

U.S. Nuclear Regulatory Commission

Page 2

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cc (Enclosure):

Mr. Douglas V. Pickett, Senior Project Manager
U.S. Nuclear Regulatory Commission
Mail Stop O8G-9a
One White Flint North
11555 Rockville Pike
Rockville, Maryland 20852-2739

NRC Resident Inspector
Sequoyah Nuclear Plant
2600 Igou Ferry Road
Soddy-Daisy, Tennessee 37379-3624

Regional Administrator
U.S. Nuclear Regulatory Commission
Region II
61 Forsythe St., SW, Suite 23T85
Atlanta, Georgia 30303-3415

ENCLOSURE

TENNESSEE VALLEY AUTHORITY (TVA)
SEQUOYAH NUCLEAR PLANT (SQN)
UNIT 2

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION REGARDING
STEAM GENERATOR REPORTS FROM CYCLE 13 REFUELING OUTAGE

NRC Question 1

On Page 4-6 (of Westinghouse Report SG-SGDA-05-29, Rev.0), it was stated that only one indication was 2-volts or greater out of the 302 (sizing sample) indications at the end-of-cycle (EOC) 13 that were tested with a worn probe during the EOC 12 inspection. With this information, you concluded that probe wear has no significant effect on the population of indications. In addition, it was stated that out of 365 (population sample) indications at the EOC 13 only 81 were inspected with a worn probe during the EOC 12 inspection. You further concluded that this information indicates that tubes inspected with worn probes do not contain a larger number of new indications. The basis for these statements is not clear to the staff, therefore, please provide justification for these statements.

This justification should include a comparison of the percentage of new indications at the EOC 13 that were inspected with a worn probe during the EOC 12 inspection to the percentage of new indications that were inspected with a good probe during the EOC 12 inspection. In addition, please compare the percentage of new indications greater than or equal to 0.5-volts at the EOC 13 that were inspected with a worn probe during the EOC 12 inspection to the percentage of new indications greater than or equal to 0.5-volts at EOC 13 that were inspected with a good probe during the EOC 12 inspection. If there are significant differences, please provide an assessment of the adequacy of the probe wear criteria and its impact on your operational assessment for EOC 14. A value of 0.5-volts was chosen to be consistent with the NRC staff's approval of the alternate probe wear criterion (refer to NRC letter to the Nuclear Energy Institute dated February 9, 1996).

TVA Response.

In response to this question, the NDE data was reviewed in detail. The study reported here includes all tubes in all calibration groups that were reported out of calibration.

The indication data reported in the EOC-13 90 Day Report (Westinghouse Report SG-SGDA-05-29, Rev.0) and the EOC-12 90 Day Report (Westinghouse Report SG-SGDA-03-55, Rev.0), were compared to identify the new indications. From the EOC-12 NDE data, all tubes which were in calibration groups that were reported out of calibration are identified by comparing the NDE data list with the list of calibration groups that were reported out of calibration. Then, both new and previously existing indications can be identified as having been tested with a worn probe at EOC-12 or not, and the total number of tubes which were tested with a worn probe can also be determined. The results of this data sorting procedure are given in the Tables below.

Sequoyah Unit 2 Tube Status Prior to 2005 Inspection (EOC 13)

SG	Original Tubes	Number plugged at EOC 13	Number of open tubes at EOC 13
1	3388	71	3317
2	3388	158	3230
3	3388	114	3274
4	3388	111	3277

Results of NDE Data Review

Steam Generator 1		
Number of new indications in EOC-13		56
Worn Probe in EOC-12	Number of new indications tested with worn probe in EOC-12	21
	Number of these equal to or greater than 0.5 V in EOC-13	5
	Number of tubes tested with worn probe	1578
Good Probe in EOC-12	Number of new indications tested with good probe in EOC-12	35
	Number of these equal to or greater than 0.5 V in EOC-13	16
	Number of tubes tested with good probe	1739
Ratio of new indications in tubes tested with worn probe to number of tubes tested with a worn probe		$21/1578 = 0.0133$
Ratio of new indications in tubes tested with good probe to number of tubes tested with a good probe		$35/1739 = 0.0201$
Percentage of new indications equal to or greater than 0.5 V in tubes tested with worn probe		$5/21 = 24\%$
Percentage of new indications equal to or greater than 0.5 V in tubes tested with good probe		$16/35 = 46\%$

Steam Generator 1		
Number of previous indications in EOC-13		238
Worn Probe in EOC-12	Number of prev indications tested with worn probe in EOC-12	89
	Number of these exceeding 2.0 V in EOC-13	0
	Highest voltage indication of these in EOC-13	1.16 V

Steam Generator 2		
Number of new indications in EOC-13		65
Worn Probe in EOC-12	Number of new indications tested with worn probe in EOC-12	16
	Number of these equal to or greater than 0.5 V in EOC-13	5
	Number of tubes tested with worn probe	1290
Good Probe in EOC-12	Number of new indications tested with good probe in EOC-12	49
	Number of these equal to or greater than 0.5 V in EOC-13	14
	Number of tubes tested with good probe	1940
Ratio of new indications in tubes tested with worn probe to number of tubes tested with a worn probe		$16/1290 = 0.0124$
Ratio of new indications in tubes tested with good probe to number of tubes tested with a good probe		$49/1940 = 0.0253$
Percentage of new indications equal to or greater than 0.5 V in tubes tested with worn probe		$5/16 = 31\%$
Percentage of new indications equal to or greater than 0.5 V in tubes tested with good probe		$14/49 = 29\%$

Steam Generator 2		
Number of previous indications in EOC-13		240
Worn Probe in EOC-12	Number of prev indications tested with worn probe in EOC-12	90
	Number of these exceeding 2.0 V in EOC-13	0
	Highest voltage indication of these in EOC-13	1.97V

Steam Generator 3		
Number of new indications in EOC-13		119
Worn Probe in EOC-12	Number of new indications tested with worn probe in EOC-12	59
	Number of these equal to or greater than 0.5 V in EOC-13	35
	Number of tubes tested with worn probe	1583
Good Probe in EOC-12	Number of new indications tested with good probe in EOC-12	60
	Number of these equal to or greater than 0.5 V in EOC-13	32
	Number of tubes tested with good probe	1691
Ratio of new indications in tubes tested with worn probe to number of tubes tested with a worn probe		$59/1583 = 0.0373$
Ratio of new indications in tubes tested with good probe to number of tubes tested with a good probe		$60/1691 = 0.0355$
Percentage of new indications equal to or greater than 0.5 V in tubes tested with worn probe		$35/59 = 59\%$
Percentage of new indications equal to or greater than 0.5 V in tubes tested with good probe		$32/60 = 53\%$

Steam Generator 3		
Number of previous indications in EOC-13		293
Worn Probe in EOC-12	Number of prev indications tested with worn probe in EOC-12	125
	Number of these exceeding 2.0 V in EOC-13	1
	Highest voltage indication of these in EOC-13	2.36V

Steam Generator 4		
Number of new indications in EOC-13		125
Worn Probe in EOC-12	Number of new indications tested with worn probe in EOC-12	81
	Number of these equal to or greater than 0.5 V in EOC-13	31
	Number of tubes tested with worn probe	1992
Good Probe in EOC-12	Number of new indications tested with good probe in EOC-12	44
	Number of these equal to or greater than 0.5 V in EOC-13	16
	Number of tubes tested with good probe	1285
Ratio of new indications in tubes tested with worn probe to number of tubes tested with a worn probe		$81/1992 = 0.0407$
Ratio of new indications in tubes tested with good probe to number of tubes tested with a good probe		$44/1285 = 0.0342$
Percentage of new indications equal to or greater than 0.5 V in tubes tested with worn probe		$31/81 = 38\%$
Percentage of new indications equal to or greater than 0.5 V in tubes tested with good probe		$16/44 = 36\%$

Steam Generator 4		
Number of previous indications in EOC-13		711
Worn Probe in EOC-12	Number of prev indications tested with worn probe in EOC-12	428
	Number of these exceeding 2.0 V in EOC-13	0
	Highest voltage indication of these in EOC-13	1.74V

All Steam Generators Combined		
Number of new indications in EOC-13		365
Worn Probe in EOC-12	Number of new indications tested with worn probe in EOC-12	177
	Number of these equal to or greater than 0.5 V in EOC-13	76
	Number of tubes tested with worn probe	6443
Good Probe in EOC-12	Number of new indications tested with good probe in EOC-12	188
	Number of these equal to or greater than 0.5 V in EOC-13	78
	Number of tubes tested with good probe	6655
Ratio of new indications in tubes tested with worn probe to number of tubes tested with a worn probe		$177/6443 = 0.0275$
Ratio of new indications in tubes tested with good probe to number of tubes tested with a good probe		$188/6655 = 0.0282$
Percentage of new indications equal to or greater than 0.5 V in tubes tested with worn probe		$76/177 = 42.9\%$
Percentage of new indications equal to or greater than 0.5 V in tubes tested with good probe		$78/188 = 41.5\%$

All Steam Generators Combined		
Number of previous indications in EOC-13		1482
Worn Probe in EOC-12	Number of prev indications tested with worn probe in EOC-12	732
	Number of these exceeding 2.0 V in EOC-13	1
	Highest voltage indication of these in EOC-13	2.36V

The indications found in the current inspection that were tested with a worn probe in the previous (EOC-12) inspection were identified as seen in the tables above. Of the 732 indications found in the current inspection that were tested with a worn probe in the previous inspection, only one was 2 volts or greater. Of the 750 indications found in the current inspection that were tested with a good probe in the previous inspection, two were 2 volts or greater. Therefore, there is no significant difference in the number of repairable indications for tubes previously tested with a worn probe.

As required by the NRC letter to the Nuclear Energy Institute dated February 9, 1996, the number of new indications detected in the present inspection in tubes that were inspected with a worn probe in the last inspection was also determined. Out of a total of 365 new indications reported in the current inspection, 177

were in tubes inspected with a worn probe during the last inspection. Steam Generator 4 has the highest number of indications and the highest ratio of new indications that were identified in tubes tested with a worn probe in EOC-12 to the number of tubes tested with a worn probe in EOC-12 of 0.0407. The ratio of new indications that were identified in tubes tested with a good probe in EOC-12 to the number of tubes tested with a good probe in EOC-12 for Steam Generator 4 is 0.0342. The percentage of new indications equal to or greater than 0.5 V in tubes tested with a worn probe in SG 4 is 38%, and the percentage of new indications equal to or greater than 0.5 V in tubes tested with good probe in SG 4 is 36%. The similarity of these ratios and percentages indicate that there is no significant difference in the rate of occurrence or magnitude of new indications found in the EOC-13 inspection due to testing with a worn probe in the EOC-12 inspection. Thus, the requirements specified for applying the alternate probe wear criteria are met.

NRC Question 2

In Section 6.4 of Enclosure 1 to your August 15, 2005, letter, it was indicated that the EOC 14 voltage distribution (using both the Cycle 12 and Cycle 13 growth rates) are shown in Table 6-2 and in Figures 6-1 through Figure 6-4. In reviewing the table and figures only one voltage distribution was provided for each steam generator.

Please clarify whether the tables and graphs provided were determined using the Cycle 12 or Cycle 13 voltage growth rate distribution.

In addition, Section 6.4 indicates that the voltage distributions predicted using both growth rates are similar, however, the predictions using the Cycle 13 growth rates were populated with somewhat greater frequency in the lower voltages and with higher tail-end voltages. Since the most limiting voltage growth rate distribution is the one that results in the highest projected probability of burst and leakage, discuss how it was determined that the Cycle 12 growth rate distribution was the most limiting. The staff notes that sometimes the higher tail end voltages can result in more limiting probability of burst or leakage estimates (i.e., the largest voltage indication may have a significant effect on the leakage and burst calculations depending on the distribution of indications).

TVA Response

The Cycle 12 growth rate clearly has a longer upper tail due to the inclusion of the one large voltage indication found at EOC-12. Only the results using the Cycle 12 growth rate were included in the EOC-13 90 Day Report (Westinghouse Report SG-SGDA-05-29, Rev.0) since this did produce the more conservative results. The Table 6-2 and Figures 6-1 to 6-4 and Table 6-3 all are results using the Cycle 12 growth rate.

The reference to using both growth rates is an editorial error. The statement "voltage distributions predicted using both growth rates are similar, however, the predictions using the Cycle 13 growth rates were populated with somewhat greater frequency in the lower voltages and with higher tail-end voltages" is also an editorial error.

In order to demonstrate that the Cycle 12 growth rate results in the more conservative predictions the predictive results of using both the Cycle 12 and Cycle 13 growth rates are presented here. The analyses clearly indicate that the Cycle 12 growth rate results are more conservative. Therefore, the results in the report are correct.

Operational Assessment: Tube Leak Rate and Burst Probabilities at EOC-14

1. Analysis Approach

The BOC-14 voltage distributions are developed, within the Cyclesim3.1 program, from the measured EOC-13 distribution by considering the probability of detection (POD) and the indications that are removed from service. The EOC-14 voltage distribution is developed considering the NDE uncertainties and voltage growth during the cycle. Both the bounding Cycle 12 growth rate and the bounding Cycle 13 growth rate were used in these projections in order to assure the more conservative results. The latest burst and leakage correlations, are used for the EOC-14 predictions. The burst probabilities and leak rates are computed using the computed EOC-14 voltage predictions to address the acceptance criteria at the end of the cycle.

2. POD

The POD used is the NRC accepted value of 0.6 for all voltages. The beginning of Cycle 14 (BOC-14) voltage distributions are shown in Table 1.

Table 1: BOC-14 Voltage Distributions

Volts	SG 1	SG 2	SG 3	SG 4
0.1	0	0	0	0
0.2	13.33	21.67	15	33.33
0.3	68.33	53.33	59	137.33
0.4	83.33	89	68.33	212.33
0.5	70	95.67	97.33	224
0.6	60	51.67	76.67	193.33
0.7	59	61.67	91.67	158.33
0.8	45	49	72.33	119
0.9	35	25.67	40	110
1	18.33	19	38.33	72.33
1.1	16.67	10.67	31.67	43.33
1.2	11.67	8.33	28.33	30
1.3	3.33	10	21.67	18.33
1.4	0	1.67	13.33	11.67
1.5	1.67	0	10	8.33
1.6	0	3.33	7.33	8.33
1.7	1.67	0	1.67	7.33
1.8	0	0	5	0
1.9	0	0	0	0
2	1.67	0.67	0	0
2.1	0	0	1.33	0
2.2	0	0	0	0
2.3	0	0	0	0
2.4	0	0	0.67	0
2.5	0	0	0	0
Total	489	501.3	679.7	1387.3

3. Voltage Growth Rates for Cycle 14

The Cycle 12 and Cycle 13 bounding voltage growth rates, shown in Figure 3-15 and Figure 3-16 of EOC-13 90 Day Report (Westinghouse Report SG-SGDA-05-29, Rev.0), indicate that the Cycle 12 growth rate is the more conservative. To assure the more conservative results, both growth rates were used in these projections.

4. Prediction of Voltage Distributions at EOC-14

The prediction of the EOC-14 voltage distributions is based on the BOC-14 indications and the composite growth rate. The length of Cycle 14 is established at 545 effective full power days (EFPD). The EOC-14 predicted voltage distributions (using both the Cycle 12 and Cycle 13 growth rates) are shown in Table 2 and in Figure 1 through Figure 4. The voltage distributions predicted using both growth rates are similar, with the predictions using the Cycle 13 growth rates populated with somewhat greater frequency in the lower voltages and with higher tail-end voltages as seen in Table 2.

Table 2 EOC -14 Voltage Distributions								
	Cycle 12 Growth Rate				Cycle 13 Growth Rate			
	EOC-14 Voltage Distributions				EOC-14 Voltage Distributions			
Volts	SG1	SG2	SG3	SG4	SG1	SG2	SG3	SG4
0.1	0.17	0.28	0.19	0.43	0.17	0.27	0.18	0.41
0.2	4.79	6.29	4.92	11.11	4.62	6.07	4.75	10.71
0.3	19.98	19.06	17.92	43.4	19.04	18.03	17.02	41.3
0.4	37.39	37.83	34.19	88.81	34.67	35.21	31.73	82.73
0.5	51.95	55.37	52.3	134.58	47.96	51.52	48.7	124.85
0.6	59.57	63.96	66.57	163.78	56.74	60.4	63.05	154.57
0.7	59.13	63.33	72.95	168.95	58.31	62.11	70.58	164.27
0.8	55.24	57.8	73.45	158.74	55.8	58.5	72.57	159.08
0.9	48.52	49.26	67.56	140.03	49.53	50.83	67.84	143.2
1	40.03	39.34	58.17	117.28	41.68	41.31	59.91	121.97
1.1	31.33	29.77	48.53	93.56	33.72	32.27	51.05	99.54
1.2	23.37	21.72	39.88	71.2	25.92	24.59	42.73	77.96
1.3	16.71	15.58	32.53	52.24	19.02	17.94	35.06	58.9
1.4	11.59	11.16	26.18	37.78	13.44	12.88	28.41	43.27
1.5	7.91	8.02	20.73	27.46	9.1	9.15	22.54	31.14
1.6	5.23	5.7	15.94	19.99	5.98	6.29	17.34	22.16
1.7	3.5	4.02	12.08	14.53	3.85	4.23	13	15.61
1.8	2.53	2.85	9	10.64	2.53	2.86	9.54	10.91
1.9	1.88	2.12	6.56	7.7	1.81	1.99	6.92	7.71
2	1.4	1.5	4.69	5.45	1.38	1.46	4.96	5.51
2.1	1.07	1.06	3.31	3.8	1.04	1.09	3.54	3.87
2.2	0.95	0.83	2.45	2.79	0.77	0.75	2.5	2.63
2.3	0.83	0.73	1.82	2.2	0.59	0.52	1.77	1.75
2.4	0.65	0.61	1.39	1.73	0.33	0.06	1.24	1.15
2.5	0.48	0.44	1.06	1.3	0	0.7	0.84	0.77
2.6	0.36	0.32	0.83	0.96	0.7	0	0.58	0.33

Table 2 EOC -14 Voltage Distributions								
	Cycle 12 Growth Rate				Cycle 13 Growth Rate			
	EOC-14 Voltage Distributions				EOC-14 Voltage Distributions			
Volts	SG1	SG2	SG3	SG4	SG1	SG2	SG3	SG4
2.7	0.27	0.24	0.63	0.7	0	0.3	0.31	0
2.8	0.19	0.17	0.45	0.52	0.3	0	0	0.7
2.9	0.13	0.11	0.32	0.37	0	0	0.7	0
3	0.08	0.07	0.24	0.25	0	0	0	0.3
3.1	0.06	0.05	0.17	0.17	0	0	0.3	0
3.2	0.03	0.03	0.13	0.11	0	0	0	0
3.3	0.02	0.02	0.09	0.07	489	501.35	679.66	1387.3
3.4	0.01	0.01	0.06	0.05				
3.5	0.01	0.01	0.04	0.03				
3.6	0	0.01	0.03	0.02				
3.7	0	0	0.02	0.01				
3.8	0	0	0.01	0.01				
3.9	0	0	0.01	0				
4	0	0	0	0				
4.1	0	0	0	0				
4.2	0	0	0	0				
4.3	0	0	0	0				
4.4	0	0	0	0				
4.5	0	0	0	0				
4.6	0	0	0	0				
4.7	0	0	0	0				
4.8	0	0	0	0				
4.9	0	0	0	0				
5	0	0	0	0				
5.1	0	0	0	0				
5.2	0	0	0	0				
5.3	0	0	0	0				
5.4	0	0	0	0				
5.5	0	0	0	0				
5.6	0	0	0	0				
5.7	0	0	0	0				
5.8	0	0	0	0				
5.9	0	0	0	0				
6	0	0	0	0				
6.1	0	0	0	0				
6.2	0	0	0	0				
6.3	0	0	0	0				
6.4	0	0	0	0				
6.5	0	0	0	0				
6.6	0	0	0	0				
6.7	0	0	0	0				
6.8	0	0	0	0				
6.9	0	0	0	0				
7	0	0	0	0				
7.1	0	0	0	0				
7.2	0	0	0	0				
7.3	0	0	0	0				
7.4	0	0	0	0				
7.5	0	0	0	0				

Table 2 EOC -14 Voltage Distributions								
	Cycle 12 Growth Rate				Cycle 13 Growth Rate			
	EOC-14 Voltage Distributions				EOC-14 Voltage Distributions			
Volts	SG1	SG2	SG3	SG4	SG1	SG2	SG3	SG4
7.6	0	0	0	0				
7.7	0	0	0	0				
7.8	0	0	0	0				
7.9	0	0	0	0				
8	0	0	0	0				
8.1	0	0	0	0				
8.2	0	0	0	0				
8.3	0	0	0	0				
8.4	0	0	0	0				
8.5	0	0	0	0				
8.6	0	0	0	0				
8.7	0.05	0.07	0.06	0.13				
8.8	0.21	0.18	0.18	0.44				
8.9	0.26	0.28	0.24	0.67				
9	0.09	0.13	0.29	0.71				
9.1	0	0	0.28	0.63				
9.2	0.7	0.7	0.2	0.52				
9.3	0	0	0	0.41				
9.4	0	0	0	0.07				
9.5	0.3	0.3	0.7	0				
9.6	0	0	0	0.7				
9.7	0	0	0	0				
9.8	0	0	0.3	0.3				
9.9	0	0	0	0				
	489.00	501.35	679.66	1387.30				

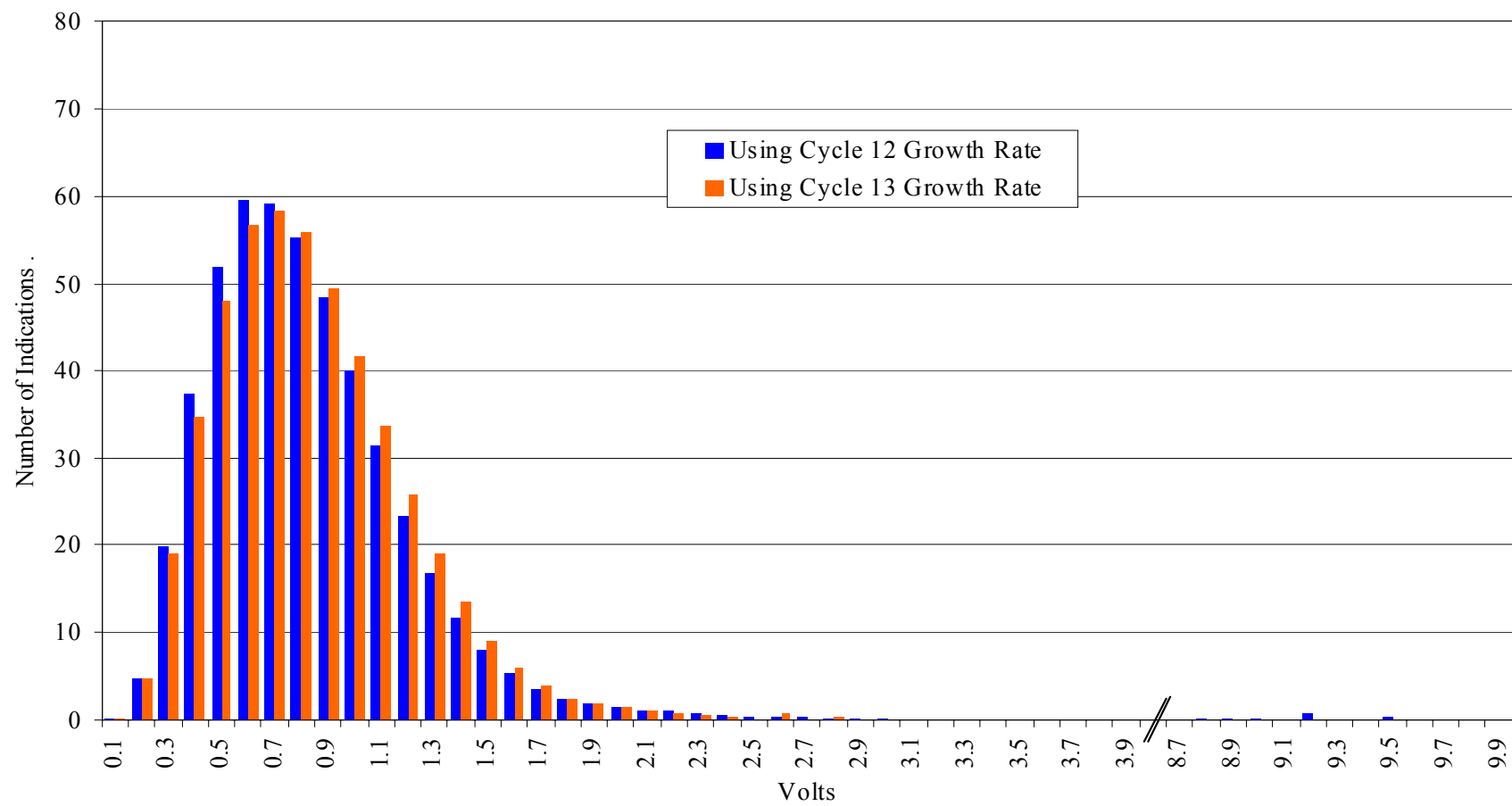


Figure 1: Predicted EOC-14 Voltage Distribution, SG1

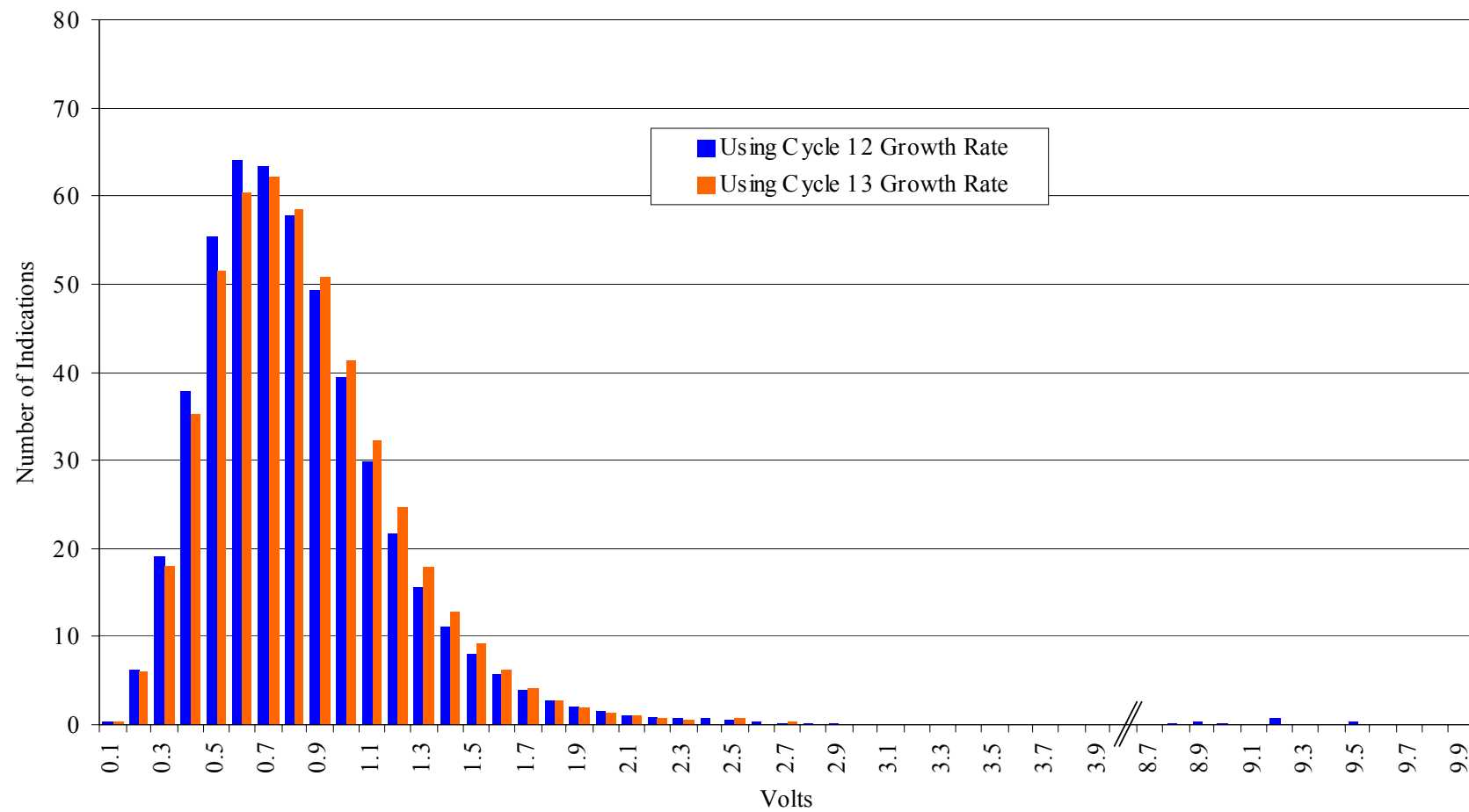


Figure 2: Predicted EOC-14 Voltage Distribution, SG2

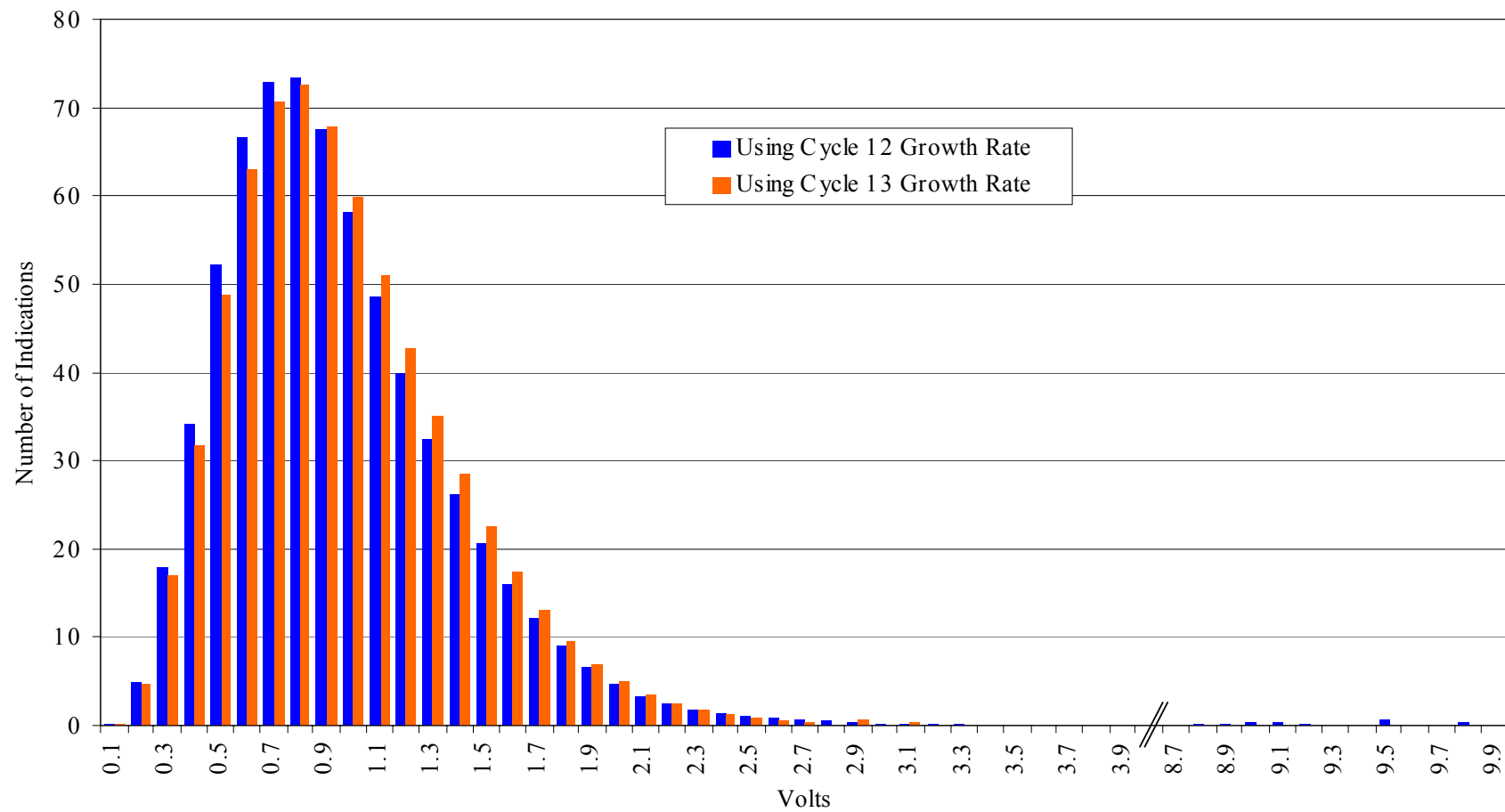


Figure 3: Predicted EOC-14 Voltage Distribution, SG 3

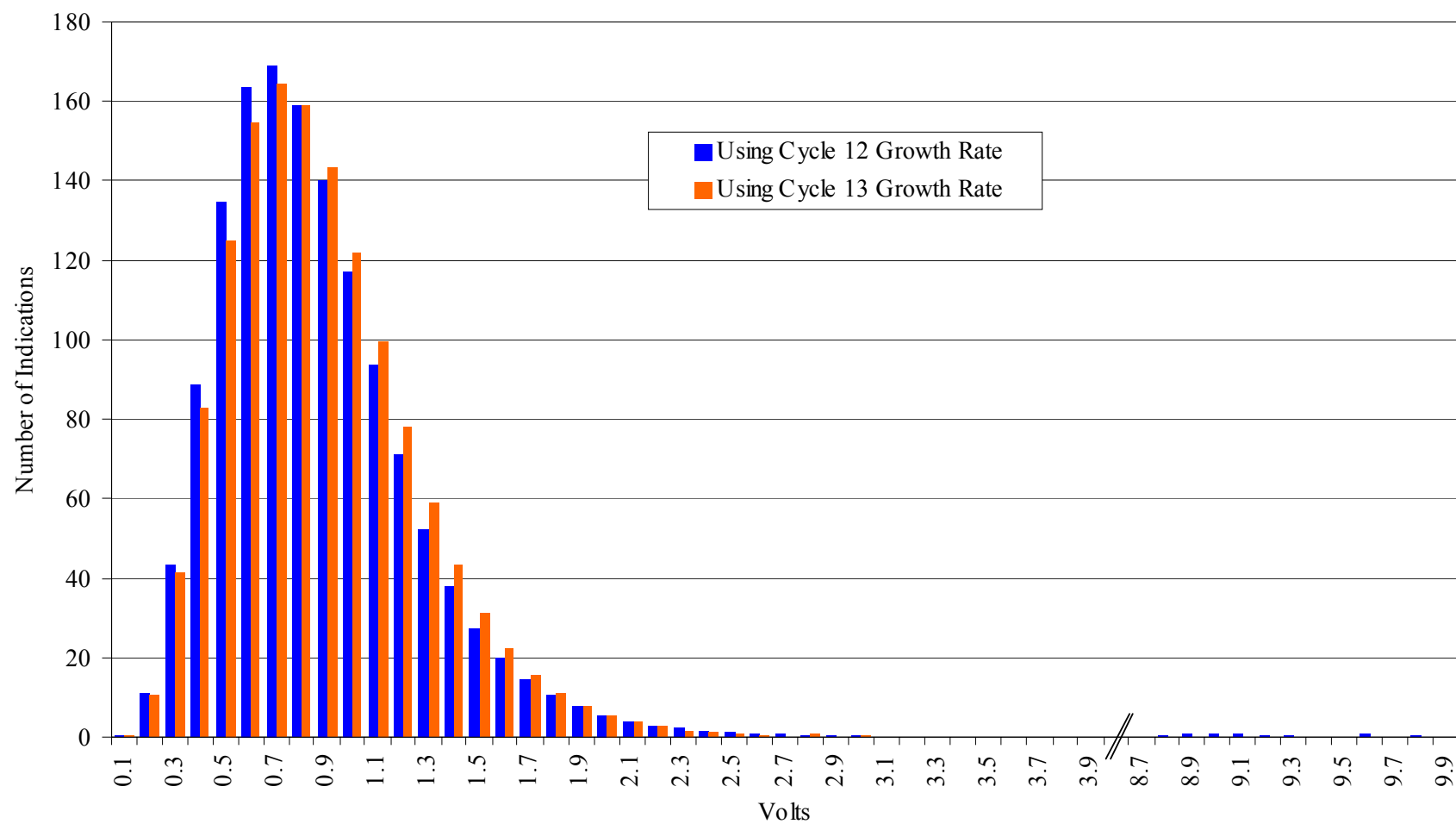


Figure 4: Predicted EOC-14 Voltage Distribution, SG 4

5. Prediction of Tube Leak Rates and Burst Probabilities at EOC-14

The Monte Carlo analysis results for predicted EOC-14 voltage distributions are shown in Tables 3A and 3B. One-quarter-million Monte Carlo trials were performed for each steam generator in this operational assessment. The leakage rate is the 95th percentile evaluated at 95% confidence. The burst probability is 95% confidence based on the number of trials.

The predictions using the Cycle 12 growth rate distribution, Table 3A, results in significantly larger values for both the burst probability and the bounding leak rate as would be expected due to the longer tail of the voltage growth curve.

Table 3A: EOC-14 Predicted Results Using Cycle 12 Growth Rate

SG	Number of Monte Carlo Trials	Number of Indications	Maximum Volts*	Burst Probability 95% Confidence	95/95 SLB Leak Rate (gpm)
1	250,000	489.0	9.5	2.20×10^{-3}	0.519
2	250,000	501.3	9.5	2.47×10^{-3}	0.530
3	250,000	679.7	9.8	3.41×10^{-3}	0.874
4	250,000	1387.3	9.8	6.51×10^{-3}	1.47

* Voltage where tail is accumulated to 0.3 indications

Table 3B: EOC-14 Predicted Results Using Cycle 13 Growth Rate

SG	Number of Monte Carlo Trials	Number of Indications	Maximum Volts*	Burst Probability 95% Confidence	95/95 SLB Leak Rate (gpm)
1	250,000	489.0	2.8	6.79×10^{-5}	0.184
2	250,000	501.3	2.7	9.24×10^{-5}	0.182
3	250,000	679.7	3.1	1.90×10^{-4}	0.413
4	250,000	1387.3	3.0	1.86×10^{-4}	0.628

* Voltage where tail is accumulated to 0.3 indications

6. Comparison with Acceptance Criteria

All steam generators are below the burst acceptance criterion of 1.0×10^{-2} , and the Sequoyah Unit 2 leakage criterion of 3.7 gpm.