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Generic Letter 95-05

U S Nuclear Regulatory Commission
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PRAIRIE ISLAND NUCLEAR GENERATING PLANT
Docket Nos. 50-282 License Nos. DPR-42

Unit 1, Cycle 21 Steam Generator Tube Support Plate Voltage Based Repair Criteria 90-Day Report

During the Unit 1 May 2001 Refueling Outage following operating cycle 20, the Voltage Based Repair Criteria for ODSCC at Tube Support Plates (TSPs) was used in accordance with the requirements of NRC Generic Letter (GL) 95-05 and the Safety Evaluation by the Office of Nuclear Reactor Regulation related to Amendment Nos. 133 and 125 to Facility Operating License Nos. DPR-42 and DPR-60 for the Prairie Island Nuclear Generating Plant, dated November 18, 1997, "Voltage-Based Repair Criteria for Westinghouse Steam Generator Tubes Affected by Outside Diameter Stress Corrosion Cracking." This SG tube repair criteria allows bobbin coil indications of less than 2 Volts at TSPs to remain in service provided the total leakage under postulated Main Steam Line Break (MSLB) conditions is less than 1.0 gpm at room temperature and provided the End of Cycle (EOC) conditional probability of burst is less than 1×10^{-2}.

Under the conditions of the GL 95-05 industry tube pull program approved by the NRC in 2000, a tube pull was not required for this inspection.

During the end of cycle 19 inspection, two tubes were pulled per GL 95-05 for the first use of the voltage based repair criteria on Prairie Island Unit 1. One of the TSP intersections contained a volumetric indication. Metallurgical examination of this intersection identified an area of true volumetric wastage separate from areas of intergranular attack. Since this mixed mode degradation is not explicitly evaluated in GL 95-05, Prairie Island assures compliance by examining all of the bobbin coil distorted TSP indications (DSI's), regardless of voltage, with a rotating coil probe. The intersections with volumetric indications are conservatively included in the leakage and burst calculations.

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Since it is not certain that the volumetric eddy current indications at TSPs meet the requirements of Technical Specification 4.12.D.4.a, volumetric indications at TSPs not associated with qualified sizing techniques are plugged. There were 4 tubes plugged during this inspection due to volumetric indications found during the rotating coil examination of all DSI's at TSPs.

The maximum voltage DSIs were 1.80 Volts in the 11 SG and 1.27 Volts in the 12 SG. The combined population average voltage growth rate for cycle 20 was -0.003 Volts per EFPY.

The calculated leak rates under Main Steam Line Break conditions for the actual end of cycle 20 conditions are 0.18 gpm and 0.07 gpm for 11 and 12 steam generators, respectively. These rates are less than the allowable leak rate of 1 gpm and less than the predicted leak rates for end of cycle 20. All leak rates are at room temperature.

The calculated conditional probabilities of burst under MSLB conditions for the actual end of cycle 20 conditions are $1.9X10^{-5}$ and $<1.2X10^{-5}$ for 11 and 12 steam generators, respectively. These values are less than the allowable value of $1X10^{-2}$ and less than the predicted values for end of cycle 20.

The predicted leak rates for end of cycle 21 under Main Steam Line Break conditions are 0.42 gpm and 0.19 gpm for 11 and 12 steam generators, respectively. These rates are less than the allowable leak rate of 1 gpm. All leak rates are at room temperature.

The predicted conditional probabilities of burst for end of cycle 21 under MSLB conditions are $3.7X10^{-5}$ and $2.5X10^{-5}$ for 11 and 12 steam generators, respectively. These values are less than the allowable value of $1X10^{-2}$.

The analyses performed used the latest database, Addendum 3 to EPRI Report NP-7480-L, May 1999.

During the outage, none of the conditions of Technical Specification 4.12.E.5 (section 6.a of GL 95-05) arose which require notification of the NRC staff prior to returning the steam generators to service. That is:

a. The projected end-of-cycle leakage did not exceed the 1 gpm limit,
b. no circumferential crack-like indications were detected at the TSP intersections,
c. no indications extended beyond the confines of the TSP intersections,
d. no indications at the TSP elevations were attributable to primary water stress corrosion cracking,
e. the calculated conditional burst probability did not exceed $1X10^{-2}$.

The Upper Repair Limit of 4.96 Volts used a cycle length of 575 EFPD, a growth rate of 30% per EFPY and an NDE measurement uncertainty of 20%.

The attached Westinghouse Report SG-01-05-001, dated May 2001, provides the third 90-day report for implementation of the voltage based repair criteria at Prairie Island Unit 1. This report fulfills the requirements of Section 6.b of Attachment 1 to Generic Letter 95-05.

In this letter we have made no new Nuclear Regulatory Commission commitments. Please contact Richard Pearson (651-388-1121) if you have any questions related to this letter.

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Senior Resident Inspector, NRC
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Attachments:
1. Westinghouse Report SG-01-05-001, "Prairie Island Unit 1 Cycle 21 Voltage-Based Repair Criteria 90-Day Report."

SG-01-05-001

PRAIRIE ISLAND UNIT-1

CYCLE 21 VOLTAGE-BASED REPAIR CRITERIA 90-DAY REPORT

May 2001

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P.O. Box 158
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SG-01-05-001

PRAIRIE ISLAND UNIT-1

CYCLE 21 VOLTAGE-BASED REPAIR CRITERIA 90-DAY REPORT

May 2001

PRAIRIE ISLAND UNIT-1

CYCLE 10 VOLTAGE-BASED REPAIR CRITERIA

90-DAY REPORT

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90-DAY REPORT

1.0 INTRODUCTION

This report provides the Prairie Island Unit-1 steam generator (SG) 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 application of the 2.0-volt repair criteria for TSP indications during Cycle 21 as outlined in the NRC Generic Letter 95-05 (Reference 8-1). The plant has operated for two cycles with this repair criteria. Information required by GL 95-05 is provided in this report including projections of bobbin voltage distributions, leak rates and burst probabilities at the end of the ongoing cycle (EOC-21). The methodology used in these evaluations is described in Reference 8-2 and is consistent with the NRC SER for 2-volt repair criteria (Reference 8-3) as well as the methodology used in the last two 90-day reports (References 8-4 and 8-5).

The application of the 2-volt repair criteria for outside diameter stress corrosion cracking (ODSCC) indications at TSPs in the Prairie Island Unit-1 SGs involves a complete, 100% Eddy Current (EC) bobbin coil inspection of all TSP intersections in the tube bundles of both SGs and plugging of tubes with TSP indications greater than 2 volts that are confirmed by a Rotating Pancake Coil (RPC) probe. In the EOC-20 inspection, all TSP intersections with a Distorted Signal Indication (DSI) were RPC inspected due to the possibility of wastage in combination with ODSCC indications. The Prairie Island Unit-1 EC inspection plan also calls for RPC testing of TSP locations with the following types of bobbin signals: all dents $\geq$ 5.0 volts, mixed residual indications (MRIs) $\geq$ 2 volts, copper deposit (CUD) signals $\geq$ 1 volt, scale deposit (DEP) signals $\geq$ 2 volts, indications not reportable (INRs) $\geq$ 1.5 volts, cold leg thinning $\geq$ 40% through wall, and cold leg thinning $<$ 40% through and $\geq$ 1.5 volts. No MRI, DEP or CUD bobbin signals were detected during the EOC-20 inspection.

Eddy current and repair data for TSP indications from the EOC-20 inspection are provided in Section 3. The actual EOC-20 voltage distributions as well as the leak rates and tube burst probabilities calculated for these distributions are compared with the projections for the EOC-20 conditions performed after the last (EOC-19) outage. Leak rates and burst probabilities projected for the end of the current cycle (EOC-21) are reported in Section 7 and compared with the allowable limits.

2.0 SUMMARY AND CONCLUSIONS

SLB leak rate and tube burst probability analyses were performed for both SGs based on their actual measured EOC-20 voltage distributions and the results compared with the projections performed after the last (EOC-19) outage. The total number of indications found at TSPs in each SG during the current inspection and the measured peak voltages are less than those projected using a constant POD of 0.6 per the Generic Letter 95-05 requirements. Also, the SLB leak rates and tube burst probabilities calculated using the actual measured voltages are equal to or below the projected values. The EOC-20 projections based on the voltage-dependent POD POPCD also envelope the results for the actual voltages.

For the actual EOC-20 bobbin voltage distribution, the largest SLB leak rate is calculated for SG-11, which had the larger number of indications among the 2 SGs as well as the largest indication detected in this inspection. This leak rate is based on the same leak and burst database used for its projections (Addendum-2 database, Reference 8-6) is 0.18 gpm and is 0.17 gpm based on the more recent Addendum-3 (Reference 8-7) database. These leak rate values are volumetric rates at room temperature. They are less than 1/5th of the current allowable SLB leakage limit (1 gpm at room temperature) and are also below their projected values. The largest conditional tube burst probability based on the measured voltage data is also calculated for SG-11. Its magnitude is 1.9×10^{-5}, which is more than 2 orders of magnitude below the NRC reporting guideline of 10^{-2}. Thus, the results meet the voltage-based repair criteria requirements for continued Cycle 21 operation.

A total of 501 indications were found in the EOC-20 inspection, and the largest indication detected had 1.8 volts. A total of nine indications were found on the cold leg side in both SGs combined, and they all had a bobbin voltage below 1 volt. About 57% of the combined indication population for the 2 SGs is under 0.5 volts, which explains the low values of SLB leak rates and tube burst probabilities calculated using the measured EOC-20 voltages. All TSP indications were RPC inspected and a total of only 11 indications from both SGs were confirmed. Six of the RPC confirmed indications are single axial indications (SAIs), one is a multiple axial indication (MAI) and the remaining four are single volumetric indications (SVIs). All four tubes with SVIs were repaired. The RPC inspection did not find any axial indication extending outside a TSP intersection.

An augmented RPC inspection was also performed consistent with the GL 95-05 requirements. All TSP intersections with a dent over 5 volts were RPC inspected in this outage; no PWSCC axial or circumferential cracks were detected. The augmented RPC inspection plan also called for inspection of all MRIs ≥2 volts, DEP signals ≥2 volts and CUD signals ≥1 volt. No bobbin signals indicating MRIs, DEPs

or CUDs were detected during this inspection.

Of the 501 indications detected, 48 were new indications and the beginning of cycle voltages were not available for the new indications. Therefore, growth rate statistics for Cycle 20 were established using the data for the 453 indications detected in both EOC-19 and EOC-20 inspections. Both SGs show a small negative value for the average Cycle 20 growth just as in the Cycle 19 indicating that ODSCC indications in Prairie Island Unit-1 grow only modestly and their growth magnitudes are comparable to NDE uncertainities.

SG-11 is projected to have a larger number of indications between the two SGs as well as the largest indication at EOC-21 conditions. The EOC-21 leak rate projection was performed using a leak rate versus bobbin voltage correlation meeting the Generic Letter 95-05 requirement. Using the NRC mandated constant POD of 0.6 and the latest leak and burst database for 7/8" tubes (Addendum-3 database), the limiting EOC-21 SLB leak rate projected for SG-11 is 0.42 gpm, which is less than one-half of the current licensed limit of 1 gpm. All leak rate values quoted are equivalent volumetric rates at room temperature. The limiting EOC-21 tube burst probability, 3.7×10^{-5}, is also calculated for SG-11, and it is more than two orders of magnitude below the NRC reporting guideline of 10^{-2}. Thus, the GL 95-05 requirements for continued implementation of the 2-volt repair criteria during Cycle 21 are met.

3.0 EOC-20 INSPECTION RESULTS AND VOLTAGE GROWTH RATES

3.1 EOC-20 INSPECTION RESULTS

In accordance with the guidance provided by the NRC Generic Letter 95-05 (Reference 8-1) for application of voltage-based repair criteria, the EOC-20 inspection of the Prairie Island Unit-1 SGs consisted of a complete, 100% EC bobbin probe, full length examination of the tube bundles in both SGs. A 0.720 inch diameter probe was used to inspect all hot and cold leg TSP intersections where the 2-volt repair criterion was applied.

Eddy current data for both steam generators were from the plant site via e-mail, References 8-8 through 8-10, which were analyzed to develop the database applicable to the voltage based repair criteria. The results of these analyses are summarized in Table 3-1 and are discussed below.

All indications detected during the present inspection were under the 2-volt repair limit, and only a total of 14 indications exceeded 1 volt. A total of nine TSP indications was detected on the cold leg side in both SGs combined, and they all were under 1.0 bobbin volt. Nearly 57% of the combined indication population for the two SGs were under 0.5 volts, and therefore SLB leak rates and tube burst probabilities based on these voltages are expected to be small. All TSP indications detected were RPC inspected and a total of 11 indications were confirmed. Six of the RPC confirmed indications were SAIs, one was a MAI and the remaining four were SVIs. All four tubes with SVIs were repaired. The RPC inspection did not find any axial indication extending outside a TSP intersection.

An augmented RPC inspection was performed consistent with the GL 95-05 requirements. All TSP intersections that had dents ≥ 5 volts were RPC inspected in this inspection; no PWSCC axial or circumferential cracks were detected. The Prairie Island Unit-1 EC inspection plan for TSP intersections also includes RPC testing of MRIs ≥ 2 volts CUDs ≥1 volt, DEPs ≥2 volts, INRs ≥1.5 volts, cold leg thinning ≥40% through wall, and cold leg thinning <40% through and ≥1.5 volts. No MRI, DEP or CUD bobbin signals were detected during the EOC-20 inspection.

A summary of eddy current signal voltage distributions for all steam generators is shown on Table 3-1, which tabulates the number of field bobbin indications, the number of these field bobbin 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 21 operation is the difference between the observed and the ones removed from service. Only a total of 8 indications were taken out of service due to tube repairs in both SGs combined. Of

these 8 indications, four SVIs, two in each SG, are the only indications repaired because of potential ODSCC concerns, and the other 4 indications were in tubes repaired for reasons other than TSP indications. Figure 3-1 shows the actual bobbin voltage distribution for tubes that were in service during Cycle 20, as determined from the EOC-20 EC inspection. Since only 8 (out of 501) indications were taken out of service due to tube repairs, the bobbin voltage distribution of indications returned to service at BOC-20 is essentially the same as the actual bobbin voltage distribution shown in Figure 3-1. A review of Table 3-1 indicates that more indications (a quantity of 335, with 10 indications above 1.0 volt) were returned to service for Cycle 21 operation in SG-11 than in SG-12. Therefore, SG-11 is likely to be the limiting SG at EOC-21. The bobbin voltage distributions for indications returned to service for Cycle 21 are very similar those for the last cycle.

The distribution of EOC-20 indications as a function of support plate elevation, summarized in Table 3-2 and illustrated on Figure 3-2, shows the predisposition of ODSCC to occur in the first few hot leg TSPs (422 of the 501 PIs, or about 84%, occurred in the first three hot leg TSPs), although the mechanism does extend to higher TSPs. Only a total of 9 TSP bobbin indication were reported on the cold leg side in both SGs combined. The occurrence of a majority of ODSCC indications in the first few TSPs on the hot leg side in Prairie Island Unit-1 shows predominant dependency on temperature, which is consistent with that observed at other plants.

3.2 Voltage Growth Rates

For projection of leak rates and tube burst probabilities at EOC-21 condition, voltage growth rates were developed from EOC-20 and EOC-19 inspection data. Of the 501 indications detected, 48 are new indications and beginning of cycle voltage was not available for new indications. Therefore, the growth rate statistics for Cycle 20 were established using only the data for the 453 indications detected in both EOC-19 and EOC-20 inspections.

Table 3-3 summarizes growth data for Cycle 20. The average Cycle 20 voltage growth rates for both SGs have a small negative value indicating that the magnitude of growth during Cycle 20 was small and comparable to NDE uncertainties. Indications with a BOC bobbin voltage above 0.75 volts show a negative growth while those below 0.75 BOC volts show a small positive growth in both SGs, which, although unusual, is not meaningful because of the small growth magnitude. The same trend was noted in the last cycle growth data also.

Table 3-4 provides a comparison of average growth data for the last 4 operating cycles for Prairie Island Unit-1, and the data show that TSP indications in both SGs had only a modest growth during the last 4 cycles. The average growth rates were below

3%/EFPY in all 4 cycles. Table 3-5 shows the cumulative probability distribution function (CPDF) of growth rate per EFPY for each steam generator during Cycle 20. The growth CPDF data are also plotted in Figure 3-3. The curve labelled 'cumulative' in Figure 3-3 represents averaged composite growth data from both SGs. The average growth rate distribution for Cycle 20 is compared with that for the last cycle (Cycle 19) in Figure 3-4. The growth data are presented on an EFPY basis to account for the difference in the length of the two operating periods. It is evident from Figure 3-4 that Cycle 19 growth distribution is slightly more limiting than the Cycle 20 growth distribution. The NRC guidelines require that the more conservative growth distribution for the last two operating periods be applied for projecting the next cycle voltage distributions. Therefore, Cycle 19 growth data will be applied to obtain the EOC-21 projections.

According to the Westinghouse tube integrity analysis methodology presented in Reference 8-2, 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 above, Cycle 19 growth rates should be used to perform the EOC-21 projections as they are higher than the Cycle 20 growth rates. Since the Cycle 19 growth rates for SG-11 are below the composite growth rate (see Table 3-3), the composite growth rate is applied to SG-11 to provide a conservative basis for predicting EOC-21 conditions. Cycle 19 growth rates for SG-12 are slightly higher than the composite growth rate; however, SG-12 growth distribution is based on fewer indications than the minimum number (200) required by GL 95-05. Nevertheless, EOC-21 predictions for SG-12 were obtained using its own growth rate since it is higher than the composite rate.

In the past, some plants with 3/4" tube SGs experienced growth rates that are dependent on the BOC voltage. To determine if Prairie Island Unit-1 exhibited a similar trend during Cycle 20, growth rate data for Cycle 20 were plotted against BOC voltage, and the resulting plot is shown in Figure 3-5. It is evident that the Cycle 20 growth decreases with increasing BOC voltage. The indications with the top 5 growths had a BOC voltage under about 0.4 volts. Thus, it is conservative to assume growth is independent of BOC voltage.

Table 3-6 lists the top 30 indications from the standpoint of growth during Cycle 20. This data shows more clearly that there was only a modest growth during Cycle 20 since all but one of these 30 indications had growth under 0.5 volts. Only one of these 30 indications was confirmed during the RPC inspection.

3.3 Probe Wear Criteria

An alternate probe wear criterion discussed in Reference 8-11 was applied during

the EOC-20 inspection. This criterion was also applied during the last inspection for Prairie Island Unit-1. When a probe does not pass the 15% wear limit, this alternate criterion requires that all tubes with indications detected above 75% of the repair limit since the last successful probe wear check be reinspected with a good probe. Accordingly, only tubes containing indications for which the worn probe voltage is above 1.5 volts need to be inspected with a new probe.

During the EOC-20 inspection, only one tube had an indication greater than the 1.5 volts (voltage needed to trigger a retest condition for worn probes) and the probe passed wear check subsequent to the inspection of that indication. Therefore, no tubes had to be retested because of probe wear. The alternate probe wear criteria used in the EOC-20 inspection is consistent with the NRC guidance provided in Reference 8-11.

3.4 Assessment of RPC Confirmation Rates

Generic Letter 95-05, upon NRC approval, allows inclusion of only a fraction of indications for which RPC detected no degradation (NDD) in performing the Monte Carlo analyses for leak rate and tube burst probability. The fractional value appropriate for a voltage-based repair criteria evaluation is the largest RPC confirmation rate for prior cycle RPC NDD indications from the last two outages. This section tracks the 1999 EOC-19 indications left in service at BOC-20 relative to RPC inspection results in 2001 at EOC-20. The composite results for both SGs are given in Table 3-7. For the 1999 bobbin indications left in service, the indications are tracked relative to 1999 RPC confirmed, 1999 RPC NDD, 1999 bobbin indications not RPC inspected and 1999 bobbin indications with no indication found in 2001. Also included are new 2001 indications. The table shows, for each category of indications, the number of indications RPC inspected and RPC confirmed in 2001 as well as the percentage of RPC confirmed indications. Forty-eight (48) new indications were detected during the EOC-20 inspection, and only three of them was confirmed by RPC. Six prior cycle (EOC-19) indications were called NDD by bobbin in the present inspection.

All RPC NDD indications left in service at BOC- 20 were RPC tested at EOC-20 and a total of nine were confirmed. Therefore, EOC-20 RPC confirmation rate for prior cycle RPC NDD indications is only 1.8%. Since all indications left in service at the beginning of the current cycle are RPC NDDs, this RPC confirmation rate data suggest that only a small fraction of BOC-20 indications need to be considered in the tube integrity evaluations for the EOC-21 condition. However, since NRC approval for using a fraction of RPC NDD indications in tube integrity evaluations has not been obtained, all indications left in service were included in the EOC-21 tube integrity evaluation reported here.

3.5 Probability of Prior Cycle Detection

The inspection results at EOC-20 permit an evaluation of the probability of detection (POD) at the prior EOC-19 inspection. This evaluation provides data to support a voltage-dependent POD distribution. 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-19 inspection can then be defined as follows.

$$\text{POPCD (EOC-19)} = \frac{\text{EOC-19 cycle reported indications confirmed by RPC in EOC-20 inspection} + \text{Indications confirmed and repaired in EOC-19 inspection}}{\{\text{Terms in the Numerator}\} + \text{New indications RPC confirmed in EOC-20 inspection}}$$

POPCD is evaluated at the 1999 EOC-19 voltage values since it is an EOC-19 POPCD assessment. The indications at EOC-19 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-20. 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-20 indications not reported in the EOC-19 inspection. The new indications include EOC-19 indications present at detectable levels but not reported, indications present at EOC-19 below detectable levels and indications that initiated during Cycle 20. 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.

As shown in Table 3-7 there were 48 new indications in the EOC-20 inspection, and only three of them were confirmed by RPC. (All new indications were RPC inspected in this inspection.). So, on the basis of RPC inspection there are only three new indications in the EOC-20 inspection. With the exception of these three new indications, the above definition of POPCD yields 100% detection, i.e., POPCD value

is unity at all voltages except in the voltage range containing the three RPC confirmed new indications (0 to 0.2 volts). Since 490 out of 501 indications RPC tested are NDDs, there are only 11 indications available to perform the POPCD evaluation. Because of the small population size, the present POPCD for Prairie Island Unit-1 should not be included in the EPRI POPCD database.

3.6 NDE Uncertainties

The NDE uncertainties applied for the EOC-20 voltage projections in this report are same as those used in the last two tube integrity evaluations for Prairie Island Unit-1 (References 8-4 and 8-5). The probe wear uncertainty has a standard deviation of 7% about a mean of zero and has a cutoff at 15% based on the 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 presented in Table 3-8 as well as graphically illustrated in Figure 3-6. The NDE uncertainty distributions are included in the Monte Carlo analyses used to project the EOC-21 voltage distributions.

Table 3-1
Prairie Island Unit-1 February 01 Outage
Summary of Inspection and Repair For Tubes in Service During Cycle 20

Voltage Bin	Steam Generator 11						Steam Generator 12					
	In-Service During Cycle 20				RTS for Cycle 21		In-Service During Cycle 20				RTS for Cycle 21	
	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
0.2	19	19	0	0	19	0	9	9	0	1	8	0
0.3	38	38	1	0	38	1	23	23	1	0	23	1
0.4	67	67	0	0	67	0	31	31	2	1	30	1
0.5	69	69	1	0	69	1	29	29	1	1	28	1
0.6	51	51	1	3	48	0	31	31	0	0	31	0
0.7	46	46	2	0	46	2	15	15	1	1	14	0
0.8	28	28	1	1	27	0	11	11	0	0	11	0
0.9	8	8	0	0	8	0	8	8	0	0	8	0
1	3	3	0	0	3	0	1	1	0	0	1	0
1.1	4	4	0	0	4	0	1	1	0	0	1	0
1.2	3	3	0	0	3	0	2	2	0	0	2	0
1.3	1	1	0	0	1	0	1	1	0	0	1	0
1.4	1	1	0	0	1	0	0	0	0	0	0	0
1.8	1	1	0	0	1	0	0	0	0	0	0	0
Total	339	339	6	4	335	4	162	162	5	4	158	3
>1v	10	10	0	0	10	0	4	4	0	0	4	0

Voltage Bin	Composite of All SGs					
	In-Service During Cycle 20				RTS for Cycle 21	
	Field Bobbin Indications	RPC Inspected	RPC Confirmed	Indications Repaired	All Indications	RPC Confirmed Indications Only
0.2	28	28	0	1	27	0
0.3	61	61	2	0	61	2
0.4	98	98	2	1	97	1
0.5	98	98	2	1	97	2
0.6	82	82	1	3	79	0
0.7	61	61	3	1	60	2
0.8	39	39	1	1	38	0
0.9	16	16	0	0	16	0
1	4	4	0	0	4	0
1.1	5	5	0	0	5	0
1.2	5	5	0	0	5	0
1.3	2	2	0	0	2	0
1.4	1	1	0	0	1	0
1.8	1	1	0	0	1	0
Total	501	501	11	8	493	7
>1v	14	14	0	0	14	0

Table 3-2
Prairie Island Unit-1 February 2001
TSP ODSCC Indication Distributions for Tubes in Service During Cycle 20

Tube Support Plate	Steam Generator 11					Steam Generator 12					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	Number of Indications	Maximum Voltage	Average Voltage	Largest Growth	Average Growth
01H	108	1.40	0.46	0.35	-0.01	59	1.16	0.51	0.61	0.00	167	1.40	0.48	0.61	-0.01
02H	124	1.80	0.53	0.44	0.00	62	0.89	0.50	0.30	-0.01	186	1.80	0.52	0.44	0.00
03H	48	1.17	0.49	0.27	-0.02	21	1.27	0.50	0.23	0.01	69	1.27	0.49	0.27	-0.01
04H	23	1.10	0.53	0.35	0.00	11	0.78	0.38	0.26	0.01	34	1.10	0.48	0.35	0.00
05H	26	0.84	0.44	0.12	0.01	6	0.71	0.31	0.07	-0.07	32	0.84	0.42	0.12	-0.01
06H	4	0.83	0.61	0.16	-0.05	0	-	-	-	-	4	0.83	0.61	0.16	-0.05
07C	1	0.38	0.38	-	-	0	-	-	-	-	1	0.38	0.38	-	-
03C	1	0.42	0.42	-	-	0	-	-	-	-	1	0.42	0.42	-	-
01C	4	0.97	0.74	0.03	0.03	3	0.69	0.61	-	-	7	0.97	0.68	0.03	0.03
Total	339					162					501				

Table 3-3
Prairie Island Unit-1 - February 2001 Outage
Average Voltage Growth During Cycle 20

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	453	0.50	-0.005	-0.003	-1.1%	-0.7%
V_{BOC} < .75 Volts	402	0.45	0.007	0.004	1.6%	1.0%
≥ .75 Volts	51	0.89	-0.105	-0.066	-11.8%	-7.4%
	Steam Generator 11					
Entire Voltage Range	313	0.50	-0.005	-0.003	-1.0%	-0.6%
V_{BOC} < .75 Volts	279	0.45	0.006	0.003	1.2%	0.8%
≥ .75 Volts	34	0.92	-0.091	-0.057	-10.0%	-6.3%
	Steam Generator 12					
Entire Voltage Range	140	0.49	-0.007	-0.004	-1.4%	-0.8%
V_{BOC} < .75 Volts	123	0.44	0.011	0.007	2.5%	1.6%
≥ .75 Volts	17	0.84	-0.133	-0.083	-15.8%	-9.9%

Based on Cycle 20 duration of 584 EFPD (1.599 EFPY)

Table 3-4
Prairie Island Unit-1 February 2001
Average Voltage Growth for Cycle 20
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 20 (1999 - 2001) - 584 EFPD					
Entire Voltage Rang	453	0.50	-0.005	-0.003	-1.1%	-0.7%
V_{BOC} < .75 Volts	402	0.45	0.007	0.004	1.6%	1.0%
≥ .75 Volts	51	0.89	-0.105	-0.066	-11.8%	-7.4%
	Cycle 19 (1998 - 1999) - 440 EFPD					
Entire Voltage Rang	356	0.52	-0.022	-0.018	-4.3%	-3.5%
V_{BOC} < .75 Volts	318	0.46	-0.004	-0.003	-0.8%	-0.7%
≥ .75 Volts	38	0.96	-0.175	-0.145	-18.2%	-15.1%
	Cycle 18 - 566 EFPD					
Entire Voltage Rang	380	0.520	0.021	0.014	4.0%	2.6%
V_{BOC} < .75 Volts	250	0.521	0.02	0.012	3.5%	2.2%
≥ .75 Volts	130	0.519	0.027	0.017	5.2%	3.4%
	Cycle 17 - 536 EFPD					
Entire Voltage Rang	250	0.542	0.017	0.015	3.1%	2.8%
V_{BOC} < .75 Volts	168	0.519	-0.002	0.000	-0.4%	0.0%
≥ .75 Volts	82	0.592	0.055	0.043	9.3%	7.3%

Table 3-5
Prairie Island Unit-1 February 01
Signal Growth Statistics For Cycle 20 on an EFPY Basis

Delta Volts	Steam Generator 11			Steam Generator 12			Cumulative		
	Cycle 19	Cycle 20		Cycle 19	Cycle 20		Cycle 19	Cycle 20	
	CPDF	No. of Inds	CPDF	CPDF	No. of Inds	CPDF	CPDF	No. of Inds	CPDF
-0.7	0.0	0	0.0	0.008	0	0.0	0.003	0	0.0
-0.4	0.009	1	0.003	0.016	1	0.007	0.011	2	0.004
-0.3	0.018	2	0.01	0.023	0	0.007	0.02	2	0.009
-0.2	0.044	4	0.022	0.055	5	0.043	0.048	9	0.029
-0.1	0.18	16	0.073	0.164	13	0.136	0.174	29	0.093
0	0.671	142	0.527	0.469	61	0.571	0.598	203	0.541
0.1	0.925	130	0.942	0.883	38	0.843	0.91	168	0.912
0.2	0.978	15	0.99	0.938	20	0.986	0.963	35	0.989
0.3	1.0	3	1.0	0.969	1	0.993	0.989	4	0.998
0.4		0		0.984	1	1.0	0.994	1	1.0
0.5		0		0.992	0		0.997	0	
0.6		0		1.0	0		1.0	0	
Total		313			140			453	

Table 3-6
Prairie Island Unit-1 February 2001
Summary of Largest Voltage Growth Rates for BOC-20 to EOC-20

Steam Generator				Bobbin Voltage			RPC	New
SG	Row	Col	Elevation	EOC	BOC	Growth	Confirmed ?	Indication ?
12	34	60	01H	0.94	0.33	0.61	N	N
11	26	84	02H	0.85	0.41	0.44	N	N
12	29	50	01H	0.76	0.38	0.38	N	N
11	23	55	01H	0.73	0.38	0.35	N	N
11	29	52	04H	0.63	0.28	0.35	N	N
11	8	83	04H	1.1	0.78	0.32	N	N
11	26	53	02H	0.66	0.36	0.3	N	N
12	12	76	02H	0.75	0.45	0.3	N	N
12	10	34	01H	0.54	0.26	0.28	N	N
12	20	18	02H	0.49	0.21	0.28	N	N
11	30	59	03H	0.66	0.39	0.27	N	N
11	19	35	02H	0.66	0.4	0.26	N	N
12	19	64	04H	0.6	0.34	0.26	N	N
11	8	20	01H	0.72	0.47	0.25	Y	N
12	26	52	02H	0.44	0.19	0.25	N	N
11	27	13	03H	0.93	0.69	0.24	N	N
12	28	52	02H	0.59	0.35	0.24	N	N
12	19	9	01H	0.56	0.33	0.23	N	N
12	11	58	03H	0.88	0.65	0.23	N	N
12	26	61	01H	0.55	0.33	0.22	N	N
12	10	33	03H	0.43	0.21	0.22	N	N
12	25	64	03H	0.77	0.55	0.22	N	N
12	35	68	02H	0.48	0.26	0.22	N	N
11	32	28	01H	1.06	0.86	0.2	N	N
11	42	44	02H	1.13	0.93	0.2	N	N
12	20	18	01H	0.79	0.59	0.2	N	N
12	32	55	01H	0.73	0.53	0.2	N	N
11	26	36	02H	0.78	0.6	0.18	N	N
11	35	39	02H	0.61	0.43	0.18	N	N
11	13	11	01H	0.35	0.17	0.18	N	N

Table 3-7
Prairie Island Unit-1
Analysis of RPC Data from 1999 and 2001 Inspections
Combined Data from All Steam Generators

Group of Indications	Total 1999 Inspection Bobbin Indication	Total 2001 Inspection Bobbin Indication	Total 2001 Inspection RPC Inspected	Total 2001 Inspection RPC Confirmed	Percent 2001 Inspection RPC Confirmed
Less than or Equal to 1.0 Volt in 2001 Inspection					
1999 Inspection Bobbin Left in Service	449	443	443	8	1.8
- 1999 Inspection RPC Confirmed	0	0	0	0	-
- 1999 Inspection RPC NDD	443	443	443	8	1.8
- 1999 Inspection RPC Not Inspected	0	0	0	0	-
- No 2001 Inspection Bobbin *	6	-	-	-	-
New 2001 Inspection Indication	-	44	44	3	6.8
Sum of All 2001 Inspection Indication	449	487	487	11	2.3
Greater than 1.0 Volt in 2001 Inspection					
1999 Inspection Bobbin Left in Service	10	10	10	0	0.0
- 1999 Inspection RPC Confirmed	0	0	0	0	-
- 1999 Inspection RPC NDD	10	10	10	0	0.0
- 1999 Inspection RPC Not Inspected	0	0	0	0	-
- No 2001 Inspection Bobbin *	0	-	-	-	-
New 2001 Inspection Indication	-	4	4	0	0.0
Sum of All 2001 Inspection Indication	10	14	14	0	0.0
All Voltages in 2001 Inspection					
1999 Inspection Bobbin Left in Service	459	453	453	8	1.8
- 1999 Inspection RPC Confirmed	0	0	0	0	-
- 1999 Inspection RPC NDD	453	453	453	8	1.8
- 1999 Inspection RPC Not Inspected	0	0	0	0	-
- No 2001 Inspection Bobbin *	6	-	-	-	-
New 2001 Inspection Indication	-	48	48	3	6.3
Sum of All 2001 Inspection Indication	459	501	501	11	2.2

* Indications split is based on 1999 Inspection bobbin voltage

Table 3-8
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

Figure 3-1
Prairie Island Unit-1 February 2001 Outage
Bobbin Voltage Distributions at EOC-20 for Tubes in Service During Cycle 20

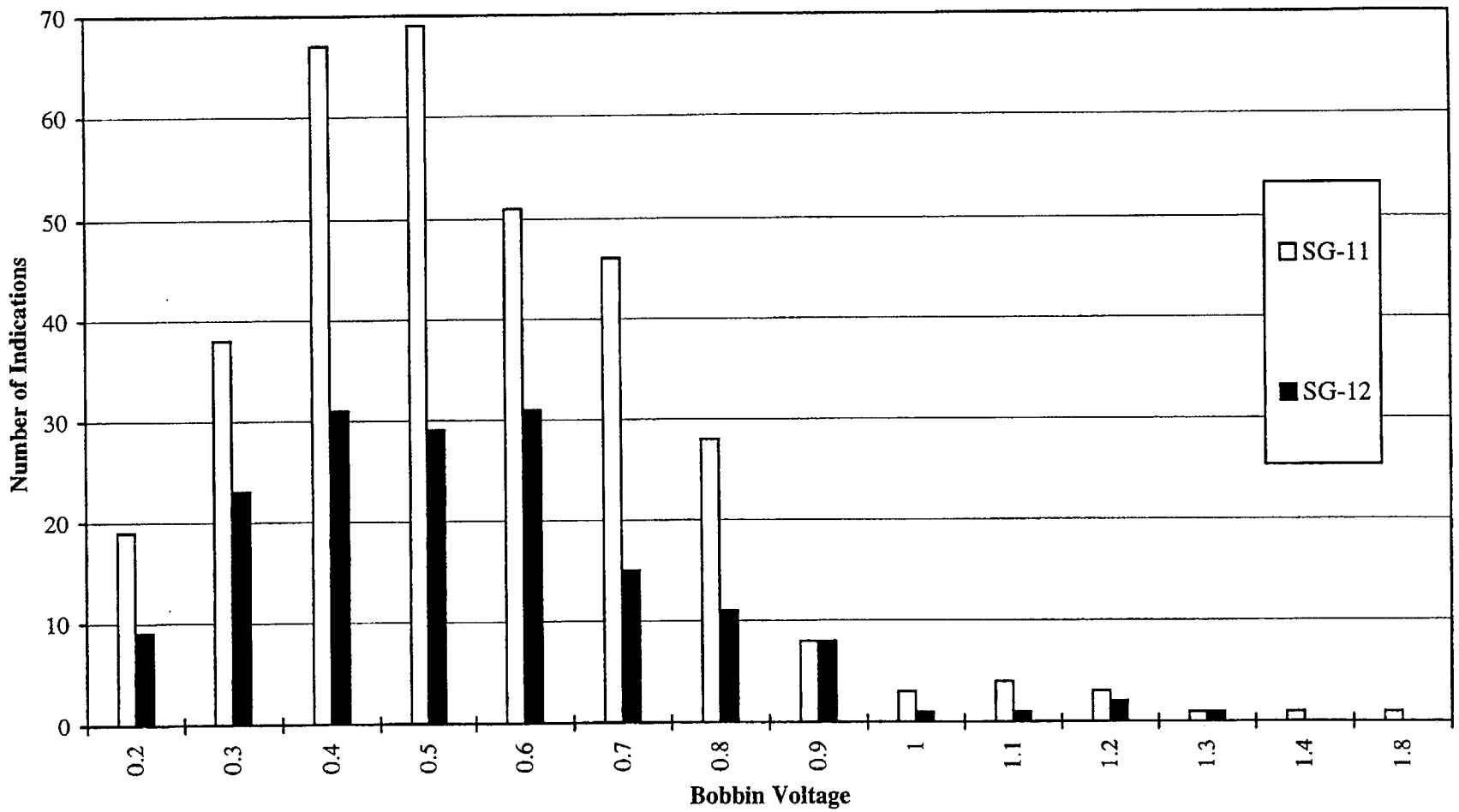


Figure 3-2
Prairie Island Unit-1 - February 2001
ODSCC Axial Distributions for Tubes in Service During Cycle 20

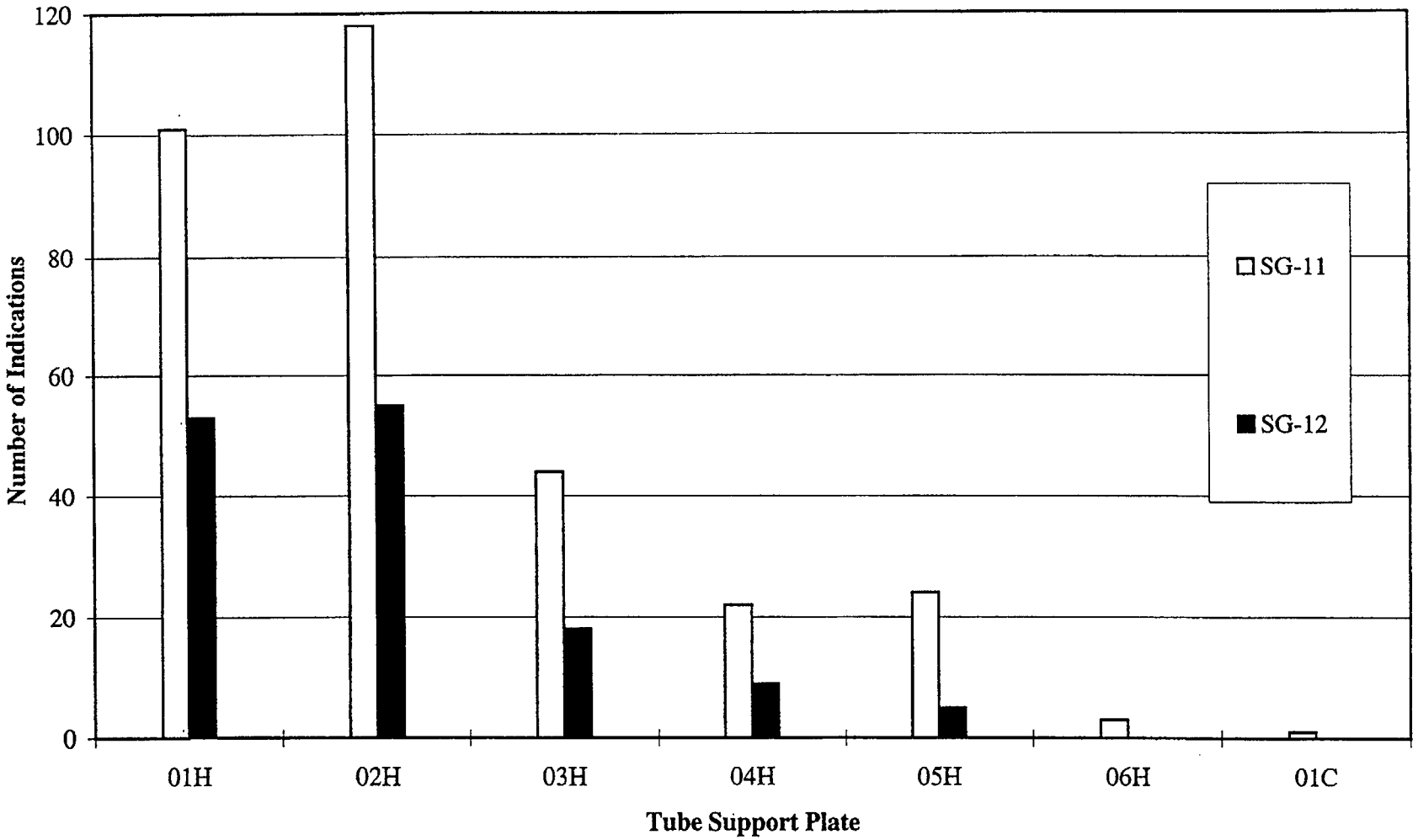


Figure 3-3
Prairie Island Unit-1Cycle 20 (May 1999 to Feb. 2001)
Cumulative Probability Distributions for Voltage Growth on an EFPY Basis

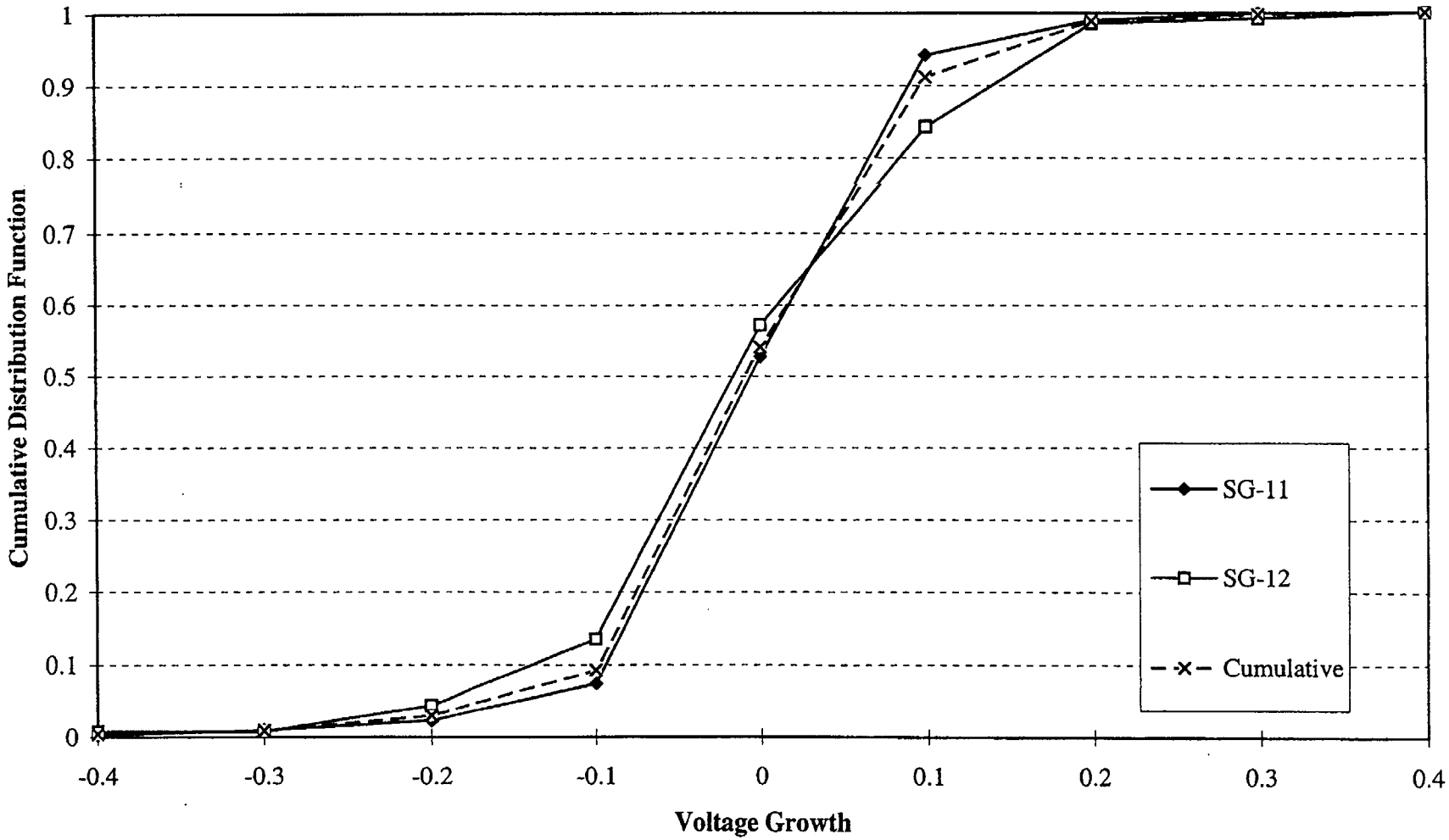


Figure 3-4
Prairie Island Unit-1 - February 2001
Bobbin Signal Growth History - Cumulative Probability Distributions on an EFPY Basis
Composite of All Steam Generators

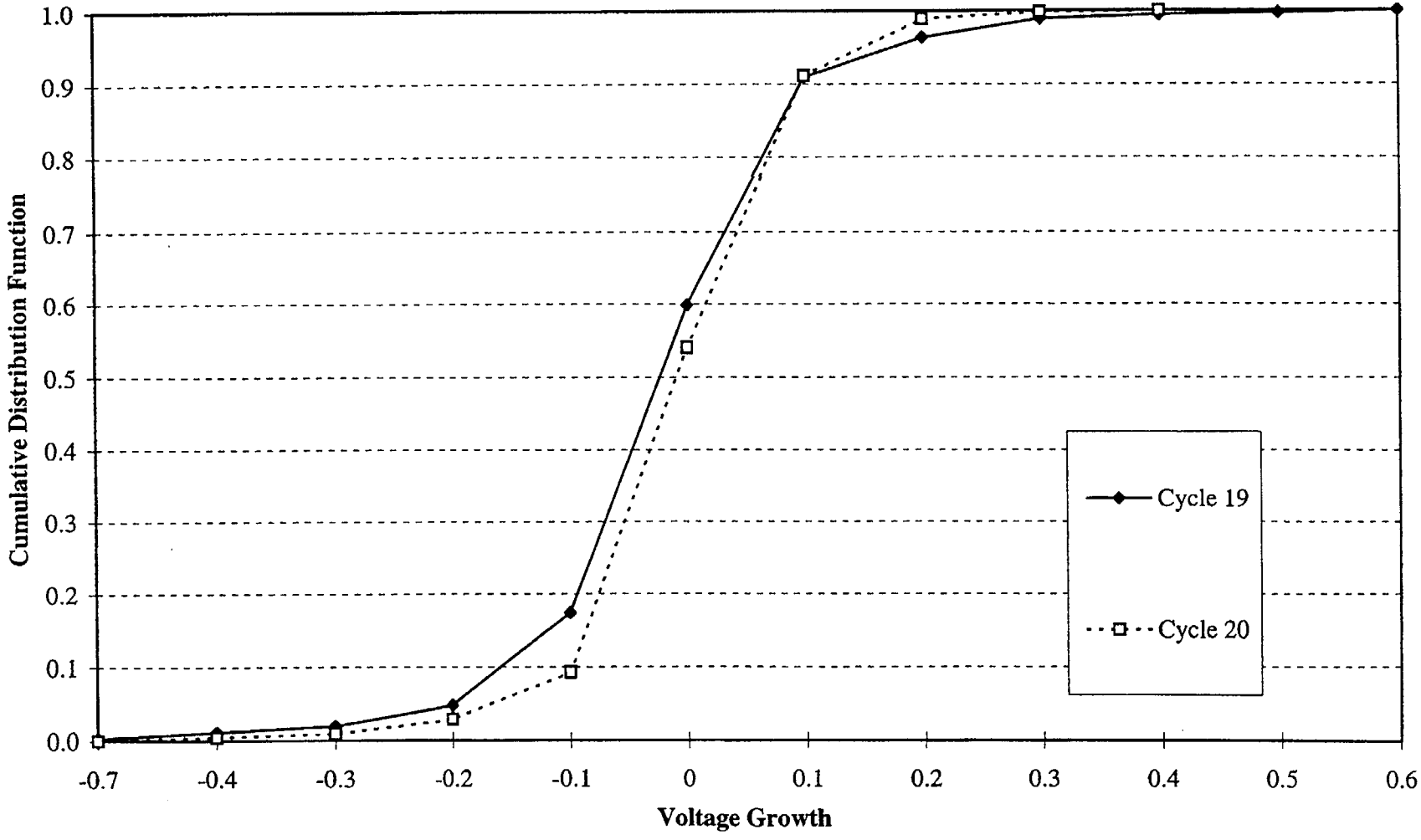


Figure 3-5
Prairie Island Unit -1 February 2001 Outage
Voltage Growth During Cycle 20 vs BOC-20 Voltage -- Combined SG Data

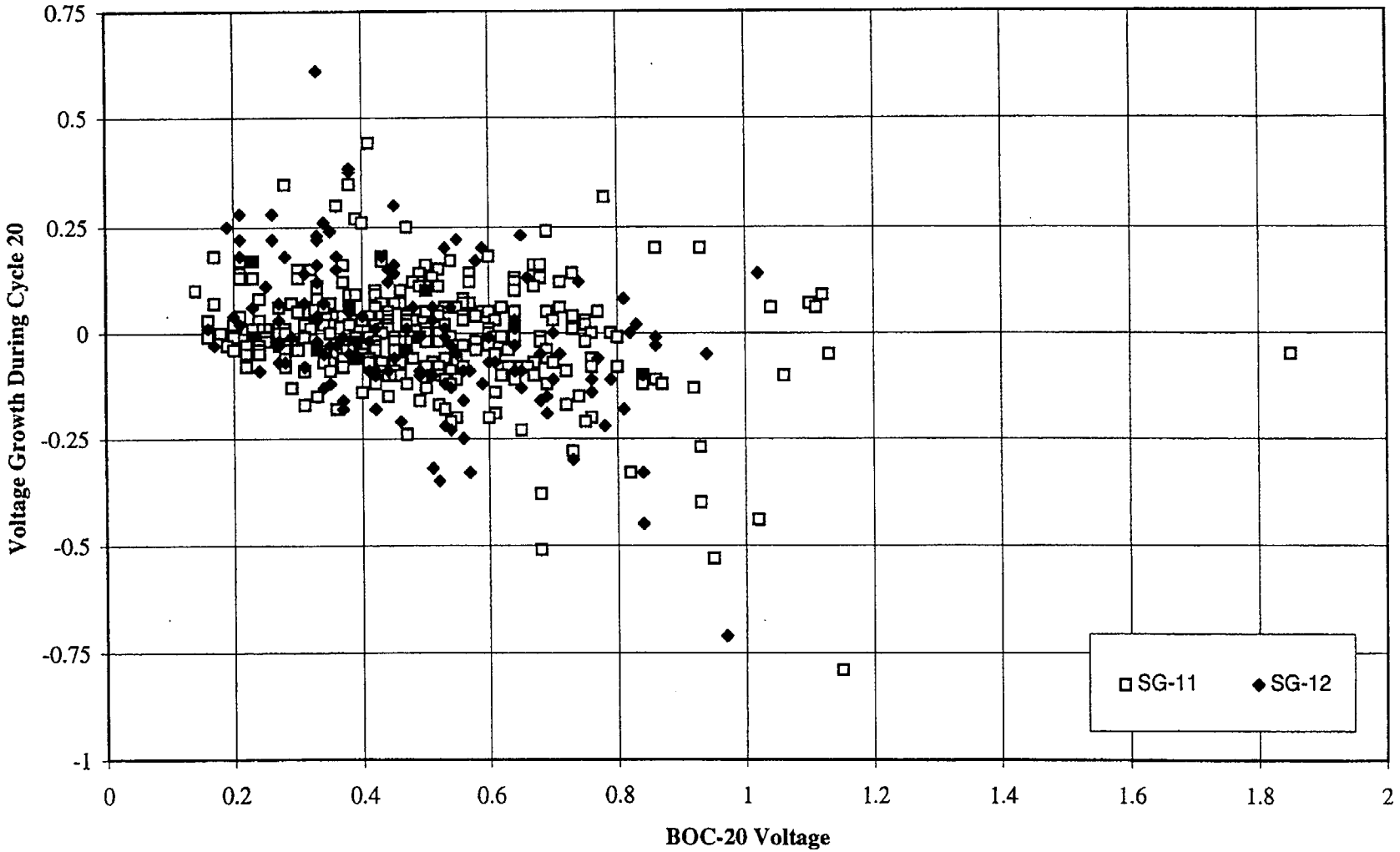
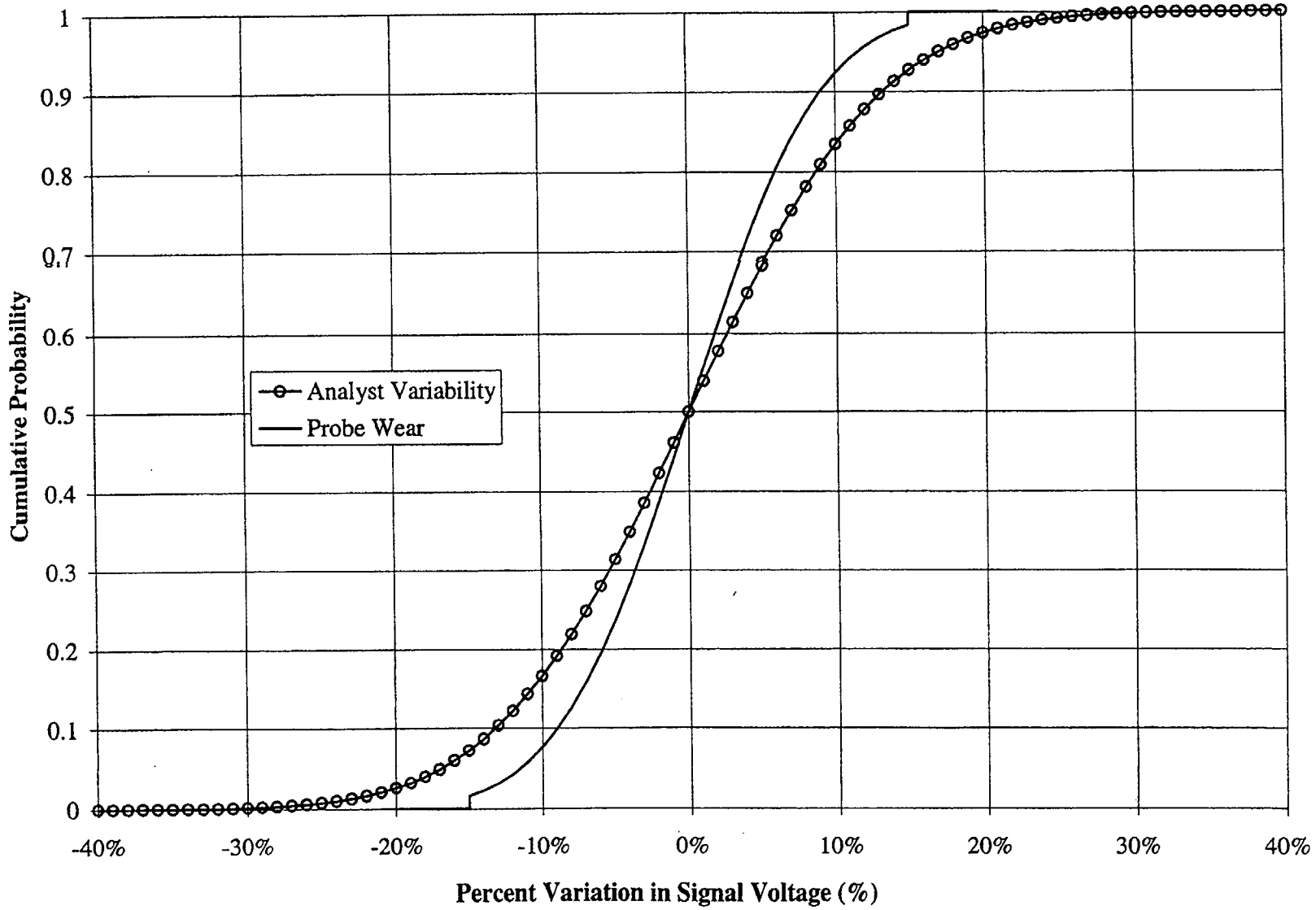


Figure 3-6
NDE Uncertainty Distributions



4.0 DATA BASE APPLIED FOR LEAK AND BURST CORRELATIONS

The correlations applied to project SLB leak rate and tube burst probability for the EOC-21 conditions are based on the latest voltage-based repair criteria database for 7/8" tubes submitted to the NRC (Reference 8-7). Data for the tube segments pulled from the Prairie Island Unit-1 SGs during the 1997 outage are included in this database.

Leak rate vs. bobbin voltage correlation for 7/8" tubes from Reference 8-7 was used to perform EOC-21 SLB leak rate projections for both SGs. The leak rate data in the database represent a room temperature measurement of leakage at prototypic SLB conditions (i.e., leakage at SLB conditions was condensed and measured at room temperature). Therefore, SLB leak rate calculated using the leak rate correlations provides a volumetric rate at room temperature.

5.0 SLB ANALYSIS METHODS

Monte Carlo analyses are used to predict EOC-21 voltage distributions and to calculate the SLB leak rates and tube burst probabilities for both the actual EOC-20 voltage distributions and the predicted EOC-21 voltage distributions. These methods are described in the generic methods report of WCAP-14277, Revision 1 (Reference 8-2), and are in accordance with NRC Generic Letter 95-05 (Reference 8-1). Leak rates calculated with the WCAP-14277 methodology provide a volumetric leak rate at room temperature, and they are compared with allowable volumetric leak rate at room temperature.

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. Voltage distribution projections at the end of an 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 and as well as leak and burst results based on those distributions. Equation 3.5 in Reference 8-2 was used to determine the true BOC voltage.

As mentioned in the previous section, leak rate analysis for the EOC-21 condition was carried out using the leak rate vs. bobbin correlation for 7/8" tubes shown in Reference 8-7.

6.0 BOBBIN VOLTAGE DISTRIBUTIONS

This section describes the prediction of the EOC voltage distribution used for evaluating the SLB leak rate and tube burst probability at the end of the operating period. The calculation consists of establishing the initial conditions (i.e., the bobbin indication population distribution) based on eddy current 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 correlations. This is accomplished by using a POD factor. Where appropriate, adjustments are also made for tubes either removed from service 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.

There were no deplugged tubes returned to service in the recent inspection.

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. A voltage-dependent POD known as POPCD

has been established using data from 23 post-1992 inspections at 10 different plants. It takes into account newly initiated indications that are important for voltage-based repair criteria application. The development of POPCD and supporting data are presented in References 8-7. POPCD data as a function of bobbin voltage is illustrated graphically in Figure 6-1. It is evident from Figure 6-1 that the NRC recommended POD of 0.6 is too conservative above about 0.5 volts. It is of interest to apply POPCD for sensitivity analysis and compare the results for the case with a POD value of 0.6.

6.2 Cycle Operating Time

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

Cycle 20 = 584 EFPD Cycle 21 = 575 EFPD (estimated)

6.3 Predicted EOC-21 Voltage Distributions

Bobbin voltage projections start with a cycle initial voltage distribution which 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 Prairie Island 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. As noted in Section 3.2, the 1997 - 1999 operation (Cycle 19) growth rates slightly exceed those of the 1999 - 2001 (Cycle 20) operation and are used to predict the EOC-21 bobbin voltage distributions. Further conservatism for the EOC-21 bobbin voltage prediction is provided by the use of the larger of the composite growth rate for both SGs and the SG-specific growth rate in projecting EOC voltages for each SG. The methodology used in the calculations of EOC bobbin voltage distributions is described in Reference 8-2.

For each SG, the initial bobbin voltage distribution of indications being returned to service for the next cycle (BOC-21) is derived from the actual EOC-20 inspection results adjusted for tubes that are taken out of service by plugging. Table 6-1 shows EOC-20 bobbin voltage indications, the subsequent plugged indications (which were in service for Cycle 20 and then taken out of service, albeit not all for reasons of ODSCC at TSP), and the BOC-21 indications corresponding to a constant POD value of 0.6 as well as the voltage dependent generic POPCD. POPCD distribution is developed based on bobbin and RPC data from 23 EC inspections at 10 different plants, and its distribution is shown in Figure 6-1.

Table 6-2 provides the EOC-21 voltage distributions predicted using the BOC-21

voltage distribution shown in Table 6-1. As anticipated, a larger number of indications is predicted for SG-11, about 561 indications for a constant POD of 0.6, than for SG-12. The assumed BOC-21 and predicted EOC-21 bobbin voltage frequency distributions for both SGs are also graphically illustrated on Figures 6-2 and 6-3. The largest bobbin voltage predicted for EOC-21 is in SG-11 (assuming a constant POD of 0.6), and its magnitude is 2.3 volts

6.4 Comparison of Predicted and Actual EOC-20 Voltage Distributions

The actual EOC-20 bobbin voltage distributions and the corresponding predictions presented in the last 90-day report (for the EOC-20 inspection, Reference 8-5), are compared in Table 6-3 and on Figure 6-4. SG-11 was predicted to be limiting for EOC-20 based on the total number of indications, and it was confirmed to have the highest number of indications. Also, the largest indication was found in SG-11, as predicted. The total number of EOC-20 indications for SGs 11 and 12 are overpredicted by 50% to 55%, in the licensing-basis analysis with a POD of 0.6, and the voltage population over 1 volt are overpredicted by a factor of 3 to 5. The overprediction of indications in virtually every voltage size range demonstrates conservatism in the projection methodology.

As evident in Table 6-3, EOC-20 projections based on the voltage-dependent POD POPCD also overestimates the number of indications, peak voltage, leak rate and burst probability. These results demonstrate that the EPRI POPCD distribution yields more realistic, yet conservative results.

Table 6-1
Prairie Island Unit-1 February 2001
EOC-20 Bobbin and Assumed BOC-21 Bobbin Distributions in SLB Leak Rate and Tube Burst Analyses

Voltage Bin	Steam Generator 11				Steam Generator 12			
	EOC - 20		BOC - 21		EOC - 20		BOC - 21	
	Field Bobbin Indications	Indications Repaired	POD 0.6	POPCD	Field Bobbin Indications	Indications Repaired	POD 0.6	POPCD
0.2	19	0	31.67	52.78	9	1	14.00	24.00
0.3	38	0	63.33	82.61	23	0	38.33	50.00
0.4	67	0	111.67	124.07	31	1	50.67	56.41
0.5	69	0	115.00	109.52	29	1	47.33	45.03
0.6	51	3	82.00	70.91	31	0	51.67	44.93
0.7	46	0	76.67	61.33	15	1	24.00	19.00
0.8	28	1	45.67	34.44	11	0	18.33	13.92
0.9	8	0	13.33	9.76	8	0	13.33	9.76
1	3	0	5.00	3.57	1	0	1.67	1.19
1.1	4	0	6.67	4.68	1	0	1.67	1.17
1.2	3	0	5.00	3.45	2	0	3.33	2.30
1.3	1	0	1.67	1.14	1	0	1.67	1.14
1.4	1	0	1.67	1.12	0	0	0.00	0.00
1.5	0	0	0.00	0.00	0	0	0.00	0.00
1.6	0	0	0.00	0.00	0	0	0.00	0.00
1.7	0	0	0.00	0.00	0	0	0.00	0.00
1.8	1	0	1.67	1.09	0	0	0.00	0.00
1.9	0	0	0.00	0.00	0	0	0.00	0.00
2	0	0	0.00	0.00	0	0	0.00	0.00
2.3	0	0	0.00	0.00	0	0	0.00	0.00
3.2	0	0	0.00	0.00	0	0	0.00	0.00
Total	339	4	561.00	560.47	162	4	266.00	268.84
> 1V	10	0	16.67	11.47	4	0	6.67	4.60
> 2V	0	0	0.00	0.00	0	0	0.00	0.00

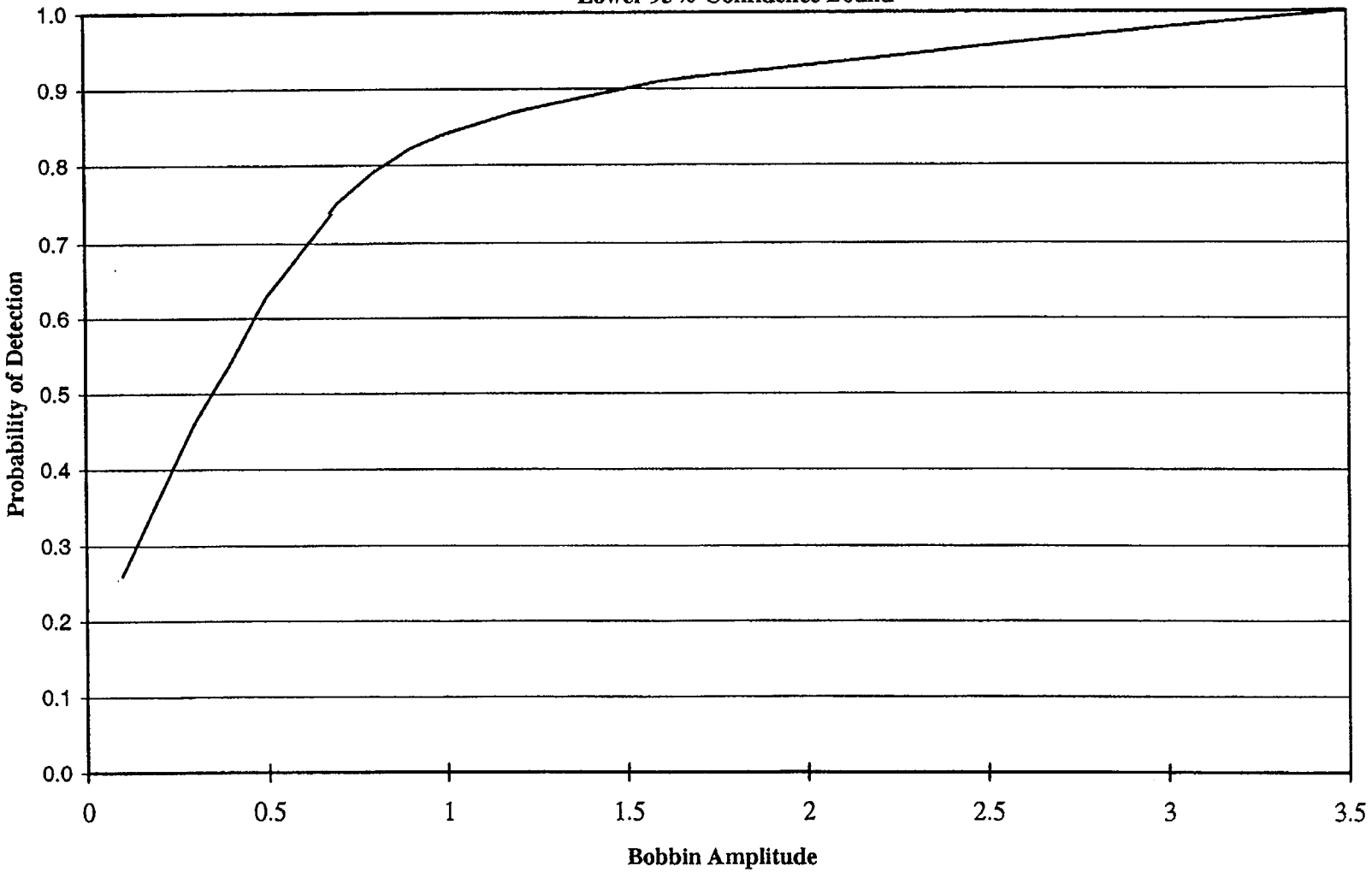
Table 6-2
Prairie Island Unit-1 February 2001
Voltage Distribution Projection for EOC - 21
Combined Data for Hot and Cold Leg Indications

Voltage Bin	Steam Generator 11		Steam Generator 12	
	Projected Number of Indications at EOC - 21			
	POD 0.6	POPCD	POD 0.6	POPCD
0.1	0.92	1.66	0.34	0.62
0.2	19.86	34.24	7.75	13.20
0.3	44.46	59.03	20.46	27.64
0.4	77.19	89.39	33.45	40.47
0.5	91.64	94.89	41.92	44.89
0.6	89.76	85.02	42.41	41.11
0.7	77.48	68.28	36.10	32.55
0.8	58.11	48.71	27.65	23.63
0.9	38.76	31.45	19.14	15.77
1.0	23.57	18.69	12.72	10.27
1.1	14.17	11.01	8.20	6.56
1.2	8.93	6.83	5.41	4.34
1.3	5.77	4.34	3.79	3.00
1.4	3.65	2.72	2.65	2.04
1.5	2.26	1.65	1.73	1.31
1.6	1.42	1.01	1.04	0.64
1.7	0.93	0.65	0.23	0.00
1.8	0.64	0.40	0.70	0.70
1.9	0.46	0.00	0.00	0.30
2.0	0.00	0.70	0.30	
2.1	0.70	0.00		
2.2	0.00	0.30		
2.3	0.30			
TOTAL	561.0	561.0	266.0	269.0
> 1 V	39.2	29.6	24.1	18.9
> 2 V	1.0	0.3	0.0	0.0

Table 6-3
Prairie Island Unit-1 February 2001
Comparison of Predicted and Actual EOC-20 Voltage Distributions

Voltage Bin	Steam Generator 11			Steam Generator 12		
	Number of Indications					
	EOC-20 Prediction		EOC-20 Actual	EOC-20 Prediction		EOC-20 Actual
	POD = 0.6	POPCD		POD = 0.6	POPCD	
0.1	0.41	0.68	0	0.16	0.27	0
0.2	10.56	16.37	19	4.48	6.93	9
0.3	37.13	48.21	38	18.11	23.62	23
0.4	64.43	75.13	67	31.66	36.95	31
0.5	87.47	92.77	69	38.71	41.60	29
0.6	88.52	86.13	51	39.50	38.66	31
0.7	76.89	69.46	46	32.83	29.76	15
0.8	56.47	48.34	28	25.89	22.37	11
0.9	37.48	30.85	8	18.77	15.68	8
1.0	22.92	18.43	3	12.77	10.39	1
1.1	14.10	11.23	4	8.13	6.49	1
1.2	9.45	7.51	3	4.80	3.86	2
1.3	6.80	5.40	1	3.03	2.60	1
1.4	4.70	3.68	1	2.00	1.75	
1.5	3.02	2.34	0	1.26	1.07	
1.6	1.79	1.36	0	0.83	0.51	
1.7	1.07	0.78	0	0.08	0.00	
1.8	0.68	0.48	1	0.70	0.70	
1.9	0.49	0.17		0.00	0.30	
2.0	0.26	0.00		0.30		
2.1	0.00	0.70				
2.2	0.70	0.00				
2.3	0.00	0.30				
2.4	0.30					
TOTAL	525.6	520.3	339.0	244.0	243.5	162.0
> 1 V	43.4	34.0	10.0	21.1	17.3	4.0
> 2 V	1.0	1.0	0.0	0.0	0.0	0.0

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



PREDCOMP.xls|Fig_1|5/1/01|4:08 PM

Figure 6-2
Prairie Island Unit-1 SG-11
Predicted Bobbin Voltage Distribution for Cycle 21

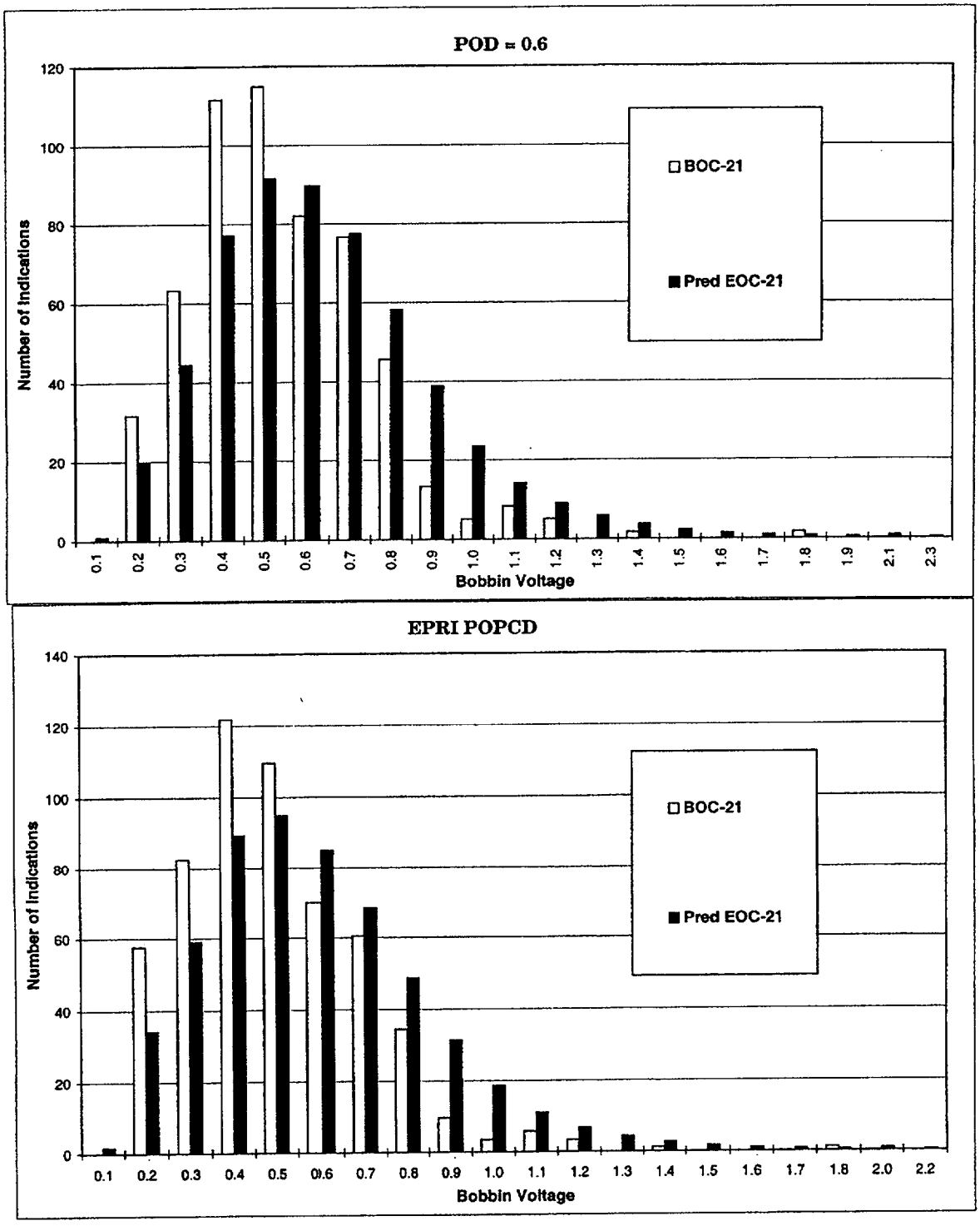
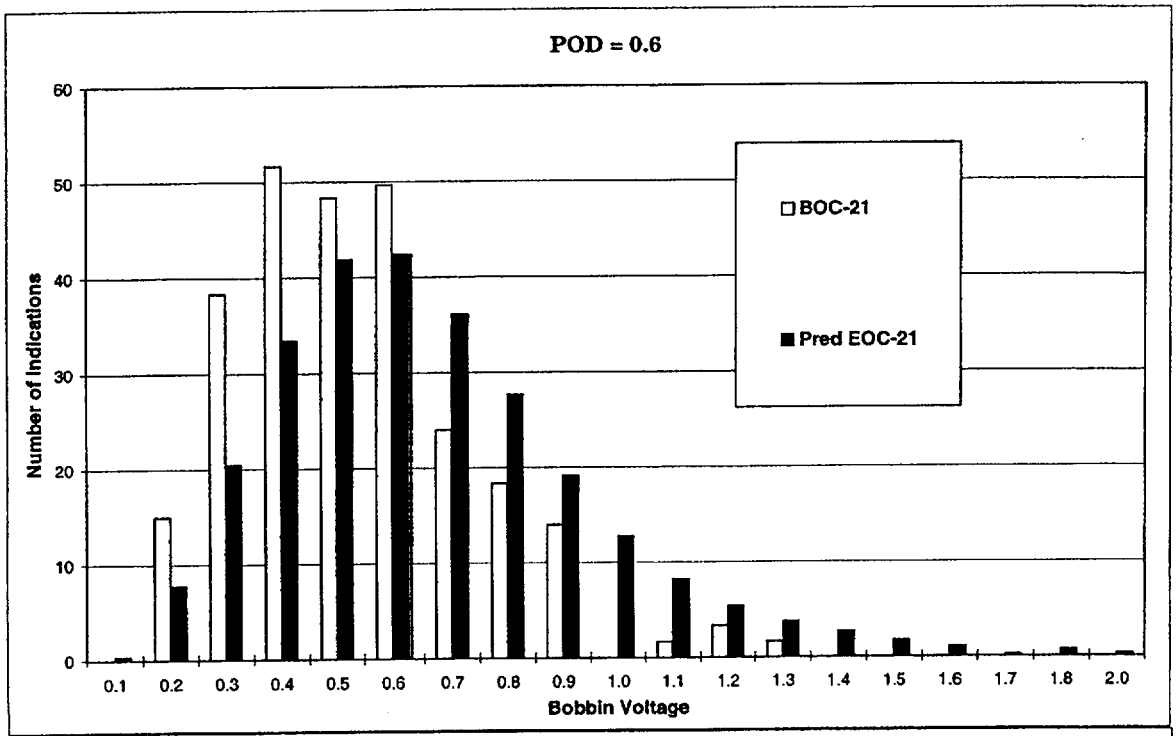


Figure 6-3
Prairie Island Unit-1 SG-12
Predicted Bobbin Voltage Distribution for Cycle 21



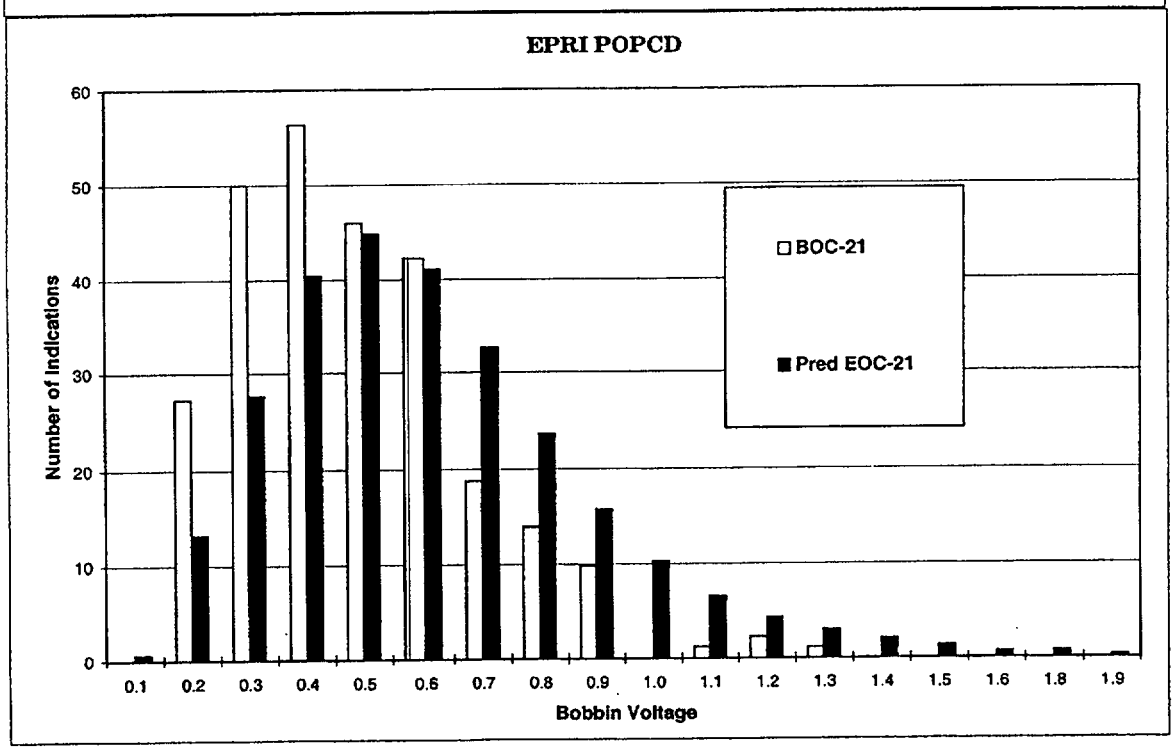
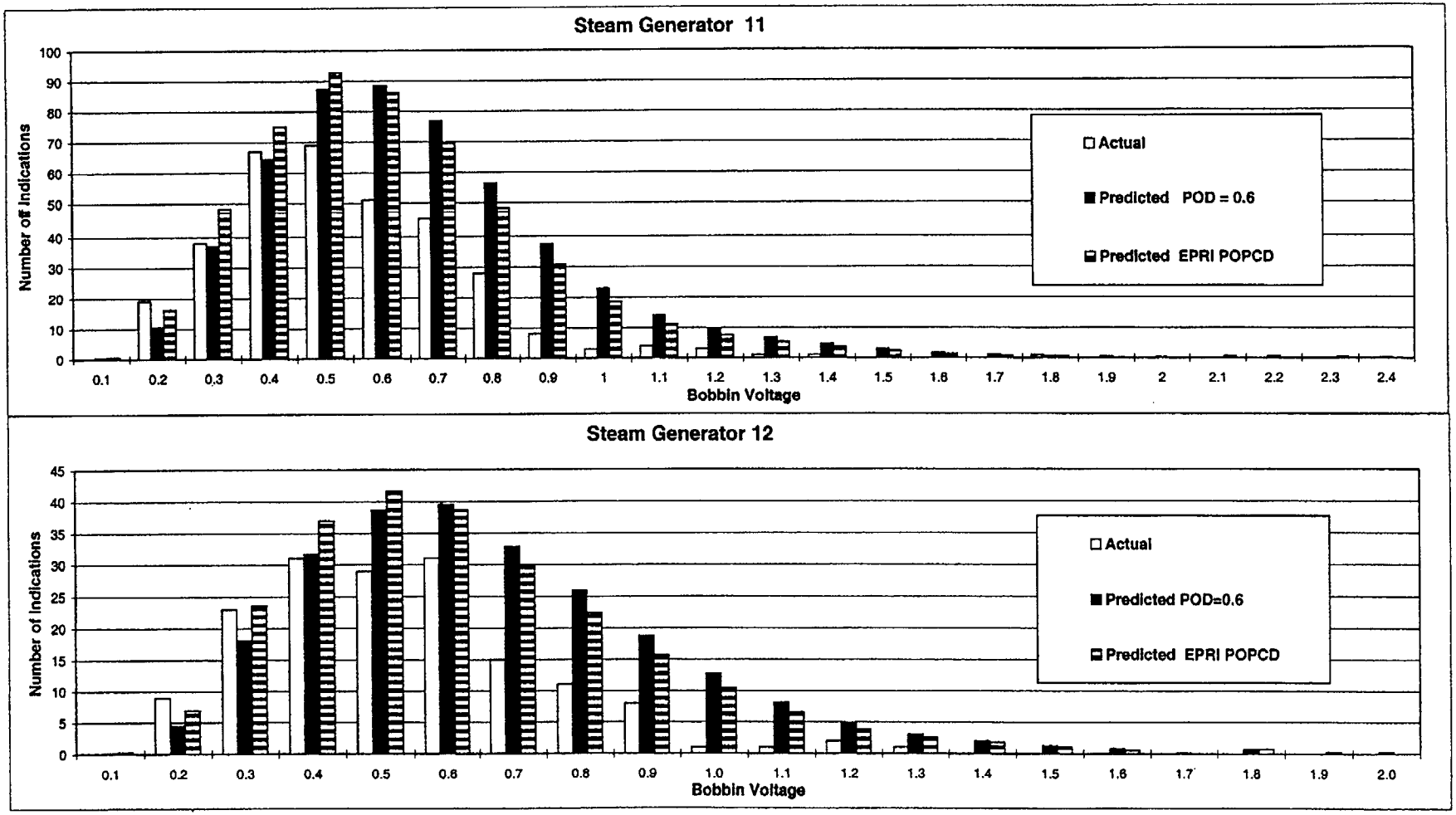


Figure 6-4
Prairie Island Unit-1 February 2001
Bobbin Voltage Distributions for Cycle 20



7.0 TUBE LEAK RATE AND TUBE BURST PROBABILITIES

7.1 Calculation of Leak Rate and Tube Burst Probabilities

This section presents the SLB leak rates and tube burst probabilities obtained using the actual measured EOC-20 voltage distributions and projected EOC-21 voltage distributions. 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 8-2, and is consistent with NRC criteria and guidelines of References 8-1. The latest leak and burst correlations approved by the NRC were applied for the EOC-21 projections, and they are documented in Reference 8-7. A leak rate vs. bobbin voltage correlation was used. The calculated leak rates are volumetric rates at room temperature and they should be compared with allowable leak rates at room temperature. Leak rate and burst probability calculations based on the actual measured EOC-20 voltages were performed using both the database used in the projections (Addendum-2 database, Reference 8-6) as well as a more recent database (Addendum-3 database, Reference 8-7).

7.2 Predicted and Actual Leak Rate and Tube Burst Probability for EOC-20 (Condition Monitoring Assessment)

Monte Carlo analyses were performed to calculate SLB leak rates and tube burst probabilities based on the actual bobbin voltage distributions at EOC-20, including the NDE uncertainties. The results are shown on Table 7-1. Projected EOC-20 results for both SGs originally presented in the last 90-day report are also included for comparison in Table 7-1. The allowable SLB rate for the last operating cycle (Cycle 20) was 1 gpm (at room temperature).

Comparisons of the EOC-20 actuals with the corresponding projections indicate the following:

a) SG-11 was projected to be the limiting steam generator for EOC-20 based on EOC-19 data, and SG-11 was confirmed to have the limiting leak rate based on the actual bobbin measurements for EOC-20 (0.18 gpm at room temperature). All estimated EOC-20 leak rates are well below the acceptance limit for Prairie Island Unit-1 (1 gpm).

b) The tube burst probabilities based on the actual voltage distributions are equal to or less than the projections with POD=0.6. The highest tube burst probability based on the measured voltages was calculated for SG-11 (1.9×10^{-5}) which had the largest indication detected in this inspection. Tube

burst probability results for both SGs are well below the NRC reporting guideline of 10^{-2}.

In summary, the limiting SLB leak rate (0.18 gpm at room temperature) calculated using the actual measured EOC-20 bobbin voltage distributions and leak rate vs. voltage correlation is less than $1/5^{th}$ of the allowable limit of 1 gpm. The corresponding tube burst probability (1.9×10^{-5}) is more than 2 orders of magnitude below the corresponding allowable limit. The results meet the Generic Letter 95-05 requirement for continued Cycle 21 operation.

7.3 Projected Leak Rate and Tube Burst Probability for EOC-21 (Operational Assessment)

Using the methodology previously described, calculations were performed to predict the EOC-21 conditions of both steam generators in Prairie Island Unit-1, and the results are summarized in Table 7-2. EOC-21 bobbin voltage distributions as well as the leak rates and tube burst probabilities based on these distributions are predicted. As mentioned earlier, EOC-21 leak rates and tube burst probabilities are calculated using the latest burst and leak correlations presented in Reference 8-7. The projected leak rates are compared with the allowable leak rate at room temperature (1 gpm). The leak rate vs. bobbin voltage correlation appropriate for 7/8" tubes is applied. Since the growth rate for Cycle 19 is higher than that for Cycle 20, Cycle 19 growth data were used in the EOC-21 projection analysis.

The predicted EOC-21 SLB leak rate and burst probability for both SGs are shown in Table 7-2. It is evident that the projected maximum voltage, SLB leak rate and tube burst probability at the EOC-21 conditions for SG-11 are slightly higher than those for SG-12. Thus, SG-11 is once again projected to be limiting at the end of the current cycle (EOC-21). The limiting EOC-21 SLB leak rate predicted for SG-11 based on constant POD of 0.6 is 0.42 gpm (room temperature), which is less than half of the current licensed limit of 1 gpm at room temperature. The corresponding limiting EOC-21 burst probability with POD=0.6, predicted for SG-11 is 3.7×10^{-5}; it is better than 2 orders of magnitude below the NRC acceptance limit of 10^{-2}. The results based on the voltage-dependent POPCD also show similar margins. Thus, the projected EOC-21 results meet the voltage-dependent repair criteria requirement for continued operation.

In summary, SLB leak rates and tube burst probabilities projected for EOC-21 for both SGs using the NRC-mandated POD = 0.6 meet the SER limits for Prairie Island Unit-1. Results based on voltage dependent POPCD show even a greater margin between EOC-21 predictions and acceptance limits.

Table 7-1
Prairie Island Unit-1 1999 EOC-20 Outage
Summary of Calculations of Tube Leak Rate and Burst Probability

Steam Generator	POD	No. of Indications[1]	Max. Volts	Burst Probability		SLB Leak Rate (gpm)[2]	Comments
				1 Tube	One or More Tubes		
EOC - 20 Projections							
11	0.6	5.26	2.4	1.9×10^{-5}	1.9×10^{-5}	0.46	Addendum-2 Leak rate Correlation applied
12		2.44	2.3	2.5×10^{-5}	2.5×10^{-5}	0.40	
11	POPCD	5.20	2.0	1.2×10^{-5}	1.2×10^{-5}	0.19	
12		2.44	1.9	1.9×10^{-5}	1.9×10^{-5}	0.16	
Based on Actual Measured EOC - 20 Voltage Distributions							
11	1	3.39	1.8	1.9×10^{-5}	1.9×10^{-5}	0.18	Addendum-2 Leak rate Correlation applied
12		1.62	1.3	$< 1.2\times10^{-5}$	$< 1.2\times10^{-5}$	0.07	
11		3.39	1.8	$< 1.2\times10^{-5}$	$< 1.2\times10^{-5}$	0.17	Addendum-3 Leak rate Correlation applied
12		1.62	1.3	$< 1.2\times10^{-5}$	$< 1.2\times10^{-5}$	0.06	

Notes: (1) Adjusted for POD.

(2) Volumetric leak rate adjusted to room temperature.

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Table 7-2
Prairie Island Unit-1
Summary of Projected Tube Leak Rate and Burst Probability for EOC-21
(Based on projected Cycle 21 length 575 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 Applied							
11[3]	0.6	561	2.3	3.7×10^{-5}	3.7×10^{-5}	0.42	Leak rate Correlation applied
12[4]		266	2.0	2.5×10^{-5}	2.5×10^{-5}	0.19	
11[3]	POPCD	561	2.2	1.9×10^{-5}	1.9×10^{-5}	0.36	
12[4]		269	1.9	$<1.2\times10^{-5}$	$<1.2\times10^{-5}$	0.17	

Notes

(1) Number of indications adjusted for POD.
(2) Volumetric leak rate adjusted to room temperature.
(3) SG-11 specific Cycle 19 growth rate distribution applied.
(4) All SG composite Cycle 19 growth rate distribution applied.

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

8-3 NRC Safety Evaluation Related to Amendment Nos.133 and 125 to Facility Operating License Nos. DPR-42 and DPR-60, Northern States Power Company, Prairie Island Nuclear Generating Plant Unit Nos. 1 and 2, Docket Nos. 50-282 and 50-306, November 18, 1997.

8-4 SG-98-03-002, "Prairie Island Unit-1 Cycle 19 Voltage Based Repair Criteria 90-Day Report," Westinghouse Nuclear Services Division, March 1998.

8-5 SG-99-07-006, "Prairie Island Unit-1 Cycle 20 Voltage Based Repair Criteria 90-Day Report," Westinghouse Nuclear Services Division, July 1999.

8-6 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.

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 E-Mail from S. Redner (XcelEnergy) to V. Srinivas (Westinghouse), "Eddy Current Data," February 3, 2001.

8-9 E-Mail from R. Peason (XcelEnergy) to V. Srinivas (Westinghouse), "Cycle Duration," February 12, 2001.

8-10 E-Mail from S. Redner (XcelEnergy) to V. Srinivas (Westinghouse), "Tube Plugging Spreadsheets," February 13, 2001.

8-11 Letter from B. W. Sheron, Nuclear Regulatory Commission, to A. Marion, Nuclear Energy Institute, dated February 9, 1996.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.