment 256}, TS 4.4.6.5.b.4):

Postulated SLB Leakage = Assumed Leakage 0 inches-8 inches <TTS + Assumed Leakage 8 inches-12 inches <TTS + Assumed Leakage >12inches <TTS

Assumed Leakage 0 inches - 8 inches <TTS is the postulated leakage for indications that are deemed via flaw depth estimation techniques to be 100% through wall, and therefore present a potential leak path. This term is applicable to detected indications during an in-service inspection and potentially undetected indications in the steam generator tubes left in service between 0 inches and 8 inches below the top of the tubesheet (TTS). Since tubes with indications detected between 0 inches and 8 inches below the TTS are plugged upon detection, the calculation of this term for the assessment of SLB leakage for the subsequent operation cycle following an in-service inspection only requires consideration of potentially undetected indications. The calculation of this term for the assessment of Steamline Break (SLB) leakage for the

previous operation cycle, following an in-service inspection, requires consideration of both detected and potentially undetected indications.

Assumed Leakage 8 inches -12 inches <TTS is the conservatively projected leakage in steam generator tubes between 8 inches and 12 inches below the TTS. Implementation of Technical Specification inspections do not require tube inspection below the W* distance, therefore the methodology for conservatively calculating the population of indications between 8 inches and 12 inches below the TTS is provided by fitting a regression line to the cumulative inspection data (detected indications) from all SGs and projecting the number of indications (to minus 12 inches below TTS) using a 95-percent probability prediction bound. The cumulative indications from all steam generators are conservatively assumed to occur in one SG. The conservative leakage rate for the indications between 8 inches and 12 inches is 0.0033 gpm multiplied by the number of projected indications (as discussed in Amendment 256). The leak rate of indications detected between 8 inches and 12 inches are bounded by the projected total discussed above, assuming that the inspection results for detected indications do not contradict the calculated population as described previously.

Assumed Leakage >12 inches <TTS is the calculated leakage from the steam generator tubes left in service below 12 inches from the top of the tubesheet. This is 0.00009 gpm times the number of tubes left in service in the steam generator.

WEXTEX Summary

The indications located from 0 to 8 inches below the Hot Leg (HL) WEXTEX (Tubesheet region) were evaluated for leakage integrity based on the +Point voltage thresholds provided in EPRI Report 1007904, Steam Generator In Situ Pressure Test Guidelines. All of the indications (see Table 2 below) detected in the WEXTEX region are well below the leakage thresholds, therefore the CM MSLB leak rate contribution is 0 (zero) gpm from indications detected during 2R15 within the WEXTEX region. Since inspections performed in the WEXTEX region utilized +Point inspections, a probe capable of detecting all forms of degradation in the tubesheet region, potentially undetected indications within the first 8 inches of the TTS would also be reasonably assured of not providing any significance for normal operation or accident (MSLB) leak potential. Therefore, the CM MSLB leak rate from detected indications, and OA MSLB leak rate from potentially undetected indications is 0 (zero) gpm.

The potential leakage (or leak rate) for the undetected indications in the second zone (Assumed Leakage 8 inches to 12 inches <TTS) is estimated by calculating the population of indications between 8 inches and 12 inches below the TTS, and is provided by fitting a regression line to the cumulative inspection data (detected indications) from all SGs and projecting the number of indications (to minus 12 inches below TTS) using a 95-percent probability prediction bound. The cumulative indications from all steam generators are conservatively assumed to occur in one steam generator. A review of Table 2 indicates that a majority of the WEXTEX indications are near the TTS expansion transition, and therefore exclusion of the expansion transition indications would be expected to provide the best (conservative) dataset for estimating indications

at deeper depths because of the significantly higher residual surface stresses associated with the expansion transition (Amendment 256, Westinghouse LTR-CDME-05-30-NP). A best fit regression of the cumulative Salem WEXTEX indications (including 2R15 indications), with the expansion transition excluded (0 inches to 0.99 inches below TTS) is provided in Figure 1 below. Indication totals for the 1 inch through 7 inch (the 7 inch bin includes 7 inches to 8 inches, and also includes the circumferential indication located at approximately 8.09 inches below TTS) bins below the TTS were used for the regression analysis as this range excludes the expansion transition effect on initiation and considers all historical indications in the applied nominal +Pt inspection program of 8 inches below TTS. Note that the 1 inch below the TTS bin of the x-axis on Figure 1 represents the elevation range from -1.00 inches to -1.99 inches below the TTS. This updated regression, using 2R15 data, conservatively estimates a maximum of 20 indications would be expected to reside in the 8 inch to 12 inch region of all SGs, and are conservatively assumed to be in one SG. The conservative leakage rate for the indications between 8 inches and 12 inches is 0.0033 gpm multiplied by the number of estimated (from discussion above) indications. Also see Table 3 for further details of the estimated leakage (leak rate) for the 8 to 12 inch WEXTEX region. The CM and OA MSLB leak rate potential for 8 inches to 12 inches is conservatively estimated as approximately 0.066 gpm.

For the region more than 12 inches below the WEXTEX transition (Assumed Leakage >12inches <TTS), a leak rate of 0.00009 gpm for each in-service tube is conservatively assumed in accordance with Amendment 256. This leak rate is conservative since it assumes that the tube is completely severed at this point (12 inches below the TTS). See Table 3 for details of the estimated leakage (leak rate) for the region more than 12 inches below the WEXTEX transition.

Using the methodologies described above, a conservative estimate of HL WEXTEX accident leakage (MSLB) was calculated for each steam generator. This resulted in a total postulated leak rate for the limiting SG of approximately 0.349 GPM. See Table 3 for details of the estimated CM and OA leakage for the HL WEXTEX region. In addition, the indications detected within the HL WEXTEX region were consistent with the expectations regarding the number of flaws and flaw severity. This is further emphasized by the fact that the indications detected were all relatively trivial (based on measured indication voltage, lengths, and quantity), and that the indications were predominantly near the expansion transition (as typically expected from experience). Thus, the methodology described above is conservative and provides reasonable assurance for tube integrity and estimating potential leakage within the WEXTEX region.

In addition to the primary to secondary (P-S) leakage estimated from the WEXTEX region, leakage from the tube plugs themselves was also considered. SG 24 contains the most plugged tubes in any single SG (386 tubes / 772 plugs), and applying a conservative leak rate (Bounding value selected from conservative vendor plug qualification, leakage adjusted to room temperature conditions per plug of ~3.2×10^{-6} gpm, applicable to both accident and normal operating conditions) to all installed plugs yields a leak rate for SG 24 of approximately 0.00247 gpm or 3.56 gpd. Furthermore,

the Salem SGs have a total of 1155 tubes plugged in all SGs (2310 plugs), and therefore a conservative estimate of tube plug leakage would lead to a total of approximately 0.00739 gpm from all four SGs. However, since the majority of the Salem Unit 2 SG tubes have been preventatively plugged or plugged with degradation much less than through-wall, the potential for a leak path to the secondary side is relatively negligible. This is further supported by cycle 15 primary to secondary leakage monitoring, which did not detect any significant leakage (P-S leakage below detection thresholds, or essentially non-existent). Therefore, significant tube plug leakage has not been substantiated. No other potential sources of primary to secondary (P-S) leakage were identified based on degradation detected during outage 2R15 (e.g., all other damage mechanisms were not through-wall and well below leakage screening criteria provided from EPRI Steam Generator In Situ Pressure Test Guidelines). Therefore, the conservatively postulated accident leakage (MSLB) from all sources leads to a total estimated leak rate less than approximately 0.36 gpm for the worst-case steam generator, and total for all SGs. The total postulated accident leakage is estimated to be much less than the total allowable for all SGs (1 gpm), and any single SG (0.6 gpm). Normal operation P-S leakage is also expected to be negligible as compared to the operational leakage limit.

Table 2
WEXTEX Region Service Induced Degradation Detected at 2R15

SG	Row	Col	Ind	Volts	Type	Crack #	MD	LCT	UCT	Crack Length	Total Length	UCT to TTS (0.22" uncert incl)	UCT below TTS	W* ZONE	W* Length (0.12" uncert incl)	BWT	Dist UCT to BWT (0.28" uncert incl)	UCT Below W* Length ?	UCT Below BWT?	Inspect Extent	W* Insp Ext wrt BWT (0.09" uncert incl)	CM Flexible W* Length	Insp Ext Satisfied?	CM Leak Rate
21	25	44	SCI	0.37	ID SCI	1	47	-8.09	-8.09	0.2	0.2	NA	NA	B3	7.12	-0.3	NA	NA	NA	-9.42	NA	NA	Yes	0.000
21	30	36	SAI	0.65	ID SAI	1	43	-0.54	-0.43	0.11	0.11	0.21	Yes	B4	7.12	-0.37	-0.22	No	No	-9.20	8.74	7.12	Yes	0.000
22	5	54	SAI	0.38	ID SAI	1	59	-2.98	-2.85	0.13	0.13	2.63	Yes	B1	7.12	-0.27	2.30	No	Yes	-8.03	7.67	7.12	Yes	0.000
22	6	62	SAI	0.24	ID SAI	1	60	-0.32	-0.23	0.09	0.09	0.01	Yes	B2	7.12	-0.24	-0.29	No	No	-8.47	8.14	7.12	Yes	0.000
23	12	46	SCI	0.15	OD SCI	1	54	-0.31	-0.31	0.29	0.29	NA	NA	B1	7.12	-0.35	NA	NA	NA	-9.21	NA	NA	Yes	0.000
24	6	11	SAI	0.10	ID SAI	1	47	-0.30	-0.23	0.07	0.07	0.01	Yes	A	7.12	-0.09	-0.14	No	No	-9.41	9.23	7.12	Yes	0.000
24	10	77	SAI	0.17	OD SAI	1	47	-0.36	-0.28	0.08	0.08	0.06	Yes	B4	7.12	-0.26	-0.26	No	No	-8.42	8.07	7.12	Yes	0.000
24	14	5	SAI	0.35	ID SAI	1	36	-0.80	-0.67	0.13	0.13	0.45	Yes	A	7.12	-0.29	0.10	No	Yes	-9.41	9.03	7.12	Yes	0.000
24	21	6	SAI	0.32	ID SAI	1	14	-0.69	-0.62	0.07	0.07	0.40	Yes	A	7.12	-0.22	0.12	No	Yes	-9.32	9.01	7.12	Yes	0.000
24	23	19	SAI	0.35	ID SAI	1	38	-1.72	-1.63	0.09	0.09	1.41	Yes	A	7.12	-0.20	1.15	No	Yes	-9.36	9.07	7.12	Yes	0.000
24	23	54	SAI	0.38	ID SAI	1	41	-0.38	-0.27	0.11	0.11	0.05	Yes	B3	7.12	-0.24	-0.25	No	No	-9.89	9.56	7.12	Yes	0.000
24	30	64	SAI	0.78	ID SAI	1	55	-0.43	-0.23	0.20	0.20	0.01	Yes	A	7.12	-0.22	-0.27	No	No	-8.89	8.58	7.18	Yes	0.000
24	33	25	SAI	0.66	ID SAI	1	73	-0.38	-0.28	0.10	0.10	0.06	Yes	A	7.12	-0.11	-0.11	No	No	-9.79	9.59	7.12	Yes	0.000

Notes:

1) PSEG is not licensed to apply the Flexible W* Criteria. However, the CM Flexible W* Length is provided to show that the required inspection extent accounting for the flaw lengths is also satisfied. The term "CM" is added to the Flexible W* Length heading to signify that the growth portion of the Flexible W* criteria is not included since Salem does not return any of these flaws to service.

Figure 1

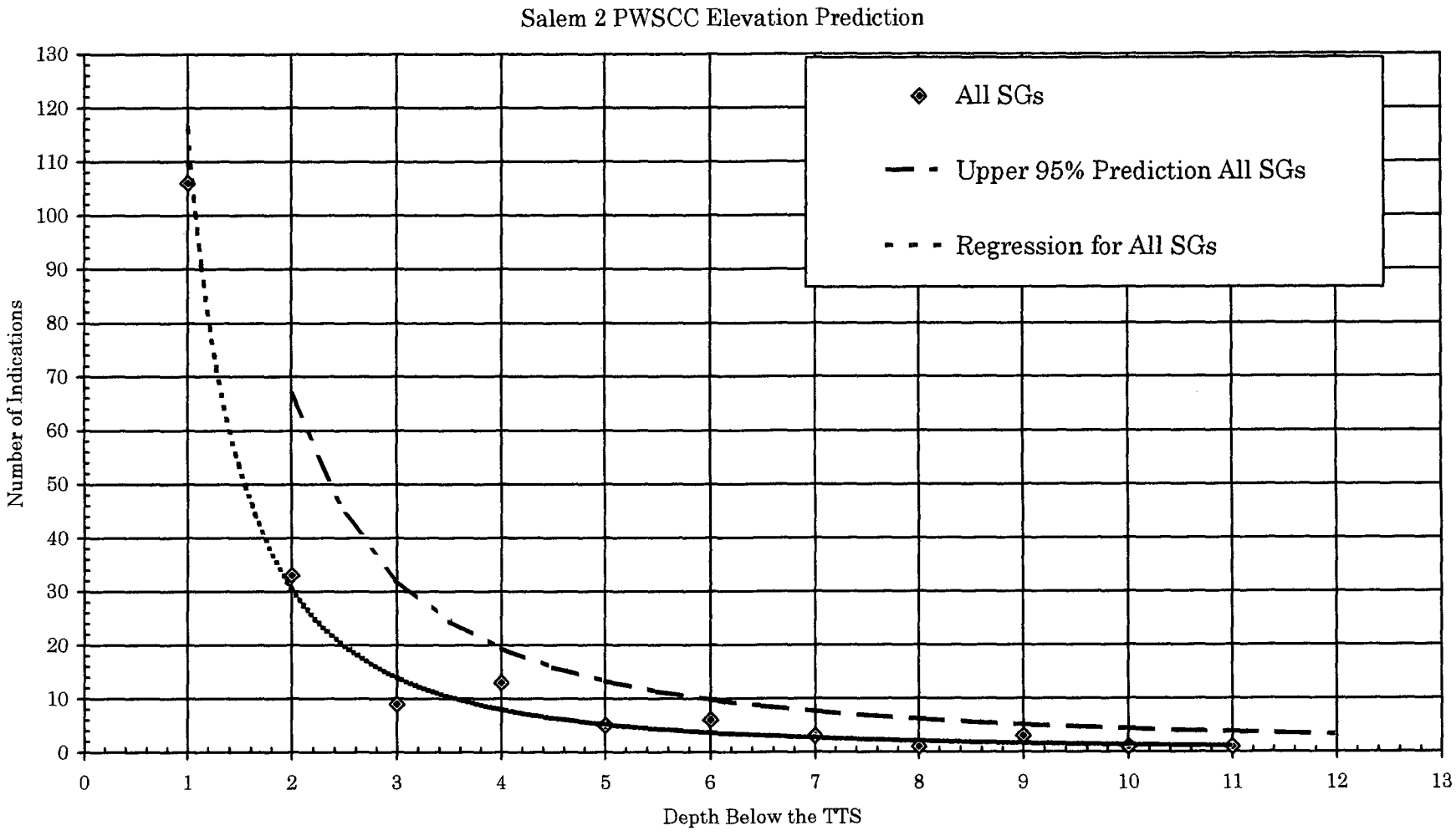
Salem 2 PWSCC Elevation Prediction
All SGs
Upper 95% Prediction All SGs
Regression for All SGs
Number of Indications
Depth Below the TTS
0
10
20
30
40
50
60
70
80
90
100
110
120
130
0
1
2
3
4
5
6
7
8
9
10
11
12
13

Table 3
2R15 Leakage Assessment for Tubesheet Indications

In-Service Tube Counts

	SG21	SG22	SG23	SG24
No. of In-Service Tubes Pre-2R15	3138	3139	3149	3026
Plugged During 2R15	16	10	5	24
No. of In-Service Tubes Post-2R15	3122	3129	3144	3002

CM Leakage Assessment for Tubesheet Indications

Location Range	Steam Generator			
	SG21	SG22	SG23	SG24
TSH +0" to TSH -8"	0	0	0	0
TSH -8" to TSH -12"	0.066	0.066	0.066	0.066
Below TSH -12"	0.28242	0.28251	0.28341	0.27234
Total CM Tubesheet Leakage	0.34842	0.34851	0.34941	0.33834

OA Leakage Assessment for Tubesheet Indications

Location Range	Steam Generator			
	SG21	SG22	SG23	SG24
TSH +0" to TSH -8"	0	0	0	0
TSH -8" to TSH -12"	0.066	0.066	0.066	0.066
Below TSH -12"	0.28098	0.28161	0.28296	0.27018
Total OA Tubesheet Leakage	0.34698	0.34761	0.34896	0.33618

Note: The CM leakage below 12 inches uses the pre-2R15 tubes in-service count, and the OA leakage below 12 inches uses the post-2R15 tubes in-service count.

SCC at HL TSP Intersection Inspections

There were a total of 11 axial PWSCC indications at TSP locations (8 at 01H, 2 at 02H, and 1 at 03H). Two axial ODSCC indications at TSP locations were observed, one at the 01H elevation and the other at the 02H elevation. The table below shows the tubes plugged for TSP SCC. The tubes repaired for Stress Corrosion Cracking at dented HL TSP locations are shown in the table below:

SG	Tube ID	Indications	TSP Location	2R15 Dent Voltage	Damage Mechanism
21	R10C12	SAI	01H	2.06	PWSCC
21	R12C13	SAI	02H	2.88	PWSCC
21	R20C27	SAI	01H	2.33	ODSCC
21	R19C28	SCI	01H	3.09	ODSCC
21	R21C37	SAI	03H	1.23	PWSCC
21	R5C38	SAI	01H	1.03	PWSCC
21	R5C41	SAI	01H	1.13	PWSCC
21	R6C41	SAI	01H	2.14	PWSCC
21	R6C65	SAI	02H	1.76	PWSCC
22	R9C56	SAI	01H	1.28	PWSCC
24	R12C4	SAI	01H	2.28	PWSCC
24	R20C64	(2) SAI's	01H	N/A - bobbin DSI of 1.1 volt	PWSCC
24	R23C82	SAI	02H	1.08	ODSCC

Anti-vibration Bar (AVB) Wear

AVB wear indications are plugged if bobbin indicates a depth ≥ 40% TW. Tubes with degradation less than 40% TW may be left in service, using the bobbin sizing technique. A total of seven tubes were repaired for this damage mechanism. The table below lists the tubes plugged for AVB wear during 2R15:

SG	Tube ID	Indication	TSP Location
21	R27C64	40% TW	AV3
22	R34C49	40% TW	AV4
23	R30C35	41% TW	AV2
23	R32C45	42% TW	AV2
		43% TW	AV3
23	R27C51	43% TW	AV2
24	R31C31	40% TW	AV3
24	R42C55	40% TW	AV1

Appendix 1 provides a listing of the AVB percent through-wall indications reported during 2R15.

Dents and Dings within the U-bend Regions

20% of the ≥ 1 volt dented AVB locations, and ≥ 2 volt ding locations within the U-bend region were inspected with a +Point probe and no degradation was reported.

Cold Leg Thinning (CLT)

Cold leg thinning (CLT) is caused by surface wastage (corrosion) and occurs principally within the confines of the lower cold leg tube support plates on the periphery of the tube bundle. CLT indications are plugged if bobbin indicates a depth of ≥ 40% TW. Tubes with degradation less than 40% through wall (TW) may be left in service, using the bobbin sizing technique.

A total of five tubes were plugged for this damage mechanism as shown in the table below:

SG	Tube ID	Indication	TSP Location	DSI Voltage
22	R32C78	58 % TW	02C	N/A
23	R11C3	64 % TW	01C	N/A
24	R10C3	9 % *TW	01C	.55
24	R32C16	7 % *TW	03C	.39
24	R29C82	44 % TW	01C	N/A

* Low voltage (0.39 – 0.55 volts) bobbin coil DSI's that via Rotating Coil produces a volumetric response typical of cold leg thinning. The percent through wall depth could not be accurately determined with the bobbin coil phase technique due to the influence of tube support plate residual on the signal. The indication was sized with using a bobbin coil amplitude curve. This sizing technique was judged to be more representative of the actual depth based on indication voltage.

Appendix 2 provides a listing of the CLT percent through-wall indications reported by bobbin during 2R15 (Low voltage bobbin coil distorted support indications (DSIs) confirmed as CLT with Rotating Coil probe are provided in the table above).

Rotating Coil Inspection of the U-bends

In response to Series 51 SG operating experience, 100% of the Row 2 thru Row 10 tubes in each steam generator was inspected with a +Point probe in the U-bend (eg: 07H to 07C). Also note that all of row 1 tubes were preventatively plugged during a previous outage. No degradation was detected in the U-bend region.

Loose Parts

During 2R15, 100% of the bobbin and Rotating Coil data was reviewed for possible loose part indications. Secondary Side Inspections (SSI) and Foreign Object Search and Retrieval (FOSAR) activities were also performed, as possible. Foreign objects not removed were evaluated to remain in place. Additional +Point inspections were performed in tubes located adjacent to foreign material identified via eddy current exams and/or visual inspections. These supplemental +Point inspections were typically within at least one tube radius of the object. There were no indications of tube wear due to loose parts in any SG, on any tube inspected.

A total of nine tubes were preventative plugged for loose parts (foreign objects) that could not be removed from the Steam Generator. No tube wear was associated with any of these locations. Many tubes were conservatively stabilized within the area of the loose part, even though no tube wear was evident. SG 22, tubes R30 C23 and R31 C24 were preventatively plugged due to one foreign object confirmed by visual inspections. SG 24, tube R7 C51, was preventatively plugged due to a PLP indication at the TSP. Visual inspections were not performed at this location. SG 24, R15 C90, R16 C90, R17 C90, R15 C91, R16 C91, R17 C91, was preventatively plugged due to one foreign object confirmed by visual inspections.

SG	Tube ID	Indication	TSP Location	Stabilization Conservatively Performed	Depth via EPRI ETSS 96910.1
22	R30C23	PLP	TSH	Yes	No Wear Identified
22	R31C24	PLP	TSH	Yes	No Wear Identified
24	R7C51	PLP	01H	No	No Wear Identified
24	R15C90	PLP	TSH	Yes	No Wear Identified
24	R16C90	PTP	TSH	Yes	No Wear Identified
24	R17C90	PTP	TSH	Yes	No Wear Identified
24	R15C91	PTP	TSH	Yes	No Wear Identified
24	R16C91	PTP	TSH	Yes	No Wear Identified
24	R17C91	PTP	TSH	Yes	No Wear Identified

Data Quality

Data quality is an important parameter influencing the overall performance of a steam generator tube examination system as it has an effect on probability of detection and sizing uncertainties. The following list reflects the tubes preventatively plugged for Data Quality Concerns:

SG	Tube ID	Indication
21	R12C24	Permeability Variation
21	R23C40	Permeability Variation
22	R14C9	Permeability Variation
22	R15C18	Permeability Variation
22	R7C41	Permeability Variation

Freespan Indications

When reported during the outage inspection, freespan bobbin coil indications (Manufacturing Burnish Mark (MBM) type indications) are compared to the first ISI data (1983) to determine if change has occurred. As documented in the bobbin coil Examination Technique Specification Sheet (ETSS), change is defined as either:

- A phase shift of 10 degrees towards the flaw plane or having signal amplitudes inconsistent with that present in 1983 with consideration given to voltage normalization changes or
- If the location has been Rotating Coil inspected (+Point) two times previously and dispositioned as MBM or No Degradation Found (NDF) **AND** the current outage bobbin signal has not changed by > 5 degrees towards the flaw plane or greater than 0.3 volt since the first outage (2R9 and later) it was Rotating Coil inspected

+Point inspections were performed on all freespan locations during 2R15 that were outside the change criterion, and no degradation was found.

Tube Support Plate Integrity Inspections

Consistent with Westinghouse study SG-96-05-003 "Investigation of Applicability of Eddy Current to the Detection of Potentially Degraded Tube Support Structures" (VTD 327729), bobbin coil probes were used for the initial screening of the support structures for signals that might be indicative of degradation. Signals identified with bobbin probes (called "Possible Support Indication (PSI)") require confirmation ("No Degradation Detected (NDD)" or "Suspect Ligament Crack (SLC)") using a Rotating Coil +Point probe. The repair criterion of ligament cracking is ≥145 degrees. During outage 2R15 the scope of inspections included:

- +Point inspection of new PSI indications for confirmation and
- +Point inspection of previously identified SLC indications to monitor for change.

In addition to the scopes outlined above, all TSP locations inspected with Rotating Coil (+Pont) during 2R15 for other reasons were assessed for evidence of degraded support structures.

Two newly reported possible ligament crack indications were identified during 2R15. Both of these locations had single ligament crack indications as determined with the +Point probe. One of these SLCs was detected with bobbin. A review of historical data showed that this indication was present in history with no significant change. The second new SLC location was not detected with bobbin, which is not unexpected for single indications with no missing ligament. Based on previously performed SLC assessments that considered both the review of previous inspection data (bobbin and RC) and previously performed visual inspections, no growth or change could be inferred considering analyst variability and the techniques utilized. The table below provides a current summary of support structures with SLC indications:

SG	Tube ID	IND	LOCATION	SIZING INFORMATION
21	R14C6	SLC	06H	SINGLE
21	R42C36	SLC	06H	SINGLE
21	R36C40	SLC	06H	SINGLE
21	R43C40	SLC	06H	SINGLE
21	R45C41	SLC	06H	SINGLE
21	R20C53	SLC	05H	SINGLE
22	R37C54	SLC	03H	SINGLE
22	R41C54	SLC	03H	SINGLE
22	R13C92	SLC	07H	SINGLE (New)
23	R6C27	SLC	04H	43 DEG
23	R17C27	SLC	04H	58 DEG
23	R14C37	SLC	04H	SINGLE
23	R14C38	SLC	04H	35 DEG
23	R9C40	SLC	06C	39 DEG
23	R45C54	SLC	07H	SINGLE
23	R46C54	SLC	07H	SINGLE
23	R9C55	SLC	02H	35 DEG
23		SLC	03H	58 DEG
23	R45C55	SLC	07H	SINGLE
23	R3C56	SLC	06C	35 DEG
23	R39C56	SLC	01H	SINGLE
23	R44C56	SLC	07H	SINGLE
23	R14C57	SLC	05C	39 DEG
23	R42C58	SLC	07H	SINGLE (New)
23	R42C59	SLC	04H	SINGLE
23	R41C68	SLC	07H	SINGLE
23	R22C75	SLC	01H	39 DEG
23		SLC	07H	54 DEG
23	R29C81	SLC	01C	35 DEG
23		SLC	07C	58 DEG
23	R25C87	SLC	07C	SINGLE
24	R26C9	SLC	05C	SINGLE
24	R23C28	SLC	02H	20 DEG
24	R20C29	SLC	07C	SINGLE
24	R41C39	SLC	02C	SINGLE
24	R45C41	SLC	07H	SINGLE
24	R46C41	SLC	01H	SINGLE
24		SLC	07H	SINGLE
24	R34C46	SLC	02C	SINGLE
24	R46C54	SLC	07H	DOUBLE
24	R45C57	SLC	01H	36 DEG

"Double" represents a location with two separated single indications.

Free Span Ding Inspections

According to the based scope inspection plan, Rotating Coil inspections were performed on at least 20% sample of the HL ≥ 2-volt free span Dings to identify potential PWSCC and/or ODSCC. The 20% sample included free span Dings reported from the TSH +0.5 inches to 07H +2.0 inches. One axial ODSCC indications occurred in a 6.83-volt ding approximately 1.55 inches above TSH that coincided with an associated DNI bobbin call of 2.72 volts. This resulted in expanding the H/L free span Dings inspection to inspecting 100% HL Dings ≥ 5 V in SG 24 between TSH +0.5 inches and 07H +2.0 inches, and 20% of HL Dings ≥ 5V in steam generators 21, 22 and 23 (the 20% samples also include a minimum of 20% of HL Dings between TSH and 01H).

Two tubes in 21 SG were also preventatively plugged due to ding signals above the top of the hot leg tubesheet. These tubes had no degradation detected with either the bobbin or the +Point coils. However, it was noted that these two Dings are in the same relative proximity to the HL tubesheet as the ODSCC axial Ding in 24 SG. Therefore, based on this heightened awareness for the potential of ding ODSCC in this region it was conservatively decided to remove these two tubes from service.

SG	Tube ID	Indication
24	R28C10	Ding associated ODSCC above HL TTS
21	R26C86	NDD - Preventative for Ding Signal above HL TTS (Complex Signal)
21	R31C82	NDD- Preventative for Ding Signal above HL TTS (Complex Signal)

Appendix 1

Anti-Vibration Bar Wear Percent Through-Wall Indications

SG	Row	Col	%TW	Supp	Inch1
SG21	16	24	7	AV1	-0.09
SG21	16	66	11	AV1	-0.34
SG21	16	66	12	AV4	-0.96
SG21	17	25	13	AV3	0.02
SG21	17	35	8	AV1	0.15
SG21	17	37	12	AV4	-0.37
SG21	17	39	15	AV1	-0.2
SG21	17	39	13	AV2	0.09
SG21	17	39	13	AV3	-0.07
SG21	17	52	13	AV1	-2.23
SG21	17	52	14	AV1	2.33
SG21	17	52	11	AV2	-0.87
SG21	17	52	10	AV2	1.11
SG21	17	52	9	AV3	-0.93
SG21	17	52	14	AV3	1.09
SG21	17	52	13	AV4	-0.33
SG21	17	56	17	AV2	0.09
SG21	17	56	10	AV3	0.24
SG21	17	63	14	AV2	0.11
SG21	17	63	12	AV3	-0.16
SG21	17	63	9	AV3	0.06
SG21	18	34	11	AV2	0.02
SG21	18	67	9	AV1	-0.92
SG21	18	67	5	AV4	0.67
SG21	19	58	26	AV2	0.55
SG21	19	58	16	AV4	0.31
SG21	19	66	12	AV1	-0.53
SG21	19	66	22	AV2	0.15
SG21	19	66	25	AV3	0.19
SG21	19	66	6	AV4	-1.02
SG21	21	29	8	AV3	0.17
SG21	21	29	16	AV4	-0.56
SG21	21	60	12	AV2	-0.3
SG21	21	60	15	AV3	-0.36
SG21	22	60	15	AV2	-0.26
SG21	23	64	20	AV2	0.09
SG21	23	64	22	AV3	0.19
SG21	23	67	23	AV1	-0.94
SG21	23	67	29	AV2	-0.35

SG	Row	Col	%TW	Supp	Inch1
SG21	23	67	26	AV3	-0.13
SG21	23	70	14	AV4	1.64
SG21	24	41	8	AV1	-1
SG21	24	52	10	AV1	-1.92
SG21	24	52	18	AV2	1.13
SG21	24	52	8	AV3	1.15
SG21	24	52	14	AV4	0.9
SG21	24	67	15	AV2	-0.28
SG21	24	68	22	AV2	0.51
SG21	24	68	24	AV3	0.04
SG21	24	70	8	AV1	0.6
SG21	25	24	9	AV3	0.02
SG21	26	46	12	AV2	0.3
SG21	26	56	25	AV1	0.32
SG21	26	56	26	AV2	0.11
SG21	26	56	29	AV3	0.13
SG21	26	56	32	AV4	-0.73
SG21	26	58	12	AV2	-0.53
SG21	26	58	19	AV3	-0.71
SG21	26	59	12	AV2	0.11
SG21	26	59	15	AV3	0.3
SG21	26	59	10	AV4	-0.43
SG21	26	63	12	AV4	-0.62
SG21	26	64	19	AV1	-0.06
SG21	26	64	10	AV2	0.19
SG21	26	64	10	AV3	0.19
SG21	26	67	22	AV1	-0.49
SG21	26	67	9	AV2	-0.28
SG21	27	44	14	AV1	-0.47
SG21	27	44	31	AV2	-0.04
SG21	27	44	34	AV3	0.26
SG21	27	44	27	AV4	0.57
SG21	27	45	18	AV4	0.35
SG21	27	46	15	AV2	-0.37
SG21	27	46	32	AV2	0.2
SG21	27	46	36	AV3	0.2
SG21	27	46	25	AV4	-0.39
SG21	27	50	10	AV2	-0.81
SG21	27	50	19	AV3	-0.86
SG21	27	50	8	AV4	-0.64
SG21	27	56	21	AV1	0.34
SG21	27	56	34	AV2	0.11
SG21	27	56	35	AV3	0.06
SG21	27	56	23	AV4	-0.53

SG	Row	Col	%TW	Supp	Inch1
SG21	27	56	10	AV4	0.48
SG21	27	59	22	AV4	-0.45
SG21	27	64	22	AV1	-0.21
SG21	27	64	26	AV2	0.28
SG21	27	64	40	AV3	0.19
SG21	29	46	20	AV1	-0.55
SG21	29	46	34	AV2	0.04
SG21	29	46	39	AV3	0.02
SG21	29	46	13	AV4	-0.17
SG21	29	57	22	AV2	0.3
SG21	29	57	24	AV3	-0.23
SG21	29	57	21	AV4	-0.11
SG21	29	65	12	AV3	0.43
SG21	29	65	27	AV4	-0.43
SG21	31	64	28	AV2	-0.13
SG21	31	67	15	AV2	0.36
SG21	32	39	10	AV4	0.06
SG21	32	48	25	AV2	-0.11
SG21	32	48	30	AV3	0.22
SG21	32	49	12	AV3	1.24
SG21	32	49	12	AV4	-0.7
SG21	32	51	12	AV2	1.07
SG21	32	51	27	AV3	-1.35
SG21	32	51	28	AV3	1.15
SG21	32	51	20	AV4	1.54
SG21	32	54	10	AV3	-0.24
SG21	33	41	8	AV2	-0.04
SG21	33	41	7	AV3	-0.2
SG21	33	41	12	AV4	0.67
SG21	33	55	14	AV3	0.01
SG21	33	60	25	AV1	0.23
SG21	33	60	27	AV3	0.4
SG21	34	36	9	AV1	-0.31
SG21	34	36	11	AV1	0.34
SG21	34	36	27	AV2	-0.36
SG21	34	36	14	AV3	-0.28
SG21	34	37	9	AV1	0.49
SG21	34	37	23	AV2	0.36
SG21	34	37	19	AV3	0.23
SG21	34	37	9	AV4	0.06
SG21	34	44	10	AV1	0.32
SG21	34	44	24	AV2	-0.06
SG21	34	44	35	AV3	0.13
SG21	34	44	10	AV4	0.58

SG	Row	Col	%TW	Supp	Inch1
SG21	34	45	9	AV1	0.11
SG21	34	45	15	AV2	-0.09
SG21	34	45	26	AV3	-0.48
SG21	34	45	18	AV4	-0.26
SG21	34	49	10	AV2	1.15
SG21	34	49	11	AV3	1.17
SG21	34	51	24	AV1	-0.13
SG21	34	51	23	AV2	1.27
SG21	34	51	23	AV3	1.14
SG21	34	52	14	AV2	0.86
SG21	34	65	29	AV3	-0.45
SG21	34	65	25	AV4	-0.32
SG21	35	53	9	AV4	0.07
SG21	35	63	10	AV1	-0.6
SG21	35	63	15	AV2	0.17
SG21	35	68	15	AV1	-0.47
SG21	35	68	15	AV2	-0.25
SG21	35	68	9	AV3	0.01
SG21	36	41	21	AV3	0.13
SG21	36	43	16	AV3	-0.35
SG21	36	43	9	AV4	0.2
SG21	36	50	9	AV2	0.83
SG21	36	53	9	AV1	-0.52
SG21	36	53	10	AV2	0.62
SG21	36	56	24	AV2	0.01
SG21	36	58	21	AV1	0.36
SG21	36	58	33	AV2	-0.51
SG21	36	58	12	AV2	0.46
SG21	36	58	30	AV3	-0.46
SG21	39	37	9	AV1	-0.15
SG21	39	37	15	AV1	0.28
SG21	39	37	24	AV2	0.02
SG21	39	54	10	AV1	-0.21
SG21	39	61	23	AV1	-0.49
SG21	39	61	28	AV2	-0.49
SG21	40	58	15	AV2	-0.43
SG21	41	50	10	AV1	0.09
SG21	41	53	10	AV1	0.43
SG21	41	53	16	AV2	-0.24
SG21	41	58	10	AV1	0.13
SG21	41	58	8	AV4	0.02
SG21	42	31	10	AV3	-0.02
SG21	42	34	6	AV4	-0.19
SG22	16	68	16	AV2	-0.32

SG	Row	Col	%TW	Supp	Inch1
SG22	16	68	13	AV3	0.25
SG22	16	68	13	AV4	0.72
SG22	18	65	25	AV1	-1.53
SG22	18	65	13	AV1	1.4
SG22	18	65	20	AV2	-0.58
SG22	18	65	22	AV2	0.84
SG22	18	65	29	AV3	0.02
SG22	18	65	18	AV4	-0.75
SG22	18	65	11	AV4	0.85
SG22	22	62	11	AV2	-0.19
SG22	22	62	25	AV3	-0.23
SG22	23	71	17	AV1	-1.71
SG22	23	71	10	AV2	0.02
SG22	23	71	19	AV3	0.22
SG22	23	71	13	AV4	0.18
SG22	23	74	13	AV2	-0.21
SG22	23	74	12	AV4	-0.45
SG22	25	9	12	AV2	0.43
SG22	25	9	19	AV3	0.04
SG22	25	30	18	AV1	1.88
SG22	25	30	25	AV2	0.06
SG22	25	30	35	AV3	0.19
SG22	25	55	12	AV1	1.03
SG22	25	63	12	AV3	-0.47
SG22	25	69	16	AV2	-0.39
SG22	25	69	22	AV2	0.32
SG22	25	69	31	AV3	0.39
SG22	25	71	18	AV3	0.3
SG22	26	23	18	AV3	-0.09
SG22	26	62	28	AV1	0.52
SG22	26	62	27	AV2	0.06
SG22	26	62	25	AV3	-0.22
SG22	26	62	11	AV4	0.31
SG22	27	28	18	AV2	-0.43
SG22	27	28	16	AV3	0.13
SG22	31	27	21	AV2	-0.06
SG22	31	28	15	AV1	0.53
SG22	31	28	26	AV2	0.38
SG22	32	52	12	AV2	-0.17
SG22	32	52	14	AV3	-0.19
SG22	33	67	12	AV2	-0.22
SG22	33	67	16	AV2	0.39
SG22	34	32	33	AV1	0.09
SG22	34	32	36	AV2	0.38

SG	Row	Col	%TW	Supp	Inch1
SG22	34	32	29	AV3	0.02
SG22	34	39	14	AV3	-0.04
SG22	34	41	10	AV3	0.06
SG22	34	46	14	AV3	-0.04
SG22	34	47	14	AV3	-0.08
SG22	34	49	40	AV4	-0.59
SG22	34	50	10	AV1	0.86
SG22	34	50	16	AV2	-0.24
SG22	34	50	29	AV3	0.28
SG22	34	50	20	AV4	0.87
SG22	34	58	19	AV2	0.02
SG22	34	70	14	AV4	-0.19
SG22	35	26	11	AV1	0.11
SG22	35	26	11	AV2	0.11
SG22	35	53	16	AV2	0.02
SG22	35	53	12	AV3	-0.28
SG22	36	34	29	AV3	0.11
SG22	36	51	15	AV2	0.04
SG22	40	36	30	AV4	-0.21
SG22	40	37	17	AV1	1.2
SG22	40	37	22	AV2	0.04
SG22	40	44	22	AV1	0.4
SG22	40	44	32	AV2	0.05
SG22	41	32	12	AV3	-0.04
SG23	15	77	11	AV2	0.64
SG23	15	77	10	AV4	-1.48
SG23	16	57	19	AV1	0.64
SG23	16	57	12	AV2	-0.21
SG23	16	57	20	AV3	-0.34
SG23	16	57	15	AV4	-1.02
SG23	20	31	11	AV1	1.24
SG23	20	56	8	AV4	-1.62
SG23	20	58	8	AV1	0.02
SG23	20	64	10	AV4	0.02
SG23	20	67	13	AV1	-0.88
SG23	20	67	9	AV2	-0.13
SG23	21	22	12	AV2	0.17
SG23	21	32	10	AV1	-0.13
SG23	21	44	11	AV1	0.66
SG23	21	44	13	AV2	0.02
SG23	23	40	13	AV3	0.21
SG23	23	44	8	AV2	0.11
SG23	23	49	6	AV1	-0.63
SG23	23	53	9	AV1	0.77

SG	Row	Col	%TW	Supp	Inch1
SG23	23	53	14	AV2	-0.15
SG23	23	53	9	AV2	0.43
SG23	23	53	26	AV3	-0.09
SG23	23	53	8	AV4	-0.21
SG23	23	58	12	AV1	-0.22
SG23	23	58	26	AV2	-0.26
SG23	23	58	16	AV2	0.23
SG23	23	58	38	AV3	0.06
SG23	23	58	14	AV4	0.51
SG23	24	46	11	AV3	0.45
SG23	24	48	11	AV1	-0.07
SG23	24	48	13	AV2	-0.13
SG23	24	53	7	AV3	0.04
SG23	24	55	7	AV1	-1.1
SG23	24	55	16	AV1	1.28
SG23	24	55	8	AV4	-3.03
SG23	24	56	21	AV1	-0.66
SG23	24	56	18	AV2	-0.87
SG23	24	56	18	AV2	1.11
SG23	24	56	21	AV3	-0.83
SG23	24	56	27	AV3	0.87
SG23	24	56	15	AV4	-1.61
SG23	24	56	5	AV4	1.47
SG23	24	60	8	AV2	0.06
SG23	25	44	9	AV2	0.11
SG23	25	57	11	AV1	0.49
SG23	25	57	10	AV2	-0.19
SG23	26	44	9	AV1	-0.57
SG23	26	44	13	AV1	0.6
SG23	26	44	30	AV2	0.02
SG23	26	44	28	AV3	0.02
SG23	26	44	17	AV4	-0.09
SG23	26	45	30	AV1	-0.07
SG23	26	45	28	AV2	-0.02
SG23	26	45	13	AV4	0.66
SG23	26	55	23	AV1	-0.82
SG23	26	55	31	AV2	0.32
SG23	26	55	13	AV3	0.11
SG23	26	63	9	AV1	-1.02
SG23	26	63	9	AV2	-0.15
SG23	27	49	9	AV1	0.82
SG23	27	49	12	AV2	-0.41
SG23	27	49	12	AV3	0.09
SG23	27	51	23	AV1	-1.04

SG	Row	Col	%TW	Supp	Inch1
SG23	27	51	43	AV2	0.11
SG23	27	51	34	AV3	0.04
SG23	27	51	34	AV4	-0.36
SG23	27	59	31	AV1	0.42
SG23	27	59	19	AV2	0.53
SG23	27	59	13	AV3	0.27
SG23	27	59	12	AV4	0.37
SG23	27	63	30	AV1	1.41
SG23	27	63	39	AV2	0.17
SG23	27	63	29	AV3	0.28
SG23	27	63	23	AV4	-0.89
SG23	27	64	11	AV1	-0.84
SG23	27	64	8	AV2	0.08
SG23	27	65	16	AV2	0.02
SG23	27	65	17	AV3	-0.23
SG23	27	65	12	AV3	0.3
SG23	27	65	16	AV4	1.21
SG23	28	45	19	AV2	-0.02
SG23	30	25	10	AV4	-0.09
SG23	30	27	8	AV3	-0.12
SG23	30	27	11	AV4	0.07
SG23	30	35	41	AV2	-0.04
SG23	30	35	21	AV3	-0.37
SG23	30	35	26	AV4	0.86
SG23	30	57	11	AV1	0.04
SG23	30	57	10	AV2	-0.25
SG23	30	64	10	AV4	-0.15
SG23	31	63	13	AV2	-0.04
SG23	32	41	16	AV2	0.09
SG23	32	41	37	AV3	-0.24
SG23	32	45	36	AV1	-0.09
SG23	32	45	42	AV2	-0.02
SG23	32	45	43	AV3	0.02
SG23	32	45	15	AV4	-0.56
SG23	32	45	35	AV4	0.56
SG23	32	59	24	AV3	0.17
SG23	32	59	13	AV4	0.39
SG23	32	61	13	AV1	0.38
SG23	32	61	27	AV3	-0.25
SG23	33	26	9	AV1	0.07
SG23	33	26	15	AV2	-0.02
SG23	33	26	19	AV3	-0.5
SG23	33	50	8	AV1	0.13
SG23	33	51	6	AV2	0.06

SG	Row	Col	%TW	Supp	Inch1
SG23	33	51	5	AV3	-0.08
SG23	33	52	10	AV1	0.08
SG23	34	38	12	AV3	-0.04
SG23	34	38	9	AV4	-0.04
SG23	34	41	11	AV3	-0.19
SG23	34	52	13	AV4	0.02
SG23	34	54	10	AV4	1.94
SG23	35	53	14	AV3	-0.08
SG23	35	53	16	AV4	0.02
SG23	35	54	11	AV4	1.37
SG23	36	44	11	AV3	-0.02
SG23	36	44	24	AV4	-0.02
SG23	36	45	15	AV3	0.11
SG23	36	45	16	AV4	-0.41
SG23	36	45	12	AV4	0.51
SG23	36	58	24	AV4	0.07
SG23	36	63	14	AV1	-0.68
SG23	36	63	10	AV1	0.76
SG23	36	63	21	AV2	0.02
SG23	36	66	9	AV4	-0.74
SG23	36	71	8	AV2	0.15
SG23	37	42	15	AV3	0.26
SG23	37	42	19	AV4	-0.41
SG23	37	45	16	AV3	0.11
SG23	37	45	25	AV4	-0.32
SG23	37	52	32	AV4	0.02
SG23	38	41	10	AV2	0.04
SG23	38	44	8	AV2	0.04
SG23	38	46	11	AV3	0.32
SG23	38	46	15	AV4	-0.15
SG23	38	47	23	AV3	0.02
SG23	38	47	20	AV4	-0.02
SG23	38	48	33	AV3	-0.51
SG23	39	50	12	AV1	-0.02
SG23	39	50	21	AV2	0.34
SG23	39	51	19	AV1	0.47
SG23	39	51	10	AV3	0.01
SG23	39	52	23	AV1	0.08
SG23	39	52	23	AV2	0.02
SG23	39	58	22	AV1	0.04
SG23	39	58	32	AV2	0.23
SG23	39	60	12	AV3	0.1
SG23	39	60	15	AV4	-0.42
SG23	39	60	10	AV4	0.17

SG	Row	Col	%TW	Supp	Inch1
SG23	40	42	14	AV1	0.09
SG23	40	42	38	AV2	0.32
SG23	40	43	9	AV2	-0.19
SG23	40	43	17	AV3	0.04
SG23	40	50	28	AV2	0.15
SG23	40	50	11	AV3	0.02
SG23	40	50	3	AV4	-0.06
SG23	40	51	21	AV1	-0.25
SG23	40	51	32	AV2	0.1
SG23	40	51	14	AV3	0.02
SG23	40	56	10	AV1	-0.28
SG23	40	56	8	AV1	0.35
SG23	40	62	11	AV1	0.13
SG23	40	66	21	AV2	0.08
SG23	41	29	8	AV3	-0.13
SG23	41	52	13	AV2	0.02
SG23	41	52	20	AV3	-0.19
SG23	41	55	36	AV1	-0.67
SG23	41	55	15	AV1	0.51
SG23	41	55	10	AV2	-0.38
SG23	41	55	32	AV2	0.06
SG23	41	60	12	AV2	0.06
SG23	41	61	14	AV1	0.02
SG23	41	63	10	AV3	0.04
SG23	41	65	14	AV2	0.1
SG23	42	52	11	AV1	0.08
SG23	42	60	9	AV3	-0.04
SG23	42	65	26	AV2	0.06
SG23	42	66	7	AV2	0.17
SG23	42	66	9	AV3	-0.02
SG23	42	67	31	AV1	0.04
SG23	42	67	27	AV2	0.11
SG23	42	67	36	AV3	-0.08
SG23	43	34	11	AV4	0.01
SG23	43	63	18	AV2	0.02
SG23	44	40	12	AV4	-0.06
SG23	45	58	8	AV1	-0.08
SG23	45	58	9	AV3	0.02
SG23	45	58	17	AV4	-0.13
SG24	15	33	10	AV1	0.22
SG24	15	33	10	AV3	-0.26
SG24	17	32	8	AV2	0.35
SG24	17	32	17	AV3	-0.37
SG24	17	32	11	AV4	-0.72

SG	Row	Col	%TW	Supp	Inch1
SG24	17	65	23	AV2	-0.11
SG24	17	65	10	AV3	-0.3
SG24	17	65	16	AV3	0.31
SG24	17	65	18	AV4	-1.51
SG24	17	78	14	AV2	0.11
SG24	18	23	20	AV4	-0.31
SG24	18	55	14	AV1	0.09
SG24	18	55	17	AV2	0.11
SG24	18	55	14	AV3	0.09
SG24	18	55	15	AV4	0.43
SG24	20	6	8	AV2	-0.04
SG24	21	28	13	AV1	-0.61
SG24	21	28	21	AV2	0.04
SG24	21	28	27	AV3	-0.22
SG24	21	28	14	AV4	0.64
SG24	21	30	13	AV1	-0.22
SG24	21	30	17	AV2	-0.26
SG24	21	30	17	AV2	0.33
SG24	21	30	9	AV3	-0.74
SG24	21	30	13	AV3	0.72
SG24	21	72	21	AV4	-0.15
SG24	22	72	30	AV2	0.02
SG24	23	28	37	AV3	0.2
SG24	23	28	13	AV4	0.57
SG24	23	33	13	AV1	-0.2
SG24	23	33	27	AV2	-0.33
SG24	23	33	13	AV2	0.24
SG24	23	33	21	AV3	0.2
SG24	23	33	14	AV4	-0.37
SG24	23	33	7	AV4	0.18
SG24	23	53	20	AV4	-0.07
SG24	23	56	10	AV3	0.51
SG24	23	56	19	AV4	0.16
SG24	23	57	11	AV1	0.39
SG24	23	57	14	AV2	-0.44
SG24	23	57	13	AV2	0.31
SG24	23	57	32	AV3	-0.04
SG24	23	57	34	AV4	-0.09
SG24	23	59	22	AV1	1.25
SG24	23	59	26	AV2	0.39
SG24	23	59	16	AV3	-0.37
SG24	23	59	17	AV3	0.27
SG24	23	62	12	AV1	0.99
SG24	23	62	22	AV2	-0.73

SG	Row	Col	%TW	Supp	Inch1
SG24	23	62	29	AV3	-0.18
SG24	23	62	18	AV4	0.72
SG24	23	72	14	AV2	0.4
SG24	23	72	29	AV4	-0.73
SG24	24	34	23	AV2	-0.07
SG24	24	34	21	AV3	0.07
SG24	24	34	17	AV4	-0.76
SG24	24	35	17	AV1	0.31
SG24	24	35	13	AV2	0.18
SG24	24	35	20	AV3	0.2
SG24	25	72	18	AV2	0.02
SG24	26	34	25	AV1	0.26
SG24	26	34	33	AV2	-0.09
SG24	26	34	23	AV3	0.06
SG24	26	34	17	AV4	0.58
SG24	26	58	17	AV1	-0.28
SG24	26	58	28	AV2	0.11
SG24	26	58	29	AV3	0.28
SG24	26	58	16	AV4	1.3
SG24	26	62	18	AV4	0.5
SG24	26	67	14	AV1	0.11
SG24	26	67	17	AV2	0.22
SG24	27	62	12	AV1	0.72
SG24	27	62	14	AV2	-0.77
SG24	27	68	31	AV3	-0.13
SG24	27	68	26	AV4	-0.11
SG24	28	59	15	AV1	0.24
SG24	28	59	23	AV2	0.15
SG24	31	31	40	AV3	-0.02
SG24	31	48	9	AV3	0.06
SG24	32	64	16	AV2	-0.11
SG24	33	29	13	AV1	0.21
SG24	33	29	15	AV2	0.13
SG24	33	36	11	AV1	-0.78
SG24	33	41	17	AV1	-0.37
SG24	33	48	10	AV1	-0.77
SG24	33	48	9	AV1	0.02
SG24	33	48	13	AV2	0.04
SG24	33	50	10	AV3	0.09
SG24	33	50	11	AV4	0.09
SG24	33	51	7	AV1	-0.78
SG24	33	51	34	AV2	-0.67
SG24	33	51	9	AV3	-0.84
SG24	33	57	14	AV1	0.02

SG	Row	Col	%TW	Supp	Inch1
SG24	33	57	12	AV2	-0.37
SG24	33	57	21	AV3	0.56
SG24	33	57	28	AV4	-0.09
SG24	33	58	23	AV3	-0.26
SG24	33	58	8	AV4	-0.09
SG24	33	65	12	AV3	-0.24
SG24	33	66	30	AV2	-0.11
SG24	33	66	10	AV3	-0.18
SG24	33	67	24	AV1	0.04
SG24	34	63	30	AV2	-0.06
SG24	34	63	31	AV3	0.02
SG24	34	63	15	AV4	0.37
SG24	34	65	31	AV3	-0.4
SG24	34	65	24	AV4	0.29
SG24	36	63	16	AV3	-0.09
SG24	38	39	13	AV3	-0.21
SG24	38	39	18	AV4	-0.28
SG24	38	52	15	AV3	-0.37
SG24	38	52	29	AV4	0.39
SG24	38	67	27	AV2	0.02
SG24	38	67	36	AV3	-0.17
SG24	38	68	31	AV2	0.24
SG24	38	68	39	AV3	-0.09
SG24	38	68	39	AV4	-0.09
SG24	39	42	14	AV3	0.09
SG24	39	42	13	AV4	0.51
SG24	39	49	9	AV3	0.15
SG24	39	49	33	AV4	-0.21
SG24	39	65	32	AV1	-0.07
SG24	39	65	20	AV2	0.02
SG24	40	37	29	AV1	0.06
SG24	40	37	23	AV2	-0.06
SG24	40	55	10	AV1	-0.13
SG24	40	56	23	AV1	0.09
SG24	40	56	17	AV2	-0.15
SG24	40	57	10	AV4	0.11
SG24	41	35	19	AV1	-0.02
SG24	41	35	20	AV2	-0.13
SG24	41	53	14	AV1	-0.19
SG24	41	53	33	AV2	-0.19
SG24	41	53	30	AV3	-0.34
SG24	41	53	20	AV3	0.24
SG24	41	53	25	AV4	0.02
SG24	41	57	7	AV1	0.02

SG	Row	Col	%TW	Supp	Inch1
SG24	41	59	19	AV4	0.11
SG24	42	53	10	AV1	0.02
SG24	42	53	12	AV2	0.06
SG24	42	55	40	AV1	-0.19
SG24	42	55	17	AV2	0.02
SG24	44	35	28	AV1	0.11
SG24	44	35	11	AV2	0.04
SG24	44	35	8	AV3	-0.04
SG24	44	55	7	AV4	0.17
SG24	45	54	17	AV1	0.23

Appendix 2

Cold Leg Thinning
Percent Through-Wall Indications

SG	Row	Col	%TW	Supp	Inch1	Volts
SG21	34	79	26	01C	-0.04	1.11
SG21	35	76	22	02C	-0.04	0.7
SG21	44	59	12	03C	-0.28	0.46
SG21	45	57	14	03C	-0.23	0.41
SG21	45	58	28	04C	-0.27	0.48
SG21	46	48	1	01C	0.41	0.22
SG22	3	1	33	01C	0.19	0.35
SG22	6	2	26	01C	0.04	1.81
SG22	22	87	1	01C	0.17	0.28
SG22	32	78	58	02C	0.02	3.75
SG22	32	79	17	02C	-0.02	0.49
SG22	32	79	5	03C	-0.09	0.99
SG22	33	17	20	01C	0.42	0.45
SG22	33	76	1	01C	-0.17	0.54
SG22	34	17	25	01C	0.36	0.93
SG22	34	18	1	03C	-0.25	0.6
SG22	36	18	23	02C	-0.15	1.18
SG22	36	18	21	01C	-0.06	2.1
SG22	37	19	31	01C	-0.02	0.89
SG22	37	68	6	02C	-0.04	0.27
SG22	40	67	1	02C	0.19	0.64
SG22	40	69	23	01C	-0.06	0.23
SG22	41	62	26	02C	0.13	0.92
SG22	41	67	1	02C	-0.09	0.84
SG22	42	41	33	02C	0.08	0.97
SG22	42	61	26	02C	0	0.64
SG22	42	62	30	02C	-0.02	0.5
SG22	42	63	1	02C	0	0.58
SG22	42	65	21	01C	0.39	0.5
SG22	42	67	1	01C	0.23	0.48
SG22	43	37	12	02C	-0.09	0.25
SG22	43	53	21	02C	0.26	0.27
SG22	43	58	15	02C	0.04	0.21
SG22	43	61	1	02C	-0.09	0.48
SG22	43	64	19	02C	0.04	0.96
SG22	43	64	1	01C	0.38	0.33
SG22	43	65	30	02C	0.11	1.35
SG22	44	37	5	02C	-0.11	0.57
SG22	44	38	13	01C	0.06	0.66

SG	Row	Col	%TW	Supp	Inch1	Volts
SG22	44	39	25	02C	-0.06	0.45
SG22	44	39	19	01C	0.23	0.51
SG22	44	46	9	02C	0.19	0.54
SG22	44	47	1	02C	0.19	0.63
SG22	44	56	8	02C	0.15	1.41
SG22	44	58	4	02C	-0.11	0.49
SG22	44	59	1	02C	-0.06	0.41
SG22	44	60	1	02C	0.08	0.61
SG22	44	61	1	04C	0.21	0.29
SG22	44	62	1	03C	-0.17	0.54
SG22	45	41	8	02C	0.17	0.82
SG22	45	45	4	02C	0.11	0.49
SG22	45	47	1	02C	0.21	0.6
SG22	45	48	26	03C	-0.06	0.22
SG22	45	48	15	01C	-0.02	0.29
SG22	45	50	22	02C	0.26	0.89
SG22	45	52	1	02C	0.22	0.43
SG22	45	55	1	02C	0.17	0.46
SG22	45	56	1	02C	0.19	0.52
SG22	45	58	1	01C	0.21	0.44
SG22	46	41	11	02C	-0.13	0.51
SG22	46	47	18	02C	0.06	0.82
SG22	46	51	1	02C	0.13	0.41
SG22	46	52	24	02C	0.28	0.36
SG22	46	54	1	01C	0.23	0.35
SG23	2	1	12	02C	-0.24	0.37
SG23	3	1	26	01C	-0.02	0.84
SG23	6	3	2	01C	0.23	0.64
SG23	8	3	22	01C	0.06	0.9
SG23	9	2	5	01C	0.21	0.36
SG23	11	2	24	01C	-0.02	0.22
SG23	11	3	64	01C	0	0.95
SG23	12	4	32	01C	-0.06	0.71
SG23	14	5	12	01C	-0.08	0.22
SG23	23	8	1	01C	-0.15	0.44
SG23	25	9	18	01C	0.21	0.85
SG23	27	10	20	01C	0.19	0.37
SG23	30	12	1	01C	-0.21	0.5
SG23	30	14	10	02C	-0.26	0.26
SG23	31	14	35	01C	0.02	0.64
SG23	33	18	13	01C	-0.02	0.44
SG23	34	17	36	01C	0	3.02
SG23	34	18	27	01C	0.04	2.15
SG23	37	19	30	02C	-0.11	1.14

SG	Row	Col	%TW	Supp	Inch1	Volts
SG23	40	33	29	02C	-0.3	0.3
SG23	44	34	2	01C	-0.13	0.59
SG23	44	36	12	01C	-0.17	2.36
SG24	2	94	1	01C	0.17	0.76
SG24	11	3	28	01C	-0.04	1.54
SG24	25	87	1	01C	0	0.28
SG24	27	83	1	01C	-0.11	0.79
SG24	28	83	29	01C	-0.06	1.35
SG24	28	85	1	01C	0.31	0.68
SG24	29	82	44	01C	0	2.06
SG24	30	82	10	01C	-0.11	0.79
SG24	31	79	1	02C	0.17	0.75
SG24	31	82	15	01C	0.04	0.25
SG24	36	75	1	02C	0.19	0.5
SG24	36	76	7	01C	0.09	0.55
SG24	36	76	1	02C	0.11	0.58
SG24	37	73	5	01C	-0.17	0.43
SG24	37	75	1	01C	-0.11	0.78
SG24	38	23	28	02C	0	0.24
SG24	38	73	15	01C	-0.06	1.14
SG24	39	23	1	02C	-0.11	1.27
SG24	39	71	5	01C	-0.2	0.61
SG24	41	59	24	01C	-0.02	0.35
SG24	42	59	10	02C	0	0.39
SG24	43	33	30	02C	-0.02	0.32
SG24	43	58	9	02C	0.3	1.14
SG24	43	62	4	02C	0.21	2.32
SG24	43	62	1	01C	0.15	0.97
SG24	43	64	25	02C	0.15	0.96
SG24	44	36	11	03C	0.04	0.6
SG24	44	58	26	01C	-0.04	0.98
SG24	44	58	1	02C	-0.27	0.78
SG24	44	59	22	01C	-0.11	1.45
SG24	44	59	5	02C	0.19	1.24
SG24	44	60	1	01C	0.11	0.51
SG24	44	62	5	02C	0.09	1.44
SG24	45	37	1	02C	0.02	0.69
SG24	45	48	20	02C	0.04	0.66
SG24	45	51	5	02C	0.06	0.32
SG24	45	57	1	01C	-0.17	0.56
SG24	45	59	1	02C	-0.28	0.6