FENOC
FirstEnergy Nuclear Operating Company

Beaver Valley Power Station
P.O. Box 4
Shippingport, PA 15077-0004

Lew W. Myers
Senior Vice President

412-393-5234
Fax: 724-643-8069

July 13, 2000
L-00-096

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

Subject: Beaver Valley Power Station, Unit No. 1
Docket No. 50-334, License No. DPR-66
Cycle 14 Steam Generator Tube Inspection 90 Day Report

Reference 1: NRC Generic Letter 95-05, "Voltage-Based Repair Criteria for the Repair of Westinghouse Steam Generator Tubes Affected by Outside Diameter Stress Corrosion Cracking," August 3, 1995.

Enclosed is a copy of the "Beaver Valley Unit 1, Cycle 14 Voltage-Based Repair Criteria 90 Day Report," which supports continued implementation of the 2.0 volt repair criteria as outlined in Reference 1. This report provides a summary of the steam generator inspections performed during the thirteenth refueling outage at tube support plate intersections along with postulated steam line break leak rate and tube burst probability analysis results.

The permissible accident-induced primary to secondary leak rate that would maintain offsite and control room doses within the applicable limits of 10 CFR 100 and GDC 19 is currently 3.0 gpm. As explained in FENOC Letter L-00-041, dated March 31, 2000, and FENOC Letter L-00-059, dated May 5, 2000, changes to the Steam Generator Degradation Specific Management database (used to perform projected accident leakage estimates per Reference 1) to account for inclusion of EdF data has caused the projected EOC-14 leak rate calculated to exceed the current allowable accident-induced leakage limit. In response, FENOC will be shortly submitting a License Amendment Request (1A-284) to lower the Beaver Valley Power Station (BVPS) Unit 1 Technical Specification limit for primary coolant specific activity (DEI-131) from 0.35 to 0.20 microcuries/gram. Following NRC approval of this primary coolant specific activity limit reduction, FENOC will be able to revise the BVPS Unit 1 safety analysis to raise the permissible accident-induced primary to secondary leakage rate to 5.5 gpm. The enclosed report has been written assuming the requested BVPS Unit 1 primary coolant Technical Specification limit reduction has been approved and the associated BVPS Unit 1 Steam Line Break analysis has been revised, via 10 CFR 50.59, to allow a maximum permissible accident-induced primary to secondary leakage rate of 5.5 gpm.

AU01

FENOC has currently implemented administrative controls to limit the BVPS Unit 1 primary coolant activity to less than 0.20 microcuries/gram during power operation. These actions were taken pursuant to NRC Generic Letter 91-18 until such time as the technical specification amendment on primary activity can be approved, as previously described in FENOC Letter L-00-059, dated May 5, 2000.

If you have any questions regarding the attached information, please contact Mr. Thomas S. Cosgrove, Manager, Licensing at 724-682-5203.

Sincerely,

Lew W. Myers

c: Mr. D. S. Collins, Project Manager
Mr. D. M. Kern, Sr. Resident Inspector
Mr. H. J. Miller, NRC Region I Administrator
Ms. M. E. O'Reilly (FirstEnergy Legal Department)

SG-00-06-009

BEAVER VALLEY UNIT-1

CYCLE 14 VOLTAGE-BASED REPAIR CRITERIA 90-DAY REPORT

July 2000

Westinghouse Electric Company LLC
Nuclear Services Business Unit
P.O. Box 158
Madison, Pennsylvania 15663-0158

SG-00-06-009

BEAVER VALLEY UNIT-1

CYCLE 14 VOLTAGE-BASED REPAIR CRITERIA 90-DAY REPORT

July 2000

BEAVER VALLEY UNIT-1

CYCLE 14 VOLTAGE-BASED REPAIR CRITERIA 90-DAY REPORT

TABLE OF CONTENTS

		Page No.
1.0	Introduction	1-1
2.0	Summary and Conclusions	2-1
3.0	EOC-13 Inspection Results and Voltage Growth Rates	3-1
	3.1 EOC-13 Inspection Results	3-1
	3.2 Voltage Growth Rates	3-2
	3.3 Probe Wear Criteria	3-3
	3.4 Probability of Prior Cycle Detection (POPCD)	3-4
	3.5 Assessment of RPC Confirmation Rates	3-6
	3.6 NDE Uncertainties	3-6
4.0	Data Base Applied for Leak and Burst Correlations	4-1
5.0	SLB Analysis Methods	5-1
6.0	Bobbin Voltage Distributions	6-1
	6.1 Probability of Detection	6-1
	6.2 Cycle Operating Time	6-2
	6.3 Calculation of Voltage Distributions	6-2
	6.4 Predicted EOC-14 Voltage Distributions	6-2
	6.5 Comparison of Predicted and Actual EOC-13 Voltage Distributions	6-3
7.0	Tube Leak Rate and Tube Burst Probabilities	7-1
	7.1 Calculation of Leak Rate and Tube Burst Probabilities	7-1
	7.2 Predicted and Actual Leak Rate and Tube Burst Probability for EOC-13	7-1
	7.3 Projected Leak Rate and Tube Burst Probability for EOC-14	7-2
8.0	References	8-1

Beaver Valley Unit - 1

Cycle 14 Voltage-Based Repair Criteria 90 Day-Report

1.0 INTRODUCTION

This report provides the Beaver Valley Unit-1 steam generator tube support plate (TSP) bobbin voltage data summary, together with postulated Steam Line Break (SLB) leak rate and tube burst probability analysis results. These results support continued implementation of the 2.0-volt repair criteria for TSP ODSCC indications during Cycle 14 as outlined in the NRC Generic Letter 95-05 (Reference 8-1). Information required by the Generic Letter is provided in this report including projections of bobbin voltage distributions, leak rates and burst probabilities for Cycle 14 operation. The methodology used in these evaluations is consistent with the NRC SER, Reference 8-2, Westinghouse generic methodology described in Reference 8-3, as well as the methodology reported in the prior 90-day reports for Beaver Valley Unit-1 (References 8-4 through 8-6).

Eddy current (EC) and repair data for TSP indications are provided in Section 3. A large number of tubes were deplugged in the current inspection in steam generators (SGs) A and B and inspected in accordance with GL 95-05. Tubes containing only TSP indications were returned to service after installing sleeves at all 1H intersections with a bobbin voltage above 1 volt and 2H intersections with a bobbin voltage above 1.2 volts. All deplugged tubes with bobbin voltages <1 volt at the 3H elevation and above were left in service. The remaining deplugged tubes were replugged.

The actual EOC-13 voltage distributions as well as leak rates and tube burst probabilities calculated for these distributions are compared in Section 6 with the projections for EOC-13 conditions presented in the last 90-day report (Reference 8-4). Leak rates and burst probabilities for the projected EOC-14 voltage distributions are reported in Section 7 and compared with allowable limits.

2.0 SUMMARY AND CONCLUSIONS

SLB leak rate and tube burst probability analyses were performed for all three SGs based on their actual measured EOC-13 voltage distributions and the results compared with the projections presented in the last 90-day report (Reference 8-4). SG-A was predicted to be the limiting SG at EOC-13 and was also found limiting based on the actual measured EOC-13 voltage data. The total number of ODSCC indications found at TSPs in each SG in the current inspection and the measured peak voltages are less than those projected at the beginning of the cycle per the GL 95-05 requirements using a constant POD of 0.6 as well as the voltage-dependent POPCD. The projected EOC-13 burst probability values for POD=0.6 and POPCD are also below the corresponding values based on the actual measured voltages. However, the SLB leak rates based on the actual EOC-13 voltages are higher than the projections presented in the last 90-day report (Reference 8-4), and the differences are largely attributable to the differences in the probability of leakage (PoL) and leak rate correlations applied for the two analyses. To ensure consistency in the comparison of the leak rates based on the projected and actual EOC-13 voltages, the EOC-13 projection for the limiting SG (SG-A) was repeated using the same PoL and leak rate correlations used for the condition monitoring analysis. The revised leak rate projections for SG-A based on both POD=0.6 and POPCD exceed the calculated leak rate based on the actual measured voltages. Therefore, the leak and burst projection methodology applied for Beaver Valley Unit-1 is conservative.

For the actual EOC-13 bobbin voltage distribution, the largest SLB leak rate is calculated for SG-A, and its magnitude is 1.7 gpm. The projected values based on the latest NRC approved leak and burst database for 7/8" tubes (Reference 8-7) are 2.9 gpm for POD=0.6 and 2.4 gpm for POPCD, both overpredicting the value based on the measured EOC-13 voltage data. These leak rate values were calculated using the leak rate vs. bobbin voltage correlation provided in Reference 8-7. This limiting leak rate (1.7 gpm) is well within the allowable SLB leakage limit of 3.0 gpm for the faulted SG applicable for Cycle 13. All leak rate values quoted are equivalent volumetric rates at room temperature. The corresponding conditional tube burst probability based on the actual SG-A voltage data is 5.3×10^{-5}, and it is well within the NRC reporting guideline of 10^{-2}. The predicted values were 1.2×10^{-4} for POD=0.6 and 6.3×10^{-4} for POPCD. Thus, the results show that the projections based on voltage-dependent POD (POPCD) provide a more realistic but still a conservative estimate for leak rate and burst probability.

SG-A is again predicted to be the limiting SG for Cycle 14 since it had the largest total number of indications at EOC-13 as well as about 42% of all indications over 1 volt returned to service in all 3 SGs. The EOC-14 leak rate projection utilized the PoL and leak rate correlations based on the latest NRC approved database for 7/8" tubes (Reference 8-7). Both the NRC mandated constant POD of 0.6 and the voltage-dependent distribution POPCD are considered.

The allowable accident induced leakage limit during Cycle 13 was 3.0 gpm. An amendment to the Unit-1 technical specifications will be requested to lower the allowable reactor coolant activity limit to 0.2 micro curies/ gram dose equivalent I-131 which will result in a corresponding increase to the permissible SLB leak rate to 5.5 gpm. This technical specification amendment is currently being processed. Provided the technical specification allowable reactor coolant activity limit is revised to 0.2 micro curies/ gram dose equivalent I-131, the SLB leak rate predicted with both constant POD=0.6 (4.5 gpm) and voltage-dependent POPCD (3.4 gpm) will meet the new 5.5 gpm limit for a full Cycle 14 duration of 520 days. The tube burst probability with POD=0.6 for SG-A after full Cycle 14 operation is 1.7×10^{-4}, which is substantially below the NRC reporting guideline of 10^{-2}.

A total of 3024 indications were found in the EOC-13 inspection, of which 506 were over 1 volt and 12 over 2 volts. All indications over 2 volts plus 440 indications under 2 volts were inspected with a RPC probe, and 435 were confirmed as flaws. All 12 indications over 2 volts were confirmed by RPC and repaired. No circumferential indications, axial indications extending outside the TSP, PWSCC or volumetric-type signals were identified by RPC inspection at TSP intersections. RPC inspection of dented intersections did not show any circumferential indications or primary water stress corrosion cracking (PWSCC).

3.0 EOC-13 INSPECTION RESULTS AND VOLTAGE GROWTH RATES

3.1 EOC-13 Inspection Results

In accordance with the guidance provided by the NRC generic letter (Reference 8-1), the EOC-13 inspection of the Beaver Valley Unit-1 SGs consisted of a 100% bobbin probe full length examination of all TSP intersections in the tube bundles of all three SGs. A 0.720 inch diameter probe was used for all hot and cold leg TSPs. Subsequently, RPC examination was performed for all hot leg indications with amplitude above 2 volts (a total of 12 indications in all SGs combined) plus 440 indications below 2 volts. All 12 indications above 2 volts were confirmed as flaws and repaired. Four hundred and twenty-three (423) indications below 2 volts were also confirmed as flaws but were not repaired, as they do not exceed the 2-volt repair limit. There were no circumferential indications at the TSPs, and no indications extending outside the TSPs.

A summary of the EC results for TSP indications in all three steam generators is shown in Table 3-1, which tabulates the number of field bobbin indications, the number of those indications that were RPC inspected, the number of RPC confirmed indications, and the number of indications removed from service due to tube repairs. The indications that remain active for Cycle 14 operation is the difference between the observed and the ones removed from service. It is noted that, in general, the bin labelled 2 volts in Table 3-1 may contain indications with voltages between 1.9+ up to and including 2 volts; but, for the present inspection, all 6 indications falling into that bin had voltages between 1.91 to 1.98 volts (i.e., no RPC confirmed 2-volt indications were returned to service).

A large number of tubes were deplugged in the current inspection in SGs A and B and inspected in accordance with GL 95-05. Tubes containing only TSP indications were returned to service after installing sleeves at all 1H intersections with a bobbin voltage above 1 volt and 2H intersections with a bobbin voltage above 1.2 volts. The remaining deplugged tubes with TSP indications ≥1 volt were replugged. A total of 103 indications in SG-A and 78 indications in SG-B were returned to service with the deplugged tubes, and these indications were included in the operational assessment for Cycle 14. No tubes were deplugged in SG-C with the intention of returning them to service.

A review of Table 3-1 indicates that more indications (a quantity of 1361, with 207 indications above 1.0 volt) will be returned to service in SG-A. Clearly, SG-A will be the limiting SG at EOC-14. Of the 27 indications removed from service, only 12 indications, all exceeding 2 volts, were repaired due to ODSCC at TSPs. The rest of the indications are in tubes plugged for degradation mechanisms other than ODSCC at TSPs.

Figure 3-1 shows the actual bobbin voltage distribution for tubes that were in service

during Cycle 13, as determined from the EOC-13 EC inspection. Figure 3-2 shows the distribution of the EOC-13 bobbin indications that were repaired and taken out of service, and Figure 3-3 shows the bobbin voltage distribution of indications returned to service for BOC-14.

The distribution of EOC-12 indications as a function of support plate location is summarized in Table 3-2 and plotted in Figure 3-4. The data show a strong predisposition of ODSCC to occur in the first few hot leg TSPs (2848 out of 3024 indications occurred at the hot leg intersections in the first three TSPs), although the mechanism extended to higher TSPs. Only 5 indications were detected on the cold leg side in the EOC-13 inspection. This distribution indicates the predominant temperature dependence of ODSCC at Beaver Valley Unit-1, similar to that observed at other plants.

3.2 Voltage Growth Rates

For projection of leak rates and tube burst probabilities at the end of Cycle 14 operation, voltage growth rates were developed from EOC-13 inspection data and a reevaluation of the same indications from the EOC-12 inspection EC signals. Table 3-3 shows the average growth rate for each SG during Cycle 13. SG-B has a slightly larger average growth rate (0.108 volts/EFPY) than the other 2 SGs. The average growth rates observed for all voltages vary between 16.9% (0.097 volts/EFPY) and (0.108 volts/EFPY) 20.5% between SGs, with an overall average of 18.1% (0.101 volts/EFPY), on an EFPY basis. However, the absolute magnitude of average voltage growth is small for all 3 SGs (less than 0.11 volts/EFPY), and growth as a percent increase appears relatively high because the average BOC-13 voltage was itself small (less that 0.6 volts for all 3 SGs).

The average growth rate for indications with a BOC bobbin voltage above 0.75 volt is 12.8% per EFPY and for indications below 0.75 volt it is 21.7% per EFPY. The magnitude of the actual voltage growth is small for both indications below and above 0.75 volts and the differences are insignificant. Table 3-4 provides a comparison of the average growth data for the last 7 operating cycles, and the data generally show a steady reduction in the average growth rates until the last cycle. The average composite voltage growth rate from 3 SGs during Cycle 13, 18.10%/EFPY, is significantly higher than that for Cycle 12 (-3.8%/EFPY). The negative growth for Cycle 12 is attributable to the calibration technique used during the EOC-11 inspection. Therefore, the difference in growth rates for Cycles 12 and 13 may not be as pronounced as indicated by the data. Also, the higher voltage increases observed for Cycle 13 are likely to be the consequence of unusually long total duration of the cycle that included a mid-cycle plant shutdown; the larger voltage increases may be the result of changes in the oxide layer on the crack faces rather than growth in length or depth.

The bobbin voltage growth distributions for the last two cycles in the form of cumulative probability distribution functions (CPDF) are shown in Table 3-5, and the same data is presented in a graphical form on Figures 3-5 and 3-6. These growth data are presented on an EFPY basis to account for the difference in the length of the two operating periods. The data in Figure 3-6 clearly show that the Cycle 13 growth distribution is more limiting, and it was applied to obtain EOC-14 projections.

Some plants have experienced growth rates that are dependent on the BOC voltage. To determine if Beaver Valley Unit-1 exhibited a similar trend during Cycle 13, growth rate data for Cycle 13 were plotted against BOC voltage, and the resulting plot is shown in Figure 3-7. It is evident that Cycle 13 growth values are nearly uniformly distributed. Thus, Cycle 13 growth is taken to be independent of the BOC voltage.

Table 3-6 lists the top 30 indications from the standpoint of growth during Cycle 13, and the data show that the growth rate during Cycle 13 was moderate. Total voltage growth during Cycle 13 was under 1 volt for all indications. With the exception of a single indication in SG-C, all indications in Table 3-6 were detected during the EOC-12 inspection also. Of these 30 indications, all but 3 were confirmed by RPC Inspection.

According to the Westinghouse analysis methodology presented in Reference 8-3, the larger of the composite growth rate for all SGs and the SG-specific growth rate should be used in projecting SLB leak rate and tube burst probability for individual SGs. As noted earlier, Cycle 13 growth rates were used to perform EOC-14 projections as they are slightly higher than the Cycle 12 growth rates. Since the Cycle 13 growth rates for SGs A and C are slightly below the composite growth rate (see Table 3-5 and Figure 3-5), the composite growth rate is applied to these two SGs to provide a conservative basis for predicting the EOC-14 conditions. However, the predictions for SG-B are obtained using its own growth rate since it is slightly higher than the composite rate.

3.3 Probe Wear Criteria

An alternate probe wear criterion discussed in Reference 8-8 was applied during the EOC-13 inspection. When a probe does not pass the 15% wear limit, this alternate criterion requires that all tubes with indications above 75% of the repair limit inspected since last successful probe wear check be reinspected with a good probe. Accordingly, all tubes containing indications for which the worn probe voltage was above 1.5 volts were inspected with a new probe. An evaluation of worn probe and new probe data is presented in the following paragraphs.

In accordance with the guidance provided in Reference 8-8, voltages measured with a worn probe and a new probe at the same location were analyzed to ensure that the 75% criteria is adequate. No new large indications were detected with new probes;

thus, worn probes did not miss any significant indications. Figure 3-8 shows plots of the worn probe voltages plotted against the new probe voltages for all three SGs. As only a relatively few tubes required retesting in SGs B and C, data for those two SGs are combined in Figure 3-8. The data in Figure 3-8 show a consistent relationship between the two voltages, with more than 2/3rds of the indications retested having voltages equal to or less than the worn probe voltages. Only one indication had a retest voltage more than 20% above the worn probe voltage; all 3 tubes tested in that calibration group were retested with a good probe, and both the worn probe volts and new probe volts for the indications in those tubes are well below the 2 volt repair limit.

Composite data from all three SGs are plotted in Figure 3-9. Also shown in Figure 3-9 as a solid line is a linear regression for the data, dashed lines representing tolerance limits that bound 90% of the population at 95% confidence, and chained lines representing ±25% band for the new probe voltages (another reasonable tolerance band). The mean regression line has a slope of about 1.0 indicating that, on the average, worn probe voltages are comparable to the new probe voltages. The dotted horizontal line at 1.5 worn probe volts demarcates indications requiring retest from those that do not. The shaded area at the bottom right hand corner shows the region where a tube requiring repair may be left in service because of probe wear. In the Beaver Valley-1 EOC-13 inspection, there are no occurrences for which a worn probe was less than 1.5 volts and the new probe voltage exceeded the plugging limit, i.e., no pluggable tubes were missed due to probe wear considerations. Only one indication falls outside the band formed by the chained lines representing ±25% of the new probe voltage as well as the 90%/95% tolerance limit. Both the worn probe volts and new probe volts for that indication are well below the 2-volt repair limit, and therefore this data is acceptable.

Overall, it is concluded that the criteria to retest tubes with worn probe voltages above 75% of the repair limit is adequate. The alternate probe wear criteria used in the EOC-13 inspection is consistent with the NRC guidance provided in Reference 8-8.

3.4 Probability of Prior Cycle Detection (POPCD)

The inspection results at EOC-13 permit an evaluation of the probability of detection (POD) at the prior EOC-12 inspection. 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 RPC inspection. Thus, the population of interest for POD assessments is the EOC RPC confirmed indications that were detected or not detected at the prior inspection. The probability of prior cycle detection (POPCD) for the EOC-12 inspection can then be defined as follows.

$$\text{POPCD (EOC-12)} = \frac{\text{EOC-12 reported indications confirmed by RPC in EOC-13 inspection} + \text{Indications confirmed and repaired in EOC-12 inspection}}{\text{\{Numerator\}} + \text{New indications RPC confirmed in EOC-13 inspection}}$$

POPCD is evaluated at the 1997 EOC-12 voltage values (from 2000 reevaluation for growth rate) since it is an EOC-12 POPCD assessment. The indications at EOC-12 that were RPC confirmed and plugged are included as it can be expected that these indications would also have been detected and confirmed at EOC-13. It is also appropriate to include the plugged tubes for voltage-based repair criteria applications since POD adjustments to define the BOC distribution are applied prior to reduction of the EOC indication distribution for plugged tubes.

It should be noted that the above POPCD definition includes all new EOC-13 indications not reported in the EOC-12 inspection. The new indications include EOC-12 indications present at detectable levels but not reported, indications present at EOC-12 below detectable levels and indications that initiated during Cycle 13. Thus, this definition, by including newly initiated indications, differs from the traditional POD definition. Since the newly initiated indications are appropriate for voltage-based repair criteria applications, POPCD is an acceptable definition and eliminates the need to adjust the traditional POD for new indications.

The above definition for POPCD would be entirely appropriate if all EOC-13 indications were RPC inspected. Since only a fraction of bobbin indications are generally RPC inspected, POPCD could be distorted by using only the RPC inspected indications. Thus, a more appropriate POPCD estimate can be made by assuming that all bobbin indications not RPC inspected would have been RPC confirmed. This definition is applied only for the 2000 EOC-13 indications not RPC inspected since inclusion of the EOC-12 repaired indications could increase POPCD by including indications on a tube plugged for non-ODSCC causes which could be RPC NDD indications. In addition, the objective of using RPC confirmation for POPCD is to distinguish detection of an indication at EOC_{n-1} that could contribute to burst at EOC_n so that the emphasis is on EOC_n RPC confirmation. This POPCD can be obtained by replacing the EOC-13 RPC confirmed by RPC confirmed plus not RPC inspected in the above definition of POPCD. For this report, both POPCD definitions are evaluated for Beaver Valley Unit-1.

The POPCD evaluation for the 1997 EOC-12 inspection data is summarized in Table 3-7 and illustrated on Figure 3-10. Also shown in the figure is a generic POPCD distribution developed by analyses of 18 inspections in 10 plants and presented in Table 7-4 of Reference 8-9. It is seen from Figure 3-10 that the predicted POPCD

values for Beaver Valley-1 based on both RPC-confirmed indications only and RPC-confirmed and not inspected indications are equal to or better than the generic POPCD above 0.5 volt. POPCD for Beaver Valley-1 exceeds 0.9 beyond about 0.6 volt and reaches unity at about 2 volts.

In summary, the Beaver Valley Unit-1 EOC-12 POPCD supports a voltage dependent POD higher than the NRC mandated POD value of 0.6 above about 0.5 volt and approaching unity at about 2 volts. It is concluded that the POD applied for leak and burst projections to support a voltage-based repair criteria needs to be upgraded from the constant POD value of 0.6 to a voltage dependent POD.

3.5 Assessment of RPC Confirmation Rates

This section tracks the 1997 EOC-12 indications left in service at BOC-13 relative to RPC inspection results in 2000 at EOC-13. The composite results for all SGs are given in Table 3-8. For EOC-12 bobbin indications left in service, the indications are tracked relative to EOC-12 RPC confirmed, EOC-12 RPC NDD, EOC-12 bobbin indications not RPC inspected and EOC-12 bobbin indications not found in the EOC-13 inspection. Also included are new Cycle 13 indications. The table shows, for each category of indications, the number of indications RPC inspected and RPC confirmed in the EOC-13 inspection as well as the percentage of RPC confirmed indications.

Of the 165 RPC NDD indications left in service at BOC-13, 31 were RPC tested during the EOC-13 inspection, and 27 were confirmed. Therefore, the confirmation rate for EOC-12 RPC NDD indications is about 87%. This overall confirmation rate is higher than that found for RPC NDD indications tested in last four inspections. (27% in 1997, 60% in 1996, 50.9% in 1995 and 27% in 1993). For successive inspections at other plants, the confirmation rate for RPC NDD indications left in service was typically < 40%.

The NRC SER for Beaver Valley-1 (Reference 8-2) allows for consideration of only a fraction of RPC NDD indications from current inspection in establishing BOC voltage distribution for the next cycle. The fractional value applicable is the largest RPC confirmation rate for prior cycle RPC NDD indications found during the last two outages, but it may not be less than 0.7. Thus, only 87% of 2000 RPC NDD indications need to be included in the leak and burst evaluations. However, as there were only 17 RPC NDD indications at EOC-13, they were all conservatively included in the leak and burst analyses presented in this report.

3.6 NDE Uncertainties

The NDE uncertainties applied for the EOC-13 voltage projections in this report are those given in the prior Beaver Valley Unit-1 90-day reports (References 8-4 through 8-6). The probe wear uncertainty has a standard deviation of 7.0 % about a mean of zero and has a cutoff at 15% based on implementation of the probe wear standard.

The analyst variability uncertainty has a standard deviation of 8.3% about a mean of zero with no cutoff. These NDE uncertainty distributions are included in the Monte Carlo analyses used to project the EOC-13 voltage distributions.

Table 3-1 (Sheet 1 of 2)
Beaver Valley Unit 1 March 2000 Outage
Summary of Inspection and Repair For Tubes in Service During Cycle 13

Voltage Bin	Steam Generator A							Steam Generator B						
	In-Service During Cycle				BOC-14	EOC-13	Cycle - 14	In-Service During Cycle				BOC-14	EOC-13	Cycle - 14
	Field Bobbin Indications	RPC Inspected	RPC Confirmed	Indications Repaired	All Tubes RTS	Deplugged Tubes Returned to Service#	All Tubes Returned to Service	Field Bobbin Indications	RPC Inspected	RPC Confirmed	Indications Repaired	All Tubes RTS	Deplugged Tubes Returned to Service#	All Tubes Returned to Service
0.2	11	2	2	0	11	1	12	16	0	0	0	16	3	19
0.3	74	2	2	0	74	7	81	55	0	0	0	55	5	60
0.4	148	3	3	0	148	10	158	136	1	1	0	136	10	146
0.5	170	1	1	0	170	16	186	131	2	2	0	131	14	145
0.6	185	2	2	0	185	15	200	136	0	0	0	136	14	150
0.7	174	2	2	1	173	15	188	108	0	0	0	108	12	120
0.8	123	1	1	1	122	16	138	83	4	4	0	83	10	93
0.9	87	4	3	0	87	4	91	80	15	15	0	80	4	84
1	85	12	11	0	85	15	100	50	8	8	0	50	5	55
1.1	60	11	9	0	60	1	61	23	2	2	0	23	0	23
1.2	42	18	18	1	41	3	44	34	26	25	0	34	1	35
1.3	27	27	27	0	27	0	27	25	25	25	0	25	0	25
1.4	24	24	23	2	22	0	22	22	22	22	0	22	0	22
1.5	14	14	14	0	14	0	14	8	8	8	0	8	0	8
1.6	13	13	13	1	12	0	12	14	14	14	0	14	0	14
1.7	7	7	7	0	7	0	7	6	6	6	0	6	0	6
1.8	10	10	10	0	10	0	10	2	2	2	0	2	0	2
1.9	8	8	7	0	8	0	8	3	3	3	0	3	0	3
2	2	2	2	0	2	0	2	0	0	0	0	0	0	0
2.1	5	5	5	5	0	0	0	2	2	2	2	0	0	0
2.2	2	2	2	2	0	0	0	2	2	2	2	0	0	0
Total	1271	170	164	13	1258	103	1361	936	142	141	4	932	78	1010
>1 V	214	141	137	11	203	4	207	141	112	111	4	137	1	138
> 2V	7	7	7	7	0	0	0	4	4	4	4	0	0	0

Table 3-1 (Sheet 2 of 2)
Beaver Valley Unit 1 March 2000 Outage
Summary of Inspection and Repair For Tubes in Service During Cycle 13

Voltage Bin	Steam Generator C							Composite of All Steam Generators						
	In-Service During Cycle				BOC-14	EOC-13	Cycle - 14	In-Service During Cycle				BOC-14	EOC-13	Cycle - 14
	Field Bobbin Indications	RPC Inspected	RPC Confirmed	Indications Repaired	All Tubes RTS	Deplugged Tubes Returned to Service#	All Tubes Returned to Service	Field Bobbin Indications	RPC Inspected	RPC Confirmed	Indications Repaired	All Tubes RTS	Deplugged Tubes Returned to Service#	All Tubes Returned to Service
0.2	18	2	2	0	18	0	18	45	4	4	0	45	4	49
0.3	56	6	5	0	56	0	56	185	8	7	0	185	12	197
0.4	111	1	1	1	110	0	110	395	5	5	1	394	20	414
0.5	103	0	0	4	99	0	99	404	3	3	4	400	30	430
0.6	104	0	0	0	104	0	104	425	2	2	0	425	29	454
0.7	92	3	3	1	91	0	91	374	5	5	2	372	27	399
0.8	85	3	2	2	83	0	83	291	8	7	3	288	26	314
0.9	53	5	4	0	53	0	53	220	24	22	0	220	8	228
1	44	8	6	1	43	0	43	179	28	25	1	178	20	198
1.1	35	3	2	0	35	0	35	118	16	13	0	118	1	119
1.2	27	20	18	0	27	0	27	103	64	61	1	102	4	106
1.3	20	20	20	0	20	0	20	72	72	72	0	72	0	72
1.4	19	19	18	0	19	0	19	65	65	63	2	63	0	63
1.5	14	14	14	0	14	0	14	36	36	36	0	36	0	36
1.6	14	14	13	0	14	0	14	41	41	40	1	40	0	40
1.7	9	9	9	0	9	0	9	22	22	22	0	22	0	22
1.8	1	1	1	0	1	0	1	13	13	13	0	13	0	13
1.9	7	7	7	0	7	0	7	18	18	17	0	18	0	18
2	4	4	4	0	4	0	4	6	6	6	0	6	0	6
2.1	1	1	1	1	0	0	0	8	8	8	8	0	0	0
2.2	0	0	0	0	0	0	0	4	4	4	4	0	0	0
Total	817	140	130	10	807	0	807	3024	452	435	27	2997	181	3178
>1 V	151	112	107	1	150	0	150	506	365	355	16	490	5	495
> 2V	1	1	1	1	0	0	0	12	12	12	12	0	0	0

Table 3-2
Beaver Valley Unit 1 March 2000
TSP ODSCC Indication Distributions for Tubes in Service During Cycle 13

Tube Support Plate	Steam Generator A					Steam Generator B				
	Number of Indications	Maximum Voltage	Average Voltage	Largest Growth	Average Growth	Number of Indications	Maximum Voltage	Average Voltage	Largest Growth	Average Growth
01H	703	2.20	0.73	0.74	0.13	500	2.18	0.76	0.77	0.16
02H	423	2.07	0.68	0.59	0.14	265	1.66	0.64	0.72	0.15
03H	93	1.87	0.69	0.41	0.12	91	1.88	0.54	0.72	0.12
04H	30	1.38	0.59	0.37	0.11	58	1.29	0.51	0.37	0.11
05H	15	1.20	0.50	0.23	0.09	14	0.98	0.46	0.40	0.10
06H	4	0.53	0.39	0.17	0.03	3	0.45	0.42	0.08	-0.01
07H	2	0.92	0.57	0.62	0.34	4	0.35	0.32	0.17	0.08
07C	1	0.50	0.50	0.05	0.05	1	0.19	0.19	-0.09	-0.09
04C	0	-	-	-	-	0	-	-	-	-
02C	0	-	-	-	-	0	-	-	-	-
Total	1271					936				

Tube Support Plate	Steam Generator C					Composite of All SGs				
	Number of Indications	Maximum Voltage	Average Voltage	Largest Growth	Average Growth	Number of Indications	Maximum Voltage	Average Voltage	Largest Growth	Average Growth
01H	420	2.02	0.80	0.96	0.15	1623	2.20	0.76	0.96	0.15
02H	264	1.98	0.64	0.45	0.13	952	2.07	0.66	0.72	0.14
03H	89	1.53	0.56	0.47	0.13	273	1.88	0.60	0.72	0.12
04H	19	1.51	0.58	0.30	0.10	107	1.51	0.54	0.37	0.11
05H	15	0.58	0.34	0.27	0.09	44	1.20	0.43	0.40	0.09
06H	7	0.41	0.32	0.14	0.01	14	0.53	0.36	0.17	0.01
07H	0	-	-	-	-	6	0.92	0.40	0.62	0.17
07C	0	-	-	-	-	2	0.50	0.35	0.05	-0.02
04C	2	0.31	0.31	0.12	0.11	2	0.31	0.31	0.12	0.11
02C	1	0.44	0.44	0.05	0.05	1	0.44	0.44	0.05	0.05
Total	817					3024				

Table 3-3
Beaver Valley Unit 1 - March 2000 Outage
Average Voltage Growth During Cycle 13

Voltage Range	Number of Indications	Average Voltage BOC	Average Voltage Growth		Percent Growth	
			Entire Cycle	Per EFPY #	Entire Cycle	Per EFPY #
	Composite of All Steam Generator Data					
Entire Voltage Range	3024	0.56	0.138	0.101	24.8%	18.1%
$V_{BOC} <$ .75 Volts	2371	0.43	0.127	0.093	29.6%	21.7%
≥ .75 Volts	653	1.03	0.180	0.131	17.5%	12.8%
	Steam Generator A					
Entire Voltage Range	1271	0.57	0.132	0.097	23.2%	16.9%
$V_{BOC} <$ .75 Volts	978	0.44	0.122	0.089	28.1%	20.5%
≥ .75 Volts	293	1.03	0.166	0.122	16.2%	11.8%
	Steam Generator B					
Entire Voltage Range	936	0.53	0.148	0.108	28.1%	20.5%
$V_{BOC} <$ .75 Volts	761	0.42	0.136	0.099	32.4%	23.6%
≥ .75 Volts	175	1.00	0.204	0.149	20.3%	14.8%
	Steam Generator C					
Entire Voltage Range	817	0.57	0.135	0.099	23.9%	17.4%
$V_{BOC} <$ .75 Volts	632	0.42	0.123	0.090	28.9%	21.1%
≥ .75 Volts	185	1.06	0.179	0.131	16.9%	12.4%

Based on Cycle 13 duration of 500 EFPD (1.369 EFPY)

Table 3-4
Beaver Valley Unit 1 March 2000
Signal Growth Statistics for ODSCC Indications at TSPs
Composite of All Steam Generator Data

Bobbin Voltage Range	Number of Indications	Average Voltage BOC	Average Voltage Growth		Average Percentage Growth	
			Entire Cycle	Per EFPY	Entire Cycle	Per EFPY
	Cycle 13 (1997 - 2000) - 500 EFPD					
Entire Voltage Range	3024	0.56	0.138	0.101	24.8%	18.1%
V_{BOC} < .75 Volts	2371	0.43	0.127	0.093	29.6%	21.7%
≥.75 Volts	653	1.03	0.180	0.131	17.5%	12.8%
	Cycle 12 (1996 - 1997) - 415.4 EFPD					
Entire Voltage Range	2910	0.60	-0.025	-0.022	-4.3%	-3.8%
V_{BOC} < .75 Volts	2181	0.46	-0.020	-0.017	-4.4%	-3.8%
≥.75 Volts	729	1.01	-0.042	-0.037	-4.1%	-3.6%
	Cycle 11 (1995 - 1996) - 352.94 EFPD					
Entire Voltage Range	1936	0.60	-0.005	-0.005	-0.8%	-0.9%
V_{BOC} < .75 Volts	1434	0.46	0.006	0.007	1.3%	1.4%
≥.75 Volts	502	0.94	-0.037	-0.038	-4.0%	-4.1%
	Cycle 10 (1993 - 1995) - 435.79 EFPD					
Entire Voltage Range	1089	0.66	0.020	0.017	3.0%	2.5%
V_{BOC} < .75 Volts	751	0.50	0.040	0.034	8.0%	6.7%
≥.75 Volts	338	1.01	-0.010	-0.008	-1.0%	-0.8%
	Cycle 9 (1991 - 1993) - 492.75 EFPD					
Entire Voltage Range	1125	0.57	0.090	0.067	15.8%	11.7%
V_{BOC} < .75 Volts	918	0.47	0.090	0.067	19.1%	14.2%
≥.75 Volts	207	1.02	0.090	0.067	8.8%	6.5%
	Cycle 8 (1989 - 1991) - 390.82 EFPD					
Entire Voltage Range	952	0.95	0.180	0.168	18.9%	17.7%
V_{BOC} < .75 Volts	366	0.58	0.160	0.150	27.6%	25.8%
≥.75 Volts	586	1.18	0.190	0.178	16.1%	15.0%
	Cycle 7 (1987 - 1989) - 438.3 EFPD					
Entire Voltage Range	918	0.66	0.290	0.242	43.9%	36.6%
V_{BOC} < .75 Volts	622	0.49	0.270	0.225	55.1%	45.9%
≥.75 Volts	296	1.01	0.340	0.283	33.7%	28.1%

Table 3-5
Beaver Valley Unit 1 March 2000
Signal Growth Statistics For Cycle 13 on an EFPY Basis

Delta Volts	Steam Generator A			Steam Generator B			Steam Generator C			Cumulative		
	Cycle 12	Cycle 13		Cycle 12	Cycle 13		Cycle 12	Cycle 13		Cycle 12	Cycle 13	
	CPDF	No. of Inds	CPDF	CPDF	No. of Inds	CPDF	CPDF	No. of Inds	CPDF	CPDF	No. of Inds	CPDF
-0.4	0.0	0	0.0	0.0	0	0.0	0.001	0	0.0	0.0	0	0.0
-0.3	0.001	0	0.0	0.012	0	0.0	0.005	0	0.0	0.005	0	0.0
-0.2	0.02	0	0.0	0.079	0	0.0	0.04	0	0.0	0.044	0	0.0
-0.1	0.139	4	0.003	0.337	4	0.004	0.517	1	0.001	0.3	9	0.003
0	0.514	115	0.094	0.749	69	0.078	0.877	82	0.102	0.682	266	0.091
0.1	0.875	656	0.61	0.949	443	0.551	0.976	418	0.613	0.924	1517	0.593
0.2	0.962	370	0.901	0.99	305	0.877	0.996	210	0.87	0.98	885	0.885
0.3	0.987	100	0.98	0.997	87	0.97	0.999	87	0.977	0.993	274	0.9759
0.4	0.997	21	0.996	0.999	24	0.996	1.0	14	0.994	0.9983	59	0.9954
0.5	0.998	4	0.999	1.0	1	0.997		3	0.998	0.9993	8	0.998
0.6	0.998	1	1.0		3	1.0		1	0.999	0.9993	5	0.9997
0.7	0.998	0			0			1	1.0	0.9993	1	1.0
0.9	0.999	0			0			0		0.9997	0	
1	1.0	0			0			0		1.0		
Total		1271			936			817			3024	

Table 3-6
Beaver Valley Unit 1 March 2000
Summary of Largest Voltage Growth Rates for BOC-13 to EOC-13

Steam Generator				Bobbin Voltage			RPC	New
SG	Row	Col	Elevation	EOC	BOC	Growth	Confirmed ?	Indication ?
C	2	11	01H	1.57	0.61	0.96	Y	N
B	2	12	01H	1.38	0.61	0.77	Y	N
A	22	23	01H	1.14	0.4	0.74	Y	N
B	19	82	03H	1.88	1.16	0.72	Y	N
B	7	12	02H	1.39	0.67	0.72	Y	N
C	4	11	01H	0.87	0.17	0.7	Y	N
C	4	33	01H	0.98	0.34	0.64	Y	N
A	7	11	07H	0.92	0.3	0.62	Y	N
A	36	66	01H	1.32	0.71	0.61	Y	N
C	3	16	01H	1.04	0.43	0.61	Y	N
A	23	29	02H	2.07	1.48	0.59	Y	N
B	10	66	01H	1.54	0.96	0.58	Y	N
C	15	61	01H	1.93	1.35	0.58	Y	N
A	22	23	02H	0.96	0.39	0.57	Y	N
B	25	22	01H	1.55	1.01	0.54	Y	N
C	8	11	01H	0.75	0.21	0.54	N	Y
A	11	63	01H	1.05	0.52	0.53	N	N
A	28	60	01H	2.14	1.61	0.53	Y	N
B	18	18	01H	2.18	1.65	0.53	Y	N
C	24	72	01H	1.86	1.33	0.53	Y	N
A	36	68	02H	1.06	0.54	0.52	Y	N
B	23	64	01H	1.2	0.68	0.52	Y	N
B	12	8	01H	2.03	1.51	0.52	Y	N
C	9	8	01H	1.43	0.92	0.51	Y	N
B	7	10	01H	1.32	0.82	0.5	Y	N
B	10	66	02H	1.59	1.09	0.5	Y	N
B	14	6	01H	1.6	1.1	0.5	Y	N
B	24	38	01H	1.06	0.56	0.5	N	N
C	2	6	01H	1.35	0.85	0.5	Y	N
C	9	10	01H	1.31	0.81	0.5	Y	N

Table 3-7
Beaver Valley Unit 1 2000 EOC-13 Evaluation for Probability of Prior Cycle Detection
Composite of All Steam Generator Data

Voltage Bin	New Indications		1997 Bobbin, Field Call in 1997 Inspection		1997 Inspection Bobbin	POPCD			
	2000 Inspection RPC Confirmed	2000 Inspection RPC Confirmed plus not Inspected	2000 Inspection RPC Confirmed	2000 Inspection RPC Confirmed plus not Inspected	1997 Inspection Confirmed and Plugged	RPC Confirmed		RPC Confirmed Plus Not Inspected	
						Frac.	Count	Frac.	Count
> 0 - 0.2	6	31	1	127	1	0.3	2 / 8	0.805	128 / 159
0.2 - 0.4	14	127	5	877	2	0.333	7 / 21	0.874	879 / 1006
0.4 - 0.6	8	40	19	799	4	0.742	23 / 31	0.953	803 / 843
0.6 -0 .8	3	14	42	464	2	0.936	44 / 47	0.971	466 / 480
0.8 - 1.0	5	6	81	250	3	0.944	84 / 89	0.977	253 / 259
1.0 - 1.5	7	7	207	228	6	0.968	213 / 220	0.971	234 / 241
1.5 - 2.0	1	1	36	36	8	0.978	44 / 45	0.978	44 / 45
2.0 - 2.5	0	0	0	0	2	1.000	2 / 2	1.000	2 / 2
TOTAL	44	226	391	2781	26				
> 1V	1	1	36	36	8				

Table 3-8
Beaver Valley Unit 1
Analysis of RPC Data from 1997 and 2000 Inspections
Combined Data from All Steam Generators

Group of Indications	Total 1997 Inspection Bobbin Indication	Total 2000 Inspection Bobbin Indication	Total 2000 Inspection RPC Inspected	Total 2000 Inspection RPC Confirmed	Percent 2000 Inspection RPC Confirmed
Less than or Equal to 1.0 Volt in 2000 Inspection					
1997 Inspection Bobbin Left in Service	2338	2303	51	46	90.2
- 1997 Inspection RPC Confirmed	298	298	16	16	100.0
- 1997 Inspection RPC NDD	128	128	5	4	80.0
- 1997 Inspection RPC Not Inspected	1877	1877	30	26	86.7
- No 2000 Inspection Bobbin *	35	-	-	-	-
New 2000 Inspection Indication	-	215	36	34	94.4
Sum of All 2000 Inspection Indication	2338	2518	87	80	92.0
Greater than 1.0 Volt in 2000 Inspection					
1997 Inspection Bobbin Left in Service	493	493	355	345	97.2
- 1997 Inspection RPC Confirmed	346	346	277	276	99.6
- 1997 Inspection RPC NDD	37	37	26	23	88.5
- 1997 Inspection RPC Not Inspected	110	110	52	46	88.5
- No 2000 Inspection Bobbin *	0	-	-	-	-
New 2000 Inspection Indication	-	13	10	10	100.0
Sum of All 2000 Inspection Indication	493	506	365	355	97.3
All Voltages in 2000 Inspection					
1997 Inspection Bobbin Left in Service	2831	2796	406	391	96.3
- 1997 Inspection RPC Confirmed	644	644	293	292	99.7
- 1997 Inspection RPC NDD	165	165	31	27	87.1
- 1997 Inspection RPC Not Inspected	1987	1987	82	72	87.8
- No 2000 Inspection Bobbin *	35	-	-	-	-
New 2000 Inspection Indication	-	228	46	44	95.7
Sum of All 2000 Inspection Indication	2831	3024	452	435	96.2

* Indications split is based on 1997 Inspection bobbin voltage

Figure 3-1
Beaver Valley Unit 1 March 2000 Outage
Bobbin Voltage Distributions at EOC-13 for Tubes in Service During Cycle 13

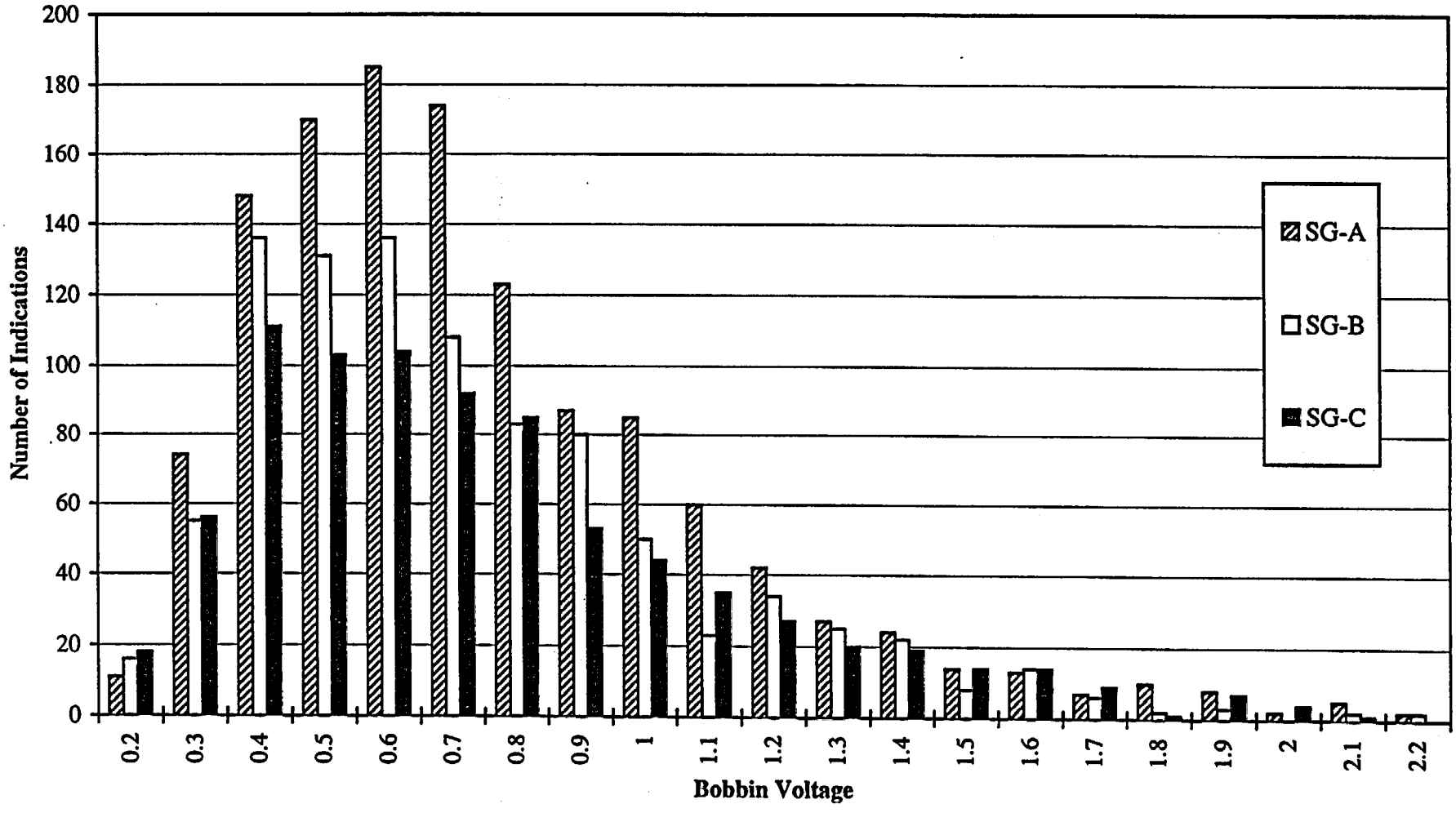


Figure 3-2
Beaver Valley Unit 1 March 2000 Outage
Bobbin Voltage Distribution for Tubes Plugged After Cycle 13 Service

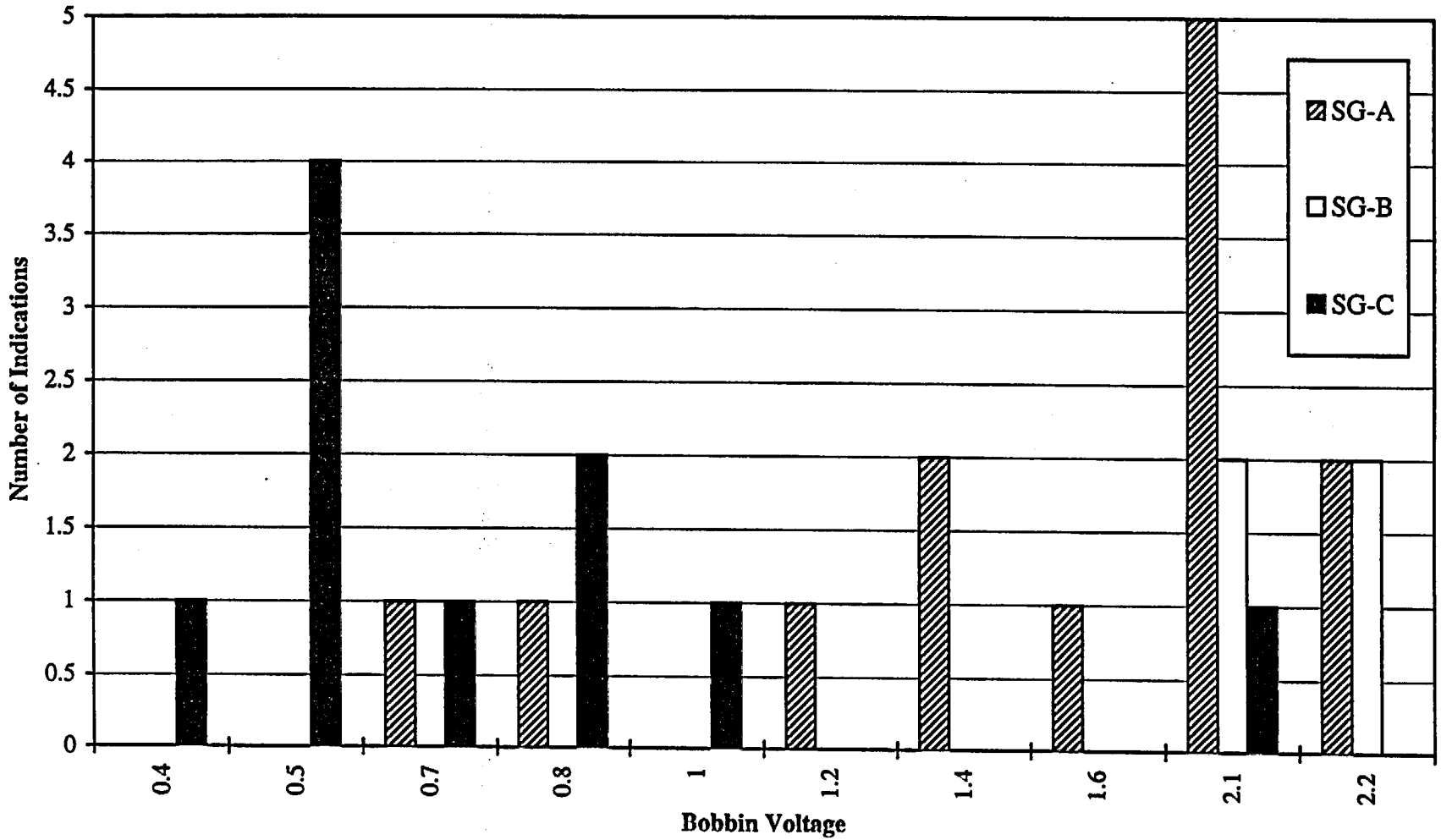


Figure 3-3
Beaver Valley Unit 1 March 2000 Outage
Bobbin Voltage Distributions for Tubes Returned to Service for Cycle 14

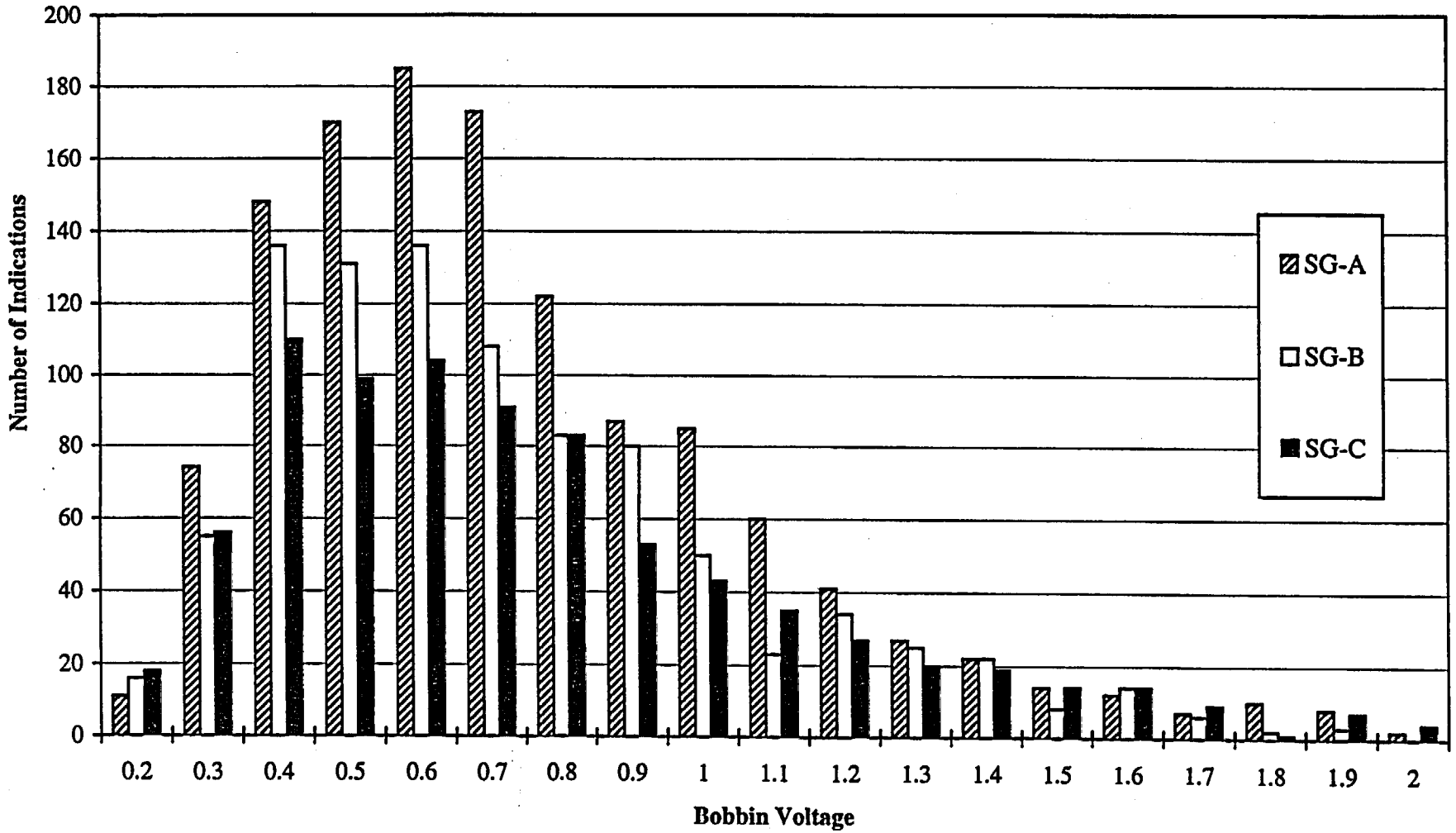


Figure 3-4
Beaver Valley Unit 1 - March 2000
ODSCC Axial Distributions for Tubes in Service During Cycle 13

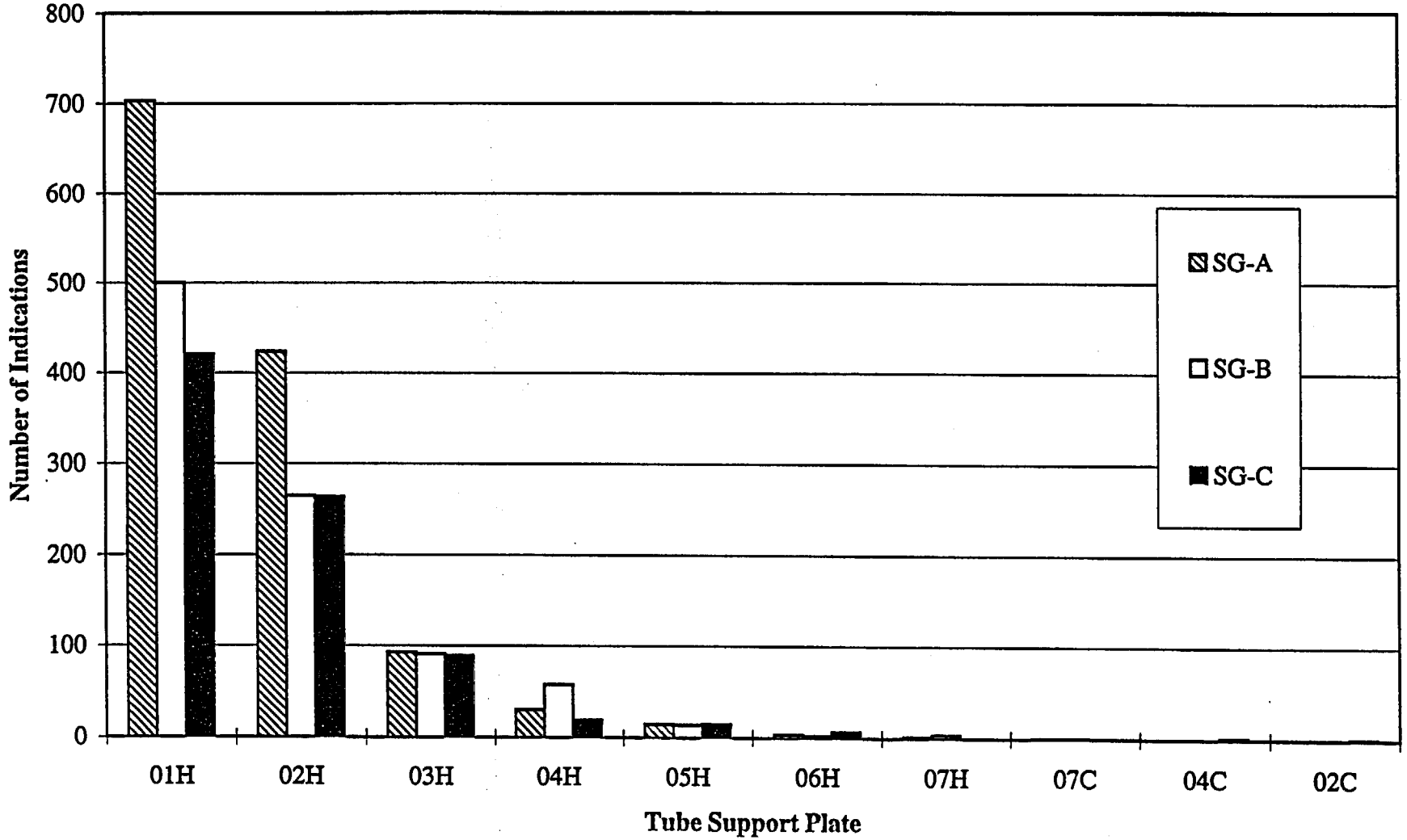
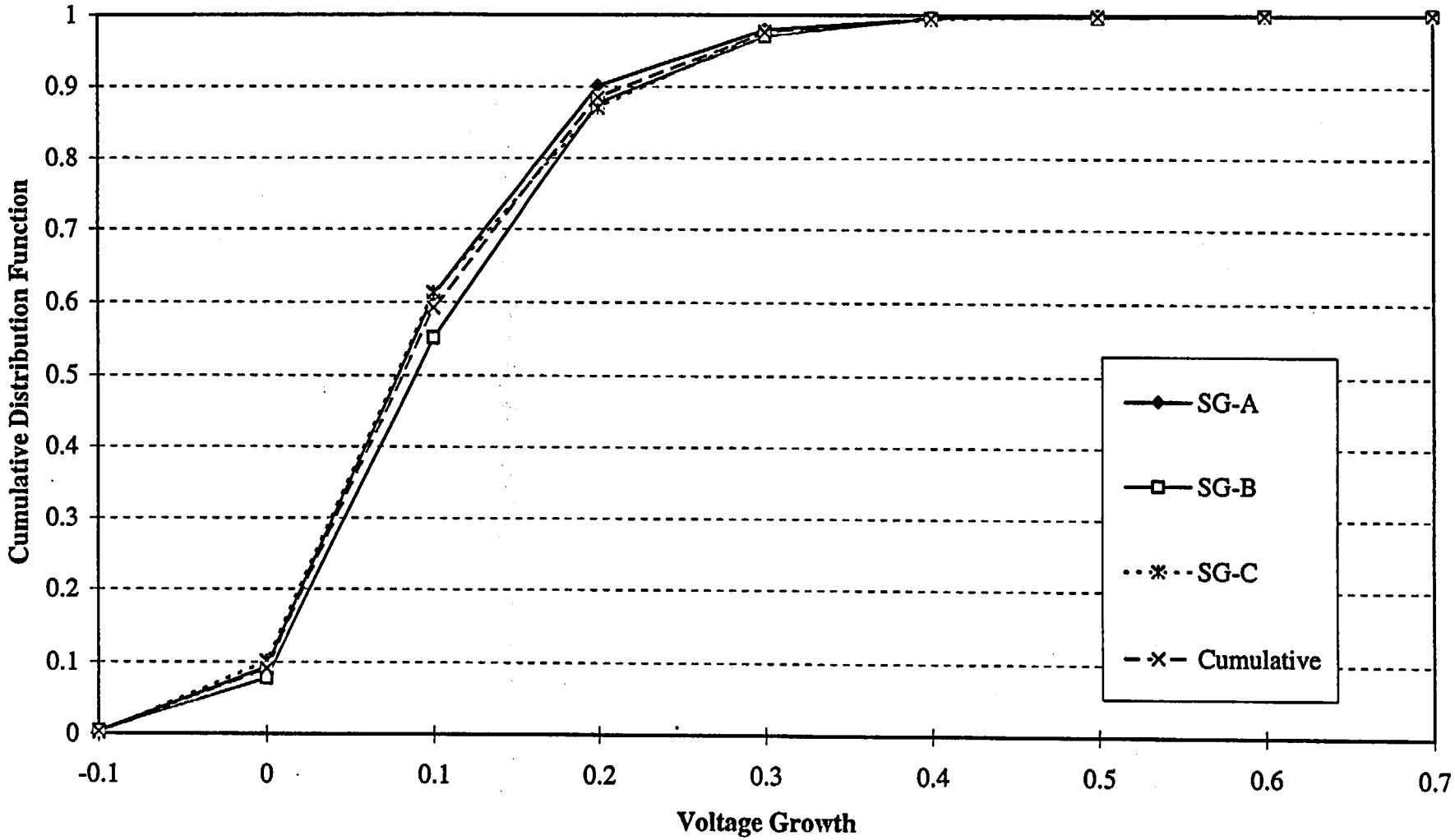


Figure 3-5
Beaver Valley Unit 1 Cycle 13 (Sept. 1997 to March 2000)
Cumulative Probability Distributions for Voltage Growth on an EFPY Basis



Growth.xls Fig2 7/10/00 11:49 AM

Figure 3-6
Beaver Valley Unit 1 - March 2000
Bobbin Signal Growth History - Cumulative Probability Distributions on an EFPY Basis
Composite of All Steam Generators

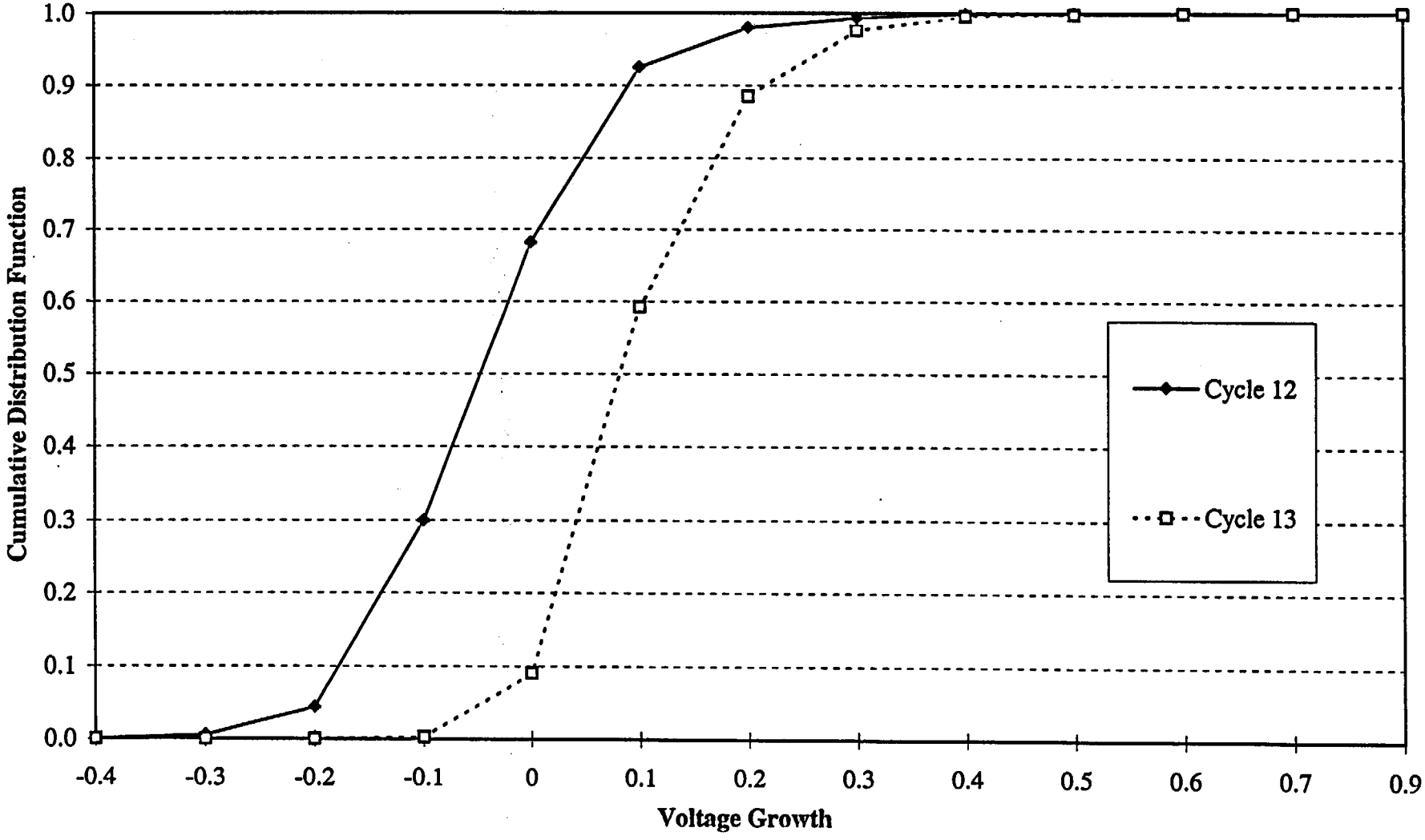


Figure 3-7
Beaver Valley Unit -1 March 2000 Outage
Voltage Growth During Cycle 13 vs BOC-13 Voltage -- All SG Data

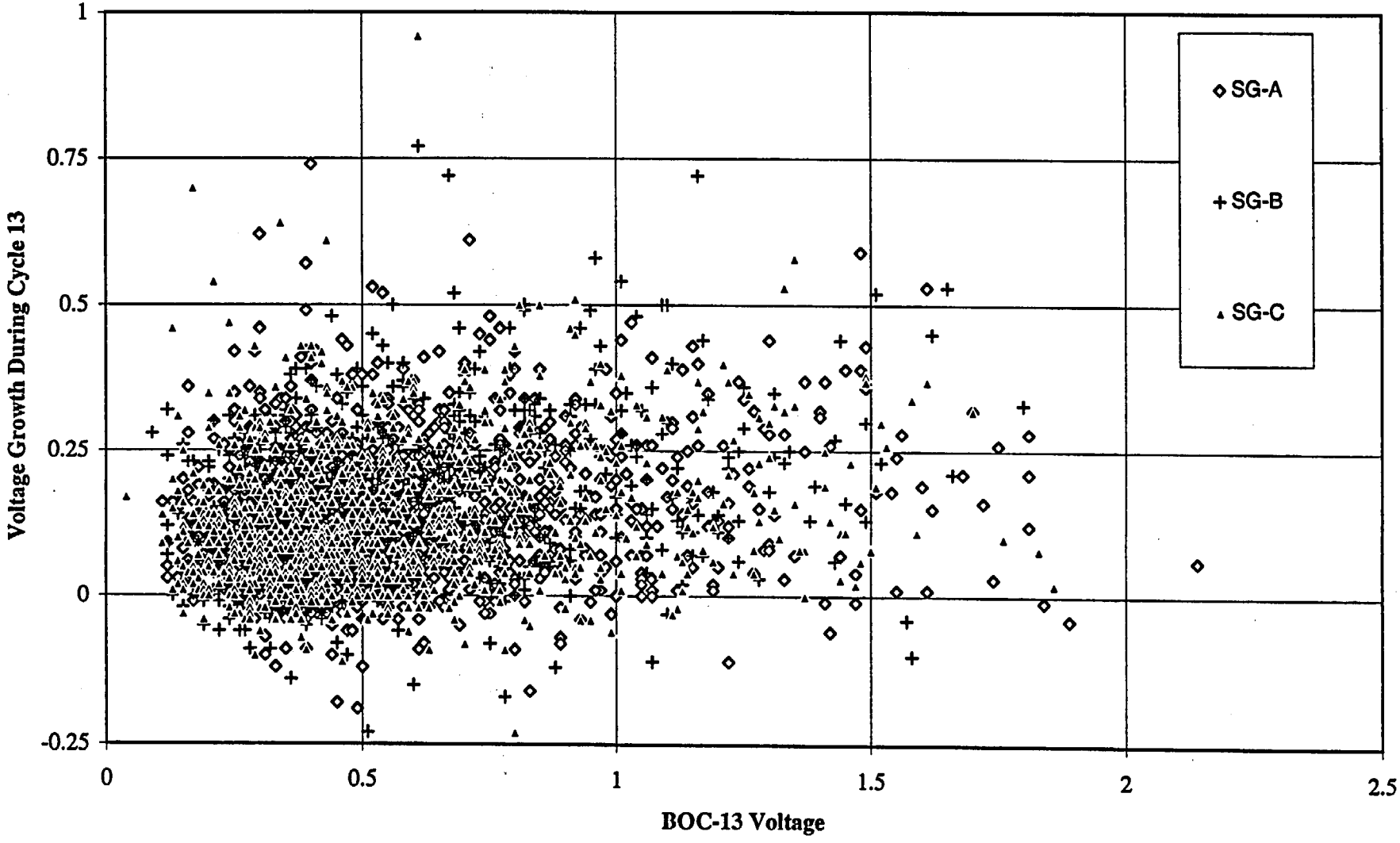
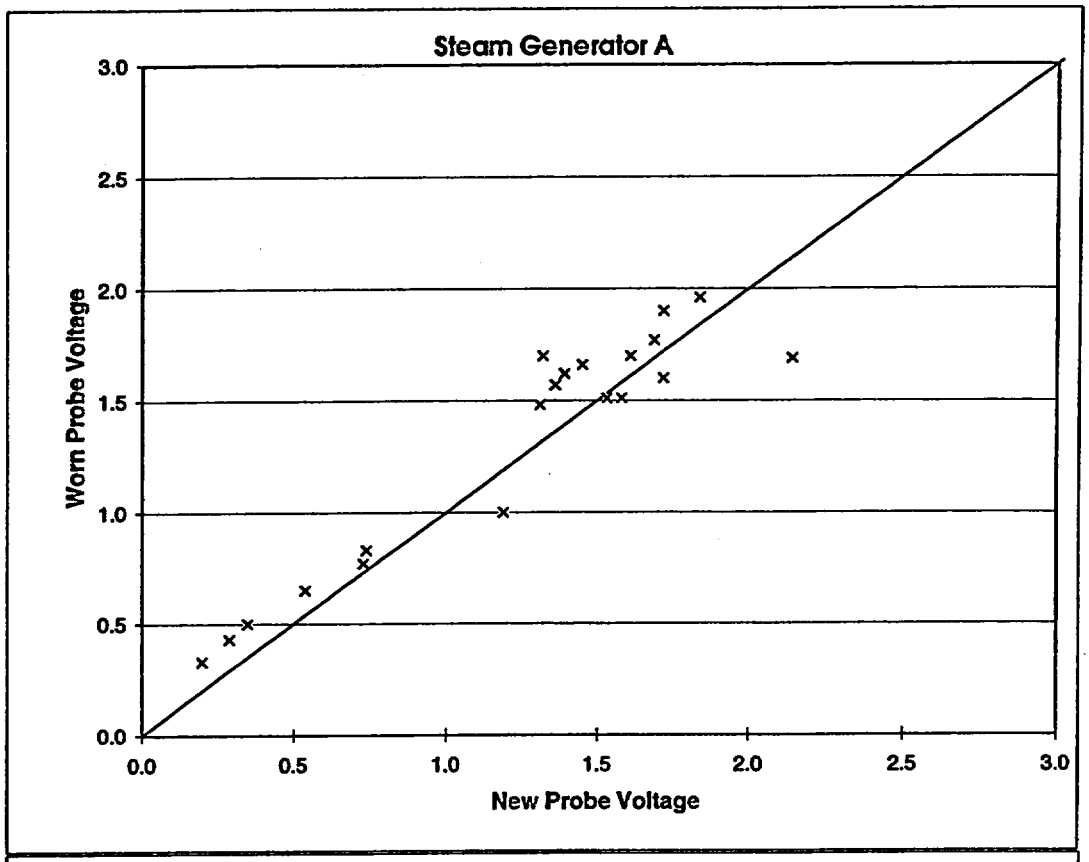


Figure 3-8
Beaver Valley Unit-1 EOC-14 Inspection
Comparison of Worn Probe Voltage Against New Probe Voltage



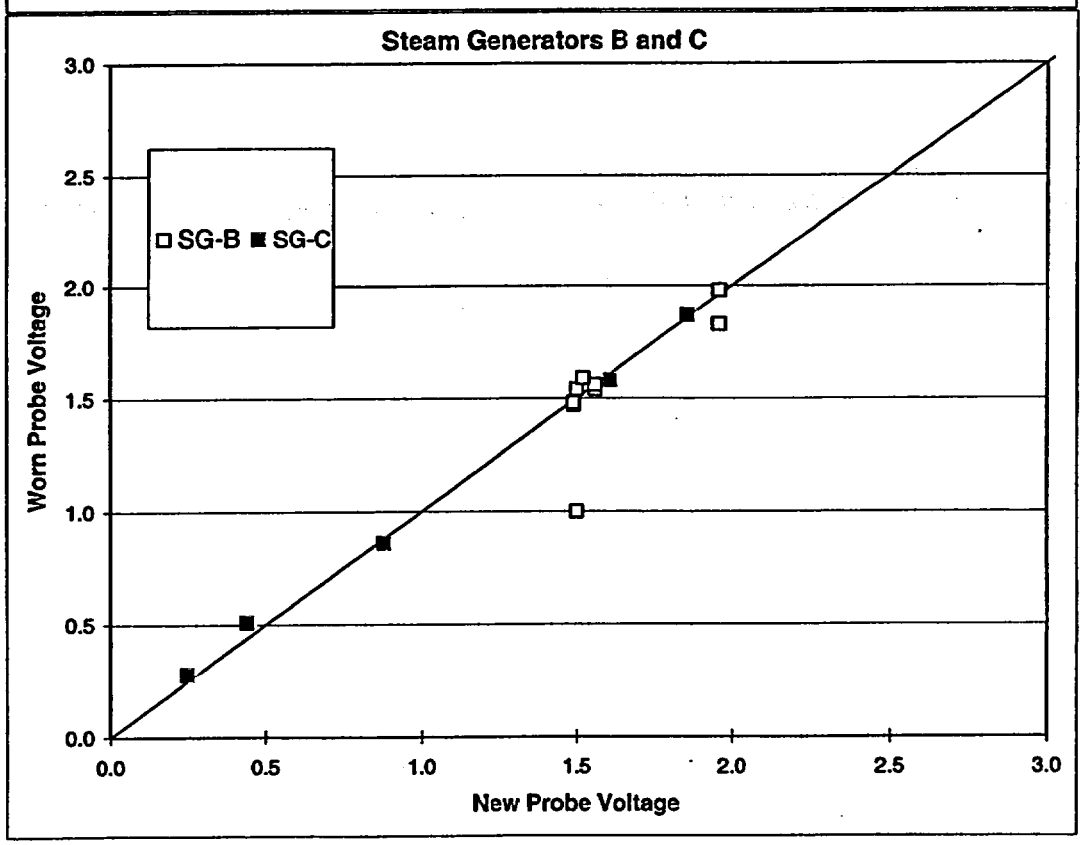
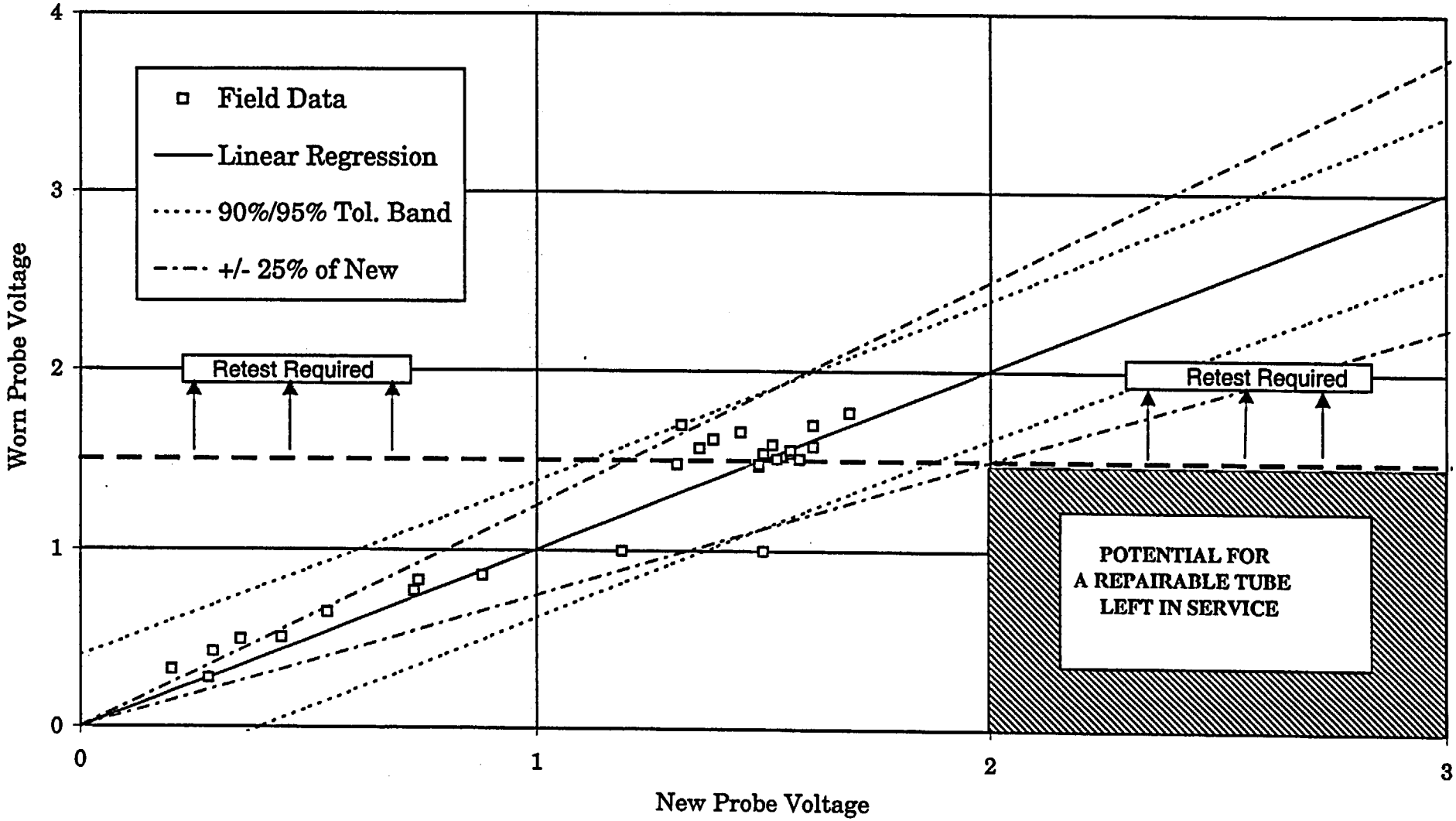


Figure 3-9
Beaver Valley Unit-1 April 2000
Worn Probe Volts vs New Probe Volts



4.0 DATA BASE APPLIED FOR LEAK AND BURST CORRELATIONS

Leak and burst correlations based on the latest NRC approved database for 7/8" tubes (Reference 8-7) are applied in the analyses presented in this report, and these correlations are documented in Reference 8-7. The database meets the NRC requirement that the p value obtained from the regression analysis of leak rates be less than or equal to 5%. Therefore, a SLB leak rate versus voltage correlation is applied for the leak rate analyses of this report. The following are the correlations for burst pressure, probability of leakage and leak rate used in this report (Reference 8-7).

$$\text{Burst Pressure } (ksi) = 7.57661 - 2.39816 \times \log(volts)$$

$$\text{Probability of Leak} = \frac{1}{1 + e^{\left(4.31236 - 4.21125 \times \log(volts)\right)}}$$

$$\text{Leak Rate } (l/hr) = 10^{\left(-0.526882 + 0.987179 \times \log\left(volts\right)\right)}$$

The above leak rate equation is the same as the one in Addendum 2 of the EPRI Database Report (Reference 8-9) as there was no new leak rate data when Reference 8-7 was prepared. It corresponds to 2560 psi pressure differential across the tube wall.

The upper voltage repair limit applied at the EOC-13 inspection was developed using the database presented in Reference 8-7, which is the latest database available for 7/8" diameter tubes. The structural limit is 8.34 volts. The allowance for voltage growth is 30%/EFPY, which bounds the Beaver Valley Unit-1 data and is the minimum growth allowance required by Generic Letter 95-05. With an assumed Cycle 14 duration of 500 EFPD or 1.37 EFPY (which is slightly below the later defined 520 EFPD cycle length used for leak rate and burst probability projections presented in Section 7), the growth allowance becomes 41.1%. The allowance for NDE uncertainty is 20% per Generic Letter 95-05. The upper voltage repair limit is then 8.34 volts/1.610 = 5.18 volts.

5.0 SLB ANALYSIS METHODS

Monte Carlo analyses are used to calculate the SLB leak rates and tube burst probabilities for both actual EOC-13 and projected EOC-14 voltage distributions. The Monte Carlo analyses account for parameter uncertainty. The analysis methodology is described in the Westinghouse generic methods report of Reference 8-3, and it is consistent with the guidelines provided in the Generic Letter 95-05 (Reference 8-1).

In general, the methodology involves application of correlations for burst pressure, probability of leak and leak rate to a measured or calculated EOC distribution to estimate the likelihood of tube burst and primary-to-secondary leakage during a postulated SLB event. NDE uncertainties and uncertainties associated with burst pressure, leak rate probability and leak rate correlations are explicitly included by considering many thousands of voltage distributions through a Monte Carlo sampling process. The voltage distributions used in the projection analyses for the next operating cycle are obtained by applying growth data to the BOC distribution. The BOC voltage distributions include an adjustment for detection uncertainty and occurrence of new indications, in addition to the adjustments for NDE uncertainties. Comparisons of projected EOC voltage distributions with actual distributions after a cycle of operation have shown that the Monte Carlo analysis technique yields conservative estimates for EOC voltage distributions; therefore, leak and burst results based on those distributions are also conservative. Equation 3.5 in Reference 8-3 was used to determine the true BOC voltage.

6.0 BOBBIN VOLTAGE DISTRIBUTIONS

This section describes prediction of the EOC voltage distribution used for evaluating tube leakage and burst probabilities at the end of the operating period. The calculation consists of establishing the initial conditions (i.e., the bobbin indication population distribution) based on the EC inspection data and projecting the indication growth over the operating period. Since indication growth is considered proportional to operating time, the limiting tube conditions occur at the end of any given time period or cycle.

The bobbin voltage distribution established for the BOC conditions is adjusted for measurement uncertainty using a quantity termed probability of detection, as described in the following paragraphs. Other input used for predicting the EOC voltage distribution and the results are presented below.

6.1 Probability of Detection

The number of bobbin indications used to predict tube leak rate and burst probability is obtained by adjusting the number of reported indications to account for measurement uncertainty and confidence level in voltage sizing. This is accomplished by using a POD factor. Adjustments are also made for indications either removed from or returned to service. The calculation of projected bobbin voltage frequency distribution is based on a net total number of indications returned to service, defined as:

$$N_{Tot\,RTS} = \frac{N_i}{POD} - N_{Repaired} + N_{deplugged} \,,$$

where:

$N_{Tot\,RTS}$ = Number of bobbin indications being returned to service for the next cycle.

N_i = Number of bobbin indications (in tubes in service during the previous cycle) reported in the current inspection.

POD = Probability of Detection.

$N_{repaired}$ = Number of N_i which are repaired (plugged) after the last cycle.

$N_{deplugged}$ = Number of previously plugged indications which are deplugged after the last cycle and are returned to service.

As noted in Section 3-1, a large number of tubes in SGs A and B (none in SG-C) were deplugged in the EOC-13 inspection, inspected and those meeting the criteria described in Section 3-1 were returned to service.

The NRC generic letter (Reference 8-1) requires the application of a constant POD = 0.6 to define the BOC distribution for the EOC voltage projections, unless an

alternate POD is approved by the NRC.

6.2 Cycle Operating Time

The following operating period values are used in the voltage projection calculations:

Cycle 13 = 500 EFPD (actual) Cycle 14 = 520 EFPD (estimated)

6.3 Calculation of Voltage Distributions

Bobbin voltage projection start with a cycle initial voltage distribution that is projected to the corresponding cycle final voltage distribution, based on the growth rate adjusted for the anticipated cycle operating time period. The overall growth rates for each of the Beaver Valley Unit-1 steam generators during the last two operating periods, as represented by their CPDFs, are shown on Table 3-5. A Generic Letter 95-05 requirement is that limiting growth rate for the past two cycles of operation should be used in the projections. The growth distribution for Cycle 13 is more limiting, and it was applied to obtain EOC-14 projections. Further conservatism for the EOC-14 bobbin voltage prediction is provided by using the composite growth distribution for SGs A and C (since their own growth rates are smaller than the composite growth rate) and its own growth rate distribution for SG-B (since it is slightly higher than the composite growth rate). This approach is recommended in Reference 8-3. Growth data were represented by a histogram in the Monte Carlo analyses.

For each SG, the initial bobbin voltage distribution of indications being returned to service for the next cycle (BOC-14) is derived from the actual EOC-13 inspection results adjusted for tubes that are taken out of service by plugging. Adjustments are also made to include the TSP indications in deplugged tubes returned to service that were not repaired by installing a sleeve. The BOC-14 bobbin voltage distributions obtained are summarized on Table 6-1. The table shows EOC-13 bobbin voltage indications, the subsequent plugged indications (which were in service for Cycle 13 and then taken out of service, albeit not all for reasons of ODSCC at TSP), and the BOC-14 indications corresponding to a constant POD value of 0.6 as well as the voltage dependent generic POPCD. The POPCD distribution used is shown in Figure 6-1.

6.4 Predicted EOC-14 Voltage Distributions

The licensing-basis calculations to predict EOC-14 bobbin voltage distributions were performed for all SGs with a constant POD value of 0.6 in accordance with a NRC requirement. In addition, calculations were also performed using a voltage dependent generic POPCD distribution developed based on bobbin and RPC data

from 18 EC inspections at 10 different plants. The development of a generic POPCD distribution is described in Reference 8-9.

Table 6-2 provides the EOC-14 voltage distributions predicted using the BOC-14 voltage distribution shown in Table 6-1. As anticipated, the largest number of indications is predicted for SG-A, 2208 indications for a constant POD of 0.6. The assumed BOC-14 and predicted EOC-14 bobbin voltage frequency distributions for all three SGs are also graphically illustrated on Figures 6-2 to 6-4. The largest bobbin voltage predicted for EOC-14 is in SG-A, and its magnitude is 3.1 volts for a constant POD of 0.6

6.5 Comparison of Predicted and Actual EOC-13 Voltage Distributions

The actual EOC-13 bobbin voltage distributions and the corresponding predictions presented in the last 90-day report (Reference 8-4), are compared in Table 6-3 and on Figure 6-5. SG-A was predicted to be limiting at EOC-13, which is consistent with the actual measurements since this SG had the highest number of indications as well as the largest indication found in the EOC-13 inspection. The total number of indications for all SGs is overpredicted by 53% to 59% in the licensing-basis analysis with POD of 0.6. Also, the licensing-basis analysis overpredicted by 90% to 143% the actual EOC-13 bobbin voltage population over 1 volt as well as the population above 2 volts in all three SGs. The overprediction for indications in virtually every voltage size range demonstrates conservatism in the projection methodology. The EOC-13 voltage projections based on the voltage-dependent POPCD also yield conservative results. In essentially every voltage size range, the predictions based on POPCD are 10% to 120% over the actual population, in all three SGs. Thus, EOC voltage projections based on the voltage-dependent POPCD yield more realistic but still conservative results for Beaver Valley-1.

Table 6-1
Beaver Valley Unit 1 March 2000
EOC-13 Bobbin and Assumed BOC-14 Bobbin Distributions in SLB Leak Rate and Tube Burst Analyses

Voltage Bin	Steam Generator A				Steam Generator B				Steam Generator C			
	EOC - 13		BOC - 14#		EOC - 13		BOC - 14#		EOC - 13		BOC - 14	
	Field Bobbin Indications	Indications Repaired	POD 0.6	POPCD	Field Bobbin Indications	Indications Repaired	POD 0.6	POPCD	Field Bobbin Indications	Indications Repaired	POD 0.6	POPCD
0.2	11	0	19.33	31.56	16	0	29.67	47.44	18	0	30.00	50.00
0.3	74	0	130.33	167.87	55	0	96.67	124.57	56	0	93.33	121.74
0.4	148	0	256.67	284.07	136	0	236.67	261.85	111	1	184.00	204.56
0.5	170	0	299.33	285.84	131	0	232.33	221.94	103	4	167.67	159.49
0.6	185	0	323.33	283.12	136	0	240.67	211.10	104	0	173.33	150.72
0.7	174	1	304.00	246.00	108	0	192.00	156.00	92	1	152.33	121.67
0.8	123	1	220.00	170.70	83	0	148.33	115.06	85	2	139.67	105.59
0.9	87	0	149.00	110.10	80	0	137.33	101.56	53	0	88.33	64.63
1	85	0	156.67	116.19	50	0	88.33	64.52	44	1	72.33	51.38
1.1	60	0	101.00	71.18	23	0	38.33	26.90	35	0	58.33	40.94
1.2	42	1	72.00	50.28	34	0	57.67	40.08	27	0	45.00	31.03
1.3	27	0	45.00	30.68	25	0	41.67	28.41	20	0	33.33	22.73
1.4	24	2	38.00	24.97	22	0	36.67	24.72	19	0	31.67	21.35
1.5	14	0	23.33	15.56	8	0	13.33	8.89	14	0	23.33	15.56
1.6	13	1	20.67	13.29	14	0	23.33	15.38	14	0	23.33	15.38
1.7	7	0	11.67	7.65	6	0	10.00	6.56	9	0	15.00	9.84
1.8	10	0	16.67	10.87	2	0	3.33	2.17	1	0	1.67	1.09
1.9	8	0	13.33	8.65	3	0	5.00	3.24	7	0	11.67	7.57
2	2	0	3.33	2.15	0	0	0.00	0.00	4	0	6.67	4.30
2.1	5	5	3.33	0.35	2	2	1.33	0.14	1	1	0.67	0.07
2.2	2	2	1.33	0.13	2	2	1.33	0.13	0	0	0.00	0.00
Total	1271	13	2208.33	1931.18	936	4	1634.00	1460.67	817	10	1351.67	1199.64
> 1V	214	11	349.67	235.73	141	4	232.00	156.62	151	1	250.67	169.85
> 2V	7	7	4.67	0.48	4	4	2.67	0.27	1	1	0.67	0.07

Includes unrepaired TSP indications in deplugged tubes returned at BOC-14

Table 6-2
Beaver Valley Unit 1 March 2000
Projected Bobbin Voltage Distribution at EOC - 14

Voltage Bin	Steam Generator A		Steam Generator B		Steam Generator C	
	Projected Number of Indications at EOC - 14					
	POD 0.6	POPCD	POD 0.6	POPCD	POD 0.6	POPCD
0.1	0.09	0.14	0.11	0.18	0.13	0.22
0.2	2.65	3.94	2.70	4.10	3.15	4.96
0.3	18.21	24.83	16.73	23.64	17.84	26.01
0.4	66.15	82.02	51.64	65.19	50.74	65.56
0.5	141.70	160.54	115.90	133.37	100.65	117.69
0.6	216.12	224.35	170.89	180.30	137.04	145.62
0.7	265.32	253.82	204.99	200.01	156.07	151.63
0.8	278.34	248.17	204.79	185.95	155.94	139.52
0.9	258.20	217.83	186.05	159.11	143.92	120.39
1.0	220.01	177.41	157.96	128.31	123.19	97.79
1.1	179.43	139.23	126.43	98.58	100.14	76.29
1.2	142.16	106.98	97.42	73.57	79.53	58.67
1.3	109.46	80.30	74.16	54.51	62.78	45.16
1.4	82.02	58.88	57.17	41.01	49.79	35.09
1.5	60.49	42.54	44.56	31.33	39.87	27.64
1.6	44.35	30.59	34.56	23.89	32.08	21.93
1.7	32.78	22.22	26.30	17.93	25.64	17.34
1.8	24.63	16.43	19.44	13.11	20.19	13.53
1.9	18.74	12.31	13.92	9.28	15.54	10.33
2.0	14.25	9.20	9.67	6.35	11.71	7.72
2.1	10.67	6.73	6.55	4.22	8.59	5.61
2.2	7.74	4.73	4.37	2.71	6.11	3.96
2.3	5.41	3.17	2.87	1.69	4.19	2.69
2.4	3.63	2.03	1.84	1.02	2.75	1.74
2.5	2.33	1.24	1.18	0.34	1.73	1.08
2.6	1.44	0.58	0.74	0.00	1.04	0.45
2.7	0.87	0.00	0.07	0.70	0.31	0.00
2.8	0.13	0.70	0.70	0.30	0.00	0.70
2.9	0.70	0.30	0.00	0.00	0.70	0.30
3.0	0.00	0.00	0.30	0.00	0.30	0.00
3.1	0.30	0.00	0.00	0.00	0.00	0.00
TOTAL	2208.32	1931.21	1634.01	1460.70	1351.66	1199.62
> 1 V	741.53	538.16	522.25	380.54	462.99	330.23
> 2 V	33.22	19.48	18.62	10.98	25.72	16.53

Table 6-3
Beaver Valley Unit 1 March 2000
Comparison of Predicted and Actual EOC-13 Voltage Distributions

Voltage Bin	Steam Generator A			Steam Generator B			Steam Generator C		
	Number of Indications								
	EOC-13 Prediction		EOC-13 Actual	EOC-13 Prediction		EOC-13 Actual	EOC-13 Prediction		EOC-13 Actual
	POD = 0.6	POPCD		POD = 0.6	POPCD		POD = 0.6	POPCD	
0.1	0.79	1.40	0	0.63	1.28	0	1.00	1.78	0
0.2	19.23	32.00	11	10.65	18.19	16	21.28	36.16	18
0.3	74.69	107.63	74	45.04	67.56	55	59.75	90.76	56
0.4	159.63	204.47	148	103.65	138.82	136	102.52	137.69	111
0.5	235.06	273.42	170	159.69	195.76	131	138.08	165.83	103
0.6	269.33	287.93	185	190.68	217.16	136	156.78	170.15	104
0.7	262.43	260.01	174	196.07	206.92	108	153.15	152.55	92
0.8	231.47	214.23	123	178.20	175.09	83	133.90	124.70	85
0.9	190.66	166.51	87	148.63	137.48	80	109.86	96.55	53
1.0	150.45	124.92	85	118.44	104.20	50	87.15	72.66	44
1.1	114.63	91.06	60	91.53	76.88	23	68.07	54.13	35
1.2	85.09	64.93	42	69.19	55.53	34	52.97	40.36	27
1.3	62.39	45.90	27	51.63	39.76	25	41.58	30.51	20
1.4	45.71	32.54	24	38.34	28.60	22	32.87	23.41	19
1.5	33.73	23.31	14	28.14	20.54	8	25.82	17.98	14
1.6	25.02	16.87	13	20.28	14.46	14	19.92	13.62	14
1.7	18.62	12.28	7	14.38	10.05	6	14.88	10.05	9
1.8	13.79	8.93	10	10.08	6.92	2	10.71	7.16	1
1.9	10.09	6.45	8	6.95	4.71	3	7.42	4.93	7
2.0	7.24	4.57	2	4.66	3.13	0	4.98	3.28	4
2.1	5.06	3.16	5	3.04	2.02	2	3.24	2.13	1
2.2	3.45	2.10	2	1.93	1.28	2	2.05	1.34	0
2.3	2.29	1.35	0	1.19	0.78	0	1.26	0.83	0
2.4	1.50	0.85	0	0.64	0.07	0	0.76	0.14	0
2.5	0.99	0.22	0	0.00	0.70	0	0.00	0.70	0
2.6	0.65	0.00	0	0.70	0.00	0	0.70	0.00	0
2.7	0.36	0.70	0	0.30	0.30	0	0.00	0.30	0
2.8	0.00	0.30	0	0.00	0.00	0	0.30	0.00	0
2.9	0.70	0.00	0	0.00	0.00	0	0.00	0.00	0
3.0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
3.1	0.30	0.00	0	0.00	0.00	0	0.00	0.00	0
TOTAL	2025.35	1988.04	1271.00	1494.66	1528.19	936.00	1251.00	1259.70	817.00
> 1 V	431.61	315.52	214.00	342.98	265.73	141.00	287.53	210.87	151.00
> 2 V	15.30	8.68	7.00	7.80	5.15	4.00	8.31	5.44	1.00

Figure 6-1
Generic POPCD Distribution Based on 18 Inspections in 10 Plants
[Presented in EPRI Report NP-7480, Addendum-2]

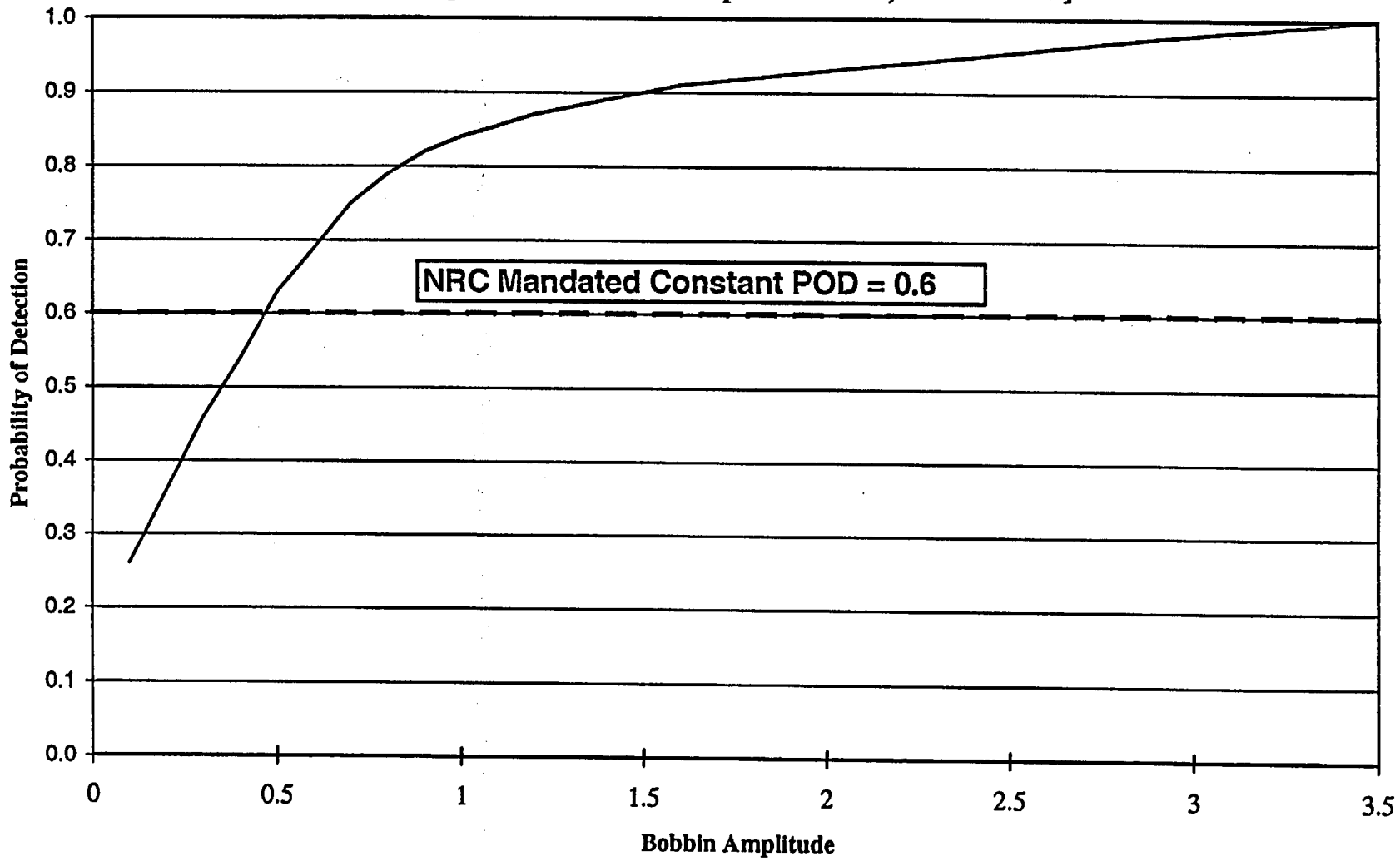


Figure 6-2
Beaver Valley Unit 1 SG-A
Predicted Bobbin Voltage Distribution for Cycle 14

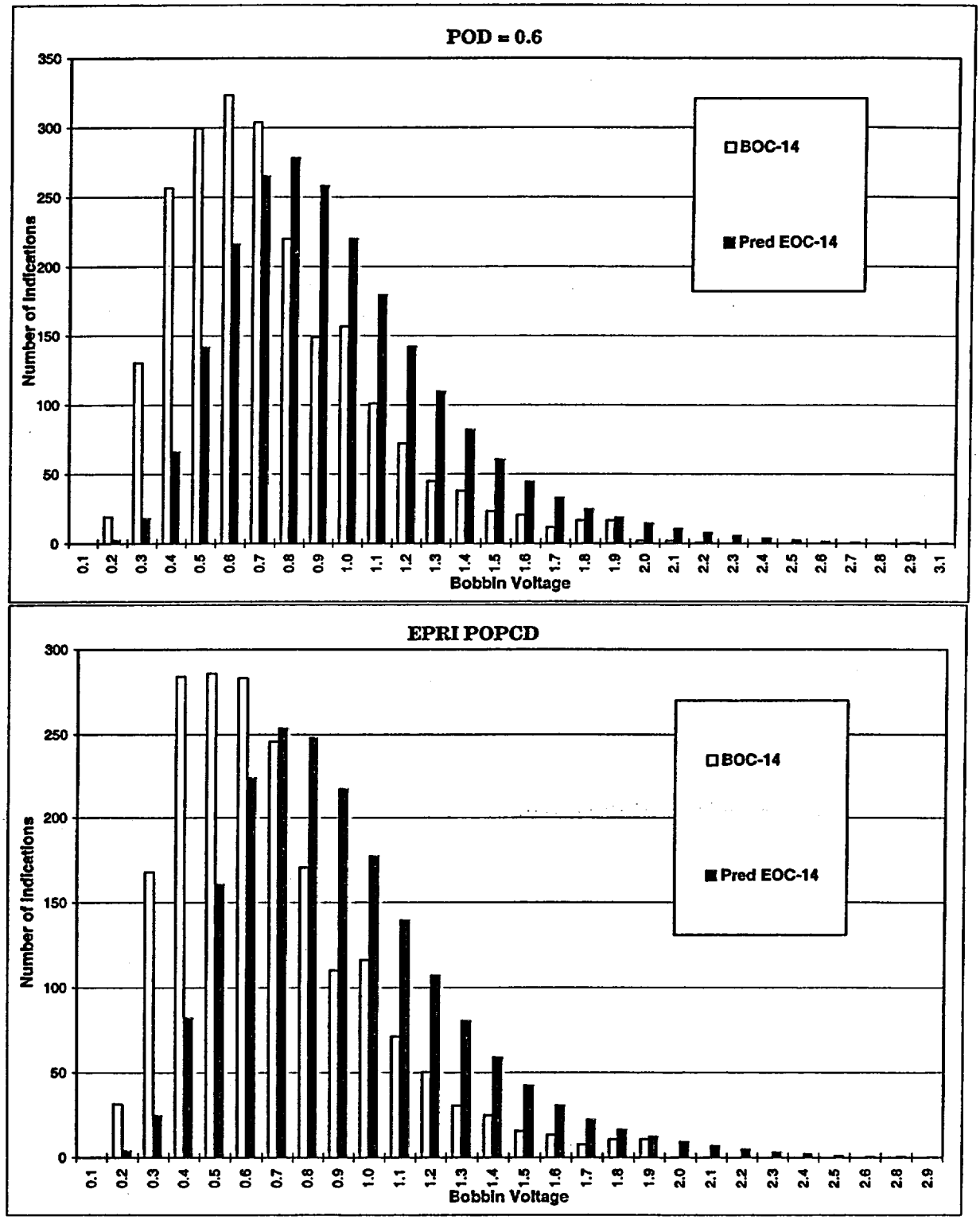
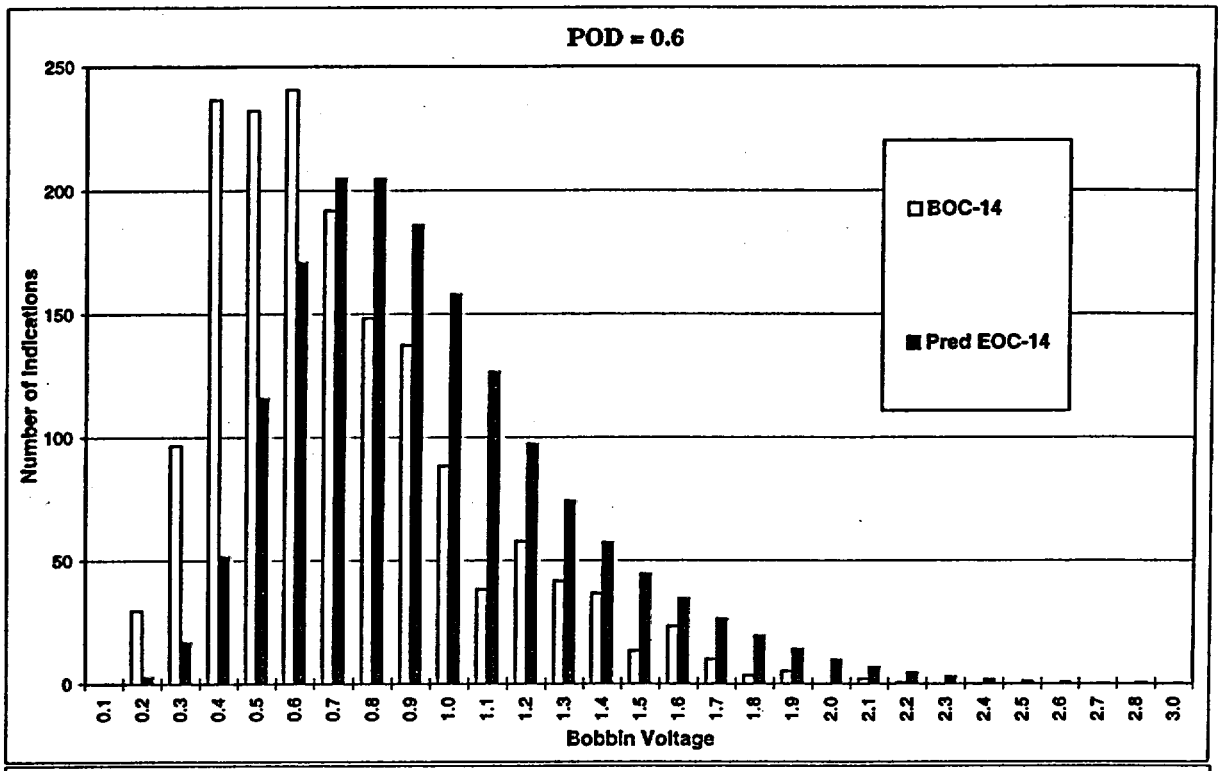


Figure 6-3
Beaver Valley Unit 1 SG-B
Predicted Bobbin Voltage Distribution for Cycle 14



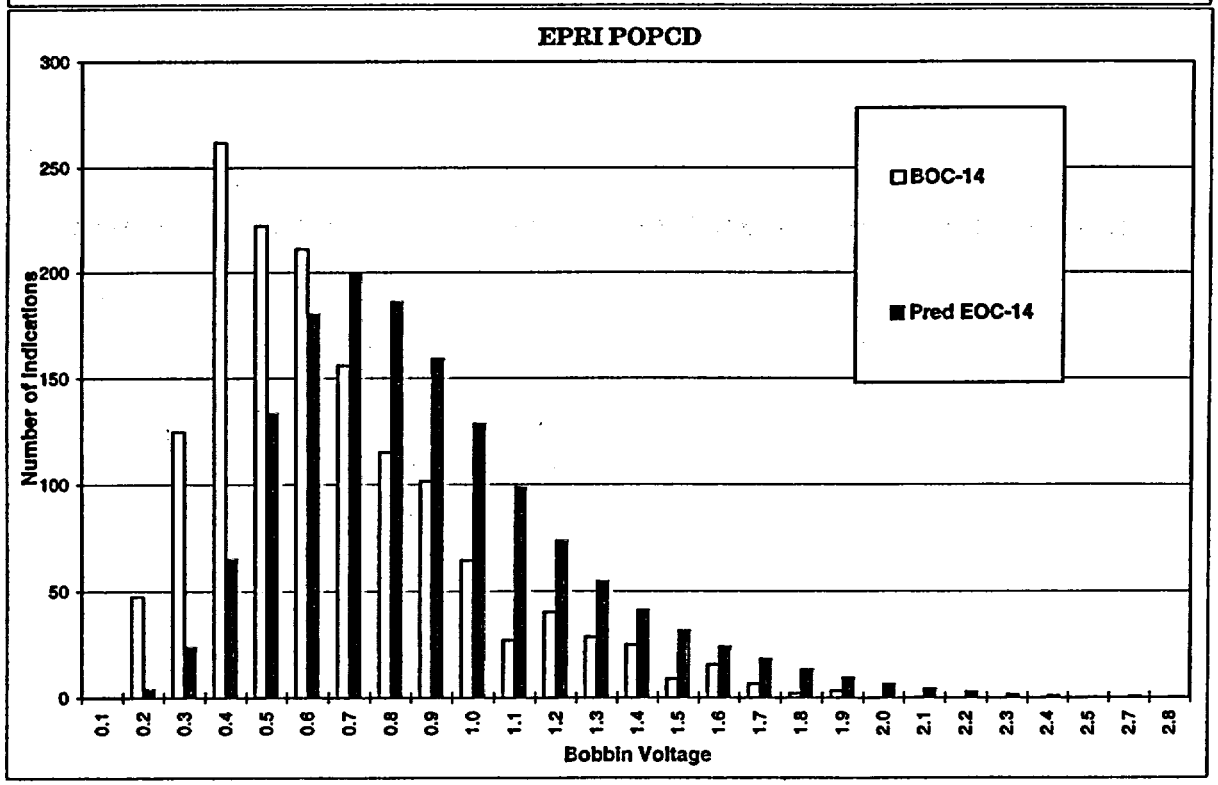
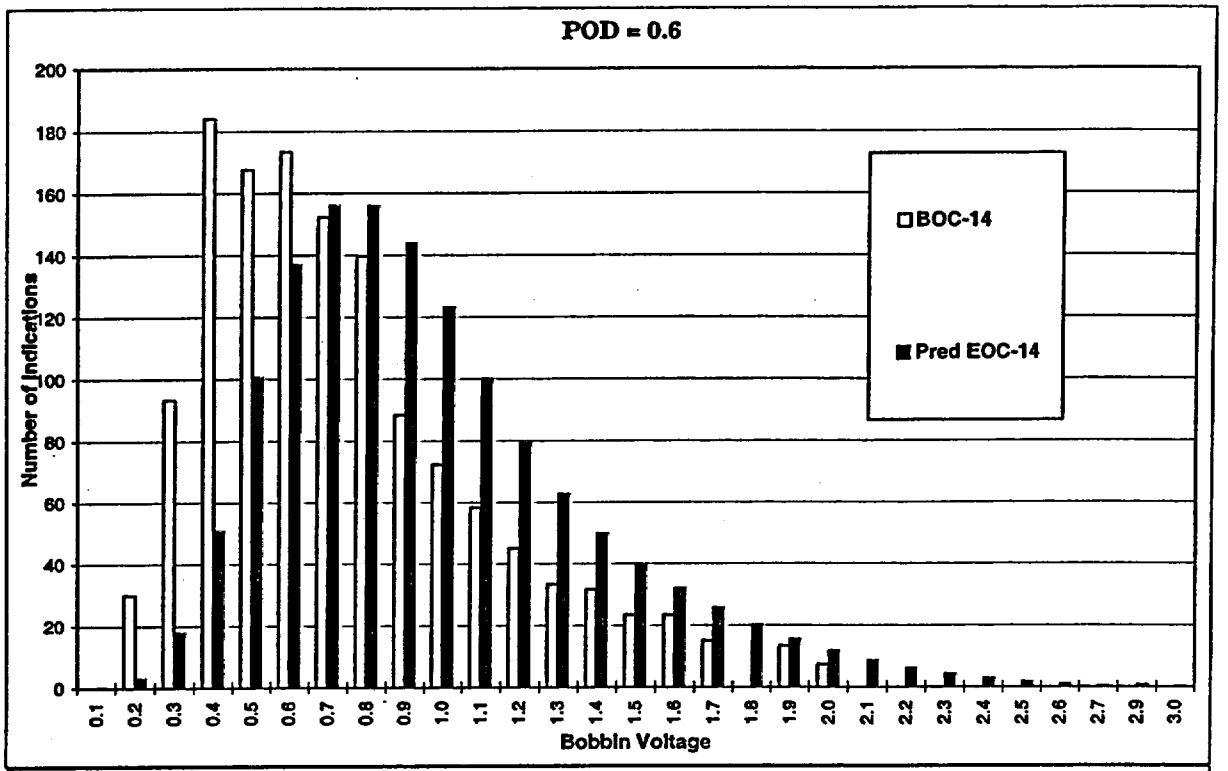


Figure 6-4
Beaver Valley Unit 1 SG-C
Predicted Bobbin Voltage Distribution for Cycle 14



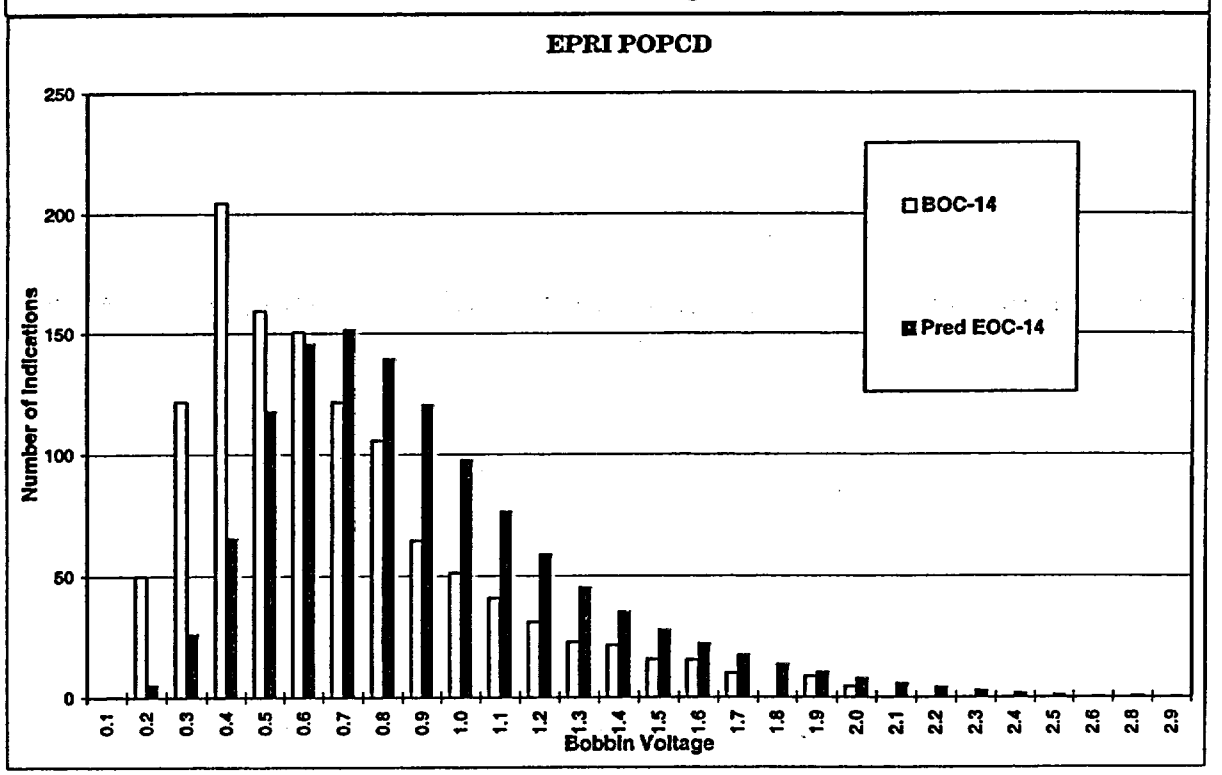
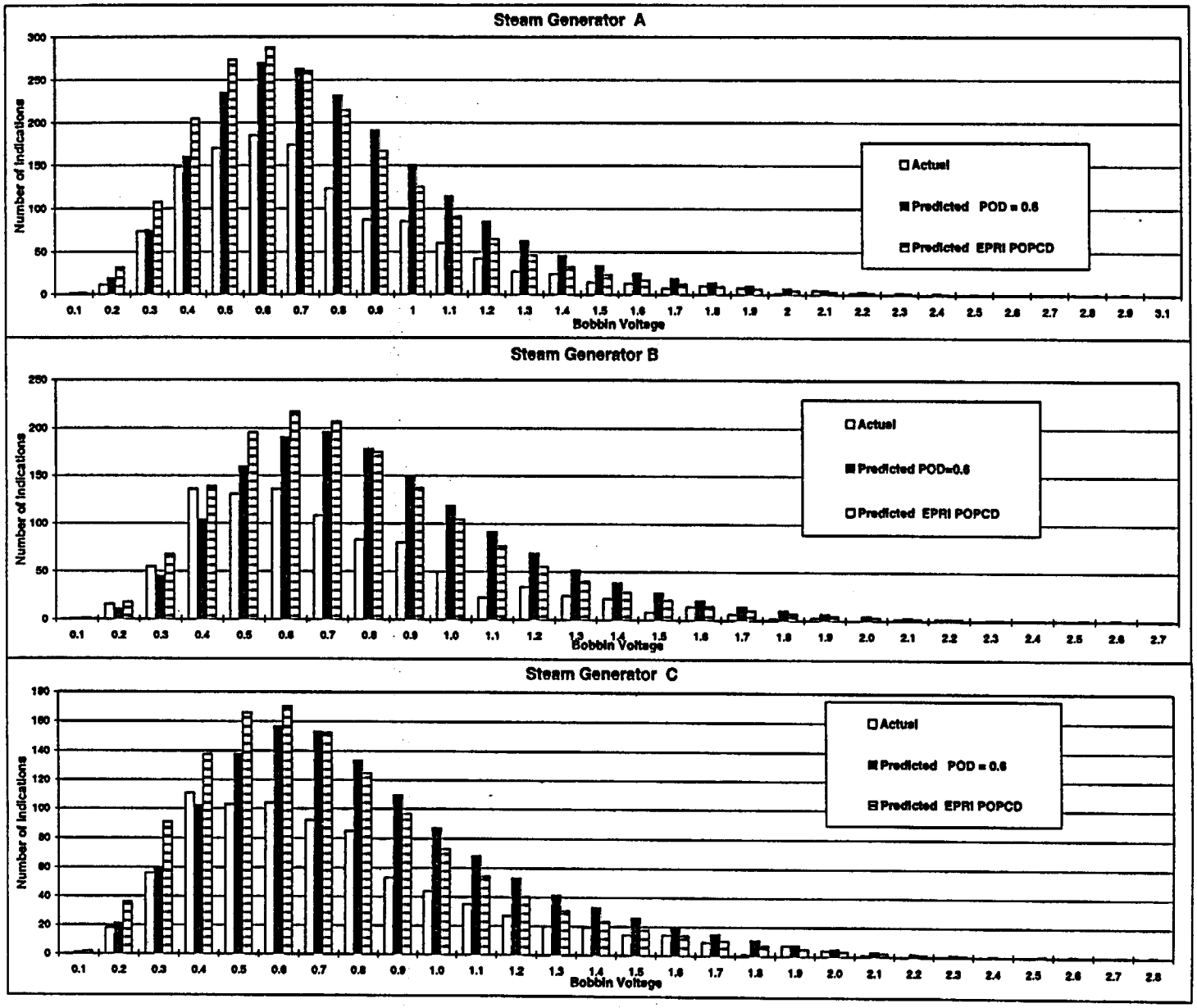


Figure 6-5
Beaver Valley Unit 1 March 2000
Bobbin Voltage Distributions at EOC-13



7.0 TUBE LEAK RATE AND TUBE BURST PROBABILITIES

7.1 Calculation of Leak Rate and Tube Burst Probabilities

This section discusses tube leak and burst probability analyses using voltage distributions projected for the end of the operating period. The calculation utilizes correlations relating bobbin voltage amplitudes (either measured or calculated) to free span burst pressure, probability of leakage and associated leak rates for ODSCC indications at TSP locations. The methodology used is documented in Reference 8-3, and is consistent with NRC criteria and guidelines of References 8-1. The calculated leak rates are volumetric rates at room temperature and they should be compared with allowable leak rates at room temperature.

7.2 Predicted and Actual Leak Rate and Tube Burst Probability for EOC-13

Analyses were performed to calculate SLB tube leak rate and probability of burst for the actual bobbin voltage distribution at EOC-13 previously presented in this report. The results of Monte Carlo calculations performed based on the actual voltage distributions including NDE uncertainties are shown on Table 7-1. Projections for the EOC-13 conditions of all three SGs presented in the last 90-day report (Reference 8-4) are also included for comparison in Table 7-1. The allowable SLB rate for the last operating cycle (Cycle 13) was 3.0 gpm (at room temperature).

Due to the differences in the probability of leakage and leak rate correlations used for the EOC-13 projections and the present condition monitoring analyses, the leak rates based on the actual measured EOC-13 voltages are higher than the projections presented in the last 90-day report for all SGs. The EOC-13 projections presented in the last 90-day report (Reference 8-4) used the database documented in Reference 8-9 (latest leak and burst database submitted to the NRC at that time) while the latest database available currently for 7/8" tubes (Reference 8-7) was used for the condition monitoring analysis. The latter database includes a number of data points from EdF plants for indications with high voltages (> 15 volts) that did not leak. Inclusion of this EdF data significantly increases PoL for indications below 1 volt (by a factor of 3 to 10, or more), which resulted in the calculated leakage based on the actual EOC-13 voltages to exceed the projections presented in the last 90-day report (see Table 7-1). To compare leak rates based on the projected and actual EOC-13 voltages on a consistent basis, the EOC-13 projection for the limiting SG (SG-A), was repeated using the latest NRC approved database (Reference 8-7), and these results are also shown in Table 7-1. The projected SLB leak rate and burst probabilities with the latest database are higher than those based on the actual voltages, for both POD=0.6 and POPCD, which confirms that the database used for the original EOC-13 projections caused underestimation of the projected leak rate. Thus, the methodology used for EOC-13 leak rate and burst probability is conservative.

For all SGs, tube burst probabilities based on the actual voltage distributions are less than the projections with POD=0.6 as well as POPCD; they are also below the NRC reporting guideline of 10^{-2}.

In summary, the limiting SLB leak rate (1.7 gpm at room temperature) and tube burst probability (5.3×10^{-4}) calculated using the actual measured EOC-13 bobbin voltage distributions and the latest leak and burst database are well below the corresponding allowable limits (3.0 gpm and 10^{-2}, respectively). The results also show that the projections based on voltage-dependent POD (POPCD) provide more realistic but still conservative estimates for leak rate and burst probability.

7.3 Projected Leak Rate and Tube Burst Probability for EOC-14

Using the methodology previously described, calculations were performed to predict the EOC-14 condition of all three steam generators in Beaver Valley Unit-1. EOC-14 bobbin voltage distributions are predicted as well as the leak rates and tube burst probabilities based on these distributions. The leak rate vs. bobbin voltage correlation shown in Section 4.0 is applied. The projected leak rates are compared with the allowable leak rate at room temperature.

SG-A is again predicted to be the limiting SG since it had the largest total number of indications at EOC-13 as well as 42% of indications over 1 volt returned to service in all 3 SGs. As the growth rates during Cycle 13 are higher than that for Cycle 12, the Cycle 13 growth distribution is more limiting and is used in the EOC-14 projection analysis.

The projected EOC-14 SLB leak rates and burst probabilities for all 3 SGs are shown in Table 7-2. The analysis based on POD=0.6 yields an EOC-14 SLB leak rate of 4.5 gpm, while the voltage-dependent POPCD yields 3.1 gpm. The corresponding tube burst probabilities are 1.7×10^{-4} and 1.3×10^{-4}, respectively. The limiting EOC-14 leak rate calculated will be below the new allowable leak limit of 5.5 gpm provided the technical specifications are revised to lower the allowable reactor coolant activity limit to 0.2 micro curies/gram of dose equivalent I-131. This technical specification amendment is currently being processed.

As noted in Section 7.2, the inclusion of EdF data that show no leakage at high bobbin voltages (> 15 volts) in the leak and burst data base for voltage-based repair criteria significantly increases PoL for indications below 1 volt (by a factor of 3 to 10, or more), which results in higher predicted leak rates. To estimate the extent of this impact on the EOC-14 leak rates, a new correlation was developed for PoL excluding the EdF data with bobbin voltage >15 volts without SLB leakage and was used to recalculate the EOC-14 leak rate for the limiting SG (SG-A).

Results for this sensitivity case, also shown in Table 7-2, show that the inclusion of the EdF data nearly doubles the predicted EOC-14 leak rate. Therefore, the limiting EOC-14 leak rate value predicted, 4.5 gpm, is conservative.

Another sensitivity calculation was also performed to illustrate conservatism in the manner in which growth data is applied. The growth data used for SLB leak rate and burst probability analysis are usually binned in 0.1 volt intervals and the data are inputted in the form of a cumulative probability distribution. The Monte Carlo methodology presented in Reference 8-3 recommends a linear interpolation between discrete values used for the cumulative growth distribution. With a growth distribution that has an unusually large growth value, interpolation of the growth data may result in the largest growth value not used in the Monte Carlo simulations. (Growth rate for a simulation is selected by drawing a random number between 0 and 1, and unless a number exactly equal to 1 is drawn the largest growth value would not be used.) Therefore, an alternate method of growth rate selection wherein the cumulative distribution inputted is treated as a histogram is now used. Although it is necessary to treat only the upper tail of the growth distribution as a histogram to improve the likelihood of the largest growth value being picked, for convenience the entire growth distribution is treated as a histogram, which introduces additional conservatism in the analysis.

Since a growth distribution used for SLB leak rate and burst probability analysis must contain at least 200 points (the distributions applied in the present EOC-14 projections for SG-A contain 3024 points) it is justified to use a continuous distribution (i.e., interpolation of discrete input values) away from the tail of the distribution. Furthermore, Cycle 13 growth data used for Cycle 14 projections do not contain any unusually large growth values that require histogram representation. Nevertheless, the Cycle 13 growth data used for the EOC-14 projections discussed above were represented by a histogram. As a sensitivity analysis, an additional case with the following growth distribution was also considered. Additional discrete data points were included in the growth distribution between 0 to 0.4 volts by using a bin width of 0.02 volt, while the tail between 0.4 to 0.7 volts still used 0.1 volt bins. With this approach, the limiting SLB leak rate (4.5 gpm, based on treating the entire growth distribution as a histogram) decreases to 4.1 gpm. Hence, histogram representation of growth adds about 10% conservative margin to the predicted EOC-14 leak rate for Beaver Valley-1.

In summary, postulated SLB leak rates at EOC 14 for all three SGs will meet a revised SLB leak rate limit of 5.5 gpm using the NRC-mandated POD = 0.6 provided the technical specifications are revised to lower the allowable reactor coolant activity limit to 0.2 micro curies/gram of dose equivalent I-131. This technical specification amendment is currently being processed. Tube burst probabilities projected for EOC-14 are below GL 95-05 limits. Results based on voltage dependent POPCD show even a greater margin between EOC-14 predictions and acceptance limits.

q:\arc\dlw00\dlw90day.doc

Table 7-1
Beaver Valley Unit 2 2000 EOC-13 Outage
Summary of Calculations of Tube Leak Rate and Burst Probability

Steam Generator	POD	Number of Indications(1)	Max. Volts	Burst Probability		SLB Leak Rate [gpm(2)]
				1 Tube	1 or More Tubes	
EOC - 13 PROJECTIONS						
Original Projections Based on Leak and Burst Database Presented in Reference 8-9						
Leak Rate vs. Bobbin Voltage Correlation Applied						
A		1983	3.1	1.6×10^{-4}	1.6×10^{-4}	1.0
B		1474	2.7	1.1×10^{-4}	1.1×10^{-4}	0.7
C		1224	2.8	9.9×10^{-5}	9.9×10^{-5}	0.6
A		1948	2.8	7.8×10^{-5}	7.8×10^{-5}	0.7
B		1507	2.7	9.0×10^{-5}	9.5×10^{-5}	0.6
C		1229	2.7	7.9×10^{-5}	7.9×10^{-5}	0.5
Revised EOC - 13 PROJECTIONS for SG-A						
Based on the Latest Leak and Burst Database Presented in Reference 8-7						
Leak Rate vs. Bobbin Voltage Correlation Applied						
A	0.6	1983	3.1	1.2×10^{-4}	1.2×10^{-4}	2.9
	POPCD	1948	2.8	6.3×10^{-5}	6.3×10^{-5}	2.4
EOC – 13 ACTUALS(3)						
A	1	1271	2.2	5.3x10- 5	5.3x10- 5	1.7
B		936	2.2	4.7x10- 5	4.7x10- 5	1.1
C		817	2.0	5.3x10- 5	5.3x10- 5	1.0

Notes:
(1) Adjusted for POD.
(2) Equivalent volumetric rate at room temperature
(3) Based on leak and burst database presented in Reference 8-7 (Addendum-3 database).

q:\arc\dlw00\dlw90day.doc

Table 7-2
Beaver Valley Unit-1
Summary of Projected Tube Leak Rate and Burst Probability for EOC-14
(Based on a projected Cycle 14 length 520 EFPD)

Steam Generator	POD	No. of Indications[1]	Max Volts	Burst Probability		SLB Leak Rate (gpm)[2]	Comments
				1 Tube	One or More Tubes		
Leak and Burst Database and Correlations Reported in Reference 8-7 (Addendum-3) Applied							
A[3]	0.6	2208	3.1	1.7×10^{-4}	1.7×10^{-4}	4.5	Leak rate Correlation applied
B[4]		1634	3.0	1.4×10^{-4}	1.4×10^{-4}	3.1	
C[3]		1352	3.0	1.4×10^{-4}	1.4×10^{-4}	2.8	
A[3]	POPCD	1931	2.9	1.3×10^{-4}	1.3×10^{-4}	3.4	
B[4]		1461	2.8	1.1×10^{-4}	1.1×10^{-4}	2.4	
C[3]		1200	2.9	1.0×10^{-4}	1.0×10^{-4}	2.1	
Sensitivity Analysis for the Limiting SG (SG-A) Leak and Burst Correlations Reported in Reference 8-7 (Addendum-3) Applied							
A	0.6	2208	3.1	1.7×10^{-4}	1.7×10^{-4}	2.3	EdF Data showing no leakage at bobbin volts >15 volts excluded from PoL correlation
			3.0	$<1.7\times10^{-4}$	$< 1.7\times10^{-4}$	4.1	Smaller volts bin used for Cycle 13 growth distribution[5]

Notes

1. Number of indications adjusted for POD.
2. Volumetric leak rate adjusted to room temperature.
3. All SG composite growth rate distribution applied.
4. SG-B specific growth rate distribution applied.
5. 0.02 volt bins versus the standard 0.1 volt bins.

q:\arc\dlw00\dlw90day.doc

8.0 REFERENCES

8-1 NRC Generic Letter 95-05, "Voltage-Based Repair Criteria for Westinghouse Steam Generator Tubes Affected by Outside Diameter Stress Corrosion Cracking", USNRC Office of Nuclear Reactor Regulation, August 3, 1995.

8-2 U.S. N.R.C. Report, "Safety Evaluation by the Office of Nuclear Reactor Regulation Related to Amendment No. 198 to Facility Operating License DPR-66 Duquesne Light Company, Ohio Edison Company and Pennsylvania Power Company, Beaver Valley Power Station, Unit No. 1 Docket No. 50-334", April 1, 1996.

8-3 WCAP-14277, Revision 1, "SLB Leak Rate and Tube Burst Probability Analysis Methods for ODSCC at TSP Intersections," Westinghouse Nuclear Services Division, December 1996.

8-4 SG-98-03-003, "Beaver Valley Unit-1 Cycle 13 Voltage Based Repair Criteria 90 Day Report," Westinghouse Nuclear Services Division, March 1998.

8-5 SG-96-07-009, "Beaver Valley Unit-1 1996 Alternate Repair Criteria 90 Day Report," Westinghouse Electric Corporation, July 1996.

8-6 SG-95-06-006, "Beaver Valley Unit-1, 1995 Interim Plugging Criteria 90 Day Report," Westinghouse Electric Corporation, July 1995.

8-7 Addendum-3 to EPRI Report NP-7480-L, "Steam Generator Outside Diameter Stress Corrosion Cracking at Tube Support Plates – Database for Alternate Repair Criteria," May 1999.

8-8 Letter from B. W. Sheron, Nuclear Regulatory Commission, to A. Marion, Nuclear Energy Institute, dated February 9, 1996.

8-9 Addendum-2 to EPRI Report NP-7480-L, "Steam Generator Outside Diameter Stress Corrosion Cracking at Tube Support Plates – Database for Alternate Repair Criteria," April 1998.