ENCLOSURE 1

TENNESSEE VALLEY AUTHORITY
SEQUOYAH NUCLEAR PLANT, UNIT 2

SEQUOYAH 2C17 VOLTAGE-BASED ARC 90-DAY REPORT
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Title Sequoyah 2C17 Voltage-Based ARC 90-Day Report

PURPOSE AND SUMMARY OF RESULTS:

Purpose: This report summarizes the results of the Sequoyah-2 2C17 inspection results relative to the voltage-based alternate repair criterion as specified in NRC Generic Letter 95-05 [1] . This document provides the "as-found" and projected probability of burst and leak rate calculations for submittal to the NRC. This report provides a non-proprietary summary of the results. The supporting proprietary calculations and code verifications are contained in Reference [2].

Summary: The calculated as-found probability of burst and leak rate for the bounding steam generator (SG24) meet all requirements of Generic Letter 95-05. In addition, the probability of burst and leak rate for the projected conditions at EOC-18 also meet the requirements of Generic Letter 95-05..

[redacted]

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1.0 INTRODUCTION

Sequoyah Unit 2 (SQN2) completed the seventeenth cycle of operation in May 2011. The unit employs four Westinghouse-designed Model 51 SGs with ⅞-inch OD mill annealed alloy 600 tubing and ¾-inch carbon steel drilled-hole tube support plates (TSPs). The 2C17 scope of the eddy current inspections at Sequoyah (SQN) included a bobbin coil inspection of the straight legs of all in-service tubes in all four steam generators. The inspections were performed in accordance with the requirements of NRC Generic Letter (GL) 95-05, "Voltage-Based Repair Criteria for Westinghouse Steam Generator Tubes Affected by Outside Diameter Stress Corrosion Cracking" [1]. This is the last scheduled in-service inspection for the SQN2 steam generators. Steam generator replacement is scheduled for the 2C18 outage in 2012.

In accordance with Generic Letter 95-05, ARC (Alternate Repair Criteria) implementation requires a pre-startup assessment [3] and a 90-day post-startup tube integrity assessment. NRC Generic Letter 95-05 outlines ARC requirements for allowing tubes containing ODSCC (Outside Diameter Stress Corrosion Cracking) indications to remain in service if the indications are contained within the TSP structure and the measured bobbin voltage is $\leq$2.0 volts. A complete list of criteria for excluding TSP intersections from ARC application is provided in section 1.b of Reference [1].

The steam generator TSP inspection results and the postulated MSLB leak rate and tube burst probabilities are summarized in this report. AREVA uses Monte Carlo codes, as described in References [4] and [5], to provide the burst and leak rate analysis simulations. Although the voltage-dependent POPCD (Probability of Prior Cycle Detection) has been approved for use at SQN2 [6], the results documented herein use the more conservative POD (Probability of Detection) of 0.6 from GL 95-05.

These evaluations are based on the methods in Reference [7] (for burst) and the slope sampling method for calculating the leak rate as discussed in Reference [13].

2.0 SUMMARY

During the 2C17 inspection, a total of 3711 bobbin DSIs (Distorted Support Indications) were reported. There were an additional four axial ODSCC indications detected with +Point™ that did not have a corresponding bobbin OD signal. For the four indications not detected with bobbin, a bobbin voltage was inferred based on the +Point™ voltage. Therefore, a total of 3715 indications were included in the condition monitoring assessment documented herein.

The condition monitoring assessment is an assessment of the as-found conditions. The results of the condition monitoring assessment show that the as-found leak rate and probability of burst (POB) were well below the acceptance criteria of 3.7 gpm for leakage and 1.0E-02 for POB. In addition, the as-found leak rate, POB, and number and voltages of the indications were well below the values projected during the previous operational assessment prepared after the 2C16 outage [9].

This report also documents the projected conditions at the end of Cycle 18 (EOC-18) conditions. As required by GL 95-05, the limiting growth rate from the last two operating cycles should be used in the operational assessment. A comparison of the growth rates from Cycles 16 and 17 showed that the Cycle 16 growth rates were clearly bounding. Hence, the Cycle 16 growth rates were used in the operational assessment. The EOC-18 projections for leak rate and POB were well below the acceptance criteria.

Implementation of the voltage-based ARC requires that SQN2 participate in a tube pull program approved by the NRC. The industry developed a tube pull program which was approved by the NRC in 2000. The NRC-approved tube pull requirements are provided in the latest EPRI update of the ARC database [13]. Normally, a tube pull (minimum of two intersections) is required after three cycles of operation since the last tube pull. Since the last tube pull at SQN2 occurred during the 2C14 outage, a tube pull would normally have been required during the 2C17 outage. However, the NRC also approved an exemption for plants planning to replace steam generators. This exemption waives the tube pull requirement if the above requirements coincide with the plant's last scheduled outage before steam generator replacement. Since SQN2 is scheduled to replace steam generators during the next outage (2C18), no tube pull was required nor performed during the 2C17 outage.

3.0 ASSUMPTIONS

No assumptions were used in the calculations summarized in this document.

4.0 2C17 INSPECTION RESULTS AND VOLTAGE GROWTH RATES

The SQN 2C17 bobbin coil inspection consisted of a full-length bobbin coil examination of all in-service tubes in all four steam generators except for the u-bends of Rows 1 through 10 which were inspected with either +Point™ or array coils. All in-service TSP intersections on both the hot leg and cold leg sides of the tube bundle were inspected with 0.720" diameter bobbin probes.

Special interest +Point™ examinations were conducted in support of the voltage-based ARC, and in accordance with the Degradation Assessment [8] as follows:

- 100% of bobbin DSIs ≥1.0v
- 100% of intersections with dents ≥2.0v from H01 through C06
- 100% of new DSIs in cold leg thinning region
- 100% of mixed residual indications (MRI)
- 100% of copper signals

4.1 Inspection Results

Based on the bobbin inspections, a total of 3711 indications were identified. Four additional TSP intersections had axial ODSCC indications confirmed with +Point™, but had no bobbin indication reported. Therefore, a total of 3715 intersections were included in the analyses documented in this report. The results of the inspection are summarized as follows:

1. Ten DSIs were greater than the lower repair limit of 2.0 volts. All of these indications were confirmed as axial ODSCC and were removed from service by plugging the affected tubes. All of these indications were located in SG24 as shown in Table 4-1.
2. No indications were identified that exceeded the upper repair limit of 5.91 volts. The largest bobbin indication had a bobbin voltage of 3.08 volts. This same location in SG24 also had the largest +Point™ voltage detected (2.15v).
3. As mentioned above, four intersections were identified as containing AONDB (axial ODSCC not detected by bobbin) indications. These are +Point™ indications of axial ODSCC that have no signal present in the bobbin data. All four of these indications were small voltage +Point™ indications at dented intersections. As discussed in Section 4.3, a correlation was developed to infer a bobbin voltage from the +Point™ voltage. All of the inferred voltages were relatively small (less than 1.2 equivalent bobbin volts). All four of these intersections were removed from service by plugging the affected tubes. These locations are shown in Table 4-2.
4. A total of 72 DSI/AONDB indications were removed from service during the 2C17 outage (11 in SG21, 6 in SG22, 13 in SG23, and 42 in SG24). Some of these were removed from service due to axial ODSCC at TSPs, but others were removed from service due to other indications in the affected tube.
5. All DSI indications that were confirmed as axial ODSCC were at hot leg TSP intersections. No axial ODSCC indications were confirmed at cold leg TSP intersections.

6. A total of 518 intersections with DSIs were inspected with +Point™. Of these intersections, 445 were confirmed as containing axial ODSCC indications for an overall confirmation rate of 86%. Excluding the cold leg intersections, of which none were confirmed, the confirmation rate increases to 88%.
7. Of the confirmed axial ODSCC at TSPs, none extended outside of the TSP.
8. No indications of copper deposits were detected.
9. Four Mixed Residual Indications (MRIs) were reported with the bobbin coil. All four intersections were inspected with +Point™ as required by GL 95-05. Three of the four indications were reported as NDF (No Defect Found) from the +Point™ examination. One intersection was confirmed as containing an axial PWSCC indication. This location, however, was also accompanied by a dent and a DDI (Distorted Dent with Indication) from the bobbin coil inspection (i.e., this indication was detected with bobbin). Since the alternate repair criteria don't apply to PWSCC indications, this tube was removed from service.

Table 4-3 through Table 4-6 show the as-found voltage distributions for SG21 through SG24, respectively. These tables also show the 2C17 voltage distributions based on +Point™ inspection results and plugging status for the affected tubes. As required by GL 95-05, these results are also shown graphically in Figure 4-1 through Figure 4-8.

As mentioned above, the largest bobbin voltage was 3.08v. This is considerably smaller than the largest bobbin voltage (6.55v) measured during the previous (2C16) inspection. In addition, as discussed in Section 7.0, the as-found voltages were considerably smaller than what was projected in the previous operational assessment [9]. The maximum 2C17 voltage is more consistent with the inspection results from the 2C15 outage during which the maximum bobbin voltage was 2.77v.

GL 95-05 requires that all indications greater than the lower repair limit (>2.0v) be inspected with a technique capable of flaw characterization (such as +Point™). During the last several outages at SQN2, additional inspections have been performed of indications less than 2.0v. These inspections are performed as a proactive measure to help identify indications that may be vulnerable to large voltage growth rates during the upcoming cycle as happened at Diablo Canyon Unit 2. During the 2C17 outage, all bobbin indications ≥1.0v were inspected with +Point™. Based on these supplemental inspections, an additional 6 tubes were preventatively plugged utilizing the +Point™ results and lessons learned from operating experiences.

The largest bobbin indication returned to service for Cycle 18 was a 1.91v indication in SG23. This indication was confirmed as a 0.12v axial ODSCC indication with +Point™.

The largest +Point™ flaw returned to service for Cycle 18 was a 0.96v axial ODSCC indication in SG24. The bobbin voltage associated with this TSP intersection was 1.24v.

4.2 Voltage Growth Rates

For projection of leak rates and tube burst probabilities at EOC-18, voltage growth rates were developed from the 2C16 and 2C17 inspection data. Cycle 17 was 523.0 EFPD (Effective Full Power Days) in length [10]. This equates to 1.432 EFPY (Effective Full Power Years; 523/365.25). For indications reported as DSI in both the 2C16 and 2C17 inspections, growth rates were determined based on comparison of the voltages reported in both inspections. For indications not reported during 2C16, but reported during 2C17 (i.e., new at 2C17), the 2C16 bobbin coil data were reviewed for presence of an OD signal. In all cases, bobbin signals were present in the 2C16 data based on the lookup reviews. The 2C16 voltages from these lookups were then used to calculate bobbin voltage growth rates for all of the newly-reported indications.

The 2C17 voltage growth rate distributions are shown in Table 4-7. These distributions are also shown graphically in Figure 4-9 and Figure 4-10. Table 4-8 and Figure 4-11 provide the growth rate distributions in cumulative probability format. This table and figure also provide a comparison of the Cycle 17 growth rates to the Cycle 16 growth rates. The Cycle 16 growth rate was taken from Reference [9] and is a bounding growth rate considering growth rate distributions from each individual steam generator. As shown in Table 4-8, the Cycle 16 bounding growth distribution clearly bounds the Cycle 17 growth rates.

Table 4-9 provides a comparison of average growth rates from Cycles 16 and 17. As shown in the table, the average change in voltage during Cycle 17 was slightly negative and less than the average voltage change in Cycle 16. This phenomenon of negative growth during Cycle 17 was noticed early during the bobbin coil inspection. Possible causes of the negative growth rates and the potential impact on both the condition monitoring and operational assessments are discussed in Section 4.6.

GL 95-05 requires that the limiting growth rate distribution from the last two cycles be used for the operational assessment. As discussed in Section 4.6, the negative bias in the Cycle 17 growth rates is believed to be due to a change in probe design. Since the Cycle 17 growth rates are not necessarily reflective of real flaw growth, a review of the Cycle 15 growth rates was also performed to determine if Cycle 15 growth rates should be considered for use in the operational assessment. As documented in Reference [9], the Cycle 16 growth rates bound the Cycle 15 growth rates. Therefore, since the growth rates from Cycle 16 bound those from both Cycle 15 and Cycle 17, the Cycle 16 growth rates were used in the operational assessment documented in this report. Additional discussion is provided in Section 4.6.

Figure 4-12 through Figure 4-16 show the Cycle 17 growth rates plotted against the BOC-17 voltages for all four steam generators individually and one chart with all steam generators combined. The intent of these charts is to determine if there's any tendency for the larger indications to grow at a higher rate than the smaller indications. This phenomenon (referred to as voltage-dependent growth) has been observed at some other similar plants and can have a non-conservative effect on the operational assessment projections. As shown in the figures, the slope is negative in all cases, thus indicating that the larger indications grow at a lower rate on average compared to the smaller indications. This is similar to the pattern observed during Cycle 16 at SQN2 as documented in Reference [9]. Therefore, voltage-dependent growth is not expected to have a detrimental effect on the operational assessment and will, therefore, not be considered in the OA projections documented herein.

4.3 +Point™ to Bobbin Voltage Correlation

As mentioned previously, four TSP intersections had axial ODSCC indications reported by +Point™ that weren't reported with bobbin. These indications are referred to as AONDB (Axial ODSCC Not Detected with Bobbin) and are typically smaller voltage ODSCC indications (by +Point™) that may be accompanied by a dent that masks the bobbin voltage. In all four of these cases, there was only one axial ODSCC indication present. These four indications are listed in Table 4-2.

In order to include these indications in the condition monitoring and operational assessments, a bobbin voltage must be inferred from the +Point™ voltage. This was accomplished by first plotting the 2C17 bobbin voltages against the corresponding +Point™ voltages for all bobbin indications at non-dented intersections that were inspected and confirmed as containing axial ODSCC. This plot is shown in Figure 4-17. An upper 95% confidence bound on the linear regression was then determined and a second order polynomial curve was fit to the upper 95th curve. The equation for the polynomial fit is:

$$V_{Bobbin-95UCL} = 0.0054 * V_{+PT}^{\ 2} + 0.817 * V_{+PT} + 0.963$$

This equation was used to infer a bobbin voltage for each of the four +Point™ indications shown in Table 4-2.

4.4 Probe Wear Monitoring

In order to maintain consistent detection and sizing capabilities throughout the inspection, probe wear is monitored by following the requirements of Reference [11], which is documented in Reference [12]. The first NRC requirement regarding probe wear is to minimize the potential for tubes to be inspected with a probe that has failed the probe wear check. This was accomplished by implementing the bobbin Examination Technique Specification Sheet (ETSS), which required the probe be discarded when failing the probe wear check. Review of the probe wear log sheets and the eddy current test results indicate that no tubes were inspected with a probe that had previously failed the probe wear check.

If the DSI voltage is at or above the retest threshold (1.5 volts or higher) and the calibration group is designated as "ARC Out" on the cal board, the indication code is changed from DSI to RPW (Retest due to Probe Wear) indicating that a retest is required with a good probe. No new indications were detected in the tubes when retested with the good probe.

The 2C17 eddy current inspection resulted in 21 bobbin indications in excess of 1.5 volts that were inspected with a worn probe. Table 4-10 shows these RPW indications, plus any indications less than 1.5 volts in the same tubes. This table also shows the DSI voltages after retest with a good probe. Figure 4-18 shows a comparison of the worn probe and good probe voltages. The average change in voltage from the worn probe to the good probe was slightly negative at -0.03v (i.e., on average, the voltage with the good probe was about 0.03v less than the voltage with the worn probe). As shown in Table 4-10 and Figure 4-18, there were five cases where the worn probe voltage was less than the lower repair limit of 2.0v but greater than the lower repair limit with the good probe. However, there were no indications that went from <1.5v with a worn probe to >2.0v with a good probe. Therefore, the 1.5v criterion for retesting DSIs is reasonable and justified. In the event that an indication <1.5v

was undersized due to probe wear, there are multiple conservatisms in both the inspection and analyses processes to offset such a condition. Among these conservatisms are 1) the fact that TVA proactively inspects all bobbin indications ≥1.0v with +Point™, 2) TVA preventatively plugs some bobbin indications ≤2.0v based on the +Point™ results, and 3) TVA applies a probability of detection of 0.6 for the operational assessment.

The next requirement involves monitoring tubes that contain new DSIs 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. Table 4-11 shows the new 2C17 DSI indications along with the probe wear results from both the 2C16 and 2C17 inspections. As shown in Table 4-11, the largest new indication in a tube inspected with a worn probe in 2C16 was a 1.02v indication in SG21. The 2C16 lookup voltage for this indication was 0.81v. In addition, there were ten other new indications ≥1.0v in tubes that were inspected with good probes in 2C16. The facts that 1) all newly-reported indications were detectable on a lookup review of the 2C16 data, and 2) the largest new indications were inspected with good probes in 2C16, show that the new indications are more related to the probability of detection and not probe wear.

To determine if there is a non-proportionately large percentage of new indications in tubes inspected with probes that failed the probe wear check in the previous outage, one must first look at the overall percentage of inspections performed with worn probes in the previous outage. This information is provided in Table 4-12. As shown in the table, 5402 inspections were performed with worn probes, compared to 12825 inspections that were performed with good probes. Therefore, 29.6% of the inspections in the previous outage were performed with worn probes.

Table 4-13 summarizes new DSI indications for probe wear comparisons. Overall, there were 3711 DSIs detected during the 2C17 inspection. 68 of these DSIs were newly-reported indications. Of the 68 total new indications, 20 were in tubes inspected with a worn probe in 2C16 for a ratio of 29.4%. Additionally, the number of new large indications (≥0.5v) was determined to be 56. Out of these 56 indications, 17 were in tubes that were inspected with a worn probe in 2C17 for a ratio of 30.4%. Since these ratios for new indications (29.4%) and new large indications (30.4%) are comparable to the ratio for all 2C16 inspections (29.6%), the new indications are not biased toward tubes inspected with worn probes in 2C16.

In summary, the NRC analysis requirements regarding probe wear monitoring were met during the 2C17 bobbin coil inspection and a more stringent wear tolerance is not required at SQN2.

4.5 Upper Voltage Repair Limit

Per GL 95-05, the upper repair limit must be calculated prior to each outage. 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. Since the average growth rate for Cycle 16 was 6.8%/EFPY (Table 4-9), the required 30%/EFPY was used for the upper repair limit calculation. The structural limit of 9.40v used for this calculation is based on the Addendum 7 database at an accident pressure differential of 2405 psid. The expected cycle length for the upcoming cycle (Cycle 18) is 1.30 EFPY (Effective Full Power Years) [10]. Based on these inputs and the following formula, the upper repair limit was calculated to be 5.91v.

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

where:

V_{URL} = upper voltage repair limit,
V_{NDE} = NDE voltage measurement uncertainty = 20%,
V_{CG} = voltage growth anticipated between inspections = 30%/EFPY x 1.30 EFPY = 39.0%,
V_{SL} = voltage structural limit from the burst pressure – Bobbin voltage correlation, where the limit of 9.40 volts was used based on Reference 8.

4.6 Evaluation of Negative Growth Rates

As discussed previously, it was noted during the inspection that an unusually large number of DSIs were decreasing in bobbin voltage compared to what was reported during the 2C16 inspection. The primary differences between the two inspections were the facts that a different frequency generator was used and a different probe manufacturer was used. The 2C16 inspection was performed by Westinghouse which used a Corestar frequency generator and Westinghouse designed probes (built by Corestar or Zetec) while the 2C17 inspection was performed by AREVA which used a Zetec frequency generator and Zetec probes (not built to the Westinghouse design).

When this was first noticed early during the bobbin coil inspection, the lead analyst reviewed the bobbin data for several indications that showed a decrease in bobbin voltage. This review (of both the 2C16 and 2C17 results) showed that the indications were correctly reported in both outages.

After the outage, additional reviews were done to determine the cause of this downward bias in the 2C17 bobbin voltages. This review covered calibration standards, voltage normalization, and probe design.

The calibration standards were the same in both outages. The voltage normalization processes were also the same in both outages and in accordance with the requirements of GL 95-05. In addition, the voltage normalization process used by AREVA during the 2C17 inspection at SQN2 is the same process used by AREVA during previous outages at Diablo Canyon (which also applied the voltage-based ARC prior to steam generator replacement).

A review of the probe design, however, showed that the design of the bobbin probe was slightly different between the two inspections. The probes used by AREVA in the 2C17 outage were standard bobbin coil probes designed and built by Zetec. The probes used during the 2C16 were built by either Zetec or Corestar, but were built to a Westinghouse design.

A review of probes used in outages prior to 2C16 showed that the change from the Zetec design to the Westinghouse design was made during the 2C14 outage. The 2C14 inspection showed an abnormally high growth rate and an abnormally large number of new indications. The high growth rate and large number of new indications observed during 2C14 is believed to be associated with the change in probe design. Based on the increase in growth and number of indications seen during 2C14, a similar decrease would be expected when going back to the Zetec designed probe as occurred during 2C17.

Table 4-14 and Figure 4-19 show the indication counts for the 2C11 through the 2C17 inspections as well as the growth in percent growth per EFPY for Cycles 11 through 17. It should be noted that the number of indications shown in the table were taken from the previous 90-Day Reports. Since the number of AONDB indications has been relatively small, no attempt was made to remove these from the indication counts. The small number of AONDB indications seen at SQN2 would not affect the conclusions drawn from this study.

As shown in the table, the number of indications reported typically increases by about 500 indications in each cycle provided there is no change in probe design. From 2C13 to 2C14, however, the population of detected indications increased by 900 indications. Likewise, the growth increased from previous values of about 10% per EFPY to nearly 18% per EFPY.

When going from the Westinghouse probe design (2C16) back to the Zetec design (2C17), the number of indications remained relatively flat (3747 indications in 2C16 to 3715 indications in 2C17). The growth rate also decreased from a rate of 6.8% per EFPY in Cycle 16 to -7.4% per EFPY in Cycle 17. These decreases seen at 2C17 are similar in magnitude to the increases seen at 2C14. Therefore, the apparent inspection transient observed during the 2C17 inspection is believed to be reflective of the change in probe design.

Since the Cycle 17 growth rate had a negative bias that was not necessarily reflective of a decrease in flaw growth, the Cycle 15 growth rate was also reviewed. This was done because GL 95-05 requires that the limiting growth distribution from the last two cycles be used for the operational assessment. Since the Cycle 17 growth rates are not necessarily indicative of real flaw growth, a comparison of growth rates from the two cycles prior to Cycle 17 was performed. This comparison, as documented in Reference [9], showed that the Cycle 16 growth rates bound those from Cycle 15. Therefore, the Cycle 16 growth was used in the operational assessment.

In conclusion, the probes, eddy current techniques, calibration standards, and voltage normalization practices used during the 2C17 inspection were all in accordance with the requirements of GL 95-05. A review of probes used in previous inspections relative to growth of indications showed that there was an upward bias on growth rates when going from the Zetec design to the Westinghouse design. The decrease in growth rates when going back to the Zetec design was similar in magnitude to the above-mentioned increase in growth rates. Therefore, the 2C17 results are believed to be consistent with the results from inspections prior to 2C14 relative to bobbin voltage response for a given axial ODSCC flaw.

In addition, since the Cycle 17 growth rates were affected by the change in probe design, the most limiting growth distribution from the last three cycles (Cycles 15, 16, and 17) was used for the OA. The comparison of Cycle 16 to Cycle 17 growth rates is provided in Section 4.2. The comparison of Cycle 16 to Cycle 15 growth rates is provided in Reference [9]. These comparisons showed that the Cycle 16 growth rates bounded those from both Cycle 15 and Cycle 17. Therefore, the Cycle 16 growth rates were used for the operational assessment documented in this report.

Table 4-1: 2C17 DSIs >2 Volts

SG	Row	Col	Ind	Elev	Volts
SG24	17	26	DSI	H02	2.42
SG24	18	18	DSI	H01	2.21
SG24	18	33	DSI	H01	2.01
SG24	20	30	DSI	H02	2.65
SG24	20	39	DSI	H05	2.64
SG24	20	48	DSI	H05	2.25
SG24	20	49	DSI	H04	2.2
SG24	20	59	DSI	H04	3.08
SG24	29	26	DSI	H02	2.02
SG24	34	50	DSI	H03	2.03

Table 4-2: 2C17 AONDB Indications

SG	Row	Col	Elev	Ind	+Point™ Volts	Dent Volts	Inferred Bobbin Volts
SG22	6	13	H02	SAI	0.14	1.19	1.077
SG22	36	24	H01	SAI	0.18	4.08	1.110
SG24	12	2	H02	SAI	0.24	1.13	1.159
SG24	36	75	H01	SAI	0.21	1.25	1.135

Table 4-3: Summary of Inspection Results for SG21

Voltage Bin	2C17 As-Found	+Point™ Inspection Results			Plugged	DSI's Returned to Service	
		Confirmed as Axial ODSCC	Inspected but Not Confirmed as Axial ODSCC	Not Inspected		Confirmed or Not Inspected w/ +Point™	Total
0.1	1	0	0	1	0	1	1
0.2	45	0	0	45	0	45	45
0.3	68	0	0	68	1	67	67
0.4	73	2	0	71	2	71	71
0.5	103	0	0	103	3	100	100
0.6	91	1	2	88	0	91	89
0.7	84	1	1	82	3	81	80
0.8	47	1	0	46	0	47	47
0.9	38	0	0	38	0	38	38
1	37	1	1	35	1	36	35
1.1	21	19	2	0	1	20	18
1.2	11	11	0	0	0	11	11
1.3	9	9	0	0	0	9	9
1.4	6	5	1	0	0	6	5
1.5	3	3	0	0	0	3	3
1.6	4	2	2	0	0	4	2
1.7	0	0	0	0	0	0	0
1.8	1	1	0	0	0	1	1
1.9	1	1	0	0	0	1	1
2	0	0	0	0	0	0	0
2.1	0	0	0	0	0	0	0
2.2	0	0	0	0	0	0	0
2.3	0	0	0	0	0	0	0
2.4	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0
2.6	0	0	0	0	0	0	0
2.7	0	0	0	0	0	0	0
2.8	0	0	0	0	0	0	0
2.9	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0
3.1	0	0	0	0	0	0	0
3.2	0	0	0	0	0	0	0
3.3	0	0	0	0	0	0	0
3.4	0	0	0	0	0	0	0
3.5	0	0	0	0	0	0	0
>3.5	0	0	0	0	0	0	0
Total	643	57	9	577	11	632	623
>1V	56	51	5	0	1	55	50
>2V	0	0	0	0	0	0	0

Table 4-4: Summary of Inspection Results for SG22

Voltage Bin	2C17 As-Found	+Point™ Inspection Results			Plugged	DSI's Returned to Service	
		Confirmed as Axial ODSCC	Inspected but Not Confirmed as Axial ODSCC	Not Inspected		Confirmed or Not Inspected w/ +Point™	Total
0.1	4	0	0	4	0	4	4
0.2	32	0	0	32	0	32	32
0.3	73	1	2	70	2	71	69
0.4	120	1	1	118	0	120	119
0.5	105	1	0	104	0	105	105
0.6	102	0	1	101	0	102	101
0.7	86	2	0	84	0	86	86
0.8	57	4	0	53	0	57	57
0.9	37	1	1	35	0	37	36
1	33	3	0	30	0	33	33
1.1	21	18	3	0	1	20	17
1.2	12	10	2	0	2	10	8
1.3	17	15	2	0	0	17	15
1.4	9	8	1	0	0	9	8
1.5	5	4	1	0	0	5	4
1.6	1	1	0	0	0	1	1
1.7	1	1	0	0	0	1	1
1.8	0	0	0	0	0	0	0
1.9	1	1	0	0	1	0	0
2	0	0	0	0	0	0	0
2.1	0	0	0	0	0	0	0
2.2	0	0	0	0	0	0	0
2.3	0	0	0	0	0	0	0
2.4	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0
2.6	0	0	0	0	0	0	0
2.7	0	0	0	0	0	0	0
2.8	0	0	0	0	0	0	0
2.9	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0
3.1	0	0	0	0	0	0	0
3.2	0	0	0	0	0	0	0
3.3	0	0	0	0	0	0	0
3.4	0	0	0	0	0	0	0
3.5	0	0	0	0	0	0	0
>3.5	0	0	0	0	0	0	0
Total	716	71	14	631	6	710	696
>1V	67	58	9	0	4	63	54
>2V	0	0	0	0	0	0	0

Table 4-5: Summary of Inspection Results for SG23

Voltage Bin	2C17 As-Found	+Point™ Inspection Results			Plugged	DSI's Returned to Service	
		Confirmed as Axial ODSCC	Inspected but Not Confirmed as Axial ODSCC	Not Inspected		Confirmed or Not Inspected w/ +Point™	Total
0.1	9	0	0	9	0	9	9
0.2	22	0	0	22	0	22	22
0.3	75	0	0	75	0	75	75
0.4	107	1	1	105	2	105	104
0.5	108	1	2	105	0	108	106
0.6	113	1	1	111	3	110	109
0.7	110	0	4	106	3	107	103
0.8	86	3	3	80	0	86	83
0.9	57	1	1	55	1	56	55
1	51	2	3	46	0	51	48
1.1	39	31	8	0	2	37	30
1.2	33	28	5	0	0	33	28
1.3	28	24	4	0	1	27	23
1.4	20	15	5	0	1	19	14
1.5	4	4	0	0	0	4	4
1.6	8	8	0	0	0	8	8
1.7	5	5	0	0	0	5	5
1.8	0	0	0	0	0	0	0
1.9	2	2	0	0	0	2	2
2	1	1	0	0	0	1	1
2.1	0	0	0	0	0	0	0
2.2	0	0	0	0	0	0	0
2.3	0	0	0	0	0	0	0
2.4	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0
2.6	0	0	0	0	0	0	0
2.7	0	0	0	0	0	0	0
2.8	0	0	0	0	0	0	0
2.9	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0
3.1	0	0	0	0	0	0	0
3.2	0	0	0	0	0	0	0
3.3	0	0	0	0	0	0	0
3.4	0	0	0	0	0	0	0
3.5	0	0	0	0	0	0	0
>3.5	0	0	0	0	0	0	0
Total	878	127	37	714	13	865	829
>1V	140	118	22	0	4	136	115
>2V	0	0	0	0	0	0	0

Table 4-6: Summary of Inspection Results for SG24

Voltage Bin	2C17 As-Found	+Point™ Inspection Results			Plugged	DSI's Returned to Service	
		Confirmed as Axial ODSCC	Inspected but Not Confirmed as Axial ODSCC	Not Inspected		Confirmed or Not Inspected w/ +Point™	Total
0.1	4	0	0	4	0	4	4
0.2	45	0	0	45	0	45	45
0.3	162	0	0	162	1	161	161
0.4	207	1	2	204	10	197	195
0.5	210	1	2	207	2	208	206
0.6	208	1	1	206	2	206	205
0.7	165	1	2	162	4	161	159
0.8	118	1	1	116	0	118	117
0.9	105	1	0	104	0	105	105
1	74	13	0	61	1	73	73
1.1	49	47	2	0	2	47	45
1.2	50	48	2	0	6	44	42
1.3	15	15	0	0	1	14	14
1.4	16	15	1	0	0	16	15
1.5	11	11	0	0	0	11	11
1.6	11	11	0	0	0	11	11
1.7	6	6	0	0	0	6	6
1.8	6	6	0	0	2	4	4
1.9	5	5	0	0	0	5	5
2	1	1	0	0	1	0	0
2.1	3	3	0	0	3	0	0
2.2	1	1	0	0	1	0	0
2.3	2	2	0	0	2	0	0
2.4	0	0	0	0	0	0	0
2.5	1	1	0	0	1	0	0
2.6	0	0	0	0	0	0	0
2.7	2	2	0	0	2	0	0
2.8	0	0	0	0	0	0	0
2.9	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0
3.1	1	1	0	0	1	0	0
3.2	0	0	0	0	0	0	0
3.3	0	0	0	0	0	0	0
3.4	0	0	0	0	0	0	0
3.5	0	0	0	0	0	0	0
>3.5	0	0	0	0	0	0	0
Total	1478	194	13	1271	42	1436	1423
>1V	180	175	5	0	22	158	153
>2V	10	10	0	0	10	0	0

Table 4-7: Cycle 17 Voltage Growth Rates

Voltage Growth per EFPY	SG21	SG22	SG23	SG24	All SGs
≤0	462	511	626	1048	2647
0.1	125	146	156	297	724
0.2	41	42	57	89	229
0.3	13	13	26	17	69
0.4	2	2	8	10	22
0.5	0	0	4	4	8
0.6	0	0	1	3	4
0.7	0	0	0	4	4
0.8	0	0	0	2	2
0.9	0	0	0	1	1
1	0	0	0	1	1
1.1	0	0	0	0	0
1.2	0	0	0	0	0
1.3	0	0	0	0	0
1.4	0	0	0	0	0
1.5	0	0	0	0	0
1.6	0	0	0	0	0
1.7	0	0	0	0	0
1.8	0	0	0	0	0
1.9	0	0	0	0	0
2	0	0	0	0	0
>2	0	0	0	0	0
Total	643	714	878	1476	3711

Table 4-8: Cycle 17 vs. Cycle 16 Growth Comparison (Cumulative Distributions)

Voltage Growth per EFPY	Cycle 17 Growth					Cycle 16 Growth
	SG21	SG22	SG23	SG24	All SGs	Bounding Composite
0	0.7185	0.7157	0.7130	0.7100	0.7133	0.3442
0.1	0.9129	0.9202	0.8907	0.9112	0.9084	0.7455
0.2	0.9767	0.9790	0.9556	0.9715	0.9701	0.9010
0.3	0.9969	0.9972	0.9852	0.9831	0.9887	0.9568
0.4	1.0000	1.0000	0.9943	0.9898	0.9946	0.9802
0.5	1.0000	1.0000	0.9989	0.9925	0.9968	0.9887
0.6	1.0000	1.0000	1.0000	0.9946	0.9978	0.9915
0.7	1.0000	1.0000	1.0000	0.9973	0.9989	0.9947
0.8	1.0000	1.0000	1.0000	0.9986	0.9995	0.9954
0.9	1.0000	1.0000	1.0000	0.9993	0.9997	0.9969
1	1.0000	1.0000	1.0000	1.0000	1.0000	0.9969
1.1	1.0000	1.0000	1.0000	1.0000	1.0000	0.9985
1.2	1.0000	1.0000	1.0000	1.0000	1.0000	0.9985
1.3	1.0000	1.0000	1.0000	1.0000	1.0000	0.9985
1.4	1.0000	1.0000	1.0000	1.0000	1.0000	0.9985
1.5	1.0000	1.0000	1.0000	1.0000	1.0000	0.9989
1.6	1.0000	1.0000	1.0000	1.0000	1.0000	0.9989
2.2	1.0000	1.0000	1.0000	1.0000	1.0000	0.9989
2.3	1.0000	1.0000	1.0000	1.0000	1.0000	0.9993
4.6	1.0000	1.0000	1.0000	1.0000	1.0000	0.9993
4.7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
>4.7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Table 4-9: Cycle 17 vs. Cycle 16 Average Growth Comparison

		SG21	SG22	SG23	SG24	All SGs
Cycle 16	Average BOC Volts	0.671	0.663	0.756	0.707	0.704
	Average Growth per EFPY	0.057	0.033	0.037	0.057	0.048
	Average Percent Growth per EFPY	8.5%	5.0%	4.9%	8.0%	6.8%
Cycle 17	Average BOC Volts	0.666	0.650	0.749	0.688	0.691
	Average Growth per EFPY	-0.059	-0.051	-0.060	-0.042	-0.051
	Average Percent Growth per EFPY	-8.9%	-7.8%	-8.0%	-6.1%	-7.4%

Table 4-10: Retested DSIs that Were on Cal Groups that Failed the Probe Wear Check

SG	Row	Col	Elev	Worn Probe			Good Probe			% Diff
				Ind	Volts	Leg-Cal	Ind	Volts	Leg-Cal	
SG23	20	86	H01	RPW	1.68	Cold-24	DSI	1.13	Cold-35	-32.7%
SG23	24	12	H01	RPW	1.82	Cold-13	DSI	1.62	Cold-48	-11.0%
SG23	24	12	H02	RPW	1.01	Cold-13	DSI	0.7	Cold-48	-30.7%
SG23	24	16	H01	RPW	1.74	Cold-13	DSI	1.61	Cold-48	-7.5%
SG23	24	16	H02	RPW	0.59	Cold-13	DSI	1.03	Cold-48	74.6%
SG23	26	11	H03	RPW	1.11	Cold-13	DSI	0.83	Cold-48	-25.2%
SG23	26	12	H01	RPW	0.73	Cold-13	DSI	0.69	Cold-48	-5.5%
SG23	26	12	H03	RPW	1.59	Cold-13	DSI	0.9	Cold-48	-43.4%
SG23	26	28	H01	RPW	1.85	Cold-13	DSI	1.23	Cold-48	-33.5%
SG23	26	28	H03	RPW	1.09	Cold-13	DSI	0.79	Cold-48	-27.5%
SG23	34	25	H01	RPW	2.22	Cold-13	DSI	1.62	Cold-48	-27.0%
SG23	34	25	H02	RPW	1	Cold-13	DSI	0.84	Cold-48	-16.0%
SG23	34	25	H03	RPW	0.81	Cold-13	DSI	0.54	Cold-48	-33.3%
SG23	34	25	H04	RPW	0.77	Cold-13	DSI	0.58	Cold-48	-24.7%
SG23	35	58	H02	RPW	1.66	Cold-23	DSI	1.6	Cold-48	-3.6%
SG23	35	58	H04	RPW	0.28	Cold-23	DSI	0.27	Cold-48	-3.6%
SG23	35	58	H05	RPW	0.44	Cold-23	DSI	0.39	Cold-48	-11.4%
SG24	17	27	H01	RPW	1.62	Cold-14	DSI	1.55	Cold-34	-4.3%
SG24	17	27	H03	RPW	0.39	Cold-14	DSI	0.38	Cold-34	-2.6%
SG24	18	18	H01	RPW	2.3	Cold-14	DSI	2.21	Cold-34	-3.9%
SG24	20	25	H01	RPW	1.8	Cold-14	DSI	1.76	Cold-34	-2.2%
SG24	20	25	H02	RPW	0.93	Cold-14	DSI	0.96	Cold-34	3.2%
SG24	20	25	H04	RPW	1.16	Cold-14	DSI	1.14	Cold-34	-1.7%
SG24	20	25	H06	RPW	0.61	Cold-14	DSI	0.5	Cold-34	-18.0%
SG24	20	25	H07	RPW	0.29	Cold-14	DSI	0.31	Cold-34	6.9%
SG24	20	29	H02	RPW	1.86	Cold-14	DSI	1.94	Cold-34	4.3%
SG24	20	29	H04	RPW	0.5	Cold-14	DSI	0.61	Cold-34	22.0%
SG24	20	30	H02	RPW	1.74	Cold-14	DSI	2.65	Cold-34	52.3%
SG24	20	30	H04	RPW	0.32	Cold-14	DSI	0.34	Cold-34	6.3%
SG24	20	48	H01	RPW	1.18	Cold-19	DSI	1.21	Cold-45	2.5%
SG24	20	48	H02	RPW	0.86	Cold-19	DSI	1.14	Cold-45	32.6%
SG24	20	48	H05	RPW	1.55	Cold-19	DSI	2.25	Cold-45	45.2%
SG24	20	49	H01	RPW	0.34	Cold-19	DSI	0.32	Cold-45	-5.9%
SG24	20	49	H02	RPW	0.44	Cold-19	DSI	0.41	Cold-45	-6.8%

Table 4-10: Retested DSIs that Were on Cal Groups that Failed the Probe Wear Check

SG	Row	Col	Elev	Worn Probe			Good Probe			% Diff
				Ind	Volts	Leg-Cal	Ind	Volts	Leg-Cal	
SG24	20	49	H03	RPW	1.17	Cold-19	DSI	1.2	Cold-45	2.6%
SG24	20	49	H04	RPW	1.88	Cold-19	DSI	2.2	Cold-45	17.0%
SG24	20	59	H01	RPW	1	Hot-20	DSI	1.05	Cold-45	5.0%
SG24	20	59	H04	RPW	3.02	Hot-20	DSI	3.08	Cold-45	2.0%
SG24	20	59	H05	RPW	0.32	Hot-20	DSI	0.4	Cold-45	25.0%
SG24	21	51	H01	RPW	1.58	Cold-19	DSI	1.71	Cold-45	8.2%
SG24	21	51	H02	RPW	0.45	Cold-19	DSI	0.44	Cold-45	-2.2%
SG24	25	60	H01	RPW	1.72	Hot-21	DSI	1.63	Cold-45	-5.2%
SG24	25	60	H02	RPW	1.3	Hot-21	DSI	1.28	Cold-45	-1.5%
SG24	25	60	H04	RPW	0.43	Hot-21	Not Reported			NA
SG24	27	27	H02	RPW	1.73	Cold-14	DSI	1.59	Cold-34	-8.1%
SG24	29	26	H02	RPW	1.83	Cold-14	DSI	2.02	Cold-34	10.4%
SG24	31	58	H02	RPW	1.13	Hot-21	DSI	1.12	Cold-45	-0.9%
SG24	31	58	H03	RPW	1.53	Hot-21	DSI	1.37	Cold-45	-10.5%
SG24	34	50	H03	RPW	1.89	Cold-19	DSI	2.03	Cold-45	7.4%
SG24	34	50	H04	RPW	0.28	Cold-19	DSI	0.37	Cold-45	32.1%

Table 4-11: New DSIs with 2C16 and 2C17 Probe Wear Results

SG	Row	Col	Ind	Elev	2C17			2C16		
					Cal	ARC Out*	Volts	Cal	ARC Out*	Volts**
SG21	10	15	DSI	H01	Hot-1		0.6	Cold-18		0.84
SG21	10	41	DSI	H01	Hot-43		0.99	Cold-24		1.45
SG21	32	71	DSI	H02	Hot-24	Out	1.02	Cold-30	Out	0.81
SG21	44	54	DSI	C01	Hot-21		0.57	Cold-26	Out	0.28
SG21	44	59	DSI	H04	Hot-22		0.62	Cold-27		0.56
SG22	2	85	DSI	H05	Hot-63		0.56	Hot-5		0.52
SG22	8	6	DSI	H03	Hot-3		0.36	Hot-1		0.19
SG22	8	93	DSI	H02	Hot-57		0.6	Hot-5		0.45
SG22	10	13	DSI	H03	Hot-3		0.29	Cold-15		0.37
SG22	10	72	DSI	H02	Hot-7	Out	0.83	Cold-31		1
SG22	10	91	DSI	H02	Hot-63		0.78	Cold-30		0.99
SG22	12	37	DSI	H01	Cold-14		0.92	Cold-39		1
SG22	15	40	DSI	H01	Cold-21	Out	0.92	Cold-22		0.7
SG22	15	62	DSI	H02	Hot-35		0.62	Cold-27	Out	0.7
SG22	20	55	DSI	H01	Hot-33	Out	0.58	Cold-25	Out	0.51
SG22	24	26	DSI	H02	Cold-18		0.82	Cold-18		0.45
SG22	25	32	DSI	H02	Cold-19		0.7	Cold-20	Out	0.3
SG22	28	45	DSI	H01	Cold-22		0.44	Cold-22		0.45
SG22	30	12	DSI	C01	Cold-16		0.27	Cold-16		0.24
SG22	31	37	DSI	H01	Cold-21	Out	1.31	Cold-19		1.05
SG22	33	18	DSI	H05	Cold-17	Out	1.01	Cold-16		1.09
SG22	35	62	DSI	H03	Hot-35		0.84	Cold-23		0.76
SG22	38	29	DSI	H02	Cold-18		0.97	Cold-17	Out	0.8
SG22	41	43	DSI	H01	Cold-21	Out	0.47	Cold-40		0.52
SG22	43	64	DSI	H01	Hot-35		0.67	Cold-23		0.76
SG22	44	39	DSI	C01	Cold-20		0.52	Cold-39		0.58
SG23	2	31	DSI	H06	Hot-61		1	Hot-3		1.05
SG23	2	39	DSI	H05	Hot-62	Out	0.75	Hot-3		0.92
SG23	2	88	DSI	C03	Cold-9		0.68	Cold-5	Out	0.73
SG23	8	18	DSI	H01	Hot-2		1.14	Hot-3		1.26
SG23	9	42	DSI	H01	Hot-62	Out	0.69	Hot-3		0.72
SG23	11	11	DSI	H05	Cold-6		0.6	Cold-13		0.66
SG23	16	15	DSI	H01	Cold-13	Out	1.05	Cold-13		0.72
SG23	19	45	DSI	H02	Cold-18		0.63	Cold-46		0.5
SG23	23	84	DSI	H03	Cold-21		0.76	Cold-23		0.82

Table 4-11: New DSIs with 2C16 and 2C17 Probe Wear Results

SG	Row	Col	Ind	Elev	2C17			2C16		
					Cal	ARC Out*	Volts	Cal	ARC Out*	Volts**
SG23	26	10	DSI	H02	Cold-13	Out	0.88	Cold-14		0.73
SG23	26	13	DSI	H01	Cold-13	Out	1.16	Cold-13		1.15
SG23	26	16	DSI	H01	Cold-13	Out	0.6	Cold-14		0.45
SG23	31	13	DSI	H01	Cold-13	Out	0.87	Cold-14		0.36
SG23	31	35	DSI	H02	Cold-16		0.62	Cold-16	Out	0.76
SG23	35	26	DSI	H02	Cold-14		0.82	Cold-10	Out	0.98
SG23	36	35	DSI	H03	Cold-15		0.8	Cold-10	Out	0.9
SG23	38	26	DSI	H01	Cold-13	Out	1	Cold-10	Out	0.68
SG23	38	40	DSI	H02	Cold-18		0.81	Cold-11	Out	0.48
SG23	39	36	DSI	H02	Cold-15		0.87	Cold-10	Out	0.96
SG23	42	33	DSI	C02	Cold-16		0.38	Cold-10	Out	0.57
SG23	44	44	DSI	C01	Cold-18		0.48	Cold-16	Out	0.82
SG24	3	20	DSI	H03	Hot-2		0.51	Hot-1		0.44
SG24	7	26	DSI	H02	Hot-1		0.65	Hot-3	Out	0.59
SG24	8	28	DSI	H02	Hot-1		0.86	Hot-4	Out	0.82
SG24	8	30	DSI	H02	Hot-1		0.68	Hot-4	Out	0.55
SG24	8	88	DSI	H07	Hot-5		0.31	Hot-3	Out	0.13
SG24	9	20	DSI	H03	Hot-2		0.56	Hot-1		0.65
SG24	15	39	DSI	H02	Cold-13		0.76	Cold-16		0.91
SG24	19	48	DSI	H02	Cold-18		1.9	Cold-15		1.82
SG24	20	26	DSI	H01	Cold-15		0.57	Cold-9		0.69
SG24	20	26	DSI	H04	Cold-15		0.69	Cold-9		0.76
SG24	20	48	DSI	H05	Cold-45		2.25	Cold-15		1.52
SG24	23	74	DSI	H03	Hot-24		0.24	Cold-19		0.31
SG24	27	23	DSI	H03	Cold-14	Out	0.91	Cold-10		0.88
SG24	29	24	DSI	H01	Cold-15		0.7	Cold-9		0.81
SG24	29	58	DSI	H05	Hot-21	Out	0.32	Hot-31		0.3
SG24	34	16	DSI	C01	Cold-16		0.63	Cold-7		0.47
SG24	34	18	DSI	C01	Cold-16		0.49	Cold-9		0.47
SG24	35	18	DSI	C01	Cold-17		0.67	Cold-9		0.48
SG24	39	57	DSI	C05	Hot-21	Out	0.44	Cold-18		0.51
SG24	43	63	DSI	C03	Hot-22		1.09	Hot-31		1.22
SG24	44	34	DSI	C01	Cold-12		0.53	Cold-11	Out	0.51

* "Out" indicates that the probe on the specified calibration group failed the probe wear check.

** 2C16 voltages for newly-reported indications were obtained from lookups of the 2C16 raw bobbin data.

Table 4-12: Summary of Probe Wear Results from 2C16 Inspection

SG	Number of Inspections with Good Probe (2C16)	Number of Inspections with Worn Probe (2C16)	Total Number of Inspections (2C16)	Percent of Inspections with Worn Probe (2C16)
SG21	3092	1473	4565	32.3%
SG22	3199	1187	4386	27.1%
SG23	3116	1530	4646	32.9%
SG24	3418	1212	4630	26.2%
Total	12825	5402	18227	29.6%

Table 4-13: Summary of New DSIs for Probe Wear Comparison

SG	All 2C17 DSIs	New Inds	New Insp w/ Worn Probe in 2C16	Percent of New Inds Insp w/ Worn Probe in 2C16	New >=0.5v	New >=0.5v Insp w/ Worn Probe in 2C16	Percent of New >=0.5v Insp w/ Worn Probe in 2C16
SG21	643	5	2	40.0%	5	2	40.0%
SG22	714	21	4	19.0%	16	4	25.0%
SG23	878	21	9	42.9%	19	7	36.8%
SG24	1476	21	5	23.8%	16	4	25.0%
Total	3711	68	20	29.4%	56	17	30.4%

Table 4-14: Growth in Quantity and Voltage of Bobbin Indications

Operating Cycle	Probe Design	Number of Indications	Percent Growth per EFPY
Cycle 11	Zetec	1045	7.5%
Cycle 12	Zetec	1545	10.3%
Cycle 13	Zetec	1847	10.6%
Cycle 14	Westinghouse	2747	17.8%
Cycle 15	Westinghouse	3223	-0.7%
Cycle 16	Westinghouse	3747	6.8%
Cycle 17	Zetec	3715	-7.4%

Figure 4-1: 2C17 As-Found Voltage Distributions for SG21 and SG22

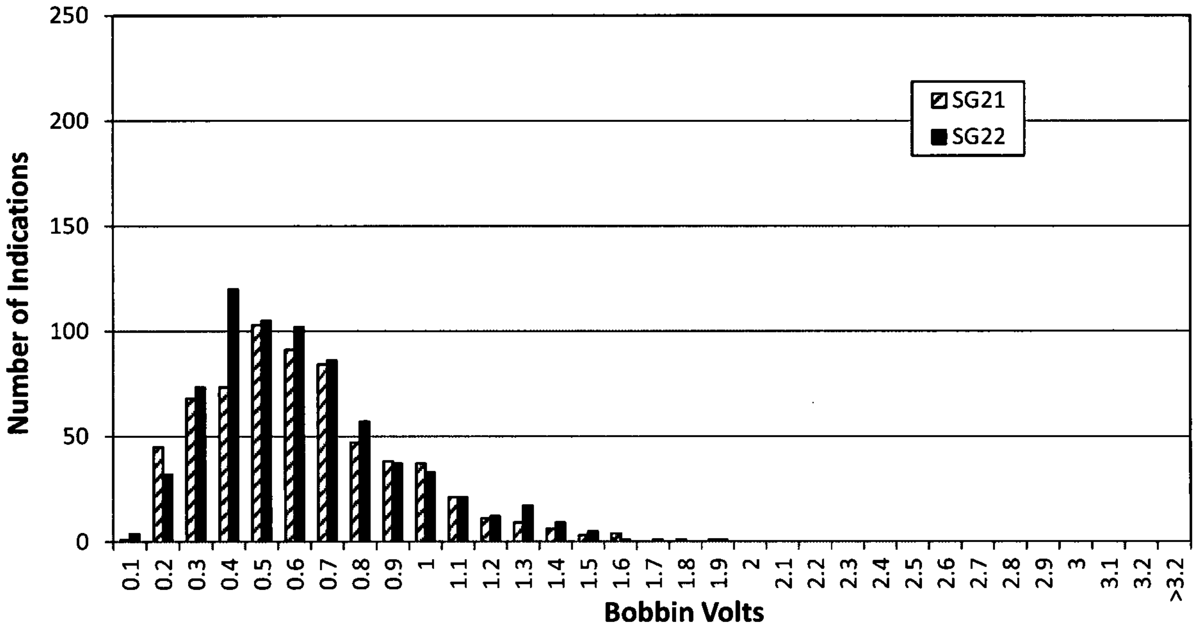


Figure 4-2: 2C17 As-Found Voltage Distributions for SG23 and SG24

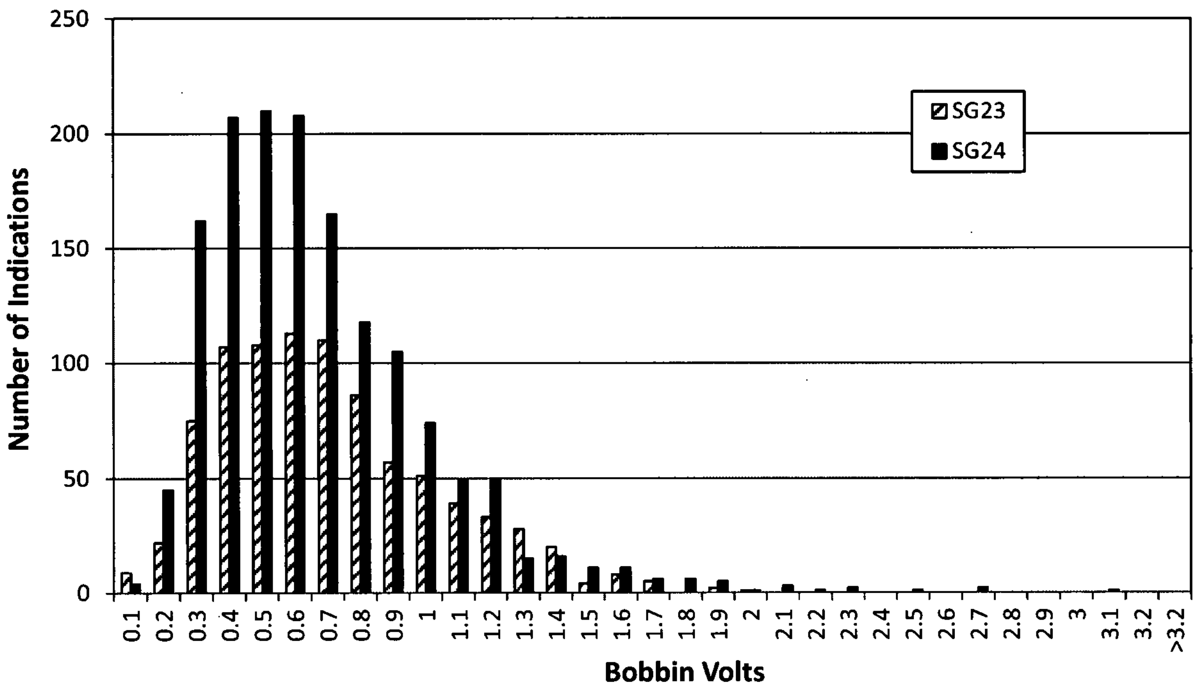


Figure 4-3: Plugged Voltage Distributions for SG21 and SG22

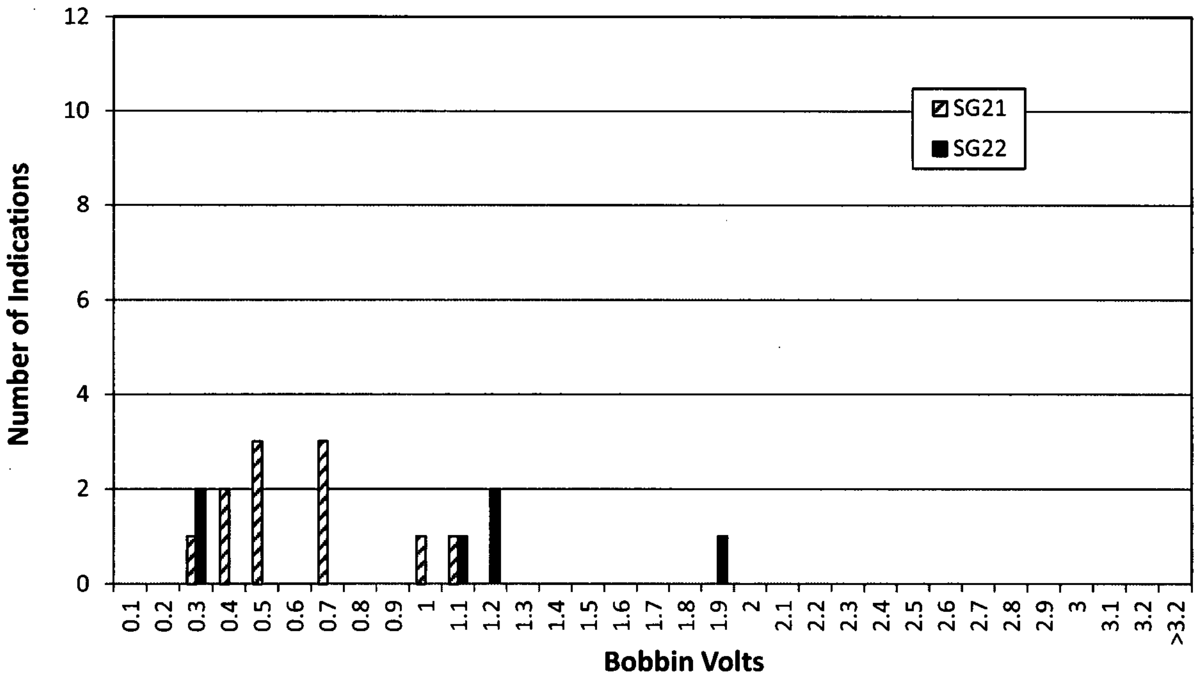


Figure 4-4: Plugged Voltage Distributions for SG23 and SG24

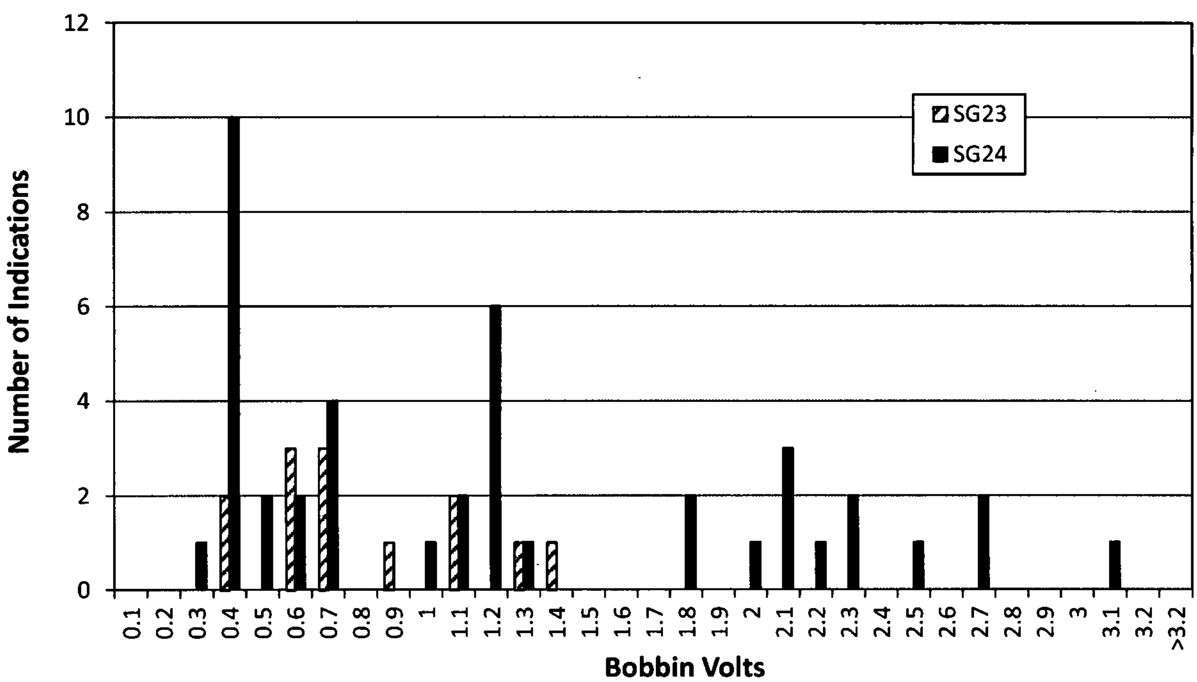


Figure 4-5: RTS and Confirmed or Not Inspected w/ +Point™ (SG21 & SG22)

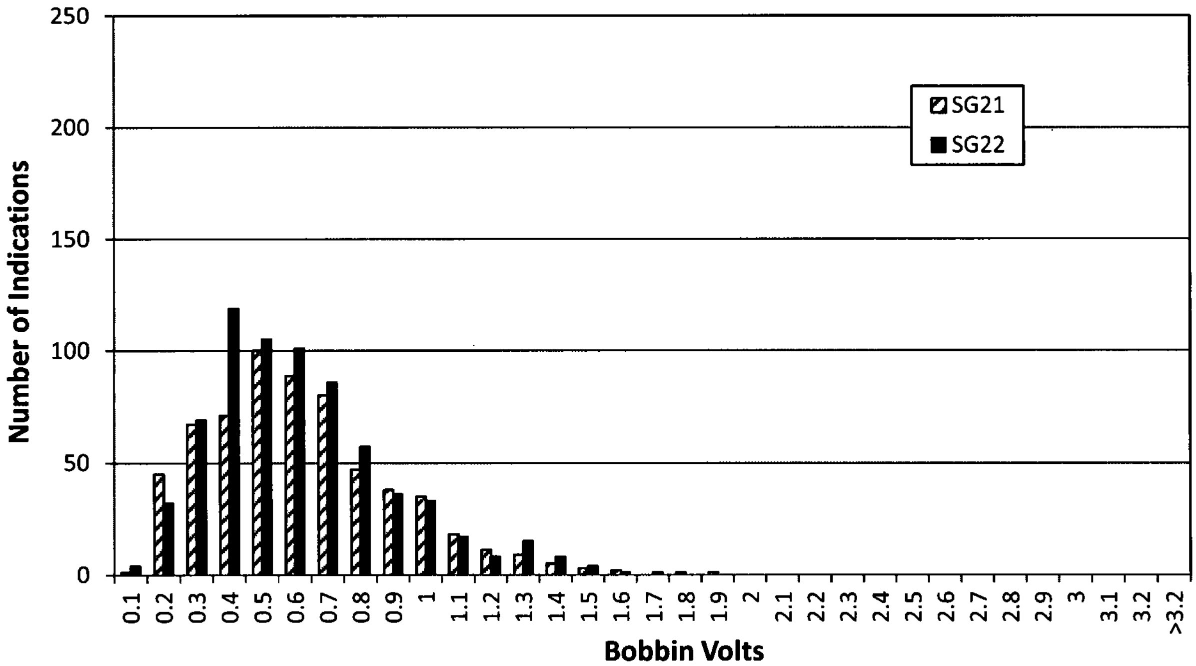


Figure 4-6: RTS and Confirmed or Not Inspected w/ +Point™ (SG23 & SG24)

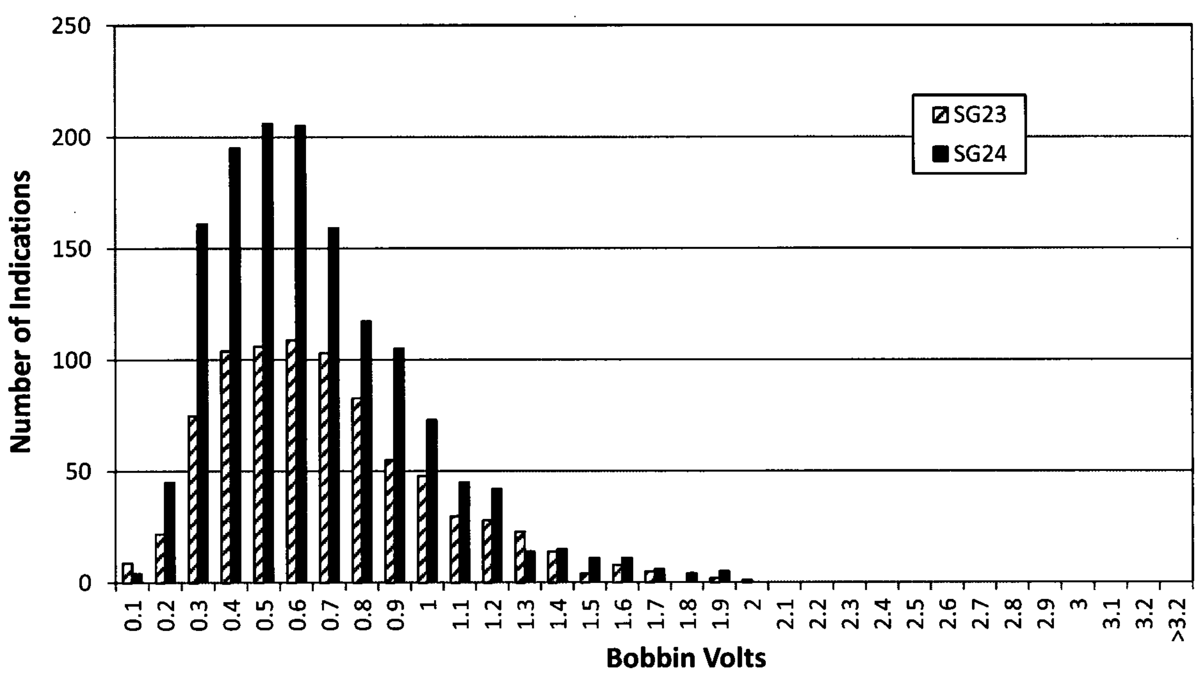


Figure 4-7: All Indications Returned to Service for SG21 and SG22

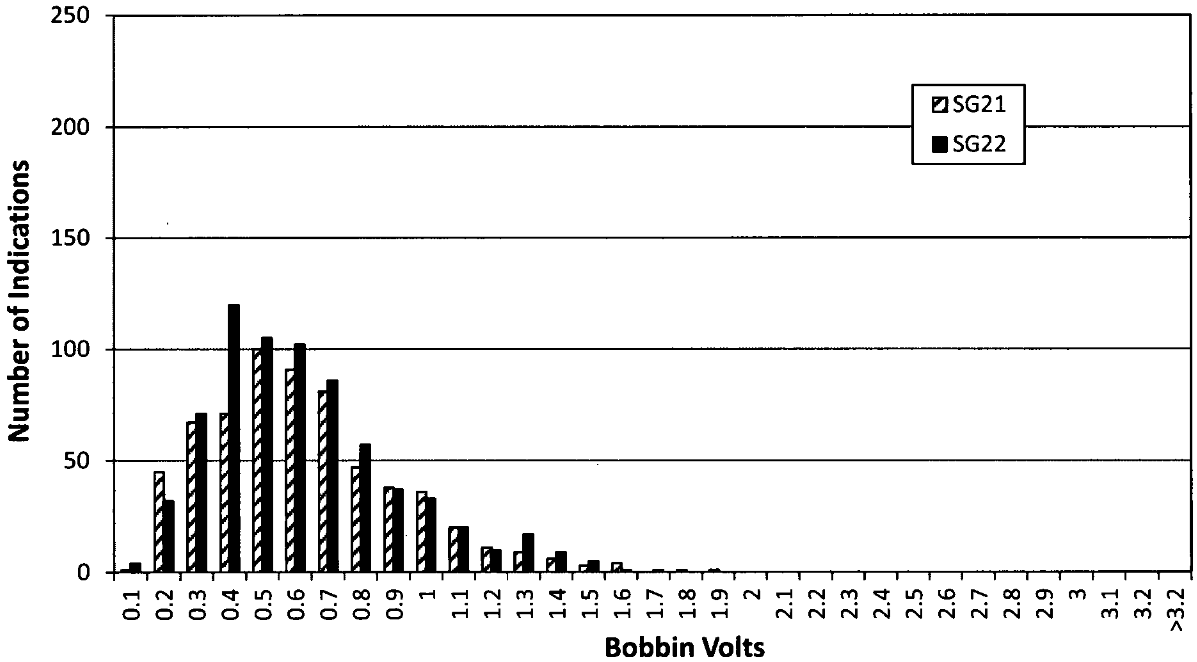


Figure 4-8: All Indications Returned to Service for SG23 and SG24

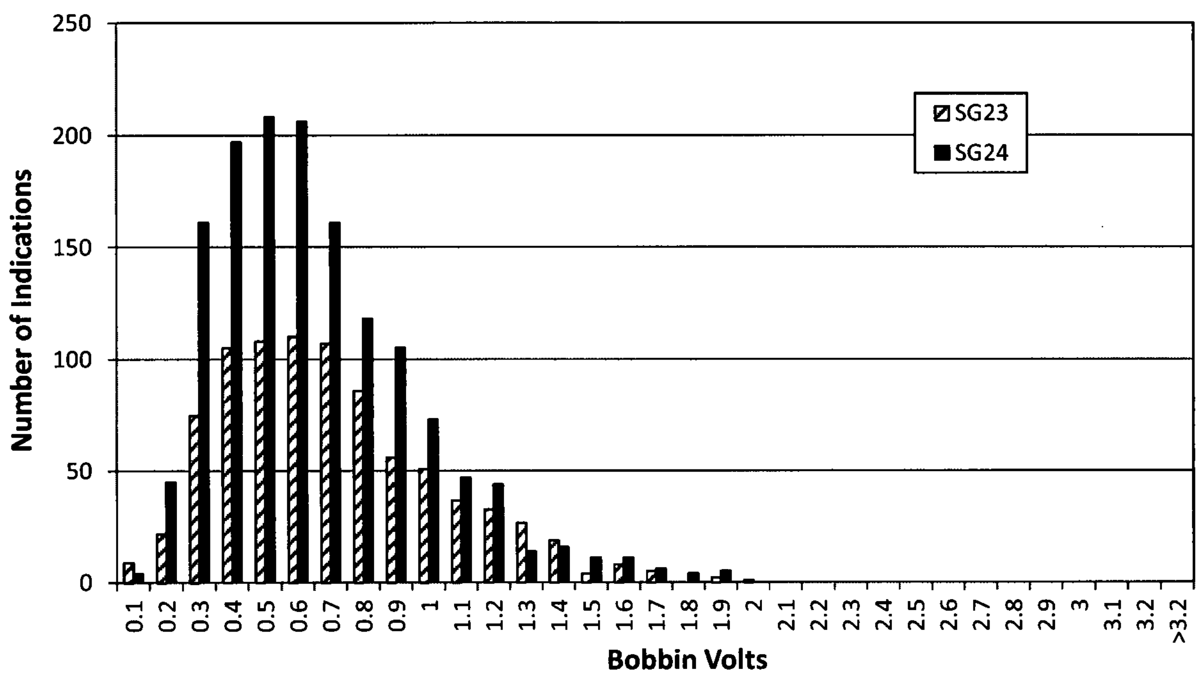


Figure 4-9: Cycle 17 Growth Distribution for SG21 and SG22

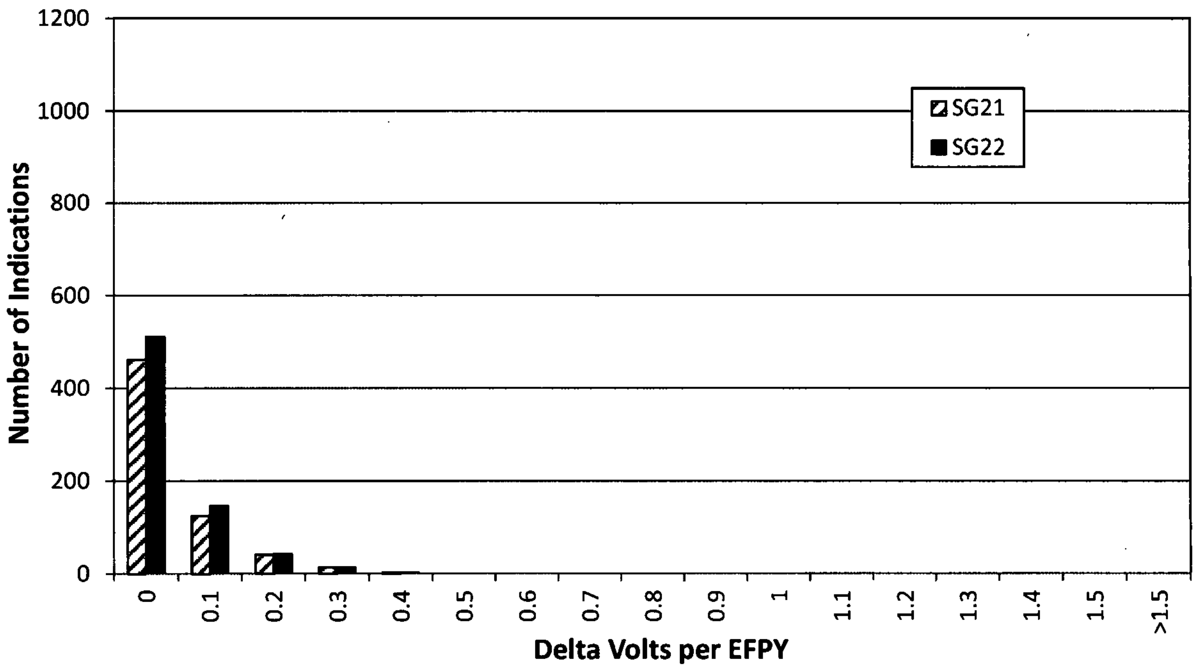


Figure 4-10: Cycle 17 Growth Distribution for SG23 and SG24

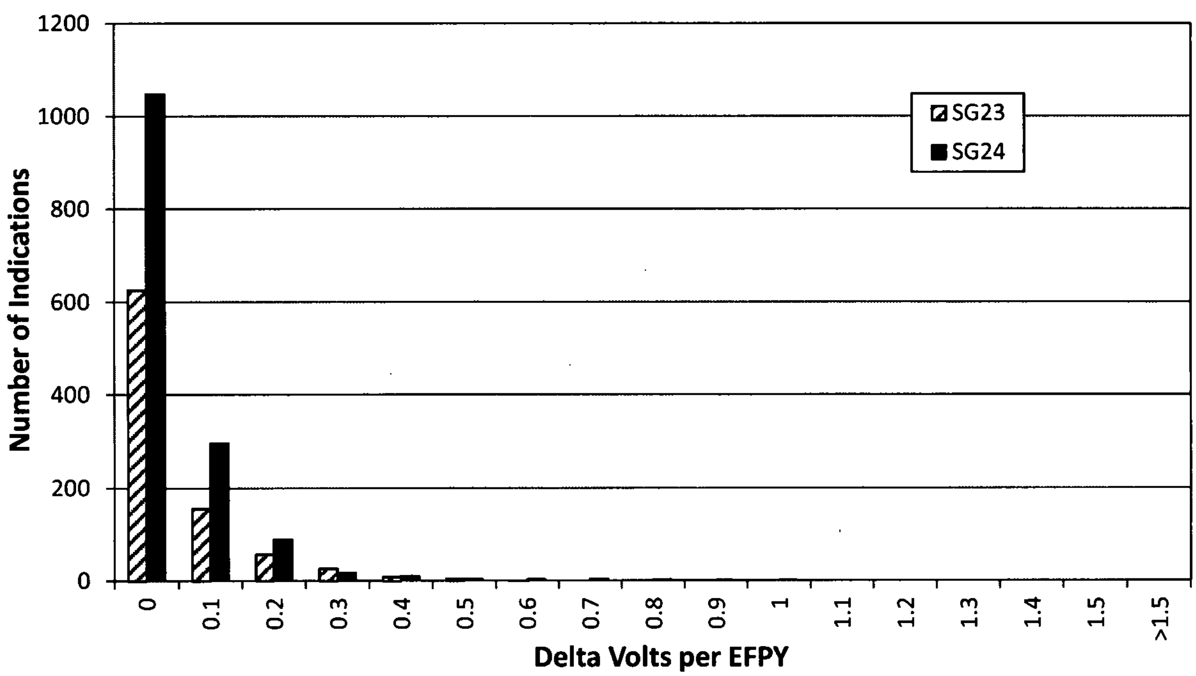


Figure 4-11: Cycle 17 vs. Cycle 16 Growth Comparison

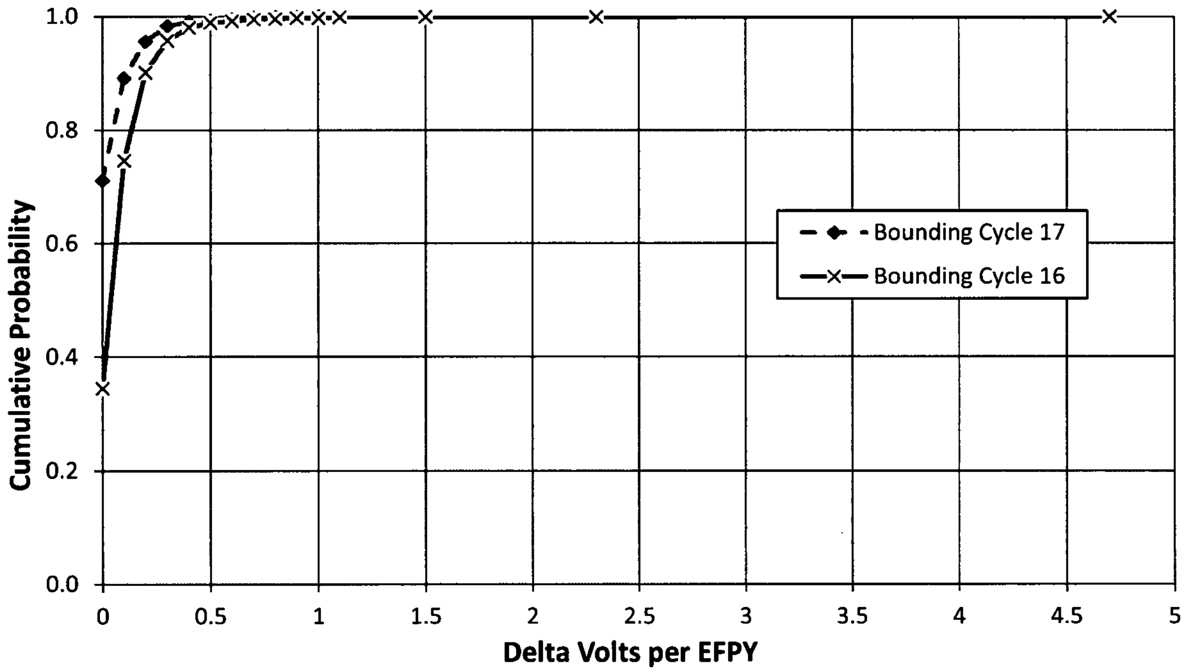


Figure 4-12: Voltage Change vs. BOC Voltage for SG21

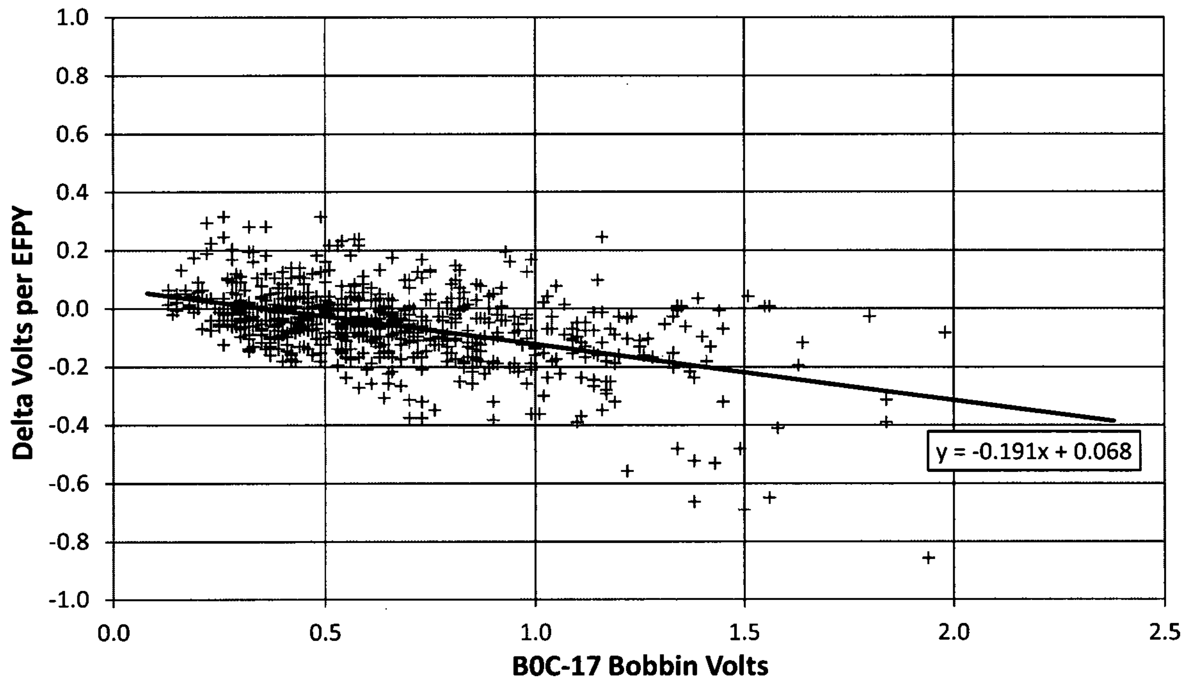


Figure 4-13: Voltage Change vs. BOC Voltage for SG22

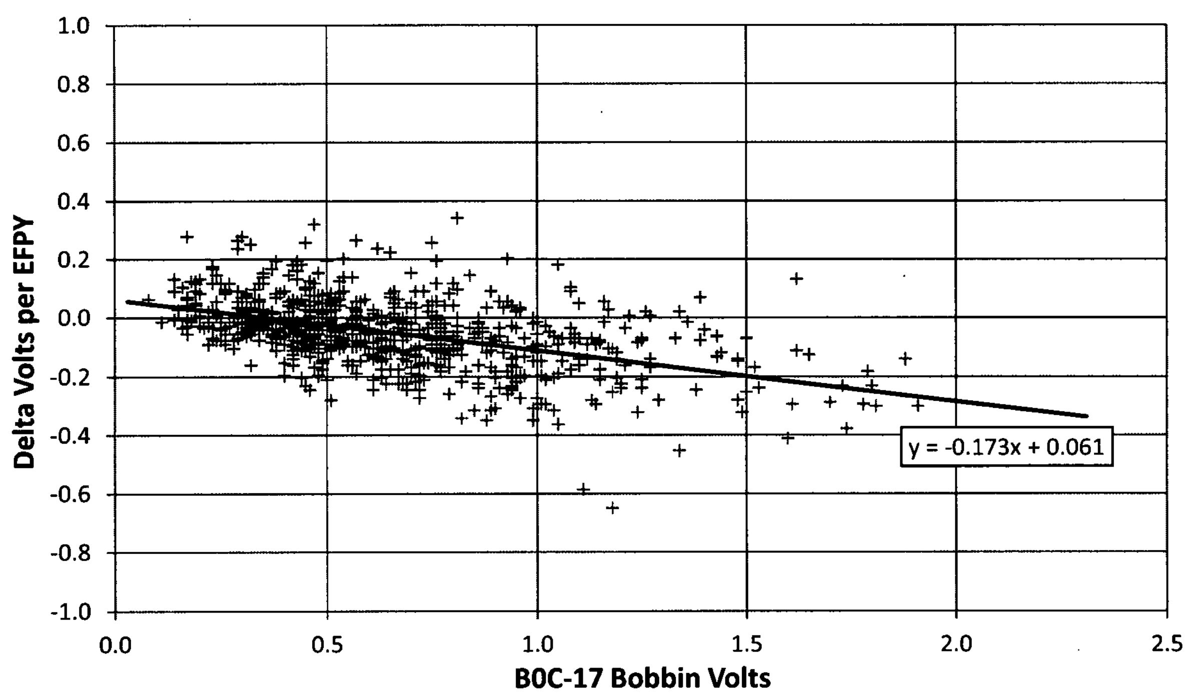


Figure 4-14: Voltage Change vs. BOC Voltage for SG23

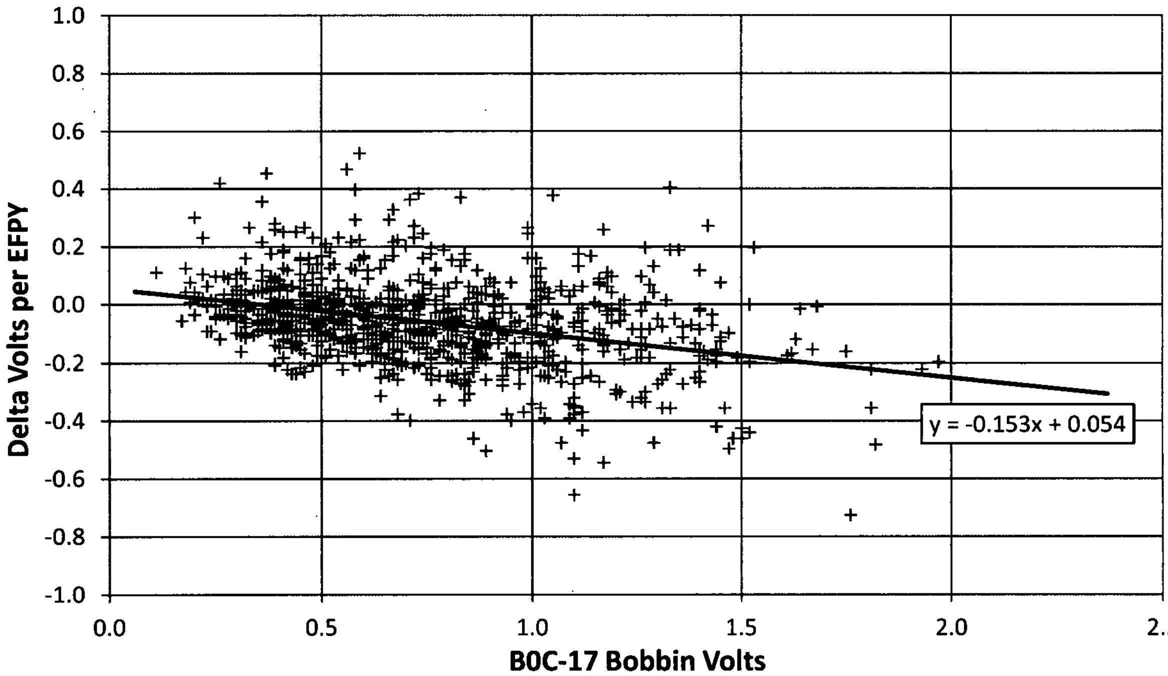


Figure 4-15: Voltage Change vs. BOC Voltage for SG24

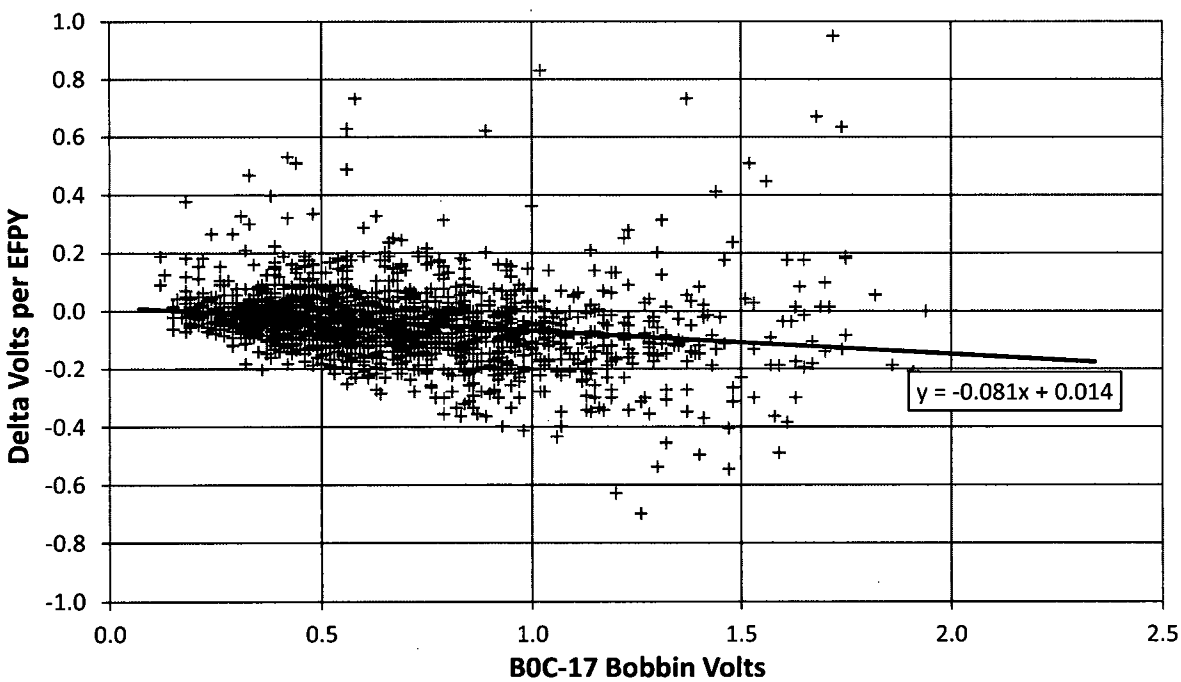


Figure 4-16: Voltage Change vs. BOC Voltage for All SGs

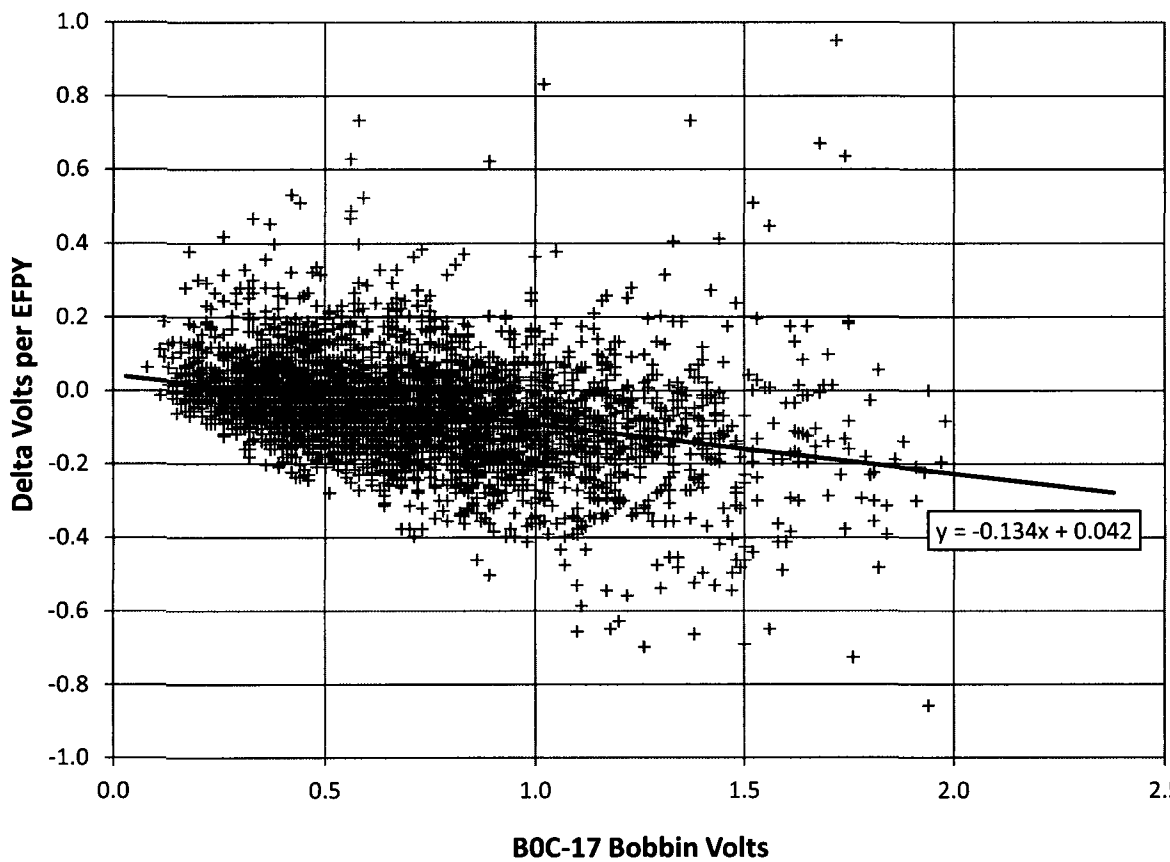


Figure 4-17: Bobbin Volts vs. +Point™ Volts for 2C17

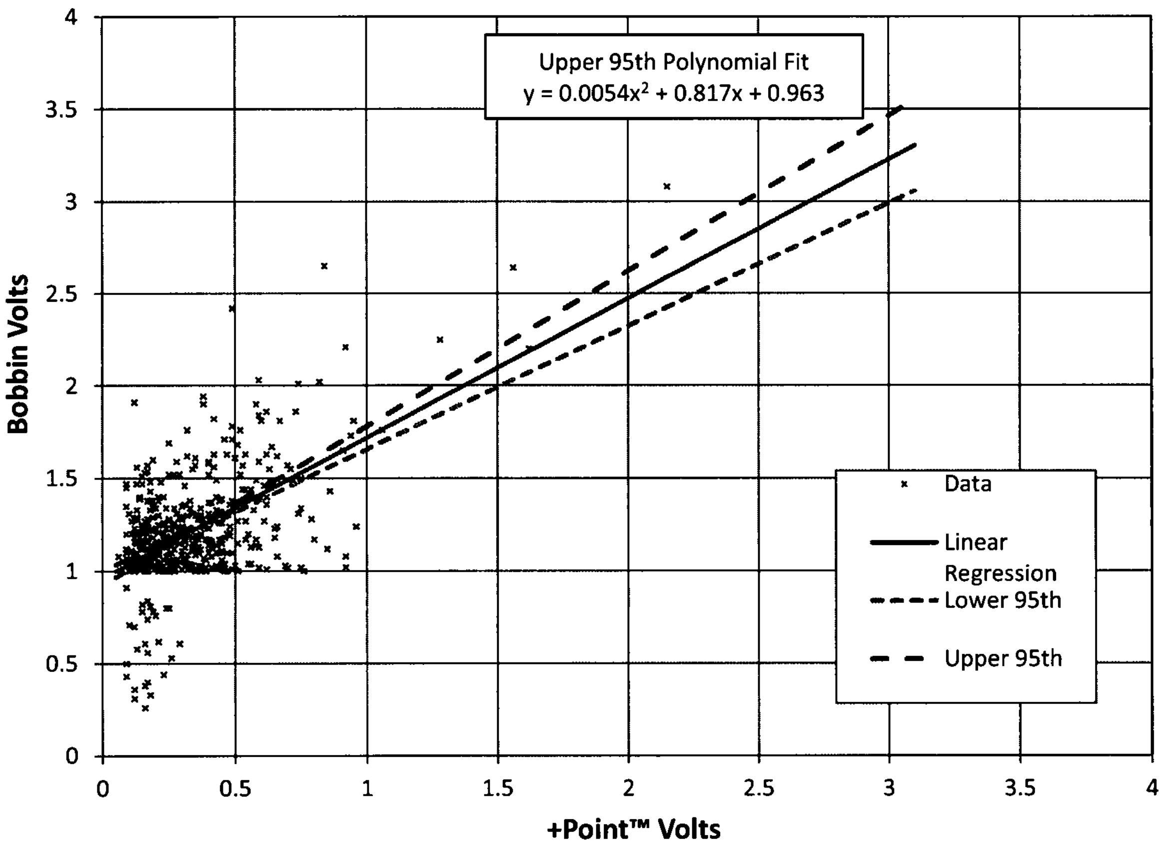


Figure 4-18: 2C17 Probe Wear Voltage Comparison

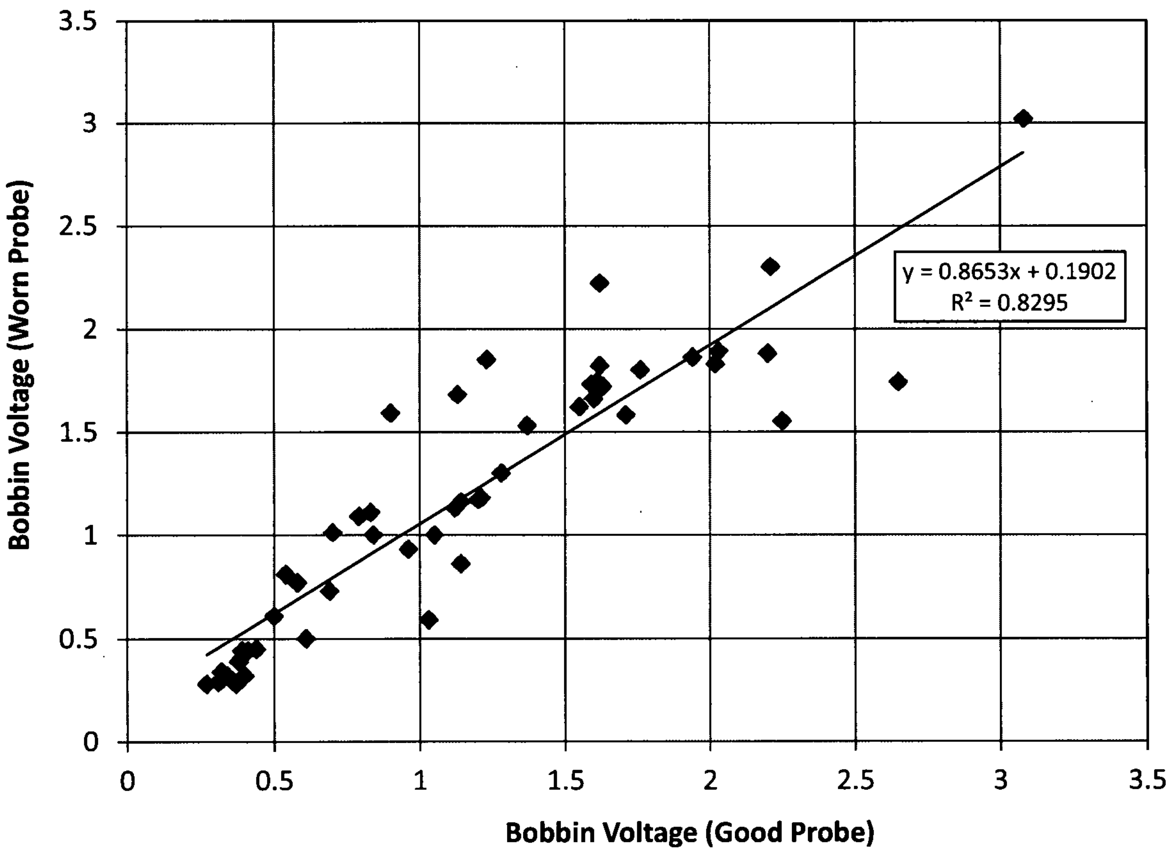
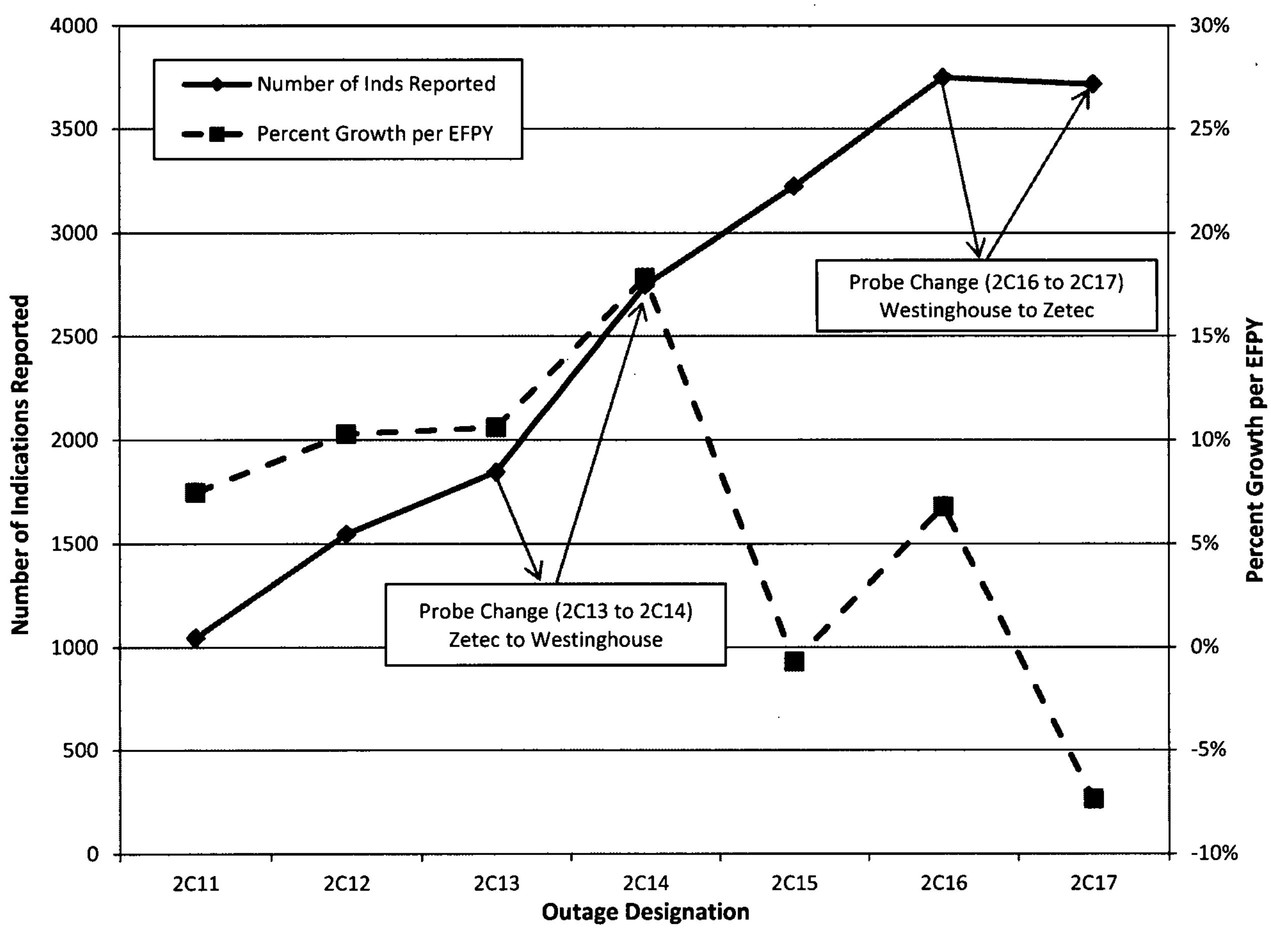


Figure 4-19: Bobbin Indication Growth History



5.0 DATABASES APPLIED FOR LEAK AND BURST CORRELATIONS

Per GL 95-05, the databases used to perform the tube integrity evaluations should be the latest NRC approved industry database. The latest approved correlations are those contained in Addendum 7 of the EPRI ARC Database [13]. The parameters for these correlations are provided in this section.

5.1 Burst Pressure Correlation

For the case of the burst pressure versus voltage correlation, the Addendum 7 database contained in Reference [13], meets all GL 95-05 requirements and was used in the as-found EOC-17 calculations and the EOC-18 projections. The correlation parameters were taken from Reference [13] and are shown in Table 5-1.

Table 5-1: Burst Pressure vs. Bobbin Amplitude Correlation

$$P_B = a_0 + a_1 \log(Volts)$$

Parameter	Addendum 6
Intercept, a_0	7.4801
Slope, a_1	-2.4002
r^2	79.67%
Std. Dev., σ_{Error}	0.8802
Mean Log(*V*)	0.3111
SS of Log(*V*)	51.6595
N (data pairs)	100
Structural Limit (2560 psi) (1)	7.51V
Structural Limit (2405 psi) (1)	9.40V
p Value for a_1 (2)	$5.60 \cdot 10^{-36}$
Reference σ_f	68.78 ksi (3)

Notes: The number of significant figures reported simply corresponds to the output from the calculation code and does not represent true engineering significance.

(1) Values reported correspond to applying a safety factor of 1.4 on the differential pressure associated with a postulated SLB event.

(2) Numerical values are reported only to compare the calculated result to a criterion value of 0.05. For such small values the relative change is statistically meaningless.

(3) This is the flow stress value to which all data was normalized prior to performing the regression analysis.

5.2 Probability of Leak and Conditional Leak Rate

Reference [13] presents the results of the regression analysis for the leak rate correlation using the Addendum 7 leak rate database for 7/8" tubes. It should be noted that, for the 2405 psi delta pressure, the one-sided p-value for the slope parameter in the voltage dependent leak rate correlation is 0.5%, which meets the 5% threshold for an acceptable correlation specified in Generic Letter 95-05. AREVA computer simulations include the slope sampling method for the leak rate correlation that is presented in Reference [13].

The methodology used in the calculation of these parameters is consistent with NRC criteria in GL 95-05. The probability of leak and leak rate correlation parameters used in the CM and OA were taken from Reference [13] and are shown in Table 5-2 and Table 5-3, respectively.

Table 5-2: Probability of Leak Correlation

$$\Pr(Leak) = \frac{1}{1 + e^{-[b_1 + b_2 \log(Volts)]}}$$

Parameter	Addendum 6
Intercept, b_1	-5.0407
Slope, b_2	7.5434
V_{11} (1)	1.3311
V_{12}	-1.7606
V_{22}	2.7744
DoF (2)	118
Deviance	32.37
Pearson SD	0.611
MSE	0.279

Notes:
1) Parameters V_{ij} are elements of the covariance matrix of the coefficients, b_i of the regression equation.
2) Degrees of freedom.

Table 5-3: Leak Rate vs. Bobbin Amplitude Correlation (2405 psi)

$$Q = 10^{[b_3 + b_4 \log(Volts)]}$$

Parameter	Addendum 6
Intercept, b_3	-0.8039
Slope, b_4	1.2077
Index of Deter., r^2	20.0%
Std. Error	0.7774
Mean of Log(Q)	0.5090
Std. Dev. of Log(Q)	22.6667
p Value for b_4	0.5%
Data Pairs, N	32
Mean of Log(V)	1.0871
SS of Log(V)	3.1116

Note: The number of significant figures reported simply corresponds to the output from the calculation code and does not represent true engineering significance.

6.0 OTHER MISCELLANEOUS INPUTS

This section provides other miscellaneous inputs necessary for the tube integrity evaluations documented in this report.

6.1 Tube Material Properties

Since the burst pressure for a given flaw varies with the material properties of the tube, the material properties of the tubes must be included as an input into the POB program. This data was obtained from Reference [7]. The values used for the both the condition monitoring and operational assessment calculations were taken directly from Reference [7] and were a mean flow stress of 68.78 ksi and a standard deviation of the flow stress of 3.1725 ksi.

6.2 Probability of Detection

The condition monitoring assessment in Section 7.0 provides an evaluation of the "as-found" conditions and, therefore uses a probability of detection (POD) of 1.

For the operational assessment, a POD must be applied to account for those indications that may have been present but not reported and, hence, returned to service for Cycle 18. Although the use of a voltage-dependent POD has been approved for use at SQN2, the analyses presented in this report use the standard and more conservative POD of 0.6 from GL 95-05.

6.3 Cycle Lengths

The actual cycle length from Cycle 17 and the projected length for the upcoming cycle were both taken from Reference [10].

The actual operating length of Cycle 17 was used to calculate the growth of indications in terms of change in voltage per EFPY (Effective Full Power Year). Per Reference [10], the operating length of Cycle 17 was 523.0 EFPD (Effective Full Power Days). Converting this value to EFPY using a calendar year of 365.25 days gives a cycle length of 1.432 EFPY (523 / 365.25).

The expected operating length of the current operating cycle (Cycle 18) is needed to project conditions at the end of Cycle 18. This value was provided in Reference [10] as 473.0 EFPD. Converting this value to EFPY gives a cycle length of 1.295 EFPY for Cycle 18. For the operational assessment (Section 8.0), this value was rounded up to 1.30 EFPY.

6.4 NDE Uncertainties

NDE (Non-Destructive Examination) uncertainties must be considered in both the condition monitoring and operational assessments documented in this report. The NDE uncertainties used in the calculations documented herein are provided in Reference [7]. 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 implementation of the probe wear criteria discussed in Section 4.4. 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 provided in both tabular and graphical format in Table 6-1 and Figure 6-1.

Table 6-1: NDE Uncertainty Distributions

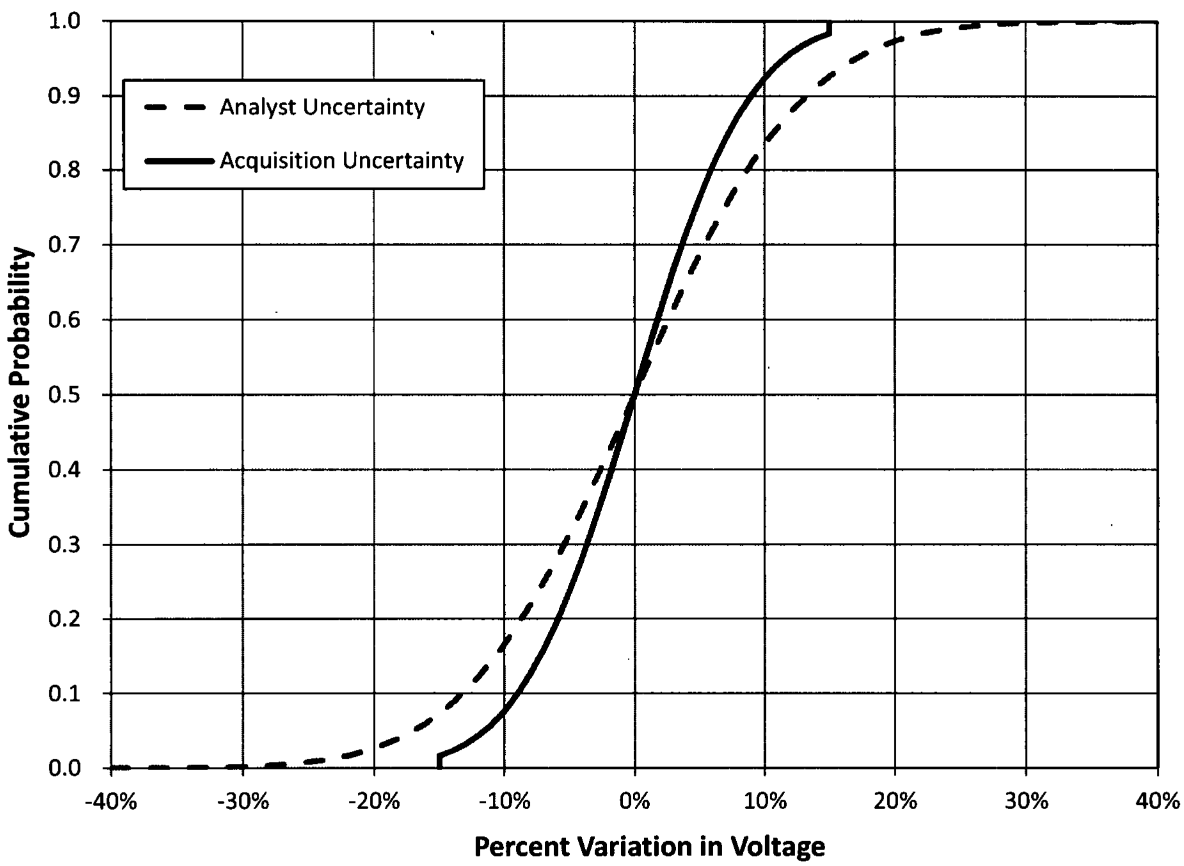
Analyst Uncertainty

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 6-1: NDE Uncertainty Distributions



7.0 2C17 CONDITION MONITORING

This section provides the 2C17 condition monitoring results as well as a comparison to the projections from the previous operational assessment prepared after the 2C16 outage [9]. The condition monitoring assessments were performed using AREVA monte carlo codes [4] [5]. All of the calculations performed for the condition monitoring assessment were based on 500000 monte carlo simulations.

The condition monitoring assessment is an evaluation of the as-found conditions. The condition monitoring assessment, therefore, uses a POD of 1.0 and includes no growth component. Material property and NDE uncertainties, however, are included as discussed in Sections 6.1 and 6.4.

The leak rate and probability of burst (POB) results are provided in Table 7-1. This table also provides a comparison to the projected leak rate and POB from the previous operational assessment. As shown in the table, the as-found leak rate, POB, and number of indications were all significantly under the values projected from the previous operational assessment. The as-found leak rate and POB are also well below the acceptance criteria of 3.7 gpm for leak rate and 1.0E-02 for POB.

Table 7-2 provides a comparison of the as-found voltages to the projected voltages from the previous operational assessment. As shown in this table, the numbers of indications detected during the 2C17 inspection as well as the voltages of the indications were well bounded by the previous operational assessment.

Table 7-1: 2C17 Condition Monitoring Leak Rate and POB Results

Summary of GL 95-05 ARC Calculations EOC-17 (As-found) vs. Projections					
		SG21	**SG22**	**SG23**	**SG24**
Number of DSI Plus AONDB	As-Found	643	716	878	1478
	Projected (1)	1082	1172	1445	2455
Leak Rate[2,3] (gpm)	As-Found	0.108	0.118	0.227	0.427
	Projected	0.654	0.694	1.07	1.67
POB(1)	As-Found	4.62×10^{-5}	6.05×10^{-5}	9.05×10^{-5}	1.42×10^{-4}
	Projected	6.53×10^{-4}	7.25×10^{-4}	1.01×10^{-3}	1.80×10^{-3}
Acceptance Criteria		1.0×10^{-2} (POB)		3.7 gpm	

Notes: (1) The 95% Upper Confidence Limit (UCL) is based on the number of trials with one or more failures.
(2) Equivalent volumetric rate at room temperature.
(3) The calculated total leak rate reflects the upper 95% quantile value at an upper 95% confidence bound.

Table 7-2: As-Found EOC-17 vs. Projected EOC-17 Conditions

Voltage Bin	SG21		SG22		SG23		SG24	
	As-Found	Projected	As-Found	Projected	As-Found	Projected	As-Found	Projected
0.1	1	1.07	4	1.27	9	0.25	4	0.72
0.2	45	12.99	32	15.98	22	6.76	45	17.79
0.3	68	40.69	73	41.6	75	30.04	162	66.72
0.4	73	72.74	120	79.6	107	69.08	207	144.53
0.5	103	101.48	105	118.23	108	108.63	210	221.71
0.6	91	120.37	102	139.43	113	137.15	208	271.89
0.7	84	124.9	86	139.53	110	151.99	165	285.56
0.8	47	118	57	126.92	86	154.15	118	270.1
0.9	38	103.95	37	109.01	57	144.91	105	240.17
1	37	87.19	33	90.23	51	128.06	74	204.72
1.1	21	70.54	21	73.02	39	109.25	49	168.23
1.2	11	55.87	12	57.96	33	91.99	50	134.08
1.3	9	43.75	17	44.96	28	76.46	15	104.83
1.4	6	33.77	9	34.19	20	61.9	16	81.05
1.5	3	25.62	5	25.61	4	48.36	11	62.18
1.6	4	19.07	1	19.1	8	36.27	11	47.42
1.7	0	13.95	1	14.41	5	26.31	6	35.82
1.8	1	10.12	0	10.9	0	18.61	6	26.77
1.9	1	7.25	1	8.24	2	13.06	5	19.72
2	0	5.17	0	6.14	1	9.11	1	14.21
2.1	0	3.63	0	4.42	0	6.37	3	10.03
2.2	0	2.52	0	3.08	0	4.43	1	7
2.3	0	1.73	0	2.11	0	3.08	2	4.86
2.4	0	1.18	0	1.43	0	2.12	0	3.42
2.5	0	0.8	0	0.98	0	1.45	1	2.43
2.6	0	0.55	0	0.68	0	0.98	0	1.72
2.7	0	0.39	0	0.47	0	0.66	2	1.22
2.8	0	0.29	0	0.33	0	0.45	0	0.87
2.9	0	0.22	0	0.24	0	0.3	0	0.62
3	0	0.17	0	0.18	0	0.2	0	0.45
4	0	0.69	0	0.75	0	0.94	0	1.79
5	0	0	0	0	0	0.61	0	0.28
>5	0	1	0	1	0	1.09	0	2.39
Total	643	1081.66	716	1172	878	1445.02	1477	2455.3
<=1	587	783.38	649	861.8	738	931.02	1298	1723.91
>1	56	298.28	67	310.2	140	514	179	731.39
>2	0	13.17	0	15.67	0	22.68	9	37.08
>3	0	1.69	0	1.75	0	2.64	0	4.46
>4	0	1.69	0	1.75	0	2.64	0	4.46
POB	4.62E-05	6.53E-04	6.05E-05	7.25E-04	9.05E-05	1.01E-03	1.42E-04	1.80E-03
Leak Rate	0.11	0.65	0.12	0.69	0.23	1.07	0.43	1.67

8.0 OPERATIONAL ASSESSMENT

This section provides the results of the EOC-18 POB and leak rate projections. The operational assessment calculations were performed using AREVA monte carlo codes [4] [5]. All of the calculations performed for the operational assessment were based on 500000 monte carlo simulations.

The AREVA monte carlo simulation codes develop the BOC-18 voltage distributions based on the as-found EOC-18 voltage distributions (Table 4-3 through Table 4-6) adjusted for both POD (Section 6.2) and the tubes removed from service (Table 4-3 through Table 4-6). As discussed previously, the operational assessment documented herein uses a conservative probability of detection (POD) of 0.6 from GL 95-05.

The operational assessment also includes NDE sizing uncertainties (Section 6.4), material property uncertainties (Section 6.1), and growth of indications (Section 4.2). As discussed in Section 4.2, the Cycle 16 growth rates bounded the Cycle 17 growth rates and were, therefore, used in the EOC-18 projections. The bounding Cycle 16 growth distribution is provided in Table 4-8. The Cycle 18 operating interval used in the operational assessment was 1.30 EFPY (Section 6.3).

Table 8-1 provides the leak rate and POB operational assessment results. As shown in the table, the projected leak rate and POB are well below the acceptance criteria of 3.7 gpm for leak rate and 1.0E-02 for POB.

The projected EOC-18 voltage distributions are provided in Table 8-2. These results are also provided graphically in Figure 8-1 through Figure 8-4 for SG21 through SG24, respectively.

Table 8-1: Operational Assessment Projections for EOC-18 Conditions

Summary of GL 95-05 ARC Calculations Operational Assessment for EOC-18 Projections				
	SG21	**SG22**	**SG23**	**SG24**
Leak Rate (gpm)	0.45	0.49	0.80	1.24
POB	4.26×10^{-4}	4.12×10^{-4}	7.04×10^{-4}	1.10×10^{-3}
Acceptance Criteria	1.0×10^{-2} (POB)		3.7 gpm	

Table 8-2: Projected EOC-18 Voltage Distributions (0.6 POD)

Voltage Bin	SG21	SG22	SG23	SG24
<=0.1	1.80	3.07	5.53	3.43
0.2	26.30	21.66	19.41	33.01
0.3	59.28	59.40	55.95	112.31
0.4	89.47	108.13	102.17	203.20
0.5	116.51	143.49	138.53	269.22
0.6	133.91	156.52	160.10	300.39
0.7	133.31	150.64	166.33	294.46
0.8	118.04	131.08	157.27	262.65
0.9	96.85	105.66	137.23	220.85
1	76.65	81.32	113.95	178.95
1.1	59.14	61.41	92.88	140.37
1.2	43.95	46.02	75.35	106.77
1.3	31.58	34.58	60.33	78.89
1.4	22.38	25.84	46.97	57.24
1.5	15.67	18.90	35.29	41.43
1.6	10.97	13.30	25.57	30.23
1.7	7.63	8.97	18.06	22.50
1.8	5.25	5.87	12.51	16.85
1.9	3.60	3.73	8.52	12.53
2	2.43	2.32	5.71	9.19
2.1	1.63	1.44	3.80	6.63
2.2	1.07	0.90	2.51	4.74
2.3	0.70	0.59	1.64	3.39
2.4	0.46	0.39	1.07	2.42
2.5	0.31	0.26	0.70	1.75
2.6	0.20	0.18	0.46	1.27
2.7	0.13	0.12	0.30	0.94
2.8	0.08	0.08	0.20	0.71
2.9	0.05	0.05	0.13	0.54
3	0.04	0.03	0.08	0.42
3.1	0.03	0.03	0.06	0.33
3.2	0.05	0.04	0.06	0.30
3.3	0.06	0.07	0.09	0.32
3.4	0.07	0.09	0.10	0.31
3.5	0.08	0.09	0.10	0.27
3.6	0.07	0.08	0.09	0.23
3.7	0.06	0.06	0.08	0.18
3.8	0.04	0.05	0.07	0.14
3.9	0.03	0.03	0.05	0.11
4	0.02	0.02	0.04	0.08
5	0.05	0.06	0.11	0.18
6	0.00	0.00	0.00	0.01
7	0.59	0.66	0.74	1.30
8	0.11	0.12	0.22	0.28
>8	0.00	0.00	0.00	0.01
Total	1060.67	1187.33	1450.33	2421.33

Figure 8-1: Projected EOC-18 Voltage Distribution for SG21

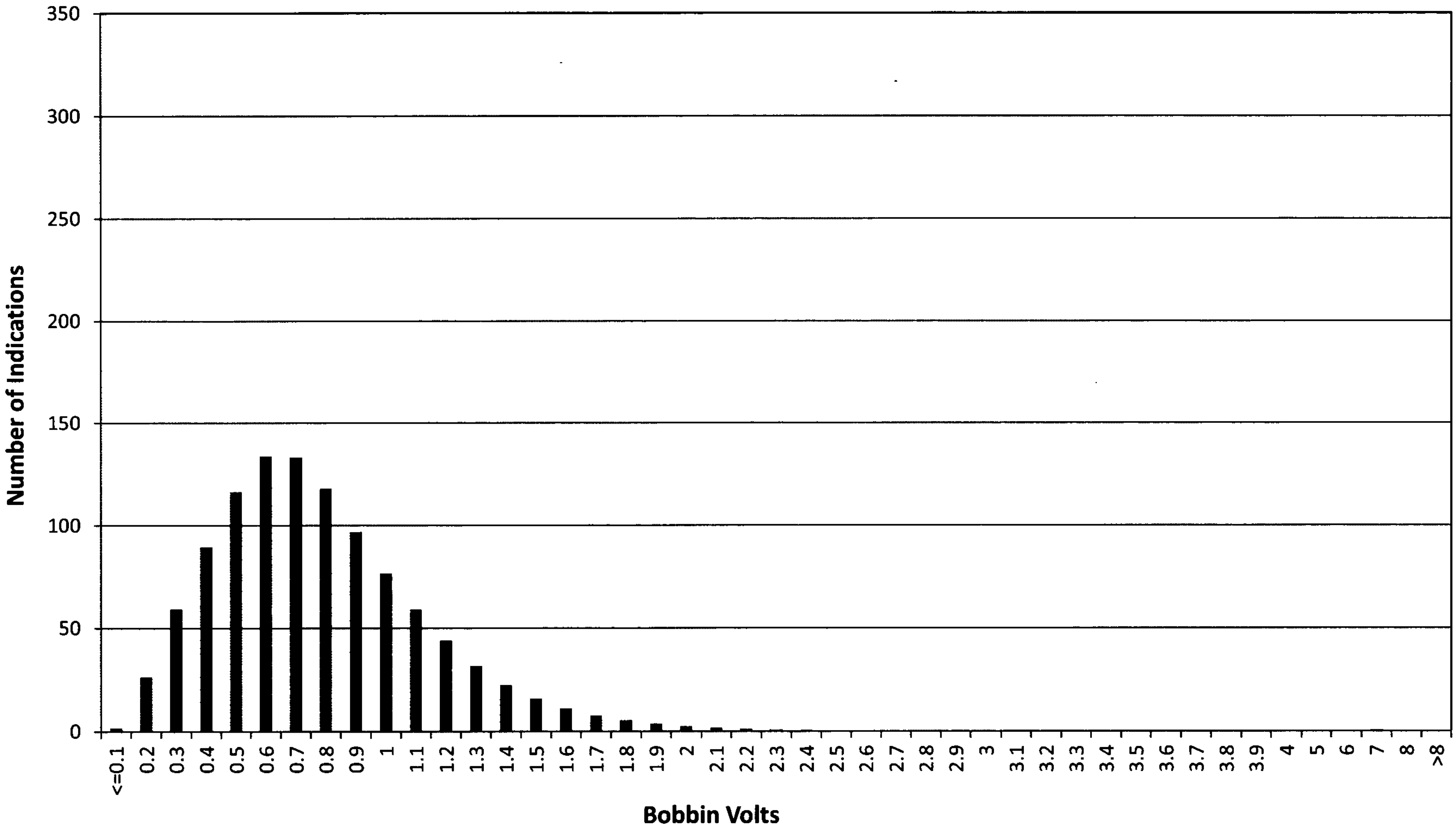


Figure 8-2: Projected EOC-18 Voltage Distribution for SG22

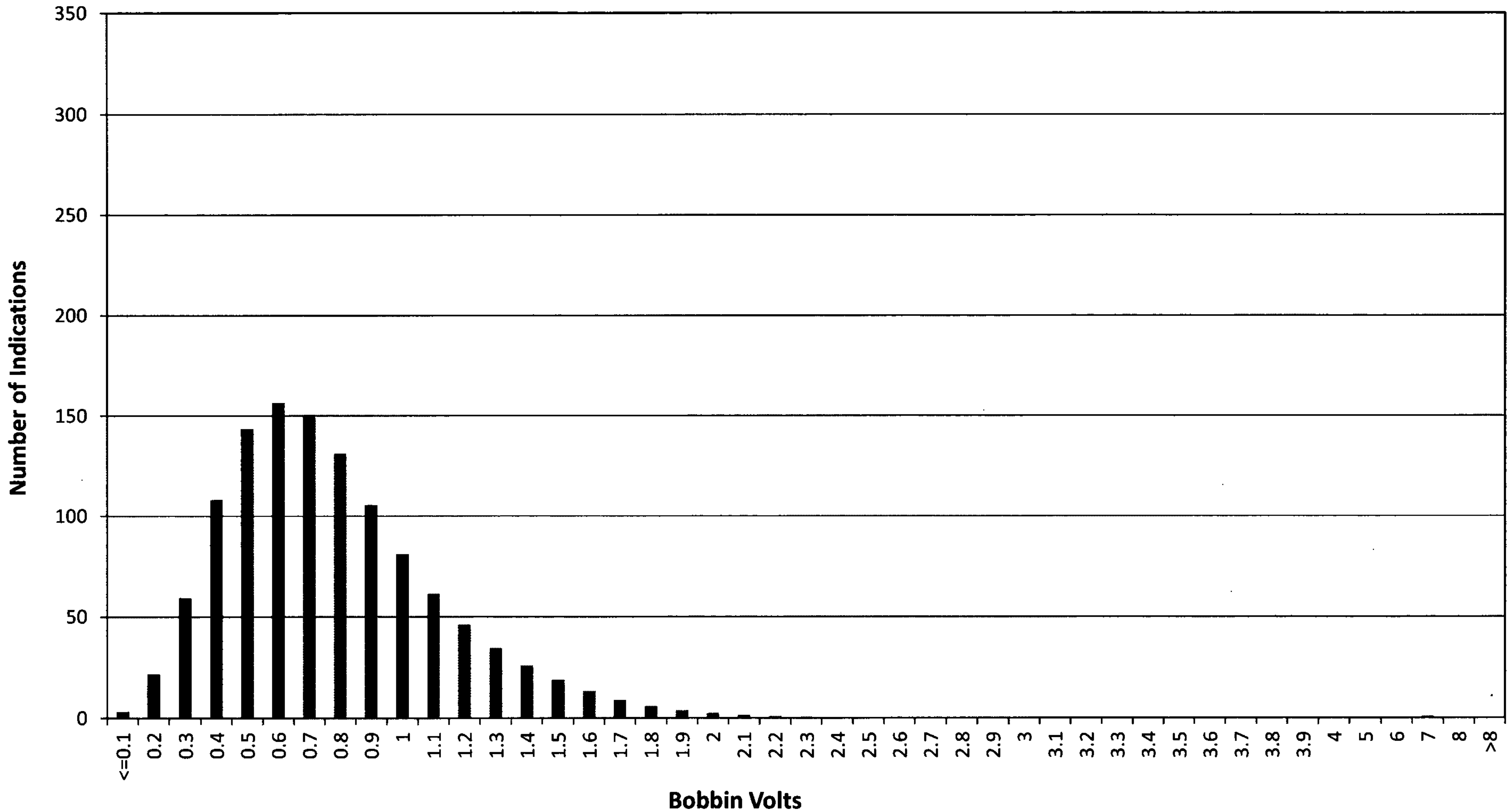


Figure 8-3: Projected EOC-18 Voltage Distribution for SG23

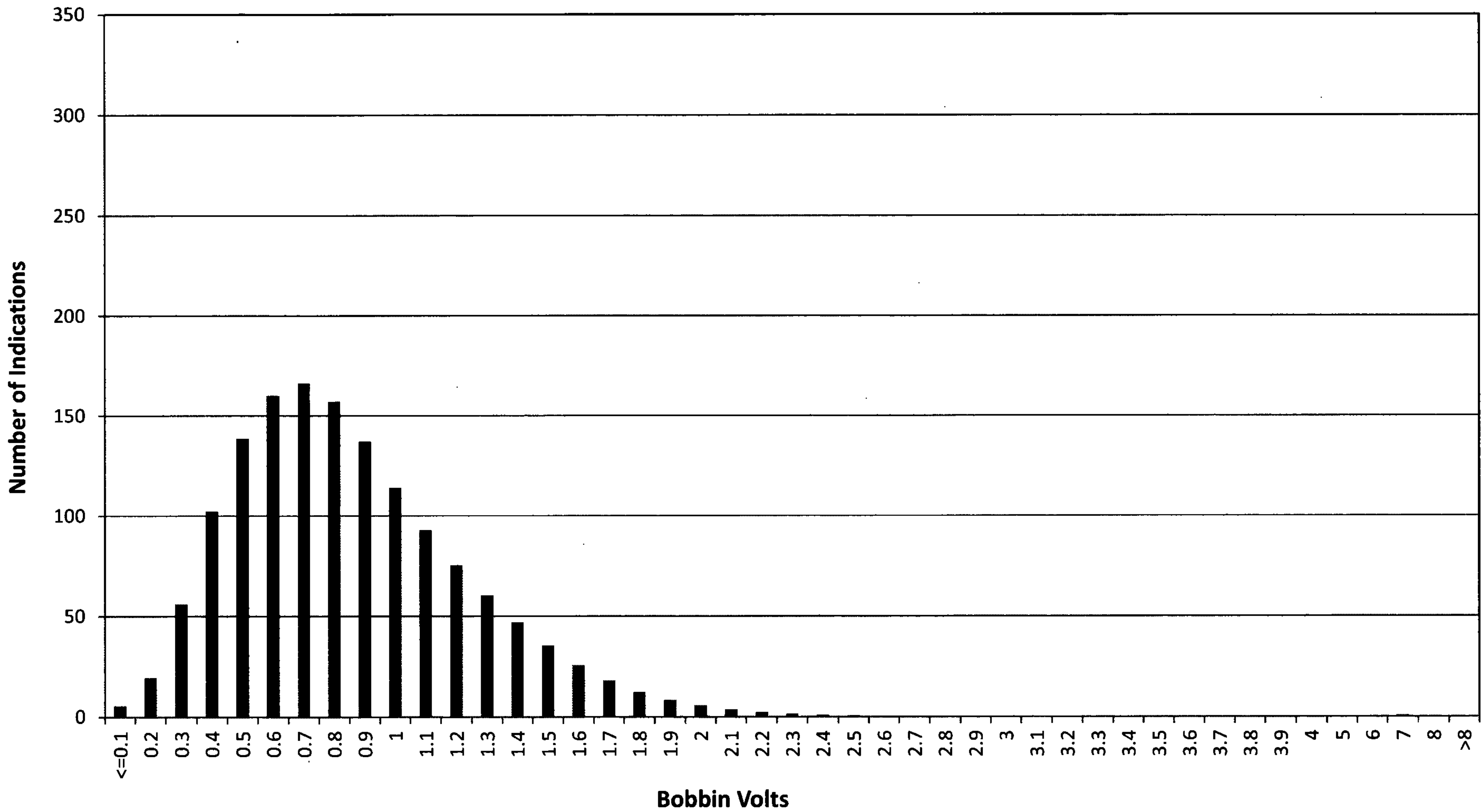
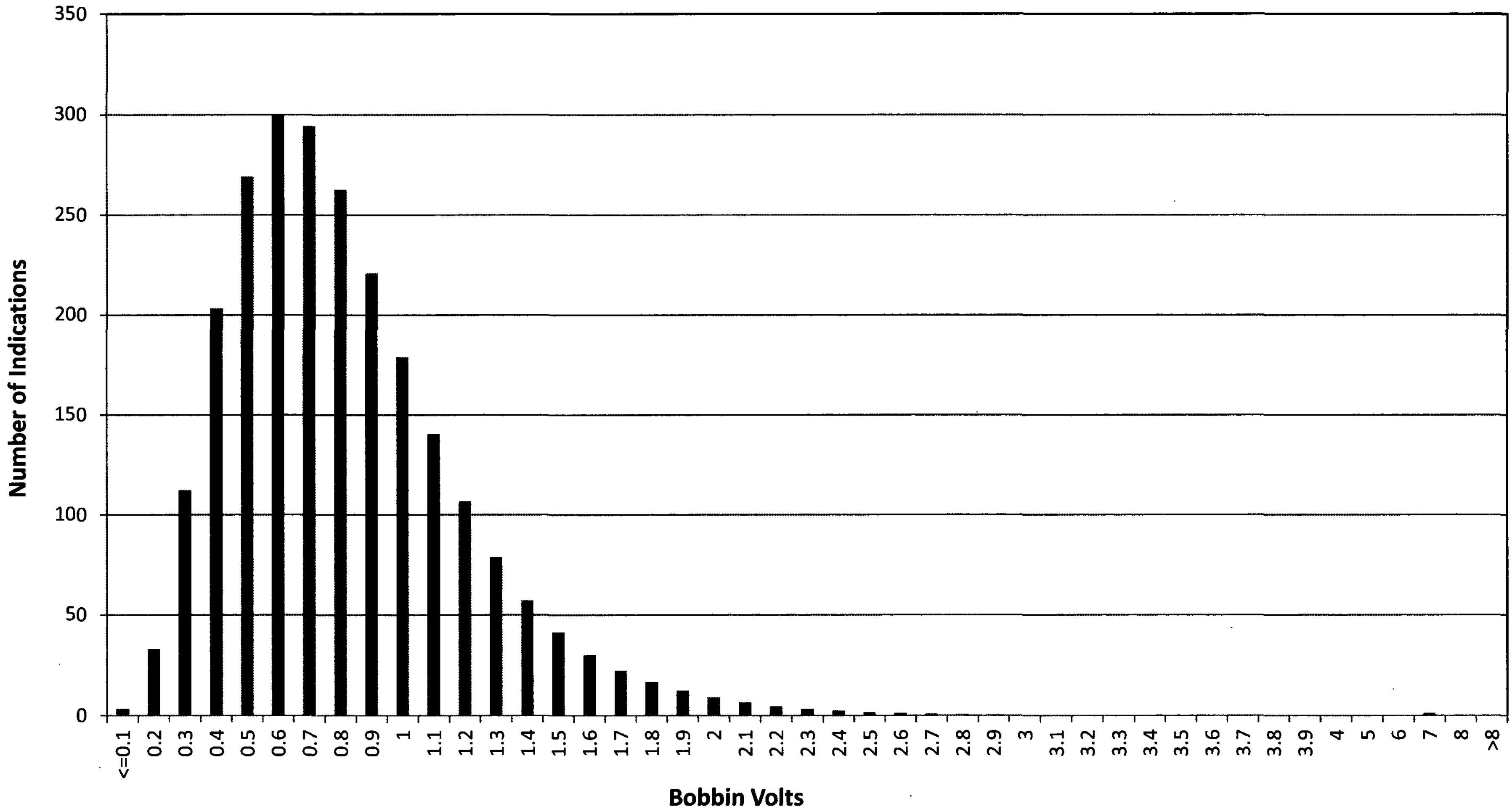


Figure 8-4: Projected EOC-18 Voltage Distribution for SG24



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ENCLOSURE 2

TENNESSEE VALLEY AUTHORITY
SEQUOYAH NUCLEAR PLANT, UNIT 2

SEQUOYAH 2C17 W-STAR 90-DAY REPORT
Document No. 51-9168622-000