NSD-SGD-1176

# Braidwood Unit 1

# Interim Plugging Criteria Return to Power Report

# November 1995

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# Braidwood Unit 1

## Interim Plugging Criteria Return to Power Report

### 1.0 Introduction

This report provides the Braidwood Unit 1 steam generator tube Eddy Current Test (ECT) inspection results at the end of Cycle 5* together with Steam Line Break (SLB) leak rate and tube burst probability analysis results calculated using the measured voltage data, in support of the implementation of the 3.0 volt Interim Plugging Criteria (IPC). SLB leak rates and tube burst probabilities were calculated considering conditions before and after tube support plate (TSP) locking. Since the EOC-5B results represent completion of a cycle implementing a 1 volt IPC, the reference leak and burst analyses are based on methods which assume that the TSP indications are exposed due to TSP displacement under SLB conditions. The leak and burst analyses based on the assumptions of TSP locking are provided for information as sensitivity analyses. Leak rate and probability of burst (PoB) values calculated with the actual voltage distributions are compared with the corresponding projections for EOC-5B (based on projected indication population using the EOC-5A data). The methodology used in these evaluations is in accordance with previously published Westinghouse reports (References 7.1 and 7.2). Projections of ECT tube voltage distributions, and leak rate and burst probability analyses based on the 3.0 volt repair criteria for the upcoming Cycle 6 operation will be presented in the 90-day report.

### 2.0 Summary and Conclusions

SLB leak rate and tube burst probability analyses were performed for the actual EOC-5B ECT bobbin voltage distributions and the results are conservative (lower) relative to corresponding projections for EOC-5B, calculated with a probability of detection of 0.6, by at least a factor of 5. As with the projections, SG C was found to be the limiting SG at actual EOC-5B voltage distributions.

For the actual EOC-5B bobbin voltage distribution, free span SLB leak rate (applicable prior to TSP locking) is calculated to be 0.07 gpm and the burst probability is $6.49\times10^{-4}$ for the limiting SG which is SG C; these values are below the corresponding projections for SG C assuming a voltage frequency based on the NRC SER endorsed probability of detection of 0.6. Also, these values are much lower than the allowable Cycle 5B SLB leakage limit of 9.1 gpm and the NRC reporting guideline

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* Since there was a mid-cycle inspection in February '95, for clarity the first-half of Cycle 5 is referred to as Cycle 5A and the second-half as Cycle 5B

of $10^{-2}$ for the conditional tube burst probability. The corresponding values calculated for a locked TSP condition are 0.07 gpm leak rate and a burst probability of less than $4\times10^{-6}$. The allowable leakage limit for Cycle 6 has been increased to 26.8 gpm, so the leakage margin is even higher at the BOC-6. Thus, the results meet the IPC requirement for at least 90 day operation.

A total of 4136 indications were found in the EOC-5B inspection of which 327 were inspected with a Rotating Pancake Coil (RPC) probe (including a minimum of 20 % of hot leg indications between 1 and 3 volts and all of the hot leg indications above 3 volts), and 200 were confirmed as flaws by the RPC inspection. The RPC confirmed indications included 178 above 1.0 volt. SG C had 1480 bobbin indications, of which 301 were above 1.0 volt, 83 of these were inspected by RPC and 46 were confirmed as flaws. Only one indication was found above 3 volts, 3.17 volts in SG A, and it was confirmed by RPC. No unexpected inspection results were found at the TSP intersections, such as circumferential indications, indications extending outside the TSP or PWSCC at dented TSP intersections.

## 3.0 EOC-5B Inspection Results and Voltage Growth Rates

### 3.1 EOC-5B Inspection Results

In accordance with the IPC guidance provided by the NRC Generic Letter 95-05, the end of Cycle 5B inspection of the Braidwood Unit 1 steam generators (SG) consisted of a complete, 100% ECT bobbin probe full length examination of the tube bundles in all four SGs. A 0.610 inch diameter probe was used for all hot and cold leg TSPs where IPC was applied. Subsequently, RPC examination was performed for a minimum of 20 percent of hot leg indications with an amplitude between 1 and 3 volts, all of hot leg indications with an amplitude 3 volts and above, and all of cold leg indications with an amplitude above 1 volt. There was only one hot leg indication above 3 volts. It was confirmed as a flaw and plugged. Also, a single indication was found above 1 volt on the cold leg side, but no degradation was detected there during RPC inspection.

In addition, an augmented RPC inspection was performed consistent with the NRC requirements. All dented intersections with a bobbin voltage greater than 5 volts and a minimum of 20 percent of intersections with a bobbin voltage between 2.5 and 5 volts were inspected with RPC. The augmented RPC inspection also included 25 TSP intersections with mixed residual artifact signals (MRI). There were no RPC flaw indications reported in the augmented inspection.

There was no evidence of any unexpected eddy current results at EOC-5B. There were no RPC circumferential indications at the TSPs, no indications extending

outside the TSPs, no RPC indications with potential PWSCC phase angles, no flaw indications at dented TSP intersections at any dent voltage and there was no signal interference from copper deposits. Thus, no flaw indications were found in the augmented RPC inspection. All RPC responses were consistent with that expected for ODSCC at TSP intersections.

A summary of ECT indications for all four steam generators is shown on Table 1, which tabulates the number of field bobbin indications, the number of these field bobbin indications that were RPC inspected, the number of RPC confirmed indications, and the number of plugged indications. The indications that remain active for Cycle 6 operation is the difference between the observed and the plugged. Overall, the combined data for all four steam generators of Braidwood Unit 1 shows that:

- Out of a total of 4136 indications identified during the inspection, a total of 4083 indications are being returned to service for Cycle 6.
- Of the 4136 indications, a total of 327 were RPC inspected.
- Of the 327 RPC inspected, a total of 200 were RPC confirmed.
- A total of 53 indications were removed from service. Consistent with the new 3 volt IPC, RPC confirmed hot leg indications with bobbin an amplitude of less than or equal 3.0 volts and RPC confirmed cold leg indications less than or equal to 1 volt are not removed from service.

Review of Table 1 indicates that SG C has more and higher BOC-6 indications (a quantity of 1480, with 301 indications above 1.0 volt) than SG A, B or D, thereby it potentially will be the limiting SG at EOC-6. However, SG A had the largest indication (3.17 volts) found in the EOC-5B inspection. Figure 1 shows the actual bobbin voltage distribution determined from the EOC-5B ECT inspection; Figure 2 shows the population distribution of those EOC-5B indications which were plugged and taken out of service; Figure 3 shows the indications which are being returned to service for Cycle 6. Of the 53 indications removed from service, 38 indications were in tubes plugged for degradation mechanisms other than ODSCC at TSP's.

### 3.2 Voltage Growth Rates

Table 2 shows the cumulative probability distribution function for growth rate of each Braidwood Unit 1 steam generator during Cycle 5B on an EFPY basis. Among the four steam generators, SG A has the indication with the largest voltage growth as well as a slightly larger average voltage growth during Cycle 5B. Figure 4 provides a comparison of the composite voltage growth from all four steam generators for the

last three operating periods (1992 - 1994, 1994 - February 1995 and February 1995 - October 1995). Growth rates during Cycle 5B are below those observed for Cycles 4 and 5A.

### 3.3 NDE Uncertainties

The NDE uncertainties applied for the Cycle 5B voltage distributions in the Monte Carlo analyses for leak rate and burst probability are the same as those previously reported in the Braidwood Unit 1 IPC report of Reference 7.1. The probe wear standard used in the analyses has a standard deviation of 7.0 % about a mean of zero and a cutoff at 15 % for voltage response variability, which is consistent with the alternate probe wear measurement approach used during the EOC-5B inspection. The analyst variability u certainty has a standard deviation of 10.3% about a mean of zero with no cutoff.

## 4.0 Database Applied for IPC Correlations

The database used for the IPC correlations that are applied in the analyses of this report are an updated version of the database documented in Reference 7.2. South Texas pulled tube data have been added to the IPC database. The updated database is in compliance with the NRC guidelines for application of leak rate versus voltage correlations and for removal of data outliers in the 3/4 inch tubing burst and leak rate correlations.

## 5.0 SLB Analysis Methods

Monte Carlo analyses are used to calculate the SLB leak rates and tube burst probabilities for actual voltage distributions. The methodology used complies with the Braidwood Unit 1 SER and is described in Reference 7.1 and also in the Westinghouse generic methods report of Reference 7.2.

Monte Carlo analyses for leak rates and tube burst probabilities include NDE uncertainties. Based on the 3/4" diameter tubing database, the NRC requirement that the p value obtained from the regression analysis be less than or equal to 5% to apply the SLB leak rate versus voltage correlation is satisfied and the correlation is applied for the leak rate analyses of this report.

SLB leak rates and tube burst probabilities are calculated considering conditions before and after tube support plate (TSP) locking. When TSP's are locked with tube expansion, indications in the hot leg side are restrained from bursting so the burst

probability calculations are based only on indications found on the cold side. Since only a small fraction of the indication population is on the cold leg side, the burst probabilities are expected to be substantially smaller than those estimated with the usual IPC/APC methodology (which includes the entire indication population). Leak rates and PoB calculated by both methods using the actual voltage distributions are compared with the corresponding prior projections for EOC-5B.

## 6.0 SLB Leak Rate and Tube Burst Probability for EOC-5B

Using the methodology described above, analyses were performed to calculate EOC-5B SLB leak rate and tube burst probabilities for the actual bobbin voltage distribution presented in Table 1. The analyses considered conditions before and after TSP locking. The results of Cycle 5B Monte Carlo calculations are summarized on Table 3. The free span analyses (appropriate prior to TSP locking) are the reference analyses for Cycle 5B and their results are to be compared with allowable limits. Comparison of the EOC-5B actuals with the corresponding predictions indicates that:

a) SG C was predicted to be the most limiting steam generator for EOC-5B with the highest tube leak and PoB numbers.

b) SG C was also determined to have the highest tube leak rate and PoB numbers based on actual ECT bobbin measurements for EOC-5B.

c) The leak rate and PoB predictions (based on projected indication population from EOC-5A inspection) for all four SGs are conservative compared to actual leak and PoB values (based on ECT bobbin measurements for EOC-5B) even for free span conditions. Overall, the earlier projections for all SG's are conservative by at least a factor of 5.

d) With TSP's locked, tube burst probability decreases by more than two orders of magnitude.

In summary, the limiting free span SLB leak rate (0.07 gpm) and tube burst probability ($6.49\times10^{-4}$) calculated using the actual EOC-5B bobbin voltage distributions are below the corresponding projections assuming a voltage frequency based on the NRC SER endorsed probability of detection of 0.6. Also, these values are much lower than the allowable Cycle 5B SLB leakage limit of 9.1 gpm and the NRC reporting guideline of $10^{-2}$ for the tube burst probability. The major impact of restraining indications on the hot leg side from bursting is to decrease tube burst probability by over two orders of magnitude. Since the allowable SLB leakage rate

for Braidwood Unit-1 has been increased to 26.8 gpm, there is even a greater margin between the calculated and allowable SLB leak rate at the BOC-6. Thus, the results meet the IPC requirement for continued operations for at least 90 days.

## 7.0 REFERENCES


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

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

7.3 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.

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

**Table 1 ( 1 of 2)**
**Braidwood Unit -1 October 1995 Outage**
**Summary of Inspection and Repair For Tubes in Service During Cycle 5B**

| Voltage Bin | Steam Generator A | | | | | Steam Generator B | | | | | Steam Generator C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | In-Service During Cycle 5B | | | | BOC - 6 | In-Service During Cycle 5B | | | | BOC - 6 | In-Service During Cycle 5B | | | | BOC - 6 |
| | Field Bobbin Indications | RPC Inspected | RPC Confirmed | Indications Repaired | All Indications Returned to Service | Field Bobbin Indications | RPC Inspected | RPC Confirmed | Indications Repaired | All Indications Returned to Service | Field Bobbin Indications | RPC Inspected | RPC Confirmed | Indications Repaired | All Indications Returned to Service |
| 0.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 0.2 | 3 | 0 | 0 | 0 | 3 | 2 | 0 | 0 | 0 | 2 | 7 | 0 | 0 | 0 | 7 |
| 0.3 | 50 | 1 | 0 | 0 | 50 | 10 | 0 | 0 | 0 | 10 | 25 | 1 | 0 | 1 | 24 |
| 0.4 | 105 | 3 | 1 | 1 | 104 | 65 | 1 | 1 | 0 | 65 | 122 | 1 | 0 | 1 | 121 |
| 0.5 | 139 | 2 | 2 | 3 | 136 | 60 | 1 | 0 | 0 | 60 | 168 | 5 | 1 | 1 | 167 |
| 0.6 | 144 | 3 | 2 | 3 | 141 | 95 | 0 | 0 | 0 | 95 | 164 | 3 | 2 | 3 | 161 |
| 0.7 | 117 | 4 | 3 | 5 | 112 | 68 | 0 | 0 | 0 | 68 | 199 | 3 | 0 | 3 | 196 |
| 0.8 | 115 | 1 | 0 | 1 | 114 | 63 | 1 | 0 | 1 | 62 | 200 | 5 | 1 | 3 | 197 |
| 0.9 | 104 | 1 | 1 | 2 | 102 | 52 | 1 | 1 | 0 | 52 | 164 | 3 | 2 | 2 | 162 |
| 1 | 66 | 2 | 1 | 2 | 64 | 53 | 2 | 1 | 0 | 53 | 129 | 1 | 0 | 2 | 127 |
| 1.1 | 67 | 9 | 5 | 1 | 66 | 25 | 25 | 16 | 0 | 25 | 107 | 8 | 5 | 0 | 107 |
| 1.2 | 45 | 4 | 2 | 0 | 45 | 28 | 25 | 11 | 0 | 28 | 71 | 8 | 5 | 1 | 70 |
| 1.3 | 24 | 2 | 1 | 0 | 24 | 12 | 12 | 9 | 0 | 12 | 36 | 9 | 5 | 0 | 36 |
| 1.4 | 16 | 3 | 2 | 0 | 16 | 7 | 7 | 3 | 0 | 7 | 28 | 12 | 4 | 1 | 27 |
| 1.5 | 8 | 6 | 5 | 0 | 8 | 5 | 4 | 1 | 0 | 5 | 25 | 14 | 7 | 0 | 25 |
| 1.6 | 8 | 8 | 7 | 1 | 7 | 2 | 2 | 1 | 1 | 1 | 8 | 7 | 4 | 0 | 8 |
| 1.7 | 4 | 2 | 2 | 0 | 4 | 3 | 3 | 2 | 0 | 3 | 7 | 7 | 4 | 0 | 7 |
| 1.8 | 7 | 7 | 6 | 1 | 6 | 2 | 2 | 1 | 0 | 2 | 5 | 5 | 3 | 0 | 5 |
| 1.9 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 4 | 3 | 2 | 0 | 4 |
| 2 | 3 | 2 | 1 | 0 | 3 | 3 | 3 | 3 | 0 | 3 | 1 | 1 | 0 | 0 | 1 |
| 2.1 | 2 | 2 | 1 | 0 | 2 | 1 | 1 | 0 | 0 | 1 | 3 | 3 | 2 | 0 | 3 |
| 2.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 |
| 2.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 2 | 1 | 2 |
| 2.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2.5 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2.7 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2.8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 |
| 3.2 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 1031 | 66 | 45 | 21 | 1010 | 556 | 90 | 50 | 2 | 554 | 1480 | 105 | 52 | 19 | 1461 |
| > 1V | 188 | 49 | 35 | 4 | 184 | 88 | 84 | 47 | 1 | 87 | 301 | 83 | 46 | 3 | 298 |

## Table 1 ( 2 of 2)
## Braidwood Unit -1 October 1995 Outage
## Summary of Inspection and Repair For Tubes in Service During Cycle 5B

| Voltage Bin | Steam Generator D | | | | | Composite of All 4 SGs | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | In-Service During Cycle 5B | | | | BOC - 6 | In-Service During Cycle 5B | | | | BOC - 6 |
| | Field Bobbin Indications | RPC Inspected | RPC Confirmed | Indications Repaired | All Indications Returned to Service | Field Bobbin Indications | RPC Inspected | RPC Confirmed | Indications Repaired | All Indications Returned to Service |
| 0.1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 0.2 | 5 | 1 | 0 | 0 | 5 | 17 | 1 | 0 | 0 | 17 |
| 0.3 | 21 | 1 | 0 | 0 | 21 | 106 | 3 | 0 | 1 | 105 |
| 0.4 | 89 | 0 | 0 | 0 | 89 | 381 | 5 | 2 | 2 | 379 |
| 0.5 | 141 | 0 | 0 | 1 | 140 | 508 | 8 | 3 | 5 | 503 |
| 0.6 | 145 | 3 | 1 | 3 | 142 | 548 | 9 | 5 | 9 | 539 |
| 0.7 | 144 | 3 | 1 | 1 | 143 | 528 | 10 | 4 | 9 | 519 |
| 0.8 | 136 | 2 | 1 | 2 | 134 | 514 | 9 | 2 | 7 | 507 |
| 0.9 | 111 | 1 | 0 | 1 | 110 | 431 | 6 | 4 | 5 | 426 |
| 1 | 88 | 0 | 0 | 1 | 87 | 336 | 5 | 2 | 5 | 331 |
| 1.1 | 63 | 3 | 3 | 0 | 63 | 262 | 45 | 29 | 1 | 261 |
| 1.2 | 36 | 7 | 6 | 0 | 36 | 180 | 44 | 24 | 1 | 179 |
| 1.3 | 36 | 9 | 8 | 2 | 34 | 108 | 32 | 23 | 2 | 106 |
| 1.4 | 19 | 4 | 2 | 0 | 19 | 70 | 26 | 11 | 1 | 69 |
| 1.5 | 13 | 10 | 10 | 0 | 13 | 51 | 34 | 23 | 0 | 51 |
| 1.6 | 5 | 5 | 5 | 0 | 5 | 23 | 22 | 17 | 2 | 21 |
| 1.7 | 7 | 7 | 6 | 0 | 7 | 21 | 19 | 14 | 0 | 21 |
| 1.8 | 4 | 4 | 4 | 0 | 4 | 18 | 18 | 14 | 1 | 17 |
| 1.9 | 2 | 2 | 2 | 0 | 2 | 7 | 6 | 5 | 0 | 7 |
| 2 | 1 | 1 | 1 | 0 | 1 | 8 | 7 | 5 | 0 | 8 |
| 2.1 | 0 | 0 | 0 | 0 | 0 | 6 | 6 | 3 | 0 | 6 |
| 2.2 | 1 | 1 | 1 | 0 | 1 | 2 | 2 | 2 | 0 | 2 |
| 2.3 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 2 | 1 | 2 |
| 2.4 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 |
| 2.5 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 |
| 2.7 | 1 | 1 | 1 | 0 | 1 | 2 | 2 | 1 | 0 | 2 |
| 2.8 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 |
| 3 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 |
| 3.2 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 |
| Total | 1069 | 66 | 53 | 11 | 1058 | 4136 | 327 | 200 | 53 | 4083 |
| > 1V | 189 | 55 | 50 | 2 | 187 | 766 | 271 | 178 | 10 | 756 |

## Table 2
## Braidwood Unit 1 October 1995
## Signal Growth Statistics For Cycle 5B on 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 |
| -1.7 | 0 | 0 | 0 | 0 | 1 | 0.001 | 0 | 0.000 | 1 | 0.0002 |
| -1 | 0 | 0 | 0 | 0 | 1 | 0.001 | 0 | 0.000 | 1 | 0.0005 |
| -0.6 | 0 | 0 | 1 | 0.002 | 0 | 0.001 | 3 | 0.003 | 4 | 0.001 |
| -0.5 | 0 | 0 | 0 | 0.002 | 2 | 0.003 | 2 | 0.005 | 4 | 0.002 |
| -0.4 | 1 | 0.001 | 3 | 0.007 | 0 | 0.003 | 6 | 0.010 | 10 | 0.005 |
| -0.3 | 6 | 0.007 | 2 | 0.011 | 9 | 0.009 | 8 | 0.018 | 25 | 0.011 |
| -0.2 | 18 | 0.024 | 13 | 0.034 | 33 | 0.031 | 11 | 0.028 | 75 | 0.029 |
| -0.1 | 40 | 0.063 | 26 | 0.081 | 84 | 0.088 | 40 | 0.065 | 190 | 0.075 |
| 0 | 122 | 0.181 | 82 | 0.228 | 164 | 0.199 | 163 | 0.218 | 531 | 0.203 |
| 0.1 | 200 | 0.375 | 95 | 0.399 | 299 | 0.401 | 230 | 0.433 | 824 | 0.403 |
| 0.2 | 191 | 0.561 | 93 | 0.567 | 306 | 0.607 | 193 | 0.614 | 783 | 0.592 |
| 0.3 | 128 | 0.685 | 85 | 0.719 | 248 | 0.775 | 125 | 0.731 | 586 | 0.734 |
| 0.4 | 91 | 0.773 | 57 | 0.822 | 122 | 0.857 | 99 | 0.823 | 369 | 0.823 |
| 0.5 | 69 | 0.840 | 31 | 0.878 | 68 | 0.903 | 63 | 0.882 | 231 | 0.879 |
| 0.6 | 50 | 0.888 | 22 | 0.917 | 47 | 0.935 | 32 | 0.912 | 151 | 0.915 |
| 0.7 | 35 | 0.922 | 12 | 0.939 | 21 | 0.949 | 20 | 0.931 | 88 | 0.936 |
| 0.8 | 23 | 0.945 | 12 | 0.960 | 19 | 0.962 | 20 | 0.949 | 74 | 0.954 |
| 0.9 | 17 | 0.961 | 4 | 0.968 | 17 | 0.974 | 12 | 0.961 | 50 | 0.966 |
| 1 | 10 | 0.971 | 4 | 0.975 | 11 | 0.981 | 13 | 0.973 | 38 | 0.976 |
| 1.1 | 5 | 0.976 | 4 | 0.982 | 7 | 0.986 | 5 | 0.978 | 21 | 0.981 |
| 1.2 | 8 | 0.984 | 2 | 0.986 | 5 | 0.989 | 6 | 0.983 | 21 | 0.986 |
| 1.3 | 4 | 0.987 | 1 | 0.987 | 3 | 0.991 | 5 | 0.988 | 13 | 0.989 |
| 1.4 | 4 | 0.991 | 1 | 0.989 | 2 | 0.993 | 3 | 0.991 | 10 | 0.991 |
| 1.5 | 1 | 0.992 | 0 | 0.989 | 0 | 0.993 | 1 | 0.992 | 2 | 0.992 |
| 1.6 | 1 | 0.993 | 2 | 0.993 | 4 | 0.995 | 2 | 0.993 | 9 | 0.994 |
| 1.7 | 0 | 0.993 | 0 | 0.993 | 2 | 0.997 | 3 | 0.996 | 5 | 0.995 |
| 1.8 | 0 | 0.993 | 1 | 0.995 | 0 | 0.997 | 1 | 0.997 | 2 | 0.996 |
| 1.9 | 2 | 0.995 | 1 | 0.996 | 0 | 0.997 | 0 | 0.997 | 3 | 0.996 |
| 2 | 2 | 0.997 | 1 | 0.998 | 0 | 0.997 | 0 | 0.997 | 3 | 0.997 |
| 2.1 | 1 | 0.998 | 1 | 1.0 | 0 | 0.997 | 1 | 0.998 | 3 | 0.998 |
| 2.3 | 0 | 0.998 | | | 1 | 0.997 | 0 | 0.998 | 1 | 0.9981 |
| 2.6 | 0 | 0.998 | | | 1 | 0.998 | 0 | 0.998 | 1 | 0.9983 |
| 2.7 | 0 | 0.998 | | | 1 | 0.999 | 0 | 0.998 | 1 | 0.9985 |
| 2.9 | 0 | 0.998 | | | 0 | 0.999 | 1 | 0.999 | 1 | 0.9988 |
| 3 | 1 | 0.999 | | | 0 | 0.999 | 0 | 0.999 | 1 | 0.9990 |
| 3.5 | 0 | 0.999 | | | 1 | 0.999 | 1 | 1 | 2 | 0.9995 |
| 4.1 | 0 | 0.999 | | | 1 | 1 | | | 1 | 0.9998 |
| 4.2 | 1 | 1 | | | | | | | 1 | 1 |
| Total | 1031 | | 556 | | 1480 | | 1069 | | 4136 | |

## Table 3

**Braidwood Unit 1 1995 EOC- 5B Outage**
**Summary of Calculations of Tube Leak Rate and Burst Probability**
**Based on Actual Bobbin Voltage - 250k Simulations**

| Steam Generator | | POD | No. of Indications | Max. Volts* | Burst Probability | | SLB Leak Rate gpm |
|---|---|---|---|---|---|---|---|
| | | | | | 1 Tube | 2 Tubes | |
| **EOC - 5B PROJECTIONS FROM EOC-5A** | | | | | | | |
| A | | 0.6 | 1401. | 4.5 | 2.92 E-03 | 4.75 E-05 | 0.33 |
| B | | 0.6 | 627. | 3.7 | 7.81 E-04 | < 4 E-06 | 0.08 |
| C | | 0.6 | 2051. | 5.6 | 4.94 E-03 | 4.20 E-05 | 0.48 |
| D | | 0.6 | 1269. | 4.1 | 1.97 E-03 | 4.20 E-05 | 0.22 |
| **EOC - 5B ACTUAL (Free Span - Without Tube Support Plates Locked)** | | | | | | | |
| A | | 1 | 1031. | 3.5 | 2.98E-04 | < 4 E-06 | 0.06 |
| B | | 1 | 556. | 2.5 | 9.72E-05 | < 4 E-06 | 0.01 |
| C | | 1 | 1480 | 3.4 | 6.49E-04 | < 4 E-06 | 0.07 |
| D | | 1 | 1069. | 3.0 | 4.12E-04 | < 4 E-06 | 0.04 |
| **EOC - 5B ACTUAL (Tube Support Plates Assumed Locked)** | | | | | | | |
| A | Hot Side | 1 | 1020 | 3.5 | Negligible# | Negligible# | 0.06 |
| | Cold Side | 1 | 11 | 1.3 | < 4 E-06 | < 4 E-06 | 1 E-04 |
| | Combined | - | 1031 | - | < 4 E-06 | < 4 E-06 | 0.06 |
| B | Hot Side | 1 | 551 | 2.5 | Negligible# | Negligible# | 0.02 |
| | Cold Side | 1 | 5 | 0.9 | < 4 E-06 | < 4 E-06 | 1 E-4 |
| | Combined | - | 556 | - | < 4 E-06 | < 4 E-06 | 0.02 |
| C | Hot Side | 1 | 1479 | 3.4 | Negligible# | Negligible# | 0.07 |
| | Cold Side | 1 | 1 | 0.7 | < 4 E-06 | < 4 E-06 | 1 E-4 |
| | Combined | - | 1480 | - | < 4 E-06 | < 4 E-06 | 0.07 |
| D | Hot Side | 1 | 1068 | 3.0 | Negligible# | Negligible# | 0.04 |
| | Cold Side | 1 | 1 | 0.6 | < 4 E-06 | < 4 E-06 | 1 E-4 |
| | Combined | - | 1069 | - | < 4 E-06 | < 4 E-06 | 0.04 |

* Voltages include NDE uncertainties from Monte Carlo analyses and exceed measured voltages.
# Below $10^{-10}$ (Reference 7-4)

Figure 1

Braidwood Unit -1 October 1995 Outage

Bobbin Voltage Distributions for Tubes in Service During Cycle 5B

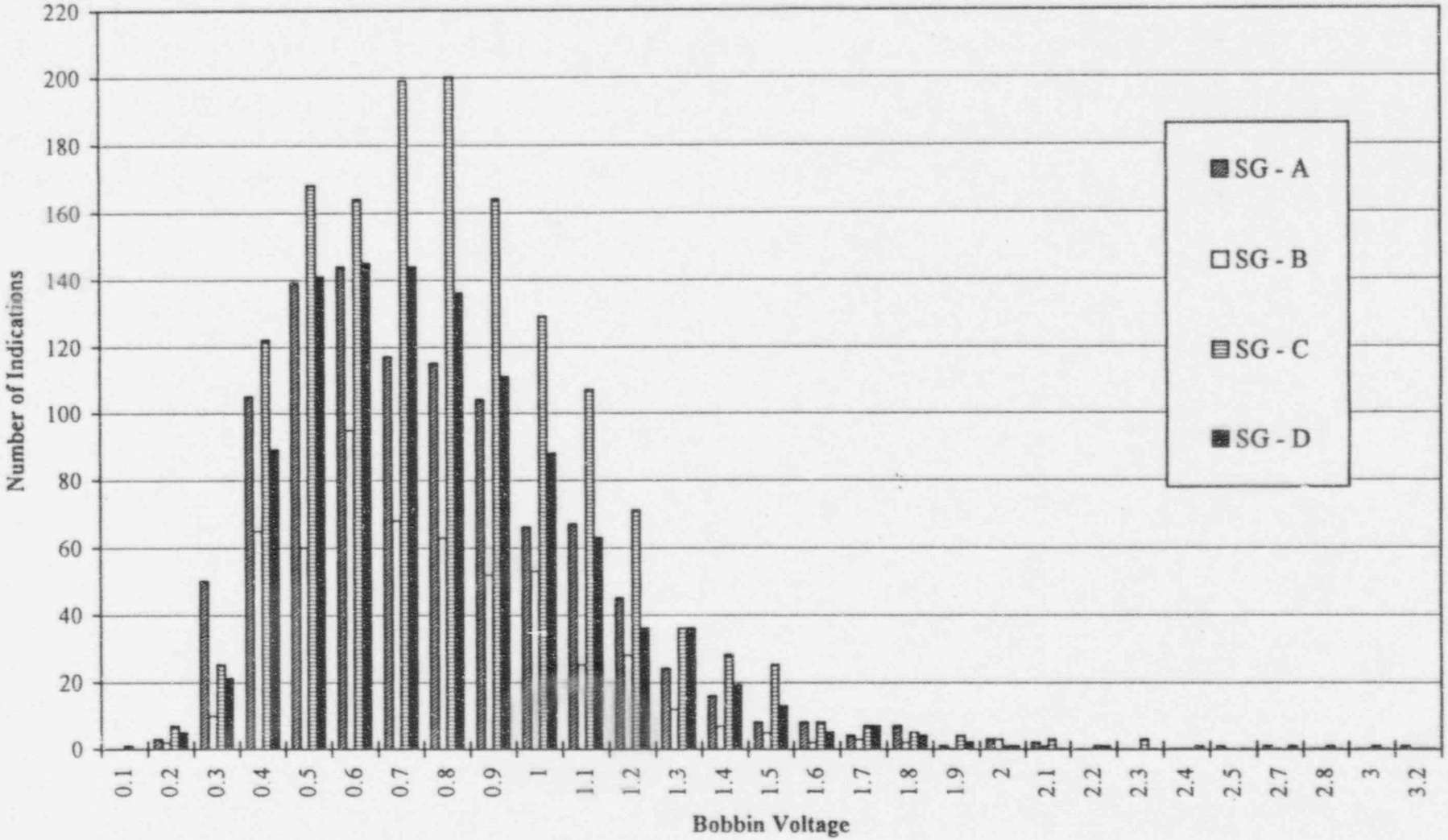


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Figure 2
Braidwood Unit -1 October 1995 Outage
Bobbin Voltage Distribution for Tubes Plugged After Cycle 5B Service

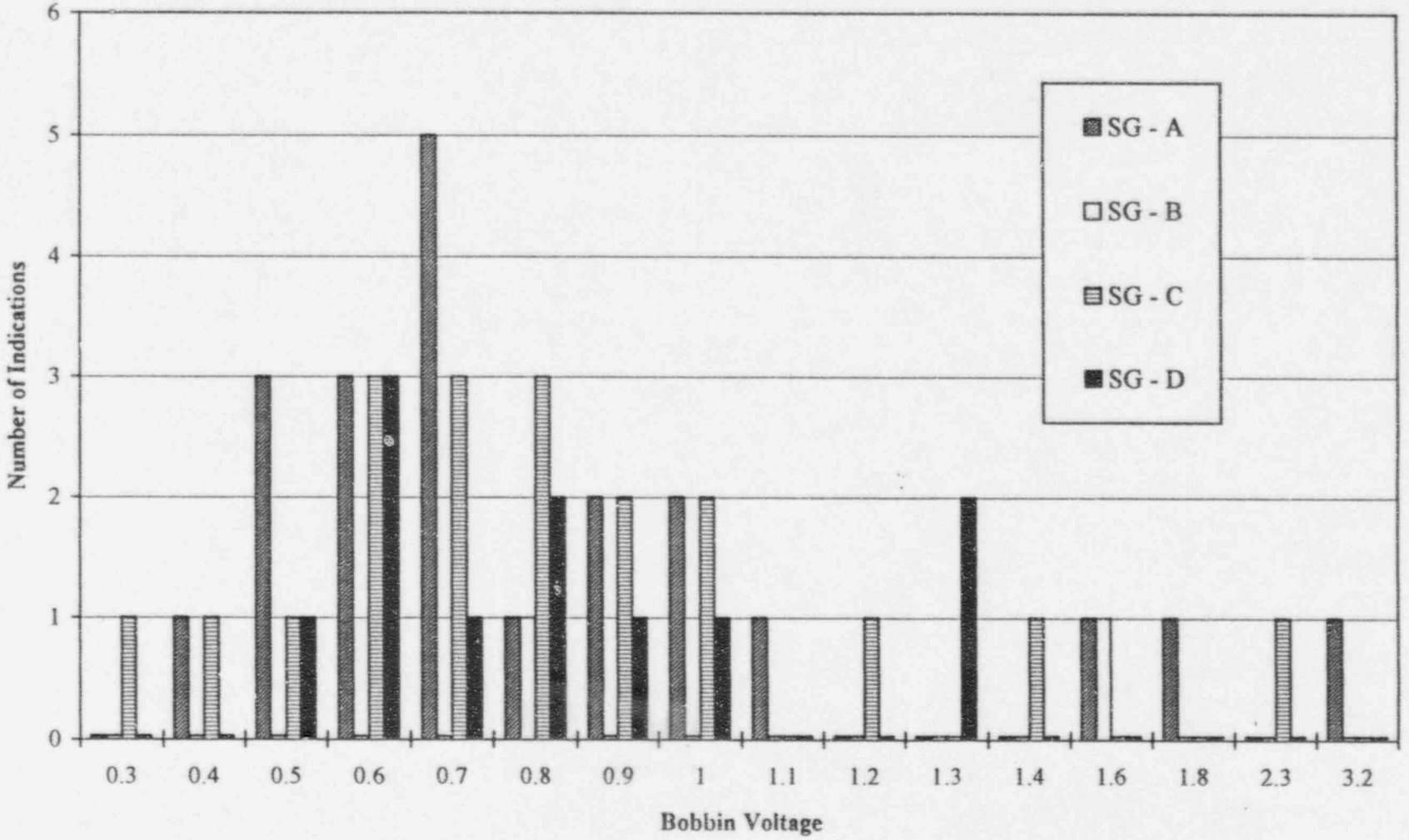


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Figure 3
Braidwood Unit -1 October 1995 Outage
Bobbin Voltage Distributions for Tubes Returned to Service for Cycle 6

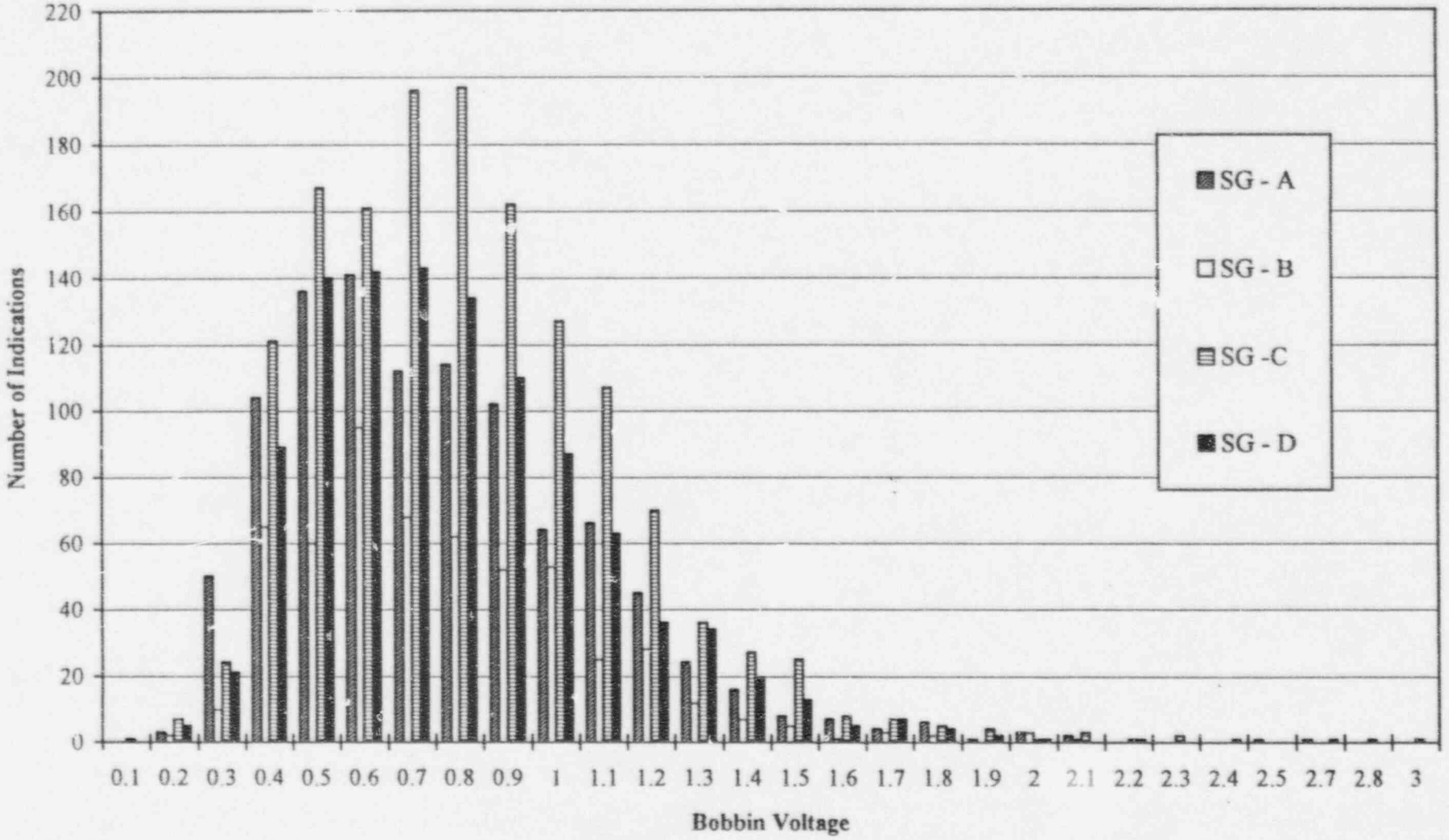


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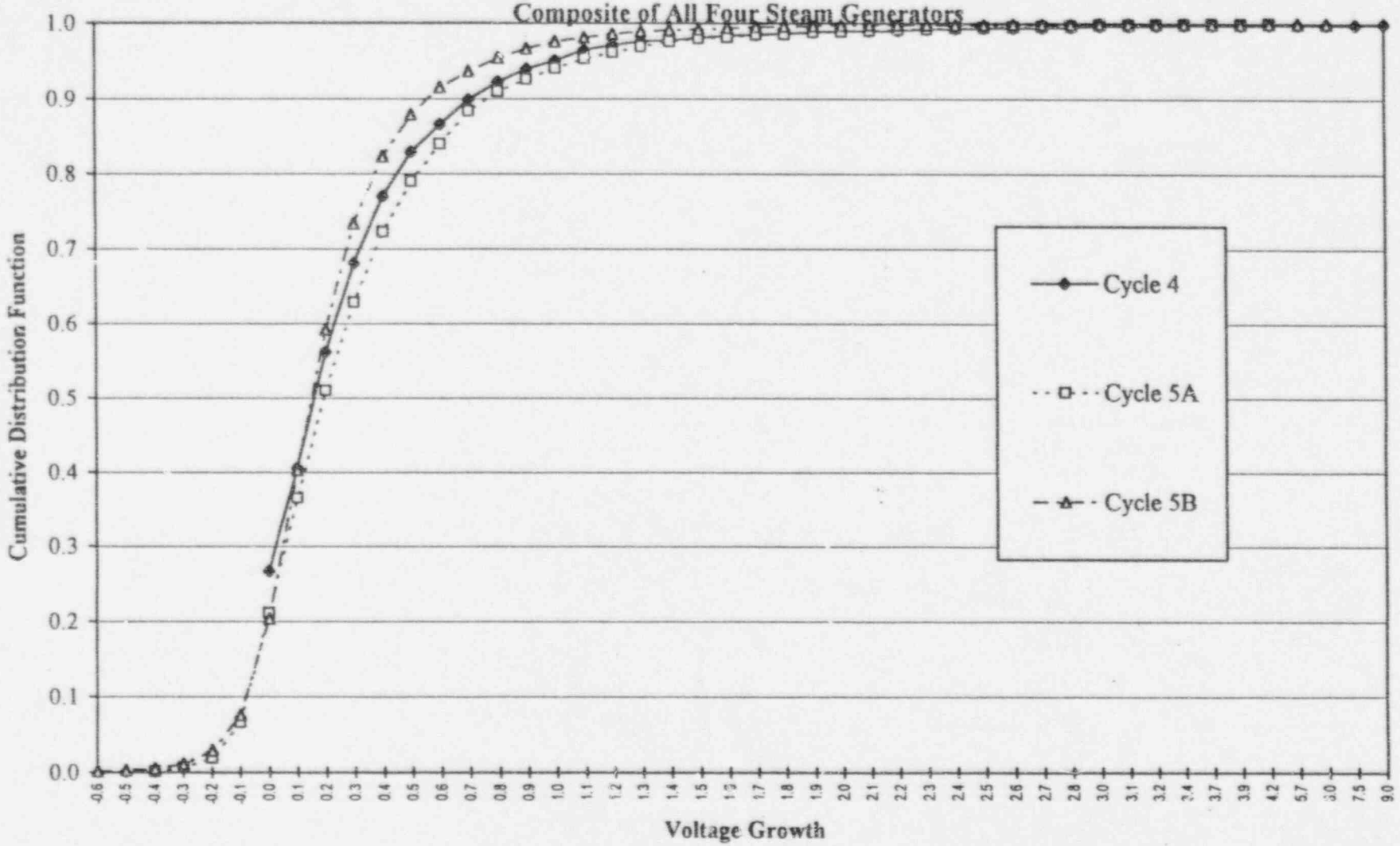
**Figure 4**
**Braidwood Unit -1**
**Bobbin Signal Growth History - Cumulative Probability Distributions on EFPY Basis**
**Composite of All Four Steam Generators**

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