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Docket No. 50-275, OL-DPR-80
Diablo Canyon Unit 1
Special Report 02-02 - Results of Steam Generator Inspections for Diablo Canyon Power Plant Unit 1 Eleventh Refueling Outage

Dear Commissioners and Staff:

In accordance with Technical Specifications (TS) 5.6.10.e and 5.6.10.f, Enclosure 1 provides the 90-day reporting of results of Unit 1 steam generator (SG) W* alternate repair criteria (ARC) tubesheet inspections and calculated steam line break leakage from application of all ARC.

In accordance with TS 5.6.10.h, Enclosure 2 provides the 120-day reporting of results of Unit 1 SG primary water stress corrosion cracking ARC inspections at dented tube support plate intersections.

In accordance with PG&E's commitment to NEI 97-06, Revision 1, Enclosure 3 provides the 120-day SG condition monitoring report. This report is required when greater than one percent of inspected SG tubes are classified as defective.

In accordance with PG&E's commitment to Generic Letter 95-05, "Voltage-Based Repair Criteria for Westinghouse Steam Generator Tubes Affected by Outside Diameter Stress Corrosion Cracking," Enclosure 4 provides the 90-day reporting of results of Unit 1 SG voltage-based ARC inspections at tube support plate intersections provided by Framatone ANP.

Sincerely,

David Miklush for
Lawrence F. Womack

A001

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SPECIAL REPORT 02-02

RESULTS OF STEAM GENERATOR W* ALTERNATE REPAIR CRITERIA TUBESHEET INSPECTIONS

DIABLO CANYON POWER PLANT UNIT 1 ELEVENTH REFUELING OUTAGE

NRC Reporting Requirements

Diablo Canyon Power Plant (DCPP) Technical Specification (TS) 5.6.10.e requires that the results of the inspection of Wstar (W*) tubes be reported to the Commission pursuant to 10 CFR 50.4 within 90 days following return to service of the steam generators (SGs). The report shall include:

1. Identification of W* tubes. Per TS 5.5.9.d.1.k, a W* tube is a tube left in service with degradation within or below the W* length.

2. W* inspection distance measured with respect to the Bottom of the WEXTEX Transition (BWT) or the top of tubesheet, whichever is lower.

3. Elevation and length of axial indications within the flexible W* distance and the angle of inclination of clearly skewed axial cracks (if applicable).

4. The total steam line break leakage for the limiting SG per WCAP-14797 ("Generic W* Tube Plugging Criteria for 51 Series Steam Generator Tubesheet Region WEXTEX Expansions").

DCPP TS 5.6.10.f requires that the aggregate calculated steam line break leakage from application of all alternate repair criteria (ARC) be reported to the Commission pursuant to 10 CFR 50.4 within 90 days following return to service of the SGs.

W* Inspections and Results

This report implements the DCPP TS reporting criteria. W* ARC was implemented for the third time during the Unit 1 eleventh refueling outage (1R11). Following 1R11 SG inspections and repairs completed in May 2002, the SGs were returned to service.

One hundred percent of the SG tubes were inspected by bobbin from tube end to tube end. One hundred percent of the hot leg top of tubesheet (TTS) region was inspected by Plus Point. Cold leg TTS inspections by Plus Point were not required.

Table 1 provides a comprehensive list of axial primary water stress corrosion cracking (PWSCC) indications detected in the WEXTEX region during 1R11 Plus Point inspections. The following TS-required reporting information is extracted from the table:

1. *Identification of W* tubes.* See "W* Tube" column in Table 1. A total of 14 tubes with 16 indications are identified in Table 1. Thirteen tubes, containing a total of 14 single axial PWSCC indications (SAI) and 1 single volumetric indication (SVI) located below the W* length, are categorized as W* tubes and left in service. One tube with axial PWSCC was plugged because of failure to meet W* ARC (upper crack tip was above BWT). There were 6 additional tubesheet indications in non-W* tubes that were plugged and are not listed in Table 1: five circumferential outside diameter stress corrosion cracking (ODSCC) indications at the top of tubesheet were plugged because the crack type and location excluded application of W* ARC; one circumferential PWSCC indication located below the W* length was plugged due to a pluggable indication at a tube support plate location.

2. *W* inspection distance measured with respect to BWT or TTS, whichever is lower.* For the one hundred percent Plus Point hot leg TTS exam, the inspection extent relative to the TTS was specified as +2/-8 inches. Assuming no degradation in the W* length, eight inches below the TTS constitutes the W* inspection distance. This distance bounds W* lengths for Zone A and Zone B (5.2 inch and 7.0 inch, respectively, relative to BWT), and includes margin for a nominal distance from BWT to TTS plus nondestructive examination (NDE) uncertainty in measuring W* length. If degradation is detected in the W* region, the inspection extent must bound the calculated flexible W* length. The "W* Insp Dist" column in Table 1 lists the W* inspection distances measured with respect to BWT for tubes in which axial PWSCC was detected (in all cases, BWT was lower than the TTS).

3. *Elevation and length of axial indications within the flexible W* distance.* See "From-To" and "L" columns in Table 1 for elevation and length of axial indications. Five axial PWSCC indications and one volumetric indication (SVI) were located below the flexible W* distance and left in service. The upper elevation of the SVI was treated as an upper crack tip in the W* calculations.

4. *Angle of inclination of clearly skewed axial cracks (if applicable).* None of the axial indications were skewed, so this reporting requirement is not applicable.

5. *The total steam line break leakage for the limiting SG per WCAP-14797.* Steamline break (SLB) leakage attributed to each W* indication at end of the cycle (EOC) 11 (condition monitoring) and projected EOC 12 (operational assessment) are listed in "CM LR" and "OA LR" columns in Table 1. It can be noted that the W* leakage model assumes all W* indications are throughwall cracks. Based on the maximum depths given in Table 1 (largest is 82%), none of the W* indications would be expected to leak at SLB conditions. The total SLB leakage for the limiting SG is listed in Table 2.

Table 2 reports the following SLB leak rates, pursuant to TS 5.6.10.e.4 and 5.6.10.f:

1. Total W* ARC SLB leakage for each SG at EOC 11. The maximum leak rate is 0.0904 gpm (at room temperature) in SG 1-2.

2. Total W* ARC SLB leakage for each SG at EOC 12. The maximum leak rate is 0.05163 gpm (at room temperature) in SG 1-2. This leak rate is less than the condition monitoring leak rate at EOC 11 due to the new indication in SG 11 at R3C38, which extended into the expansion transition (i.e., above BWT), and the indication was plugged.

3. The aggregate calculated SLB leakage from application of voltage-based ARC, PWSCC ARC, and W* ARC at EOC 11. The maximum leak rate is 0.368 gpm (at room temperature) in SG 1-2.

4. The aggregate calculated SLB leakage from application of voltage-based ARC, PWSCC ARC, and W* ARC at EOC 12. The maximum leak rate is 1.115 gpm (at room temperature) in SG 1-1.

For W* ARC, the SLB differential pressure is assumed to be 2560 psi. For PWSCC ARC and voltage-based ARC, the SLB differential pressure is assumed to be 2405 psi.

<u>Axial PWSCC Growth Rates</u>

Of the 15 axial PWSCC indications detected in 1R11, 3 were new indications, 2 were in deplugged tubes, and 10 were repeat W* indications that had been left in service in the prior inspection. Of the 3 new indications, 2 had prior inspection data. Based on prior inspection data, one was detectable and one was not detectable, resulting in a total of 11 new growth rate data points. The average growth rate of the 11 indications was 0.015 inch per effective full power year (EFPY) at Thot of 604 degrees F.

After addition of the 11 new data points, the updated W* growth rate distribution now consists of 108 data points from DCPP Units 1 and 2. The updated growth rate at 95 percent cumulative probability is 0.071 inch per EFPY at 604 degrees F. The pre-1R11 growth rate at 95 percent cumulative probability is 0.081 inch per EFPY at 604 degrees F (based on 97 data points), and this value is conservatively used in the operational assessment for DCPP Unit 1 Cycle 12.

The actual length of Unit 1 Cycle 11 was 1.41 EFPY. The projected length of Unit 1 Cycle 12 is 1.61 EFPY.

<u>Insitu Leak Testing</u>

In support of W* leak rate model validation, PG&E letter DCL-01-095 dated September 13, 2001, defined a four step sequential screen process for determining the need for insitu leak testing of axial PWSCC indications in the WEXTEX region. The 15 axial PWSCC indications detected in 1R11 were evaluated against the four steps, none exceeded the criteria, and therefore none were leak tested. The criteria and PG&E evaluation are described below. Maximum voltages and maximum depths for each indication are provided in Table 1.

- Step 1: Prior leak tested W* indications with maximum Plus Point voltages greater than or equal to 1.25 times the prior leak test voltage are carried to Step 2. W* indications with no prior leak test are also carried to step 2.

  PG&E evaluation: No W* indications had been leak tested in prior outages, so all 15 indication were carried to step 2.

- Step 2: Indications with maximum Plus Point voltages exceeding the critical voltage (V_{crit}) are leak tested independent of other parameters. V_{crit} equals 4.0 volts for nondeplugged indications and 6.0 volts for deplugged indications. Indications with maximum Plus Point voltages less than V_{crit} are carried to Step 3.

  PG&E evaluation: The maximum voltage of the 13 nondeplugged axial PWSCC indications was 0.8 volts, less than the 4.0 volt threshold value. The maximum voltage of the 2 deplugged axial PWSCC indications was 1.25 volts, less than the 6.0 volt threshold value. Therefore, since no indications exceeded V_{crit}, all indications were carried to step 3.

- Step 3: Indications with maximum Plus Point voltages exceeding V_{thr} are carried to the Step 4 depth evaluation. A minimum of the five largest voltage indications are carried to the depth evaluation if less than five indications exceed the voltage threshold. V_{thr} equals 2.5 volts for nondeplugged indications and 4.0 volts for deplugged indications.

  PG&E evaluation: The maximum voltage of the 13 nondeplugged axial PWSCC indications was 0.8 volts, less than the 2.5 volt threshold value. The maximum voltage of the 2 deplugged axial PWSCC indications was 1.25 volts, less than the 4.0 volt threshold value. Therefore, since no indications exceeded V_{thr}, the five largest voltage indications are required to be carried to step 4.

- Step 4 (depth evaluation): Indications with maximum depths exceeding the maximum depth leakage threshold (MD_{L-thr}) over lengths greater than the deep crack length threshold (L_{L-min}) are leak tested. MD_{L-thr} equals 80% and L_{L-min} equals 0.1 inch.

  PG&E evaluation: All axial PWSCC indications in the WEXTEX region were depth profiled using the same techniques as axial PWSCC at dented TSP intersections. The maximum depth of one indication exceeded 80 percent (SG 12 R20C37), but the flaw length greater than 80 percent was much less than the 0.1 inch threshold value. Therefore, since there were no indications with maximum depth greater than $MD_{L\text{-}thr}$ over lengths greater than $L_{L\text{-}min}$, no indications required insitu leak testing.

Tube Integrity Performance Monitoring

Condition Monitoring Performance Criteria to Limit Free Span Cracking: The upper crack tip (UCT) of W* indications returned to service at EOC10 under W* ARC shall remain below the TTS at EOC 11 by at least the NDE uncertainty on locating the crack tip relative to the TTS. The "UCT to TSH" column in Table 1 provides the EOC 11 elevation of the upper crack tip relative to the top of tubesheet, accounting for NDE uncertainty in locating the crack relative to the top of tubesheet. In all cases, the EOC 11 crack tip for indications returned to service at EOC 10 is below the top of tubesheet. Therefore, the performance criterion was satisfied for condition monitoring at EOC 11.

Accident-Induced Leakage Performance Criteria: Calculated W* leak rates under postulated SLB conditions, when combined with calculated leak rates from application of GL 95-05 voltage-based ARC and PWSCC ARC, shall not exceed 12.8 gpm (at room temperature) in the faulted SG for condition monitoring and 10.5 gpm (at room temperature) for operational assessment. The 12.8 gpm condition monitoring limit is the current licensing basis leak rate limit as approved in NRC letter to PG&E dated March 12, 1998. The more conservative 10.5 gpm operational assessment limit is pending NRC approval of license amendment request (LAR) 01-05, which is expected in late 2002 during Unit 1 Cycle 12. The aggregate calculated SLB leakage from application of all ARC at EOC 11 is 0.368 gpm for the limiting SG. The aggregate calculated SLB leakage from application of all ARC at EOC 12 is 1.115 gpm for the limiting SG. In both assessments, SLB leakage is less than the allowable limit. Therefore, the performance criterion has been satisfied for condition monitoring at EOC 11 and operational assessment at EOC 12.

Table 1

DCPP Unit 1
1R11 Indications in Hot Leg WEXTEX Tubesheet Region (excluding circumferential indications that were plugged)

SG	R	C	Ind	+Pt volt	MD	From	To	L	UCT to TSH	W* Zone	W* L	BWT	EOC11 UCT-BWT	UCT Below W*	UCT Below BWT	EOC 12 UCT	UCT Below TSH at EOC12	W* Tube	Insp Ext	W* Insp Dist	Flex W* L	CM LR	EOC12 UCT-BWT	OA LR	Plug 1R11	Type
11	3	2	SAI	0 35	47	-1 53	-1 34	0.19	-1 12	A	5 32	0 22	1 28	No	Yes	-0 99	Yes	Yes	-12.8	12.93	5.50	0.00740	1.15	0.00816	No	Repeat
11	15	10	SAI	0 63	40	-9 03	-8 88	0 15	-8 66	A	5 32	-0 24	8 36	Yes	Yes	-8 53	Yes	Yes	-10 57	10 24	5 32	0	8.23	0	No	New
11	15	10	SAI	0 8	46	-8 51	-8 37	0.14	-8 15	A	5 32	-0 24	7 85	Yes	Yes	-8 02	Yes	Yes	-10 57	10 24	5 32	0	7 72	0	No	New
11	20	44	SAI	0 31	34	-7 96	-7 82	0 14	-7 6	B2	7.12	-0 31	7 23	Yes	Yes	-7 47	Yes	Yes	-10 95	10 55	7.12	0	7.10	0 00051	No	Repeat
12	3	38	SAI	0 22	67	-0 32	-0 19	0 13	0 03	B1	7.12	-0 31	-0 4	No	No	0 16	No	No	-9 74	9 34	7 24	0 04530	NA	NA	Yes	New
12	7	33	SAI	1	71	-2 03	-1	1 03	-0 78	B2	7.12	-0 35	0 37	No	Yes	-0 65	Yes	Yes	-10 32	9 88	8.14	0 03100	0 24	0 03583	No	deplug 1R11
12	20	37	SAI	1.25	82	-1 9	-1.75	0 15	-1.53	B3	7.12	-0 18	1 29	No	Yes	-1.40	Yes	Yes	-12 32	12 05	7 26	0 01410	1.16	0 01581	No	deplug 1R11
13	2	14	SVI	0 59	NA	-8 36	-8 12	0 24	-7.9	A	5 32	-0 2	7 64	Yes	Yes	-7.77	Yes	Yes	-9 28	8 99	5 32	0	7 64	0	No	deplug 1R11
13	31	36	SAI	0 47	20	-2 92	-2.77	0 15	-2 55	A	5.32	-0 25	2 24	No	Yes	-2.42	Yes	Yes	-9 43	9 09	5 46	0 00360	2.11	0 00385	No	Repeat
13	33	37	SAI	0 53	24	-5 5	-5 36	0 14	-5 14	A	5 32	-0 48	4 6	No	Yes	-5 01	Yes	Yes	-9.11	8 54	5 45	0 00054	4 47	0 00059	No	Repeat
13	30	45	SAI	0 31	20	-1.9	-1.81	0 09	-1.59	B4	7.12	-0 27	1 26	No	Yes	-1 46	Yes	Yes	-9 3	8 94	7 20	0 01100	1.13	0 01212	No	Repeat
13	39	46	SAI	0.74	26	-2.43	-2.31	0.12	-2.09	A	5.32	-0.27	1.76	No	Yes	-1.96	Yes	Yes	-9 84	9 48	5 43	0 00500	1 63	0 00556	No	Repeat
14	23	7	SAI	0 45	41	-8 21	-8.06	0.15	-7.84	A	5 32	-0.16	7.62	Yes	Yes	-7.71	Yes	Yes	-10.68	10.43	5.32	0	7.49	0	No	Repeat
14	28	57	SAI	0 27	20	-3 26	-3 11	0 15	-2 89	B4	7.12	-0 34	2 49	No	Yes	-2.76	Yes	Yes	-10 46	10 03	7.26	0.00420	2.36	0 00457	No	Repeat
14	28	57	SAI	0 35	20	-7 28	-7.13	0 15	-6 91	B4	7.12	-0 34	6 51	No	Yes	-6 78	Yes	Yes	-10 46	10 03	7.26	0 00022	6.38	0.00022	No	Repeat
14	39	58	SAI	0 32	20	-6 22	-6 07	0.15	-5 85	A	5.32	-0 11	5 68	Yes	Yes	-5 72	Yes	Yes	-10 23	10 03	5 32	0	5 55	0	No	Repeat

Column – Table 1	Legend and Notes for Table 1
SG	Steam generator
R	Row
C	Column
Ind	Plus point indication. SAI is single axial indication. SVI is single volumetric indication.
+P Volt	Peak voltage from Plus Point coil
MD	Maximum depth, percent through-wall, using TSP axial PWSCC depth sizing technique
From	Elevation (inch) of lower crack tip, relative to the top of tubesheet hot leg (TSH)
To	Elevation (inch) of upper crack tip, relative to the top of tubesheet hot leg (TSH).
L	Length of crack (inch)
UCT to TSH	Elevation (inch) of the upper crack tip (UCT) to TSH, including ΔNDE_{CT-TTS} (Plus Point NDE uncertainty on locating the crack tip relative to the TTS). None of the indications extended above the top of tubesheet.
W* Zone	W* tubesheet zone based on crack location
W* L	W* length is 7.12 inch for Zone B and 5.32 inch for Zone A, and includes ΔNDE_{W} (NDE uncertainty in measuring the W* depth)
BWT	Bottom of the WEXTEX transition (inch), measured by bobbin relative to TSH.
EOC 11 UCT to BWT	Distance (inch) from the upper crack tip (UCT) to BWT at EOC 11, minus ΔNDE_{CT-BWT} (Plus Point NDE uncertainty on locating the crack tip relative to the BWT).
UCT below W*?	If the UCT is located below the W* length, then the tube is a W* tube Any type of degradation below the W* length is acceptable
UCT below BWT?	If the UCT is located below BWT, then the tube is a W* candidate.
EOC 11 UCT	UCT location (inch) relative to TSH at the end of the next operating cycle, EOC 12, based on growing the UCT at 0 081 inch/EFPY. Unit 1 Cycle 12 is projected to be 1 61 EFPY.
UCT below TSH at EOC 11?	If the UCT is below TSH at EOC 12, a free span indication is precluded and the tube is a W* candidate.
W* Tube?	If the EOC 11 UCT is below BWT and the UCT is projected to be below TSH at EOC 12, then the tube is a W* tube
Insp Ext	Inspection extent of Plus Point relative to TSH (inch)
W* Insp Dist	W* inspection distance (inch) This is the +Point inspection extent relative to BWT. The W* inspection distance below BWT is equal to the Plus Point inspection extent below TSH, plus measured distance from BWT to TSH, plus bobbin NDE uncertainty in locating BWT relative to TSH The W* inspection distance must be greater than or equal to the flexible W* length.
Flex W* L	Flexible W* length relative to BWT (inch), equal to W* Length + $\sum Cl_i$ (total axial crack length) + $N_{CL}*\Delta NDE_{CL}$ (number of indications times Plus Point NDE uncertainty with measuring length of axial cracks) + $N_{CL}*\Delta CG$ (number of indications times crack growth allowance from prior cycle tube integrity assessment, 0 081 inch/EFPY)
CM LR	Condition monitoring SLB leak rate at EOC 11 conditions, gpm at room temperature, based on distance of UCT (at EOC 11) to BWT using Figure 6 4-3 of WCAP-14797 Rev 1. No accident leakage is assigned to deplugged indications and an indication with UCT below W* length
EOC 12 UCT to BWT	Distance (inch) from the upper crack tip (UCT) to BWT at EOC 12, minus ΔNDE_{CT-BWT} (Plus Point NDE uncertainty on locating the crack tip relative to the BWT), based on growing the UCT at 0.081 inch/EFPY (95% growth rate).
OA LR	Operational assessment leak rate at EOC 12 conditions based on EOC 12 UCT to BWT, gpm at room temperature, using Figure 6 4-3 of WCAP-14797 Rev 1. No accident leakage is assigned to an indication with UCT below W* length.
Plug 1R11?	Tube was plugged in 1R11.
Type	Identifies the flaw as new, repeat, or deplugged in 1R11.

Table 2

DCPP Unit 1 Steam Line Break Leak Rates for Alternate Repair Criteria

EOC 11 Condition Monitoring Leak Rate (gpm at room temperature)	SG 1-1	SG 1-2	SG 1-3	SG 1-4
W* ARC	0 00740	0.09040	0.02014	0 00442
Voltage-Based ARC	0.325	0.278	0.153	0.059
PWSCC ARC	0	0	0	0
Aggregate ARC	0.332	0.368	0.173	0 063

EOC 12 Operational Assessment Leak Rate (gpm at room temperature)	SG 1-1	SG 1-2	SG 1-3	SG 1-4
W* ARC	0.00868	0 05163	0.02213	0.00480
Voltage-Based ARC	1.106 (1)	0.861	0.436	0.233
PWSCC ARC	0	0	0	0
Aggregate ARC	1.115	0 913	0 458	0.238

Note 1: SG 1-1 leak rate of 1.106 gpm was calculated using a normal growth rate distribution. Using a more conservative voltage-dependent growth rate distribution, a leak rate of 1.143 gpm is calculated for SG 1-1.

SPECIAL REPORT 02-02

RESULTS OF STEAM GENERATOR PRIMARY WATER STRESS CORROSION CRACKING (PWSCC) ALTERNATE REPAIR CRITERIA INSPECTIONS AT DENTED TUBE SUPPORT PLATE INTERSECTIONS

DIABLO CANYON POWER PLANT UNIT 1 ELEVENTH REFUELING OUTAGE

NRC Reporting Requirements

For implementation of the alternate repair criteria for axial PWSCC at dented TSPs, DCPP TS 5.6.10.h requires that the results of the condition monitoring and operational assessments will be reported to the NRC within 120 days following completion of the inspection. The report will include:

- Tabulations of indications found in the inspection, tubes repaired, and tubes left in service under the ARC.
- Growth rate distributions for indications found in the inspection and growth rate distributions used to establish the tube repair limits.
- Plus Point confirmation rates for bobbin detected indications when bobbin is relied upon for detection of axial PWSCC in less than or equal to 2 volt dents.
- For condition monitoring, an evaluation of any indications that satisfy burst margin requirements based on the Westinghouse burst pressure model, but do not satisfy burst margin requirements based on the combined Argonne National Laboratory (ANL) ligament tearing and throughwall burst pressure model.
- Performance evaluation of the operational assessment methodology for prediction of flaw distributions as a function of flaw size.
- Evaluation results of number and size of previously reported versus new PWSCC indications found in the inspection, and the potential need to account for new indications in the operational assessment burst evaluation.
- Identification of mixed mode (axial PWSCC and circumferential) indications found in the inspection and an evaluation of the mixed mode indications for potential impact on the axial indication burst pressures or leakage. In addition, as committed in DCL-02-045, performance of a trending analysis to assess the potential for increasing mixed mode affects over time.
- Any corrective actions found necessary in the event that condition monitoring requirements are not met.

This report implements the DCPP TS reporting criteria. PWSCC ARC was implemented for the first time in DCPP Unit 1 during 1R11. 1R11 SG inspections and repairs were completed during May 2002.

Dented TSP Plus Point Inspection Scope

The initial 1R11 Plus Point dent inspection scope was based on greater than 2 volt dents called in the prior 1R10 outage. This initial scope was supplemented by greater than 2 volt dents called in 1R11 from three sources: previously unidentified greater than 2 volt dents, expansion scope in SG 1-4 as discussed later, and deplugged tube dents in SG 1-2. The number of dents inspected in 1R11 is provided in Table 1.

The dented TSP inspection criteria and expansion plan criteria described below are based on PG&E letter to the NRC dated April 16, 2001, and WCAP-15573, Revision 1, "Depth-Based SG Tube Repair Criteria for Axial PWSCC at Dented TSP Intersections – Alternate Burst Pressure Calculation."

Plus Point inspection criteria for axial PWSCC left in service

Plus Point inspections shall be conducted on 100 percent of axial PWSCC indications at dented TSP intersections that were left in service in Unit 1 Cycle 11. One hundred eleven axial PWSCC indications had been left in service that were less than 40 percent maximum depth.

Plus Point inspection criteria for >2 and <5 volt dents and for ≥ 5 volt dents

On a SG-specific basis, Plus Point inspections shall be conducted on 100 percent of ≥ 5 volt dented intersections up to and including the highest hot leg TSP elevation where PWSCC (at any size dent), circumferential indications (at any size dent), or axial ODSCC Not Detected by Bobbin (AONDB) (at ≥ 5 volt dent) have been previously detected in that SG in the prior two outages, or current outage (expansion required), plus 20 percent of ≥ 5 volt dents at the next higher TSP elevation. In each SG where 100 percent hot leg TSP Plus Point inspections are not required, Plus Point inspections shall be conducted on 20 percent of ≥ 5 volt dents at each hot leg TSP. For any 20 percent sample, a minimum of 50 ≥ 5 volt dents shall be inspected. If the population of ≥ 5 volt dents at that TSP elevation is less than 50, then 100 percent of the ≥ 5 volt dents at that TSP shall be inspected.

On a SG-specific basis, Plus Point inspections shall be conducted on 100 percent of > 2 and < 5 volt dented intersections up to and including the highest hot leg TSP elevation where PWSCC (at any size dent), circumferential indications (at any size dent), or ≥ 2 inferred volt AONDB (at > 2 and < 5 volt dent) have been previously detected in that SG in the prior two outages, or current outage (expansion required), plus 20 percent of > 2 and < 5 volt dent at the next higher TSP elevation. If a SG is free from PWSCC (at any size dent), circumferential indications (at any size dent) and ≥ 2 inferred volt AONDB (at > 2 and < 5 volt dent), then Plus Point inspections shall be conducted on 20 percent of > 2 and < 5 volt dents at 1H. For any 20 percent sample, a minimum of 50 > 2 and < 5 volt dents shall be inspected. If the population of > 2 and

< 5 volt dents at that TSP elevation is less than 50, then 100 percent of the > 2 and < 5 volt dents at that TSP shall be inspected.

The highest TSP where PWSCC or circumferential indications have been found in the prior two outages is 4H for SG 1-1, 6H for SG 1-2, and 3H for SG 1-4. In SG 1-3, no PWSCC or circumferential indications have been detected. Because all inferred bobbin voltages for AONDB indications have been less than 2 volts, AONDB indications do not factor into the inspection scope. Based on this information, the following Plus Point dent inspection criteria was implemented to meet the requirements specified above.

≥ 5 volt dents:

- SG 1-1: 100% at 1H to 4H, 20% at 5H to 7H
- SG 1-2: 100% at 1H to 6H, 20% at 7H
- SG 1-3: 20% at 1H to 7H
- SG 1-4: 100% at 1H to 3H, 20% at 4H to 7H

> 2 and < 5 volt dents:

- SG 1-1: 100% at 1H to 4H, 20% at 5H
- SG 1-2: 100% at 1H to 6H, 20% at 7H
- SG 1-3: 20% at 1H
- SG 1-4: 100% at 1H to 3H, 20% at 4H

In 1R11, axial PWSCC was detected at TSP 6H in SG 1-4 R26C37 at a 0.62 volt dent. The indication was originally detected by bobbin as a distorted ID support signal (DIS) indication and was confirmed by Plus Point. Because TSP 6H was a higher elevation than the original inspection scope, the Plus Point inspection scope in SG 1-4 was expanded during 1R11 in accordance with the following revised inspection criteria:

≥ 5 volt dents: 100% at 1H to 6H, 20% at 7H.
> 2 and < 5 volt dents: 100% at 1H to 6H, 20% at 7H

In addition to the dent inspection program for active tubes, a dent inspection program for deplugged tubes was implemented because 150 tubes in SG 1-2 were deplugged and inspected in 1R11 for potential return to service under alternate repair criteria. The deplugged tube dent inspection criteria was more conservative than the active tube population, requiring Plus Point inspection of 100% of > 2 volt dents at all hot leg TSP intersections.

Plus Point inspection for less than or equal to 2 volt dents

One hundred percent of the tubes were inspected by bobbin coil, and the bobbin coil was relied upon for detection of axial PWSCC in ≤ 2 volt dents. As a result, Plus Point inspection of ≤ 2 volt dents was only required if the bobbin coil detected an indication at the dented TSP intersection. One hundred percent of bobbin indications at dented TSP intersections (DIS indications) were inspected by Plus Point.

Plus Point inspection criteria for detection of circumferential indications at dents

On a SG-specific basis, if a circumferential indication or $\geq$2 inferred volt AONDB is detected in a dent of "x" volts in the prior two outages, or current outage (expansion required), then Plus Point inspections shall be conducted on 100 percent of dents greater than "x - 0.3" volts up to the affected TSP, plus 20 percent of dents greater than "x – 0.3" volts at the next higher TSP. "X" is defined as the lowest dent voltage where a circumferential crack or $\geq$ 2 inferred volt AONDB was detected in that SG. For any 20 percent sample, a minimum of 50 "x – 0.3" volt dents shall be inspected. If the population of "x – 0.3" volt dents at that TSP elevation is less than 50, then 100 percent of the "x – 0.3" volt dents at that TSP shall be inspected.

The smallest dent in which a Unit 1 circumferential crack has been detected in the prior two outages or current outage is 2.45 volts (1R11 circumferential indication in SG 1-2 R35C69). Thus, "x" = 2.45 volts, and "x – 0.3" = 2.15 volts. Since 2.15 volts is greater than 2 volts, the 2 volt dent cutoff for 1R11 Plus Point inspection was sufficient, and no expansion scope was necessary.

<u>Tabulations of indications found in the inspection, tubes repaired, and tubes left in service under the ARC.</u>

Table 5 provides all axial PWSCC indications at dented TSP intersections detected in 1R11 inspections, with the exception of indications that were deplugged and replugged. The following information is provided for each indication:

- For plugged indications, the reason for plugging
- Identifies the indication as repeat, new, or deplugged
- Adjusted NDE measurements of length, maximum depth, average depth, voltage, and crack location relative to the TSP centerline.
- Operational assessment burst pressure (free span and total length) using the ANL and Electric Power Research Institute (EPRI) burst model. A burst pressure of 6100 psi in Table 5 represents a predicted burst pressure ≥ 6100 psi since all pressures predicted to exceed 6100 psi are grouped at 6100 psi to reduce computer storage requirements in the analysis.
- Operational assessment SLB leak rate (free span and total length) using the ANL ligament tearing model.

One hundred eleven axial PWSCC indications had been left in service following 1R10 because they were <40% maximum depth in 1R10. Following 1R11 Plus Point inspection and sizing and application of PWSCC ARC requirements, all of the repeat axial PWSCC indications were again determined to be acceptable (OA burst pressure exceeded 6100 psi with no SLB leakage). However, 11 required plugging because of PWSCC ARC exclusion criteria (10 for ID/OD flaw combinations and one for a mixed mode flaw combination). Therefore, 100 of the 111 repeat axial PWSCC indications were returned to service.

In 1R11, 20 new axial PWSCC indications were detected in active tubes. Following Plus Point sizing and application of PWSCC ARC requirements, all were determined to be acceptable (OA burst pressure exceeded 6100 psi with no SLB leakage). However, 5 required plugging because of PWSCC ARC exclusion criteria (ID/OD flaw combinations).

One hundred fifty tubes were deplugged in SG 1-2 in 1R11 and 164 axial PWSCC indications at dented TSPs were detected in these tubes. Table 5 lists 100 axial PWSCC indications that were returned to service in SG 1-2 following tube deplugging, as the operational assessment (OA) burst pressure exceeded the burst margin requirements. The lowest OA burst pressure returned to service was 4152 psi. Sixty four of the 164 deplugged indications were replugged and are not included in Table 5 because they are not subject to condition monitoring and operational assessment.

In summary, 215 axial PWSCC indications were returned to service in 1R11: one hundred repeat indications, 15 new indications, and 100 deplugged indications.

Condition monitoring and operational assessment for ID/OD flaw combinations in provided in Enclosure 3.

<u>Growth rate distributions for indications used to establish the tube repair limits.</u>

The growth rate distribution used to establish the tube repair limits was based on prior outage growth data. The methodology for establishing the growth rate was established in WCAP-15573, Revision 1 as further explained in PG&E letters DCL-02-023 and DCL-02-045.

Because there are less than 200 growth rate data points over the last two Unit 1 cycles (there are 124 data points over Unit 1 Cycles 9 and 10), the methodology used to establish the growth rate distribution is described below. The number of cycles needed to total 200 growth points is determined. In this case, 6 cycles of data (i.e. Unit 1 Cycle 8, Unit 1 Cycle 9, Unit 1 Cycle 10, Unit 2 Cycle 8, Unit 2 Cycle 9, and Unit 2 Cycle 10) are evaluated because 6 cycles are needed to exceed 200 points. The data from each of these cycles was compared for consistency in growth magnitude. If a given cycle has lower growth rates than other cycles, it is not included in the growth distribution. For average depth and maximum depth, Unit 1 Cycle 8 and Unit 1 Cycle 10 data were excluded. For length, Unit 1 Cycle 8, Unit 2 Cycle 8, and Unit 2

Cycle 9 data were excluded. These evaluations for excluding data were documented in DCL-02-023 and DCL-02-045. In addition, if any deleted data points are greater than the 95 percent values in the resulting distribution, they are added back into the distribution (5 data points were added back in this manner).

Table 2 provides the growth rate data at 603 degrees F over the 6 cycles, and indicates if the data was used in the growth distribution for 1R11 repair decisions based on the above methodology.

Based on the Table 2 data that was not excluded, Table 3 provides the growth rate cumulative distribution fraction (CDF) at 604 degrees F that was used in the 1R11 Monte Carlo operational assessment calculations for determining the need for tube repair. The average Thot in Unit 1 Cycle 11 was 604 degrees F, and 604 degrees F Thot is also expected for Unit 1 Cycle 12. Unit 1 growth rates were adjusted using the Arrhenius equation to account for differences in Thot between Unit 1 and Unit 2. The 90 percentile growth values per EFPY at 604 degrees F were 0.069 inch length, 12.07 percent maximum depth, and 9.23 percent average depth.

<u>Growth rate distributions for indications found in the inspection, and growth rate distributions to be used in next operational assessment.</u>

In accordance with WCAP-15573, Revision 1, growth rates that could impact the upper tail of the growth distribution were evaluated during 1R11. The methodology requires that if new growth data cause the growth distribution above 90 percent probability to be more conservative, the new data is added to the growth distribution for the operational assessment.

Figures 1, 2, and 3 compare cumulative probability distribution (CPD) growth rate distributions for the operational assessment (pre-1R11 data), 1R11 data, and combined pre-1R11 plus 1R11 data. There were 119 growth rate data points from Unit 1 Cycle 11 based on 1R11 inspections. The 90 percent growth values per EFPY at 604 degrees F of this data set were 0.037 inch length, 7.8 percent maximum depth, and 6.29 percent average depth, which are smaller than the 90 percent values for the pre-1R11 data set (0.069 inch length, 12.07 percent maximum depth, and 9.23 percent average depth). When the pre-1R11 and the 1R11 data sets are combined, the resulting 90 percent values are 0.055 inch length, 9.36 percent maximum depth, and 8.32 percent average depth. Because the pre-1R11 growth rate is more conservative than the combined growth rate, no growth data from 1R11 was added to the growth rate distributions for the Monte Carlo operational assessment.

The number of growth rate data points in 1R10 and 1R11 are 83 and 119, respectively, such that there are 202 points over the last two cycles. Because there are a total of at least 200 points over the last two cycles on Unit 1, the growth distribution used for the next operational assessment in 1R12 should be the more conservative of 1R10 data, 1R11 data, or 1R10 plus 1R11 combined data.

Figures 1 through 3 compare the 1R10 data, 1R11 data, and the combined 1R10 plus 1R11 data. For maximum depth and average depth, the growth rate distributions are essentially the same for the 1R10 data, the 1R11 data, and the combined 1R10 plus 1R11 data (the 1R11 data is slightly more conservative than the other two data sets). However, for length, the 1R10 data is more conservative than the combined 1R10 plus 1R11 data and the 1R11 data. The 1R10 data has the most conservative length growth but the least conservative average depth growth. Average depth and length are linked, such that for the same profile, longer lengths equate to smaller average depths, thereby explaining the 1R10 growth trend. For the next operational assessment in 1R12, the following growth data will be used in accordance with the above criteria: 1R10 length data, 1R11 average depth data, and 1R11 maximum depth data.

Figures 1 through 3 also compare the pre-1R11 data with the above data. For maximum depth and average depth, the pre-1R11 data set is more conservative than all other data sets. Likewise, for length, the pre-1R11 data set is more conservative than all other data sets, with the exception of the 1R10 data set. As discussed above, the 1R10 data has the most conservative length growth but the least conservative average depth growth. Therefore, it is concluded that the 1R11 OA predictions using the pre-1R11 growth rate distribution provides the most conservative assessment for structural and leakage integrity.

<u>Plus Point confirmation rates for bobbin detected indications when bobbin is relied upon for detection of axial PWSCC in less than or equal to 2 volt dents.</u>

In 1R11, the bobbin coil was relied upon for detection of axial PWSCC in less than or equal to 2 volt dents. As identified in Table 4, there were 537 DIS indications detected by bobbin in non-repeat PWSCC indications. Tracking of Plus Point confirmation rates in repeat PWSCC indications for active and deplugged tubes is not required because these known flaws are inspected by Plus Point regardless of the bobbin call.

All DIS indications were inspected by Plus Point. Only 9 of the 537 DIS indications were confirmed as PWSCC by Plus Point, for a Plus Point confirmation rate of 1.7 percent, or a 98.3 percent bobbin overcall rate. The high bobbin overcall rate is greater than the overcall rate generated during the bobbin coil performance test documented in WCAP-15573, Revision 1. The high bobbin overcall rate ensures that the bobbin coil results are very conservative, and results in a high probability of detecting significant axial PWSCC indications in less than or equal to 2 volt dents.

<u>For condition monitoring, an evaluation of any indications that satisfy burst margin requirements based on the Westinghouse burst pressure model, but do not satisfy burst margin requirements based on the combined ANL ligament tearing and throughwall burst pressure model.</u>

This item is not applicable, because all indications satisfied condition monitoring burst margin requirements based on the combined ANL ligament tearing and EPRI throughwall burst pressure model. The total length condition monitoring burst requirement for EOC 11 was 3367 psi, based on 1.4 times the SLB differential pressure of 2405 psi (pressurizer PORV setpoint plus uncertainty). The free span length condition monitoring burst requirement for EOC 11 was 4419 psi, based on 3 times the normal operating pressure differential.

<u>Performance evaluation of the operational assessment methodology for prediction of flaw distributions as a function of flaw size.</u>

Even though the ARC was not in effect in Unit 1 Cycle 11, benchmarking was performed of the 111 repeat indications that had been left in service in Unit 1 Cycle 11 because (they were less than 40 percent maximum depth in 1R10). All projected EOC 11 burst pressures for these indications exceeded the default free span and total length burst pressure of 6100 psi, using the ANL/EPRI model. No SLB leakage was projected at EOC 11 for any of these indications, using the ANL ligament tearing leakage model. The EOC 11 projections used a very conservative industry growth rate distribution. The actual EOC 11 condition monitoring burst pressure of these 111 indications also exceeded the default free span and total length burst pressure of 6100 psi using the ANL/EPRI model, and had no SLB leakage using the ANL ligament tearing leakage model. Based on this performance evaluation via benchmarking, the operational assessment methodology is adequately conservative.

<u>Evaluation results of number and size of previously reported versus new PWSCC indications found in the inspection, and the potential need to account for new indications in the operational assessment burst evaluation.</u>

As discussed above, there were 131 axial PWSCC indications detected in 1R11: one hundred eleven repeat indications and 20 new indications. Twelve of the new indications had prior Plus Point inspections in 1R10, and 10 were detectable based on a relook of the 1R10 data. Eight of the new indications had no prior Plus Point inspection, and were detected by bobbin in 1R11 in less than 2 volt dents. Because the number of new flaws is relatively small (only 15 percent of the 138 indications were new) and all new indications have OA burst pressures well in excess of burst margin requirements, there is no need to account for new indications in the OA burst evaluation.

<u>Identification of mixed mode (axial PWSCC and circumferential) indications found in the inspection and an evaluation of the mixed mode indications for potential impact on the axial indication burst pressures or leakage. In addition, performance of a trending analysis to assess the potential for increasing mixed mode affects (e.g., circumferential crack depths, burst pressure reductions, increased leakage rates) over time.</u>

A mixed mode indication is defined as an axial PWSCC indication and a circumferential indication (either PWSCC or ODSCC) occurring at the same dented TSP intersection.

One mixed mode indication (axial PWSCC and circumferential PWSCC) in an active tube was detected during 1R11 and was plugged. The location was SG 1-2 R11C81 2H. The tube had been unplugged in 1R10, and 1R10 Plus Point inspection detected an axial PWSCC indication that was subsequently left in service in Cycle 11 because the maximum depth was less than 40 percent. The circumferential PWSCC indication was not detected in 1R10, but was detectable based on a lookup of 1R10 data. The dent was measured as 3.1 volts.

In 1R11, a null distance of 86 degrees (0.58 inch) was measured between the axial and circumferential indications using the 0.080 pancake coil technique at 600 Khz. The 0.58 inch null distance exceeds the 0.25 inch separation distance requirement, and therefore the flaw is not interacting. Even if the flaw was interacting, the NDE average depth of the circumferential flaw is 49 percent, including 95 percent uncertainty, which is less than the 75 percent average depth threshold value for mixed mode affects. In addition, neither the axial or circumferential indication are 100 percent throughwall at any point. The circumferential indication is 69 percent maximum depth, including 95 percent NDE uncertainty. The measured maximum depth of the axial indication is 27 percent, and has no predicted SLB leakage at 95/50 confidence for condition monitoring (CM). The CM burst pressure of the axial indication is in excess of 6100 psi. Based on this mixed mode assessment, there is no potential impact on the axial PWSCC indication burst pressure or leakage.

There are several conditions that require evaluation to determine the need for corrective actions. These are discussed below.

- If an interacting mixed mode indication is found to have led to a reduction in the axial indication burst pressure by more than 10 percent and to less than 4000 psi, or to have caused an indication to not satisfy burst margin requirements, the burst margin requirements for implementation in the OA at the next and subsequent outages must be increased by the percentage reduction in the burst pressure found for the mixed mode indication. As discussed above, because this condition did not occur, there are no corrective actions needed to adjust burst margin requirements for future operational assessments.

- If an interacting mixed mode indication is found, and the axial indication condition monitoring predicts SLB leakage at 95/50, and the circumferential indication has > 50 percent average depth including NDE uncertainty, then the CM leak rate for the axial indication must be increased by a leakage factor. In addition, the OA SLB leak rate for each SG must be increased by a leakage factor. As discussed above, because this condition did not occur, there are no corrective actions needed to adjust SLB leak rates for CM or OA.

- If a previously Plus Point inspected TSP intersection is found to have a circumferential indication with average depth > 80 percent after accounting for NDE uncertainty, then the OA SLB leak rate for each SG must be increased by a leakage factor. All 1R11 circumferential indications were previously Plus Point inspected in 1R10. The deepest 1R11 circumferential indication was 56 percent average depth, including NDE uncertainty, less than the 80 percent average depth threshold. Therefore, no corrective actions are needed to adjust the OA SLB leak rates.

In response to NRC request for additional information, PG&E letter DCL-02-045 dated April 18, 2002, committed to perform a trending analysis in the 120 day report to assess the potential for increasing mixed mode affects (e.g., circumferential crack depths, burst pressure reductions, increased leakage rates) over time. Since no burst pressure reductions or leakage rate multipliers have been required, there is no data to trend for these parameters. Trending of circumferential depths and number of circumferential indications is provided in Figures 4, 5, and 6. Figure 4 provides all DCPP Units 1 and 2 TSP PWSCC and ODSCC circumferential indication measured average depths versus year detected. The average depths show a fairly flat trend line. Figure 5 data is a subset of Figure 4, showing the mixed mode circumferential indication average depths versus year detected. Only one mixed mode circumferential indication was detected in an axial PWSCC indication that was returned to service (1R11 R11C81, discussed above). The Figure 5 average depths show a decreasing trend line. Figure 6 provides the cumulative distribution of the number of DCPP Units 1 and 2 TSP PWSCC and ODSCC circumferential indications detected over time. The trend does not indicate a large increase in the numbers of circumferential indications in recent inspections.

This trending assessment does not indicate a need to modify the criteria that cause an increase in the burst margin requirements.

<u>Any corrective actions found necessary in the event that condition monitoring requirements are not met.</u>

This item is not applicable because condition monitoring requirements were satisfied.

Condition monitoring requirements for active tubes are satisfied for burst and leakage; therefore no corrective actions are required. All CM burst pressures for active tubes exceeded 6100 psi using the ANL/EPRI throughwall model, at 95 percent probability and 50 percent confidence (95/50). There was no CM SLB free span or total length leakage at 95/50 for active tubes.

Condition monitoring requirements for mixed mode (axial PWSCC and circumferential) indications and circumferential indications were satisfied, and no corrective actions are needed to adjust burst margin requirements or SLB leak rates.

Table 1
Number of > 2 Volt Dents Inspected in 1R11

TSP	SG 1-1	SG 1-2	SG 1-3	SG 1-4	TOTAL
1H	14	254	70	717	1055
2H	75	197	4	206	482
3H	21	160	9	285	475
4H	10	190	7	226	433
5H	11	85	41	121	258
6H	1	26	17	466	510
7H	50	87	50	121	308
TOTAL	182	952	195	2142	3471

Table 2
Axial PWSCC Growth/EFPY Data Set at 603 Degrees F for 1R11 Tube Repair OA

Outage	SG	Row	Col	TSP	Crack No	Length (in.)	Include Data?	Max. Depth (%)	Include Data?	Avg. Depth (%)	Include Data?	Max. Volts
1R8	1	17	39	01H	1	-0 09		-25 58		-18 37		0.37
1R8	1	21	42	01H	1	0.02		-15 89		-9.82		0.20
1R8	1	21	44	01H	1	-0.02		4.65		3 39		0.28
1R8	1	18	64	01H	1	0 05		0 78		2.08		0.54
1R8	1	18	64	03H	1	0 01		1.55		1.25		0.29
1R8	2	26	43	02H	1	-0.06		-9.30		0.10		0.17
1R8	2	43	49	03H	1	-0.01		-2.58		-1.05		0.26
1R8	2	35	56	02H	1	-0.07		0.00		-0.77		0.34
1R8	2	5	66	02H	1	0.02		-14.73		-4.98		0.36
1R8	2	35	67	03H	1	0.02		-19.38		-7.27		0.39
1R8	2	7	68	03H	1	-0.02		8 53		8.17		0.19
1R8	2	14	72	02H	1	0.04		-10.85		-8.15		0.23
1R8	2	16	73	01H	1	0.00		-3.10		-1.07		0 28
1R8	2	14	74	01H	1	-0 04		-8 53		-7.05		0 40
1R8	2	35	77	01H	1	-0 02		23 26	Yes	12 85	Yes	0 30
1R8	2	35	77	01H	2	-0.01		-25 58		-16 36		0.55
1R8	2	13	81	01H	1	0.00		-23 64		-20.30		0 32
1R8	2	16	82	01H	1	-0 05		5 04		7.09		0 06
1R8	3	32	47	03H	1	0 04		-7.75		-4.08		0 65
1R8	4	38	27	01H	1	0 00		-9.30		-4.36		0 55
1R8	4	39	58	01H	1	0.00		-18.99		-11.33		0 32
2R8	2	2	2	01H	1	-0.02		13.58	Yes	10 01	Yes	-0.01
2R8	2	14	15	01H	1	0.06		1.85	Yes	2 89	Yes	0.19
2R8	2	19	15	01H	1	0.02		3.09	Yes	4.20	Yes	0.01
2R8	2	18	16	01H	1	0.04		0.93	Yes	3.93	Yes	0.18
2R8	2	6	24	01H	1	0.02		1.85	Yes	0 15	Yes	0.09
2R8	2	4	28	01H	1	0.05		1.85	Yes	2 11	Yes	0 18
2R8	2	12	28	01H	1	0.02		11.73	Yes	12.50	Yes	0 25
2R8	2	14	29	01H	1	0.01		0.00	Yes	-2.64	Yes	0.06
2R8	2	17	36	01H	1	0.02		-19.75	Yes	-13 48	Yes	0.14
2R8	2	15	42	01H	1	0.00		0.00	Yes	1.98	Yes	0.04
2R8	2	18	44	01H	1	0.02		8.64	Yes	5 40	Yes	0.11
2R8	2	22	45	01H	1	0.02		0.00	Yes	0 81	Yes	0.15
2R8	4	34	34	01H	1	0.02		7.41	Yes	4.88	Yes	0.07
2R8	4	4	37	01H	1	-0.01	Yes	9 26	Yes	4.01	Yes	0 19
1R9	1	9	6	01H	1	0 01	Yes	6.17	Yes	3.93	Yes	-0 08
1R9	1	22	7	03H	1	0.01	Yes	6 79	Yes	6.78	Yes	0.31
1R9	1	23	14	03H	1	0.02	Yes	8 64	Yes	6.98	Yes	0 11
1R9	1	19	15	03H	1	0 03	Yes	3.70	Yes	0.87	Yes	0 07

Outage	SG	Row	Col	TSP	Crack No.	Length (in.)	Include Data?	Max. Depth (%)	Include Data?	Avg Depth (%)	Include Data?	Max. Volts
1R9	1	24	20	02H	1	-0 01	Yes	4.94	Yes	5.56	Yes	0.07
1R9	1	30	21	02H	1	0 05	Yes	-2.47	Yes	-3.28	Yes	0.01
1R9	1	34	24	03H	1	0.07	Yes	4.94	Yes	1.88	Yes	0.03
1R9	1	20	33	01H	1	0.01	Yes	3 09	Yes	0.11	Yes	0 01
1R9	1	38	42	03H	1	-0.01	Yes	2.47	Yes	2.78	Yes	0 04
1R9	1	22	71	02H	1	-0.01	Yes	5 56	Yes	8.52	Yes	0.06
1R9	2	17	9	06H	1	-0 02	Yes	14.20	Yes	9.61	Yes	-0 01
1R9	2	15	10	01H	1	0.02	Yes	-15 43	Yes	-3 96	Yes	0 06
1R9	2	11	27	01H	1	0 01	Yes	14.20	Yes	14.03	Yes	0.10
1R9	2	26	39	02H	1	0.00	Yes	4.94	Yes	6.64	Yes	0.08
1R9	2	11	45	01H	1	0 01	Yes	1.23	Yes	-0.11	Yes	0.01
1R9	2	6	47	01H	1	0 02	Yes	3.70	Yes	2 08	Yes	0.05
1R9	2	11	47	02H	1	-0 01	Yes	0 00	Yes	-2.58	Yes	0.04
1R9	2	20	48	03H	1	-0.09	Yes	-7.41	Yes	-2 03	Yes	0.07
1R9	2	27	50	01H	1	0 00	Yes	4.32	Yes	1.98	Yes	0.17
1R9	2	35	52	03H	1	0 11	Yes	4.94	Yes	2 81	Yes	0.17
1R9	2	7	53	03H	1	-0.07	Yes	12.35	Yes	8.68	Yes	0.03
1R9	2	25	55	02H	1	-0.02	Yes	-1.54	Yes	-3.29	Yes	0.09
1R9	2	16	57	01H	1	-0.01	Yes	4 94	Yes	1.20	Yes	0 20
1R9	2	38	66	01H	1	0.02	Yes	1.23	Yes	4.20	Yes	0 09
1R9	2	33	68	02H	1	-0.14	Yes	8.64	Yes	5.31	Yes	0 02
1R9	2	4	69	01H	1	0.01	Yes	0 00	Yes	4.69	Yes	0 05
1R9	2	19	74	02H	1	0 01	Yes	6 79	Yes	1.58	Yes	0.06
1R9	2	13	75	02H	1	0.01	Yes	0 00	Yes	-1.06	Yes	-0 02
1R9	2	5	77	05H	1	0.01	Yes	8 02	Yes	5 94	Yes	0 07
1R9	2	26	79	01H	1	0.04	Yes	8.02	Yes	6.86	Yes	0.12
1R9	2	8	80	02H	1	0 04	Yes	0.00	Yes	1.08	Yes	0 04
1R9	2	23	82	01H	1	0 00	Yes	3.09	Yes	2.30	Yes	0 00
1R9	2	5	84	01H	1	-0 01	Yes	5.56	Yes	4.79	Yes	0.19
1R9	2	9	87	4H	1	-0 09	Yes	-8.02	Yes	-9.59	Yes	-0 01
1R9	2	8	90	03H	1	0 01	Yes	8.64	Yes	8.61	Yes	0.15
1R9	2	2	92	05H	1	0.02	Yes	0.00	Yes	-0.34	Yes	-0.06
1R9	4	17	24	01H	1	0.03	Yes	0.00	Yes	0 06	Yes	-0.02
1R9	4	20	25	01H	1	-0.02	Yes	0 00	Yes	1.84	Yes	-0.02
1R9	4	46	42	01H	1	0.01	Yes	3.70	Yes	3.93	Yes	-0.05
1R9	4	35	68	03H	1	-0.01	Yes	0.62	Yes	-0 20	Yes	0.12
1R9	4	21	76	01H	1	0 04	Yes	5.56	Yes	4 60	Yes	-0.05
2R9	2	6	3	01H	1	0.02		7.53	Yes	3 49	Yes	0 05
2R9	2	18	7	01H	1	0.08	Yes	10.96	Yes	8.09	Yes	0 23
2R9	2	5	21	01H	1	0 02		17.81	Yes	14.56	Yes	0 08
2R9	2	21	23	02H	1	-0 01		7.53	Yes	8.46	Yes	-0 04
2R9	2	8	26	01H	1	0.01		-10 62	Yes	-10 69	Yes	0.15
2R9	2	5	33	01H	1	0.00		0.00	Yes	0 45	Yes	0.12
2R9	2	28	38	01H	1	0 01		6.16	Yes	3.83	Yes	0.01

Outage	SG	Row	Col	TSP	Crack No.	Length (in.)	Include Data?	Max. Depth (%)	Include Data?	Avg. Depth (%)	Include Data?	Max. Volts
2R9	2	16	39	04H	1	-0 04		4.11	Yes	4.36	Yes	0.09
2R9	2	16	39	04H	2	-0 02		0.68	Yes	1.75	Yes	0.05
2R9	2	14	40	01H	1	0 02		-4.79	Yes	-0.16	Yes	0.36
2R9	2	21	40	01H	1	-0 04		2.74	Yes	5 64	Yes	0.07
2R9	2	22	46	01H	1	-0.01		-0 68	Yes	-0.13	Yes	0.08
2R9	3	21	78	03H	1	0.09	Yes	8.90	Yes	10.81	Yes	0.08
2R9	4	17	31	03H	1	-0.02		4 11	Yes	0 68	Yes	0.13
2R9	4	14	53	03H	1	-0 01		0 00	Yes	0.33	Yes	0.06
1R10	1	22	7	03H	1	0 07	Yes	6.71		3.04		0.25
1R10	1	23	14	03H	1	0.01	Yes	-4.70		-3 69		0.09
1R10	1	19	15	03H	1	0.03	Yes	0.67		0.43		0.09
1R10	1	15	16	02H	1	-0.03	Yes	0 67		1.94		0.09
1R10	1	24	20	02H	1	0.02	Yes	1.34		-5.35		0.00
1R10	1	30	21	02H	1	-0.05	Yes	0 00		-0.05		-0.04
1R10	1	22	23	02H	1	-0.01	Yes	2.68		3.86		-0 01
1R10	1	22	23	02H	2	0.00	Yes	0 00		4 63		0 05
1R10	1	34	24	03H	1	0 08	Yes	-4.70		0.75		0 05
1R10	1	3	28	02H	1	0 01	Yes	0 67		4.38		0.21
1R10	1	14	28	02H	1	0 00	Yes	-6.71		-5.61		0 11
1R10	1	36	30	02H	1	0 02	Yes	-0.67		1.41		0.34
1R10	1	20	33	01H	1	-0.01	Yes	-3.36		-0.06		-0.02
1R10	1	4	41	01H	1	0.08	Yes	10.07		10.05		0 08
1R10	1	24	67	02H	1	0 04	Yes	0 00		0 50		0.10
1R10	1	22	71	02H	1	0 07	Yes	1.34		-3.73		0 11
1R10	2	13	10	01H	1	0.01	Yes	2.68		1.71		0.17
1R10	2	15	10	01H	1	0 03	Yes	-6.71		-6.12		0 05
1R10	2	16	12	05H	1	0 01	Yes	0.67		3 89		-0 05
1R10	2	8	15	02H	1	0.01	Yes	4.03		1.66		0.14
1R10	2	14	16	04H	1	0.00	Yes	-3 36		-1.24		0.15
1R10	2	30	16	01H	1	-0 07	Yes	-8 72		-3.69		0 23
1R10	2	25	17	02H	1	0.08	Yes	-2.01		-2.72		0.14
1R10	2	23	25	03H	1	0.03	Yes	2.68		4.54		0.31
1R10	2	42	28	02H	1	-0.01	Yes	6 04		6.25		0.17
1R10	2	7	31	01H	1	0.05	Yes	-4.70		-5.33		0.13
1R10	2	19	31	04H	1	-0.05	Yes	0 67		-0.53		0.09
1R10	2	9	34	02H	1	-0.03	Yes	0.67		-1.22		0.11
1R10	2	33	37	01H	1	0.01	Yes	0 00		-0 58		0.08
1R10	2	26	39	02H	1	0.03	Yes	-0.67		-1.91		0.30
1R10	2	11	45	01H	1	0 04	Yes	8.72		3.57		0 26
1R10	2	14	45	01H	1	0.00	Yes	0.00		-0.11		0.02
1R10	2	20	48	03H	1	0 07	Yes	3 36		-0.99		0.15
1R10	2	27	50	01H	1	0.01	Yes	2 68		0.40		0 24

Outage	SG	Row	Col	TSP	Crack No.	Length (in)	Include Data?	Max. Depth (%)	Include Data?	Avg. Depth (%)	Include Data?	Max. Volts
1R10	2	29	51	02H	1	0.07	Yes	-0 67		-3.39		0 20
1R10	2	34	51	06H	1	0.06	Yes	-0 67		0.03		0.15
1R10	2	35	52	03H	1	-0 01	Yes	-2.68		-0.83		0.13
1R10	2	23	54	01H	1	0.04	Yes	0 00		-0 06		0.05
1R10	2	25	55	02H	1	-0 01	Yes	-2.01		0.33		-0.08
1R10	2	9	56	01H	1	0 00	Yes	1.34		1.81		0.17
1R10	2	27	56	01H	1	0.02	Yes	0 00		1.34		0.15
1R10	2	4	57	01H	1	-0 02	Yes	0.00		-0 38		-0 01
1R10	2	36	60	04H	1	0 03	Yes	-2.68		-6.09		0 09
1R10	2	8	61	02H	1	0.05	Yes	-5.37		-2.02		0 21
1R10	2	8	61	02H	2	0.08	Yes	3 36		0.32		0.10
1R10	2	32	62	01H	1	0 06	Yes	6.71		7.11		0.01
1R10	2	41	62	01H	1	-0 05	Yes	4.70		4.21		0 09
1R10	2	38	63	01H	1	0.06	Yes	1.34		2.63		0.32
1R10	2	39	64	03H	1	0 00	Yes	5.37		5.97		0 11
1R10	2	28	66	02H	1	-0 01	Yes	-11.41		-7.59		0.09
1R10	2	38	66	01H	1	0 05	Yes	7.38		1.55		0.10
1R10	2	33	68	02H	1	0 03	Yes	-4 03		-4 31		0.05
1R10	2	4	69	01H	1	0.01	Yes	0.00		-1.23		0 08
1R10	2	27	71	01H	1	0.05	Yes	0.67		-1.67		0.12
1R10	2	6	74	03H	1	0 03	Yes	0 00		-1.22		0 06
1R10	2	19	74	02H	1	0 01	Yes	-4 03		3 03		0.05
1R10	2	25	74	01H	1	0 01	Yes	6 71		5.89		0.13
1R10	2	2	76	02H	1	0 04	Yes	0 00		-3.46		0.07
1R10	2	5	77	05H	1	0.04	Yes	2.01		1.13		0.12
1R10	2	24	77	01H	1	0.05	Yes	3 36		4.11		0.11
1R10	2	2	78	01H	1	-0.01	Yes	-2.01		0.66		0.27
1R10	2	31	78	05H	1	0.07	Yes	4.70		-1.40		0.11
1R10	2	26	79	01H	1	0.01	Yes	0 00		1.52		0.21
1R10	2	23	82	01H	1	0.03	Yes	3 36		2 52		0.03
1R10	2	13	84	01H	1	0.00	Yes	-8.05		-7.42		-0 11
1R10	2	13	84	01H	2	0.03	Yes	-2.01		-5.69		-0 23
1R10	2	2	92	05H	1	0.02	Yes	0 00		0.29		0 03
1R10	2	2	92	05H	2	0.01	Yes	0.00		-0.37		0 05
1R10	2	2	92	05H	3	0 05	Yes	0 00		-4.53		0 06
1R10	2	2	93	04H	1	0.02	Yes	-14 09		-13 69		0.00
1R10	2	8	93	01H	1	-0.03	Yes	-6.71		-4 50		0.10
1R10	4	17	24	01H	1	-0 03	Yes	0.00		0.95		0 01
1R10	4	20	25	01H	1	0.02	Yes	0.00		0.43		0 01
1R10	4	35	36	02H	1	0.01	Yes	0.00		1.09		-0 03
1R10	4	46	42	01H	1	0.13	Yes	0.67		-3.12		0.01
1R10	4	39	48	03H	1	0 01	Yes	0.00		0 42		-0 03

Outage	SG	Row	Col	TSP	Crack No.	Length (in)	Include Data?	Max. Depth (%)	Include Data?	Avg. Depth (%)	Include Data?	Max. Volts
1R10	4	39	58	01H	1	0.11	Yes	0 00		-0.77		0.16
1R10	4	35	61	02H	1	0.01	Yes	1.34		5.16		0.07
1R10	4	35	68	03H	1	0.03	Yes	-2.01		0.27		-0 09
1R10	4	38	69	02H	1	0.02	Yes	5 37		8 42		0.05
1R10	4	21	70	03H	1	0 02	Yes	14.09	Yes	8 83		0.09
1R10	4	21	76	01H	1	-0.01	Yes	3 36		1.98		-0 03
1R10	4	21	84	01H	1	0.07	Yes	1.34		3 78		0 01
2R10	2	5	3	01H	1	0 12	Yes	8.33	Yes	4.41	Yes	-0 05
2R10	2	17	12	01H	1	0 02	Yes	6.94	Yes	4 85	Yes	0.33
2R10	2	14	15	02H	1	0 01	Yes	6.25	Yes	8.11	Yes	0 06
2R10	2	19	15	01H	1	0 02	Yes	0.00	Yes	0 45	Yes	0 02
2R10	2	11	19	01H	1	0.03	Yes	10 42	Yes	4.69	Yes	0.13
2R10	2	15	22	01H	1	0 03	Yes	7.64	Yes	3.79	Yes	0.14
2R10	2	2	23	01H	1	0 00	Yes	4.86	Yes	4.74	Yes	0.00
2R10	2	21	23	02H	1	0.03	Yes	8 33	Yes	7.22	Yes	0.06
2R10	2	27	23	01H	1	0.00	Yes	14.58	Yes	11.87	Yes	-0.03
2R10	2	6	24	01H	1	0.04	Yes	-3 47	Yes	-2.79	Yes	-0.04
2R10	2	13	25	03H	1	0.01	Yes	4.17	Yes	6.57	Yes	0.08
2R10	2	2	26	01H	1	0 01	Yes	13.19	Yes	11.62	Yes	0.03
2R10	2	5	26	01H	1	0.02	Yes	6 25	Yes	4.52	Yes	0.10
2R10	2	8	26	01H	1	0 01	Yes	18.75	Yes	15.74	Yes	-0 12
2R10	2	7	27	01H	1	0.05	Yes	-1.39	Yes	-2.13	Yes	0.03
2R10	2	4	28	01H	1	0 02	Yes	4.86	Yes	3 84	Yes	-0 10
2R10	2	6	31	01H	1	0 03	Yes	0.00	Yes	2.70	Yes	0.04
2R10	2	7	32	01H	1	0 01	Yes	6 25	Yes	3 05	Yes	0 09
2R10	2	9	32	01H	1	-0 02	Yes	0.69	Yes	0 87	Yes	-0.01
2R10	2	5	33	01H	1	0 05	Yes	11.81	Yes	8 28	Yes	-0 02
2R10	2	3	34	01H	1	-0 01	Yes	6.94	Yes	4 90	Yes	0.10
2R10	2	4	34	04H	1	0 01	Yes	0.00	Yes	-0.87	Yes	0.04
2R10	2	6	36	01H	1	0.03	Yes	7.64	Yes	6 36	Yes	-0.16
2R10	2	28	38	01H	1	0.01	Yes	0 00	Yes	-4.91	Yes	-0.01
2R10	2	12	39	01H	1	0.01	Yes	6 25	Yes	2.71	Yes	-0.17
2R10	2	16	39	04H	1	0.03	Yes	7.64	Yes	6.43	Yes	0.05
2R10	2	16	39	04H	2	0.01	Yes	11.11	Yes	6.88	Yes	0.03
2R10	2	21	40	01H	1	0.00	Yes	1.39	Yes	1.95	Yes	-0.01
2R10	2	13	41	01H	1	-0.02	Yes	8.33	Yes	6.55	Yes	-0.01
2R10	2	21	41	01H	1	0.03	Yes	-3.47	Yes	-1.71	Yes	0.01
2R10	2	15	42	01H	1	-0 02	Yes	-4.17	Yes	-2.42	Yes	-0.03
2R10	2	8	43	04H	1	0 00	Yes	7.64	Yes	5 64	Yes	0 01
2R10	2	22	44	04H	1	0.03	Yes	10 07	Yes	2.66	Yes	-0 01
2R10	2	25	44	05H	1	0.08	Yes	0.00	Yes	-0 03	Yes	-0 08
2R10	2	14	45	01H	1	0.03	Yes	0.00	Yes	-4.00	Yes	-0 06

Outage	SG	Row	Col	TSP	Crack No.	Length (in.)	Include Data?	Max. Depth (%)	Include Data?	Avg Depth (%)	Include Data?	Max. Volts
2R10	2	22	45	01H	1	0 04	Yes	9.72	Yes	9.30	Yes	-0.06
2R10	2	16	49	01H	1	0.03	Yes	5.56	Yes	-0 50	Yes	-0 06
2R10	2	15	51	01H	1	0 01	Yes	-1.39	Yes	-2.45	Yes	-0 03
2R10	2	27	59	01H	1	0 06	Yes	16.67	Yes	19.26	Yes	0.17
2R10	3	45	56	01H	1	0.01	Yes	-5 56	Yes	-5.39	Yes	0 06
2R10	3	21	78	03H	1	0 02	Yes	-5 56	Yes	-3.98	Yes	0.03
2R10	4	16	11	03H	1	0 06	Yes	-6 94	Yes	-7.96	Yes	0.03
2R10	4	11	17	03H	1	0 04	Yes	2.78	Yes	0.28	Yes	-0.13
2R10	4	12	17	03H	1	0 01	Yes	2.08	Yes	2.00	Yes	0.10
2R10	4	14	53	03H	1	0.03	Yes	1.39	Yes	-0 96	Yes	0.05
Average						0.014		1.39		1.26		0.09
95%						0.075		11.81		9.61		0 33
Max						0.128		23 3		19.3		0 6

Table 3
Axial PWSCC Growth/EFPY Distributions at 604F for 1R11 Tube Repair OA

Length (inch)	CDF	Max Depth (%)	CDF	Avg Depth (%)	CDF
0.0000	0.287	0.0000	0.299	0.0000	0.250
0 0101	0.386	0.0239	0.402	0.0198	0 397
0.0201	0.532	0.0477	0.513	0.0395	0.552
0 0302	0.661	0 0716	0.692	0.0593	0.741
0.0403	0.760	0.0955	0.846	0.0791	0.836
0.0503	0.836	0.1194	0.889	0.0988	0.914
0.0604	0.877	0.1432	0.932	0.1186	0.931
0.0705	0.918	0.1671	0.966	0.1384	0.966
0.0805	0.947	0 1910	0.983	0.1581	0.983
0.0906	0.971	0.2149	0.991	0.1779	0.991
0.1007	0.977	0 2390	1.000	0.1980	1.000
0.1208	0 988				
0.1310	1.000				

Table 4
DIS Confirmation Rates

	SG 1-1	SG 1-2	SG 1-2 deplugged	SG 1-3	SG 1-4	Total
Number of bobbin DIS (excludes repeat PWSCC indications)	75	190	23	48	201	537
Number of new PWSCC indications confirmed by Plus Point	2	3	2	0	2	9
Plus Point confirmation rate	2.7%	1.6%	8 7%	0%	1%	1.7%
Bobbin DIS overcall rate	97.3%	98.4%	91.3%	100%	99%	98.3%

Table 5
1R11 Axial PWSCC Indications at Dented Tube Support Plate Intersections - Adjusted NDE
PWSCC ARC Operational Assessment Burst and Leakage Monte Carlo Calculations (ANL/EPRI Burst Model)

Insp Year	SG	Row	Col.	TSP	Crack No	Cal Num	Type	Reason for 1R11 Plugging	Length inch	MD (%)	AD (%)	Max. Volt	From	To	FS Burst Pressure psi	FS Leakage gpm	Total Length Burst Press psi	Total Length Leakage gpm
2002	1	3	28	02H	1	00051	repeat		0.10	40.0	28 3	0 48	-0.19	-0 09	6100	0 000	6100	0 000
2002	1	4	41	01H	1	00051	repeat		0 07	20.0	12.4	0.35	-0.04	0 03	6100	0 000	6100	0 000
2002	1	14	28	02H	1	00051	repeat		0 06	26 0	18.9	0.41	0.16	0 22	6100	0 000	6100	0 000
2002	1	14	87	02H	1	00075	new	ID-OD 2H	0 09	30 0	20 8	0 29	0 09	0.18	6100	0 000	6100	0 000
2002	1	15	16	02H	1	00051	repeat		0 16	22 0	13 2	0 42	-0.15	0 01	6100	0 000	6100	0.000
2002	1	15	76	02H	1	00051	repeat		0 07	29 0	19 0	0 33	-0 14	-0 07	6100	0 000	6100	0.000
2002	1	15	81	02H	1	00075	new	ID-OD 2H	0 19	21.5	12 4	0 50	-0 03	0 16	6100	0 000	6100	0 000
2002	1	16	45	02H	1	00074	new	ID-OD 2H	0 14	34 0	22.1	0 84	-0 10	0 04	6100	0 000	6100	0 000
2002	1	19	15	03H	1	00051	repeat		0 20	46 0	33 0	0 96	-0 08	0 12	6100	0 000	6100	0 000
2002	1	20	28	02H	1	00051	repeat		0.12	26 0	18 8	0 72	-0 23	-0 11	6100	0 000	6100	0 000
2002	1	20	29	02H	1	00051	repeat		0.19	37 0	24 6	0 60	0 04	0 23	6100	0 000	6100	0 000
2002	1	20	33	01H	1	00051	repeat		0.07	20.0	9.1	0.21	-0.15	-0 08	6100	0 000	6100	0 000
2002	1	22	23	02H	1	00051	repeat		0 09	32.0	21.7	0 68	-0.27	-0.18	6100	0 000	6100	0 000
2002	1	22	23	02H	2	00051	repeat		0 09	29 0	21 0	0 63	0.12	0.21	6100	0.000	6100	0 000
2002	1	22	71	02H	1	00051	repeat	ID-OD 2H	0 11	40 0	28 6	0 67	-0 01	0 10	6100	0 000	6100	0.000
2002	1	23	14	03H	1	00074	repeat		0.10	39 0	28 8	0 58	-0 13	-0 03	6100	0 000	6100	0 000
2002	1	24	20	02H	1	00051	repeat	ID-OD 2H	0 07	43 0	22.7	0 71	0 01	0 08	6100	0 000	6100	0 000
2002	1	24	67	02H	1	00051	repeat		0 07	26 0	15.9	0 53	-0 11	-0 04	6100	0 000	6100	0 000
2002	1	25	57	03H	1	00051	repeat		0.19	37.0	29.4	0.49	-0.06	0.13	6100	0 000	6100	0 000
2002	1	26	25	01H	1	00051	repeat		0.14	37.0	27.9	1.00	0.13	0.27	6100	0 000	6100	0 000
2002	1	27	75	02H	1	00051	repeat		0 09	30 5	21.0	0 73	-0 05	0.04	6100	0.000	6100	0 000
2002	1	28	27	01H	1	00051	repeat		0 29	35 0	20 6	0 80	-0 32	-0 03	6100	0 000	6100	0.000
2002	1	29	37	02H	1	00051	repeat		0 16	29 0	21 8	0 60	0 07	0 23	6100	0 000	6100	0 000
2002	1	30	21	02H	1	00051	repeat		0 06	26 0	15 7	0 48	-0 12	-0 06	6100	0 000	6100	0 000
2002	1	30	67	02H	1	00051	repeat		0.29	32.0	21.2	0 91	-0.17	0.12	6100	0 000	6100	0 000
2002	1	33	40	02H	1	00073	new	ID-OD 2H	0.26	45.0	28.7	1.13	-0.23	0 03	6100	0 000	6100	0 000
2002	1	34	24	03H	1	00051	repeat		0 32	21 0	8 3	0 38	-0 08	0.24	6100	0.000	6100	0 000

Insp Year	SG	Row	Col.	TSP	Crack No.	Cal. Num	Type	Reason for 1R11 Plugging	Length inch	MD (%)	AD (%)	Max. Volt	From	To	FS Burst Pressure psi	FS Leakage gpm	Total Length Burst Press. psi	Total Length Leakage gpm
2002	1	35	59	03H	1	00070	new		0.27	28 0	17.1	0 85	-0 17	0.10	6100	0 000	6100	0.000
2002	1	36	30	02H	1	00051	repeat	ID-OD 2H	0.17	43.0	30 5	1.34	-0 25	-0 08	6100	0 000	6100	0.000
2002	1	38	41	04H	1	00051	repeat		0.10	32.0	22.2	0 64	-0 24	-0.14	6100	0 000	6100	0 000
2002	1	39	57	02H	1	00070	new		0 10	23 0	17.3	0.57	-0.21	-0.11	6100	0 000	6100	0 000
2002	2	2	10	03H	1	00075	deplug 1R11		0 31	45 0	33 9	1 28	-0.16	0.15	6100	0.000	5680	0 000
2002	2	2	28	03H	1	00011	deplug 1R11		0 24	32.0	18 0	0 58	-0 22	0 02	6100	0.000	6100	0 000
2002	2	2	76	02H	1	00006	repeat		0 13	21 0	9 7	0 39	-0 20	-0 07	6100	0 000	6100	0 000
2002	2	2	78	01H	1	00006	repeat		0.11	20 0	11 4	0 45	0 04	0 15	6100	0 000	6100	0.000
2002	2	2	79	03H	1	00006	repeat		0.41	20.0	11.3	0 77	-0.19	0 22	6100	0 000	6100	0 000
2002	2	2	90	04H	1	00013	deplug 1R11		0.12	41.0	31.7	1.61	-0 37	-0 25	6100	0 000	6100	0 000
2002	2	2	90	04H	2	00013	deplug 1R11		0 17	56 0	37.4	2.49	-0.13	0 04	6100	0 000	6100	0 000
2002	2	2	92	05H	1	00006	repeat		0 07	20 0	13.0	0.27	-0.43	-0 36	6100	0 000	6100	0 000
2002	2	2	92	05H	2	00006	repeat		0.12	20 0	15.3	0.54	-0.08	0 04	6100	0 000	6100	0 000
2002	2	2	92	05H	3	00006	repeat		0 17	20 0	13 6	0 50	0 07	0.24	6100	0 000	6100	0 000
2002	2	2	93	04H	1	00006	repeat		0 13	32 0	22 2	0 51	0 10	0 23	6100	0.000	6100	0 000
2002	2	4	54	02H	1	00012	deplug 1R11		0 24	38 0	25 9	0 75	-0 08	0.16	6100	0 000	6100	0 000
2002	2	4	57	01H	1	00006	repeat		0.12	21.0	13 5	0 49	-0 01	0.11	6100	0 000	6100	0 000
2002	2	4	58	01H	1	00012	deplug 1R11		0 60	66 0	33.1	1.05	-0.31	0 29	6100	0 000	4976	0 000
2002	2	4	58	01H	2	00012	deplug 1R11		0 42	50 0	39 9	2 42	-0.10	0.32	6100	0 000	4913	0 000
2002	2	4	84	01H	1	00006	repeat		0 17	21 0	11.7	0 47	-0 02	0.15	6100	0.000	6100	0 000
2002	2	5	39	02H	1	00011	deplug 1R11		0 17	35 0	18 7	0 81	-0 22	-0.05	6100	0.000	6100	0 000
2002	2	5	65	01H	1	00006	repeat		0 25	20 0	11 9	0 47	-0 26	-0 01	6100	0.000	6100	0 000
2002	2	5	66	02H	1	00006	repeat		0 10	27 0	20 0	0 72	-0 11	-0 01	6100	0.000	6100	0 000
2002	2	5	77	05H	1	00006	repeat		0 18	32 0	22 2	0 78	-0 30	-0 12	6100	0 000	6100	0.000
2002	2	5	78	01H	1	00013	deplug 1R11		0.25	36.0	25 2	1 26	-0 03	0 22	6100	0 000	6100	0 000
2002	2	5	93	01H	1	00006	repeat		0 20	21.0	11.8	0.68	-0 25	-0 05	6100	0 000	6100	0 000
2002	2	6	74	03H	1	00006	repeat		0 19	27.0	14 2	0 63	-0.16	0 03	6100	0 000	6100	0 000
2002	2	7	31	01H	1	00006	repeat		0 26	26 5	13 7	0 71	-0 02	0 24	6100	0.000	6100	0.000
2002	2	7	53	03H	1	00012	deplug 1R11		0.18	32 0	22 6	0 70	-0 05	0 13	6100	0 000	6100	0.000
2002	2	7	68	03H	1	00006	repeat		0.12	29.0	16.7	0 82	0 10	0 22	6100	0 000	6100	0 000
2002	2	8	15	02H	1	00006	repeat		0 37	27.0	13.8	0.96	-0.15	0 22	6100	0 000	6100	0 000

Insp. Year	SG	Row	Col	TSP	Crack No	Cal Num.	Type	Reason for 1R11 Plugging	Length inch	MD (%)	AD (%)	Max. Volt	From	To	FS Burst Pressure psi	FS Leakage gpm	Total Length Burst Press psi	Total Length Leakage gpm
2002	2	8	55	01H	1	00012	deplug 1R11		0 20	41.0	22 7	0 99	-0 11	0 09	6100	0 000	6100	0 000
2002	2	8	57	01H	1	00012	deplug 1R11		0 41	56 0	39 0	1 95	-0 32	0 09	6100	0 000	4972	0 000
2002	2	8	61	02H	1	00006	repeat		0 10	27 0	16 7	0 85	-0 27	-0 17	6100	0 000	6100	0 000
2002	2	8	61	02H	2	00006	new		0 10	38 0	25 3	0 24	-0 09	0 01	6100	0 000	6100	0 000
2002	2	8	61	02H	3	00006	repeat		0 17	38 0	23 1	0 49	0 03	0 20	6100	0 000	6100	0 000
2002	2	8	66	02H	1	00006	repeat		0.10	20 0	12 0	0 48	-0 34	-0 24	6100	0 000	6100	0 000
2002	2	8	67	01H	1	00006	repeat	ID-OD 1H	0.20	29.0	16 9	0 88	-0 05	0 15	6100	0 000	6100	0 000
2002	2	8	93	01H	1	00006	repeat		0 12	27.0	19 6	0.67	-0.19	-0.07	6100	0 000	6100	0 000
2002	2	9	27	03H	1	00011	deplug 1R11		0 10	20 0	11 3	0 28	-0.17	-0 07	6100	0.000	6100	0 000
2002	2	9	30	01H	1	00008	deplug 1R11		0 34	51 0	41 2	2 11	-0.17	0.17	6100	0 000	5071	0.000
2002	2	9	38	02H	1	00008	deplug 1R11		0 39	51 0	38 4	2 21	-0 26	0 13	6100	0 000	5069	0 000
2002	2	9	45	01H	1	00008	deplug 1R11		0.16	45 0	30 3	1 27	0 05	0 21	6100	0 000	6100	0 000
2002	2	9	53	01H	1	00012	deplug 1R11		0.29	44.0	28 6	1.19	-0.15	0.14	6100	0 000	6100	0 000
2002	2	9	56	01H	1	00006	repeat		0.17	35.0	18 4	0 64	-0 37	-0 20	6100	0 000	6100	0 000
2002	2	9	82	03H	1	00013	deplug 1R11		0.17	42.0	29.7	1.61	0.10	0 27	6100	0 000	6100	0 000
2002	2	10	49	03H	1	00008	deplug 1R11		0.09	22.0	15.3	0 69	0 13	0 22	6100	0 000	6100	0 000
2002	2	10	62	01H	1	00072	deplug 1R11		0.29	48.0	35.3	1.08	-0 10	0.19	6100	0 000	5623	0 000
2002	2	10	67	01H	1	00006	repeat		0 17	20 0	11.0	0 69	-0.25	-0 08	6100	0 000	6100	0 000
2002	2	10	68	01H	1	00013	deplug 1R11		0 13	42 0	32 5	1.32	-0 19	-0 06	6100	0.000	6100	0.000
2002	2	10	69	02H	1	00051	new		0 06	20 0	12 5	0 47	-0 22	-0 16	6100	0 000	6100	0.000
2002	2	10	80	01H	1	00052	new		0.13	26 0	16 5	0 37	-0 30	-0 17	6100	0 000	6100	0 000
2002	2	10	85	04H	1	00006	repeat		0 08	21.0	13.0	0.51	0.18	0 26	6100	0 000	6100	0 000
2002	2	11	20	02H	1	00011	deplug 1R11		0 23	47 0	35 5	0 99	-0.10	0.13	6100	0 000	5784	0 000
2002	2	11	45	01H	1	00006	repeat		0 46	20 0	7 8	0 94	-0.17	0.29	6100	0.000	6100	0 000
2002	2	11	66	03H	1	00068	new		0 21	20 0	12 5	0 90	-0 21	0 00	6100	0.000	6100	0.000
2002	2	11	71	01H	1	00013	deplug 1R11		0 27	39 0	30 1	1 48	-0 30	-0 03	6100	0 000	6100	0.000
2002	2	11	71	01H	2	00013	deplug 1R11		0 07	20 0	11 6	0 56	0 02	0 09	6100	0 000	6100	0.000
2002	2	11	71	01H	3	00013	deplug 1R11		0.10	39 0	24.1	0 62	-0 19	-0 09	6100	0 000	6100	0 000
2002	2	11	71	01H	4	00013	deplug 1R11		0.12	23.0	12.1	0 58	0 05	0 17	6100	0 000	6100	0 000
2002	2	11	81	02H	1	00006	repeat	Mixed Mode 2H	0.10	27.0	17.8	0.67	0.04	0.14	6100	0 000	6100	0 000
2002	2	11	84	02H	1	00013	deplug 1R11		0.14	28 0	20 8	0 68	-0.21	-0.07	6100	0 000	6100	0 000

Insp Year	SG	Row	Col.	TSP	Crack No.	Cal. Num.	Type	Reason for 1R11 Plugging	Length inch	MD (%)	AD (%)	Max. Volt	From	To	FS Burst Pressure psi	FS Leakage gpm	Total Length Burst Press psi	Total Length Leakage gpm
2002	2	11	84	02H	2	00013	deplug 1R11		0.20	39.0	28.0	1.05	0 00	0 20	6100	0 000	6100	0 000
2002	2	11	87	01H	1	00013	deplug 1R11		0 27	53 0	36.7	2.48	-0.19	0 08	6100	0 000	5603	0 000
2002	2	12	77	01H	1	00013	deplug 1R11		0 33	45 0	32 6	1.28	-0.23	0.10	6100	0 000	5702	0 000
2002	2	13	10	01H	1	00006	repeat		0 10	32 0	19 6	0 95	-0 43	-0.33	6100	0.000	6100	0 000
2002	2	13	34	01H	1	00008	deplug 1R11		0 19	45 0	29 3	1 26	0 03	0 22	6100	0.000	6100	0.000
2002	2	13	44	01H	1	00008	deplug 1R11		0 29	51 0	42 4	1 52	-0 18	0 11	6100	0 000	5248	0 000
2002	2	13	60	02H	1	00012	deplug 1R11		0.25	41.0	23 8	1 48	-0 18	0 07	6100	0 000	6100	0 000
2002	2	13	84	01H	1	00006	repeat		0 07	20 0	12.8	0.46	-0 07	0 00	6100	0 000	6100	0 000
2002	2	13	84	01H	2	00006	repeat		0 11	21 0	11 0	0.33	-0.07	0.04	6100	0 000	6100	0 000
2002	2	14	16	04H	1	00006	repeat		0 11	29 0	14 2	0 46	-0.07	0.04	6100	0 000	6100	0 000
2002	2	14	45	01H	1	00006	repeat		0 10	20 0	11 6	0 35	-0 08	0.02	6100	0 000	6100	0 000
2002	2	14	68	01H	1	00006	repeat		0 40	20 0	12 3	0 79	-0 27	0.13	6100	0.000	6100	0 000
2002	2	14	70	01H	1	00006	repeat		0 07	20 0	12.1	0 36	-0.11	-0.04	6100	0.000	6100	0 000
2002	2	14	74	01H	1	00013	deplug 1R11		0 22	23 0	15 0	1 29	-0 26	-0 04	6100	0.000	6100	0.000
2002	2	16	12	05H	1	00064	repeat		0 06	23 5	15 5	0 60	-0 09	-0 03	6100	0 000	6100	0.000
2002	2	16	59	02H	1	00012	deplug 1R11		0.22	53.0	38 5	1 84	-0 08	0 14	6100	0 000	5784	0 000
2002	2	16	73	01H	1	00006	repeat	ID-OD 1H	0 12	21.0	15.2	0 64	-0.32	-0 20	6100	0 000	6100	0 000
2002	2	16	73	01H	2	00006	repeat	ID-OD 1H	0 15	20 0	12 3	0 50	-0 25	-0.10	6100	0.000	6100	0 000
2002	2	16	76	02H	1	00006	repeat	ID-OD 2H	0 18	20 0	9 7	0 39	-0 13	0 05	6100	0.000	6100	0.000
2002	2	16	82	01H	1	00013	deplug 1R11		0 22	20 0	10 9	0 82	-0 09	0 13	6100	0 000	6100	0.000
2002	2	16	82	04H	1	00013	deplug 1R11		0 21	34 0	19 6	1 20	-0 05	0.16	6100	0 000	6100	0.000
2002	2	16	85	02H	1	00013	deplug 1R11		0 09	34 0	24 0	0 83	-0 24	-0 15	6100	0 000	6100	0 000
2002	2	16	85	02H	2	00013	deplug 1R11		0.15	26 0	15 8	0 56	-0 11	0 04	6100	0 000	6100	0 000
2002	2	16	87	02H	1	00013	deplug 1R11		0.21	39 0	29.3	1 25	0 32	0 53	6100	0 000	6100	0 000
2002	2	16	88	02H	1	00013	deplug 1R11		0.18	47.0	33.7	1.31	-0.11	0 07	6100	0 000	6100	0 000
2002	2	17	9	06H	1	00011	deplug 1R11		0 07	32 0	16 0	0 68	-0.11	-0.04	6100	0 000	6100	0 000
2002	2	17	54	01H	1	00012	deplug 1R11		0 31	50 0	39 5	0 91	-0 12	0.19	6100	0.000	5281	0.000
2002	2	17	59	01H	1	00012	deplug 1R11		0 24	44 0	34 5	1 87	-0 07	0.17	6100	0 000	5863	0 000
2002	2	17	66	01H	1	00013	deplug 1R11		0.37	36.0	28.9	2 68	-0 23	0 14	6100	0 000	5809	0 000
2002	2	17	67	01H	1	00013	deplug 1R11		0 15	31.0	22.2	0.97	-0.33	-0.18	6100	0 000	6100	0 000
2002	2	17	67	01H	2	00013	deplug 1R11		0 09	20 0	12 8	0 26	-0.32	-0.23	6100	0 000	6100	0 000

Insp. Year	SG	Row	Col.	TSP	Crack No.	Cal. Num.	Type	Reason for 1R11 Plugging	Length inch	MD (%)	AD (%)	Max Volt	From	To	FS Burst Pressure psi	FS Leakage gpm	Total Length Burst Press psi	Total Length Leakage gpm
2002	2	17	88	02H	1	00013	deplug 1R11		0 25	20 0	10 6	0.90	-0 01	0.24	6100	0 000	6100	0 000
2002	2	18	64	03H	1	00072	deplug 1R11		0.18	26 0	16 7	0 70	-0 22	-0.04	6100	0 000	6100	0 000
2002	2	19	31	04H	1	00006	repeat		0.10	25 0	15 2	0 44	-0 08	0 02	6100	0 000	6100	0 000
2002	2	19	34	02H	1	00008	deplug 1R11		0.44	51 0	38 0	2 60	-0 20	0 24	6100	0 000	4968	0 000
2002	2	19	74	02H	1	00006	repeat		0.13	21 0	11.1	0 41	-0 18	-0 05	6100	0 000	6100	0 000
2002	2	20	48	03H	1	00006	repeat		0.20	27.0	13 5	0 59	-0 19	0 01	6100	0 000	6100	0 000
2002	2	20	77	01H	1	00013	deplug 1R11		0 23	36.0	26.8	1 37	-0 15	0 08	6100	0.000	6100	0 000
2002	2	21	38	01H	1	00008	deplug 1R11		0 24	45 0	35.5	1.23	-0.15	0 09	6100	0 000	5921	0 000
2002	2	21	57	01H	1	00012	deplug 1R11		0 40	56 0	41 6	2.37	-0 20	0 20	6100	0 000	4874	0 000
2002	2	21	60	02H	1	00006	repeat		0 24	24 0	14 8	0 73	-0.27	-0.03	6100	0 000	6100	0.000
2002	2	21	65	02H	1	00013	deplug 1R11		0.36	56 0	33 9	1.34	-0.12	0.24	6100	0 000	5432	0 000
2002	2	22	42	01H	1	00008	deplug 1R11		0.33	45 0	32 4	1 81	-0 07	0 26	6100	0 000	5692	0 000
2002	2	22	54	02H	1	00012	deplug 1R11		0.26	53.0	41.4	1 61	-0 15	0 11	6100	0 000	5414	0 000
2002	2	22	55	03H	1	00068	new		0 21	40.0	28.5	1 02	-0 05	0 16	6100	0.000	6100	0 000
2002	2	23	25	03H	1	00006	repeat		0 25	20 0	12.9	0 91	-0 35	-0 10	6100	0.000	6100	0 000
2002	2	23	54	01H	1	00006	repeat		0 11	20 0	9.8	0 34	0 01	0 12	6100	0.000	6100	0 000
2002	2	23	82	01H	1	00006	repeat		0.10	27 0	17.9	0.48	0 11	0 21	6100	0 000	6100	0 000
2002	2	24	77	01H	1	00006	repeat		0 13	21 0	12.9	0.43	0 18	0 31	6100	0 000	6100	0 000
2002	2	25	17	02H	1	00006	repeat		0 23	29 0	17 9	0 84	-0.36	-0.13	6100	0 000	6100	0 000
2002	2	25	50	02H	1	00012	deplug 1R11		0 43	53 0	37 8	1.76	-0.25	0.18	6100	0 000	4953	0.000
2002	2	25	55	02H	1	00006	repeat		0.10	21 0	13 4	0 36	0 08	0.18	6100	0 000	6100	0 000
2002	2	25	72	01H	1	00050	new	ID-OD 1H	0 09	24.0	17.3	0 48	0 00	0 09	6100	0.000	6100	0 000
2002	2	25	74	01H	1	00006	repeat		0 08	35 0	24.1	0 67	-0 35	-0 27	6100	0 000	6100	0 000
2002	2	25	85	04H	1	00052	new		0 20	31 0	25 2	0 86	-0.17	0 03	6100	0 000	6100	0 000
2002	2	25	87	04H	1	00013	deplug 1R11		0 20	39 0	29 0	1 36	-0.11	0.09	6100	0 000	6100	0.000
2002	2	26	22	04H	1	00011	deplug 1R11		0 27	44 0	32 0	1 68	-0 09	0.18	6100	0 000	6100	0 000
2002	2	26	39	02H	1	00006	repeat		0.10	27 0	17.8	0 75	-0 10	0 00	6100	0 000	6100	0 000
2002	2	26	73	01H	1	00013	deplug 1R11		0.23	42.0	29 0	1 52	-0 14	0 09	6100	0.000	6100	0 000
2002	2	26	79	01H	1	00006	repeat		0 29	32.0	22.5	0 79	-0 12	0 17	6100	0.000	6100	0 000
2002	2	27	50	01H	1	00006	repeat	ID-OD 1H	0 11	27.0	17.4	0 88	-0 30	-0 19	6100	0.000	6100	0 000
2002	2	27	55	01H	1	00037	new		0 07	20 0	12.5	0.61	0 21	0 28	6100	0 000	6100	0 000

Insp. Year	SG	Row	Col	TSP	Crack No.	Cal Num.	Type	Reason for 1R11 Plugging	Length inch	MD (%)	AD (%)	Max Volt	From	To	FS Burst Pressure psi	FS Leakage gpm	Total Length Burst Press. psi	Total Length Leakage gpm
2002	2	27	56	01H	1	00006	repeat		0 11	24 0	16.1	0.72	-0.22	-0.11	6100	0.000	6100	0 000
2002	2	27	63	02H	1	00012	deplug 1R11		0 48	38 0	25 1	0 98	-0 25	0.23	6100	0.000	5822	0 000
2002	2	27	63	02H	2	00012	deplug 1R11		0 15	38 0	29 5	0 81	-0 19	-0 04	6100	0.000	6100	0.000
2002	2	27	64	03H	1	00006	repeat		0.12	20 0	10 2	0 42	-0.13	-0 01	6100	0 000	6100	0.000
2002	2	27	65	02H	1	00013	deplug 1R11		0 24	36 0	27 6	0 60	-0 09	0 15	6100	0 000	6100	0 000
2002	2	27	67	01H	1	00013	deplug 1R11		0.29	50.0	35 8	1 54	-0 31	-0 02	6100	0 000	5535	0 000
2002	2	27	67	04H	1	00068	deplug 1R11		0 18	23 0	13.9	0.47	-0.23	-0 05	6100	0 000	6100	0 000
2002	2	27	69	01H	1	00013	deplug 1R11		0 18	28 0	14.7	0.79	-0.02	0.16	6100	0 000	6100	0 000
2002	2	27	69	01H	2	00013	deplug 1R11		0 35	53 0	42 0	2 43	-0 25	0.10	6100	0.000	4981	0 000
2002	2	28	47	03H	1	00008	deplug 1R11		0 24	30 0	21 7	0 78	-0 01	0 23	6100	0.000	6100	0 000
2002	2	28	66	02H	1	00006	repeat		0 08	27.0	13 0	0 31	-0 02	0 06	6100	0 000	6100	0.000
2002	2	29	24	03H	1	00011	deplug 1R11		0 28	35 0	25 9	0 98	0 06	0 34	6100	0 000	6100	0.000
2002	2	29	51	02H	1	00006	repeat		0.10	27 0	18 8	0 49	-0 11	-0 01	6100	0 000	6100	0 000
2002	2	29	66	01H	1	00013	deplug 1R11		0.15	65 0	39 7	1 26	-0 05	0 10	6100	0 000	6100	0 000
2002	2	30	16	01H	1	00006	repeat	ID-OD 1H	0.15	41.0	28 0	0 70	-0 08	0 07	6100	0 000	6100	0 000
2002	2	30	56	01H	1	00012	deplug 1R11		0.50	56.0	42.7	2 69	-0 40	0 10	6100	0 000	4553	0 000
2002	2	30	62	01H	1	00006	repeat		0 08	20.0	11.2	0.47	-0.15	-0 07	6100	0 000	6100	0 000
2002	2	30	62	01H	2	00006	new		0 08	20 0	10 4	0 28	0 02	0.10	6100	0.000	6100	0 000
2002	2	30	67	02H	1	00013	deplug 1R11		0 19	62 0	46 4	1 62	-0 33	-0 14	6100	0 000	5520	0 000
2002	2	31	37	03H	1	00006	repeat		0 09	24 0	15 4	0 66	-0 15	-0 06	6100	0 000	6100	0 000
2002	2	31	37	03H	2	00006	repeat		0.10	27.0	16 9	0 45	-0 03	0 07	6100	0 000	6100	0 000
2002	2	31	47	02H	1	00008	deplug 1R11		0.42	58.0	48.1	2.35	-0 28	0 14	6100	0 000	4319	0 000
2002	2	31	53	02H	1	00012	deplug 1R11		0 23	53.0	36.4	1.57	-0.28	-0 05	6100	0 000	5834	0 000
2002	2	31	66	04H	1	00013	deplug 1R11		0 15	28 0	17.7	1.17	-0.02	0.13	6100	0 000	6100	0 000
2002	2	31	68	01H	1	00013	deplug 1R11		0 19	24 5	14 1	0 91	-0 04	0.15	6100	0.000	6100	0 000
2002	2	31	78	05H	1	00006	repeat		0 13	38 0	28 8	0 44	0 48	0 61	6100	0.000	6100	0 000
2002	2	32	30	02H	1	00008	deplug 1R11		0 22	33 0	16 3	0 88	-0 27	-0 05	6100	0 000	6100	0 000
2002	2	32	37	03H	1	00006	repeat		0.15	24 0	17.0	0 42	-0 03	0 12	6100	0 000	6100	0 000
2002	2	32	44	04H	1	00008	deplug 1R11		0.21	39.0	26 0	1 07	-0.19	0 02	6100	0 000	6100	0 000
2002	2	32	47	03H	1	00008	deplug 1R11		0.18	48.0	37.3	1.63	-0.24	-0 06	6100	0 000	6100	0 000
2002	2	32	62	01H	1	00006	repeat		0 10	24 0	16 8	0 44	-0.11	-0.01	6100	0.000	6100	0 000

Insp. Year	SG	Row	Col.	TSP	Crack No.	Cal. Num.	Type	Reason for 1R11 Plugging	Length inch	MD (%)	AD (%)	Max. Volt	From	To	FS Burst Pressure psi	FS Leakage gpm	Total Length Burst Press psi	Total Length Leakage gpm
2002	2	33	57	02H	1	00012	deplug 1R11		0.12	56.0	37 0	1 04	0 07	0.19	6100	0.000	6100	0 000
2002	2	33	68	02H	1	00006	repeat		0 08	32.0	17.8	0 41	0 00	0 08	6100	0 000	6100	0 000
2002	2	33	72	04H	1	00072	deplug 1R11		0.18	37.0	23.8	0.96	-0 09	0 09	6100	0 000	6100	0 000
2002	2	34	36	03H	1	00006	repeat		0 20	20 0	12.0	0 64	-0.15	0 05	6100	0 000	6100	0 000
2002	2	34	42	02H	1	00030	new		0 12	20 0	12.1	0.50	0 02	0.14	6100	0 000	6100	0.000
2002	2	34	47	02H	1	00008	deplug 1R11		0 14	36 0	22.7	0.85	-0 03	0 11	6100	0 000	6100	0.000
2002	2	34	49	02H	1	00008	deplug 1R11		0 42	75 0	49.7	3 81	-0.31	0.11	6100	0 000	4153	0.000
2002	2	34	51	06H	1	00006	repeat		0 09	38 0	20 6	0 38	0.04	0.13	6100	0 000	6100	0.000
2002	2	34	53	02H	1	00012	deplug 1R11		0.31	50 0	40 9	1 66	-0 20	0.11	6100	0 000	5254	0 000
2002	2	34	53	02H	2	00012	deplug 1R11		0.12	35.0	19.1	0 38	-0.14	-0 02	6100	0 000	6100	0 000
2002	2	34	55	01H	1	00012	deplug 1R11		0 26	53 0	37.2	1.87	-0 31	-0 05	6100	0.000	5637	0 000
2002	2	34	57	02H	1	00012	deplug 1R11		0 45	59 0	48 0	3.11	-0 26	0 19	6100	0 000	4207	0 000
2002	2	34	57	02H	2	00012	deplug 1R11		0 46	59 0	48 1	2.78	-0.28	0 18	6100	0 000	4199	0.000
2002	2	34	58	02H	1	00012	deplug 1R11		0 22	62 0	42.3	1.36	-0.16	0 06	6100	0 000	5686	0.000
2002	2	34	59	02H	1	00012	deplug 1R11		0 13	32 0	17.7	0.71	-0.05	0 08	6100	0 000	6100	0 000
2002	2	34	65	02H	1	00006	repeat		0 11	20 0	14 5	0.36	-0.09	0 02	6100	0 000	6100	0 000
2002	2	35	49	02H	1	00008	deplug 1R11		0 27	39 0	25 6	1.40	-0.18	0 09	6100	0 000	6100	0.000
2002	2	35	52	03H	1	00006	repeat		0 20	20 0	12 8	0 78	-0.16	0.04	6100	0 000	6100	0.000
2002	2	35	56	02H	1	00006	repeat		0.21	20 0	10 9	0 56	-0 05	0.16	6100	0.000	6100	0 000
2002	2	35	70	02H	1	00068	new		0.17	55.0	35.1	1 08	-0 14	0 03	6100	0.000	6100	0 000
2002	2	36	53	03H	1	00012	deplug 1R11		0 24	35 5	22.9	0.64	-0 19	0 05	6100	0 000	6100	0 000
2002	2	36	60	04H	1	00006	repeat		0.10	29 0	15 7	0 92	-0.20	-0.10	6100	0 000	6100	0.000
2002	2	37	53	02H	1	00012	deplug 1R11		0 50	56 0	41 5	1 52	-0 29	0.21	6100	0 000	4536	0 000
2002	2	37	69	03H	1	00013	deplug 1R11		0.16	23.0	12 6	0 89	0 05	0 21	6100	0.000	6100	0 000
2002	2	37	69	01H	1	00013	deplug 1R11		0.11	28.0	19.0	0 83	-0 18	-0 07	6100	0.000	6100	0 000
2002	2	37	69	01H	2	00013	deplug 1R11		0 10	36 0	19.4	1.26	-0 05	0 05	6100	0 000	6100	0 000
2002	2	37	69	01H	3	00013	deplug 1R11		0 27	36 0	25 8	1.70	0 04	0 31	6100	0 000	6100	0 000
2002	2	37	70	01H	1	00013	deplug 1R11		0 31	53 0	40 5	1.70	-0.18	0.13	6100	0 000	5237	0.000
2002	2	37	73	03H	1	00006	repeat		0 18	27 0	20 7	0 83	-0.10	0.08	6100	0 000	6100	0.000
2002	2	37	74	03H	1	00013	deplug 1R11		0 36	42 0	31 6	1.75	-0.13	0.23	6100	0 000	5617	0 000
2002	2	38	66	01H	1	00006	repeat		0.18	35 0	22.7	0 86	-0 01	0.17	6100	0 000	6100	0 000

Insp. Year	SG	Row	Col	TSP	Crack No.	Cal. Num	Type	Reason for 1R11 Plugging	Length inch	MD (%)	AD (%)	Max. Volt	From	To	FS Burst Pressure psi	FS Leakage gpm	Total Length Burst Press psi	Total Length Leakage gpm
2002	2	42	28	02H	1	00006	repeat	ID-OD 2H	0 11	32 0	20.1	0 88	-0 07	0 04	6100	0 000	6100	0 000
2002	2	43	49	03H	1	00008	deplug 1R11		0 24	48 0	32 6	1.32	-0 24	0.00	6100	0 000	6100	0.000
2002	4	17	24	01H	1	00042	repeat		0.08	20.0	8.1	0.30	0.29	0.37	6100	0.000	6100	0.000
2002	4	20	25	01H	1	00042	repeat		0.15	21.0	14.7	0.22	-0 66	-0.51	6100	0 000	6100	0 000
2002	4	21	67	05H	1	00070	new		0.18	36 0	22.9	0 69	-0.19	-0 01	6100	0 000	6100	0 000
2002	4	21	76	01H	1	00042	repeat		0.16	30 5	20.1	0 53	0 18	0 34	6100	0 000	6100	0 000
2002	4	21	84	01H	1	00042	repeat		0 08	35 0	20 3	0 62	0 00	0 08	6100	0 000	6100	0 000
2002	4	26	37	06H	1	00031	new		0.11	48 0	30 8	1.41	0 03	0 14	6100	0 000	6100	0 000
2002	4	35	36	02H	1	00042	repeat		0 10	21 0	13 0	0 39	0 16	0 26	6100	0 000	6100	0 000
2002	4	35	56	03H	1	00042	repeat		0 09	21 0	14 0	0 23	-0.18	-0 09	6100	0 000	6100	0 000
2002	4	35	56	03H	2	00042	repeat		0.12	24 0	17 3	0 36	0 00	0.12	6100	0 000	6100	0 000
2002	4	35	61	02H	1	00042	repeat		0.10	26.0	17.7	0.24	-0.11	-0.01	6100	0.000	6100	0 000
2002	4	35	68	03H	1	00042	repeat		0.24	47.0	32.3	0.47	-0.20	0.04	6100	0.000	6100	0 000
2002	4	38	69	02H	1	00042	repeat		0 08	35 0	19 6	0 39	0 00	0 08	6100	0 000	6100	0 000
2002	4	38	72	01H	1	00024	new		0 12	33 0	21 9	0 50	0 22	0 34	6100	0 000	6100	0 000
2002	4	39	48	03H	1	00042	repeat		0 13	20 0	14 3	0 27	0 03	0 16	6100	0 000	6100	0 000
2002	4	39	58	01H	1	00042	repeat		0 24	35 0	24 5	0 86	0 08	0 32	6100	0 000	6100	0 000
2002	4	46	42	01H	1	00042	repeat		0 15	29 0	18 6	0 38	-0 19	-0 04	6100	0 000	6100	0 000

Figure 1

Axial PWSCC Length Growth Rate at 604F

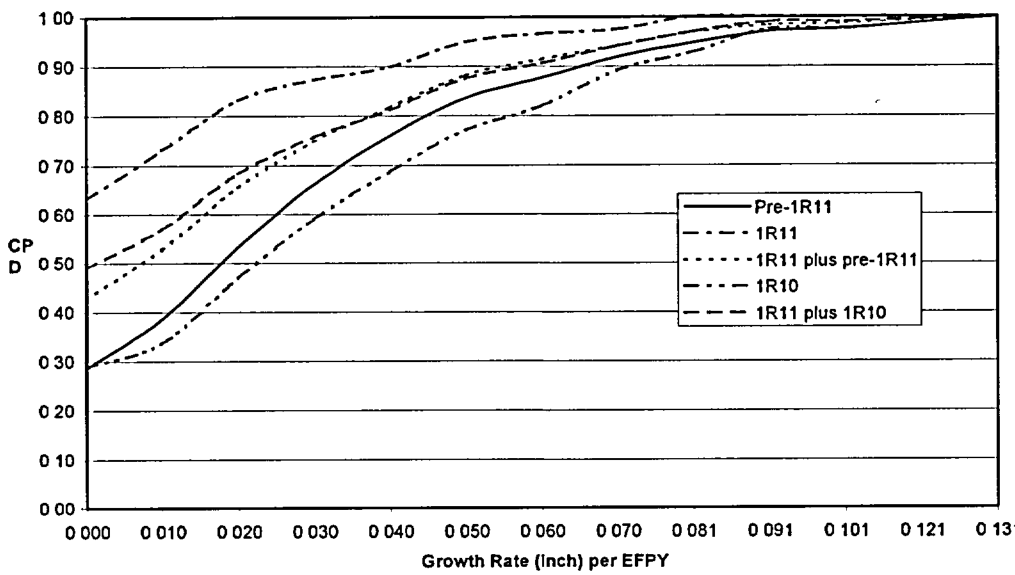


Figure 2

Axial PWSCC Maximum Depth Growth Rate at 604F

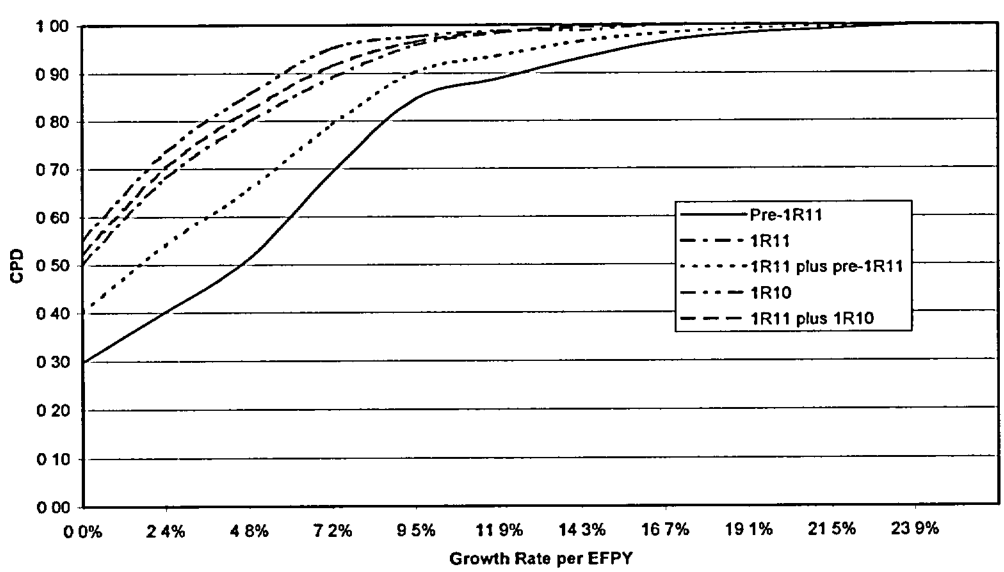


Figure 3

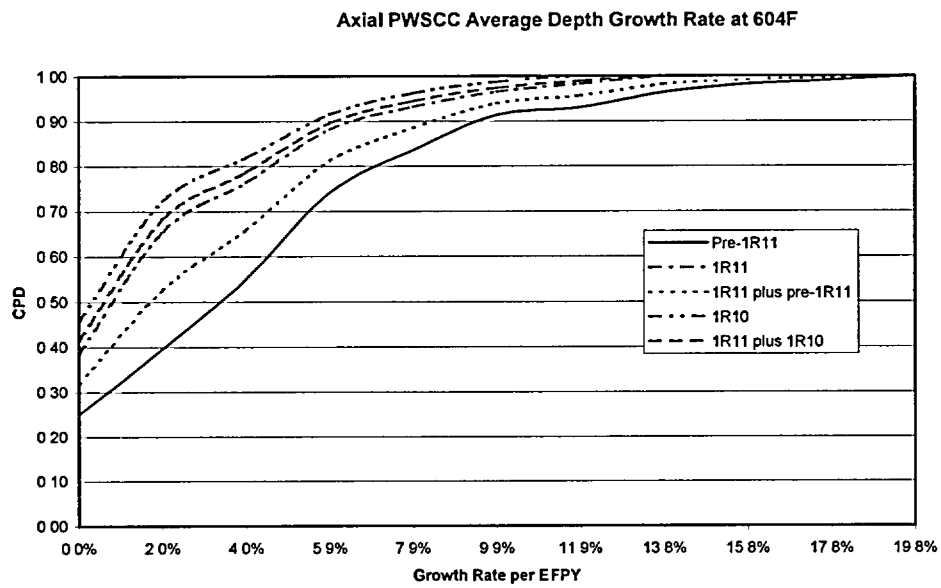


Figure 4

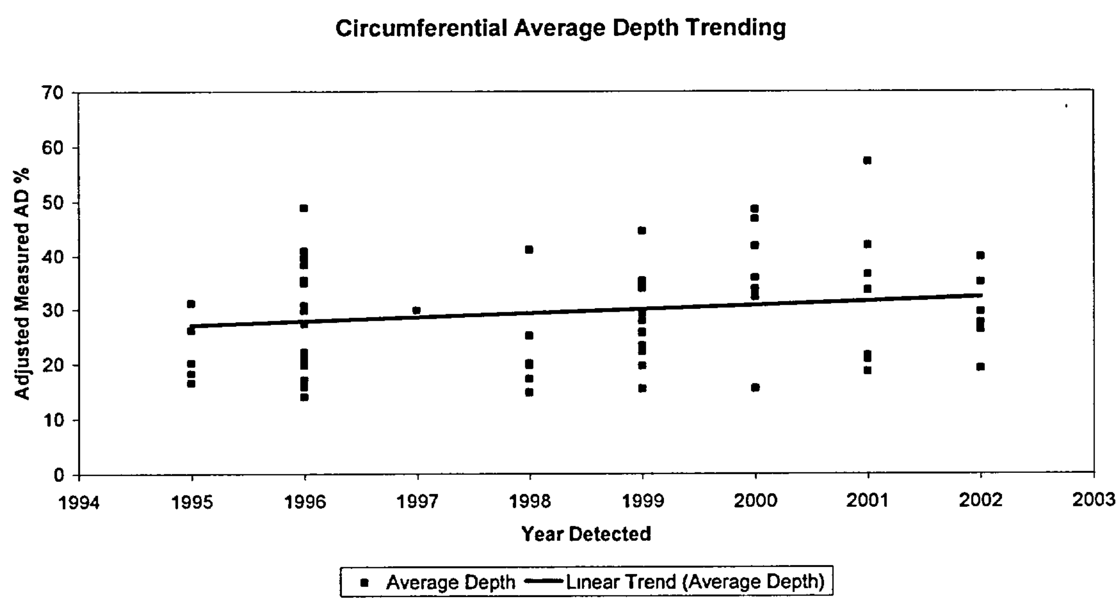


Figure 5

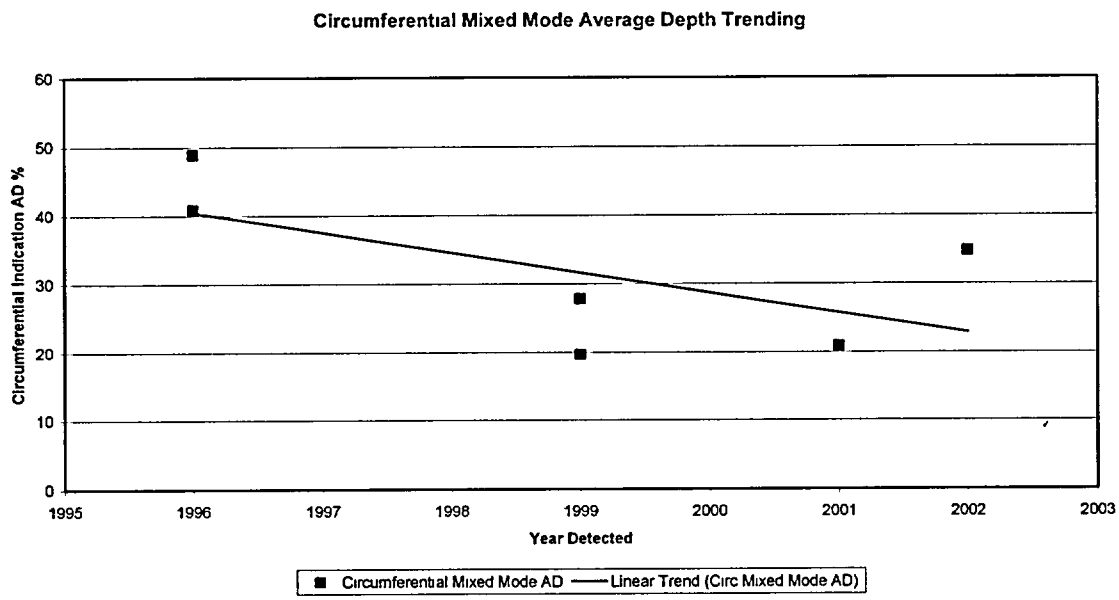
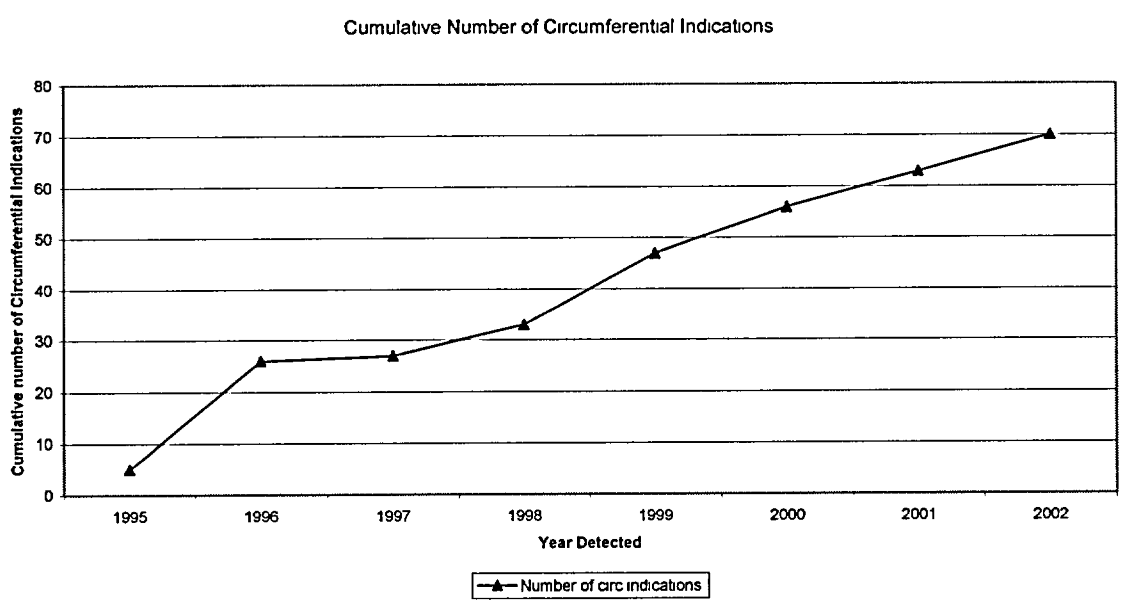


Figure 6



SPECIAL REPORT 02-02

STEAM GENERATOR CONDITION MONITORING REPORT DIABLO CANYON POWER PLANT UNIT 1 ELEVENTH REFUELING OUTAGE

1.0 Summary

During the Unit 1 eleventh refueling outage (1R11), greater than 1 percent of inspected tubes in steam generator (SG) 1-2 were defective and required plugging. If greater than 1 percent of inspected tubes in any SG exceed the repair criteria, Nuclear Energy Institute (NEI) 97-06, Revision 1, requires that a Condition Monitoring (CM) report be submitted to the NRC within 120 days after returning the SG to service. This report provides a SG tube CM assessment for Unit 1 Cycle 11 based on 1R11 tube inspection results.

For degradation subject to alternate repair criteria (ARC), PG&E follows the tube integrity assessment requirements of Diablo Canyon Power Plant (DCPP) technical specifications (TS) and NRC-approved licensing basis. W* ARC report, PWSCC ARC report, and voltage-based ARC report are provided in separate enclosures in this letter. For all other degradation, PG&E follows the tube integrity assessment guidance provided in Electric Power Research Institute (EPRI) Report TR-107621, "Steam Generator Integrity Assessment Guidelines," Revision 1, dated March 2000.

NEI 97-06, Revision 1, structural and leakage performance criteria for condition monitoring were satisfied at the end of Unit 1 Cycle 11 (EOC 11). This conclusion is based on assessing the 1R11 as-found conditions of the tubing on a degradation-specific basis. Unit 1 Cycle 11 had an actual duration of 1.41 effective full power years (EFPY).

- Structural integrity performance criteria: $3\Delta P_{NO}$ and $1.4\Delta P_{SLB}$ are the burst margin requirements for free span degradation and degradation confined to tube support plate (TSP) crevice, respectively. Structural integrity performance criteria were satisfied at EOC 11.

- Accident-induced leakage performance criteria: Accident-induced leakage assessments are based on the steam line break (SLB) differential pressure. For degradation subject to ARC, the maximum allowable SLB induced leak rate limit is 12.8 gpm in a faulted SG, based on an analysis which uses current licensing basis assumptions and approved by the NRC in License Amendment (LA) 124/122. As described in Enclosure 1, the limiting EOC 11 SLB leak rate is 0.368 gpm in SG 1-2, much less than the 12.8 gpm limit. For degradation not subject to ARC, the maximum allowable SLB-induced leak rate is 1 gpm in a faulted SG per NEI 97-06. The DCPP-specific non-ARC SLB-induced leak rate limit is 0.18 gpm at room temperature. There is no EOC 11 SLB leakage attributed to any non-ARC

degradation. Therefore, accident-induced leakage integrity performance criteria were satisfied at EOC 11.

- Operational leakage performance criterion: Primary-to-secondary leakage through any one SG must be limited to 150 gallons per day (gpd). This limit is reflected in DCPP TS. A small leak was detected in Unit 1 Cycle 11, ranging from about 1 to 3 gpd, which is well below the 150 gpd limit. Therefore, the operational leakage performance criterion was satisfied at EOC 11. The leak was initially detected in Unit 1 Cycle 9 and continued in cycles 10 and 11. Injection of Argon-40 into the Unit 1 reactor coolant system was initiated in Unit 1 Cycle 11. The Argon-40 is activated to Argon-41, which is detectable by gamma spectroscopy. This improves the consistency, sensitivity and accuracy of leak rate calculations due to higher Argon-41 concentrations in the reactor coolant system and the steam jet air ejector (SJAE). SG 1-4 has the highest tritium concentration and leak rate based on steam generator blowdown sampling. No eddy current indications were detected in 1R11 that could account for primary to secondary leakage, nor was leakage identified during visual examination of the tubesheet and tube plugs. Therefore, the cause of the small leak is not known.

2.0 Introduction

Steam Generator Background

DCPP Units 1 and 2 use Westinghouse Model 51 SGs with explosively expanded (WEXTEX) transitions. The SGs contain Alloy 600 Mill Annealed (MA) tubing. The nominal outside diameter of the tubing is 0.875 inch with a 0.050-inch nominal wall thickness. The DCPP SGs have historically operated with a nominal hot leg temperature (T_{hot}) of 603 degrees F. Unit 1 Cycle 11 operated at a nominal T_{hot} of 604 degrees F due to an uprate. The commercial operation dates for Units 1 and 2 are May 1985 and March 1986, respectively.

Both units have historically operated on 18-month fuel cycles. However, starting with DCPP Unit 2 Cycle 8 and Unit 1 Cycle 9, the cycle lengths have been extended to nominal 20-month operation.

PG&E has implemented several initiatives to minimize primary water stress corrosion cracking (PWSCC) and outside diameter stress corrosion cracking (ODSCC). Primary side initiatives include U-bend heat treatment, WEXTEX tubesheet shotpeening, and zinc injection. Secondary chemistry initiatives include: copper removal program; ethanol amine (ETA) to control pH; increased hydrazine levels; molar ratio control program to prevent excess alkalinity; boric acid addition program (including boric acid soaks at startup to mitigate denting and ODSCC at TSPs); tube sheet sludge lancing every outage; SG blowdown is maintained at 1 percent of the main steam flow rate; condensate polishers were installed and emergency (plant curtailment) procedures issued to protect against seawater condenser tube leaks.

Technical Specification Repair Criteria

DCPP TS require plugging of any tube that has degradation greater than or equal to 40 percent of the nominal tube wall thickness, unless ARC are implemented. Prior to 1R9, the DCPP TS were revised to allow implementation of ARC for (a) ODSCC at TSPs pursuant to Generic Letter (GL) 95-05, "Voltage-Based Repair Criteria for Westinghouse Steam Generator Tubes Affected by Outside Diameter Stress Corrosion Cracking," and (b) W* repair criteria for axial PWSCC in the WEXTEX tubesheet region. The ODSCC ARC TS changes were granted by the NRC in LA 124/122 dated March 12, 1998, in response to license amendment request (LAR) 97-03. The W* ARC TS for Cycles 10 and 11 were granted by the NRC in LA 129/127 dated February 19, 1999 (in response to LAR 97-04). The W* ARC TS for Cycles 12 and 13 were granted by the NRC in LA 151 dated April 29, 2002 (in response to LAR 01-03). These two ARC were implemented in Unit 1 starting in 1R9.

Prior to 1R11, the DCPP TS were revised to allow implementation of ARC for axial PWSCC at dented TSPs. The PWSCC ARC TS changes were granted by the NRC in LA 152 dated May 1, 2002 (in response to LAR 00-06 Supplement 3). Validated depth sizing of axial PWSCC at dented TSP intersections was previously implemented in 1R9 and 1R10, such that axial PWSCC less than the TS limit of 40 percent maximum depth limit was allowed to remain in service. The PWSCC ARC was implemented in 1R11, allowing greater than 40% indications to remain in service.

Other than degradation subject to ARC, all crack-like indications are required to be plugged on detection by a rotating coil probe, regardless of depth measurements. Cold leg thinning and antivibration bar (AVB) wear are sized by bobbin and allowed to remain in service if less than 40 percent.

NRC Reporting

A teleconference with the NRC staff was made on May 20, 2002, to report the findings from SG inspections performed during 1R11. The phone call included discussion topics identified in NRC letter to PG&E dated October 12, 2000, TS 5.6.10.d items, and preliminary results of tube inspections performed. Table 1 was sent to the NRC prior to the phone call to provide a description of the eddy current exam scope. No open items were identified.

TS 5.6.10.c requires that a licensee event report (LER) be submitted within 30 days and prior to resumption of plant operation if greater than one percent of inspected tubes in any SG are identified as defective, which fall into TS 5.5.9, Category C-3. SG 1-2 was determined to be in Category C-3 following completion of eddy current testing. Therefore, LER 1-2002-002 dated May 22, 2002, was submitted via PG&E letter DCL-02-064 to the NRC prior to the SGs return to service.

Degradation Assessment

NEI 97-06, Revision 1, requires completion of a degradation assessment (of both existing and potential degradation mechanisms) prior to each inspection. A degradation assessment, inspection/expansion plan, and tube repair plan were prepared and issued before 1R11. A summary of the inspection plan and expansion plan is provided in Table 1. The degradation assessment provides a summary of the EPRI nondestructive examination (NDE) techniques used in 1R11, including detection and sizing capabilities. The SG tube inspection contractor (Framatone) performed a site specific technique qualification to demonstrate that the EPRI techniques are applicable for use at DCPP.

Tube Repairs

Following eddy current inspections, 87 active tubes were plugged. Framatome I-690 roll plugs were used in both legs. Table 3 provides the plugging breakdown for each SG and reasons for plugging.

In SG 1-2, 150 tubes were deplugged and subsequently eddy current inspected for potential return to service under three ARC. For these 150 tubes, Table 2 provides a breakdown of the ARC type and type of plug. The following inspections were performed on recovered tubes:

- 100 percent bobbin inspection.
- Plus Point inspection of original flawed location.
- Plus Point inspection of all distorted bobbin tube support plate indications, regardless of voltage.
- Plus Point inspection of hot leg > 2 volt dented intersections.
- Plus Point inspection of TTS region from plus 2 to minus 8 inches.

Following the tube inspections, 53 of the 150 tubes required replugging because of detected degradation that was excluded by ARC. Framatome I-690 roll plugs were used in both legs. Ninety-seven tubes were returned to service using ARC.

No tube pulls were required in 1R11.

Insitu Testing

To support condition monitoring, degradation was assessed for leakage and structural integrity against the screening threshold values documented in the degradation assessment. The screening methodology is provided in EPRI Steam Generator In Situ Pressure Test Guidelines (EPRI Final Report TR-107620-R1 dated June 1999). None of the indications detected in 1R11 required insitu testing.

1R11 Damage Mechanisms

Tables 3 through 5 provide the number of SG tubes plugged in 1R11 and historical tubes plugged in Unit 1.

The following degradation mechanisms were detected in 1R11 and are assessed for SG tube integrity in this report:

- Axial PWSCC at hot leg dented TSP intersections (PWSCC ARC).
- Axial ODSCC at hot leg TSP intersections (voltage-based ARC).
- Combined axial ODSCC and axial PWSCC at hot leg TSP intersections (ID/OD).
- Circumferential PWSCC at hot leg dented TSP intersections.
- Circumferential ODSCC at hot leg dented TSP intersections.
- Circumferential PWSCC and Axial PWSCC at Dented TSP Intersections (PWSCC Mixed Mode).
- Circumferential ODSCC and Axial ODSCC at Dented TSP Intersections (ODSCC Mixed Mode).
- Axial PWCC in hot leg WEXTEX tubesheet region (W* ARC).
- Circumferential PWSCC in hot leg WEXTEX tubesheet region.
- Circumferential ODSCC at hot leg WEXTEX top of tubesheet region.
- Volumetric indications at hot leg WEXTEX tubesheet region and hot leg TSP intersections.
- Cold leg thinning at cold leg TSP intersections.
- AVB wear in U-bend region.
- TSP ligament thinning.

This report also provides inspection results of the following degradation mechanisms that were not detected in 1R11.

- PWSCC in Rows 1 and 2 U-bends.
- Stress corrosion cracking (SCC) at free span dings.
- Tube damage due to loose parts and foreign objects.
- SCC in I-690 mechanical plugs.

3.0 Axial PWSCC in WEXTEX Region

Axial PWSCC in the WEXTEX tubesheet region is assessed under W* ARC. Enclosure 1 provides the CM OA for axial PWSCC in the WEXTEX region pursuant to W* ARC requirements.

4.0 Axial PWSCC at Dented TSP Intersections

Axial PWSCC at dented TSP intersections is assessed under PWSCC ARC. Enclosure 2 provides the CM OA for axial PWSCC at dented TSP intersections pursuant to PWSCC ARC requirements.

5.0 Axial ODSCC at TSP Intersections

Axial ODSCC at TSP intersections is assessed under ODSCC ARC. Enclosure 4 provides the CM OA for axial ODSCC at TSP intersections pursuant to GL 95-05 requirements.

6.0 Combined Axial PWSCC and Axial ODSCC at Dented TSP intersections (ID/OD)

A total of 14 active tubes contained axial PWSCC and axial ODSCC (ID/OD) indications located at the same dented TSP intersection, 7 in SG 11 and 7 in SG 12. These tubes were plugged because this type of flaw combination is excluded from both PWSCC ARC and ODSCC ARC application. Eleven of these intersections had either ID or OD indications that were left inservice in the prior inspection (1R10): two axial ODSCC indications under ODSCC ARC, and nine axial PWSCC indications because they were less than 40 percent maximum depth. The remaining 3 intersections had no indications of either ID or OD degradation in 1R10, and 2 of these 3 intersections had no prior Plus Point inspection.

Based on review of the eddy current data and terrain maps for all 14 intersections, the axial PWSCC and axial ODSCC components are separated by hoop direction ligament gaps in excess of 30 degrees. This separation exceeds the required hoop direction ligament thickness of $2*(1-d_{max}/t)*t$, as developed in this section. Therefore, the flaws are treated independently for CM, under their respective ARC, for structural and leakage integrity. The basis for treating ID/OD indications independently is described below.

The following paragraphs discuss criteria for ID/OD axial crack interactions. The first criterion is a bounding conservative separation distance such that if this separation distance in the hoop direction is met or exceeded, there is no interaction relative to either burst pressure or leak rate. Figure 1 shows the limiting bounding case. Each crack is 50 percent through wall (TW) and of equal length. If the hoop separation distance, L, is zero the cracks became a single 100%TW crack. For L > 0 the ligament between the cracks must fail in shear for the cracks to join. A free body diagram of the Section A-A (Figure 1) reveals two moments, a side force, S and a distributed shear stress, τ_R on two of the Section A-A faces. These are second order effects in terms of affecting the onset of plastic collapse and can be neglected.

The hoop force per unit axial length, F, must be balanced by the shear force per unit axial length, V. Here the force V equals $\tau_{LIG\ AVG}*L$. The maximum possible value for F is $0.6*(\sigma_{YP} + \sigma_{UTS})*t$, where "t" is the wall thickness. This is the maximum hoop force per unit length at the burst pressure of an unflawed tube. This is the maximum possible force that can be transmitted around the circumference of the tube, i.e. from one hoop location to another. The ligament resistance, V, is at the shear flow strength and is equal to $0.5*(0.6*(\sigma_{YP} + \sigma_{UTS}))*L$. Equating these forces assures that the maximum possible hoop force can be transmitted from one crack to another without failure of the separating ligament. Hence, in a bounding argument, if L => 2*t there is no possible ID/OD axial crack interaction.

Given that a dent causes local bending of the tubing wall thickness, initiation of ID and OD axial cracks will be displaced in the hoop direction as the tube dent surface changes in sign of curvature. A review of eddy current inspection results of the 14 ID/OD indications in 1R11 shows that the closest hoop distance of approach of ID and OD cracks is about 0.22" (30 degrees). This distance is greater than 2*t, or 0.1 inch. Hence, bounding non-interaction conditions are met and ID axial and OD axial cracks may be treated independently.

The hoop separation distance for non-interaction is actually a function of maximum crack depth, d_{max}. The hoop force that must be transmitted without ligament failure is essentially $((t- d_{max})/t)*0.6*(\sigma_{YP} + \sigma_{UTS})*t$. Hence, L for no interaction is a function of d_{max}. Thus $L => 2*(1- d_{max}/t)*t$ is a more reasonable criterion for no interaction of ID and OD cracks. If the maximum crack depth is 50 percent TW then L => t becomes the required no interaction distance.

The above analytical results for no interaction distances are supported by burst test results for multiple parallel cracks. Reference 6.1 includes burst test results for 20 evenly distributed TW electro discharge machining (EDM) notches up to about 0.6" long for which the burst pressures for multiple axial indications in tubesheet expansion transitions were the same as a single indication of the same size. Reference 6.2, Appendix C includes Westinghouse burst test results for 7 and 14 parallel axial EDM notches 0.35" long in expansion transitions leading to the same conclusions as found in Reference 6.1.

References

6.1 Cochet, B.; "Assessment of the Integrity of Steam Generator Tubes - Burst Test Data – Validation of Rupture Criteria (Framatome Data)", Electric Power Research Institute, NP-6865-L, Vol. 1, (June, 1991)

6.2 "PWR Steam Generator Tube Repair Limits: Technical Support Document for Expansion Zone PWSCC in Roll Transitions – Rev. 2", Electric Power Research Institute, NP-6864-L, (August 1993)

7.0 Circumferential PWSCC and ODSCC at Dented TSP Intersections

Two circumferential PWSCC indications and five circumferential ODSCC indications were detected by Plus Point at > 2 volt dented hot leg TSP intersections, as listed in Table 7. All the circumferential indications (SCI) were plugged. The smallest dent voltage at which circumferential cracking was detected is 2.45 volts.

The SCI were sized using the technique described in Appendix B of WCAP-15573, Revision 1. The depth profiles were then processed for corrections in accordance with the depth adjustment rules in Section 4.10.4 of WCAP-15573, Revision 1. The adjusted NDE results were corrected for 95 percent NDE uncertainty using the NDE uncertainty regression parameters in Tables 4-19 to 4-21 in WCAP-15573, Revision 1. The adjusted NDE and adjusted NDE with uncertainty results are listed in Table 7.

The $3\Delta P_{NO}$ structural limit for a SCI is about 264 degrees, assuming a 100% throughwall defect. The longest NDE length was 33 degrees for PWSCC and 48 degrees for ODSCC, and are adjusted to 87 degrees and 180 degrees after applying large 95 percent NDE uncertainties. These lengths are less than the 264 degree structural limit. Therefore, structural integrity was satisfied at EOC 11.

The largest NDE maximum voltages were 0.25 volts for ODSCC and 0.58 volts for PWSCC. These values are much less than the insitu leak testing threshold voltage values of 1 volt for ODSCC and 1.5 volt for PWSCC. In addition, the largest NDE maximum depths were 73 percent for ODSCC and 69 percent for PWSCC, including 95 percent NDE uncertainty. Based on these NDE measurements, the SCI were shallow and no SLB leakage should be postulated for these indications at EOC 11.

Per WCAP-15573, Revision 1, Section 4.13, the largest projected EOC average depths are 54 percent for PWSCC and 64 percent for ODSCC. The largest average depths detected in 1R11 were 35 percent for PWSCC and 40 percent for ODSCC with no NDE uncertainty added and 50 percent and 57 percent with 95 percent NDE uncertainty. Thus, the projected EOC indications bound the largest indications found in 1R11.

8.0 Circumferential PWSCC and Axial PWSCC at Dented TSP Intersections (PWSCC Mixed Mode)

One dented TSP intersection containing a circumferential PWSCC indication and an axial PWSCC indication, termed PWSCC mixed mode, was detected and plugged in 1R11. The location was SG 1-2, R11C81 2H. The CM OA of this degradation is provided in Enclosure 2 pursuant to PWSCC ARC requirements.

9.0 Circumferential ODSCC and Axial ODSCC at Dented TSP Intersections (ODSCC Mixed Mode)

One dented TSP intersection containing a circumferential ODSCC indication and an axial ODSCC indication, termed ODSCC mixed mode, was detected in an active tube and was plugged in 1R11. The location was SG 1-2, R35C69 2H. The dent was measured as 2.45 volts. This was the first occurrence of ODSCC mixed mode in either DCPP unit.

The axial ODSCC indication was previously detected by Plus Point in 1R9 and 1R10 and left in service in cycles 10 and 11 under ODSCC ARC because the bobbin voltage was less than 2 volts. The circumferential ODSCC indication was not detected in prior inspections, and was not detectable based on a lookup of 1R10 data.

Based on review of the 1R11 data, a return to null between the indications was not discernable, and therefore the indications are treated as interacting based on the mixed mode indication guidance of WCAP-15573, Revision 1. The NDE average depth of the circumferential flaw is 49.5 percent, including 95 percent uncertainty, which is less than the 75 percent average depth threshold value for mixed mode effects as defined for PWSCC ARC mixed mode requirements in WCAP-15573, Revision 1. In addition, neither the axial or circumferential indication are 100 percent throughwall at any point. The circumferential indication is 64 percent maximum depth, including 95 percent NDE uncertainty. The Plus Point voltage of the axial ODSCC indication is 0.44 volt, indicating a shallow flaw. Based on this ODSCC mixed mode assessment, there is no potential impact on the axial ODSCC indication burst pressure or leakage for condition monitoring.

10.0 Circumferential PWSCC and ODSCC in WEXTEX Region

Three circumferential PWSCC indications and 5 circumferential ODSCC indications in the hot leg WEXTEX region were detected by Plus Point in 1R11, as listed in Table 7. All the SCI were plugged.

The SCI were sized using the technique described in Appendix B of WCAP-15573, Revision 1. The depth profiles were then processed for corrections in accordance with the depth adjustment rules in Section 4.10.4 of WCAP-15573, Revision 1. The adjusted NDE results were corrected for 95 percent NDE uncertainty using the NDE uncertainty regression parameters in Tables 4-19 to 4-21 in WCAP-15573, Revision 1. The adjusted NDE and adjusted NDE with uncertainty results are listed in Table 7.

Table 7 provides the location of the SCI relative to the top of tubesheet. All SCI, except two PWSCC indications, are located above BWT. The PWSCC indication in SG 1-4 R17C39 is located below the W* length and does not contribute to burst or leakage in accordance with W* ARC, and no further condition monitoring assessment is required for this indication. R17C39 was plugged due to a defect at another location.

Table 7 also provides the tubesheet zone location of the SCI. All SCI, with the exception of one PWSCC SCI, are located in WEXTEX Zone 4 (center region) of the top of tubesheet. Zone 4 is noted to have the most tube scale buildup.

The $3\Delta P_{NO}$ structural limit for a SCI is about 264 degrees, assuming a 100 percent throughwall defect. The longest measured length was 23 degrees for PWSCC and 42 degrees for ODSCC, and are adjusted to 77 degrees and 178 degrees after applying large 95 percent NDE uncertainties. These lengths are less than the 264 degree structural limit. Therefore, structural integrity was satisfied at EOC 11.

The largest measured maximum voltages were 0.28 volts for ODSCC and 0.82 volts for PWSCC (excluding R17C89). These values are much less than the insitu leak testing threshold voltage values of 1 volt for ODSCC and 1.5 volt for PWSCC. Based on these voltages, the SCI were shallow and no SLB leakage should be postulated for these indications at EOC 11. Two indications, R27C52 and R17C60, have high NDE estimated maximum depths of 96 percent (0.24 volts ODSCC) and 90 percent (0.34 volts PWSCC), respectively. However, the deep depths at these low voltages are not reliable and are most likely due to difficulties in sizing indications below about 0.5 volts.

11.0 Volumetric Indications at TSP Intersections and at WEXTEX Region

Six OD volumetric indications (SVI) were detected by Plus Point in 1R11, as listed in Table 6. The SVI in R2C14 was located within the hot leg tubesheet below the W* length and was left in service under W* ARC because the tubesheet provides constraint against leakage and burst. The other 5 SVI were located at dented TSP 1H intersections and were plugged. Table 6 provides Plus Point sizing estimates. There is no EPRI quantified sizing technique for volumetric indications at hot leg TSP intersections.

The SVI calls may be attributed to closely spaced axial ODSCC. For example, in 1R10, axial ODSCC (SAI-OD) was confirmed by Plus Point in R28C50, and was left in service under ODSCC ARC. In 1R11, the Plus Point signal was similar, but was called as two indications, SVI-OD and SAI-OD, causing the tube to be plugged.

EPRI insitu guidelines state that if the flaw length is greater than 0.125 inch and the extent is greater than 30 degree, then the flaw should be treated as volumetric. Based on the 1R11 SVI sizing estimates, the SVI are treated as volumetric.

The SVI dimensions are bounded by specimen dimensions used in development of a cold leg thinning (CLT) structural model simulating the flaws as elliptical wastage, which show that indications with a length of 0.7 inch and a depth of about 78 percent in tubes with LTL material properties may be expected to meet the requirements of $3\Delta P_{NO}$. The longest axial length was estimated as 0.23 inches, and the maximum depths were estimated to be less than 40%. These NDE measurements are much less than the structural limit length and depth combination. If the indications were assumed to be axial cracks, the burst pressures would be very high due to the short lengths. Therefore, structural integrity performance criteria were met for the volumetric indications at EOC 11.

Because the SVI maximum depths of less than 40 percent are too shallow to consider ligament tearing (pop through), SLB leakage at EOC 11 would not be expected.

12.0 Cold Leg Thinning (CLT)

CLT indications at cold leg TSP intersections are detected by bobbin probes as part of the 100 percent full-length bobbin inspection. CLT indications are sized by bobbin using EPRI ETSS 96001.1. CLT indications are plugged if bobbin indicates a depth greater than or equal to 40 percent through-wall.

In 1R11, bobbin indications at cold leg TSPs were called as distorted OD support (DOS) indications. If the intersection had no prior Plus Point history, it was then inspected using Plus Point. Volumetric indications confirmed by Plus Point in the CLT region were depth sized by bobbin. If Plus Point did not confirm the indication, the DOS indication was left in service.

In 1R11, 135 CLT indications were detected and sized by bobbin, of which 4 were greater than or equal to 40 percent and plugged. 10 new CLT indications were detected. All CLT indications were located at either 1C or 2C.

Based on development of a CLT structural model assuming elliptical wastage for the flaws, the $1.4\Delta P_{SLB}$ structural limit for a tube with CLT confined to the TSP is about 84 percent. The CLT repair limit is 40 percent, thereby allowing for NDE uncertainty and flaw growth progression.

The deepest indication identified in 1R11 was 46 percent through-wall. In accordance with EPRI ETSS 96001.1, sizing of CLT with bobbin coil has an NDE standard regression error of 16.4 percent at 90/50 confidence. Standard error for analyst uncertainty at 90/50 confidence is 0.89 percent times 1.28, or 1.14 percent (reference "Appendix G Generic NDE Information from CM/OA," extracted from "Capabilities of Eddy Current Analysts to Detect and Characterize Defects in SG Tubes," Doug Harris, presented at November 1996 EPRI NDE workshop). The combined NDE system uncertainty (SRSS) of the analyst and technique uncertainties is 16.4 percent. Adding total NDE uncertainty to the bounding indication results in a CLT flaw of 62 percent, which is less than the CLT structural limit of 84 percent. Therefore, the structural integrity performance criteria were satisfied for this bounding indication at EOC 11. Because CLT was too shallow to consider ligament tearing (pop through), no leakage is postulated in a faulted SG following a SLB at EOC 11. The largest 1R11 flaw size was less than the bounding flaw size projected in the prior cycle OA.

13.0 Antivibration Bar (AVB) Wear

AVB wear indications are detected by bobbin probes during the 100 percent full-length bobbin inspection. AVB wear indications are sized by bobbin using EPRI ETSS 96004.1. AVB wear indications are plugged if bobbin indicates a depth greater than or equal to 40 percent through-wall.

In 1R11, bobbin identified 266 AVB wear indications, of which 5 were greater than or equal to 40 percent and plugged. 18 new indications were detected. Three indications in 1R11 deplugged tubes were detected.

The $3\Delta P_{NO}$ structural limit for a tube with AVB wear is about 71 percent. The AVB wear repair limit is 40 percent, thereby allowing for NDE uncertainty and flaw growth progression.

The deepest indication identified in 1R11 was 42 percent through-wall. In accordance with EPRI ETSS 96004.1, sizing of AVB wear with bobbin coil has an NDE standard regression error of 5.74 percent at 90/50 confidence. Standard error for analyst uncertainty at 90/50 confidence is 0.86 percent times 1.28, or 1.1 percent (reference "Appendix G Generic NDE Information from CM/OA," extracted from "Capabilities of Eddy Current Analysts to Detect and Characterize Defects in SG Tubes," Doug Harris, presented at November 1996 EPRI NDE workshop). The combined NDE system uncertainty is SRSS of the analyst and technique uncertainties, 5.8 percent. Adding total NDE uncertainty to the bounding indication results in a AVB wear flaw of 47.8 percent, which is less than the AVB wear structural limit of 71 percent. Therefore, the structural integrity performance criteria were satisfied for this bounding indication at EOC 11. Because AVB wear was too shallow to consider ligament tearing (pop through), no leakage is postulated in a faulted SG following a SLB at EOC 11. The largest 1R11 flaw size was less than the bounding flaw size projected in the prior cycle OA.

14.0 Tube Support Plate (TSP) Ligament Thinning

In 1R8, 1R9 and 1R10, PG&E performed eddy current inspections to detect degradation of steam generator TSPs. A summary of this program was previously reported to the NRC in response to GL 97-06 (PG&E Letter DCL-98-046 dated March 27, 1998). Visual inspections performed in 1R8 confirmed several missing TSP ligaments. Westinghouse has concluded that the missing TSP ligaments are related to suspected TSP drilled hole manufacturing anomalies. The TSP manufacturing practices employed at the time that the DCPP steam generators were produced used a stacked drilling procedure. Several TSPs were clamped together and drilled simultaneously. A review of the suspect ligament crack (SLC) locations indicates distinct location patterns, indicative of manufacturing anomalies of the automatic drilling equipment.

The eddy current inspection program consists of several steps: bobbin inspection to detect SLC using computerized data screening; Plus Point sample inspection of existing Plus Point confirmed "baseline" indications; and Plus Point inspection of newly detected bobbin SLC indications. Plus Point confirmed indications are called either ligament crack indication (LIC) or ligament gap indication (LIG). The following provides a summary of the 1R11 inspection results.

Baseline Inspection and Results

To satisfy 20 percent inspection recommendations in the EPRI guidelines and to ensure that the current TSP condition is not changing, Plus Point inspection of 100 percent of the baseline indications in SG 1-1 and SG 1-4 was performed.

In SG 1-1, Plus Point confirmed 63 baseline indications (43 LIC and 20 LIG). Two baseline indications did not confirm. In SG 1-4, Plus Point confirmed all 20 baseline indications (15 LIC and 5 LIG). For the LIG indications, gap measurements were performed for a growth assessment, and the small changes did not indicate any change in the material condition of the TSPs.

Inspection for New Indications

Plus Point confirmed 5 new indications (4 LIC and 1 LIG). Based on a review of the baseline data, the LIG was present, but the LIC indications could not be clearly identified due to the quality of the baseline data.

Based on the 1R11 inspections, there are now of a total of 236 Plus Point TSP ligament indications in Unit 1.

Assessment of Plugging Criteria

The largest measured LIG gap was 120 degrees, less than the 146 degree threshold gap. As such, tube plugging was not required.

15.0 PWSCC in Row 1 and 2 U-Bends

Unit 1 SG tubes in Rows 1 and 2 U-bends were heat treated following two cycles of operation to relieve stresses and mitigate the potential for PWSCC in this location. One hundred percent of Rows 1 and 2 U-bends have been inspected each refueling outage. Starting in 1R8, a Plus Point probe was used to inspect Rows 1 and 2 U-bends.

In 1R11, 100 percent of Rows 1 and 2 U-bends in all SGs, and 20 percent of Row 3 U-bends in SG 1-1 and SG 1-3, were inspected by 0.680 mid range (MR) Plus Point probe. No indications were detected by Plus Point. Because PWSCC was not detected in 1R11, this degradation is not considered active in Unit 1 Cycle 11 and condition monitoring is not required.

In light of lessons learned from the Indian Point (IP2) U-bend tube failure event, data quality requirements were implemented. If questionable data (e.g., excessive noise) was collected from the 0.680 MR, the U-bend was reinspected with a 0.680 high frequency (HF) Plus Point probe. If questionable data was subsequently collected with the 0.680 HF, then the tube was plugged for precautionary measures. This resulted in 9 tubes being plugged.

16.0 Free Span Ding Inspections

Plus Point inspection was performed on a 20 percent sample of greater than 2 volt free span dings in the hot leg to verify that no PWSCC or ODSCC is occurring in free span dings. The entire length of free span between the support structures was inspected. No indications at free span dings were detected by Plus Point. No occurrences of stress corrosion cracking at free span dings has been observed at DCPP Units 1 and 2.

17.0 Possible Loose Part (PLP) Inspections

The bobbin and Plus Point data were reviewed for possible loose part (PLP) indications. In addition, a foreign object search and removal (FOSAR) visual examination of the tube sheet annulus and blowdown lane regions was performed to identify loose parts.

In SG 1-1, a PLP indication was detected by Plus Point at R30C78, 0.2 inch above the hot leg top of tubesheet. The Plus Point inspection was performed after sludge lancing. Subsequent FOSAR inspection recovered the loose part at this tube location. The loose part was a small (0.25 inch) round piece of weld slag. Eddy current detected no tube wear at the top of tubesheet, such that this loose part was not a tube integrity concern.

In SG 1-1, a repeat PLP indication was detected by bobbin and confirmed by Plus Point between SG 1-1 R30C78 and R31C78, 3 inches above the cold leg top of tubesheet. The Plus Point inspection was performed after sludge lancing. This PLP indication was previously detected in 1R8, 1R9, and 1R10, but was not detectable by FOSAR. Bounding Plus Point inspections were performed on adjacent tubes as required by procedure. This tubesheet area was once again specifically reviewed during FOSAR activities, and once again no foreign object was identified. Based on this result, the PLP may be an anomalous eddy current trace pattern on the secondary side of the tube wall (conductive sludge, for example). No tube wear was detected by Plus Point. Eddy current inspections will be performed on this location again in 1R12, along with FOSAR examinations to detect and remove any potential loose parts. Continued operation during Unit 1 Cycle 12 is acceptable because eddy current detected no tube wear.

In SG 1-3, a foreign object was detected by FOSAR between tubes R1C49 and R1C50 at the hot leg top of tubesheet. The approximate size of the object is 0.4 inch by 0.75 inch. The object appeared to be metallic and is tightly lodged between the two tubes. Multiple attempts to dislodge the object were unsuccessful. Plus Point data was re-reviewed at this location and a PLP signal was detected. The signal was traced to 1R9 and 1R10 Plus Point data, and has not changed. No tube wear was detected by Plus Point. Eddy current inspections will be performed at this location again in 1R12, along with FOSAR examinations to detect and remove any potential loose parts. Continued operation during Unit 1 Cycle 12 is acceptable because no tube wear was detected by eddy current and because the loose part is adhered to the tubesheet and should not move during plant operation.

PLP indications were detected by Plus Point at SG 1-3 R1C75, 0.5 inch above the hot leg top of tubesheet, and at SG 1-4 R32C17, 0.5 inch above the hot leg top of tubesheet. No tube wear was detected by Plus Point. Subsequent FOSAR inspections at these locations did not locate a loose part. The PLP indications were detected by Plus Point prior to sludge lance tubesheet cleaning, so it is possible that sludge lancing could have removed these objects. Post-sludge lance eddy current inspections were not performed at these locations. Eddy current inspections will be performed at these locations in 1R12, along with FOSAR examinations to detect and remove any potential loose parts. Continued operation during Unit 1 Cycle 12 is acceptable because eddy current detected no tube wear.

18.0 I-690 Mechanical Plug Visual Inspections

All mechanical plugs installed in DCPP Unit 1 are fabricated from Alloy 690. There has been no occurrence of stress corrosion cracking in I-690 plugs in the industry. Two types of I-690 mechanical plugs are installed in DCPP Unit 1: Westinghouse rib plugs and Framatome roll plugs. A visual inspection of all mechanical plugs was performed to verify they are intact and show no signs of leaking. No abnormalities were identified.

Table 1
1R11 SG Tube Inspection and Expansion Criteria

	Area	Probe	Inspection Criteria	Expansion Criteria
1	Full Length	Bobbin	100%	N/A
2	Short Radius U-Bends	+Point	100% - Rows 1 and 2 U-bends in all SGs 20% - Row 3 U-bends in SG 11 and SG 13	If SCC found in Row 2, inspect 20% of Row 3 in affected SG If SCC found in Row 3, inspect 100% of Row 3 and 20% of Row 4 in affected SG Continue expansion in this manner until a flaw free 20% sample is obtained in the next row U-bend
3	WEXTEX TTS Region	+Point	• 100% of HL TTS • Extent is +2" to -8" • PTE/NTE anomaly extent is +2 to tube end	If C-3 condition is identified in HL TTS, inspect 20% of CL TTS in affected SG If indications found in CL, follow EPRI Tables 3-1 and 3-2 for further expansion requirements If cracking found in HL tubesheet anomalies, inspect 100% of CL tubesheet anomalies
4	Repeat PWSCC at dents and TTS	+Point	• 100%	N/A
5	≥5 volt dents	+Point	• SG 1-1: 100% at 1H to 4H, 20% at 5H to 7H • SG 1-2. 100% at 1H to 6H, 20% at 7H • SG 1-3· 20% at 1H to 7H • SG 1-4: 100% at 1H to 3H, 20% at 4H to 7H • For each 20% sample, inspect at least 50 dents, or else inspect 100% if there are less than 50 dents	If PWSCC (at any size dent), circumferential indications (at any size dent), or AONDB (at ≥5 volt dent) are detected at a TSP elevation where 100% inspections were not required, expand the Plus Point inspections (in a step-wise manner, 100% to affected TSP and 20% at next TSP) up through the hot leg side of the SG and down the cold leg side until a 20% sample is obtained that is free from PWSCC, circumferential cracking, or ≥ 2 inferred volt AONDB
6	>2 and <5 volt dents	+Point	• SG 1-1: 100% at 1H to 4H, 20% at 5H • SG 1-2 100% at 1H to 6H, 20% at 7H • SG 1-3 20% at 1H • SG 1-4 100% at 1H to 3H, 20% at 4H • For each 20% sample, inspect at least 50 dents, or else inspect 100% if there are less than 50 dents.	If PWSCC (at any size dent), circumferential indications (at any size dent), or ≥ 2 inferred volt AONDB (at >2 and <5 volt dent) are detected at a TSP elevation where 100% inspections were not required, expand the Plus Point inspections (in a step-wise manner, 100% to affected TSP and 20% at next TSP) up through the hot leg side of the SG and down the cold leg side until a 20% sample is obtained that is free from PWSCC, circumferential cracking, or ≥ 2 inferred volt AONDB
7	Distorted ID support plate bobbin signals (DIS)	+Point	• 100% of DIS calls by bobbin	If a circ indication or ≥2 inferred volt AONDB is detected in a dent of "x" volts, then Plus Point inspections shall be conducted on 100% of dents greater than "x - 0 3" volts up to the affected TSP, plus 20% of dents greater than "x – 0 3" volts at the next higher TSP. "x" is defined as the lowest dent voltage where a circ crack or ≥2 inferred volt AONDB was detected in that SG Note: For any 20% sample, a minimum of 50 "x – 0.3" volt dents shall be inspected If the population of "x – 0 3" volt dents at that TSP elevation is less than 50, then 100% of the "x – 0 3" volt dents at that TSP shall be inspected

	Area	Probe	Inspection Criteria	Expansion Criteria
8	Distorted OD support plate bobbin signals (DOS) and voltage-based ARC implementation	+Point	• DOS at < 5 volt dented intersections • ≥ 2 volt DOS • DOS with suspected TSP ligament cracking • DOS in the wedge region exclusion zone • DOS at 7th TSP exclusion zone • DOS that extend outside the TSP crevice • copper signals • Mix residuals: all HL intersections > 2 3 SPR volts, and minimum of 5 largest HL SPR per SG (CDS determines SPR voltage at each TSP)	N/A
9	Suspected TSP Ligament Cracking (SLC)	+Point	• Plus Point inspect 20% of existing baseline indications, satisfied by 100% inspection of baseline indications in SG 11 and 14 • Plus Point inspect all new bobbin SLC indications Bobbin analysis • CDS of 1R11 bobbin data to identify SLC • Low frequency bobbin review of TSP at intersections with distorted support signals to identify SLC	If active degradation is detected in the 20% sample inspection, then the Plus Point inspection will be expanded to 100 percent of the baseline population. Active degradation is defined as service-induced TSP ligament erosion-corrosion and/or cracking
10	Free Span Dings (> 2 volts)	+Point	• In each SG, 20% from TSH to 7H	If PWSCC is found in 20% sample, then expand inspections in the affected SG by inspecting 100% of >2 volt dings up to affected free span
11	Mechanical Plugs	Visual	Visual inspection of all existing plugs to verify they are intact and show no signs of leaking	
12	Cold Leg Thinning	+Point	• New CLT indications • CLT indications in the wedge zone	N/A
13	Free Span Bobbin Indications	+Point	100% of free span bobbin indications that are new or exhibit growth or change (MBI, FSI, DNI)	N/A
14	Loose Parts	Bobbin +Point	• Review bobbin data of row 1&2 and periphery tubes • +Point of PLP and surrounding tubes • +Point of loose parts detected by FOSAR	N/A
15a	Deplugged Tubes full length	Bobbin	• 100%	N/A
15b	Deplugged Tubes WEXTEX region	+Point	• 100% of HL TTS • Extent is +2" to -8"	N/A
15c	Deplugged Tubes TSP	+Point	• Original flawed TSP • 100% of DOS and DIS, regardless of voltage • 100% of >2 volt hot leg dents • 100% of SLC indications	N/A

Table 2
Number of Tubes Unplugged in SG 1-2 in 1R11

Reason for Unplug	Number of tubes	Type of Plug
PWSCC ARC	76	Roll
PWSCC ARC	61	Rib
95-05 ARC	4	Roll
95-05 ARC	6	Rib
W* ARC	2	Rib
No degradation	1	Roll
Total	150	

Table 3
DCPP Unit 1 Tubes Plugged by Mechanism and SG in 1R11
Active and Deplugged Tubes

LOCATION	MECHANISM	ORIENT	1-1	1-2	1-2 unplug	1-3	1-4	Total
WEXTEX Region	PWSCC	Axial		1				1
	PWSCC	Circ	2					2
	ODSCC	Circ	4			1		5
Hot Leg TSP	PWSCC	Axial			5			5
	PWSCC	Circ		1				1
	ODSCC	Axial	8	16		7	6	37
	ODSCC	Circ		2	1		1	4
	PWSCC Mix Mode	Axial PWSCC/Circ		1	1			2
	ODSCC Mix Mode	Axial ODSCC/Circ		1	1			2
	PWSCC/ODSCC	Axial	7	7	44			58
	Volumetric	OD		1			2	3
Cold Leg TSP	Cold Leg Thinning			3			1	4
U-Bends	AVB Wear		1	3		2		6
Rows 1 and 2 U-bend	Preventive Data Quality		7	2				9
Restriction					1			1
Tubes Plugged			29	38	53	10	10	140
Tubes Unplugged					150			150
Net Plugged			29	38	-97	10	10	-10

Table 4
DCPP Unit 1 Historical Tube Plugged by Mechanism and SG

LOCATION	MECHANISM	ORIENT	1-1	1-2	1-3	1-4	Total
WEXTEX Region	PWSCC	Axial	2	3	0	2	7
	PWSCC	Circ	4	4	0	1	9
	ODSCC	Circ	7	0	9	0	16
	Volumetric		3	0	5	4	12
Hot Leg TSP	PWSCC	Axial	38	34	0	15	87
	PWSCC	Circ	1	8	0	0	9
	ODSCC	Axial	21	32	9	10	72
	ODSCC	Circ	0	7	0	2	9
	PWSCC Mix Mode	Ax/Circ	0	3	0	0	3
	ODSCC Mix Mode	Ax/Circ	0	2	0	0	2
	PWSCC/ODSCC	Axial	10	65	0	0	75
	PWSCC/ODSCC	Circ		1			1
	Volumetric		1	1	1	3	6
	Preventive Data Quality	PVN		1			1
Cold Leg TSP	Cold Leg Thinning		17	27	1	8	53
	Volumetric		2	1	1	1	5
Rows 1 and 2 U-bend	PWSCC	Axial	6	17	2	1	26
	PWSCC	Circ	7	5	0	1	13
	Preventive Data Quality		8	10	4	9	31
U-bend	AVB Wear		5	13	14	16	48
Factory Plug			0	1	0	0	1
Restriction			0	3	0	0	3
Free span	SVI or SAI scratch		1	0	2	2	5
Fatigue (88-02)	Preventive		5	0	1	0	6
Implant Tubes			16	0	0	0	16
Tubes Plugged			154	238	49	75	516
% Plugged			4.5	7.0	1.4	2.2	3.8

Table 5 - DCPP Unit 1 Tubes Plugged by Mechanism and Outage

LOCATION	MECHANISM	ORIENT	Pre	1R1	1R2	1R3	1R4	1R5	1R6	1R7	1R8	1R9	1R10	1R11	UnPlug	Total
Cumulative EFPYs				1.25	2 27	3 45	4 49	5 86	7.14	8 46	9.75	11.4	12 87	14 28		
Cycle EFPY				1.25	1 02	1.18	1 04	1.37	1.28	1.32	1.29	1 62	1.49	1 41		
WEXTEX Tubesheet	PWSCC	Axial							2	2	1	1	2	1	2	7
	PWSCC	Circ								1	4		2	2		9
	ODSCC	Circ										2	9	5		16
	Volumetric	SVI								1	5	5	1	0		12
Hot Leg TSP	PWSCC	Axial							31	72	124	20	13	5	178	87
	PWSCC	Circ								4	1	2	1	1		9
	PWSCC Mix Mode	Ax/Circ										1		2		3
	ODSCC Mix Mode	Ax/Circ												2		2
	PWSCC/ODSCC	Axial									1	3	13	58		75
	PWSCC/ODSCC	Circ											1	0		1
	ODSCC	Axial							7	8	44	10	18	37	52	72
	ODSCC	Circ											5	4		9
	Volumetric										2	1		3		6
Cold Leg TSP	Thinning								10	14	2	11	12	4		53
	SVI										1	4				5
Row 1 and 2 U-bend	PWSCC	Axial				4		13	4		5					26
	PWSCC	Circ						4		1	4		4			13
U-bend	AVB Wear					2	1	12	8	12	3	1	3	6		48
U-bend or straight leg	Probe restriction					1			1					1		3
Free Span	SVI or scratch								1			4				5
Factory Plug	Preservice		1													1
Possible UB indication					1										1	0
Preventive Plugging	Fatigue (88-02)					5					1					6
Preventive Plugging	UB Data Quality												23	9	1	31
Preventive Plugging	TSP Data Quality	PVN											1			1
Implant Tubes									4	2	1	9				16
Tubes Plugged			1	0	1	12	1	29	68	117	199	74	108	140		
Tubes Unplugged						1						40	43	150		
Cum Tubes Plugged			1	1	2	13	14	43	111	228	427	461	526	516		
Cum Tubes Plugged (%)			0 01	0 01	0 01	0 10	0 10	0 32	0.82	1.68	3.15	3 4	3 9	3 8		

Table 6
1R11 Volumetric Indications

SG	Row	Col	Location	Ind	Orient	Dent volt	PP Volts	Axial Length (inch)	Width (inch)	Extent (deg)	EPRI flaw treatment	1R10 PP Volts	1R10 Axial Length (inch)	1R10 Width (inch)	1R10 CA deg
12	2	68	1H + 0.23	SVI	OD	1 5	0 23	0 23	0 50	67	Volumetric	NDD			
12	2	68	1H – 0.20	SVI	OD	1 5	0 24	0 19	0 22	30	Volumetric	NDD			
12	28	50	1H + 0 02	SVI	OD	1 7	0 28	0 22	0 61	81	Volumetric	0 69 (Note 3)			
13	2	14	TSH –8 36 to – 8 12	SVI	OD		0 59	0.23	0 31	40	Volumetric	0 45	0 22	0 34	45
14	8	30	1H – 0 02	SVI	OD	5 4	0 52	0 12	0 42	56	Volumetric	NDD			
14	17	39	1H – 0 08	SVI	OD	2 9	0 23	0 14	0 40	53	Volumetric	0.16	0.16	0.34	44

Notes

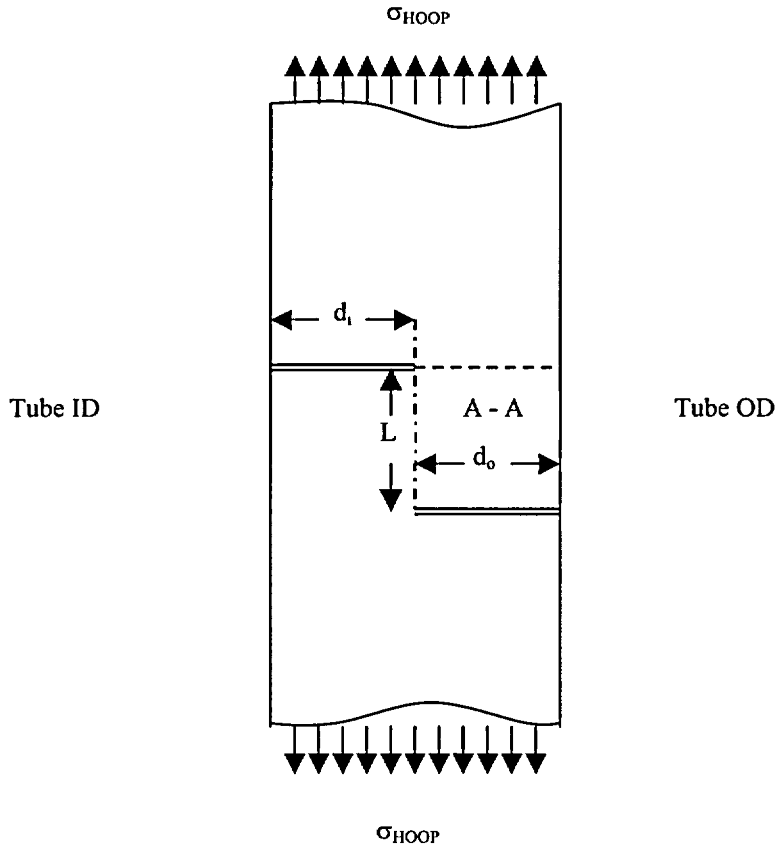
1. EPRI insitu pressure test guidelines provide the following pressure test criteria If the length is > 0 125 inch and the crack angle is < 30 degrees, evaluate as an axial flaw. If length < 0.125 inch and CA > 30 deg, evaluate as a circumferential flaw. If length > 0 125 and CA > 30 deg, evaluate as a volumetric flaw.
2. 1R10 sizes are based on lookup analysis of eddy current data NDD indicates no detectable degradation based on lookup analysis.
3. SG 12 R28C50 1H was characterized as axial ODSCC in 1R10, with a maximum Plus Point voltage of 0.69 volts. In 1R11, it was characterized as two flaws: axial ODSCC and volumetric OD.
4. Max depth of these indications is estimated to less than 40%

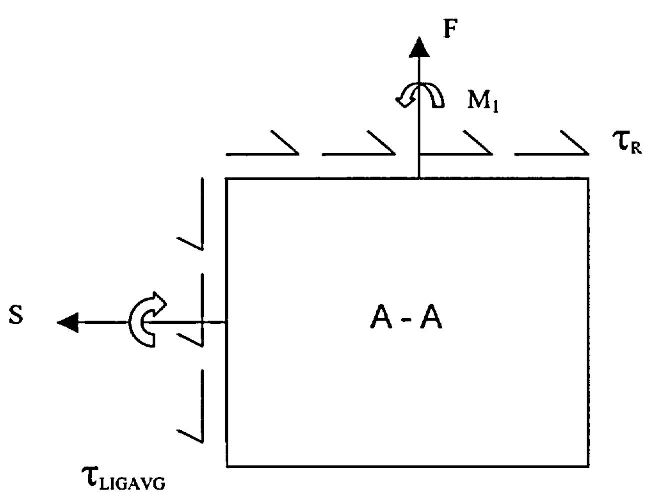
Table 7
1R11 Circumferential Indications

SG	Row	Col	Crack	Support	Location inch	Circ Type	TS Zone	BWT inch	Dent volt	Mixed Mode?	Flaw Volt	Unadjusted NDE Angle deg	Unadjusted NDE Max Depth %	Unadjusted NDE Avg Depth %	Adjusted NDE Angle deg	Adjusted NDE Max Depth %	Adjusted NDE Avg Depth %	Adjusted for Upper 95% NDE Uncertainty Angle deg	Adjusted for Upper 95% NDE Uncertainty Max Depth %	Adjusted for Upper 95% NDE Uncertainty Avg Depth %	Growth Rate per EFPY Angle deg	Growth Rate per EFPY Max Depth %	Growth Rate per EFPY Avg Depth %
11	2	6	1	TSH	-1.77	PWSCC	3	-0 20		no	0.82	23.2	44 0	23 5	23 2	44 0	31 7	77 0	67.1	47.4	-3 6	-2 8	-2 2
11	6	49	1	TSH	-0 18	ODSCC	4	-0 35		no	0 28	41 7	64 0	39.7	41.7	64.0	55 4	177 7	81 9	66 0	NDD		
11	14	68	1	TSH	0.00	ODSCC	4	-0 26		no	0 23	30.9	92.0	70 3	30 9	78 6	67 6	173 2	92 6	73 6	-0 3	-3 8	-2 4
11	17	58	1	TSH	-0 02	ODSCC	4	-0 51		no	0 26	38 7	83 0	67 1	38 7	75 3	63.8	176.5	90 2	71 2	-5 5	14 7	12 2
11	17	60	1	TSH	0 00	PWSCC	4	-0 91		no	0 34	23 2	91 0	72.7	23.2	90 0	69 3	77 0	100 0	72 7	0 0	-4.3	-4.9
11	18	39	1	TSH	0 00	ODSCC	4	-0 61		no	0.13	22.4	54 0	30 8	22 4	42 0	32 3	169 7	65.8	51.6	4.7	4 0	6 1
12	8	84	1	1H	0 30	ODSCC			21.48	no	0 15	36 7	38 0	19 4	36 7	40 0	26.7	175 6	64 3	48 2	NDD		
12	8	85	1	1H	0 35	ODSCC			19 31	no	0 13	29 4	55 0	22.5	29 4	40 0	26 2	172 6	64 3	47 8	NDD		
12	8	85	2	1H	0 34	ODSCC			19 31	no	0.16	22.1	34 0	20 3	22.1	40 0	29 5	169 6	64.3	49.9	NDD		
12	11	81	1	2H	0 11	PWSCC			3.11	yes	0 43	29 7	97 0	60 8	29 7	47.0	34 8	83 6	69 3	49 5	2.1	4 6	3 4
12	35	69	1	2H	0.09	ODSCC			2 45	yes	0 15	22.7	53 0	35.0	22.7	40 0	27.5	169 9	64 3	48 6	NDD		
12	37	34	1	3H	0 04	PWSCC			8.32	no	0 58	33 4	55 0	27 7	33 4	40 0	19.2	87.4	64 2	39 0	1 2	0 0	-0 3
13	27	52	1	TSH	0 00	ODSCC	4	-0 19		no	0 24	39 1	98 0	67.8	39.1	96 0	77 2	176 6	100 0	79 6	3 0	17.7	13.0
14	17	39	1	TSH	-9 39	PWSCC	4	-0 29		no	1.21	24.0	46 0	27.5	24 0	41 0	28 5	77 8	64.9	45.2	-2.8	-3 5	-3.1
14	43	55	1	2H	0 27	ODSCC			23.84	no	0 25	48 0	53 0	39 4	48 0	51.5	39.8	180 3	72 8	56 3	0 0	6 0	5 3

Note 1: For SG 12 R11C81 mixed mode, the axial component is PWSCC.
Note 2: For SG 12 R35C69 mixed mode, the axial component is ODSCC. NDE average depth adjusted for upper 95% uncertainty for mixed mode affects evaluation is 50 2% instead of 48.6%.
Note 3. All locations where circumferential indications were detected in 1R11 were previously inspected in 1R10 If a growth rate is indicated, the 1R10 lookup evaluation detected degradation. If NDD is indicated, the 1R10 lookup evaluation did not detect degradation
Note 4: BWT is the location (in inches) of the bottom of the WEXTEX transition relative to the top of tubesheet

Figure 1, ID/OD Flaw Interaction





$$V = \tau_{LIG\,AVG} L$$
$$\sum \text{Vertical Forces} = 0$$
$$F = V$$

SPECIAL REPORT 02-02

RESULTS OF STEAM GENERATOR VOLTAGE-BASED ALTERNATE REPAIR CRITERIA INSPECTIONS AT TUBE SUPPORT PLATE INTERSECTIONS (GENERIC LETTER 95-05)

DIABLO CANYON POWER PLANT UNIT 1 ELEVENTH REFUELING OUTAGE

FRAMATOME ANP

CALCULATION SUMMARY SHEET (CSS)

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PURPOSE AND SUMMARY OF RESULTS:

This report summarizes the Diablo Canyon Unit 1 - 1R11 May 2002 inspection of the steam generator tubing with respect to the implementation of the Voltage-based Repair Criteria as specified in NRC Generic Letter 95-05. This document provides the projected probability of burst and leak rate calculations needed for submittal to the NRC. This report provides a non-proprietary summary of the results. The supporting proprietary calculations and necessary code verifications required for safety-related calculations are contained in Ref. 19.

THE FOLLOWING COMPUTER CODES HAVE BEEN USED IN THIS DOCUMENT:

CODE/VERSION/REV	CODE/VERSION/REV
BURST97/1.0/01	
LEAKER97/2.0/01	

THE DOCUMENT CONTAINS ASSUMPTIONS THAT MUST BE VERIFIED PRIOR TO USE ON SAFETY-RELATED WORK

☐ YES ☒ NO

RECORD OF REVISIONS

Revision Number	Affected Page(s)	Description of Change(s)
0	All	Original Release

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Glossary of Acronyms

Term	Definition
AONDB	Axial ODSCC Not Detected by Bobbin
ARC	Alternate Repair Criteria
BOC	Beginning of Cycle
CPDF	Cumulative Probability Distribution Function
CFR	Code of Federal Regulations
CLT	Cold-Leg Thinning
DCPP	Diablo Canyon Power Plant
DIS	Distorted ID Support Signal with possible Indication
DOS	Distorted OD Support Signal with possible Indication
DNF	Degradation Not Found
EFPD	Effective Full Power Day
EFPY	Effective Full Power Year
ECT	Eddy Current Test
EOC	End of Cycle
FS	Free Span
FRA-ANP	Framatome Advanced Nuclear Power
GL	NRC Generic Letter 95-05
GPM	Gallons per Minute
ISI	In-service Inspection
LRL	Lower Repair Limit
MSLB	Main Steam Line Break
NDE	Non Destructive Examination
NDD	No Degradation Detected
NRC	Nuclear Regulatory Commission
ODSCC	Outside Diameter Stress Corrosion Cracking
PG&E	Pacific Gas and Electric Company
POB	Probability of Burst
POD	Probability of Detection
POPCD	Probability of Prior Cycle Detection
POL	Probability of Leak
PWSCC	Primary Water Stress Corrosion Cracking
RPC	Rotating Pancake Coil
RSS	Retest Support Plate Signal
RTS	Return to Service
SG	Steam Generator
SER	Safety Evaluation Report
TS	Technical Specification
TSP	Tube Support Plate
WEXTEX	Westinghouse Explosive Tubesheet Expansion
+Point	Plus Point Coil

1.0 Introduction

The Diablo Canyon Power Plant (DCPP) Unit 1 completed the eleventh cycle of operation and subsequent steam generator ISI in May 2002. The unit employs four Westinghouse-designed Model 51 SGs with 7/8-inch OD mill annealed alloy 600 tubing and ¾-inch carbon steel drilled-hole tube support plates.

In accordance with the Generic Letter 95-05, ARC implementation requires a pre-startup assessment (Ref. 1) and a 90-day post-startup tube integrity assessment. The NRC Generic Letter 95-05, Ref. 2, outlines an alternate repair criterion (ARC) for allowing tubes containing ODSCC indications to remain in service if the indications are contained within the TSP structure and the measured Bobbin voltage is ≤2.0 volts. A complete list of exclusion criteria is provided in section 1.b of Ref. 2 and in Ref. 3. The NRC has approved implementation of the voltage-based repair criteria at both DCPP units per Ref. 3. The steam generator TSP ISI results and the postulated MSLB leak rate and tube burst probabilities are summarized in this report. FRA-ANP uses Monte Carlo codes, as described in Refs. 4 and 5, to provide the burst and leak rate analysis simulations. These evaluations are based on the methods in Ref. 6 (for burst) and the new slope sampling method for calculating the leak rate as defined in Ref. 21. The correlation parameters used in the simulations are taken from the March 2002 update (Ref. 20) to Addendum 4 of the EPRI ODSCC ARC Database (Ref. 10).

2.0 Executive Summary

Based on the number of indications and the size of the indications, SG 1-1 is predicted to be the limiting generator for Diablo Canyon Unit 1 at the end of Cycle 12. During Cycle 11, SG 1-1 started experiencing voltage dependent growth, where the larger indications were growing faster as measured by voltage. Of the 270 plus point inspections of DOS (distorted OD support signal) indications, 249 were confirmed yielding an overall confirmation rate of about 92%. Based on the plus point confirmation rate, approximately 800 tubes were saved by the implementation of the ARC during 1R11.

The leak rate and burst pressure correlations used were based on the latest NRC approved database for 7/8" tubing (Ref. 20). The limiting EOC-12 SLB leak rates (SG 1-1) predicted with constant POD were 1.11 gpm (Normal growth) and 1.14 gpm (voltage dependent growth), where both predictions meet the limit of 10.5 gpm for a full cycle of operation. The tube burst probabilities with constant POD for the limiting generator (SG 1-1) were 6.89×10^{-5} (normal growth) and 1.17×10^{-4} (voltage dependent growth), which is well below the NRC reporting guideline of 1.0×10^{-2}.

A total of 924 DOS indications were found in active tubes during the EOC-11 inspection, of which 137 were over 1 volt, and 11 were over 2 volts. All indications over 2 volts were confirmed by plus point inspection and repaired by plugging. 98 additional indications in active tubes were identified as AONDB (axial ODSCC not detected by bobbin). All of the inferred voltages for these indications were less than 1 volt. None of the detected DOS or AONDB indications exceeded the upper repair limit of 6.36 volts.

In addition to the indications in the active tubes, there were also indications detected in tubes that were deplugged. During the 1R11 outage, 150 tubes in SG 1-2 were deplugged for potential return to service by applying the various ARCs that are approved for DCPP. A total of 34 DOS and 60 AONDB indications were detected in the deplugged tubes, of which 17 DOS and 10 AONDB indications were returned to service under ARC. 53 of the 150 tubes had to be replugged, mostly due to ID and OD axial indications detected at the same TSP intersection. As a result, only 17 DOS and 10 AONDB indications were deplugged and subsequently returned to service. Only one of the deplugged indications returned to service was greater than 1 volt.

The EOC-11 projections for leak rate and probability of burst exceeded the as-found conditions by a relatively wide margin for all steam generators. SG 1-1 experienced voltage dependent growth over the previous cycle; however, it was not significant enough to invalidate the projections from the previous 90-day report.

3.0 EOC-11 Inspection Results and Voltage Growth Rates

3.1 EOC-11 Inspection Results

The DCPP 1R11 bobbin coil inspection consisted of a 100% complete full-length bobbin coil examination of tubes in all four steam generators except Rows 1 and 2 U-bends. 0.720" replaceable feet bobbin probes were used for the straight length examinations including all TSP intersections in the hot and cold legs except for the 07H intersection in SG 1-4 Tube 7-89. This intersection was inspected with a 0.700" bobbin probe because a large dent would not permit a 0.720" probe to pass. There was no DOS indication reported at the intersection. Special interest plus point TSP examinations were conducted as follows in support of the voltage-based ARC, as specified in Reference 9.

- 100% of DOS greater than 2 volts
- 100% of DOS in tubes deplugged in 1R11
- 100% of DOS in dented intersections)
- 100% of DIS (distorted ID support signal at dented intersection)
- Greater than 2 volt dent examinations based on NRC-approved criteria
- Other Special Interest programs, such as free span dings that may also inspect TSP intersections

Based upon the 100% bobbin inspection of all steam generators, a total of 924 DOS indications and 98 AONDB indications were identified in active tubes. An additional 17 DOS indications and 10 AONDB indications were detected in tubes that were deplugged and returned to service in SG 1-2. The results of the inspections are summarized as follows:

1. Table 3-1 lists the DOS indications that were above the LRL (2.0 volts). Each of the indications was confirmed as ODSCC and was repaired by plugging.

2. Five circumferential ODSCC indications and two circumferential PWSCC indications were detected at dented support plates in active tubes and were plugged. All of the dent voltages exceeded 2 volts.

3. Table 3-2 lists the indications that were identified as AONDB (axial ODSCC not detected by bobbin) in active tubes and in deplugged tubes returned to service. These indications have axial ODSCC but with no indication of a bobbin DOS signal. These locations are typically smaller voltage ODSCC, by plus point, and are accompanied by a dent that masks the bobbin voltage with one exception. Tube 27-83 in SG 1-2 has an AONDB associated with an SPR (Support Plate Residual) call. Per Refs. 8 and 9, a methodology has been developed to assign a bobbin voltage based on a correlation to the plus point voltage (Ref. 17). Once the calculated voltages are obtained, the locations are subjected to the same exclusion criteria as the DOS population, per Ref. 12. All of the inferred voltages were less than 1 volt. The repair limits for the AONDB indications are 2.00 volts for the dented intersections and 1.00 volt for the SPR intersections.

4. Seven DOS indications in the cold leg thinning (CLT) region were included in the DOS analysis pool. These indications were inspected with plus point and were not confirmed as CLT or ODSCC.

5. Overall, 65 DOS/AONDB indications in 57 active tubes were repaired during 1R11 (including all damage mechanisms for which tube repair is required).

6. There were additional 17 DOS and 50 AONDB indications that were deplugged and subsequently replugged in SG 1-2. These indications do not factor into this analysis since they were not in service before or after the 1R11 outage and not subject to condition monitoring and operational assessment.

Table 3-3 summarizes the TSP voltage distributions for the as-found condition of the indications, the repaired indications, the indications returned to service that were either confirmed by plus point or not inspected with plus point, and finally, the total indications returned to service. Eleven confirmed DOS were repaired because they exceeded the 2 volt repair limit. The other main reasons for repair included the wedge exclusion criterion, combined ID/OD degradation at the same intersection, and AONDB at intersections with dents greater than 5 volts.

The plus point inspections required for DOS indications were accomplished as a part of the special interest exams. The 1R11 plus point inspection scope also included greater than 2 volt dents based on criteria in the degradation assessment (Ref. 9). 270 plus point inspections were performed where DOS indications were called by bobbin, i.e., excluding the AONDB intersections. Of these inspections, 249 were confirmed yielding an overall confirmation rate of about 92%. Based on the plus point confirmation rate, approximately 800 tubes were saved by the implementation of the ARC during 1R11.

Figures 3-1 and 3-2 show the actual bobbin voltage distribution for all tubes that were in service during Cycle 11. Figure 3-3 shows the voltage distribution for the indications in the tubes in SG 1-2 which were deplugged and returned to service. Figures 3-4 and 3-5 show the indications removed from service at EOC-11. Figure 3-6 and Figure 3-7 illustrate all the indications returned to service following the EOC-11 ECT inspection. Note that SG 1-1 and SG 1-2 have larger quantities of indications being returned to service compared to the other steam generators. Table 3-1 shows all of the indications greater than the 2 volt lower repair limit. All of these indications were confirmed as axial ODSCC and were removed from service by plugging.

The TSP voltage distribution is provided in Table 3-5. Table 3-5 and Figure 3-8 show that the ODSCC mechanism is most active at the lower hot leg TSPs, and the number of indications tends to decrease as a function of higher TSP elevations. This distribution shows the temperature dependence of ODSCC.

3.2 *Voltage Growth Rates*

For projection of leak rates and tube burst probabilities at the end of Cycle 12 operations, voltage growth rates were developed from the EOC-11 inspection data. For indications not reported during the EOC-10 inspection (i.e. new at EOC-11), the indications were sized using the EOC-10 ECT signals based on a lookup review. There were 500 newly reported DOS indications in 1R11. Of these 500 new indications, 494 were detected during the 1R10 lookup and were assigned a 1R10 voltage. The remaining 6 indications were not detectable during the lookup and were, therefore, not included in the growth rate calculations. Table 3-4 provides a summary of indications with the largest growth during cycle 11. Table 3-5 provides the maximum and average voltage growth distribution by TSP. Table 3-6 shows the voltage growth distributions for each SG and the composite for all four SGs. The cumulative probability distribution function is also provided here. Figures 3-9 and 3-10 show the voltage growth distributions depicted in bar charts. For the tube integrity calculations, the negative growth values were included as zero growth rates as required by Generic Letter 95-05. Reviewing the average and maximum voltage growth for all indications for each SG shows that the ODSCC mechanism is most active in SG 1-1. This assumption is also supported by reviewing Table 3-6 and Figures 3-9 and 3-10. As shown in the table and figures, four of the five largest growth rates occurred in SG 1-1.

In order to illustrate any dependency of growth on the BOC voltage, the growth rates were plotted against the BOC voltage for all steam generators. This data is shown in Figures 3-11 and 3-12. Based on the slope of the regression lines in these figures, SG 1-1 is the only steam generator that may be experiencing voltage dependent growth. In accordance with the recommended procedure in Ref. 16, different growth distributions were developed for specific ranges of BOC voltages. Tables 3-7 and 3-8 contain the two different sets of growth rates based on BOC voltages. Figure 3-13 shows the growth rate distributions for three different ranges of BOC voltages (<=0.50V, 0.51V to 1.00V, and >1.00V). This figure includes data from all four steam generators. As shown in the figure, there is a consistent shift toward higher growth for the larger BOC voltages. Similar charts were prepared for each steam generator individually. SG 1-1 was the only steam generator that showed a bias toward voltage dependent growth. This chart for SG 1-1 is shown in Figure 3-14.

For the voltage dependent growth distributions for SG 1-1, two different categories of BOC voltages were defined (<=0.50V and >0.50V). Using a 0.50 volt breakpoint gives 124 indications in the >0.50V bin. Per Ref. 16, the upper voltage bin should include about 200 indications when a constant POD of 0.6 is being used. For Diablo Canyon's case, however, if the breakpoint is lowered such that 200 indications are in the upper voltage bin, then the voltage dependency effect is lessened. Therefore, 0.50 volts was used since there is still a significant population of indications in this category and the voltage dependency is still evident. In accordance with the recommended procedure in Ref. 16, the three largest growth values among all steam generators should be included in the growth distributions (if not already included in the SG-specific data). For Diablo Canyon Cycle 11, one of the three largest growth values occurred in SG 1-2. Therefore, this growth value (1.1 V/EFPY) was added to the voltage dependent growth distribution for SG 1-1 before running the leak rate and probability of burst calculations. The other two of the three largest growth values occurred in SG 1-1 and were, therefore, already included in the distribution. Table 5-6 gives a summary of the growth distributions that were used in the Monte Carlo simulations for each steam generator.

There were 14 DOS indications detected in tubes that were deplugged and returned to service in 1R10. Some plants have seen higher growth rates for deplugged tubes in the first cycle of operation compared to the continuously active tube population. This phenomenon has not been observed at DCPP based on past experience: 52 ODSCC indications were deplugged and returned to service in 1R9, and subsequent Cycle 10 growth rates of the indications were bounded by the active population. To once again demonstrate that this phenomenon is not occurring at DCPP, the Cycle 11 growth distributions for the 14 1R10 deplugged indications were compared with the Cycle 11 growth distributions for the active tubes. Figure 3-15 shows these distributions. As shown in the figures, the deplugged tube growth distribution is bounded by the growth distribution for the active tubes. Therefore, the deplugged and active tube growth distributions were combined for the leak rate and probability of burst projections.

Per the Generic Letter, growth distributions should be determined for each of the last two inspection cycles. The most limiting of the two growth distributions should be used. Figure 3-16 shows the growth distributions for the last two inspection cycles for Diablo Canyon Unit 1. As shown in the figure, the growth distribution for Cycle 10 bounds the growth distribution for Cycle 11. However, the SG-specific growth distributions for Cycle 10 all contain less than 200 indications. Therefore, per the Generic Letter, the growth distributions for the two cycles should be combined. For SGs 1-1, 1-2, and 1-3, the combined growth distributions contain the minimum of 200 indications and were, therefore, used in the leak rate and POB projections.

For SG 1-4, the combined growth distribution from Cycles 10 and 11 contained less than 200 indications. Therefore, the data for all steam generators were combined to obtain a Cycle 10 and a Cycle 11 growth distribution for all steam generators combined. The Cycle 10 growth rate is bounding for the smaller growth bins. However, in the upper tails of the distributions, Cycle 11 is bounding. Therefore, the CPDF values from Cycle 10 were used for growth bins up to 1.1 volts inclusively, and for the growth bins above 1.1 volts, the CPDF values from the Cycle 11 growth distribution were used. Table 3-9 provides a summary of the growth distributions that were used for the EOC-12 leak rate and probability of burst projections. Table 3-10 provides the CPDF values for the growth distributions used in the EOC-12 projections.

3.3 Probe Wear Criteria

The first NRC requirement regarding probe wear is to minimize the potential for tubes to be inspected with a probe that had failed the probe wear check. This was accomplished by implementing ETSS #1 (Ref. 11) which required the probe have its feet replaced when failing the probe wear check, or in the case of non-changeable feet probes, the probe discarded.

If the DOS voltage is at the retest threshold (1.5 volts or higher) and the Cal is designated as "ARC Out" on the cal board, the indication code is changed from a DOS to an RSS (retest support plate signal). No new indications were detected in the tubes when inspected with the new probe.

The 1R11 eddy current inspection resulted in 19 bobbin indications in excess of 1.5 volts that were inspected with a worn probe. Those indications are shown in Table 3-11. The RSS and DOS voltage variation was tabulated for each worn probe inspection. The retest voltage values compare reasonably with the worn probe voltages. The largest increase in voltage compared to the worn probe voltage was 15.1%. Figure 3-17 shows a comparison of the worn probe and good probe voltages. This figure shows that the voltages do not change significantly between the worn probes and the good probes. Therefore, continued use of the 1.5 volt retest threshold is justified (Ref. 13).

All RSS bobbin indications were inspected in accordance with the Ref. 11 analysis guidelines. Review of the probe wear log sheets and the eddy current test results indicate that no tubes were inspected with a probe known to have failed the probe wear check. These reviews in conjunction with the results in Table 3-11 address the NRC requirements listed in Ref. 15.

The next requirement involves monitoring tubes that contain new DOS indications that were inspected with probes that failed the wear check in the previous outage. This evaluation is intended to look for new large indications or a non-proportionately large percentage of new indications in tubes that failed the check in the previous outage. Large is defined as ≥ 0.5 volt DOS. The new 1R11 >= 0.5 volt DOS indications in tubes that failed the probe wear check in 1R10 are shown in Table 3-12.

Overall there were 924 DOS indications detected in the 1R11 inspection of the active tube population. 500 or ~54% of the DOS indications were new indications. In order to assess the new indications against the probe wear requirements, Table 3-13 is presented. Of the 500 total new indications, 303 were in tubes inspected with a worn probe in 1R10 and 197 were in tubes inspected with a good probe in 1R10. The number of new indications ≥ 0.5 volts was determined to be 215. Out of these, 138 were in tubes that were inspected with a worn probe in 1R10. When these numbers are compared to the total number of inspections in 1R10, the results shown in Table 3-14 are obtained. This table shows the approximate percentage of tubes with new indications. The results are categorized based on whether the previous inspection was performed with a worn probe or a good probe. This table shows that about 2.9% of the 1R10 worn probe inspections yielded new indications in 1R11. This is slightly less than the 3.3 % rate for the tubes inspected with good probes in 1R10. For the new indications ≥ 0.5 volts, the rates were the same (1.3% for the both worn and good probes).

Since 494 of the 500 newly reported DOS indications were detected during the lookup review of the 1R10 data, probe wear is not considered to be significantly affecting the quality of the data and, therefore, the ODSCC detection capability. In addition, the fact that the rate of new indications is slightly higher for the tubes inspected with good probes in 1R10 suggests that detection of these indications is not affected by probe wear.

New indications are more a result of probability of detection rather than the fact that the tube was inspected with a worn probe in 1R10. These percentages are not considered to indicate that a disproportionate number of new DOSs are present in tubes that were inspected with a worn probe in the previous outage. In summary, the NRC analysis requirements regarding probe wear monitoring were met during the 1R11 bobbin coil inspection and a more stringent wear tolerance is not required.

3.4 Upper Voltage Repair Limit

Per Generic Letter 95-05, the upper repair limit must be calculated prior to each outage, and the more conservative of the plant-specific average growth rate per EFPY or 30 percent per EFPY should be used as the anticipated growth rate input for this calculation. The upper voltage repair limit was calculated prior to the 1R11 inspection and was determined to be 6.36 volts (Ref. 12) based on the following formula. This calculation used a 32.8 percent per EFPY growth based on the 1R10 90-day report (Ref. 7).

$$V_{URL} = \frac{V_{SL}}{1 + \frac{\%V_{NDE}}{100} + \frac{\%V_{CG}}{100}}$$

where: V_{URL} = upper voltage repair limit,
V_{NDE} = NDE voltage measurement uncertainty = 20%,
V_{CG} = voltage growth anticipated between inspections = 32.8%/EFPY x 1.61 EFPY = 52.8%,
V_{SL} = voltage structural limit from the burst pressure – Bobbin voltage correlation, where the limit of 11.0 volts was used based on Ref. 20.

Although the upper repair limit will not be calculated again until shortly before the next inspection, the average growth rates from Cycle 11 are documented in this report to verify the limiting growth rate to be used for the 1R12 outage. Table 3-15 shows the average growth values for each steam generator as well as the average growth for all steam generators combined. As shown in the table, the average growth for all steam generators combined was 19.8% per EFPY. Since this value is less than the NRC minimum limit of 30% per EFPY, the NRC minimum value should be used when calculating the upper repair limit for 1R12.

3.5 NDE Uncertainty Distributions

NDE uncertainties must be taken into account when projecting the end-of-cycle voltages for the next operating cycle. The NDE uncertainties used in the calculations of the EOC-12 voltages are described in Ref. 6. The acquisition uncertainty was sampled from a normal distribution with a mean of zero, a standard deviation of 7%, and a cutoff limit of 15% based on the use of the probe wear standard. The analyst uncertainty was sampled from a normal distribution with a mean of zero, a standard deviation of 10.3%, and no cutoff limit. These uncertainty distributions are shown in Table 3-16 and Figure 3-18.

Table 3-1: 1R11 DOS Indications > 2.0 volts (Active Tubes)

SG	Row	Col	Ind	Elev	Volts
SG11	2	46	DOS	1H	3.23
	4	67	DOS	1H	2.64
	27	47	DOS	1H	2.26
	30	32	DOS	1H	2.4
SG12	4	48	DOS	1H	2.8
	6	53	DOS	1H	2.11
	20	87	DOS	1H	2.14
	22	43	DOS	1H	2.25
	40	27	DOS	1H	2.33
SG13	33	40	DOS	1H	2.4
SG14	8	29	DOS	1H	2.33

Table 3-2: 1R11 AONDB Indications

SG	Row	Col	Elev	Dent Voltage	Plus Pt Voltage	Assigned DOS Voltage
SG11	8	69	1H	1.09	0.1	0.42
SG11	8	69	1H	1.09	0.15	0.47
SG11	8	69	1H	1.09	0.25	0.57
SG11	11	15	3H	2.2	0.17	0.49
SG11	14	12	2H	9.15	0.11	0.43
SG11	14	62	2H	0.62	0.14	0.46
SG11	16	79	2H	0.73	0.15	0.47
SG11	19	61	1H	0.45	0.14	0.46
SG11	19	61	1H	0.45	0.24	0.56
SG11	22	71	2H	0.83	0.16	0.48
SG11	23	58	3H	0.38	0.1	0.42
SG11	24	20	2H	1.43	0.22	0.54
SG11	24	51	1H	0.53	0.21	0.53
SG11	27	44	2H	4.39	0.11	0.43
SG11	36	30	2H	0.56	0.18	0.50
SG11	36	30	2H	0.56	0.22	0.54
SG11	38	54	2H	3.16	0.23	0.55
SG11	41	68	2H	0.42	0.11	0.43
SG11	41	68	2H	0.42	0.18	0.50
SG11	42	50	4H	0.7	0.12	0.44
SG12	5	20	6H	2.4	0.13	0.45
SG12	6	49	1H	2.54	0.16	0.48
SG12	6	81	1H	3.75	0.2	0.52
SG12	7	65	2H	1.46	0.14	0.46
SG12	8	17	1H	3.05	0.16	0.48
SG12	8	67	1H	1.2	0.14	0.46
SG12	8	81	1H	8.02	0.17	0.49
SG12	9	66	2H	6.4	0.12	0.44
SG12	9	70	1H	6.33	0.23	0.55
SG12	9	70	1H	6.33	0.14	0.46
SG12	10	43	1H	1.64	0.24	0.56
SG12	10	45	2H	1.62	0.15	0.47
SG12	11	18	2H	3.41	0.22	0.54
SG12	11	75	2H	4.36	0.22	0.54
SG12	12	76	1H	2.92	0.14	0.46
SG12	13	66	2H	3.28	0.17	0.49
SG12	13	83	3H	2.59	0.13	0.45
SG12	13	83	3H	2.59	0.13	0.45
SG12	13	83	5H	2.3	0.28	0.60
SG12	13	83	5H	2.3	0.23	0.55
SG12	14	76	1H	2.27	0.34	0.66
SG12	14	84	2H	2	0.18	0.50
SG12	16	73	1H	18.03	0.19	0.51
SG12	17	45	1H	4.2	0.16	0.48
SG12	18	22	1H	3.13	0.11	0.43

Table 3-2: 1R11 AONDB Indications (cont'd)

SG	Row	Col	Elev	Dent Voltage	Plus Pt Voltage	Assigned DOS Voltage
SG12	19	57	2H	2.15	0.32	0.64
SG12	19	85	2H	3.06	0.32	0.64
SG12	19	85	2H	3.06	0.15	0.47
SG12	20	72	1H	2.42	0.12	0.44
SG12	20	83	1H	2.69	0.18	0.50
SG12	21	32	1H	2.43	0.22	0.54
SG12	22	54	7H	2.54	0.31	0.63
SG12	22	62	2H	4.38	0.32	0.64
SG12	22	83	1H	2.79	0.12	0.44
SG12	23	71	2H	2.13	0.13	0.45
SG12	23	71	2H	2.13	0.16	0.48
SG12	25	72	1H	2.06	0.15	0.47
SG12	27	50	1H	1.95	0.19	0.51
SG12	27	66	2H	2.32	0.15	0.47
SG12	27	83	2H	SPR/2.17V	0.21	0.53
SG12	28	36	2H	1.77	0.2	0.52
SG12	29	49	3H	2.45	0.14	0.46
SG12	29	69	1H	3.74	0.19	0.51
SG12	30	16	1H	0.9	0.32	0.64
SG12	31	44	4H	2.29	0.12	0.44
SG12	31	62	1H	2.34	0.16	0.48
SG12	31	80	4H	4.84	0.17	0.49
SG12	32	57	2H	5.15	0.24	0.56
SG12	33	40	1H	0.28	0.2	0.52
SG12	34	57	4H	2.99	0.23	0.55
SG12	36	53	1H	2.82	0.15	0.47
SG12	36	53	1H	2.82	0.2	0.52
SG12	39	70	1H	2.54	0.16	0.48
SG12	41	54	3H	2.47	0.17	0.49
SG12	42	28	2H	1.41	0.28	0.60
SG13	6	36	1H	3.19	0.21	0.53
SG13	8	77	1H	5.52	0.14	0.46
SG13	11	50	1H	7.21	0.18	0.50
SG13	19	80	1H	3.41	0.12	0.44
SG13	25	82	1H	3.03	0.15	0.47
SG13	27	49	1H	2.32	0.11	0.43
SG14	2	50	2H	5.57	0.19	0.51
SG14	3	44	1H	0.8	0.16	0.48
SG14	5	72	2H	2.97	0.12	0.44
SG14	7	31	1H	26.33	0.11	0.43
SG14	9	37	1H	2.1	0.25	0.57
SG14	11	46	1H	2.46	0.16	0.48
SG14	11	46	1H	2.46	0.12	0.44
SG14	13	6	2H	2.92	0.36	0.67
SG14	13	10	2H	1.96	0.13	0.45

Table 3-2: 1R11 AONDB Indications (cont'd)

SG	Row	Col	Elev	Dent Voltage	Plus Pt Voltage	Assigned DOS Voltage
SG14	13	31	1H	2.14	0.09	0.41
SG14	13	51	1H	1.57	0.1	0.42
SG14	14	34	1H	2.58	0.31	0.63
SG14	15	29	1H	2.64	0.19	0.51
SG14	15	47	1H	2.66	0.17	0.49
SG14	16	65	2H	2.51	0.11	0.43
SG14	17	32	1H	2.3	0.37	0.68
SG14	17	45	1H	9.03	0.25	0.57
SG14	19	32	1H	4.02	0.32	0.64
SG14	19	40	1H	3.57	0.11	0.43
SG14	21	51	1H	3.19	0.11	0.43
SG14	22	55	1H	5.93	0.24	0.56
SG14	24	62	1H	2.03	0.12	0.44
SG14	25	60	1H	2	0.28	0.60
SG14	30	59	1H	2.46	0.21	0.53
SG14	33	58	1H	4.05	0.32	0.64
SG14	36	47	1H	3.66	0.32	0.64
SG14	42	32	1H	8.85	0.18	0.50

Table 3-3: Summary of Inspection and Repair for Tubes

Voltage Bin	SG11 As-Found EOC-11	SG11 Repaired Tubes	SG11 DOSs Returned to Service: Conf OD-SCC or Not Insp w/+Pt	SG11 DOSs Returned to Service: Total (1)	SG12 As-Found EOC-11	SG12 Repaired Tubes (Active)	SG12 DOSs Returned to Service (2): Conf OD-SCC or Not Insp w/+Pt	SG12 DOSs Returned to Service (2): Total (1)	SG13 As-Found EOC-11	SG13 Repaired Tubes	SG13 DOSs Returned to Service: Conf OD-SCC or Not Insp w/+Pt	SG13 DOSs Returned to Service: Total (1)
0 1					1	1						
0 2	9		9	9	8	1	9	9	3		3	3
0 3	49	1	47	48	21	1	20	20	11		11	11
0 4	62		62	62	29		32	32	19		19	19
0 5	81	3	76	78	71	7	68	70	28	2	24	26
0 6	66	3	62	63	71	7	71	72	20	2	16	18
0 7	41	3	37	38	34	2	33	34	16	1	15	15
0 8	24	1	23	23	32	2	29	31	10	1	9	9
0 9	21	1	19	20	14		13	16	8		8	8
1	19	2	17	17	15	2	15	15	7		7	7
1 1	13	1	12	12	11		10	11	9		9	9
1 2	8		8	8	5		6	6	5		5	5
1 3	7	2	5	5	3		3	3	8		8	8
1 4	6		6	6	9		9	9	2		2	2
1 5	2		2	2	3		3	3	1		1	1
1 6	2		2	2	3		3	3	1		1	1
1 7	2		2	2					1		1	1
1 8	3		3	3	2		2	2	2		2	2
1 9					1	1			3		3	3
2	1		1	1					3		3	3
2 1												
2 2					2	2						
2 3	1	1			1	1						
2 4	1	1			1	1			1	1		
2 5												
>2 5	2	2			1	1						
Total	420	21	393	399	338	29	326	336	158	7	147	151
>1V	48	7	41	41	42	6	36	37	36	1	35	35
>2V	4	4			5	5			1	1		

Voltage Bin	SG14 As-Found EOC-11	SG14 Repaired Tubes	SG14 DOSs Returned to Service: Conf OD-SCC or Not Insp w/+Pt	SG14 DOSs Returned to Service: Total (1)	Composite of All SGs As-Found EOC-11	Composite Repaired Tubes	Composite DOSs Returned to Service: Conf OD-SCC or Not Insp w/+Pt	Composite DOSs Returned to Service: Total (1)
0 1					1	1		
0 2	7		7	7	27	1	28	28
0 3	9		9	9	90	2	87	88
0 4	20		20	20	130		133	133
0 5	18	1	17	17	198	13	185	191
0 6	18	4	14	14	175	16	163	167
0 7	10	1	9	9	101	7	94	96
0 8	8	1	7	7	74	5	68	70
0 9	4		4	4	47	1	44	48
1	1		1	1	42	4	40	40
1 1	3		3	3	36	1	34	35
1 2	1		1	1	19		20	20
1 3	1		1	1	19	2	17	17
1 4	1		1	1	18		18	18
1 5					6		6	6
1 6					6		6	6
1 7	1		1	1	4		4	4
1 8	2		2	2	9		9	9
1 9					4	1	3	3
2	1		1	1	5		5	5
2 1								
2 2					2	2		
2 3					2	2		
2 4	1	1			4	4		
2 5								
>2 5					3	3		
Total	106	8	98	98	1022	65	964	984
>1V	11	1	10	10	137	15	122	123
>2V	1	1			11	11		

(1) Total includes all DOS/AONDB indications returned to service (confirmed, not inspected, and not confirmed with Plus Point)
(2) DOSs returned to service for SG12 includes tubes that were deplugged during the 1R11 outage

Table 3-4: Summary of Largest Voltage Growth Rates per EFPY

SG_ID	Row	Col	Elev	Volts	Prev Volts (1R10)	Growth/ EFPY	Plus Pt Result	New?	Deplugged In 1R10?
SG11	2	46	1H	3.23	0.94	1.624	SAI	Repeat	No
SG11	4	67	1H	2.64	1	1.163	SAI	Repeat	No
SG12	4	48	1H	2.8	1.38	1.007	SAI	Repeat	No
SG11	30	32	1H	2.4	1.09	0.929	SAI	Repeat	No
SG11	27	47	1H	2.26	1.14	0.794	SAI	Repeat	No
SG14	3	36	1H	1.79	0.69	0.780		Repeat	No
SG12	40	27	1H	2.33	1.38	0.674	SAI	Repeat	No
SG12	6	53	1H	2.11	1.17	0.667	SAI	Repeat	No
SG11	6	61	1H	1.67	0.8	0.617		Repeat	No
SG11	17	73	1H	1.96	1.11	0.603		Repeat	No
SG11	20	54	1H	1.8	0.98	0.582		Repeat	No
SG12	22	43	1H	2.25	1.44	0.574	SAI	Repeat	No
SG11	31	38	1H	1.31	0.51	0.567		Repeat	No
SG11	10	71	1H	1.75	0.95	0.567	SAI	Repeat	No
SG11	18	31	2H	1.2	0.43	0.546	SAI	Repeat	No
SG12	17	47	1H	1.48	0.72	0.539	SAI	Repeat	No
SG11	24	31	1H	1.51	0.77	0.525		Repeat	No
SG11	20	47	1H	1.17	0.44	0.518		Repeat	No
SG11	36	45	1H	1.38	0.65	0.518		Repeat	No
SG12	13	56	1H	1.48	0.75	0.518		Repeat	No

Table 3-5: Voltage and Growth Distribution by TSP

Growth units are volts/EFPY

Tube Support Plate	Steam Generator 1-1				
	No. of Indications	Maximum Voltage	Average Voltage	Maximum Growth	Average Growth
1H	274	3 23	0 66	1.62	0.15
2H	100	1.40	0.55	0 55	0.10
3H	28	0.86	0 44	0 34	0.07
4H	9	0 67	0 43	0 19	0.07
5H	1	0.80	0 80	0 19	0.19
6H	1	0 57	0 57	0 08	0 08
7H	1	0 29	0 29	0 01	0 01
CL	6	0 69	0.50	0 09	-0 01
All Inds	420	3.23	0.61	1.62	0 13

Tube Support Plate	Steam Generator 1-2				
	No of Indications	Maximum Voltage	Average Voltage	Maximum Growth	Average Growth
1H	207	2 80	0.69	1.01	0 12
2H	132	1.76	0.59	0 40	0 09
3H	47	1.59	0.58	0.49	0 06
4H	23	1 06	0.60	0 20	0 03
5H	10	0.95	0.58	0.14	0 02
6H	8	0.57	0.46	0 06	0 01
7H	1	0.63	0.63		
CL	4	0.80	0 51	0 09	0 03
All Inds	432	2.80	0 63	1 01	0 09

Tube Support Plate	Steam Generator 1-3				
	No. of Indications	Maximum Voltage	Average Voltage	Maximum Growth	Average Growth
1H	78	2 40	0 76	0.46	0 08
2H	30	1.54	0 75	0 50	0 06
3H	20	1.30	0.77	0 43	0 07
4H	9	1.48	0.71	0 19	0.10
5H	7	1.33	0 71	0.14	0.02
6H	7	1.97	0 58	0 10	0.02
7H	1	0 36	0 36	0 09	0.09
CL	6	0 66	0 49	0 03	-0.02
All Inds	158	2.40	0 73	0 50	0 07

Tube Support Plate	Steam Generator 1-4				
	No of Indications	Maximum Voltage	Average Voltage	Maximum Growth	Average Growth
1H	66	2.33	0 60	0.78	0.11
2H	25	1.91	0 55	0.30	0.07
3H	9	1.17	0 58	0.26	0.03
4H	4	0.80	0 78	0.10	0.04
5H	2	0 40	0.36	0.13	0 09
6H					
7H					
CL					
All Inds	106	2.33	0.59	0 78	0.08

Tube Support Plate	Composite of All Four SGs				
	No. of Indications	Maximum Voltage	Average Voltage	Maximum Growth	Average Growth
1H	625	3.23	0.68	1.62	0.13
2H	287	1.91	0.59	0.55	0 08
3H	104	1.59	0.58	0.49	0 06
4H	45	1.48	0 60	0 20	0 06
5H	20	1.33	0 62	0 19	0 04
6H	16	1.97	0 52	0 10	0.03
7H	3	0 63	0 43	0 09	0.05
CL	16	0 80	0 50	0 09	0.00
All Inds	1116	3 23	0 63	1.62	0.10

Table 3-6: Summary of Voltage Growth per EFPY

Delta Volts	SG11		SG12		SG13		SG14		Total	
	No. of Obs.	CPDF	No. of Obs.	CPDF	No. of Obs.	CPDF	No. of Obs.	CPDF	No. of Obs.	CPDF
<=-0.5	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000
-0.4	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000
-0.3	0	0.000	0	0.000	1	0.007	0	0.000	1	0.001
-0.2	3	0.008	5	0.017	1	0.013	2	0.026	11	0.013
-0.1	4	0.018	11	0.055	2	0.026	1	0.039	18	0.033
0	71	0.196	58	0.253	35	0.258	17	0.260	181	0.230
0.1	128	0.519	104	0.608	73	0.742	31	0.662	336	0.596
0.2	108	0.791	61	0.816	26	0.914	13	0.831	208	0.822
0.3	39	0.889	34	0.932	5	0.947	10	0.961	88	0.918
0.4	24	0.950	11	0.969	5	0.980	0	0.961	40	0.962
0.5	7	0.967	3	0.980	3	1.000	2	0.987	15	0.978
0.6	7	0.985	3	0.990	0	1.000	0	0.987	10	0.989
0.7	2	0.990	2	0.997	0	1.000	0	0.987	4	0.993
0.8	1	0.992	0	0.997	0	1.000	1	1.000	2	0.996
0.9	0	0.992	0	0.997	0	1.000	0	1.000	0	0.996
1	1	0.995	0	0.997	0	1.000	0	1.000	1	0.997
1.1	0	0.995	1	1.000	0	1.000	0	1.000	1	0.998
1.2	1	0.997	0	1.000	0	1.000	0	1.000	1	0.999
1.3	0	0.997	0	1.000	0	1.000	0	1.000	0	0.999
1.4	0	0.997	0	1.000	0	1.000	0	1.000	0	0.999
1.5	0	0.997	0	1.000	0	1.000	0	1.000	0	0.999
1.6	0	0.997	0	1.000	0	1.000	0	1.000	0	0.999
1.7	1	1.000	0	1.000	0	1.000	0	1.000	1	1.000
1.8	0	1.000	0	1.000	0	1.000	0	1.000	0	1.000
1.9	0	1.000	0	1.000	0	1.000	0	1.000	0	1.000
2	0	1.000	0	1.000	0	1.000	0	1.000	0	1.000
>2	0	1.000	0	1.000	0	1.000	0	1.000	0	1.000
Total	397	NA	293	NA	151	NA	77	NA	918	NA

Table 3-7: Voltage Dependent Growth (BOC-11 Voltage ≤ 0.50 Volts)

Delta Volts	SG11		SG12		SG13		SG14		Total	
	No. of Obs.	CPDF	No. of Obs.	CPDF	No. of Obs.	CPDF	No. of Obs.	CPDF	No. of Obs.	CPDF
<=-0.5	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000
-0.4	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000
-0.3	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000
-0.2	1	0.004	0	0.000	0	0.000	0	0.000	1	0.002
-0.1	3	0.015	3	0.018	0	0.000	0	0.000	6	0.013
0	47	0.187	25	0.169	13	0.194	13	0.277	98	0.190
0.1	103	0.564	72	0.602	42	0.821	23	0.766	240	0.624
0.2	81	0.861	40	0.843	11	0.985	6	0.894	138	0.873
0.3	25	0.952	23	0.982	1	1.000	5	1.000	54	0.971
0.4	8	0.982	3	1.000	0	1.000	0	1.000	11	0.991
0.5	3	0.993	0	1.000	0	1.000	0	1.000	3	0.996
0.6	2	1.000	0	1.000	0	1.000	0	1.000	2	1.000
0.7	0	1.000	0	1.000	0	1.000	0	1.000	0	1.000
0.8	0	1.000	0	1.000	0	1.000	0	1.000	0	1.000
0.9	0	1.000	0	1.000	0	1.000	0	1.000	0	1.000
1	0	1.000	0	1.000	0	1.000	0	1.000	0	1.000
1.1	0	1.000	0	1.000	0	1.000	0	1.000	0	1.000
1.2	0	1.000	0	1.000	0	1.000	0	1.000	0	1.000
1.3	0	1.000	0	1.000	0	1.000	0	1.000	0	1.000
1.4	0	1.000	0	1.000	0	1.000	0	1.000	0	1.000
1.5	0	1.000	0	1.000	0	1.000	0	1.000	0	1.000
1.6	0	1.000	0	1.000	0	1.000	0	1.000	0	1.000
1.7	0	1.000	0	1.000	0	1.000	0	1.000	0	1.000
1.8	0	1.000	0	1.000	0	1.000	0	1.000	0	1.000
1.9	0	1.000	0	1.000	0	1.000	0	1.000	0	1.000
2	0	1.000	0	1.000	0	1.000	0	1.000	0	1.000
>2	0	1.000	0	1.000	0	1.000	0	1.000	0	1.000
Total	273	NA	166	NA	67	NA	47	NA	553	NA

Table 3-8: Voltage Dependent Growth (BOC-11 Voltage > 0.50 Volts)

Delta Volts	SG11		SG12		SG13		SG14		Total	
	No. of Obs.	CPDF	No. of Obs.	CPDF	No. of Obs.	CPDF	No. of Obs.	CPDF	No. of Obs	CPDF
<=-0.5	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000
-0.4	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000
-0.3	0	0.000	0	0.000	1	0.012	0	0.000	1	0.003
-0.2	2	0.016	5	0.039	1	0.024	2	0.067	10	0.030
-0.1	1	0.024	8	0.102	2	0.048	1	0.100	12	0.063
0	24	0.218	33	0.362	22	0.310	4	0.233	83	0.290
0.1	25	0.419	32	0.614	31	0.679	8	0.500	96	0.553
0.2	27	0.637	21	0.780	15	0.857	7	0.733	70	0.745
0.3	14	0.750	11	0.866	4	0.905	5	0.900	34	0.838
0.4	16	0.879	8	0.929	5	0.964	0	0.900	29	0.918
0.5	4	0.911	3	0.953	3	1.000	2	0.967	12	0.951
0.6	5	0.952	3	0.976	0	1.000	0	0.967	8	0.973
0.7	2	0.968	2	0.992	0	1.000	0	0.967	4	0.984
0.8	1	0.976	0	0.992	0	1.000	1	1.000	2	0.989
0.9	0	0.976	0	0.992	0	1.000	0	1.000	0	0.989
1	1	0.984	0	0.992	0	1.000	0	1.000	1	0.992
1.1	0	0.984	1	1.000	0	1.000	0	1.000	1	0.995
1.2	1	0.992	0	1.000	0	1.000	0	1.000	1	0.997
1.3	0	0.992	0	1.000	0	1.000	0	1.000	0	0.997
1.4	0	0.992	0	1.000	0	1.000	0	1.000	0	0.997
1.5	0	0.992	0	1.000	0	1.000	0	1.000	0	0.997
1.6	0	0.992	0	1.000	0	1.000	0	1.000	0	0.997
1.7	1	1.000	0	1.000	0	1.000	0	1.000	1	1.000
1.8	0	1.000	0	1.000	0	1.000	0	1.000	0	1.000
1.9	0	1.000	0	1.000	0	1.000	0	1.000	0	1.000
2	0	1.000	0	1.000	0	1.000	0	1.000	0	1.000
>2	0	1.000	0	1.000	0	1.000	0	1.000	0	1.000
Total	124	NA	127	NA	84	NA	30	NA	365	NA

Table 3-9: Summary of Growth Used for Monte Carlo Simulations

	Growth Distribution
SG 1-1	1. SG11-Specific Normal Growth (Combined Cycles 10 and 11) 2. SG11-Specific Voltage-Dependent Growth from Cycle 11 (plus one large growth value from SG 1-2)
SG 1-2	1. SG12-Specific Normal Growth (Combined Cycles 10 and 11)
SG 1-3	1. SG13-Specific Normal Growth (Combined Cycles 10 and 11)
SG 1-4	1. Normal Growth; All SGs Combined; Bounding of Cycles 10 and 11

Table 3-10: Growth Distributions Used for Monte Carlo Simulations

Delta Volts per EFPY	Normal Growth (CPDF)				Voltage Dependent Growth for SG11 (CPDF)	
	SG11	SG12	SG13	SG14	<=0.5V @ BOC-11	>0.5V @ BOC-11
0	0.1609	0.2104	0.2458	0.1265	0.1868	0.2177
0.1	0.4753	0.5701	0.6695	0.4630	0.5641	0.4194
0.2	0.7550	0.7919	0.8475	0.7208	0.8608	0.6371
0.3	0.8757	0.9072	0.9280	0.8616	0.9524	0.7500
0.4	0.9506	0.9593	0.9534	0.9379	0.9817	0.8790
0.5	0.9689	0.9751	0.9831	0.9666	0.9927	0.9113
0.6	0.9835	0.9864	0.9958	0.9833	1.0000	0.9516
0.7	0.9890	0.9955	0.9958	0.9905	1.0000	0.9677
0.8	0.9909	0.9977	0.9958	0.9928	1.0000	0.9758
0.9	0.9909	0.9977	0.9958	0.9928	1.0000	0.9758
1	0.9927	0.9977	1.0000	0.9952	1.0000	0.9839
1.1	0.9945	1.0000	1.0000	0.9976	1.0000	0.9839
1.2	0.9982	1.0000	1.0000	0.9989	1.0000	0.9919
1.3	0.9982	1.0000	1.0000	0.9989	1.0000	0.9919
1.4	0.9982	1.0000	1.0000	0.9989	1.0000	0.9919
1.5	0.9982	1.0000	1.0000	0.9989	1.0000	0.9919
1.6	0.9982	1.0000	1.0000	0.9989	1.0000	0.9919
1.7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1.8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1.9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Table 3-11: Re-tested DOSs ≥ 1.5 Volts that Failed the Probe Wear Check

SG	Row	Col	Ind	Elev	Volts	Probe	Cal Group	ARC Out 1R11	% Diff
SG11	6	61	RSS	1H	1.63	720RF	5	Yes	
SG11	6	61	DOS	1H	1.67	720RF	55		2.4%
SG11	10	71	RSS	1H	1.65	720RF	13	Yes	
SG11	10	71	RSS	1H	1.75	720RF	48	Yes	
SG11	10	71	DOS	1H	1.75	720RF	55		5.7% / 0.0%
SG11	17	73	RSS	1H	1.81	720RF	14	Yes	
SG11	17	73	RSS	1H	1.96	720RF	51	Yes	
SG11	17	73	DOS	1H	1.96	720RF	62		7.7% / 0.0%
SG11	17	74	RSS	1H	1.75	720RF	14	Yes	
SG11	17	74	RSS	1H	1.71	720RF	51	Yes	
SG11	17	74	DOS	1H	1.63	720RF	62		-7.4% / -4.9%
SG11	20	54	RSS	1H	1.61	720RF	6	Yes	
SG11	20	54	RSS	1H	1.88	720RF	51	Yes	
SG11	20	54	DOS	1H	1.8	720RF	62		10.6% / -4.4%
SG11	27	47	RSS	1H	2.01	720RF	6	Yes	
SG11	27	47	DOS	1H	2.26	720RF	55		11.1%
SG11	30	32	RSS	1H	2.15	720RF	4	Yes	
SG11	30	32	RSS	1H	2.32	720RF	48	Yes	
SG11	30	32	DOS	1H	2.4	720RF	55		10.4% / 3.3%
SG11	42	37	RSS	1H	1.52	720RF	4	Yes	
SG11	42	37	RSS	1H	1.59	720RF	48	Yes	
SG11	42	37	DOS	1H	1.58	720RF	55		3.8% / -0 6%
SG12	6	53	RSS	1H	1.93	720RF	32	Yes	
SG12	6	53	DOS	1H	2.11	720RF	51		8.5%
SG12	20	87	RSS	1H	2.08	720RF	34	Yes	
SG12	20	87	DOS	1H	2.14	720RF	51		2.8%
SG12	22	43	RSS	1H	2.19	720RF	25	Yes	
SG12	22	43	DOS	1H	2.25	720RF	51		2.7%
SG12	26	52	RSS	2H	1.81	720RF	30	Yes	
SG12	26	52	DOS	2H	1.76	720RF	38		-2.8%
SG12	28	50	RSS	1H	2.02	720RF	29	Yes	
SG12	28	50	DOS	1H	1.85	720RF	38		-9.2%
SG12	31	51	RSS	1H	1.63	720RF	29	Yes	
SG12	31	51	DOS	1H	1.76	720RF	38		7.4%
SG12	37	23	RSS	3H	1.83	720RF	19	Yes	
SG12	37	23	DOS	3H	1.59	720RF	38		-15.1%
SG12	40	27	RSS	1H	2.24	720RF	20	Yes	
SG12	40	27	DOS	1H	2.33	720RF	38		3.9%
SG13	10	71	RSS	1H	1.87	720RF	16	Yes	
SG13	10	71	DOS	1H	1.93	720RF	31		3.1%
SG14	3	36	RSS	1H	1.52	720RF	10	Yes	
SG14	3	36	DOS	1H	1.79	720RF	54		15.1%
SG14	25	26	RSS	2H	1.8	720RF	7	Yes	
SG14	25	26	DOS	2H	1.91	720RF	43		5.8%

Table 3-12: New 1R11 DOSs >=0.5 Volts In Tubes Inspected With A Worn Probe In 1R10

SG	Row	Col	Ind	Elev	Volts	Cal	ARC Out 1R11	ARC Out 1R10
SG11	11	40	DOS	2H	1.4	CL-3	Yes	Yes
SG11	6	31	DOS	1H	1.35	CL-3	Yes	Yes
SG11	16	45	DOS	2H	1.29	CL-1		Yes
SG11	33	40	DOS	2H	1.26	CL-5		Yes
SG11	4	54	DOS	1H	1.09	HL-10		Yes
SG11	26	77	DOS	1H	1.07	CL-11	Yes	Yes
SG11	18	39	DOS	2H	0.93	CL-2	Yes	Yes
SG11	30	35	DOS	1H	0.84	CL-4	Yes	Yes
SG11	24	20	DOS	2H	0.81	CL-28		Yes
SG11	10	39	DOS	1H	0.81	CL-3	Yes	Yes
SG11	32	48	DOS	2H	0.81	CL-5		Yes
SG11	31	41	DOS	1H	0.81	CL-4	Yes	Yes
SG11	14	80	DOS	1H	0.81	CL-14	Yes	Yes
SG11	6	78	DOS	2H	0.78	CL-14	Yes	Yes
SG11	12	74	DOS	2H	0.77	CL-13	Yes	Yes
SG11	24	40	DOS	1H	0.77	CL-2	Yes	Yes
SG11	20	76	DOS	3H	0.77	CL-11	Yes	Yes
SG11	19	39	DOS	1H	0.76	CL-2	Yes	Yes
SG11	7	37	DOS	3H	0.75	CL-3	Yes	Yes
SG11	26	61	DOS	1H	0.75	CL-9	Yes	Yes
SG11	6	73	DOS	1H	0.72	CL-14	Yes	Yes
SG11	4	64	DOS	1H	0.71	HL-10		Yes
SG11	33	43	DOS	1H	0.7	CL-4	Yes	Yes
SG11	30	31	DOS	1H	0.7	CL-5		Yes
SG11	22	69	DOS	1H	0 68	CL-11	Yes	Yes
SG11	25	44	DOS	1H	0.68	CL-2	Yes	Yes
SG11	30	58	DOS	4H	0.67	CL-10		Yes
SG11	5	68	DOS	1H	0.67	HL-9		Yes
SG11	12	70	DOS	1H	0.67	CL-13	Yes	Yes
SG11	6	25	DOS	2H	0.66	CL-26	Yes	Yes
SG11	25	43	DOS	2H	0.66	CL-1		Yes
SG11	29	38	DOS	1H	0.65	CL-7	Yes	Yes
SG11	12	27	DOS	2H	0.62	CL-26	Yes	Yes
SG11	11	22	DOS	2H	0.62	CL-25	Yes	Yes
SG11	41	32	DOS	2H	0.61	CL-5		Yes
SG11	19	48	DOS	1H	0.59	CL-1		Yes
SG11	28	53	DOS	1H	0.59	CL-10		Yes
SG11	19	40	DOS	2H	0.58	CL-1		Yes
SG11	43	48	DOS	3H	0.58	CL-5		Yes
SG11	5	54	DOS	1H	0.57	HL-9		Yes
SG11	19	46	DOS	1H	0.57	CL-2	Yes	Yes
SG11	22	38	DOS	1H	0.57	CL-2	Yes	Yes
SG11	15	30	DOS	2H	0.56	CL-2	Yes	Yes
SG11	8	42	DOS	1H	0.56	CL-3	Yes	Yes
SG11	17	75	DOS	2H	0.56	CL-14	Yes	Yes
SG11	43	47	DOS	2H	0.55	CL-4	Yes	Yes

Table 3-12: New 1R11 DOSs >=0.5 Volts In Tubes Inspected With A Worn Probe In 1R10 (cont'd)

SG	Row	Col	Ind	Elev	Volts	Cal	ARC Out 1R11	ARC Out 1R10
SG11	8	24	DOS	2H	0.55	CL-25	Yes	Yes
SG11	30	70	DOS	1H	0.55	CL-11	Yes	Yes
SG11	26	66	DOS	1H	0.54	CL-10		Yes
SG11	21	36	DOS	3H	0.54	CL-2	Yes	Yes
SG11	21	42	DOS	3H	0.54	CL-1		Yes
SG11	19	31	DOS	2H	0.54	CL-1		Yes
SG11	13	44	DOS	2H	0.53	CL-3	Yes	Yes
SG11	5	49	DOS	2H	0.53	HL-8		Yes
SG11	15	24	DOS	1H	0.53	CL-25	Yes	Yes
SG11	37	36	DOS	1H	0.53	CL-5		Yes
SG11	17	87	DOS	1H	0.52	CL-17	Yes	Yes
SG11	14	78	DOS	1H	0.52	CL-13	Yes	Yes
SG11	10	74	DOS	1H	0.52	CL-13	Yes	Yes
SG11	7	78	DOS	2H	0.51	CL-14	Yes	Yes
SG11	10	23	DOS	3H	0.51	CL-26	Yes	Yes
SG11	46	50	DOS	1C	0.5	CL-6	Yes	Yes
SG12	23	12	DOS	1H	1.6	CL-11		Yes
SG12	45	42	DOS	1H	1.46	CL-24		Yes
SG12	20	63	DOS	2H	1.4	CL-31		Yes
SG12	21	82	DOS	1H	1.21	CL-33	Yes	Yes
SG12	21	72	DOS	4H	1.06	CL-34	Yes	Yes
SG12	35	65	DOS	3H	1.02	CL-1		Yes
SG12	33	71	DOS	1H	1.01	CL-34	Yes	Yes
SG12	4	48	DOS	2H	0.98	HL-5		Yes
SG12	27	83	DOS	3H	0.98	CL-34	Yes	Yes
SG12	35	68	DOS	1H	0.95	CL-29	Yes	Yes
SG12	3	80	DOS	1H	0.95	HL-4		Yes
SG12	19	41	DOS	1H	0.89	CL-26		Yes
SG12	6	87	DOS	2H	0.88	CL-35		Yes
SG12	37	35	DOS	2H	0.86	CL-21	Yes	Yes
SG12	15	66	DOS	2H	0.81	CL-32	Yes	Yes
SG12	6	56	DOS	2H	0.79	CL-32	Yes	Yes
SG12	28	63	DOS	1H	0.79	CL-30	Yes	Yes
SG12	32	55	DOS	2H	0.76	CL-30	· Yes	Yes
SG12	38	45	DOS	4H	0.75	CL-23		Yes
SG12	32	59	DOS	1H	0.75	CL-30	Yes	Yes
SG12	30	57	DOS	2H	0.72	CL-30	Yes	Yes
SG12	39	66	DOS	3H	0.72	CL-29	Yes	Yes
SG12	35	46	DOS	2H	0.71	CL-23		Yes
SG12	20	89	DOS	3H	0.66	CL-34	Yes	Yes
SG12	20	83	DOS	3H	0.65	CL-34	Yes	Yes
SG12	46	49	DOS	1H	0.65	CL-24		Yes
SG12	5	51	DOS	1H	0.63	HL-4		Yes
SG12	33	73	DOS	1H	0.62	CL-33	Yes	Yes
SG12	32	45	DOS	3H	0.61	CL-23		Yes
SG12	26	52	DOS	3H	0.6	CL-30	Yes	Yes

Table 3-12: New 1R11 DOSs >=0.5 Volts In Tubes Inspected With A Worn Probe In 1R10 (cont'd)

SG	Row	Col	Ind	Elev	Volts	Cal	ARC Out 1R11	ARC Out 1R10
SG12	26	52	DOS	3H	0.6	CL-38		Yes
SG12	6	49	DOS	2H	0.58	CL-27	Yes	Yes
SG12	4	49	DOS	1H	0.58	HL-4		Yes
SG12	39	37	DOS	1H	0.58	CL-21	Yes	Yes
SG12	37	33	DOS	2H	0.58	CL-21	Yes	Yes
SG12	17	38	DOS	2H	0.57	CL-25	Yes	Yes
SG12	17	24	DOS	1H	0.57	CL-14	Yes	Yes
SG12	43	48	DOS	4H	0.56	CL-23		Yes
SG12	6	65	DOS	2H	0.56	CL-32	Yes	Yes
SG12	10	7	DOS	4H	0.56	CL-16	Yes	Yes
SG12	30	76	DOS	5H	0.56	CL-33	Yes	Yes
SG12	29	72	DOS	6H	0.55	CL-34	Yes	Yes
SG12	12	63	DOS	1H	0.55	CL-32	Yes	Yes
SG12	26	83	DOS	1H	0.55	CL-33	Yes	Yes
SG12	19	48	DOS	1H	0.55	CL-25	Yes	Yes
SG12	20	43	DOS	3H	0.55	CL-25	Yes	Yes
SG12	36	33	DOS	2H	0.55	CL-22		Yes
SG12	8	86	DOS	3H	0.54	CL-35		Yes
SG12	34	61	DOS	1H	0.53	CL-30	Yes	Yes
SG12	9	3	DOS	3H	0.53	CL-16	Yes	Yes
SG12	19	39	DOS	2H	0.52	CL-26		Yes
SG12	5	57	DOS	1H	0.52	HL-4		Yes
SG12	26	64	DOS	2H	0.51	CL-30	Yes	Yes
SG12	42	61	DOS	2H	0.51	CL-29	Yes	Yes
SG12	11	82	DOS	2H	0.51	CL-36		Yes
SG12	19	65	DOS	2H	0.51	CL-32	Yes	Yes
SG12	5	50	DOS	3H	0.5	HL-4		Yes
SG12	40	66	DOS	3H	0.5	CL-29	Yes	Yes
SG13	9	63	DOS	1H	1.38	HL-1		Yes
SG13	25	81	DOS	1H	1.25	CL-15		Yes
SG13	10	10	DOS	2H	1.18	HL-8	Yes	Yes
SG13	24	41	DOS	1H	1.05	CL-5	Yes	Yes
SG13	27	32	DOS	2H	1.05	CL-7		Yes
SG13	25	76	DOS	1H	1.04	CL-15		Yes
SG13	9	58	DOS	1H	1.02	HL-3		Yes
SG13	19	90	DOS	1H	0.86	CL-17	Yes	Yes
SG13	9	67	DOS	4H	0.82	HL-2		Yes
SG13	8	6	DOS	3H	0.8	HL-10		Yes
SG13	7	75	DOS	2H	0.77	CL-15		Yes
SG13	20	68	DOS	1H	0.77	HL-2		Yes
SG13	32	40	DOS	1H	0.71	CL-8	Yes	Yes
SG13	20	33	DOS	1H	0.62	CL-1		Yes
SG13	15	73	DOS	1H	0.57	CL-15		Yes
SG13	9	57	DOS	3H	0.55	HL-4		Yes
SG13	19	44	DOS	1H	0.5	CL-5	Yes	Yes

Table 3-12: New 1R11 DOSs >=0.5 Volts In Tubes Inspected With A Worn Probe In 1R10 (cont'd)

SG	Row	Col	Ind	Elev	Volts	Cal	ARC Out 1R11	ARC Out 1R10
SG14	9	21	DOS	2H	0.75	HL-5	Yes	Yes
SG14	29	57	DOS	2H	0.69	CL-7		Yes
SG14	3	74	DOS	1H	0.69	HL-10	Yes	Yes
SG14	2	50	DOS	1H	0.61	HL-4	Yes	Yes
SG14	27	55	DOS	1H	0.6	CL-7		Yes
SG14	11	86	DOS	1H	0.54	CL-14		Yes
SG14	13	48	DOS	2H	0.53	CL-5	Yes	Yes
SG14	28	63	DOS	1H	0.5	CL-9		Yes

Table 3-13: Summary of New DOS Indications Sorted by Category

SG	1R11 DOSs in Active Tubes (Total)	New 1R11 Not Detected in 1R10	New 1R11 Ind. In Tubes Insp. w/ Worn Probe in 1R10	New 1R11 Ind. In Tubes Insp. w/ Good Probe in 1R10	New 1R11 Ind. ≥0.5 Volts	New 1R11 Ind. ≥0.5 Volts in Tubes Insp. w/ Worn Probe in 1R10
SG11	400	238	145	93	92	61
SG12	293	158	106	52	82	54
SG13	152	62	32	30	28	16
SG14	79	42	20	22	13	7
Total	**924**	**500**	**303**	**197**	**215**	**138**

Table 3-14: Percentage of Tubes With New Indications

	Worn Probe In 1R10	Good Probe In 1R10
Number of Inspections In 1R10	10494	5949
New Indications in 1R11	303	197
Percentage w/ New Indications	2.9%	3.3%
New Indications ≥0.5V in 1R11	138	77
Percentage w/ New Indications ≥0.5V	1.3%	1.3%

Table 3-15: Average Growth Rates for Cycle 11

SG	No of Inds In Growth Dist.	Average BOC-11 Voltage	Average Voltage Growth	Average Growth per EFPY	Average Percent Growth for Cycle 11	Average Percent Growth per EFPY
SG11	397	0.440	0.179	0.127	40.6%	28.8%
SG12	293	0.548	0.128	0.091	23.4%	16.6%
SG13	151	0.653	0.093	0.066	14.2%	10.1%
SG14	77	0.500	0.119	0.085	23.9%	17.0%
Total	918	0.515	0.143	0.102	27.9%	19.8%

Table 3-16: NDE Uncertainty Distributions

Analyst Uncertainty

Percent Variation	Cumulative Probability
-40 0%	0 00005
-38.0%	0 00011
-36.0%	0 00024
-34 0%	0 00048
-32.0%	0 00095
-30 0%	0.00179
-28 0%	0 00328
-26 0%	0 00580
-24 0%	0 00990
-22 0%	0 01634
-20 0%	0 02608
-18 0%	0 04027
-16 0%	0 06016
-14 0%	0 08704
-12 0%	0 12200
-10 0%	0 16581
-8 0%	0 21867
-6 0%	0 28011
-4 0%	0 34888
-2 0%	0 42302
0.0%	0 50000
2.0%	0 57698
4 0%	0 65112
6 0%	0 71989
8 0%	0.78133
10 0%	0.83419
12 0%	0 87800
14 0%	0 91296
16 0%	0 93984
18 0%	0 95973
20 0%	0 97392
22 0%	0 98366
24 0%	0 99010
26 0%	0 99420
28 0%	0 99672
30.0%	0 99821
32.0%	0 99905
34 0%	0 99952
36 0%	0 99976
38 0%	0 99989
40 0%	0 99995

Std Deviation = 10.3%
Mean = 0 0%
No Cutoff

Acquisition Uncertainty

Percent Variation	Cumulative Probability
<-15 0%	0 00000
-15.0%	0 01606
-14 0%	0 02275
-13 0%	0 03165
-12 0%	0.04324
-11 0%	0.05804
-10 0%	0.07656
-9 0%	0 09927
-8 0%	0 12655
-7.0%	0 15866
-6 0%	0 19568
-5 0%	0 23753
-4 0%	0 28385
-3 0%	0 33412
-2 0%	0 38755
-1 0%	0 44320
0 0%	0 50000
1 0%	0 55680
2 0%	0 61245
3 0%	0 66588
4 0%	0 71615
5 0%	0 76247
6 0%	0 80432
7 0%	0 84134
8 0%	0 87345
9.0%	0.90073
10 0%	0.92344
11 0%	0.94196
12 0%	0 95676
13 0%	0 96835
14 0%	0 97725
15 0%	0 98394
>15 0%	1 00000

Std Deviation = 7 0%
Mean = 0 0%
Cutoff = +/- 15 0%

Figure 3-1

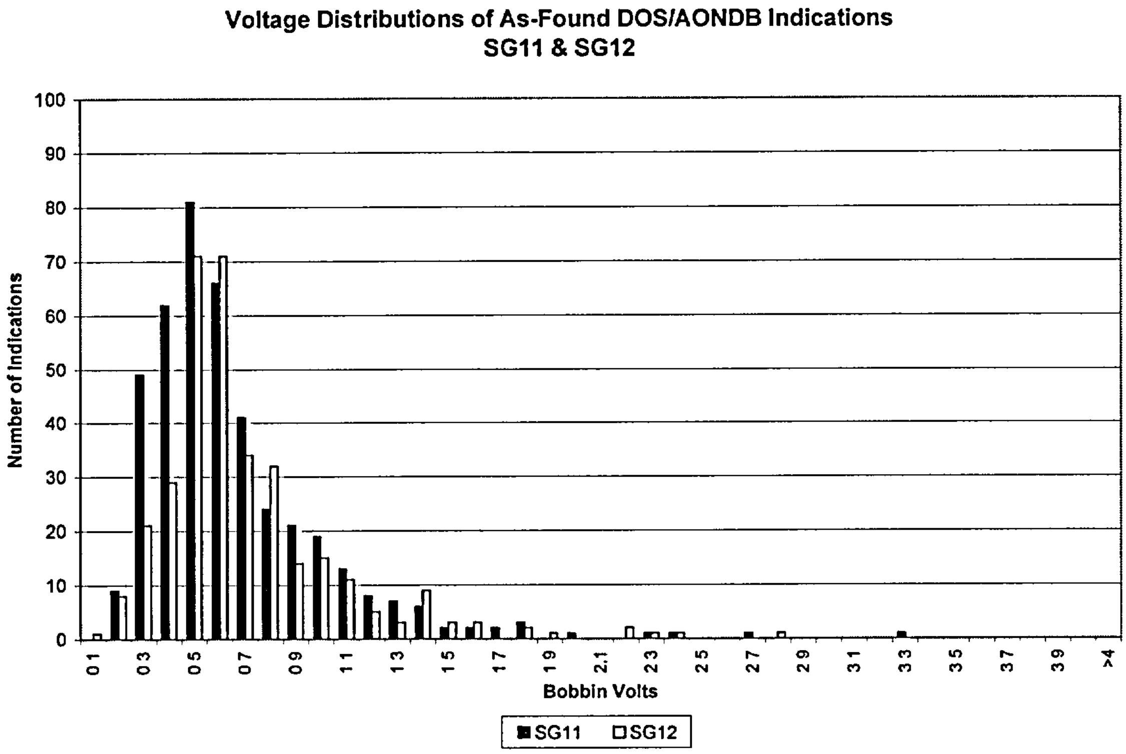


Figure 3-2

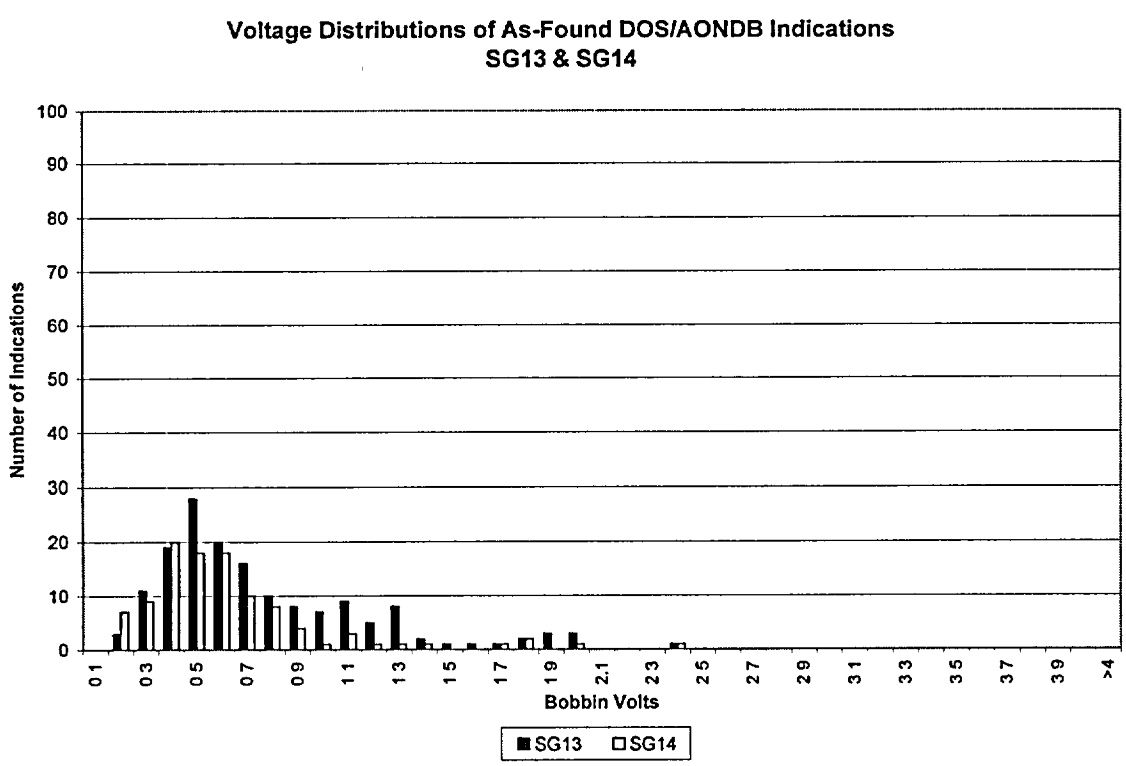


Figure 3-3

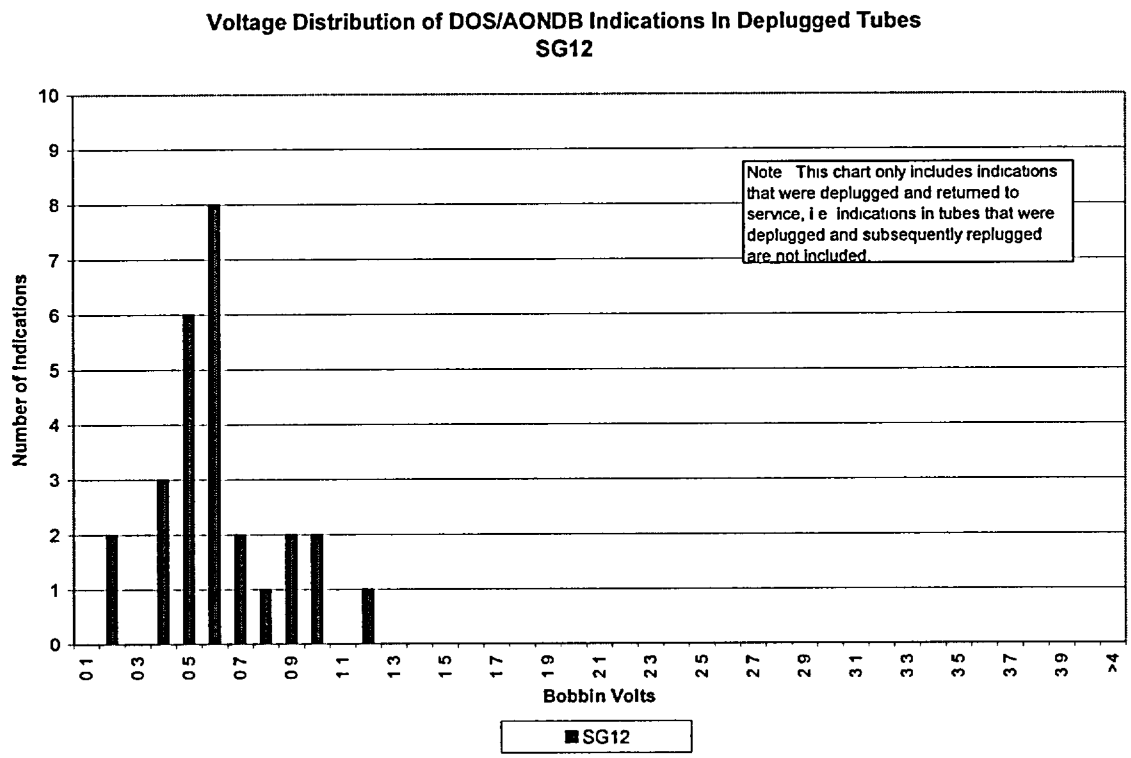

Voltage Distribution of DOS/AONDB Indications In Deplugged Tubes
SG12
Number of Indications
Bobbin Volts
0
1
2
3
4
5
6
7
8
9
10
01
03
05
07
09
11
13
15
17
19
21
23
25
27
29
31
33
35
37
39
>4
Note This chart only includes indications that were deplugged and returned to service, i e indications in tubes that were deplugged and subsequently replugged are not included.
SG12

Figure 3-4

Repaired Tube Voltage Distributions
SG11 & SG12

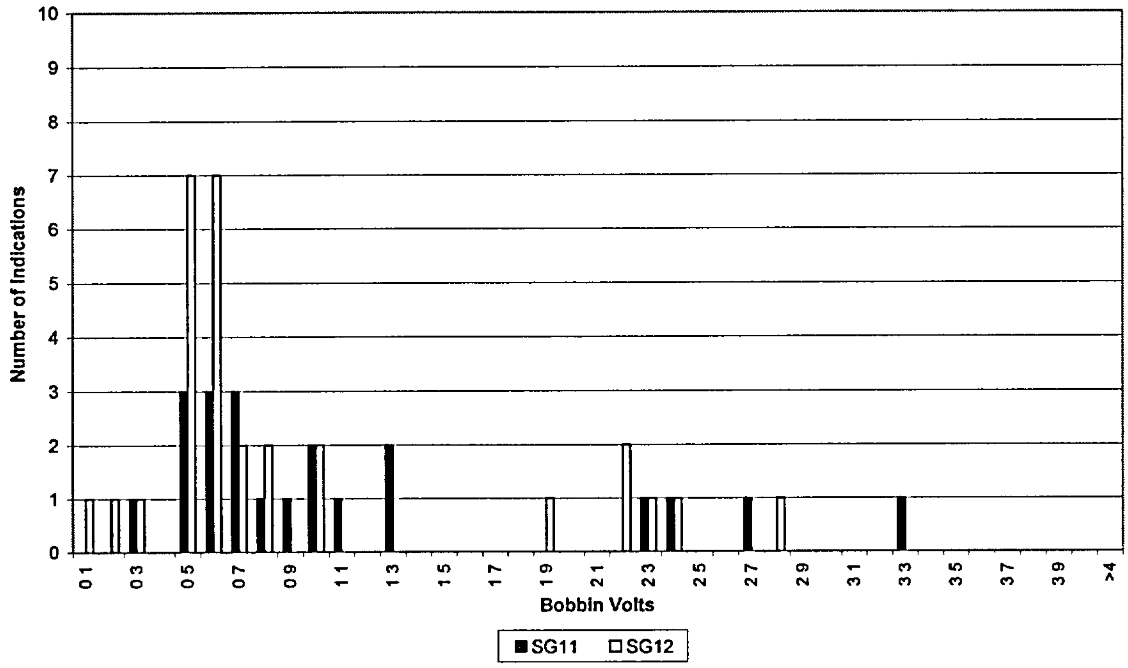


Figure 3-5

Repaired Tube Voltage Distributions
SG13 & SG14

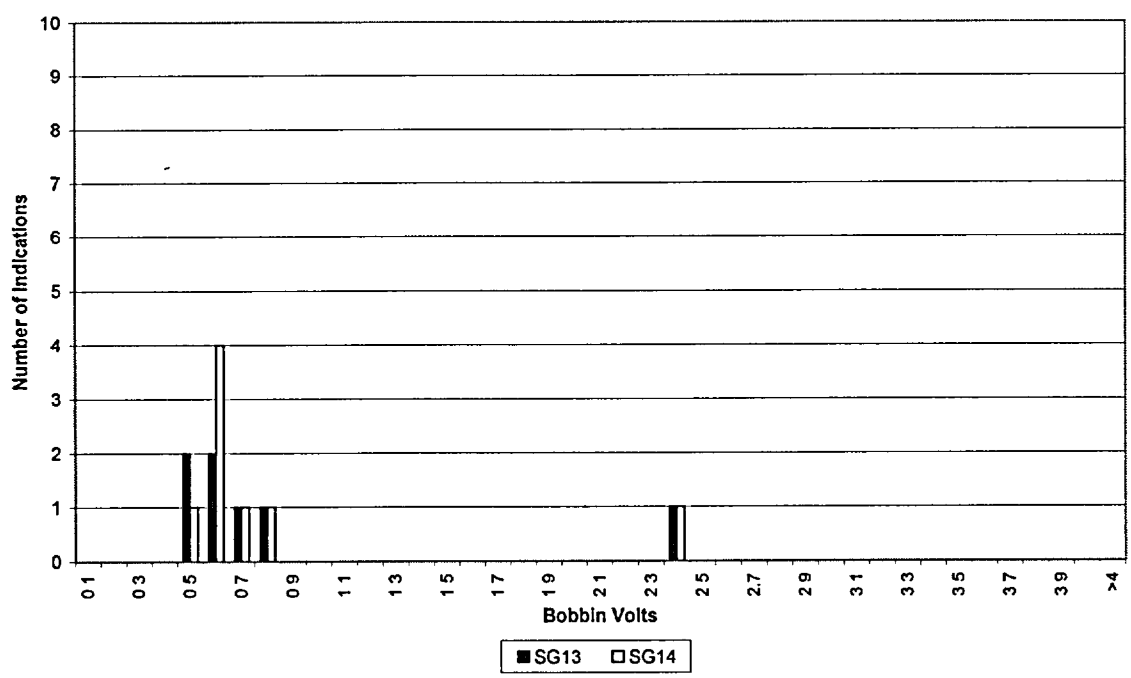


Figure 3-6

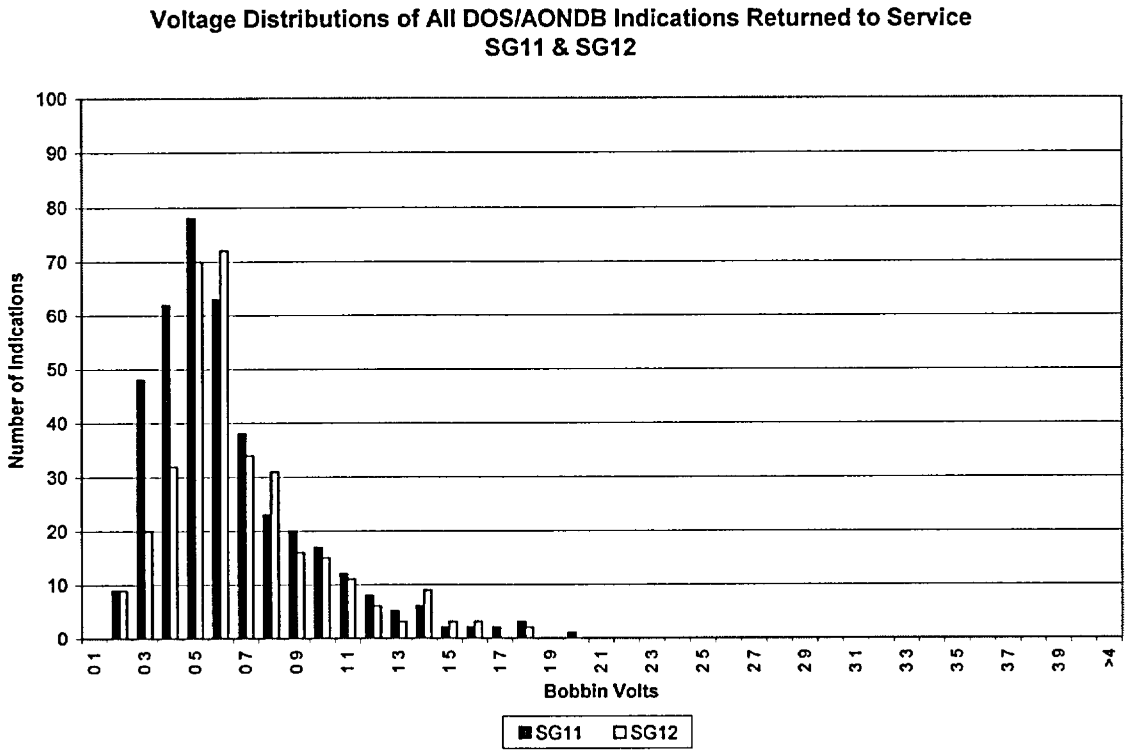


Figure 3-7

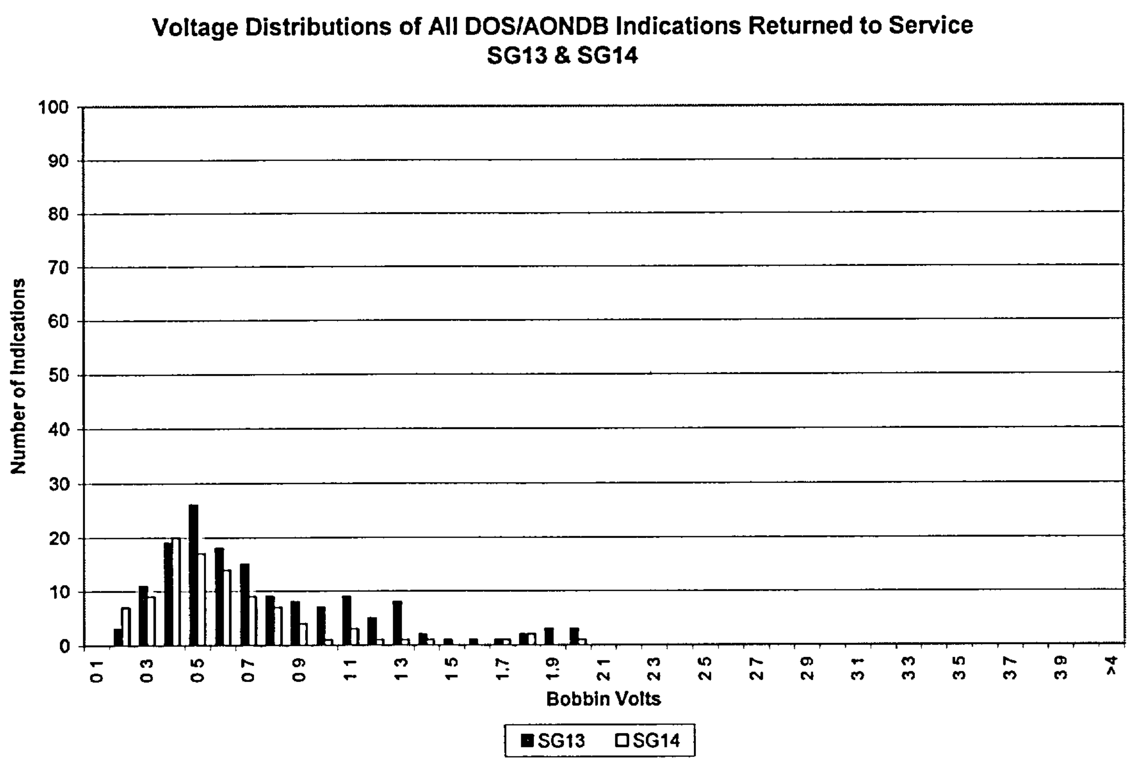
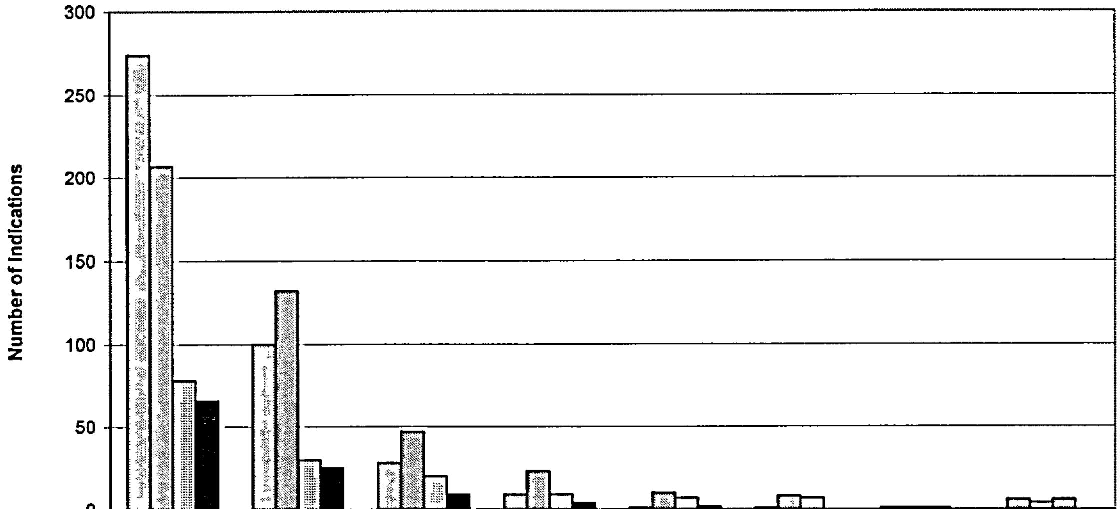


Figure 3-8

Distribution of Indications by TSP Location



	1H	2H	3H	4H	5H	6H	7H	CL
SG11	274	100	28	9	1	1	1	6
SG12	207	132	47	23	10	8	1	4
SG13	78	30	20	9	7	7	1	6
SG14	66	25	9	4	2			

Tube Support Plate

Figure 3-9

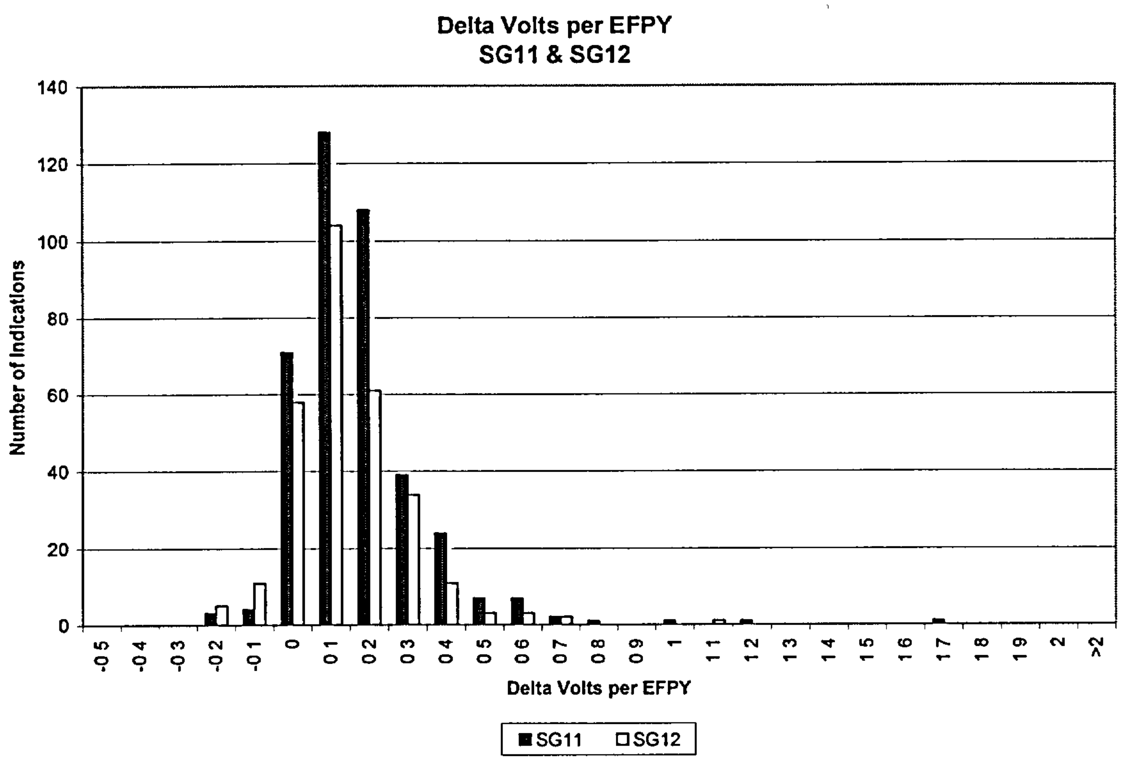


Figure 3-10

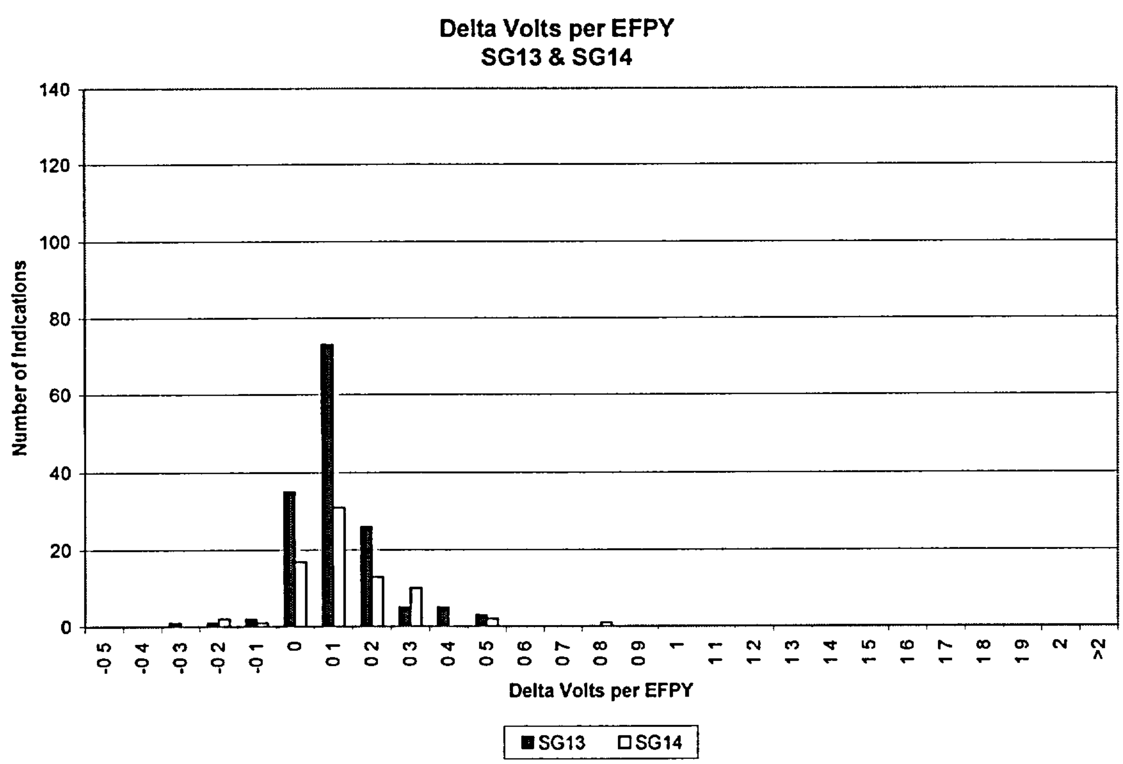


Figure 3-11

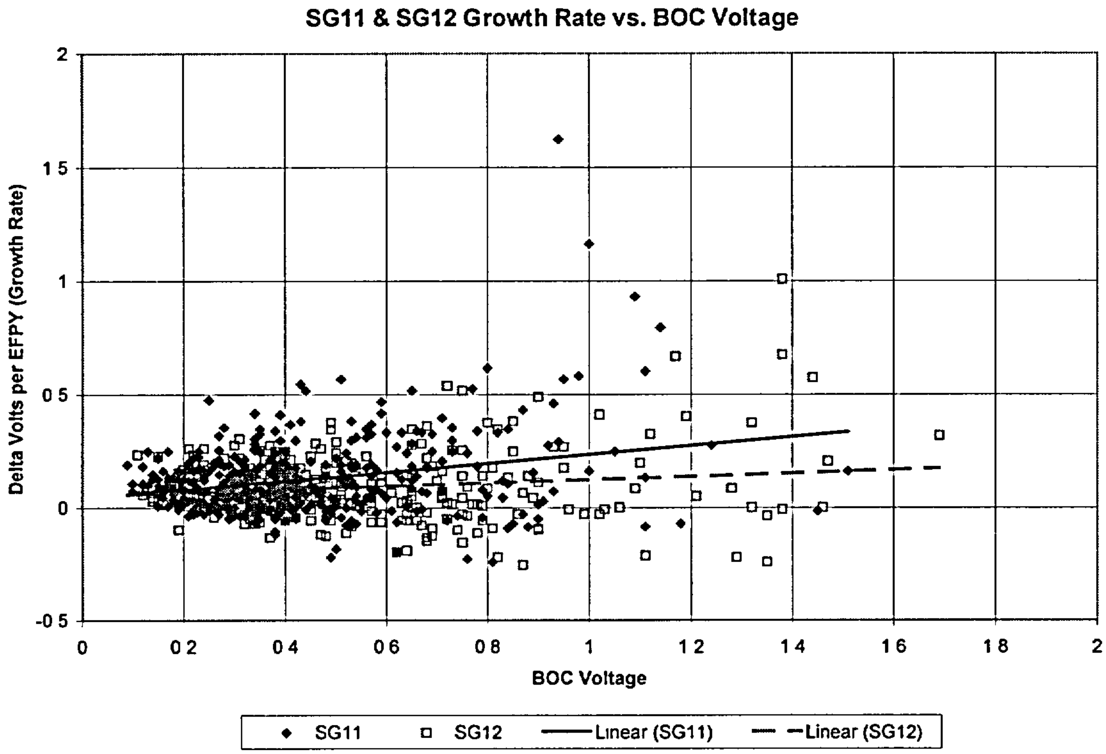


Figure 3-12

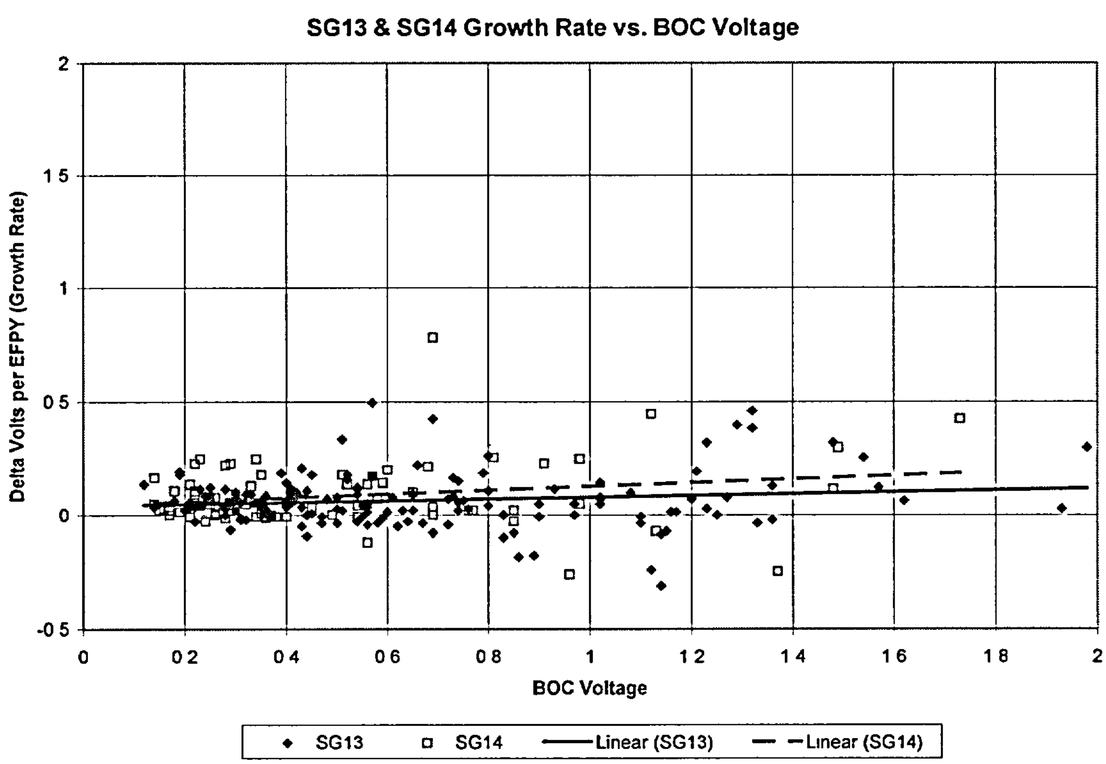


Figure 3-13

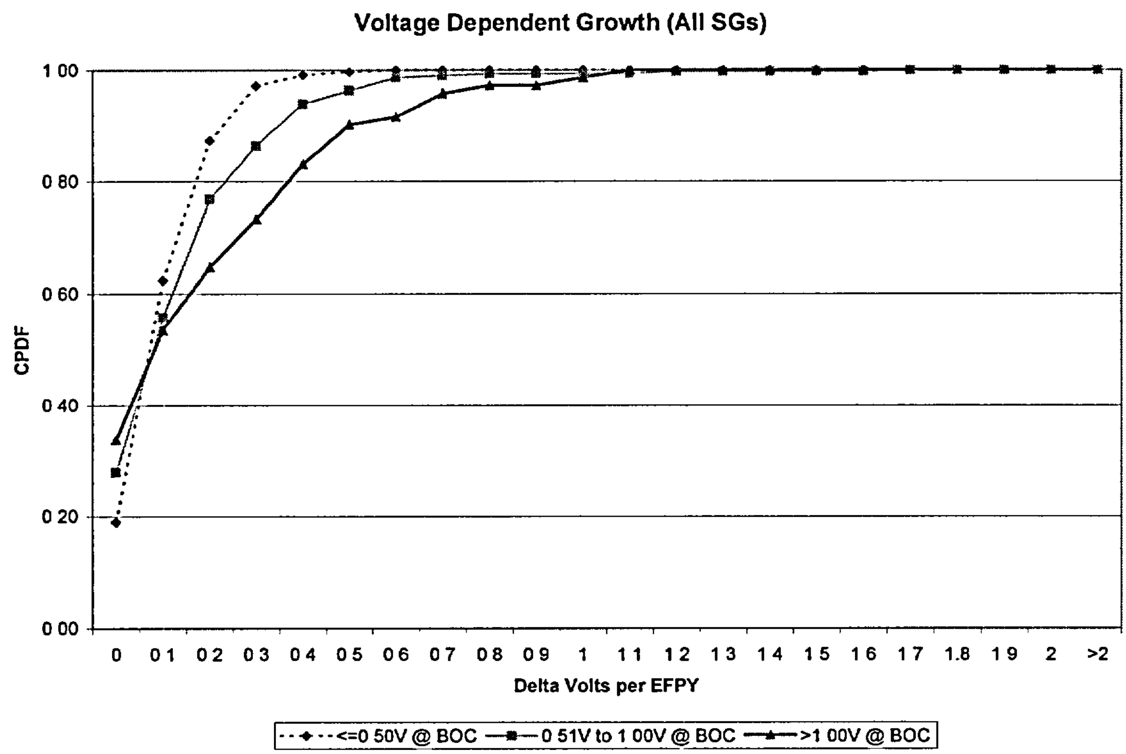


Figure 3-14

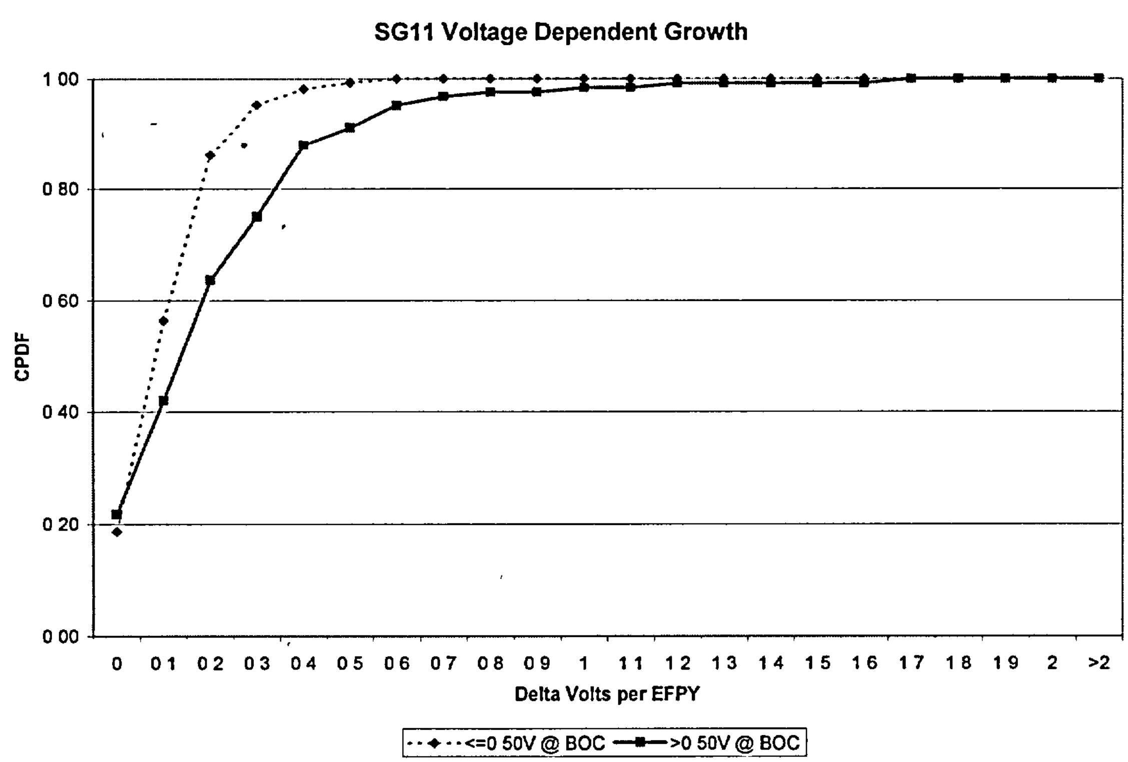


Figure 3-15

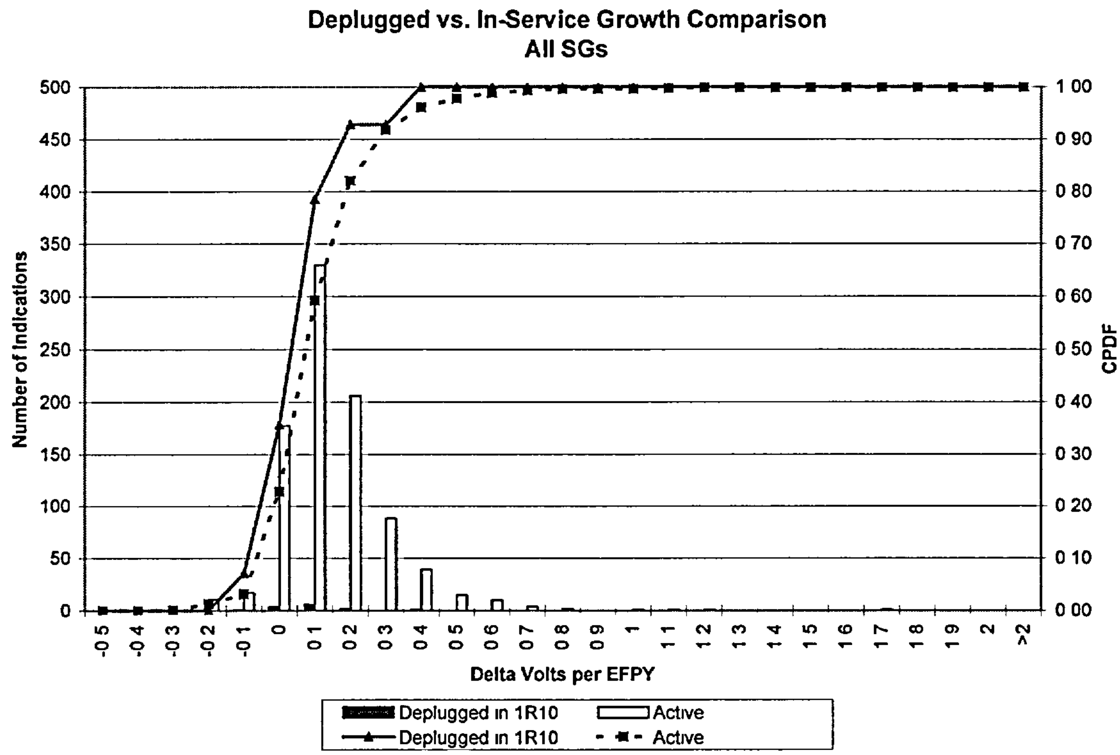


Figure 3-16

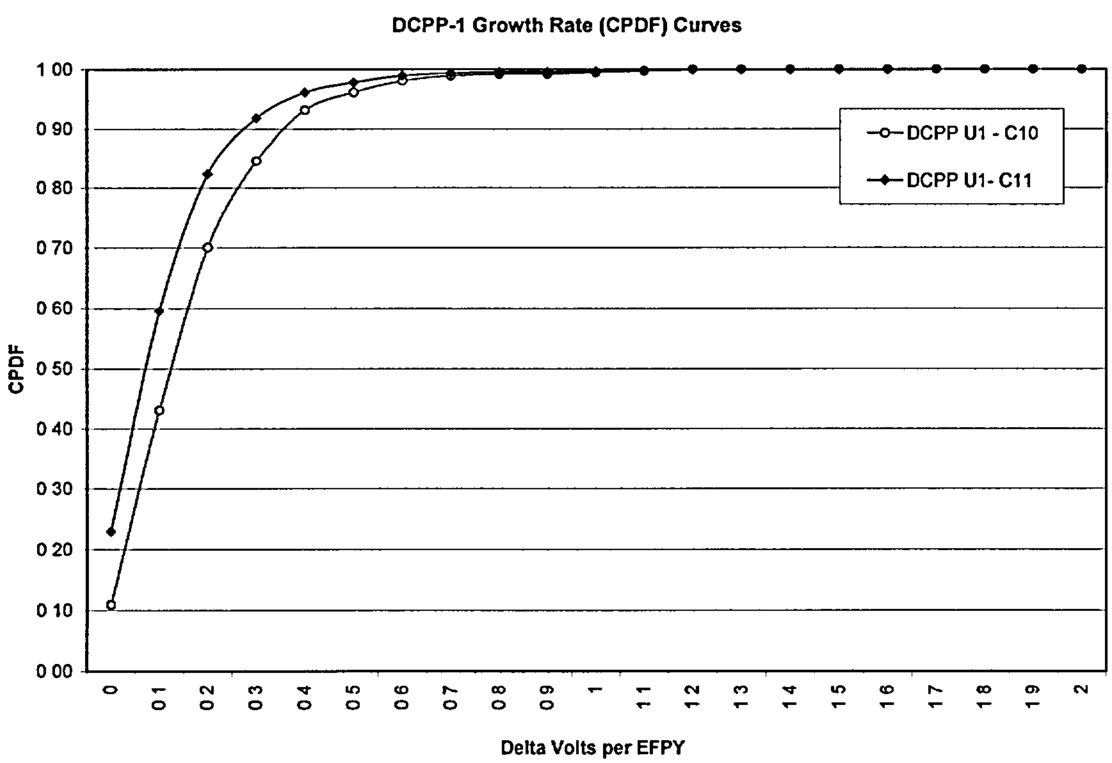


Figure 3-17

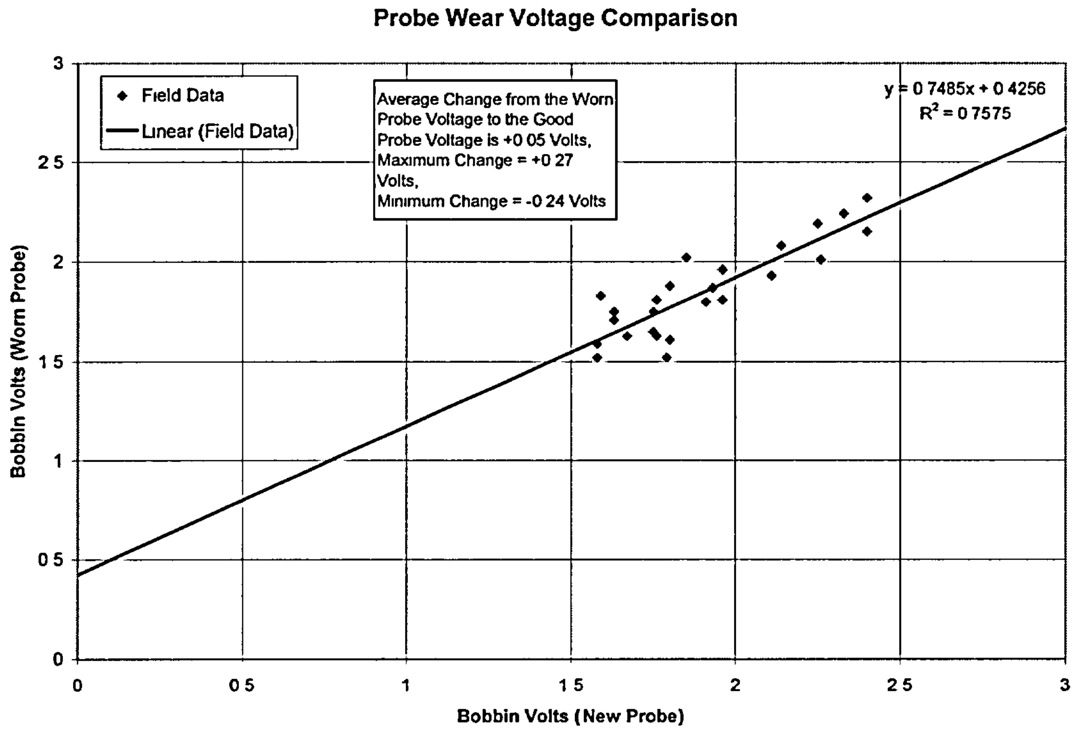
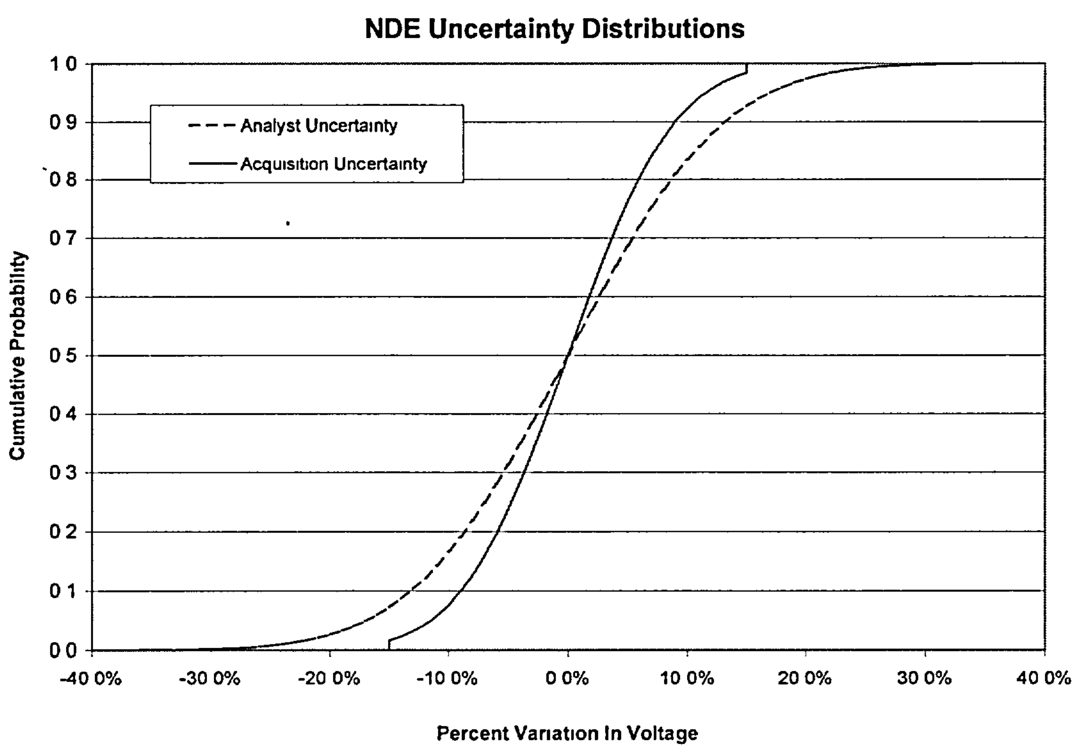


Figure 3-18



4.0 Database and Methods Applied for Leak and Burst Correlations

The leak and burst correlations utilized in the analyses presented in this report are based on the updated databases contained in the May 2002 letter from NEI to the NRC (Ref. 20). This letter contains the latest industry database that includes the Beaver Valley pulled tubes that affected the leak rate correlation and ultimately the methods used to postulate the leak rate. The leak rate correlations used were developed for a MSLB delta P of 2405 psi. The correlations have been developed specifically for the evaluation of ODSCC indications at TSP locations in Model 51 steam generators and relate Bobbin voltage amplitudes, free span burst pressure, probability of leakage and associated leak rates to assess end of next cycle structural integrity.

4.1 Conditional Probability of Burst

For the burst pressure versus voltage correlation, the database contained in Ref. 20 meets all GL 95-05 requirements and was used in these calculations. Material properties were also considered as part of the calculations and were obtained from Ref. 6. The FRA-ANP Monte Carlo computer code was utilized to predict the POB at the end of cycle 12 based upon the input parameters shown in Table 4-1 (from Ref. 20, Table 2). This simulation follows the statistical methods presented in Ref. 6.

Table 4-1: Tube Burst Pressure vs. Bobbin Amplitude Correlation

$$P_B = \alpha_0 + \alpha_1 \log(Volts)$$

Parameter	Database
α_0	7.55184
α_1	-2.39285
r^2	82.0%
σ_{Error}	0.82802
N (data pairs)	95
p Value for α_2	1.1×10^{-36}
Reference σ_f	68.78 ksi

4.2 Conditional Leak Rate

The POL and leak rate correlation parameters used in this analysis are shown in Tables 4-2 and 4-3. The inputs are taken directly from Ref. 20 Tables 3 and 5, respectively. The methodology used in the calculation of these parameters is consistent with the NRC criteria in Ref. 2. The methodology used for the leak rate calculations is referred to as p value sampling method. This method is described in Ref. 21 and supersedes the leak rate method in Ref. 6.

Table 4-2: 7/8" Tube Probability of Leak Correlation

$$Pr(Leak) = \{1 + e^{-[\beta 1+\beta 2 \log(V)]}\}^{-1}$$

Parameter	Database
β_1	-4.15642
β_2	4.11275
$V_{11}^{(1)}$	0.59110
V_{12}	-0.52488
V_{22}	0.53648
$DoF^{(2)}$	141
Deviance	81.83
Pearson SD	74.7%

Notes:

(1) Parameters V_{ij} are elements of the covariance matrix of the coefficients, β_i, of the regression equation.

(2) Degrees of freedom.

Table 4-3: Leak Rate Database for 7/8" Tube ARC Applications (2405 psi)

$$Q = 10^{\left(b_3 + b_4 \times \log(volts) \right)}$$

Parameter	**Database**
Intercept, b_3	-0.658481
Slope, b_4	0.973499
Index of Deter, r^2	11.7%
Residuals, σ_{Error} (b_5)	0.810399
Data Pairs, N	30
Mean of Log(Q)	0.45134
Std Dev of Log(Q)	0.84746
Mean of Log(V)	1.14003
SS of Log(V)	2.57620
p Value for b_4	3.2%

5.0 Bobbin Voltage Distributions

This section describes the prediction of the EOC voltage distribution used for evaluating tube leakage and burst probabilities at the end of the operating period.

5.1 Probability of Detection

The number of bobbin indications used to predict the tube leak rate and burst probability is obtained by adjusting the number of reported indications to account for the detection capability of the bobbin coil. This is accomplished by using a POD factor. The calculation of the bobbin voltage distribution is a net total number of indications returned to service, defined as:

$$N_{BOC12} = \frac{N_{EOC11}}{POD} - N_{repaired} + N_{deplugged}$$

where:

N_{BOC12}	=	Number of bobbin indications being returned to service for the next operating cycle
N_{EOC11}	=	Number of bobbin indications reported in the current inspection
POD	=	Probability of Detection
$N_{repaired}$	=	Number of bobbin indications repaired after the last cycle
$N_{deplugged}$	=	Number of previously plugged indications which are deplugged after the last cycle and are returned to service

Note that the deplugged tube component of this equation only applies to SG 1-2. No tubes were deplugged and subsequently returned to service in SGs 1-1, 1-3, and 1-4.

The NRC generic letter (Ref. 2) requires the application of a constant POD equal to 0.6 to define the BOC distribution for the EOC voltage projections. The operating cycle length is required for proper voltage projection calculations: Cycle 11 (actual) = 1.41 EFPY and Cycle 12 (estimated)=1.61 EFPY (Ref. 18).

5.2 Probability of Prior Cycle Detection

Per the Generic Letter, the beginning-of-cycle voltage distribution must be developed using a constant POD of 0.6 as mentioned above. In reality, however, the POD is a function of the bobbin voltage. The larger voltage indications should have a higher POD. EPRI has developed a voltage-dependent POD based on data from 19 inspections at plants with 7/8" diameter tubing. The latest update of the probability of prior cycle detection (POPCD) is documented in Ref. 10. The POPCD was not used in any of the leak rate and probability of burst projections contained in this document. However, the Diablo Canyon POPCD is documented in this report for comparison to the EPRI POPCD.

For voltage-based repair criteria applications, the important indications are those that could significantly contribute to EOC leakage or burst probability. These significant indications can be expected to be detected by bobbin and confirmed by the plus point inspection. Thus, the population of interest for POD assessments is the EOC RPC confirmed indications that were or were not detected at the prior inspection. The probability of prior cycle detection (POPCD) is defined as follows:

$$POPCD_{EOC\text{-}10} = \frac{\text{EOC-11 Plus Pt confirmed and detected at EOC-10} + \text{EOC-10 Plus Pt confirmed and repaired at EOC-10}}{\text{(NUMERATOR)} + \text{New EOC-11 Plus Pt confirmed indications}}$$

Note that the above definition for POPCD is based on the premise that all indications which contribute significantly to leakage or burst probability are confirmed with Plus Point. However, only a fraction of the bobbin indications are inspected with a Plus Point coil. Therefore, a more realistic definition of POPCD is obtained by replacing the "EOC-11 Plus Pt confirmed" category with a category of "EOC-11 Plus Pt confirmed plus not inspected".

The POPCD evaluation for the EOC-10 inspection data is summarized in Table 5-1 and Figure 5-1. For the most part, the Diablo Canyon POPCD for the EOC-10 inspection results is slightly below the EPRI POPCD for voltages below about 1.6 volts. The Diablo Canyon POPCD equals 1.0 for bobbin voltages greater than 1.7 volts.

5.3 Calculation of BOC-12 Voltage Distributions

The first step in performing the leak rate and probability of burst projections is to determine the number and voltages of the indications being returned to service for the next operating cycle. The BOC-12 distribution is calculated by dividing the as-found condition of the SG by the probability of detection (POD), subtracting the number of repaired tubes, and adding the number of deplugged tubes that are being returned to service. For this analysis, the BOC-12 distributions for each SG were calculated using the constant POD of 0.6 as required per the Generic Letter. Tables 5-2 through 5-5 and Figures 5-2 through 5-5 summarize the as-found distribution, repaired tubes, deplugged tubes, and the calculated BOC-12 distributions for SG 1-1, SG 1-2, SG 1-3, and SG 1-4 respectively.

5.4 Predicted EOC-12 Voltage Distributions

Once the BOC-12 voltage distribution has been determined, the EOC-12 voltage distributions are obtained by applying a Monte Carlo sampling process to the BOC-12 voltages. This process randomly assigns uncertainty values and a growth value to each of the BOC-12 indications. The EOC-12 voltage distributions are used to calculate a leak rate and probability of tube burst. Section 3.2 provides information on the growth distributions that were used in the analyses.

Table 5-6 summarizes the projected EOC-12 voltage distributions for 0.6 POD. Figures 5-6 through 5-9 show the calculated BOC-12 and projected EOC-12 voltage distributions using normal growth for SG 1-1, SG 1-2, SG 1-3, and SG 1-4, respectively. Figure 5-10 shows the projected EOC-12 voltage distribution for SG 1-1 using voltage dependent growth.

5.5 Comparison of Predicted and Actual EOC-11 Conditions

The as-found EOC-11 bobbin voltage distributions and the predicted distributions from the previous 90-day report (Ref. 7) are compared in Table 5-7 and Figures 5-11 through 5-14. As shown in Table 5-7, the number of indications was under-predicted using the 0.6 POD for all steam generators. Figures 5-11 through 5-14 show that the under predictions generally occurred in voltage bins less than about 0.7 volts. For bins exceeding 0.7 volts, the predictions generally exceed the as-found voltages except for the tail of the distribution for SG 1-2, in which there were 5 indications detected that exceeded 2.1 volts, but only 1.75 indications were projected to be above 2.1 volts.

The projected EOC 11 leak rate and POB in Ref. 7 used a SLB dP of 2560 psi, the correlations of Addendum 4, and the leak rate method of Ref. 6. The EOC 11 projected leak rate and POB were recalculated using a SLB dP of 2405 psi, updated correlations of Ref. 20 and the revised leak rate method of Ref. 21 to permit a direct comparison to the EOC 11 as-found leak rate and POB. These projections replace the Ref. 7 projections and are provided in Table 5-8. The as-found leak rates and probabilities of burst were bounded by the updated projected values. The LR and POB projections are conservative because for voltage bins exceeding 0.7 volts (which tend to drive the leak rate and burst probability), the predictions generally exceed the as-found voltages.

Table 5-1: Diablo Canyon Unit 1 POPCD Evaluation

Composite of All Steam Generator Data

Voltage Bin	New Indications		Bobbin Call In Both Inspections		First Inspection	POPCD			
						RPC Confirmed		RPC Confirmed Plus Not Inspected	
	RPC Confirmed	RPC Confirmed Plus Not Inspected	RPC Confirmed	RPC Confirmed Plus Not Inspected	RPC Confirmed and Plugged	Frac	Count	Frac	Count
>0 - 0.2	11	63	5	7		0.313	5/16	0.100	7/70
0.2 - 0.4	29	231	38	117	6	0.603	44/73	0.347	123/354
0.4 - 0.6	33	112	26	112	4	0.476	30/63	0.509	116/228
0.6 - 0.8	15	41	18	86	4	0.595	22/37	0.687	90/131
0.8 - 1.0	10	18	10	43	1	0.524	11/21	0.710	44/62
1.0 - 1.2	4	10	5	21	1	0.600	6/10	0.688	22/32
1.2 - 1.6	3	8	6	25		0.667	6/9	0.758	25/33
1.6 - 2.0			3	5		1.000	3/3	1.000	5/5
2.0 - 2.5					1	1.000	1/1	1.000	1/1
2.5 - 3.2					2	1.000	2/2	1.000	2/2
3.2 - 3.5									
TOTAL	105	483	111	416	19				
Total >1v	7	18	14	51	4				

Table 5-2: SG11 As-Found and BOC-12 Voltage Distribution

Voltage Bin	As-Found EOC-11	POD (0.6)	Repaired Tubes	Calculated BOC-12	DOSs/AONDBs Returned to Service: Conf. OD-SCC or Not Insp w/+Pt	DOSs/AONDBs Returned to Service: Total
0.1						
0.2	9	15		15	9	9
0.3	49	81.67	1	80.67	47	48
0.4	62	103.33		103.33	62	62
0.5	81	135	3	132	76	78
0.6	66	110	3	107	62	63
0.7	41	68.33	3	65.33	37	38
0.8	24	40	1	39	23	23
0.9	21	35	1	34	19	20
1	19	31.67	2	29.67	17	17
1.1	13	21.67	1	20.67	12	12
1.2	8	13.33		13.33	8	8
1.3	7	11.67	2	9.67	5	5
1.4	6	10		10	6	6
1.5	2	3.33		3.33	2	2
1.6	2	3.33		3.33	2	2
1.7	2	3.33		3.33	2	2
1.8	3	5		5	3	3
1.9						
2	1	1.67		1.67	1	1
2.1						
2.2						
2.3	1	1.67	1	0.67		
2.4	1	1.67	1	0.67		
2.5						
2.6						
2.7	1	1.67	1	0.67		
2.8						
2.9						
3						
3.1						
3.2						
3.3	1	1.67	1	0.67		
3.4						
3.5						
>3.5						
Total	420	700	21	679	393	399

Table 5-3: SG12 As-Found and BOC-12 Voltage Distribution

Voltage Bin	As-Found EOC-11	POD (0.6)	Repaired Tubes (Active)	Deplugged & Returned to Service	Calculated BOC-12	DOSs/AONDBs Returned to Service: Conf. OD-SCC or Not Insp w/+Pt	DOSs/AONDBs Returned to Service: Total
0.1	1	1.67	1		0.67		
0.2	8	13.33	1	2	14.33	9	9
0.3	21	35	1		34	20	20
0.4	29	48.33		3	51.33	32	32
0.5	71	118.33	7	6	117.33	68	70
0.6	71	118.33	7	8	119.33	71	72
0.7	34	56.67	2	2	56.67	33	34
0.8	32	53.33	2	1	52.33	29	31
0.9	14	23.33		2	25.33	13	16
1	15	25	2	2	25	15	15
1.1	11	18.33			18.33	10	11
1.2	5	8.33		1	9.33	6	6
1.3	3	5			5	3	3
1.4	9	15			15	9	9
1.5	3	5			5	3	3
1.6	3	5			5	3	3
1.7							
1.8	2	3.33			3.33	2	2
1.9	1	1.67	1		0.67		
2							
2.1							
2.2	2	3.33	2		1.33		
2.3	1	1.67	1		0.67		
2.4	1	1.67	1		0.67		
2.5							
2.6							
2.7							
2.8	1	1.67	1		0.67		
2.9							
3							
3.1							
3.2							
3.3							
3.4							
3.5							
>3.5							
Total	338	563.33	29	27	561.33	326	336

Table 5-4: SG13 As-Found and BOC-12 Voltage Distribution

					DOSs/AONDBs Returned to Service	
Voltage Bin	As-Found EOC-11	POD (0.6)	Repaired Tubes	Calculated BOC-12	Conf. OD-SCC or Not Insp w/+Pt	Total
0.1						
0.2	3	5		5	3	3
0.3	11	18.33		18.33	11	11
0.4	19	31.67		31.67	19	19
0.5	28	46.67	2	44.67	24	26
0.6	20	33.33	2	31.33	16	18
0.7	16	26.67	1	25.67	15	15
0.8	10	16.67	1	15.67	9	9
0.9	8	13.33		13.33	8	8
1	7	11.67		11.67	7	7
1.1	9	15		15	9	9
1.2	5	8.33		8.33	5	5
1.3	8	13.33		13.33	8	8
1.4	2	3.33		3.33	2	2
1.5	1	1.67		1.67	1	1
1.6	1	1.67		1.67	1	1
1.7	1	1.67		1.67	1	1
1.8	2	3.33		3.33	2	2
1.9	3	5		5	3	3
2	3	5		5	3	3
2.1						
2.2						
2.3						
2.4	1	1.67	1	0.67		
2.5						
2.6						
2.7						
2.8						
2.9						
3						
3.1						
3.2						
3.3						
3.4						
3.5						
>3.5						
Total	158	263.33	7	256.33	147	151

Table 5-5: SG14 As-Found and BOC-12 Voltage Distribution

					DOSs/AONDBs Returned to Service	
Voltage Bin	As-Found EOC-11	POD (0.6)	Repaired Tubes	Calculated BOC-12	Conf. OD-SCC or Not Insp w/+Pt	Total
0.1						
0.2	7	11.67		11.67	7	7
0.3	9	15		15	9	9
0.4	20	33.33		33.33	20	20
0.5	18	30	1	29	17	17
0.6	18	30	4	26	14	14
0.7	10	16.67	1	15.67	9	9
0.8	8	13.33	1	12.33	7	7
0.9	4	6.67		6.67	4	4
1	1	1.67		1.67	1	1
1.1	3	5		5	3	3
1.2	1	1.67		1.67	1	1
1.3	1	1.67		1.67	1	1
1.4	1	1.67		1.67	1	1
1.5						
1.6						
1.7	1	1.67		1.67	1	1
1.8	2	3.33		3.33	2	2
1.9						
2	1	1.67		1.67	1	1
2.1						
2.2						
2.3						
2.4	1	1.67	1	0.67		
2.5						
2.6						
2.7						
2.8						
2.9						
3						
3.1						
3.2						
3.3						
3.4						
3.5						
>3.5						
Total	106	176.67	8	168.67	98	98

Table 5-6: Projected EOC-12 Distributions with POD=0.6

Voltage Bin	Normal Growth				Voltage Dependent Growth
	SG11	SG12	SG13	SG14	SG11
<=0.1	0.12	0.28	0.06	0.07	0.14
0.2	3.32	3.37	1.49	1.44	3.85
0.3	14.33	9.45	5.49	3.72	16.70
0.4	29.96	21.07	12.31	8.16	35.32
0.5	51.22	39.77	20.50	13.64	60.94
0.6	70.89	57.10	26.28	17.53	83.11
0.7	78.75	67.95	27.57	20.26	82.27
0.8	78.98	68.25	25.33	19.42	71.85
0.9	70.57	61.02	21.72	17.65	57.08
1	59.68	51.49	18.50	14.72	45.04
1.1	48.69	41.46	16.06	11.64	36.65
1.2	38.86	32.29	14.32	8.96	33.31
1.3	30.48	24.74	12.67	6.72	29.10
1.4	23.59	19.11	10.65	5.04	23.24
1.5	18.19	15.06	8.51	3.76	19.05
1.6	13.90	11.97	6.56	2.81	15.82
1.7	10.45	9.32	5.14	2.18	12.75
1.8	7.83	7.01	4.25	1.78	10.06
1.9	5.95	5.14	3.73	1.52	7.90
2	4.58	3.75	3.32	1.37	5.96
2.1	3.63	2.75	2.89	1.23	4.58
2.2	2.98	2.09	2.37	1.08	3.86
2.3	2.44	1.66	1.84	0.91	3.30
2.4	1.96	1.26	1.38	0.74	2.86
2.5	1.51	0.95	1.01	0.57	2.57
2.6	1.10	0.72	0.74	0.43	2.11
2.7	0.81	0.55	0.53	0.32	1.57
2.8	0.61	0.43	0.38	0.23	1.18
2.9	0.49	0.33	0.26	0.18	0.90
3	0 48	0.25	0.17	0.14	0.68
3.1	0.47	0.19	0.11	0.11	0.52
3.2	0.45	0.15	0.07	0.09	0.48
3.3	0.39	0.11	0.05	0.07	0.79
3.4	0.30	0.08	0.03	0.05	0.82
3.5	0.23	0.06	0.02	0.04	0.61
3.6	0.18	0.04	0.02	0.02	0.46
3.7	0.15	0.03	0.01	0.02	0.37
3.8	0.12	0.02	0.01	0.01	0.29
3.9	0.09	0.02	0.00	0.01	0.22
4	0.07	0.01	0.00	0.01	0.16
4.1	0.05	0.01	0.00	0.00	0.12
4.2	0.04	0.01	0.00	0.00	0.09
4.3	0.03	0.00	0.00	0.00	0.07
4.4	0.02	0.00	0.00	0.00	0.06
4.5	0.02	0.00	0.00	0.00	0.04
>4.5	0.05	0.00	0.00	0.01	0.13
Total	679.01	561.32	256.34	168.69	679.01

Table 5-7: EOC-11 As-Found vs Projected Voltage Distribution

Voltage Bin	POD = 0.6							
	SG11 EOC-11		SG12 EOC-11		SG13 EOC-11		SG14 EOC-11	
	As-Found	Projected	As-Found	Projected	As-Found	Projected	As-Found	Projected
0.1	0	0.01	1	0.02	0	0.01	0	0.03
0.2	9	0.34	8	0.47	3	0.30	7	0.55
0.3	49	2.39	21	2.70	11	1.68	9	1.76
0.4	62	8.19	29	8.93	19	4.54	20	3.35
0.5	81	17.51	71	20.08	28	8.09	18	5.71
0.6	66	27.80	71	30.84	20	12.02	18	8.00
0.7	41	34.87	34	35.88	16	14.23	10	9.82
0.8	24	36.28	32	35.44	10	14.84	8	9.92
0.9	21	35.23	14	32.09	8	14.30	4	8.88
1	19	31.06	15	27.60	7	12.75	1	7.41
1.1	13	24.49	11	21.71	9	11.04	3	6.21
1.2	8	18.50	5	15.85	5	9.61	1	5.08
1.3	7	13.57	3	11.65	8	8.54	1	3.96
1.4	6	9.66	9	8.97	2	7.71	1	3.16
1.5	2	6.63	3	7.07	1	6.87	0	2.57
1.6	2	4.46	3	5.54	1	5.96	0	2.09
1.7	2	3.00	0	4.21	1	5.01	1	1.70
1.8	3	2.05	2	3.11	2	4.07	2	1.38
1.9	0	1.58	1	2.23	3	3.25	0	1.12
2	1	1.40	0	1.53	3	2.56	1	0.90
2.1	0	1.26	0	1.00	0	2.01	0	0.70
2.2	0	1.04	2	0.64	0	1.55	0	0.53
2.3	1	0.80	1	0.41	0	1.17	0	0.39
2.4	1	0.61	1	0.27	1	0.86	1	0.26
2.5	0	0.47	0	0.17	0	0.62	0	0.17
2.6	0	0.37	0	0.11	0	0.44	0	0.11
2.7	1	0.31	0	0.06	0	0.31	0	0.08
2.8	0	0.27	1	0.04	0	0.22	0	0.05
2.9	0	0.24	0	0.02	0	0.15	0	0.03
3	0	0.22	0	0.01	0	0.11	0	0.02
3.1	0	0.20	0	0.00	0	0.07	0	0.02
3.2	0	0.18	0	0.00	0	0.05	0	0.01
3.3	1	0.15	0	0.00	0	0.03	0	0.01
3.4	0	0.13	0	0.00	0	0.02	0	0.01
3.5	0	0.10	0	0.00	0	0.01	0	0.00
3.6	0	0.08	0	0.00	0	0.01	0	0.00
3.7	0	0.06	0	0.00	0	0.01	0	0.00
3.8	0	0.04	0	0.00	0	0.00	0	0.00
3.9	0	0.03	0	0.00	0	0.00	0	0.00
4	0	0.02	0	0.00	0	0.00	0	0.00
4.1	0	0.02	0	0.00	0	0.00	0	0.00
4.2	0	0.01	0	0.00	0	0.00	0	0.00
4.3	0	0.01	0	0.00	0	0.00	0	0.00
4.4	0	0.01	0	0.00	0	0.00	0	0.00
4.5	0	0.01	0	0.00	0	0.00	0	0.00
>4.5	0	0.01	0	0.00	0	0.00	0	0.00
Total	420	285.67	338	278.66	158	155.00	106	86.00

Table 5-8: EOC-11 Projected vs Actual POB & Leak Rate

	EOC-11 Projected		EOC-11 Actual	
Steam Generator	**Probability of Burst**	**SLB Leak Rate**	**Probability of Burst**	**SLB Leak Rate**
SG11	2.67×10^{-5}	0.406	1.82×10^{-5}	0.325
SG12	1.57×10^{-5}	0.355	1.31×10^{-5}	0.278
SG13	1.94×10^{-5}	0.288	1.44×10^{-5}	0.153
SG14	1.05×10^{-5}	0.109	7.75×10^{-6}	0.059

Figure 5-1

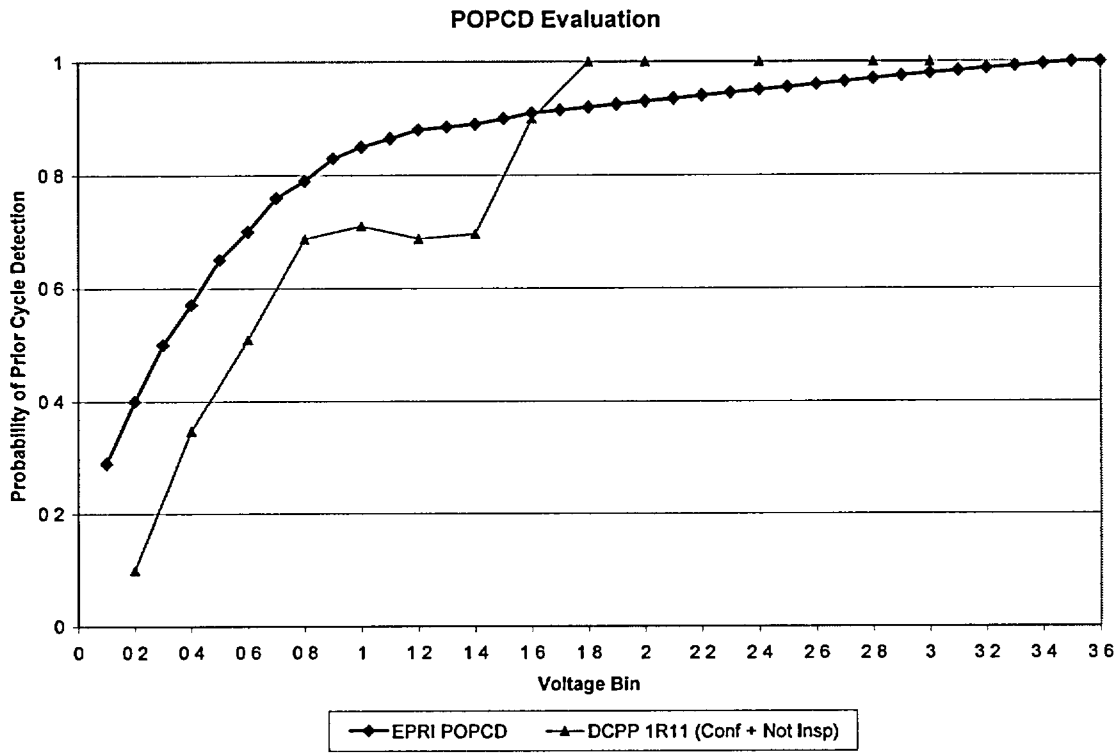

POPCD Evaluation
Probability of Prior Cycle Detection
1
0 8
0 6
0 4
0 2
0
0
0 2
0 4
0 6
0 8
1
1 2
1 4
1 6
1 8
2
2 2
2 4
2 6
2 8
3
3 2
3 4
3 6
Voltage Bin
EPRI POPCD
DCPP 1R11 (Conf + Not Insp)

Figure 5-2

As-Found EOC-11 and Calculated BOC-12 Voltage Distributions
SG11 (POD=0.6)

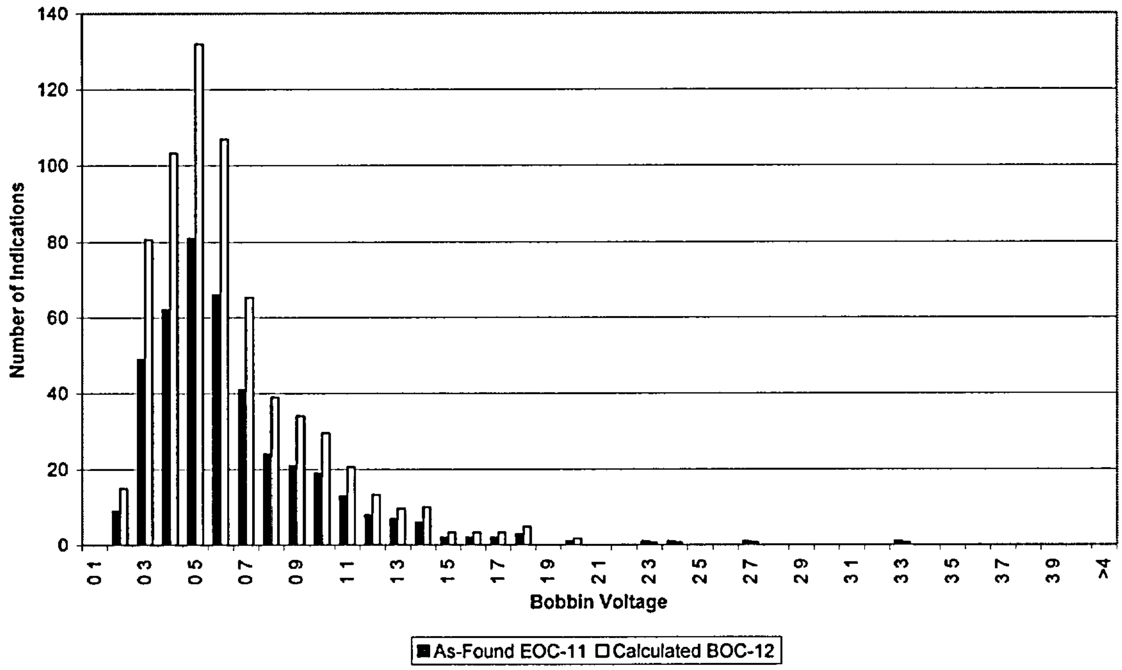


Figure 5-3

As-Found EOC-11 and Calculated BOC-12 Voltage Distributions
SG12 (POD=0.6)

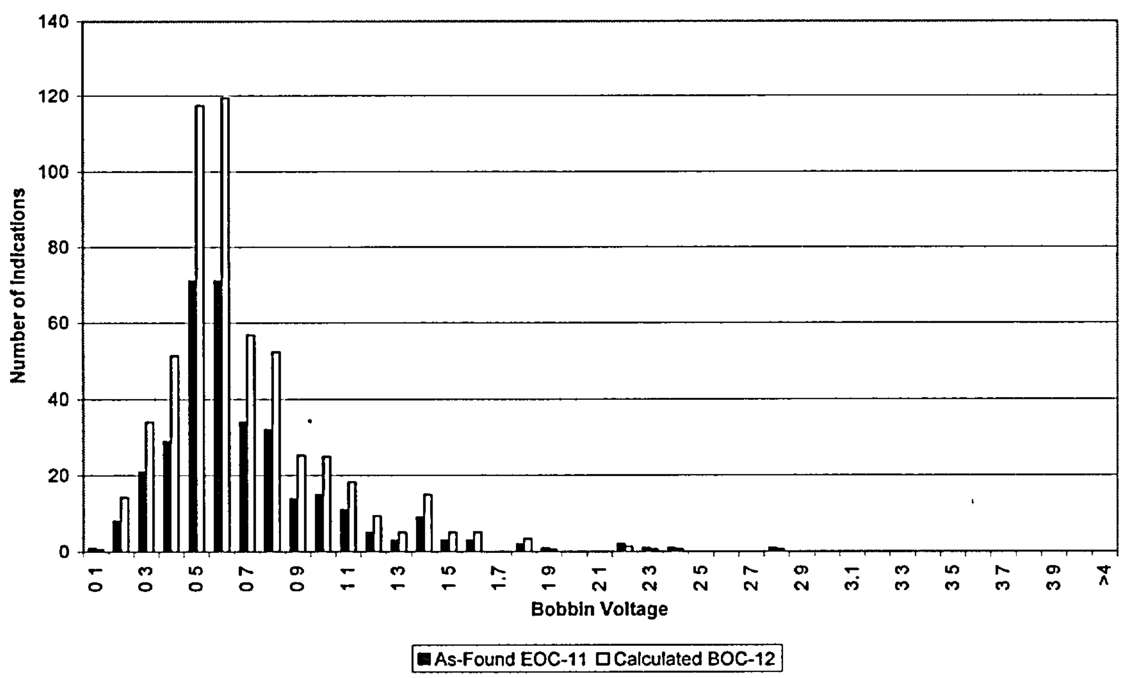


Figure 5-4

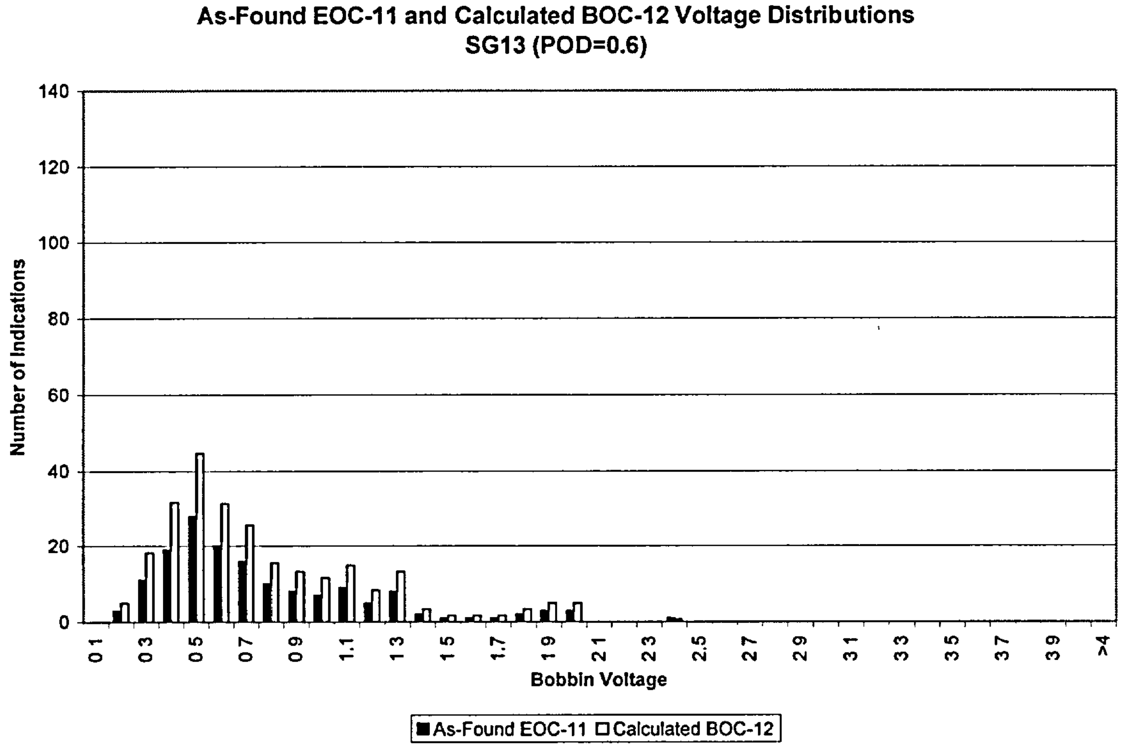


Figure 5-5

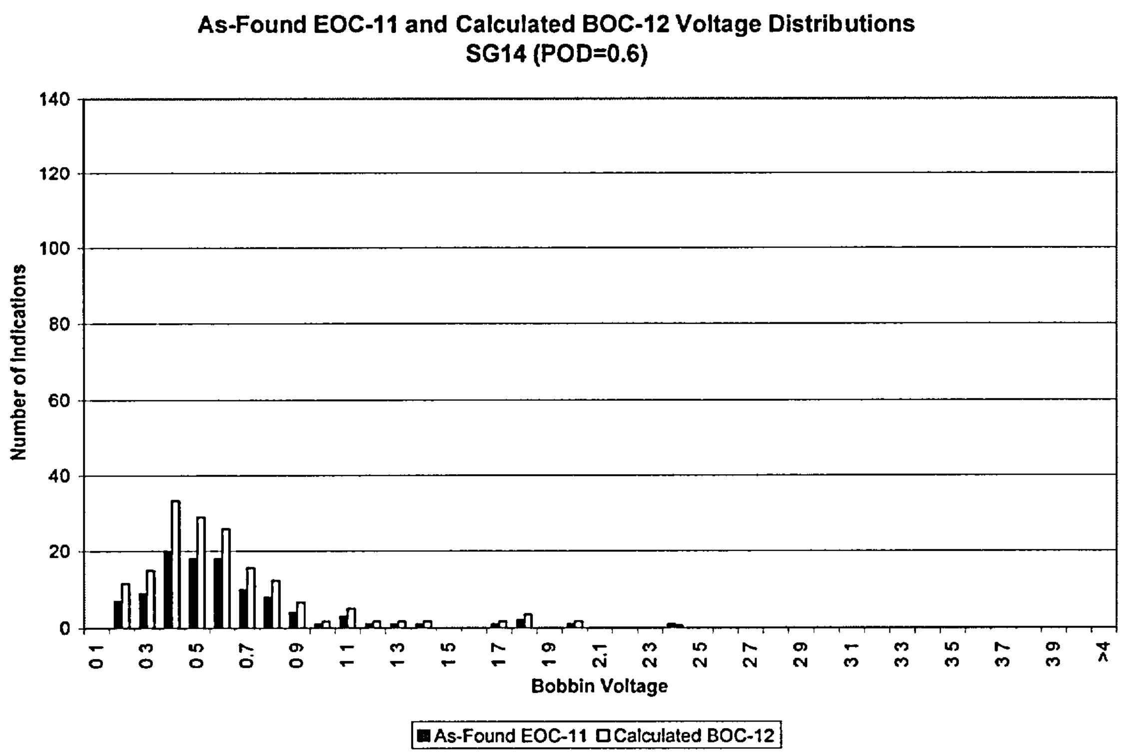


Figure 5-6

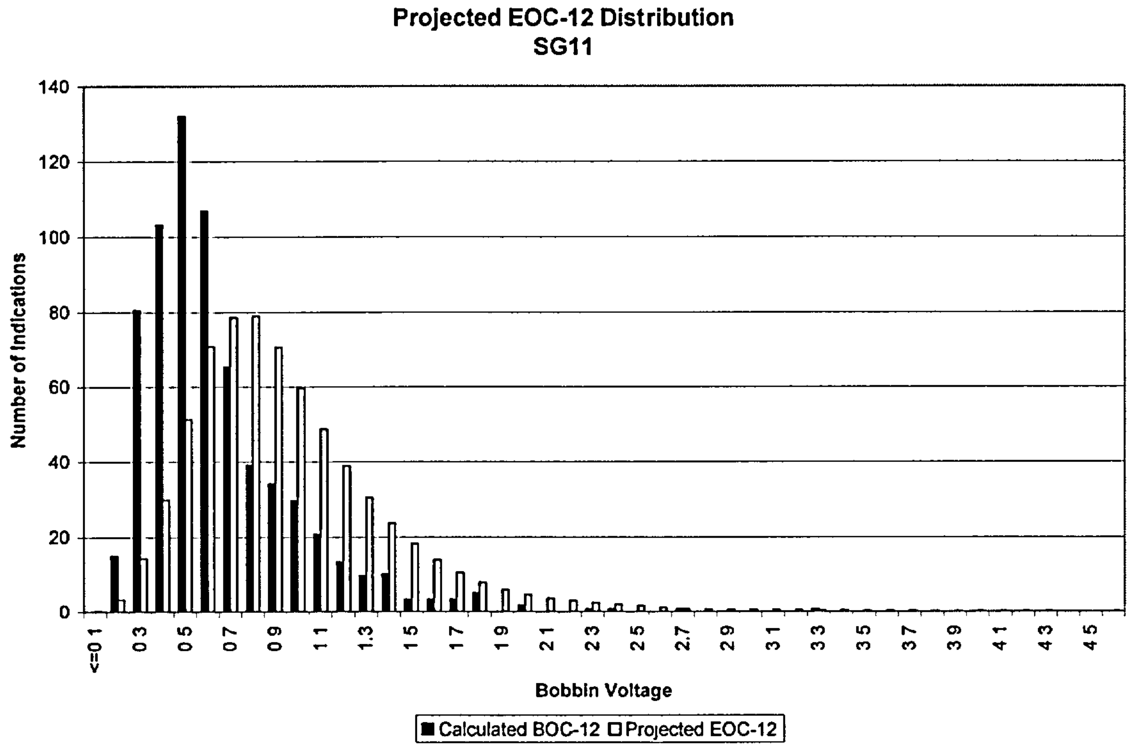


Figure 5-7

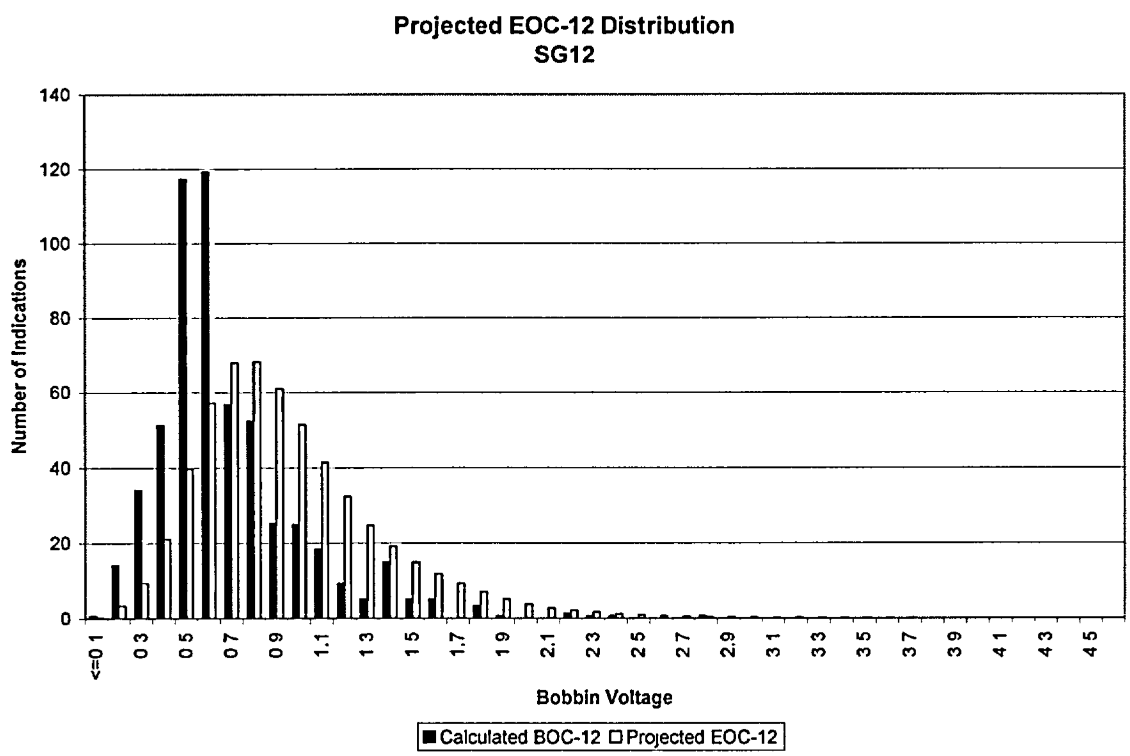


Figure 5-8

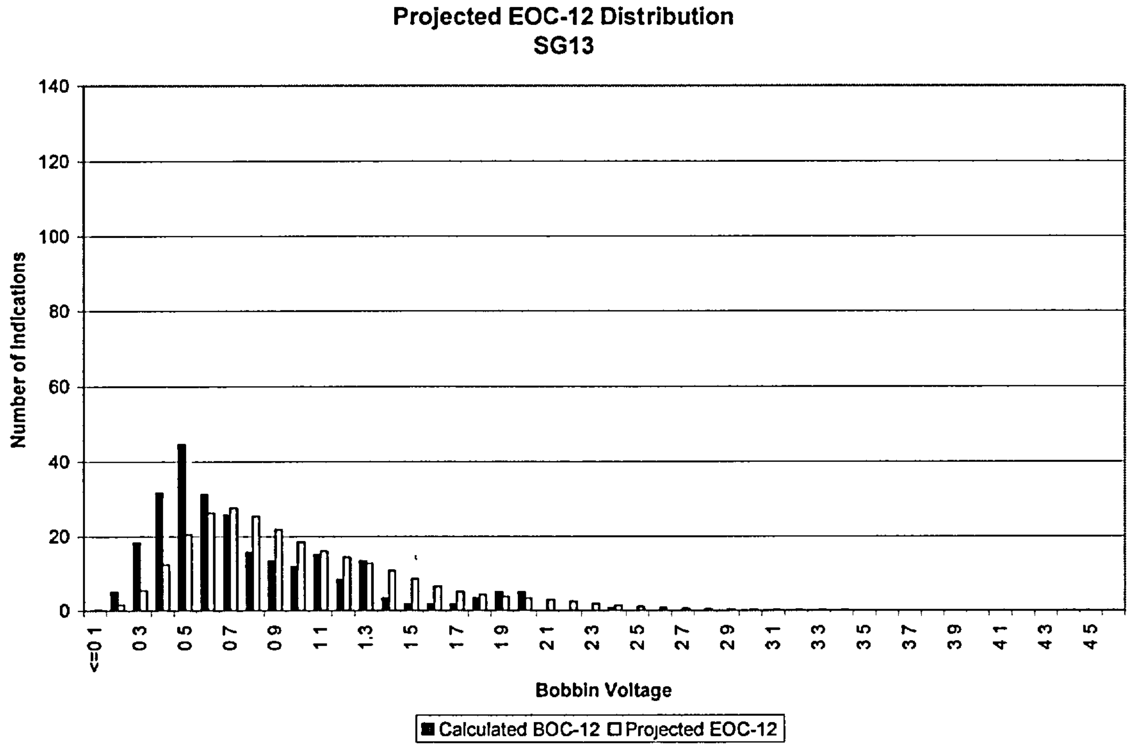


Figure 5-9

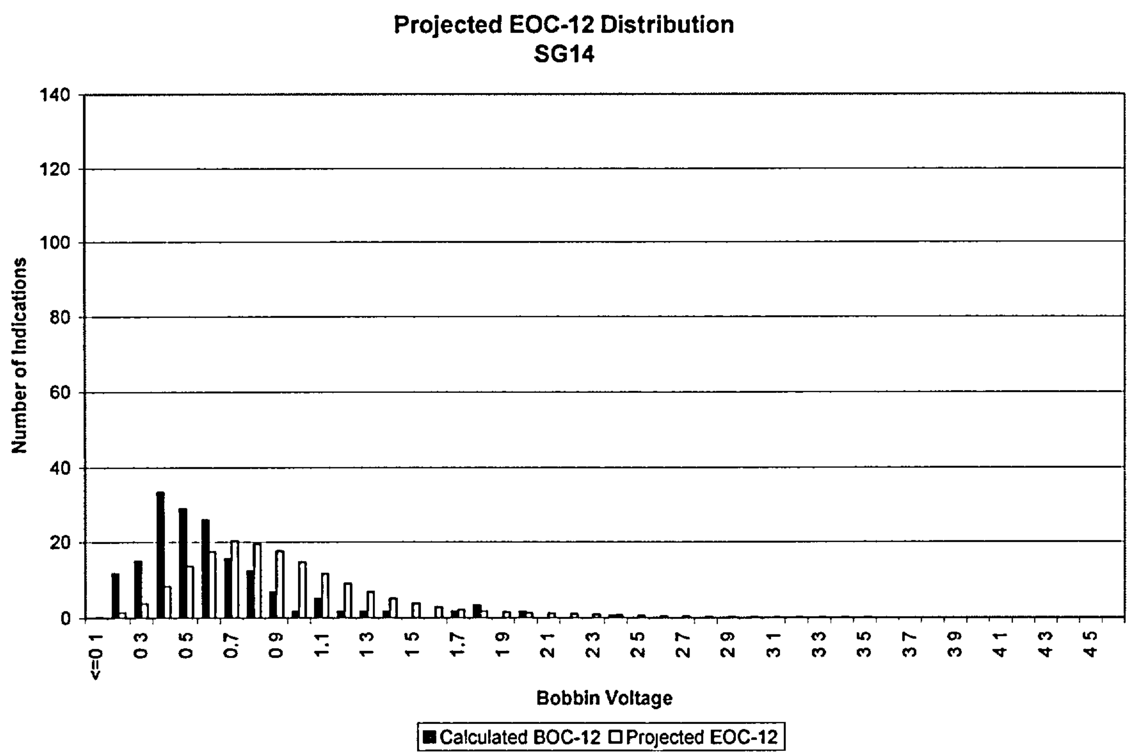


Figure 5-10

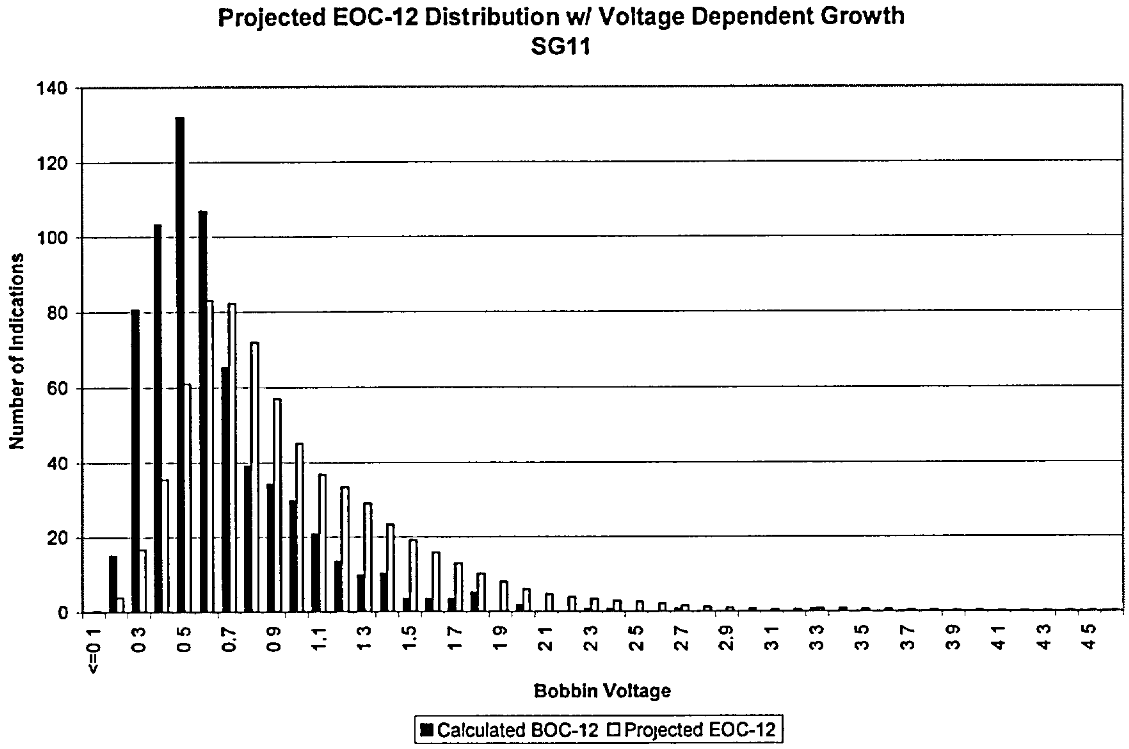

Projected EOC-12 Distribution w/ Voltage Dependent Growth
SG11
Number of Indications
140
120
100
80
60
40
20
0
<=0.1
0.3
0.5
0.7
0.9
1.1
1.3
1.5
1.7
1.9
2.1
2.3
2.5
2.7
2.9
3.1
3.3
3.5
3.7
3.9
4.1
4.3
4.5
Bobbin Voltage
Calculated BOC-12
Projected EOC-12

Figure 5-11

As-Found vs. Previous Projected EOC-11 Distribution
SG11 (POD=0.6)

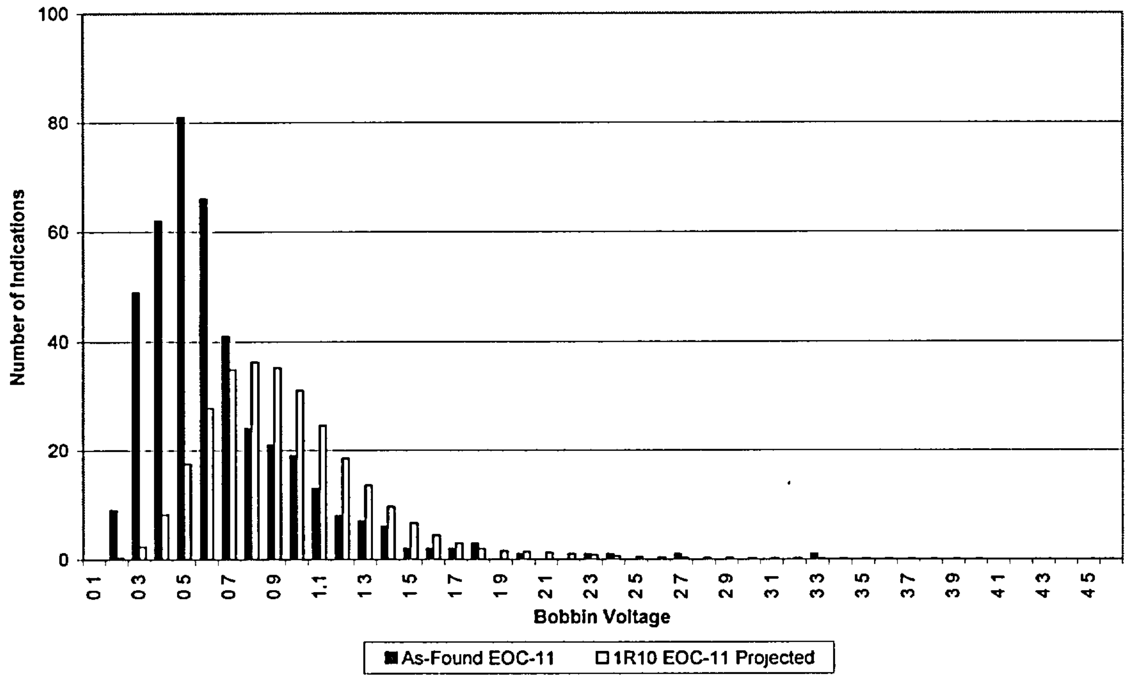


Figure 5-12

As-Found vs. Previous Projected EOC-11 Distribution
SG12 (POD=0.6)

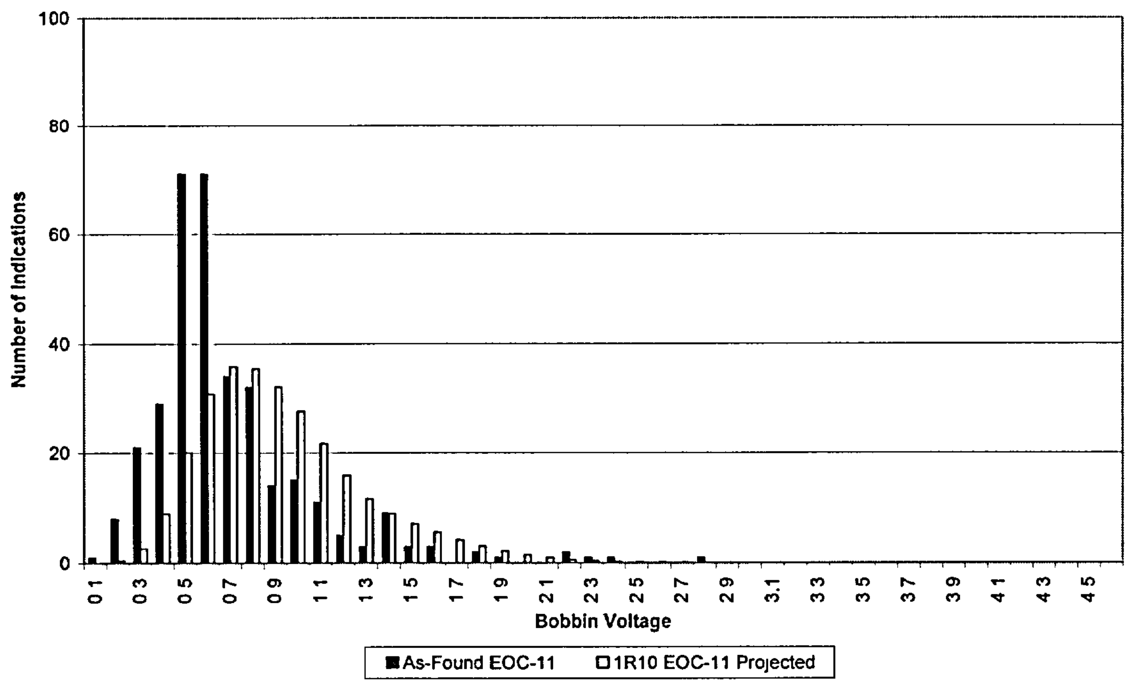


Figure 5-13

As-Found vs. Previous Projected EOC-11 Distribution
SG13 (POD=0.6)

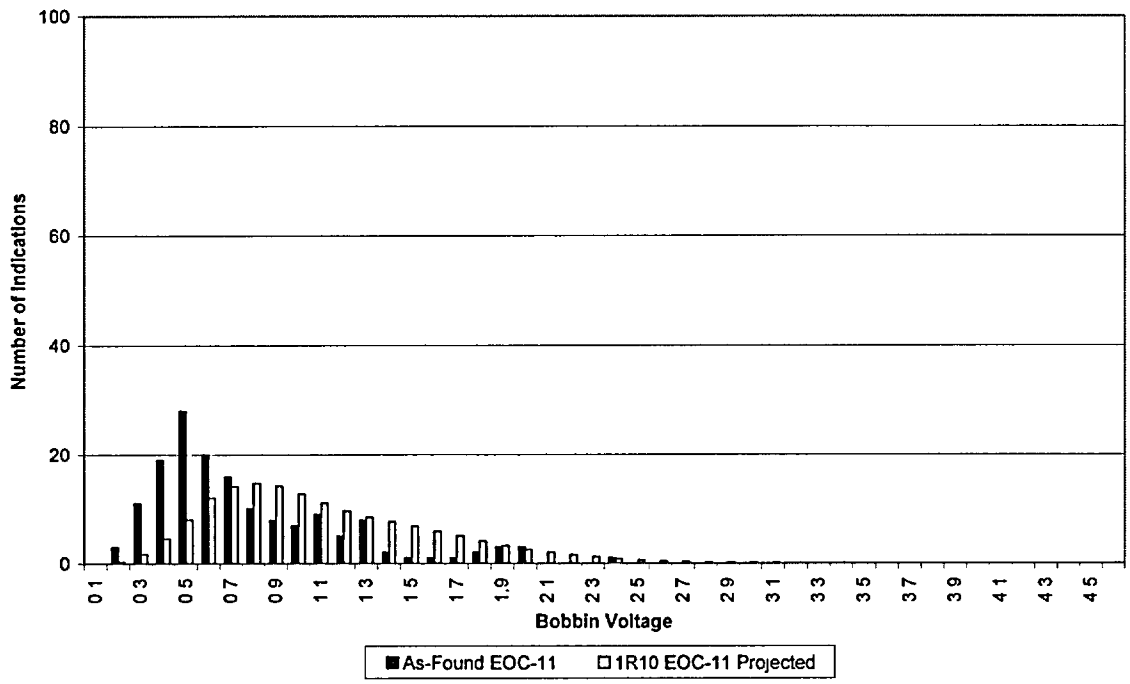
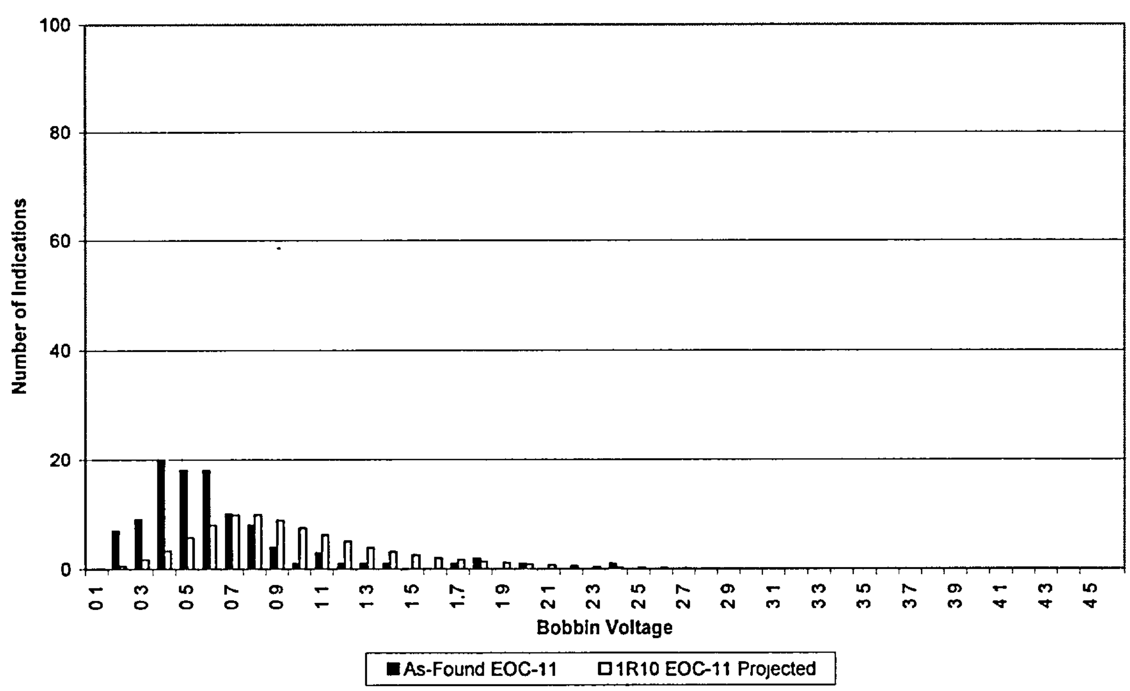


Figure 5-14

As-Found vs. Previous Projected EOC-11 Distribution
SG14 (POD=0.6)



6.0 Tube Leak Rate and Tube Burst Probabilities

This section presents the results of analyses carried out to predict leak rates and tube burst probabilities for postulated SLB conditions for the projected EOC-12 voltage distributions.

6.1 Leak Rate and Tube Burst Probability for EOC-12

Calculations to predict SLB leak rate and tube burst probability for each steam generator in DCPP Unit-1 at the projected EOC-12 conditions were carried out using the NRC-required constant POD value of 0.6. As described in Section 3.2, normal (non-voltage dependent) growth distributions were used for all steam generators, and additional calculations were performed for SG 1-1 using voltage dependent growth. These results are shown in Table 6-1. For SG 1-1, the results from the two voltage dependent growth analyses (≤0.50 volt, >0.50 volt) had to be combined. Conservatively, the leak rate and burst results for each analysis was simply summed together.

As shown in Table 6-1, the effect of the voltage dependent growth is minimal on the leak rate result. The leak rate for SG 1-1 increased by about 3% when using the voltage dependent growth distributions. For the probability of burst calculation, the number of bursts increased by about 75%. However, the calculated probability of burst is about two orders of magnitude below the acceptance criterion of $1x10^{-2}$. Therefore, relative to the remaining margin, the effect of the voltage dependent growth on the probability of burst is not significant.

6.2 Summary and Conclusions

The requirements for burst probabilities are met at EOC-12 with no steam generator exceeding the $1x10^{-2}$ criteria. For the leak rate, the plant-specific value of 10.5 gpm (at room temperature) for the faulted steam generator was not exceeded for any steam generator.

Table 6-1: Leak Rate and Burst Probability Using 0.6 POD

DCPP Unit 1 May 2002 Outage (1R11)
Summary of Calculations of Tube Leak Rate and Burst Probability at EOC-12 for 1 million Simulations Using 0.6 POD

Steam Generator	POD Applied	Number of Indications at EOC-12 (1)	Probability of Burst		SLB Leak Rate (3,5)	Voltage Dependent Growth
			Best Estimate(2)	95% UCL (4) (1 or More Failures)	(gpm)	
SG11	0.6	679.01	5.50×10^{-5}	6.89×10^{-5}	1.106	No
SG11	0.6	679.01	9.60×10^{-5}	1.17×10^{-4}	1.143	Yes
SG12	0.6	561.32	3.10×10^{-5}	4.18×10^{-5}	0.861	No
SG13	0.6	256.34	1.90×10^{-5}	2.79×10^{-5}	0.436	No
SG14	0.6	168.69	1.20×10^{-5}	1.94×10^{-5}	0.233	No
Acceptance Criteria				1.0×10^{-2}	10.5(6)	

Notes:
1) Adjusted for POD.
2) Best Estimate is the number of trials with a failure divided by the number of trials.
3) Equivalent volumetric rate at room temperature.
4) The 95% Upper Confidence Limit (UCL) is based on the number of trials with one or more failures.
5) The calculated total leak rate reflects the upper 95% quantile value at an upper 95% confidence bound.
6) This limit has not been adjusted for leakage contributions from other ARCs that have been implemented during 1R11.

7.0 References

1. FRA-ANP Document 86-5018456-00, "DCPP 1R11 Bobbin Coil Voltage ARC, Return-to-Power Report," May 2002.

2. NRC Generic Letter 95-05, "Voltage-Based Repair Criteria for the Repair of Westinghouse Steam Generator Tubes Affected by Outside Diameter Stress Corrosion Cracking," USNRC Office of Nuclear Reactor Regulation, August 3, 1995.

3. NRC SER for Diablo Canyon Units 1 and 2 for Voltage-Based Repair Criteria, letter to PG&E dated March 12, 1998.

4. FTI Document 51-5001160-01, "Steam Generator POB Simulation Code - POB97vb.F90", March 2000.

5. FTI Document 51-5001151-01, "Steam Generator Leak Rate Simulation Code LKR97VB2.F90", May 2002.

6. WCAP 14277, Revision 1, SLB Leak Rate and Tube Burst Probability Analysis Methods for ODSCC at TSP Intersections, December, 1996.

7. FTI Document 86-5010437-00, "Diablo Canyon Unit 1 – 1R10 Voltage-Based Repair Criteria 90 Day Report", January 2001.

8. EPRI Report NP 7480-L, Addendum 3, 1999 Database Update, "Steam Generator Tubing Outside Diameter Stress Corrosion Cracking at Tube Support Plates Database for Alternate Repair Limits", Electric Power Research Institute, May 1999.

9. Pacific Gas and Electric, Diablo Canyon Unit 1 Refueling Outage 1R11, "Steam Generator Tubing Degradation Assessment", Revision 0, April 23, 2002.

10. EPRI Report NP 7480-L, Addendum 4, 2001 Database Update, "Steam Generator Tube Outside Diameter Stress Corrosion Cracking at Tube Support Plates Database for Alternate Repairs Limits", Electric Power Research Institute, March 2001.

11. Diablo Canyon Power Plant Procedure, NDE ET-7, "Eddy Current Examination of Steam Generator Tubing", Revision 1, May 2, 2002.

12. Pacific Gas and Electric Company, Diablo Canyon Power Plant, Surveillance Test Procedure, STP M-SGTI, Revision 6, "Steam Generator Tube Inspection."

13. FRA-ANP Document 51-5018527-00, "Probe Wear Monitoring for DCPP 1R11", May 2002.

14. Not Used.

15. NRC Letter to NEI, dated February 9, 1996, "Probe Wear Criteria."

16. EPRI Report NP 7480-L, Addendum 2 1998 Database Update, "Steam Generator Tubing Outside Diameter Stress Corrosion Cracking at Tube Support Plates Database for Alternate Repair Limits," Electric Power Research Institute, April 1998.

17. FTI Document 51-5005962-00, "Bobbin Voltage Correlation for AONDB Indications at DCPP", October 1999.

18. E-mail, John Arhar to Jeff Fleck, "Cycle Lengths", April 30, 2002.

19. FRA-ANP Document 32-5019217-00, "DCPP Unit 1 – 1R11 90 Day ARC Calculations", August 2002.

20. NEI Letter to NRC, "Steam Generator Degradation Specific Management Database Update", May 8, 2002.

21. NEI Letter to NRC, March 15, 2002, "Refining the Leak Rate Sampling Methodology for ODSCC ARC Applications (GL 95-05)".