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

South Texas Project
Unit 2
Docket No. STN 50-499
2RE08 Steam Generator Tube Voltage-Based Repair Criteria 90-Day Report

Reference: NRC letter "Summary of Meeting with STPNOC/Westinghouse Regarding Results of Steam Generator Tube Inspections and In Situ Tube Pressure Tests Conducted During End-of-Cycle 8 Refueling Outage for South Texas Project Unit 2," dated May 15, 2001 (AE-NOC-01000812)

Attached is a copy of the voltage-based repair criteria 90-day report for the steam generator tube examination performed under NRC Generic Letter 95-05 during refueling outage 2RE08. This report meets the requirements of Technical Specification 4.4.5.5.e and Section 6.b of Attachment 1 to Generic Letter 95-05. Also attached is a report with a more complete explanation of our preventive tube plugging strategy as requested by the NRC at an April 19, 2001, meeting and documented in the referenced meeting summary.

If there are any questions regarding these reports, please contact Mr. Chet McIntyre at (361) 972-8597 or me at (361) 972-7181.

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Attachments:
1. Westinghouse Report SG-01-06-001, "South Texas Unit - 2 Cycle 9 Voltage-Based Repair Criteria 90-Day Report," dated June 2001
2. Westinghouse Report LTR-SGDA-01-169, "Normal Operating Leakage Assessment for Preventive Plugging of ODSCC at TSPs South Texas Project Unit-2," dated June 18, 2001

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ATTACHMENT 1

SG-01-06-001

SOUTH TEXAS UNIT - 2

CYCLE 9 VOLTAGE-BASED REPAIR CRITERIA 90-DAY REPORT

June 2001

Westinghouse Electric Company LLC
Nuclear Services
P.O. Box 158
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SG-01-06-001

SOUTH TEXAS UNIT - 2

CYCLE 9 VOLTAGE-BASED REPAIR CRITERIA 90-DAY REPORT

June 2001

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South Texas Unit - 1
Cycle 9 Voltage-Based Repair Criteria
90-Day Report

1.0 Introduction

This report provides a summary of the South Texas Unit-2 steam generator bobbin and rotating pancake coil (RPC) probe data for outside diameter stress corrosion cracking (ODSCC) at tube support plate (TSP) intersections from the end of Cycle 8 (EOC-8) inspection, together with postulated Steam Line Break (SLB) leak rate and tube burst probability analysis results consistent with NRC Generic Letter 95-05 (Reference 8-1). The repair threshold for ODSCC indications on the hot leg side of TSPs C, F and J (the first three TSPs above the flow distribution baffle, these locations are also referred to as TSPs 2, 3 and 4 in this report) was increased to 3 volts for Cycle 9 operation; however, STPNOC chose to preventively plug all indications over 1.5 volts to minimize the potential for normal operation leakage. A majority of the TSP indications between 0.6 and 1.5 volts (over 52%) were also plugged as part of the preventive plugging program. Details on the basis used for selecting tubes for preventive plugging are provided in Reference 8-2.

Information required by the Generic Letter is provided in this report including SLB leak rates and tube burst probabilities calculated using the EOC conditions for the recently completed cycle (Cycle 8) and projection of bobbin voltage distributions, leak rates and burst probabilities for the ongoing cycle (Cycle 9). Analyses for Cycle 8 were carried out using the actual bobbin voltage distributions measured during the EOC-8 outage and the results compared with the corresponding values from the projections performed based on the last inspection (EOC-7) bobbin voltage data. The evaluations reported here are based on the Westinghouse generic methodology presented in Reference 8-3 and a revision to this methodology to support higher voltage repair criteria, which is described in Reference 8-4.

Analyses were also performed to project leak rates and tube burst probabilities for postulated SLB conditions at the end of the ongoing cycle (Cycle 9). These analyses utilized bobbin voltage distributions measured during the recent (EOC-8) inspection and a limiting growth rate distribution from the last two inspections (EOC-7 and EOC-8 inspections). To justify a 3-volt repair limit for TSP indications on the hot leg side of TSPs C, F and J, 16 tubes were expanded at each of these 3 TSPs to "lock" them in place. Therefore, ODSCC indications on the hot leg side of these TSP intersections are restrained from bursting and their burst probability is small. Leak rate at these TSP intersections during a postulated SLB event were calculated using a methodology appropriate for indications restrained from bursting (IRBs), which is described in Reference 8-4

Two other supplemental evaluations are also presented in this report. One of them

examines the probability of detection for the Cycle 7 inspection (probability of prior cycle detection – POPCD) and the other tracks 1999 EOC-7 indications left in service at beginning of Cycle 8 (BOC-8) relative to RPC confirmation rate in 2001 at EOC-8.

This will be the last report to support volt-based repair criteria for Unit-2 as the steam generators will be replaced at the next refueling outage.

2.0 Summary and Conclusions

A total of 3580 distorted support plate indications (DSIs) were found at TSP intersections in the EOC-8 inspection of which 449 indications were over 1 volt and 102 over 3 volts. An extensive RPC inspection was performed during this outage for TSP indications to identify potential leakers for preventive plugging prior to Cycle 9 operation. About 70% of all indications over 0.6 volts were inspected with a +Point probe including all 101 indications above 3 volts at 2H, 3H and 4H (per the 3-volt repair criteria) and all indications over 1 volt at the remaining TSP intersections where a 1-volt repair criteria apply. A total of 1172 indications were RPC inspected and 1152 were confirmed as flaws. SG-B had the largest number of indications among the four SGs with 1229 bobbin indications, of which 108 were above 1.0 volt. The largest indication, 11.06 volts, was found in SG-D. No ID indications at dented TSP intersections or circumferential indications at the TSP intersections or indications extending outside the TSP were found in this inspection. An automated analysis of bobbin coil data was performed to identify Mixed Residual Indications (MRIs) with a mix residual voltage above 1 volt. However, the primary and secondary bobbin data analysts could assign DSI voltages for many of these MRIs, especially the larger ones. For TSP locations where 3 volts repair criteria apply (hot side of TSPs 2, 3 and 4) all MRIs with a mix residual voltage above 3 volts were RPC inspected, and the DSI calls from primary and secondary analyses at those locations were confirmed. At other TSP locations with 1-volt repair criteria, MRIs over 1.5 mix residual volts were RPC inspected. Two indications each in SGs A and C were identified as flaws; as they were also called as DSIs by primary and secondary bobbin analyses, no RPC inspection expansion was required.

SLB leak rate and tube burst probability analyses were performed for all 4 SGs based on their actual measured EOC-8 bobbin voltage distributions as well as the projected EOC-9 bobbin voltage distributions. An evaluation presented in Reference 8-5 shows that the lower tube support plates, specifically TSPs 2, 3 and 4, undergo only a limited displacement during a postulated SLB event and, consequently, ODSCC indications at these TSP locations would be restrained from bursting even if their burst limit is exceeded. Therefore, in addition to calculating leak rates for a postulated SLB event using the conventional GL 95-05 methodology (Reference 8-3), leak rates for indications at the lower 3 TSPs were also calculated using the IRB leakage methodology discussed in Reference 8-4. SLB leak rates for all four SGs based on both the conventional GL 95-05 methodology as well as the IRB methodology are well within the allowable limit of 15.4 gpm.

Leak rates calculated using the actual measured EOC-8 voltages are higher than the projections presented in the last 90-day report (Reference 8-6) because the actual growth rates during Cycle 8 were higher than those assumed for the projections. The growth distribution applied for the EOC-8 projection was obtained

by examining the growth data for the prior two cycles and selecting the limiting distribution, consistent with the GL 95-05 guidelines. Steam generator C was projected to be the limiting SG at EOC-8, but the condition monitoring analysis predicts a higher SLB leak rate for SG-D. However, if the two largest indications in SG-D are removed, both SGs C and D yield comparable leak rates and burst probabilities. A few large indications in the population distribution tail may occur randomly in any SG, and they may not be predicted by a Monte Carlo analysis.

Tube burst probabilities under SLB conditions based on the conventional GL 95-05 methodology, which ignores the effect of TSPs restricting indications from bursting, are higher than the NRC recommended guideline of 10^{-2} for all 4 SGs. However, 92% of the EOC-8 indications were present at locations 2H, 3H and 4H and, as noted above, the support plates at those locations undergo only a limited displacement. The contribution from all such indications to the total SG burst probability is estimated to be 10^{-5} (Reference 8-5). Thus, the highest burst probability calculated among the 4 SGs, 1.0×10^{-3} for SG-B, is well within the NRC guideline of 10^{-2}.

The leak rate and tube burst probability projections at the EOC conditions for the current cycle (Cycle 9) are also well within their acceptable limits. Since TSPs 2, 3 and 4 are locked on the hot leg side by tube expansion, leak and burst analysis for indications at those intersections was based on the IRB methodology, with the conventional GL 95-05 methodology applied to the remaining indications. The limiting SLB leak rate projected for the EOC-9 conditions using the NRC SER endorsed probability of detection of 0.6 is 14.37 gpm. This value is projected for SG-B that had the largest number of indications at the EOC-8. Thus, the limiting EOC-9 leak rate projected is within the allowable leakage limit of 15.4 gpm (room temperature). The highest tube burst probability is also predicted for SG-B, and its magnitude is 3.5×10^{-3}. Therefore, steam generator tube burst probabilities are well within the NRC guideline of 10^{-2} for all 4 SGs.

Probability of detection (POPCD) for EOC-7 inspection was assessed using EOC-7 and EOC-8 inspection data. The POPCD values for EOC-7 inspection are below the generic POPCD in the voltage range 0.6 to 1 volt, but are above the 0.6 value specified in the GL 95-05 guidelines for tube integrity evaluations. Only one EOC-7 RPC NDD indications was left in service during Cycle 8; it was RPC tested during the EOC-8 inspection and confirmed. RPC NDF database for South Texas Unit-2 is still too small to recommend a confirmation rate for use in projection analyses. All RPC NDD indications are included in the EOC-9 projections presented in this report.

3.0 EOC-8 Inspection Results and Voltage Growth Rates

3.1 EOC-8 Inspection Results

According to the guidance provided by the NRC Generic Letter 95-05, the EOC-8 inspection of the South Texas Unit-2 SGs consisted of a complete, 100% eddy current (EC) bobbin probe examination of all tube support plate intersections in all four SGs. A 0.610 inch diameter probe was used for all hot and cold leg TSPs where the voltage-based repair criteria were applied. An extensive RPC inspection was performed during this inspection for TSP indications to identify potential leakers during normal operation for preventive plugging prior to Cycle 9 operation. About 70% of all indications over 0.6 volts were inspected with a +Point probe including all 101 indications above 3 volts at 2H, 3H and 4H (per the 3-volt repair criteria, one other indication above 5 volts was found at 5H) and all indications over 1 volt at the remaining TSP intersections for which 1-volt repair criteria apply. A total of 1172 indications were RPC inspected and 1152 were confirmed as flaws. SG-B had the largest number of indications among the four SGs with 1229 bobbin indications, of which 108 were above 1.0 volt. The largest indication, 11.06 volts, was found in SG-D. Only 3 indications were found on the cold leg side, and they all had a bobbin voltage below 0.5 volts. No ODSCC indications were found at the flow distribution baffle elevation. Tubes in the wedge regions are not excluded from the voltage-based repair criteria as they are not expected to deform excessively under design-basis SLB conditions.

There were no RPC circumferential indications at the TSPs and no RPC indications with potential ID phase angles. Also, no signal interference from copper deposits was found during this inspection, and no volumetric indications were reported during RPC inspection of ODSCC indications. No indications were found in 15 thermally-treated tubes in SG-D for which voltage-based repair criteria do not apply.

A total of 74 dents with a bobbin voltage over 5 volts were found at TSPs in all 4 SGs combined. (Dents called within ± 0.5" in the topmost TSP and within ± 0.4" in the remaining TSPs are considered to be within TSP.) All dented TSP intersections above 5 volts were inspected with a RPC probe in this inspection, and no degradation was found at those locations.

An automated analysis of bobbin coil data was performed to identify MRIs that may be of sufficient size where a small crack might be distorted and thus missed during the analysis. A mix residual voltage of 1 volt was used as the cut-off for this automated analysis. However, primary and secondary bobbin data analysts could assign DSI voltages for many of these MRIs, especially the larger ones. For TSP locations where 3 volts repair criteria apply (hot side of TSPs 2, 3 and 4) all MRIs with a mix residual voltage above 3 volts were RPC inspected and the DSI calls from the primary and secondary analyses for those locations was confirmed.

At other TSP locations with 1-volt repair criteria, MRIs over 1.5 mix residual volts were RPC inspected. Two indications each in SGs A and C were identified as flaws; as they were also called DSIs by primary and secondary bobbin analyses, no RPC inspection expansion was required.

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 number of indications that remain active for Cycle 9 operation is the difference between the observed and the ones removed from service.

Although a total of 1124 indications were removed from service at this outage, only 112 of those failed to meet the repair criteria applicable to them (3 volts for indications at 2H to 4H and 1 volt for the remainder indications). A large majority of the remaining indications were repaired preventively to minimize the potential for normal operation leakage during Cycle 9; some were repaired for non-ODSCC causes. All indications over 1.5 volts and a majority of the TSP indications between 0.6 and 1.5 volts (over 50%) were also plugged as part of the preventive plugging program. No cold leg TSP ODSCC indications required repair. A review of Table 3-1 indicates that more indications (a quantity of 950 indications, with 15 above 1.0 volt) were returned to service in SG-B than the other SGs, thereby it potentially will be the limiting SG at EOC-9 from the standpoint of SLB leak rate and tube burst probability.

Figure 3-1 shows the actual bobbin voltage distribution determined from the EOC-8 EC inspection; Figure 3-2 shows the population distribution of those EOC-8 indications removed from service as part of the preventive plugging program and tube repairs; Figure 3-3 shows the distribution for indications returned to service for Cycle 9. The distribution of EOC-8 indications as a function of support plate location is summarized in Table 3-2 and plotted in Figure 3-4. The data show a strong predisposition of ODSCC to occur in the first few hot leg TSPs (3308 out of 3580 indications occurred at hot leg intersections in the first three TSPs above the flow distribution baffle plate), although the mechanism extended to higher TSPs. Only 4 ODSCC indications were detected on the cold leg side. This distribution indicates the predominant temperature dependence of ODSCC at South Texas Unit-2, 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 9 operation, voltage growth rates were developed from EOC-8 inspection data and a reevaluation of the EOC-7 inspection EC signals for the same indications. Table 3-3 shows the cumulative probability distribution (CPDF) for growth rate in each South Texas Unit-2 steam generator during Cycle 8 (November 1999 to

March 2001) on an EFPY basis, along with the corresponding Cycle 7 growth rate distributions. Cycle 8 growth data are also plotted in Figure 3-5. The curve labelled 'cumulative' in Figure 3-5 represents averaged composite growth data from all four SGs.

Average growth rates for each SG during Cycle 8 are summarized in Table 3-4. Among the four steam generators, SG-D had a slightly larger magnitude for average voltage growth during Cycle 8; it also had the indication with the largest voltage growth (see Table 3-2). Steam generators A and C were tied for the largest average growth during Cycle 7. The average composite voltage growth rate for the four SGs during Cycle 8 is 81.9%/EFPY, which is about 80% higher than the last cycle growth rate (45.4%/EFPY). The increase in Cycle 8 average growth rate reflects growth increase for smaller indications (BOC indications below 0.75 volts, about 84%/EFPY) since larger indications (above 0.75 volts) had a smaller increase (about 52%/EFPY).

Large growth also occurred during the Cycle 6 operation of Braidwood Unit-1 and the second half of Cycle 7 in Byron Unit-1. Figure 3-6 compares the growth distributions for these two cycles with the latest growth data for South Texas Unit-2. Cumulative probability distribution functions for the all SG composite voltage growth are shown. The growth data are presented on an EFPY basis to account for the differences in the operating periods. The data in Figure 3-6 show that the South Texas Unit-2 Cycle 8 growth distribution is comparable to the Braidwood Unit-1 Cycle 6 growth data. The largest voltage growth observed in Braidwood-1 Cycle 6 was 8.1 volts/EFPY versus 8.6 volts/EFPY for South Texas Unit-2 Cycle 8.

The voltage growth data for the above Braidwood-1 and Byron-1 cycles exhibited a dependency on the BOC voltage. The Cycle 7 growth data for South Texas Unit-2 also appeared to be dependent on the BOC voltage. To determine if the latest growth data for South Texas Unit-2 exhibited a dependency on the BOC voltage, Cycle 8 growth values were plotted against their BOC-8 voltage, and the resulting plot is shown in Figure 3-7. The data in Figure 3-7 do not show a meaningful dependency on BOC voltage as the relative frequencies for large growths among indications under 0.5 volts are comparable to those for indications over 0.5 volts. For example, the frequency of growth over 5 volts for indications under 0.5 volts is about 1.9% (56 out 2912) compared to about 4.4% (29 out of 659) for indications above 0.5 volts. Therefore, EOC-9 leak rate and burst probability projections assumed growth to be independent of BOC voltage.

Averaged composite voltage growth data from all four steam generators for the last four operating periods are summarized in Table 3-5. It is evident that the average growth rate during Cycle 8 is significantly higher than that during Cycle 7. In Figure 3-8, the cumulative probability distribution (CPDF) for composite growth rate data from all SGs during Cycle 8 is compared with that for Cycle 7. Clearly

the growth distribution for Cycle 8 is more limiting than that for Cycle 7. The guidelines in 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 operating cycle. Therefore, Cycle 8 growth distribution was used to develop EOC-9 predictions.

Since TSPs 2, 3 and 4 are locked on the hot side by tube expansion, leak and burst analysis for indications at those intersections should be based on the IRB methodology, with the conventional GL 95-05 methodology applied to the remaining indications. Therefore, separate growth distributions are needed for the indications at the bottom 3 TSPs and the rest of the population. Cycle 8 growth distributions for the indications on the hot side at bottom 3 TSPs are shown in Table 3-6 for all 4 SGs on an EFPY basis. The analysis methodology presented in WCAP-14277 (Reference 8-3) recommends that 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 the individual SGs. SG-D had the limiting growth during Cycle 8, and its distribution was conservatively applied to indications at the lower 3 TSPs in all SGs. To further increase conservatism in the projections for Cycle 9, top 5 growth values from the remaining 3 SGs were added to the SG-D Cycle 8 growth distribution. So, the composite growth distribution applied for the Cycle 9 projections for indications at 2H to 4H includes 9 largest growth values for Cycle 8. The growth data was assumed to be independent of the beginning of cycle voltage, as discussed above.

Separate Cycle 8 growth distributions were established for indications above the TSP 4 for all SGs and they are shown in Table 3-7 along with the composite growth distribution based on all indications for Cycle 7. Cycle 8 composite distribution is more conservative than the Cycle 7 distribution. Also, the Cycle 8 composite distribution is nearly the same as the SG-D distribution (which is the limiting SG distribution) and, therefore, it was applied for all indications above TSP 4 in all SGs.

Table 3-8 lists the top 50 indications on the basis of Cycle 8 growth rates in the descending order. All of those indications were RPC confirmed during this inspection. Seven of the 50 indications shown are new indications and EOC-7 voltages used to estimate growth rates for them were obtained by revaluating the last inspection data. Thirty-three of these indications had a BOC-8 voltage less than 0.5 volts, which supports earlier observation that small indications had higher growth during Cycle 8 than larger indications.

3.3 NDE Uncertainties

The NDE uncertainties applied for the Cycle 8 voltage distributions in the Monte Carlo analyses for leak rate and burst probabilities are the same as those previously reported in the South Texas Unit-2 voltage-based repair criteria report

of Reference 8-6 and NRC Generic Letter 95-05 (Reference 8-1). They are presented in Table 3-9 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 for SLB leak rates and tube burst probabilities based on the EOC-8 actual voltage distributions as well as for the EOC-9 projections.

3.4 Probability of Prior Cycle Detection (POPCD)

The inspection results at EOC-8 permit an evaluation of the probability of detection (POD) at the prior EOC-7 inspection. For voltage-based repair criteria applications, the important indications are those that could significantly contribute to EOC leakage or burst probability. These significant indications can be expected to be detected by bobbin and confirmed by RPC inspection. Thus, the population of interest for voltage-based repair criteria 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-7 inspection can then be defined as follows.

$$\text{POPCD (EOC-7)} = \frac{\text{EOC-7 cycle reported indications confirmed by RPC in EOC-8 inspection} + \text{Indications confirmed and repaired in EOC-7 inspection}}{\text{\{Numerator\}} + \text{New indications RPC confirmed in EOC-8 inspection}}$$

POPCD is evaluated at the 1999 EOC-7 voltage values (from 2001 EOC-8 reevaluation for growth rate) since it is an EOC-7 POPCD assessment. The indications detected at EOC-7 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-8. 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-8 indications not reported in the EOC-7 inspection. The new indications include EOC-7 indications present at detectable levels but not reported, indications present at EOC-7 below detectable levels and indications that initiated during Cycle 8. Thus, this definition, by including newly initiated indications, differs from the traditional POD definition. Since the newly initiated indications are appropriate

for voltage-based repair criteria applications, POPCD is an acceptable definition and eliminates the need to adjust the traditional POD for new indications.

The above definition for POPCD would be entirely appropriate if all EOC-8 indications were RPC inspected. Since only a fraction of bobbin indications are generally RPC inspected, POPCD could be distorted by using only the RPC inspected indications. Thus, a more appropriate POPCD estimate can be made by assuming that all bobbin indications not RPC inspected would have been RPC confirmed. This definition is applied only for the EOC-8 indications not RPC inspected since inclusion for the EOC-7 inspection could increase POPCD by including indications on a tube plugged for non-ODSCC causes which could be RPC NDF indications. In addition, the objective of using RPC confirmation for POPCD is to distinguish detection of indications at EOC_{n-1} that could contribute to burst at EOC_n so that the emphasis is on EOC_n RPC confirmation. This POPCD can be obtained by replacing the EOC-8 RPC confirmed by RPC confirmed plus not RPC inspected in the above definition of POPCD. For this report, both POPCD definitions are evaluated for South Texas Unit-2.

The POPCD evaluation for the 1999 EOC-7 inspection data is summarized in Table 3-10 and illustrated on Figure 3-10. A generic POPCD distribution developed by analyses of 23 inspections in 10 plants and presented in Table 7-4 of Reference 8-7 is also shown in the figure. It is seen from Figure 3-10 that the POPCD values for South Texas Unit-2 are below the generic POPCD in the voltage range 0.6 to 1 volt, but are higher than the 0.6 value specified in Reference 1 for tube integrity evaluations.

3.5 Assessment of RPC Confirmation Rates

This section tracks the 1999 EOC-7 indications were left in service at BOC-8 relative to RPC inspection results in 2001 at EOC-8. The composite results for all SGs are given in Table 3-11. For EOC-7 bobbin indications left in service, the indications are tracked relative to EOC-7 RPC confirmed, EOC-7 RPC NDD, EOC-7 bobbin indications not RPC inspected, and EOC-7 bobbin indications with no indication found in EOC-8. Also included are new EOC-8 indications. The table shows, for each category of indications, the number of indications RPC inspected and RPC confirmed in EOC-8, as well as the percentage of RPC confirmed indications.

Only one EOC-7 RPC NDD indication was left in service at BOC-8, and it was RPC tested during the EOC-8 inspection and confirmed. Therefore RPC confirmation rate for prior RPC NDD indications is 100%. Including the similar data from the previous inspections for both units, 10 out 16 NDD indications have been confirmed in the subsequent inspection, thus yielding a confirmation rate of 63%. All RPC NDD indications are included in the EOC-9 projections presented in this report.

3.6 Probe Wear Criteria

An alternate probe wear criterion approved by the NRC (Reference 8-8) was applied during the EOC-8 inspection. When a probe does not pass the 15% wear limit, this alternate criteria requires that only 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 indications at 2H, 3H and 4H locations is 3 volts, for purposes of probe wear evaluation the repair limit for indications is taken as 1 volt. Therefore, all tubes containing indications for which worn probe voltage was above 0.75 volts were inspected with a new probe. An evaluation of worn probe and new probe data is presented in the following paragraphs.

In accordance with the guidance provided in Reference 8-8, voltages measured with a worn probe and a new probe at the same location were analyzed to ensure that the voltages measured with worn probes are within 15% of the new probe voltages. No new indications were detected with new probes; thus, worn probes did not miss significant indications. Figures 3-11 and 3-12 show plots of the worn probe voltages plotted against the new probe voltages for all four SGs. The data in these figures show a consistent relationship between the two voltages. Composite data from all 4 SGs are plotted in Figure 3-13. Also shown in Figure 3-13 as a solid line is a linear regression for the data and dashed lines representing tolerance limits that bound 90% of the population at 95% confidence. The mean regression line has nearly 45° slope indicating that, on the average, both the worn probe and new probe yielded essentially the same voltage. As the repair limit for all indications is treated as 1 volt, the dotted horizontal line at 0.75 worn probe volts demarcates indications requiring retest from those that do not. The shaded area at the bottom shows the region where a tube requiring repair may be left in service because of probe wear (assuming that a 1-volt repair criteria applies also to indications at 2H, 3H and 4H). In the South Texas Unit-2 EOC-8 inspection, there are no occurrences for which a worn probe was less than 0.75 volts and the new probe voltage exceeded the plugging limit, i.e., no pluggable tubes were missed due to probe wear considerations.

Among the indications requiring retesting (worn probe volts > 0.75 volts), only 5 indications fall outside the 90%/95% tolerance limit bands. Even these indications are bounded by the band formed by the dot-dash lines representing ±20% of the new probe voltages. For one of those 5 indications the worn probe voltage is higher than the corresponding new probe voltage, i.e., the worn probe voltage is conservative, and for the other 4 indications both the worn and new probe voltages above 3 volts, i.e., they would be flagged for repair based on either of the two voltages. Therefore, the data for the 5 indications outside the 90%/95% tolerance band are acceptable.

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

Table 3-1 (Part 1 of 4)
South Texas Unit-2 March 2001 Outage
Summary of Inspection and Repair For Tubes in Service During Cycle 8

Voltage Bin	Steam Generator A						Steam Generator B					
	In-Service During Cycle 8				RTS for Cycle 9		In-Service During Cycle 8				RTS for Cycle 9	
	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	1	0	0	0	1	1	0	0	0	0	0	0
0.2	10	0	0	1	9	9	24	0	0	0	24	24
0.3	53	0	0	9	44	44	141	1	0	9	132	131
0.4	92	1	1	19	73	73	252	2	1	23	229	228
0.5	94	6	6	15	79	79	208	15	15	18	190	190
0.6	85	12	12	21	64	64	200	30	28	29	171	169
0.7	62	44	43	39	23	23	129	75	74	34	95	94
0.8	54	40	40	39	15	15	81	56	55	31	50	49
0.9	37	33	33	28	9	9	55	37	36	23	32	31
1	17	15	15	12	5	5	31	26	26	19	12	12
1.1	13	13	13	12	1	1	25	24	24	17	8	8
1.2	10	10	10	10	0	0	18	18	17	14	4	3
1.3	4	3	3	4	0	0	3	3	3	2	1	1
1.4	12	12	12	12	0	0	9	9	9	7	2	2
1.5	6	6	6	6	0	0	6	5	5	6	0	0
1.6	4	1	1	4	0	0	4	0	0	4	0	0
1.7	6	0	0	6	0	0	3	1	1	3	0	0
1.8	4	0	0	4	0	0	4	0	0	4	0	0
1.9	2	0	0	2	0	0	3	0	0	3	0	0
2	2	0	0	2	0	0	0	0	0	0	0	0
2.1	1	0	0	1	0	0	3	0	0	3	0	0
2.2	2	0	0	2	0	0	2	0	0	2	0	0
2.3	4	0	0	4	0	0	0	0	0	0	0	0
2.4	4	0	0	4	0	0	2	0	0	2	0	0
2.5	1	0	0	1	0	0	1	0	0	1	0	0
2.6	5	0	0	5	0	0	1	0	0	1	0	0
2.7	0	0	0	0	0	0	1	0	0	1	0	0
2.8	1	0	0	1	0	0	1	0	0	1	0	0
2.9	0	0	0	0	0	0	2	0	0	2	0	0
3	3	0	0	3	0	0	1	0	0	1	0	0
3.1	0	0	0	0	0	0	0	0	0	0	0	0
3.2	2	2	2	2	0	0	2	2	2	2	0	0
3.3	2	2	2	2	0	0	1	1	1	1	0	0
3.4	0	0	0	0	0	0	0	0	0	0	0	0
3.5	0	0	0	0	0	0	1	1	1	1	0	0
3.6	0	0	0	0	0	0	1	1	1	1	0	0
3.8	0	0	0	0	0	0	0	0	0	0	0	0
3.9	0	0	0	0	0	0	1	1	1	1	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0

Table continues on the next page

Table 3-1 (Part 2 of 4)
South Texas Unit-2 March 2001 Outage
Summary of Inspection and Repair For Tubes in Service During Cycle 8

Voltage Bin	Steam Generator A						Steam Generator B					
	In-Service During Cycle 8				RTS for Cycle 9		In-Service During Cycle 8				RTS for Cycle 9	
	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
Table continues from the previous page												
4.1	1	1	1	1	0	0	0	0	0	0	0	0
4.2	0	0	0	0	0	0	0	0	0	0	0	0
4.3	1	1	1	1	0	0	0	0	0	0	0	0
4.4	2	2	2	2	0	0	0	0	0	0	0	0
4.5	3	3	3	3	0	0	1	1	1	1	0	0
4.6	1	1	1	1	0	0	0	0	0	0	0	0
4.8	0	0	0	0	0	0	0	0	0	0	0	0
4.9	0	0	0	0	0	0	2	2	2	2	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
5.1	1	1	1	1	0	0	0	0	0	0	0	0
5.2	0	0	0	0	0	0	0	0	0	0	0	0
5.3	0	0	0	0	0	0	2	2	2	2	0	0
5.4	1	1	1	1	0	0	0	0	0	0	0	0
5.5	1	1	1	1	0	0	2	2	2	2	0	0
5.7	0	0	0	0	0	0	1	1	1	1	0	0
5.9	1	1	1	1	0	0	0	0	0	0	0	0
6	1	1	1	1	0	0	1	1	1	1	0	0
6.1	0	0	0	0	0	0	0	0	0	0	0	0
6.2	0	0	0	0	0	0	0	0	0	0	0	0
6.3	0	0	0	0	0	0	0	0	0	0	0	0
6.4	1	1	1	1	0	0	0	0	0	0	0	0
6.5	0	0	0	0	0	0	1	1	1	1	0	0
6.7	0	0	0	0	0	0	1	1	1	1	0	0
6.8	0	0	0	0	0	0	0	0	0	0	0	0
6.9	0	0	0	0	0	0	0	0	0	0	0	0
7	1	1	1	1	0	0	1	1	1	1	0	0
7.1	1	1	1	1	0	0	0	0	0	0	0	0
7.3	0	0	0	0	0	0	0	0	0	0	0	0
7.4	1	1	1	1	0	0	0	0	0	0	0	0
7.5	0	0	0	0	0	0	0	0	0	0	0	0
7.7	0	0	0	0	0	0	0	0	0	0	0	0
7.9	0	0	0	0	0	0	0	0	0	0	0	0
8.1	1	1	1	1	0	0	0	0	0	0	0	0
8.2	0	0	0	0	0	0	0	0	0	0	0	0
9.8	0	0	0	0	0	0	1	1	1	1	0	0
10.4	0	0	0	0	0	0	0	0	0	0	0	0
11.06	0	0	0	0	0	0	0	0	0	0	0	0
Total	611	218	217	288	323	323	1229	321	313	279	950	942
>1 v	106	67	67	105	1	1	108	79	78	93	15	14
> 3 v	22	22	22	22	0	0	19	19	19	19	0	0
>5 v	10	10	10	10	0	0	10	10	10	10	0	0

Table 3-1 (Part 3 of 4)
South Texas Unit-2 March 2001 Outage
Summary of Inspection and Repair For Tubes in Service During Cycle 8

Voltage Bin	Steam Generator C						Steam Generator D						Composite of All SGs					
	In-Service During Cycle 8				RTS for Cycle 9		In-Service During Cycle 8				RTS for Cycle 9		In-Service During Cycle 8				RTS for Cycle 9	
	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	Field Bobbin Indications	RPC Inspected	RPC Confirmed	Indications Repaired	All Indications	Confirmed & Not Inspected Indications Only
0.1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1
0.2	10	2	2	2	8	8	4	0	0	0	4	4	48	2	2	3	45	45
0.3	77	2	1	7	70	69	54	3	3	8	46	46	325	6	4	33	292	290
0.4	169	2	2	17	152	152	116	8	8	18	98	98	629	13	12	77	552	551
0.5	150	7	6	15	135	134	154	17	16	19	135	134	606	45	43	67	539	537
0.6	152	27	27	25	127	127	139	44	43	26	113	112	576	113	110	101	475	472
0.7	119	73	72	36	83	82	79	54	51	34	45	42	389	246	240	143	246	241
0.8	94	68	68	40	54	54	61	45	44	30	31	31	290	209	207	140	150	149
0.9	50	32	32	21	29	29	27	24	24	17	10	10	169	126	125	89	80	79
1	34	30	29	14	20	19	16	16	16	14	2	2	98	87	86	59	39	38
1.1	16	16	16	12	4	4	22	21	21	16	6	6	76	74	74	57	19	19
1.2	15	13	12	9	6	6	14	14	14	13	1	1	57	55	53	46	11	10
1.3	12	12	12	11	1	1	10	10	10	10	0	0	29	28	28	27	2	2
1.4	7	7	7	6	1	1	6	6	6	5	1	1	34	34	34	30	4	4
1.5	8	8	8	7	1	1	6	6	6	6	0	0	26	25	25	25	1	1
1.6	1	0	0	1	0	0	1	0	0	1	0	0	10	1	1	10	0	0
1.7	1	0	0	1	0	0	4	0	0	4	0	0	14	1	1	14	0	0
1.8	3	0	0	3	0	0	4	0	0	4	0	0	15	0	0	15	0	0
1.9	8	0	0	8	0	0	1	0	0	1	0	0	14	0	0	14	0	0
2	5	0	0	5	0	0	3	1	1	3	0	0	10	1	1	10	0	0
2.1	4	0	0	4	0	0	2	0	0	2	0	0	10	0	0	10	0	0
2.2	2	0	0	2	0	0	0	0	0	0	0	0	6	0	0	6	0	0
2.3	2	0	0	2	0	0	0	0	0	0	0	0	6	0	0	6	0	0
2.4	2	0	0	2	0	0	2	1	1	2	0	0	10	1	1	10	0	0
2.5	2	0	0	2	0	0	4	1	1	4	0	0	8	1	1	8	0	0
2.6	0	0	0	0	0	0	1	0	0	1	0	0	7	0	0	7	0	0
2.7	0	0	0	0	0	0	2	1	1	2	0	0	3	1	1	3	0	0
2.8	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0
2.9	0	0	0	0	0	0	1	1	1	1	0	0	3	1	1	3	0	0
3	1	0	0	1	0	0	2	0	0	2	0	0	7	0	0	7	0	0
3.1	2	2	2	2	0	0	1	1	1	1	0	0	3	3	3	3	0	0
3.2	1	1	1	1	0	0	0	0	0	0	0	0	5	5	5	5	0	0
3.3	1	1	1	1	0	0	1	1	1	1	0	0	5	5	5	5	0	0
3.4	1	1	1	1	0	0	1	1	1	1	0	0	2	2	2	2	0	0
3.5	1	1	1	1	0	0	1	1	1	1	0	0	3	3	3	3	0	0
3.6	0	0	0	0	0	0	1	1	1	1	0	0	2	2	2	2	0	0
3.8	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1	0	0
3.9	2	2	2	2	0	0	0	0	0	0	0	0	3	3	3	3	0	0
4	1	1	1	1	0	0	2	2	2	2	0	0	3	3	3	3	0	0

Table continues on the next page

Table 3-1 (Part 4 of 4)
South Texas Unit-2 March 2001 Outage
Summary of Inspection and Repair For Tubes in Service During Cycle 8

Voltage Bin	Steam Generator C						Steam Generator D						Composite of All SGs					
	In-Service During Cycle 8				RTS for Cycle 9		In-Service During Cycle 8				RTS for Cycle 9		In-Service During Cycle 8				RTS for Cycle 9	
	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	Field Bobbin Indications	RPC Inspected	RPC Confirmed	Indications Repaired	All Indications	Confirmed & Not Inspected Indications Only
Table continues from the previous page																		
4.1	3	3	3	3	0	0	2	2	2	2	0	0	6	6	6	6	0	0
4.2	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1	0	0
4.3	0	0	0	0	0	0	1	1	1	1	0	0	2	2	2	2	0	0
4.4	0	0	0	0	0	0	2	2	2	2	0	0	4	4	4	4	0	0
4.5	1	1	1	1	0	0	2	2	2	2	0	0	7	7	7	7	0	0
4.6	1	1	1	1	0	0	2	2	2	2	0	0	4	4	4	4	0	0
4.8	1	1	1	1	0	0	2	2	2	2	0	0	3	3	3	3	0	0
4.9	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	0	0
5	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1	0	0
5.1	0	0	0	0	0	0	2	2	2	2	0	0	3	3	3	3	0	0
5.2	0	0	0	0	0	0	1	1	1	1	0	0	1	1	1	1	0	0
5.3	1	1	1	1	0	0	1	1	1	1	0	0	4	4	4	4	0	0
5.4	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0
5.5	0	0	0	0	0	0	1	1	1	1	0	0	4	4	4	4	0	0
5.7	1	1	1	1	0	0	0	0	0	0	0	0	2	2	2	2	0	0
5.9	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	0	0
6.1	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1	0	0
6.2	2	2	2	2	0	0	1	1	1	1	0	0	3	3	3	3	0	0
6.3	0	0	0	0	0	0	1	1	1	1	0	0	1	1	1	1	0	0
6.4	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0
6.5	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0
6.7	0	0	0	0	0	0	1	1	1	1	0	0	2	2	2	2	0	0
6.8	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1	0	0
6.9	0	0	0	0	0	0	1	1	1	1	0	0	1	1	1	1	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	0	0
7.1	0	0	0	0	0	0	1	1	1	1	0	0	2	2	2	2	0	0
7.3	0	0	0	0	0	0	1	1	1	1	0	0	1	1	1	1	0	0
7.4	1	1	1	1	0	0	0	0	0	0	0	0	2	2	2	2	0	0
7.5	0	0	0	0	0	0	1	1	1	1	0	0	1	1	1	1	0	0
7.7	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1	0	0
7.9	0	0	0	0	0	0	1	1	1	1	0	0	1	1	1	1	0	0
8.1	1	1	1	1	0	0	0	0	0	0	0	0	2	2	2	2	0	0
8.2	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1	0	0
9.8	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0
10.4	0	0	0	0	0	0	1	1	1	1	0	0	1	1	1	1	0	0
11.06	0	0	0	0	0	0	1	1	1	1	0	0	1	1	1	1	0	0
Total	972	327	322	281	691	687	768	306	300	276	492	487	3580	1172	1152	1124	2456	2439
>1 v	117	84	83	104	13	13	118	95	95	110	8	8	449	325	323	412	37	36
> 3 v	28	28	28	28	0	0	33	33	33	33	0	0	102	102	102	102	0	0
>5 v	10	10	10	10	0	0	15	15	15	15	0	0	45	45	45	45	0	0

Table 3-2
South Texas Unit-2 March 2001
TSP ODSCC Indication Distributions for Tubes in Service During Cycle 8

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
02H	305	8.05	1.02	7.67	0.66	497	9.72	0.76	9.54	0.39	360	8.16	0.90	7.86	0.52
03H	196	5.37	0.76	4.96	0.36	408	6.93	0.60	6.73	0.22	324	6.08	0.66	5.39	0.29
04H	76	1.37	0.52	1.02	0.19	238	2.56	0.49	2.27	0.13	200	7.36	0.70	6.82	0.32
05H	31	1.46	0.49	0.73	0.14	80	5.27	0.54	4.92	0.21	53	1.33	0.56	1.07	0.18
06H	2	0.49	0.43	0.09	0.05	5	0.44	0.40	0.17	0.06	27	1.28	0.56	0.55	0.18
07H	1	0.43	0.43	0.23	0.23	0	-	-	-	-	4	0.67	0.43	0.18	0.10
08H	0	-	-	-	-	0	-	-	-	-	1	0.42	0.42	0.13	0.13
11C	0	-	-	-	-	0	-	-	-	-	3	0.21	0.19	0.03	-0.01
21C	0	-	-	-	-	1	0.31	0.31	0.04	0.04	0	-	-	-	-
Total	611					1229					972				

Tube Support Plate	Steam Generator D					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
02H	378	10.37	0.86	9.93	0.52	1540	10.37	0.87	9.93	0.50
03H	267	11.06	0.88	10.72	0.50	1195	11.06	0.71	10.72	0.32
04H	59	7.85	0.84	7.00	0.49	573	7.85	0.60	7.00	0.24
05H	42	2.42	0.53	1.98	0.21	206	5.27	0.54	4.92	0.19
06H	20	0.79	0.46	0.55	0.18	54	1.28	0.51	0.55	0.17
07H	1	0.43	0.43	0.14	0.14	6	0.67	0.43	0.23	0.13
08H	1	0.53	0.53	0.12	0.12	2	0.53	0.48	0.13	0.13
11C	0	-	-	-	-	3	0.21	0.19	0.03	-0.01
21C	0	-	-	-	-	1	0.31	0.31	0.04	0.04
Total	768					3580				

Table 3-3 (Part 1 of 2)
South Texas Unit-2 March 2001
Signal Growth Statistics For Cycle 8 on an EFPY Basis

Delta Volts	Steam Generator A			Steam Generator B			Steam Generator C			Steam Generator D			Cumulative		
	Cycle 7	Cycle 8		Cycle 7	Cycle 8		Cycle 7	Cycle 8		Cycle 7	Cycle 8		Cycle 7	Cycle 8	
	CPDF	No. of Inds	CPDF	CPDF	No. of Inds	CPDF	CPDF	No. of Inds	CPDF	CPDF	No. of Inds	CPDF	CPDF	No. of Inds	CPDF
-0.3	0.0	1	0.002	0.002	1	0.001	0.0	1	0.001	0.0	0	0.0	0.001	3	0.001
-0.2	0.0	0	0.002	0.005	1	0.002	0.0	0	0.001	0.0	0	0.0	0.002	1	0.001
-0.1	0.006	4	0.008	0.021	8	0.008	0.008	2	0.003	0.012	3	0.004	0.013	17	0.006
0	0.085	49	0.088	0.136	113	0.1	0.06	61	0.066	0.111	36	0.051	0.103	259	0.078
0.1	0.358	172	0.37	0.48	505	0.511	0.4	324	0.399	0.493	213	0.328	0.444	1214	0.417
0.2	0.688	134	0.589	0.81	297	0.753	0.724	274	0.681	0.757	220	0.615	0.757	925	0.676
0.3	0.818	93	0.741	0.907	142	0.868	0.846	121	0.806	0.868	120	0.771	0.869	476	0.809
0.4	0.879	44	0.813	0.951	57	0.915	0.905	51	0.858	0.922	48	0.833	0.922	200	0.865
0.5	0.924	20	0.846	0.968	24	0.934	0.935	41	0.9	0.936	30	0.872	0.946	115	0.897
0.6	0.948	15	0.871	0.974	12	0.944	0.95	18	0.919	0.948	17	0.895	0.958	62	0.914
0.7	0.964	6	0.881	0.978	16	0.957	0.962	9	0.928	0.957	8	0.905	0.967	39	0.925
0.8	0.967	5	0.889	0.98	4	0.96	0.963	6	0.934	0.961	4	0.91	0.969	19	0.93
0.9	0.976	6	0.899	0.98	2	0.962	0.97	8	0.942	0.965	9	0.922	0.973	25	0.937
1	0.976	7	0.91	0.982	6	0.967	0.973	1	0.943	0.975	5	0.928	0.977	19	0.942
1.1	0.976	8	0.923	0.983	4	0.97	0.977	5	0.949	0.979	2	0.931	0.979	19	0.948
1.2	0.976	2	0.926	0.984	4	0.973	0.978	8	0.957	0.979	3	0.935	0.98	17	0.953
1.3	0.976	2	0.93	0.987	2	0.975	0.98	4	0.961	0.981	0	0.935	0.982	8	0.955
1.4	0.979	3	0.935	0.988	2	0.976	0.98	3	0.964	0.983	4	0.94	0.983	12	0.958
1.5	0.979	7	0.946	0.989	2	0.978	0.983	6	0.97	0.99	1	0.941	0.986	16	0.963
1.6	0.982	4	0.953	0.99	0	0.978	0.983	0	0.97	0.994	3	0.945	0.988	7	0.965
1.7	0.982	2	0.956	0.993	3	0.98	0.983	0	0.97	0.994	2	0.948	0.989	7	0.966
1.8	0.985	1	0.957	0.994	1	0.981	0.983	0	0.97	0.994	4	0.953	0.99	6	0.968
1.9	0.985	0	0.957	0.994	3	0.984	0.987	1	0.971	0.994	1	0.954	0.991	5	0.97
2	0.985	1	0.959	0.994	1	0.985	0.987	0	0.971	0.994	2	0.957	0.991	4	0.971
2.1	0.985	1	0.961	0.995	1	0.985	0.987	1	0.972	0.996	0	0.957	0.992	3	0.972
2.2	0.988	3	0.966	0.995	0	0.985	0.99	2	0.974	0.996	1	0.958	0.993	6	0.973
2.3	0.988	3	0.971	0.995	1	0.986	0.992	2	0.976	0.996	0	0.958	0.993	6	0.975
2.4	0.988	0	0.971	0.995	2	0.988	0.992	1	0.977	0.996	2	0.961	0.993	5	0.976
2.5	0.988	0	0.971	0.996	1	0.989	0.992	1	0.978	0.996	2	0.964	0.994	4	0.977
2.7	0.988	1	0.972	0.998	0	0.989	0.992	1	0.979	0.996	0	0.964	0.994	2	0.978
2.8	0.994	0	0.972	0.998	1	0.989	0.993	3	0.983	0.996	2	0.966	0.996	6	0.98
2.9	0.997	1	0.974	0.998	0	0.989	0.993	2	0.985	1.0	1	0.967	0.997	4	0.981
3	1.0	0	0.974	0.998	0	0.989	0.995	1	0.986		3	0.971	0.998	4	0.982

Table Continues on the Next Page

Table 3-3 (Part 2 of 2)
South Texas Unit-2 March 2001
Signal Growth Statistics For Cycle 8 on an EFPY Basis

Delta Volts	Steam Generator A			Steam Generator B			Steam Generator C			Steam Generator D			Cumulative		
	Cycle 7	Cycle 8		Cycle 7	Cycle 8		Cycle 7	Cycle 8		Cycle 7	Cycle 8		Cycle 7	Cycle 8	
	CPDF	No. of Inds	CPDF	CPDF	No. of Inds	CPDF	CPDF	No. of Inds	CPDF	CPDF	No. of Inds	CPDF	CPDF	No. of Inds	CPDF
Table Continues from Previous Page															
3.1		1	0.975	0.998	0	0.989	0.995	1	0.987		1	0.973	0.998	3	0.983
3.2		1	0.977	0.998	1	0.99	0.995	0	0.987		2	0.975	0.998	4	0.984
3.3		3	0.982	0.998	0	0.99	0.995	1	0.988		1	0.977	0.998	5	0.985
3.4		1	0.984	0.999	0	0.99	0.997	1	0.989		1	0.978	0.999	3	0.986
3.5		0	0.984	0.999	1	0.991	0.997	0	0.989		1	0.979	0.999	2	0.987
3.6		0	0.984	0.999	1	0.992	0.997	0	0.989		2	0.982	0.999	3	0.987
3.7		1	0.985	0.999	1	0.993	0.997	0	0.989		2	0.984	0.999	4	0.989
3.8		0	0.985	0.999	0	0.993	0.998	2	0.991		0	0.984	0.999	2	0.989
3.9		0	0.985	0.999	2	0.994	0.998	0	0.991		1	0.986	0.999	3	0.99
4		1	0.987	0.999	1	0.995	0.998	0	0.991		1	0.987	0.999	3	0.991
4.1		1	0.989	1.0	1	0.996	1.0	0	0.991		0	0.987	1.0	2	0.991
4.3		0	0.989		1	0.997		3	0.994		0	0.987		4	0.992
4.4		2	0.992		0	0.997		0	0.994		0	0.987		2	0.993
4.6		0	0.992		0	0.997		1	0.995		0	0.987		1	0.993
4.7		0	0.992		0	0.997		0	0.995		2	0.99		2	0.994
4.8		1	0.993		1	0.998		0	0.995		0	0.99		2	0.994
4.9		0	0.993		1	0.998		0	0.995		1	0.991		2	0.995
5		0	0.993		0	0.998		1	0.996		0	0.991		1	0.995
5.1		1	0.995		0	0.998		0	0.996		0	0.991		1	0.996
5.2		0	0.995		0	0.998		0	0.996		1	0.992		1	0.996
5.4		0	0.995		1	0.999		0	0.996		2	0.995		3	0.997
5.5		1	0.997		0	0.999		1	0.997		0	0.995		2	0.997
5.6		1	0.998		0	0.999		0	0.997		1	0.996		2	0.998
5.8		0	0.998		0	0.999		1	0.998		1	0.997		2	0.998
6.2		1	1.0		0	0.999		0	0.998		0	0.997		1	0.999
6.3		0			0	0.999		2	1.0		0	0.997		2	0.999
7.7		0			1	1.0		0			0	0.997		1	0.999
8		0			0			0			1	0.999		1	1.0
8.6		0			0			0			1	1.0		1	
Total		611			1229			972			768			3580	

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Table 3-4
South Texas Unit-2 - March 2001 Outage
Average Voltage Growth During Cycle 8

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	3580	0.37	0.378	0.301	102.7%	81.9%
$V_{BOC} <$ .75 Volts	3488	0.36	0.372	0.297	104.8%	83.6%
≥ .75 Volts	92	0.85	0.552	0.440	65.3%	52.1%
	Steam Generator A					
Entire Voltage Range	611	0.37	0.477	0.380	129.9%	103.6%
$V_{BOC} <$ .75 Volts	594	0.35	0.478	0.381	135.4%	108.0%
≥ .75 Volts	17	0.85	0.359	0.287	42.2%	33.7%
	Steam Generator B					
Entire Voltage Range	1229	0.37	0.268	0.214	72.6%	57.9%
$V_{BOC} <$ .75 Volts	1192	0.35	0.266	0.213	75.1%	59.9%
≥ .75 Volts	37	0.84	0.275	0.219	32.8%	26.2%
	Steam Generator C					
Entire Voltage Range	972	0.38	0.370	0.295	97.8%	78.0%
$V_{BOC} <$ .75 Volts	948	0.37	0.361	0.288	98.6%	78.6%
≥ .75 Volts	24	0.86	0.720	0.575	83.9%	66.9%
	Steam Generator D					
Entire Voltage Range	768	0.35	0.483	0.386	137.2%	109.4%
$V_{BOC} <$ .75 Volts	754	0.34	0.470	0.375	136.9%	109.2%
≥ .75 Volts	14	0.83	1.231	0.981	147.5%	117.6%

Based on Cycle 8 duration of 458 EFPD (1.254 EFPY)

Table 3-5
South Texas Unit-2 March 2001
Average Voltage Growth for Cycle 8
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 8 (1999 - 2001) - 458 EFPD					
Entire Voltage Range	3580	0.37	0.378	0.301	102.7%	81.9%
$V_{BOC} <$ .75 Volts	3488	0.36	0.372	0.297	104.8%	83.6%
≥ .75 Volts	92	0.85	0.552	0.440	65.3%	52.1%
	Cycle 7 (1998 - 1999) - 342.5 EFPD					
Entire Voltage Range	2262	0.41	0.174	0.185	42.6%	45.4%
$V_{BOC} <$ .75 Volts	2141	0.38	0.164	0.175	43.0%	45.9%
≥ .75 Volts	121	0.89	0.348	0.371	39.2%	41.8%
	Cycle 6 (1997 - 1998) - 564.9 EFPD					
Entire Voltage Range	1484	0.31	0.13	0.08	42%	27%
$V_{BOC} <$ .75 Volts	1437	0.29	0.13	0.08	44%	29%
≥ .75 Volts	47	0.93	0.16	0.10	17%	11%
	Cycle 5 (1995 - 1997) - 450 EFPD					
Entire Voltage Range	703	0.31	0.12	0.10	39%	31%
$V_{BOC} <$ .75 Volts	696	0.31	0.12	0.10	39%	32%
≥ .75 Volts	7	0.91	0.20	0.16	22%	18%

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Table 3-6
South Texas Unit-2 Cycle 8 Growth Data
Signal Growth Statistics for Indications at TSPs 2H to 4H on an EFPY Basis

Delta Volts	Steam Generator A		Steam Generator B		Steam Generator C		Steam Generator D		Cumulative	
	No. of Obs	CPDF	No. of Obs	CPDF	No. of Obs	CPDF	No. of Obs	CPDF	No. of Obs	CPDF
-0.3	1	0.002	1	0.001	0	0.0	0	0.0	2	0.001
-0.2	0	0.002	1	0.002	1	0.001	0	0.0	2	0.001
-0.1	3	0.007	4	0.005	0	0.001	2	0.003	9	0.004
0	47	0.088	103	0.095	171	0.195	22	0.034	343	0.108
0.1	141	0.333	445	0.485	224	0.448	165	0.268	975	0.402
0.2	141	0.577	299	0.746	227	0.705	210	0.567	877	0.667
0.3	82	0.719	126	0.857	104	0.822	118	0.734	430	0.797
0.4	49	0.804	63	0.912	46	0.874	49	0.804	207	0.86
0.5	15	0.83	19	0.928	29	0.907	29	0.845	92	0.888
0.6	19	0.863	16	0.942	16	0.925	15	0.866	66	0.908
0.7	6	0.873	13	0.954	7	0.933	4	0.872	30	0.917
0.8	5	0.882	5	0.958	6	0.94	5	0.879	21	0.923
0.9	6	0.893	2	0.96	8	0.949	11	0.895	27	0.931
1	6	0.903	5	0.964	0	0.949	5	0.902	16	0.936
1.1	9	0.919	5	0.969	4	0.954	6	0.911	24	0.943
1.2	2	0.922	4	0.972	7	0.962	2	0.913	15	0.948
1.3	2	0.925	2	0.974	4	0.966	2	0.916	10	0.951
1.4	3	0.931	1	0.975	1	0.967	6	0.925	11	0.954
1.5	7	0.943	3	0.977	4	0.972	2	0.928	16	0.959
1.6	4	0.95	0	0.977	0	0.972	2	0.93	6	0.961
1.7	2	0.953	3	0.98	0	0.972	4	0.936	9	0.964
1.8	1	0.955	1	0.981	0	0.972	5	0.943	7	0.966
1.9	0	0.955	3	0.983	1	0.973	1	0.945	5	0.967
2	1	0.957	1	0.984	0	0.973	2	0.947	4	0.969
2.1	1	0.958	1	0.985	1	0.974	2	0.95	5	0.97
2.2	3	0.964	0	0.985	1	0.975	2	0.953	6	0.972
2.3	2	0.967	1	0.986	2	0.977	0	0.953	5	0.973
2.4	1	0.969	2	0.988	1	0.979	2	0.956	6	0.975
2.5	0	0.969	1	0.989	0	0.979	4	0.962	5	0.977
2.6	0	0.969	0	0.989	0	0.979	0	0.962	0	0.977
2.7	1	0.971	0	0.989	1	0.98	0	0.962	2	0.977
2.8	0	0.971	1	0.99	3	0.983	0	0.962	4	0.979
2.9	1	0.972	0	0.99	1	0.984	0	0.962	2	0.979
3	0	0.972	0	0.99	2	0.986	1	0.963	3	0.98
3.1	1	0.974	0	0.99	1	0.988	2	0.966	4	0.981
3.2	1	0.976	1	0.99	0	0.988	2	0.969	4	0.982
3.3	3	0.981	0	0.99	1	0.989	2	0.972	6	0.984
3.4	1	0.983	0	0.99	1	0.99	0	0.972	2	0.985
3.5	0	0.983	1	0.991	0	0.99	2	0.974	3	0.986
3.6	0	0.983	1	0.992	0	0.99	4	0.98	5	0.987
3.7	1	0.984	1	0.993	0	0.99	2	0.983	4	0.989
3.8	0	0.984	0	0.993	1	0.991	0	0.983	1	0.989
3.9	0	0.984	2	0.995	0	0.991	2	0.986	4	0.99
4	1	0.986	0	0.995	0	0.991	1	0.987	2	0.991
4.1	1	0.988	1	0.996	0	0.991	0	0.987	2	0.991
4.2	0	0.988	0	0.996	0	0.991	0	0.987	0	0.991
4.3	0	0.988	1	0.997	3	0.994	0	0.987	4	0.992
4.4	2	0.991	0	0.997	0	0.994	0	0.987	2	0.993
4.5	0	0.991	0	0.997	0	0.994	0	0.987	0	0.993
4.6	0	0.991	0	0.997	1	0.995	0	0.987	1	0.993
4.7	0	0.991	0	0.997	0	0.995	0	0.987	0	0.993
4.8	1	0.993	1	0.997	0	0.995	0	0.987	2	0.994
4.9	0	0.993	0	0.997	0	0.995	0	0.987	0	0.994
5	0	0.993	1	0.998	1	0.997	0	0.987	2	0.995
5.1	1	0.995	0	0.998	0	0.997	0	0.987	1	0.995
5.2	0	0.995	0	0.998	0	0.997	2	0.99	2	0.995
5.3	0	0.995	0	0.998	0	0.997	0	0.99	0	0.995
5.4	0	0.995	1	0.999	0	0.997	2	0.993	3	0.996
5.5	1	0.997	0	0.999	0	0.997	0	0.993	1	0.997
5.6	1	0.998	0	0.999	0	0.997	1	0.994	2	0.997
5.7	0	0.998	0	0.999	0	0.997	0	0.994	0	0.997
5.8	0	0.998	0	0.999	1	0.998	2	0.997	3	0.998
5.9	0	0.998	0	0.999	0	0.998	0	0.997	0	0.998
6	0	0.998	0	0.999	0	0.998	0	0.997	0	0.998
6.1	0	0.998	0	0.999	0	0.998	0	0.997	0	0.998
6.2	1	1.0	0	0.999	0	0.998	0	0.997	1	0.998
6.3	0		0	0.999	2	1.0	0	0.997	2	0.999
7.7	0		1	1.0	0		0	0.997	1	0.999
8	0		0		0		2	1.0	2	1.0
Total	577		1143		884		704		3308	

Table 3-7
South Texas Unit-2 Cycle 8 Growth Data
Signal Growth Statistics on an EFPY Basis for Indications above TSP 4H

Delta Volts	Steam Generator A		Steam Generator B		Steam Generator C		Steam Generator D		Cumulative		Cycle 7 All SG
	No. of Obs	CPDF	No. of Obs	CPDF	No. of Obs	CPDF	No. of Obs	CPDF	No. of Obs	CPDF	Composite CPDF
0	3	0.088	14	0.163	12	0.143	3	0.047	32	0.119	0.103
0.1	16	0.559	25	0.453	24	0.429	14	0.266	79	0.414	0.444
0.2	5	0.706	27	0.767	22	0.69	27	0.688	81	0.716	0.757
0.3	7	0.912	9	0.872	9	0.798	14	0.906	39	0.862	0.869
0.4	1	0.941	5	0.93	8	0.893	2	0.938	16	0.922	0.922
0.5	1	0.971	2	0.953	3	0.929	0	0.938	6	0.944	0.946
0.6	0	0.971	1	0.965	4	0.976	2	0.969	7	0.97	0.958
0.7	0	0.971	0	0.965	1	0.988	1	0.984	2	0.978	0.967
0.8	1	1.0	2	0.988	0	0.988	0	0.984	3	0.989	0.969
1.1	0		0	0.988	1	1.0	0	0.984	1	0.993	0.979
4.1	0		0	0.988	0		0	0.984	0	0.993	1
5	0		1	1.0	0		0	1.0	1	1.0	
Total	34		86		84		64		268		

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Table 3-8
South Texas Unit-2 March 2001
Summary of Largest Voltage Growth Rates for BOC-8 to EOC-8

Steam Generator				Bobbin Voltage			RPC	New
SG	Row	Col	Elevation	EOC	BOC	Growth	Confirmed ?	Indication ?
D	24	47	03H	11.06	0.34	10.72	Y	N
D	10	109	02H	10.37	0.44	9.93	Y	N
B	15	89	02H	9.72	0.18	9.54	Y	N
C	20	106	02H	8.16	0.3	7.86	Y	N
C	20	73	02H	8.07	0.28	7.79	Y	N
A	23	24	02H	8.05	0.38	7.67	Y	N
D	25	72	02H	7.45	0.27	7.18	Y	Y
C	19	79	02H	7.69	0.53	7.16	Y	N
D	24	68	04H	7.85	0.85	7	Y	N
A	20	80	02H	7.32	0.39	6.93	Y	N
A	22	78	02H	7.05	0.22	6.83	Y	N
C	22	92	04H	7.36	0.54	6.82	Y	N
D	25	47	02H	7.21	0.47	6.74	Y	N
B	20	48	03H	6.93	0.2	6.73	Y	N
D	24	46	03H	7.06	0.39	6.67	Y	N
D	23	42	02H	6.82	0.3	6.52	Y	N
A	22	30	02H	6.95	0.61	6.34	Y	Y
C	23	105	02H	6.74	0.49	6.25	Y	N
B	17	31	02H	6.45	0.3	6.15	Y	N
D	19	77	03H	6.67	0.62	6.05	Y	N
A	19	29	02H	6.35	0.34	6.01	Y	N
B	28	71	03H	6.67	0.68	5.99	Y	Y
D	25	47	03H	6.15	0.28	5.87	Y	N
D	26	40	03H	6.29	0.42	5.87	Y	N
C	17	70	02H	6.13	0.45	5.68	Y	N
A	11	92	02H	5.83	0.31	5.52	Y	N
A	13	27	02H	5.97	0.47	5.5	Y	N
B	17	39	03H	5.95	0.56	5.39	Y	N
C	17	69	02H	5.61	0.22	5.39	Y	N
C	22	88	03H	6.08	0.69	5.39	Y	N
C	21	88	02H	6.12	0.8	5.32	Y	Y
A	19	54	02H	5.45	0.33	5.12	Y	N
B	11	94	02H	5.44	0.36	5.08	Y	N
A	24	82	03H	5.37	0.41	4.96	Y	N
D	27	28	04H	5.25	0.3	4.95	Y	N
B	20	29	05H	5.27	0.35	4.92	Y	N
B	18	40	02H	5.24	0.38	4.86	Y	N
D	24	47	02H	5.44	0.59	4.85	Y	N
B	12	16	02H	5.44	0.62	4.82	Y	N
C	20	98	04H	5.27	0.5	4.77	Y	N
C	14	94	02H	5	0.33	4.67	Y	N
D	24	33	03H	5.13	0.53	4.6	Y	N
A	22	105	02H	5.02	0.43	4.59	Y	N
D	21	27	02H	5.08	0.51	4.57	Y	N
B	11	100	02H	4.85	0.29	4.56	Y	Y
D	27	20	02H	4.73	0.25	4.48	Y	N
B	31	62	02H	4.81	0.38	4.43	Y	N
D	25	39	02H	5.03	0.62	4.41	Y	Y
D	22	36	02H	4.8	0.42	4.38	Y	N
B	25	66	02H	5.69	1.37	4.32	Y	Y

Table 3-9
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 3-10
South Texas Unit-2 2001 EOC-8 Evaluation for Probability of Prior Cycle Detection
Composite of All Steam Generator Data

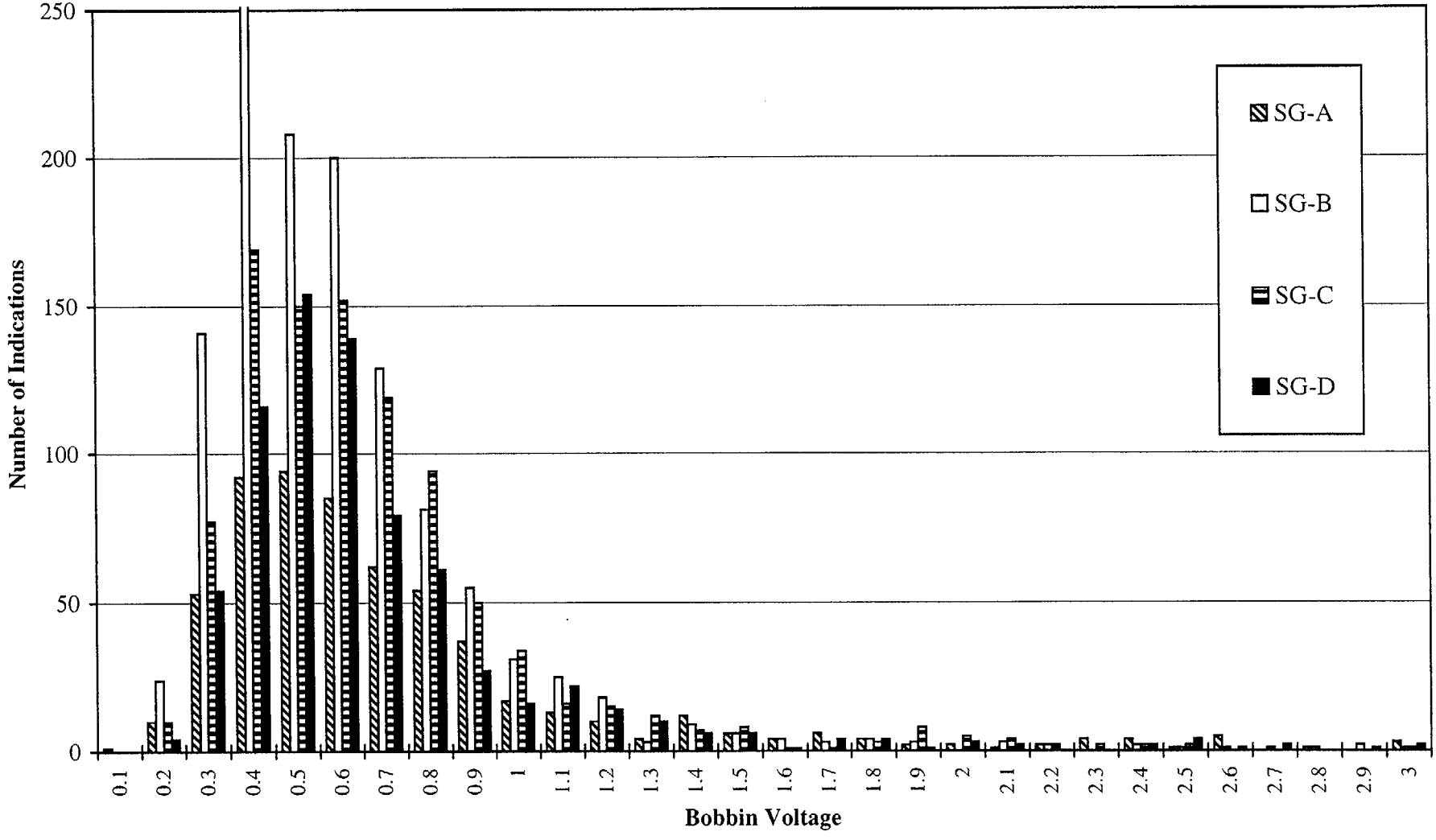
Voltage Bin	New Indications		EOC-8 Bobbin, Field Call in EOC-7 Inspection		EOC-7 Inspection Bobbin	POPCD			
	EOC-8 Inspection RPC Confirmed	EOC-8 Inspection RPC Confirmed plus not Inspected	EOC-8 Inspection RPC Confirmed	EOC-8 Inspection RPC Confirmed plus not Inspected	EOC-7 Inspection Confirmed and Plugged	RPC Confirmed		RPC Confirmed Plus Not Inspected	
						Frac.	Count	Frac.	Count
> 0 - 0.2	13	226	23	182	0	0.6	23 / 36	0.446	182 / 408
0.2 - 0.4	146	891	292	1077	0	0.667	292 / 438	0.547	1077 / 1968
0.4 - 0.6	156	354	320	573	0	0.672	320 / 476	0.618	573 / 927
0.6 -0 .8	64	82	105	132	0	0.621	105 / 169	0.617	132 / 214
0.8 - 1.0	9	14	21	24	1	0.710	22 / 31	0.641	25 / 39
1.0 - 1.5	2	4	1	1	105	0.981	106 / 108	0.964	106 / 110
1.5 - 2.0	0	0	0	0	20	1.000	20 / 20	1.000	20 / 20
2.0 - 2.5	0	0	0	0	15	1.000	15 / 15	1.000	15 / 15
2.5 - 3.0	0	0	0	0	5	1.000	5 / 5	1.000	5 / 5
> 3.0	0	0	0	0	14	1.000	14 / 14	1.000	14 / 14
TOTAL	390	1571	762	1989	126				
> 1V	2	4	1	1	159				

Table 3-11
South Texas Unit-2
Analysis of RPC Data from EOC-7 and EOC-8 Inspections
Combined Data from All Steam Generators

Group of Indications	Total EOC-7 Inspection Bobbin Indication	Total EOC-8 Inspection Bobbin Indication	Total EOC-8 Inspection RPC Inspected	Total EOC-8 Inspection RPC Confirmed	Percent EOC-8 Inspection RPC Confirmed
Less than or Equal to 1.0 Volt in EOC-8 Inspection					
EOC-7 Inspection Bobbin Left in Service	1703	1695	550	533	96.9
- EOC-7 Inspection RPC Confirmed	12	12	12	12	100.0
- EOC-7 Inspection RPC NDD	0	0	0	0	-
- EOC-7 Inspection RPC Not Inspected	1683	1683	538	521	96.8
- No EOC-8 Inspection Bobbin *	8	-	-	-	-
New EOC-8 Inspection Indication	-	1436	297	296	99.7
Sum of All EOC-8 Inspection Indication	1703	3131	847	829	97.9
Greater than 1.0 Volt in EOC-8 Inspection					
EOC-7 Inspection Bobbin Left in Service	312	312	230	229	99.6
- EOC-7 Inspection RPC Confirmed	4	4	4	4	100.0
- EOC-7 Inspection RPC NDD	1	1	1	1	100.0
- EOC-7 Inspection RPC Not Inspected	307	307	225	224	99.6
- No EOC-8 Inspection Bobbin *	0	-	-	-	-
New EOC-8 Inspection Indication	-	137	95	94	98.9
Sum of All EOC-8 Inspection Indication	312	449	325	323	99.4
All Voltages in EOC-8 Inspection					
EOC-7 Inspection Bobbin Left in Service	2015	2007	780	762	97.7
- EOC-7 Inspection RPC Confirmed	16	16	16	16	100.0
- EOC-7 Inspection RPC NDD	1	1	1	1	100.0
- EOC-7 Inspection RPC Not Inspected	1990	1990	763	745	97.6
- No EOC-8 Inspection Bobbin *	8	-	-	-	-
New EOC-8 Inspection Indication	-	1573	392	390	99.5
Sum of All EOC-8 Inspection Indication	2015	3580	1172	1152	98.3

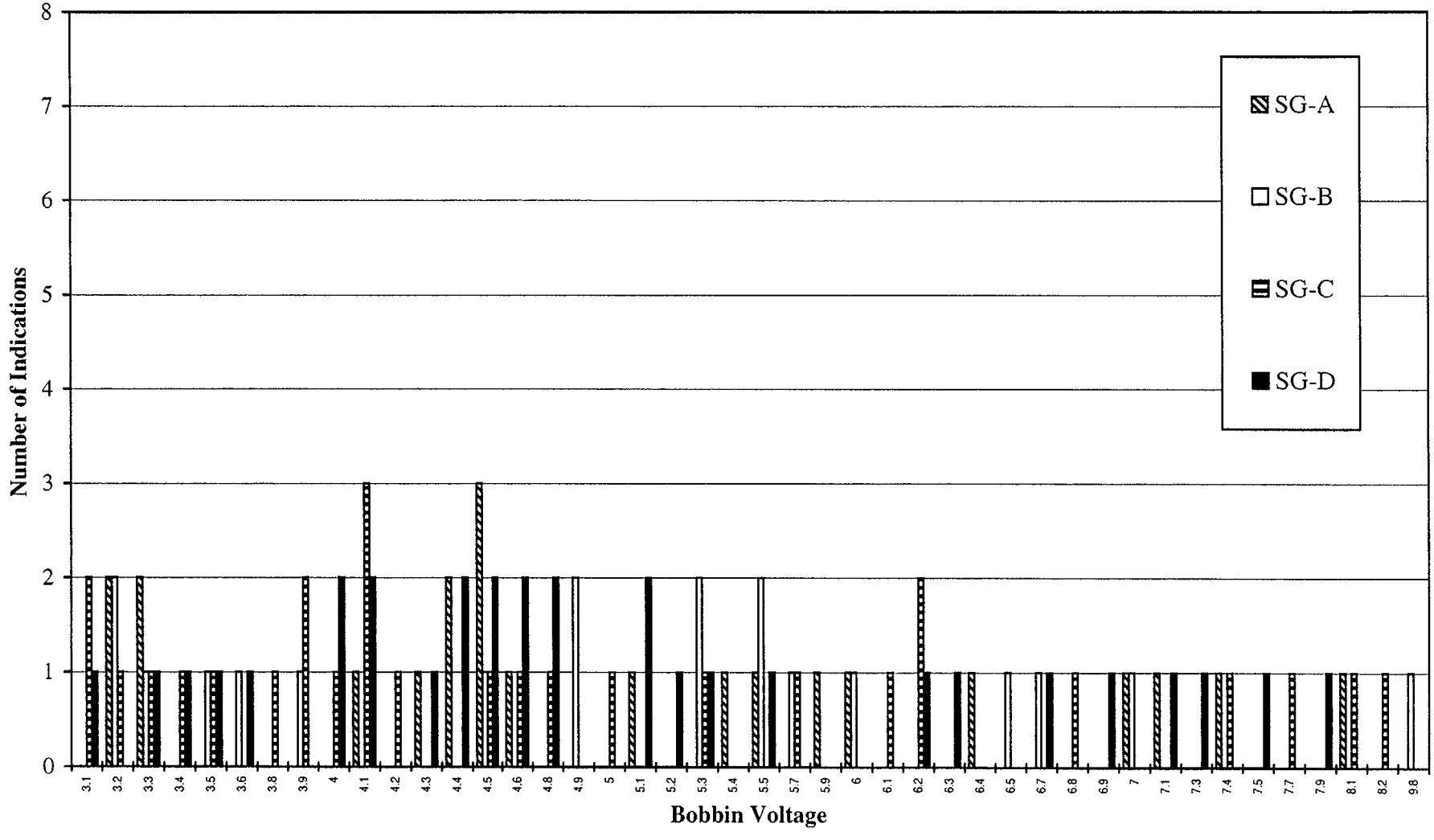
* Indications split is based on EOC-7 Inspection bobbin voltage

Figure 3-1 (Part 1 of 2)
South Texas Unit-2 March 2001 Outage
Bobbin Voltage Distributions at EOC-8 for Tubes in Service During Cycle 8"



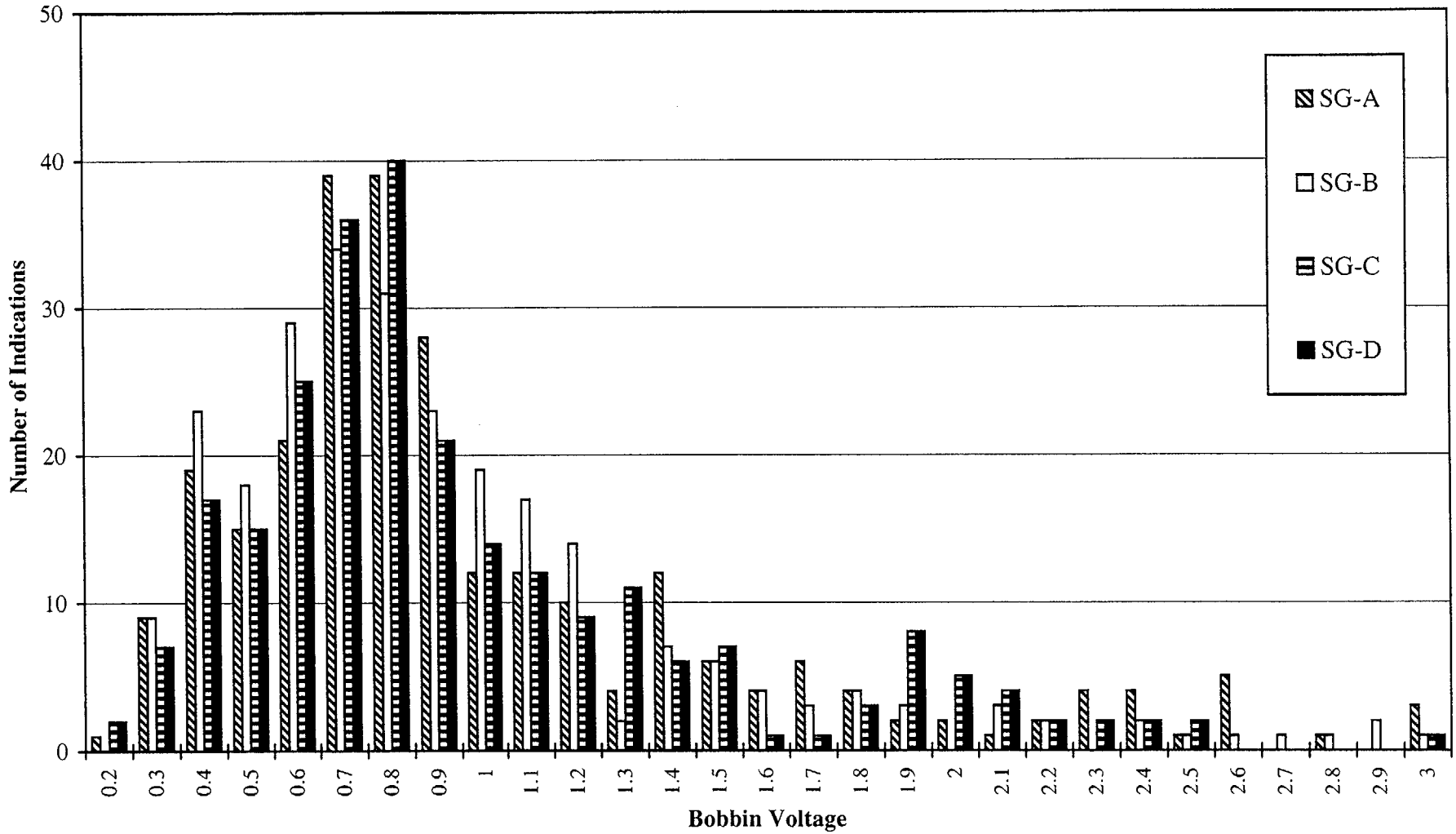
Bobnrpc.xlsFig1 (1of2)]

Figure 3-1 (Part 2 of 2)
South Texas Unit-2 March 2001 Outage
Bobbin Voltage Distributions at EOC-8 for Tubes in Service During Cycle 8"



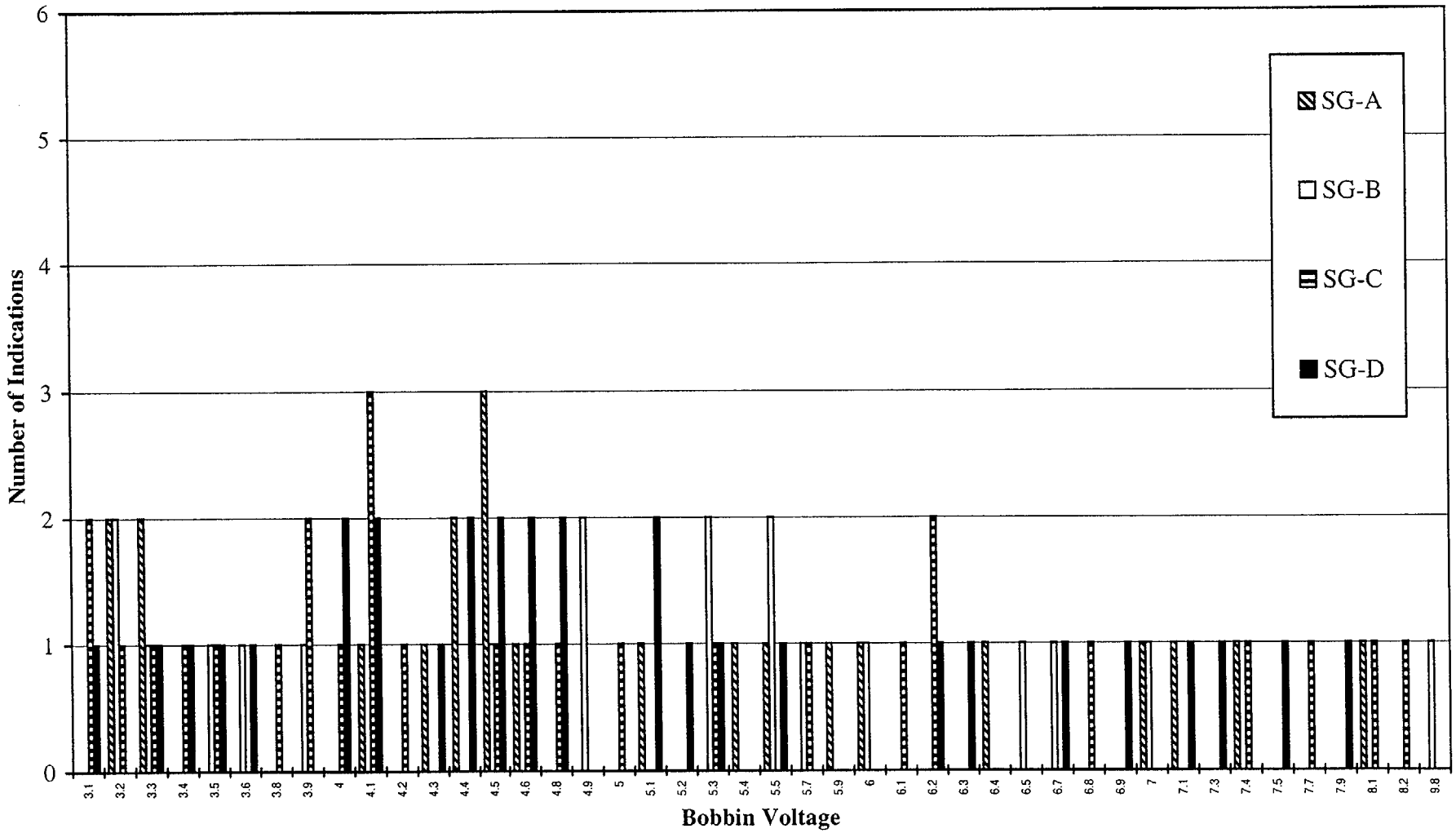
Bobnrpc.xlsFig1 (2of2)]

Figure 3-2 (Part 1 of 2)
South Texas Unit-2 March 2001 Outage
Bobbin Voltage Distributions for Tubes Plugged After Cycle 8 Service



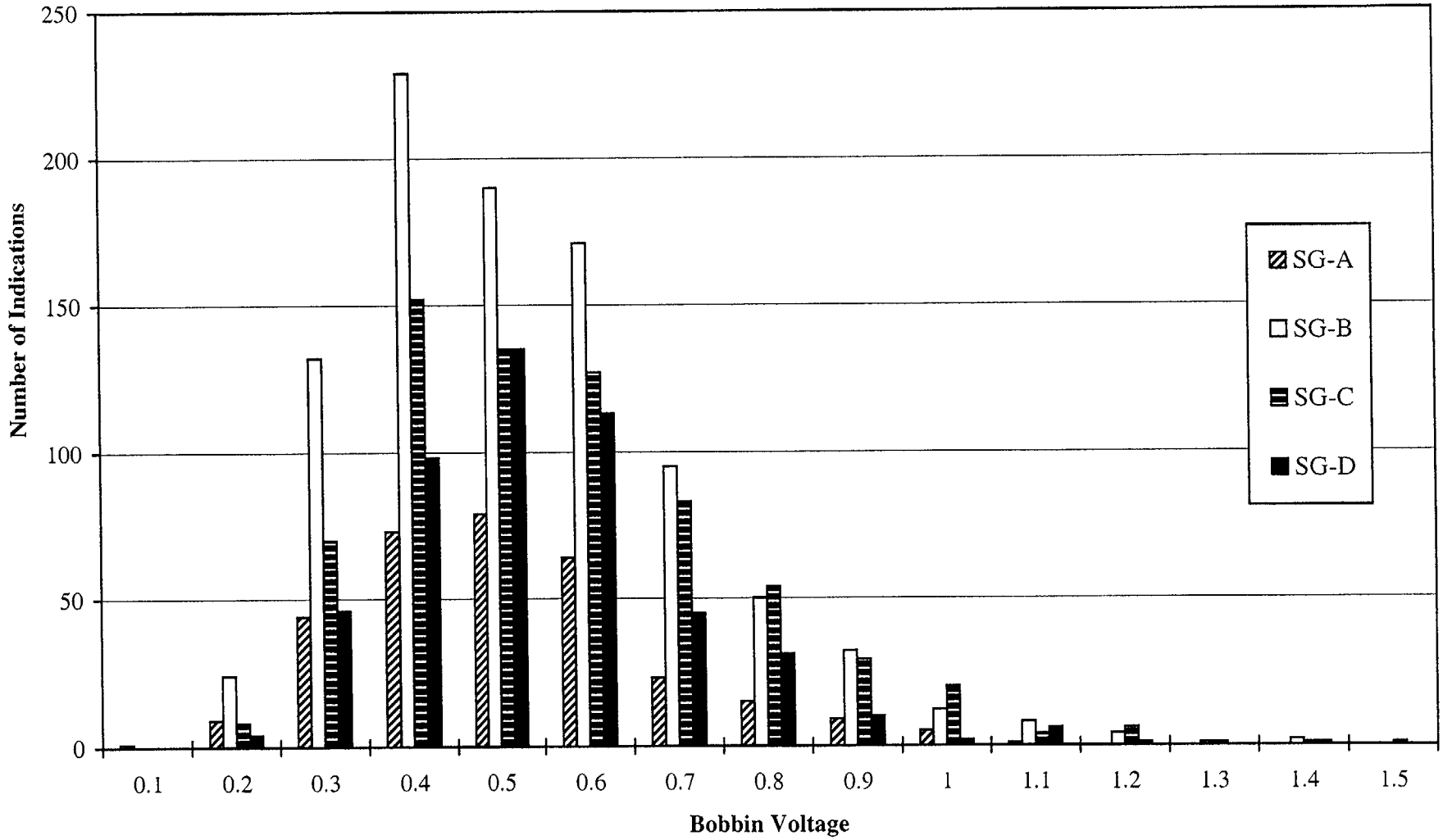
Bobnrpc.xlsFig2 (1of2)]

Figure 3-2 (Part 2 of 2)
South Texas Unit-2 March 2001 Outage
Bobbin Voltage Distributions for Tubes Plugged After Cycle 8 Service



Bobnrpc.xlsFig2 (2of2)]

Figure 3-3
South Texas Unit-2 March 2001 Outage
Bobbin Voltage Distributions for Tubes Returned to Service for Cycle 9



Bobnrpc.xlsFig3

Figure 3-4
South Texas Unit-2 - March 2001
ODSCC Axial Distributions for Tubes in Service During Cycle 8

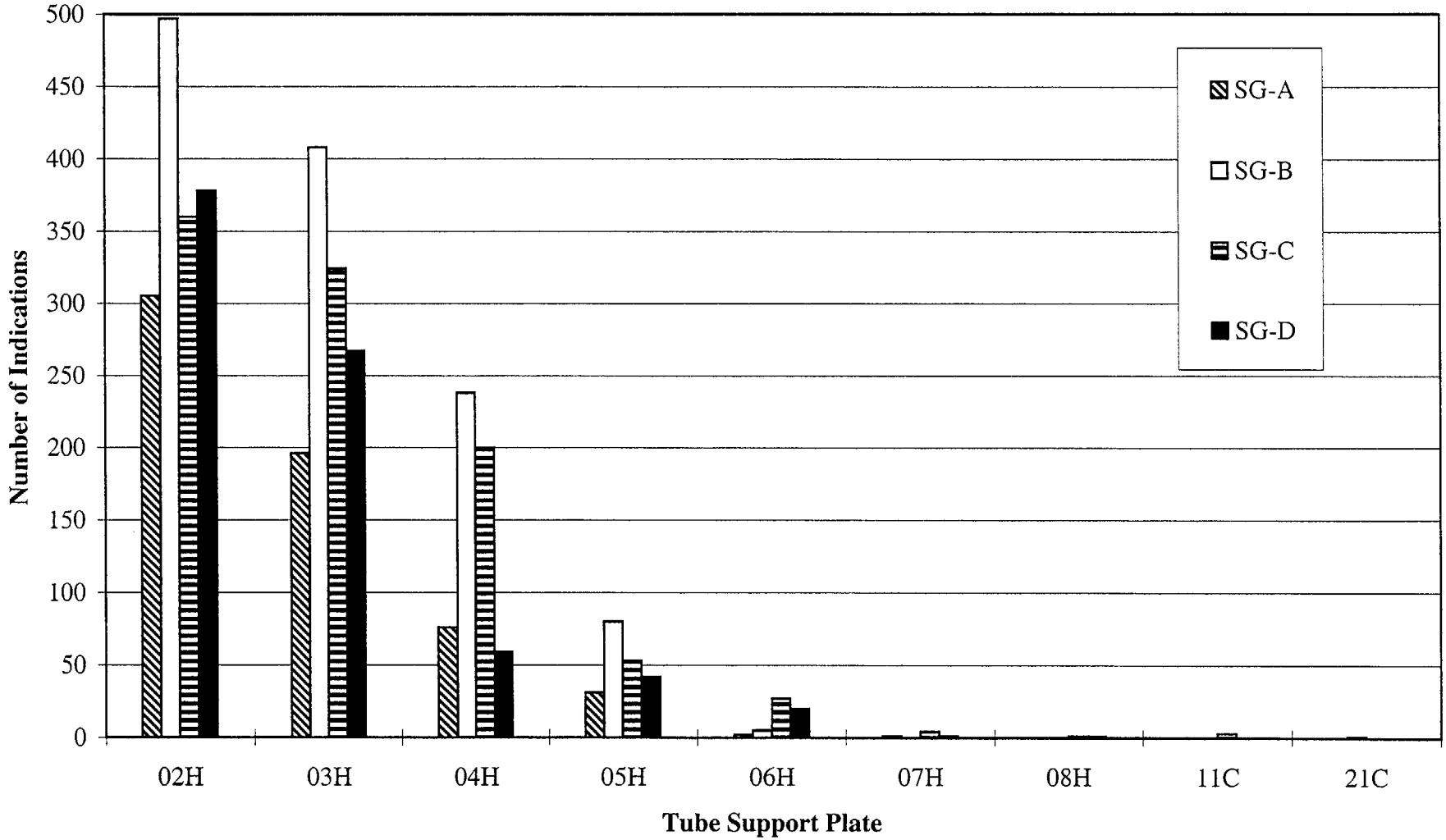


Figure 3-5
South Texas Unit-2 Cycle 8 (November 1999 to March 2001)
Cumulative Probability Distributions for Voltage Growth on an EFPY Basis

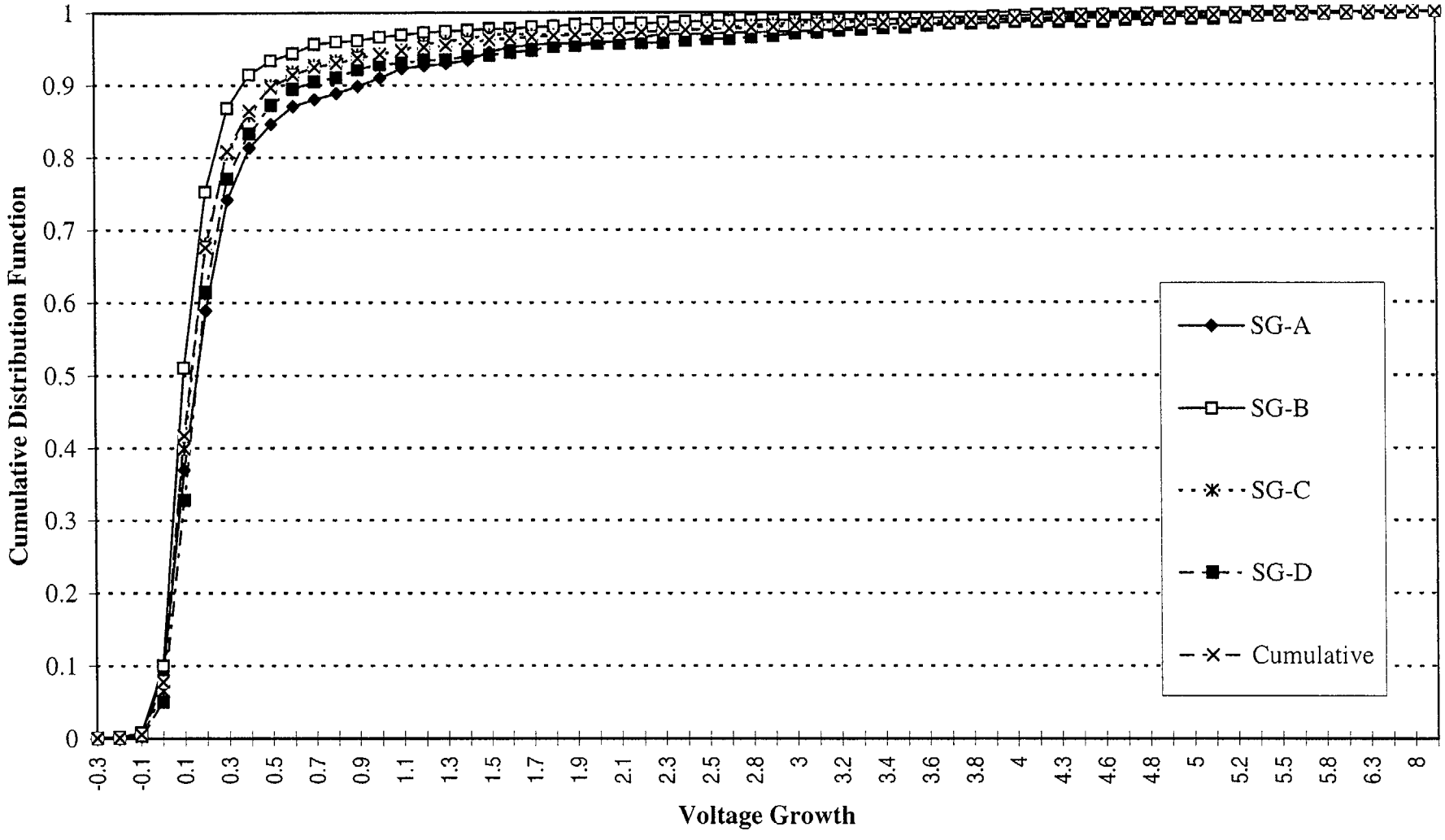


Figure 3-6
South Texas Unit-2 March 2001
Comparison of Cycle 8 Growth Rates with Braidwood-1 and Byron-1 Data
Composite of All Steam Generators

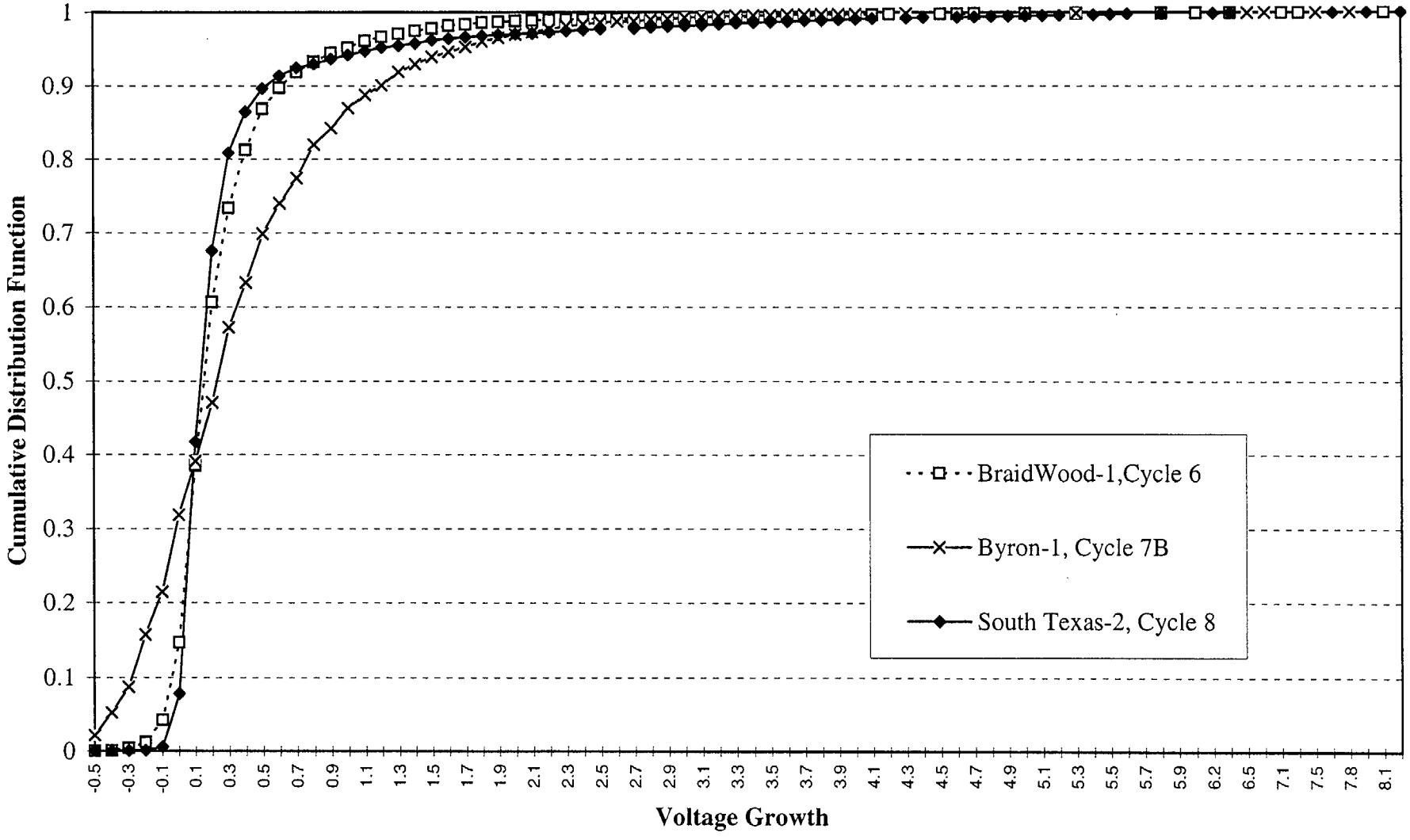
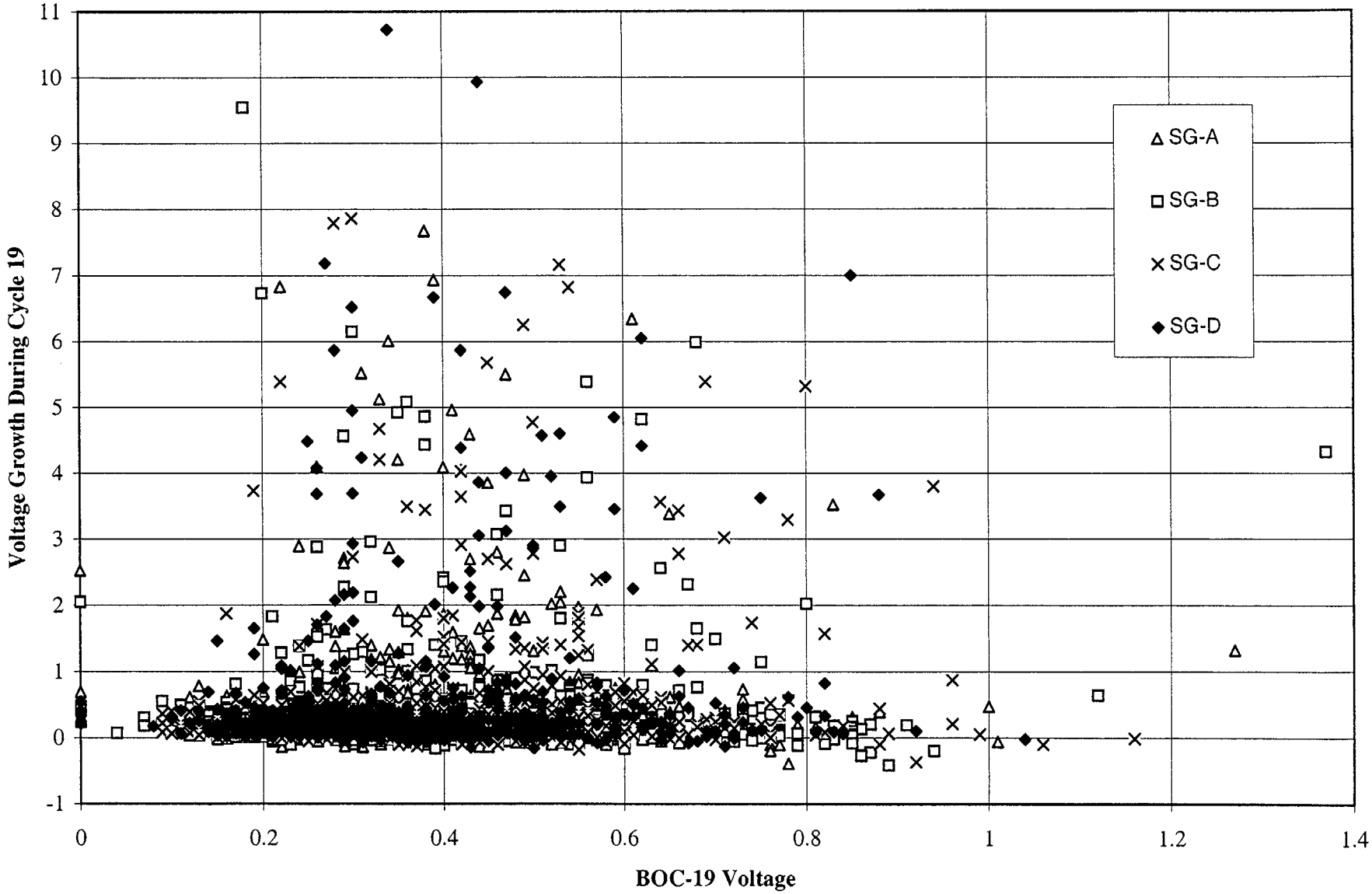


Figure 3-7
South Texas Unit - 2 March 2001 Outage
Voltage Growth During Cycle 8 vs BOC-8 Voltage



Growth.xlsChart16/18/01 10:52 AM

Figure 3-8
South Texas Unit-2 - March 2001
Bobbin Signal Growth History - Cumulative Probability Distributions on an EFPY Basis
Composite of All Steam Generators

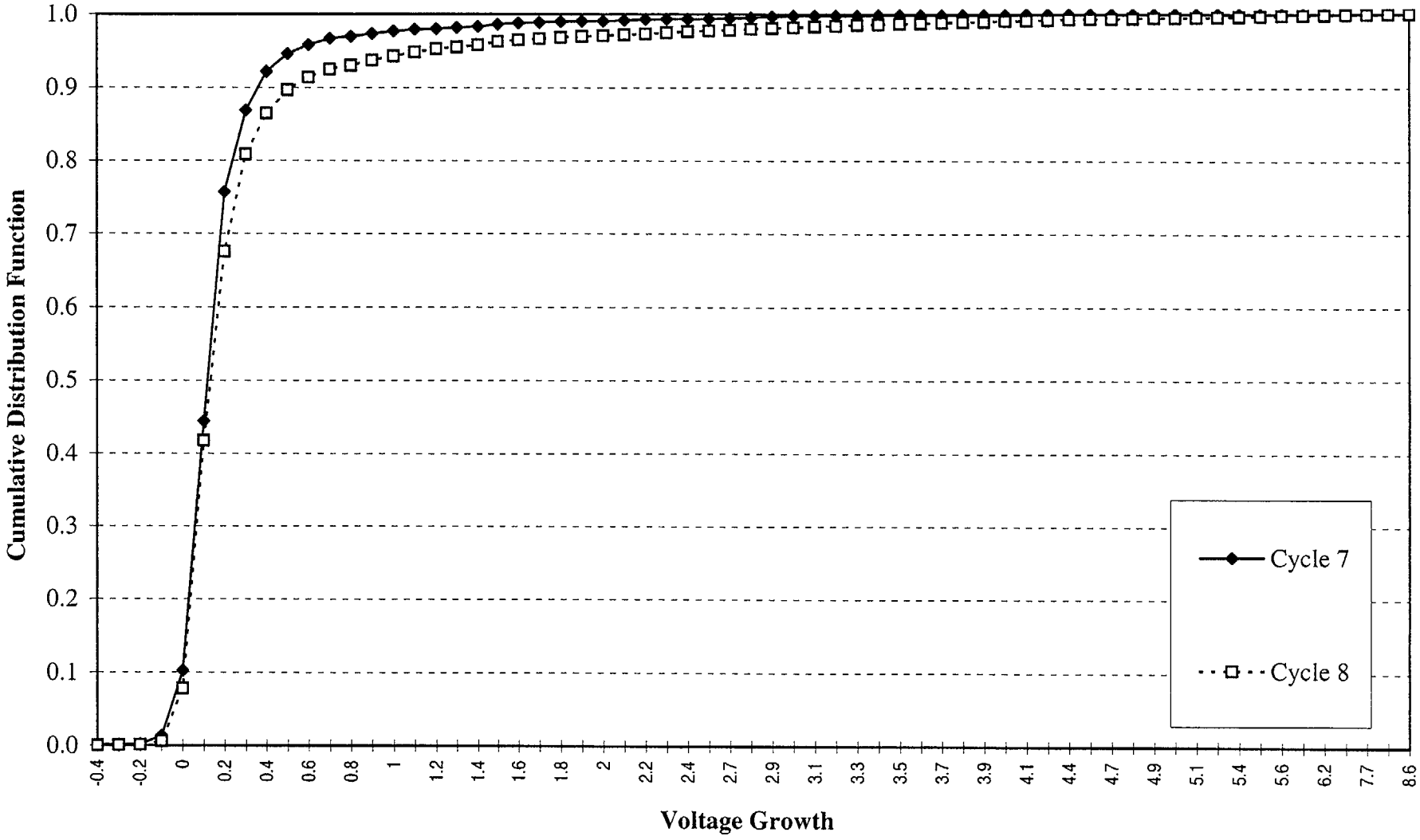


Figure 3-9
NDE Uncertainty Distributions

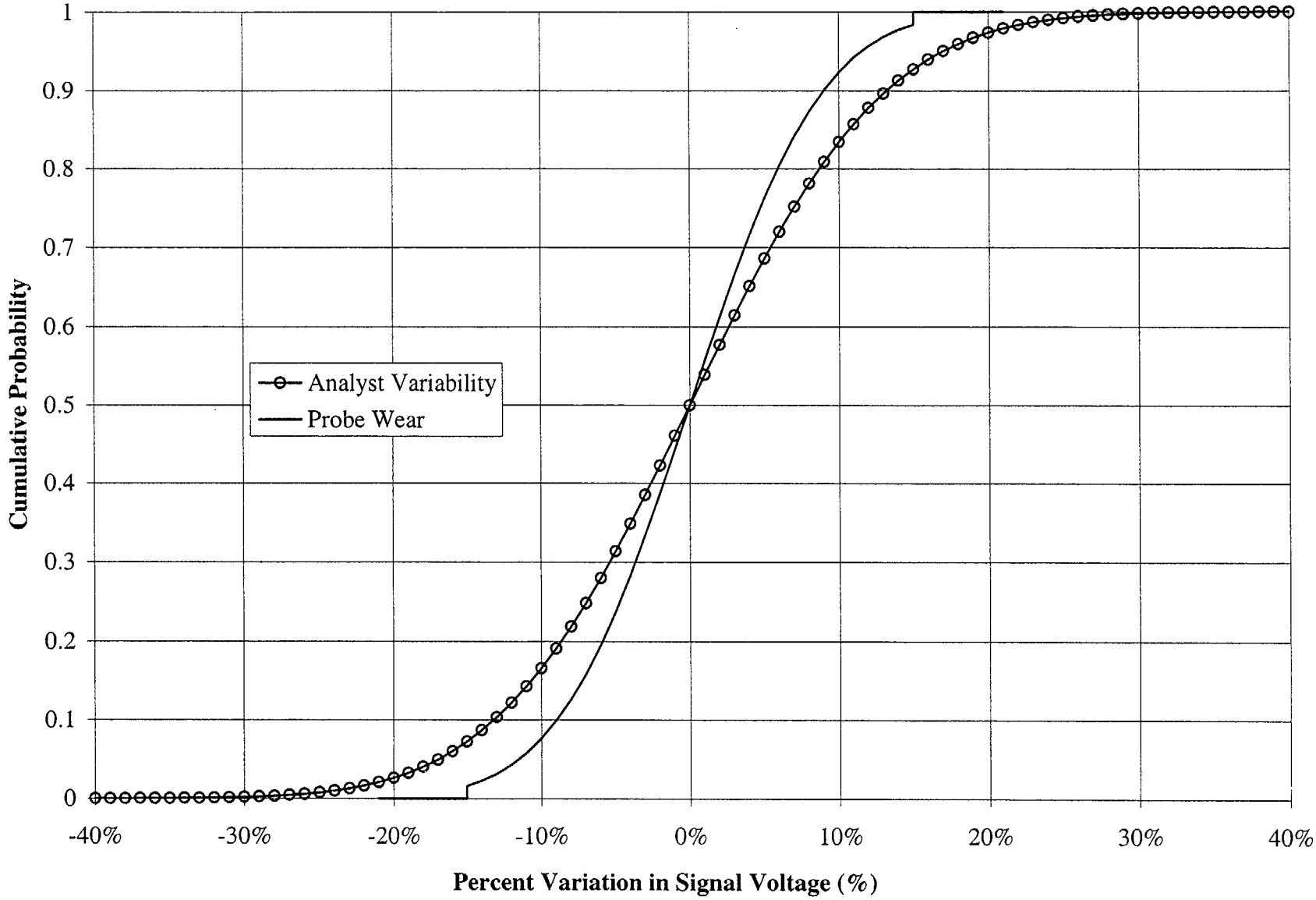
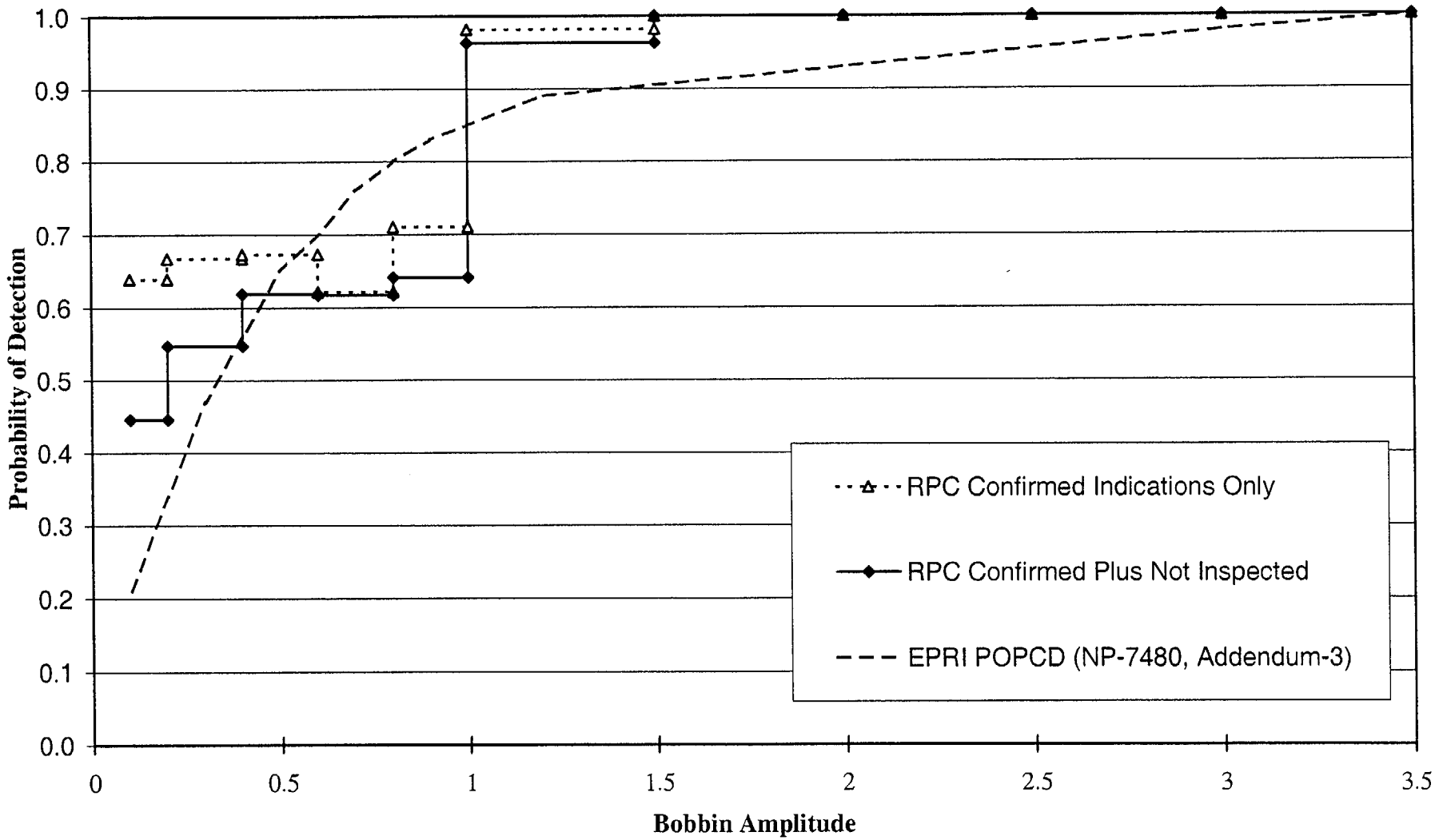
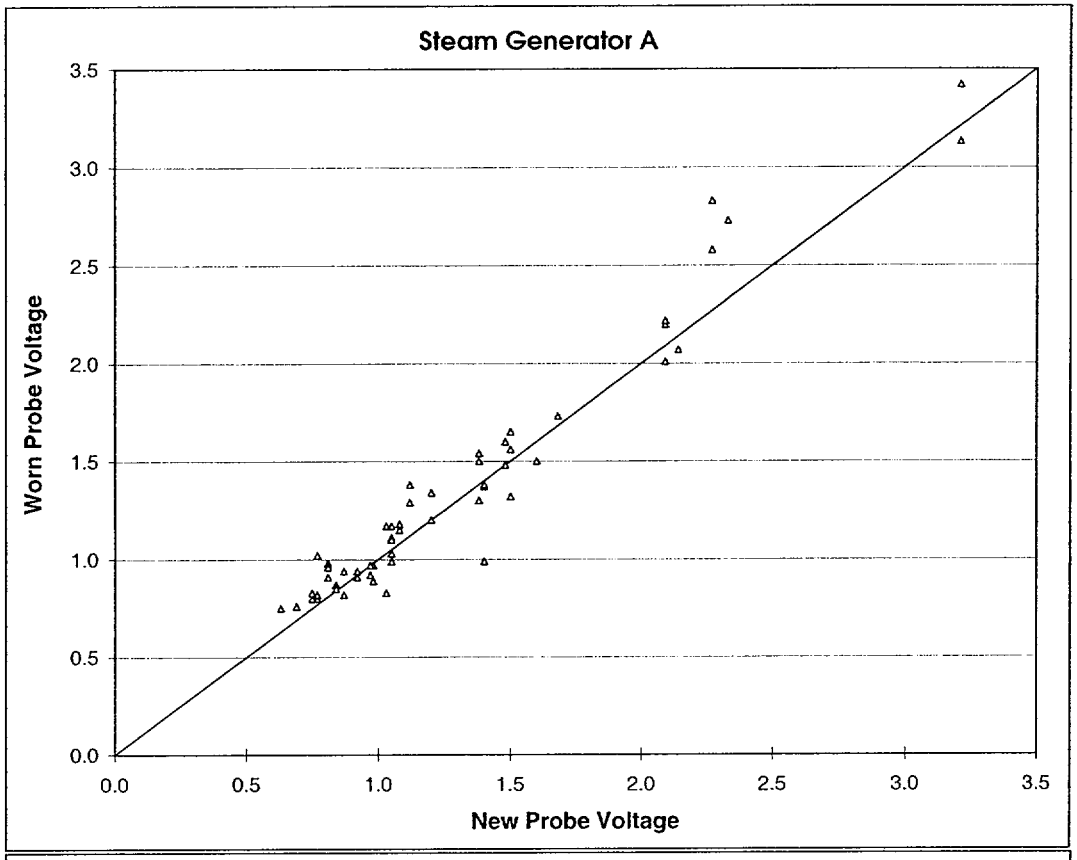


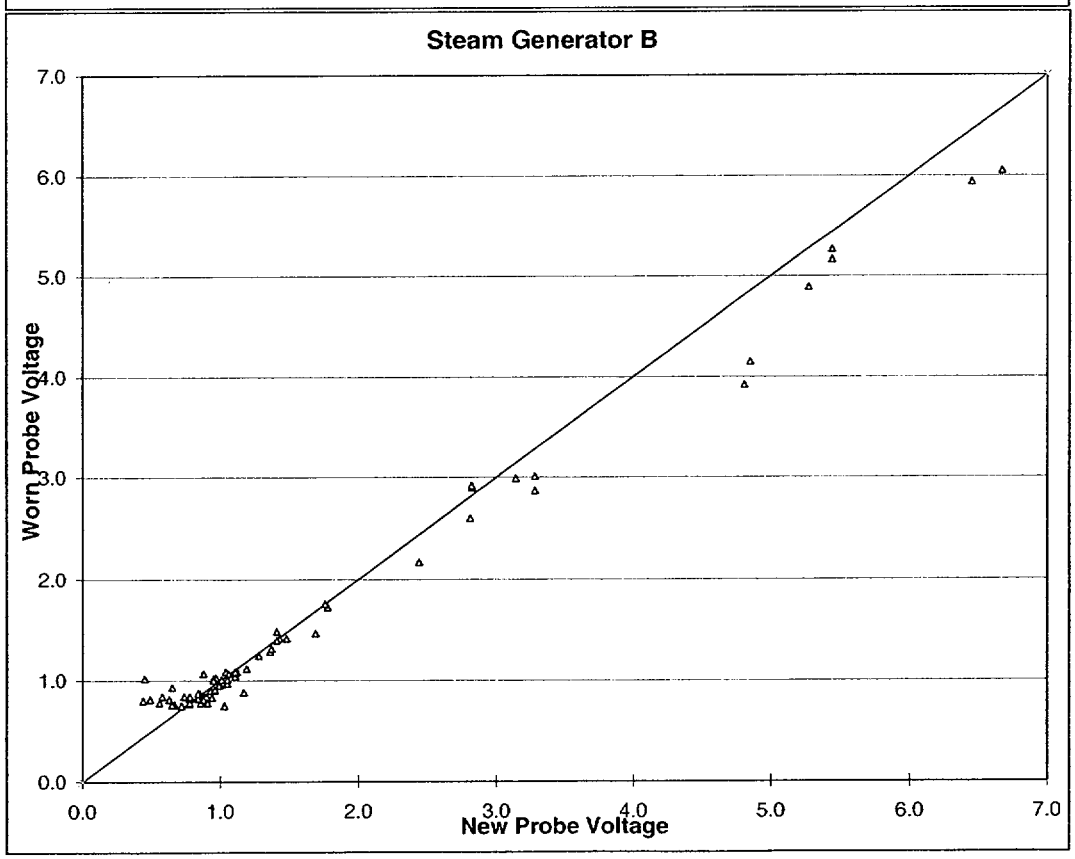
Figure 3-10
South Texas Unit-2
2001 EOC-8 Evaluation for POPCD at EOC-7



Popcd.xls|Fig1|6/18/01|3:35 PM

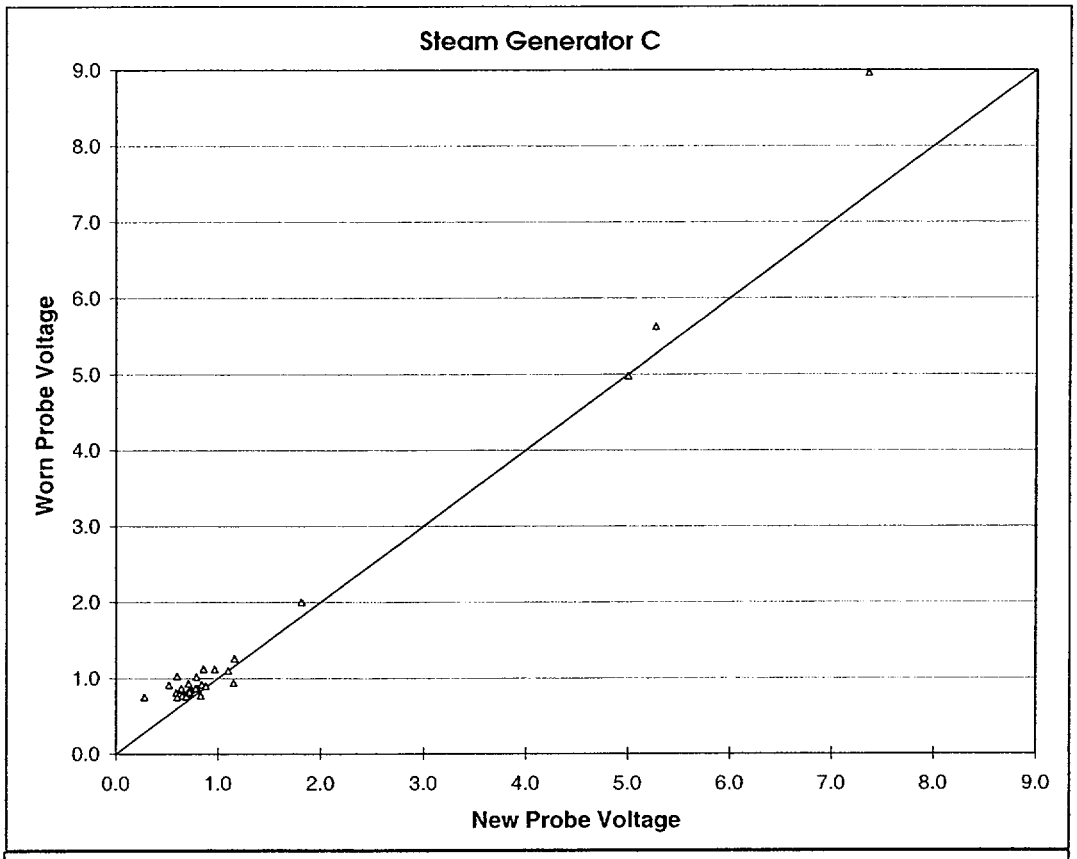
Figure 3-11
South Unit-1 EOC-8 Inspection
Comparison of Worn Probe Voltage Against New Probe Voltage

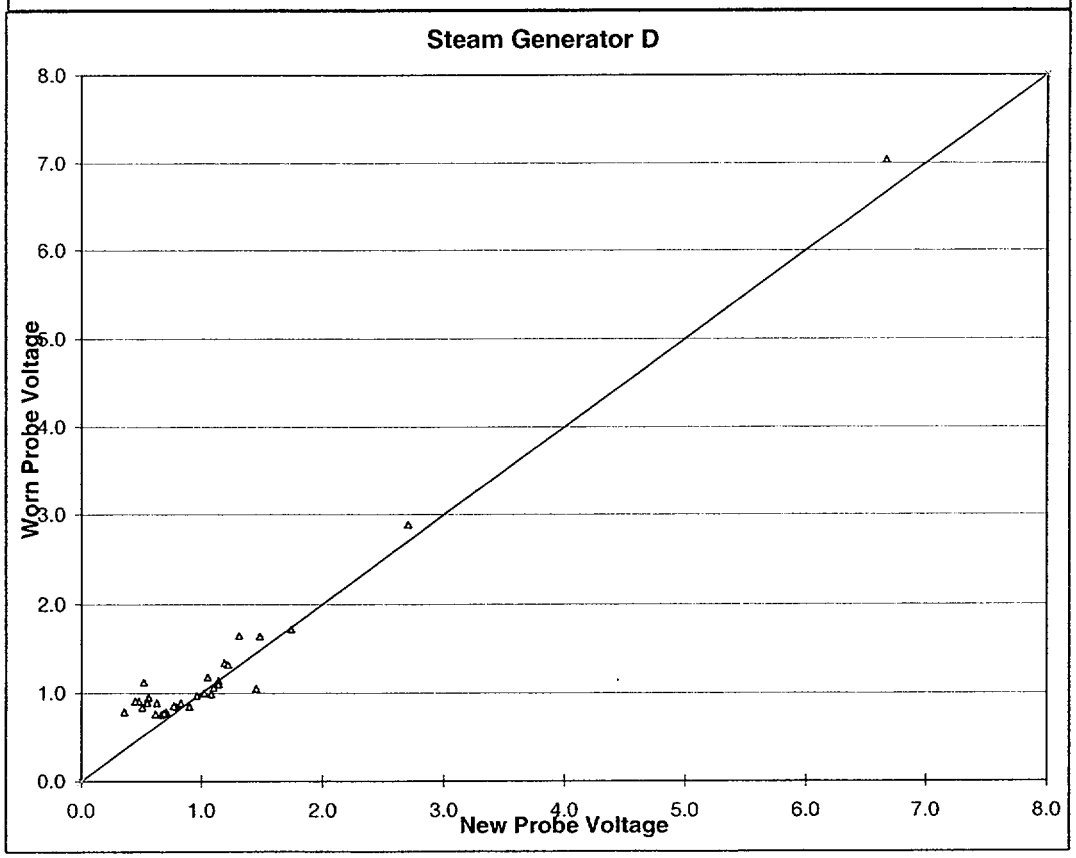




ProbeWear.xls Fig3-11 6/18/01 3:40 PM

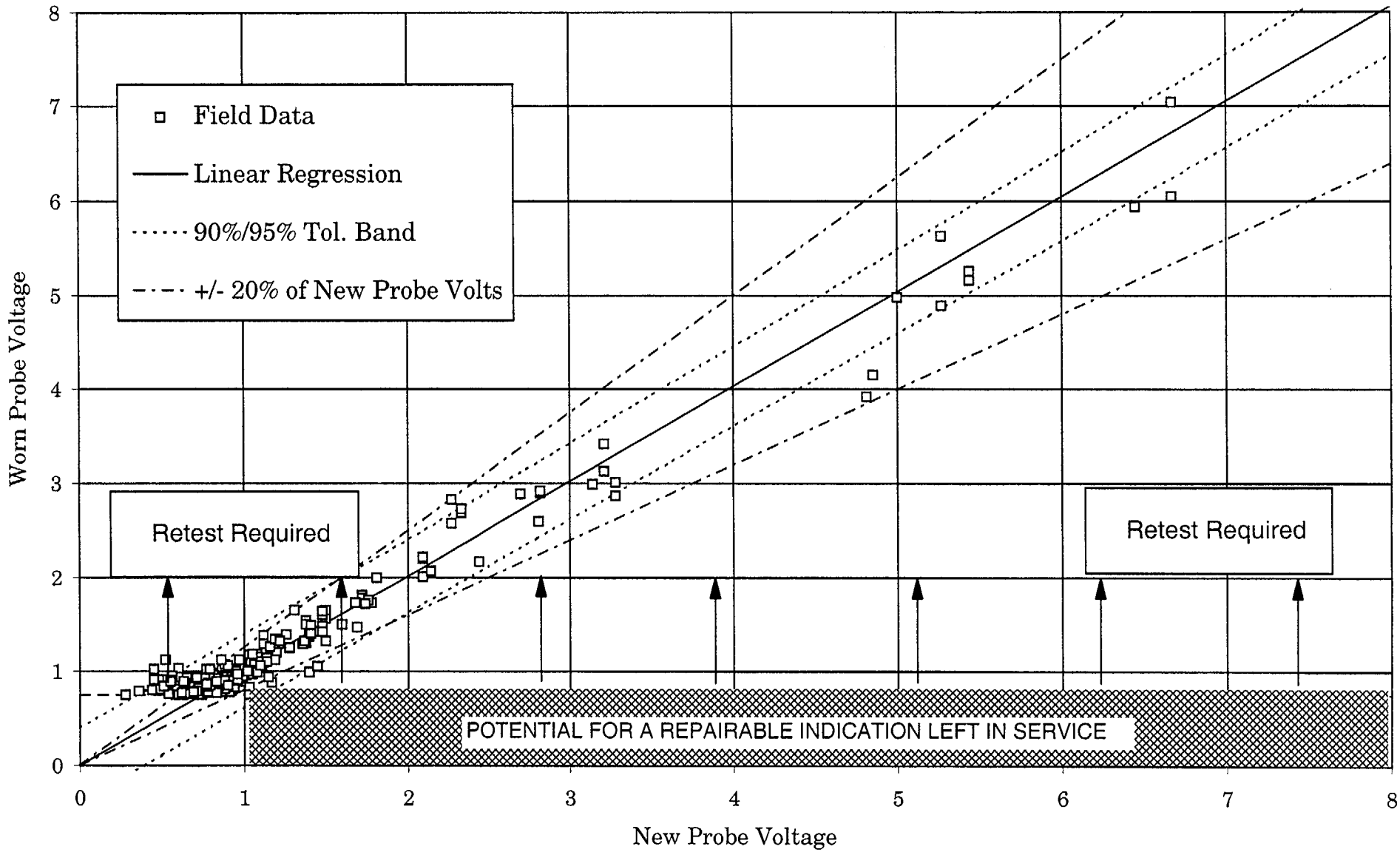
Figure 3-12
South Unit-1 EOC-8 Inspection
Comparison of Worn Probe Voltage Against New Probe Voltage





ProbeWear.xls Fig3-12 6/18/01 3:40 PM

Figure 3-13
South Unit-2 March 2001 EOC-8 Outage
Worn Probe Volts vs New Probe Volts



[ProbeWear.xls] Fig3-13 6/18/01 3:52 PM

4.0 Database Applied for Leak and Burst Correlations

Leak and burst correlations based on the latest available database for ¾" tubes are applied in the analyses presented in this report, and these correlations are documented in Reference 8-7. South Texas pulled tube data from 1998, 1995 and 1993 inspections are included in the database utilized. The database meets the NRC requirement that the p value obtained from the regression analysis of leak rate be less than or equal to 5%. Therefore, a SLB leak rate versus voltage correlation is applied for the leak rate analyses of this report.

The following are the correlations for burst pressure, probability of leakage and leak rate used in this report (Reference 8-7). The leak rate correlation shown is for SLB differential pressure of 2405 psi.

$$\text{Burst Pressure } (ksi) = 7.40278 - 2.91382 \times \log(volts)$$

$$\text{Probability of Leak} = \frac{1}{1 + e^{\left(4.8082 - 8.4215 \times \log(volts)\right)}}$$

$$\text{Leak Rate } (l/hr) = 10^{\left(-1.8708 + 2.9767 \times \log(volts)\right)}$$

The upper voltage repair limit applied at the EOC-8 inspection, documented in Reference 8-9, was developed using the database presented in Reference 8-7. The structural limit (V_{sl}) for the TSP indications established using 3 times normal operation ΔP value (3750 psid) is 5.69 volts, and V_{sl} for the FDB intersections using 1.43 times the maximum SLB ΔP of 2407 psid is 4.33 volts. The allowance for voltage growth used is 52.3%/EFPY, which is the highest average growth rate on an individual SG basis for South Texas Unit-2 Cycle 7 operation and it is above the minimum value (30%/EFPY) specified in the Generic Letter 95-05. For the expected 1.33 EFPY (485 EFPD) for Cycle 9, the growth allowance becomes 68%. The allowance for NDE uncertainty is 20% per Generic Letter 95-05. The upper voltage repair limit then become 3.0 volts for TSP indications and 2.3 volts for FDB indications. However, to minimize the potential for normal operation leakage during Cycle 9, all tubes with a TSP ODSCC indication over 1.5 volts were preventively plugged.

5.0 SLB Analysis Methods

Monte Carlo analyses are used to calculate the SLB leak rates and tube burst probabilities for both actual EOC-8 and projected EOC-9 voltage distributions. The Monte Carlo analyses account for parameter uncertainty. The analysis methodology is described in the Westinghouse generic methods report of Reference 8-3. It is consistent with the methodology applied to obtain the leak rate and tube burst probability results presented in the last 90-day report (Reference 8-6).

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

6.5 Projected EOC-9 Voltage Distribution

Calculations for EOC-9 bobbin voltage projections were performed for all four SGs based on the EOC-8 distributions shown in Table 6-1. The BOC distributions were adjusted to account for probability of detection as described above, and the adjusted number of indications at BOC-9 are also shown in Table 6-1. The calculations assumed a constant POD of 0.6. Since separate projection calculations were performed for the indications at the lower 3 TSPs and those above TSP 4, the BOC-9 voltage distributions for these two indication categories are shown separately in Table 6-1. Cycle 8 growth distributions applicable these two indication categories are shown in Tables 3-6 and 3-7. The EOC-9 voltage distributions thus projected for all four SGs are summarized on Table 6-2 and are also shown graphically on Figures 6-1 to 6-4. The EOC-9 voltage distributions shown were obtained by adding the EOC-9 distributions calculated separately for the indications at the lower 3 TSPs and those above TSP 4.

6.6 Comparison of Actual and Projected EOC-8 Voltage Distributions

Table 6-3, and Figures 6-5 and 6-6 provide a comparison of the EOC-8 actual measured bobbin voltage distributions with the corresponding projections performed using the last (EOC-7) inspection bobbin voltage data. EOC-8 projections based on a constant POD of 0.6 are shown for all 4 SGs and the projection using the EPRI POPCD distribution is also shown for SG-C. As reported in Reference 8-6, SG-B was projected to have the highest number of indications, which is consistent with the EOC-8 inspections data. The projections for all 4 SGs overestimate the number of indications over 1 volt indication found in the EOC-8 inspection. However, the total number of indications for SGs A and C as well as the number of indications over about 2 volts in all 4 SGs are underestimated. The primary cause for underestimating the larger indication (over 2 volts) population is that the actual growth rates during Cycle 8 were higher than those assumed for the projections. The growth distribution applied for the EOC-8 projection was obtained by examining the growth data for the prior two cycles and selecting the limiting distribution, consistent with the GL 95-05 guidelines. As shown in Table 3-7, the average growth rate during Cycle 8 was 80% higher than the Cycle 7 average growth rate.

Table 6-1 (Part 1 of 2)
South Texas Unit-2 March 2001
EOC-8 Bobbin and Assumed BOC-9 Bobbin Distributions in SLB Leak Rate and Tube Burst Analyses

Steam Generator A							Steam Generator B						
Indications at 2H, 3H and 4H				Indications at Other TSP Crevices			Indications at 2H, 3H and 4H				Indications at Other TSP Crevices		
Voltage Bin#	EOC - 8		BOC - 9 POD = 0.6	EOC - 8		BOC - 9 POD = 0.6	Voltage Bin#	EOC - 8		BOC - 9 POD = 0.6	EOC - 8		BOC - 9 POD = 0.6
	Field Bobbin Indications	Indications Repaired		Field Bobbin Indications	Indications Repaired			Field Bobbin Indications	Indications Repaired		Field Bobbin Indications	Indications Repaired	
0.1	0	0	0.0	1	0	1.7	0.1	0	0	0.0	0	0	0.0
0.2	10	1	15.7	0	0	0.0	0.2	19	0	31.7	5	0	8.3
0.3	49	8	73.7	4	1	5.7	0.3	130	7	209.7	11	2	16.3
0.4	86	15	128.3	6	4	6.0	0.4	231	22	363.0	21	1	34.0
0.5	85	14	127.7	9	1	14.0	0.5	191	17	301.3	17	1	27.3
0.6	77	21	107.3	8	0	13.3	0.6	184	25	281.7	16	4	22.7
0.7	60	39	61.0	2	0	3.3	0.7	125	34	174.3	4	0	6.7
0.8	51	38	47.0	3	1	4.0	0.8	77	30	98.3	4	1	5.7
0.9	37	28	33.7	0	0	0.0	0.9	53	22	66.3	2	1	2.3
1	17	12	16.3	0	0	0.0	1	29	19	29.3	2	0	3.3
1.1	13	12	9.7	0	0	0.0	1.1	25	17	24.7	0	0	0.0
1.2	10	10	6.7	0	0	0.0	1.2	15	12	13.0	3	2	3.0
1.3	4	4	2.7	0	0	0.0	1.3	3	2	3.0	0	0	0
1.4	12	12	8.0	0	0	0.0	1.4	9	7	8.0	0	0	0
1.5	5	5	3.3	1	1	0.7	1.5	6	6	4.0	0	0	0
1.6	4	4	2.7			0	1.6	4	4	2.7	0	0	0
1.7	6	6	4.0			0	1.7	3	3	2.0	0	0	0
1.8	4	4	2.7			0	1.8	4	4	2.7	0	0	0
2	4	4	2.7			0	1.9	3	3	2.0	0	0	0
2.2	3	3	2.0			0	2.05	3	3	2.0	0	0	0
2.3	4	4	2.7			0	2.12	1	1	0.7	0	0	0
2.4	4	4	2.7			0	2.19	1	1	0.7	0	0	0
2.6	6	6	4.0			0	2.33	2	2	1.3	0	0	0
2.73	1	1	0.7			0	2.44	1	1	0.7	0	0	0
3.00	3	3	2.0			0	2.56	1	1	0.7	0	0	0
3.13	2	2	1.3			0	2.61	1	1	0.7	0	0	0
3.26	2	2	1.3			0	2.75	1	1	0.7	0	0	0
4.03	1	1	0.7			0	2.82	2	2	1.3	0	0	0
4.30	1	1	0.7			0	2.98	1	1	0.7	0	0	0
4.35	2	2	1.3			0	3.14	1	1	0.7	0	0	0
4.48	3	3	2.0			0	3.20	1	1	0.7	0	0	0
4.55	1	1	0.7			0	3.28	1	1	0.7	0	0	0
5.02	1	1	0.7			0	3.43	1	1	0.7	0	0	0
5.27	0	0	0.0			0	5.27	0	0	0.0	1	1	0.7
5.37	1	1	0.7			0	3.53	1	1	0.7			0
5.45	1	1	0.7			0	3.89	1	1	0.7			0
5.83	1	1	0.7			0	4.49	1	1	0.7			0
5.97	1	1	0.7			0	4.85	2	2	1.3			0
6.35	1	1	0.7			0	5.27	1	1	0.7			0
6.95	1	1	0.7			0	5.44	2	2	1.3			0
7.05	1	1	0.7			0	5.69	1	1	0.7			0
7.32	1	1	0.7			0	5.95	1	1	0.7			0
8.05	1	1	0.7			0	6.45	1	1	0.7			0
			0			0	6.67	1	1	0.7			0
			0			0	6.93	1	1	0.7			0
			0			0	9.72	1	1	0.7			0
Total	577	280	681.7	34	8	48.7	Total	1143	266	1639.0	86	13	130.3
> 1V	105	104	71.0	1	1	0.7	> 1V	104	90	83.3	4	3	3.7
> 3V	22	22	14.7	0	0	0.0	> 2V	18	18	19.33	1	1	0.67

The voltages shown with two decimal digits are actual indication voltages (while the lower values represent upper limit for binned voltages)

Table 6-1 (Part 2 of 2)
South Texas Unit-2 March 2001
EOC-8 Bobbin and Assumed BOC-9 Bobbin Distributions in SLB Leak Rate and Tube Burst Analyses

Steam Generator C							Steam Generator D						
Indications at 2H, 3H and 4H				Indications at Other TSP Crevices			Indications at 2H, 3H and 4H				Indications at Other TSP Crevices		
Voltage Bin#	EOC - 8		BOC - 9 POD = 0.6	EOC - 8		BOC - 9 POD = 0.6	Voltage Bin#	EOC - 8		BOC - 9 POD = 0.6	EOC - 8		BOC - 9 POD = 0.6
	Field Bobbin Indications	Indications Repaired		Field Bobbin Indications	Indications Repaired			Field Bobbin Indications	Indications Repaired		Field Bobbin Indications	Indications Repaired	
0.1	0	0	0	0	0	0	0.1	0	0	0	0	0	0
0.2	7	1	10.7	3	1	4.0	0.2	4	0	6.7	9	2	13.0
0.3	63	6	99.0	14	1	22.3	0.3	45	6	69.0	13	4	17.7
0.4	159	15	250.0	10	2	14.7	0.4	103	14	157.7	16	3	23.7
0.5	133	14	207.7	17	2	26.3	0.5	138	16	214.0	13	2	19.7
0.6	142	25	211.7	10	0	16.7	0.6	126	24	186.0	8	2	11.3
0.7	102	30	140.0	17	6	22.3	0.7	71	32	86.3	2	1	2.3
0.8	87	37	108.0	7	3	8.7	0.8	59	29	69.3	1	0	1.7
0.9	47	21	57.3	3	0	5.0	0.9	26	17	26.3	0	0	0
1	33	13	42.0	1	1	0.7	1	16	14	12.7	0	0	0
1.1	14	10	13.3	2	2	1.3	1.1	22	16	20.7	1	1	0.7
1.2	14	8	15.3	1	1	0.7	1.2	13	12	9.7	0	0	0
1.3	10	9	7.7	2	2	1.3	1.3	10	10	6.7	0	0	0
1.4	6	5	5.0	1	1	0.7	1.4	6	5	5.0	0	0	0
1.5	8	7	6.3			0	1.5	6	6	4.0	0	0	0
1.8	5	5	3.3			0	1.53	1	1	0.7	0	0	0
1.9	8	8	5.3			0	1.64	3	3	2.0	0	0	0
2	5	5	3.3			0	1.71	2	2	1.3	0	0	0
2.1	4	4	2.7			0	1.77	2	2	1.3	0	0	0
2.14	1	1	0.7			0	1.84	2	2	1.3	0	0	0
2.25	3	3	2.0			0	1.99	3	3	2.0	0	0	0
2.39	2	2	1.3			0	2.1	2	2	1.3	0	0	0
2.47	3	3	2.0			0	2.4	2	2	1.3	0	0	0
3.03	1	1	0.7			0	2.5	3	3	2.0	1	1	0.7
3.09	1	1	0.7			0	2.56	1	1	0.7			0
3.15	1	1	0.7			0	2.7	2	2	1.3			0
3.28	1	1	0.7			0	2.86	1	1	0.7			0
3.33	1	1	0.7			0	3	2	2	1.3			0
3.44	1	1	0.7			0	3.23	2	2	1.3			0
3.73	1	1	0.7			0	3.4	1	1	0.7			0
3.85	2	2	1.3			0	3.49	1	1	0.7			0
3.92	1	1	0.7			0	3.59	1	1	0.7			0
4.09	3	3	2.0			0	4.04	4	4	2.7			0
4.2	1	1	0.7			0	4.3	1	1	0.7			0
4.44	1	1	0.7			0	4.37	2	2	1.3			0
4.53	1	1	0.7			0	4.47	2	2	1.3			0
4.74	1	1	0.7			0	4.55	2	2	1.3			0
5	1	1	0.7			0	4.73	1	1	0.7			0
5.27	1	1	0.7			0	4.8	1	1	0.7			0
5.61	1	1	0.7			0	5.08	2	2	1.3			0
6.08	1	1	0.7			0	5.13	1	1	0.7			0
6.13	2	2	1.3			0	5.25	1	1	0.7			0
6.74	1	1	0.7			0	5.44	1	1	0.7			0
7.36	1	1	0.7			0	6.15	1	1	0.7			0
7.69	1	1	0.7			0	6.29	1	1	0.7			0
8.07	1	1	0.7			0	6.67	1	1	0.7			0
8.16	1	1	0.7			0	6.82	1	1	0.7			0
			0			0	7.06	1	1	0.7			0
			0			0	7.21	1	1	0.7			0
			0			0	7.45	1	1	0.7			0
			0			0	7.85	1	1	0.7			0
			0			0	10.37	1	1	0.7			0
			0			0	11.06	1	1	0.7			0
Total	884	260	1213.3	88	22	124.7	Total	704	260	913.3	64	16	90.7
> 1V	111	98	87.0	6	6	0.0	> 1V	116	108	43.3	2	2	0.7
> 3V	28	28	18.7	0	0	0.0	> 3V	33	33	26.00	0	0	0.00

The voltages shown with two decimal digits are actual indication voltages (while the lower values represent upper limit for binned voltages)

Table 6-2 (Part 1 of 2)
South Texas Unit-2 March 2001
Voltage Distribution Projection for EOC - 9
Combined Data for Hot and Cold Leg Indications

Voltage Bin	Steam Generator A	Steam Generator B	Steam Generator C	Steam Generator D
	Projected Number of Indications at EOC - 9			
	POD = 0.6	POD = 0.6	POD = 0.6	POD = 0.6
0.1	0.22	0.10	0.04	0.01
0.2	1.10	2.65	1.30	0.42
0.3	6.06	16.27	8.72	16.69
0.4	21.06	59.09	33.05	35.44
0.5	44.73	124.98	76.53	69.33
0.6	70.30	189.00	122.64	101.97
0.7	86.07	225.60	155.30	123.00
0.8	85.92	220.58	161.42	118.88
0.9	74.85	189.05	146.83	105.16
1.0	60.21	149.58	122.59	81.47
1.1	46.18	112.02	95.86	60.98
1.2	33.90	80.32	70.75	43.40
1.3	24.17	55.98	50.17	30.76
1.4	17.43	39.43	35.46	21.96
1.5	13.46	29.61	26.15	16.64
1.6	11.16	23.49	20.45	13.63
1.7	9.46	19.05	16.17	11.61
1.8	7.95	16.02	13.39	9.82
1.9	6.75	13.14	11.14	8.19
2.0	6.39	10.59	9.25	6.68
2.1	4.95	9.06	8.05	5.48
2.2	4.59	8.46	7.52	4.93
2.3	4.30	7.79	7.00	4.73
2.4	3.98	6.98	6.21	5.09
2.5	3.73	6.47	5.64	3.98
2.6	3.69	6.45	5.37	3.79
2.7	3.78	6.80	5.42	3.99
2.8	3.66	6.63	5.28	4.09
2.9	3.31	5.89	4.66	3.84
3.0	2.95	5.28	4.18	3.37
3.1	2.68	4.78	3.79	2.98
3.2	2.47	4.44	3.52	2.77
3.3	2.21	3.95	3.20	2.55
3.4	1.89	3.33	2.75	2.26
3.5	1.76	3.21	2.57	2.04
3.6	1.84	3.66	2.82	2.13
3.7	1.88	3.86	3.10	2.38
3.8	1.69	3.35	2.83	2.38
3.9	1.38	2.64	2.41	2.01
4.0	1.07	1.90	1.94	1.51
4.1	0.86	1.29	1.52	1.16
4.2	0.76	0.98	1.23	0.97
4.3	0.78	1.06	1.17	0.97
4.4	0.93	1.51	1.39	1.19
4.5	1.14	2.07	1.75	1.52
4.6	1.33	2.54	2.06	1.83
4.7	1.43	2.85	2.31	2.03
4.8	1.38	2.71	2.28	2.00
4.9	1.29	2.49	2.08	1.83
5.0	1.35	2.76	2.19	1.75
5.1	1.58	3.44	2.57	2.02
5.2	1.82	3.91	2.95	2.38
5.3	1.76	3.74	2.88	2.70
5.4	1.47	3.18	2.52	2.55
5.5	1.38	3.10	2.38	1.98
5.6	1.40	3.03	2.26	1.92
5.7	1.19	2.39	1.92	1.67
5.8	1.03	1.99	1.56	1.45
5.9	0.74	1.55	1.25	1.05
6.0	0.64	1.10	0.84	0.75

Table continues on the Next Page

Table 6-2 (Part 2 of 2)
South Texas Unit-2 March 2001
Voltage Distribution Projection for EOC - 9
Combined Data for Hot and Cold Leg Indications

Voltage Bin	Steam Generator A	Steam Generator B	Steam Generator C	Steam Generator D
	Projected Number of Indications at EOC - 9			
	POD = 0.6	POD = 0.6	POD = 0.6	POD = 0.6
Table Continues from the Previous Page				
6.1	0.51	0.78	0.67	0.52
6.2	0.42	0.50	0.47	0.41
6.3	0.44	0.49	0.57	0.40
6.4	0.33	0.36	0.56	0.26
6.5	0.31	0.28	0.31	0.41
6.6	0.22	0.28	0.33	0.36
6.7	0.31	0.21	0.27	0.28
6.8	0.23	0.29	0.24	0.17
6.9	0.19	0.28	0.26	0.29
7.0	0.16	0.28	0.18	0.36
7.1	0.59	1.09	1.00	0.35
7.2	0.42	0.84	0.50	0.44
7.3	0.58	1.42	0.78	0.69
7.4	0.74	1.31	1.16	1.00
7.5	0.83	1.61	1.17	1.10
7.6	0.83	1.63	1.19	1.06
7.7	0.76	1.68	1.29	1.09
7.8	0.85	1.81	1.39	1.17
7.9	0.82	1.75	1.38	1.15
8.0	0.90	2.10	1.56	1.27
8.1	0.94	2.25	1.77	1.28
8.2	0.91	1.86	1.48	1.37
8.3	0.67	1.44	1.38	1.08
8.4	0.58	1.00	1.02	0.71
8.5	0.42	0.66	0.82	0.48
8.6	0.40	0.67	0.65	0.43
8.7	0.47	1.01	0.82	0.55
8.8	0.52	1.11	0.90	0.69
8.9	0.46	0.94	0.80	0.70
9.0	0.36	0.73	0.67	0.54
9.1	0.27	0.49	0.50	0.37
9.2	0.21	0.32	0.37	0.24
9.3	0.16	0.20	0.27	0.17
9.4	0.12	0.14	0.20	0.14
9.5	0.10	0.09	0.15	0.12
9.6	0.08	0.07	0.12	0.09
9.7	0.07	0.05	0.10	0.08
9.8	0.06	0.05	0.08	0.07
9.9	0.06	0.12	0.07	0.06
10.0	0.05	0.13	0.06	0.05
10.1	0.05	0.04	0.06	0.05
10.2	0.04	0.09	0.05	0.04
10.3	0.04	0.06	0.05	0.04
10.4	0.05	0.09	0.06	0.06
10.5	0.12	0.28	0.16	0.11
10.6	0.19	0.49	0.33	0.31
10.7	0.24	0.57	0.38	0.43
10.8	0.29	0.74	0.48	0.46
10.9	0.30	0.77	0.57	0.43
11.0	0.26	0.63	0.49	0.44
11.1	0.20	0.49	0.39	0.34
11.2	0.14	0.33	0.28	0.29
11.3	0.10	0.21	0.20	0.15
11.4	0.07	0.14	0.14	0.21
11.5	0.05	0.09	0.09	0.15
11.6	0.06	0.11	0.08	0.11
11.7	0.12	0.30	0.17	0.16
11.8	0.19	0.48	0.32	0.27
11.9	0.04	0.47	0.34	0.34
12.0	0.00	0.40	0.30	0.30
12.1	0.70	0.06	0.04	0.21
12.2	0.00	0.00	0.00	0.10
12.3	0.00	0.70	0.70	0.00
12.7	0.30	0.30	0.00	0.70
12.9	0.00	0.00	0.30	0.00
14.1	0.00	0.00	0.00	0.30
TOTAL	730.34	1769.33	1338.07	1004.06
> 1 V	279.82	592.43	509.65	351.69
> 3 V	64.03	122.97	101.53	84.73
> 5 V	33.91	67.59	54.62	46.47

Table 6-3 (Sheet 1 of 2)
South Texas Unit-2 March 2001
Comparison of Predicted and Actual EOC-8 Voltage Distributions

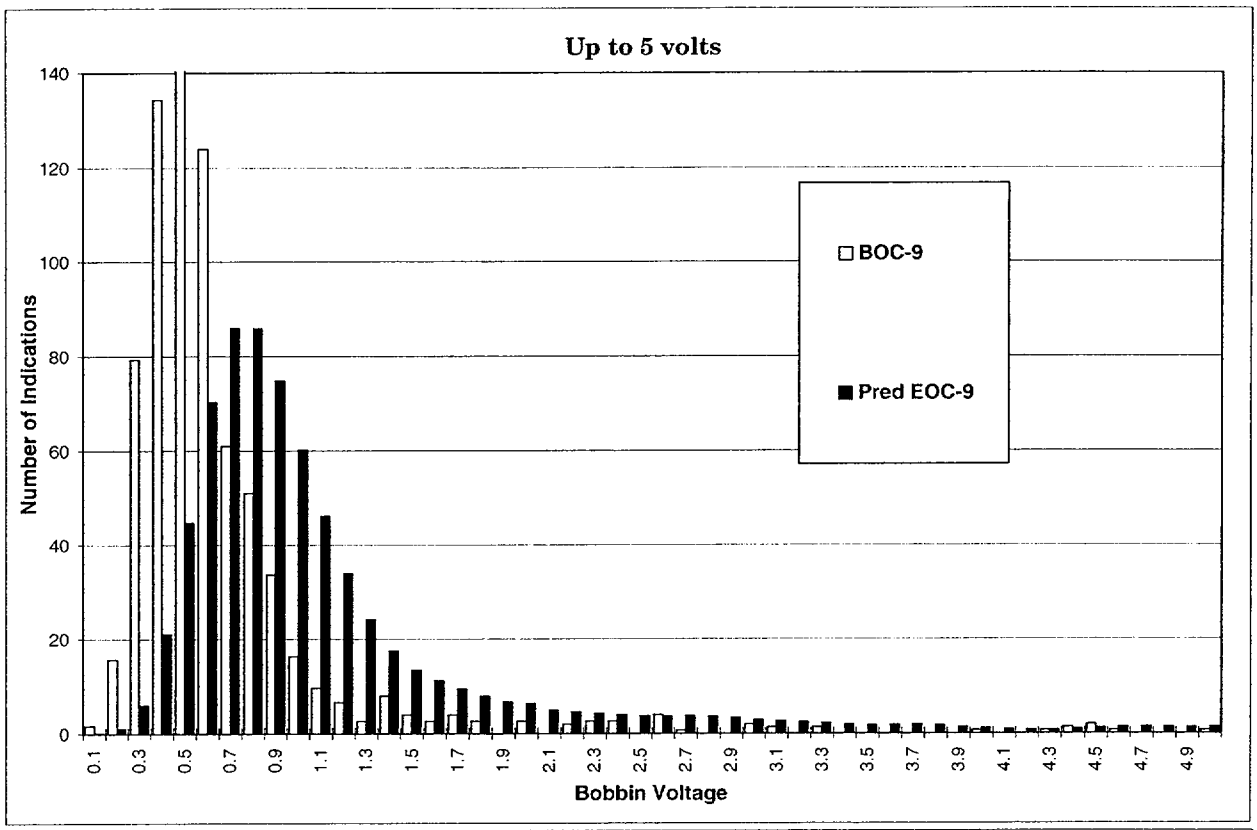
Voltage Bin	Steam Generator A		Steam Generator B		Steam Generator C			Steam Generator D	
	Number of Indications								
	EOC-8 Prediction POD = 0.6	EOC-8 Actual	EOC-8 Prediction POD = 0.6	EOC-8 Actual	EOC-8 Prediction POD = 0.6	EOC-8 Prediction POPCD	EOC-8 Actual	EOC-8 Prediction POD = 0.6	EOC-8 Actual
0.1	0.03	1	0.11	0	0.06	0.10	0	0.06	0
0.2	0.84	10	3.44	24	1.54	2.42	10	1.82	4
0.3	5.96	53	22.78	141	10.83	17.08	77	12.50	54
0.4	21.03	92	74.37	252	37.28	53.09	169	42.08	116
0.5	44.07	94	143.22	208	77.45	97.54	150	84.82	154
0.6	64.42	85	193.20	200	115.63	124.84	152	115.31	139
0.7	72.66	62	201.45	129	134.91	131.19	119	121.97	79
0.8	68.49	54	174.73	81	129.75	112.38	94	107.57	61
0.9	58.23	37	136.38	55	108.77	81.36	50	85.42	27
1.0	46.49	17	100.39	31	83.76	55.23	34	62.58	16
1.1	35.06	13	71.02	25	61.56	41.54	16	43.49	22
1.2	24.84	10	48.18	18	43.67	35.95	15	29.25	14
1.3	16.57	4	31.27	3	29.69	28.08	12	19.40	10
1.4	10.69	12	19.81	9	19.58	18.18	7	12.91	6
1.5	6.95	6	12.84	6	13.01	11.44	8	9.01	6
1.6	4.78	4	8.80	4	9.01	7.59	1	6.58	1
1.7	3.52	6	6.40	3	6.62	5.73	1	4.92	4
1.8	2.74	4	4.78	4	5.05	4.08	3	3.66	4
1.9	2.18	2	3.67	3	3.92	2.68	8	2.78	1
2.0	1.79	2	3.02	0	3.05	1.83	5	2.26	3
2.1	1.52	1	2.68	3	2.42	1.52	4	2.00	2
2.2	1.37	2	2.65	2	2.04	1.58	2	1.96	0
2.3	1.28	4	2.67	0	1.79	2.20	2	2.00	0
2.4	1.16	4	2.51	2	1.53	2.17	2	1.88	2
2.5	1.01	1	2.18	1	1.23	1.28	2	1.67	4
2.6	0.86	5	1.85	1	1.03	0.57	0	1.42	1
2.7	0.75	0	1.59	1	1.02	0.28	0	1.19	2
2.8	0.64	1	1.32	1	1.09	0.60	0	0.97	0
2.9	0.55	0	1.08	2	1.07	0.76	0	0.76	1
3.0	0.50	3	1.00	1	1.04	0.70	1	0.67	2
3.1	0.52	0	1.04	0	1.12	1.15	2	0.66	1
3.2	0.55	2	1.04	2	1.27	1.32	1	0.66	0
3.3	0.53	2	0.90	1	1.31	1.06	1	0.57	1
3.4	0.49	0	0.72	0	1.18	1.18	1	0.47	1
3.5	0.46	0	0.59	1	0.94	1.36	1	0.41	1
3.6	0.42	0	0.50	1	0.70	1.08	0	0.35	1
3.7	0.39	0	0.46	0	0.55	0.69	0	0.32	0
3.8	0.39	0	0.57	0	0.52	0.39	1	0.38	0
3.9	0.42	0	0.77	1	0.56	0.19	2	0.50	0
4.0	0.47	0	0.97	0	0.62	0.09	1	0.61	2

Table continues on the Next Page

Table 6-3 (Sheet 2 of 2)
South Texas Unit-2 March 2001
Comparison of Predicted and Actual EOC-8 Voltage Distributions

Voltage Bin	Steam Generator A		Steam Generator B		Steam Generator C			Steam Generator D	
	Number of Indications								
	EOC-8 Prediction POD = 0.6	EOC-8 Actual	EOC-8 Prediction POD = 0.6	EOC-8 Actual	EOC-8 Prediction POD = 0.6	EOC-8 Prediction POPCD	EOC-8 Actual	EOC-8 Prediction POD = 0.6	EOC-8 Actual
Table Conitues from the last Page									
4.1	0.49	1	1.05	0	0.68	0.18	3	0.66	2
4.2	0.45	0	0.95	0	0.69	0.59	1	0.60	0
4.3	0.37	1	0.73	0	0.63	0.88	0	0.46	1
4.4	0.28	2	0.52	0	0.52	1.08	0	0.33	2
4.5	0.21	3	0.40	1	0.45	0.89	1	0.24	2
4.6	0.19	1	0.40	0	0.46	0.56	1	0.23	2
4.7	0.18	0	0.42	0	0.49	0.33	0	0.24	0
4.8	0.15	0	0.35	0	0.48	0.37	1	0.20	2
4.9	0.09	0	0.25	2	0.40	0.68	0	0.15	0
5.0	0.00	0	0.19	0	0.34	0.64	1	0.11	0
5.1	0.00	1	0.19	0	0.38	0.43	0	0.11	2
5.2	0.00	0	0.21	0	0.43	0.27	0	0.12	1
5.3	0.00	0	0.18	2	0.43	0.33	1	0.04	1
5.4	0.70	1	0.18	0	0.42	0.66	0	0.00	0
5.5	0.00	1	0.26	2	0.44	0.78	0	0.00	1
5.6	0.00	0	0.11	0	0.45	1.08	0	0.70	0
5.7	0.00	0	0.00	1	0.42	0.92	1	0.00	0
5.8	0.30	0	0.70	0	0.06	0.77	0	0.00	0
5.9	0	1	0.00	0	0.00	0.77	0	0.30	0
6.0	0	1	0.30	1	0.70	0.32	0	0	0
6.1	0	0	0	0	0.00	0.00	1	0	0
6.2	0	0	0	0	0.30	0.70	2	0	1
6.3	0	0	0	0	0	0.30	0	0	1
6.4	0	1	0	0	0	0	0	0	0
6.5	0	0	0	1	0	0	0	0	0
6.7	0	0	0	1	0	0	0	0	1
6.8	0	0	0	0	0	0	1	0	0
6.9	0	0	0	0	0	0	0	0	1
7.0	0	1	0	1	0	0	0	0	0
7.1	0	1	0	0	0	0	0	0	1
7.3	0	0	0	0	0	0	0	0	1
7.4	0	1	0	0	0	0	1	0	0
7.5	0	0	0	0	0	0	0	0	1
7.7	0	0	0	0	0	0	1	0	0
7.9	0	0	0	0	0	0	0	0	1
8.1	0	1	0	0	0	0	1	0	0
8.2	0		0	0	0	0	1	0	0
9.8	0		0	1	0	0		0	0
10.0	0		0		0	0		0	1
TOTAL	509	611	1294	1229	927	866	972	792	767
> 1 V	127	106	244	108	227	191	117	158	117
> 3 V	8	22	15	19	18	22	28	9	32
> 5 V	1	10	2	10	4	7	10	1	14

Figure 6-1
South Texas Unit-2 SG-A
Predicted Bobbin Voltage Distribution for Cycle 9
Combined Data for Hot and Cold Leg Indications - POD=0.6



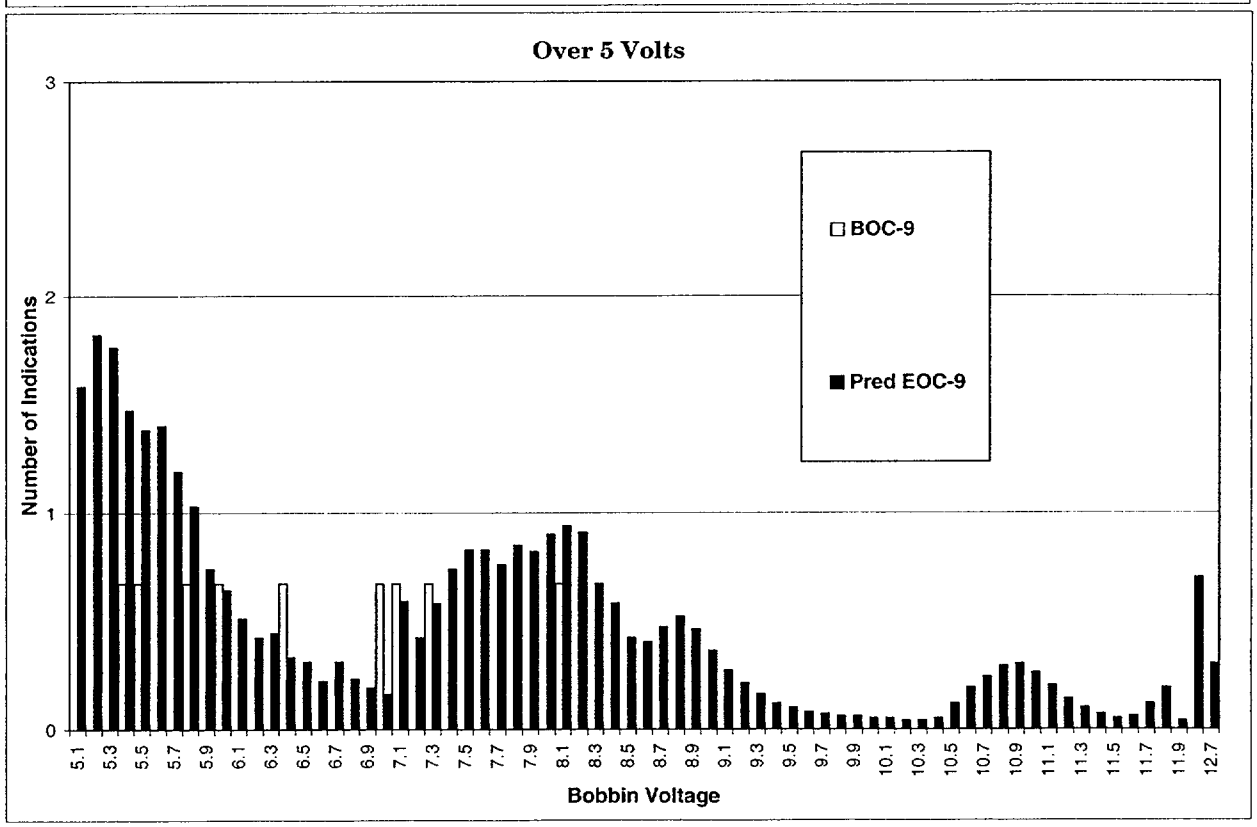


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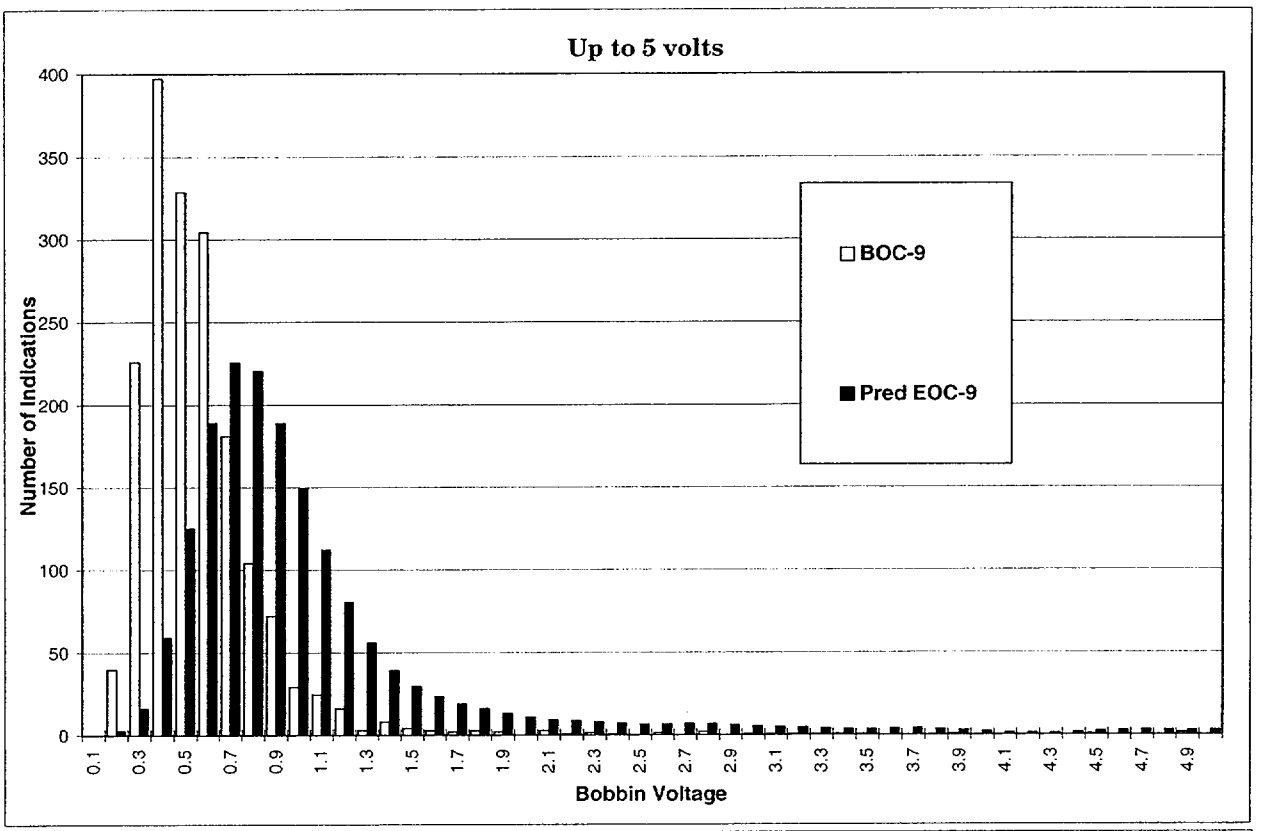
Figure 6-2
South Texas Unit-2 SG-B
Predicted Bobbin Voltage Distribution for Cycle 9
Combined Data for Hot and Cold Leg Indications - POD=0.6



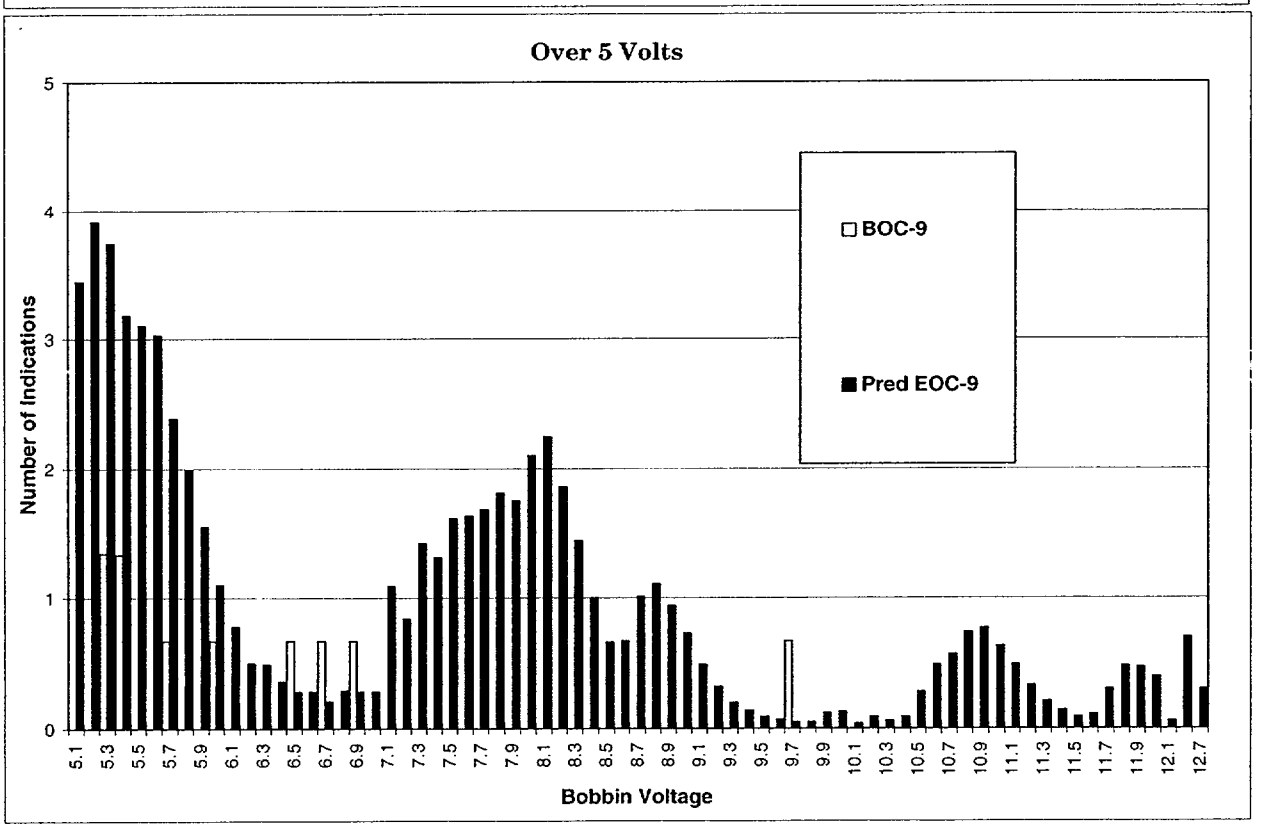


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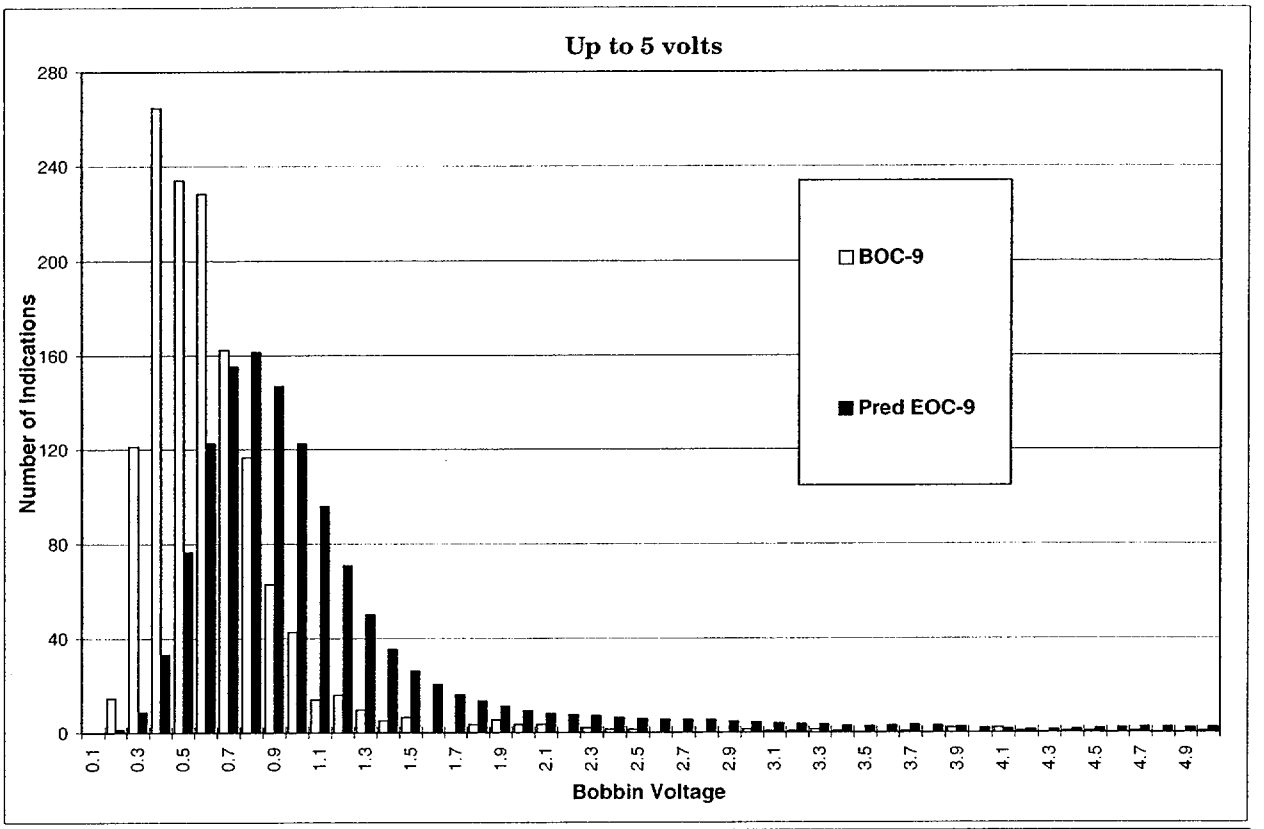
Figure 6-3
South Texas Unit-2 SG-C
Predicted Bobbin Voltage Distribution for Cycle 9
Combined Data for Hot and Cold Leg Indications - POD=0.6



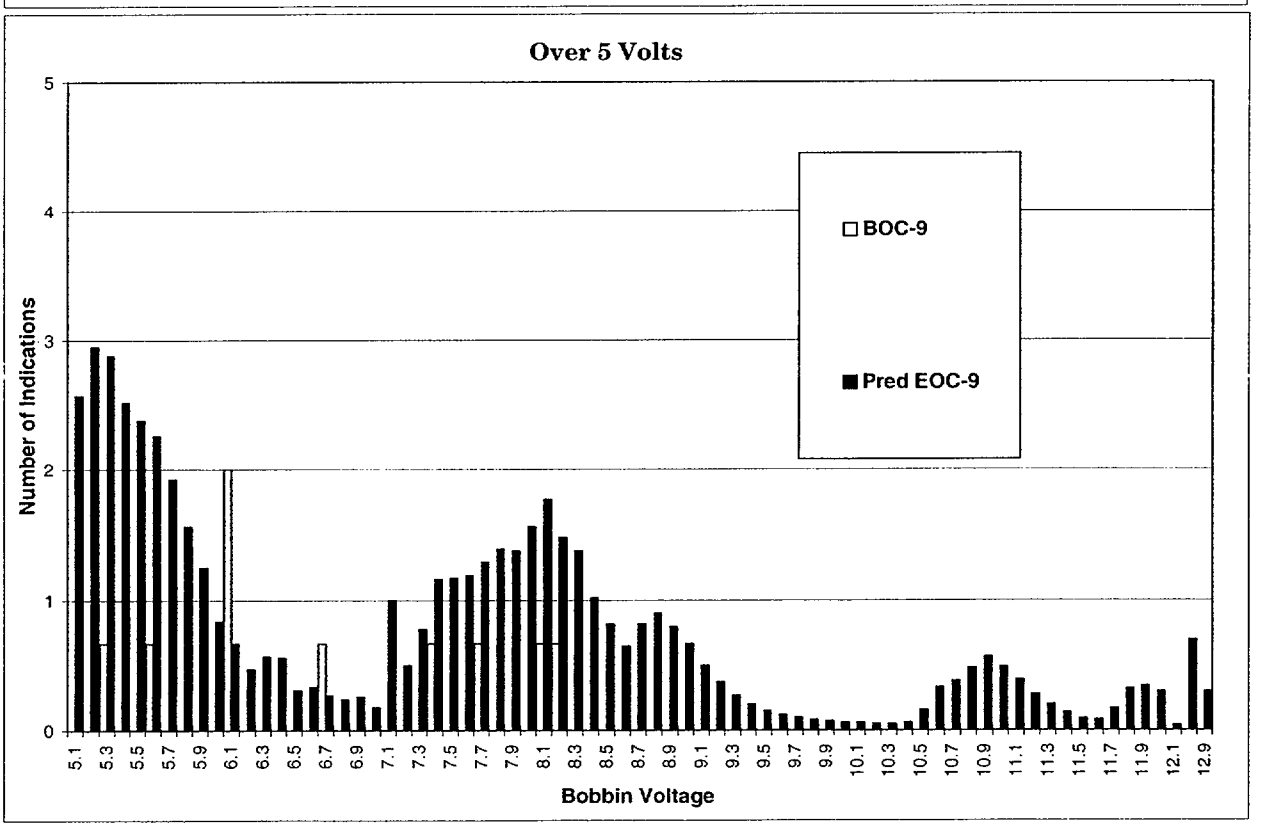
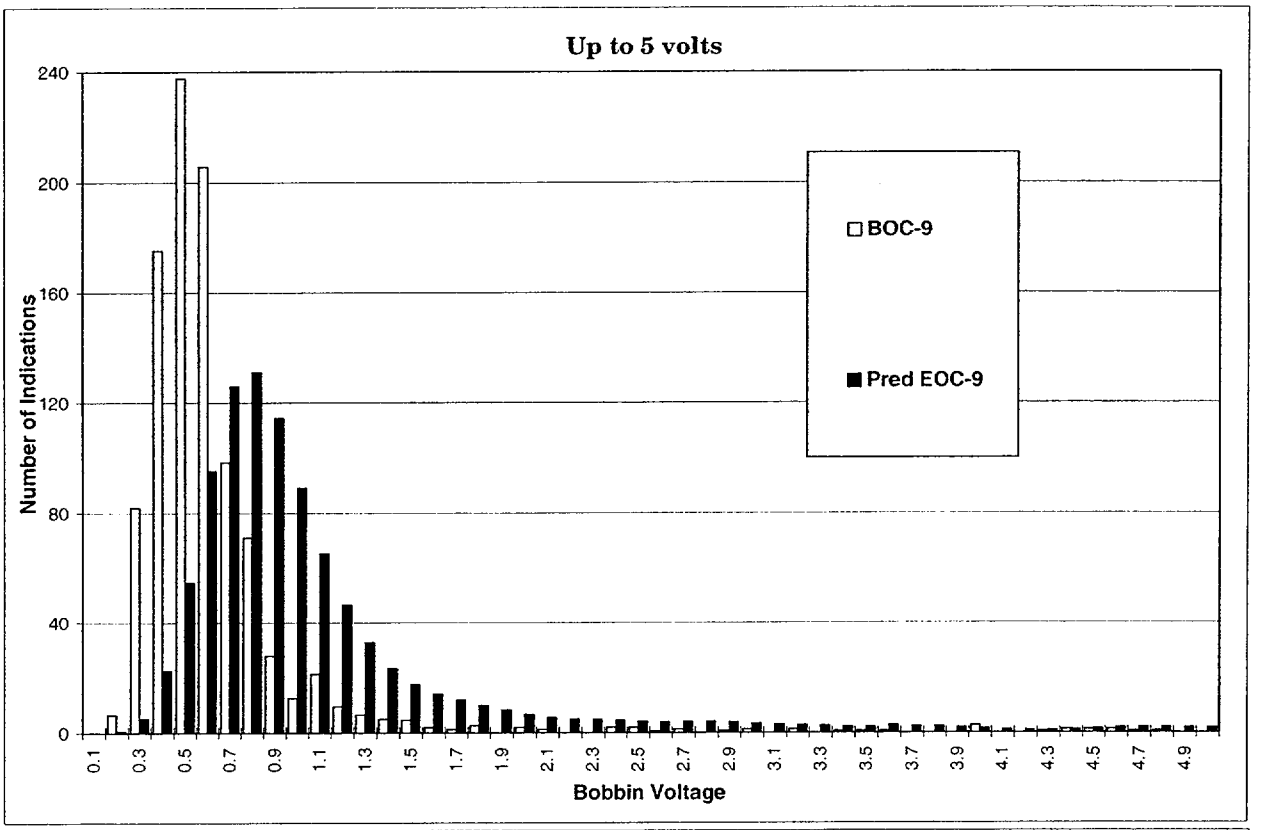


Figure 6-4
South Texas Unit-2 SG-D
Predicted Bobbin Voltage Distribution for Cycle 9
Combined Data for Hot and Cold Leg Indications - POD=0.6



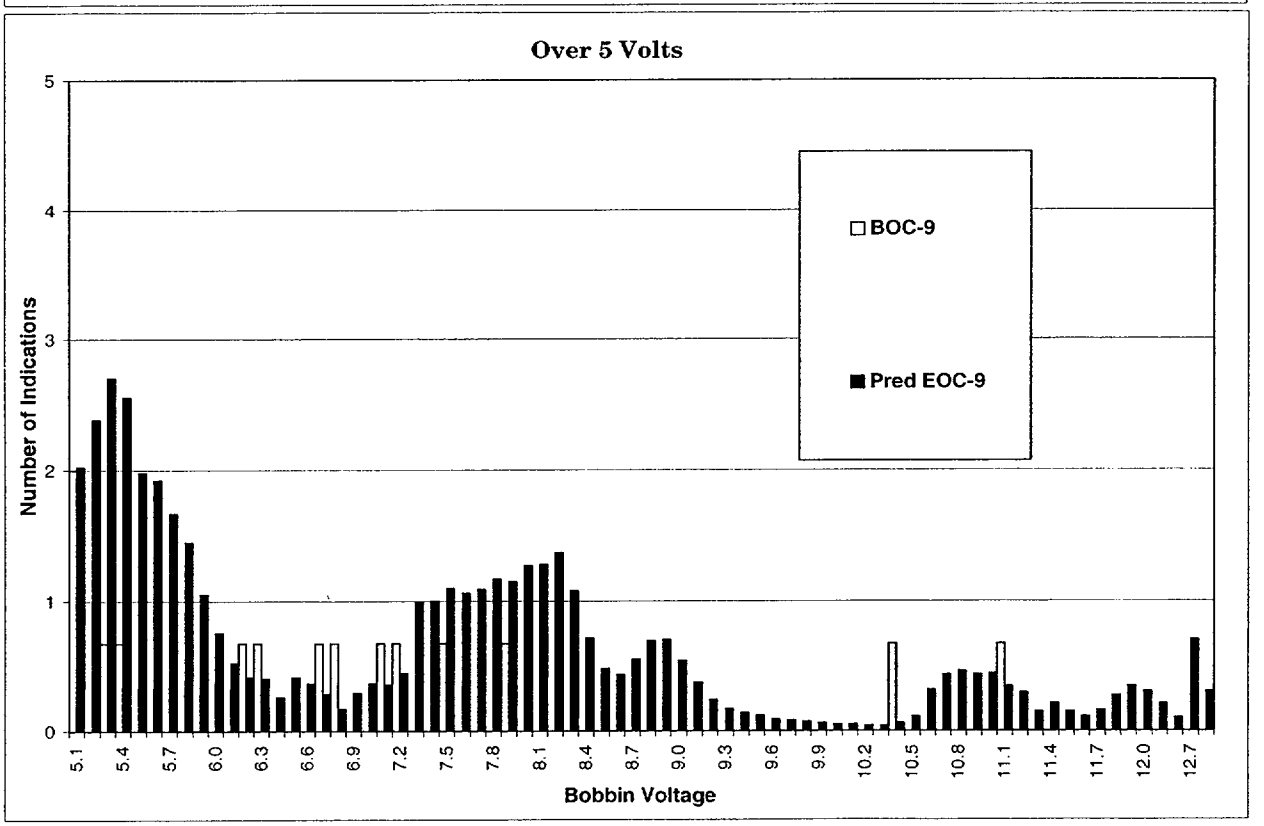


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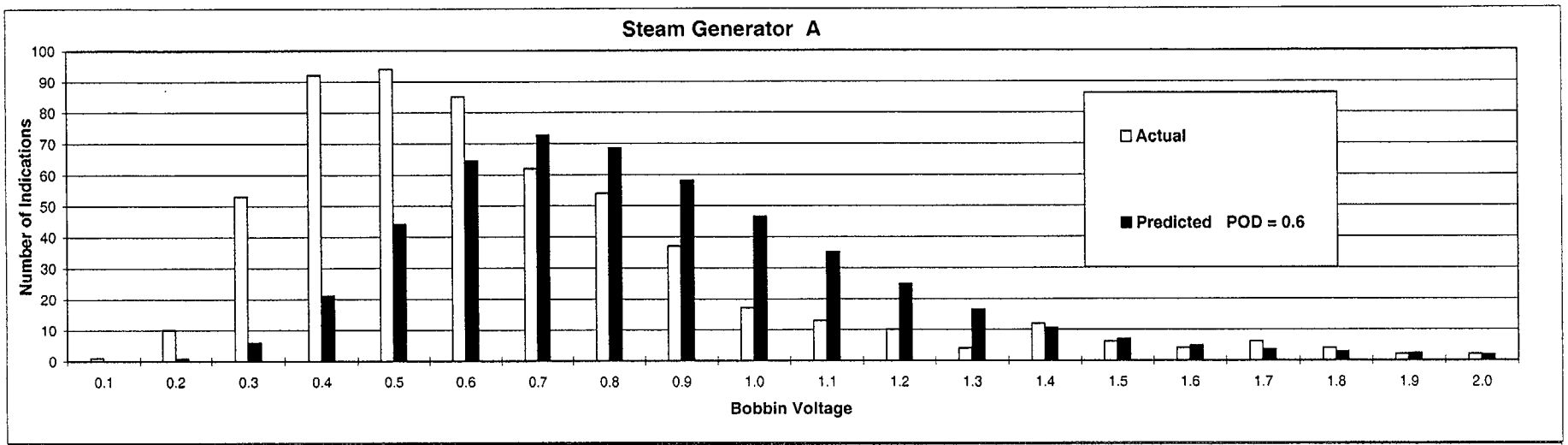
Figure 6-5 (Part 1 of 2)
South Texas Unit-2 March 2001 - Steam Generators A and B
Comparison of Predicted and Actual Bobbin Voltage Distributions for Cycle 8 - Indications up to 2 volts



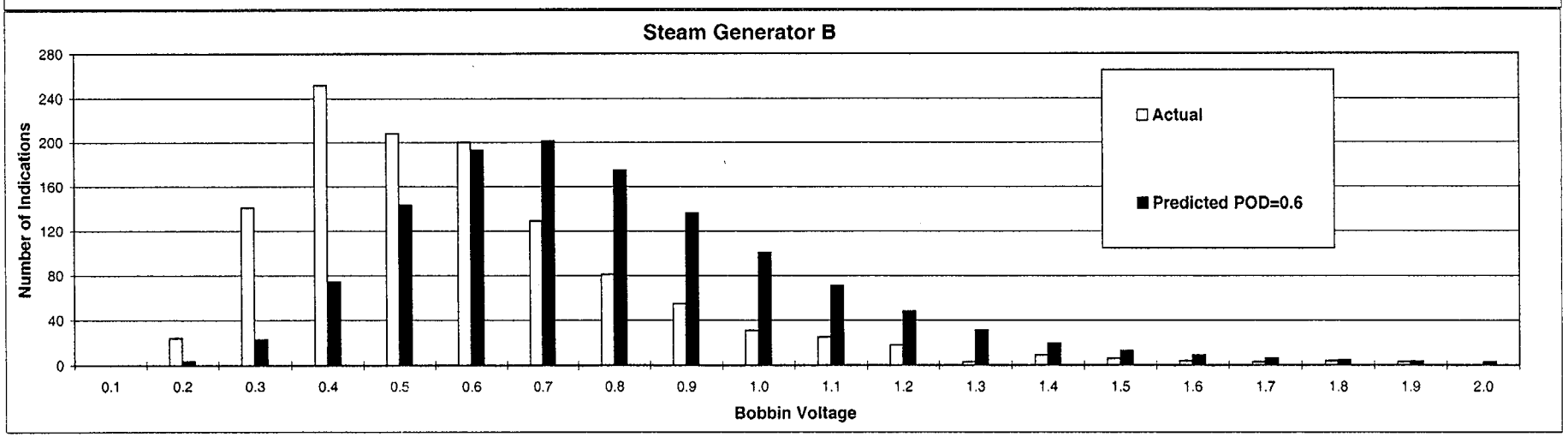


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Figure 6-5 (Part 2 of 2)
South Texas Unit-2 March 2001 - Steam Generators A and B
Comparison of Predicted and Actual Bobbin Voltage Distributions for Cycle 8 - Over 2 volts

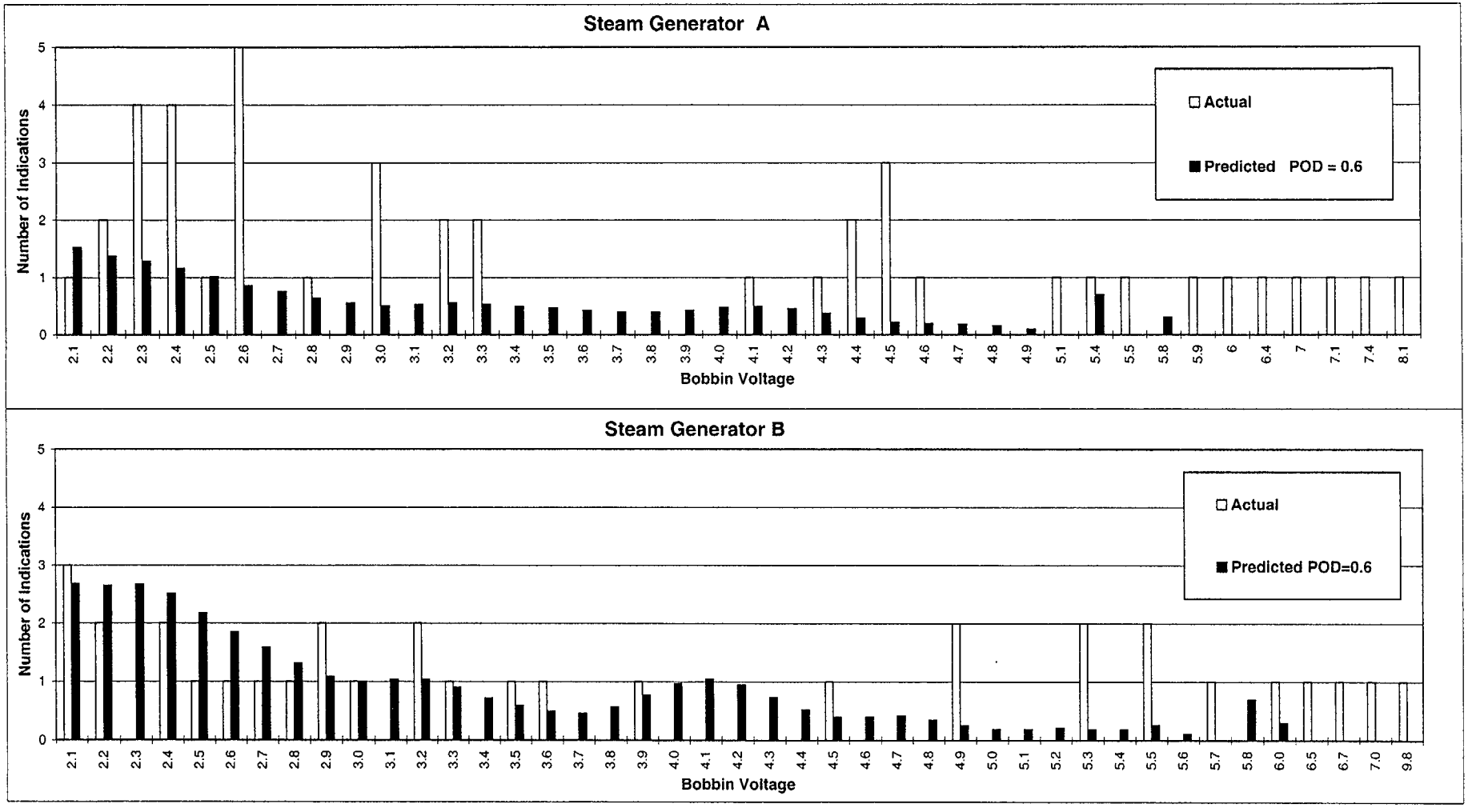

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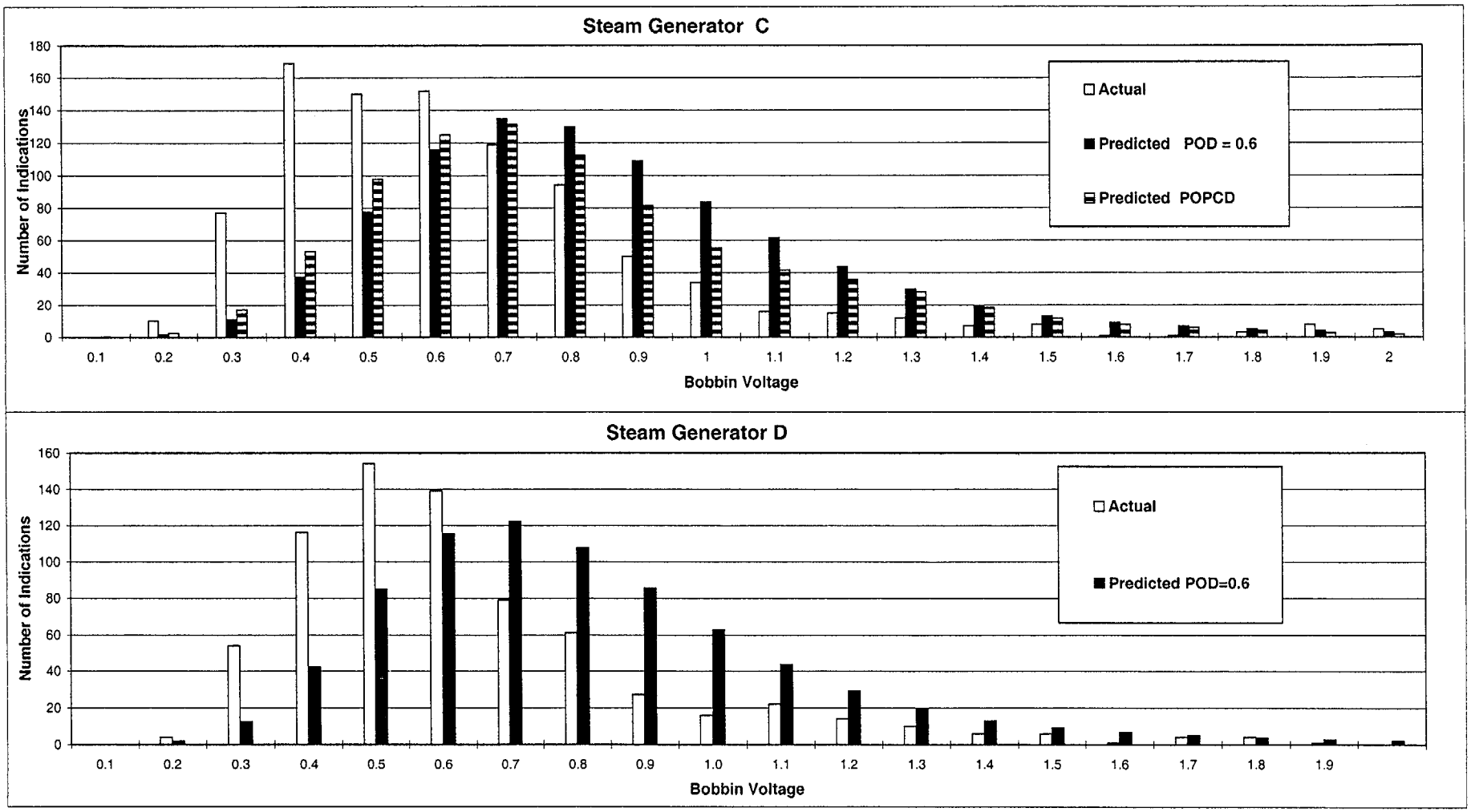
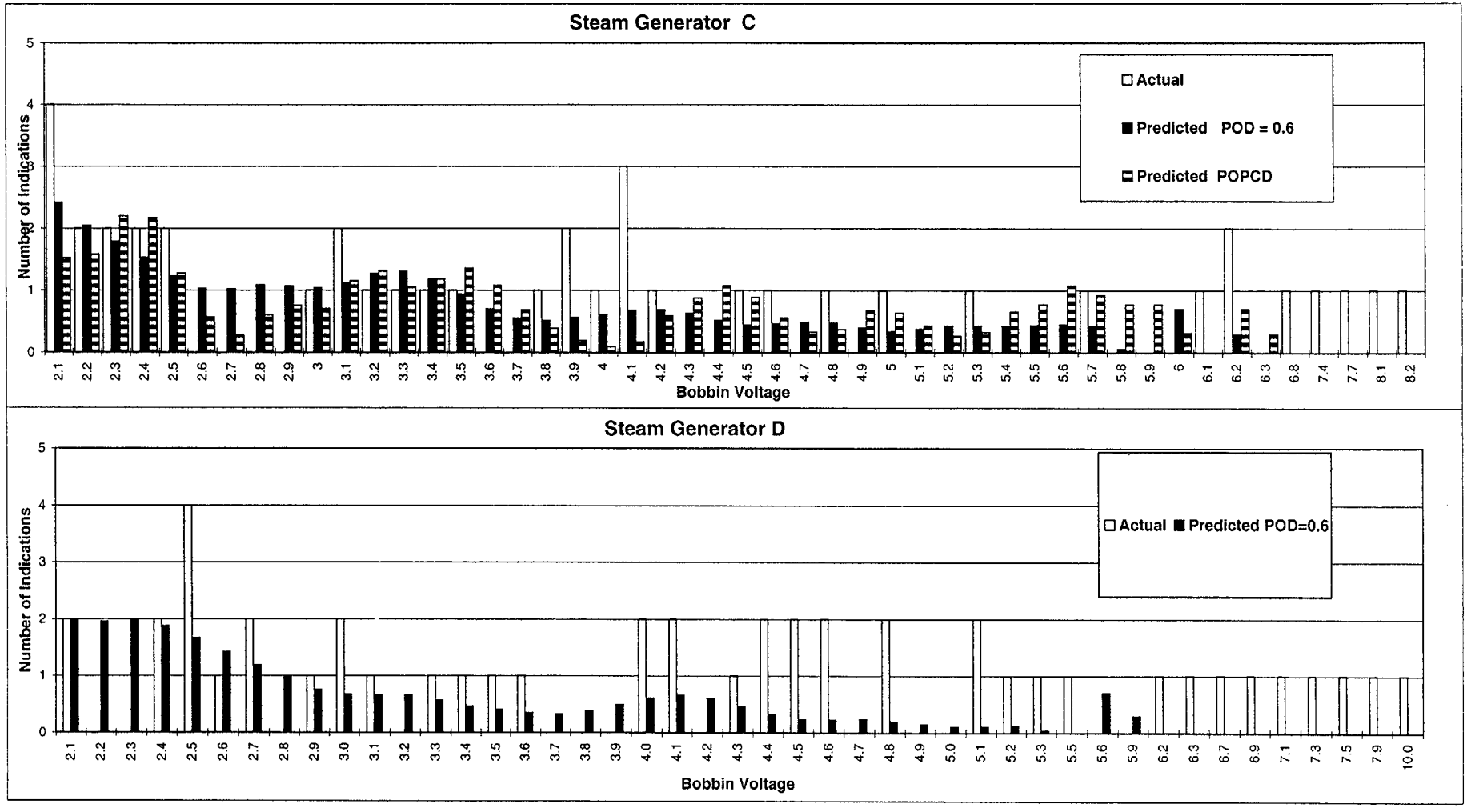
Figure 6-6 (Part 1 of 2)
South Texas Unit-2 March 2001 - Steam Generators C and D
Comparison of Predicted and Actual Bobbin Voltage Distributions for Cycle 8 - Indications up to 2 volts



Predcomp.xls Fig_Cy7_C-D_upto2v 6/18/01 4:09 PM

Figure 6-6 (Part 2 of 2)
South Texas Unit-2 March 2001 - Steam Generators C and D
Comparison of Predicted and Actual Bobbin Voltage Distributions for Cycle 8 - Over 2 volts



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-8 inspection as well as for the projected EOC-9 voltage distributions. The methodology used in these analyses is described in Section 5.0. SG-B with the largest total number of indications as well as indications over 1 volt returned to service is expected to yield the limiting SLB leak rate and burst probability for Cycle 9.

7.1 Leak Rate and Tube Burst Probability for EOC-8 (Condition Monitoring Assessment)

Condition monitoring analyses to estimate EOC-8 SLB leak rates and tube burst probabilities were performed using the actual bobbin voltage distributions presented in Table 6-1. Results of Monte Carlo calculations are summarized in Table 7-1.

An analysis presented in Reference 8-5 shows that lower tube support plates, specifically TSPs 2, 3 and 4, undergo only a limited displacement during a postulated SLB event and, consequently, ODSCC indications at those TSP locations would be restrained from bursting even if their burst limit is exceeded. Therefore, SLB leak rates for indications at the lower 3 TSPs were calculated using the IRB leakage methodology discussed in Reference 8-4. Leak rates and burst probabilities for the remaining indications were calculated using the standard GL 95-05 methodology (Reference 8-3). It is evident from the results shown in Table 7-1 that the SLB leak rates for all four SGs based on the IRB methodology are within the allowable limit of 15.4 gpm. With the contribution to SG burst probability from all indications at 2H to 4H taken to be 10^{-5} (Reference 8-5), the total SG tube burst probabilities for all 4 SGs are well within the NRC guideline of 10^{-2}.

The leak rates calculated using the actual measured EOC-8 voltages are higher than the projections presented in the last 90-day report because the actual growth rates during Cycle 8 were higher than those assumed for the projections. The growth distribution applied for the EOC-8 projection was obtained by examining the growth data for the prior two cycles and selecting the limiting distribution, consistent with the GL 95-05 guidelines. Steam generator C was projected to be the limiting SG at EOC-8, but the condition monitoring analysis predicts a higher SLB leak rate for SG-D. However, if the two largest indications in SG-D are removed, both SGs C and D yield comparable leak rates and burst probabilities. A few large indications in the population distribution tail may occur randomly in any SG, and they may not be predicted by a Monte Carlo analysis.

Table 7-1 also shows the condition monitoring results based on the conventional GL 95-05 methodology, which ignores the effect of TSPs restricting indications

from bursting. Again, EOC-8 leak rates for all SGs are well below their allowable limit of 15.4 gpm, but the burst probabilities are higher than the NRC recommended guideline of 10^{-2}. However, 92% of the EOC-8 indications were present at elevations 2H, 3H and 4H and, as noted above, the support plates at those locations undergo only a limited displacement. The contribution from all such indications to the total SG burst probability is estimated to be 10^{-5} (Reference 8-5) and, therefore, tube probabilities calculated using the conventional GL 95-05 methodology are not relevant.

In summary, the limiting SLB leak rate calculated using the actual measured EOC-8 bobbin voltage distributions (5.7 gpm at room temperature for SG-D) is well below the allowable limit of 15.4 gpm. With credit taken for limited displacement of the lower 3 TSPs, tube burst probabilities for all SGs based on the as found EOC-8 conditions are well below the NRC recommended guideline of 10^{-2}.

7.2 Leak Rate and Tube Burst Probability for EOC-9 (Operational Assessment)

Calculations to project SLB leak rate and tube burst probability for all 4 SGs at the EOC-9 condition were carried out using a constant POD value of 0.6. Since the indications at the lower 3 TSPs are restrained from bursting due to limited TSP displacement during a SLB event that is further assured by expansion of 16 tubes at 2H, 3H and 4H, SLB leak rates for indications at those locations were estimated using the IRB methodology (Reference 8-4). Conventional GL 95-05 methodology was used to predict EOC-9 SLB leak rates and burst probabilities for the remaining indications. Projected results for the EOC-9 conditions are summarized on Table 7-2. With a constant POD of 0.6, the limiting EOC-9 SLB leak rate projected is 14.4 gpm (room temperature), which is within the allowable Cycle 9 SLB leakage limit of 15.4 gpm (room temperature).

Since TSPs 2, 3 and 4 are locked on the hot side by tube expansion, the tube burst probabilities for indications at these locations are expected to very small. A total burst probability of 10^{-5} can be assigned for all these indications (for which 3-volt ARC apply) in developing the total SG burst probability for the operational assessment (Reference 8-5). The limiting tube burst probability thus predicted among the 4 SGs is 3.5×10^{-3}, for SG-B, which is about 1/3rd of the NRC reporting guideline of 10^{-2}.

In summary, SLB leak rates and tube burst probabilities predicted for EOC-9 are well within their respective limits.

Table 7-1
South Texas Unit-2 March 2001 EOC- 8 Outage
Summary of Calculations of Tube Leak Rate and Burst Probability
Based on Actual Bobbin Voltage – 250k Simulations

SG	Indication	POD	Number of Indications(1)	Max. Volts	Burst Probability		SLB Leak Rate (gpm)(2)
					1 Tube	1 or More Tubes	
EOC - 8 PROJECTIONS(3)							
A	All Indications in the SG	0.6	509	5.8	2.4×10^{-3}	2.4×10^{-3}	0.20
B			1294	6.0	4.5×10^{-3}	4.5×10^{-3}	0.37
C			927	6.2	6.3×10^{-3}	6.4×10^{-3}	0.48
D			792	5.9	2.7×10^{-3}	2.7×10^{-3}	0.25
EOC - 8 ACTUALS (Limited TSP Displacement)							
A	At TSPs 2H to 4H	1	577	8.1	(See footnote 4)	(See footnote 4)	1.9
	At Other TSPs		34	1.5	$< 4.0\times10^{-6}$	$< 4.0\times10^{-6}$	1.0×10^{-4}
	Total		611	-	$< 4.0\times10^{-6}$	$< 4.0\times10^{-6}$	1.9
B	At TSPs 2H to 4H		1143	9.7	(See footnote 4)	(See footnote 4)	2.0
	At Other TSPs		86	5.3	1.0×10^{-3}	1.0×10^{-3}	0.09
	Total		1229	-	1.0×10^{-3}	1.0×10^{-3}	2.1
C	At TSPs 2H to 4H		884	8.2	(See footnote 4)	(See footnote 4)	2.7
	At Other TSPs		88	1.3	$< 4.0\times10^{-6}$	$< 4.0\times10^{-6}$	4.1×10^{-4}
	Total		962	-	$< 1.4\times10^{-5}$	$< 1.4\times10^{-5}$	2.7
D	At TSPs 2H to 4H		704	11.1	(See footnote 4)	(See footnote 4)	5.7
	At Other TSPs		64	2.4	$< 4.0\times10^{-6}$	$< 4.0\times10^{-6}$	2.8×10^{-3}
	Total		768	-	$< 1.4\times10^{-5}$	$< 1.4\times10^{-5}$	5.7
EOC - 8 ACTUALS (GL 95-05 Methodology)							
A	All Indications in the SG	1	611	8.1	2.6×10^{-2}	2.7×10^{-2}	1.4
B			1229	9.7	2.8×10^{-2}	2.9×10^{-2}	1.4
C			972	8.2	3.4×10^{-2}	3.5×10^{-2}	1.7
D			768	11.1	6.2×10^{-2}	6.5×10^{-2}	2.9

Notes: (1) Adjusted for POD.
(2). Equivalent volumetric rate at room temperature.
(3) Based on a Projected Cycle 8 length of 461 EFPD (vs 458 EFPD actual).
(4) Total contribution from all indications at TSPs 2 to 4 to the total SG tube burst probability is estimated at 10^{-5} (Reference 8-5).

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Table 7-2
South Texas Unit-2 March 2001 Outage
Summary of Projected Tube Leak Rate and Burst Probability for EOC-9 – 250k Simulations

SG	Indication	POD	No. of Indic-ations(1)	Max. Volts(2)	Burst Probability		SLB Leak Rate gpm
					1 Tube	1 or more Tubes	
A	At TSPs 2H to 4H	0.6	682	12.7	(See footnote 3)	(See footnote 3)	8.29
	At Other TSPs	0.6	49	7.1	1.0×10^{-3}	1.0×10^{-3}	0.09
	Total	-	731	-	1.0×10^{-3}	1.0×10^{-3}	8.38
B	At TSPs 2H to 4H	0.6	1639	12.7	(See footnote 3)	(See footnote 3)	14.10
	At Other TSPs	0.6	130	7.3	3.5×10^{-3}	3.5×10^{-3}	0.27
	Total	-	1769	-	3.5×10^{-3}	3.5×10^{-3}	14.37
C	At TSPs 2H to 4H	0.6	1213	12.9	(See footnote 3)	(See footnote 3)	12.20
	At Other TSPs	0.6	125	7.4	2.6×10^{-3}	2.6×10^{-3}	0.22
	Total	-	1338	12.9	2.6×10^{-3}	2.6×10^{-3}	12.42
D	At TSPs 2H to 4H	0.6	913	14.1	(See footnote 3)	(See footnote 3)	11.60
	At Other TSPs	0.6	91	7.3	1.8×10^{-3}	1.8×10^{-3}	0.17
	Total	-	1004	-	1.8×10^{-3}	1.8×10^{-3}	11.77

Notes:

(1) Number of indications adjusted for POD.

(2) Voltages include NDE uncertainties from Monte Carlo analyses.

(3) Total contribution from all indications at TSPs 2 to 4 to the total SG tube burst probability is estimated at 10^{-5} (Reference 8-5).

8.0 References

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

8-2 South Texas-2 Normal Operating Leakage Evaluation for Preventive Plugging of ODSCC at TSPs," Westinghouse Electric Company, June 2001.

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

8-4 WCAP-15163, Revision 1, "Technical Support for Implementing High Voltage Alternate Repair Criteria at Hot Leg Limited Displacement TSP Intersections for South Texas Plan Unit 2, Model E Steam Generator," March 1999.

8-5 WCAP-15163, Revision 1 and Addendum 1, "South Texas Unit-2: 3V Alternate Repair Criteria Application Bounding Analysis and Tube Expansions, Westinghouse Electric Company, January 2001.

8-6 SG-99-12-010, "South Texas Unit-2 Cycle 8 Voltage-Based Repair Criteria 90-Day Report," Westinghouse Electric Corporation, December 1999.

8-7 EPRI Report NP 7480-L, Addendum 3, "Steam Generator Tubing Outside Diameter Stress Corrosion Cracking at Tube Support Plates Database for Alternate repair Limits," Electric Power Research Institute, May 1999.

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

8-9 SG-01-02-001, Rev. 1, "South Texas Unit 2, Steam Generator Degradation Assessment 2RE08 Refueling Outage," Westinghouse Electric Company, February 2001.

ATTACHMENT 2

LTR-SGDA-01-169

Normal Operating Leakage Assessment for Preventive Plugging of ODSCC at TSPs South Texas Project Unit-2

June 18, 2001

Prepared by Westinghouse Electric Company, LLC

for

South Texas Project Nuclear Operating Company

Normal Operating Leakage Assessment for Preventive Plugging of ODSCC at TSPs at South Texas Project Unit-2

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Normal Operating Leakage Assessment for Preventive Plugging of ODSCC at TSPs at South Texas Project Unit-2

1.0 Introduction

South Texas Project, Unit-2 (STP-2) experienced low levels (up to about 11 gpd for highest SG) of continuous normal operating leakage during Cycle 8 operation. Upon occurrence of the leakage, the best judgment of the cause for leakage was axial ODSCC at TSP intersections, although there was no way to confirm this conclusion from the leakage data. The EOC-8 inspection results ultimately confirmed the leakage as attributable to ODSCC. Given that operating leakage could potentially occur at an increased rate in subsequent operating periods, STNOC elected during Cycle 8 to embark on a program to identify potential leakers during the EOC-8 inspection and prepare a preventive tube plugging program prior to Cycle 9 operation. This program to select preventive plugging candidate tubes was an STP-2 initiative outside the scope of the technical specification examination, licensing requirements, or the requirements of 10 CFR50, Appendix B, and as such, was performed to normal industrial standards.

A program was undertaken to identify axial ODSCC indications at TSP intersections for preventive plugging at the EOC-8 inspection in order to minimize the potential for normal operating leakage, and thereby reduce the potential for a forced outage due to leakage at normal operating conditions exceeding the industry guideline 75 gallons per day. The preventive plugging further increases the margin against accident condition leakage as confirmed by the 3.0 volt ARC analyses for EOC-9. The ARC ODSCC methods for SLB leakage are based on correlations of leakage with voltage. These methods are statistically based in that each indication at the same voltage has the same probability of leakage and leak rate. The methods are adequate and conservative for predicting the total SG burst probability and leakage. However, not all indications at the same voltage level have the same leakage potential due to differences in crack depths and lengths, and bobbin coil voltage-based methods are not adequate for selective preventive plugging to reduce potential leakage. The bobbin voltage represents an integrated response around the tube circumference and over the axial field of the coil, and does not have a strong correlation with depth. Therefore, methods based on depth profiling of the indications using the +Point probe were planned for this analysis. These methods are currently applied to support an axial PWSCC ARC for which the need to repair a tube is based upon the results of an operational assessment for indications sized by +Point. The Monte Carlo analyses for the normal operating leakage assessment are performed using the Westinghouse AutoAxprofile code, which is a generalized (ID, OD indications, etc.) version of the PWSCC ARC code accepted for the ARC analyses.

Analysis supporting preventive plugging to reduce leakage requires growth rates, NDE sizing uncertainties and a leak rate correlation. In this case, the leak rate correlation is required for normal operating leakage rather than the more common SLB leak rate correlations. For this program, a normal operating leak rate correlation was developed between leak rates for throughwall crack lengths calculated using the Westinghouse CRACKFLO code and test-measured leak rates as described in Section 3.3. The throughwall lengths for the leakage analysis are obtained by analyses for ligament tearing lengths applying the Argonne National Laboratory (ANL) model at the normal operating pressure differential. To obtain NDE sizing uncertainties, pulled tube indications in the EPRI ARC database that have field +Point data were used, including three indications from STP-2. NDE sizing uncertainties were developed for length, average depth and maximum depth as a correlation between destructive exam data and analyses of the +Point data performed by STP-2 analysts (See Section 3.1).

Growth rates for length, average depth and maximum depth were obtained from South Texas-2 and Braidwood-1 data (See Section 3.2). Bobbin coil indications were selected for +Point inspection, beyond those required for the voltage-based plugging criteria, based upon voltage and location considerations as described in Section 3.4. To benchmark the analysis methods, calculations of leakage at EOC-8 are compared with the measured operating leakage in Section 4. Section 5 describes the analysis results for identification of potential leaking tubes as a function of the probability level in the leakage analysis. Section 6 describes the selection of tubes for plugging based on the results of these analyses.

2.0 Background

Tubes with 0.6 to 1.5 bobbin volt indications, with emphasis on rows 10 to 30 where the large growth indications were found, were selected for +Point inspection. All bobbin indications between 1.5 and 3.0 volts were preventively repaired and indications below about 0.6 are typically difficult to size due to low signal-toto-noise ratios. About 1100 confirmed +Point indications in tubes not previously planned for repair were sized (depth vs. length profile) for this evaluation. An operational assessment was performed by Monte Carlo analyses using the AutoAxprofile code for each indication to project normal operating leakage at EOC-9. The +Point profile is projected to EOC conditions including the above noted allowances for NDE sizing uncertainties, tube material properties (flow stress) and growth rates. Distributions defining uncertainties are included for NDE sizing, tube material properties (flow stress), growth rates and leak rates. The uncertainties permit defining the EOC leak rate for each indication as a function of the probability level included in the analysis. Leak rates were evaluated at 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90% and 95% probabilities with an evaluation at 99.9% to represent approximately 100% probability. The best estimate, or nominal evaluation, is at 50% probability.. If the analysis methods were perfect, nominal analyses for predicting leakage (no growth) would exactly predict the measured leak rates such as operational leakage and in situ leakage measurements.

NDE uncertainties are large (about 11% standard deviation for average depth) and uncertainties in leak rate correlations are very large. Due to the significant uncertainties, leak rates increase rapidly with increasing probability levels in the analysis. The number of indications predicted to leak and the predicted leak rate will increase with increasing probability levels as larger NDE uncertainties and growth rates are effectively included in the assessment results. For identification of tubes for preventive plugging, the most important assessment output is the ranking or probability level for onset of leakage for each indication; that is, the assessment prediction of the probability level below which the indication would not leak. For potential leakage from the population of tubes evaluated, the number of tubes required to be plugged for no leakage at a given probability level can be defined. It needs to be noted that not all indications below 1.5 volts were sized and indications not sized are not evaluated for potential leakage. Some indications in this population can be expected to have large growth in the next cycle and potentially lead to some leakage. The current evaluation focused on the larger bobbin voltage indications potentially left in service.

3.0 Input Data for Normal Operation Leakage Assessment

Assessments to determine normal operating leakage require growth rates, NDE sizing uncertainties and a leak rate correlation. In this case, the leak rate correlation is required for normal operating leakage rather than the more common SLB leak rate correlations.

3.1 +Point Sizing Uncertainties

To obtain NDE sizing uncertainties, pulled tube indications in the EPRI ARC database that have field +Point data were used including three indications from STP-2. NDE sizing uncertainties were developed for length, average depth and maximum depth as a correlation between destructive exam data and analyses of the +Point data. NDE analysis instructions, including training material, were prepared for sizing axial ODSCC indications. One element of the +Point sizing technique that conservatively influences the leakage calculations is that all +Point indications with > 4.25 maximum volts have depth profiles adjusted to 100% maximum depth. This technique is applied as the pulled tube data indicate a very high probability of throughwall corrosion for these voltages, while direct phase angle based sizing tends to indicate maximum depths between 90% and 100%. The analysis instructions were provided to the NDE analysts, but no extensive training of the analysts was conducted. The analysts performing the sizing at South Texas-2 during the EOC-8 inspection were tested against the pulled tube indications so that six or seven +Point profiles were obtained for each indication in the pulled tube database used for this study. Seventeen indications from the axial ODSCC ARC database were included in the NDE uncertainty evaluation. Seven shallow indications from freespan ODSCC in CE SGs were also analyzed but not included in the correlations since the lengths for freespan indications can be very long compared to the 0.75" limit for ODSCC at TSP intersections. Inclusion of the freespan indications tended to improve the mean correlation for average depth but increased the variability in the length correlation.

Figures 1 and 2 show the NDE uncertainty correlation for length and average depth, respectively. The resulting sizing uncertainties are reasonable with standard deviations of 0.065 inch for length and 11.1% for average depth. These NDE uncertainties are included in the Monte Carlo simulations for the normal operational leakage assessment.

3.2 Growth Rates for Axial ODSCC at TSP Intersections

Growth rates for length and average depth were obtained by reanalyzing +Point and pancake coil NDE data from STP-2 and Braidwood-1 data. Growth rates for average depth were used for the leakage analyses rather than maximum depth since the leakage analyses are based on ligament tearing lengths. Ligament tearing lengths are more sensitive to average depths than single point maximum depths. Braidwood-1 had similar large voltage indications and the growth rates are comparable to Cycle 8 for South Texas-2. A large growth tail was added to the data based on the large +Point indications found in the EOC-8 inspection and assumed shallow depths (30% maximum depth, 24% average depth) at EOC-7. The larger EOC-8 indications were not inspected by +Point at the EOC-7 inspection.

Based upon including the largest +Point indications, the growth rates for average depth are SG dependent with a separate distribution for each SG. Growth in length was assigned to be the same for all SGs since the available data did not indicate significant differences between SGs. The growth rate distributions used in the analyses are given in Table 1. The average depth growth distribution for SG D is plotted in Figure 3. From Table 1, it can be seen that the depth growth rates are the same for all SGs up to 32% growth. Above 32% growth, the distributions differ between SGs due to the addition of the SG dependent growth tails based on the largest indications found at EOC-8.

3.3 Normal Operating Leakage Correlation

For this study, a normal operating leak rate correlation was developed between leak rates for throughwall crack lengths calculated using the Westinghouse CRACKFLO code and test measured leak rates. The throughwall crack length is based upon the ligament tearing length at normal operating

pressure differential calculated using the ANL correlation applied to the destructive exam profile (for correlation development) or +Point depth profile for field applications. The correlation then relates calculated leak rates to measured leak rates and includes leak rate uncertainties in the correlation with measurements.

Only leakage measurements for which a crack profile was obtained by destructive examination can be used in the correlation due to the need to calculate the ligament tearing length from the crack profile. Both ODSCC and PWSCC indications are used in the correlation since leakage has only a minor dependence upon ID or OD initiation. In the CRACKFLO analysis, tortuousity of the crack is increased for OD cracks compared to ID cracks based on observations of more complex leakage paths for the OD indications. The increased tortuousity for OD indications improves the agreement with measured leakage to values comparable to that for ID indications. For some of the available PWSCC indications, only the ID and OD length were measured in the destructive exam. Since these indications from expansion transitions are close to uniformly throughwall, a crack shape that results in ligament tearing close to the OD length was assumed for these indications. The ligament tearing length is the longest length predicted to tear throughwall at normal operating pressure differentials. It should be noted that this is different from the conventional ligament tearing pressure, which is zero for a throughwall crack.

The resulting correlation between measured and calculated leak rates at normal operating pressure differential is shown in Figure 4. The typical spread in leakage measurements for cracks of the same size is seen in the data. The data spread is similar to that found in corresponding correlations for leak rates at SLB conditions. The resulting correlation including uncertainties is used in the Monte Carlo simulations for the normal operational leakage assessment.

3.4 Selection and Prioritization of Indications for +Point Sizing

About 3580 ODSCC indications at TSP intersections were found in the EOC-8 inspection. Since outage time would be excessive to +Point inspect and size all ODSCC indications, the indications were prioritized for +Point inspection and sizing. One observation used to prioritize the inspection was that all indications above 5 bobbin coil volts were located between rows 10 and 30. Figure 5 shows the location of all indications above 4 volts. Of 74 indications above 4 volts, 46 indications exceeded 5 volts and all of these indications were between rows 10 and 30. Of the 28 indications between 4 and 5 volts, 23 indications were between rows 10 and 20. Below 4 volts, the indications were more randomly located in the SGs. These results show a higher likelihood of the large growth indications between rows 10 and 20.

Based on the above, the priorities for +Point inspection were:

- All indications between 1.0 and 1.5 bobbin volt (about 216 indications) not otherwise identified for repair for other causes were +Point inspected. About 102 indications above 3 volts were required inspections per the 3 volt ARC
- Indications between 0.6 and 1.0 bobbin volt prioritized by smallest phase angle (deepest bobbin indicated depth) between rows 10 and 20. Indications below about 0.6 bobbin volt were not emphasized for +Point inspection since it was expected that the smallest indications might not be adequately sized by +Point to support the operational assessment. About 66 indications below 0.6 volt were included in the +Point inspection

A total of about 1172 bobbin indications were + Point inspected and all but 20 of the bobbin indications were confirmed by the +Point inspection. +Point indications above 0.2 maximum volts and indicated

lengths greater than about 0.2 inch were depth versus length profiled by +Point analyses applying the techniques used to develop the sizing uncertainties described in Section 3.1 above. More than 1000 +Point indications were sized in this evaluation.

4.0 Comparison of Predictions with EOC-8 Operating Leakage Levels

The leakage analysis methods using +Point profiles have been verified against other calculational methods for SLB leakage analyses, but no prior efforts had been made to calculate normal operating leakage. The analysis methods can be benchmarked by comparing predictions of operating leakage at EOC-8 with the operating leakage found just prior to plant shutdown for refueling. The analysis predictions were performed based on calculating leakage applying the +Point profiles for indications that primarily had bobbin amplitudes >4 volts. Benchmarking was limited as it had to be completed within a 36 hour window allotted from receipt of the +Point profiles to identification of tubes for preventive plugging. The benchmarking analyses were the first step in the preventive plugging analysis process. No iterations on analysis methods were possible in this time frame, i.e, these are "blind" analyses for comparison with the leakage results. The benchmarking analyses were performed as normal operation leakage assessments that include NDE sizing, tube material properties (flow stress) and leak rate correlation uncertainties in the evaluation process.

Table 2 provides a summary of the benchmark analyses including predictions of the total SG leak rate and the number of actual leaking tubes (tubes identified as leakers in the SG pressure tests) that were predicted to leak. Table 3 provides a detailed spreadsheet for the benchmarking analyses that includes results for all indications included in the analysis. The best estimate (50/50) analysis methods lead to over-predictions of the SG leak rates by about a factor of 3 to 4 for SGs A, B and C, and a factor of 5 for SG D. The operational leak rates include potential reductions in leakage compared to freespan indications due to restricted tube to TSP crevices. The analysis methods are freespan leak rates, which could exceed packed crevice leak rates. However, the in situ test results for the ODSCC indications at TSP intersections show good agreement with the EPRI ARC correlation for freespan SLB leak rates. Consequently, there may not be a significant reduction in leak rates due to packed crevices for the South Texas-2 stainless steel TSPs. Given the small leak rates, and that this is a first time application of the analysis methods for ODSCC and leakage at normal operating conditions, the results are considered quite good' although conservative on leak rate predictions for this application.

The predicted leak rates increase dramatically with increasing probability levels in the analysis as expected when the sizing and leak rate correlation uncertainties are large. Given that the leak rates are conservative at 50/50, the large leak rates at higher probabilities are not meaningful for the current application. An important benchmark for the current application is the ability of the analysis methods to predict the tubes that actually leak while not substantially over predicting as leakers the number of tubes that did not leak. This information is given in the bottom 4 rows of Table 2. A total of 78 indications (sum over 4 SGs including all indications > 4 bobbin volts) were included in the benchmarking analyses where 54 were identified as leakers in the pressure test and 24 were not identified as leakers. It should be noted that indications identified as potential leakers in the pressure test included all tubes that had any probable wetness at the tubesheet with no dripping, and thus, could include some potential false calls as leakers. Although total leakage was over-predicted, the number of indications that leak is under-predicted (41% and 61% of total leakers at 50/50 and 75/50 probability) at the lower probability levels. At a probability of 85%, about 83% of the leaking tubes were predicted to leak, although it is expected that most of the leakage occurred in the fraction of tubes predicted to leak at 50% probability levels. At an 85% probability, about 42% of the tubes that were not reported as leakers are predicted to leak (i.e.,

false call rate). At a 95% probability, all indications reported as leakers are predicted to leak, and 96% of the tubes that were not reported as leakers are predicted to leak (i.e., false call rate). Consequently, the methods are very conservative in predicting tubes that leak when applied at the high probability levels such as 95/50.

Based on these results, a probability level of about 80% to 85% would be conservative for selecting tubes for preventive plugging to obtain a prediction that includes about 75% of all leakers as well as all the potential large leakers in the population.

For indications in situ leak tested, the leakage predictions can be compared with the test results for additional benchmarking of the analysis methods. This comparison is shown in the following table:

Comparisons of In Situ Test and Predicted Normal Operating Leak Rates				
		In Situ Tests - gpd		**Calculated - gpd**
SG	**Tube**	**Case 1(1)**	**Case 2(2)**	**Predicted at 50% Probability**
B	R15C89-2H	0.03	0.6	9.3
	R20C48-3H	0.0	0.0	9.3
D	R24C47-3H	0.06	1.0	4.9
	R24C68-4H	0.0	1.0	9.7
	R25C72-2H	0.0	2.4	3.0
	R10C109-2H	0.0	2.6	5.9

Notes:
1. Case 1: Best estimate normal operating (1225 psi, 616°F) leak rates based on adjusting measurements at 1400 psi to operating conditions.
2. Case 2: Leak rates extrapolated from measurements near 2000 psi, which conservatively includes plastic crack opening at higher pressures.

The predictions at 50% probability conservatively over predict the in situ measurements at normal operating pressure differentials. This includes Case 2 in the above table for which hysteresis effects from testing at higher pressures lead to larger crack openings when extrapolating to the lower normal operating pressure differential. As found above for the plant operating leakage prior to shutdown, the analysis methods over predict leak rates even when applied at the best estimate 50% probability.

5.0 Selection of Tubes for Preventive Plugging

A summary of the analysis results is given in Table 4. For each SG, the first two rows of Table 4 provide the number of indications and number of tubes predicted to leak as a function of the probability level in the calculation. The second row identifies the number of tubes that would be plugged at each confidence level to have no predicted leakage for the indications evaluated and represents the principal output from this assessment. The 3rd row for each SG provides the predicted leakage from all indications at the given probability level. The predicted leak rates have been reduced by a factor of three based on differences between measurement and nominal calculation in Table 2, and by factors variable with probability level to reduce the influence of leak rate correlation uncertainties. These adjustment factors were obtained by comparing results with and without leak rate correlation uncertainties. For this preventive plugging application, the leakage trend with higher probability levels in the analysis is more important than absolute leakage values.

The 4th to 8th rows provide the predicted leak rate if all tubes identified to leak at the noted probability level are plugged. For example, plugging 58 tubes in SG A for all leakers at 80% probability, the predicted leak rate is zero at 80% probability and is reduced by a factor of about 16 (from estimated 715 to 44 gpd at 85% probability). Plugging 44 tubes at 75% probability leads to a reduction in the estimated leak rate by about a factor of 15 (from 383 to 25 gpd at 80% probability). It can be noted that plugging to a higher probability leads to higher remaining leak rates because the probability level for the leak rate is also increased. However, the factor for a reduction in leak rate relative to no plugging increases with increasing plugging levels although the incremental reduction in leakage decreases for each 5% increase in probability at the high probability levels above about 70% probability.

Figure 6 provides an informative interpretation of the results. The figure shows the leak rate reduction factor (leakage with plugging divided by leakage without plugging) at 95% probability as a function of the number of tubes plugged for each SG. For a factor of 10 reduction in normal operating leak rates at the 95% probability level (factor is more relevant than predicted absolute leak rates), the number of tubes requiring preventive plugging varies from 75 to 120 in each SG. SG C is unusual at 95% probability in that a large number of tubes are predicted to initiate leakage first at the 95% probability level.

Example probabilities and associated plugging levels are:

- Repair to the 75% probability level requires 43+57+43+63=206 plugged tubes.
- Repair to the 80% probability level requires 58+69+61+71=259 plugged tubes.
- Repair to the 95% probability level requires 139+124+177+139=579 plugged tubes.

6.0 Preventive Plugging Implementation

As described in Section 5, the assessment methods were developed to define the number of tubes to repair as a function of the analysis probability level in order to obtain no leakage. The selection of tubes for plugging is entirely preventive plugging beyond that required by the ARC repair limits. Thus, none of the tubes require repair to meet licensing requirements, and the choice of tubes for repair is a STPNOC option.

STPNOC elected to preventatively plug at the 95% probability level in SGs A, B and D and plug 122 tubes in SG C (about 90% probability). The number of tubes repaired in SG C was reduced to maintain total plugging levels below the 10% plugging limit. The total number of tubes preventively plugged based on this analysis is 524 tubes including about 564 indications. In addition, preventive plugging of all indications between 1.5 and the 3.0 volt ARC repair limit resulted in plugging of an additional 105 tubes with 125 indications. Thus, the total STP-2 preventive plugging program resulted in plugging of 629 tubes with 689 indications to reduce the leakage potential during Cycle 9 operation.

At 95% probability, leak rates are reduced by a factor of about 25. At 95% probability, the benchmarking analyses indicate that all potential leakers within the population evaluated would be repaired.

It is recognized that not all indications were included in the preventive plugging analyses due to time limitations in performing the +Point inspections and sizing of the indications as well as difficulties in sizing the very small indications. A few of the indications found to leak at EOC-8 grew in Cycle 7 from

less than 0.6 bobbin volt indications at EOC-7. Indications < 0.6 bobbin volts and indications outside rows 10 to 30 below 1.0 volt were not included in the leakage assessment. Thus, the preventive plugging would not be expected to eliminate all normal operating leakage during Cycle 8. However, the conservative preventive plugging efforts can be expected to maintain Cycle 8 operating leakage below the normal operating guideline limit of 75 gpd.

Table 1. South Texas-2 Average Depth and Length Growth per EFPY Cumulative Probability Distributions											
All SGs		SG-A		SG-B		SG-C		SG-D			
Length Growth		Average Depth Growth		Average Depth Growth		Average Depth Growth		Average Depth Growth			
Length (in.)	Cum. Prob.	% Depth	Cum. Prob.	% Depth	Cum. Prob.	% Depth	Cum. Prob.	% Depth	Cum. Prob.		
0.00	0.417	0.00	0.278	0.00	0.278	0.00	0.278	0.00	0.278		
0.02	0.438	0.02	0.340	0.02	0.340	0.02	0.340	0.02	0.340		
0.04	0.510	0.04	0.361	0.04	0.361	0.04	0.361	0.04	0.361		
0.06	0.604	0.06	0.454	0.06	0.454	0.06	0.454	0.06	0.454		
0.08	0.688	0.08	0.474	0.08	0.474	0.08	0.474	0.08	0.474		
0.10	0.813	0.10	0.536	0.10	0.536	0.10	0.536	0.10	0.536		
0.12	0.917	0.12	0.588	0.12	0.588	0.12	0.588	0.12	0.588		
0.14	0.938	0.14	0.598	0.14	0.598	0.14	0.598	0.14	0.598		
0.16	0.948	0.16	0.629	0.16	0.629	0.16	0.629	0.16	0.629		
0.18	0.958	0.18	0.680	0.18	0.680	0.18	0.680	0.18	0.680		
0.20	0.969	0.20	0.742	0.20	0.742	0.20	0.742	0.20	0.742		
0.22	0.969	0.22	0.773	0.22	0.773	0.22	0.773	0.22	0.773		
0.24	0.979	0.24	0.794	0.24	0.794	0.24	0.794	0.24	0.794		
0.26	0.979	0.26	0.804	0.26	0.804	0.26	0.804	0.26	0.804		
0.28	0.990	0.28	0.887	0.28	0.887	0.28	0.887	0.28	0.887		
0.30	0.990	0.30	0.918	0.30	0.918	0.30	0.918	0.30	0.918		
0.32	1.000	0.32	0.938	0.32	0.938	0.32	0.938	0.32	0.938		
		0.35	0.969	0.35	0.979	0.35	0.979	0.35	0.959		
		0.38	0.979	0.37	0.990	0.40	0.990	0.37	0.969		
		0.42	0.990	0.43	1.000	0.44	1.000	0.40	0.979		
		0.45	1.000					0.43	0.990		
								0.45	1.000		

Table 2. South Texas-2 Comparison of Predicted and Actual Normal Operating Leak Rates and No. Leaking Tubes at EOC-9 Calculations Based on Indications with Bobbin Amplitudes > 4 Volts						
SG	**Operating Leakage (gpd)**	**+Point Profile Based Leak Rates (gpd) for Bobbin Indications > 4 Volts**				
		50/50 Prob/Conf	**60/50 Prob/Conf**	**75/50 Prob/Conf**	**90/50 Prob/Conf**	**95/50 Prob/Conf**
A	10.5	39	183	602	2000	3880
B	7.5	24	62	189	880	1907
C	8	38	125	373	1512	3190
D	9	51	174	528	1982	4352
Number of Pressure Test Leakers Predicted		22	31	33	50	54
Fraction of Pressure Test Leakers Predicted		22/54=0.41	31/54=0.57	33/54=0.70	50/54=0.93	54/54=1.00
Reported Non-leakers Predicted to Leak		3	5	6	14	23
Fraction of Reported Non-leakers Predicted to Leak		3/24=0.13	5/24=0.21	6/24=0.25	14/24=0.58	23/24=0.96

Table 3. South TexasSTP-2 Comparison of Normal Operating Leak Rates – Operation and NDE Based Predictions															
SG	Operating Leakage (gpd)	Pressure Test Leaking Tube	Tube-TSP > 4 Volts	Bobbin Volts	+Point Data				+Point Profile Based LR - gpd						
					Length	Max. Depth	Avg. Depth	+Point Volts	50/50 Prob/Conf	60/50 Prob/Conf	75/50 Prob/Conf	80/50 Prob/Conf	85/50 Prob/Conf	90/50 Prob/Conf	95/50 Prob/Conf
A	10.5	X	23/24-2H	8.05	0.47	100.0	84.2	7.17	3.3	14.1	45.5	67.4	99.6	154.3	300.9
		X	20/80-2H	7.32	0.40	100.0	73.4	7.47		18.6	62.9	93.0	134.4	203.4	378.8
		X	22/78-2H	7.05	0.45	100.0	75.7	6.56		12.3	70.5	101.9	147.4	223.0	396.6
		X	22/30-2H	6.65	0.45	100.0	83.3	5.59	7.4	19.0	53.5	75.6	109.2	169.2	329.9
		X	19/29-2H	6.36	0.44	100.0	80.1	5.30		5.9	32.2	47.7	73.9	122.6	233.5
		X	13/27-2H	5.99	0.51	100.0	78.5	4.34		12.3	42.5	62.9	95.1	154.3	315.0
		X	11/92-2H	5.83	0.47	100.0	85.4	5.94	4.9	17.3	51.1	73.9	111.8	173.1	322.4
		X	19/54-2H	5.45	0.51	100.0	85.1	4.45	6.9	19.0	53.5	75.6	111.8	177.2	322.4
		X	24/82-3H	5.37	0.40	83.0	65.4	4.03						9.1	57.3
			22/105-2H	5.01	0.48	81.0	59.7	3.50							9.7
		X	25/66-2H	4.55	0.46	100.0	82.4	4.43	3.8	15.1	44.5	62.9	88.8	144.0	280.8
		X	21/88-2H	4.46	0.45	100.0	79.8	7.17	5.9	19.0	56.0	77.3	114.4	177.2	329.9
			16/87-2H	4.35	0.40	80.0	67.0	3.21							28.7
		X	20/34-2H	4.31	0.41	100.0	82.7	4.35		11.7	39.7	57.3	86.8	134.4	256.1
			23/56-2H	4.30	0.34	79.0	65.8	3.01							3.2
		X	29/28-2H	4.26	0.42	100.0	80.7	5.15	6.9	19.0	49.9	72.2	104.3	157.9	300.9
		X	18/34-2H	4.19	0.43	81.5	65.1	2.87							14.1
						Total Leak Rate-gpd			39.0	183.0	601.9	867.5	1277.4	1999.6	3880.1
B	7.5	X	15/89-2H	9.72	0.53	100.0	87.0	6.29	9.3	22.3	58.7	81.0	117.0	181.3	337.6
		X	20/48-3H	6.93	0.44	100.0	87.3	4.28	9.3	21.8	60.0	82.9	119.8	181.3	353.5
		X	28/71-3H	6.67	0.47	89.5	74.3	4.09				6.7	22.8	48.8	119.8
		X	17/31-2H	6.27	0.44	87.5	69.9	3.62					14.4	41.5	106.7
		X	25/66-2H	5.69	0.54	98.0	80.0	3.25		19.8	74.3	110.6	165.2	261.2	511.2
		X	12/16-2H	5.44	0.38	92.0	77.5	3.52			11.4	24.5	44.5	79.1	181.3
			11/94-2H	5.44	0.34	88.0	67.0	2.09				10.0	27.4	60.0	144.0
		X	17/39-3H	5.38	0.45	100.0	78.6	5.23	5.5	17.7	52.3	72.2	106.7	165.3	322.4
			20/29-5H	5.27	0.42	90.0	70.8	3.10			6.4	16.9	33.8	68.9	150.8
			18/40-2H	5.22	0.35	86.5	69.3	3.60					12.0	37.0	109.2
		X	11/100-2H	4.87	0.44	84.0	67.7	2.53						16.2	65.8
			31/62-2H	4.81	0.35	97.0	84.8	2.98		12.3	43.5	62.9	95.2	151.2	280.8
			24/28-2H	4.49	0.30	84.5	62.1	2.52							15.4
						Total Leak Rate-gpd			24.1	93.9	306.6	467.6	758.8	1291.9	2698.5
C	8	X	22/92-4H	8.96	0.32	89.5	56.3	0.29	2.4	15.1	49.9	72.2	106.7	157.9	294.0
			20/106-2H	8.16	0.47	100.0	87.0	7.34	5.1	16.2	47.7	68.9	101.9	154.3	287.3

Table 3. South TexasSTP-2 Comparison of Normal Operating Leak Rates – Operation and NDE Based Predictions															
SG	Operating Leakage (gpd)	Pressure Test Leaking Tube	Tube-TSP > 4 Volts	Bobbin Volts	+Point Data				+Point Profile Based LR - gpd						
					Length	Max. Depth	Avg. Depth	+Point Volts	50/50 Prob/Conf	60/50 Prob/Conf	75/50 Prob/Conf	80/50 Prob/Conf	85/50 Prob/Conf	90/50 Prob/Conf	95/50 Prob/Conf
		X	20/73-2H	8.07	0.42	100.0	82.0	7.60	5.9	16.9	45.5	64.3	93.0	144.0	268.1
			19/79-2H	7.69	0.42	100.0	84.4	7.06	8.3	19.9	51.1	70.5	99.6	154.3	300.9
			23/105-2H	6.74	0.38	100.0	82.2	6.56		4.9	30.8	47.7	73.9	125.4	244.5
		X	17/70-2H	6.13	0.39	88.5	76.0	3.83				10.2	26.8	53.5	137.5
		X	21/88-2H	6.12	0.48	100.0	82.5	6.19	4.6	16.5	45.5	65.8	95.1	147.4	274.4
		X	22/88-3H	6.08	0.50	100.0	81.5	5.94	5.1	16.9	49.9	68.9	101.9	161.6	287.3
		X	17/69-2H	5.64	0.45	86.5	69.8	3.24					6.6	30.8	88.8
		X	20/98-4H	5.63	0.43	87.5	66.9	3.89				3.2	16.2	40.6	104.3
			14/94-2H	5.15	0.42	100.0	77.2	4.31	6.1	18.1	52.3	72.2	104.3	165.3	329.9
		X	23/22-3H	4.74	0.53	88.0	65.7	3.13					13.4	41.5	111.8
		X	21/35-3H	4.53	0.49	86.5	69.3	3.56					7.7	34.5	104.3
		X	11/108-2H	4.44	0.42	81.5	66.2	2.91							34.5
		X	23/91-2H	4.21	0.44	85.5	67.6	3.72						1.7	45.5
		X	18/81-2H	4.13	0.48	88.5	71.0	3.54				8.5	23.9	52.3	122.6
		X	24/24-2H	4.06	0.56	83.5	65.5	3.71							39.7
		X	43/74-2H	4.03	0.44	88.0	71.2	3.17				3.8	19.0	46.6	114.4
						Total Leak Rate-gpd			37.5	124.5	372.8	556.2	890.2	1511.7	3189.9
D	9	X	24/47-3H	11.09	0.49	100.0	84.4	8.77	4.9	16.2	47.7	67.4	97.4	147.4	280.8
		X	10/109-2H	10.37	0.47	100.0	83.4	4.92	5.9	17.3	49.9	70.5	99.6	161.6	294.0
		X	24/68-4H	9.54	0.47	100.0	86.5	4.96	9.7	24.5	62.9	86.8	122.6	189.8	345.4
		X	25/72-2H	7.45	0.44	100.0	82.2	4.48	3.0	14.4	43.5	61.4	90.9	144.0	287.3
		X	25/47-2H	7.23	0.43	100.0	79.0	5.91		12.0	41.5	58.7	86.8	140.7	274.4
		X	24/46-3H	7.06	0.46	100.0	78.6	6.51	1.6	12.5	39.7	56.0	82.9	131.3	250.2
		X	19/77-3H	7.04	0.47	100.0	79.9	5.39	8.5	20.3	53.5	73.9	106.7	161.6	300.9
		X	23/42-2H	6.82	0.45	100.0	81.2	5.92	10.4	24.5	64.3	88.8	128.3	203.4	387.6
			26/40-3H	6.29	0.35	83.0	65.1	3.51						3.2	45.5
		X	27/28-4H	5.25	0.43	87.0	72.7	3.29					13.4	39.7	114.4
			24/33-3H	5.16	0.23	82.5	67.9	2.81						6.3	49.9
		X	21/27-2H	5.08	0.49	100.0	72.1	4.28	6.9	19.9	57.3	79.1	114.4	177.2	322.4
			25/39-2H	5.03	0.45	81.5	65.7	3.98							40.6
		X	22/36-2H	4.80	0.40	100.0	77.7	5.52		3.7	30.1	47.7	73.9	117.0	233.5
		X	27/20-2H	4.71	0.44	86.0	66.0	3.60					7.7	29.4	95.1
			9/108-2H	4.62	0.29	82.5	67.0	2.20							38.8
			33/69-3H	4.58	0.38	80.0	53.6	2.13							
			21/25-3H	4.54	0.35	79.0	62.5	1.97							8.9
			40/64-3H	4.47	0.40	88.0	69.7	3.18				8.1	23.4	49.9	119.8
		X	26/26-2H	4.40	0.41	100.0	80.4	4.66		8.7	36.2	52.3	81.0	125.4	239.0

Table 3. South TexasSTP-2 Comparison of Normal Operating Leak Rates – Operation and NDE Based Predictions															
SG	Operating Leakage (gpd)	Pressure Test Leaking Tube	Tube-TSP > 4 Volts	Bobbin Volts	+Point Data				+Point Profile Based LR - gpd						
					Length	Max. Depth	Avg. Depth	+Point Volts	50/50 Prob/Conf	60/50 Prob/Conf	75/50 Prob/Conf	80/50 Prob/Conf	85/50 Prob/Conf	90/50 Prob/Conf	95/50 Prob/Conf
			25/39-3H	4.37	0.33	83.0	66.8	2.53						2.2	41.5
		X	20/28-2H	4.30	0.46	85.0	64.5	3.28						16.9	67.4
		X	22/33-3H	4.02	0.49	84.5	58.7	2.69							15.4
			29/26-3H	3.99	0.38	81.5	62.3	3.01						1.1	40.6
		X	25/69-2H	3.59	0.46	90.0	65.8	3.02					11.7	36.2	99.6
		X	30/28-2H	3.49	0.38	89.5	72.8	2.59			1.7	12.3	28.1	56.0	144.0
			23/78-3H	3.38	0.50	83.0	64.6	2.59							35.3
		X	17/108-2H	3.36	0.50	85.5	63.1	2.42						5.0	46.6
			27/45-2H	3.01	0.39	93.0	66.7	2.36					12.5	36.2	104.3
			28/24-2H	3.37	0.49	84.5	59.0	1.74							28.7
						Total Leak Rate-gpd			50.9	173.9	528.2	762.9	1181.2	1981.5	4352.0
		Total Number of Leakers Predicted							25	36	39	46	55	64	77
		Number of Pressure Test Leakers Predicted							22	31	33	38	45	50	54
		Fraction of Pressure Test Leakers Predicted							22/54=0.41	31/54=0.57	33/54=0.61	38/54=0.70	45/54=0.83	50/54=0.93	
		Reported Non-leakers Predicted to Leak							3	5	6	8	10	14	23
		Fraction of Reported Non-leakers Predicted to Leak							3/24=0.13	5/24=0.21	6/24=0.25	8/24=0.33	10/24=0.42	14/24=0.58	

Table 4. Summary of No. Tubes Projected to Leak at EOC-9 and Estimated Leak Rate vs. No. Tube Plugged										
	Calculation Probability at 50%Confidence									
Quantity	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
SG A: 201 +Point Indications Evaluated										
Number of Indications with Leakage	1	3	11	21	40	44	59	85	118	153
Number of Tubes with Leakage	1	3	11	20	39	43	58	81	110	139
Estimated Leakage for All Indications - gpd	1	9	27	62	130	227	383	715	1097	2189
Leakage if Plug Leakers to 75% Probability	0	0	0	0	0	0	25	122	332	944
Leakage if Plug Leakers to 80% Probability							0	44	199	680
Leakage if Plug Leakers to 85% Probability								0	58	338
Leakage if Plug Leakers to 90% Probability									0	87
Leakage if Plug Leakers to 95% Probability										0
SG B: 325 +Point Indications Evaluated										
Number of Indications with Leakage	13	18	23	35	46	60	73	86	103	137
Number of Tubes with Leakage	13	18	22	34	45	57	69	80	97	124
Estimated Leakage for All Indications - gpd	46	80	115	176	263	392	606	1018	1370	2440
Leakage if Plug Leakers to 75% Probability	0	0	0	0	0	0	26	99	220	608
Leakage if Plug Leakers to 80% Probability							0	26	98	375
Leakage if Plug Leakers to 85% Probability								0	28	210
Leakage if Plug Leakers to 90% Probability									0	76
Leakage if Plug Leakers to 95% Probability										0
SG C: 321 +Point Indications Evaluated										
Number of Indications with Leakage	2	5	10	13	23	43	61	83	130	192
Number of Tubes with Leakage	2	5	10	13	23	43	61	82	127	177
Estimated Leakage for All Indications - gpd	4	11	24	47	85	167	306	611	1001	2199
Leakage if Plug Leakers to 75% Probability	0	0	0	0	0	0	20	120	349	1104
Leakage if Plug Leakers to 80% Probability							0	38	203	809
Leakage if Plug Leakers to 85% Probability								0	90	540
Leakage if Plug Leakers to 90% Probability									0	177
Leakage if Plug Leakers to 95% Probability										0
SG D: 269 +Point Indications Evaluated										
Number of Indications with Leakage	15	20	27	37	48	63	74	91	117	149
Number of Tubes with Leakage	15	20	27	37	48	63	71	87	111	139
Estimated Leakage for All Indications - gpd	29	66	108	171	261	403	617	1038	1426	2574
Leakage if Plug Leakers to 75% Probability	0	0	0	0	0	0	16	87	231	681
Leakage if Plug Leakers to 80% Probability							0	36	142	505
Leakage if Plug Leakers to 85% Probability								0	49	288
Leakage if Plug Leakers to 90% Probability									0	80
Leakage if Plug Leakers to 95% Probability										0

Figure 1
STP-2 NOP Leakage Assessment -- NDE Uncertainty
Destructive Exam vs. Burst Adjusted NDE Trends - Axial Length

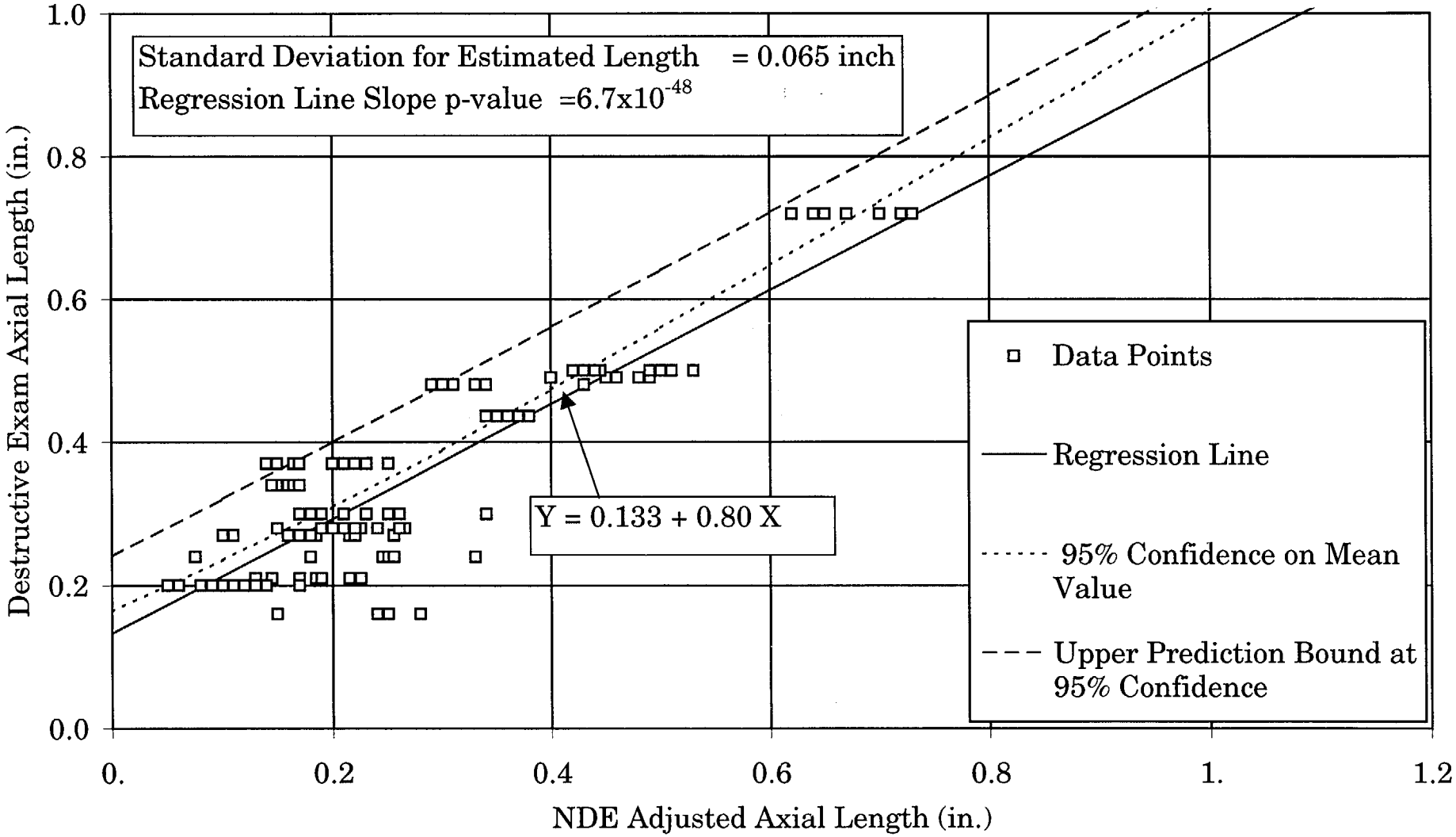

Figure 2
STP-2 NOP Leakage Assessment -- NDE Uncertainty
Destructive Exam vs. Burst Adjusted NDE Trends - Average Depth

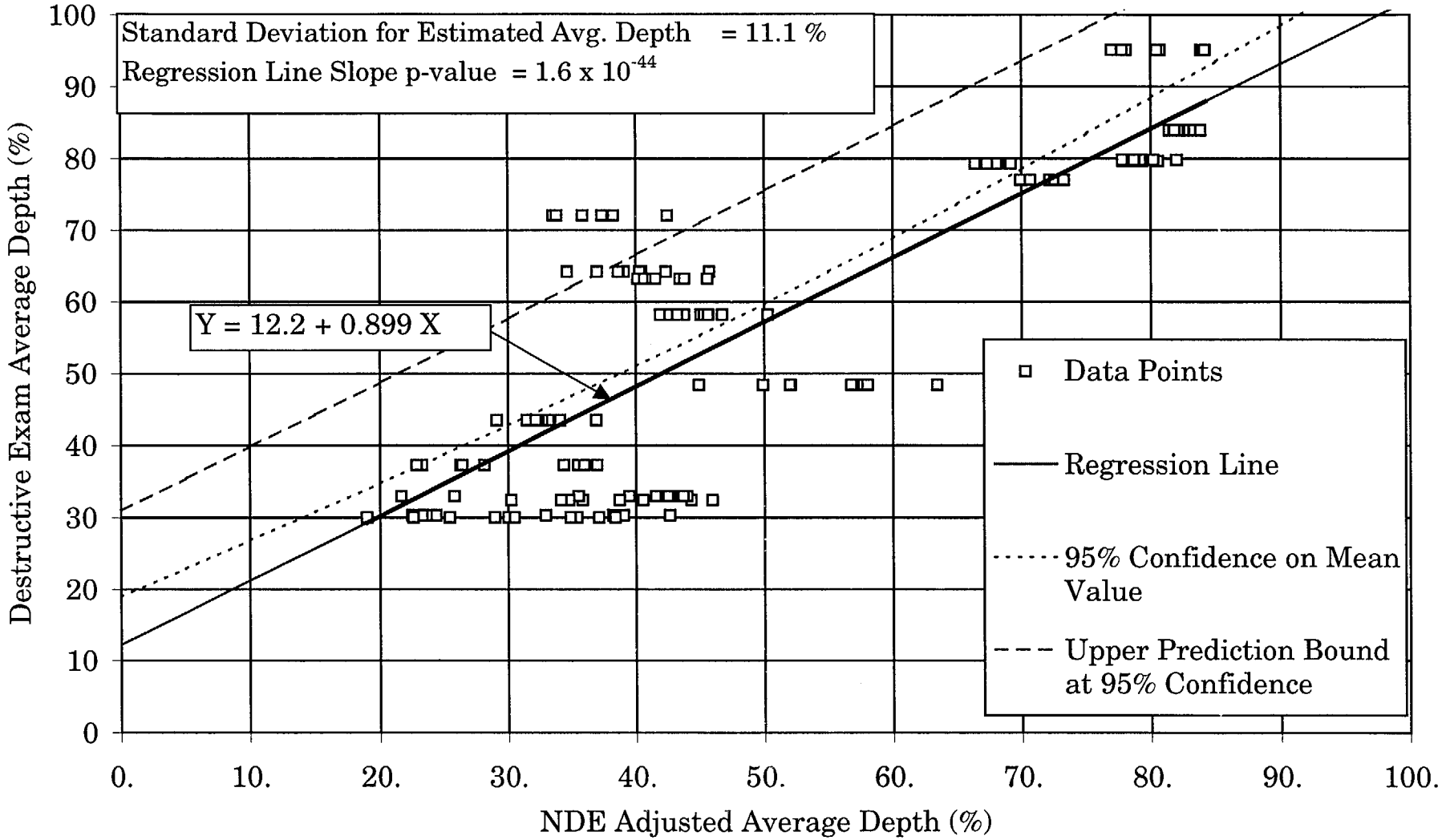

Figure 3 South Texas-2 SG D Average Depth Growth (%/EFPY)

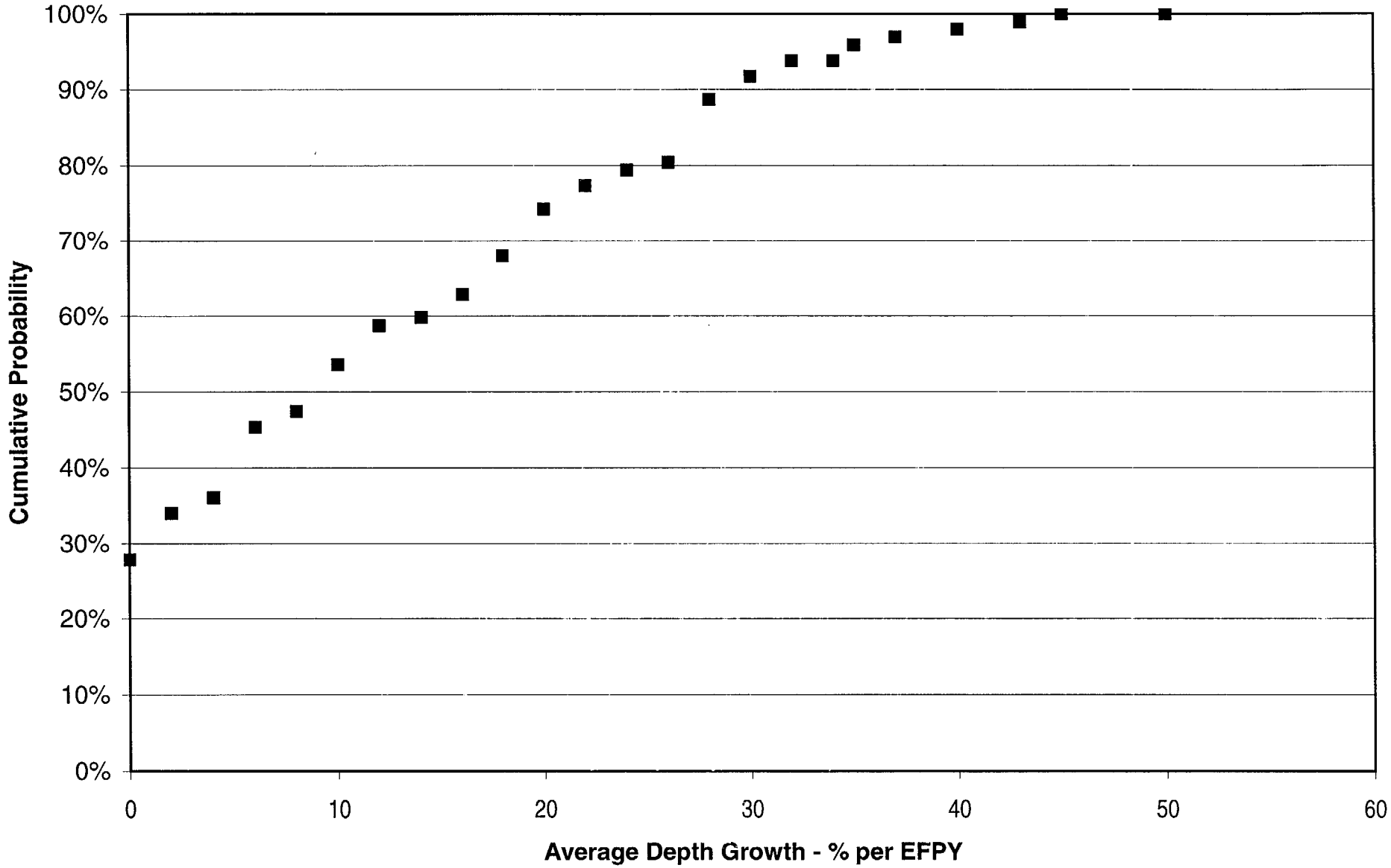

Figure 4
Measured versus Calculated CRACKFLO Leak Rate Correlation

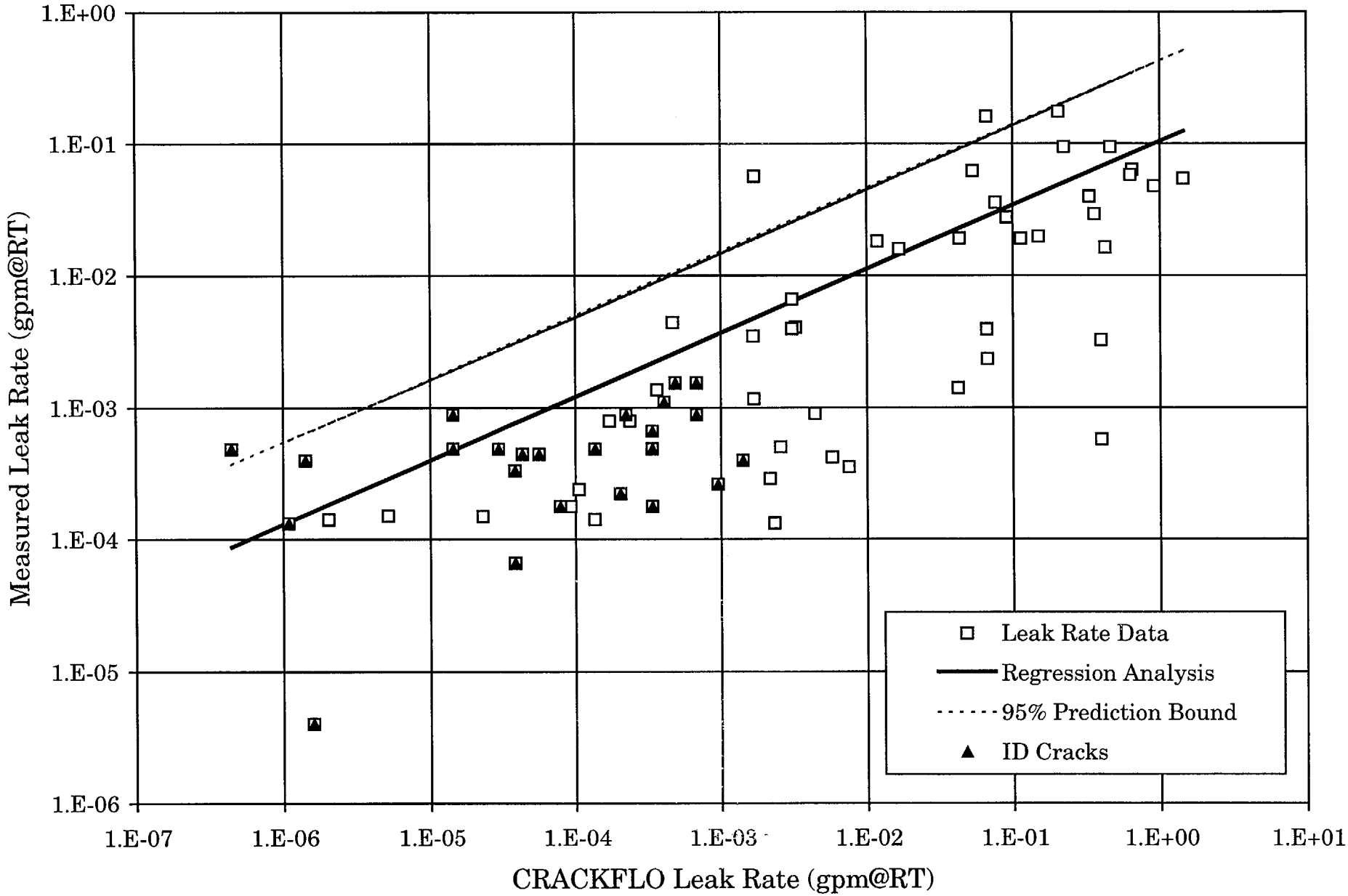

Figure 5
South Texas-2 Tubesheet Map of All ODSCC DSI >4 Volts

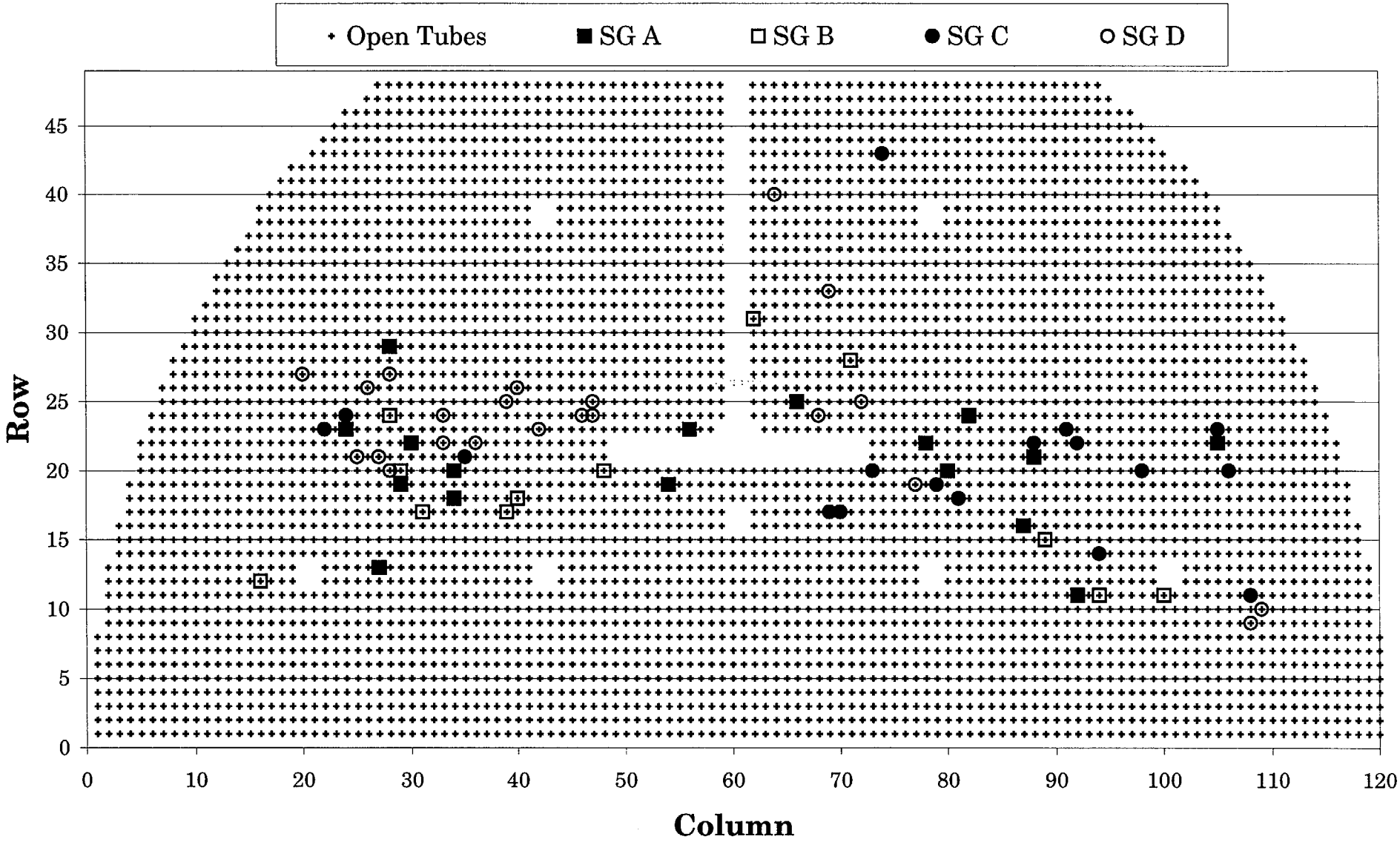
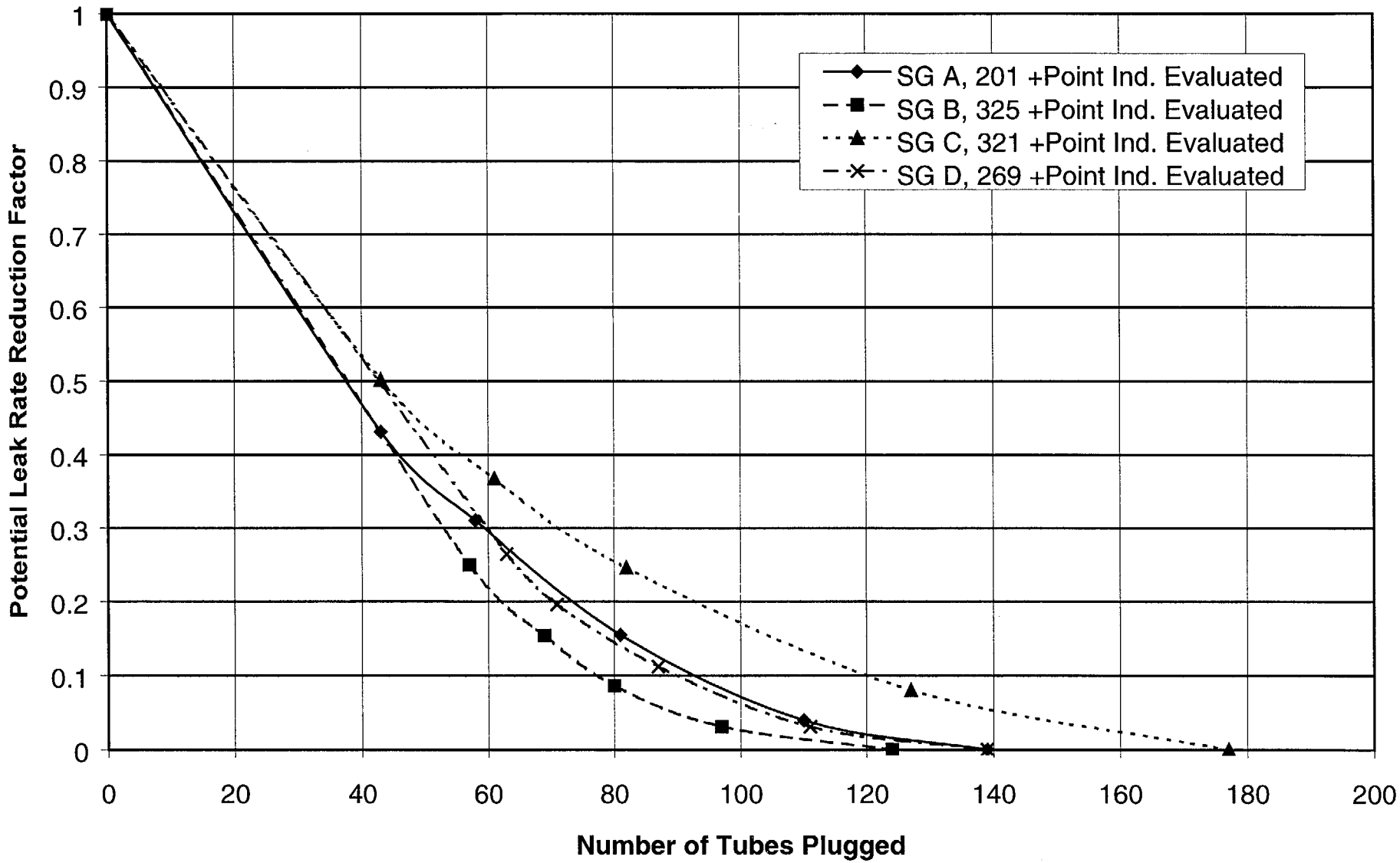
Figure 6. South Texas-2 Normal Operation Leakage Evaluation Reduction in Leakage at 95% Probability vs. No. of Tubes Plugged