WESTINGHOUSE PROPRIETARY CLASS 3

SG-96-08-005

BYRON UNIT - 1 END-OF-CYCLE 7B

INTERIM PLUGGING CRITERIA REPORT

August 1996

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Interim Plugging Criteria Report

1.0 Introduction

This report provides the Byron Unit 1 steam generator (SG) tube Eddy Current (EC) inspection results at the end of Cycle 7B* together with Steam Line Break (SLB) leak rate and tube burst probability analysis results calculated according to NRC guidelines, to implement a 3.0 volt Interim Plugging Criteria (IPC). SLB leak rates and tube burst probabilities were calculated for end of cycle (EOC) conditions of both the recently completed cycle (Cycle 7B) and the ongoing cycle (Cycle 8).

Analyses for Cycle 7B were carried out using the actual bobbin voltage distributions measured during the EOC-7B outage and the results compared with corresponding values from projections performed based on the last (EOC-7A) inspection bobbin voltage data. These analyses were carried out considering the locked tube support plate (TSP) condition. The methodology used in these evaluations is in accordance with previously published Westinghouse reports (References 8.1, 8.2 and 8.6)

Analyses were also performed to project leak rates and tube burst probability for postulated SLB conditions at the end of the ongoing cycle (Cycle 8) based on the 3.0 volt repair criteria. Those analyses utilized bobbin voltage distributions measured during the recent (EOC-7B) inspection and a limiting growth rate distribution from the last two inspections (EOC-7A and EOC-7B inspections).

An evaluation was also performed to assess the fraction of the indications that showed no degradation during the rotating pancake coil (RPC) probe inspection in 1995 EOC-7A inspection, were left in service at beginning of cycle 7B (BOC-7B), and were RPC confirmed in 1996 at EOC-7B.

*Since this is the second of two inspections conducted during Cycle 7, for clarity, the cycle completed before the mid-cycle inspection is referred to as Cycle 7A and the cycle just completed as Cycle 7B.

2.0 Summary and Conclusions

SLB leak rate and tube burst probability analyses were performed for the actual EOC-7B EC bobbin voltage distributions as well as the projected EOC-8 bobbin voltage distributions. Results for the EOC-7B actual measured bobbin voltages are generally lower than the corresponding projections performed using the EOC-7A outage bobbin voltage data and a probability of detection of 0.6 except for SG B SLB leak rate. The highest bobbin voltage measured for SG B (after adjusted for NDE uncertainty by a Monte Carlo technique) is 0.5 volts higher and the SLB leak rate based on the actual voltages is 0.02 gpm higher than the projected value (0.25 gpm). The above difference in the calculated leak rate is very small in comparison to its acceptance limit (35.7 gpm). The number of indications detected on the cold leg side in all SGs during the EOC-7B inspection are slightly higher than those assumed in the projection analyses, and the peak voltages measured are also slightly higher. However, the cold leg indication population detected is still small and, consequently, all calculated tube burst probability values are below 4×10^{-6}.

Projections performed during the last outage for EOC-7B using a constant POD of 0.6 as well as EPRI POD predicted SG-B to be the limiting SG, which is consistent with the analyses based on EOC-7B actual measured voltages. The SLB leak rate for SG-B based on actual EOC-7B bobbin voltages is calculated to be (for the locked TSP condition) 0.27 gpm, and the corresponding tube burst probability is below 4×10^{-6}. These values are much lower than the allowable Cycle 7B SLB leakage limit of 35.7 gpm and the NRC reporting guideline of 10^{-2} for the conditional tube burst probability.

The leak rate and tube burst probability projections at EOC conditions for the current cycle (Cycle 8) are also well within acceptable limits. Limiting SLB leak rate projected for the EOC-8 conditions (locked TSPs) using the NRC SER endorsed probability of detection of 0.6 is 19.0 gpm. This value is projected for SG-C which has the largest number of indications and it is well below the allowable EOC-8 leakage limit of 35.7 gpm. The highest tube burst probability, 9.4×10^{-4}, is predicted for SG B which has the largest number of indications on the cold leg side (only cold leg indications contribute to burst) and it is also well below the NRC reporting guideline of 10^{-2}.

Results projected for EOC-8 are significantly higher than found at the actual EOC-7B condition due to the longer operating cycle resulting in conservative growth rates used in the projections. Voltage growths during the 1.35 EFPY duration assumed for Cycle 8 were obtained by five fold extrapolation of the measured growth rates for Cycle 7B, which was a very short cycle (0.24 EFPY). Uncertainties in the bobbin voltage measurements would exaggerate growth rates obtained with such large extrapolation. Also, the NRC requirement to adjust the number of indications upwards using a probability of detection factor of 0.6 increased conservatism in the projections.

A total of 5719 indications were found in the EOC-7B inspection of which 291 were inspected with a RPC probe (including a minimum of 20 % of hot leg indications between 1 and 3 volts and all hot leg indications above 3 volts), and 220 were confirmed as flaws. The RPC confirmed indications included 191 above 1.0 volt. SG-C had the largest number among the four SGs with 2040 bobbin indications, of which 369 were above 1.0 volt, 84 of these were inspected by RPC and 76 were confirmed as flaws. Seven indications were found above 3 volts (one each in SGs A and C, and 5 in SG B) and they were all confirmed by RPC.

All dents over 5 volts and 20% of dents between 2.5 and 5.0 volts were RPC inspected. An ID-initiated, axial indication was reported in a dent (expected to be a mechanical ding) at the edge of the sixth TSP on the cold leg side of tube R1-C74 in SG-A. The indication starts at the top of the TSP and extends upwards 0.21" outside the TSP. Its RPC voltage is 1.17 volts (115 mil pancake coil) and the bobbin voltage of the dent is 15.77 volts. There is also another dent of magnitude 7.13 volts at that intersection located entirely within TSP. No other ID indications at dented TSP intersections or circumferential indications at the TSP intersections or indications extending outside the TSP were found in this inspection.

3.0 EOC-7B Inspection Results and Voltage Growth Rates

3.1 EOC-7B Inspection Results

According to the IPC guidance provided by the NRC Generic Letter 95-05, the end of Cycle 7B inspection of the Byron Unit 1 SGs consisted of a complete, 100% EC bobbin probe full length examination of the tube bundles in all four SGs. A 0.610 inch diameter probe was used for all hot and cold leg TSPs where IPC was applied. Subsequently, RPC examination was performed for a minimum of 20 percent of the hot leg indications with an amplitude between 1 and 3 volts, all hot leg indications with an amplitude 3 volts and above, and all cold leg indications. Seven hot leg indications had a bobbin voltage above 3 volts; they were all confirmed as flaws and plugged. The only cold leg indication with a bobbin voltage above 1 volt was not confirmed by RPC. It was also below the upper voltage limit calculated for the cold leg indications, 2.56 volts, and hence it was not repaired.

In addition, an augmented RPC inspection was performed consistent with the NRC requirements. All dented intersections with a bobbin voltage greater than 5 volts and a minimum of 20 percent of the dented intersections with a bobbin voltage between 2.5 and 5 volts were inspected with a RPC probe. Only one flaw was reported in the augmented inspection: an ID-initiated, axial indication was found in a dent at the edge of the sixth TSP on the cold leg side of tube R1-C74 in SG-A. The indication starts at the top of the TSP and extends upwards 0.21 inch outside the TSP. Its RPC voltage is 1.17 volts (115 mil pancake coil) and the bobbin voltage of the dent is 15.77 volts. There is also another dent of magnitude 7.13 volts at that intersection located entirely within the TSP. The 0.21 inch flaw is too small to challenge structural integrity for a free span indication. Apart from this ID indication, there was no other unexpected eddy current results in this inspection. There were no RPC circumferential indications at the TSPs, no indications (other than R1-C14) extending outside the TSPs, and no RPC indications with potential ID phase angles (except for R1-C14 in SG-A). Also, no mixed residual artifact signals or signal interference from copper deposits were found during this inspection.

A summary of EC indications for all four SGs is shown on 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 8 operation is the difference between the observed and the ones removed from service.

Overall, the combined data for all four SGs of Byron Unit 1 shows the following.

- Out of a total of 5719 TSP indications identified during the inspection, a total of 291 were RPC inspected.

Of the 291 RPC inspected, a total of 220 were RPC confirmed.

- A total of 299 indications were removed from service of which only 26 indications were repaired because of TSP ODSCC related causes (7 indications exceeded 3 volt IPC repair limit and the other 19 were RPC-confirmed indications near the wedge locations where IPC does not apply). No cold leg TSP ODSCC indications required repair. Consistent with the 3 volt IPC, hot leg indications with bobbin amplitude less than or equal 3.0 volts and cold leg indications less than or equal to 1 volt are not considered for removal from service, regardless of RPC data.

A review of Table 3-1 indicates that more indications (a quantity of 1964 indications, with 348 above 1.0 volt) were returned to service in SG-C than the other SGs, thereby it potentially will be the limiting SG at EOC-8 from the standpoint of SLB leak rate. SG-B had the largest number of cold leg indications found in the EOC-7B inspection (12) and, since tube burst probability is determined by cold leg indication population only, it potentially will yield the limiting tube burst probability at EOC-8. As discussed in Section 7, the SG-C bobbin voltage distribution yielded the largest SLB leak rate projected for the EOC-8 condition, while SG-B yielded the largest tube burst probability.

A total of ten RPC probe signals from all four SGs were classified as volumetric calls in the field inspection and the C-Scan pictures for two of them with the largest bobbin and RPC voltages are shown here in Figures 3-1 and 3-2. RPC signals for all ten indications are consistent with those of axial indications with cellular patches and the more appropriate classification for the signals would be axial OD indication consistent with IPC application.

Figure 3-3 shows the actual bobbin voltage distribution determined from the EOC-7B EC inspection; Figure 3-4 shows the population distribution of those EOC-7B indications removed from service due to tube repairs; Figure 3-5 shows the distribution for indications returned to service for Cycle 7B. Of the 299 indications removed from service, only 26 indications are in tubes repaired for TSP IPC-related issues. The rest are in tubes plugged for degradation mechanisms other than ODSCC at TSPs. Among the 26 ODSCC indications removed from service due to IPC-related issues, only three indications were above the 3 volt IPC limit. The remaining 19 indications are in tubes near the wedge supports for which the TSP IPC does not apply.

The distribution of EOC-7B indications as a function of support plate location is summarized in Table 3-2 and plotted in Figure 3-6. The data show a strong predisposition of ODSCC to occur in the first few hot leg TSPs (5120 out of 5593 indications occurred at the first three hot leg TSP intersections), although the mechanism extended to higher TSPs. One indication was found at the FDB (1H)

in SG A, and this indication was repaired. Only 31 indications were detected on the cold leg side. This distribution indicates the predominant temperature dependence of ODSCC at Byron 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 8 operation, voltage growth rates were developed from EOC-7B (April 1996) inspection data and a reevaluation of the same indications from the EOC-7A (November 1995) inspection EC signals. Table 3-3 shows the cumulative probability distribution of growth rate for each Byron Unit-1 steam generator during Cycle 7B (December '95 - April '96) on an EFPY basis, along with the corresponding Cycle 7A growth rate distributions. Out of the 5719 indications detected during the EOC-7B inspection, reevaluated EOC-7A voltages are not available for 126 indications and, therefore, growth data is presented for 5593 indications only. Cycle 7B growth data are plotted in Figure 3-7. Among the four steam generators, SG-B has a slightly larger average voltage growth during Cycle 7B, and it also has the indication with the largest voltage growth. The curve labelled 'cumulative' in Figure 3-7 represents averaged composite growth data from all four SGs.

Composite growth rates from all SGs for Cycle 7B are compared with those of Cycles 6 and 7A in Figure 3-8; the data for Cycle 7B appear to be higher than those for the two prior operating periods. However, since Cycle 7B was a very short cycle (only 87.8 EFPDs), the differences between the current and last inspection bobbin voltages were multiplied by a factor of about 4 to convert them to the growth rate/ EFPY values shown in Table 3-3 and Figure 3-8. Some of the large differences noted between the EOC-7B and previous cycle growth rates are attributable to the uncertainties associated with measured bobbin voltages, which are exaggerated since voltage differences used to compute EOC-7B growth rates are multiplied by a factor as high as 4 to convert the growth rates to an EFPY basis. Thus, the larger EFPY growth values for Cycle 7B in Table 3-3 and Figure 3-7, both positive and negative values, are likely to be overestimated. Since Cycle 7B growth rates are used in the SLB leak and burst projections for Cycle 8, the projected values are considerably overestimated as discussed in Section 7.2.

Average growth rates for each SG during Cycle 7B are summarized in Table 3-4. The average growth rates over the entire voltage range vary between 38.9% and 78.0% (of the BOC voltage) per EFPY, between SGs, with an overall average of 63.4% per EFPY. The average growth for indications greater than or equal to 0.75 volts is 54.7% per EFPY and for indications less than 0.75 volts it is 70.0% per EFPY. Steam generators B and C had the highest average voltage at BOC-7B whereas SG-B had the largest average voltage growth during Cycle 7B. Steam

generator D had the largest voltage growth rate during the last (EOC-7A) inspection.

Averaged composite voltage growth data from all four steam generators for the last three operating periods are summarized in Table 3-5. Also included in Table 3-5 are growth data from EOC-4 and EOC-5 inspections, which are available only for tubes plugged during those inspections. Table 3-6 lists top 30 indications on the basis of Cycle 7B growth rates, in descending order. Eleven of those indications were RPC confirmed and the remaining nineteen were not inspected. Nine of the 30 indications shown are new indications, and EOC-7A voltages used to estimate growth rates for them were obtained by revaluating the last inspection data.

The guidelines in the Generic Letter 95-05 require the use of the more conservative growth rate distributions from the past two inspections for projecting EOC distributions for the next cycle. From Figure 3-8 it is evident that growth rates for Cycle 7B are higher than those of Cycle 7A and, hence, Cycle 7B growth rates were used to develop the EOC-8 predictions. Cycle 7B growth rates for SGs B and C are slightly higher than the composite growth distribution and, per the methodology described in Reference 8.2, SG-specific growth rates are to be used for SGs B and C while the composite growth rates should be applied for SGs A and D. However, the limiting growth rate for SG B was imposed on all four steam generators to provide a conservative basis for predicting EOC-8 performance.

Separate voltage projections to EOC-7B are required for the hot and cold legs since tube expansion to limit TSP displacement has been implemented only in the hot leg. Table 3-2 shows average and maximum growth rates by TSP elevation including the cold leg. It is seen that except one indication with 0.53 volts growth all other growth rates for the cold leg below 0.15 volts. The cold leg results tend to indicate lower growth rates than found for hot leg indications. It is therefore very conservative to use the bounding growth rate (Cycle 7B distribution) for the cold leg as well as the hot leg indications, and this conservatism is applied for the EOC-8 analysis in Sections 6 and 7.

3.3 NDE Uncertainties

The NDE uncertainties applied for the Cycle 7B voltage distributions in the Monte Carlo analyses for leak rate and burst probabilities are the same as those previously reported in the Byron Unit-1 IPC report of Reference 8.7 and NRC GL 95-05 (Reference 8.4). They are presented in Table 3-7 as well as graphically illustrated in Figure 3-9. 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 10.3% about a mean of zero with no cutoff. These NDE uncertainty

distributions are included in the Monte Carlo analyses used to project the EOC-7B voltage distributions.

3.4 Assessment of RPC Confirmation Rates

This section tracks the 1995 EOC-7A indications left in service at EOC-7B relative to RPC inspection results in 1996 at EOC-7B. The composite results for all SGs are given in Table 3-8. For 1995 bobbin indications left in service, the indications are tracked relative to 1996 RPC confirmed, 1996 RPC NDD, 1996 bobbin indications not RPC inspected and 1995 bobbin indications with no indication found in 1996. Also included are new 1996 indications. The table shows, for each category of indications, the number of indications RPC inspected and RPC confirmed in 1996 as well as the percentage of RPC confirmed indications.

Of the 39 RPC NDD indications left in service at BOC-7B, 33 were RPC tested during the EOC-7B inspection and only 9 were confirmed. This RPC confirmation rate for prior RPC NDD indications (27.3%) is smaller than the 48.1% value found during the last inspection. It has been recommended by industry that the largest RPC NDD confirmation rates over the prior two cycles be used for projections. Thus, it would be justifiable to include only 50% of the RPC NDD indications in the BOC-8 voltage distribution used for EOC-8 projections, and leak rate and burst probability analyses. However, 100% of RPC NDD indications reported in the EOC-7B inspection are considered in the SLB leak rate and tube burst probability analyses presented in this report for EOC-8 conditions.

Table 3-1 (Sheet 1 of 2)
Byron Unit -1 April 1996 Outage
Summary of Inspection and Repair For Tubes in Service During Cycle 7B

Voltage Bin	Steam Generator A						Steam Generator B						Steam Generator C					
	In-Service During Cycle 7B				RTS for Cycle 8		In-Service During Cycle 7B				RTS for Cycle 8		In-Service During Cycle 7B				RTS for Cycle 8	
	Field Bobbin Indn.	RPC Inspected	RPC Confirmed	Indications Repaired	All Indn.	Confirmed & Not Inspected Indn.	Field Bobbin Indn.	RPC Inspected	RPC Confirmed	Indications Repaired	All Indn.	Confirmed & Not Inspected Indn.	Field Bobbin Indn.	RPC Inspected	RPC Confirmed	Indications Repaired	All Indn.	Confirmed & Not Inspected Indn.
0.1	1	0	0	0	1	1	2	0	0	0	2	2	0	0	0	0	0	0
0.2	36	2	0	0	36	34	25	0	0	0	25	25	33	0	0	1	32	32
0.3	125	1	0	1	124	123	135	6	2	6	129	125	171	5	0	5	166	162
0.4	160	7	2	6	154	150	235	6	2	9	226	222	257	6	1	7	250	245
0.5	146	3	1	11	135	133	252	1	1	11	241	241	275	3	1	7	268	266
0.6	127	7	3	10	117	113	246	2	0	8	238	236	280	6	2	7	273	270
0.7	110	3	1	8	102	100	222	6	5	14	208	208	231	5	2	13	218	217
0.8	74	1	1	6	68	68	146	0	0	6	140	140	204	3	1	8	196	194
0.9	67	0	0	7	60	60	109	0	0	3	106	106	119	2	0	2	117	116
1	42	0	0	5	37	37	95	1	0	8	87	86	101	2	1	5	96	95
1.1	33	1	0	2	31	31	80	0	0	5	75	75	89	2	1	2	87	86
1.2	24	0	0	4	20	20	49	0	0	6	43	43	57	1	0	1	56	55
1.3	20	0	0	1	19	19	59	0	0	1	58	58	66	1	0	1	65	64
1.4	15	0	0	3	12	12	31	0	0	3	28	28	41	7	5	1	40	38
1.5	12	0	0	3	9	9	19	0	0	3	16	16	34	16	14	0	34	32
1.6	7	5	5	0	7	7	29	20	20	3	26	26	19	14	14	0	19	19
1.7	7	7	7	0	7	7	13	10	9	1	12	11	14	6	6	0	14	14
1.8	4	4	4	0	4	4	7	6	5	1	6	5	9	8	8	3	6	6
1.9	6	6	5	1	5	4	7	6	5	0	7	6	11	7	7	2	9	9
2	1	1	1	0	1	1	2	2	2	1	1	1	4	3	3	2	2	2
2.1	2	2	2	0	2	2	4	4	4	1	3	3	6	4	4	3	3	3
2.2	1	1	0	1	0	0	6	5	5	2	4	4	3	2	2	0	3	3
2.3	1	1	1	1	0	0	2	2	2	0	2	2	6	4	4	2	4	4
2.4	0	0	0	0	0	0	1	1	1	0	1	1	5	4	4	4	1	1
2.5	0	0	0	0	0	0	7	7	7		5	5	1	1	1	0	1	1
2.6	0	0	0	0	0	0	2	2	2	1	1	1	1	1	1	0	1	1
2.7	0	0	0	0	0	0	1	1	1	0	1	1	1	1	1	0	1	1
2.8	1	1	1	1	0	0	0	0	0	0	0	0	2	1	1	0	2	2
3.1	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0
3.3	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0
3.4	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0
3.5	1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0
4.5	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0
Total	1023	54	35	72	951	935	1791	93	78	100	1691	1677	2040	115	84	76	1964	1938
> 1V	135	30	27	18	117	116	324	71	68	35	289	286	369	83	76	21	348	341
> 3V	1	1	1	1	0	0	5	5	5	5	0	0	0	0	0	0	0	0

Table 3-1 (Sheet 2 of 2)
Byron Unit -1 April 1996 Outage
Summary of Inspection and Repair For Tubes in Service During Cycle 7B

Voltage Bin	Steam Generator D						Composite of All 4 SGs					
	In-Service During Cycle 7B				RTS for Cycle 8		In-Service During Cycle 7B				RTS for Cycle 8	
	Field Bobbin Indications	RPC Inspected	RPC Confirmed	Indications Repaired	All Indications	Confirmed & Not Inspected Indications Only	Field Bobbin Indications	RPC Inspected	RPC Confirmed	Indications Repaired	All Indications	Confirmed & Not Inspected Indications Only
0.1	0	0	0	0	0	0	3	0	0	0	3	3
0.2	39	1	0	1	38	37	133	3	0	2	131	128
0.3	141	3	0	2	139	136	572	15	2	14	558	546
0.4	179	1	0	9	170	170	831	20	5	31	800	787
0.5	142	2	1	4	138	137	815	9	4	33	782	777
0.6	97	1	1	4	93	93	750	16	6	29	721	712
0.7	62	0	0	6	56	56	625	14	8	41	584	581
0.8	45	1	1	4	41	41	469	5	3	24	445	443
0.9	29	0	0	4	25	25	324	2	0	16	308	307
1	35	0	0	2	33	33	273	3	1	20	253	251
1.1	31	0	0	1	30	30	233	3	1	10	223	222
1.2	14	0	0	0	14	14	144	1	0	11	133	132
1.3	13	0	0	0	13	13	158	1	0	3	155	154
1.4	5	0	0	0	5	5	92	7	5	7	85	83
1.5	6	0	0	0	6	6	71	16	14	6	65	63
1.6	8	1	1	2	6	6	63	40	40	5	58	58
1.7	4	4	4	3	1	1	38	27	26	4	34	33
1.8	4	4	4	2	2	2	24	22	21	6	18	17
1.9	4	4	4	2	2	2	28	23	21	5	23	21
2	3	3	3	2	1	1	10	9	9	5	5	5
2.1	0	0	0	0	0	0	12	10	10	4	8	8
2.2	1	1	1	0	1	1	11	9	8	3	8	8
2.3	0	0	0	0	0	0	9	7	7	3	6	6
2.4	0	0	0	0	0	0	6	5	5	4	2	2
2.5	2	2	2	2	0	0	10	10	10	4	6	6
2.6	0	0	0	0	0	0	3	3	3	1	2	2
2.7	0	0	0	0	0	0	2	2	2	0	2	2
2.8	0	0	0	0	0	0	3	2	2	1	2	2
3.1	1	1	1	1	0	0	2	2	2	2	0	0
3.3	0	0	0	0	0	0	1	1	1	1	0	0
3.4	0	0	0	0	0	0	1	1	1	1	0	0
3.5	0	0	0	0	0	0	2	2	2	2	0	0
4.5	0	0	0	0	0	0	1	1	1	1	0	0
Total	865	29	23	51	814	809	5719	291	220	299	5420	5359
> 1V	96	20	20	15	81	81	924	204	191	89	835	824
> 3V	1	1	1	1	0	0	7	7	7	7	0	0

Table 3-2 (Sheet 1 of 2)
Byron Unit-1 April 1996
TSP ODSCC Indication Distributions for Tubes in Service During Cycle 7B

Tube Support Plate	Steam Generator A					Steam Generator B					Steam Generator C				
	Number of Indications	Maximum Voltage	Average Voltage	Largest Growth	Average Growth	Number of Indications	Maximum Voltage	Average Voltage	Largest Growth	Average Growth	Number of Indications	Maximum Voltage	Average Voltage	Largest Growth	Average Growth
1H	1	0.69	0.69	0.09	0.09	0	-	-	-	-	0	-	-	-	-
3H	491	3.49	0.66	1.26	0.05	989	4.45	0.79	1.86	0.14	1177	2.72	0.75	1.74	0.12
5H	283	2.78	0.64	0.57	0.06	457	2.46	0.66	0.72	0.08	610	2.36	0.67	0.85	0.08
7H	127	1.84	0.61	0.57	0.06	145	1.77	0.53	0.47	0.07	74	2.05	0.57	0.53	0.08
8H	52	1.8	0.56	0.55	0.04	102	2.14	0.56	0.76	0.09	92	1.6	0.53	0.58	0.06
9H	41	1.13	0.42	0.33	0.03	33	0.94	0.46	0.21	0.02	46	0.87	0.42	0.42	0.06
10H	15	0.87	0.34	0.33	0.04	9	0.61	0.39	0.26	0.09	9	1.02	0.46	0.3	0.03
11H	1	0.45	0.45	0.13	0.13	0	-	-	-	-	10	0.74	0.42	0.14	0.00
11C	0	-	-	-	-	4	0.66	0.50	0.36	0.08	4	1.34	0.76	0.53	0.17
10C	3	0.54	0.39	0.12	0.08	1	0.25	0.25	0.07	0.07	0	-	-	-	-
9C	5	0.41	0.34	0.12	0.05	0	-	-	-	-	0	-	-	-	-
8C	1	0.32	0.32	-0.02	-0.02	1	0.28	0.28	-0.07	-0.07	0	-	-	-	-
7C	0	-	-	-	-	3	0.95	0.61	0.07	0.00	0	-	-	-	-
5C	0	-	-	-	-	0	-	-	-	-	1	0.69	0.69	0.1	0.10
2C	0	-	-	-	-	2	0.39	0.30	0.07	0.04	0	-	-	-	-
Total	1020					1746					2023				

Table 3-2 (Sheet 2 of 2)
Byron Unit-1 April 1996
TSP ODSCC Indication Distributions for Tubes in Service During Cycle 7B

Tube Support Plate	Steam Generator D					Composite of All Four SGs				
	Number of Indications	Maximum Voltage	Average Voltage	Largest Growth	Average Growth	Number of Indications	Maximum Voltage	Average Voltage	Largest Growth	Average Growth
2H	0	-	-	-	-	1	0.69	0.69	0.09	0.09
3H	463	3.06	0.64	0.77	0.06	3129	4.45	0.74	1.86	0.11
5H	237	2.46	0.53	0.51	0.04	1587	2.78	0.64	0.85	0.07
7H	67	1.77	0.46	0.38	0.04	413	2.05	0.55	0.57	0.07
8H	8	0.67	0.45	0.24	0.04	254	2.14	0.55	0.76	0.07
9H	12	0.56	0.37	0.2	0.06	132	1.13	0.43	0.42	0.04
10H	6	0.37	0.28	0.05	0.00	39	1.02	0.37	0.33	0.04
11H	5	0.56	0.38	0.15	0.05	16	0.74	0.41	0.15	0.03
11C	5	0.44	0.29	0.11	0.04	13	1.34	0.50	0.53	0.09
10C	0	-	-	-	-	4	0.54	0.36	0.12	0.08
9C	1	0.18	0.18	0.03	0.03	6	0.41	0.31	0.12	0.05
8C	0	-	-	-	-	2	0.32	0.30	-0.02	-0.05
7C	0	-	-	-	-	3	0.95	0.61	0.07	0.00
5C	0	-	-	-	-	1	0.69	0.69	0.1	0.10
2C	0	-	-	-	-	2	0.39	0.00	0.07	0.04
Total	804					5593				

Table 3-3
Byron Unit-1 April 1996
Signal Growth Statistics For Cycle 7B on an EFPY Basis

Delta Volts	Steam Generator A			Steam Generator B			Steam Generator C			Steam Generator D			Cumulative		
	Cycle 7A	Cycle 7B		Cycle 7A	Cycle 7B		Cycle 7A	Cycle 7B		Cycle 7A	Cycle 7B		Cycle 7A	Cycle 7B	
	CPDF	No. of Obs	CPDF	CPDF	No. of Obs	CPDF	CPDF	No. of Obs	CPDF	CPDF	No. of Obs	CPDF	CPDF	No. of Obs	CPDF
-1.6		0	0		0	0		1	0.000		1	0.001		2	0.000
-1.5		0	0		0	0		1	0.001		0	0.001		1	0.001
-1.4		0	0		0	0		1	0.001		0	0.001		1	0.001
-1.3		0	0		1	0.001		1	0.002		0	0.001		2	0.001
-1.2		1	0.001		0	0.001		2	0.003		0	0.001		3	0.002
-1.1		0	0.001		0	0.001		3	0.004		1	0.002		4	0.002
-1		0	0.001		0	0.001		3	0.006		1	0.004		4	0.003
-0.9		1	0.002		0	0.001		3	0.007		1	0.005		5	0.004
-0.8		0	0.002		0	0.001		6	0.010		2	0.007		8	0.005
-0.7		0	0.002		0	0.001		11	0.016		1	0.009		12	0.008
-0.6		1	0.003		1	0.001		4	0.018		0	0.009		6	0.009
-0.5		13	0.016	0	16	0.010		31	0.033		12	[illegible]	0	72	0.021
-0.4		38	0.053	0.0006	41	0.034		70	0.068	0	23	[illegible]	0.0002	172	0.052
-0.3	0	40	0.092	0.0012	50	0.062	0	70	0.102	0.0011	35	[illegible]	0.0006	195	0.087
-0.2	0.002	100	0.190	0.0050	98	0.119	0.003	120	0.162	0.0023	75	[illegible]89	0.0034	393	0.157
-0.1	0.018	60	0.249	0.0206	84	0.167	0.021	107	0.215	0.0158	68	0.274	0.0196	319	0.214
0	0.081	145	0.391	0.1149	161	0.259	0.125	188	0.307	0.0948	90	0.386	0.1085	584	0.319
0.1	0.305	95	0.484	0.3702	124	0.330	0.381	123	0.368	0.3262	63	0.464	0.3536	405	0.391
0.2	0.501	100	0.582	0.5743	128	0.403	0.563	153	0.444	0.5327	67	0.547	0.5499	448	0.471
0.3	0.696	90	0.671	0.7291	207	0.522	0.716	185	0.535	0.6919	84	0.652	0.7123	566	0.573
0.4	0.831	56	0.725	0.8227	110	0.585	0.831	117	0.593	0.7901	54	0.719	0.8210	337	0.633
0.5	0.897	61	0.785	0.8752	126	0.657	0.884	130	0.657	0.8533	53	0.785	0.8781	370	0.699
0.6	0.938	37	0.822	0.9182	79	0.702	0.924	87	0.700	0.9120	27	0.818	0.9227	230	0.740
0.7	0.961	36	0.857	0.9438	65	0.739	0.951	70	0.735	0.9402	21	0.845	0.9487	192	0.774
0.8	0.975	33	0.889	0.9563	88	0.790	0.968	95	0.782	0.9582	39	0.893	0.9638	255	0.820
0.9	0.988	26	0.9147	0.9682	34	0.809	0.981	50	0.807	0.9673	16	0.9129	0.9756	126	0.842
1	0.992	18	0.9324	0.9775	56	0.841	0.986	61	0.837	0.9786	19	0.9366	0.9830	154	0.870
1.1	0.992	14	0.9461	0.9850	32	0.860	0.990	45	0.859	0.9842	8	0.9465	0.9878	99	0.888
1.2	0.996	7	0.9529	0.9875	25	0.874	0.994	32	0.875	0.9876	9	0.9577	0.9910	73	0.901
1.3	0.997	7	0.9598	0.9931	40	0.897	0.997	48	0.899	0.9932	7	0.9664	0.9950	102	0.9190
1.4	0.998	11	0.9706	0.9950	19	0.9078	0.997	26	0.9115	0.9944	4	0.9714	0.9962	60	0.9297
1.5	0.999	7	0.9775	0.9969	19	0.9187	0.998	23	0.9229	0.9955	7	0.9801	0.9974	56	0.9397

Table continues on next page

Table 3-3 (contd.)
Byron Unit-1 April 1996
Signal Growth Statistics For Cycle 7B on an EFPY Basis

Delta Volts	Steam Generator A			Steam Generator B			Steam Generator C			Steam Generator D			Cumulative		
	Cycle 7A	Cycle 7B		Cycle 7A	Cycle 7B		Cycle 7A	Cycle 7B		Cycle 7A	Cycle 7B		Cycle 7A	Cycle 7B	
	CPDF	No. of Obs	CPDF	CPDF	No. of Obs	CPDF	CPDF	No. of Obs	CPDF	CPDF	No. of Obs	CPDF	CPDF	No. of Obs	CPDF
1.6	0.999	1	0.9784	0.9969	17	0.9284	0.999	18	0.9318	0.9955	2	0.9826	0.9976	38	0.9465
1.7	1.000	3	0.9814	0.9975	13	0.9359	0.999	17	0.9402	0.9955	4	0.9876	0.9980	37	0.9532
1.8		2	0.9833	0.9988	16	0.9450	0.999	20	0.9501	0.9977	4	0.9925	0.9990	42	0.9607
1.9		4	0.9873	0.9988	7	0.9490	0.999	15	0.9575	0.9977	1	0.9938	0.9990	27	0.9655
2		2	0.9892	0.9988	13	0.9565	0.999	10	0.9624	0.9989	0	0.9938	0.9992	25	0.9700
2.1		1	0.9902	0.9994	10	0.9622	1.000	7	0.9659	0.9989	0	0.9938	0.9996	18	0.9732
2.2		2	0.9922	0.9994	7	0.9662		11	0.9713	1.000	2	0.9963	0.9998	22	0.9771
2.3		3	0.9951	0.9994	9	0.9714		13	0.9778		0	0.9963	0.9998	25	0.9816
2.4		2	0.9971	0.9994	4	0.9737		7	0.9812		0	0.9963	0.9998	13	0.9839
2.5		0	0.9971	1.000	9	0.9788		4	0.9832		0	0.9963	1.000	13	0.9862
2.6		0	0.9971		4	0.9811		3	0.9847		0	0.9963		7	0.9875
2.7		0	0.9971		1	0.9817		1	0.9852		1	0.9975		3	0.9880
2.8		1	0.9980		6	0.9851		4	0.9871		1	0.9988		12	0.9902
2.9		0	0.9980		4	0.9874		1	0.9876		0	0.9988		5	0.9911
3		0	0.9980		5	0.9903		5	0.9901		0	0.9988		10	0.9928
3.1		0	0.9980		2	0.9914		1	0.9906		0	0.9988		3	0.9934
3.2		0	0.9980		3	0.9931		3	0.9921		0	0.9988		6	0.9945
3.3		0	0.9980		1	0.9937		2	0.9931		1	1.0000		4	0.9952
3.4		0	0.9980		0	0.9937		2	0.9941		0			2	0.9955
3.5		0	0.9980		0	0.9937		2	0.9951		0			2	0.9959
3.6		0	0.9980		2	0.9948		2	0.9960		0			4	0.9966
3.8		0	0.9980		2	0.9960			0.9960		0			2	0.9970
4		0	0.9980		0	0.9960		2	0.9970		0			2	0.9973
4.5		1	0.9990		3	0.9977		1	0.9975		0			5	0.9982
5		0	0.9990		1	0.9983		1	0.9980		0			2	0.9986
5.5		1	1.0000		0	0.9983		1	0.9985		0			2	0.9989
6.5		0			1	0.9989		2	0.9995		0			3	0.9995
7		0			1	0.9994		0	0.9995		0			1	0.9996
7.5		0			0	0.9994		1	1.0000		0			1	0.9998
8		0			1	1.0000		0			0			1	1.0000
Total		1020			1746			2023			804			5593	

Table 3-4
Byron Unit -1 April 1996 Outage
Average Voltage Growth During Cycle 7B

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	5593	0.58	0.089	0.370	15.2%	63.4%
V_{BOC} < .75 Volts	4229	0.44	0.073	0.306	16.8%	70.0%
≥ .75 Volts	1364	1.04	0.137	0.571	13.1%	54.7%
	Steam Generator A					
Entire Voltage Range	1020	0.57	0.054	0.223	9.3%	38.9%
V_{BOC} < .75 Volts	779	0.43	0.040	0.168	9.4%	39.2%
≥ .75 Volts	241	1.04	0.096	0.402	9.3%	38.6%
	Steam Generator B					
Entire Voltage Range	1746	0.60	0.112	0.468	18.7%	78.0%
V_{BOC} < .75 Volts	1299	0.45	0.091	0.379	20.3%	84.5%
≥ .75 Volts	447	1.04	0.175	0.728	16.8%	69.8%
	Steam Generator C					
Entire Voltage Range	2023	0.60	0.101	0.421	16.9%	70.3%
V_{BOC} < .75 Volts	1498	0.45	0.086	0.360	19.3%	80.3%
≥ .75 Volts	525	1.03	0.143	0.597	13.9%	57.9%
	Steam Generator D					
Entire Voltage Range	804	0.53	0.052	0.217	9.9%	41.0%
V_{BOC} < .75 Volts	653	0.40	0.048	0.200	12.1%	50.5%
≥ .75 Volts	151	1.10	0.069	0.289	6.3%	26.3%

* Based on Cycle 7B duration of 87.7 EFPD (0.24 EFPY)

Table 3-5
Byron Unit-1 April 1996
Average Voltage Growth for Cycle 7B
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 7B (12/95 - 4/96) - 87.7 EFPD					
Entire Voltage Range	5593	0.58	0.089	0.371	15.2%	63.4%
V_{BOC} < .75 Volts	4229	0.44	0.073	0.306	16.8%	70.1%
≥ .75 Volts	1364	1.04	0.137	0.571	13.1%	54.7%
	Cycle 7A (1994 - 1995) - 317.4 EFPD					
Entire Voltage Range	5005	0.49	0.204	0.235	41.9%	48.3%
V_{BOC} < .75 Volts	4276	0.42	0.189	0.217	45.3%	52.1%
≥ .75 Volts	729	0.90	0.298	0.343	32.9%	37.9%
	Cycle 6 (1993 - 1994) - 466.5 EFPD					
Entire Voltage Range	2851	0.47	0.320	0.251	68.1%	53.3%
V_{BOC} < .75 Volts	2377	0.37	0.35	0.274	94.6%	74.1%
≥ .75 Volts	474	0.99	0.180	0.141	18.2%	14.2%
	Cycle 5 (1991 - 1993) - 411.6 EFPD (Plugged Tubes Only)					
Entire Voltage Range	532	0.46	0.310	0.275	67.4%	59.8%
	Cycle 4 (1990 - 1991) - 463.9 EFPD (Plugged Tubes Only)					
Entire Voltage Range	550	0.32	0.260	0.205	81.3%	64.0%

Table 3-6
Byron Unit-1 April 1996
Summary of Largest Voltage Growth Rates for BOC-7B to EOC-7B

Steam Generator				Bobbin Voltage			RPC Confirmed ?	New Indication ?
SG	Row	Col	Elevation	EOC-7B	BOC-7B	Growth		
B	21	103	03H	3.33	1.47	1.86	Y	Y
C	12	16	03H	2.38	0.64	1.74	NI#	Y
B	14	109	03H	3.44	1.83	1.61	Y	N
B	19	104	03H	4.45	2.95	1.5	Y	N
C	24	28	03H	2.23	0.73	1.5	NI	N
C	40	79	03H	2.72	1.24	1.48	NI	N
C	38	81	03H	2.21	0.91	1.3	Y	N
A	13	4	03H	3.49	2.23	1.26	Y	N
C	46	52	03H	1.66	0.52	1.14	NI	N
B	9	83	03H	2.12	1	1.12	NI	Y
C	20	64	03H	2.23	1.17	1.06	NI	N
B	12	23	03H	1.32	0.3	1.02	NI	Y
B	29	48	03H	1.56	0.55	1.01	NI	N
A	5	41	03H	1.84	0.85	0.99	Y	N
B	8	94	03H	1.69	0.7	0.99	NI	N
C	19	88	03H	2.03	1.07	0.96	NI	N
C	40	34	03H	1.47	0.52	0.95	NI	Y
B	2	51	03H	3.29	2.39	0.9	Y	N
B	27	35	03H	1.87	0.97	0.9	NI	Y
B	3	58	03H	2.1	1.24	0.86	Y	N
B	3	112	03H	1.15	0.3	0.85	NI	Y
C	7	56	05H	2.01	1.16	0.85	Y	N
C	36	28	03H	1.36	0.51	0.85	NI	Y
C	11	18	03H	2.14	1.31	0.83	NI	N
C	33	23	03H	1.82	1	0.82	NI	N
C	14	72	05H	2.36	1.55	0.81	Y	N
C	36	35	03H	1.46	0.66	0.8	NI	N
B	14	93	03H	1.22	0.43	0.79	NI	N
C	24	79	03H	1.24	0.45	0.79	NI	Y
C	12	69	03H	2.32	1.54	0.78	Y	N

#N I = Not inspected

Table 3-7
Probe Wear and Analyst Variability - Tabulated Values

Analyst Variability Std. Dev = 10.3% Mean = 0.0% No Cutoff	
Value	Cumul. Prob.
-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

Probe Wear Variability Std. Dev = 7.0% Mean = 0.0% Cutoff at +/- 15%	
Value	Cumul. Prob.
< -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

Table 3-8
Byron Unit-1
Analysis of RPC Data from 1995 and 1996 Inspections
Combined Data from All Four Steam Generators

Group of Indications	Total 1995 Bobbin Indication	Total 1996 Bobbin Indication	Total 1996 RPC Inspected	Total 1996 RPC Confirmed	Percent 1996 RPC Confirmed
Less than or Equal to 1.0 Volt in 1996					
'95 Bobbin Left in Service	3589	3165	32	10	31.3
- '95 RPC Confirmed	8	8	2	1	50.0
- '95RPC NDD	32	32	30	9	30.0
- '95 RPC Not Inspected	3125	3125	0	0	-
- No '96 Bobbin *	424	-	-	-	-
New '96 Indication	-	1630	55	19	34.5
Sum of All '96 Indication	3589	4795	87	29	33.3
Greater than 1.0 Volt in 1996					
'95 Bobbin Left in Service	885	869	196	186	94.9
- '95 RPC Confirmed	106	106	63	61	96.8
- '95RPC NDD	7	7	3	0	0.0
- '95 RPC Not Inspected	756	756	130	125	96.2
- No '96 Bobbin *	16	-	-	-	-
New '96 Indication	-	55	8	5	62.5
Sum of All '96 Indication	885	924	204	191	93.6
All Voltages in 1996					
'95 Bobbin Left in Service	4474	4034	228	196	86.0
- '95 RPC Confirmed	114	114	65	62	95.4
- '95RPC NDD	39	39	33	9	27.3
- '95 RPC Not Inspected	3881	3881	130	125	96.2
- No '96 Bobbin *	440	-	-	-	-
New '96 Indication	-	1685	63	24	38.1
Sum of All '96 Indication	4474	5719	291	220	75.6

* Indications split is based on '95 bobbin voltage

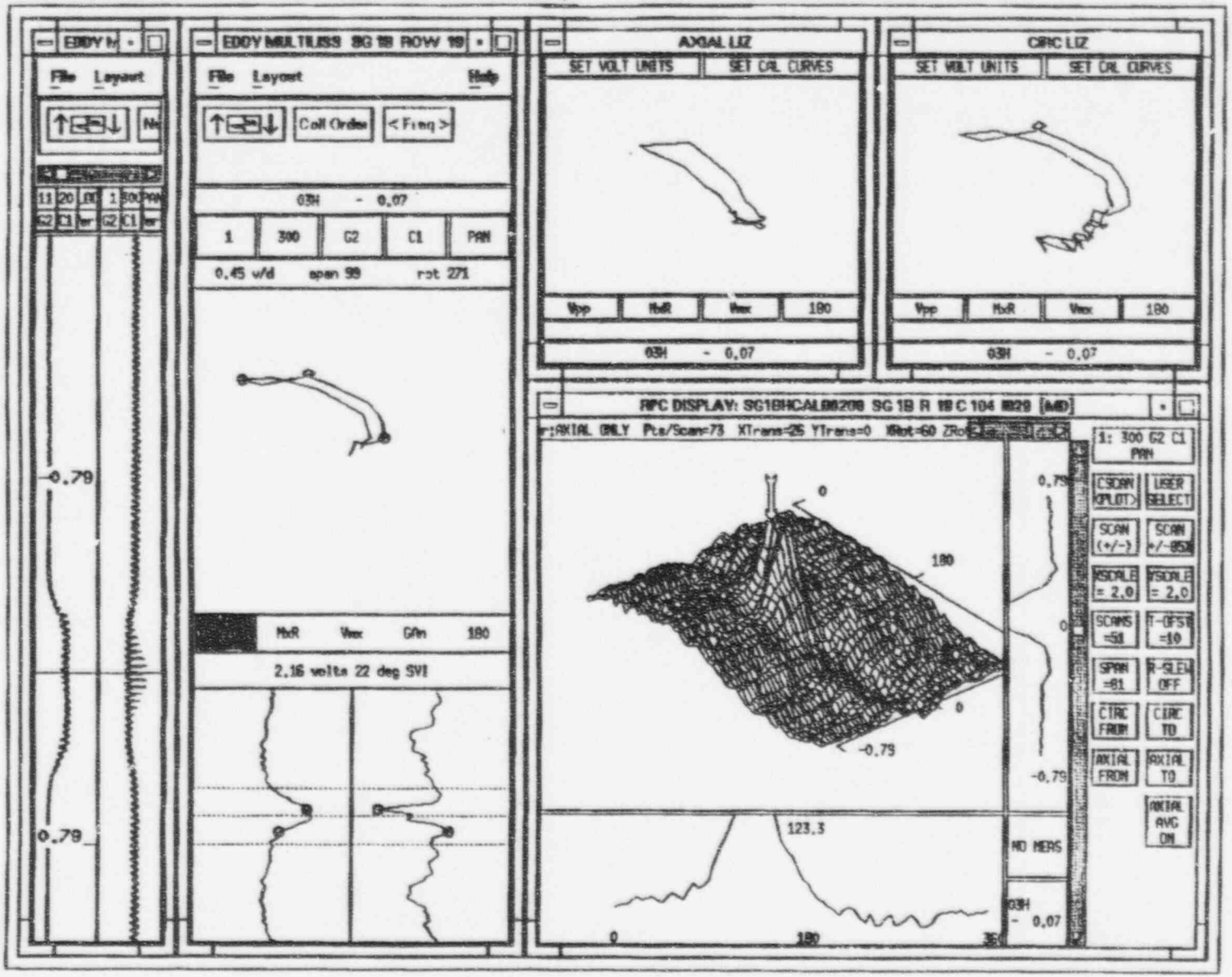


Figure 3-1 Steam Generator B R19-C104 - 3H 115 mil Pancake Coil Field Data

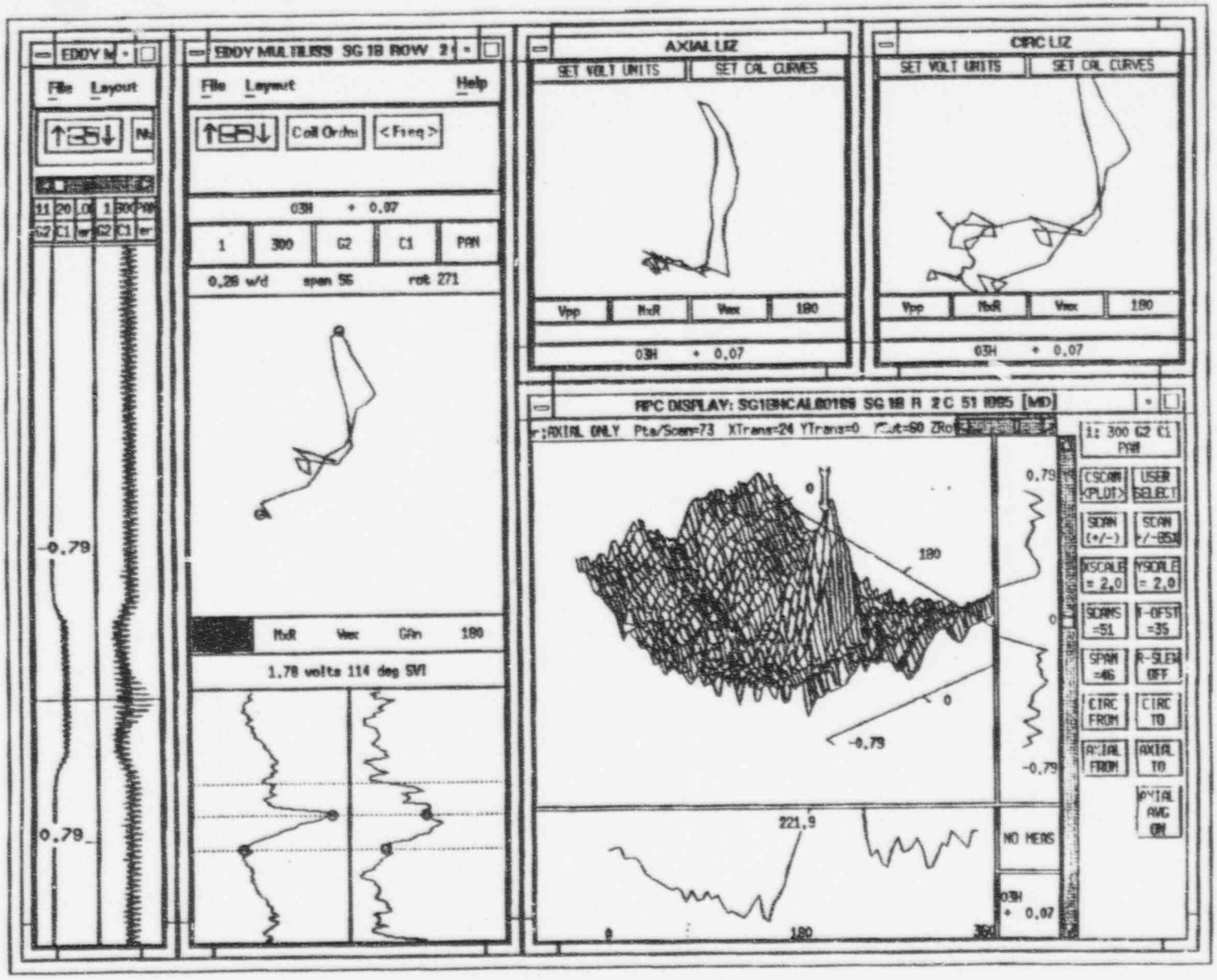
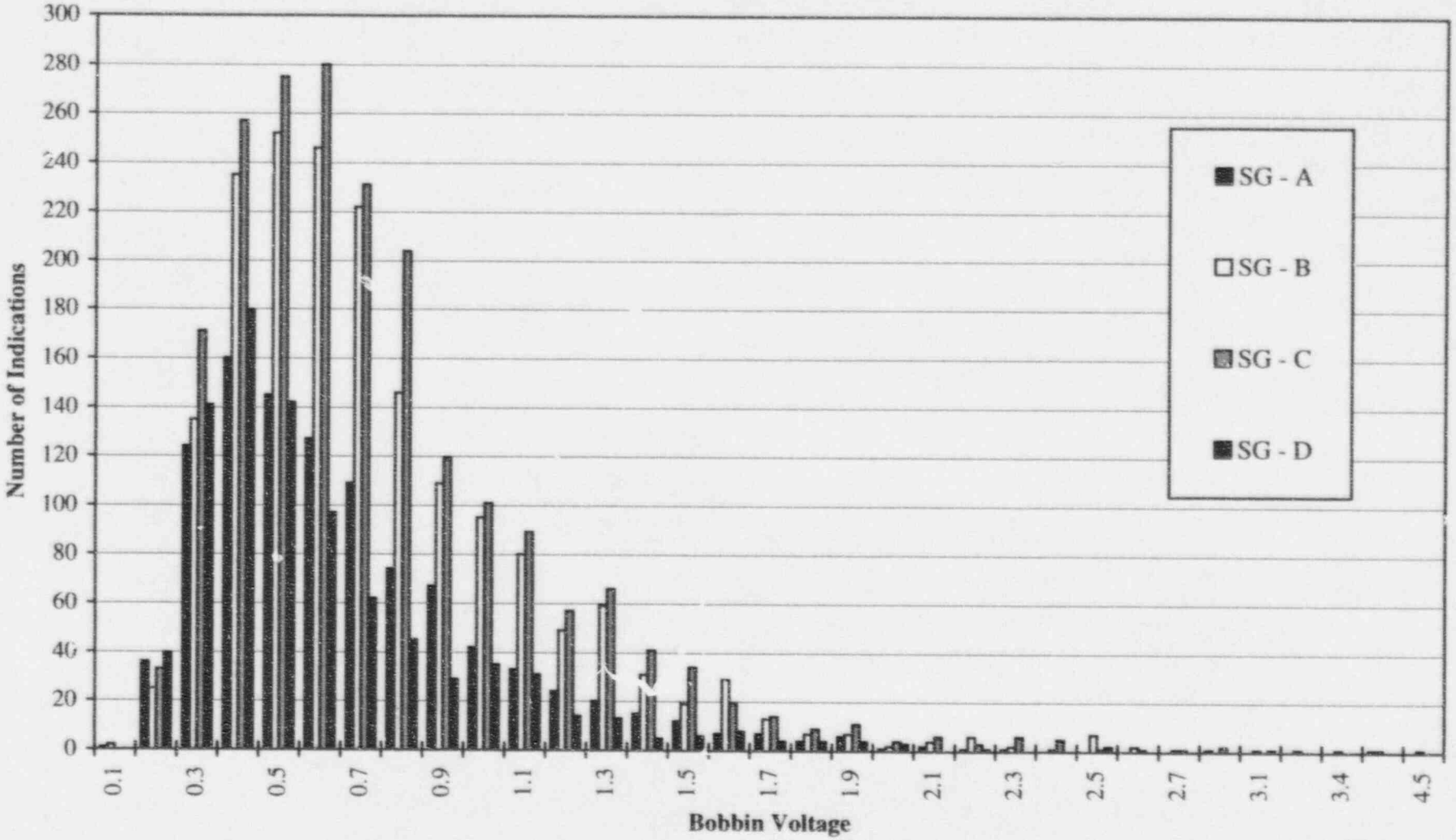


Figure 3-2 Steam Generator B R19-C51 - 3H 115 mil Pancake Coil Field Data

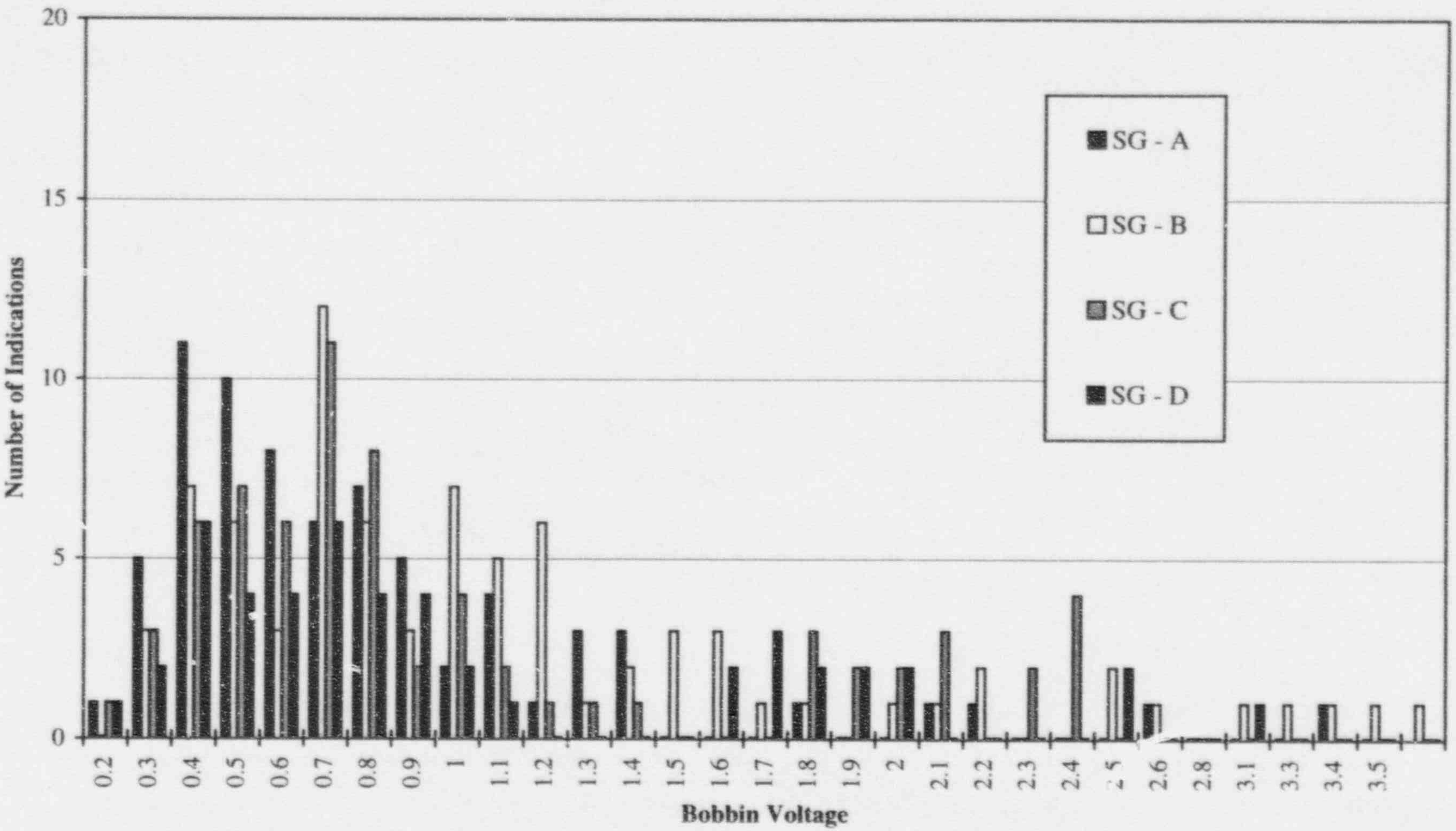
s:\apc\cae96\cy8_90day.wp5

Figure 3-3
Byron Unit -1 April 1996 Outage
Bobbin Voltage Distributions at EOC-7B for Tubes in Service During Cycle 7B



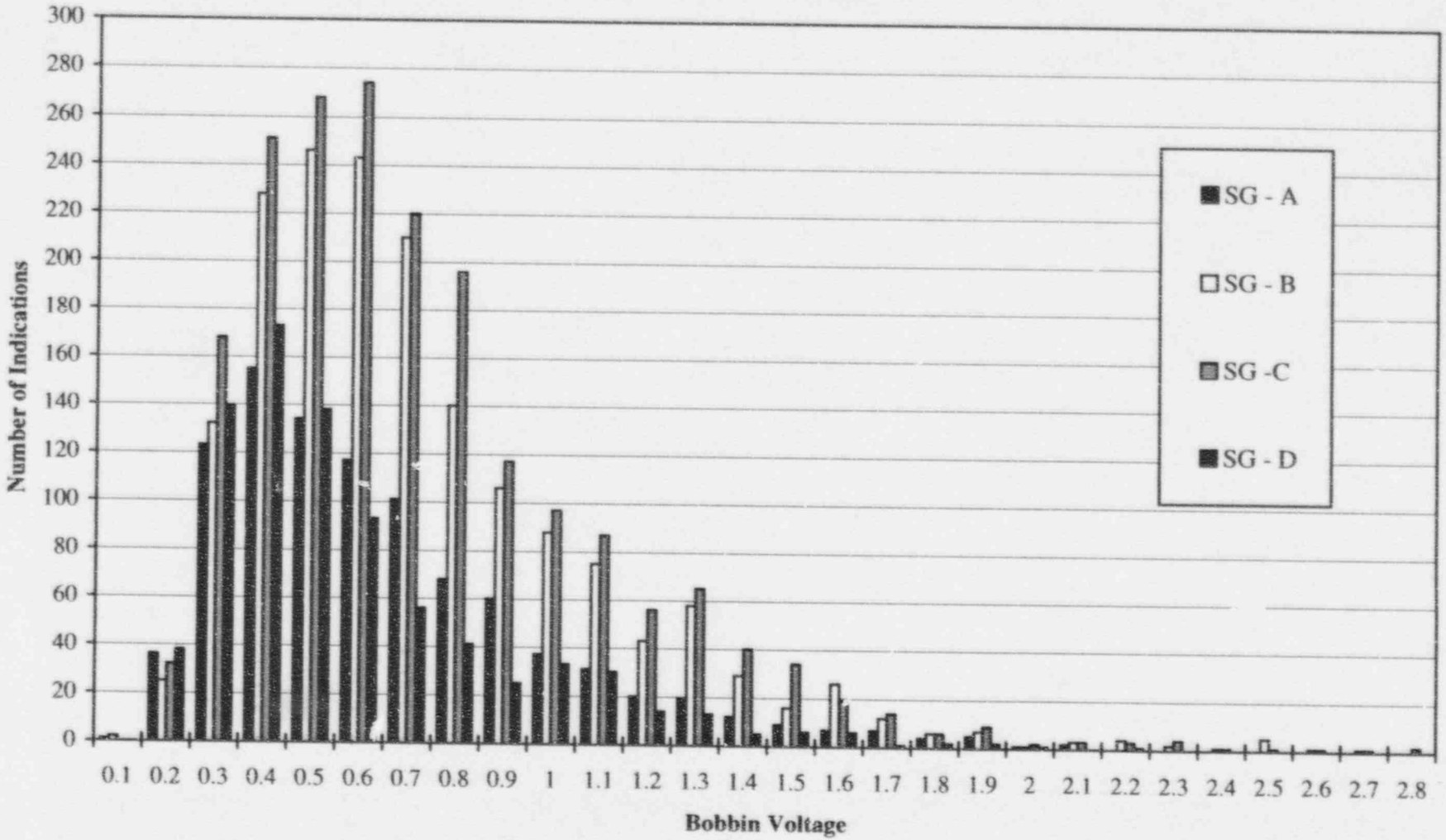
BOBNRPC.XLS[Fig_3-3]

Figure 3-4
Byron Unit -1 April 1996 Outage
Bobbin Voltage Distribution for Tubes Plugged After Cycle 7B Service



BOBNRPC.XLSFig. 3-4

Figure 3-5
Byron Unit -1 April 1996 Outage
Bobbin Voltage Distributions for Tubes Returned to Service for Cycle 8



BOBNRPC.XLSFig. 3-5

Figure 3-6
Byron Unit-1 April 1996
ODSCC Axial Distributions for Tubes in Service During Cycle 7B

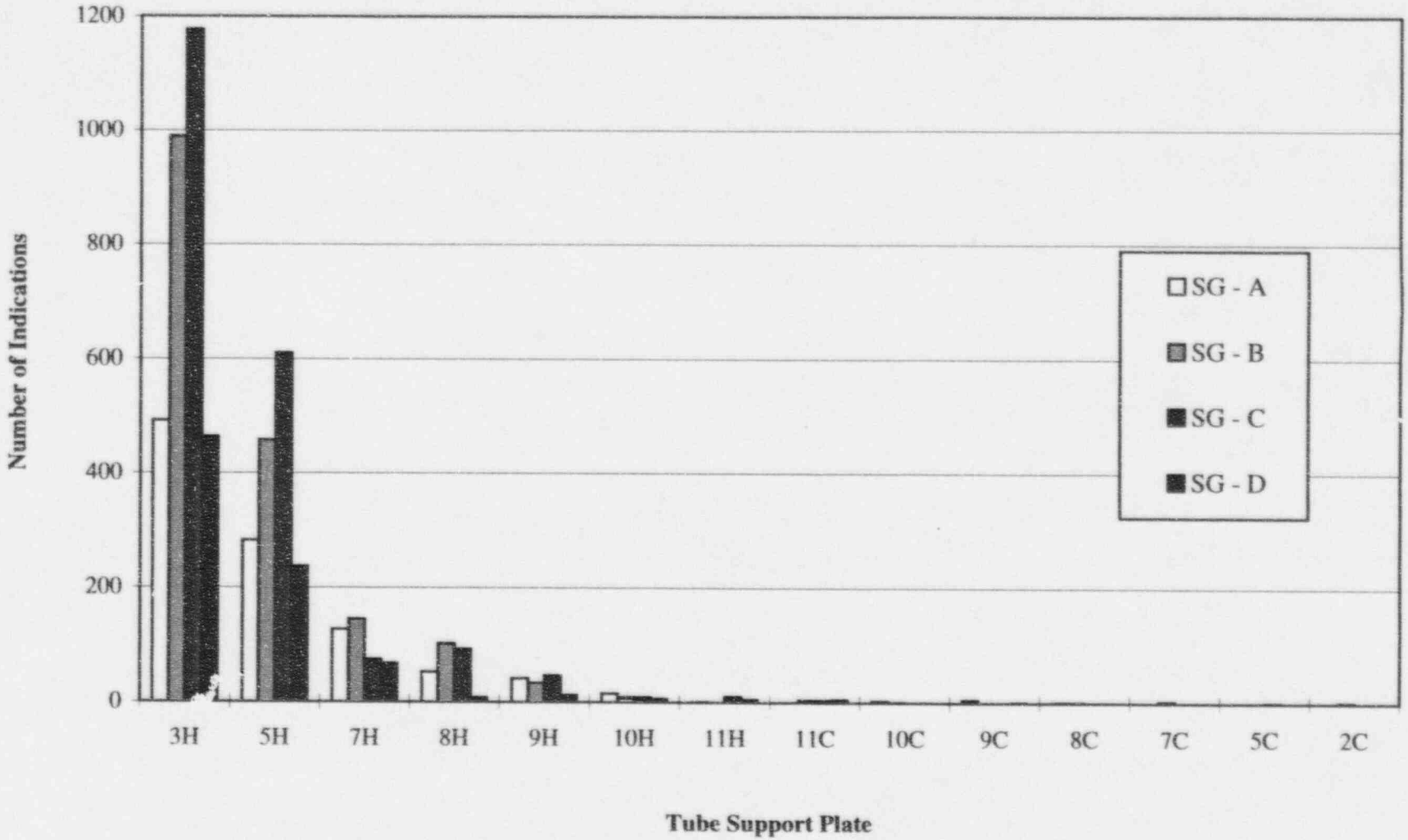


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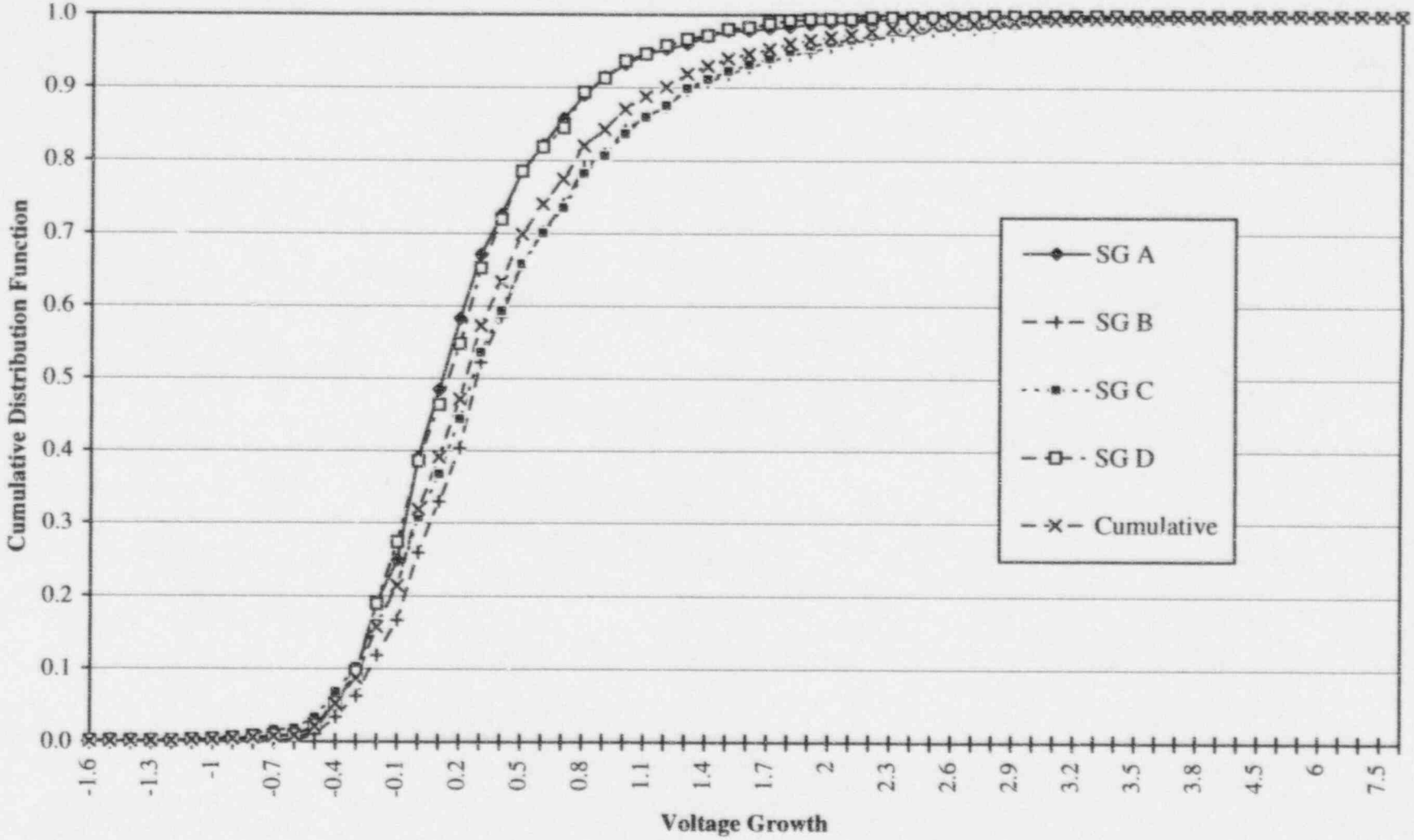
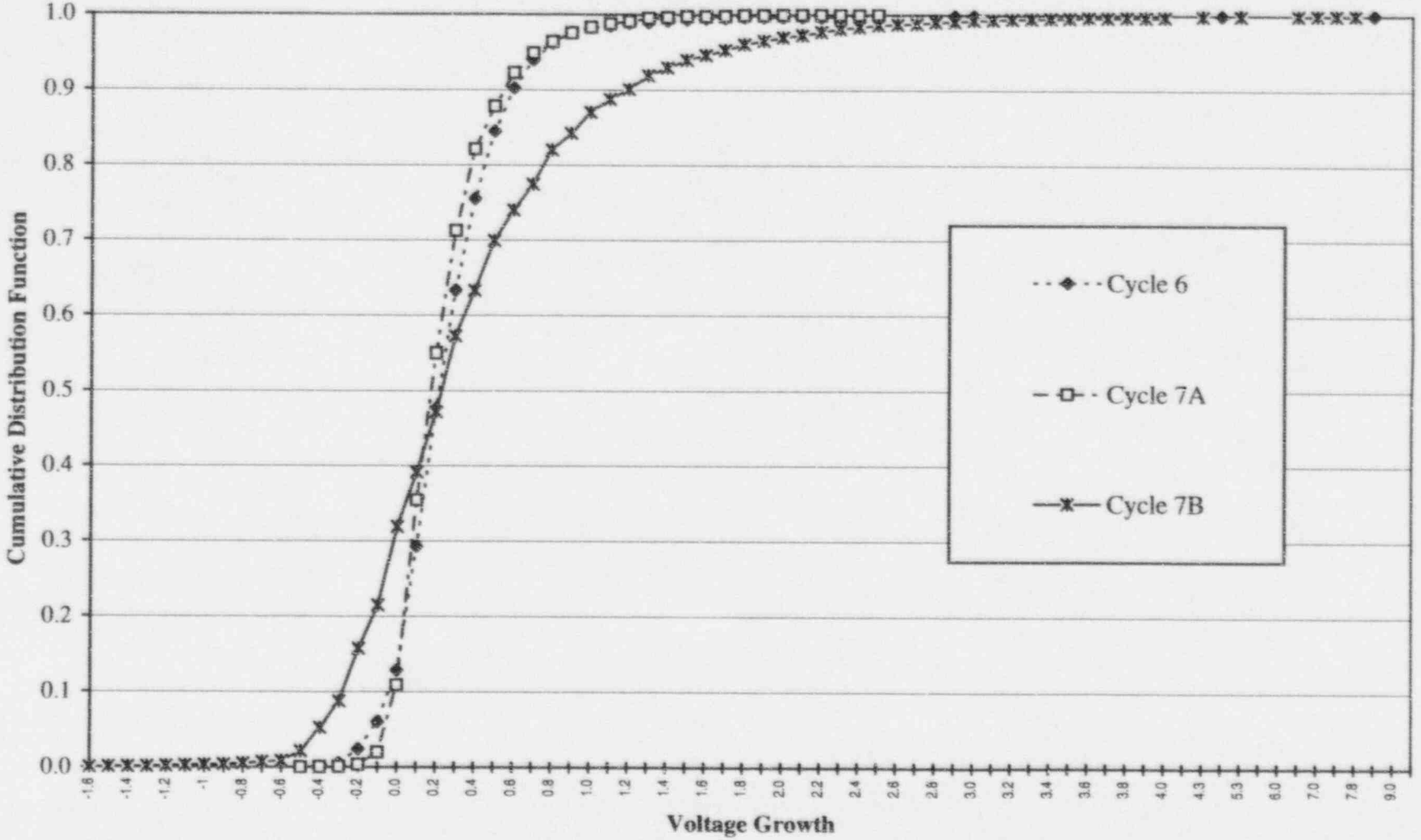
Figure 3-7
Byron Unit -1 Cycle 7B (December 1995 to April 1996)
Cumulative Probability Distributions for Voltage Growth on an EFPY Basis



GROWTH.XLS!Fig_3-7 8/27/96 3:25 PM

Figure 3-8
Comparison of Byron-1 Growth Rates
Cumulative Probability Distributions on EFPY Basis
Composite of All Four Steam Generators



GROWTH.XLS\Fig 3-8

Figure 3-9
NDE Uncertainty Distributions

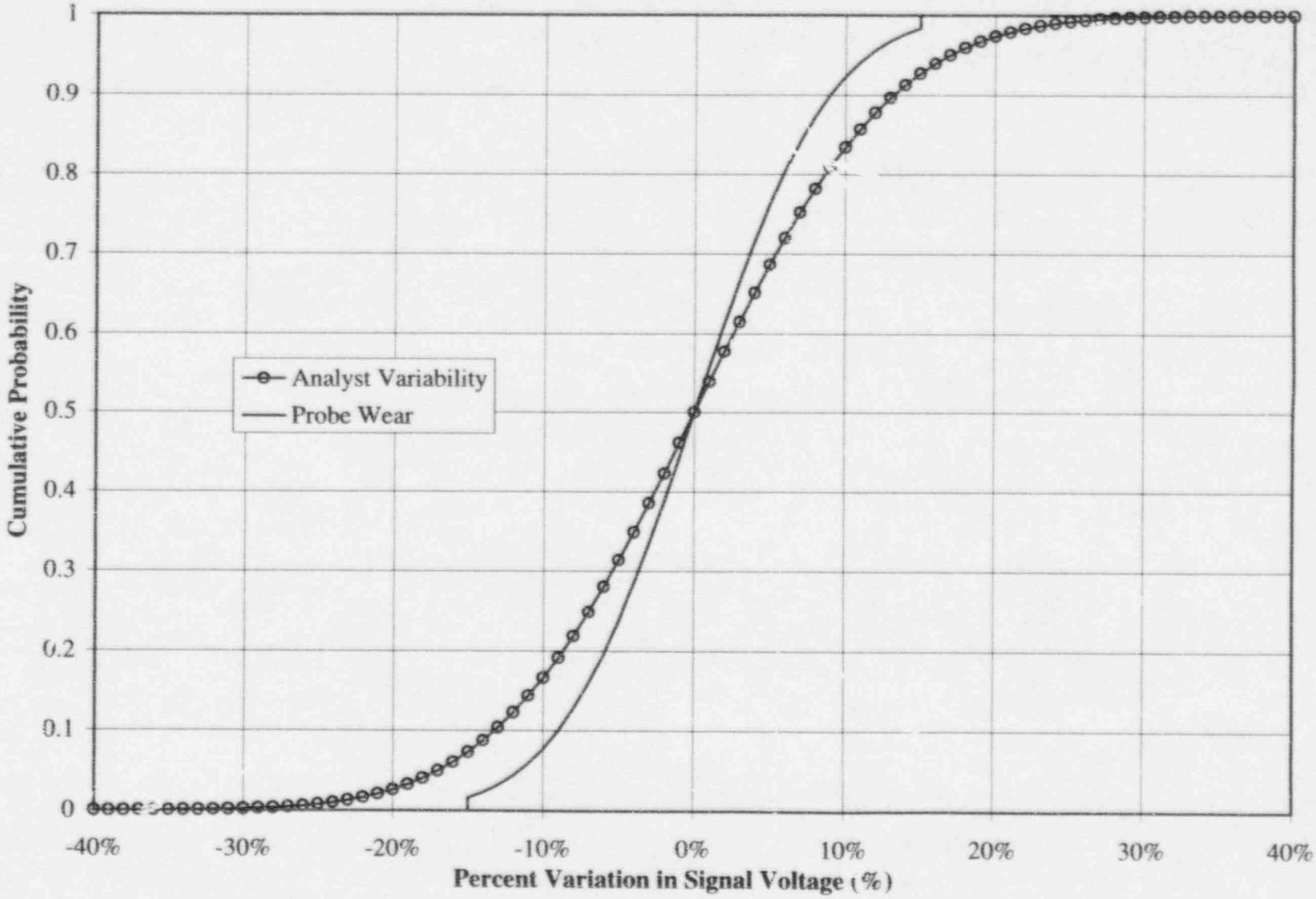


Fig3-9 Chart 1 Fig3-9 Chart 1 8/27/96 3:23 PM

4.0 Database Applied for IPC Correlations

The database used for the IPC correlations that are applied in the analyses of this report is an updated version of the IPC database described in Reference 8.3. Model Boiler specimen 598-1 is excluded from the IPC database based on application of EPRI data exclusion criterion for very high voltage indications and concurrence by the NRC. Byron-1 and Braidwood-1 pulled tube indications R16C42, TSP 5 (0.28 volt) and R20C7, TSP 7 (0.38 volt), respectively, are excluded from the correlation based on EPRI data exclusion criterion 2a accepted by the NRC. Criterion 2a excludes indications with burst pressures high on the voltage correlation if the maximum crack depth is less than 60% and there are less than 2 remaining uncorroded ligaments. Plant S pulled tube indication R28C41 is included in the leak rate correlation at a SLB leak rate of 2496 lph consistent with NRC recommendations.

South Texas pulled tube data from 1993 and 1995 inspections are also included in the IPC database. The updated database is in compliance with NRC guidelines for application of leak rate vs. voltage correlations and for removal of data outliers in the 3/4 inch tubing burst and leak rate correlations. The updated IPC database for 3/4" tubes is documented in Reference 8.9 and that database was used to perform the SLB leak rate and tube burst probability analyses reported here. The same database was also applied for EOC-7A analyses reported in Reference 8.5.

5.0 SLB Analysis Methods

Monte Carlo analyses are used to calculate the SLB leak rates and tube burst probabilities for both actual EOC-7B and projected EOC-8 voltage distributions. The Monte Carlo analyses account for parameter uncertainty and they are consistent with the Byron Unit-1 SER. The analysis methodology is described in Braidwood-1 document Reference 8-1 as well as in the Westinghouse generic methods report of Reference 8-2.

In general, Monte Carlo analyses include POD adjustments, voltage growth and NDE uncertainties in the projected analyses for the next operating cycle while only NDE uncertainties are included in the analyses based on the actual measured voltage distribution (for the cycle just completed). Based on the 3/4" diameter tubing database, the NRC requirement that the p value obtained from the regression analysis be less than or equal to 5% to apply the SLB leak rate versus voltage correlation is satisfied and the correlation is applied for the leak rate analyses of this report.

SLB leak rates and tube burst probabilities are calculated considering the locked TSP condition. With TSPs locked (by tube expansion), indications in the hot leg side are restrained from bursting so the burst probability calculations are based only on indications found on the cold side. Since only a small fraction of the indication population is on the cold leg side, the burst probabilities are expected to be substantially smaller than those estimated with the usual IPC/APC methodology (which includes the entire indication population). Leak rate analyses for the hot leg indications include indications restrained from burst (IRBs) based on a 6.0 gpm leak rate for IRBs. Leak rates for cold leg indications are calculated using the methods of GL 95-05 (Reference 8.4) and Reference 8.2. Leak rates and PoB calculated using the actual voltage distributions are compared with the corresponding prior projections for EOC-7B.

6.0 Bobbin Voltage Distributions

This section describes salient input data used to calculate EOC bobbin voltage distributions and presents the results of calculations to project EOC-7B voltage distributions. Also, EOC-7B voltage distributions projected based on the EOC-7A inspection bobbin voltage data are compared with the actual bobbin distributions from the current inspection.

6.1 Calculation of Voltage Distributions

The analysis for EOC voltage distribution starts with a cycle initial voltage distribution which is projected to the end of cycle conditions based on the growth rate and the anticipated cycle operating period. The number of indications assumed in the analysis to project EOC voltage distributions, and to perform tube leak rate and burst probability analyses, is obtained by adjusting the number of reported indications to account for detection uncertainty and birth of new indications over the projection period. This is accomplished by using a Probability of Detection (POD) factor, which is defined as the ratio of the actual number of indications detected to total number of indications present. A conservative value is assigned to POD based on historic data, and the value used herein is discussed in Section 6-2. The calculation of projected bobbin voltage frequency distribution is based on a net total number of indications returned to service, defined as follows.

$$N_{\text{Tot RTS}} = N_i / \text{POD} - N_{\text{repaired}} + N_{\text{deplugged}}$$

where,

$N_{\text{Tot RTS}}$	=	Number of bobbin indications being returned to service for the next cycle
N_i	=	Number of bobbin indications (in tubes in service) identified after the previous cycle
POD	=	Probability of detection
N_{repaired}	=	Number of N_i which are repaired (plugged) after the last cycle
$N_{\text{deplugged}}$	=	Number of N_i which are deplugged after the last cycle and are returned to service in accordance with IPC applicability.

There are no deplugged tubes returned to service at BOC-7B.

The methodology used in the projection of bobbin voltage frequency predictions is described in Reference 8-2, and it is same as that used in performing similar predictions during the last (EOC-7A) inspection (Reference 8.5). Salient input data used for projecting EOC-7B bobbin voltage frequency are further discussed below.

6.2 Probability of Detection (POD)

The Generic Letter 95-05 (Reference 8-4) requires the application of a constant POD value of 0.6 to define the BOC distribution for the EOC voltage projections, unless an alternate POD is approved by the NRC. A POD value of 1.0 represents the ideal situation where all indications are detected; a voltage-dependent POD may provide a more accurate prediction of voltage distributions consistent with IPC/APC experience. In addition to a constant POD of 0.6, a voltage-dependent POD developed for EPRI is also used. The EPRI POD is based on expert opinion and multiple analyst's evaluation for plants with 3/4" diameter tubes, and it represents the lower 95% confidence bound. This POD distribution is graphically illustrated in Figure 6-1.

6.3 Limiting Growth Rate Distribution

As discussed in Section 3.2, the NRC guidelines in Generic Letter 95-05 stipulate that the more conservative growth rate distributions from the past two inspections should be utilized for projecting EOC distributions for the next cycle. Since it is evident from Figure 3-8 that growth rates for Cycle 7B on an EFPY basis are higher than those of Cycles 7A or 6, Cycle 7B growth rate distribution is used to develop the EOC-7B predictions. The actual growth distribution used for EOC-8 projections is the SG B growth distribution which has the highest average growth rate among the four SGs during Cycle 7B as well as the indication with the largest voltage growth. As noted in Section 3.2, larger positive and negative values in the growth/EFPY distribution are likely to be overestimated since they were obtained by multiplying the actual growth observed during Cycle 7B by a factor of about 4, and as the negative values in the growth distribution used for next cycle projections are set to zero the average growth rate used for EOC-8 projections is very conservative.

The same conservative growth distribution was imposed on all four steam generators to provide a conservative basis for predicting EOC-8 performance. In addition, as discussed in Section 3.2, it is conservative to apply the same conservative growth rate distribution for the cold leg indications.

6.4 Cycle Operating Period

The operating periods used in the growth rate/EFPY calculations and voltage projections are shown on the next page.

Cycle 7B - MOC-7 to EOC-7 - 87.7 EFPD or 0.24 EFPY (actual)
Cycle 8 - BOC-8 to EOC-8 - 493.1 EFPD or 1.35 EFPY (estimated)

6.5 Projected EOC-8 Voltage Distribution

Calculation of the predicted EOC-8 bobbin voltage distributions was performed for all four SGs based on the EOC-7B distributions shown in Table 6-1. The bobbin voltage distributions are shown separately for hot leg and cold leg indications in Table 6-1 since tube burst analyses need only be performed for the cold leg indications (locked TSPs constrain rupture of hot leg indications). The BOC distributions were adjusted to account for probability of detection as described above, and the adjusted number of indications at BOC-8 are also shown in Table 6-1. Calculations were performed using a constant POD of 0.6 as well as the EPRI POD distribution. The highest growth rates observed among the four SGs in last two cycles operation, which are the EOC-7B SG B growth rates shown in Table 3-3, were used. The IPC voltage distributions projected for EOC-8 for all four SGs are summarized on Table 6-2. These results are also shown graphically on Figures 6-2 to 6-5. Only 31 indications were found on the cold leg side for all four SGs combined during the EOC-7B inspection, three of them were removed from service due to tube repairs, and the total at EOC-8 is projected to be about 49 for a POD of 0.6. The results for the cold leg indications are shown separately in Table 6-2, but they are combined with the hot leg results in Figures 6-2 to 6-5 because of the relatively smaller population of cold leg indications. The results based on a constant POD of 0.6 are more conservative than those using the voltage-dependent EPRI POD.

The predicted EOC-8 voltage distributions have a long tail which is a result of the long tail in the Cycle 7B growth distribution used in the projections. The peak voltages predicted for EOC-8 are more than 250% of those measured the during EOC-7B inspection and it is due to the longer operating cycle with associated conservatism in the EOC-7B growth rates used. Actual peak voltages at EOC-8 may be expected to be significantly below the projections shown here.

6.6 Comparison of Actual and Projected EOC-7B Voltage Distributions

Table 6-3, and Figures 6-6 and 6-7 provide a comparison of the EOC-7B actual measured bobbin voltage distributions with the corresponding projections performed using the last (EOC-7A) inspection bobbin voltage data. EOC-7B projections based on a constant POD of 0.6 as well as the voltage-dependent EPRI POD are shown. As reported in Reference 8-5 at BOC-7B, SG-B was projected to be the limiting SG and it was confirmed to have the largest indication measured in the EOC-7B inspection. The actual peak voltage for SG B was found to be about

0.5 volts higher than projected value.

A comparison of the actual and projected voltage distributions in Figures 6-6 and 6-7 show that in general the indication population above 0.6 volts is substantially overestimated in the projections based on a constant POD of 0.6. This POD value is conservative for voltages above about 1 volt but non-conservative below 1 volt. The voltage-dependent EPRI POD shows a much better agreement with the actual measured distribution, although the projected distribution is still conservative.

6.7 Probe Wear Criteria

An alternate probe wear criteria discussed in Reference 8.7 was applied during the EOC-7B inspection. When a probe does not pass the 15% wear limit, this alternate criteria requires that all tubes with indications above 75% of the repair limit since the last successful probe wear check be reinspected with a good probe. Although the repair limit for hot leg indications is 3 volts, all indications for which worn probe voltage was above 0.75 volt 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 8.7, voltages measured with a worn probe and a new probe at the same location were analyzed to ensure that the voltages measured with worn probes are within 75% of the new probe voltages. Figures 6-8 and 6-9 show plots of the worn probe voltages plotted against the new probe voltages for all four SGs. These figures show a consistent relationship between the two voltages for all four SGs. Composite data from all four SGs are plotted in Figure 6-10. Also shown in Figure 6-10 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. The mean regression line shows a slight bias for the average worn probe voltages to be higher than the new probe voltages. In addition, more data points are above (high worn probe volts) the 90%/95% tolerance band than below (low worn probe volts) the tolerance band. The results show that use of the worn probe volts would be conservative compared to use of the new probe volts for leak and burst analyses.

Only five indications are significantly below the chained line representing 75% of the new probe voltage while a relatively large number of indications have worn probe voltages above 75% of the new probe volts. There are no occurrences for which a worn probe was less than 2.25 volts and the new probe voltage exceeded the plugging limit, i.e., no pluggable tubes were missed due to probe wear considerations. There is only one indication (at 1.3 volts new, 0.7 volt worn, at R45C74-05H in SG C) which could have been considered below the repair limit based on worn probe response while potentially pluggable for the 1 volt cold leg repair criteria. This was a hot leg indication and all voltages were well below the

3.0 volt repair limit. The worn probe would have identified 6 indications as being above 1 volt that had a new probe voltage below 1 volt.

Overall, it is concluded that the criteria to retest tubes with worn probe voltages above 75% of the repair limit is adequate and moderately conservative due to the average trend for worn probe volts to exceed new probe voltages.

Comparison of the actual and projected EOC-7B voltages presented in Section 6-6 does not show anything unusual attributable to the alternate probe wear criteria. The projected voltages are conservative, which is attributable to conservatism in the growth rates and the POD value (0.6). In summary, the alternate probe wear criteria used in the EOC-7B inspection is consistent with the NRC guidance provided in Reference 8.7.

Table 6 - 1 (Sheet 1 of 2)
Byron Unit-1 April 1996
Actual EOC-7B and Assumed BOC-8 Voltage Distributions
Used in SLB Leak Rate and Tube Burst Probability Analyses

Voltage Bin	Steam Generator A								Steam Generator B							
	EOC-7B				BOC-8				EOC-7B				BOC-8			
	In service		Repaired		POD = 0.6		EPRI POD		In service		Repaired		POD = 0.6		EPRI POD	
	Hot Side	Cold Side	Hot Side	Cold Side	Hot Side	Cold Side	Hot Side	Cold Side	Hot Side	Cold Side	Hot Side	Cold Side	Hot Side	Cold Side	Hot Side	Cold Side
0.1	1	0	0	0	1.67	0.00	3.33	0.00	2	0	0	0	3.33	0.00	6.66	0.00
0.2	35	1	0	0	58.33	1.67	109.38	3.20	25	0	0	0	41.67	1.67	78.13	0.00
0.3	124	1	1	0	205.67	1.67	287.37	2.60	131	4	6	0	212.33	5.00	298.65	10.50
0.4	155	5	6	0	252.33	8.34	281.04	10.30	231	4	9	0	376.00	6.67	418.78	8.30
0.5	145	1	11	0	230.67	1.67	236.16	1.80	252	0	11	0	409.00	0.00	418.55	0.00
0.6	126	1	10	0	200.00	1.67	188.95	1.70	245	1	8	0	400.33	1.67	378.84	1.70
0.7	110	0	8	0	175.33	0.00	153.77	0.00	220	2	13	1	353.67	2.33	310.53	2.60
0.8	74	0	6	0	117.33	0.00	95.37	0.00	146	0	6	0	237.33	0.00	194.00	0.00
0.9	67	0	7	0	104.67	0.00	78.90	0.00	109	0	3	0	178.67	0.00	136.74	0.00
1	42	0	5	0	65.00	0.00	46.69	0.00	94	1	8	0	148.67	1.67	107.69	1.30
1.1	33	0	2	0	53.00	0.00	37.05	0.00	80	0	5	0	128.33	0.00	89.68	0.00
1.2	24	0	4	0	36.00	0.00	23.35	0.00	49	0	6	0	75.67	0.00	49.84	0.00
1.3	20	0	1	0	32.33	0.00	20.98	0.00	59	0	1	0	97.33	0.00	63.84	0.00
1.4	15	0	3	0	22.00	0.00	13.23	0.00	31	0	3	0	48.67	0.00	30.55	0.00
1.5	12	0	3	0	17.00	0.00	9.79	0.00	19	0	3	0	28.67	0.00	17.26	0.00
1.6	7	0	0	0	11.67	0.00	7.35	0.00	29	0	3	0	45.33	0.00	27.46	0.00
1.7	7	0	0	0	11.67	0.00	7.25	0.00	13	0	1	0	20.67	0.00	12.46	0.00
1.8	4	0	0	0	6.67	0.00	4.08	0.00	7	0	1	0	10.67	0.00	6.14	0.00
1.9	6	0	1	0	9.00	0.00	5.11	0.00	7	0	0	0	11.67	0.00	7.13	0.00
2	1	0	0	0	1.67	0.00	3.00	0.00	2	0	1	0	2.33	0.00	1.03	0.00
2.1	2	0	0	0	3.33	0.00	0.00	0.00	4	0	1	0	5.67	0.00	3.06	0.00
2.2	1	0	1	0	0.67	0.00	0.01	0.00	6	0	2	0	8.00	0.00	4.08	0.00
2.3	1	0	1	0	0.67	0.00	0.01	0.00	2	0	0	0	3.33	0.00	2.02	0.00
2.4	0	0	0	0	0.00	0.00	0.00	0.00	1	0	0	0	1.67	0.00	1.01	0.00
2.5	0	0	0	0	0.00	0.00	0.00	0.00	7	0	2	0	9.67	0.00	6.10	0.00
2.6	0	0	0	0	0.00	0.00	0.00	0.00	2	0	1	0	2.33	0.00	1.01	0.00
2.7	0	0	0	0	0.00	0.00	0.00	0.00	1	0	0	0	1.67	0.00	0.00	0.00
2.8	1	0	1	0	0.67	0.00	0.00	0.00	0	0	0	0	0.00	0.00	0.00	0.00
3.1	0	0	0	0	0.00	0.00	0.00	0.00	1	0	1	0	0.67	0.00	0.00	0.00
3.3	0	0	0	0	0.00	0.00	0.00	0.00	1	0	1	0	0.67	0.00	0.01	0.00
3.4	0	0	0	0	0.00	0.00	0.00	0.00	1	0	1	0	0.67	0.00	0.00	0.00
3.5	1	0	1	0	0.67	0.00	0.00	0.00	1	0	1	0	0.67	0.00	0.00	0.00
4.5	0	0	0	0	0.00	0.00	0.00	0.00	1	0	1	0	0.67	0.00	0.00	0.00
Total	1014	9	72	0	1618.00	15.00	1612.17	19.60	1779	12	99	1	2866.00	19.00	2671.25	23.80
> 1V	135	0	18	0	207.00	0.00	131.23	0.00	324	0	35	0	505.00	0.00	322.68	0.00
> 3V	1	0	1	0	0.67	0	0.00	0	5	0	5	0	3.33	0.00	0.01	0.00

Table 6 - 1 (Sheet 2 of 2)
Byron Unit-1 November 1995
Actual EOC-7A and Assumed BOC-7B Voltage Distributions
Used in SLB Leak Rate and Tube Burst Probability Analyses

Voltage Bin	Steam Generator C								Steam Generator D							
	EOC-7B				BOC-8				EOC-7B				BOC-8			
	In service		Repaired		POD = 0.6		EPRI POD		In service		Repaired		POD = 0.6		EPRI POD	
	Hot Side	Cold Side	Hot Side	Cold Side	Hot Side	Cold Side	Hot Side	Cold Side	Hot Side	Cold Side	Hot Side	Cold Side	Hot Side	Cold Side	Hot Side	Cold Side
0.1	0	0	0	0	0.00	0.00	0.00	0.00	0	0	0	0	0.00	0.00	0.00	0.00
0.2	33	0	1	0	54.00	0.00	102.13	0.00	38	1	1	0	62.33	1.67	117.75	3.20
0.3	171	0	5	0	280.00	0.00	392.67	0.00	137	4	1	1	227.33	5.67	317.61	9.70
0.4	255	2	7	0	418.00	3.33	465.22	4.20	179	0	9	0	289.33	0.00	322.48	1.79
0.5	275	0	7	0	451.33	0.00	461.75	0.00	141	1	4	0	231.00	1.67	236.34	0.00
0.6	280	0	7	0	459.67	0.00	435.11	0.00	97	0	4	0	157.67	0.00	149.16	0.00
0.7	230	1	12	1	371.33	0.67	326.24	0.50	62	0	6	0	97.33	0.00	85.18	0.00
0.8	204	0	8	0	332.00	0.00	271.45	0.00	45	0	4	0	71.00	0.00	57.64	0.00
0.9	119	0	2	0	196.33	0.00	150.56	0.00	29	0	4	0	44.33	0.00	33.18	0.00
1	100	1	5	0	161.67	1.67	118.08	1.23	35	0	2	0	56.33	0.00	41.08	0.00
1.1	89	0	2	0	146.33	0.00	103.33	0.00	31	0	1	0	50.67	0.00	35.69	0.00
1.2	57	0	1	0	94.00	0.00	63.96	0.00	14	0	0	0	23.33	0.00	15.95	0.00
1.3	66	0	1	0	109.00	1.67	71.53	1.09	13	0	0	0	21.67	0.00	14.29	0.00
1.4	40	1	1	0	65.67	0.00	42.29	0.00	5	0	0	0	8.33	0.00	5.41	0.00
1.5	34	0	0	0	56.67	0.00	36.25	0.00	6	0	0	0	10.00	0.00	6.40	0.00
1.6	19	0	0	0	31.67	0.00	19.96	0.00	8	0	2	0	11.33	0.00	6.40	0.00
1.7	14	0	0	0	23.33	0.00	14.49	0.00	4	0	3	0	3.67	0.00	1.14	0.00
1.8	9	0	3	0	12.00	0.00	6.18	0.00	4	0	2	0	4.67	0.00	2.08	0.00
1.9	11	0	2	0	16.33	0.00	9.21	0.00	4	0	2	0	4.67	0.00	2.08	0.00
2	4	0	2	0	4.67	0.00	2.07	0.00	3	0	2	0	3.00	0.00	1.05	0.00
2.1	6	0	3	0	7.00	0.00	3.09	0.00	0	0	0	0	1.67	0.00	1.02	0.00
2.2	3	0	0	0	5.00	0.00	3.04	0.00	1	0	0	0	0.00	0.00	0.00	0.00
2.3	6	0	2	0	8.00	0.00	4.07	0.00	0	0	0	0	0.00	0.00	0.00	0.00
2.4	5	0	4	0	4.33	0.00	2.10	0.00	0	0	0	0	0.67	0.00	0.01	0.00
2.5	1	0	0	0	1.67	0.00	1.00	0.00	2	0	2	0	0.67	0.00	0.00	0.00
2.6	1	0	0	0	5.00	0.00	0.00	0.00	0	0	0	0	0.00	0.00	0.00	0.00
2.7	1	0	0	0	1.67	0.00	3.02	0.00	0	0	0	0	0.00	0.00	0.00	0.00
2.8	2	0	0	0	0.00	0.00	0.00	0.00	0	0	0	0	0.00	0.00	0.00	0.00
3.1	0	0	0	0	0.00	0.00	0.00	0.00	1	0	1	0	0.67	0.00	0.00	0.00
3.3	0	0	0	0	0.00	0.00	0.00	0.00	0	0	0	0	0.00	0.00	0.00	0.00
3.4	0	0	0	0	0.00	0.00	0.00	0.00	0	0	0	0	0.00	0.00	0.00	0.00
3.5	0	0	0	0	0.00	0.00	0.00	0.00	0	0	0	0	0.00	0.00	0.00	0.00
4.5	0	0	0	0	0.00	0.00	0.00	0.00	0	0	0	0	0.00	0.00	0.00	0.00
Total	2035	5	75	1	3316.67	7.34	3108.78	7.02	859	6	50	1	1381.67	9.00	1451.92	14.69
> 1V	368	1	21	0	592.34	1.67	385.57	1.09	96	0	15	0	145.00	0	91.51	0
> 3V	0	0	0	0	0	0	0	0	1	0	1	0	0.67	0	0.00	0

Table 6 - 2 (Sheet 1 of 4)
Byron Unit-1 April 1996
Voltage Distribution Projection for EOC - 8

Voltage Bin	Steam Generator A				Steam Generator B			
	POD 0.6		EPRI POD		POD 0.6		EPRI POD	
	Hot Leg	Cold Leg	Hot Leg	Cold Leg	Hot Leg	Cold Leg	Hot Leg	Cold Leg
	Projected Number of Indications at EOC - 8							
0.1	1.20	0.00	2.29	0.00	1.44	0.00	2.81	0.00
0.2	19.81	0.36	34.67	0.69	15.99	0.16	27.42	0.28
0.3	60.10	0.90	83.36	1.80	65.22	1.55	89.06	2.40
0.4	83.46	1.91	99.58	2.44	117.08	2.09	135.86	2.78
0.5	94.30	1.52	106.11	1.88	149.78	1.12	162.16	1.47
0.6	103.06	1.17	111.85	1.48	172.77	1.32	178.94	1.69
0.7	106.73	1.09	111.27	1.38	183.16	1.49	182.86	1.83
0.8	104.16	0.99	105.15	1.25	180.56	1.18	174.97	1.44
0.9	99.78	0.82	98.40	1.05	175.16	1.10	165.69	1.32
1.0	93.13	0.74	89.58	0.93	168.07	1.09	154.95	1.25
1.1	85.03	0.61	80.05	0.77	157.28	0.89	141.66	1.01
1.2	77.72	0.52	72.57	0.66	145.26	0.75	128.80	0.87
1.3	71.56	0.47	66.30	0.61	134.28	0.73	117.89	0.87
1.4	64.62	0.45	58.80	0.57	122.94	0.65	106.43	0.75
1.5	57.86	0.38	52.26	0.47	111.14	0.50	95.21	0.57
1.6	52.25	0.31	46.94	0.40	100.44	0.48	85.50	0.56
1.7	46.58	0.29	41.22	0.37	89.95	0.43	75.85	0.49
1.8	41.09	0.24	36.13	0.30	79.36	0.33	66.48	0.38
1.9	36.70	0.21	32.48	0.27	70.34	0.30	58.85	0.35
2.0	33.19	0.20	29.54	0.26	63.13	0.31	53.01	0.37
2.1	29.57	0.20	26.11	0.25	56.70	0.27	47.41	0.32
2.2	26.09	0.16	22.93	0.20	50.61	0.21	42.14	0.24
2.3	23.05	0.13	20.26	0.17	45.16	0.19	37.48	0.22
2.4	20.37	0.12	17.85	0.15	40.14	0.18	33.17	0.20
2.5	17.97	0.11	15.76	0.13	35.58	0.15	29.29	0.17
2.6	16.01	0.10	14.15	0.12	31.75	0.14	26.15	0.16
2.7	14.29	0.01	12.60	0.11	28.50	0.13	23.49	0.16
2.8	12.65	0.00	11.13	0.10	25.43	0.11	20.90	0.12
2.9	11.40	0.00	10.17	0.07	22.80	0.10	18.83	0.11
3.0	10.45	0.00	9.41	0.00	20.72	0.06	17.22	0.12
3.1	9.52	0.00	8.55	0.00	18.84	0.00	15.73	0.11
3.2	8.65	0.70	7.78	0.00	17.13	0.00	14.30	0.03
3.3	7.90	0.00	7.15	0.00	15.65	0.00	13.10	0.00
3.4	7.18	0.00	6.46	0.70	14.24	0.00	11.91	0.00
3.5	6.54	0.00	5.91	0.00	12.89	0.70	10.78	0.00
3.6	6.09	0.00	5.58	0.00	11.85	0.00	9.98	0.00
3.7	5.58	0.00	5.04	0.00	10.91	0.00	9.17	0.70
3.8	4.90	0.00	4.29	0.00	9.82	0.00	8.13	0.00
3.9	4.29	0.00	3.78	0.00	8.68	0.00	7.11	0.00
4.0	3.97	0.30	3.57	0.00	7.82	0.00	6.47	0.00
4.1	3.73		3.42	0.00	7.19	0.00	6.02	0.00
4.2	3.55		3.31	0.00	6.75	0.00	5.74	0.00
4.3	3.38		3.14	0.30	6.44	0.30	5.52	0.00
4.4	3.11		2.86		6.06		5.16	0.00
4.5	2.85		2.60		5.56		4.72	0.30
4.6	2.56		2.29		5.04		4.23	
4.7	2.21		1.92		4.45		3.65	
4.8	1.87		1.57		3.82		3.06	
4.9	1.57		1.28		3.25		2.54	
5.0	1.31		1.06		2.74		2.10	
5.1	1.10		0.92		2.32		1.77	
5.2	0.98		0.83		2.03		1.56	
5.3	0.89		0.77		1.81		1.42	
5.4	0.80		0.70		1.64		1.31	
5.5	0.72		0.62		1.48		1.17	
5.6	0.63		0.54		1.31		1.04	
5.7	0.56		0.48		1.15		0.91	
5.8	0.50		0.43		1.01		0.80	
5.9	0.45		0.39		0.90		0.72	
6.0	0.41		0.36		0.82		0.66	

Table continues on Sheet 2

Table 6 - 2 (Sheet 2 of 4)
Byron Unit-1 April 1996
Voltage Distribution Projection for EOC - 8

Voltage Bin	Steam Generator A				Steam Generator B			
	POD 0.6		EPRI POD		POD 0.6		EPRI POD	
	Hot Leg	Cold Leg	Hot Leg	Cold Leg	Hot Leg	Cold Leg	Hot Leg	Cold Leg
	Projected Number of Indications at EOC - 8							
6.1	0.38		0.34		0.75		0.61	
6.2	0.36		0.33		0.71		0.58	
6.3	0.34		0.31		0.66		0.55	
6.4	0.31		0.28		0.61		0.51	
6.5	0.28		0.25		0.56		0.46	
6.6	0.25		0.22		0.50		0.41	
6.7	0.22		0.20		0.45		0.37	
6.8	0.20		0.18		0.40		0.33	
6.9	0.19		0.17		0.37		0.30	
7.0	0.17		0.15		0.33		0.28	
7.1	0.15		0.13		0.30		0.25	
7.2	0.13		0.11		0.27		0.21	
7.3	0.11		0.10		0.23		0.18	
7.4	0.10		0.08		0.20		0.16	
7.5	0.09		0.07		0.17		0.13	
7.6	0.08		0.06		0.15		0.12	
7.7	0.07		0.06		0.14		0.11	
7.8	0.06		0.06		0.12		0.10	
7.9	0.06		0.05		0.11		0.09	
8.0	0.06		0.05		0.11		0.09	
8.1	0.05		0.05		0.10		0.09	
8.2	0.05		0.05		0.10		0.08	
8.3	0.05		0.05		0.09		0.08	
8.4	0.05		0.05		0.09		0.08	
8.5	0.05		0.05		0.09		0.08	
8.6	0.05		0.05		0.09		0.08	
8.7	0.05		0.05		0.09		0.08	
8.8	0.05		0.05		0.09		0.08	
8.9	0.05		0.05		0.08		0.08	
9.0	0.05		0.05		0.09		0.08	
9.1	0.06		0.06		0.10		0.10	
9.2	0.07		0.08		0.11		0.12	
9.3	0.09		0.09		0.14		0.14	
9.4	0.10		0.11		0.16		0.16	
9.5	0.11		0.11		0.18		0.18	
9.6	0.12		0.12		0.19		0.19	
9.7	0.12		0.12		0.20		0.20	
9.8	0.11		0.11		0.20		0.19	
9.9	0.11		0.10		0.19		0.18	
10.0	0.10		0.07		0.18		0.16	
10.1	0.07		0.00		0.17		0.15	
10.2	0.00		0.00		0.16		0.14	
10.3	0.00		0.00		0.15		0.13	
10.4	0.00		0.00		0.14		0.13	
10.5	0.00		0.70		0.14		0.13	
10.6	0.70		0.00		0.14		0.07	
10.7	0.00		0.00		0.13		0.00	
10.8	0.00		0.00		0.01		0.00	
11.0	0.00		0.00		0.00		0.70	
11.1	0.30		0.30		0.70		0.00	
11.3					0.00		0.30	
11.5					0.30			
TOTAL	1618.01	15.01	1612.23	19.88	2866.01	19.01	2671.21	23.64
> 1 V	852.29	5.51	769.98	6.98	1636.79	7.91	1396.51	9.18
> 3 V	103.87	1.00	93.24	1.00	205.31	1.00	170.77	1.14

Table 6 - 2 (Sheet 3 of 4)
Byron Unit-1 April 1996
Voltage Distribution Projection for EOC - 8

Voltage Bin	Steam Generator C				Steam Generator D			
	POD 0.6		EPRI POD		POD 0.6		EPRI POD	
	Hot Leg	Cold Leg	Hot Leg	Cold Leg	Hot Leg	Cold Leg	Hot Leg	Cold Leg
	Projected Number of Indications at EOC - 8							
0.1	0.68	0.00	1.30	0.00	0.79	0.00	1.50	0.00
0.2	20.54	0.00	35.34	0.00	21.25	0.47	37.28	0.88
0.3	82.70	0.14	113.20	0.19	66.58	1.45	92.17	2.58
0.4	133.98	0.68	156.47	0.86	92.72	0.68	110.58	1.09
0.5	169.65	0.30	184.54	0.37	96.44	0.76	109.53	1.12
0.6	190.80	0.22	205.26	0.29	94.77	0.72	105.81	1.18
0.7	209.93	0.34	210.34	0.38	91.51	0.58	99.54	0.93
0.8	210.19	0.32	203.79	0.35	89.22	0.50	91.51	0.79
0.9	203.05	0.30	192.67	0.31	81.43	0.48	84.58	0.76
1.0	193.17	0.38	178.79	0.37	76.24	0.37	76.89	0.58
1.1	181.21	0.37	163.81	0.34	69.17	0.31	68.21	0.48
1.2	168.39	0.36	149.90	0.31	62.33	0.29	61.33	0.47
1.3	156.49	0.38	138.01	0.33	57.12	0.30	56.12	0.49
1.4	143.32	0.41	124.44	0.35	51.52	0.21	49.70	0.32
1.5	129.50	0.35	111.37	0.28	45.74	0.20	43.69	0.31
1.6	116.98	0.31	100.15	0.25	40.91	0.19	38.97	0.30
1.7	104.55	0.29	88.57	0.24	36.24	0.14	33.98	0.22
1.8	92.56	0.24	77.68	0.19	31.62	0.12	29.33	0.19
1.9	82.03	0.20	68.95	0.16	28.14	0.12	26.39	0.20
2.0	73.70	0.19	62.12	0.16	25.83	0.11	24.36	0.21
2.1	66.00	0.18	55.31	0.15	23.24	0.00	21.67	0.14
2.2	58.76	0.14	49.05	0.12	20.40	0.00	18.87	0.13
2.3	52.35	0.12	43.54	0.03	17.88	0.00	16.52	0.12
2.4	46.54	0.11	38.51	0.00	15.74	0.00	14.49	0.10
2.5	41.24	0.00	34.07	0.00	13.91	0.00	12.83	0.08
2.6	36.71	0.00	30.41	0.00	12.52	0.70	11.63	0.00
2.7	32.84	0.00	27.19	0.00	11.28	0.00	10.44	0.00
2.8	29.20	0.00	24.09	0.70	9.98	0.00	9.21	0.00
2.9	26.22	0.70	21.84	0.00	9.00	0.00	8.46	0.00
3.0	23.80	0.00	19.99	0.00	8.34	0.00	7.90	0.00
3.1	21.64	0.00	18.21	0.00	7.67	0.00	7.26	0.70
3.2	19.63	0.00	16.56	0.00	6.95	0.00	6.58	0.00
3.3	17.87	0.00	15.18	0.00	6.35	0.00	6.04	0.00
3.4	16.25	0.00	13.77	0.00	5.75	0.00	5.42	0.00
3.5	14.71	0.00	12.49	0.00	5.20	0.30	4.96	0.00
3.6	13.55	0.00	11.65	0.00	4.89		4.74	0.00
3.7	12.42	0.00	10.62	0.30	4.52		4.30	0.00
3.8	11.14	0.00	9.36		3.90		3.59	0.00
3.9	9.84	0.30	8.22		3.32		3.06	0.30
4.0	8.91		7.56		3.07		2.94	
4.1	8.20		7.05		2.99		2.93	
4.2	7.69		6.69		2.93		2.91	
4.3	7.30		6.41		2.83		2.79	
4.4	6.82		5.95		2.58		2.49	
4.5	6.32		5.47		2.28		2.20	
4.6	5.72		4.91		2.00		1.89	
4.7	5.03		4.22		1.69		1.53	
4.8	4.33		3.54		1.38		1.22	
4.9	3.66		2.95		1.13		0.97	
5.0	3.09		2.45		0.95		0.81	
5.1	2.63		2.07		0.82		0.71	
5.2	2.28		1.82		0.75		0.67	
5.3	2.04		1.67		0.71		0.65	
5.4	1.85		1.52		0.65		0.61	
5.5	1.65		1.36		0.57		0.52	
5.6	1.46		1.21		0.49		0.44	
5.7	1.29		1.06		0.42		0.39	
5.8	1.13		0.93		0.38		0.35	
5.9	1.00		0.83		0.35		0.32	
6.0	0.91		0.76		0.33		0.31	

Table continues on Sheet 4

Table 6 - 2 (Sheet 4 of 4)
Byron Unit-1 April 1996
Voltage Distribution Projection for EOC - 8

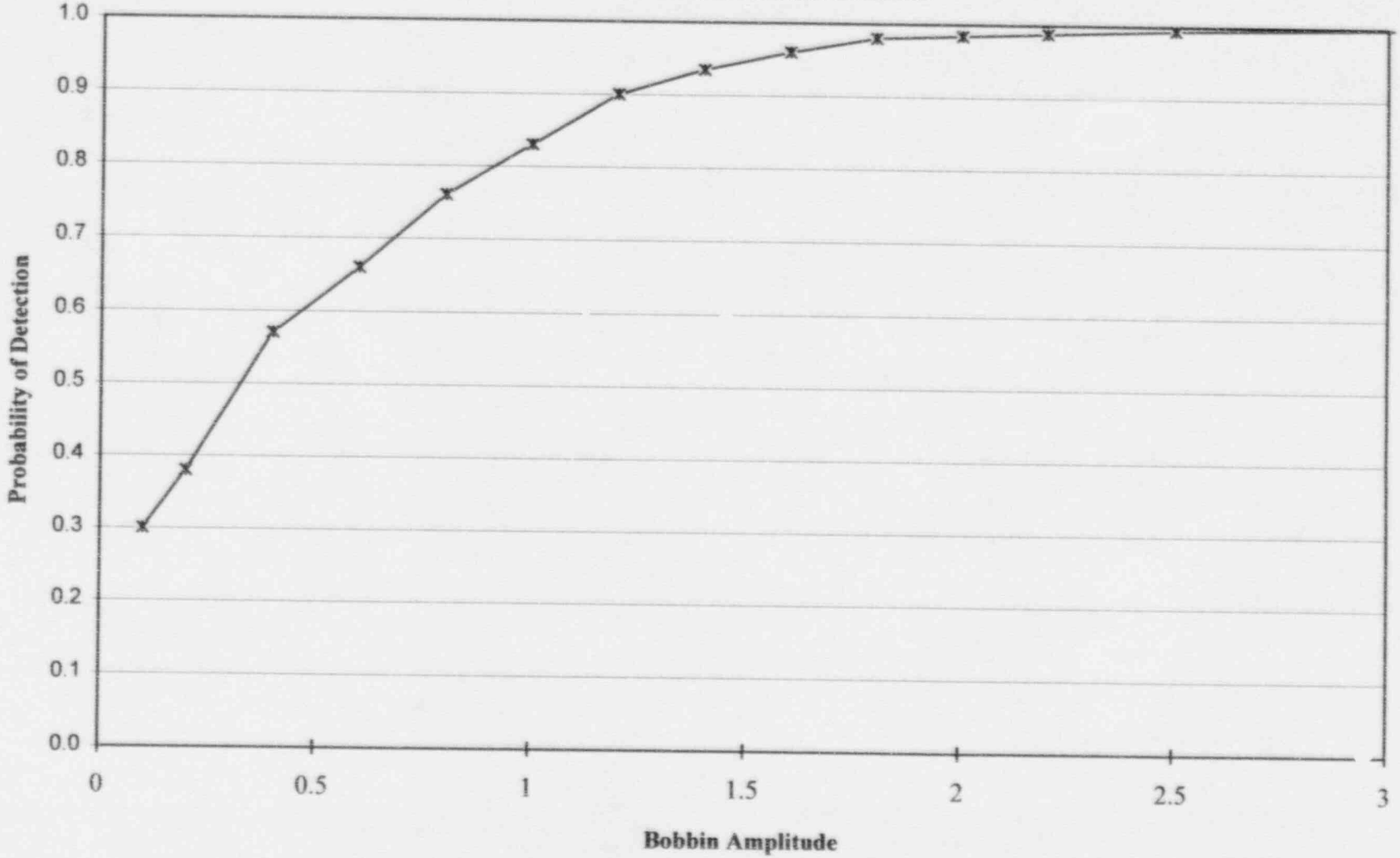
Voltage Bin	Steam Generator C				Steam Generator D			
	POD 0.6		EPRI POD		POD 0.6		EPRI POD	
	Hot Leg	Cold Leg	Hot Leg	Cold Leg	Hot Leg	Cold Leg	Hot Leg	Cold Leg
	Projected Number of Indications at EOC - 8							
6.1	0.84		0.71		0.31		0.30	
6.2	0.79		0.68		0.29		0.29	
6.3	0.74		0.64		0.28		0.27	
6.4	0.69		0.59		0.25		0.24	
6.5	0.62		0.53		0.22		0.21	
6.6	0.56		0.47		0.19		0.18	
6.7	0.50		0.42		0.17		0.16	
6.8	0.45		0.38		0.16		0.15	
6.9	0.41		0.35		0.15		0.14	
7.0	0.38		0.32		0.14		0.13	
7.1	0.34		0.28		0.12		0.11	
7.2	0.30		0.25		0.10		0.09	
7.3	0.26		0.21		0.08		0.07	
7.4	0.22		0.18		0.07		0.06	
7.5	0.19		0.16		0.06		0.06	
7.6	0.17		0.14		0.06		0.05	
7.7	0.15		0.13		0.05		0.05	
7.8	0.14		0.12		0.05		0.05	
7.9	0.13		0.11		0.05		0.05	
8.0	0.12		0.10		0.04		0.04	
8.1	0.11		0.10		0.04		0.04	
8.2	0.11		0.10		0.04		0.04	
8.3	0.11		0.09		0.04		0.04	
8.4	0.10		0.09		0.04		0.04	
8.5	0.10		0.09		0.04		0.04	
8.6	0.10		0.09		0.04		0.04	
8.7	0.10		0.09		0.04		0.04	
8.8	0.10		0.09		0.04		0.04	
8.9	0.10		0.09		0.04		0.04	
9.0	0.10		0.09		0.04		0.05	
9.1	0.11		0.11		0.05		0.06	
9.2	0.13		0.14		0.07		0.08	
9.3	0.16		0.16		0.08		0.09	
9.4	0.18		0.19		0.09		0.10	
9.5	0.20		0.21		0.10		0.11	
9.6	0.22		0.22		0.10		0.11	
9.7	0.23		0.23		0.10		0.11	
9.8	0.23		0.22		0.10		0.09	
9.9	0.22		0.21		0.02		0.00	
10.0	0.21		0.19		0.00		0.00	
10.1	0.20		0.18		0.00		0.00	
10.2	0.18		0.16		0.00		0.00	
10.3	0.18		0.16		0.00		0.70	
10.4	0.17		0.15		0.70		0.00	
10.5	0.16		0.15		0.00		0.00	
10.6	0.16		0.14		0.00		0.00	
10.7	0.15		0.11		0.00		0.00	
10.8	0.15		0.00		0.00		0.00	
10.9	0.01		0.00		0.00		0.30	
11.0	0.00		0.70		0.30			
11.2	0.70		0.00					
11.4	0.00		0.30					
11.5	0.30							
TOTAL	3316.67	7.33	3108.75	7.02	1381.67	9.00	1451.93	14.67
> 1 V	1895.15	4.65	1626.33	3.91	673.42	2.99	642.25	4.76
> 3 V	232.76	0.30	197.35	0.30	82.52	0.30	78.16	1.00

Table 6-3
Byron Unit-1 April 1996
Comparison of Predicted and Actual EOC-7B Voltage Distributions

Voltage Bin	Steam Generator A			Steam Generator B			Steam Generator C			Steam Generator D		
	EOC-7B Prediction		EOC-7B Actual	EOC-7B Prediction		EOC-7B Actual	EOC-7B Prediction		EOC-7B Actual	EOC-7B Prediction		EOC-7B Actual
	POD = 0.6	EPRI POD		POD = 0.6	EPRI POD		POD = 0.6	EPRI POD		POD = 0.6	EPRI POD	
	Number of Indications											
0.1	0.04	0.08	1	0.06	0.10	2	0.09	0.17	0	0.04	0.09	0
0.2	3.87	6.94	36	5.84	10.14	25	7.99	14.34	33	5.24	10.84	39
0.3	31.21	45.03	125	59.96	84.87	135	50.86	73.99	171	45.80	68.97	141
0.4	101.87	125.12	160	176.41	216.57	235	145.99	178.35	257	122.31	157.37	179
0.5	174.25	191.99	146	275.86	304.22	252	267.79	291.03	275	169.40	192.41	142
0.6	205.86	208.29	127	321.14	326.13	246	345.15	348.09	280	174.67	179.75	97
0.7	194.50	183.90	110	330.11	310.61	222	349.96	330.96	231	160.02	151.31	62
0.8	163.95	145.94	74	304.59	269.50	146	317.05	281.35	204	133.35	116.86	45
0.9	134.25	111.37	67	255.95	213.55	109	265.82	222.47	119	104.62	84.98	29
1.0	107.24	83.69	42	202.14	159.49	95	212.97	168.81	101	80.24	60.79	35
1.1	82.46	61.26	33	153.69	114.65	80	166.06	125.47	89	60.81	43.66	31
1.2	62.89	44.75	24	113.00	79.84	49	127.31	92.47	57	45.64	31.39	14
1.3	47.71	32.73	20	81.77	55.05	59	95.99	67.41	66	33.96	22.66	13
1.4	35.26	23.83	15	57.87	36.97	31	71.22	48.52	41	25.24	16.38	5
1.5	25.40	16.63	12	41.58	25.10	19	51.60	34.30	34	18.86	11.88	6
1.6	18.06	11.63	7	30.16	17.70	29	36.48	23.60	19	14.19	8.58	8
1.7	12.96	8.22	7	22.70	13.02	13	25.39	16.07	14	10.84	6.41	4
1.8	9.47	5.94	4	17.32	10.00	7	17.57	10.88	9	8.40	4.91	4
1.9	6.98	4.36	6	13.64	7.83	7	12.22	7.50	11	6.49	3.80	4
2.0	5.13	3.20	1	10.69	6.22	2	8.63	5.26	4	4.95	2.93	3
2.1	3.80	2.37	2	8.41	4.96	4	6.25	3.83	6	3.78	2.21	0
2.2	2.78	1.76	1	6.68	3.94	6	4.64	2.84	3	2.87	1.69	1
2.3	2.04	1.32	1	5.19	3.10	2	3.54	2.16	6	2.21	1.30	0
2.4	1.54	1.00	0	4.09	2.44	1	2.78	1.71	5	1.75	1.05	0
2.5	1.14	0.75	0	3.20	1.96	7	2.25	1.37	1	1.44	0.84	2
2.6	0.85	0.59	0	2.54	1.57	2	1.85	1.15	1	1.22	0.71	0
2.7	0.69	0.51	0	2.10	1.34	1	1.59	1.04	1	1.10	0.68	0
2.8	0.65	0.53	1	1.88	1.31	0	1.45	1.02	2[#]	1.11	0.77	0
2.9	0.65	0.55	0	1.74	1.23	0	1.39	1.04		1.06	0.70	0
3.0	0.60	0.48	0	1.48	1.05	0	1.27	0.97		0.91	0.57	0
3.1	0.50	0.37	0	1.24	0.89	1	1.05	0.79		0.76	0.47	1[#]
3.2	0.40	0.70	0	1.05	0.71	0	0.84	0.61		0.62	0.31	
3.3	0.33	0.30	0	0.79	0.53	1	0.64	0.45		0.47	0.70	
3.4	0.04		0	0.60	0.27	1	0.48	0.09		0.31	0.30	
3.5	0.70		1[#]	0.43	0.70	1	0.21	0.70		0.00		
3.6	0.00			0.00	0.00		0.00	0.00		0.70		
3.7	0.00			0.00	0.00		0.70	0.30		0.00		
3.8	0.00			0.70	0.30		0.00			0.00		
3.9	0.30			0.00			0.30			0.30		
4.0				0.30								
4.5						1[#]						
Total	1440.37	1325.93	1023.00	2516.90	2287.86	1791.00	2607.37	2361.11	2040.00	1245.68	1168.27	865

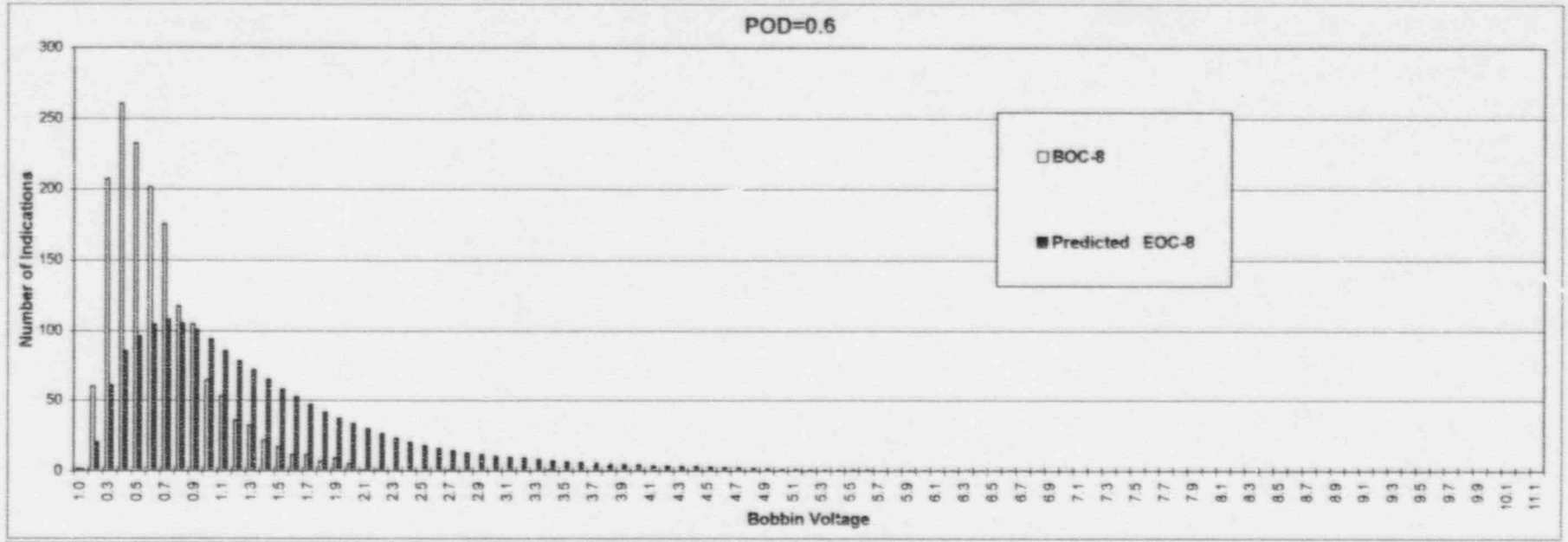
[#] Bin with the largest indication found in the steam generator

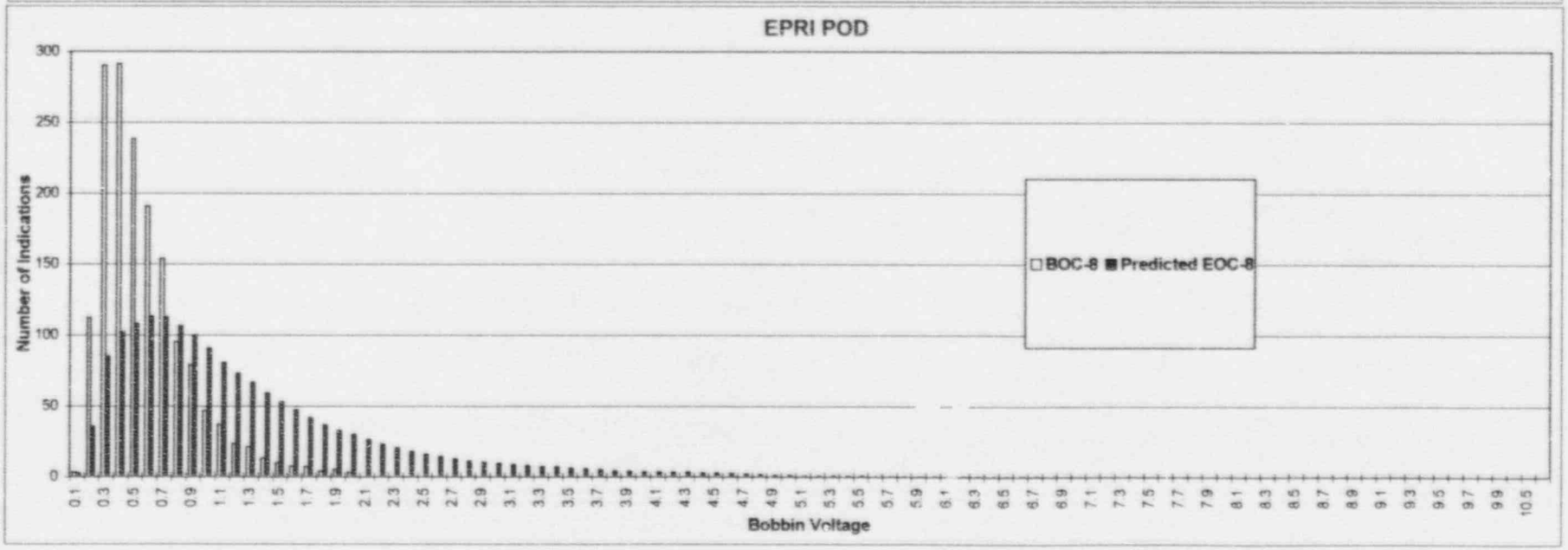
Figure 6 - 1
EPRI Probability of Detection Distribution
Lower 95% Confidence Bound



PREDCOMP.XLS|Fig6-1|8/5/96|5:43 PM

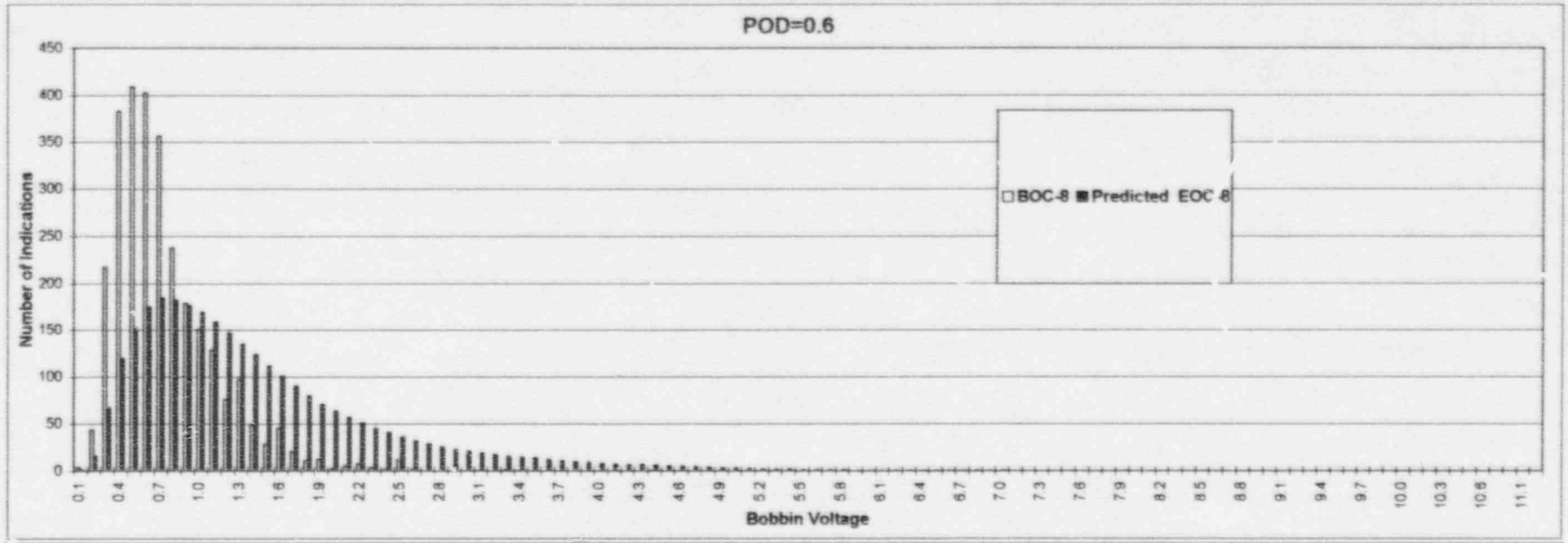
Figure 6 - 2
Byron Unit-1 April 1996
Projected Bobbin Voltage Distributions for Steam Generator A at EOC-8

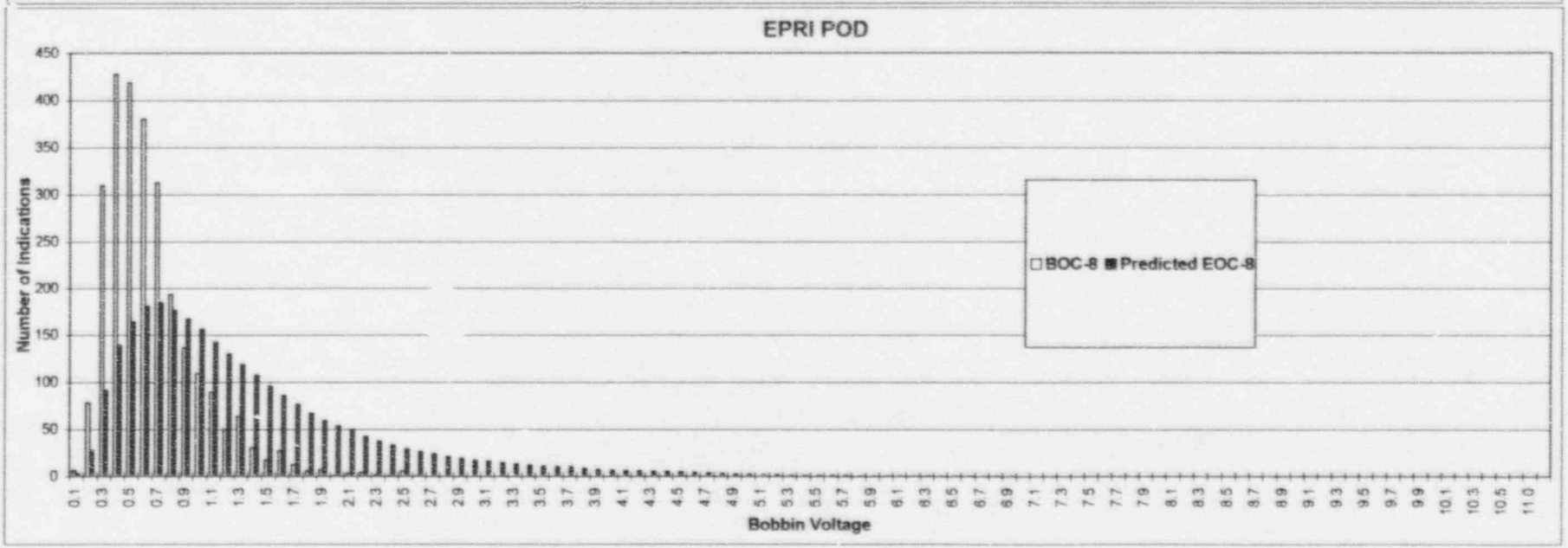




BYREPORT.XLS Fig6-2 8/9/96 10:18 AM

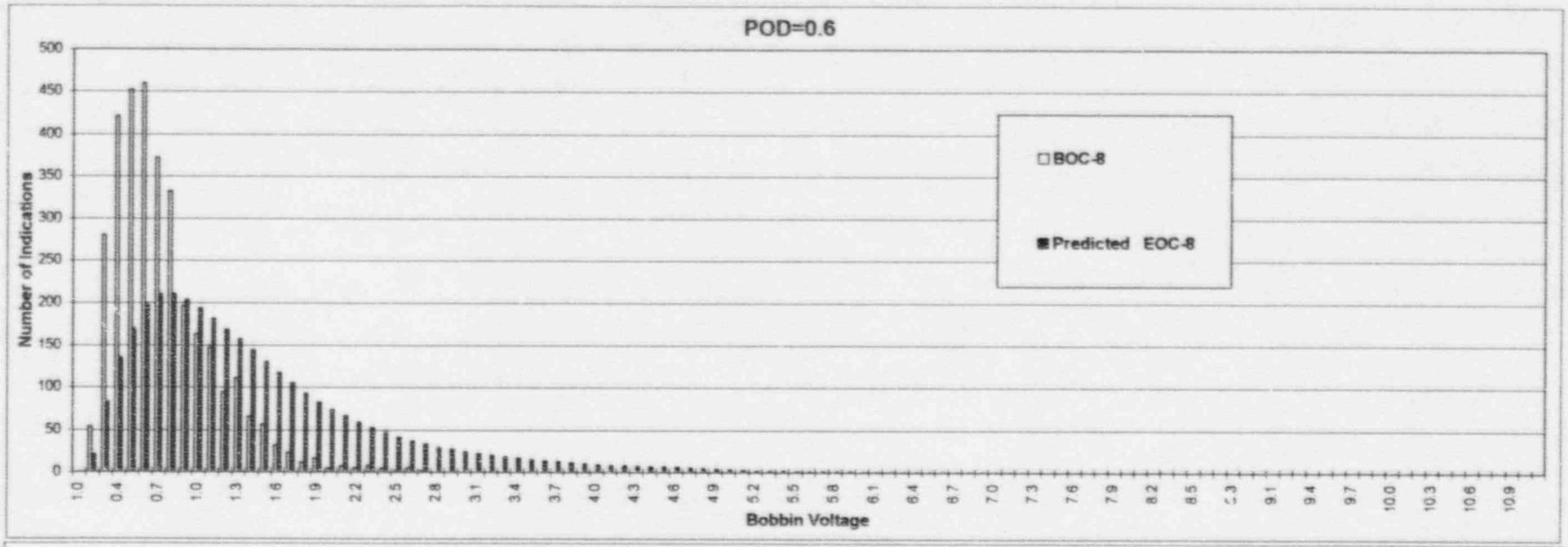
Figure 6 - 3
Byron Unit-1 April 1996
Projected Bobbin Voltage Distributions for Steam Generator B at EOC-8

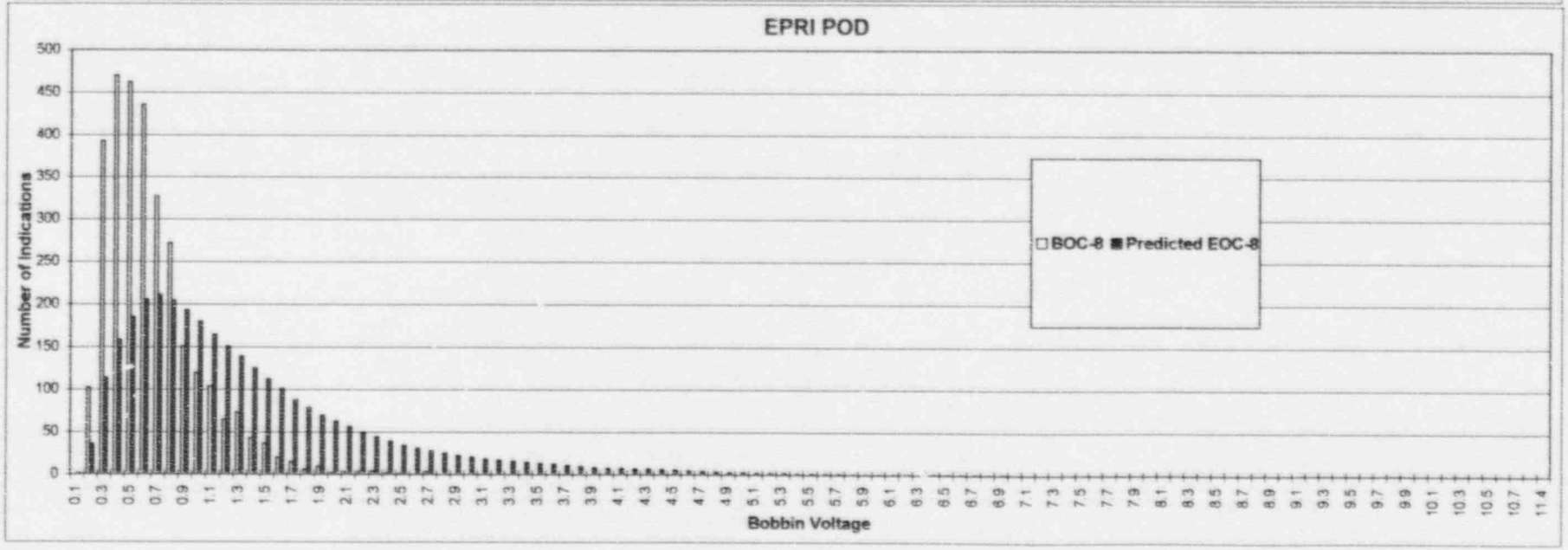




BYREPORT.XLS Fig6-3 8/9/96 10:18 AM

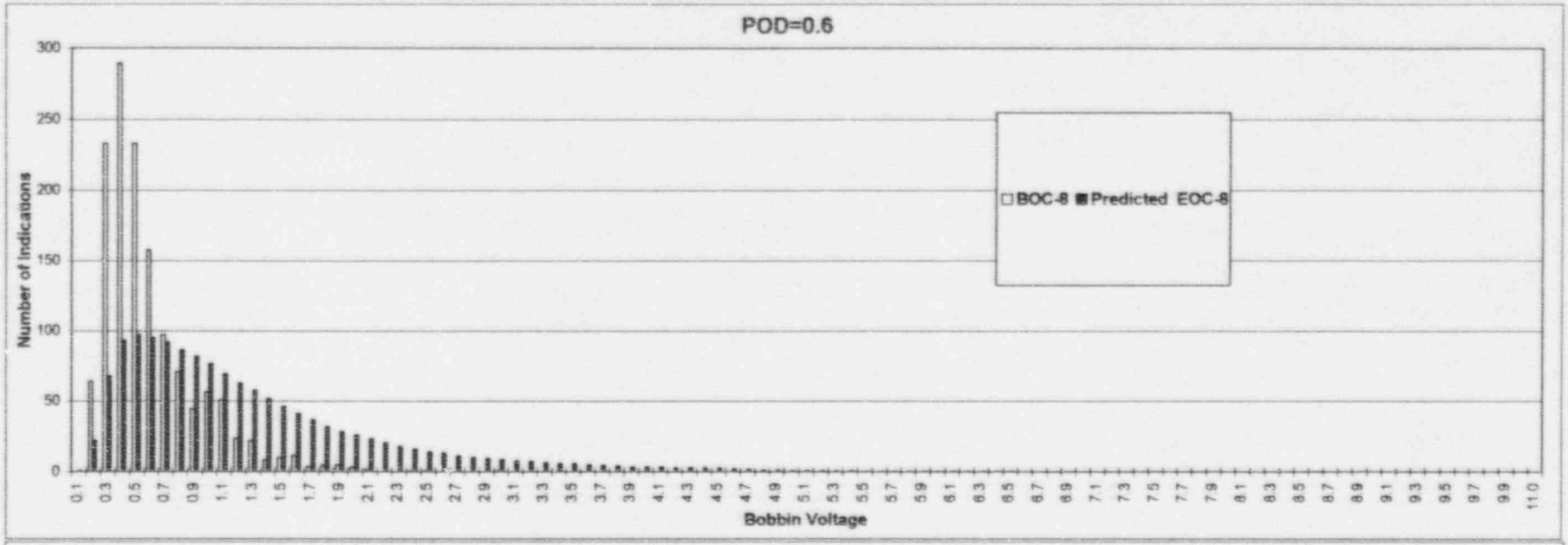
Figure 6 - 4
Byron Unit-1 April 1996
Projected Bobbin Voltage Distributions for Steam Generator C at EOC-8

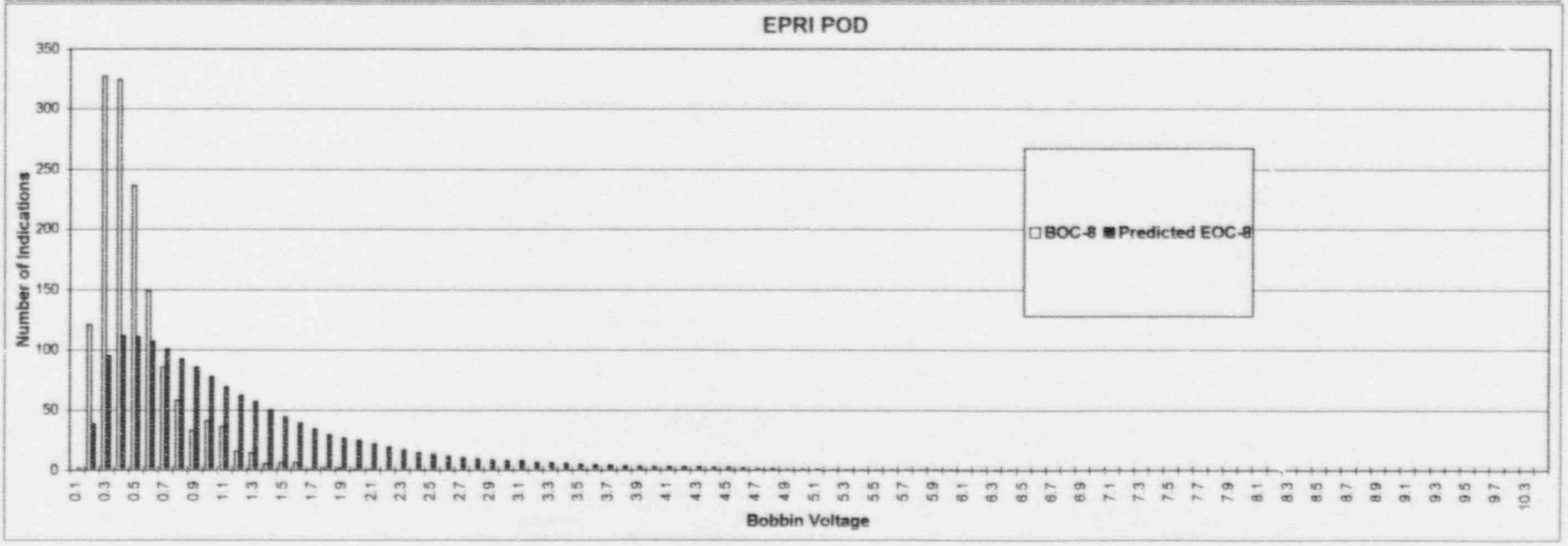




BYREPORT.XLS Fig6-4 8/9/96 10:18 AM

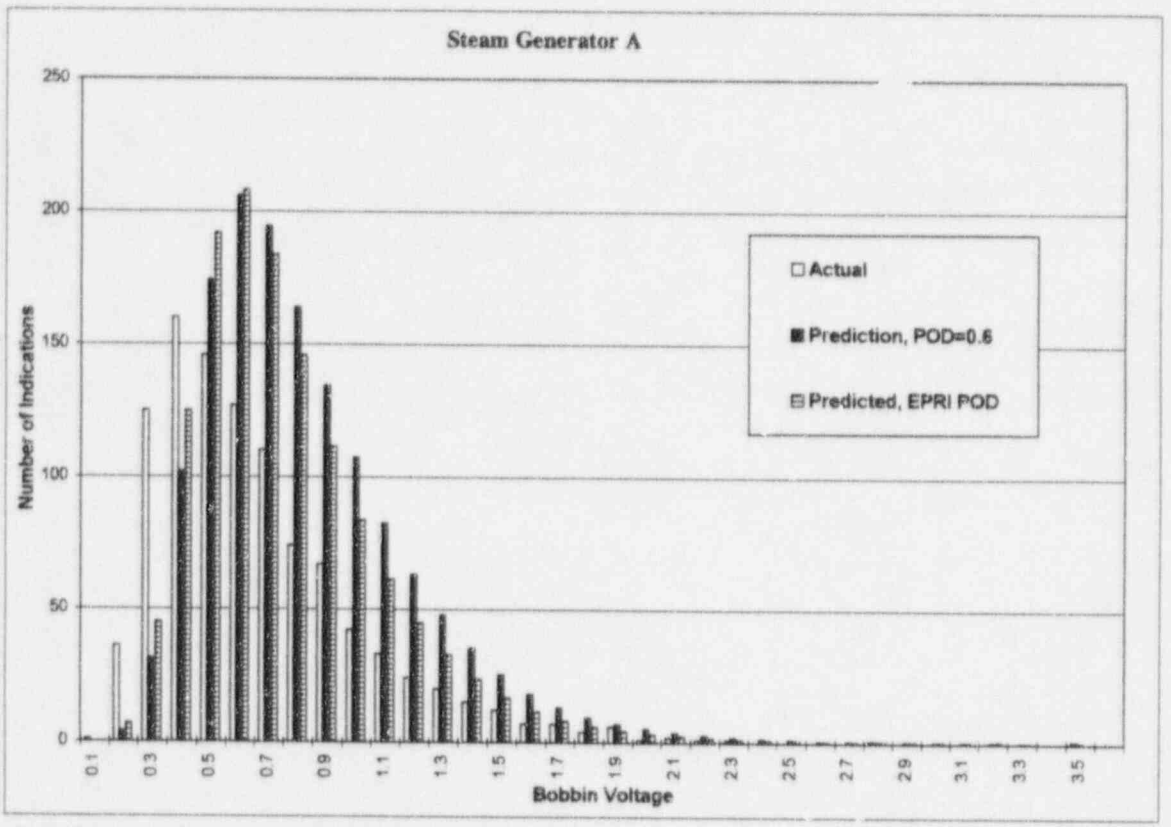
Figure 6 - 5
Byron Unit-1 April 1996
Projected Bobbin Voltage Distributions for Steam Generator D at EOC-8





BYREPORT XLS Fig6-5 8/9/96 10:18 AM

Figure 6-6
Byron Unit-1
Comparison of Predicted and Actual Bobbin Voltage Distributions for Cycle 7B
Combined Data for Hot and Cold Leg Indications



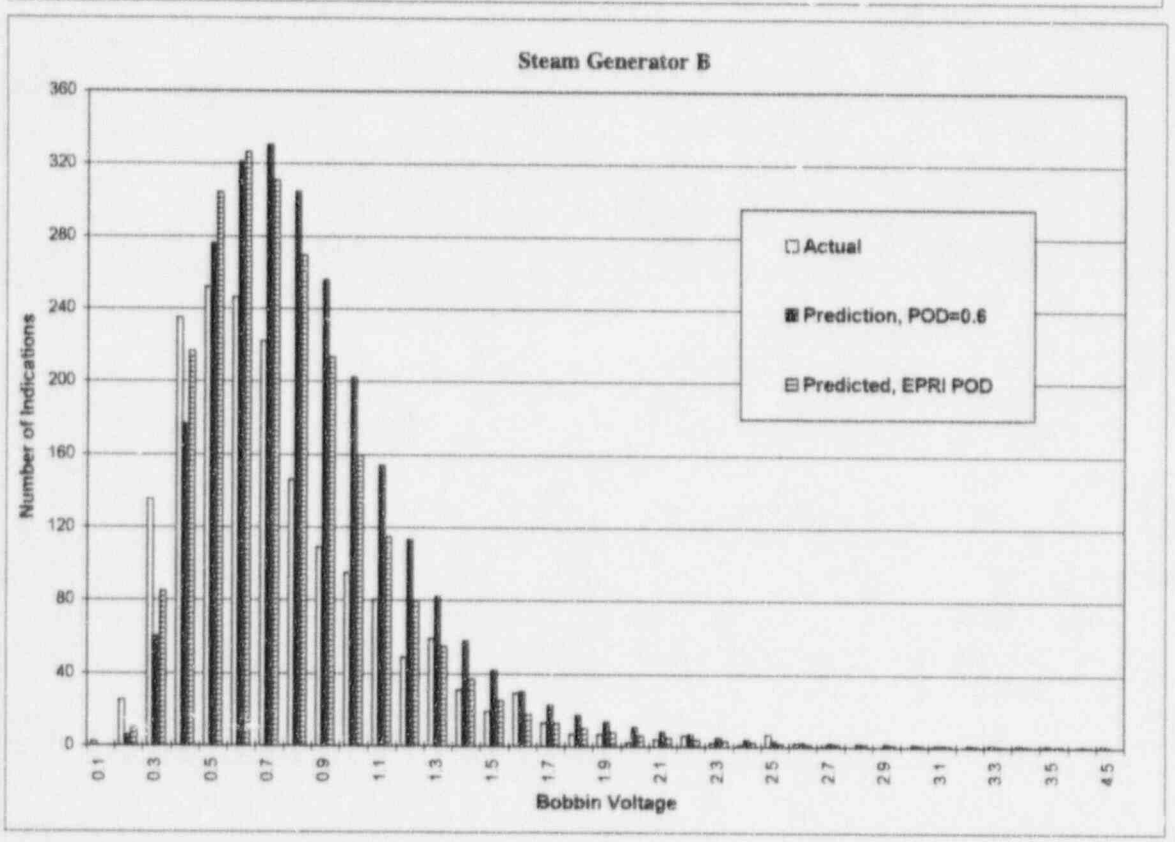
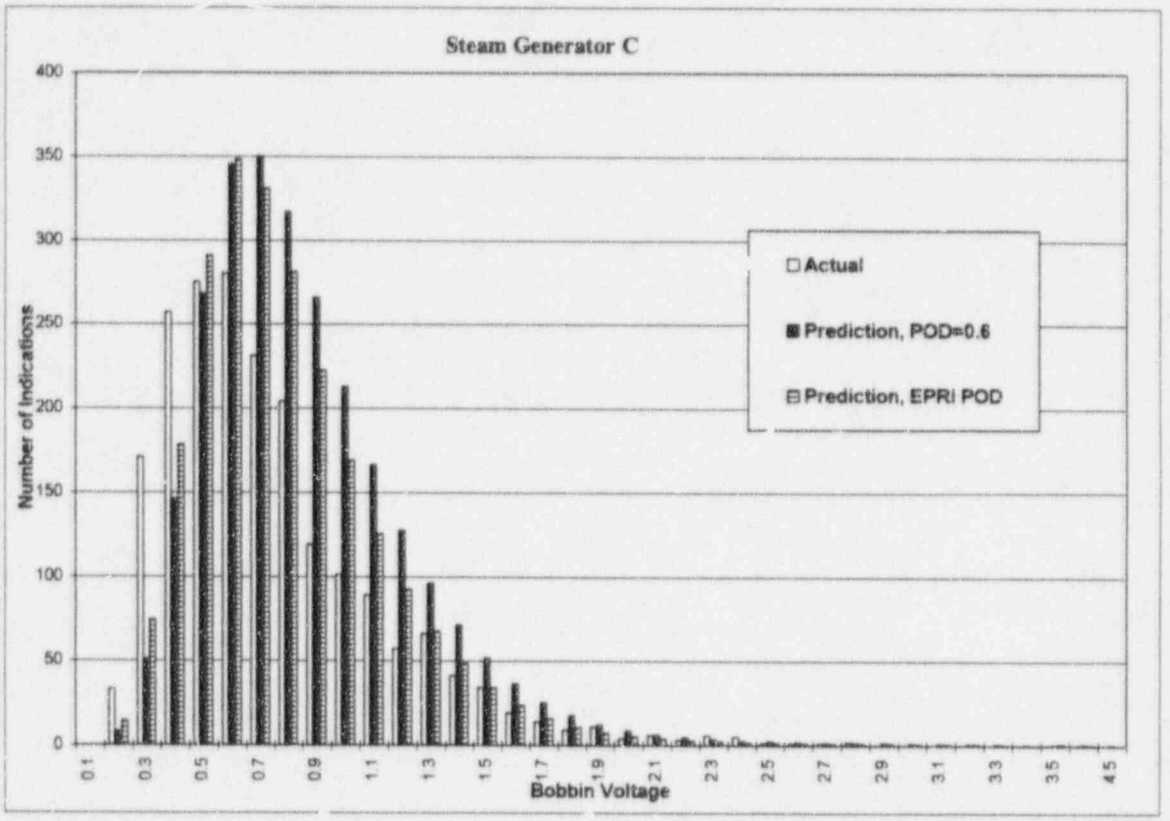


Figure 6-7
Byron Unit-1
Comparison of Predicted and Actual Bobbin Voltage Distributions for Cycle 7B
Combined Data for Hot and Cold Leg Indications



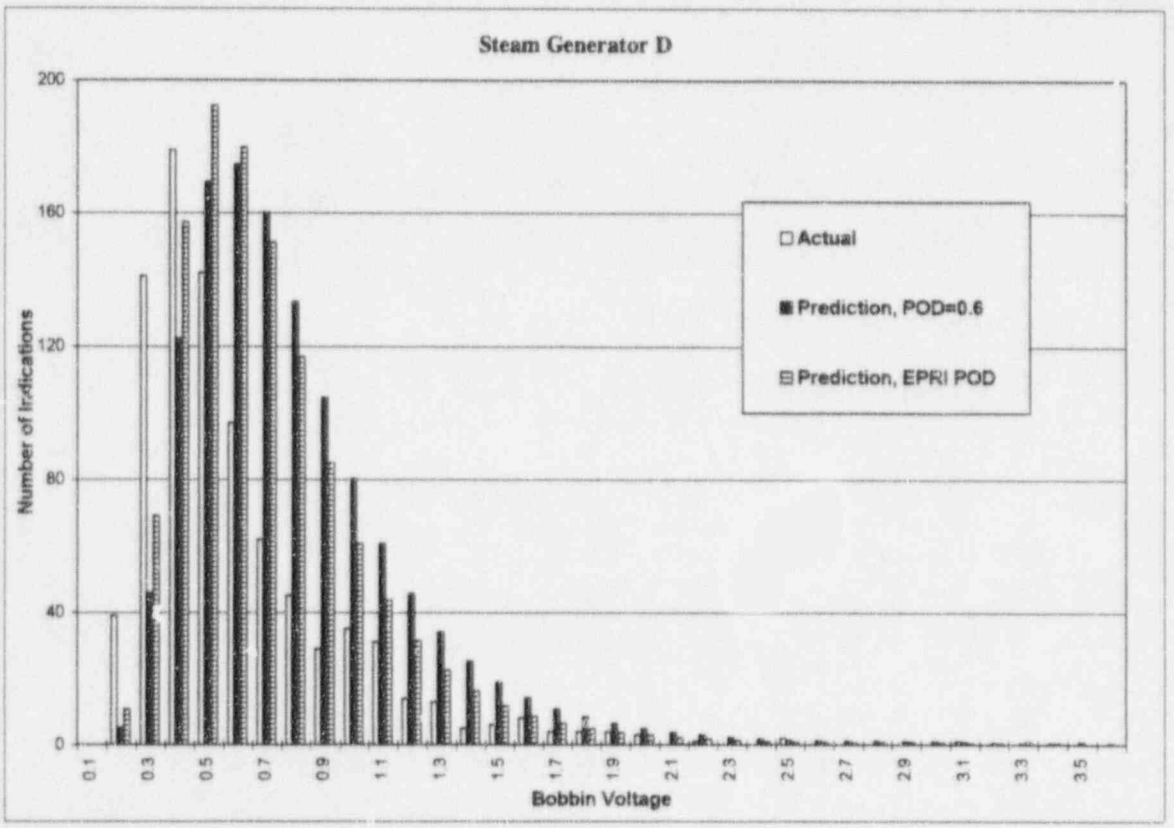


Figure 6-8
Byron Unit-1
Comparison of Worn Probe Voltage Against New Probe Voltage

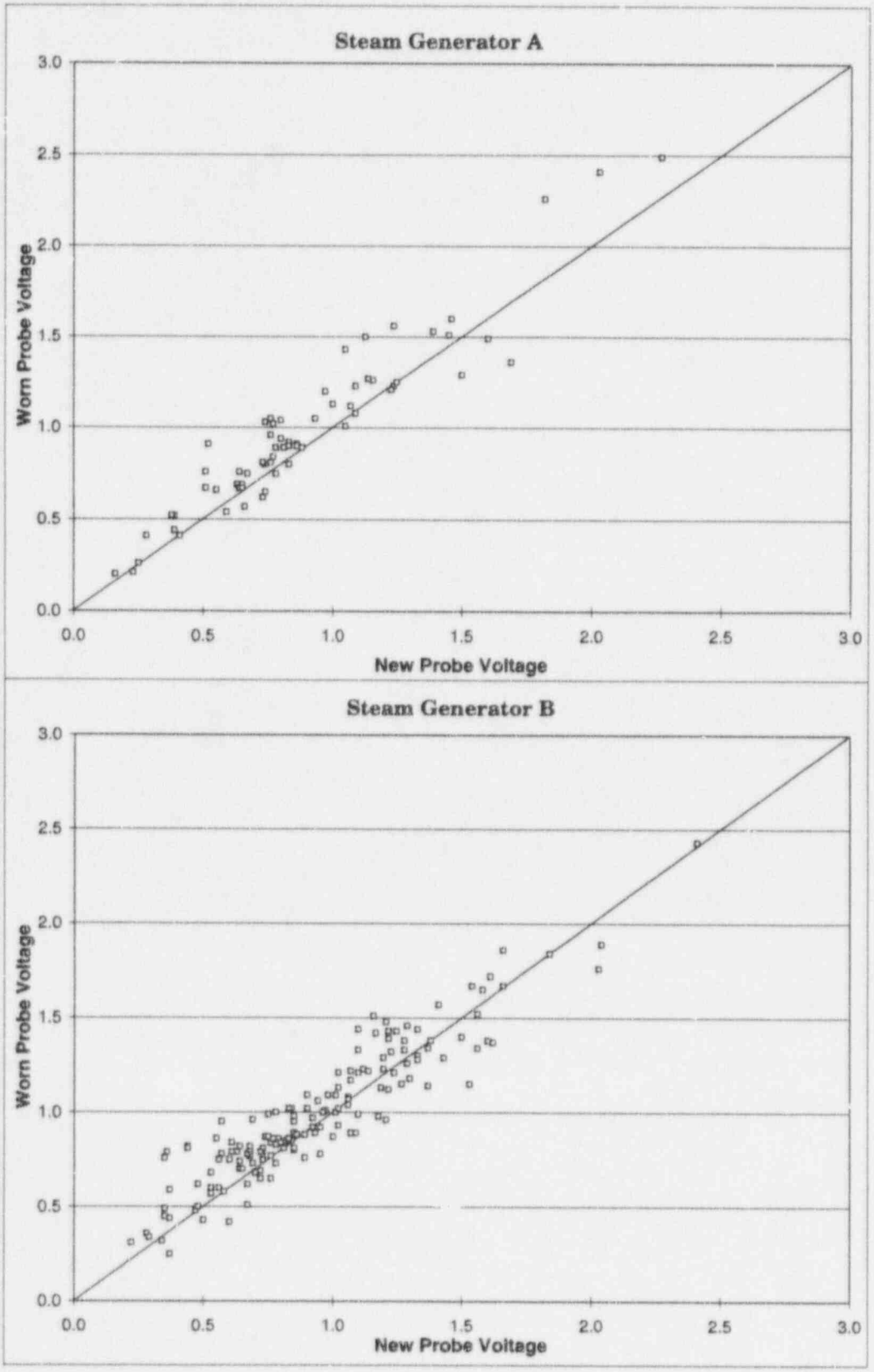
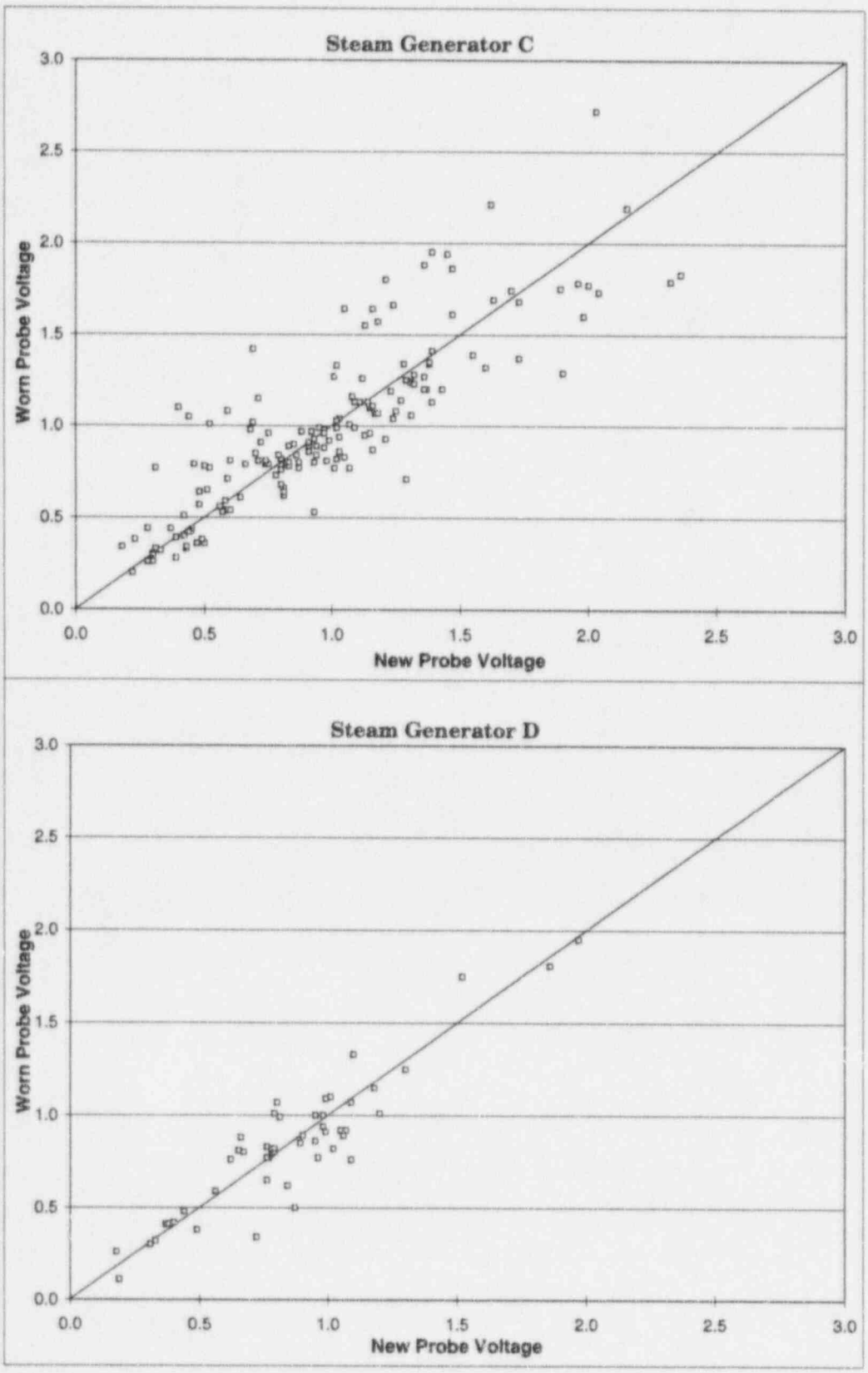
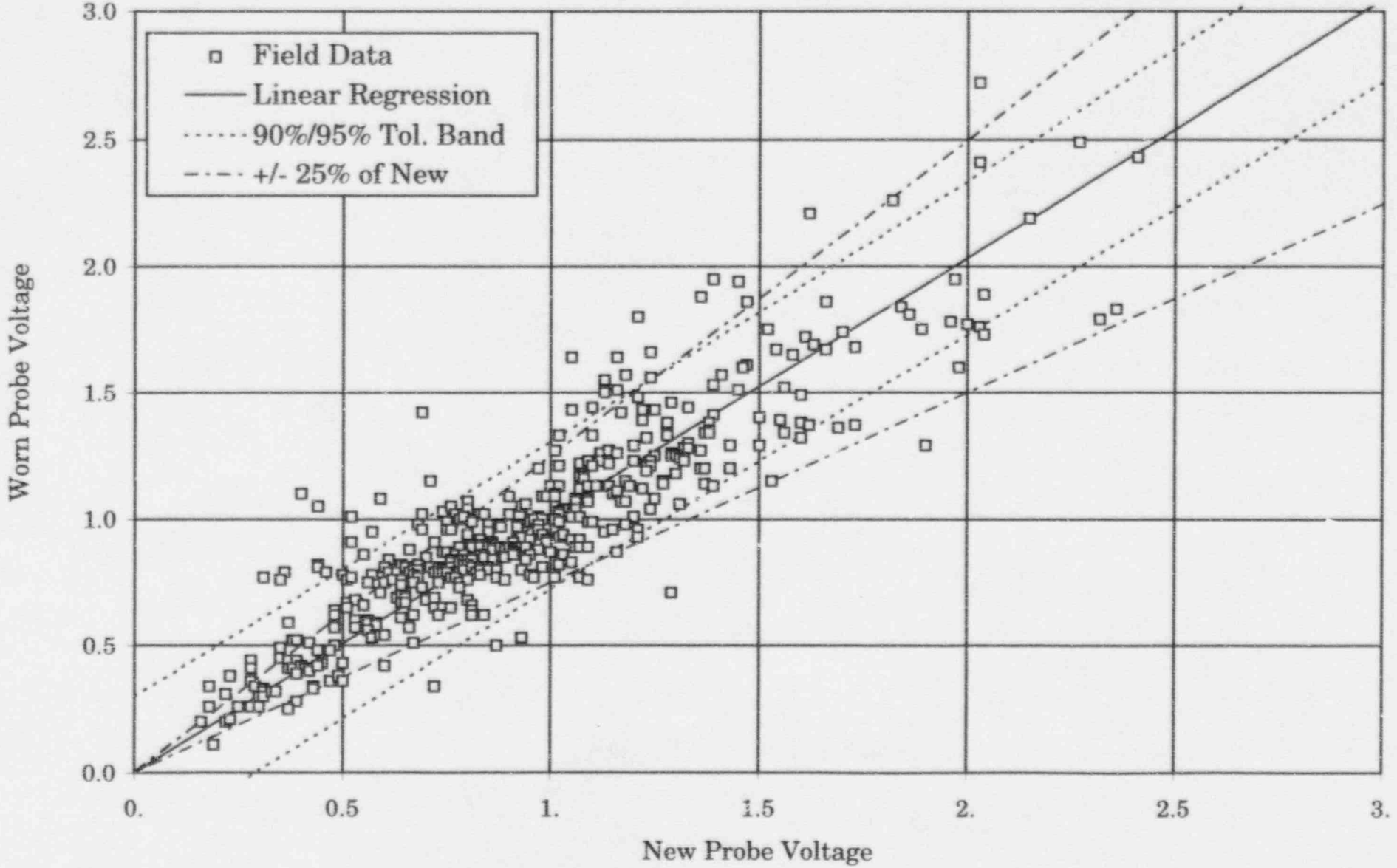


Figure 6-9
Byron Unit-1
Comparison of Worn Probe Voltage Against New Probe Voltage



PROBWEAR.XLS Fig6-9 4/24/96 2:20 PM

Figure 6-10
Byron Unit-1 April 1996
Worn Probe Volts vs New Probe Volts



[PROBWEAR.XLS] Fig6-10 8/24/96 2:22 PM

7.0 SLB Leak Rate and Tube Burst Probability Analyses

This section presents results of analyses carried out to predict leak rates and tube burst probabilities for postulated SLB conditions using the actual voltage distributions from EOC-7B inspection as well as for the projected EOC-8 voltage distributions. The methodology used in these analyses is described in Section 5.0. Since TSPs are locked by tube expansion (to support a 3 volt IPC), analyses were performed separately for the indication population on the hot leg and cold leg sides of each generator since only indications on the cold leg are to be considered for tube burst probability analysis. SG-C with the largest number of indications on the hot leg side is expected to yield the limiting SLB leak rate for Cycle 8, and SG B with the largest number of indications on the cold leg side is expected to be limiting from the tube burst probability standpoint.

7.1 Leak Rate and Tube Burst Probability for EOC-7B

Analyses to calculate EOC-7B SLB leak rate and tube burst probabilities were performed using the actual bobbin voltage distributions presented in Table 6-1 and these analyses were performed separately for hot leg and cold leg indications, as discussed above. Results of Monte Carlo calculations are summarized on Table 7-1.

A comparison of the EOC-7B actuals in Table 7-1 with the corresponding predictions performed during the EOC-7A inspection, shown here in Table 7-2, indicates the following.

a) For both POD of 0.6 and EPRI POD, SG-B was predicted to be the limiting steam generator for EOC-7B based on a voltage distribution projection performed during the EOC-7A inspection.

b) SG-B was confirmed to have the highest tube leak rate based on actual EC bobbin measurements for EOC-7B. As with the projections, tube burst probabilities based on the actual, measured voltages are below 4×10^{-6} for all SGs.

c) The leak rate and tube burst probability predictions for the projected EOC-7B indication population distribution, based on the EOC-7A inspection data, are conservative compared to the corresponding values calculated using actual measured bobbin measurements for EOC-7B for all SGs except SG B. Leak rate based on the actual measured voltage distribution for SG B is a negligible 0.02 gpm (0.09 gpm for EPRI POD) higher than its projected value, which is primarily due to the detection of just one indication at 4.5 volts that was not predicted.

d) The leak rate and tube burst probability predictions for all four SGs based EOC-7B bobbin measurements are well within the allowable limits.

In summary, with the exception of the negligible difference in the SLB leak rate for SG B, Monte Carlo analysis results based on the actual EOC-7B bobbin voltage distributions for all SGs are below the corresponding projections assuming a voltage distribution based on the NRC SER endorsed probability of detection of 0.6. Leak rate based on the actual measured voltage distribution for SG B is about 0.02 gpm higher than its projected value which is primarily due to the detection of just one indication at 4.5 volts that was not predicted. Limiting values for SLB leak rate (0.27 gpm) and tube burst probability ($< 4 \times 10^{-6}$) obtained using the actual measured voltages are more than two orders of magnitude below the allowable Cycle 7B SLB leakage limit of 35.7 gpm and the NRC reporting guideline of 10^{-2} for the tube burst probability.

7.2 Leak Rate and Tube Burst Probability for EOC-8

Calculations to predict the performance of the limiting steam generator in Byron Unit-1 at EOC-8 conditions were carried out using two values for POD: 1) NRC required constant value of 0.6, 2) voltage dependent EPRI POD distribution. The methodology used in these predictions is the same as previously described for EOC-7B. Results of the EOC-8 predictions are summarized on Table 7-3. With a constant POD of 0.6, the projected limiting EOC-8 SLB leak rate is 19.0 gpm and it is predicted for SG-C. Limiting tube burst probability, 9.4×10^{-4}, is predicted for SG B which has largest number of indications on the cold leg side. EPRI POD gives a slightly higher limiting burst probability, 1.2×10^{-3}, than POD=0.6. These limiting values are much lower than the allowable SLB leakage limit for Cycle 8 of 35.7 gpm and the NRC reporting guideline of 10^{-2} for the tube burst probability.

SLB leak rates and tube burst probabilities predicted for EOC-8 are substantially higher those for EOC-7B conditions due to the longer operating cycle and the EOC-7B growth rates used in the projections are believed to be conservative, as discussed in Section 3.2. The results based on the actual EOC-8 voltages are expected to be below these projections as was found for the EOC-7A condition (Reference 8.6).

Table 7-1

Byron Unit 1 1995 EOC- 7B Outage
Summary of Calculations of Tube Leak Rate and Burst Probability
Based on Actual Bobbin Voltage – 250k Simulations

Steam Generator		POD	Number of Indications	Max. Volts[1]	Burst Probability		SLB Leak Rate gpm
					1 Tube	2 Tubes	
EOC - 7B ACTUALS							
A	Hot Side	1	1014	3.9	Negligible[2]	Negligible[2]	0.06
	Cold Side	1	9	1.1	$< 4 \times 10^{-6}$	$< 4 \times 10^{-6}$	1×10^{-4}
	Combined	-	1023	3.9	$< 4 \times 10^{-6}$	$< 4 \times 10^{-6}$	0.06
B	Hot Side	1	1779	4.5	Negligible[2]	Negligible[2]	0.27
	Cold Side	1	12	1.2	$< 4 \times 10^{-6}$	$< 4 \times 10^{-6}$	1×10^{-4}
	Combined	-	1791	3.5	$< 4 \times 10^{-6}$	$< 4 \times 10^{-6}$	0.27
C	Hot Side	1	2035	3.5	Negligible[2]	Negligible[2]	0.13
	Cold Side	1	5	1.6	$< 4 \times 10^{-6}$	$< 4 \times 10^{-6}$	1×10^{-4}
	Combined	-	2040	3.2	$< 4 \times 10^{-6}$	$< 4 \times 10^{-6}$	0.13
D	Hot Side	1	859	3.5	Negligible[2]	Negligible[2]	0.04
	Cold Side	1	6	1.0	$< 4 \times 10^{-6}$	$< 4 \times 10^{-6}$	1×10^{-4}
	Combined	-	865	3.5	$< 4 \times 10^{-6}$	$< 4 \times 10^{-6}$	0.04

Notes:
1 Voltages include NDE uncertainties from Monte Carlo analyses and exceed measured voltages.
2 Below 10^{-10} (Reference 8.7)

Table 7-2
Byron Unit-1
Summary of Projected Tube Leak Rate and Burst Probability
for EOC-7B – 250k Simulations

Steam Generator		POD	No. of Indications[1]	Max. Volts[2]	Burst Probability		SLB Leak Rate gpm
					1 Tube	2 Tubes	
EOC - 7B PROJECTIONS BASED ON EOC-7A DATA [4]							
A	Hot Side	0.6	1436	3.9	Negligible[3]	Negligible[3]	0.11
	Cold Side	0.6	5	0.8	$< 4.0\times10^{-6}$	$< 4.0\times10^{-6}$	1×10^{-4}
	Total	0.6	1441	-	$< 4.0\times10^{-6}$	$< 4.0\times10^{-6}$	0.11
A	Hot Side	EPRI	1321	3.6	Negligible[3]	Negligible[3]	0.07
	Cold Side	EPRI	5	0.8	$< 4.0\times10^{-6}$	$< 4.0\times10^{-6}$	1×10^{-4}
	Total	EPRI	1326	-	$< 4.0\times10^{-6}$	$< 4.0\times10^{-6}$	0.07
B	Hot Side	0.6	2513	4.0	Negligible[3]	Negligible[3]	0.25
	Cold Side	0.6	4	1.5	$< 4.0\times10^{-6}$	$< 4.0\times10^{-6}$	1×10^{-4}
	Total	0.6	2517	-	$< 4.0\times10^{-6}$	$< 4.0\times10^{-6}$	0.25
B	Hot Side	EPRI	2285	3.9	Negligible[3]	Negligible[3]	0.16
	Cold Side	EPRI	3	1.4	$< 4.0\times10^{-6}$	$< 4.0\times10^{-6}$	1×10^{-4}
	Total	EPRI	2288	-	$< 4.0\times10^{-6}$	$< 4.0\times10^{-6}$	0.16
C	Hot Side	0.6	2606	3.9	Negligible[3]	Negligible[3]	0.21
	Cold Side	0.6	2	~ 1	$< 4.0\times10^{-6}$	$< 4.0\times10^{-6}$	1×10^{-4}
	Total	0.6	2608	-	$< 4.0\times10^{-6}$	$< 4.0\times10^{-6}$	0.21
C	Hot Side	EPRI	2360	3.8	Negligible[3]	Negligible[3]	0.14
	Cold Side	EPRI	2	~ 1	$< 4.0\times10^{-6}$	$< 4.0\times10^{-6}$	1×10^{-4}
	Total	EPRI	2362	-	$< 4.0\times10^{-6}$	$< 4.0\times10^{-6}$	0.14
D	Hot Side	0.6	1245	3.9	Negligible[3]	Negligible[3]	0.14
	Cold Side	0.6	1	~0.5	$< 4.0\times10^{-6}$	$< 4.0\times10^{-6}$	1×10^{-4}
	Total	0.6	1246	-	$< 4.0\times10^{-6}$	$< 4.0\times10^{-6}$	0.14
D	Hot Side	EPRI	1186	3.7	Negligible[3]	Negligible[3]	0.01
	Cold Side	EPRI	2	0.5	$< 4.0\times10^{-6}$	$< 4.0\times10^{-6}$	1×10^{-4}
	Total	EPRI	1188	-	$< 4.0\times10^{-6}$	$< 4.0\times10^{-6}$	0.01

Notes

(1) Number of indications adjusted for POD.

(2) Voltages include NDE uncertainties from Monte Carlo analyses and exceed measured voltages.

(3) Below 10^{-10} (Reference 8.7)

(4) Based on a projected cycle 7B length of 116.1 EFPD (Actual Cycle 7B duration is 87.7 EFPD)

Table 7-3
Byron Unit-1 April 1996 Outage
Summary of Projected Tube Leak Rate and Burst Probability
for EOC-8 - 250k Simulations

Steam Generator		POD	No. of Indications[1]	Max. Volts[2]	Burst Probability		SLB Leak Rate gpm
					1 Tube	2 Tubes	
EOC - 8 PROJECTIONS							
A	Hot Side	0.6	1618	11.1	Negligible[3]	Negligible[3]	9.7
	Cold Side	0.6	15	4.0	8.1×10^{-4}	$< 4.0\times10^{-6}$	0.05
	Total	0.6	1633	-	8.1×10^{-4}	$< 4.0\times10^{-6}$	9.8
A	Hot Side	EPRI	1612	11.1	Negligible[3]	Negligible[3]	9.2
	Cold Side	EPRI	19	4.3	8.5×10^{-4}	$< 4.0\times10^{-6}$	0.06
	Total	EPRI		-	8.5×10^{-4}	$< 4.0\times10^{-6}$	9.2
B	Hot Side	0.6	2866	11.5	Negligible[3]	Negligible[3]	17.0
	Cold Side	0.6	19	4.3	9.4×10^{-4}	$< 4.0\times10^{-6}$	0.07
	Total	0.6	2885	-	9.4×10^{-4}	$< 4.0\times10^{-6}$	17.1
B	Hot Side	EPRI	2671	11.3	Negligible[3]	Negligible[3]	14.8
	Cold Side	EPRI	24	4.4	1.2×10^{-3}	$< 4.0\times10^{-6}$	0.1
	Total	EPRI	2695	-	1.2×10^{-3}	$< 4.0\times10^{-6}$	14.9
C	Hot Side	0.6	3317	11.5	Negligible[3]	Negligible[3]	19.0
	Cold Side	0.6	7	3.8	5.8×10^{-4}	$< 4.0\times10^{-6}$	0.04
	Total	0.6	3324	-	5.8×10^{-4}	$< 4.0\times10^{-6}$	19.0
C	Hot Side	EPRI	3109	11.4	Negligible[3]	Negligible[3]	16.7
	Cold Side	EPRI	7	3.6	5.0×10^{-4}	$< 4.0\times10^{-6}$	0.03
	Total	EPRI	3116	-	5.0×10^{-4}	$< 4.0\times10^{-6}$	16.7
D	Hot Side	0.6	1382	11.0	Negligible[3]	Negligible[3]	8.3
	Cold Side	0.6	9	3.4	4.5×10^{-4}	$< 4.0\times10^{-6}$	0.02
	Total	0.6	1391	-	4.5×10^{-4}	$< 4.0\times10^{-6}$	8.3
D	Hot Side	EPRI	1452	10.9	Negligible[3]	Negligible[3]	8.2
	Cold Side	EPRI	15	3.9	7.1×10^{-4}	$< 4.0\times10^{-6}$	0.04
	Total	EPRI	1467	-	7.1×10^{-4}	$< 4.0\times10^{-6}$	8.3

Notes

(1) Number of indications adjusted for POD.

(2) Voltages include NDE uncertainties from Monte Carlo analyses and exceed measured voltages.

(3) Below 10^{-10} (Reference 8.7)

8.0 References

8.1 WCAP-14047, "Braidwood Unit 1 Technical Support for Cycle 5 Steam Generator Interim Plugging Criteria", Westinghouse Nuclear Service Division.

8.2 WCAP-14277, "SLB Leak Rate and Tube Burst Probability Analysis Methods for ODSCC at TSP Intersections", Westinghouse Nuclear Services Division, Jan.1995.

8.3 Westinghouse Report SG-95-01-003, "Byron Unit-1 End-of-Cycle 6 Interim Plugging Criteria Report," Westinghouse Nuclear Service Division, January 1995.

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

8.5 Westinghouse Report SG-96-03-001, "Byron Unit-1 End-of-Cycle 7A, Interim Plugging Criteria Report," Westinghouse Nuclear Service Division, March 1996.

8.6 Westinghouse Report SG-96-06-006, "Byron Unit-1, Interim Plugging Criteria Return to Power Report," Westinghouse Nuclear Service Division, June 1996.

8.7 WCAP-14273, "Technical Support for Alternate Plugging Criteria with Tube Expansion at Tube Support Plate Intersections for Braidwood-1 and Byron-1 Model D Steam Generators," Westinghouse Nuclear Service Division, February 1995.

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

8.9 Letter from N. J. Liparulo, Westinghouse Electric Corporation, to W. T. Russel, Office of Nuclear Reactor Regulation, Nuclear Regulatory Commission, CAW-96-935, dated February 28, 1996.