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ComEd

September 24, 1996

Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Attn: Document Control Desk

Subject: Braidwood Station Unit 1
NRC Docket Number 50-456

Response to Request for Additional Information Pertaining to Operating Interval Between Eddy Current Inspections for Circumferential Indications in the Braidwood Unit 1 Steam Generators

References: See Attachment

In the Reference 1, the Commonwealth Edison Company (ComEd) provided the Nuclear Regulatory Commission (NRC) with the "Braidwood Unit 1 Cycle Length Assessment Report Addendum" which justified operation of the Braidwood Unit 1 for a full cycle prior to steam generator tube inspection. This report was supplemented via Reference 2. Reference 3 transmitted the NRC's Request for Additional Information (RAI) on the elimination of the Braidwood Cycle Length. References 4, 5 and 6 transmitted ComEd's response to 21 of the 31 RAIs. Attachment A provides the complete response to all 31 RAIs. Please note that a small portion of the responses that have been previously submitted have been updated. These revisions are noted by "revision bars." Attachment B details changes to the August 2nd and September 10th submittals. Attachment C details changes to Attachment B.

The Referenced documents transmitted 3 approaches which ComEd used to evaluate if full cycle operation of Braidwood Unit 1. These evaluations consists of:

- The Probability of Detection Approach (POD) utilizes the 23 detected and repaired tubes from the Braidwood 10/95 inspection adjusted for growth rate, probe wear, analyst uncertainty and POD.

- The Look Back Approach utilizes the 23 detected and repaired tubes from the Braidwood 10/95 inspection and the Byron look back evaluation, performed on 1995 and 1996 data adjusted for growth rate, probe wear, and analyst uncertainty.

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- The End of Cycle Approach utilizes the 128 detected and repaired tubes from the Byron 1994 inspection and the Byron look back evaluations, performed on 1995 and 1996 data adjusted for probe wear and analyst uncertainty.

Attachment D presents the results of the 3 approaches. ComEd has concluded that the End of Cycle Approach envelopes the distribution of circumferential cracks estimated to be detected in Braidwood Unit 1 at the end of the current operating cycle.

The End of Cycle Approach is summarized as follows:

ComEd has assessed the margins for leak and burst using evaluation assumptions, procedures and criteria that are in compliance with the guidelines provided in GL95-05. These are:

- The EOC voltage distribution determined from the Byron 1 inspection at EOC-6 in 1994 was used for the evaluation of EOC-6 at Braidwood 1. The distribution included the tubes detected and repaired at Byron 1 in 1994 and the tubes determined by the 1995 and 1996 look-back evaluations to have indications in 1994 that were not repaired. Both average and maximum voltage distributions were evaluated.

- The distributions were adjusted for probe wear and analyst uncertainty using the values presented in response to RAIs 25 and 31, respectively. Because the EOC-6 distributions are used directly, explicit POD and growth rate analyses are not required.

- The leak rate was computed for the maximum EOC voltage distribution using the procedure describe in response to RAI 16, which includes a log-logistic fit at the 95% confidence level for probability of leakage.

- The conditional probability of tube burst was computed for both the maximum and average EOC voltage distributions. The computation was performed using the statistically developed exponential burst pressure versus voltage correlation describes in the response to RAI 8. The criteria specified in GL 95-05 will be used to evaluate the conditional probabilities for the EOC distributions.

This approach combines a conservative beginning of cycle distribution with the conservative approach outlined in GL 95-05 to provide results for assessing steam generator structural integrity.

ComEd conclusion to utilize the EOC approach is supported based upon:

- The operating time for Byron Unit 1 (EOC-6) is slightly greater than that for Braidwood Unit 1 (EOC-6),

- The Byron and Braidwood Unit 1 steam generators are identical, and

- The Byron and Braidwood Unit 1 have the same operating experience.

Based on the results of these 3 analyses (Attachment D), ComEd concludes that Braidwood Unit 1 full cycle operation is justified. To ensure additional conservatism ComEd is preparing a Technical Specification amendment to reduce the reactor coolant dose equivalent iodine limit for the remainder of Braidwood Unit 1 Cycle 6. ComEd will perform in-situ leak tests, tube pulls, repair all circumferential indications on detection and use inspection technology equivalent to or better than the 1996 Byron inspection at the March, 1997 refuel outage for Braidwood Unit 1.

ComEd is looking forward to meeting with the Staff on October 1 to present our justification for full cycle operation of Braidwood Unit 1. ComEd hopes that at the conclusion of the presentation the Staff will concur that full cycle operation is justified. In the interim, if you have any questions concerning this correspondence please contact Denise Saccomando, Senior PWR Licensing Administrator at (630) 663-7283.

Sincerely,

Harold Gene Stanley
Site Vice President
Braidwood Station

Attachment

cc:

D. Lynch, Senior Project Manager-NRR
R. Assa, Braidwood Project Manager-NRR
C. Phillips, Senior Project Manager-Braidwood
A. W. Beech, Regional Administrator-RIII
Office of Nuclear Safety-IDNS

References

1. H. Stanley letter to the Nuclear Regulatory Commission dated August 2, 1996, transmitting Operating Interval Between Eddy Current Inspections for Circumferential Indications in the Braidwood Unit 1, Steam Generator Tubes

2. H. Stanley letter to the Nuclear Regulatory Commission dated August 20, 1996, transmitting Operating Interval Between Eddy Current Inspections for Circumferential Indications in the Braidwood Unit 1, Steam Generator Tubes

3. D. Lynch letter to I. Johnson letter transmitting Requests for Additional Information dated September 9, 1996, Pertaining to Operating Interval Between Eddy Current Inspections for Circumferential Indications in the Braidwood Unit 1 Steam Generators

4. H. Stanley letter to the Nuclear Regulatory Commission dated September 10, 1996, transmitting Response to Request for Additional Information

5. H. Stanley letter to the Nuclear Regulatory Commission dated September 17, 1996, transmitting Response to Request for Additional Information

6. H. Stanley letter to the Nuclear Regulatory Commission dated September 20, 1996, Supplement to Response to Request for Additional Information Pertaining to Operating Interval Between Eddy Current Inspections for Circumferential Indications

ATTACHMENT A

REQUEST FOR ADDITIONAL INFORMATION

RELATED TO THE BRAIDWOOD, UNIT 1 CYCLE LENGTH ASSESSMENT

BASED ON STEAM GENERATOR (SG) TUBE

CIRCUMFERENTIAL INDICATION GROWTH RATES

DOCKET NUMBER 50-456

1. **In the license's submittal dated August 2, 1996, a morphology assessment was provided which attempts to demonstrate the similarity between circumferential crack indications in Braidwood, Unit 1 to Byron, Unit 1 based on the relationship between the maximum and the average eddy current (EC) voltages. However, the licensee did not provide a sufficient basis for assuming an eddy current voltage assessment is indicative of degradation morphology. Accordingly, provide data supporting the assumption that circumferential flaws (either real and/or simulated) with morphologies different from that found at Byron Unit 1 demonstrate a different and clearly distinct relationship between the average and the maximum EC voltage such that differing morphologies could be distinguished.**

Response (9/17/96):

ComEd has concluded that the outside diameter stress corrosion cracking (ODSCC) observed at the top-of-the-tubeshee (TTS) roll transition is primarily the result of tube fabrication, residual stress and operating temperature. Therefore, the same degradation and rates of degradation are expected at both Byron Unit 1 and Braidwood Unit 1. Eddy current testing (ECT) and characterization serve as a confirmation of this expectation and to identify specific tubes for repair.

Demonstration that the degradation morphology on the OD of tubes at the TTS at Braidwood Unit 1 is consistent with the circumferential indications found at Byron Unit 1 and other units is based on several factors. These factors include: Alloy 600 tubing production, location, temperature, environment, stress, and steam generator fabrication process. The EC rotating pancake coil (RPC) average and maximum voltages were used to provide additional confirmation that the morphology for circumferential indications at the TTS at Braidwood Unit 1 is within the experience base at Byron Unit 1 and other plants with circumferential indications at the TTS.

The basis for concluding that the morphology of circumferential indications at the TTS at Braidwood Unit 1 is within the industry experience base include:

(1) The indications at Braidwood Unit 1 are in the same location and have the same orientation as indications at Byron Unit 1 and other affected industry plants,

(2) the environment and temperature at Braidwood Unit 1 is the same as Byron Unit 1 in the affected region. In addition, there is no chemistry environment at Braidwood Unit 1 that would produce more adverse conditions relative to circumferential ODSCC compared to Byron Unit 1. Further, there are no conditions that would produce copper deposits that would interfere with degradation detection near the TTS,

(3) the stress and fabrication process in roll transitions at the TTS is the same as at Byron Unit 1 and other similarly designed Westinghouse plants,

(4) the indications at Braidwood Unit 1 have the same EC attributes as Byron Unit 1 and other affected plants in the industry,

(5) other modes of degradation that are specifically dependent on Alloy 600 condition, residual stress, environment and temperature have occurred at Byron Unit 1 and Braidwood Unit 1, and

(6) pulled tubes from Byron Unit 1 and Braidwood Unit 1 demonstrate the same Alloy 600 microstructure and degradation morphologies.

Additional NDE confirmation that the Braidwood Unit 1 circumferential indications are within the Byron Unit 1 and industry experience base is provided by the plots of EC maximum versus average voltage in Figures 1a and 1b. Figure 1a shows the industry data base for pulled tubes (56 data points) and the bounds that encompass the data. These data include data from Byron Unit 1. These data also include a range of degradation levels including a tube where the percent degraded area (PDA) was approximately 94% (also see response to Question 9). Figure 1b shows a comparison of the bounds for the industry experience with the indications detected during the February 1995 and October 1995 inspections at Braidwood 1. A comparison of the industry experience base, as represented by the bounding lines, with the Braidwood indications provides additional confirmation that the morphology at Braidwood Unit 1 is within the industry experience base. Three conclusions are reached based on Figures 1a and 1b.

1) Two EC parameter bounds can be defined that encompass all roll transition circumferential ODSCC degradation observed in the industry.

2) All Braidwood Unit 1 indications are within these bounds.

3) The trend in the Braidwood Unit 1 indication distribution is toward smaller indications.

ComEd has provided the NRC with all data on roll transition, circumferential ODSCC that exists from tube pulls. There is no data to suggest a different morphology.

Therefore, there is no data to support a "different and clearly distinct relationship between average and maximum EC voltage." Therefore, no basis exists to determine that different morphologies need to be distinguished.

2. **In Section 4.3 of the licensee's submittal dated August 2, 1996, it is stated that Braidwood Unit 1 growth rates had not been determined at the time of the submittal due to difficulty in converting the EC test data. State when this work will be completed and submitted to the NRC. If this conversion has been completed, submit the results of the assessment.**

Response (9/10/96):

Byron Unit 1 growth data has been used in assessment of Braidwood Unit 1 BOC-6 distributions because the Byron data is a statistically significant number of data points (over 750), meets the requirements of GL 95-05 and some of the growth rates span an entire operating cycle. Byron data for the two periods for which it was calculated (1994 to 1995 and 1994 to 1996) span long periods of operation (342 and 448 days > 500°F) minimizing the uncertainty in extrapolating the data to the proposed operating interval for Braidwood Unit 1 of 461 Days.

Two 0.080" RPC inspections have been performed at Braidwood Unit 1, one in February 1995 and one in October 1995 (EOC-5). The duration between the inspections is 202.74 days > 500°F.

Twenty three indications were detected and repaired in the October 1995 inspection. All 23 were present in the look-back to the February 1995 inspection. The growth rate data is calculated by subtracting the February 1995 voltage reading from the October 1995 voltage reading. The difference is then divided by the operating period (202.74 days) and multiplied by 365 to provide the growth rate per year. The growth rate data is then put at the top of 0.1 volts and 0.05 volts bins (e.g. 0.44 volts would be placed in the 0.5 maximum voltage bin and 0.45 average voltage bin), for maximum and average voltage growth, respectively. The growth rate results are shown in Figures 2a and 2b for maximum and average voltage, respectively.

Application of the EOC approach, discussed in the September 10, 1996 submittal (Attachment A), applies the Byron EOC-6 distribution to Braidwood directly without growth rates. This distribution provides for the entire population of indications in the worst SG at Byron, Unit 1 in 1994 (EOC-6) and therefore is conservative. The basis for concluding that this assumption is conservative is Braidwood Unit 1, in the Spring 1997, will have operated for a slightly shorter period than Byron Unit 1 in 1994.

3. **The licensee's assessment of Byron Unit 1 growth rates considered inspection data from three inspection outages. Supply the growth rate data for each of the three intervals between these outages; i.e., the interval between the first and second SG tube inspections, the interval between the second and third inspection outages and the interval between the first and third inspection outages. Indicate which of the intervals exhibited the largest growth rate on an effective full power year (EFPY) basis. Provide these data in tabular form separated into the voltage bins shown in Figures 4.3 and 4.4 of your August 2, 1996, submittal. Explain how the indications were: placed in a particular bin. That is, state whether EC voltage values were truncated or rounded up to the higher voltage bin (e.g., 0.45 volts would be raised to 0.5 volts).**

Response (9/17/96):

Byron Unit 1 growth rate data for the three operating intervals is provided in Tables 3a and 3b. The growth rate data is calculated by subtracting the voltage at the beginning of the inspection interval from the voltage at the end of the inspection interval. The difference is then divided by the operating period (342, 448 and 104 days for the three intervals) and multiplied by 365 to provide the growth rate per year. The growth rate data is then put into 0.1 and 0.05 interval voltage growth rate bins, for maximum and average voltage growth, respectively (e.g. 0.44 would be placed in the 0.5 maximum voltage growth rate bin and in the 0.45 average voltage growth rate bin).

Growth rates for the three intervals (1994 to 1995, 1994 to 1996 and 1995 to 1996) are presented in Table 3a for maximum voltage and Table 3b for average voltage. Growth rate data from 1994 to 1995 comes from the results of the 1995 (SG B) and 1996 (SG C) look-backs, the remaining growth rates come from the 1996 indication look-backs.

The interval showing the greatest variation in growth rates normalized to a year is the shortest interval between the 1995 and 1996 tube inspections. This variation in growth rate for the 1995 to 1996 interval is considered to be a result of inaccuracies that occur when changes in degradation levels are measured for relatively short time intervals. Because corrosion cracks do not grow uniformly, measurement over short time intervals results in scatter that is not representative of the average growth rate over the interval of interest. This can easily be seen by comparing the data from the three intervals. If the short interval growth rates are really representative, the variation seen in the 1995 to 1996 interval would also be seen in the 1994 to 1996 interval.

A contributing factor of the scatter in the growth rates, is the multiplication of any ECT sizing error, for the short interval, by a factor greater than three to normalize the data to one year. For this reason, Byron Unit 1 growth data for the intervals 1994 to 1995 and 1994 to 1996 were used in assessment of Braidwood Unit 1 end of cycle six, EOC-6, distributions because the Byron data is a statistically significant number of data points (over 750), meets the requirements of GL 95-05 and the growth rates span an entire operating cycle. Byron data for the two periods for which it was calculated (1994 to 1995 and 1994 to 1996) in the August 2, 1996, submittal span long periods of operation (342 and 448 days > 500°F)

minimizing the uncertainty in extrapolating the data to the proposed operating interval for Braidwood Unit 1 of 461 days.

Application of the EOC approach, discussed in the September 10, 1996, submittal (Attachment A), applies the Byron EOC-6 distribution to Braidwood directly without growth rates. This distribution provides for the entire population of indications in the worst steam generator (SG) at Byron, Unit 1 in 1994 (EOC-6) and therefore is conservative. The basis for concluding that this assumption is conservative is Braidwood Unit 1, in the Spring 1997, will have operated for a slightly shorter period than Byron Unit 1 had operated prior to their 1994 inspection.

4. Clarify the language in Section 4.2.2 of the text which states: "...one hundred three (103) indications identified during the 1994 EC inspection were re-analyzed with the 0.080 inch RPC probe."

Response (9/10/96):

The statement refers to the scope of the voltage integral look-back re-analysis performed during June of 1996. During the re-analysis the indications detected and repaired in SG B and SG C in 1994 were re-analyzed. This total represents 103 indications. A total of 128 indications in all SG's were detected and repaired at Byron Unit 1 in 1994. Subsequent to issuing the Braidwood Cycle Length Assessment Report dated August 2, 1996, the remaining 25 Byron Unit 1 1994 indications have been re-analyzed.

5. Supply in tabular form, the data used in the burst pressure and leakage correlations in the submittal dated August 2, 1996, including the following information: (1) the metallographic results (i.e., the percent degraded area, the maximum depth circumferential extent), if available; (2) the SG tube material properties; (3) the EC voltage measurements (maximum and average voltages) Indicating which inspection probe was used; (4) the maximum test pressure; and (5) the burst pressure and/or leak rate. As stated by the staff during the meeting held on August 26, 1996, some of the SG tube burst data in the correlations relating EC voltage values to burst pressure may have come from SG tubes which burst axially rather than circumferentially. Identify in this table which data points in the correlations burst axially as well as those that exhibited mixed mode cracking as determined from the destructive metallurgical examinations. Also, identify any indications that leaked during in-situ pressure testing at a rate beyond the pump capacity.

Response (9/24/96):

Table 5 provides a summary of the tube pull burst and insitu pressure test data requested in RAI Question 5. All the data are for top-of-the-tubesheet OD circumferential indications. A description of each of the columns is provided below:

Test Method: This column identifies whether the test was a burst test, whether the tube was taken to failure, insitu pressure tested or, whether the tube is taken to a target pressure to confirm structural integrity. Additionally, as discussed in response to Question 6 three large voltage indications maintained structural integrity at normal operating pressure. In no cases did a tube with a TTS circumferential indication burst during insitu pressure or under normal operating conditions.

Metallographic Results: For tubes pulled from steam generators, metallographic sizing of the defects have been performed. The results are documented for percent degraded area (PDA), Maximum depth (deepest crack penetration into the tube wall), and circumferential extent of the degradation.

Coil Size: The coil size used to acquire ECT data corresponding to the recorded voltages. All burst data was acquired with the 0.080" RPC. Insitu pressure test data has been acquired with the 0.080" and 0.115" RPC.

10V on 100% TW Hole: Maximum and average voltage results for the indication obtained by normalizing to 10 volts on a 100% throughwall hole. No corrections are applied to this data. For one tube, this flaw did not exist on the calibration standard and therefore the data is not included.

20V on 100% EDM Notch (normalized): The data in column "10V on 100% TW hole", is corrected in this field to the normalization procedure used in Byron and Braidwood look-backs. A correction factor of 0.51 and 0.68 (September 20, 1996 submittal) is used to correct the analysis data to 20V on a 100% TW EDM notch for 0.080" and 0.115" RPC, respectively. The data in column "10V on 100% TW hole" is also corrected where the 0.115" RPC probe is used. The correction factor applied to the 0.115" RPC data is 0.75 (September 20, 1996).

Insitu Pressure: Maximum pressure, in ksi, achieved during insitu pressure testing. No corrections are applied to this data.

Burst Pressure: Maximum pressure, in ksi, achieved prior to burst of the tube or EDM simulant specimen.

Operating Pressure: Normal operating differential pressure in ksi for tubes which were not burst tested or insitu pressure tested.

Leak Rate: Actual measured leak rate during tube pull or insitu leak testing in gpm.

Adjusted Leak Rate: Actual measured leak rate corrected to Braidwood Unit 1 main steam line break conditions (2560 psi, 600°F)

Insitu Leak Rate > Make-up at Maximum Pressure: In some cases during insitu pressure testing the target test pressure could not be achieved due to excessive leakage through the crack for which the test pump could not adequately make-up the necessary flow. This column indicates if this were the case during testing. Leak rate testing is performed at pressures which the test pump had adequate capacity to maintain leakage flow.

Yield Strength: Where tube pull data is available, the yield strength is reported in ksi.

Ultimate Strength: Where tube pull data is available, the ultimate strength is reported in ksi.

Axial or Circumferential Failure: During burst testing, the mode of failure is defined as axial or circumferential. In one case the burst test was terminated after high pressures were achieved (>10 ksi) due to the failure of a test rig weld.

Mixed Mode: Tube pull burst tests for which metallographic examination identified mixed mode cracking is identified in this column.

6. **Analytical predictions of circumferential burst pressure as a function of the percent of degraded SG tube area (PDA) are generally two-part correlations. Specifically, a constant upper bound value dictates the axial burst pressure for SG tube with limited degradation; However, more severely degraded tubes are governed by a relationship indicating lower circumferential burst pressures with increasing values of PDA. Since EC voltage may be related to PDA, it is possible that an empirical relationship between voltage and burst pressure may follow a trend similar to that predicted by analytical correlations. The voltage-burst pressure relationship included in the submittal dated August 2, 1996, is a monotonically decreasing function over all voltages. Discuss the basis for such a relationship in light of current analytical models for circumferential burst pressure.**

Response (9/17/96):

Available service data indicate that voltage and PDA do not necessarily follow the same trends especially at relatively high degradation levels. Burst pressure capability has been predicted to diminish relatively rapidly as a function of PDA once the PDA is beyond the value associated with axial tube burst. Available service data, however, indicate that the decrease in burst pressure as a function voltage is much more gradual for burst pressures lower than those associated with axial tube burst.

This is illustrated in Figures 6a and 6b, where burst pressure is plotted as a function of maximum and average voltage, respectively. The tubes corresponding to the three high voltage points in the figures were not burst or insitu pressure tested, and the plotted pressures for these three tubes are normal operating differential pressures (see data presented in response to Question 5). The pressure differentials shown in the figures have been corrected for Industry LTL material properties. None of these three tubes burst at normal operating differential pressures.

The dashed lines in the figures are extensions of the limit curves and were drawn as a comparison with the high voltage points at normal operating pressure. The dashed portion of the limit curves show there is a gradual drop in burst pressure immediately beyond the voltage associated with the range of available burst data. The information in Figures 6a and 6b also provides further confirmation that the deterministic burst curves are conservative, especially for average voltage where extremely large margins are indicated at high voltages.

7. **In Section 5.3 of the submittal dated August 2, 1996, it is stated that the assessment provided follows the methodology in NRC Generic Letter (GL) 95-05. However, a $2x10^{-2}$ frequency of indications greater than the structural limit is the proposed acceptance criteria as stated in Section 5.4. This latter value is twice the value given in GL 95-05. Accordingly, clarify the discussion on the basis for using this proposed acceptance criteria. In addition, provide a detailed discussion on the technical basis underlying the assumptions in the analysis which is intended to demonstrate that the conditional probability of burst for the SG tubes with voltage beyond the structural limit is less than about 10^{-4} when the frequency of indications is less than $2x10^{-2}$.**

Response (9/17/96):

The frequency of $2x10^{-2}$ is not intended to serve the same purpose as the conditional failure probability criteria of $1x10^{-2}$ in GL 95-05. ComEd believes sufficient data is not available to construct a probabilistic burst correlation as a function of voltage, therefore, a deterministic burst curve was used. Because a deterministic curve was used, and the available data base did not extend much beyond the structural limit, it was not possible to determine explicitly the conditional probability of burst for the entire distribution as specified in GL 95-05. Consequently, criteria were developed to provide a measure that could be used near the structural limit to determine if there was acceptable margin against burst for an EOC distribution.

The frequency less than $2x10^{-2}$ beyond the structural limit is not intended to ensure the conditional probability of burst is less than 10^{-4}. The criteria to ensure adequate margin against tube burst has two parts. The first part specifies that the frequency of tubes greater than the structural limit was less than $2x10^{-2}$, or, in other words, that 98% of the tubes would have voltages less than the structural limit at the EOC. The second part of the criteria (submitted to the NRC on August 2, 1996) specified that the conditional failure probability per tube would be less than 10^{-4}; this part provides assurance that the burst probability for a tube at or near the structural limit is very low. The information provided to the NRC in the August 20, 1996, submittal demonstrated that the conditional failure probability per tube at the structural limit is less than 10^{-4} for the deterministic burst curve.

This combined criteria was defined to ensure that there were relatively few tubes in the EOC distribution beyond the structural limit, and that the contribution to probability of burst would come from very few tubes or fractions of tubes at voltages beyond the structural limit, where the likelihood of having tubes with voltages this high in service would be low. There is additional margin provided by the deterministic burst curve where it is clear that the probability of burst at pressures on the burst curve is significantly less than one. Further, the response to Question 6 showed that the burst

pressure does not drop rapidly beyond the structural limit, is conservative relative to available data for high voltage indications; consequently, the probability of burst does not rise rapidly beyond the structural limit. These additional margins are not quantified but provide defense in depth to the 10^{-4} per tube value at the structural limit.

In response to a Staff request, ComEd is evaluating the feasibility of developing probabilistic correlations of burst pressure as a function of voltage as described Question 8.

8. Provide the basis for the shape of the curve used to determine the lower bound SG tube burst pressure. Determine whether a statistical fit to the data can be established using the available data set; i.e., the statistical fit should be valid at the 5% level consistent with GL 95-05. The guidance provided in GL 95-05 with respect to empirical models should be addressed; e.g., provide the order of the regression equation. If a statistical fit to the data can be established, provide a detailed probabilistic analysis of the conditional burst probability which is consistent with the intent of GL 95-05.

Response (9/24/96):

In previous submittals, the deterministic burst curve has been used by ComEd only to define the structural limit and to determine the conditional probability of burst per tube at the structural limit. Within these limits the shape of the curve used to determine the lower bound SG tube burst has no effect on either the structural limit or the conditional probability of burst at the structural limit because the curve was not used to extrapolate outside the data base, and the last data point used to construct the curve was near the structural limit. In addition, any other realistically shaped line (e.g. a straight line) would provide essentially the same curve, within the range of available data, for the two data points used to construct the curve.

The probabilistic burst analyses used to calculate a conditional burst probability for the Braidwood end of cycle six distribution is consistent with the methodology of GL 95-05. An assessment was performed to determine if a statistical fit to the data can be established. Initially, regression analyses were performed using both linear and log-linear fits for both maximum and average voltage. The data used for this fit are the burst test data presented in response to Question #5, excluding the data obtained from the two tubes with the EDM flaw simulations. The results from these analyses indicate that the only correlation that provided a valid fit at the 5% level required by GL 95-05 was the linear regression analysis of burst pressure and maximum voltage. There was a statistical correlation for burst pressure with only one of the two voltage parameters, and it is necessary to apply the correlation beyond the burst test data base when computing the conditional failure probability for the EOC distribution.

To obtain a correlation for both average and maximum voltages, the tube in the industry data base with the highest recorded voltage was added to the data base for the statistical correlation. This tube was not burst tested, and the pressure used for the correlation assessment was conservatively assumed to be normal operating pressure differential (see the data provided in the response to Question #5). Linear regression analyses were performed first with the extended data base. The results from this evaluation indicated there were valid fits at the 5% level between burst pressure and

both maximum and average voltages. The results from the statistical evaluation, including the mean regression line, and the 95% prediction bound curve are presented in Figures 8a and 8b for maximum and average voltage, respectively. Review of Figures 8a and 8b indicates that the burst pressure trends to zero at voltages less than those observed in service, as indicated by the insitu tests and the three non burst tested tubes (no failure at normal operating pressure) with the highest voltages (see the data provided in the response to Question #5). Therefore, the linear regression fit does not realistically model the service and burst data.

To more realistically model the burst pressure indicated by available service experience the extended data base was evaluated using a statistical Log burst pressure fit to the data. The statistical evaluation results in valid fits at the 5% level between Log burst pressure and both maximum and average voltage. The mean regression line and the 95% prediction bound curve are presented in Figures 8c and 8d for maximum and average voltages, respectively.

ComEd has computed the conditional failure probability for a distribution that was developed using the following: (1) the 128 detected and repaired indications at Byron, Unit 1 in 1994, and (2) the indications identified in the 1995 and 1996 look-back evaluations of the Byron, Unit 1 inspection data. This distribution is presented in Table 8a for average and maximum voltage. This distribution was used because it represents a slightly longer operating time, and the same tube material, stress and operating conditions compared to Braidwood, Unit 1 at EOC-6, and considered to be a bound to the indication distribution that may be found at Braidwood, Unit 1 at EOC-6. The distribution in Table 8a was adjusted for probe wear and analyst uncertainty to obtain the distribution for Braidwood, Unit 1 at EOC-6. The adjusted distributions for average and maximum voltages are presented in Table 8b. The distribution in Table 8b is designated as the EOC approach.

The conditional burst probability for the distributions in Table 8b were computed using the statistical linear and Log burst pressure fits developed from the extended data base described above. The leak rates were computed using the LogLogistic fit of the available data to obtain the probability of leak as described in response to Question 16. The leak and burst computations were performed using the guidelines in GL 95-05. The results are presented in Table 8c. Additional, results for the three approaches (POD, Look-Back, EOC) are presented in Attachment D.

As indicated in the response to Question 14 ComEd has selected the maximum voltage as the parameter to assess leak rate. In addition ComEd has selected the Log burst pressure fit to assess the probability of burst because, it more realistically models the relationship between burst pressure and voltage. Based on the results shown in Table 8c ComEd concludes that Braidwood, Unit 1 can operate to the EOC-6.

Table 8c. Leak Rate and Conditional Probability of Burst Results for EOC-6 Distribution at Braidwood, Unit 1 (EOC Approach)

	Maximum Voltage	Average Voltage
Conditional Burst Probability		
Linear Fit	3.9E-3	1.1E-2
Log Burst Pressure Fit	5.2E-5	1.1E-4
Leak Rate, gpm (for Circ. Indications.)		
LogLogistic Fit	19.0	n/a

9. For any given EC voltage, a variety of flaw morphologies is possible. Since the staff believes that it has not been demonstrated that EC voltage can accurately predict the morphology of degradation as stated in Item 1 above, discuss the possibility that more structurally significant morphologies may exist than those used to determine the lower bound fit. For example, discuss the possibility that a very tight coplanar flaw with a 360°, 95-percent throughwall defect exhibits the same maximum EC voltage as one of the two data points connecting the lower bound curve but which may exhibit a lower burst pressure. Provide the supporting data. If different and/or lower burst pressures are possible for the same EC voltage, discuss how the proposed probabilistic analysis accounts for this uncertainty.

Response (9/17/96):

ComEd does not claim that EC voltage can, at this time, predict morphology as indicated in ComEd's response to Question 1. In addition, as indicated in the response to Question 1 there are no data that demonstrate that "a variety of flaw morphologies" exist. To the contrary all data suggest there is one flaw morphology for roll transition circumferential ODSCC that exists over a range of degrees of degradation. The response to Question 1 indicates that EC voltage can be used as one of the variables to indicate if the morphology is within the known industry experience base.

Fortunately, service experience indicates there are very few instances of very deep uniform cracking due to circumferential ODSCC degradation at the TTS. There is only one known instance of a very deep uniform indication (>90% PDA) in the industry experience base. This indication is much larger than any indication detected at Byron Unit 1 or Braidwood Unit 1. This indication had a reported PDA of 94%, a maximum voltage of 9.51 volts, and an average voltage of 6.49 volts. This tube broke while being removed from the steam generator, and consequently, was not burst tested. However, because the indicated voltages are significantly greater than the voltage structural limit obtained from the ComEd deterministic burst curve, a low burst pressure for this tube would not contradict the burst curve (See Figures 6a and 6b in the response to Question 6). The responses to Questions 6, and 7 provide additional information concerning the potential for low burst pressures and probability of burst.

10. The burst pressure data were corrected for Braidwood lower tolerance limit (LTL) properties using information from certified material test reports. To remain consistent with the methodology in GL 95-05, burst pressure data should be normalized using material property data from the industry database used for alternate plugging criteria applications for axial cracking at SG tube support plate intersections. Accordingly, adjust the data in Figures 5.5 and 5.6 of the August 2, 1996, submittal using the industry database and determine the resulting structural limits for the average and maximum EC voltage correlations.

Response (9/10/96):

The industry insitu pressure test and burst pressures have been corrected for industry LTL properties (95/95, 650°F). In the Braidwood Cycle Length Assessment Report dated August 2, 1996 the data was corrected for Braidwood Unit 1 LTL properties, plots of the industry data corrected for industry LTL properties are included as Figures 10a and 10b.

The correction factor for industry LTL properties is the ratio of the industry 95%/95% lower tolerance limit ($s_y + s_u$) at 650°F to the industry room temperature mean ($s_y + s_u$) (EPRI Report, NP-6864-L, PWR Steam Generator Tube Repair Limits: Technical Support Document for Expansion Zone PWSCC in Roll Transitions - Rev. 2, August 1993).

$$130.65 \text{ ksi}/154.34 \text{ ksi} = 0.847$$

The insitu pressure test and burst pressures have been multiplied by this factor and the results plotted in Figures 10a and 10b against average and maximum voltage.

For the industry burst pressure tests corrected with the industry LTL properties the structural limit for average and maximum voltages at 3xNOdP (4035 psi) become 0.88 and 3.54 volts respectively. Previously reported plant specific structural limits were 0.91 and 3.64 volts respectively.

For plant specific application of the structural limits, the Braidwood Unit 1 LTL values will continue to be used in assessment of the Braidwood Unit 1 EOC distributions.

11. As discussed in Regulatory Guide 1.121, "Bases for Plugging Degraded PWR Steam Generator Tubes," SG tube repair criteria should consider the fatigue affects from cyclic loading forces. Discuss how these effects (e.g., fatigue, vibration, and flow-induced loadings) have been accounted for in the analysis of the proposed operating interval. Provide supporting test data.

Response (9/17/96):

Current operating experience and data from pulled tubes indicate there are no discernible fatigue, vibration, or flow-induced loading effects on tubes with circumferential ODSCC indications at the TTS. The effect of any subcritical low-cycle fatigue loading that may have occurred in service is captured in the growth rate described in the response to Question 3. For high cycle vibratory fatigue loading, rapid crack growth and subsequent failure would occur in much less than an operating cycle once the crack growth threshold was exceeded. Significant industry operating experience, including operating experience at Byron Unit 1, show there are no tube failures from high cycle vibratory or fatigue loads over the operating cycle length of interest at Braidwood Unit 1. Based on this experience there is no need to include explicit fatigue, vibratory, or flow-induced loading in the Braidwood Unit 1 evaluation.

12. If a SG tube were to separate or burst, discuss the possibility that multiple failures could occur as a result of SG tube whipping or impingement. Provide the supporting data and analysis.

Response (9/24/96):

The effects of jet impingement on adjacent tubes from axial cracks has been provided to the NRC in WCAP-13494, Revision 1, "Catawba Unit-1 Technical Support for Steam Generator Interim Tube Plugging Criteria for Indications at Tube Support Plates," March 1993. This report includes the test data for impingement wear coefficients and the supporting analysis model.

The analyses given in WCAP-13494 show that at a crack exit velocity of 200 ft/sec and direct impingement on the adjacent tube, it takes about > 170 hours to penetrate the wall thickness for pure water and close to 890 hours for a steam void fraction of about 0.8 which is the range expected for leakage under SLB conditions. These times are very long compared to the time required to reduce pressure differentials to negligible values in a SLB event and propagation of damage to adjacent tubes due to jet impingement is not expected.

The second part of the question relates to the potential for damage propagation to adjacent tubes as a consequence of whipping of a severed tube end. This potential propagation mechanism requires the whipping tube end to cause penetration of the wall by progressive impact wear. Whipping of a severed tube end would be most significant if caused by secondary side flow induced vibration leading to fluidelastic instability of the severed tube end. The mass and energy of the whipping tube is not large enough to cause significant damage to the adjacent tube by massive deformation. In addition, the severed tube end is weaker for distortion due to impact than the adjacent, intact tube and most of the distortion would occur at the severed tube end.

Thus, adjacent tube impact wear due to flow induced, fluidelastic tube vibration of the severed tube end is the principal; mechanism to be evaluated for potential damage propagation. In a steam line break event, the time of significant secondary flow is the first few seconds of the event during blowdown of the SG. A few seconds is too short of a time interval to cause substantial wear on an adjacent tube. In addition, the primary to secondary pressure differential is smaller during the first few seconds of a SLB since the larger pressure differentials result from pressure buildup due to safety injection. Thus, the likelihood of impact wear causing penetration of an adjacent tube in a SLB event is negligible.

The potential for impact wear from a whipping tube under normal operating conditions is conceptually higher than under accident conditions due to potentially longer times at significant secondary side velocities that could cause fluidelastic instability of the severed tube end. However, the time following a tube rupture to shut the plant down with low secondary side flow is also measured in seconds. Again, the time periods with a whipping tube end are too short to cause penetration of an adjacent tube.

13. **Because of the non-coplanar nature of stress corrosion cracking in SG tube expansion transitions, EC signals from circumferential indications may exhibit both axial and circumferential degradation. Accordingly, discuss whether an assessment of SG tube degradation using voltage measurements from several scan lines (i.e., a volumetric assessment) is necessary as opposed to selecting a single scan line.**

Response (9/17/96):

Tube failure and rupture occurs at the weakest location of the degraded tube area. The most degraded area of the tube can be assessed by the use of a single scan line for maximum and average voltage. The analysis of Braidwood Unit 1 and Byron Unit 1 data uses the same analysis methods (a single scan line) as that used to define the burst limits for maximum and average voltage. This provides a consistent analysis of the Braidwood Unit 1 and Byron Unit 1 tubes against known tube failures. A volumetric approach using more than one scan line can average undegraded areas of the tube with degraded areas to provide a non-conservative voltage signal which may not be representative of the structural integrity of the tube. Results of tube pull conclude that the area of degradation away from the crack face do not contribute to the failure of the tube. The 0.080" RPC does perform a volumetric assessment of the degraded area of a circumferential band equivalent to the size of the coil (i.e. 0.080"). Therefore, the use of a single scan line is adequate to assess the structural integrity of SG tubes.

14. **The correlation of leak rate versus maximum EC voltage applies only to the end-of-cycle (EOC) EC voltage distributions derived from maximum EC voltages. Provide a similar relationship based on EC voltage integral measurements of circumferential indications. Describe, or reference if previously submitted, the procedure used to normalize the SG tube leak rates to the operating temperature and the main steam line break (MSLB) pressure of 2560 pounds per square inch (psi).**

Response (9/10/96):

Maximum voltage was selected as the parameter to assess leakage because it provides a good measurement of the crack's depth especially when the crack is asymmetric and a segment of the crack is either through wall or substantially deeper than the remainder of the crack front. Average voltage provides a measure of the integrated degradation over the entire tube circumference and there may not be segments where the crack is either through wall or nearly through wall.

The industry leak rate data from insitu pressure tests and tube pull leak tests is provided in the response to Question 5 and is plotted in Figure 14a against average voltage. The average voltage is normalized as discussed in Section 6.2.1 of the Braidwood Cycle Length Assessment Report dated August 2, 1996. A log-logistic probability of leak vs. average ECT amplitude function was developed. The probability of leak function is based upon the data presented in Section 7.0 of the Braidwood Cycle Length Assessment Report dated August 2, 1996. A 95% confidence level of the probability of leak function is used to assess the Braidwood Unit 1 EOC leak rate for the EOC approach for average voltage. Figure 14b shows the function and its lower 95% confidence level.

Because a correlation between voltage and leak rate does not exist a maximum leak rate of 0.16 gpm is assumed for each voltage bin.

Future analysis of circumferential indication distribution leak rate will continue to use maximum voltage, since it is the voltage parameter which provides the best indication of the depth of degradation.

Braidwood Unit 1 EOC leak rates are based upon leak rate testing performed at temperatures and pressures different from MSLB conditions. The test leak rates are corrected by the following procedure. Leak rate input data which are available and used to calculate a corrected leak rate at Braidwood MSLB conditions are: observed leak rate (room temperature), leak rate temperature and pressure, MSLB temperature and pressure, PICEP regression equations relating leak rate to pressure in terms of a ratio of the crack opening area to crack length. The most limiting ratio of the leak rate at MSLB temperature to room temperature is calculated using the most limiting (largest leak rate) crack opening to length ratio at MSLB pressure. From this ratio the leak rate at MSLB temperature is determined given the leak rate at test temperature. The PICEP computer code has been used by the industry for calculating MSLB leak rates in SG tubes.

15. Assuming that the maximum EC voltage is a more accurate parameter for predicting SG tube leakage, discuss the need to assess the leakage from other portions of a circumferential SG tube indication which may have voltages that are less than the maximum EC voltage recorded for a given SG tube but that may nevertheless leak. Specifically, address the possibility that several locations in the circumferential crack pattern of a SG tube at the expansion transition may contribute to the overall leakage from the SG tube since it is possible that the individual cracks in a non-coplanar pattern could be separated by a sufficient distance such that separate EC voltages for these indications could be recorded.

Response (9/17/96):

No correlation of leak rate to ECT parameter has yet been identified. Therefore, the leak rate used to assess the end of cycle leak rate for Braidwood Unit 1 is based upon the maximum leakage recorded during testing of service induced cracks. The testing of these cracks were performed under pressurized conditions and leakage was measured from the entire area of degradation. Any leakage from degradation not detected by the ECT analysis is included in the leak rate assessment. Indications exceeding the leakage threshold are assigned the maximum leakage (from the entire area of degradation). Therefore the present methodology for assessing the leak rate from circumferential indications includes all leakage from the area of degradation.

16. Given that for any EC voltage, a variety of morphologies can exist as discussed in Items 1 and 9 above, discuss the basis for assuming that there is an EC voltage cutoff for determining when a SG tube is susceptible to leaking. Discuss how the proposed methodology would account for the uncertainty in the potential for a SG tube to leak and the uncertainty in the leak rate itself. Further, given the limited amount of SG tube leakage data for circumferential indications, discuss why the bounding value of SG tube leakage which is assumed, is conservative.

Response (9/10/96):

In order to provide additional conservatism in the leak rate analysis, to address limited data and uncertainties in the industry leak rate data, a log-logistic probability of leak vs. Maximum ECT amplitude function was developed. The probability of leak function is based upon the data presented in Section 7.0 of the Braidwood Cycle Length Assessment Report dated August 2, 1996. A 95% confidence level of the probability of leak function is used to assess the Braidwood Unit 1 EOC leak rate for the EOC approach. Figure 16 shows the function and its lower 95% confidence level. Because a correlation between voltage and leak rate does not exist a maximum leak rate of 0.16 gpm is assumed for each voltage bin. Operating experience has demonstrated that circumferential cracks, even those with significant degradation, do not leak significantly under normal operating conditions. This is most likely due to the presence of ligaments observed from tube pull metallographic results. The leakage assumed in the analysis is the largest leakage (corrected to Braidwood MSLB conditions) measured during tube pull or insitu pressure leak testing and provides more realistic results than the calculation approaches. The 0.16 gpm leak rate is applied to all voltage bins where leakage has been identified to occur. This conservatively applies the highest observed leak rate, corrected to MSLB conditions, to a distribution of indications which have been observed through testing to have significantly lower leak rates.

The EOC-6 leak rate will be calculated by summing the leak rate at each bin which is calculated as follows: obtain the product of the number of tubes in each bin and the probability of leak of tubes at the bin voltage then multiply by the bounding leak rate (from tube pull leak rate testing and insitu pressure testing).

This method will adequately account for uncertainties in the leakage data. Results of application of this method will be provided upon resolution of NRC questions on input parameters of the EOC analysis.

17. Provide the EC inspection data and the calibration setup files used in the burst and leakage correlation's. In addition, provide EC data for a representative range of circumferential indications and their corresponding EC voltage integral and maximum EC voltage measurements. The EC data should be provided in a format compatible with Eddynet95 software.

Response (9/17/96):

The eddy current inspection data are supplied on one optical disk transmitted via this response. Side A of the optical disk includes the tubes which were used to develop the burst and leakage correlations, (refer to Table 5 for the tube data). An additional fifty (50) tubes with a representative range of voltages for the circumferential indications with the maximum and average voltages are included. All of the data contains the calibration setup files. The data is formatted for the EddyNet 95 software. An optical disk with the data is being forwarded to the Senior Project Manager

18. Provide a copy of the EC data analysis guidelines used during the Braidwood Unit 1 SG tube inspections in fall 1995.

Response (9/17/96):

A copy of the eddy current d .a analysis guidelines that were used for the Braidwood Unit 1 steam generator tube inspections in the fall of 1995 is provided in Attachment 18.

19. In Section 6.2.1 of the submittal dated August 2, 1996 the EC voltage normalization procedure for adjusting the SG tube burst and leakage data is described. This EC voltage adjustment was made to obtain consistent EC voltages for circumferential indications where the calibration standard did not contain an axial EDM notch. Discuss how the EC voltages for other reflectors in the calibration standard compare with the 0.58 correction factor applied to the data. Provide a statistical analysis based on field data which supports the use of the 0.58 correction factor.

Response (9/20/96):

An evaluation of the application of the 0.58 normalization correction factor to other reflectors in the calibration standard has been performed. The results are shown in Table 19a. The table includes: the other reflectors included in the evaluation, the voltage normalized to 10 Volts on a 100% throughwall hole (TWH), the voltages normalized to 20 Volts on the 100% axial EDM notch and the ratio of the two voltages. The results indicate that the voltages normalized to 10 Volts on a 100% TWH and corrected with a 0.58 correction factor are consistent for the different reflectors included in the analysis.

Further assessment of the application of the 0.58 correction factor has been performed on the 50 field data points using the voltage integral software to evaluate the impact on the Braidwood Unit 1 cycle length assessment. The results of this field data assessment are presented in Table 19b for maximum and average volts. The data is provided for analysis of both the 0.115" and 0.080" RPC data normalized to 10 volts on the 100% throughwall hole (TWH) and 20 volts on the 100% axial EDM notch. Because industry data was acquired with the both the 0.080" and 0.115" RPC, it is necessary to have a normalization correction factor established for each coil size. The previous submittal (September 17, 1996) included a single normalization correction factor which was determined from 0.080" RPC data. This normalization correction factor was applied to both the 0.080" and 0.115" RPC data. Normalization correction factors can be determined for both the 0.115" and 0.080" RPC using the data in Table 19b. A summary of the different methods used for calculation of the normalization correction factors is included in Table 19c. A statistical analysis of the field data (maximum and average voltage combined) has been performed using a linear regression analysis. The results from the statistical evaluation indicate that the normalization correction factor is 0.51 and 0.68 for the 0.080" and 0.115" RPC, respectively, as determined from the slopes of the mean regression lines (see Figure 19).

Two normalization correction factors were provided in the September 17, 1996 submittal, one for maximum voltage and one for average voltage. The correction factors were nearly the same, and the maximum and average voltages are put into a single population for determination of the normalization correction factors. Normalization correction factors are provided for the 0.115" and 0.080" pancake coils for assessment of industry tube pull and insitu pressure test ECT data. The statistical coil size based correction factors provide the most statistically correct result and will be used.

20. A 0.76 correction factor was applied to adjust 0.115-inch probe coil EC voltages to equivalent 0.080-inch probe coil EC voltages. Describe in detail the development of this correction factor, including a discussion on the number of samples reviewed, the types of defects analyzed, and the mean and standard deviation of the study sample. Additionally, provide the recorded EC voltages, if practical, or the range of circumferential indication EC voltages included in the sample. Provide a statistical analysis based on field data which supports the use of the 0.76 correction factor.

Response (9/20/96):

During a look-back of three hundred and fifty 1996 Byron Unit 1 indications in SG C, analysis of the indications was performed using the 0.115" and 0.080" RPC. The look-back was performed prior to development of the voltage integral software. Because all the 0.080" RPC indications in one SG were included, a range of indication sizes (0.06 to 1.11, 0.080" RPC Volts) is included in the data set. The average of the three hundred and fifty 0.080" RPC voltages (mean of 0.326 Volts) was compared to the average of the 0.115" RPC voltages (mean 0.431 Volts). From this result a scale factor for the 0.115" RPC is calculated from the ratio of the mean voltages, or 0.326/0.431 = 0.76. This scale factor was applied to some of the insitu pressure test data included in the industry data base that was collected on 0.115" RPC. The scale factor was not applied to any tube pull burst data points because the data was acquired with the 0.080" RPC. Many of the data points used in the leak rate assessment had the scale factor applied since much of the data was obtained from 0.115" RPC. A listing of the data included in the study is provided in Table 20a.

Further assessment of the application of the 0.76 correction factor has been performed on 50 field data points using the voltage integral software. The results are presented in Table 19b for maximum and average volts. In the previous submittal (September 17, 1996) the coil size correction factor was determined from data normalized to 20 volts on a 100% EDM notch. The data in Table 19b can be used to determine a coil size correction factor normalizing the data in two ways (10 volts on the 100% TWH and 20 volts on a 100% EDM notch). Because the industry tube pull and insitu pressure test data was normalized to 10 volts on the 100% TWH, this normalization is appropriate to use in determining a coil size correction factor. A summary of the different methods used for calculation of the coil size correction factors is included in Table 20b. A statistical analysis of the field data (maximum and average combined) has been performed using a linear regression analysis. The results from the statistical evaluation indicate that the coil size correction factor for the field data 0.75 (for normalization to 10 volts on a 100% throughwall hole) as determined from the ratio of the slope of the 0.080" and 0.115" RPC mean regression lines from Figure 19. Figure 20 shows the 0.115" RPC data corrected using the 0.75 correction factor and the 0.080" RPC data in the same

plot. The two data sets are now consistent as determined by the overlay of the 2 data sets linear regression lines. Therefore, a 0.75 coil size correction factor is appropriate.

Two coil size correction factors were provided in the September 17, 1996 submittal, one for maximum voltage and one for average voltage. The corrections factors were nearly the same. The maximum and average voltages can be put into a single population for determination of the coil size correction factor. Statistical analyses support the statistical 10 V approach as being correct.

21. Provide a summary of the essential variables of the inspection techniques as documented in the EC acquisition technique sheets (ACTS) and the analysis technique sheets (ANTS) for the Byron Unit 1 SG EC inspections in 1994, 1995, and 1996 and for the 1995 Braidwood Unit 1 SG EC inspections. Additionally, provide the ACTS and ANTS associated with the SG EC inspections conducted at other plants where data were obtained for use in the SG tube burst and leakage correlation's presented in the August 2, 1996, submittal. Identify and discuss how the differences in the acquisition and analysis of EC data will affect the EC voltage measurements used in the analysis.

Response (9/24/96):

Table 21 provides a summary of the essential variables of the eddy current inspection techniques. These essential variables were used for the Byron 1 1994, 1995, 1996, Braidwood 1 1995, and the plants where data was obtained for use in the tube burst and leak correlations. Attachment 21 contains the ACTS and ANTS sheets, where available. Essential variables for the remaining plants are included in a typical ECT "summary" form. Essential variables were not recorded in the summary form for three plants. These essential variables are included in Table 21.

The essential variables identified in Table 21 shows equivalency for data acquisition per EPRI Appendix H. The Zetec MIZ-18A/30 with the use of the .115" pancake and Plus point probe are qualified techniques for the detection of ODSCC at the expansion transitions. Based upon comparison of the essential variables for the data identified in Table 21, the acquisition techniques will not significantly affect the voltage measurements used in the eddy current voltage measurements. Coil size and normalization factors have been applied as discussed in response to questions 19 and 20.

22. Some studies have identified a lift-off effect in SG tube expansion transitions for gimbaled probes due to SG tube geometry changes. This lift-off can decrease a probe coil's response to SG tube indications. If gimbaled probes were used in any of the inspections where data is used to support the Braidwood Unit 1 cycle length assessment, explain the basis for not accounting for this affect for EC voltage measurements in expansion transitions. Some of the data in the SG tube burst and leakage correlations were obtained from 56 tubes which had been explosively expanded into the SG tubesheet. Describe any differences between the transition geometry, particularly with respect to the length of the expansion of the explosively expanded tubes and that for roll- expanded SG tubes. Discuss the effects of the SG tube transition geometry on the recorded EC voltages. Discuss the need to account for liftoff in the EC voltage measurements for both the data used in the proposed correlations and the data obtained for the field indications.

Response (9/17/96):

Gimbaled probe data was not used for measuring the eddy current voltages in the expansion transitions for supporting the Braidwood Unit 1 cycle length assessment.

The explosive expansion transition signals are typically more uniform in their geometry than the mechanically hard roll transitions. The roll transition signals do affect the eddy current signals. The orientation of these signals is mainly horizontal while the flaw response is vertical. The voltage integral software looks at the eddy current data in a 360° scan, any affects from the flaws or roll transitions would be included in the voltage measurements. If the roll transition signal contained any vertical component, it would be included as part of the flaw voltage measurement, which means the voltage measurement would be conservative.

Liftoff is minimized since the probe is spring loaded and surface riding. With the liftoff minimized, liftoff becomes an issue of data quality and cannot be factored into the eddy current voltage measurements.

23. In Figure 3.1 of the submittal dated August 2, 1996, the number of circumferential indications detected with the plus point coil is related to those detected with the 0.080-inch rotating pancake coil (RPC) probe. The results are presented as the number of indications as a function of EC voltages as measured with the plus point probe. Explain the relationship between the circumferential indication EC voltages as measured with the 0.080-inch coil to those measured using the plus point coil. Describe the data set used in the comparison study between the two coils. Explain the differences in the analysis guidelines for the coil study to those used during the Braidwood Unit 1 A1R05 SG tube EC inspections. In addition, the EC voltages in this figure are the maximum indication EC voltages. State whether a similar relationship has been developed using average EC voltage (i.e., voltage Integral) measurements. If so, supply the results. If not, discuss the usefulness of performing such an assessment in light of the present analysis based on EC voltage integral measurements.

Response (9/24/96):

Figure 3.1 of the submittal dated August 2, 1996 is intended to provide an assessment of the probability of detection of the 0.080" RPC compared to the plus point coil. This comparison was used to support application of the POD approach included in the August 2, 1996, submittal to determine a POD to be used for EOC calculations for Braidwood Unit 1. The data in the figure is not intended to establish a relationship between 0.080" RPC and plus point voltages. The conclusion drawn from the figure is that for large indications (as determined by plus point voltages) the 0.080" RPC has a high level of detection, nearly equivalent to plus point. The conclusions support that the tail of the distribution used in the Braidwood Unit 1 analysis for the POD approach is conservative when a POD of 0.2 is used across all voltage bins.

The data set used for this study is from a look-back of the 1996 Byron Unit 1 SG C TTS circumferential indications performed in May of 1996. The voltage integral software was not used in this look-back. This look-back included analysis of SG C indications with the 0.080" RPC and plus point coil. Referring to Figure 3.1, the solid line represents indications in SG C which in 1996 could only be detected with the plus point coil (no 0.080" RPC confirmation). The broken line represents plus point indications which were confirmed with 0.080" RPC. Where the two lines (solid and broken) are close to each other, the POD of the 0.080" RPC is approaching one.

A similar relationship has not been developed for average voltage. Because the figure was developed to assess the detection capability (POD) of 0.080" RPC indications as compared to plus point coil. Data presented in Figures 4.5, 4.6 and 6.1 support the trend that as the maximum voltages increase so do the average voltages. This would support the conclusion discussed above that the detection level of the 0.080" RPC voltages is high for large indications as determined by plus point coil average voltage as well as the maximum voltage.

Additionally, in order to address concerns with the number of tubes assumed in the POD approach, ComEd has evaluated two additional end of cycle distributions. These two distributions do not use the data from Figure 3.1. Instead these distributions assume that Braidwood Unit 1 EOC-6 distribution will be similar to the distribution of indications detected at Byron Unit 1 at EOC-6.

All indications detected by the 0.080" RPC were also detected by the plus point coil.

ComEd has concluded that there is not value added to defining a POD for both maximum and average volts for the following reasons:

- Analyst initially detects and reports based upon max volts, and
- Average volts calculation is only done after detection.

Additional Response to 9/17/96 Submittal:

Differences in the analysis guidelines for the Look-Back to those used during the Braidwood 1 A1RO5 SG eddy current tube inspections are summarized below:

1. Voltage Normalization:
   Look-back voltage normalization included setting the voltage peak-to-peak from the 100% axial EDM notch to 20.00 volts for the 0.080" pancake coil in the normal lissajous window, and the axial lissajous and circumferential lissajous in the C-Scan mode. Braidwood voltage normalization included setting the voltage peak-to-peak from the 100% axial EDM notch to 20.00 volts in the normal lissajous window.

2. Voltage Measurement:
   Look-back voltage measurements were recorded using Vertical Maximum "Vert Max" for both the 0.080" pancake and Plus Point coils. Braidwood voltage measurements were recorded at volts Peak-to-Peak "Pk-Pk" in the main lissajous window for the 0.080" pancake coil.

3. Use of Slewing:
   Look-back analysis used the appropriate slewing (rotate data) for each coil. Braidwood analysis did not mention the use of slewing (rotate data) for each coil.

4. Trigger Offset:
   Look-back analysis adjusted the trigger offset so that the indications are in the center of the C-Scan plot. Braidwood guidelines do not mention adjusting the trigger offset.

5. Analysis Data:
   Look-back consisted of a direct tube to tube comparison using two Eddynet windows side by side to evaluate the indications by C-Scanning the data from the Plus Point coil. Braidwood's evaluation consisted of reviewing the strip chart data and normal lissajous window while scrolling the data using the 0.080" pancake coil.

6. Filters:
   Look-back guidelines incorporated the use of the axial line and circumferential line filters, if necessary. Braidwood guidelines allowed the use of a bandpass filter on the mix channels for the pancake, axial and circumferential coils, at the option of the data analyst or at the direction of the lead analyst.

7. Analysis Software:
   The look-back guidelines incorporate the use of EddyNet95. The Braidwood Unit 1 analysis used the ANSER analysis software.

Items 1 - 4 represent items in the guidelines which reflect the difference in the objectives of the look-back analysis (size and detection) and the initial steam generator tube inspection (detection). These items could affect the magnitude of the reported voltages but not the level of detection. Items 5 - 7 improve the analysts ability to detect the indications, however because Byron Unit 1 look-back data has been used to assess the estimated Braidwood Unit 1 end of cycle six distribution items 5 - 7 do not impact the results of the Braidwood Unit 1 cycle length assessment. The Braidwood Unit 1 October 1995 indication inspection data has been re-analyzed as part of the look-back using the guidelines discussed above.

Based on the differences discussed above, the improved techniques and methodolgy enhanced the evaluation and detection during the look-back analysis. This is why in the POD approach a POD of 0.2 is used to account for the improvements in analysis and inspection techniques, for detection, not used at Braidwood Unit 1 in October 1995.

24. Data to support the assessment of the probability of detection (POD) and the SG tube burst and leakage correlations in the August 2, 1996 submittal were taken from various sources. Since the noise levels inherent in the data and SG tube wall deposits may affect the resulting EC voltage measurements, provide an assessment comparing the influence of noise and deposits on the EC signals for the SG tube burst and leakage data. Additionally, provide a discussion as to how the noise levels were determined (i.e., SG tube location, coils, and frequencies). Given that these factors may affect EC voltage measurements, provide the basis for selecting the lowest point in the scan line as the null point for EC voltage measurements.

Response (9/24/96):

Noise and deposits will affect the eddy current signal by increasing the overall voltage response. Probe noise and deposits were monitored through the "C" scan, strip charts and lissajous signals for signals inherent to noise and deposits during the voltage measurements for the steam generator burst and leak data for overall acceptability and quality of the data. It was found that the overall quality of the data was acceptable qualitatively and no signal to noise correction factors were applied to any voltage measurements for the industry leak and burst data. Due to the top of the tube sheet location of the indications there was no presence of indications in the vicinity of the flaw which could influence the voltage measurement.

Since the Voltage Integral software selects the lowest point in the scan line to establish a 'zero' threshold, any increase in the signal amplitude will increase not only the 'zero' threshold, but also the scan line and the resultant output, again being a more conservative measurement. Letting the Voltage Integral software select the lowest point in the scan line as the null point produces a more consistent result for the voltage measurements.

25. In the Braidwood Unit 1 cycle length assessment, analyst uncertainty values of 0. 19 and 0.22 were utilized. Given that a signal for a specific type of degradation may be better defined by one coil rather than another, provide an assessment of the analyst variability based on the coil of interest (e.g., the 0.080-inch probe). Additionally, state the units associated with these values. If the values are in volts, state the corresponding analyst uncertainty as a percentage value.

Response (9/24/96):

The initial blind test included in the August 2, 1996, submittal was developed to assess detection, recorded voltage measurements were used to assess analyst error for that test. A second blind test has been performed to assess sizing. The second blind test provides a more appropriate evaluation of analyst error in voltages measured from 0.080" RPC data, by testing the following areas:

1. the analyst must select the circumferential scan line with the maximum indication peak,

2. from the selected scan line the analyst must select the maximum voltage,

3. data normalization,

4. the use of filters,

5. the effects of inconsistent use of trigger offset, and

6. the ability of the voltage integral software to consistently calculate the maximum and average voltage.

To directly address analyst uncertainty used in the Braidwood Unit 1 end of cycle calculations, an additional blind test has been performed using the voltage integral software to analyze and measure the maximum and average 0.080" RPC voltages. The guidelines used in the blind test are provided in response to Question 30. The blind test included 9 analysts and 141 indications. The indications ranged in size and were selected from the following inspection data: Braidwood Unit 1 October 1995 indications from all SG's, Byron Unit 1 1996 SG C, Byron Unit 1 1996 tubes which were insitu pressure tested from SG A, Byron Unit 1 1994 and 1995 tube pulls. The response to this question refers to the additional blind test and not the blind test submitted in the August 2, 1996 submittal.

Blind Test Protocol:

- A total of nine analysts participated in and completed the blind test of 141 indications.

- To be consistent in measuring and reporting circumferential indication voltages during the testing, analysis guidelines were written. Zetec voltage integral EddyNet 95 analysis software was used.

- Voltage was normalized to 10 Volts on a 100% throughwall hole. Analysts were allowed to used other coils to locate the indications. Voltage was recorded based upon the 0.080" pancake coil. Both maximum and average voltage was measured.

- A detailed discussion is presented in response to Question 28 of how the average and maximum voltages were determined during the blind test.

- The testing was proctored by the ComEd eddy current Level III to insure all data was analyzed using the appropriate guidelines and to observe that no indication results were being discussed between the analysts.

- The probe that was used in the 1995 Braidwood Unit 1 and 1994 Byron Unit 1 tube pull data set was a 3-Coil motorized rotating pancake coil (MRPC) which included a .080" pancake coil, axial wound coil and a circumferentially wound coil. The rotating probe used for the 1995 Byron Unit 1 tube pull and 1996 data sets consisted of a 0.080" pancake coil, a 0.115" pancake coil and a plus point coil. The analysts used all coils to aid in their analysis of detecting the circumferential indications.

Blind test analysis guidelines are included in response to Question 30.

Blind Test Results:

The blind test results were analyzed to determine analyst error and the standard deviation of the percent analyst error. The following procedure was used in the calculation for maximum and average voltage:

- The mean of the nine analysts measured indication voltages is considered the indication reference voltage. The distribution of the reference voltages for the 141 tubes is presented in Figures 25a and 25b for average and maximum volts respectively.

- The percent error from the reference voltage of each analysts' call for the 141 indications is determined. This is calculated by subtracting the the analysts' call from the reference voltage and dividing by the reference voltage.

- The standard deviation of the percent error for the entire population of calls from the 9 analysts for the 141 indications is determined.

- The standard deviation was calculated to be 32% and 30% for average and maximum voltage, respectively. No resolution of data was performed. The units for the percent analyst error are volts/volts.

The 30% and 32% analyst error for average and maximum voltage, respectively, will be used in analysis of the end of cycle distribution.

26. Discuss the basis for keeping the data from the 100 SG tube and 200 SG tube tests separate for the analyst variability study. Provide and discuss the mean, standard deviation, and shape of the distribution used for the model of analyst uncertainty (e.g., a normal distribution with a mean of x and standard deviation of y). Discuss the technical basis for the distribution which was used.

Response (9/24/96):

As discussed in response to Question 25, an additional blind test has been performed to better represent the ECT analysis methods used in the look-back analyses which are used to perform the Braidwood Unit 1 end of cycle assessments. The additional blind test was comprised of a single population of tubes (141) with a single result for average and maximum voltage being determined. The results of this blind test will be used for end of cycle analyses which are based upon results from look-backs. The distribution of percent analyst error is assumed to be normal with a mean of zero and a standard deviation of 32% and 30% for average and maximum volts, respectively. Figure 26a and 26b show the distribution of analyst deviation for average and maximum voltages, respectively including the cumulative frequency distribution for the percent analyst error and the cumulative normal distribution. The cumulative frequency distribution of percent analyst error closely approximates the cumulative normal distribution particularly at the high end tail of the distribution. The percent analyst error distribution is more peaked than a normal distribution; therefore, would predict higher analyst uncertainty just above the mean than assuming a normal distribution. A normal distribution for percent analyst error provides conservative results for larger uncertainties.

27. Discuss the basis for reevaluating the EC voltages measured in the analyst variability study based on a resolution process. Discuss whether this practice was used in the blind tests. The staff believes that this method of analyzing analyst variability is inconsistent with the methodology used in GL 95-05 (i.e., reevaluating the EC voltages). Clarify what is meant by the statement that observation EC voltages from different coils for the same indications were excluded.

Response (9/24/96):

As stated in response to question 25, there was no resolution in the second blind test. End of cycle analysis has been performed using the updated analyst error. It is believed that this provides a conservative result for the following reasons.

- The distributions to which the analyst variability are applied are obtained from look-back of the indications. During the look-back process any reported indications which appear to be inconsistent with the indication distribution are evaluated to ensure that the data was correctly analyzed. A similar methodology should be applied in the blind tests. A resolution process should occur after completion of the blind test to identify results which do not fit the distribution. The results presented in Question 25 do not incorporate any resolution of the data recorded by the analysts during the blind test however, analysis of the data identified that a large contribution of the overall analyst error is attributed to a small number of calls. Evaluation of these calls identified several root causes not associated with the interpretation of the indication.

- In order to evaluate the affects of resolution of blind test results, voltages with a percent error greater than -100% (these represent conservative calls with voltages recorded greater than the mean voltage) is applied to the data to provide a realistic assessment of the analysis results. Application of this resolution process results in a standard deviation of percent analyst error of 0.23 for average volts and 0.24 for maximum volts. The resulting distribution after resolution is

shown in Figures 27a and 27b for average and maximum voltage, respectively. The figures show that the distribution is more normal after the resolution.

Therefore, use of a normal distribution with a mean of 0 and a standard deviation of 0.32 for average and 0.30 for maximum is conservative. Additionally, the tail of the distributon is quite long in the negative direction which represents overcalls (voltages greater than the mean). This indicates that the largest uncertainty is associated with conservative overcalls and further justifies resolution of calls with a percent error greater than 100% in the negative direction.

The statement in the August 2, 1996, report that observation of EC voltages from different coils for the same indications were excluded is as follows: "During the blind test, discussed in the August 2, 1996 submittal, the objective was to demc nstrate the probability of detection of the Byron Unit 1 indications. The analysts were allowed to ıse the different coils available to them and recorded the voltage for which the indication was detected". In order to assess the analyst variability on voltage from this test, only indications which were analyzed by all analysts with the same coil were included in the assessment of analyst variability. Because the different coils would provide different voltage measurments data from a consistent coil is required. As discussed in response to Question 25 an additional blind test was performed where the voltage measurements were all recorded using the 0.080" RPC.

28. Describe the measures included in the blind test protocol which would have prevented an analyst from using information from one coil to locate and size the maximum EC voltage signal as seen by another coil. As discussed by the staff in the meeting held on August 26, 1996, the rotational slewing of the data via such mechanisms as the trigger offset feature in Eddynet95 could lead to additional variability in an analyst's ability to accurately size circumferential indications with an EC voltage integral measurement. Describe how this variability was accounted for in the assessment of analyst uncertainty.

Response (9/24/96):

During the blind test discussed in response to Question 25 the analysts were instructed to use all coils (i.e. pancake, circumferential, and plus point), for identifying flaw location. The blind test protocol permitted the analysts to use information from one coil to another coil to locate the indication. In order to obtain the best analysis for detection and measurements of any given flaw, guidelines are structured for the analysts to use all available "tools" (i.e. coils, frequencies, channels, mixes etc,) for assisting in measurements made from one coil to another.

The objective of the blind test is to assess the variability of the voltage measurement. Using different coils to aid in location of the indication does not affect the variability of the voltage measurement. The analyst variability is used to assess the end of cycle voltage distribution based upon look-back data. During the look-backs, the analysts were allowed, and did use other coils as necessary to locate the indications. Therefore, the methodology of using different coils to locate the indications is consistent between the two blind tests, the look-backs and the guidelines for field inspection.

The voltage measurements were measured and recorded during the blind test using the Zetec Voltage Integral Software. Voltage measurements are recorded as described below:

- A C-Scan plot is generated for the expansion region of interest.
- Using the Axial and Circumferential strip chart cursors, the C-Scan line associated with the maximum vertical displacement for the indication is selected.
- The Voltage Integral software plots the circumferential scan line that is selected in the main C-Scan plot.
- The average voltage is automatically calculated by the Voltage Integral software.
- The cursor is then positioned by the analyst in the Voltage Integral Software at the maximum vertical "Vert. Max"scan line displacement. The circumferential scan lines maximum and average voltage is then recorded.

The appropriate slewing (rotate data) for each coil was used for the blind test. (Ref. Blind Test Analysis Guidelines, Section 5.13 for R-Slew included with Question 30). The rotational slewing of the coils will not introduce variability for the maximum and average voltage measurements. The rotational slewing of the coils eliminates the offset in the eddy current data caused by the physical separation of the coils.

The trigger offset is discussed in the look-back and blind test analysis guidelines (see Attachment 30). The guidelines require the trigger offset to place the start and stop point of the indication in the center of the C-Scan plot minimizing the variability of the voltage integral measurement.

The blind test uncertainties discussed in detail in response to Question 25 include any uncertainty associated with the trigger offset feature in Eddynet95.

29. If the measured EC voltages in the "look back" analysis of the Byron Unit 1 EC measurements were maximum EC voltages, explain the basis for applying these results of the analyst uncertainty measurement to the EC voltage integral measurements. If circumferential indications were sized using, the lissajous signal, explain the basis for applying a variability in sizing with the lissajous signal to measurements of maximum EC voltage determined by positioning the signal cursor in the voltage integral scan.

Response (9/24/96):

The second blind test uncertainties discussed in detail in response to Question 25 include the uncertainties associated with the voltage integral software for determination of maximum and average voltage. These uncertainties will be used for end of cycle distributions using the EOC approach discussed in the September 10, 1996, submittal.

The eddy current maximum voltages were sized during the "look-back" analysis using the lissajous signal from the RPC Cir. Liz. window. The lissasjous signal displyed in the Circ Liz window represents the maximum scan line plotted in the C-Scan plot. The cursor was then positioned at the maximum displacement of the scan line in the Voltage Integral window and the vertical maximum voltage is displayed. The vertical maximum voltages are the same due to the normalization process used for these windows which is included in the "look-back" analysis guidelines provided in Question

30. Measuring the maximum voltage from either the Circ. Liz. window or positioning the cursor at the maximum displacement in the Voltage Integral window will produce the same voltage measurements. Therefore, no voltage variability adjustment is necessary.

30. Provide a copy of the EC sizing procedures used in the assessments of the analyst uncertainty, the growth rate, the burst and leakage data, and the POD. Discuss the extent of use and the influence of the following on any EC voltage measurements: (1) the use of Eddynet95 data filters; (2) the trigger offset feature and (3) the presence of 360m circumferential flaws. Address both the EC voltage integral and the EC maximum voltage measurements.

Response (9/24/96):

Attachment 30 includes a copy of the eddy current sizing procedures used in the assessment of the analyst uncertainty, growth rates, burst and leak data and POD assessment. Filters were used in the analyst uncertainty, growth rates, and POD assessment but not the burst and leak data.

As part of the ECT analysis the following filters were used in the assessment for the uncertainty and growth rates:

- Axial average filter was used to remove the effects caused by tube wall variations and data offsets.
- Circ. Line filter was used to remove the effects caused by unwanted signals such as deposits and geometry changes.

The axial average filter helps to smooth the data offsets visually represented down the axial scan lines in the C-Scan plot. The filter averages all of the data point values on a given circumferential scan line and substracts the average value from every data point on that line. This process repeats for every circumferential scan line in the C-Scan plot. The output reduces the data offsets in the axial direction. When the axial average filter is enabled the software automatically calculates and smoothes the data that is visually produced on the C-Scan plot.

The circumferential scan line filter lets the analyst choose a circumferential scan line to be used as a filter. The chosen scan line is subtracted from every circumferential scan line in the C-Scan plot. It acts as a nulling function for all of the circumferential scans and removes unwanted signals (i.e. tube wall variations, deposits, geometry changes, etc.), that occur consistently in each scan line. Analysts were trained to select a non-flawed scan line to be used as a filter for the ECT sizing used for growth rate studies and analyst uncertainty. No filters were used in the ECT analysis of the the burst and leak database.

To evaluate the impact of these filters and results, ComEd performed an evaluation on voltage measurements with the use of filters. Figure 30A represents voltage measurements for non-filtered data. Figure 30B represents voltage measurements with the use of the Axial Average filter. Figure 30C represents voltage measurements with the use of the Circ. Line filter. Figure 30D represents voltage measurements with the use of the Axial Average and Circ. Line filter.

Conclusions:

- The maximum and average voltage does not change with an Axial Average filter.
- The maximum and average voltage does change with a Circ. Line filter. The resultant output of the voltage measurements is reduced. Selecting a non-degraded circ line to be used as a filter does not reduce the flaw signal.
- The maximum and average voltage remains the same as the Circ. Line filter, when using the Axial Average and Circ. Line filters in combination.

Therefore, ComEd analysis is correct because the use of filters does not affect the voltage signal corresponding to the flaw.

The affects of the trigger offset feature is discussed in response to Question 28.

An evaluation of the affects of 360 degree flaws on the Braidwood 1 end of cycle assessment has been performed. Guidelines for the voltage integral look-back of Byron 1 1996 and 1995 indications required the analysts to identify indications which had 360 degreee ECT signals. Of the over 400 1996 0.080" RPC indications evaluated, 8 had 360 degree ECT signals. Of the over 700 1995 0.080" RPC indications evaluated, 21 had 360 degree ECT signals. Three of the 23 Braidwood Unit 1 indications were determined by ECT to be 360 degrees. Because of the small number of indications reported with 360 degree flaws the number of tubes affected by this question is small.

The effect of 360 degree flaws on voltage integral results was evaluated using Byron Unit 1 1995 tube pull voltage and metallographic (MET) results. The maximum voltage determined by the voltage integral software, where the null point is selected by the software as the lowest point of the scan line, is compared to the maximum voltage determined by the analyst, with a user balanced null point (without the use of the voltage integral software). The comparison is shown in Table 30 for the 10 Byron Unit 1 1995 tube pulls. The results indicate that for 360 degree flaws there is no trend of the maximum voltage from the voltage integral software, where the null point is selected by the software as the lowest point of the scan line, being reduced due to the affects of 360 degree flaw when compared to the maximum voltage with a user defined balanced null point. Significant effects on voltage only occur when there is uniform degradation for 360 degrees. Tube pull results from Byron Unit 1 indicate that this type of degradation does not exist.

A comparison of the maximum voltages obtained during the voltage integral look-back (where the software selects the null point based upon the lowest point in the scan line) to previous look-back results (where a user defined balanced null point is used) for indications determined by ECT to be 360 degrees was performed. The results are documented in Table 30. Similar to the tube pull data the results indicate that for 360 degree flaws there is no trend of the maximum voltage from the voltage integral software being reduced due to the affects of 360 degree flaw when compared to the maximum voltage with a user defined balanced null point.

Indications, analyzed with the voltage integral software, used to establish the burst and leak limits with 360 degree degradation would provide a conservative result. The voltage of these indications would be reduced if the 360 degree affect described in the question ("null" line set for a scan line with no undegraded area) affected the data. A reduced voltage correlated to the test pressure or leak rate would therefore provide conservative limits. The tube pull and insitu pressure test data represents some of the most degraded tubes and therefore the burst limits are conservative.

31. The probe wear allowance that was developed in the August 20, 1996, submittal was based on a small sample of the total SG tubes inspected. Provide an assessment of probe wear based on all available data. The staff believes that the methodology used to determine the probe wear allowance is significantly different from that used to determine the probe wear allowance in GL 95-05. Discuss the basis for not determining the probe wear allowance in accordance with the methodology used to support the GL 95-05 probe wear allowance given that different SG tube roughness can change the amount of probe wear observed between calibration runs.

Response (9/24/96):

No practice has been defined for measuring and tracking MRPC probe wear for circumferential indications at the top of the tubesheet. An assessment to quantify the effects of MRPC probe wear on indication voltages was performed. The assessment was structured to evaluate MRPC wear using the Bobbin probe wear method documented in GL 95-05.

The probe wear was determined from the trends of the measured calibration standard voltages from the first calibration standard to the last calibration standard measured for each calibration group.

Identified below are the similarities and differences to GL 95-05 for implementing the IPC criteria.

Similarities:

- Bobbin probe design must incorporate centering features that provide for minimum probe wobble and offset; the centering features must maintain constant probe center to tube ID offset for nominal tubing.
- MRPC probe designed as a surface riding coil and the centering features provide constant probe center to tube ID offset for nominal tubing.
- GL 95-05, probe wear should be controlled by either an inline measurement device or through the use of a (wear standard) for periodic wear measurement.
- MRPC probe wear assessment was controlled by the ASME calibration standard as the measurement device for periodic wear measurements.

- Bobbin wear standard contains four through wall holes, spaced 90 degrees apart around the tube circumference.
- ASME standard contains one through wall hole.

Differences:

- Initial Bobbin (new probe) amplitude response from each of the four holes is determined and compared on an individual basis with subsequent measurements. Signal amplitudes or voltages from the individual holes, compared with their initial amplitudes, must remain within 15% of their initial amplitude for an acceptable probe wear condition.
- Initial MRPC (new probe) amplitude response from the single hole is compared on an individual basis with subsequent measurements. Signal amplitudes or voltages from the individual hole, compared with their initial amplitudes.
- The August 2, submittal Appendix A paragraph A.2.1 showed the results to be 5.62% and 5.9% probe wear for the 100% TW EDM notch and the 100% TW drill hole respectively.

GL 95-05 describes a specific probe wear standard to be used for ODSCC at the TSP's. This standard is inappropriate for any MRPC because of the coil geometry differences. However, a single 100% TW hole or 100% TW EDM notch are the MRCP equivalent fo the bobbin coil standard.

ComEd has adequately accounted for the effects of RPC probe wear in assessment of Braidwood Unit 1 end of cycle distribution.

Probe wear evaluation was performed on an additional 14 calibration groups representing over eleven hundred tubes. The results of the additional calibration groups do not significantly change the results of the probe wear assessment. The probe wear, including the additional calibration groups, are 7.0% and 7.5% for the 100% TW drilled hole and the 100% TW EDM notch, respectively. A re-analysis of the EOC approach for average voltage was performed to assess the impact of the increased probe wear result. There is adequate conservatism used in the end of cycle calculations including analyst uncertainty to account for this probe wear increase.

Table 3a. Byron 1 Growth Rate Bins and Number of Tubes for Maximum Voltage

Maximum Voltage Growth Rate Bins and Number of Tubes					
	Bins	94 to 95	94 to 96	95 to 96	
	ΔV/EFPY				
	-1.8			1	
	-1.7			1	
	-1.6			0	
	-1.5			0	
	-1.4			2	
	-1.3			2	
	-1.2			0	
	-1.1			0	
	-1.0			2	
	-0.9			1	
	-0.8			3	
	-0.7			4	
	-0.6			10	
	-0.5			3	
	-0.4	4	0	11	
	-0.3	3	0	7	
	-0.2	12	1	11	
	-0.1	33	5	5	
	0.0	71	10	21	
	0.1	169	20	10	
	0.2	177	23	17	
	0.3	112	6	19	
	0.4	67	5	8	
	0.5	25	2	6	
	0.6	9	0	8	
	0.7	3	0	7	
	0.8			5	
	0.9			1	
	1.0			2	
	1.1			1	
	1.2			1	
	1.3			5	
	1.4			3	
	1.5			1	
	1.6			2	
	1.7			0	
	1.8			0	
	1.9			1	
	SUM >>	685	72	181	

Table 3b. Byron 1 Growth Rate Bins and Number of Tubes for Average Voltage

Average VoltageGrowth Rate Bins and Number of Tubes					
	Bins	94 to 95	94 to 96	95 to 96	
	ΔV/EFPY				
	-1.20			1	
	-1.15			0	
	-1.10			1	
	-1.05			0	
	-1.00			0	
	-0.95			0	
	-0.90			0	
	-0.85			0	
	-0.80			0	
	-0.75			1	
	-0.70			0	
	-0.65			2	
	-0.60			1	
	-0.55			3	
	-0.50			3	
	-0.45			3	
	-0.40			2	
	-0.35			6	
	-0.30			7	
	-0.25	3	0	10	
	-0.20	4	2	3	
	-0.15	7	1	4	
	-0.10	26	2	16	
	-0.05	40	6	9	
	0.00	92	7	17	
	0.05	185	25	8	
	0.10	149	9	10	
	0.15	107	14	20	
	0.20	41	2	7	
	0.25	14	1	12	
	0.30	11	3	2	
	0.35	3	0	6	
	0.40	3	0	4	
	0.45			0	
	0.50			6	
	0.55			3	
	0.60			2	
	0.65			0	
	0.70			5	
	0.75			0	
	0.80			2	
	0.85			1	
	0.90			0	
	0.95			2	
	1.00			0	
	1.05			0	
	1.10			0	
	1.15			0	
	1.20			1	
	1.25			0	
	1.30			1	
	SUM >>	685	72	181	

Table 5

Test Method	Metallographic Results PDA (%)	Max Depth (%)	Circ. Extent (degrees)	COIL SIZE	10 V on 100% TW Hole Max Volts	Avg Volts	20 V on 100% EDM Notch (Normalized) Max Volts	Avg Volts	Insitu Press (ksi)	Burst Press (ksi)	Operating Press (ksi)	Leak Rate (gpm)	Leak Rate Test Press (ksi)	Adj. Leak Rate (gpm)	Insitu Leak Rate > Make-up at Max Pressure	Yld. Strength (ksi)	Ultimate Strength (ksi)	Axial or Circ Failure	Mixed Mode
Insitu	-	-	-	0.115	1.51	0.63	0.77	0.32	4.15	-	-	n	-	n	-	-	-	-	-
Burst	65	100	360	0.08	3.13	1.02	1.60	0.52	x	8.44	-	n	-	n	-	-	-	Circ.	No
Insitu	-	-	-	0.115	3.09	1.26	1.58	0.64	4.60	-	-	0.050	2.000	0.054	yes	-	-	-	-
Insitu	-	-	-	0.115	3.62	1.66	1.85	0.85	3.60	-	-	0.150	2.000	0.161	yes	-	-	-	-
Insitu	-	-	-	0.115	2.52	1.00	1.29	0.51	4.70	-	-	0.040	4.700	0.011	-	-	-	-	-
Insitu	-	-	-	0.115	2.08	0.93	1.06	0.47	4.45	-	-	0.000	-	0.000	-	-	-	-	-
Insitu	-	-	-	0.115	1.58	0.71	0.81	0.36	4.45	-	-	0.000	-	0.000	-	-	-	-	-
Insitu	-	-	-	0.115	1.67	0.71	0.85	0.36	6.80	-	-	0.000	-	0.000	-	-	-	-	-
Insitu	-	-	-	0.115	1.63	0.79	0.83	0.40	6.80	-	-	0.000	-	0.000	-	-	-	-	-
Insitu	-	-	-	0.115	1.31	0.57	0.67	0.29	6.80	-	-	0.000	-	0.000	-	-	-	-	-
Insitu	-	-	-	0.115	1.06	0.43	0.54	0.24	6.80	-	-	0.000	-	0.000	-	-	-	-	-
Insitu	-	-	-	0.115	1.92	0.71	0.98	0.36	4.45	-	-	0.000	-	0.000	-	-	-	-	-
Insitu	-	-	-	0.08	3.03	0.97	1.55	0.49	4.70	-	-	0.000	-	0.000	-	-	-	-	-
Burst	49	100	360	0.08	4.75	1.12	2.42	0.57	-	9.40	-	0.139	2.650	0.090	-	-	-	Circ	Yes
Burst	49	71	350	0.08	3.25	1.38	1.66	0.70	-	11.20	-	n	-	n	-	-	-	Axial	No
Burst	47	91	280	0.08	4.96	1.92	2.53	0.98	-	8.45	-	n	-	n	-	-	-	Axial	No
Insitu	-	-	-	0.115	4.53	1.53	2.31	0.78	3.90	-	-	0.011	3.000	0.0064 (4)	-	-	-	-	-
Insitu	-	-	-	0.115	3.15	1.59	1.61	0.81	3.90	-	-	0.000	-	0.000	-	-	-	-	-
Insitu	-	-	-	0.115	1.69	0.90	0.86	0.46	3.90	-	-	0.000	-	0.000	-	-	-	-	-
Insitu	-	-	-	0.115	3.56	1.61	1.82	0.82	3.90	-	-	0.000	-	0.000	-	-	-	-	-
Insitu	-	-	-	0.115	2.04	0.90	1.04	0.46	3.90	-	-	0.000	-	0.000	-	-	-	-	-
Insitu	-	-	-	0.115	1.19	0.43	0.61	0.22	7.08	-	-	0.000	-	0.000	-	-	-	-	-
Insitu	-	-	-	0.115	0.61	0.17	0.31	0.09	6.70	-	-	0.000	-	0.000	-	-	-	-	-
Insitu	-	-	-	0.115	1.93	0.78	0.98	0.40	6.40	-	-	0.000	-	0.000	-	-	-	-	-
Insitu	-	-	-	0.115	0.64	0.29	0.33	0.15	7.00	-	-	0.000	-	0.000	-	-	-	-	-
Insitu	-	-	-	0.115	1.09	0.63	0.56	0.32	7.05	-	-	0.000	-	0.000	-	-	-	-	-
Insitu	-	-	-	0.115	0.95	0.36	0.48	0.18	7.05	-	-	0.000	-	0.000	-	-	-	-	-
Insitu	-	-	-	0.08	7.56	1.47	3.86	0.75	5.30	-	-	0.029	4.200	0.010	-	-	-	-	-
Insitu	-	-	-	0.08	2.16	1.14	1.10	0.58	5.75	-	-	0.000	-	0.000	-	-	-	-	-
Burst (1)	78	100	360	0.08	-	-	4.14	1.02	-	4.35 (1)	-	n	-	n	-	65.45 (1)	113.95	Circ	No
Burst	35	51	360	0.08	-	-	0.38	0.18	-	10.950	-	0.000	-	0.000	-	54.00	101.60	Axial	Yes
Burst	35	83	310	0.08	1.10	0.47	0.56	0.24	-	10.300	-	0.000	-	0.000	-	55.80	97.40	(2)	No
Burst	54	79	360	0.08	0.67	0.21	0.34	0.11	-	11.400	-	0.000	-	0.000	-	50.90	100.90	Axial	Yes
Burst	48	77	360	0.08	1.58	0.68	0.81	0.35	-	12.100	-	0.000	-	0.000	-	56.10	107.80	Axial	No
Burst (1)	65	100	359	0.08	1.94	0.56	0.99	0.29	-	7.424 (1)	-	n	-	n	-	58 (1)	106.40	Circ.	Yes
Burst	56	98	360	0.08	0.70	0.31	0.36	0.16	-	10.600	-	0.000	-	0.000	-	51.60	102.30	Axial	No
Insitu	-	-	-	0.115	1.14	0.27	0.58	0.14	5.00	-	-	0.000	-	0.000	-	-	-	-	-
Insitu	-	-	-	0.08	1.20	0.28	0.61	0.14	5.00	-	-	0.000	-	0.000	-	-	-	-	-
Insitu	-	-	-	0.08	0.98	0.52	0.50	0.27	5.00	-	-	0.000	-	0.000	-	-	-	-	-
Insitu	-	-	-	0.08	1.45	0.54	0.74	0.28	5.00	-	-	0.000	-	0.000	-	-	-	-	-
Insitu	-	-	-	0.08	0.89	0.54	0.45	0.28	5.00	-	-	0.000	-	0.000	-	-	-	-	-
Insitu	-	-	-	0.08	1.15	0.36	0.59	0.18	5.00	-	-	0.000	-	0.000	-	-	-	-	-
Insitu	-	-	-	0.08	0.90	0.20	0.46	0.10	5.00	-	-	0.000	-	0.000	-	-	-	-	-
Insitu	-	-	-	0.08	1.15	0.38	0.59	0.19	5.00	-	-	0.000	-	0.000	-	-	-	-	-
Operating	73	100	330	0.08	31.12	15.25	15.87	7.78	-	-	1.375	-	-	-	-	-	-	-	-
Operating	94	100	360	0.08	16.39	11.19	8.36	5.71	-	-	1.350	-	-	-	-	-	-	-	-
Operating	88	100	360	0.08	10.13	4.63	5.17	2.36	-	-	1.350	-	-	-	-	-	-	-	-

(1) Based upon EDM simulant of actual tube degradation level, corrected for material properties of tube pull
(2) Test rig connection failure before tube burst
(3) Data Reported in 9/10/96 Submittal as 0.88 and 0.37 Volts for max. and avg. volts respectively
the data was acquired with 0.115" RPC and correction factor not applied, this does not change conclusions of submittals
(4) Data reported in 8/2/96 and 9/10/96 submittals as 0.00352 gpm at 3.9 ksi, actual leakage is recorded at 3.0 ksi

Table 8a

BOC Distribution for EOC Approach

Maximum Volts			Average Volts	
Voltage at Top of Bin	EOC Approach		Voltage at Top of Bin	EOC Approach
0.10	3		0.05	14
0.20	105		0.10	238
0.30	404		0.15	402
0.40	285		0.20	249
0.50	188		0.25	128
0.60	97		0.30	61
0.70	43		0.35	47
0.80	29		0.40	18
0.90	20		0.45	13
1.00	5		0.50	12
1.10	3		0.55	4
1.20	1		0.60	0
1.30	0		0.65	0
1.40	0		0.70	0
1.5	2		0.75	0
			0.80	0
4.2	1		0.85	0
			0.90	0
			0.95	1

Table 8b

EOC Distribution for EOC Approach

Maximum Volts			Average Volts	
Voltage at Top of Bin	EOC Approach		Voltage at Top of Bin	EOC Approach
0.10	3.79		0.05	13.73
0.20	123.37		0.10	209.11
0.30	295.89		0.15	314.64
0.40	259.70		0.20	229.68
0.50	176.38		0.25	143.53
0.60	113.58		0.30	90.57
0.70	70.79		0.35	56.67
0.80	45.33		0.40	36.91
0.90	28.69		0.45	25.07
1.00	19.10		0.50	16.82
1.10	12.90		0.55	12.12
1.20	8.36		0.60	7.90
1.30	5.98		0.65	5.94
1.40	4.45		0.70	4.39
1.50	3.17		0.75	3.09
1.60	2.34		0.80	2.43
1.70	1.91		0.85	1.85
1.80	1.41		0.90	1.48
1.90	1.16		0.95	1.29
2.00	0.96		1.00	1.08
2.10	0.71		1.05	0.98
2.20	0.55		1.10	0.67
2.30	0.49		1.15	0.57
2.40	0.33		1.20	0.49
2.50	0.29		1.25	0.43
2.60	0.26		1.30	0.36
2.70	0.16		1.35	0.26
2.80	0.21		1.40	0.26
2.90	0.23		1.45	0.26
3.00	0.25		1.50	0.10
3.10	0.15		1.55	0.17
3.20	0.15		1.60	0.13
3.30	0.12		1.65	0.24
3.40	0.12		1.70	0.13
3.50	0.07		1.75	0.13
3.60	0.10		1.80	0.18
3.70	0.13		1.85	0.10
3.80	0.12		1.90	0.13
3.90	0.08		1.95	0.09
4.00	0.06		2.00	0.09
4.10	0.08		2.05	0.13
4.20	0.06		2.10	0.09
4.30	0.04		2.15	0.06
4.40	0.03		2.20	0.04
4.50	0.03		2.25	0.05
4.60	0.07		2.30	0.02
4.70	0.09		2.35	0.04
4.80	0.06		2.40	0.01
4.90	0.06		2.45	0.04
5.00	0.08		2.50	0.06

Table 19a

Assessment of 0.58 Correction for Other Reflectors

Voltage Normalized @ 10 volts pp on the 100% TWH		Voltage Normalized @ 20 volts pp on the 100% AXIAL EDM NOTCH		Ratio 20V 100% EDM/ 10V 100% TWH
INDICATION	VOLTS	INDICATION	VOLTS	
100% TW	3.78	100% TW	2.08	0.55
61% FBH	4.51	61% FBH	2.64	0.59
20% FBH	1.42	20% FBH	0.78	0.55
100% AXIAL EDM OD	16.26	100% AXIAL EDM OD	9.51	0.58
40 % AXIAL EDM OD	1.00	40 % AXIAL EDM OD	0.58	0.58
20 % AXIAL EDM ID	0.69	20 % AXIAL EDM ID	0.40	0.58
20 % CIRC NOTCH ID	0.98	20 % CIRC NOTCH ID	0.49	0.50
40 % CIRC NOTCH OD	1.24	40 % CIRC NOTCH OD	0.70	0.56

Table 19b

Field Data for Statistical Analysis of Industry ECT Correction Factors

		Voltage Normalized @ 10 volts on the 100% TWH				Voltage Normalized @ 20 volts on the 100% AXIAL EDM NOTCH			
		.080 PANCAKE COIL		.115 PANCAKE COIL		.080 PANCAKE COIL		.115 PANCAKE COIL	
Row	Col	Volts VM Max	Volts VM Avg	Volts VM Max	Volts VM Avg	Volts VM Max	Volts VM Avg	Volts VM Max	Volts VM Avg
1	10	0.88	0.37	1.01	0.36	0.45	0.19	0.47	0.16
18	20	1.23	0.54	1.56	0.69	0.65	0.29	0.75	0.34
25	22	1.29	0.81	1.75	0.81	0.72	0.46	1.14	0.38
5	24	1.05	0.50	0.96	0.46	0.49	0.24	0.42	0.20
40	32	1.00	0.42	1.01	0.48	0.55	0.23	0.57	0.27
47	31	0.39	0.24	0.58	0.23	0.31	0.14	0.36	0.35
42	31	0.49	0.29	0.67	0.34	0.30	0.15	0.39	0.19
41	31	0.94	0.39	1.11	0.52	0.52	0.21	0.63	0.29
13	34	0.75	0.42	0.77	0.39	0.43	0.24	0.63	0.32
45	35	0.85	0.21	0.95	0.28	0.49	0.12	0.78	0.23
35	38	0.35	0.19	0.34	0.19	0.20	0.11	0.28	0.16
14	41	0.92	0.34	0.80	0.25	0.40	0.14	0.50	0.15
21	42	2.62	1.11	2.21	0.87	1.20	0.51	1.43	0.56
38	43	2.10	1.00	1.85	0.84	0.97	0.46	1.21	0.56
39	43	1.22	0.88	1.08	0.68	0.55	0.37	0.70	0.44
17	45	1.35	0.68	1.26	0.71	0.62	0.31	0.81	0.47
26	45	1.22	0.52	1.17	0.55	0.55	0.24	0.75	0.36
42	59	0.43	0.27	0.56	0.33	0.21	0.12	0.57	0.27
17	59	0.58	0.19	0.53	0.18	0.32	0.16	0.44	0.18
16	60	0.63	0.33	0.65	0.28	0.33	0.18	0.52	0.23
18	61	0.51	0.19	0.68	0.25	0.29	0.10	0.59	0.22
14	60	1.00	0.43	1.17	0.47	0.53	0.22	0.96	0.37
13	59	1.24	0.55	1.23	0.53	0.65	0.28	1.00	0.43
8	61	1.40	0.55	1.59	0.52	0.73	0.29	1.27	0.43
8	60	0.80	0.41	0.76	0.35	0.42	0.21	0.61	0.28
4	59	0.52	0.26	0.70	0.37	0.31	[illegible]	0.52	0.26
4	63	0.52	0.19	0.71	0.32	0.26	0.11	0.57	0.25
15	62	1.00	0.49	0.80	0.23	0.52	0.26	0.66	0.18
16	63	0.75	0.29	0.99	0.40	0.47	0.18	0.87	0.36
19	62	0.69	0.31	0.52	0.23	0.35	0.16	0.22	0.11
20	61	1.15	0.57	1.19	0.41	0.61	0.30	1.06	0.45
25	62	1.11	0.49	0.87	0.33	0.57	0.26	0.71	0.26
28	64	0.79	0.31	0.72	0.21	0.38	0.14	0.92	0.39
37	64	1.29	0.57	1.30	0.57	0.67	0.30	1.04	0.46
45	66	1.22	0.59	1.31	0.58	0.64	0.31	1.06	0.47
41	65	1.37	0.58	1.24	0.55	0.67	0.27	0.99	0.44
38	46	1.13	0.27	1.20	0.35	0.69	0.17	0.88	0.26
24	47	1.30	0.61	1.11	0.52	0.79	0.37	0.81	0.38
26	49	0.73	0.34	1.01	0.47	0.43	0.20	0.75	0.35
38	49	1.43	0.58	1.49	0.64	0.86	0.35	1.09	0.47
41	49	1.16	0.50	1.18	0.58	0.71	0.30	0.87	0.43
36	66	0.42	0.20	0.60	0.36	0.24	0.11	0.34	0.21
25	65	0.73	0.46	0.61	0.47	0.38	0.24	0.37	0.28
20	66	0.55	0.28	0.46	0.21	0.26	0.12	0.34	0.15
21	65	0.95	0.61	0.89	0.73	0.50	0.32	0.53	0.44
13	64	1.54	0.41	1.68	0.51	0.80	0.21	1.00	0.30
7	65	0.74	0.30	0.54	0.23	0.38	0.15	0.32	0.14
6	66	0.70	0.30	0.69	0.24	0.45	0.20	0.37	0.14
16	67	1.80	0.90	1.83	0.87	0.90	0.45	1.03	0.48
21	69	1.46	0.70	1.69	0.84	0.75	0.36	1.02	0.50

Table 19c

Summary of Normalization Correction Factor Determination Methods

				Result		Data Result Applied to:
Approach	Submittal Date	Data Source	Coil Used	Max. Volt	Avg. Volt	
Calibration Standard	8/2/96	Calibration Standards	0.080"	0.58		0.080" and 0.115"
Statistical 0.080" Based	9/17/96	50 Field Ind's	0 080"	0.52	0.51	0.080" and 0.115"
Statistical Coil Size Based	9/20/96	50 Field Ind's	0.080" 0.115"	0.51 0.68		0.080" 0.115"

Table 20a

Data Used in Initial Coil Size Correction Factor
Comparison of 0.080" and 0.115" RPC Voltages

0.080" Volts	.115 volts
0.06	0.11
0.06	0.14
0.06	0.15
0.07	0.08
0.07	0.35
0.07	0.13
0.08	0.22
0.08	0.16
0.08	0.16
0.09	0.14
0.09	0.26
0.09	0.37
0.1	0.13
0.1	0.14
0.1	0.16
0.1	0.11
0.1	0.18
0.1	0.1
0.1	0.23
0.1	0.21
0.1	0.18
0.1	0.14
0.11	0.19
0.11	0.17
0.11	0.22
0.11	0.1
0.11	0.12
0.11	0.48
0.11	0.18
0.11	0.13
0.11	0.19
0.12	0.17
0.12	0.22
0.12	0.19
0.12	0.11
0.12	0.2
0.12	0.41
0.12	0.58
0.12	0.17
0.12	0.26
0.12	0.09
0.12	0.17
0.13	0.48
0.13	0.14
0.13	0.17
0.13	0.47
0.13	0.07
0.13	0.28
0.13	0.21
0.13	0.17
0.13	0.17
0.13	0.22
0.13	0.16
0.14	0.34
0.14	0.14
0.14	0.45
0.14	0.33
0.14	0.23
0.14	0.21
0.14	0.27
0.15	0.14

Table 20a

Data Used in Initial Coil Size Correction Factor
Comparison of 0.080" and 0.115" RPC Voltages

0.080" Volts	.115 volts
0.15	0.14
0.15	0.18
0.15	[illegible]
0.15	[illegible]
0.15	0.33
0.15	0.41
0.15	0.24
0.16	0.25
0.16	0.24
0.16	0.43
0.16	0.14
0.16	0.12
0.16	0.2
0.16	0.34
0.16	0.21
0.16	0.24
0.16	0.18
0.16	0.24
0.17	0.3
0.17	0.11
0.17	0.3
0.17	0.32
0.17	0.3
0.17	0.23
0.17	0.46
0.17	0.54
0.17	0.18
0.17	0.22
0.17	0.19
0.17	0.3
0.18	0.18
0.18	0.5
0.18	0.16
0.18	0.24
0.18	0.24
0.18	0.31
0.18	0.21
0.18	0.52
0.18	0.19
0.18	0.5
0.18	0.13
0.19	0.36
0.19	0.13
0.19	0.36
0.19	0.24
0.19	0.17
0.19	0.24
0.19	0.37
0.19	0.23
0.19	0.3
0.2	0.39
0.2	0.47
0.2	0.33
0.2	0.14
0.2	0.58
0.2	0.18
0.2	0.27
0.2	0.34
0.2	0.21
0.2	0.18
0.2	0.26

Table 20a

Data Used in Initial Coil Size Correction Factor
Comparison of 0.080" and 0.115" RPC Voltages

0.080" Volts	.115 volts
0.2	0.28
0.2	0.42
0.21	0.14
0.21	0.19
0.21	0.17
0.21	0.2
0.21	0.38
0.21	0.34
0.21	0.27
0.21	0.23
0.21	0.39
0.21	0.3
0.22	0.27
0.22	0.24
0.22	0.36
0.22	0.17
0.22	0.25
0.22	0.24
0.23	0.33
0.23	0.14
0.23	0.12
0.23	0.84
0.23	0.45
0.23	0.59
0.23	0.3
0.23	0.48
0.23	0.24
0.23	0.31
0.24	0.22
0.24	0.32
0.24	0.16
0.24	0.52
0.25	0.22
0.25	0.4
0.25	0.19
0.25	0.61
0.25	0.46
0.25	0.64
0.25	0.2
0.25	0.33
0.25	0.24
0.25	0.34
0.26	0.19
0.26	0.11
0.26	0.45
0.26	0.24
0.26	0.21
0.26	0.35
0.26	0.37
0.27	0.29
0.27	0.39
0.27	0.28
0.27	0.17
0.27	0.4
0.27	0.15
0.27	0.33
0.27	0.41
0.27	0.32
0.28	0.96
0.28	0.51
0.28	0.13

Table 20a

Data Used in Initial Coil Size Correction Factor
Comparison of 0.080" and 0.115" RPC Voltages

0.080" Volts	.115 volts
0.28	0.34
0.28	0.36
0.28	0.96
0.28	0.3
0.28	0.18
0.28	0.33
0.28	0.33
0.28	0.69
0.29	0.55
0.29	0.32
0.29	0.59
0.29	0.38
0.29	0.3
0.29	0.37
0.29	0.37
0.3	0.26
0.3	0.43
0.3	0.28
0.3	0.3
0.3	0.53
0.3	0.28
0.3	0.27
0.31	0.49
0.31	0.4
0.31	0.53
0.31	0.59
0.31	0.55
0.31	0.34
0.32	0.64
0.32	0.37
0.32	0.78
0.32	0.54
0.32	0.38
0.32	0.13
0.32	0.22
0.32	0.5
0.33	0.4
0.34	0.37
0.34	0.6
0.35	0.39
0.35	0.85
0.35	0.44
0.35	0.4
0.36	0.58
0.36	0.56
0.36	0.39
0.37	0.61
0.37	0.93
0.37	0.34
0.37	0.54
0.37	0.68
0.37	0.4
0.37	0.41
0.37	0.38
0.37	0.46
0.38	0.4
0.38	0.44
0.38	0.52
0.38	0.42
0.38	0.28
0.39	0.72

Table 20a

Data Used in Initial Coil Size Correction Factor
Comparison of 0.080" and 0.115" RPC Voltages

0.080" Volts	.115 volts
0.39	0.79
0.39	0.97
0.39	0.51
0.39	0.63
0.39	0.63
0.4	0.67
0.4	0.43
0.4	0.45
0.4	0.55
0.41	1.07
0.41	0.54
0.41	0.57
0.41	0.72
0.41	0.36
0.41	0.81
0.42	0.35
0.42	0.89
0.42	0.33
0.42	0.39
0.42	0.6
0.43	0.42
0.43	1.01
0.44	0.51
0.44	0.49
0.44	0.58
0.45	0.73
0.46	0.84
0.46	0.65
0.47	0.58
0.47	0.53
0.48	0.36
0.48	0.53
0.48	0.98
0.49	0.49
0.49	0.63
0.49	0.72
0.5	0.63
0.5	0.68
0.5	0.63
0.5	0.77
0.51	0.38
0.52	0.72
0.52	0.85
0.53	0.29
0.53	0.17
0.53	0.43
0.53	0.74
0.54	0.84
0.54	0.71
0.54	0.95
0.55	0.56
0.55	0.48
0.55	0.32
0.56	0.64
0.56	0.71
0.57	0.86
0.57	0.59
0.57	0.92
0.58	0.37
0.59	0.98
0.6	1.48

Table 20a

Data Used in Initial Coil Size Correction Factor
Comparison of 0.080" and 0.115" RPC Voltages

0.080" Volts	.115 volts
0.6	1.33
0.6	0.2
0.6	1.13
0.6	0.88
0.62	1.07
0.62	1.01
0.62	0.52
0.63	0.79
0.63	0.3
0.64	0.77
0.64	0.24
0.65	0.52
0.65	0.57
0.65	0.65
0.67	0.82
0.67	0.67
0.67	0.94
0.68	0.7
0.68	0.65
0.69	1.13
0.69	0.46
0.7	0.75
0.71	0.74
0.71	1.06
0.71	0.64
0.72	1.14
0.72	0.47
0.73	0.32
0.74	0.46
0.74	0.71
0.76	0.57
0.76	1.05
0.76	1.62
0.78	0.95
0.79	0.52
0.8	0.87
0.81	1
0.81	0.86
0.85	1.04
0.86	0.51
0.88	0.6
0.89	1.19
1.06	0.89
1.09	0.77
1.11	0.4

Table 20b

Summary of Coil Size Correction Factor Determination Methods

Approach	Submittal Date	Data Source	Voltage Normalization Used	Result: Max. Volt	Result: Avg. Volt	Data Result Applied to:
Average	8/2/96	1996 Look-Back Data	20 Volts 100% EDM	0.76		10 Volts 100% TWH
Statistical 20V	9/17/96	50 Field Ind's	20 Volts 100% EDM	0.72	0.74	10 Volts 100% TWH
Statistical 10V	9/20/96	50 Field Ind's	10 Volts 100% TWH	0.75		10 Volts 100% TWH

Table 21

ACTS/ANTS Essential Variable Summary

Plant	Probe	Coil Dia.	Cable Length	Probe Ext. Length	Instrumentation	Acquistion Software	Sample Speed	Scan Speed	Rotation Speed	Analysis Software	PrimeFrequency
Byron 1994	Zetec 3-Coil RPC	0.080"Pancake	83'	50'	Zetec MIZ-18A	Zetec Eddynet	400	.2"	300	Zetec Eddynet	300 kHz
Byron 1995	Zetec Plus Point	0.080" Pancake	83'	50'	Zetec MIZ-18A	ANSER	600	.2"	250	ANSER	300 kHz
Byron 1996	Zetec Plus Point	0.080" Pancake	83'	50'	Zetec MIZ-30	Zetec Eddynet95	1230	.6"	900	Zetec Eddynet95	300 kHz
Braidwood 1995	Zetec 3-Coil RPC	0.080" Pancake	83'	50'	Zetec MIZ-18A	ANSER	400	.2"	300	ANSER	300 kHz
South Texas	Zetec 3-Coil PRC	0.080" Pancake	83'	50'	Zetec MIZ-30	Zetec Eddynet	400	.2"	300	Zetec Eddynet	300 kHz
Calvert Cliffs	Zetec Plus Point	.115" Pancake	83'	50'	Zetec MIZ-30	Zetec Eddynet95	1230	.6"	900	Zetec Eddynet95	300 kHz
ANO	Zetec 3-Coil RPC	0.080" Pancake	83'	60'	Zetec MIZ-18A	Zetec Eddynet	400	.2"	300	Zetec Eddynet	400 kHz
Millstone	Zetec RPC	0.080" Pancake	83'	60'	Zetec MIZ-18A	Zetec DDA-4	400	.1"	200	Zetec DDA-4	400 kHz
McGuire	Zetec RPC	.115" Pancake	83'	50'	Zetec MIZ-18A	Zetec DDA-4	400	.1"	300	Zetec DDA-4	300 kHz
Palo Verde	Zetec 3-Coil RPC	.115" Pancake	83'	60'	Zetec MIZ-18A	Zetec Eddynet	800	.2"	300	Zetec Eddynet	400 kHz

Table 30
Assessment of 360 Degree Flaws on Voltage Integral Software

Row	Col.	MET Arc Length (degrees)	June 96 Look-back VIR Max Voltage (volts)	Previous Look-Backs Max Voltage (volts)	Ratio of Max/Vir Max Look-Back Voltages
		Byron Tube Pull Data			
38	55	310	0.64	0.78	1.22
27	48	360	0.39	0.18	0.46
14	93	360	0.92	0.46	0.50
24	42	340	1.24	1.17	0.95
23	43	359	1.13	1.25	1.11
38	44	279	0.37	0.18	0.48
20	85	360	0.41	0.33	0.81
28	68	319	0.32	0.1	0.31
24	91	343	0.41	NDD	n/a
14	37	360	0.31	0.59	1.92
		Braidwood ECT Inspection 360 Flaws			
46	45	-	0.38	0.4	1.05
21	54	-	1.36	1.07	0.79
13	102	-	1.06	0.8	0.75
		Byron 1996 SG C ECT Inspection 360 Flaws			
3	99	-	0.32	0.16	0.50
4	97	-	0.4	0.12	0.30
7	99	-	0.31	0.1	0.32
8	95	-	0.56	NDD	-
12	97	-	0.37	0.17	0.46
13	97	-	0.31	0.15	0.48
18	99	-	0.41	0.26	0.63
19	37	-	0.43	NDD	-
		Byron 1995 SG B ECT Inspection 360 Flaws			
1	93	-	0.79	0.7	0.89
1	104	-	0.61	0.28	0.46
5	96	-	0.42	0.56	1.33
6	107	-	0.44	0.52	1.18
9	68	-	0.27	0.26	0.96
13	77	-	0.36	0.73	2.03
13	82	-	0.44	0.39	0.89
13	93	-	0.44	0.5	1.14
14	79	-	0.47	0.47	1.00
15	60	-	0.37	0.21	0.57
17	46	-	0.7	0.68	0.97
20	89	-	0.49	0.44	0.90
20	90	-	0.75	0.7	0.93
21	96	-	0.34	0.32	0.94
24	74	-	0.75	0.81	1.08
26	44	-	0.67	0.45	0.67
27	50	-	0.53	0.45	0.85
28	49	-	0.44	0.4	0.91
30	94	-	0.64	0.61	0.95
37	72	-	0.54	0.5	0.93
39	47	-	0.43	0.17	0.40

Figure 1a. Industry Tube Pull/Insitu Indication Average Volts vs. Maximum Volts

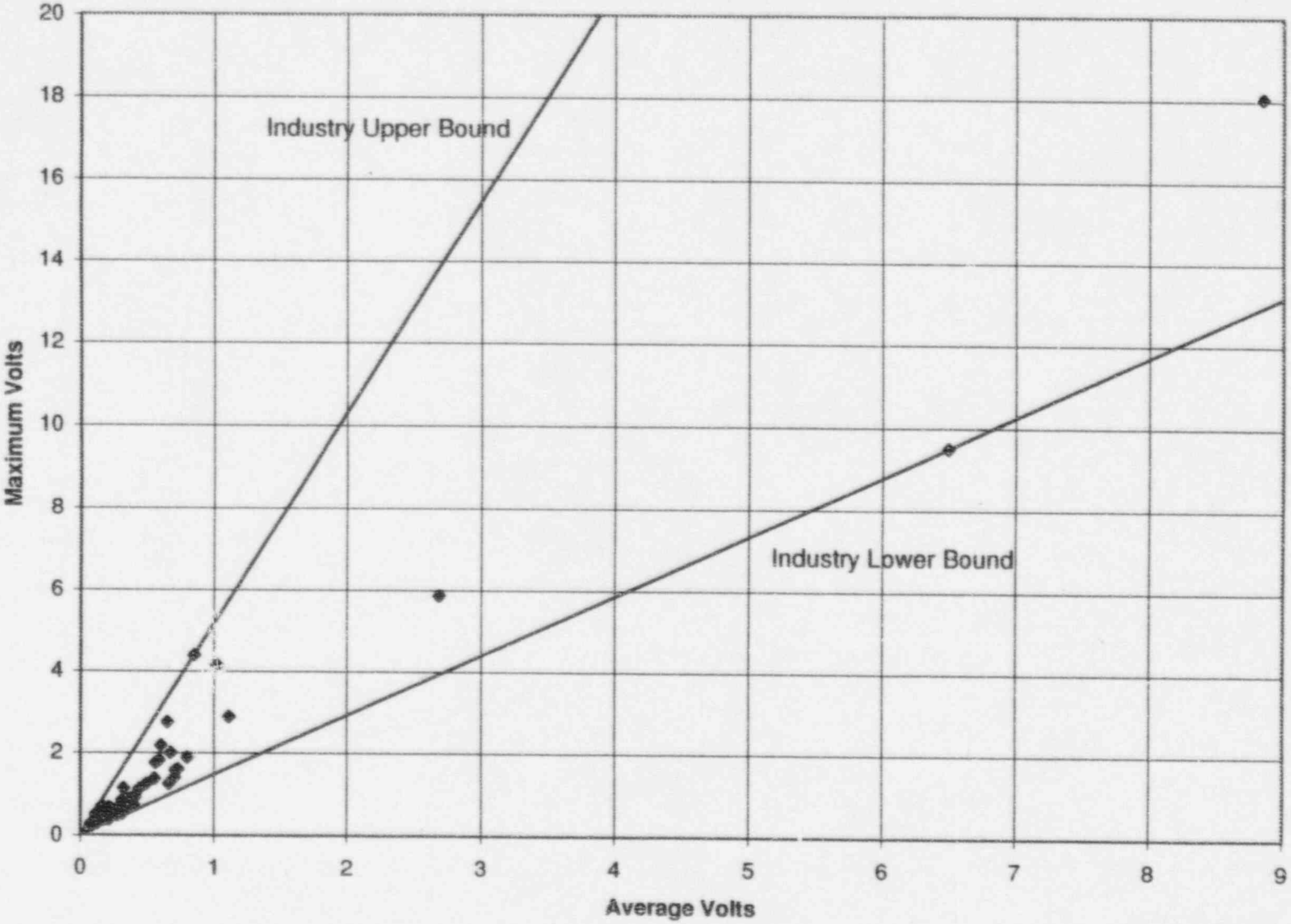
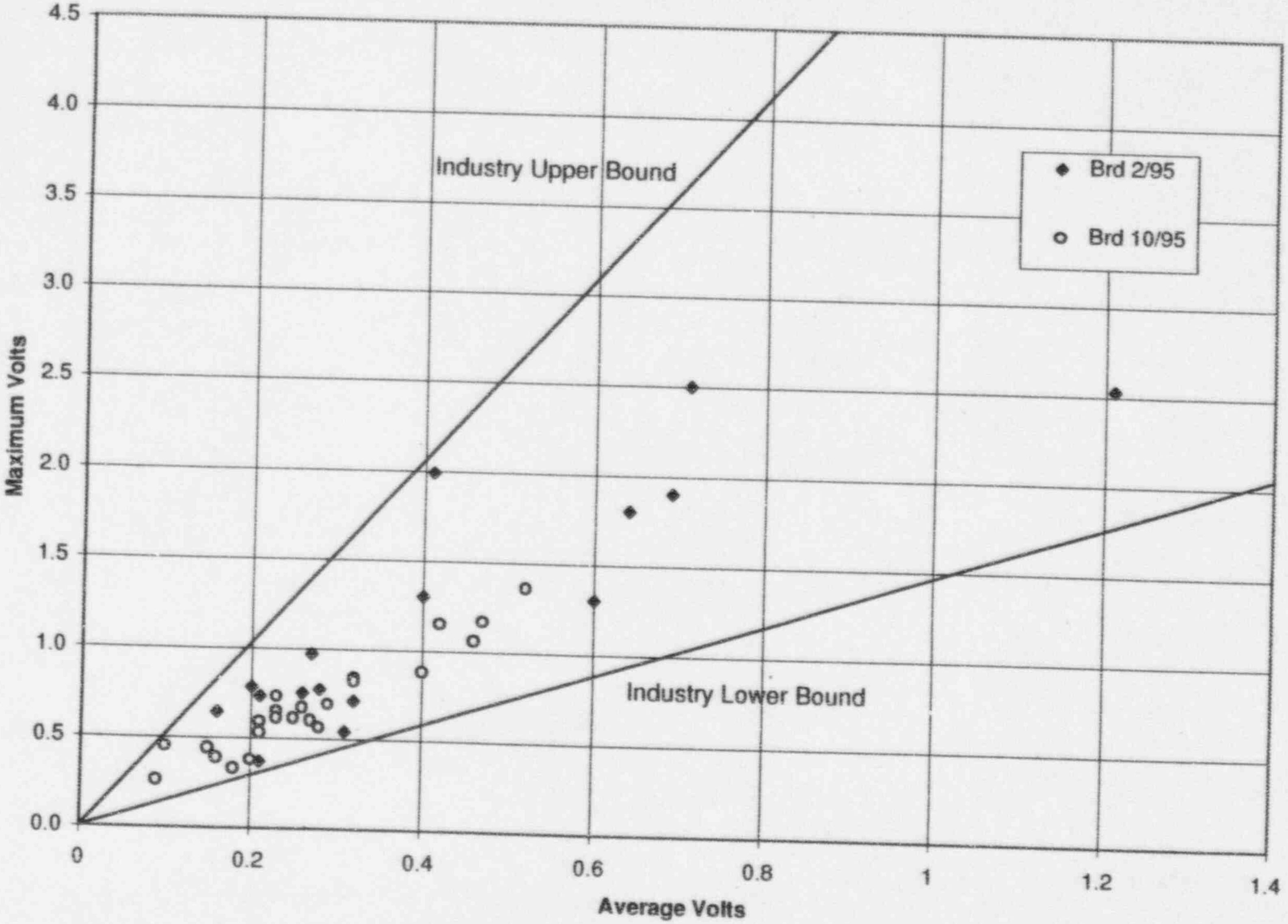
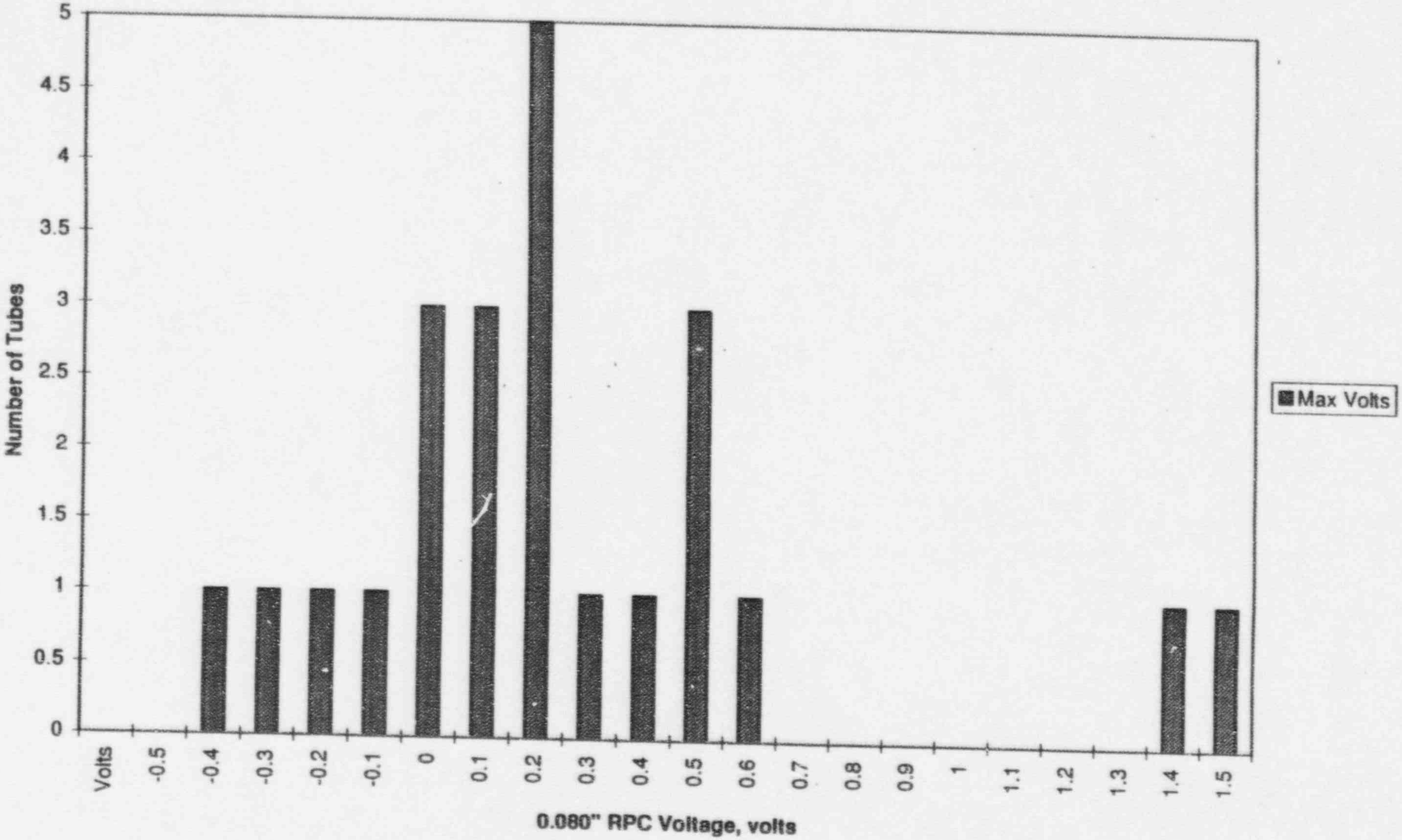


Figure 1b. Braidwood 1 Indications Average Volts vs. Maximum Volts Compared to Bounds of Industry Experience Base



Conclusion: The Size of the Indications at Braidwood are Smaller and are Bounded by Industry Data

Braidwood Unit 1 Maximum Voltage Growth 2/95 to 10/95
Figure 2a



Braidwood Unit 1 Average Voltage Growth 2/95 to 10/95
Figure 2b

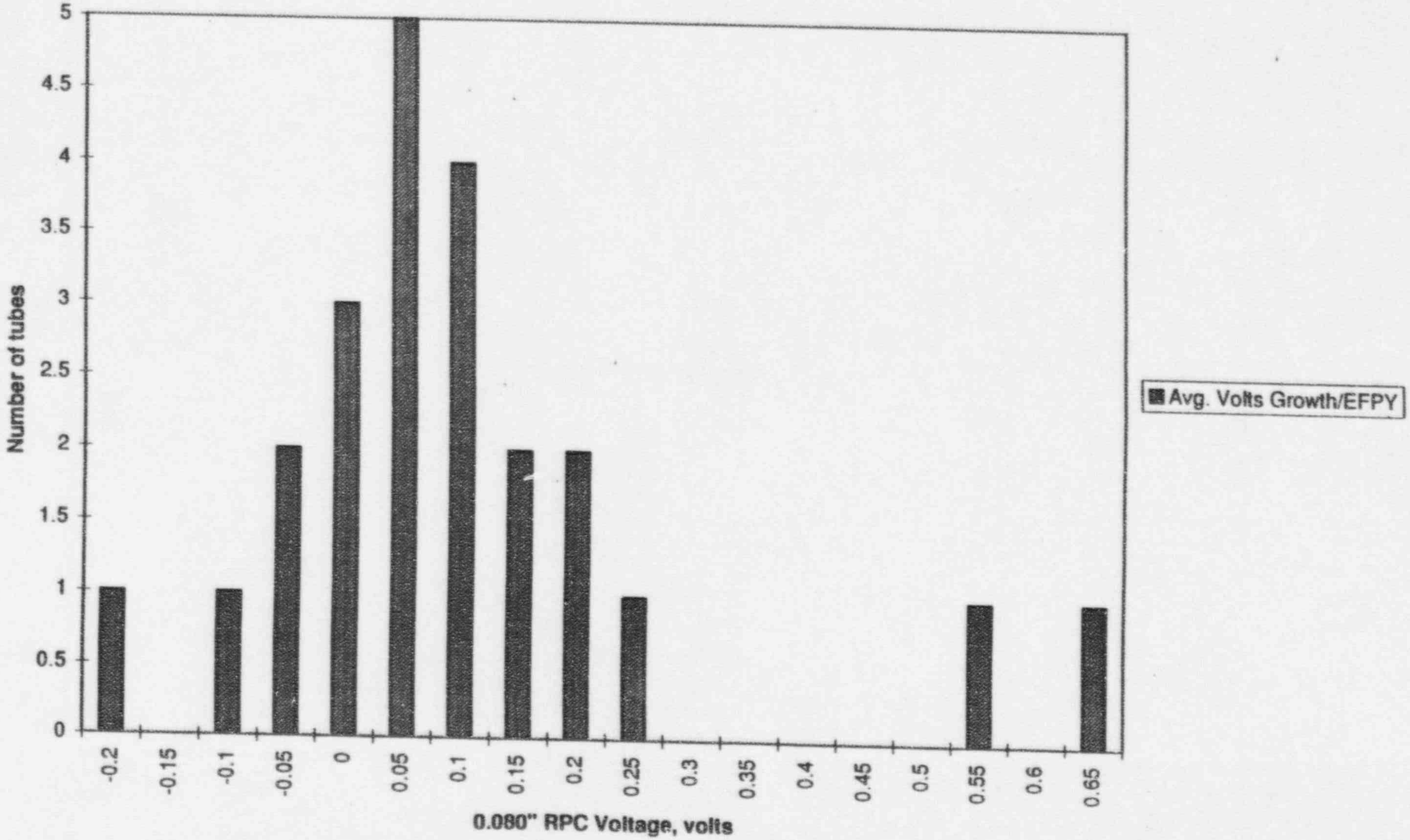


Figure 6a. Maximum Voltage vs. Adjusted Insitu or Burst Pressure

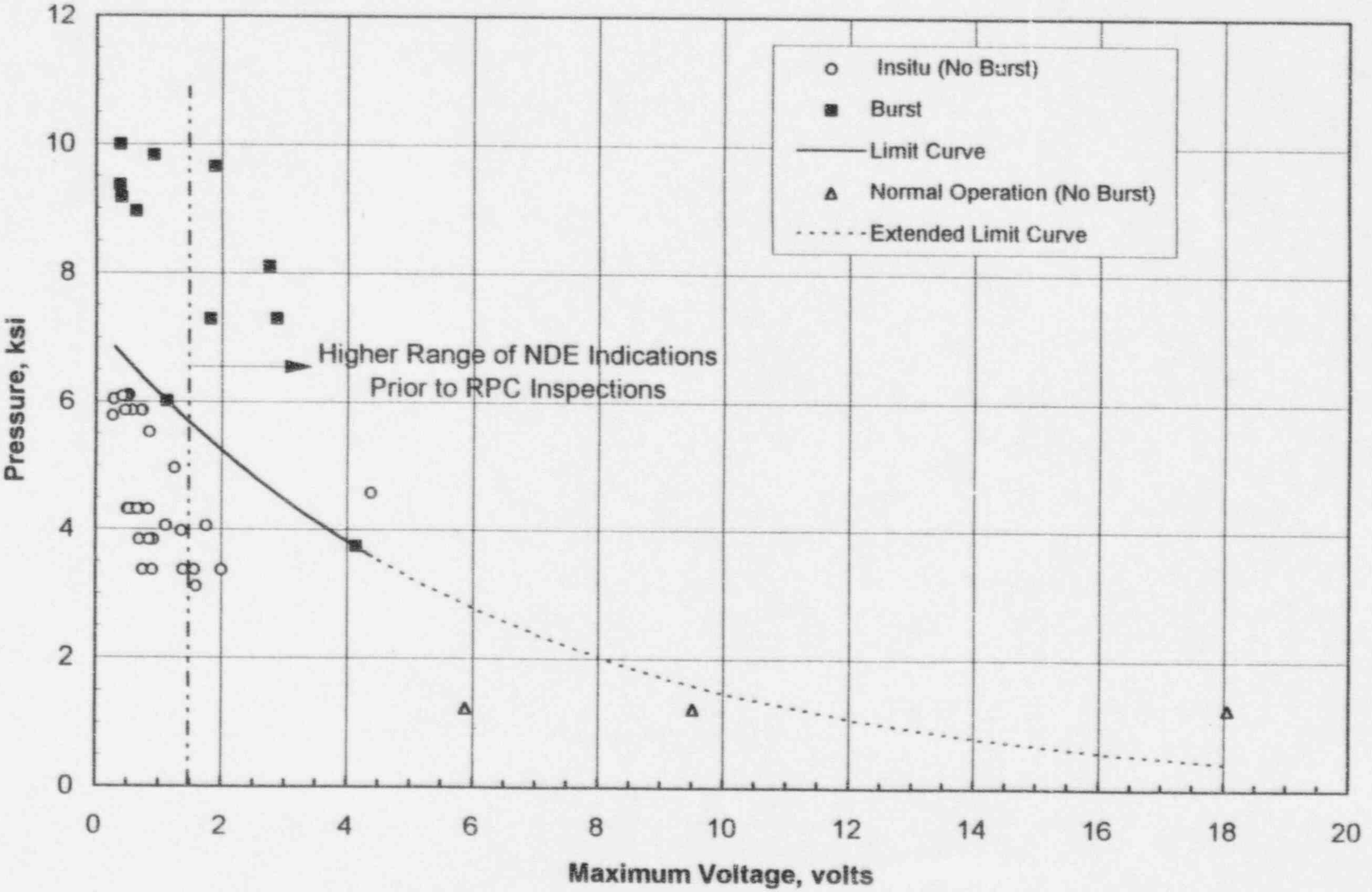


Figure 6b. Average Voltage vs. Adjusted Insitu or Burst Pressure

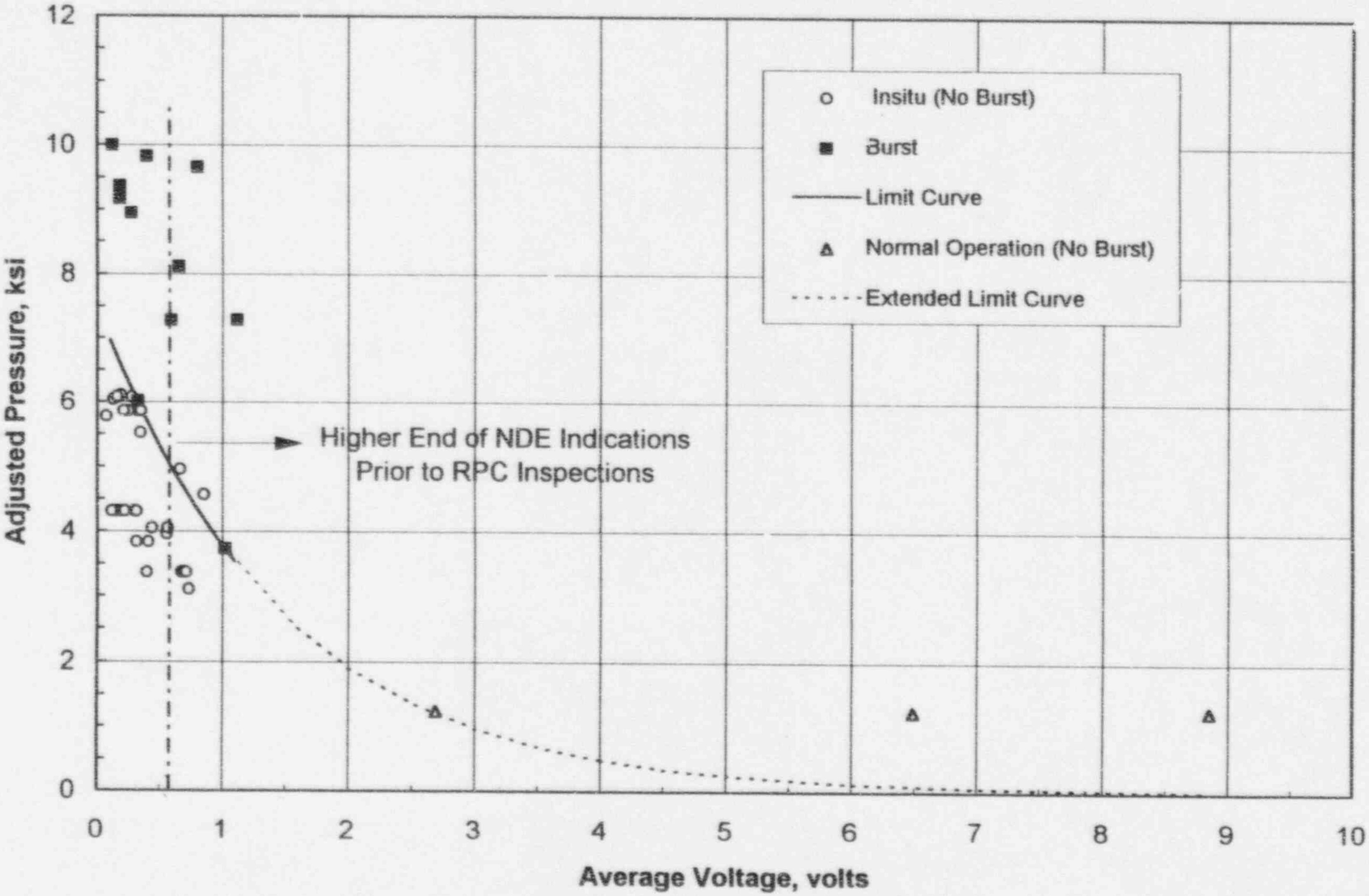
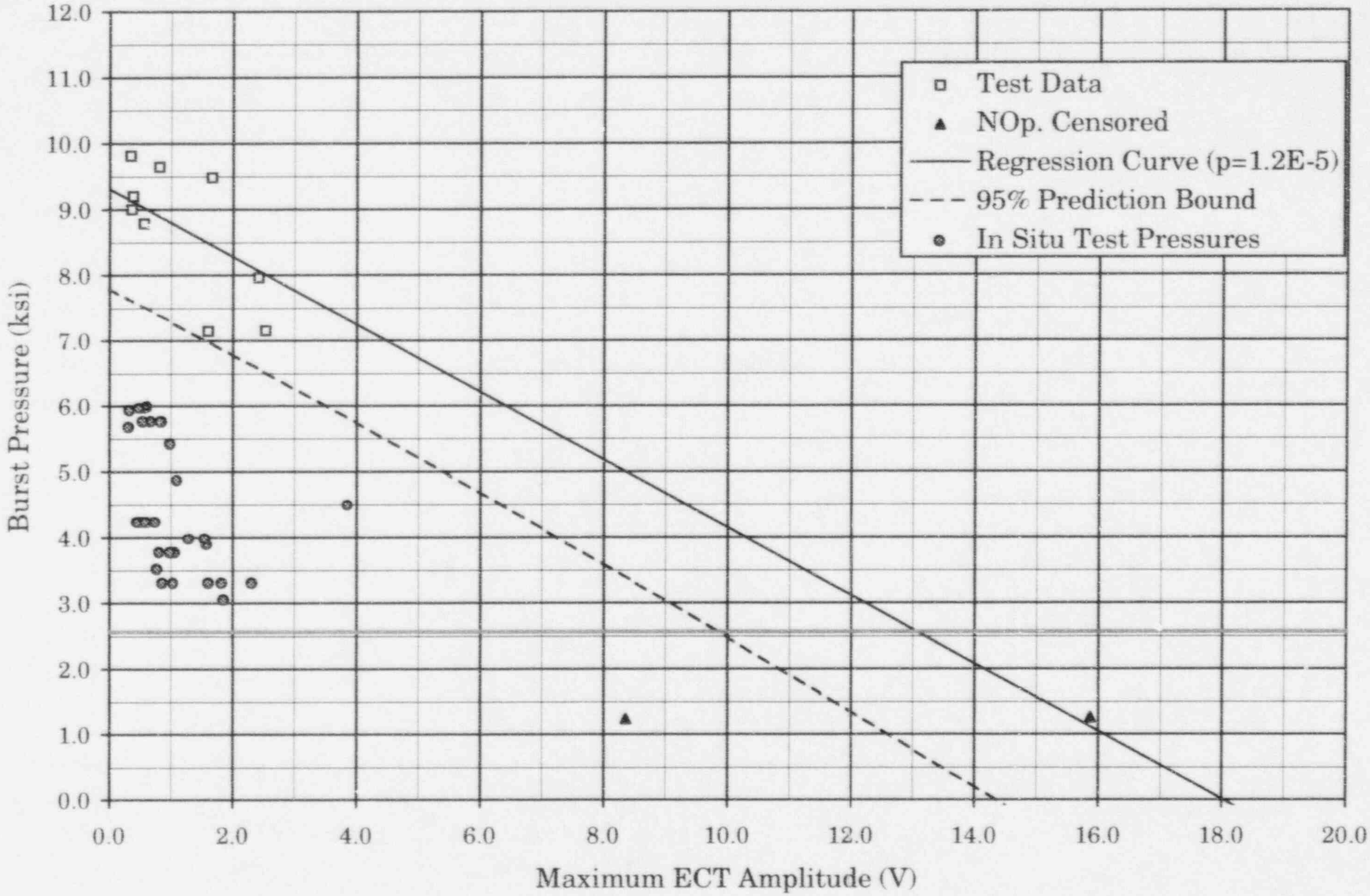


Figure 8a: Burst Pressure vs. Maximum ECT Amplitude

(Commonwealth Edison Data, LTL Flow Stress)

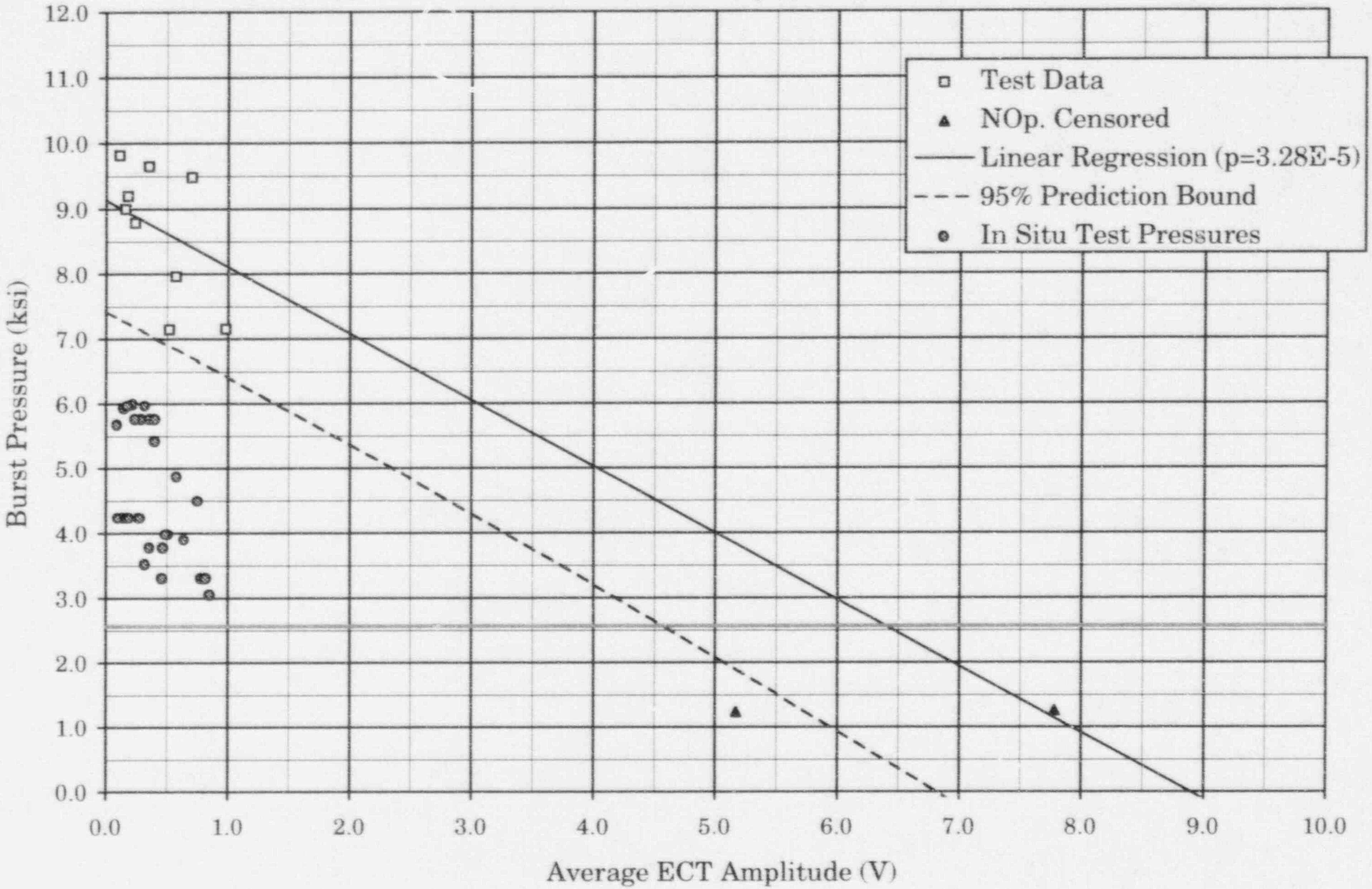


[~ME221A.XLS] Pb.Vmax

RFK: 9/24/96, 6:43 PM

Figure 8b: Burst Pressure vs. Average ECT Amplitude

(Commonwealth Edison Data, LTL Flow Stress)

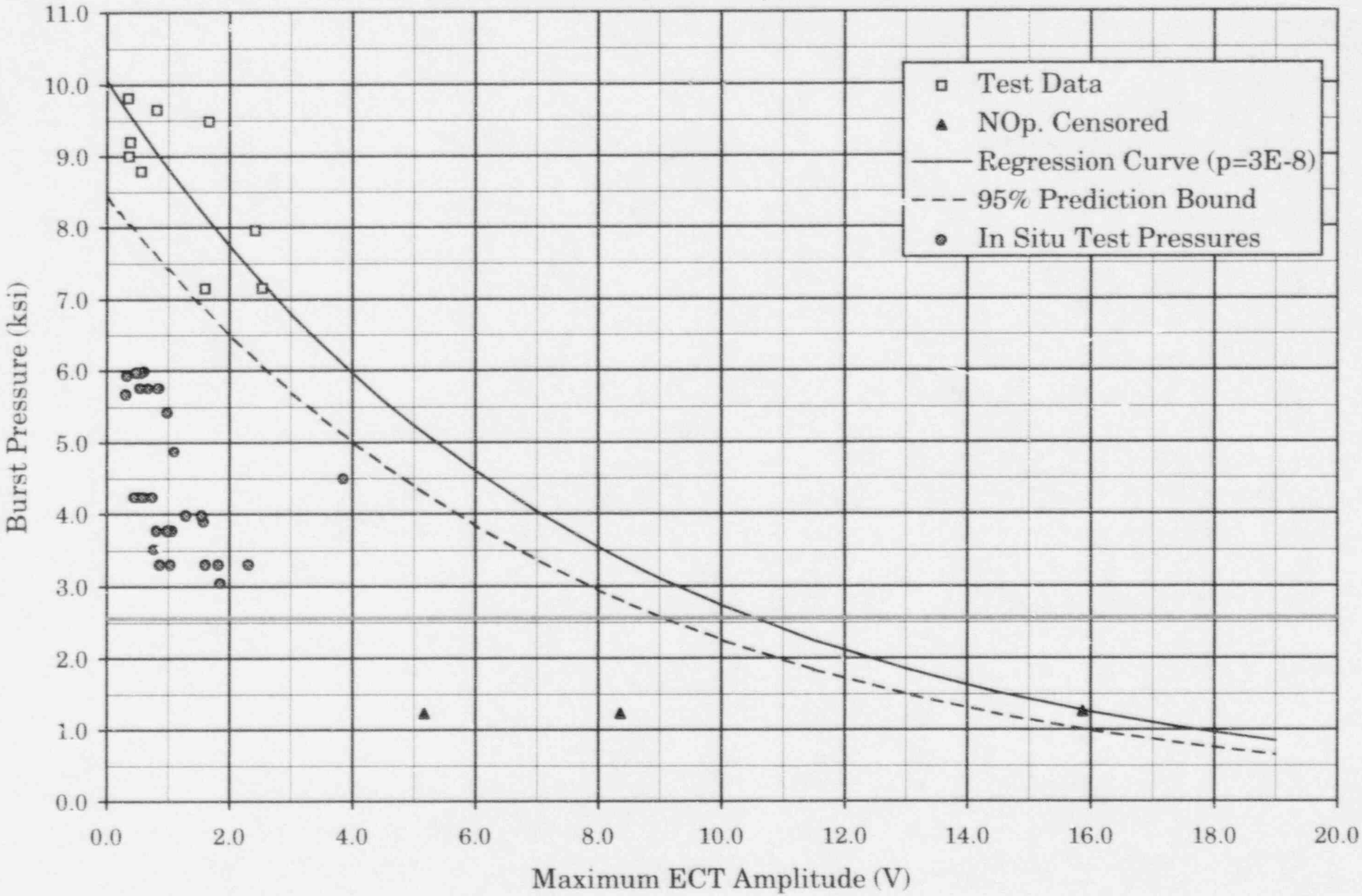


[~ME221A.XLS] Pb.Vavg

RFK: 9/24/96, 6:36 PM

Figure 8c: Burst Pressure vs. Maximum ECT Amplitude

(Commonwealth Edison Data, LTL Flow Stress)

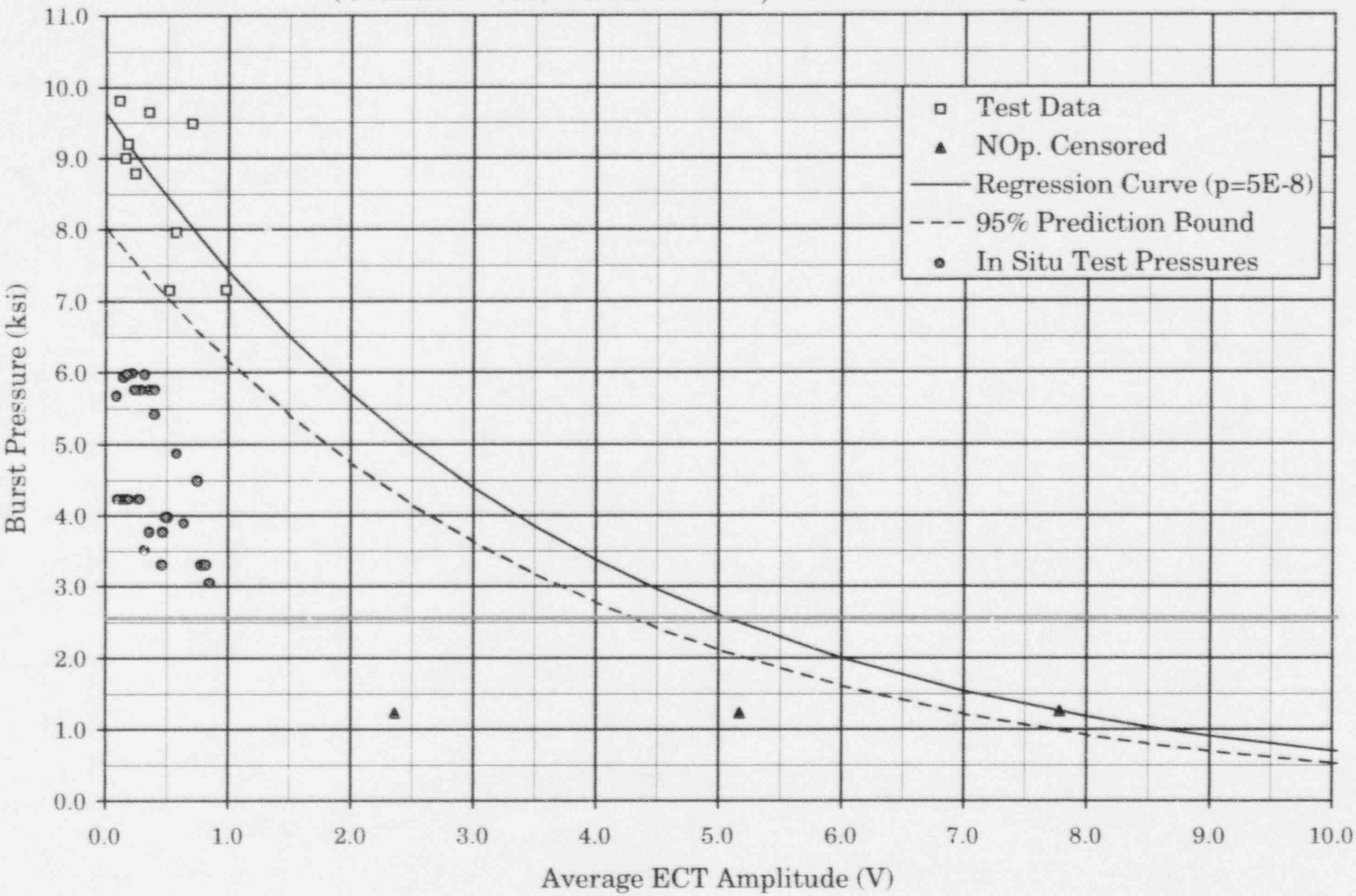


[~ME221A.XLS] LogPb.Vmax

RFK: 9/24/96, 6:37 PM

Figure 8d: Burst Pressure vs. Average ECT Amplitude

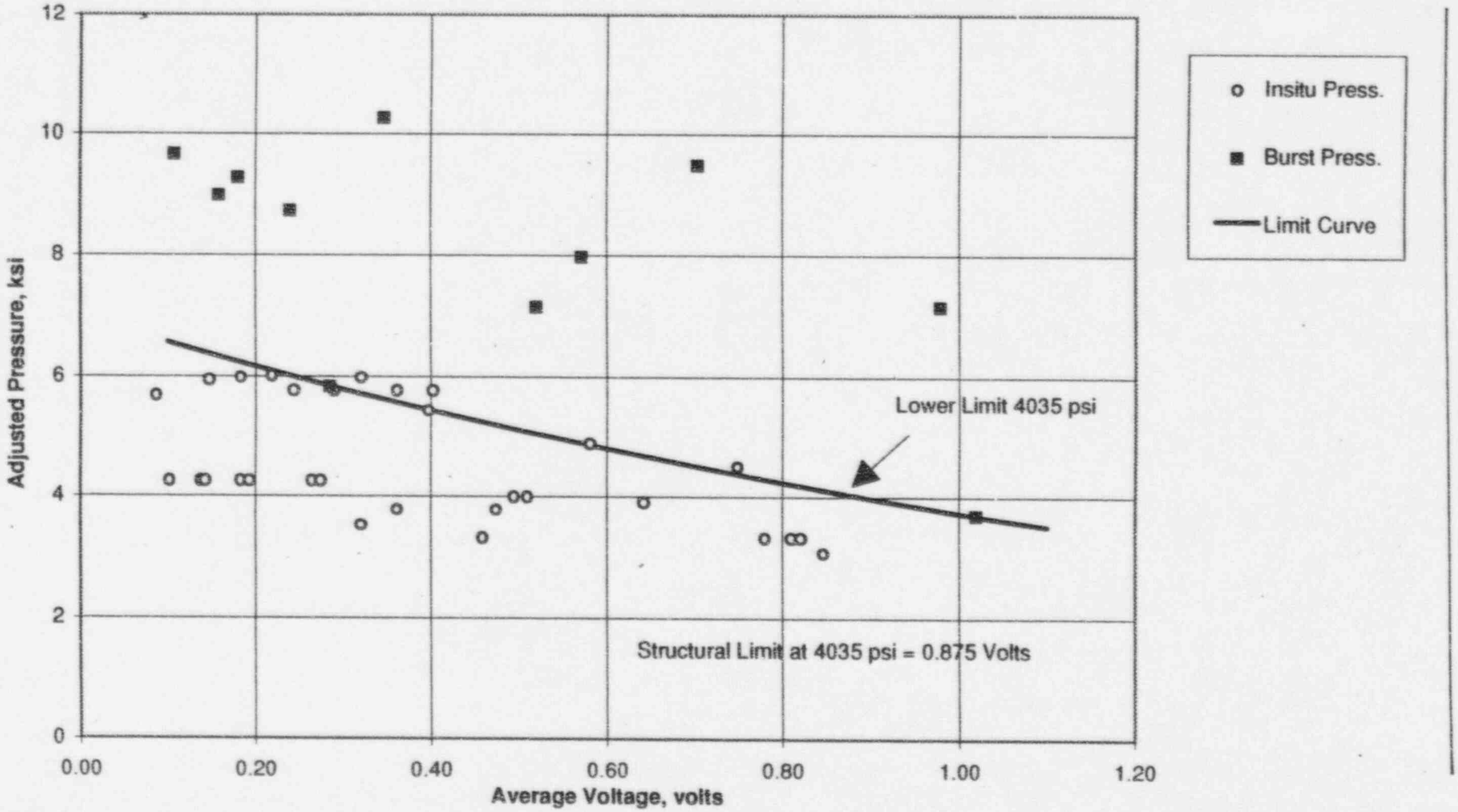
(Commonwealth Edison Data, LTL Flow Stress)



[~ME221A.XLS] LogPb.Vavg

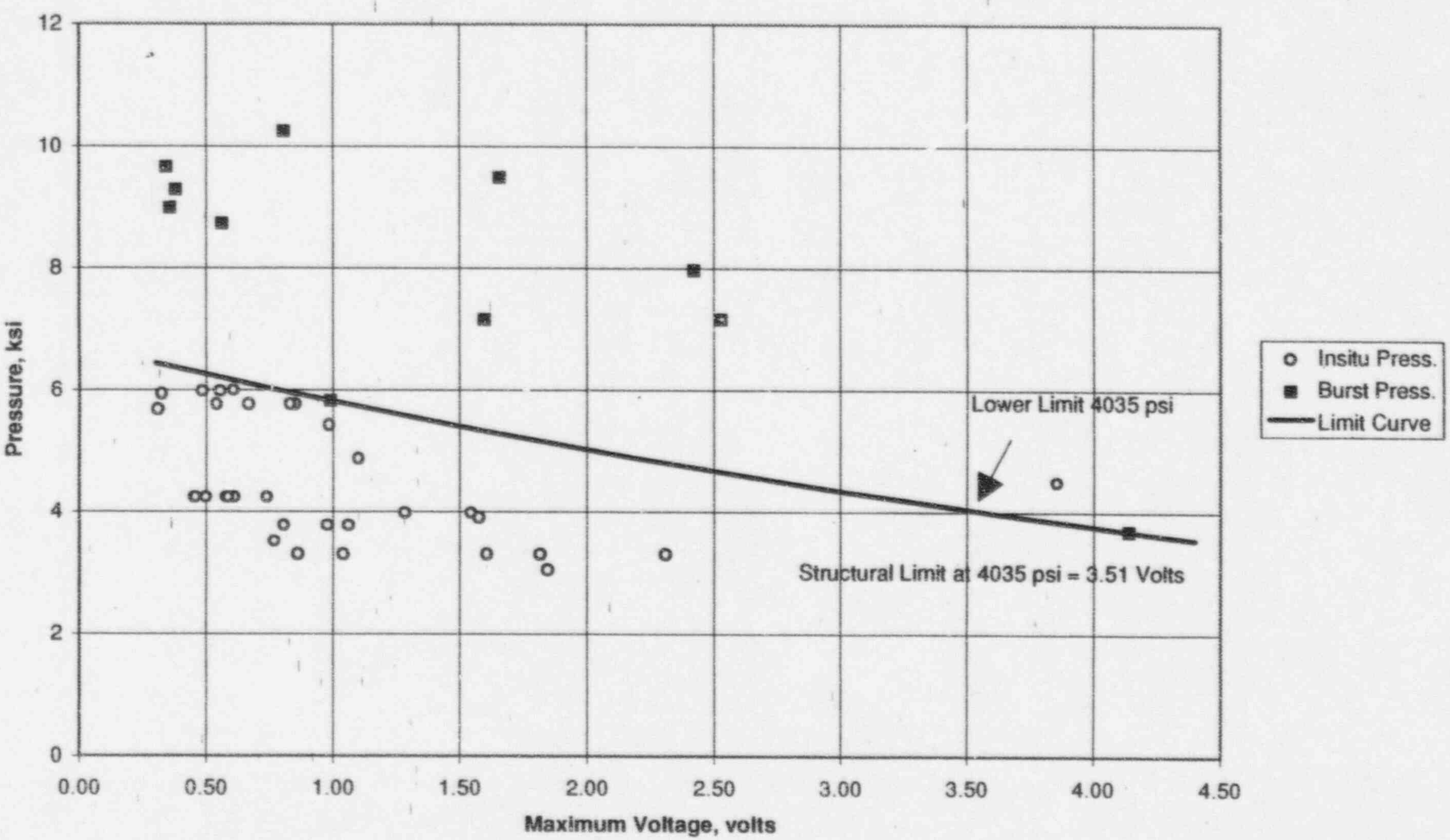
RFK: 9/24/96, 6:38 PM

Average Voltage vs. Adjusted Insitu or Burst Pressure Corrected to Industry LTL Properties (95/95 650F)
Figure 10a (9/24/96)



Maximum Voltage vs. Adjusted Insitu or Burst Pressure Corrected for Industry LTL

Figure 10b (9/24/96)



Average Voltage vs. Corrected Leak Rate at MSLB Conditions
Figure 14a (9/24/96)

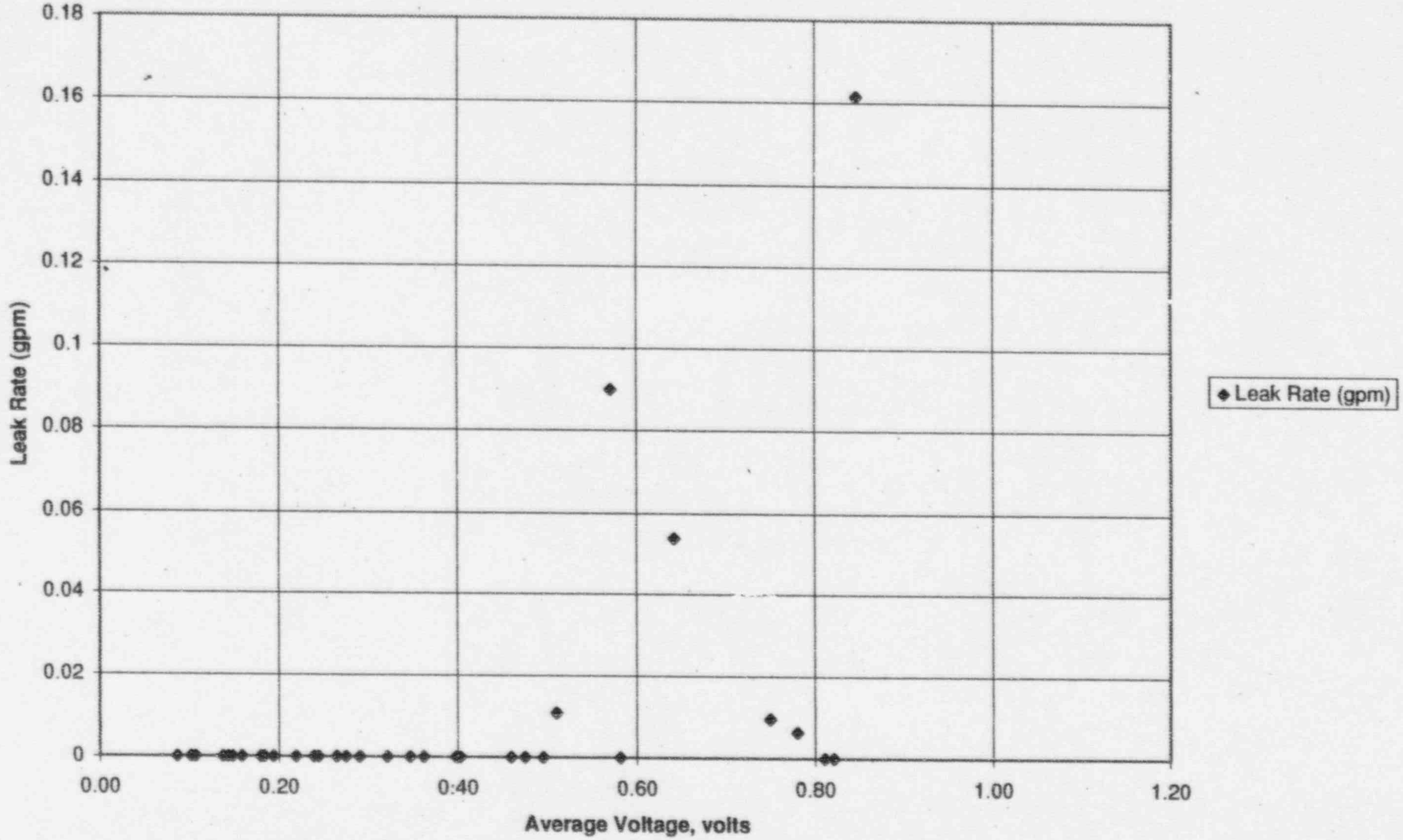
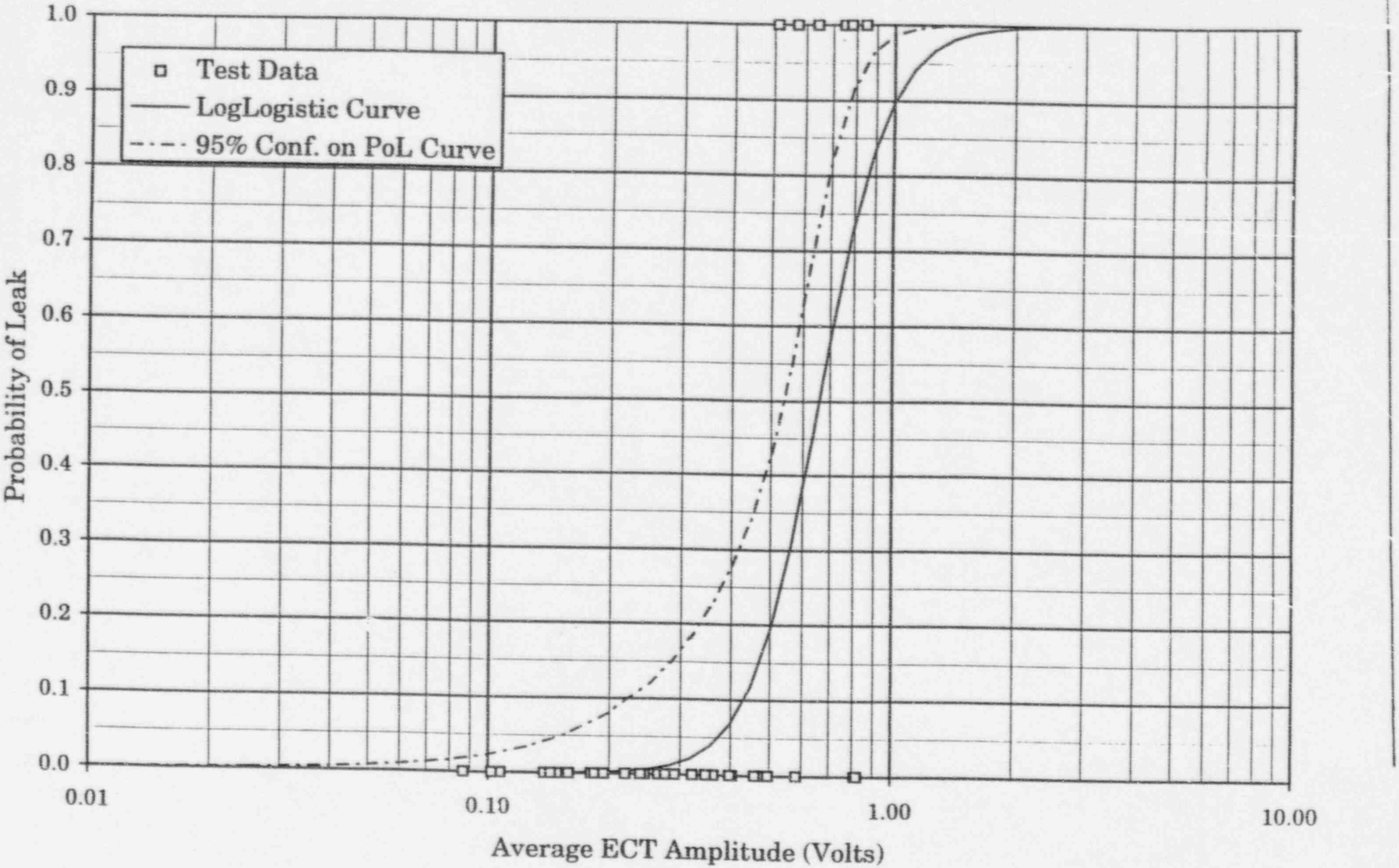


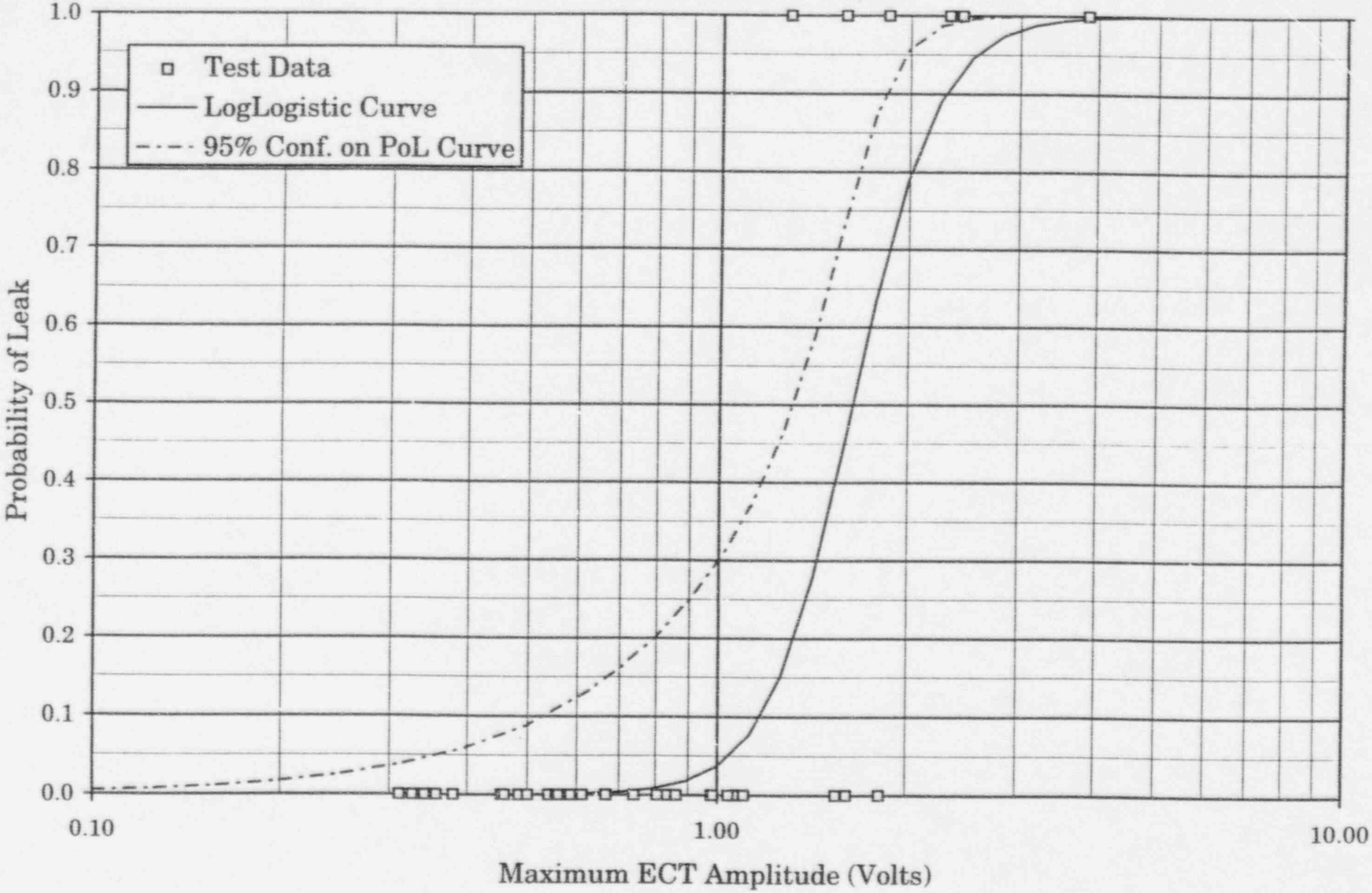
Figure 14b (9/24/96): Probability of Leak vs. Average ECT Amplitude
(Commonwealth Edison Data)



[comeddat.xls] PoL.Vavg

RFK: 9/18/96, 7:59 PM

Figure 16 (9/24/96): **Probability of Leak vs. Maximum ECT Amplitude**
(Commonwealth Edison Data)



[comeddat.xls] PoL.Vmax

RFK: 9/18/96, 7:59 PM

Figure 19. Voltage Normalization Regression Analysis, 0.080 and 0.115 inch Coils, Maximum and Average Voltage

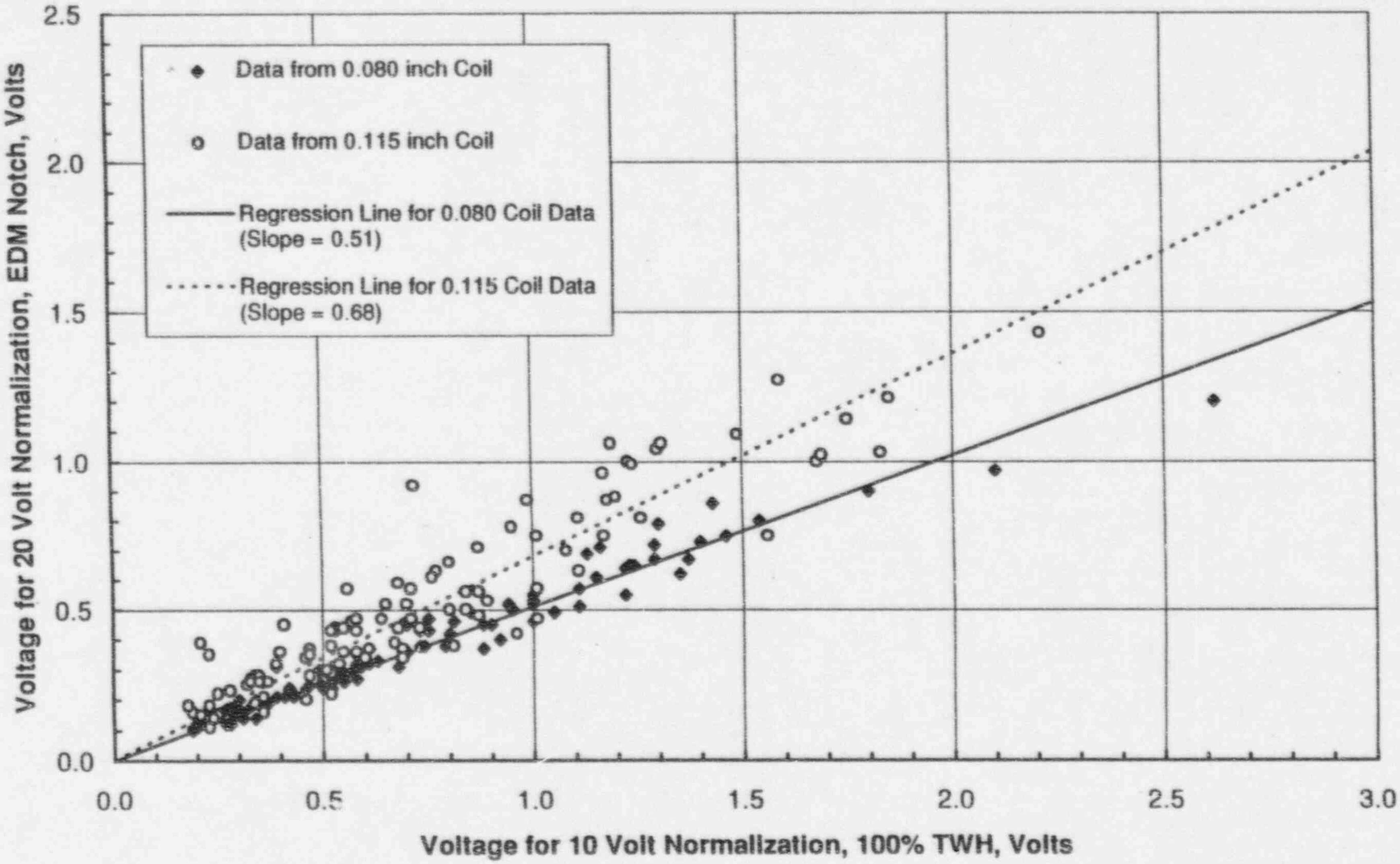
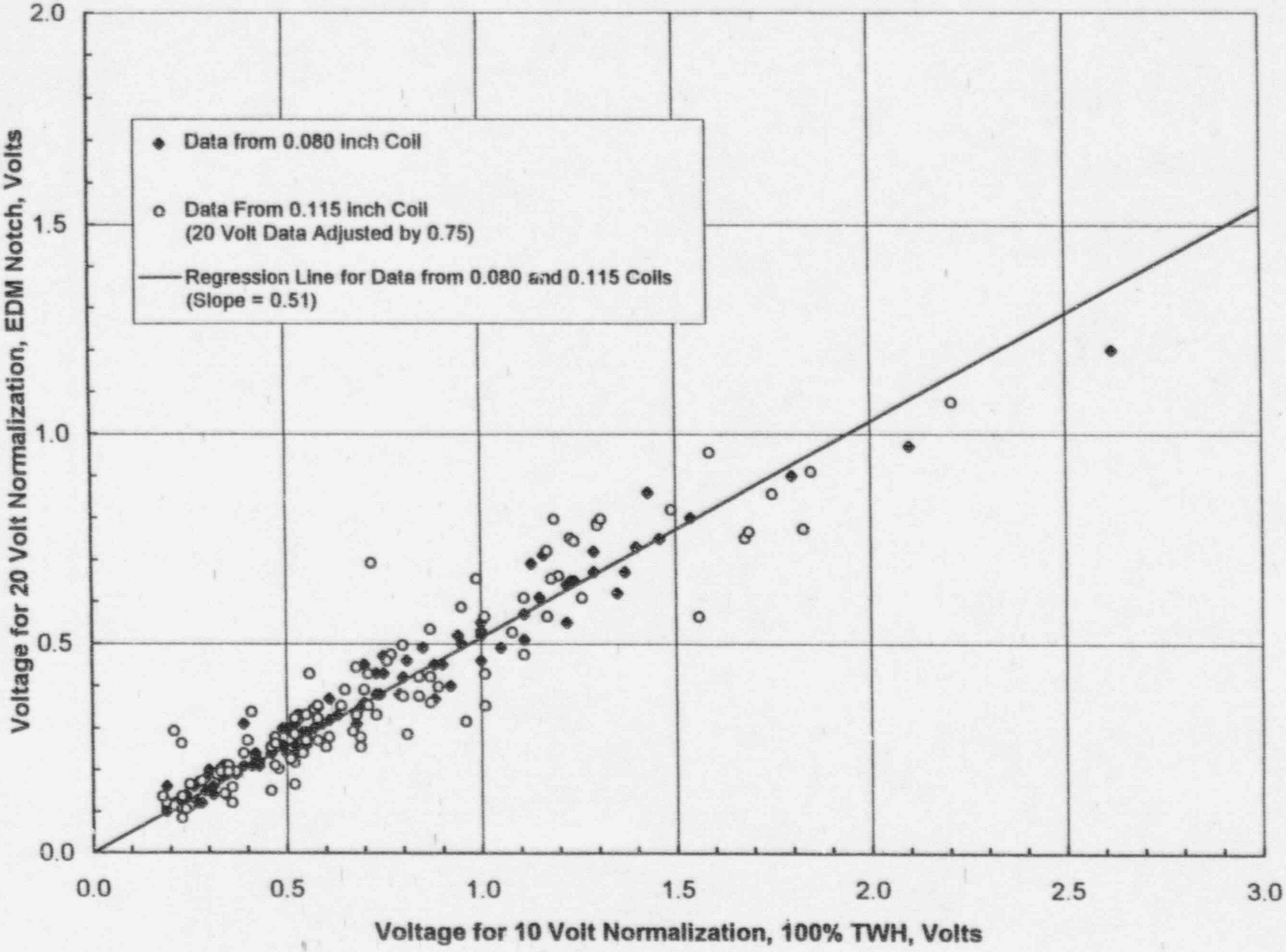
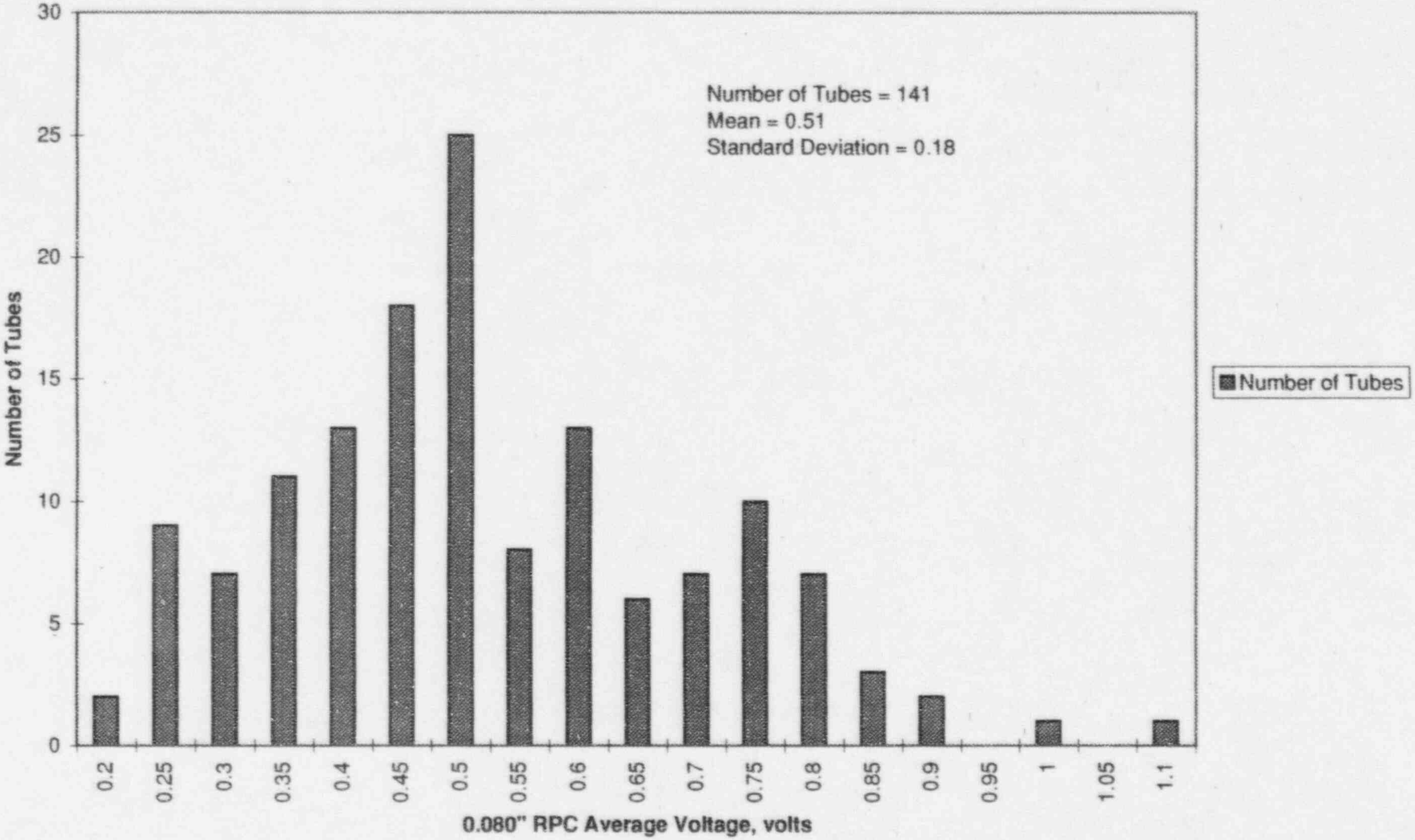


Figure 20. Correlation of 20 Volt to 10 Volt Normalization Data, 0.115 inch/20V Coil Data Adjustified by 0.75 Factor, Average & Maximum Voltage



Distribution of Blind Test Analysts Indication Means for Average Voltage
Figure 25a



Distribution of Blind Test Analysts Indication Means for Maximum Voltage
Figure 25b

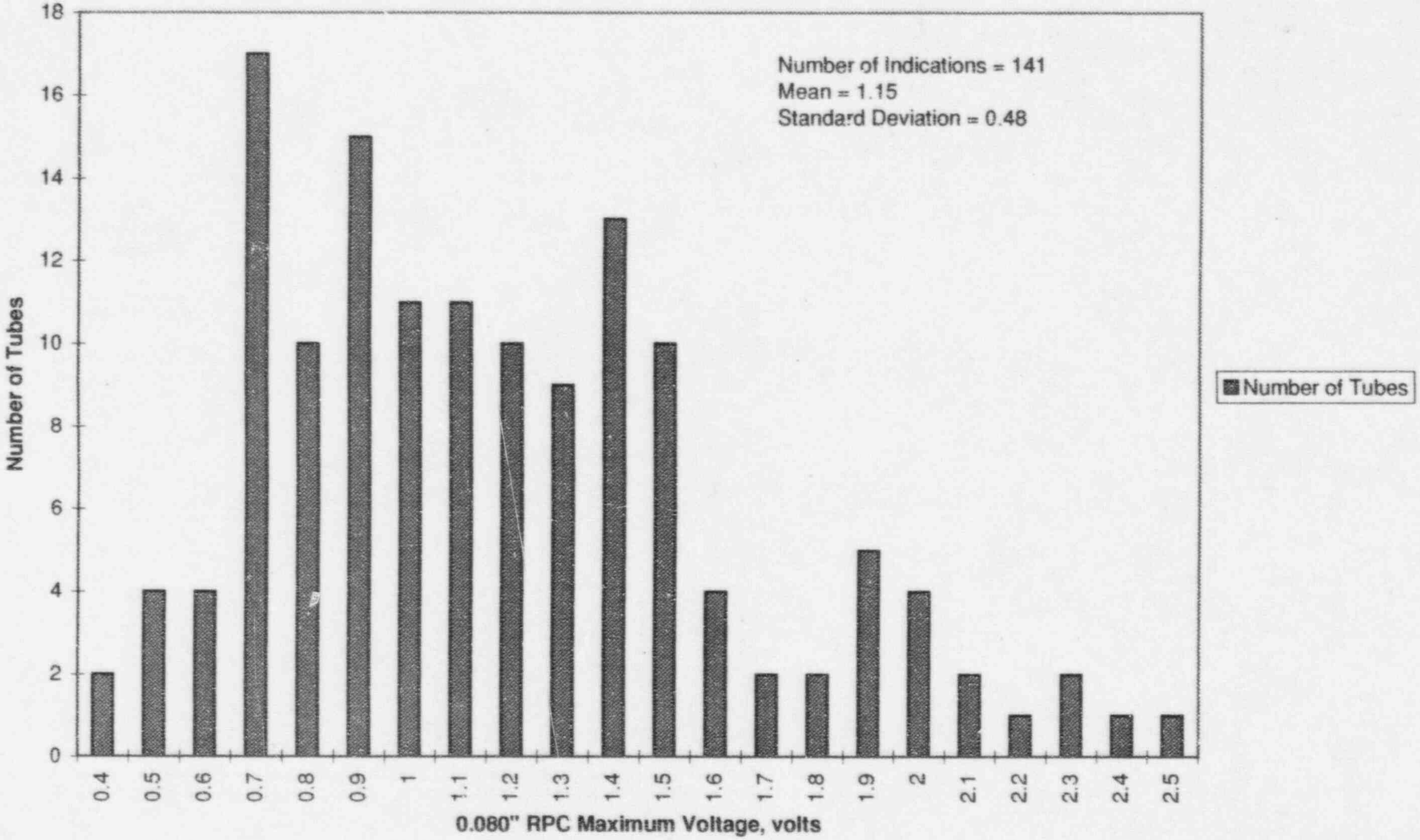


Figure 26a: Distribution of Average Volts Percent Error

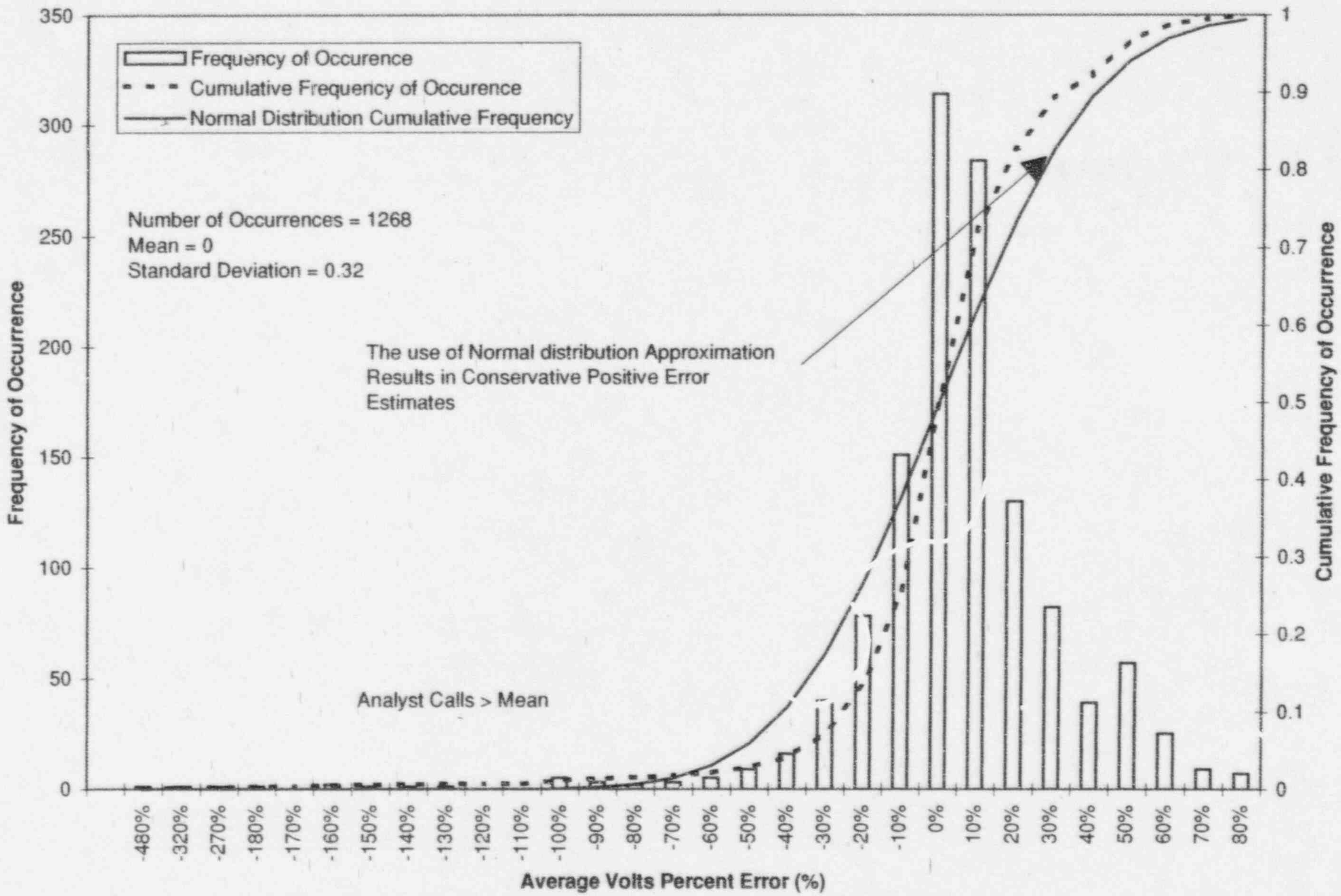


Figure 26b: Distribution of Maximum Volts Percent Error

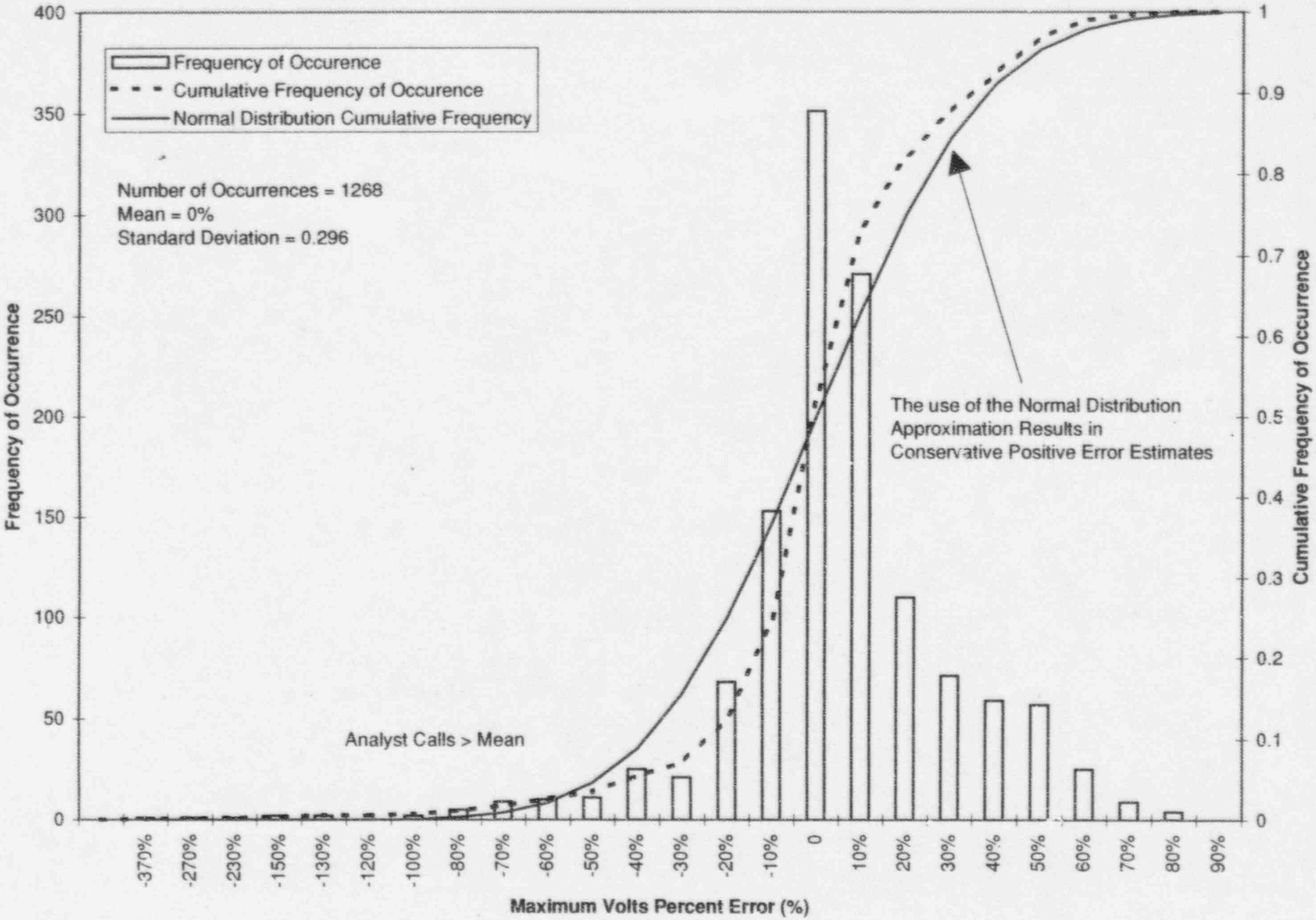


Figure 27a: Distribution of Average Volts Percent Error, Calls with > 100% Error Removed

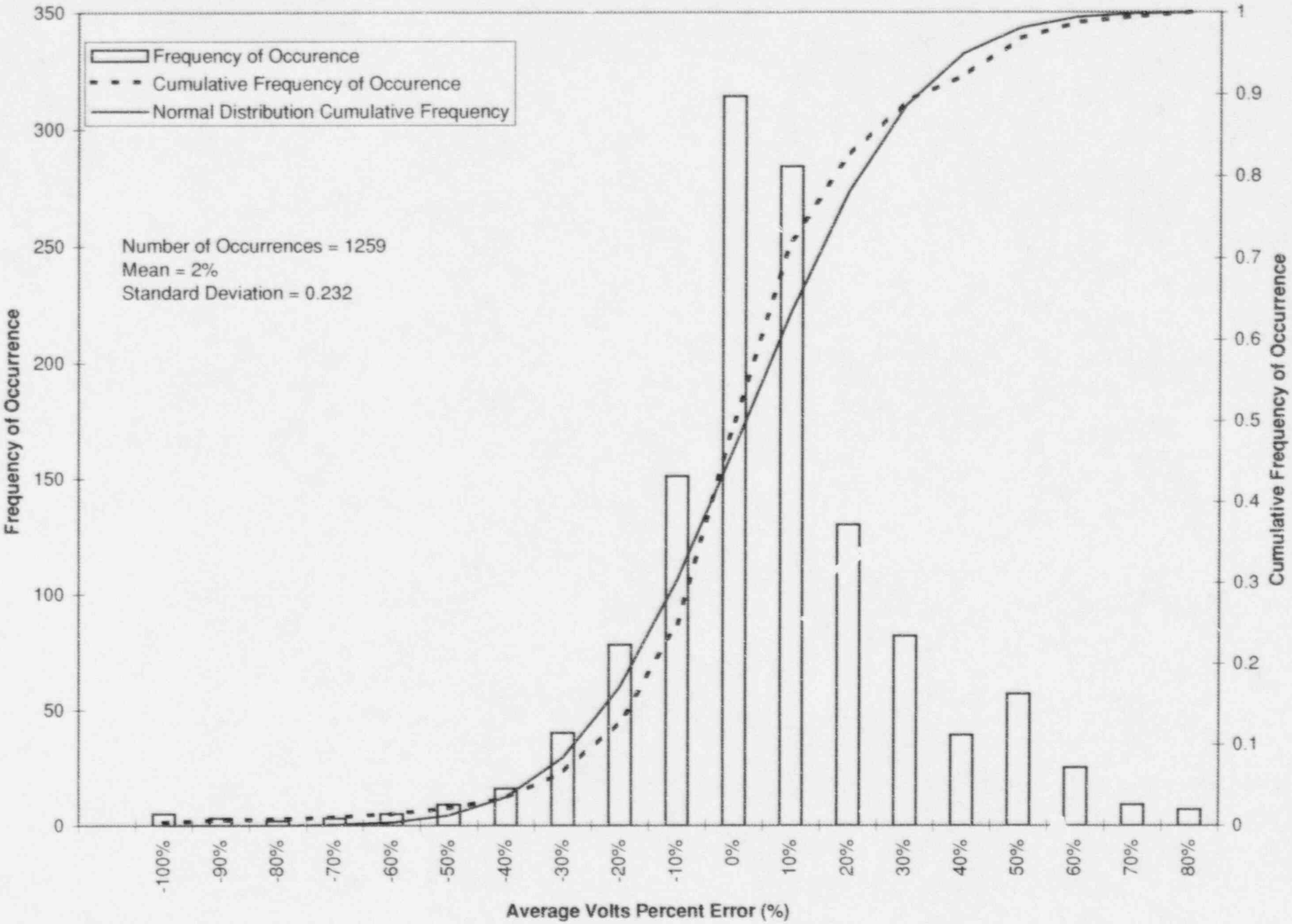


Figure 27b: Distribution of Maximum Volts Percent Error, Calls with > 100% Error Removed

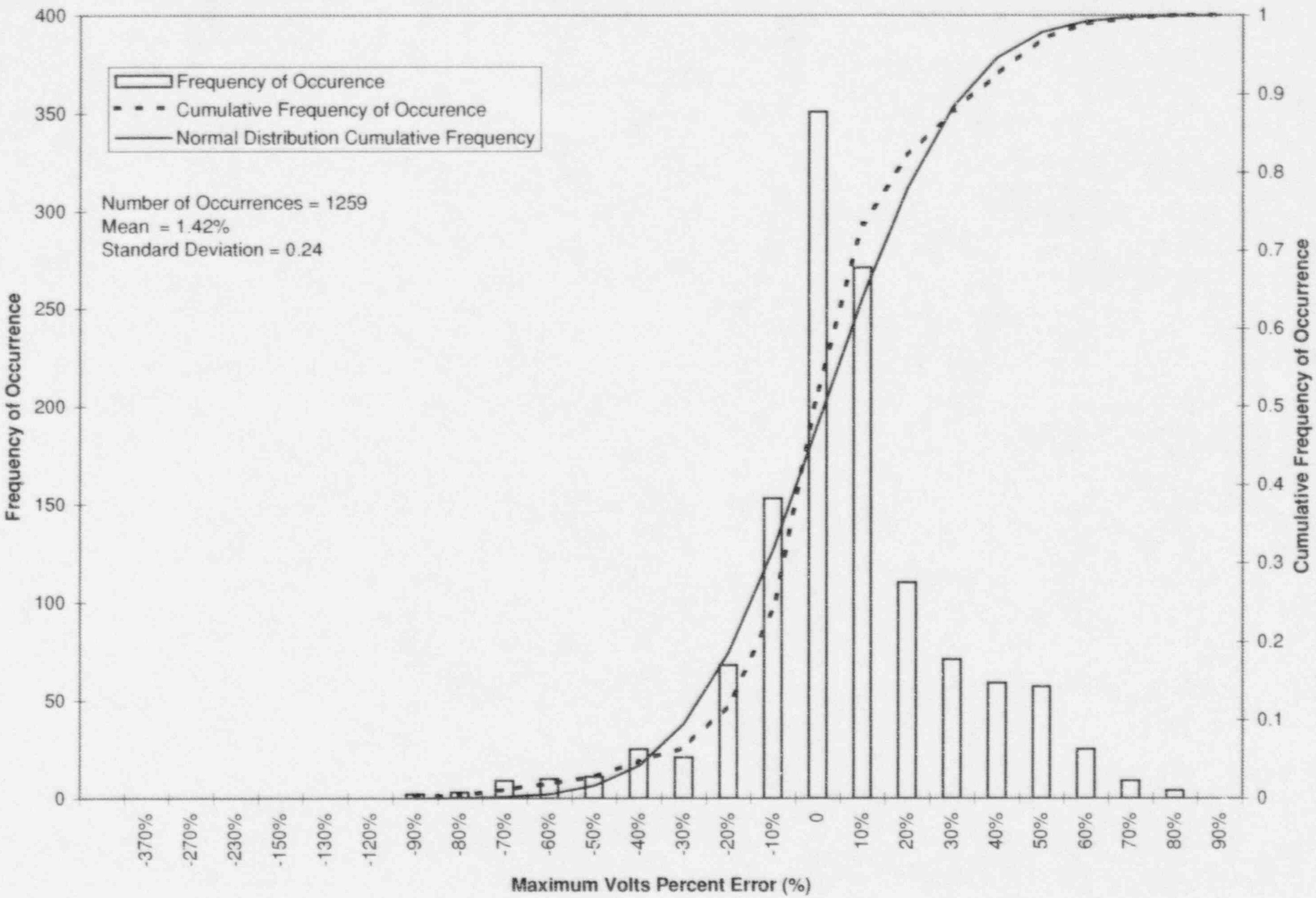
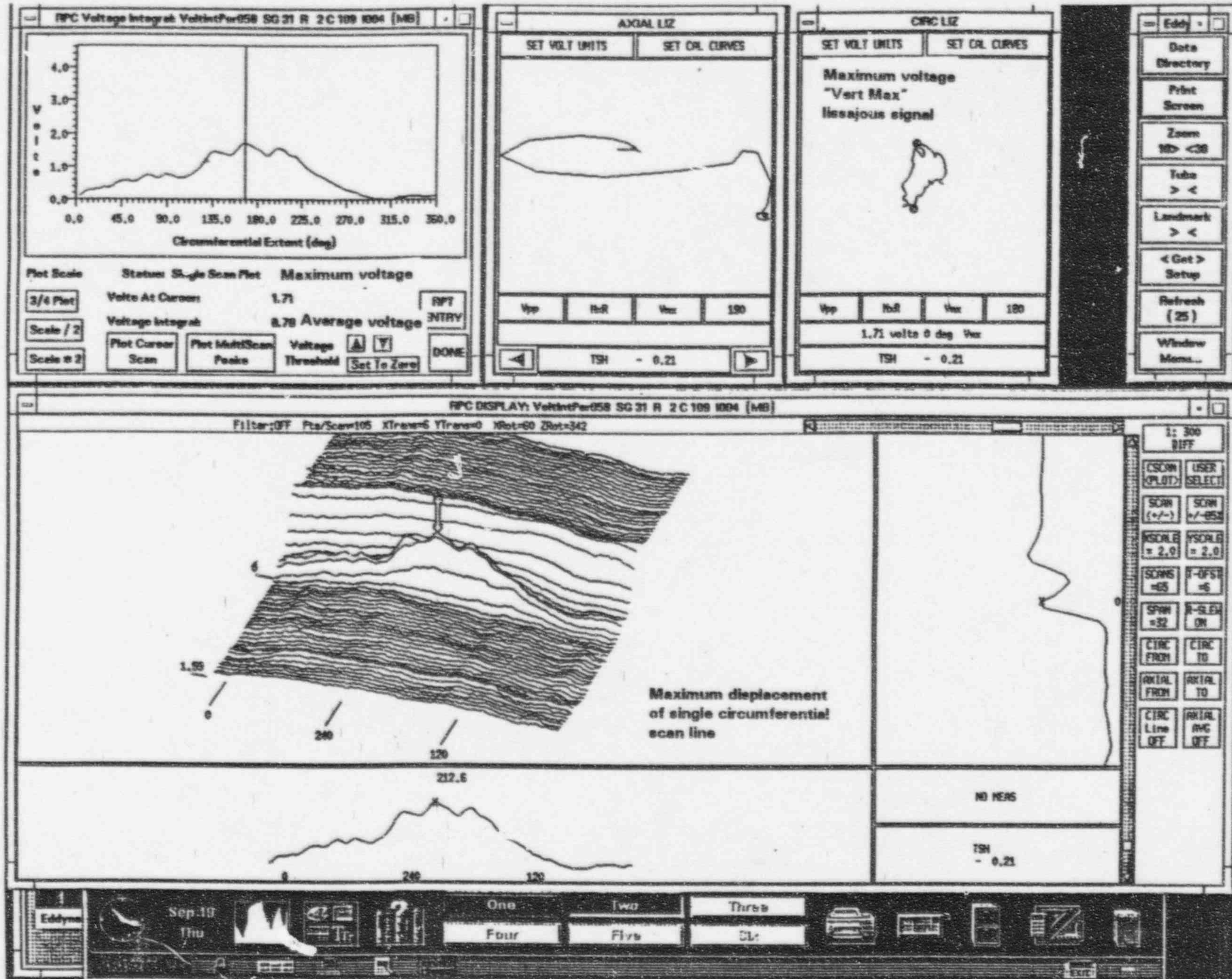
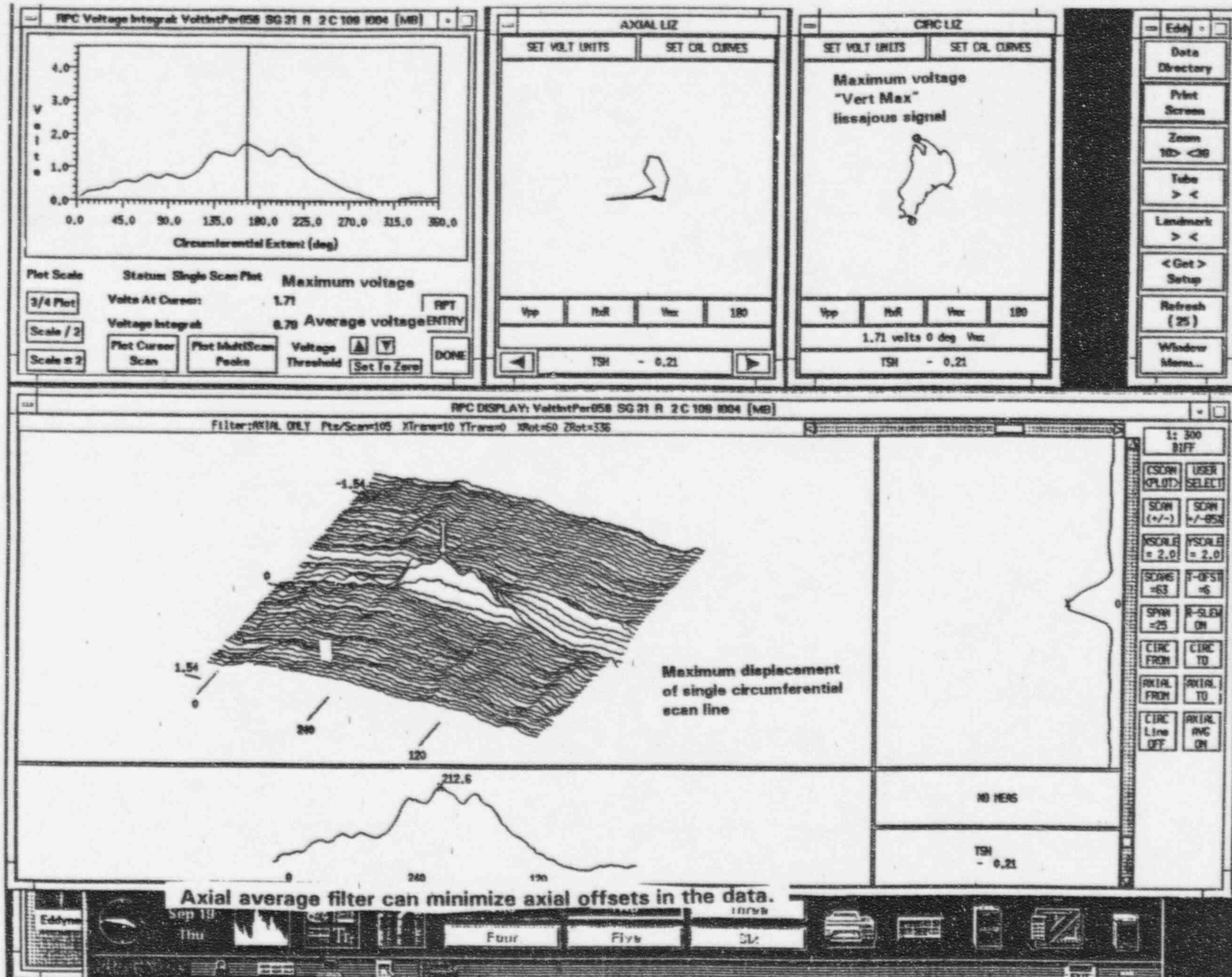


Figure 30A



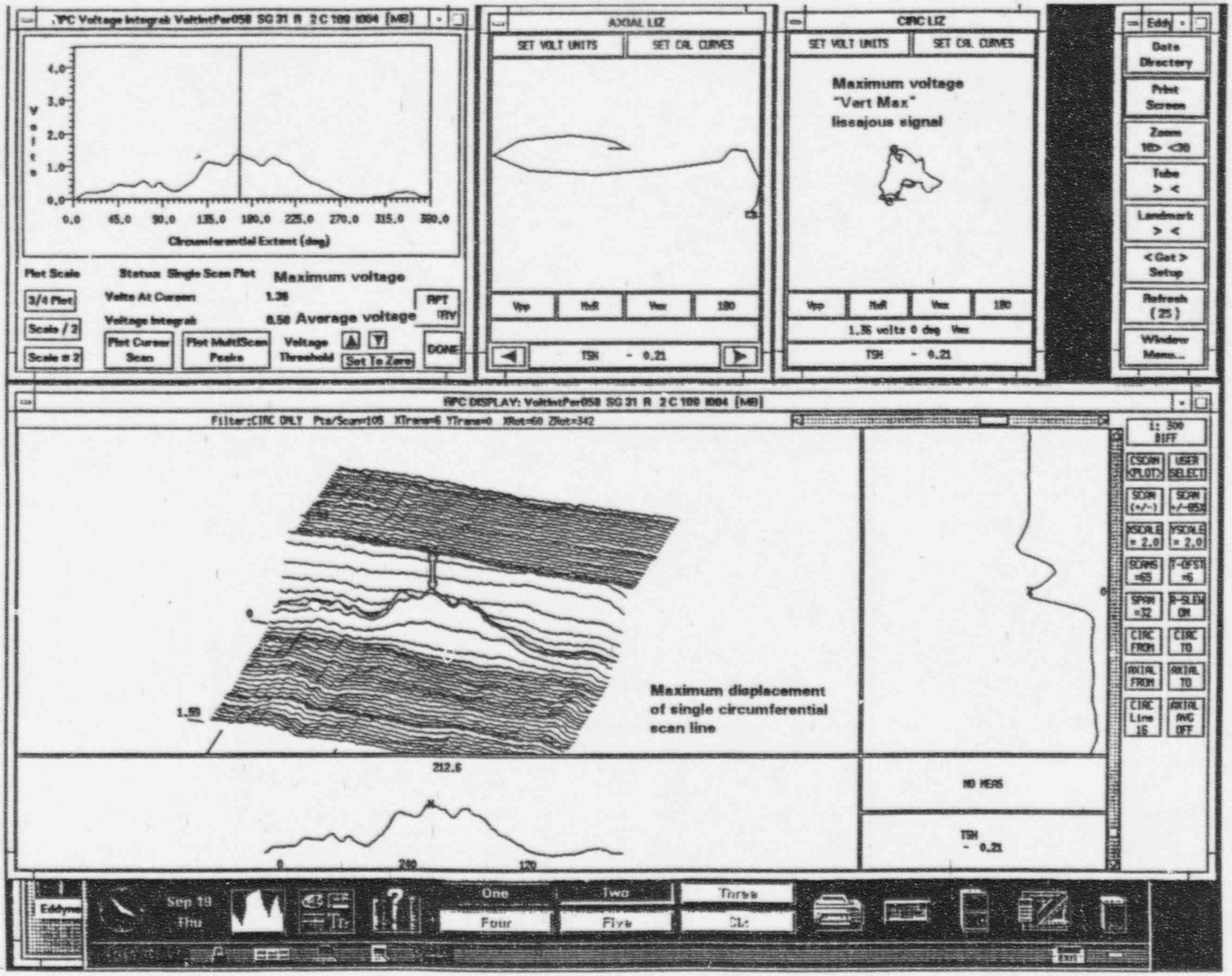
C-Scan plot
without filtering

Figure 30B



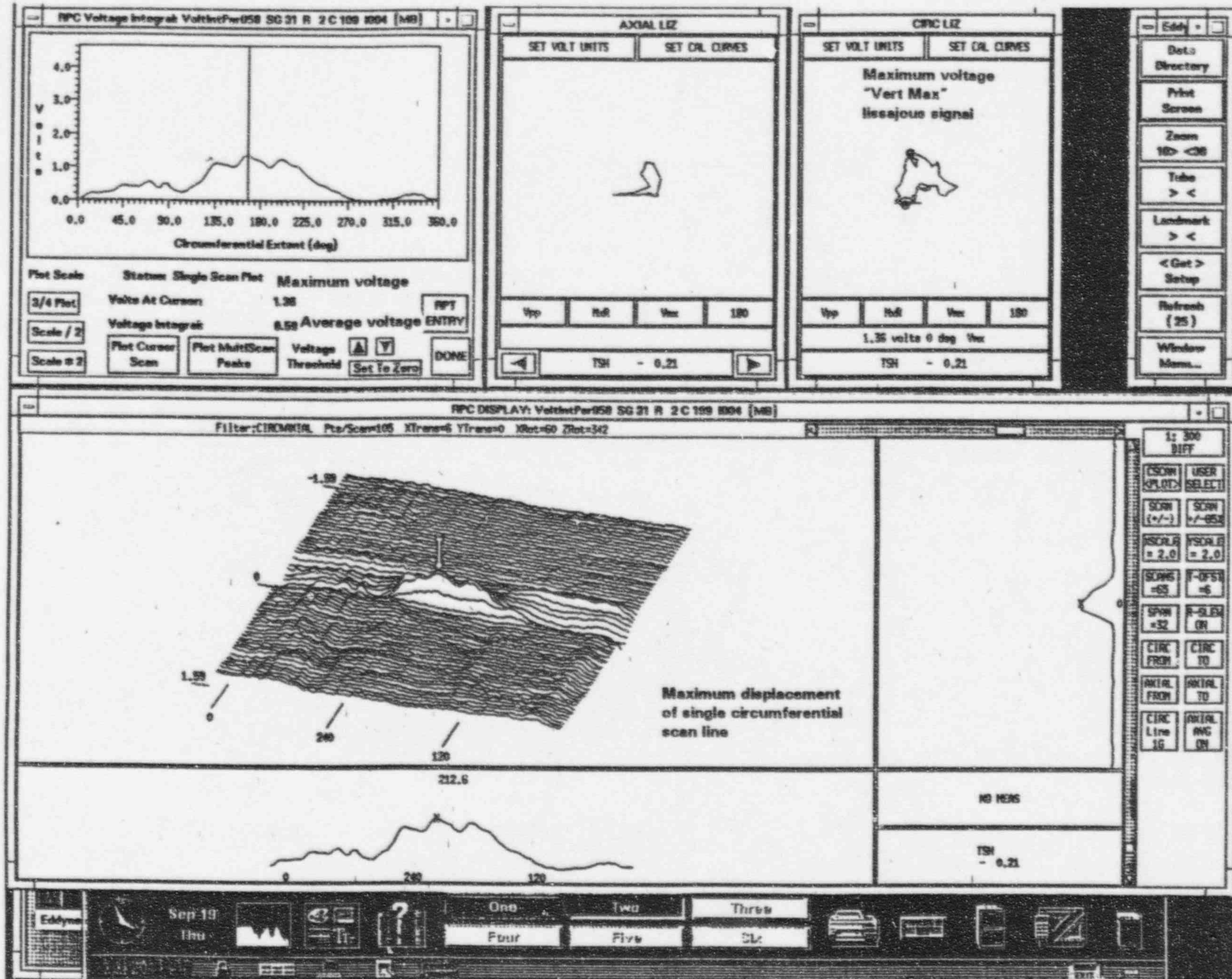
C-Scan plot with AXIAL AVG filter applied

Figure 30C



C-Scan plot
with CIRC
LINE filter
applied

Figure 30D



C-Scan plot with CIRC & AXIAL LINE filters applied

ATTACHMENT B

CHANGES TO BRAIDWOOD UNIT 1

CYCLE LENGTH ASSESSMENT REPORT

SEPTEMBER 17, 1996

During analysis of the Braidwood Unit 1 cycle length assessment 3 changes have been identified as follows:

1. August 2, 1996, Submittal, Figure 5.5, 5.6 and 6.1 do not include one insitu pressure test point. Data for this test was acquired subsequent to the submittal and therefore it was not included in the figures. The point is located at 0.67 max Volts and 0.28 avg. Volts corresponding to a corrected test pressure of 3.577 ksi.

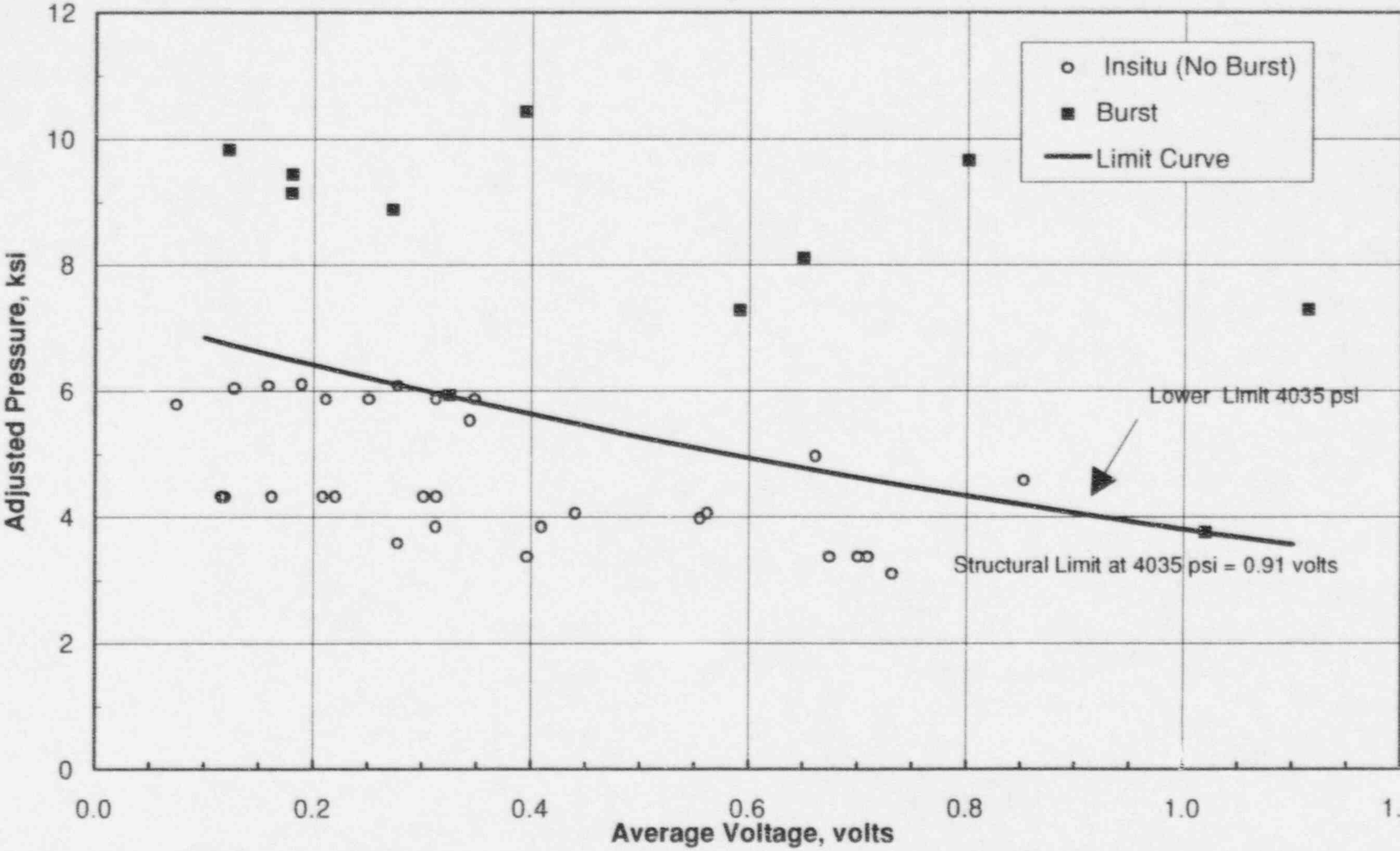
   This additional point has been included in all analyses. The additional data point does not change the results or conclusions of the report. Additionally, the axes on Figure 6.1 were incorrectly labeled in the August 2, 1996 submittal. The updated Figures 5.5, 5.6 and 6.1 are attached.

2. The leak rate of one of the data points in the August 2, 1996, submittal Figure 7.1 and Figure 14a in the September 10, 1996, submittal had an incorrect leak rate. The leak rate was previously presented on these figures as 0.00352 gpm. This leak rate was incorrectly calculated for the maximum pressure instead of the leak test pressure. The correct leak rate is 0.0064 gpm. Because a bounding leak rate is assumed for the EOC distribution this change has no effects on the report conclusions or the EOC predicted leak rate.

3. Incorrect voltages for one insitu pressure test point were presented on Figures 10a and 10b of the September 10, 1996, submittal. The voltages presented were 0.88 max and 0.63 average volts at a corrected pressure of 3.577 ksi. The voltage data were originally analyzed as 0.080" RPC and no correction applied. Further review of the data identified that the data was acquired with the 0.115" RPC and a correction factor was applied. This data point does not change the results or conclusions of the submittal.

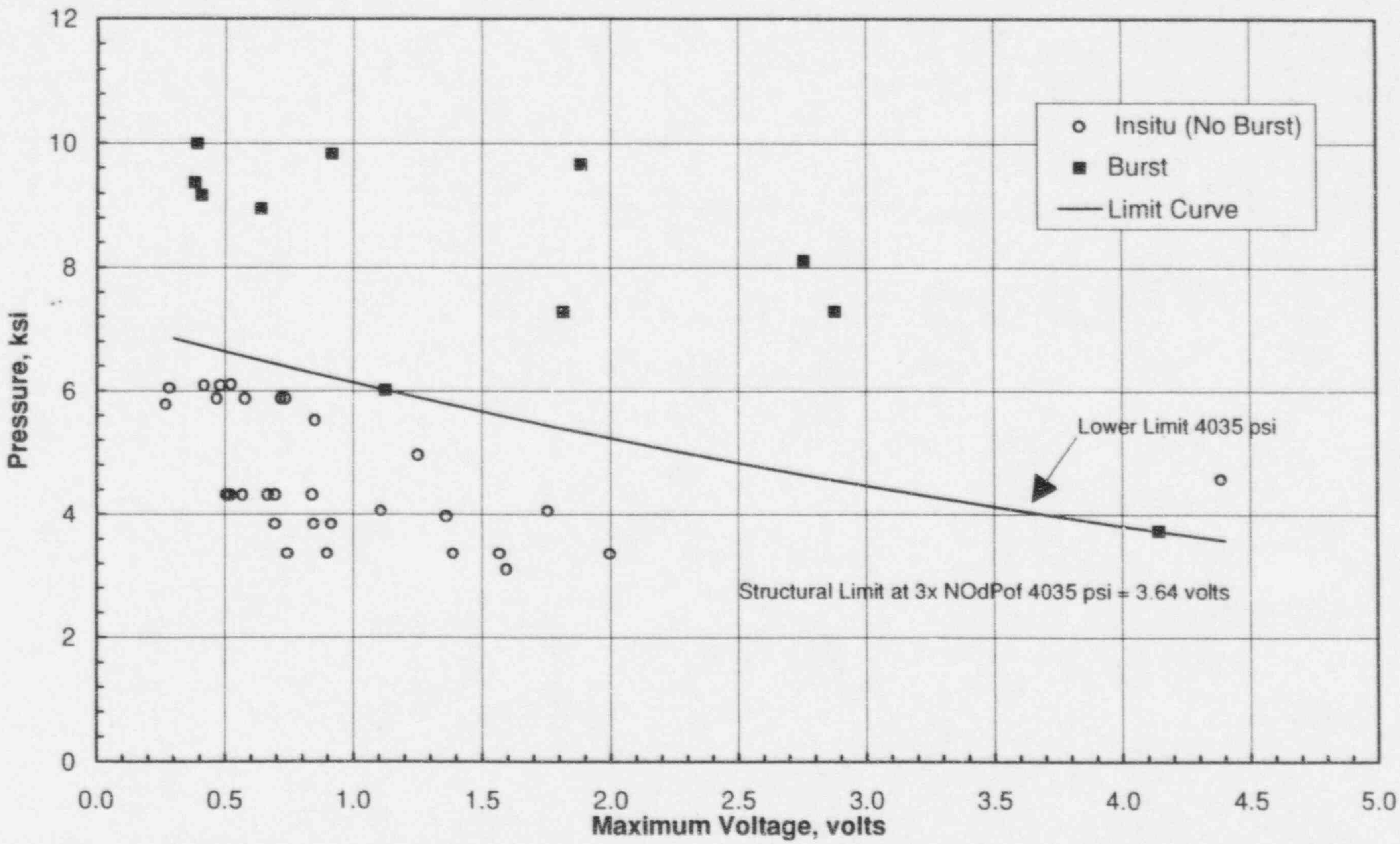
Average Voltage Structural Limit vs. Adjusted Insitu or Burst Pressure Corrected to Braidwood LTL Properties

Figure 5.5

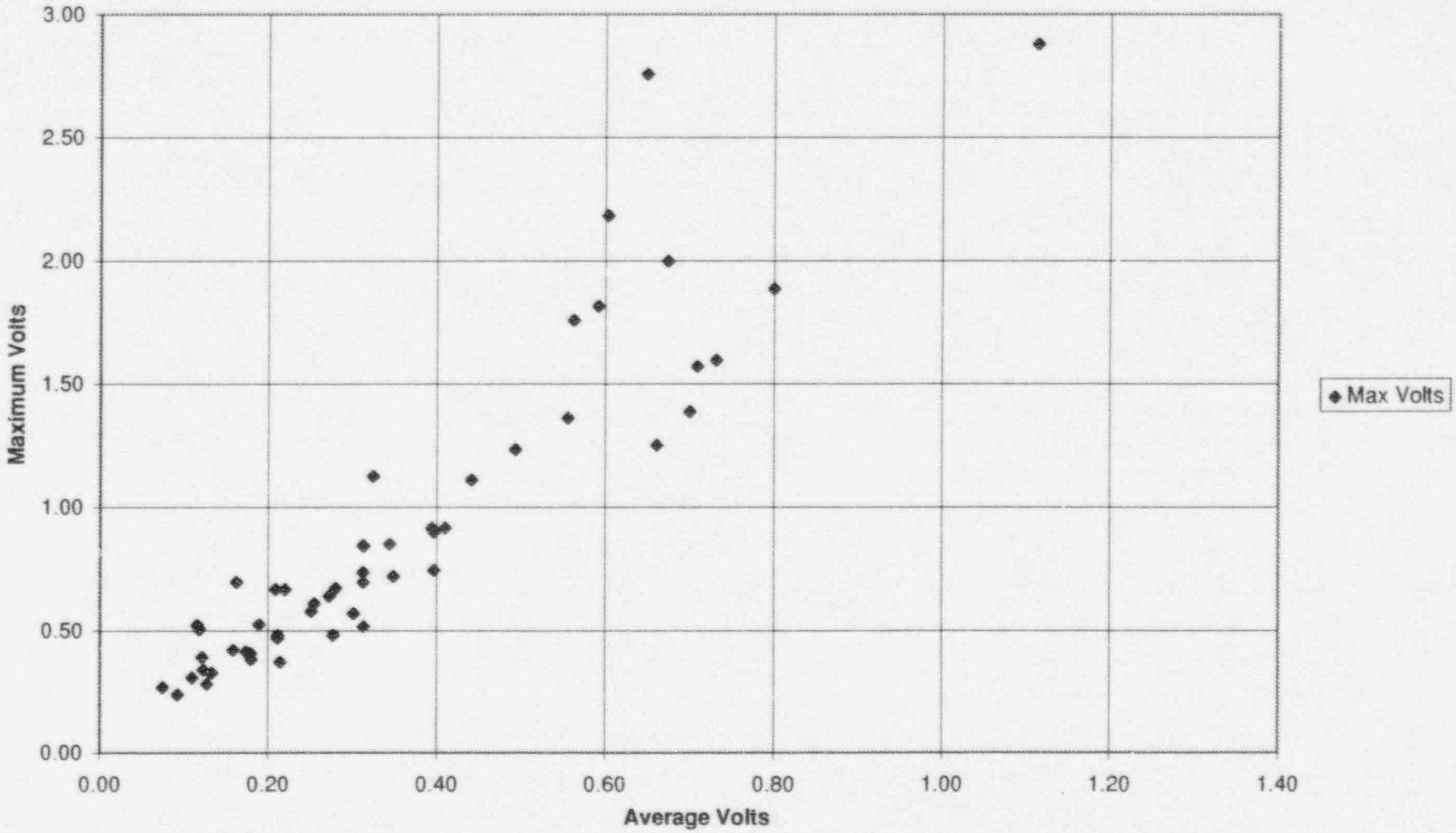


Maximum Voltage Structural Limit vs. Adjusted Insitu or Burst Pressure Corrected for Braidwood LTL Properties

Figure 5.6

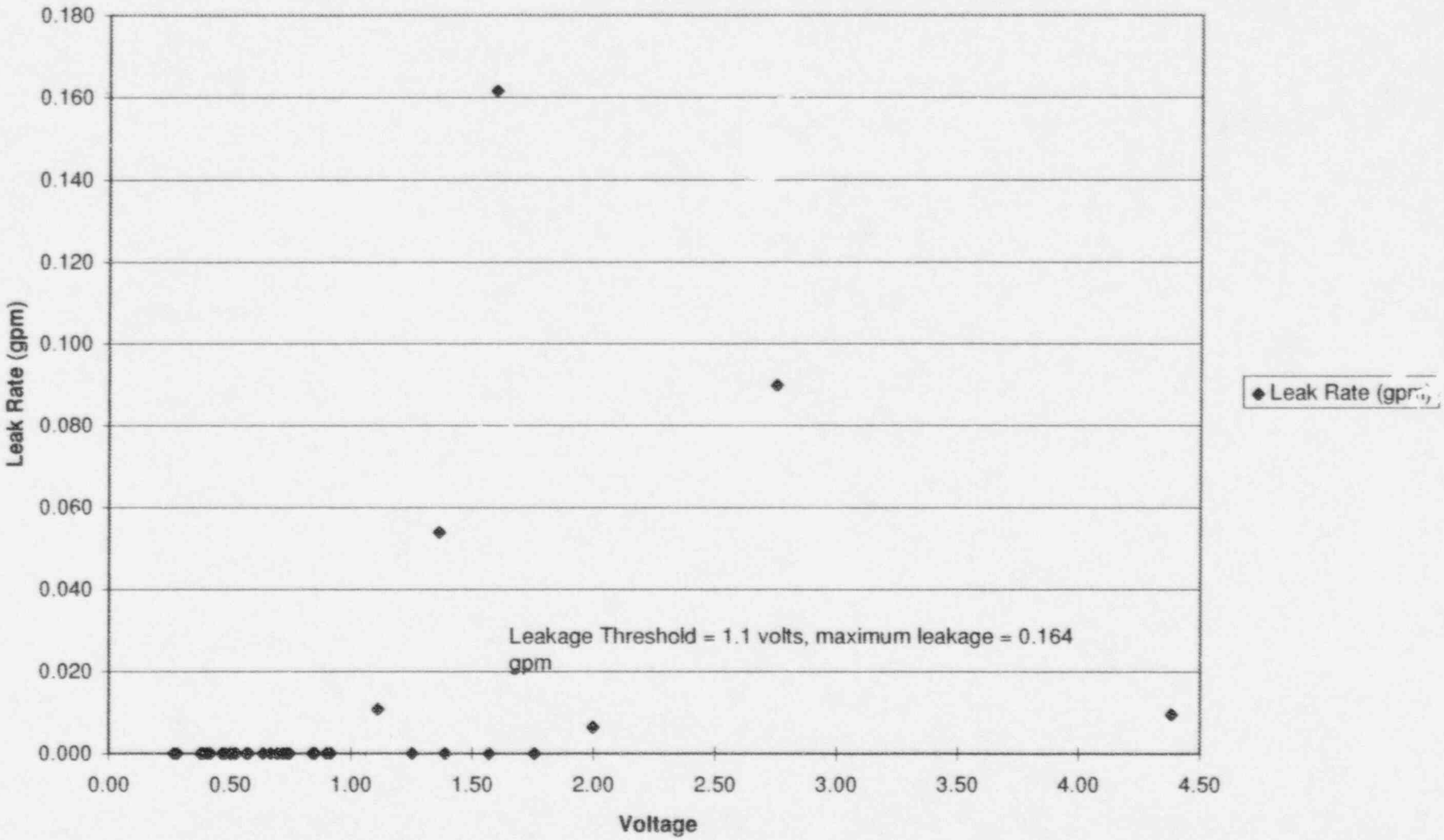


Industry Tube Pull Insitu Pressure Test Average Volts Vs Max Volts
Figure 6.1

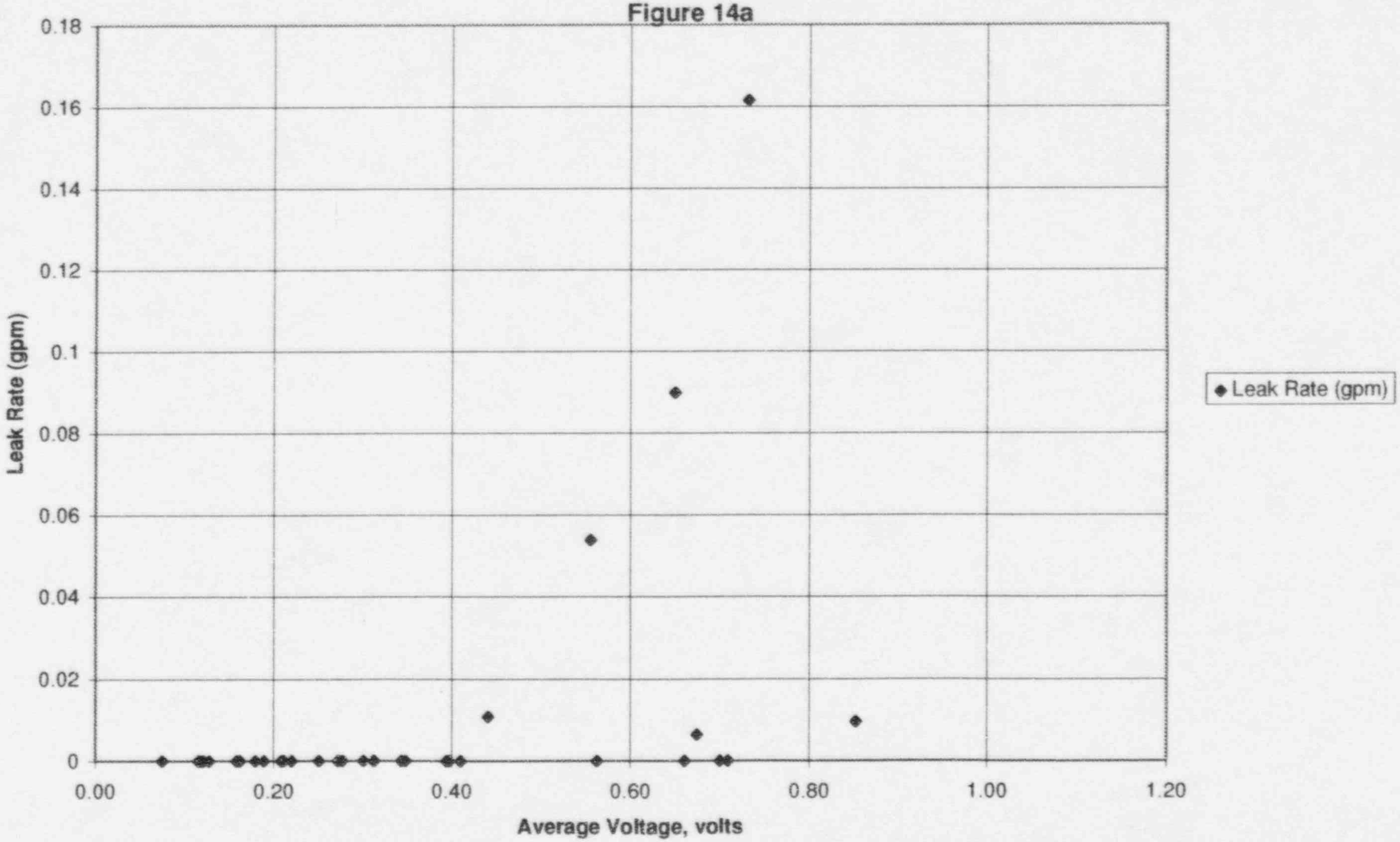


Industry Tube Pull and Insitu Pressure Test Leak Rate (Corrected for Temperature and Pressure) Vs. Maximum Voltage

Figure 7.1

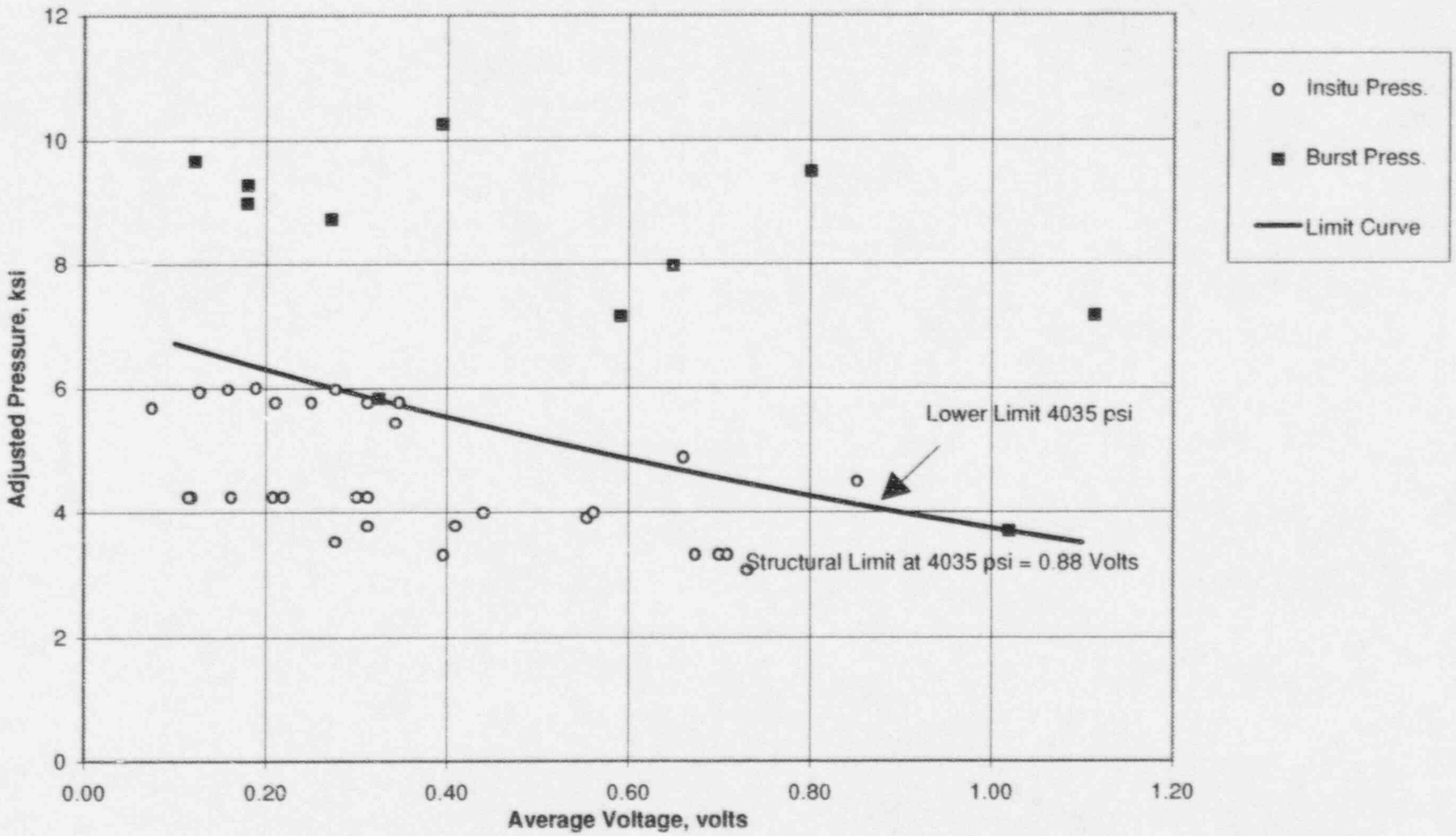


Average Voltage vs. Corrected Leak Rate at MSLB Conditions
Calculation Brw-96-456-M
Figure 14a

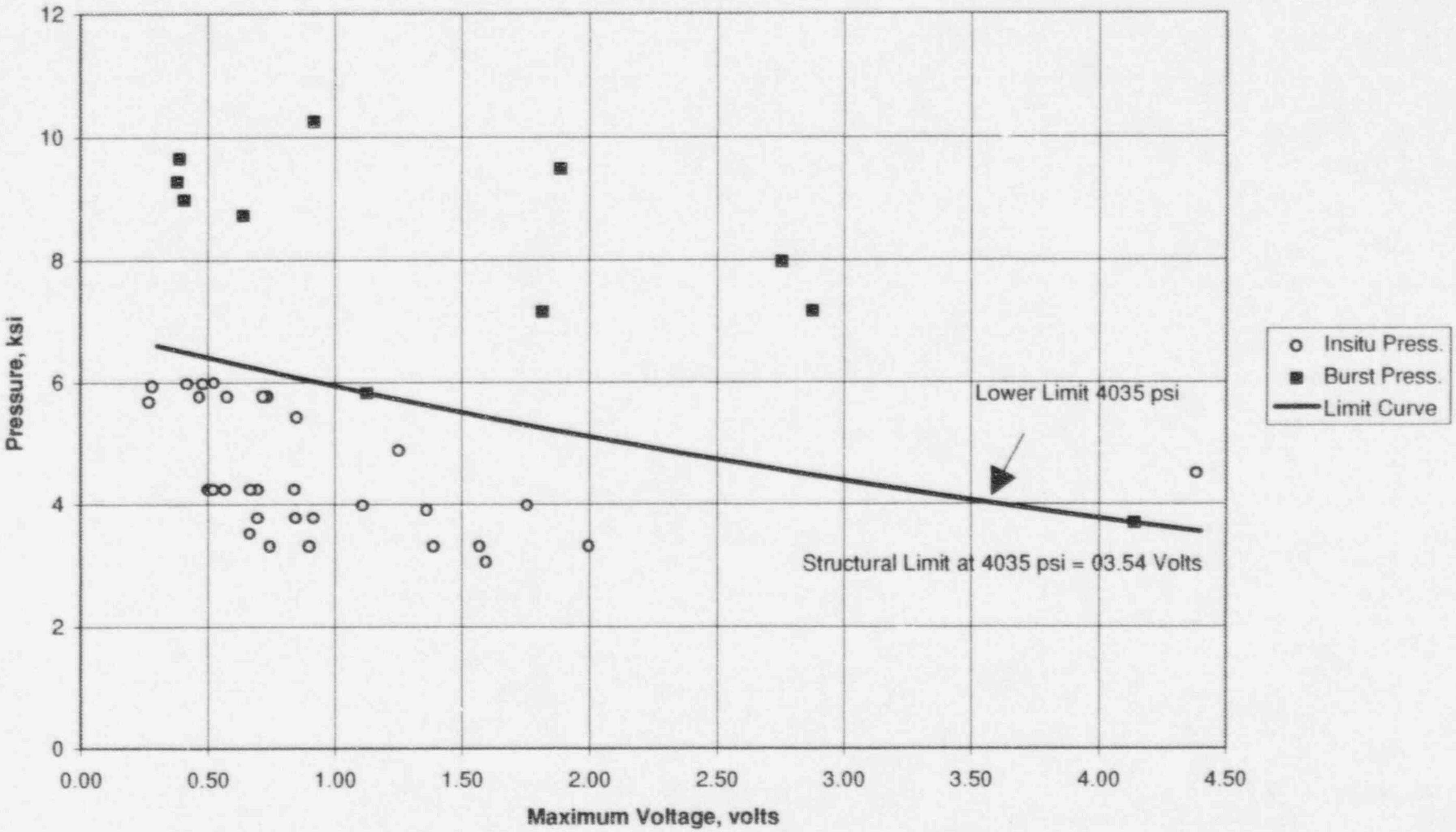


Average Voltage vs. Adjusted Insitu or Burst Pressure Corrected to Industry LTL Properties (95/95 650F) Calculation

Figure 10a



Maximum Voltage vs. Adjusted Insitu or Burst Pressure Corrected for Industry LTL
Figure 10b



ATTACHMENT C

CHANGES TO BRAIDWOOD UNIT 1

CYCLE LENGTH ASSESSMENT REPORT

SEPTEMBER 24, 1996

Subsequent to the September 17, 1996 submittal additional evaluation of normalization and coil size correction factors were performed resulting to changes in these factors. The normalization and coils size correction factors reported in the August 2, 1996 submittal were 0.58 and 0.76, respectively. As discussed in response to Questions 19 and 20 new normalization and coils size correction factors have been established to be applied to the industry database as follows:

1. Normalization correction factor to be applied to 0.080" RPC data is 0.51
2. Normalization correction factor to be applied to 0.115" RPC data is 0.68
3. Coil size correction factor to be applied to 0.115"RPC data is 0.75

Due to these changes in normalization and coil size correction factors the following figures have been updated and are attached:

1. Figures 5.5, 5.6, 6.1, 7.1, August 2, 1996 report updates included in Attachment B of the September 17, 1996 RAI response submittal;

The changes to the following table and figures are updated and included in the body of the report:

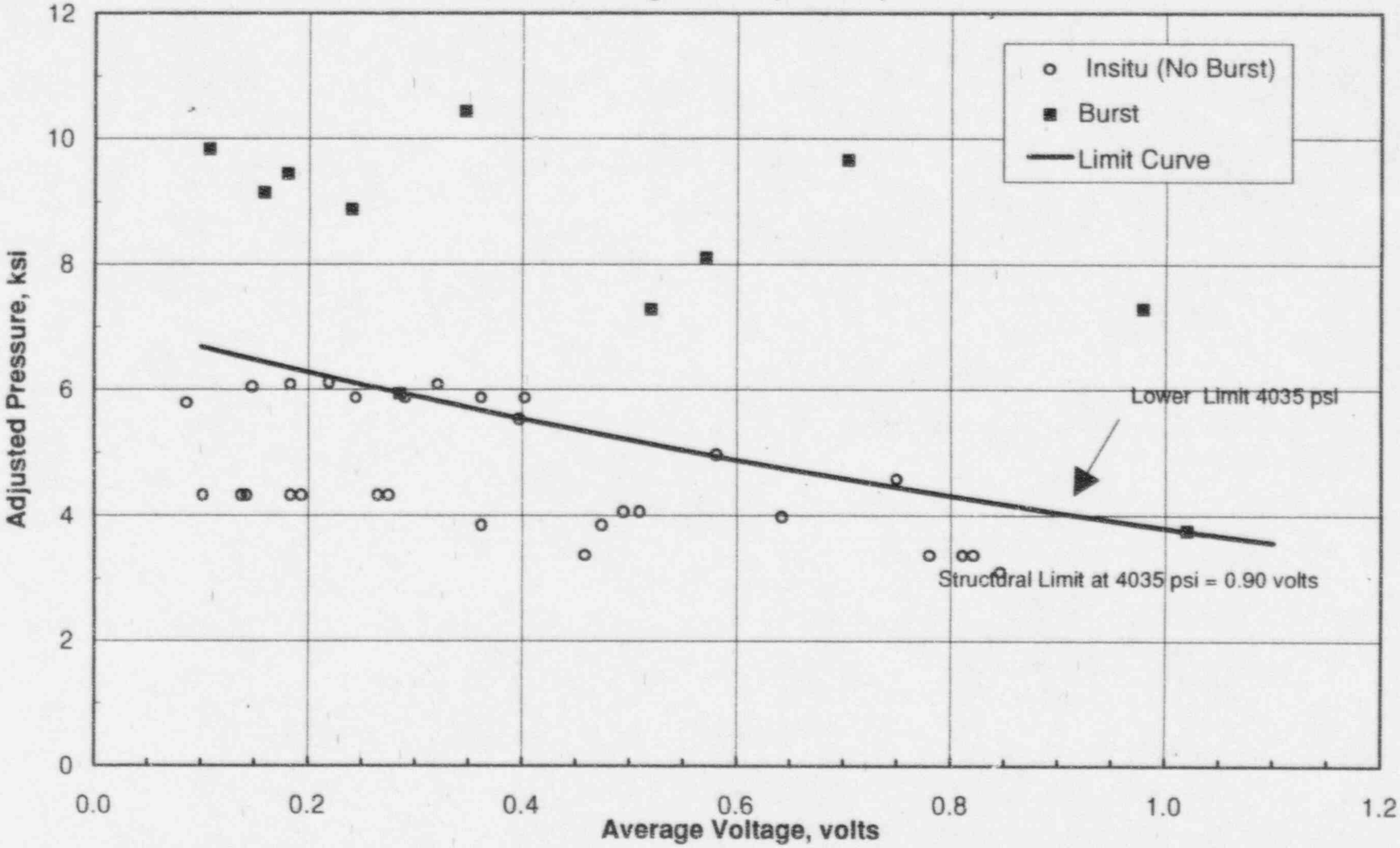
1. Table 5, submitted with the September 17, 1996 response to RAI Question 5;

3. Figure 10a and 10b included in the September 10, 1996 submittal in response to RAI Question 10, and updated in Attachment B of the September 17, 1996 submittal; and

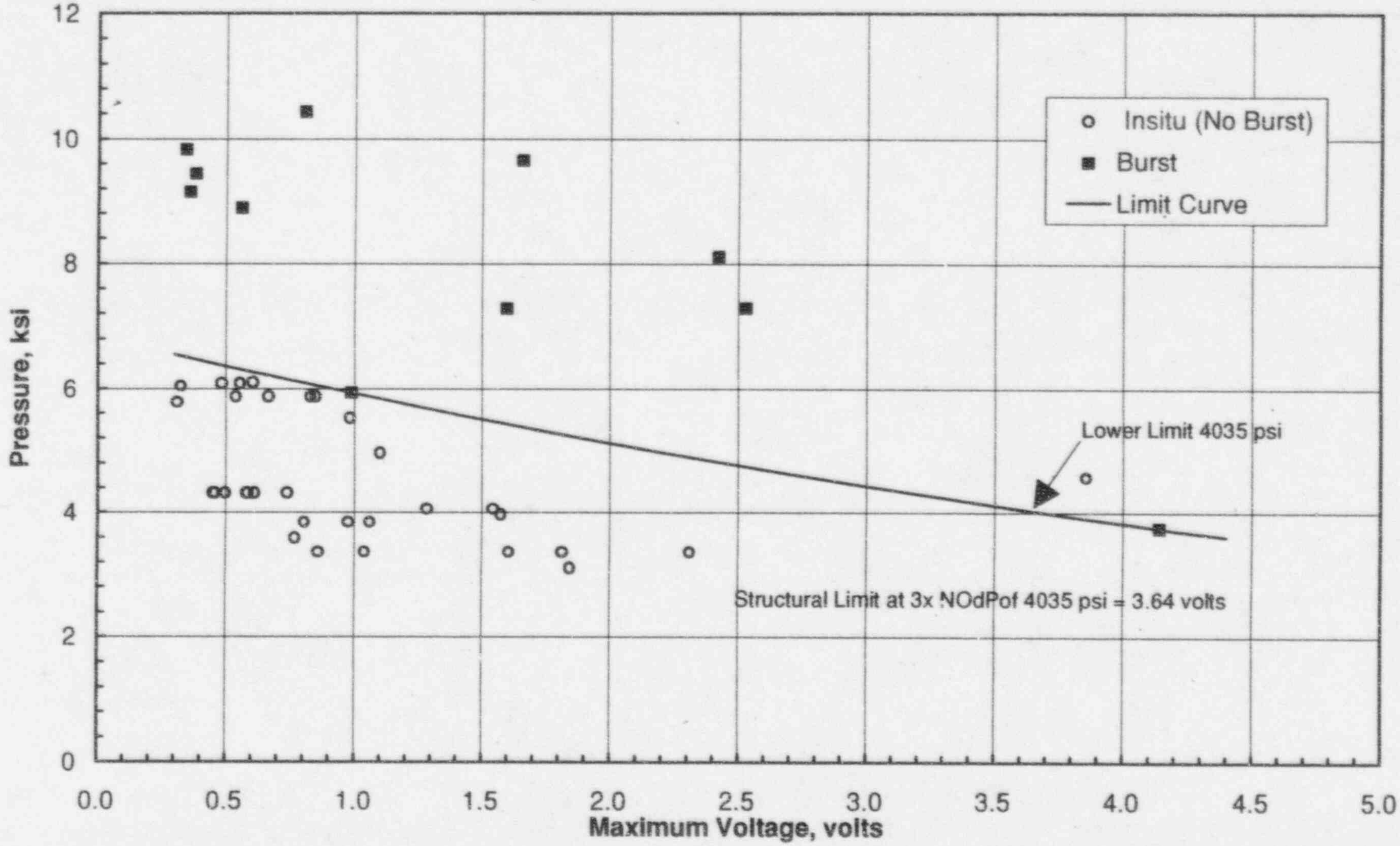
4. Figure 14a, 14b and 16 included in the September 10, 1996 submittal in response to RAI Question 14 and 16.

5. Byron Unit 1 Tube R23C44 was analyzed (0.080" RPC) with a normalization of 20 Volts on a 100% EDM Notch and therefore is not affected by the normalization or coil size correction factor change. Because this is a data point which defines the structural limts shown in Figure 5.5, 5.6, 10a and 10b the structural limit is not siznificantly changed.

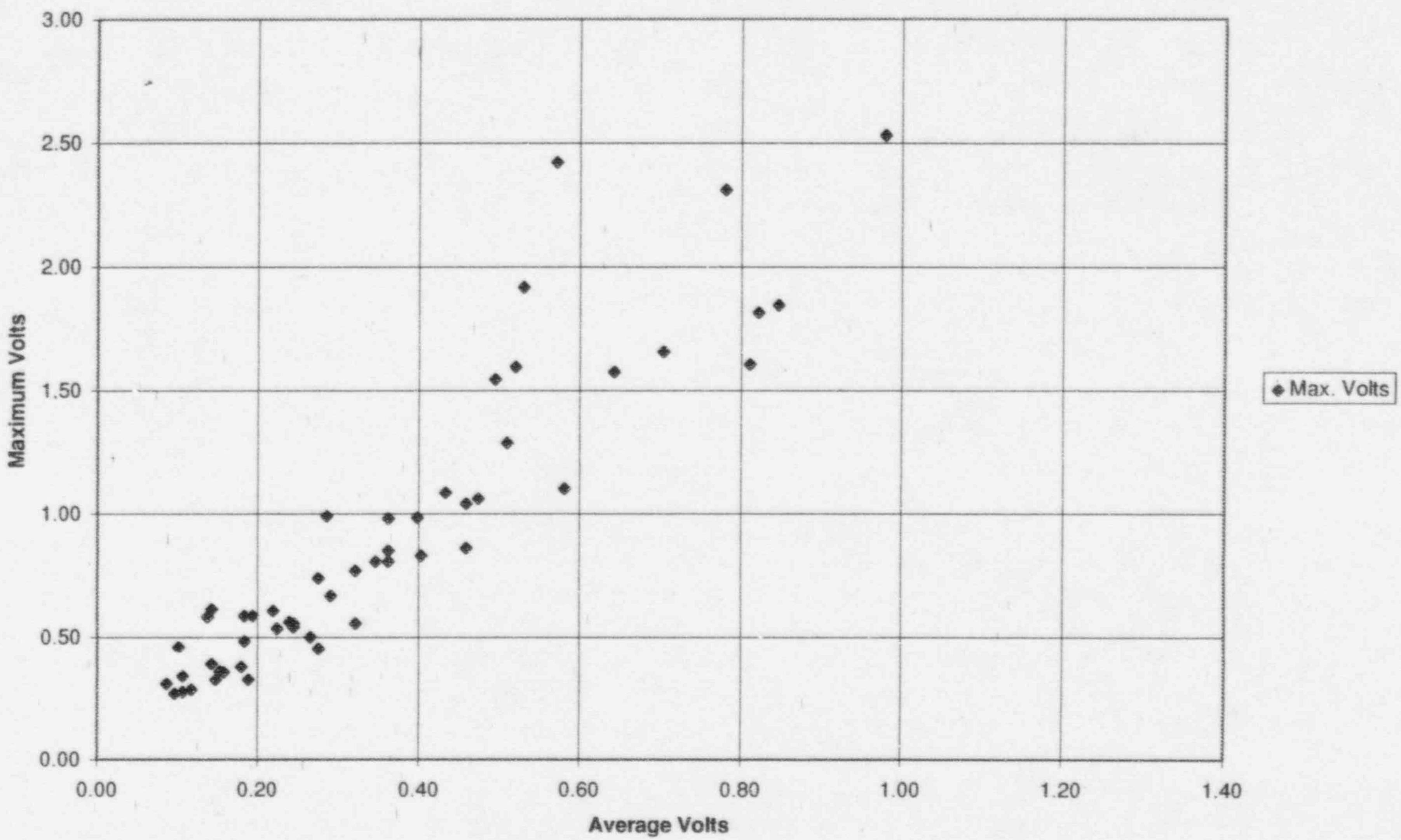
Average Voltage vs. Adjusted Insitu or Burst Pressure Corrected to Braidwood LTL Properties
Figure 5.5 (9/24/96)

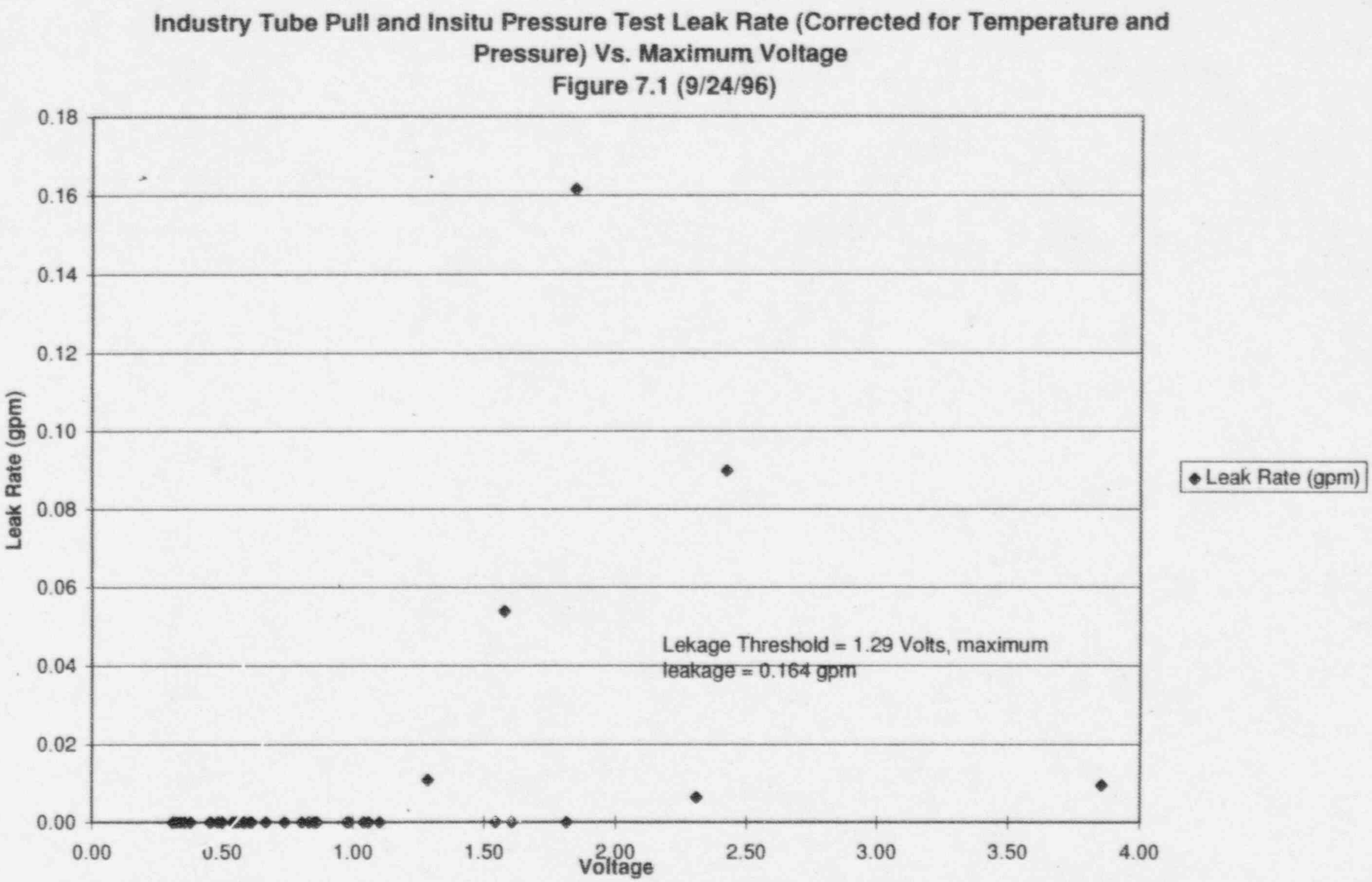


Maximum Voltage Structural Limit vs. Adjusted Insitu or Burst Pressure Corrected for Braidwood LTL Properties
Figure 5.6 (9/24/96)



Industry Tube Pull Insitu Pressure Test Average Volts Vs. Max Volts
Figure 6.1 (9/24/96)




Industry Tube Pull and Insitu Pressure Test Leak Rate (Corrected for Temperature and Pressure) Vs. Maximum Voltage
Figure 7.1 (9/24/96)
Leak Rate (gpm)
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Voltage
Lekage Threshold = 1.29 Volts, maximum leakage = 0.164 gpm
Leak Rate (gpm)

Attachment D

Evaluation Procedure for Assessment of Braidwood, Unit 1

ComEd has used 3 approaches to evaluate full cycle operation for Braidwood Unit 1. These evaluations consists of:

- The Probability of Detection Approach (POD) utilizes the 23 detected and repaired tubes from the Braidwood 10/95 inspection adjusted for growth rate, probe wear, analyst uncertainty and POD.

- The Look Back Approach utilizes the 23 detected and repaired tubes from the Braidwood 10/95 inspection and the Byron look back evaluation, performed on 1995 and 1996 data adjusted for growth rate, probe wear, and analyst uncertainty.

- The End of Cycle Approach utilizes the 128 detected and repaired tubes from the Byron 1994 inspection and the Byron look back evaluations, performed on 1995 and 1996 data adjusted for probe wear and analyst uncertainty.

ComEd has concluded that the End of Cycle Approach envelopes the projected distribution of circumferential indications in Braidwood Unit 1 at the end of the current operating cycle, EOC-6. ComEd's conclusion to utilize the EOC approach is supported based upon:

- The operating time for Byron Unit 1 (EOC-6) is slightly greater than that for Braidwood Unit 1 (EOC-6),

- The Byron and Braidwood Unit 1 steam generators are identical, and

- The Byron and Braidwood Unit 1 have the same operating experience.

This approach combines a conservative beginning of cycle distribution with the conservative approach outlined in GL 95-05 to provide results for assessing steam generator structural integrity for Braidwood Unit 1 EOC-6. For this evaluation ComEd has assessed the margins for leak and burst using evaluation assumptions, procedures and criteria that are in compliance with the guidelines provided in GL 95-05. These are:

- The EOC voltage distribution determined from the Byron 1 inspection at EOC-6 in 1994 was used for the evaluation of EOC-6 at Braidwood 1. The distribution included the tubes detected and repaired at Byron 1 in 1994 and the tubes determined by the 1995 and 1996 look-back evaluations to have indications in 1994 that were not repaired. Both average and maximum voltage distributions were evaluated.

- The distributions were adjusted for probe wear and analyst uncertainty using the values presented in response to RAIs 25 and 31, respectively. Because the EOC-6 distributions are used directly, explicit POD and growth rate analyses are not required.

- The leak rate was computed for the maximum EOC voltage distribution using the procedure describe in response to RAI 16, which includes a log-logistic fit at the 95% confidence level for probability of leakage.

- The conditional probability of tube burst was computed for both the maximum and average EOC voltage distributions. The computation was performed using the statistically developed exponential burst pressure versus voltage correlation describes in the response to RAI 8 . The criteria specified in GL 95-05 will be used to evaluate the conditional burst probabilities for the EOC distributions.

This approach is considered to be the best means to characterize the EOC distribution at Braidwood Unit 1 because of the comprehensive re-evaluation of the Byron 1994 indications, is a direct measure of the variable of interest (i.e. EOC distribution), and minimizes uncertainty associated with growth rates.

The look-back and POD approaches were not considered appropriate for the Braidwood Unit 1 evaluation for the following reasons:

POD Approach:

The POD approach is correct based on generic letter 95-05 methodologies, but will not be used because it does not fully address the possibility of inspection transients that occurred at Byron Unit 1. The EOC approach uses a more rational distribution which address the inspection transient issue.

Look-Back Approach:

The look-back approach considers the Byron Unit 1 distribution at EOC-6 and grows the distribution an additional cycle. This total operating time will correspond to operation of Braidwood Unit 1 for two full operating cycles to EOC-7. This assumed cycle length is unnecessarily conservative and inconsistent with the service experience at Byron and Braidwood.

The attached two tables summarize the computational results for the three approaches. Based on the results of these 3 analyses ComEd concludes that Braidwood Unit 1 full cycle operation is justified.

Summary Table, Maximum Voltage

	*************************** Distribution	***************************
	POD	Look Back	EOC
Maximum Voltage			
Distribution			
BOC Indications	23 Rpd @ BWD 10/95	23 Rpd @ BWD & BYN LB	128 Rpd @ BYN & BYN LB
BOC # of Tubes	23	1081	1186
EOC # of Tubes	90	1081	1186
Probe Wear	0.06	0.06	0.06
Analyst Uncertainty	0.30	0.30	0.30
Growth Rate Data	Byron 94-95 & 94-96	Byron 94-95 & 94-96	n/a
Structural Limit (volts)			
Deterministic	3.64	3.64	3.64
Probability Linear Fit	7.0	7.0	7.0
Probability LOG(Pb) Fit	5.5	5.5	5.5
Conditional Burst Probability			
Linear Fit			3.9E-03
Log(Pb) Fit			5.2E-05
Leak Rate (gpm)			
Deterministic			
TTS Circ.	3.2	8.2	4.3
TSP ODSCC	6.99	6.99	6.99
Unfaulted SG's	0.3	0.3	0.3
Total	10.5	15.5	11.5
95% LogLogistic Fit			
TTS Circ.	4.7	29.0	19.0
TSP ODSCC	6.99	6.99	6.99
Unfaulted SG's	0.3	0.3	0.3
Total	12.0	36.3	26.3

Summary Table, Average Volts

	Distribution		
	POD	Look Back	EOC
Average Voltage			
Distribution			
BOC Indications	23 Rpd @ BWD 10/95	23 Rpd @ BWD & BYN LB	128 Rpd @ BYN & BYN LB
BOC # of Tubes	23	1082	1187
EOC # of Tubes	90	1082	1187
Probe Wear	0.06	0.06	0.06
Analyst Uncertainty	0.32	0.32	0.32
Growth Rate Data	Byron 94-95 & 94-96	Byron 94-95 & 94-96	n/a
Structural Limit (volts)			
Deterministic	0.9	0.9	0.9
Probabilistic Linear Fit	3.2	3.2	3.2
Probabilistic LOG(Pb) Fit	2.5	2.5	2.5
Conditional Burst Probability			
Linear Fit			1.1E-02
Log(Pb)			1.1E-04
Leak Rate (gpm)	n/a	n/a	n/a

ATTACHMENT 18

BRAIDWOOD INSPECTION GUIDELINES

Byron/Braidwood Units 1 & 2

Steam Generator

Eddy Current Analysis Guidelines

Revision: 9 Date: 9/15/95

Reviewed By: [signature] Date: 9/20/95

Approved By: [signature] Date: 9/20/95

Contractor Level III
Concurrence: [signature] Date: 9/22/95

File Location: 3.11.0565

(Guideline Document Attached)

(Final)

APPROVED
AUG 10 1994

Table of Contents

1.0 PURPOSE

1.1 The purpose of this guideline is to provide general instructions and to define specific requirements for the analysis of eddy current data acquired for the ComEd Byron and Braidwood Units 1 & 2 steam generators.

1.2 Analysis guidelines provide a structure to ensure that data is (a) analyzed in accordance with the appropriate techniques and practices that reflect current industry experience, (b) in a consistent and repeatable manner and (c) in compliance with ComEd requirements.

1.3 Conditions encountered during the course of a steam generator examination not foreseen by this guideline are to be reported by data analysts to the Resolution or Lead Analyst of the job.

2.0 GENERAL CHARACTERISTICS OF STEAM GENERATORS

2.1 D-4 Steam Generators (Byron 1 & Braidwood 1)

2.1.1 Each plant operates at 1175 Megawatts.

2.1.2 Steam Generators are Westinghouse D-4 vertical U-Bend type tubes containing 4,578 mill-annealed Inconel 600 tubes per steam generator.

2.1.3 The tubes are mechanically rolled in the tubesheet.

2.1.4 The tube support plates are 0.750" drilled carbon steel.

2.2 D-5 Steam Generators (Byron 2 & Braidwood 2)

2.2.1 Each plant operates at 1175 Megawatts.

2.2.2 Steam Generators are Westinghouse D-5 vertical U-Bend type tubes containing 4,570 thermally treated Inconel 600 tubes per steam generator.

2.2.3 The tubes are hydraulically expanded in the tubesheet.

2.2.4 The tube support plates are 1.125" stainless steel with Quatrefoil holes.

2.3 Operating History of Steam Generators (D-4's)

2.3.1 Outer Diameter Stress Corrosion Cracking (ODSCC) at the support plates. This is the primary mode of degradation at Byron 1 and Braidwood 1. The majority of the indications are found on 3H, 5H, and 7H support plates. Most of the tubes plugged in the steam generators have been plugged as a result of this problem. These cracks are axially orientated.

2.3.2 Primary Water Stress Corrosion Cracking (PWSCC). This mode of degradation has been found at Byron only and it is considered the second highest mode of degradation. This type of degradation occurs within the confines of the hot leg tubesheet. These cracks are axial orientated and ID initiated.

2.3.3 Circumferential Cracking at the top of the tubesheet. This mode of degradation was found at Byron first during a limited inspection at the top of the tubesheet during refueling outage 6. These indications occur in the expansion transition of the tube above the tubesheet. These cracks are circumferentially orientated and OD initiated. Braidwood has also found circumferential cracking at the top of their tubesheet..

2.3.4 Pitting has also been a concern for Byron. Pitting usually occurs at the edge of support plates (above or below) and primarily on the hot leg side, however some tubes have been plugged due to cold leg pitting.

2.3.5 Low row U-Bend PWSCC has been a concern for Byron Station during earlier refueling outages. In fact Byron has had two leaker outages (April and June of 1988) as a result of cracks found in the U-Bend region. Since that time, U-Bend stress relief was performed to mitigate this problem.

2.3.6 Very limited amounts of Anti-Vibration Bar (AVB) Wear and preheater wear have been found in the Unit 1 steam generators. However, Unit 2 has seen a considerable amount of AVB wear.

2.4 Operating History of Steam Generators (D-5's)

2.4.1 AVB Wear has been the primary mode of degradation at Byron 2 and Braidwood 2. AVB wear occurs in the U-Bend region and it is caused as a result of the AVB's rubbing the tubing beyond the technical specification limit of 40% Through-Wall. Particular attention should be made in obtaining accurate % through wall for purposes of growth studies and projections.

2.4.2 Loose parts have been found in several areas in these steam generators. These parts have been found utilizing the 10 kHz channel. Tubes subject to loose part damage are either in the extreme peripheral areas or in the tube lane.

3.0 RESPONSIBILITIES

3.1 ComEd Representative

3.1.1 Responsible for interpreting, maintaining and implementing these guidelines, and determining plant specific Interim Plugging Criteria (IPC) eddy current data analysis applicability as well as dispositioning any unusual indications with the Lead Analyst of the job.

3.2.1 Responsible for selecting the Lead Analyst, Resolution Analyst and Data Analysts. The vendor may select the analysts as long as there is ComEd concurrence.

3.2 Lead Analyst

3.2.1 Analyzes eddy current data in accordance with this guideline.

3.2.2 Maintains supervision over all Shift Lead Analysts and Data Analysts during the job.

3.2.3 Responsible for communicating any problems that may arise during the inspection, i.e. "new modes of degradation" unfamiliar to the site or problems which could impact the schedule.

3.2.4 Identifies and processes required changes to the guideline during the course of the examination as circumstances may warrant. Changes are documented using the Analysis Guideline Change Form in Appendix B of this guideline and are subject to ComEd approval prior to usage.

3.2.5 Promptly informs all data Analysts of changes to this guideline as such changes occur. The Analysis Guideline Change Acknowledgment Form in Appendix B is used to document receipt and review of changes by all Analysts.

3.2.6 Perform duties of Lead Analyst or Resolution Analyst as required.

3.3 Resolution Analyst

3.3.1 Analyzes eddy current data in accordance with this guideline.

3.3.2 Resolves any discrepancies between primary and secondary analysts and resolves LAR (Lead Analyst Resolution) calls in accordance with the resolution criteria in Section 8 of this guideline.

3.3.3 Promptly informs the Lead Analyst of circumstances that arise during the course of data analysis that are not consistent with or not addressed by this guideline which may require changes to this guideline.

3.4 Data Analyst

3.4.1 Analyzes eddy current data in accordance with this guideline.

3.4.2 Prepares and submits a final report consistent with this guideline that is complete and free of errors for each calibration group.

4.0 PERSONNEL QUALIFICATIONS

4.1 Personnel analyzing data shall be qualified in accordance with SNT-TC-1A and certified to Level IIA or Level III.

4.2 In addition, the analyst shall have received training in the evaluation of eddy current data for nonferromagnetic tubing.

4.3 Data analysts will have successfully passed a ComEd eddy current data Analyst performance demonstration program consisting of site-specific training and testing prior to analyzing production data.

4.4 Per ComEd's response to Generic letter 95-03 "Circumferential Cracking of Steam Generator Tubes" all analsysts who review RPC results from the top of tubesheet RPC inspection will be Qualified Data Analsyts (QDA's) per EPRI Guidelines Appendix G.

5.0 GENERAL ANALYSIS REQUIREMENTS

5.1 All recorded indications shall be evaluated in accordance with this guideline. Guideline changes must be implemented using the change form given in Appendix B.

5.2 There is no minimum voltage threshold for reporting indications believed to be attributed to tube wall degradation.

5.3 Data analysis consists of reviewing Lissajous and strip chart displays to the extent that all indications of tube wall degradation and other signals as defined by this document are reported and dispositioned in accordance with the requirements of this document.

5.3.1 All recorded data shall be evaluated regardless of the extent tested.

5.3.2 Phase angle measurements shall be made utilizing VOLTS MAXRATE for signals which have a well-defined transition. For cases where no clear transition exists, a VOLTS PEAK-TO-PEAK approach shall be used. The use of guess angle shall be kept to a minimum

and only used when the latter two analysis functions do not give a good representation of the signal phase angle.

5.3.3 Indications for which there are no applicable reporting criteria or which the Analyst considers to be ambiguous or indeterminate should be reported as LAR. The Resolution Analyst must resolve such indications with the concurrence of the Lead Analyst.

5.4 All acquired data shall be subjected to two independent analyses. These are referred to as "primary" and "secondary" analyses.

5.4.1 The two individual analysis results shall be reviewed for discrepancies in accordance with Section 8.0 of this guideline.

5.4.2 If no discrepancies exist between the primary and secondary analyses, then the primary analysis results shall be considered as final.

5.5 All previous history must be addressed. If no indication is identified from the previous history at the location in question an INF or INR analysis code shall be reported (See Appendix C).

5.6 Axial locations in the hot leg shall be reported in a positive direction from supports, AVB's, tube sheet, and tube end up to but not including 11C.

5.7 Axial locations in the cold leg shall be reported in a positive direction from supports, tube sheet, and tube end up to 11C.

5.8 Probe speed (axial traverse speed and RPM as applicable) should be verified on the following occasions:

5.8.1 At each calibration run.

5.8.2 At any time probe speed is questionable.

5.9 Storing Analysis Setups are as follows:

5.9.1 The analysis setup established for each calibration group shall be stored to the data recording medium.

5.9.2 Each primary, secondary or resolution Analyst shall store results to primary, secondary, or resolution files respectively.

5.10 Reporting Criteria should be as follows:

5.10.1 The record of each tube analyzed shall include the Tube (Row, Column); VOLTS, DEG, % or three letter code, CH# and axial location corresponding to any reported indication(s); and the extent tested.

5.10.2 Acceptable three letter analysis codes for reported indications that are not assigned a percent through-wall are identified in Appendix C of this guideline.

5.10.3 Support structure (landmark) nomenclature and measurements are identified in Appendix D of this guideline.

5.11 Calibration Verification for the ASME Standard should be as follows:

5.11.1 Calibration verification shall be performed at the beginning and end of each calibration group. If the requirements are not met for bobbin probe data then the data Analyst will identify the affected data and determine which tubes, if any, require retest.

5.11.2 The ASME calibrations shall be compared within the following parameters using Channel 1:

(1) The phase angle of the 100% through-wall hole response should be at 40° +/- 1°.

(2) The phase angle of the 20% drill hole response should be between 50° and 130° clockwise from the 100% drill hole response.

(3) Responses from the calibration discontinuities should be clearly indicated and discernible from each other as well as probe motion.

5.12 IPC, F* and Circumferential cracking commitments with the NRC

5.12.1 Interim Plugging Criteria for TSP cracking will be implemented at both Byron and Braidwood Station's Unit 1. Plugging will be based on the upper voltage Repair Limit set forth by the site.

5.12.2 F* will be applied to both Byron and Braidwood Station. Particular detail should be placed on the location of the indications found within the tubesheet so that F* may be applied. The F* criteria includes indications which are found to be 1.7 inches or more below the top of the tubesheet.

5.12.3 Circumferential cracking has been found at both Bryon and Braidwood Station at the top of the tubesheet. NRC committments have been made to perform a representative sample (20%) of RPC inspections in low row U-bends and a 100% RPC inspection of the top of the tubesheet for all steam generators.

5.13 Probe pull speeds for implementation of IPC should not exceed 24 inches per second.

6.0 BOBBIN COIL EDDY CURRENT REQUIREMENTS

6.1 Analysis Set-up

6.1.1 Examination Frequencies (see Table 6-1)

Table 6-1 Tube Examination Frequencies

Frequency (kHz)	Differential Channel	Absolute Channel
550	1	2
300	3	4
130	5	6
10	7	8

6.1.2 Setting Mixes (see Table 6-2)

Table 6-2 Mix Set-up

Mix	Channel Sequence	Suppress on:	Save on:
Mix 1	1,5	Support Ring	N/A
Mix 2	4,6	Support Ring	N/A
Mix 3 (optional)	1,3,5	Support Ring & Clean TTS	ASME Cal Std Drill Holes & OD Groove
Mix 5	4,6	Support Ring	N/A

Note: ***Additional mixes may be established for screening and diagnostic applications at the discretion of the analyst. However, as a minimum, data screening and reporting shall be conducted using the applicable channels specified in Section 6.2.***

6.1.2.1 *Mix 1*: 550/130 kHz differential support mix; mix on ASME standard support ring. Set 3-point phase angle-depth calibration curve using ASME 100%, 60%, and 20% drill hole signals. Mix #1 is the primary channel for reporting indications at support structures (other than AVB's).

6.1.2.2 *Mix 2*: 300/130 kHz absolute; mix on ASME support ring signal. Set amplitude (voltage) 3-point calibration curve (VERTMAX) using the 0%, 20%, and 40% AVB wear scar signals. (Note: 50% wear scar may be substituted if 40% wear scar does not exist in standard). Mix 2 is used for reporting indications at AVB's.

6.1.2.3 *Mix 3 (optional)*: 550/300/130 kHz differential; suppress ASME support plate and normal in-generator roll expansion signal; save signals from ASME standard drill holes. Mix 3 is used to screen TTS expansion regions for indications and to aid in the confirmation of other indications.

6.1.2.4 *Mix 4*: Reserved for computer data screening (CDS)

6.1.2.5 *Mix 5*: 300/130 kHz absolute; mix on ASME support ring signal. Set amplitude (voltage) 3-point calibration curve (VERTMAX) using the 0%, 30%, and 50% AVB wear scar signals. (No transformation curve required). Mix 5 is used for reporting indications at cold-leg TSP's within the preheater section of the generator.

6.1.3 Setting Rotations

6.1.3.1 *Channels 1,3, and 5*: Adjust the rotation so that the phase angle of the signal from the 100% through-wall hole is 40 $^\circ$ (+/- 1 $^\circ$) with initial signal excursion down and to the right as the probe is pulled through the calibration standard.

6.1.3.2 *Channels 2, 4, 6, Mix 2, and Mix 5*: Adjust the rotation so that probe motion is horizontal with the through-wall hole signal starting upwards.

6.1.3.3 *Channel 6*: As an option, the signal response from the ASME 100% drill hole may be rotated to 32°(+/- 1°).

6.1.3.4 *Channels 7 and 8*: Adjust the rotation so that the initial excursion of the signal from the support ring is oriented vertically starting downwards.

6.1.3.5 *Mix 1 and Mix 3*: Set probe motion horizontal with the signal from the 100% drill hole starting downwards and to the right.

6.1.4 Setting Spans

6.1.4.1 *Channel 1 and Mix 1*: As a minimum, set span so that the magnitude of the ASME 20% drill hole response is approximately 25% of the full screen height (FSH) of the Lissajous display. Verify that the magnitude of the ASME 100% drill hole response is at least 50% of FSH.

6.1.4.2 *Mix 2*: Set span so that the magnitude of the AVB 20% wear scar response is approximately 25% of FSH.

6.1.4.3 *Locator Channels 7 and 8*: Set span so that the magnitude of the support plate response on Channels 7 and 8 are at least 50% and 25% of FSH, respectively.

6.1.5 Setting Volts

6.1.5.1 *Channel 1*: Set the ASME 20% Flat Bottom Hole(FBH) signal to 4 volts +/- 0.1 volts peak-to-peak in Channel 1 and save/store to all other channels and mixes.

6.1.5.2 *Mix 1*: If an IPC calibration standard is used to establish a voltage scale, then the voltage shall be set to the normalized value on th[illegible]plicable transfer standard drawing. Save/store to Mix 1. If an ASME calibratio[illegible] used, then set the 20% FBH signal to 2.75 volts +/- 0.1 volts peak-to-peak in Mix 1. Save/store to Mix 1.

6.1.5.3 *Mix 2*: Set the 40% wear scar signal (or 50% wear scar signal if applicable) to 5 volts (VERTMAX). Save/store to Mix 2.

6.1.5.4 *Mix 5*: Set the 50% wear scar signal to 5 volts (VERTMAX). Save/store to Mix 5.

6.1.6 Setting Curves

6.1.6.1 *Calibration Standard Hole Depths*:

(1) The actual depths corresponding to the nominal depths provided below shall be used in establishing calibration curves. "As built" hole dimensions shall be obtained from the applicable calibration standard drawings.

(2) Normalized calibration curves generated using phase angles based on a nominal wall thickness and a standard depth of penetration of 37% are permitted if the requirements of Section 6.1.6.1(1) ca[illegible]t be satisfied.

6.1.6.2 *Use of Artificial Curves*: The use of artificial curves i.e. set 4.1, is prohibited.

Note: ***Use max rate for Channels 1,3,5, and Mix 1, and peak-to-peak for channels 4 and 6.***

6.1.6.3 *Mix 1 and Channels 1,3, 4, 5, and 6*: Establish phase angle versus depth curves using the following nominal set points:

(1) Set Point 1: 100%
(2) Set Point 2: 60%
(3) Set Point 3: 20%

6.1.6.4 *Mix 2*: Establish a VERT MAX voltage versus depth curve using either of the following two cases of typical nominal set points, depending on the AVB calibration standard used:

		Case 1	Case 2
(1)	Set Point 1:	0%	0%
(2)	Set Point 2:	20%	30%
(3)	Set Point 3:	40%	50%

6.1.6.5 *Mix 3 (Optional Turbo Mix)*: No calibration curve is required.

6.1.6.6 *Mix 5*: Establish a VERTMAX versus depth curve using the following nominal set points:

(1) Set Point 1: 0%
(2) Set Point 2: 30%
(3) Set Point 3: 50%

6.1.7 Data Display

6.1.7.1 As a minimum, set up the display configuration for initial data screening according to Table 6-3 using the span settings established in Section 6.1.4.

Table 6-3 Minimum Display Configuration Requirements

Display	Channel
Lissajous	CH 3
Left Strip Chart	CH 6 Vertical
Right Strip Chart	Mix 1 Vertical

6.1.8 Setting Scale and Axial Locations

6.1.8.1 Set the axial scale to the nearest one-hundredth (0.00) of an inch using Appendix D for dimensions and verify proper setting each time an indication is reported.

6.1.8.2 Scale should be set using the two support structures which bound the region of interest. For U-Bend indications, set scale using the two uppermost TSP's on either leg of the steam generator.

(1) Use the TSP centerline as the zero reference point when setting scale between TSP's.

(2) Use the top of the tubesheet and next TSP or baffle plate centerline when setting scale between the top of the tubesheet and the lowest TSP or baffle plate.

(3) Use the tube end and top of tubesheet when the region of interest is within the tubesheet.

6.1.8.3 Axial locations of indications are measured with a positive offset and physically upward in relation to the adjacent landmark.

(1) Locations of indications within the boundaries of support and baffle plates are referenced (+) or (-) as they occur above or below the support structure centerline.

(2) Indications within the expansion transition region near the secondary tubesheet face are referenced relative to the top of the tubesheet.

(3) U-bend indications are referenced (+) in relation to the adjacent AVB toward the hot-leg or upper hot-leg support plate as appropriate.

(4) AVB indications are referenced to (0.00) at the corresponding AVB.

6.1.8.4 Location landmarks are identified using the appropriate three-letter codes as specified in Appendix D.

6.2 <u>Data Evaluation</u>

Note: This section defines special augmented data screening and analysis requirements for various classes of indications. Particular attention should focus on analysis procedures for 1) free-span indications, and dings. Both of these types of indications have been associated with recent industry forced outages in preheater steam generators. In addition, evaluation requirements for screening support structures, e.g., support and baffle plates, AVB's, and the tubesheet secondary face, are described.

6.2.1 Support Plates and Baffle Plates:

6.2.1.1 Scroll support plates using Channel 3 and Mix 1. There is no minimum threshold voltage for reporting.

6.2.1.2 Channel 3 is usually a very useful channel for data screening and locating the initial position for phase angle measurement.

6.2.1.3 Mix 1 shall be used to determine the final phase angle measurement point.

Note: Interim Plugging Criteria (Applicable to Byron/Braidwood Unit 1 only)

6.2.1.4 Scroll support plates using Channel 3 and Mix 1. There is no minimum threshold voltage for reporting purposes.

6.2.1.5 Initial placement of the dots for identification of the flaw location may be performed using Channel 1 or 3, but the final peak-to-peak measurements must be performed using the Mix 1 Lissajous signal to include the full flaw segment of the signal. It may be necessary to iterate the positions of the measurement points between the identifying frequency and the Mix 1 channel to obtain proper placement.

6.2.1.6 The largest amplitude portion of the Lissajous signal (not necessarily the MAXRATE position) representing the indication should then be reported using Mix 1 to establish the voltage.

6.2.1.7 See Appendix A for additional information concerning ODSCC at the supports plates for Unit 1 only. Also, Figure 1 of Attachment 1 contains a flow diagram indicating the process for the Analyst to follow while reporting indications at the supports.

6.2.2 Tube-end through Top of Tubesheet+1.00" (Hot and Cold Legs)

Note: ***This section explains the requirements for identifying and calling any type of degradation that may occur in the tubesheet +1.00". The primary modes of degradation for Byron and Braidwood at these locations are Primary Water Stress Corrosion Cracking (PWSCC) within the tubesheet and Outer Diameter Stress Corrosion Cracking (ODSCC) at the top of the tubesheet. F* will be applied to tubes which contain tubeheet indications.***

6.2.2.1 Scroll all tubesheet secondary face expansion transitions using Channels 1, 3, 5, and Mix 1 at span settings such that the expansion signal (except for Mix 1) occupies the maximum extent of the Lissajous display without saturating.

6.2.2.2 As an option, Mix 3 (Turbo mix) may be used to carefully screen for degradation-like indications at the top of the tubesheet.

6.2.2.3 Distorted tube sheet entry signals or possible indications should be reported using the appropriate analysis code.

6.2.2.4 Figure 2 of Attachment 1 shows a flowchart illustrating data screening and reporting requirements.

6.2.3 U-Bend Region (11H through 11C)

6.2.3.1 Data Screening (Data Analysis) - Freespan regions

(1) The U-bend region between the uppermost support plates shall be scrolled in the Lissajous window using Channel 5 at a numerical span setting of 10 or less. Straight-leg sections shall be scrolled at normal span settings established during calibration.

(2) Possible indications observed in Channel 5 should be confirmed using Channel 3. It is emphasized that definitive indications may not always be observed in either of the two channels. Rather, the indications may assume a noise-like structure, with multiple discrete indications occurring in close proximity over a longer axial distance.

(3) Report all confirmed indications using a Free-Span Differential (FSD) analysis code. Subsequent disposition of all reported indications will be accomplished by a resolution analyst.

(4) Single indications may be reported using a discrete location while multiple indications in close proximity may be reported using a to-from location.

(5) Figure 3 of Attachment 1 shows a flowchart illustrating U-bend data screening and reporting requirements.

6.2.3.2 Disposition (Resolution Analysts)

(1) Previous history or rotating probe diagnostics shall be used to disposition FSD's .

(2) FSD's may be further reclassified as Free-Span Indications (FSI's) or Manufacturing Burnish Mark (MBM) etc., depending on the relative response of the absolute/differential bobbin coil modes.

(3) All FSI's will be RPC'd for confirmation.

6.2.3.3 Anti-vibration Bars:

(1) Scroll Anti-vibration bar locations using Mix 1 or Mix 2.

(2) Report indications using the Mix 2 VERTMAX analysis functior Signal amplitude, as measured on the conservative leg of the indication, shall be utilized for sizing indications at AVB's.

(3) Figure 4 of Attachment 1 shows a flowchart illustrating data screening and reporting requirements.

6.2.4 Freespan Region (Straight Sections of Tubing between support plates)

6.2.4.1 Ding signals or Freespan signals discovered during data screening shall be scroled in the Lissajous window using Channels 1, 3 and 5.

6.2.4.2 Possible Indications should be detected using Channel 3.

6.2.4.3 It should be noted that generally distorted indications are more apparent in Channels 3 and 5, and often are not evident in Channel 1 because of the overwhelming horizontal response caused by local tube indentation or deformation.

6.2.4.4 Channel 1 should be used to confirm % TW. If there is a +/- 10% TW difference between channels 4 and 6, the FSD code should be used, otherwise report as MBM.

6.2.4.5 The Resoultion Analyst should be involved to evaluate all FSD's with the use of previous history. Any FSD's that grow in voltage and phase angle should be reported by the Resoultion Analyst as a FSI so that the indication will be included on the RPC list.

6.2.4.6 Figure 5 of Attachment 1 shows a flowchart illustrating data screening and reporting requirements.

6.3 Reporting Requirements

6.3.1 All quantifiable indications of tube wall degradation shall be reported. For AVB indications, the reporting threshold is 15%.

6.3.2 All non-quantifiable indications (See Appendix C, Category II) shall be reported. As a general rule, Category II indications shall be considered a repairable condition unless proven otherwise using supplemental diagnostic techniques, e.g. RPC or equivalent, or historical review.

6.3.3 Dents or dings > 5.0 volts peak-to-peak (Mix 1). With the implementation of IPC a 20% sample of dents between 2.5 and 5.0 volts will be performed.

6.3.4 Distorted dents or dings having flaw-like characteristics shall be reported as FSI in the Free-Span only. Any dents or dings found at the support plates that contain an indication should by reported as DNI's (Dent with Indication)

6.3.5 Actual test extent shall be reported as the furthest landmark from the entry leg observed.

6.4 Recording Requirements

6.4.1 As a minimum, the following graphic printouts shall be generated for each reported quantifiable indication, "I" code indication, Free-Span Differential (FSD) and LAR indication:

6.4.1.1 Multiple-channel Lissajous graphics as specified in Tables 6-4 or Table 6-5.

6.4.2 The following information will be recorded in the FINAL REPORT section of the RECORDING MEDIUM:

6.4.2.1 For each tube evaluated, an entry must be made that, as a minimum, contains the S/G, ROW, COL, and EXTENT tested.

6.4.2.2 The evaluation of all indications to include the S/G, ROW, COL, VOLTS, DEG, %, CH#, LOCATION, and EXTENT tested.

6.4.2.3 Any RESTRICTED tubes and the location where probe passage is obstructed. Restricted locations must include elevation where restriction occurs.

6.4.3 The SUMMARY portion of the RECORDING MEDIUM shall include:

6.4.3.1 All information recorded on the RECORDING MEDIUM.

Table 6-4 Eight-Channel Graphics

Location	Lissajous	Charts
Supports	1,3,5, Mix 1, 2,4,6, Mix 2	Mix 1
AVB's	1,3,5, Mix 1, 2,4,6, Mix 2	Mix 2
Free Span	1,3,5, Mix 1, 2,4,6, Mix 2	5
Top of Tubesheet	1,3,5, Mix 1, 2,4,6, Mix 2 or Mix 3	Mix 1

Table 6-5 Four-Channel Graphics

Location	Lissajous	Charts
Supports	1,3,5, Mix 1	6, Mix 1
AVB's	1,3, 6, Mix 2	6, Mix 2
Free Span	1,3,5,6	1, 5
Top of Tubesheet	1,3,5, Mix 1	5, Mix 1

7.0 ROTATING PANCAKE COIL (RPC) REQUIREMENTS

7.1 Analysis Setup

7.1.1 Examination Frequencies (see Table 7-1)

Table 7-1 Three-Coil Rotating Probe

Channel	Frequency (kHz)	Coil	Coil Type	Function
1	300	1	Pancake	General Detection
2	300	5	Circ Wound	Axial Detection
3	300	7	Axial Wound	Circumferential Detection
4	200	1	Pancake	General Confirmation
5	200	5	Circ Wound	Axial Confirmation
6	200	7	Axial Wound	Circumferential Confirmation
7	100	1	Pancake	General Confirmation
8	100	4	Pancake	Trigger
9	100	5	Circ Wound	Axial Confirmation
10	100	7	Axial Wound	Circumferential Confirmation
11	10	1	Pancake	Locator

7.1.2 Setting Mixes (Optional)

7.1.2.1 At the option of the data analysts or at the direction of the Lead Analyst, mixes may be established for information only.

7.1.3 Setting Rotations

7.1.3.1 Detection/Confirmation Channels: Set probe motion to within +/- 5° of horizontal with flaw excursions directed upwards.

7.1.3.2 Channel 8: Set the trigger pulse vertically upwards at 90°-120°.

7.1.3.3 Channel 11: Set the response of the support plate vertically downward at approximately 270°.

7.1.4 Setting Spans

7.1.4.1 *Channels 1,2,4,5,& 9*: Set spans such that the peak-to-peak response of the axially oriented 40% EDM notch is at least 25% FSH.

7.1.4.2 *Channels 3,6 & 10*: Set spans to same nominal numerical values as Channels 2,5, and 9 respectively.

7.1.4.3 *Channel 8*: Set span so that the trigger pulse occupies approximately 50% FSH.

7.1.4.4 *Channel 11*: Set span so that the support plate occupies 25%-50% FSH.

7.1.5 Setting Volts

7.1.5.1 *Pancake Coil*

(1) Set the voltage for Channel 1 to 20.00 +/- 0.3 volts on the largest peak-to-peak response of the 100% EDM notch.

(2) Normalize the voltage for other pancake coil channels (CH 4 and CH 7) in reference to Channel 1. Store to all other channels for that coil.

7.1.5.2 *Circumferential Wound Coil*

(1) Set the voltage for Channel 2 to 20.00 +/- 0.3 volts on the largest peak-to-peak response of the 100% EDM notch.

(2) Normalize the voltage for all other pancake coil channels (CH 5 and CH 9) in reference to Channel 2. Store to all other channels for that coil.

7.1.5.3 *Axial Wound Coil*

(1) Set the voltage for Channel 3 to 20.00 +/- 0.3 volts on the largest peak-to-peak response of the 100% EDM notch.

(2) Normalize the voltage for all other pancake coil channels (CH 6 and CH 10) in reference to Channel 3. Store to all other channels for that coil.

7.1.6 Setting Curves

7.1.6.1 Depth calibration curves are not required. Phase angle or amplitude curves may be established at the Analysts' option for information only.

7.1.7 Data Display

7.1.7.1 Setup the display configuration for initial data screening according to Table 7-2 using span settings established above.

Table 7-2 Display Configuration

Display	Channel
Lissajous	CH 1 (300 kHz)
Left Chart	CH 1 or CH P1 Vertical
Right Chart	CH 2 or CH 3 Vertical

7.1.8 Setting Scale and Axial Locations

7.1.8.1 Using Channel 1, set scale using the as built length of the calibration standard.

7.1.8.2 Verify proper scale setting when reporting each indication.

7.1.8.3 For support plate indications, axial locations should be referenced positively (+) upward or negatively (-) downward from the centerline (0.00) of the nearest support plate.

7.1.8.4 For top of tubesheet indications, axial locations should be referenced positively (+) upward or negatively (-)downward from the top of the tubesheet zero (0.00) reference.

7.1.9 C-Scan

7.1.9.1 C-scan features shall be adjusted consistent with the software suppliers recommended practice.

7.1.10 Indication Length Measurements

7.1.10.1 Software features for measuring indication lengths will be invoked consistent with the software supplier's recommended practice.

7.1.10.2 Setup of measurement features should be done using the nominal tube Inside Diameter (ID) and the as-built dimensions of the EDM notch standard discontinuities.

7.1.11 Filters (Optional)

7.1.11.1 At the option of the data analysts or at the direction of the Lead Analyst, bandpass filters on process channels P1, P2 and P3 using Channels 1,2 and 3 (300 KHz), respectively, may be established using the nominal settings of Table 7-3. Settings may be adjusted slightly to improve signal-to-noise.

Table 7-3 Bandpass Filter Setup

Parameter	Value
Sharpness	23 coefficients
Low cutoff frequency	10 Hz
High cutoff frequency	100 Hz

7.2 Data Evaluation

7.2.1 Screening

7.2.1.1 Review strip chart data while scrolling all acquired data using Channel 1 to establish the presence of an indication. Other analysis channels may be used for additional confirmation.

7.2.1.2 Decrease initial span settings (higher gain) as required such that proper detailed analysis is conducted on all data.

7.2.1.3 Indications which are flaw-like on any of the degradation channels shall be reported regardless of the extent to which the channels correlate.

7.2.2 Analysis

7.2.2.1 Graphic displays and relative three-coil amplitude response shall be used to determine flaw orientation and dimensionally using the basic logic summarized in Figure 7 of Attachment 1.

7.2.2.2 Three-coil relative signal response as shown in Table 7-4 may be used to assist in determining flaw dimensionally and orientation.

Table 7-4 Three-coil Relative Amplitude Response

Coil	Flaw Dimensionality/Orientation		
	Vol	Axial	Circ
Pancake	+	+	+
Axial	+	+	-
Circ	+	-	+

7.2.2.3 Three-dimensional discontinuities in general will have a comparable response from the pancake and axial/circ coils. Linear or two-dimensional discontinuities will typically show a preferred response to either the axial or circ coils (or both) dependent on flaw orientation. The pancake coil is equally sensitive to linear discontinuities independent of their orientation.

7.2.2.4 Indications with a preferred amplitude response from either the axial or circ coil shall be analyzed using a three-letter analysis code indicative of the orientation (axial or circumferential) and frequency of occurrence in a given plane. Indications with comparable amplitude responses from all three coils shall be analyzed as three-dimensional (volumetric) using an appropriate analysis code.

7.2.2.5 Locations with both axial and circumferential indications present concurrently shall be analyzed as mixed-mode.

7.3 Reporting Requirements

7.3.1 The voltage of an indication will be measured at the peak signal for each indication. This will generally be at the center most "hit" of the indication using the detection channel (CH 1 typically). Peak-to-peak voltage should be used for the voltage reading, adjusting the window width to minimize noise in the signal.

7.3.2 Indication location will be derived from the center most "hit" point of the calling channel.

7.3.3 Indications will not be reported as a percent depth, but assigned an analysis code indicative of the Dimensionality, orientation and frequency of occurrence of the flaw in a given plane. Permissible analysis codes are listed in Appendix C.

7.4 Recording Requirements

7.4.1 The following graphic printouts should be generated for each reported indication:

7.4.1.1 Main display screen typically with the Lissajous of the calling channel (CH 1), left strip chart of a low frequency channel adequate to display the bounding or nearest support and right strip chart with the vertical component of a confirmatory channel (e.g., CH P1 or CH 2).

7.4.1.2 C-scan of indication with the low frequency channel displayed on the strip chart and either the calling channel or corresponding filtered channel for the C-scan plot.

8.0 RESOLUTION CRITERIA

8.1 Primary and secondary analyses results will be compared and referred to the Lead and/or Resolution analysts for resolution and disposition.

8.2 Conditions requiring resolution include:

8.2.1 All quantifiable indications > 40% through-wall, and Category 2 Indications listed in Appendix C where primary and secondary analysis results do not match.

8.2.2 Quantifiable indications between 20% and 39% reported by one Analyst but not the other.

8.2.3 Indications in which the depth estimate differs by more than 10% through-wall

8.2.4 Indications for which location measurements differ by more than;

8.2.4.1 +/- 1" for free-span.

8.2.4.2 +/- 0.5" at support structures.

8.2.5 Indications at tube support plates for plants implementing IPC for which;

8.2.5.1 Bobbin coil indications are greater than the repair limit voltage where primary and secondary analysis results do not match.

8.2.5.2 The reported location extends beyond either support plate edge.

8.2.5.3 Indications are diagnosed as circumferential cracking by RPC.

8.2.5.4 The bobbin coil voltage values called by primary and secondary analysts deviate by more than 20% and one or both calls exceeds 1 volt.

8.2.5.5 All large mix residuals that could mask a 1.0 volt indication found at TSP's.

8.2.6 Reporting errors or discrepancies in such items as steam generator, tube or reel ID, probe type, extent tested, analysis code assignment, etc.

8.2.7 One analyst reports a tube not reported by another.

8.3 Any tube with an initially reported repairable condition - by either the primary or secondary analyst, or both - that is subsequently resolved to a non-repairable condition during resolution - shall be reported to a ComEd representative for information.

APPENDIX A
DATA ACQUISITION AND ANALYSIS REQUIREMENTS FOR TSP ODSCC

A.1.0 INTRODUCTION

A.1.1 This appendix documents techniques for the inspection of Byron and Braidwood Unit 1 steam generator tubes related to the identification of ODSCC or IGA/SCC at tube support plate (TSP) regions.

A.1.2 This appendix contains guidelines which provide direction in applying the ODSCC Interim Plugging Criteria (IPC) described in this report. The procedures for eddy current testing using bobbin coil (BC) and rotating pancake coil (RPC) techniques are summarized. The procedures given apply to the bobbin coil inspection, except as explicitly noted for RPC inspection. The methods and techniques detailed in this appendix are requisite for implementation of TSP IPC.

Note: ***The following sections define specific acquisition and analysis parameters and methods to be used for the inspection of steam generator tubing.***

A.2.0 DATA ACQUISITION

Note: ***Byron and Braidwood Unit 1 steam generators utilize 3/4" OD x 0.043" wall, Alloy 600 mill-annealed tubing. The carbon steel support plates and baffle plates are designed with drilled holes.***

A.2.1 **Instrumentation** utilized shall be the Zetec MIZ-18 (For the acquisition of Eddy current data) equipment, the Echoram ERDAU or other equipment with similar specifications.

A.2.2 **Probes** which will be used are the following:

A.2.2.1 Bobbin Coil Probes - To maximize consistency with laboratory IPC data, differential probes with the following parameters shall be used for examination of IPC tube support plate intersections:

(a) 0.610 outer diameter

(b) Two bobbin coils, each 60 mils long, with 60 mils between coils (coil centers separated by 120 mils)

(c) In addition, the probe design must incorporate centering features that provide for minimum probe wobble and offset; the centering features must maintain constant probe center to tube ID offset for nominal diameter tubing. For locations which must be inspected with smaller than nominal diameter probes, it is essential that the reduced diameter probe be calibrated to the reference normalization (Section A.2.6.1 and Section A.2.6.2) and that the centering features permit constant probe center to tube ID offset. Probes must have centering adjustment that collapse to the reference probe diameter.

(d) Once probe has been calibrated on the 20% TW holes, the voltages response for new bobbin coil probes for the 40% TW to 100% TW holes should not differ from the nominal voltage by more than 10%.

A.2.2.2 Rotating Pancake Coil Probes - Pancake coil designs (vertical dipole moment) with a coil diameter d, where d is 0.060" < d < 0.125", shall be used. While other multi-coil (i.e., 1,2 or 3-coil) probes can be utilized, it is recommended that if a 3-coil probe is used, any voltage measurements should be made with the probe's pancake coil rather than its circumferential or axial coil.

(a) The maximum probe pulling speed shall be 0.2 in./sec for the 1-coil or 3-coil probe, or 0.4 in/sec. for the 2-coil probe. The maximum rotation shall be 300 rpm. This would result in a pitch of 40 mils for the 3-coil probe.

A.2.3 <u>Calibration Standards to be utilized for IPC</u>

A.2.3.1 Bobbin Coil Standards - These standards will meet the following criteria:

A.2.3.1.1 Voltage Normalization Standard

> *Note:* ***All holes shall be machined using a mechanical drilling technique. This calibration standard will need to be calibrated against the reference standard used for the IPC laboratory work by direct testing or through the use of a transfer standard.***

(a) One 0.052" diameter 100% through wall hole

(b) Four 0.028" diameter through wall holes, 90 degrees apart in a single plane around the tube circumference; the hole diameter tolerance shall be +/- 0.001" (optional).

(c) One 0.109" diameter flat bottom hole, 60% through from OD

(d) One 0.187" diameter flat bottom hole, 40% through from the OD

(e) Four 0.187" diameter flat bottom holes, 20% through from the OD, spaced 90 apart in a single plane around the tube circumference. The tolerance on hole diameter and depth shall be +/-0.001".

(f) A simulated support ring, 0.75" long, comprised of SA-285 Grade C carbon steel or equivalent.

A.2.3.1.2 Probe Wear Standard

> *Note:* ***A probe wear standard is used for monitoring the degradation of probe centering devices leading to off-center coil positioning and potential variations in flaw amplitude responses.***

(a) Contains four 0.052" +/- 0.001 inch diameter through-wall holes, spaced 90 degrees apart around the tube circumference.

(b) Has axial spacing such that signals can be clearly distinguished from one another. See Figure A-1.

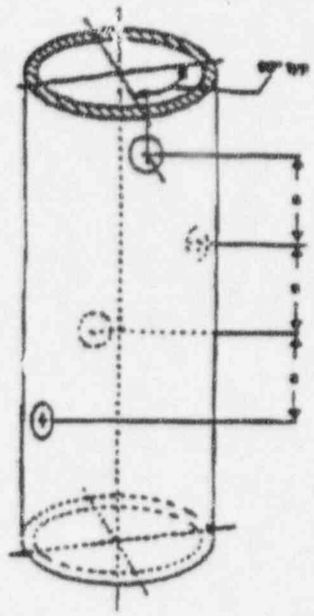


Figure A-1: Probe Wear Standard Schematic

A.2.3.2 Rotating Probe Standard - This standard may contain the following:

(a) Two axial EDM notches, located at the same axial position but 180 degrees apart circumferential, each 0.006" wide and 0.5" long, one 80% and one 100% through wall from the OD.

(b) Two axial EDM notches, located at the same axial position but 180 degrees apart circumferentially, each 0.006" wide and 0.5" long, one 60% and one 40% through-wall from the OD.

(c) Two circumferntial EDM notches, one 50% through wall from the OD with a 75 degree (0.49" arc length), and one 100% through wall with a 26 degree (0.20") arc length, with both notches 0.006" wide.

(d) A simulated support segment 270 degrees in circumferential extent, 0.75" thick, comprised of SA-285 Grade C carbon steel or equivalent.

(e) The center to center distance between the support plate simulation and the nearest slot shall be at least 1.25". The center to center distance between the EDM notches shall be at least 1.0". The tolerance for the widths and depths of the notches shall be 0.001". The tolerance for slot lengths shall be 0.010".

A.2.4 <u>Application of Bobbin Coil Wear Standard</u>

A.2.4.1 A calibration standard has been designed to monitor bobbin coil probe wear. During steam generator examination, the bobbin probe is inserted into the wear monitoring standard; the initial (new probe) amplitude response from each of the four holes is determined and compared on an individual basis with subsequent measurements. Signal amplitudes or voltages from the individual holes - compared with their initial amplitudes - must remain within 15% of their initial amplitude (i.e., {(worn-new)/new} for an acceptable probe wear condition. If this condition is not satisfied, then the probe

must be replaced. All tubes since the last acceptable probe wear measurement must be re-inspectected with the new probe.

A.2.4.2 Bobbin Coil Wear Standard Placement Under ideal circumstances, the incorporation of a wear standard in line with the conduit and guide tube configuration would provide continuous monitoring of the behavior of bobbin probe wear. However, the curvature of the channel head places restrictions on the length on in line tubing inserts which can be accommodated. The spacing of the ASME Section XI holes and the wear standard results in a length of tubing which cannot be freely positioned within the restricted space available. The flexible conduit sections inside the channel head, together with the guide tube, limit the space available for additional in line components. Voltage responses for the wear standard are sensitive to bending of the leads, and mock up tests have shown sensitivity to the robot end effector position in the tubesheet, even when the wear standard is placed on the bottom of the channel head. Wear standard measurements must permit some optimization of positions for the measurement and this should be a periodic measurement for inspection efficiency. The preexisting requirement to check calibration using the ASME tubing standard is satisfied by periodic probing at the beginning and end of each probe's use as well as at four hour intervals. This frequency is adequate for wear standard purposes as well. Evaluating the probe wear under uncontrollable circumstances would present variability in response due to channel head orientations rather than changes in the probe itself.

A.2.5 Acquisition Parameters

Note: The following parameters apply to bobbin coil data acquisition and should be incorporated in the applicable inspection procedures to supplement (not necessarily replace) the parameters normally used.

A.2.5.1 Test Frequencies

A.2.5.1.1 This technique requires the use of bobbin coil 550 kHz and 130 kHz test frequencies in the differential mode. It is recommended that the absolute mode also be used, at test frequencies of 130 kHz and 10 - 35 kHz. The low frequency (10-35 kHz) channel should be recorded to provide a means of verifying tube support plate edge detection for flaw location purposes. The 550/130 kHz mix or the 550 kHz differential channel is used to access changes in signal amplitude for the probe wear standard as well as for flaw detection.

A.2.5.1.2 RPC frequencies should include channels adequate for detection of OD degradation in the range of 100 kHz to 550 kHz, as well as a low frequency channel to support location of the TSP edges.

A.2.5.2 Digitizing Rate

A.2.5.2.1 A minimum digitizing rate of 30 samples per inch should be used. Combinations of probe speeds and instrument sample rates should be chosen such that:

$$\frac{\text{Sample Rate (samples/sec.)}}{\text{Probe Speed (in/sec)}} \geq 30 \text{ (samples/in.)}$$

A.2.6 <u>Analysis Parameters</u>

Note: This section discusses 1) the methodology for establishing bobbin coil data analysis variables such as spans, rotations, mixes, voltage scales, and calibration curves. Although indicated depth measurement may not be required to support an alternative repair limit, the methodology for establishing the calibration curves is presented. The use of these curves is recommended for consistency in reporting and to provide compatibility of results with subsequent inspections of the same steam generator and for comparison with other steam generators and/or plants.

A.2.6.1 Bobbin Coil 550 kHz Differential Channel

Note: (1) For all new probes the analyst must minimize mix residuals on the calibration standard as applicable
(2) Probes exceeding the 15% sensitivity voltage for wear shall be disposed and all tubes since the last sucessful measurement for probe wear shall be re-inspected with the new probe.

A.2.6.1.1 *Spans and Rotations*: Spans and rotations can be set at the discretion of the user and/or in accordance with applicable procedures, but all TSP intersections must be viewed at a span setting one-half or less than that which provides 3/4 full screen amplitude for 4x20% holes with bobbin probes and 1/10 or less the corresponding span for 0.5" long through-wall slot (EDM notch) with RPC probes.

A.2.6.1.2 *Voltage Scale*: The peak-to-peak signal amplitude of the signal from the four 20% through-wall holes should be set to produce a voltage equivalent to that obtained from the IPC lab standard. The laboratory standard normalization voltages are 4.0 volts at 550 kHz and 2.75 volts for the 550/130 kHz mix.

Note: The transfer/field standard will be calibrated against the laboratory standard using a reference laboratory probe to establish voltages for the field standard that are equivalent to the above laboratory standard. These equivalent voltages are then set on the field standard to establish calibration voltages for any other standard.

(a) Voltage normalization to the standard calibration voltages at 550 kHz is the preferred normalization to minimize analyst sensitivity in establishing the mix. However, if the bobbin probes used result in a 550/130 kHz mix to 550 kHz voltage ratios differing from the laboratory standard ratio of 0.69 by more than 5% (0.66 to 0.72), the 550/130 kHz mix calibration voltage should be used for voltage normalization.

A.2.6.1.3 *Calibration Curve*: Establish a phase versus depth calibration curve using measured signal phase angles in combination with the "as-built" flaw depths for the 100%, 60%, and 20% holes.

A.2.6.2 Bobbin Coil 550/130 kHz Differential Mix Channel

A.2.6.2.1 *Spans and Rotations*: Spans and rotations can be set at the discretion of the user and/or in accordance with applicable procedures.

A.2.6.2.2 Voltage scale: See Section A.2.6.1

A.2.6.2.3 Calibration Curve: Mix 1 is a 550/130 kHz differential support mix; mix on ASME standard support ring. Set 3-point phase angle-depth calibration curve using ASME 100%, 60%, and 20% drill hole signals. Mix 1 is the primary channel for reporting indications at support structures.

A.2.6.3 Rotating Pancake Coil Channel

A.2.6.3.1 Voltage Scale: The RPC amplitude will be referenced to 20 volts for a 0.5 inch long 100% through wall notch at 300 kHz. Each channel shall be set individually to the desired amplitude for the EDM notches on the plant standards; cross calibration will be achieved by comparison of the RPC responses from the 100% drilled hole.

A.2.7 Analysis Methodology

A.2.7.1 Bobbin coil indications at support plates attributable to ODSCC are quantified using the Mix 1 (550 kHz/130 kHz) data channel. This is illustrated with the example shown in Figure A-2. The 500/130 kHz mix channel or other channels appropriate for flaw detection (550 kHz, 300 kHz, or 130 kHz) may be used to locate the indications of interest within the support plate signal. The largest amplitude portion of the Lissajous signal representing the flaw should then be measured using the 550/130 kHz Mix 1 channel to establish the peak-to-peak voltage as shown in Figure A-2. Initial placement of the dots for identification of the flaw location may be performed as shown in Figures A-3 and A-4, but the final peak-to-peak measurements must be performed on the Mix 1 Lissajous signal to include the full flaw segment of the signal. It may be necessary to iterate the positions of the dots between the identifying frequency and the 550/130 kHz mix to obtain proper placement. As can be seen in Figure A-4, failure to do so can reduce the voltage measurement of Mix 1 by as much as 65% to 70% due to the interference of the support plate signal in the raw frequencies. The voltage as measured from Mix 1 is then entered as the analysis of record for comparison with the repair limit voltage.

A.2.7.2 To support the uncertainty allowances maintained in the IPC, the difference in amplitude measurements for each indication will be limited to 20%. If the voltage values called by the independent analysts deviate by more than 20% and one or both of the calls exceeds 1.0 volts, analysis by the resolution analyst will be performed. These triplicate analyses result in assurance that the voltage reported departs from the correct call by no more than 20%.

A.2.8 Reporting Guidelines

Note: The reporting requirements identified below, are in addition to any other reporting requirements specified by the user

A.2.8.1 Minimum Requirements

A.2.8.1.1 All bobbin coil flaw indications in the 550/130 kHz mix channel at the tube support plate intersections regardless of the peak-to-peak signal amplitude must be reported. All TSP locations with indications exceeding the repair limit must be examined with RPC probes.

A.2.8.2 Additional Requirements

A.2.8.2.1 For each reported indication, the following information should also be recorded:

(a) Tube identification (row, column)
(b) Signal amplitude (volts)
(c) Signal phase angle (degrees)
(d) Indication (3 letter code)
(e) Test Channel (ch#)
(f) Axial position of tube (location)
(g) Extent of test (extent)
(h) Pobe size
(I) Tape #

2.8.2.2 RPC reporting requirements should include as a minimum: type of degradation (axial, circumferential or other), maximum voltage, phase angle, crack lengths, and location of the center of the crack within the TSP. The crack axial center to edge need not coincide with the position of maximum amplitude. Locations which do not exhibit flaw-like indications in the RPC isometric plots may continue in service, except that all intersections exhibiting flaw-like bobbin behavior and bobbin amplitudes in excess of the repair limit voltage must be repaired, notwithstanding the RPC analyses. RPC isometrics should be interpreted by the analyst to characterize the signals observed; only featureless isometrics are to be reported as NDD. Signals not interpreted as flaws include dents, liftoff, deposits, copper, magnetite, etc.

A.3.0 DATA EVALUATION

A.3.1 Use of 550/130 Differential Mix for Extracting the Bobbin Flaw Signal

A.3.1.1 In order to identify a discontinuity in the composite signal as an indication of a flaw in the tube wall, a simple signal processing procedure of mixing the data from the two test frequencies is used which reduces the interference from the support plate signal by approximately one order of magnitude. The test frequencies most often used for this signal processing are 550 kHz and 130 kHz for 43 mil wall Alloy 600 tubing. Any of the differential data channels including the mix channel may be used for flaw detection (though the 130 kHz is often subject to the influence from many different effects), but the final evaluation of signal detection, amplitude and phase angle will be made from the 550/130 kHz differential mix channel. Upon detection of a flaw signal in the differential mix channel, confirmation from other raw channels is not required; all such signals must be reported as indications of possible ODSCC. The voltage scale for the 550/130 kHz differential channel should be normalized as described in Section A.2.1.6.1 and A.2.1.6.2.

A.3.1.2 The present evaluation procedure requires that there is no minimum voltage for flaw detection purposes and that all flaw signals, however small, be identified. The intersections with flaw signals > the repair limit will be inspected with RPC. Although the signal voltage is not a measure of flaw depth, it is an indicator of the tube burst pressure when the flaw is identified as axial ODSCC with or without minor IGA.

A.3.2 Amplitude Variability

A.3.2.1 It has been observed that voltage measurements taken from the same data by different analysts may vary, even when using identical analysis guidelines. This is largely due to differences in analyst interpretation of where to place the dots on the lissajous figure for the peak-to-peak amplitude measurement. Figures A-5 and A-6 show the correct placement of the dots on the Mix 1 Lissajous figures for the peak-to-peak voltage amplitude measurements for two tubes from Plant S. In Figure A-5, the placement is quite obvious. In Figure A-6, the placement requires slightly more of a judgment call. Figures A-7 and A-8 show these same two tubes with peak-to-peak measurements being made, but in both cases the dots have been placed at locations where the normal max-rate dots would be located. The reduction in the voltage amplitude measurement is 19.3% in Figure A-7 and 16.3% in Figure A-8. While this is an accepted method of analysis for phase-angle measurements, it is not appropriate for the voltage amplitude measurements required.

A.3.2.2 In Figures A-5 and A-6, the locations of the dots for the peak-to-peak measurements being performed from Mix 1 show the corresponding dots on the 550 kHz raw frequencies as also being located at the peak or maximum points of the flaw portion of the Lissajous figure. In no case should the dots to measure the voltage amplitude be at locations less than the maximum points of the flaw portion of the 550 kHz raw frequency.

A.3.2.3 Figure A-9 is an example of where the dots have been placed on the transition region of the 550 kHz raw frequency data Lissajous figure. It is clear from the Mix 1 Lissajous figure that this does not correspond to the maximum voltage measurement. The correct placement on the Mix 1 Lissajous figure is shown in Figure A-10. This placement also corresponds to the maximum voltage measurement on the 550 kHz raw frequency data channel.

A.3.2.4 In some cases, it will be found that little if any definitive help is available from the use of the raw frequencies. Such as the example shown in Figure A-11, where there are no significantly sharp transitions in any of the raw frequencies. Consequently, the placement of the measurement dots must be made completely on the basis of the Mix 1 channel Lissajous figure as shown in the upper left of the graphic. An even more difficult example is shown in Figure A-12. The logic behind the placement of the dots in Mix 1 is that sharp transitions in the residual support plate signals can be observed at the locations of both dots. In the following graphic, Figure A-13, somewhat the same logic could be applied in determining the flaw-like portion of the signal from the Mix 1 Lissajous pattern. However, inasmuch as there is no sharp, clearly defined transition, coupled with the fact that the entry lobe into the support plate is distorted on all of the raw frequencies, the dots should be placed as shown in Figure A-14. This is a conservative approach and should be taken whenever a degree of doubt as to the dot placement exists.

A.3.2.5 It is noted that by employing these techniques, identification of flaws is improved and that conservative amplitude measurements are promoted. The Mix 1 traces which result from this approach confirm to the model of TSP ODSCC which represents the degradation as a series of microcrack segments axially integrated by the bobbin coil; i.e., short segments of changing phase angle direction represent changes in average depth with changing axial position. This procedure may not yield the maximum bobbin depth call. If maximum depth is desired for information purposes, shorter segments of the overall crack may have to be evaluated to obtain the maximum depth estimate.

However, the peak to peak voltages as described herein must be reported, even if a different segment is used for the depth call.

A.3.3 Alloy Property Changes

> Note: ***Only thoseAll mix residuals located at tube supports that could mask a 1.0 volt indication shall be reported as MRI (Mix Residual Indication) and these indications will be included on the RPC list. Large mix residuals are those that could cause a 1.0 volt indication to be missed or misread. Any indications found at such intersections with RPC shall be repaired.***

A.3.3.1 This signal manifests itself as part of the support plate "mix residual" in both the differential and absolute mix channels. It has often been confused with copper deposits as the cause. Such signals are often found at support plate intersections of operating plants, as well as in some model boiler test samples, and are not necessarily indicative of tube wall degradation. Six support plate intersections from Plant A, judged as free of tube wall degradation on the basis of the mixed differential channel using the guidelines given in Section A.2.7 of this document, were pulled in 1989. Examples of the bobbin coil field data are shown in Figure A-15. (inspection data from a plant with 7/8 inch diameter tubing.) The mix residual for this example is approximately 3 volts in the differential mix channel and no discontinuity suggestive of a flaw can be found in this channel. An offset in the absolute mix channel which could be confused as a possible indication is also present. These signals persisted without any significant change even after chemically cleaning the OD and the ID of the tubes. The destructive examination of these intersections showed very minor or no tube wall degradation. Thus, the overall "residuals" of both the differential and absolute mix channels were not indications of tube wall degradation. One needs to examine the detailed structure of the "mix residual" (as outlined in Section A.2.7) in order to assess the possibility that a flaw signal is present in the residual composite. Verification of the integrity of TSP intersections exhibiting alloy property or artifact signals is accomplished by RPC testing of a representative sample of such signals.

A.3.4 Copper and Denting Interference's

A.3.4.1 Copper Interference

> Note: ***All intersections with interferring copper deposits shall be inspected with RPC. All indications found at such intersections with RPC shall be repaired.***

(a) In situations where significant copper interference in the eddy current data is noted, the eddy current technique basically becomes unreliable. This results from the unpredictability of the amount and morphology of copper deposit on the tubes which may be found in operating steam generators. The above observation is true both for bobbin and RPC or any other eddy current probe. Fortunately, significant copper interference has not occurred in the support plate crevice regions at Byron or Braidwood. Copper is not expected to become a problem since both Byron and Braidwood contain copper free secondary plants.

(b) Inspections with RPC and bobbin probes have shown good correlation for flaw amplitudes exceeding 1.0 volt; i.e., more than 50% of the bobbin signals identified have been confirmed to exhibit flaws to the RPC probe. This suggests that spurious signals from conductive deposits do not result in excessively high false call rates. Furthermore, signals judged as NDD with the bobbin guidelines have

been confirmed to be free of RPC detectable flaws. Copper is a concern for NDE only when plated directly on the tube surface in elemental form. Copper particles with the sludge in the crevice do not significantly influence the eddy current response. To Westinghouse's knowledge, no pulled tubes have been identified with copper deposits on the tube at the TSP intersections - in contrast with free span tubing. Copper deposits have not been identified at TSP intersections in the Byron or Braidwood steam generators and no copper alloys are used in the secondary system. Thus, it is not expected that copper influence will significantly influence the TSP signals in the Byron or Braidwood steam generators.

A.3.4.2 Dent Interference

Note: All interesections with dent signals greater than or equal to 2.5 volts shall be reported by the analyst. All dents > 5.0 volts will be inspected using RPC and 20% of dents at supports between 2.5 and 5.0 volts will be inspected using RPC. All dents > 5.0 volts that contain an indication per RPC shall be repaired.

(a) The 550/130 kHz (differential) support plate suppression mix reduces or eliminates the support plate and the magnetite which may be present with the support plate, but the resulting processed signal will still be a composite flaw, other artifacts and a dent, if present. These composite signals represent vectorial combinations of the constituent effects, and as such they may not conform to the behavior expected from simple flaw simulations as a function of test frequencies.

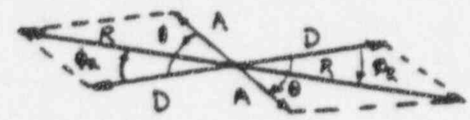
(b) The effect of the dent on the detection and evaluation of a flaw signal depends on both the relative amplitudes of the flaw and dent signals and the relative spatial relationship between them, If the flaw is located near the center of the dent signal, interference with flaw detection may become insignificant, even for relatively large dent to flaw ratios. The flaws signal in a typical support plate dent in this event occurs at mid-plane, away from the support plate edges where the dent signal exhibits maximum voltage; thus the flaw in the middle section of the support plate appears as a discontinuity in the middle of the composite signal. It can be observed in Figures A-20 through A-25, from Plant A, that one can often extract a flaw signal even when the flaw signal-to-noise ratio (S/N) is less than unity. The question of S/N ratio requirements necessary for flaw detection is not a number that can be readily determined; but as can be seen from these figures, even with ratios as low as 0.184/1.0, the flaw signal can be detected and evaluated.

(c) The greatest challenge to flaw detection due to dent interference occurs when the flaw occurs at the peak of the dent signal. Detection of flaw signals of amplitudes equal to or greater than 1.0 volts (flaws greater that 1 .0 volts require RPC testing) in the presence of peak dent voltages can be understood by vectorial combination of a 1.0 volt flaw signal across the range of phase angles associated with 40% (110 degrees) to 100% (40 degrees) through wall penetrations with dent signals of various amplitudes. It is easily shown that 1.0 volt flaw signals combined with dent signals up to approximately 5.0 volts peak to peak will yield resultant signals with phase angles that fall within the flaw reporting range, and in all cases will exceed 1.0 volts. All such dent signals with a flaw indication signal will be subjected to RPC testing. To demonstrate this, one-half the dent peak-to-peak voltage (entrance of exit lobe) can be combined with the 1.0 volt flaw signal at the desired phase angle.

(d) The Plant A inspection data is shown in Figures A-20 through A-25 to permit flaw detection and evaluation for flaws situated away from the peak dent voltages.

The vector combination analysis shows that for moderate dent voltages where flaws occur coincident with dent entrance or exit locations, flaw detection at the 1.5 volts amplitude level is successful via phase discrimination of combined flaw/dent signals from dent only signals.

(e) The vector addition model for axial cracks coincident with denting at the TSP edge is illustrated as follows:



where R = Resultant Signal Amplitude
A = Flaw Signal Amplitude
D = TSP Dent Amplitude - one edge (Peak-to-Peak = 2D)
0 = Flaw Signal Phase Angle
(100% = 40°; 40% ~110°)
ϕ_R = Phase Angle of Resultant Signal

and

$R^2 = (D + A\cos\theta)^2 + (A\sin\theta)^2$

$\theta_R = \arctan^{-1} (A\sin/D + A\cos\theta)$

Note: ***For dents without flaws, a nominal phase angle of 180° is expected. The presence of a flaw results in rotation of the phase angle to < 180° and into the flaw plane. A phase angle of 170 (10°) away from nominal dent signal) provides a sufficient change to identify a flaw. For dents with peak-to-peak amplitude of 5.0 volts, D = 2.5 v and the minimum phase angle rotation (OR) for a 1.0 volt ODSCC flaw signal greater than 40% through-wall is predicted to be at least 11°, sufficiently distinguishable from the 180° (0°) phase angle associated with a simple dent.***

(f) Supplement information to reinforce this phase discrimination basis for flaw identification can be obtained by examination of a 300/130 kHz mix channel; dent response would be lessened while the OD originating flaw response is increased relative to the 550/130 kHz mix. RPC testing of indications identified in this fashion will confirm the dependability of flaw signal detection. Intersections with dent voltages exceeding 5.0 volts for which 1.0 volt flaws may not be detectable, are candidates for RPC inspection of dented TSP intersections.

A.3.5 <u>TSP Noise Criteria</u>

Note: ***Data which contain quantitaive noise criteria (resulting from electrical noise, tube noise, calibration standard noise shall be re-inspected***

A.3.5.1 Eddy current data acquired from active tubes and calibration standards shall be reviewed for the presence of electrical and tube noise with the following criteria:

(a) *ID Chatter or Pilgering Noise*-Tubes identified with noise associated with ID chatter or pilgering at TSP locations in excess of 5 volts peak-to-peak shall be inspected with RPC. If a flaw is confirmed with RPC, the tube shall be repaired.

(b) *Probe Noise*-Electrical noise due to a failing or intermittent probe is readily recognizable as the noise signal often assumes the shape of a random square wave modulating the eddy current signal. General eddy current data quality must be monitored to ensure that a minimum 3:1 signal to noise (S/N) is maintained.

(c) *Noise Spiking*-Electrical or noise spikes at TSP's in excess of 0.3 volts peak-to-peak on the vertical channel will be rejected by the analyst and the tube will be reexamined.

Note: Data failing to meet the above requirements should be rejected and the tube should be re-inspected.

A.3.5.2 The data analysts must continuously verify probe acceptability for each tube examined by reviewing the overall quality of the data and determining if the probe is causing undesirable and interfering signal responses.

A.3.5.3 EPRI is currently developing a quantified noise criteria for industry use. The above criteria will be employed at Byron and Braidwood until the EPRI noise criteria is employed.

A.3.6 RPC Flaw Characterization

3.6.1 The RPC inspection of some support plate intersections with bobbin coil indications > 1.0 volts is recommended in order to verify the applicability of the alternate repair limit. This is based on establishing the presence of ODSCC with minor IGA as the cause of the bobbin indications.

Note: The signal voltage for RPC data evaluation will be based on 20 volts for the 100% through-wall 0.5" long EDM notch at all frequencies.

3.6.2 The nature of the degradation and its orientation (axial or circumferential) will be determined from careful examination of the isometric plots of the RPC data. The presence of axial ODSCC at the support plates has been well documented, but the presence of circumferential indications related to ODSCC at support plate intersections has also been established by tube pulls at two plants. Figures A-16 to A-18 show examples of single and multiple axial ODSCC from Plant S.

3.6.3 Figure A-19 is an example of a circumferential indication related to ODSCC at a tube support plate location from another plant. If circumferential involvement results from circumferential cracks as opposed to multiple axial cracks, discrimination between axial and circumferentially oriented cracking can be generally established for affected arc lengths of about 45 degrees to 60 degrees or larger. Axial cracking has been found by pulled tube exams for RPC arcs of 150 degrees when the axial extent is significant, such as > 0.2 inch.

Note: Pancake coil resolution is considered adequate for separation between circumferential and axial cracks. This can be supplemented by careful interpretation of 3-coil results. Since denting has not occurred at the Byron or Braidwood units, circumferential cracking is not expected to happen at the support plates.

3.6.4 The presence of IGA as a local effect directly adjacent to crack faces is expected to be indistinguishable from the crack responses and as such of no structural consequence. When IGA exists as a general phenomenon, the eddy current response is proportional to the volume of affected tube material, with phase angle corresponding to depth of penetration and amplitude relatively larger than that expected for small cracks. The presence of distributed cracking, e.g., cellular SCC, may produce responses from microcracks of sufficient individual dimensions to be detected but not resolved by the RPC, resulting in volumetric responses similar to three-dimensional degradation.

*Note: **For hot leg TSP locations, there is little industry experience on the basis of tube pulls for volumetric degradation, i.e., actual wall loss or general IGA. For cold leg TSP locations, considerable experience is available for volumetric degradation in the form of thinning of peripheral tubes, favoring the lower TSP elevations. Therefore, in the absence of confirmed pulled tube experience to the contrary, volumetric OD indications at hot-leg tube support plates should be considered to represent ODSCC.***

A.3.7 Confinement of ODSCC/IGA Within the Support Plate Region

A.3.7.1 The measurement of axial crack lengths from RPC isometrics can be determined using the following analysis practices. For the location of interest, the low frequency channel (e.g. 10 kHz) is used to set a local scale for measurement. By establishing the midpoint of the support plate response, a reference point for indication location is established. Calibration of the distance scale is accomplished by setting the displacement between the 10 kHz absolute, upper and lower support plate transitions equal to 0.75 inch.

A.3.7.2 In order to establish that a bobbin indication is within the support plate, the displacement of each end of the signal is measured relative to the support plate center. The field measurement is then corrected for field spread (look-ahead) to determine the true distance from the TSP center to the crack tip. If this distance exceeds one-half the support plate axial length (0.375"), the crack will be considered to have progressed outside the support plate. This condition requires LAR and will be reported to the site representative. Dispositioning of the conditions may include further inspection with RPC. Per the repair criteria, indications, extending outside the support plate require tube repair.

A.3.8 Length Determination with RPC Probes

A.3.8.1 At the analysis frequency, either 300 kHz or 400 kHz, the ends of the crack are located using the slope-intercept method; i.e., the leading and trailing edges of the signal pattern are extrapolated to cross the null baseline (see Figure A-26). The difference between these two positions is the crack length estimate. Alternately, the number of scan lines indicating the presence of flaw behavior times the pitch of the RPC provides an estimate of the crack length which must be corrected for EC field spread.

A.3.9 RPC Inspection Plan

A.3.9.1 The RPC inspection plan will include the following upon implementation of the IPC repair limits:

(a) Bobbin voltage indications > than 1 volt

(b) All intersections with interferring signals from copper deposits.

(c) All intersections with dent signals greater than 5.0 volts and a 20% sample of dent signals between 2.5 and 5.0 volts.

(d) All intersections with large mix residuals that could mask a 1.0 volt indication.

(e) All intersections which may exhibit PWSCC or circumferentially initiated cracks at the supports.

Note: It is ComEd's standard practice to use 3-coil RPC probes, incorporating a pancake coil, an axial preference coil, and a circumferential preference coil. Comparisons for ODSCC with bobbin amplitudes exceeding 1.0 volts have shown that the pancake coil fulfills the need for discrimination between axial and circumferential indications, when compared against the outputs of the preferred direction coils. Pancake coils have been the basis for reporting RPC voltages for model boiler and pulled tube indications in the IPC database; these data permit semi-quantitative judgments on the potential significance of RPC indications. The requirements for a pancake coil is satisfied by the single coil, 2-coil, and 3-coil probes in common use for RPC inspections.

Figure A-2: Bobbin Coil Amplitude Analysis of ODSCC at TSP.

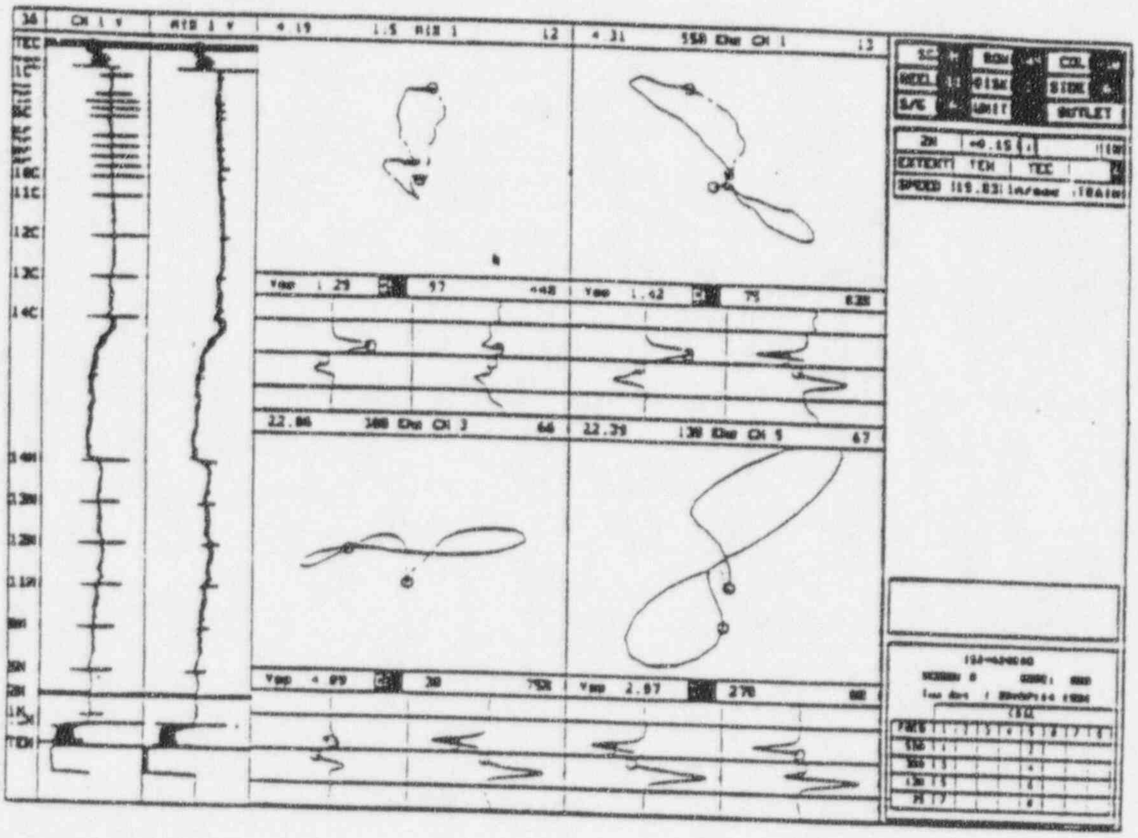


Figure A-3: Bobbin Coil Amplitude Analysis of ODSCC Indication at TSP - Improper Identification of Full Flaw Segment Resulting in Reduced Voltage Measurement When Compared with Figure A-2.

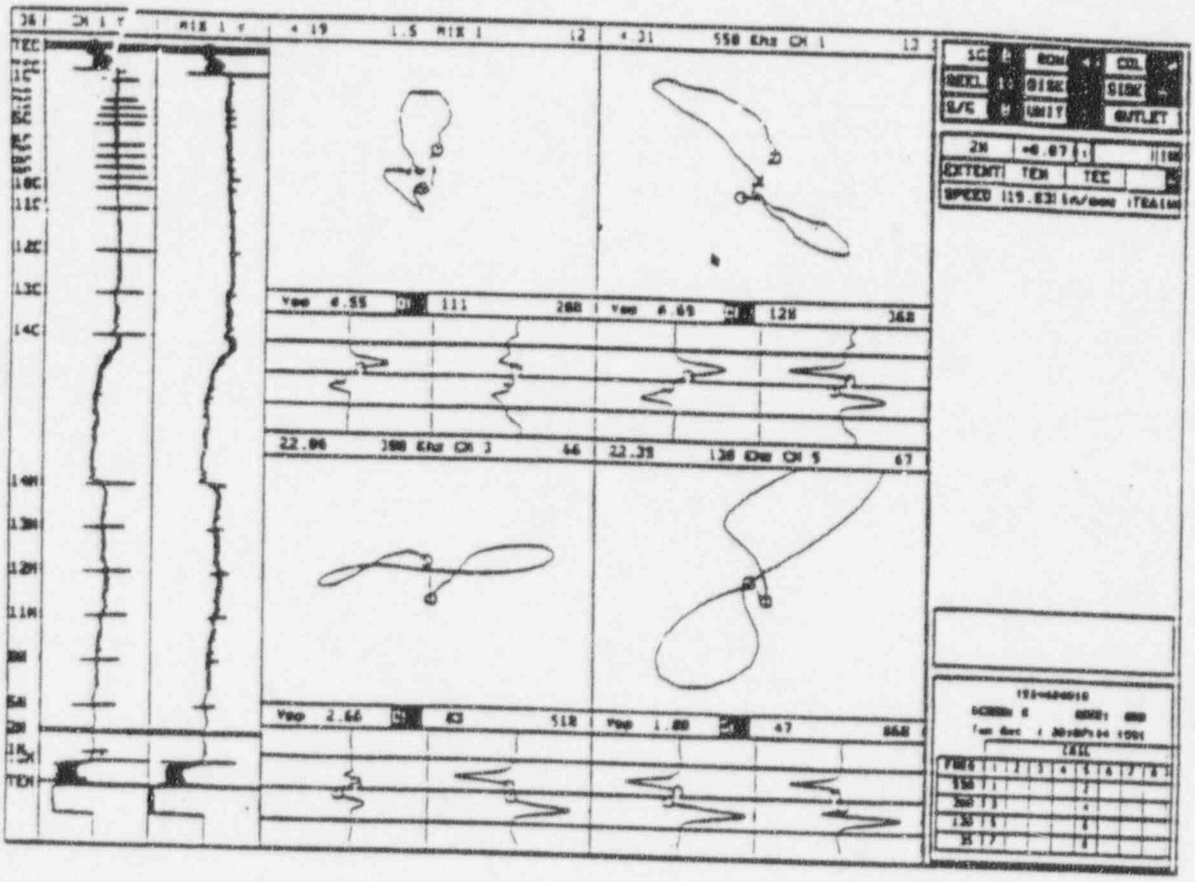


Figure A-4: Bobbin Coil Amplitude Analysis of ODSCC Indication at TSP - Improper Identification of Full Flaw Segment Resulting in Reduced Voltage Measurement When Compared to Figure A-2.

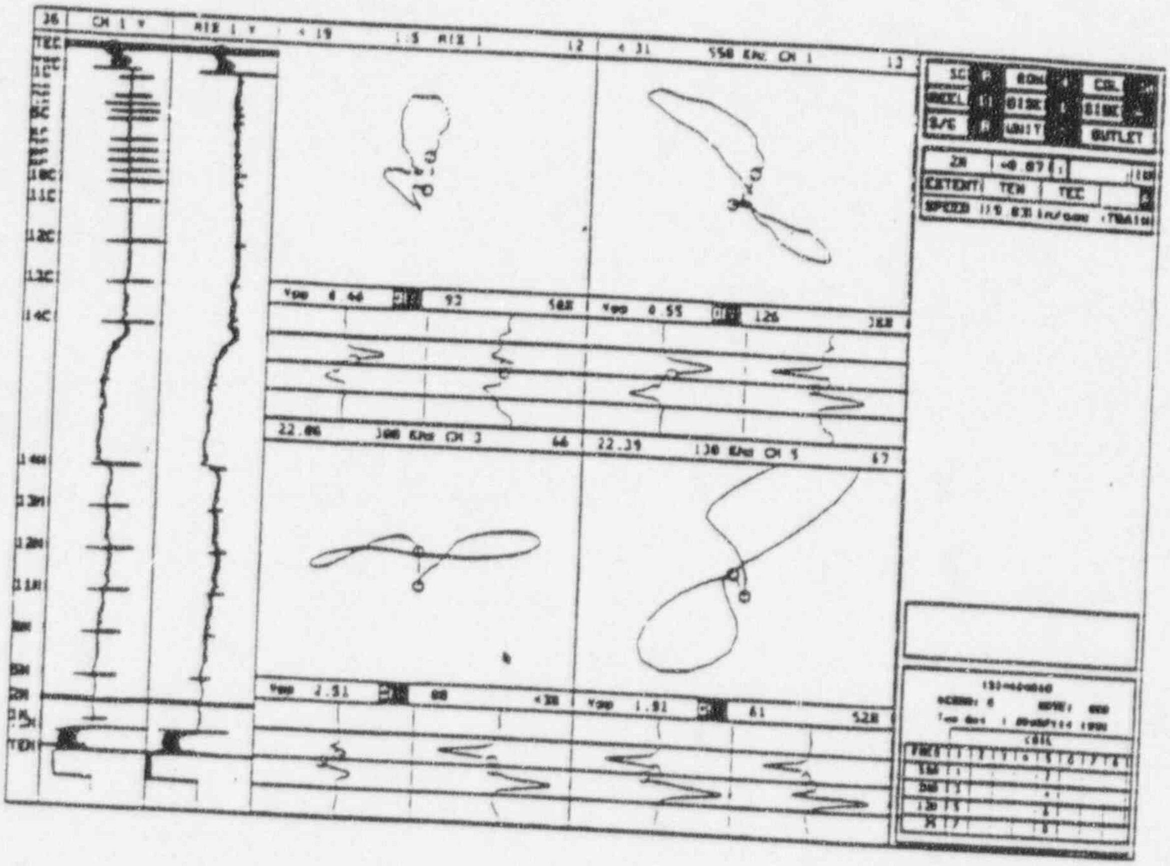


Figure A-5: Correct Placement of Voltage Set Points on Mix 1 Lissajous Traces for R18C103.

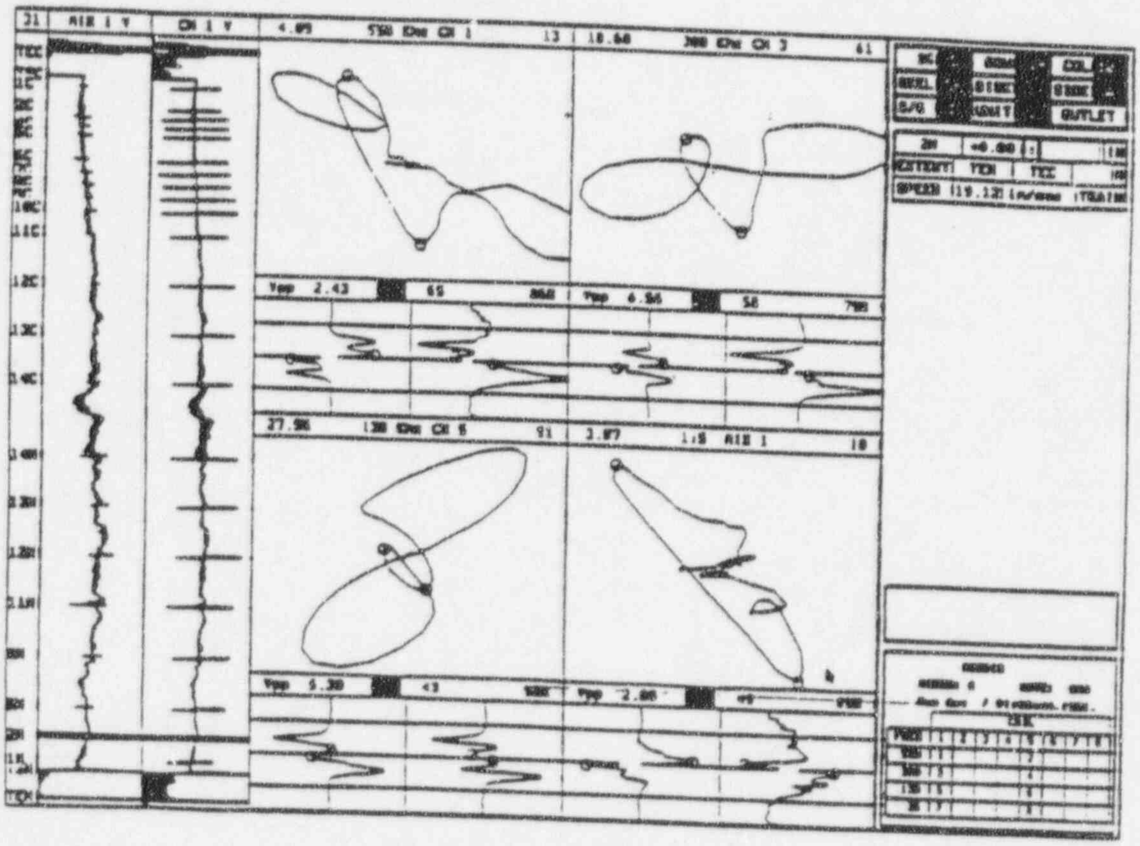


Figure A-6: Correct Placement of Vector Dots on Mix 1 Lissajous Traces for R22C40.

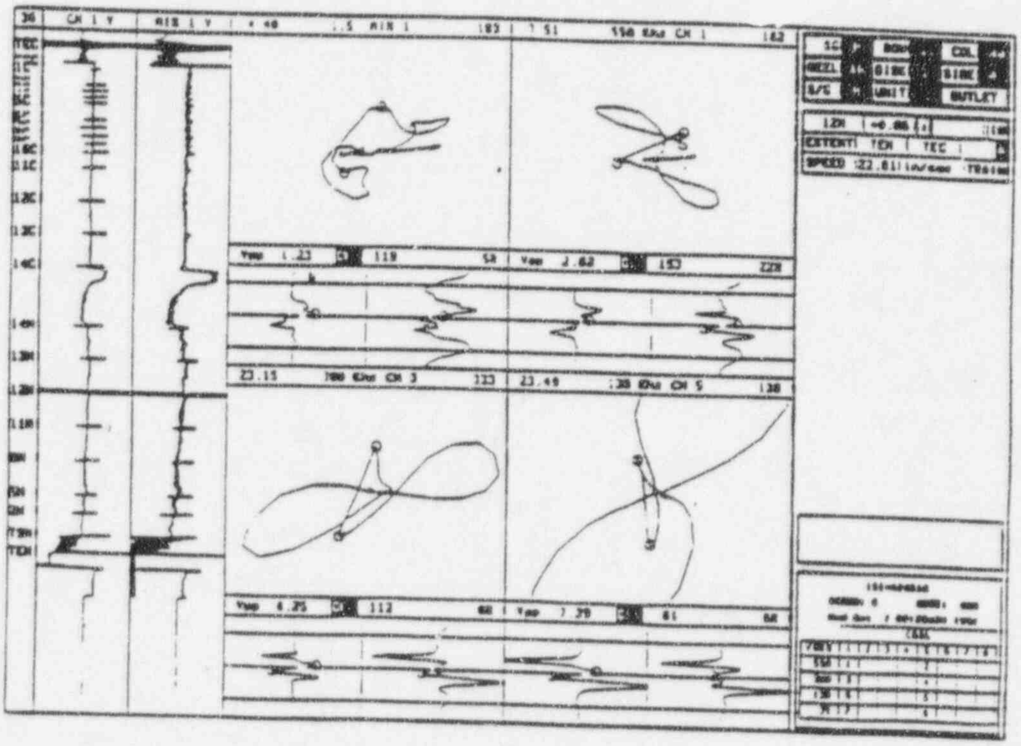


Figure A-7: Incorrect Placement of Vector Dots on Mix 1 Lissajous Traces for R18C103.

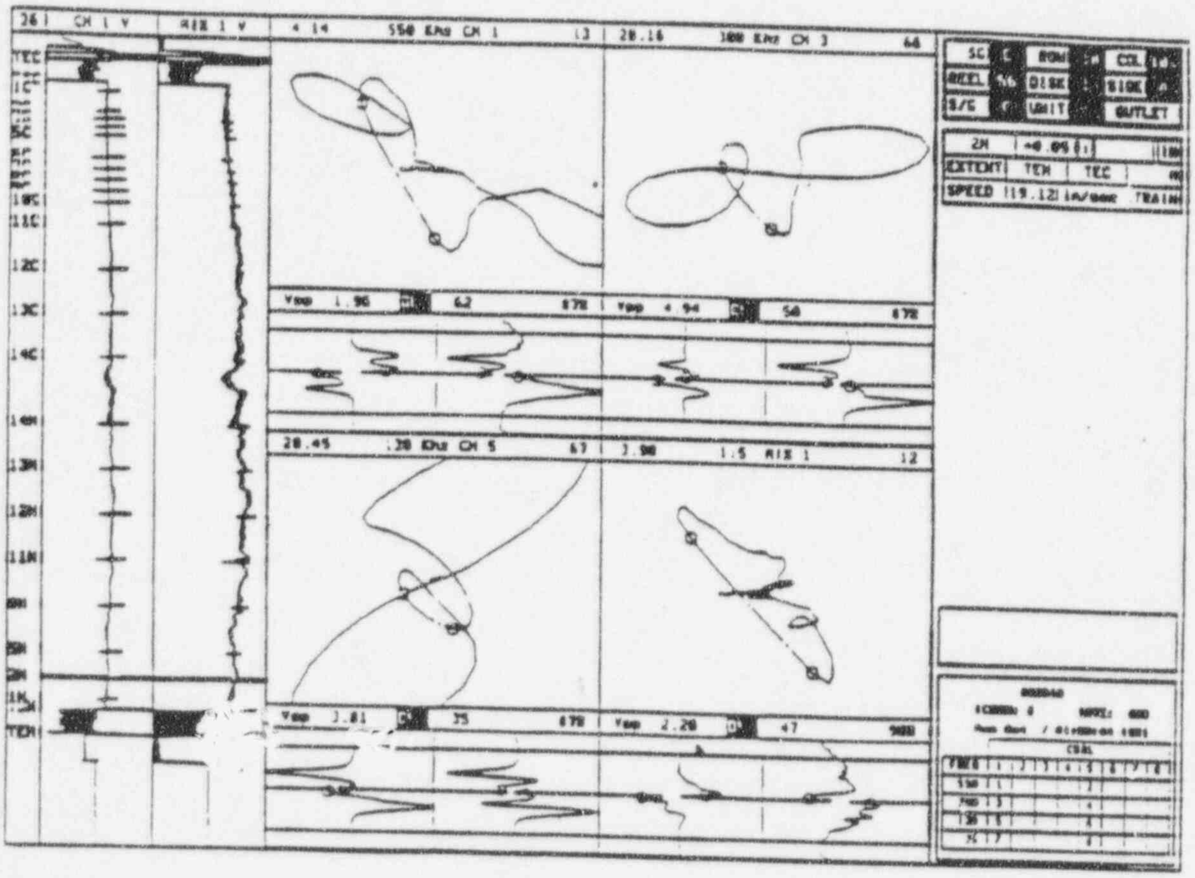


Figure A-8: Incorrect Placement of Vector Dots on Mix 1 Lissajous Traces for R22C40.

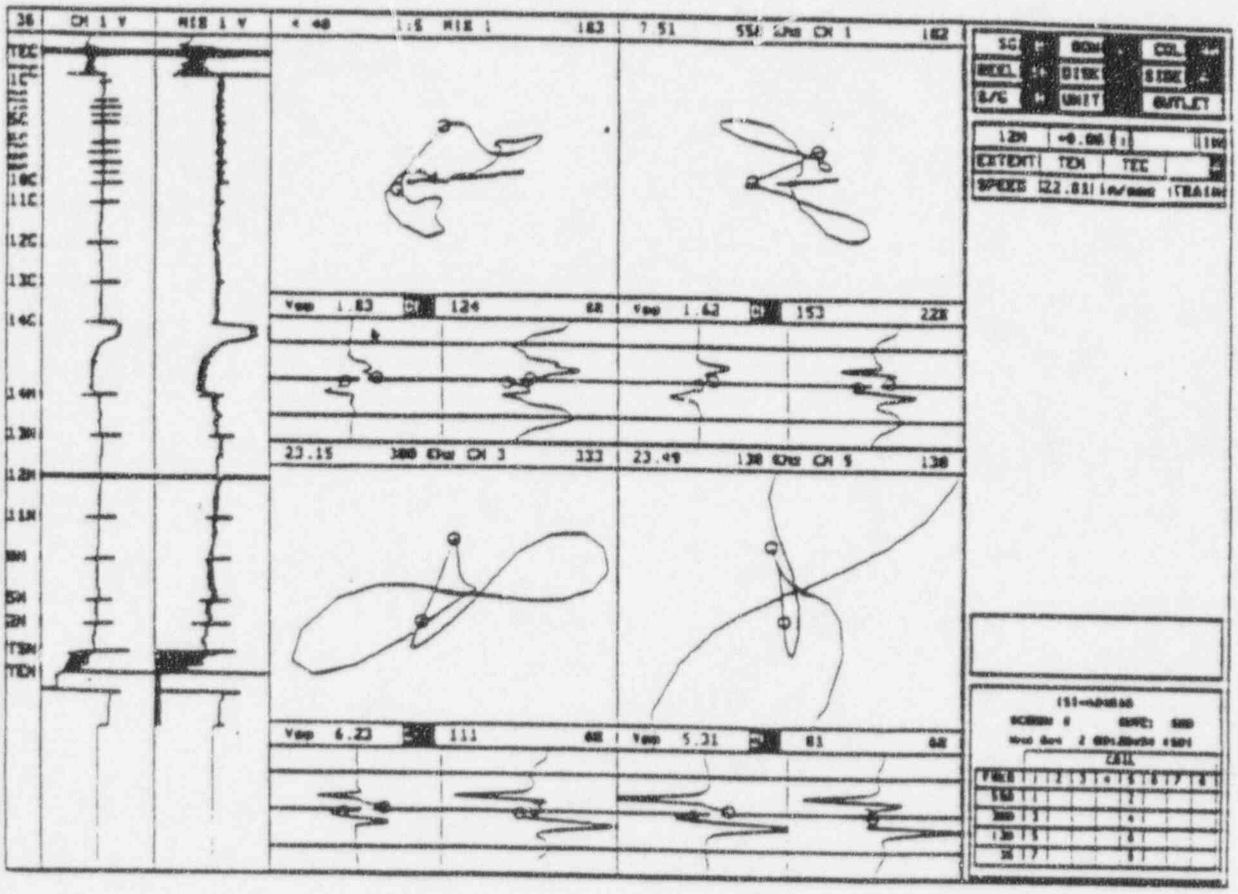


Figure A-9.: Incorrect Maximum Voltage Derived from Placement of Vector Dots on Transition Region of 550 kHz Raw Frequency Data Lissajous Trace for R42C44.

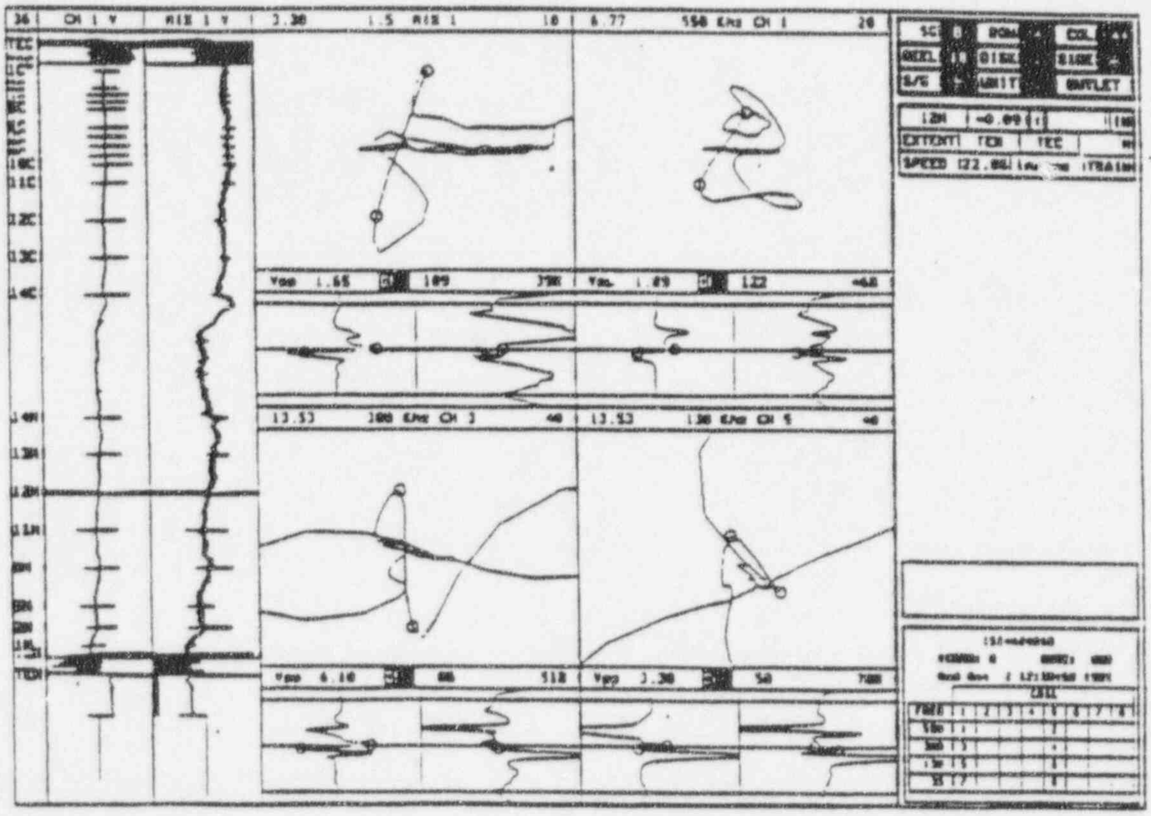


Figure A-10: Correct Placement of Vector Dots on Mix 1 Lissajous Figure for R42C44.

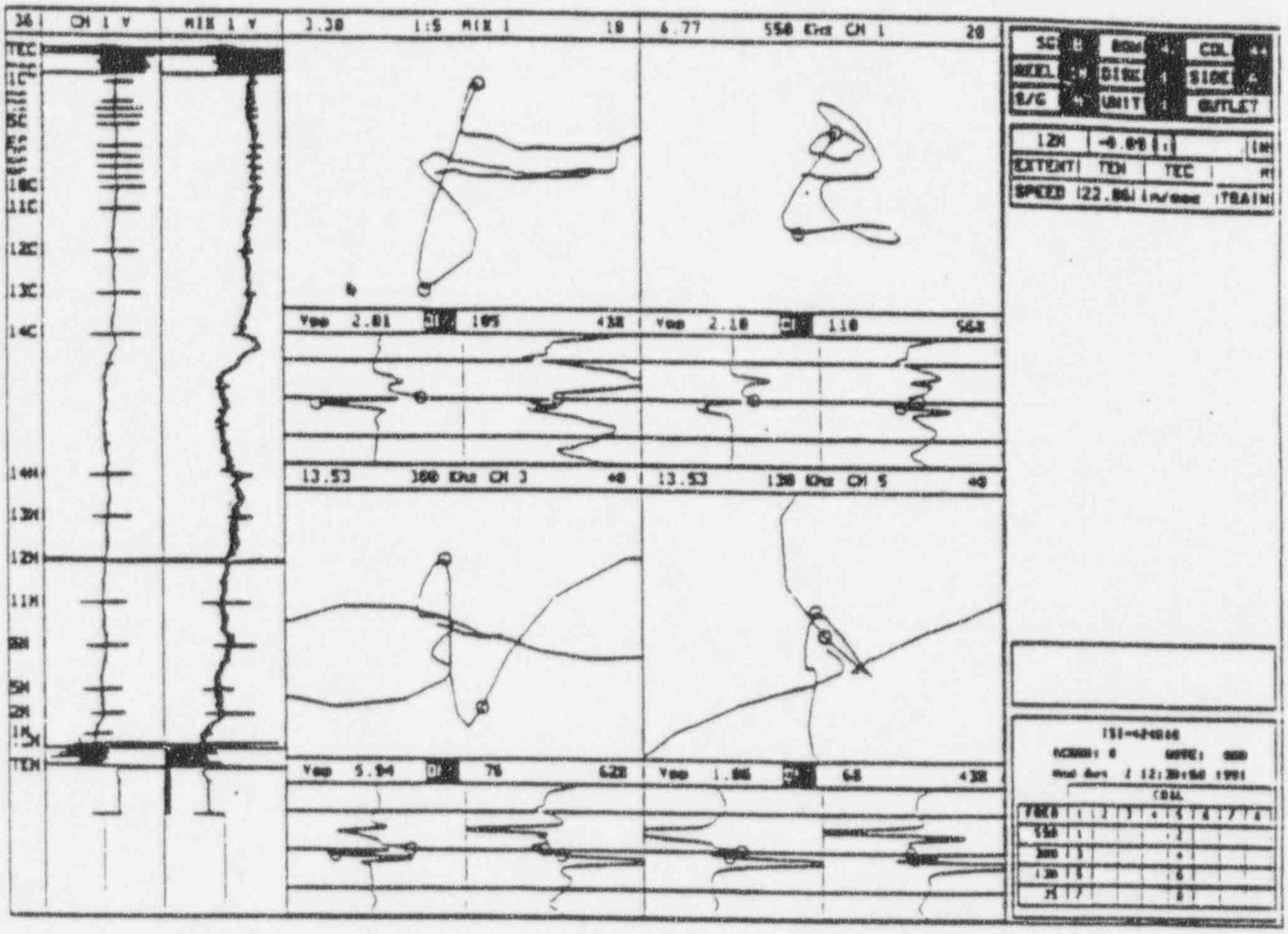


Figure A-11: Placement of Vector Dots Based Solely on Mix 1 Lissajous Figure (no significantly sharp transitions in any of the raw frequencies) - R10C44.

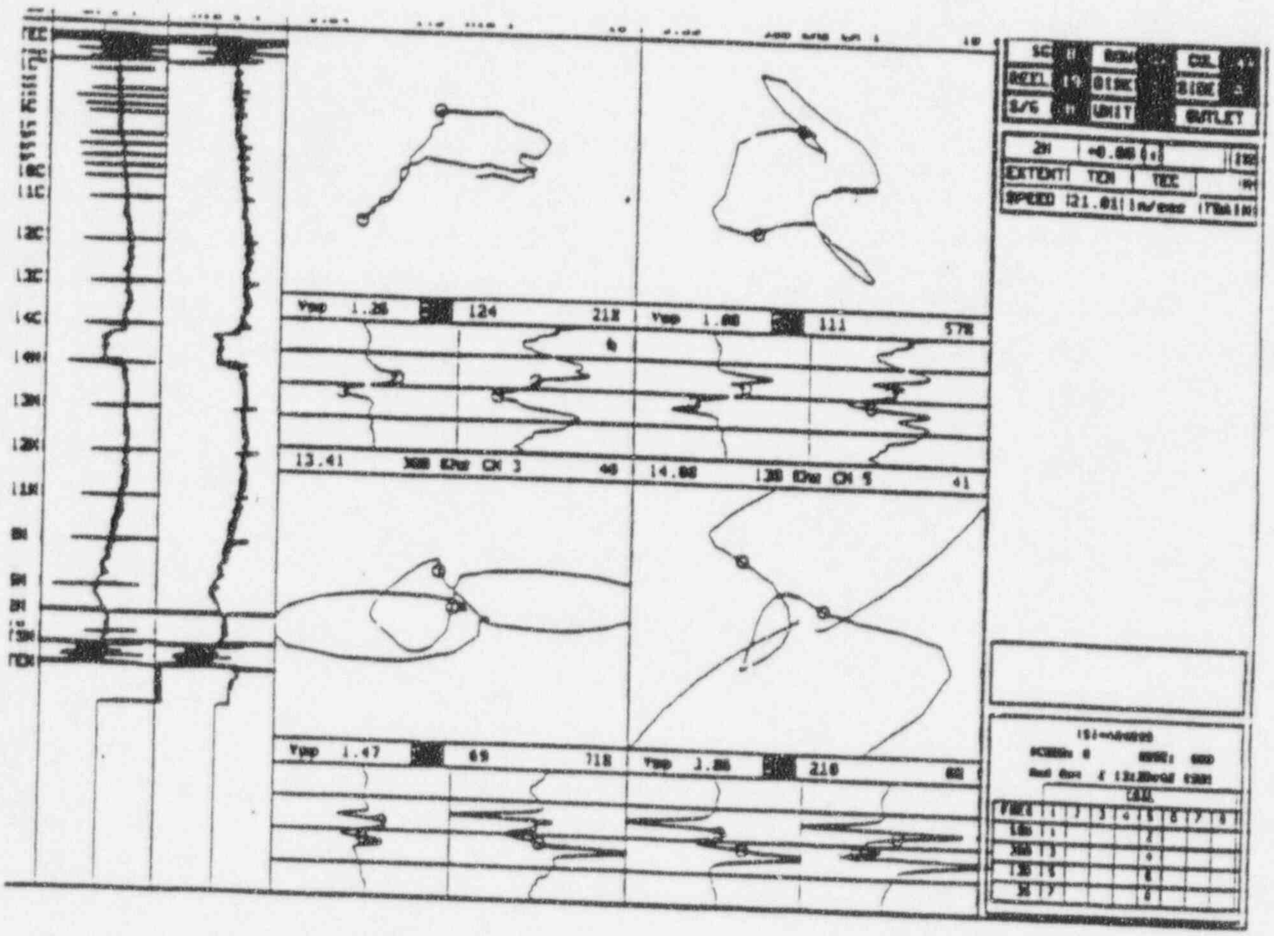


Figure A-12: Placement of Dots Marking Mix 1 Lissajous Figure for R16C26.

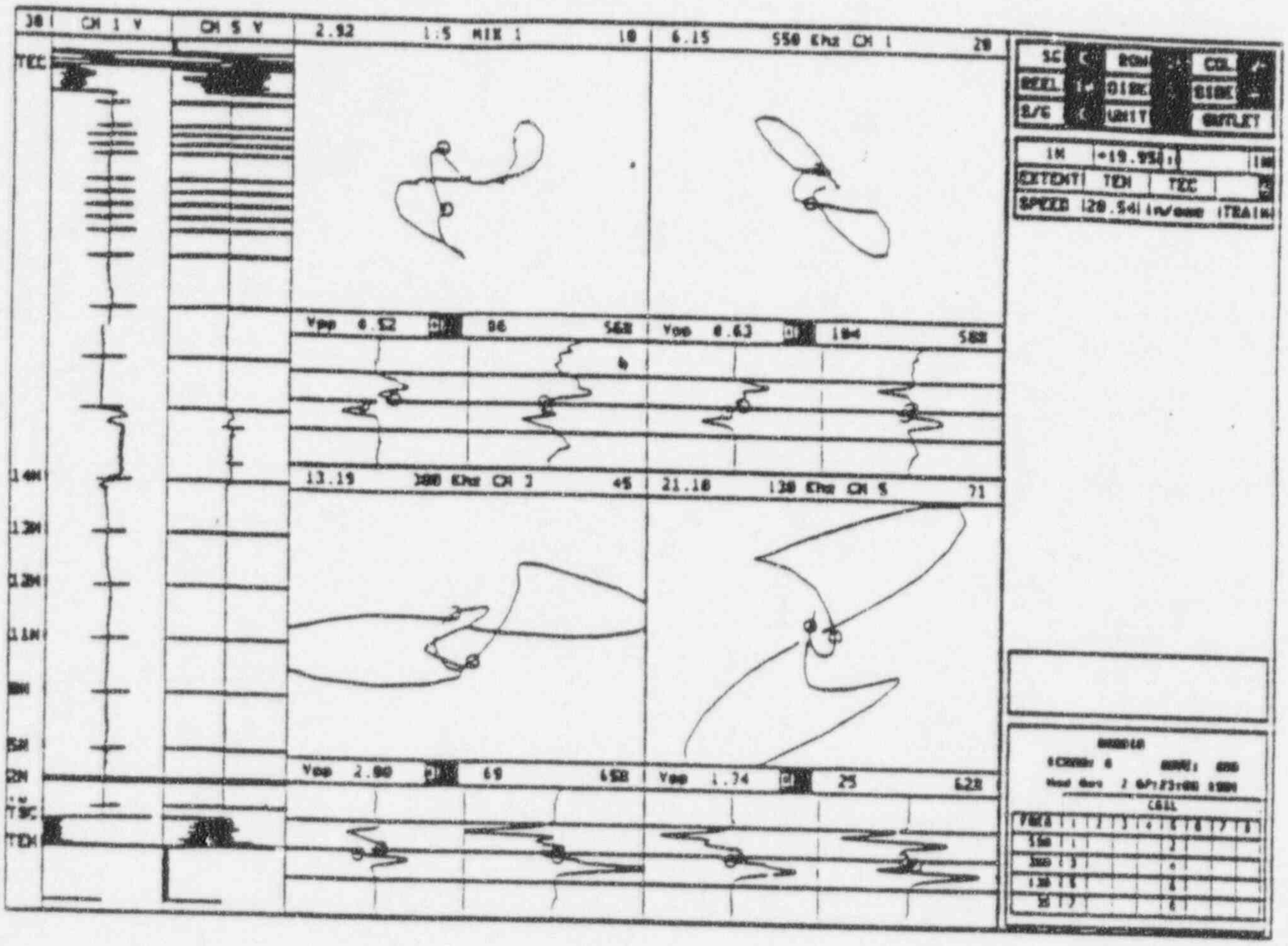


Figure A-13: Incorrect Placement of Vector Dots Marking Mix 1 Lissajous Figure for R30C74.

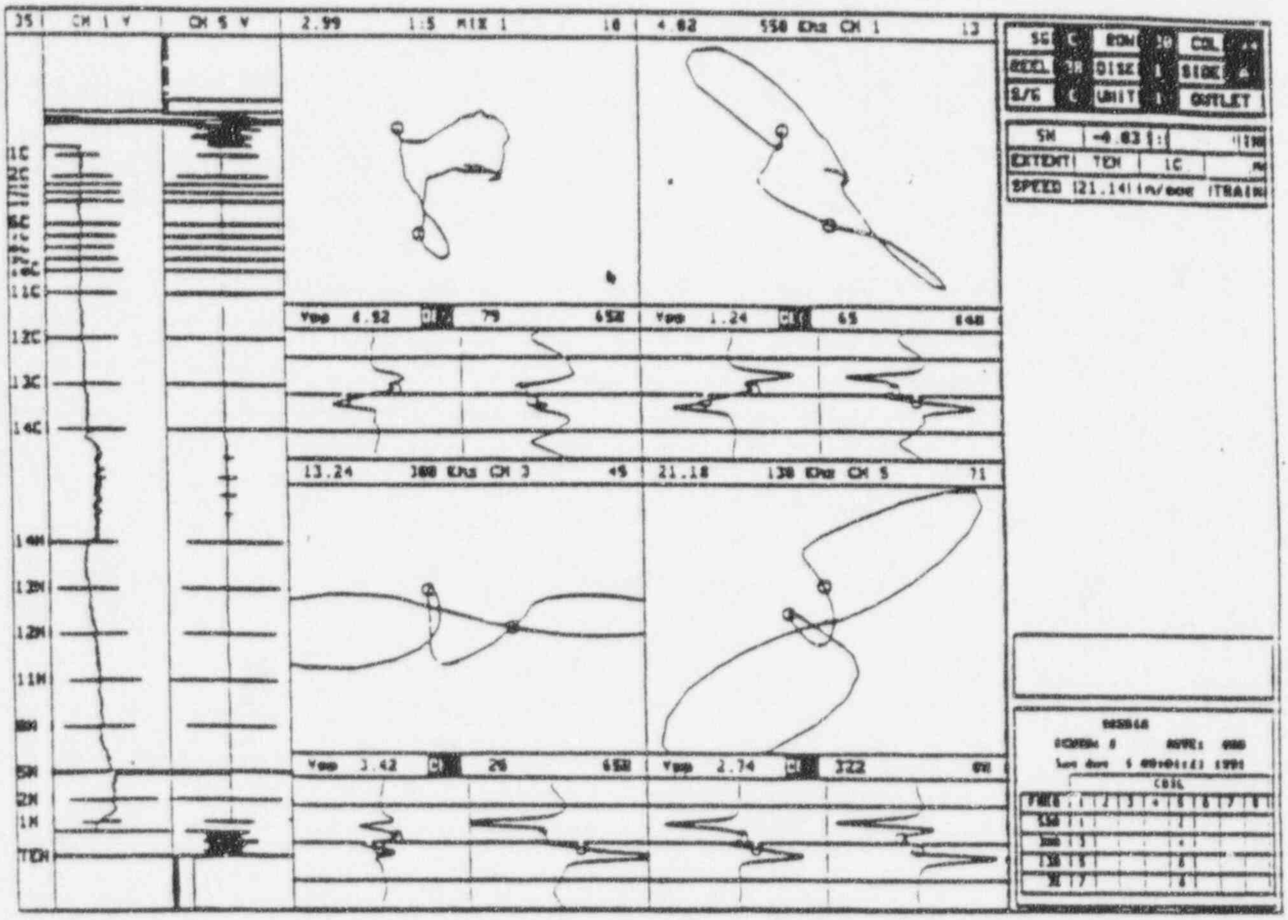


Figure A-14: Correct Placement of Dots to Effect Maximum Voltage - R30C74.

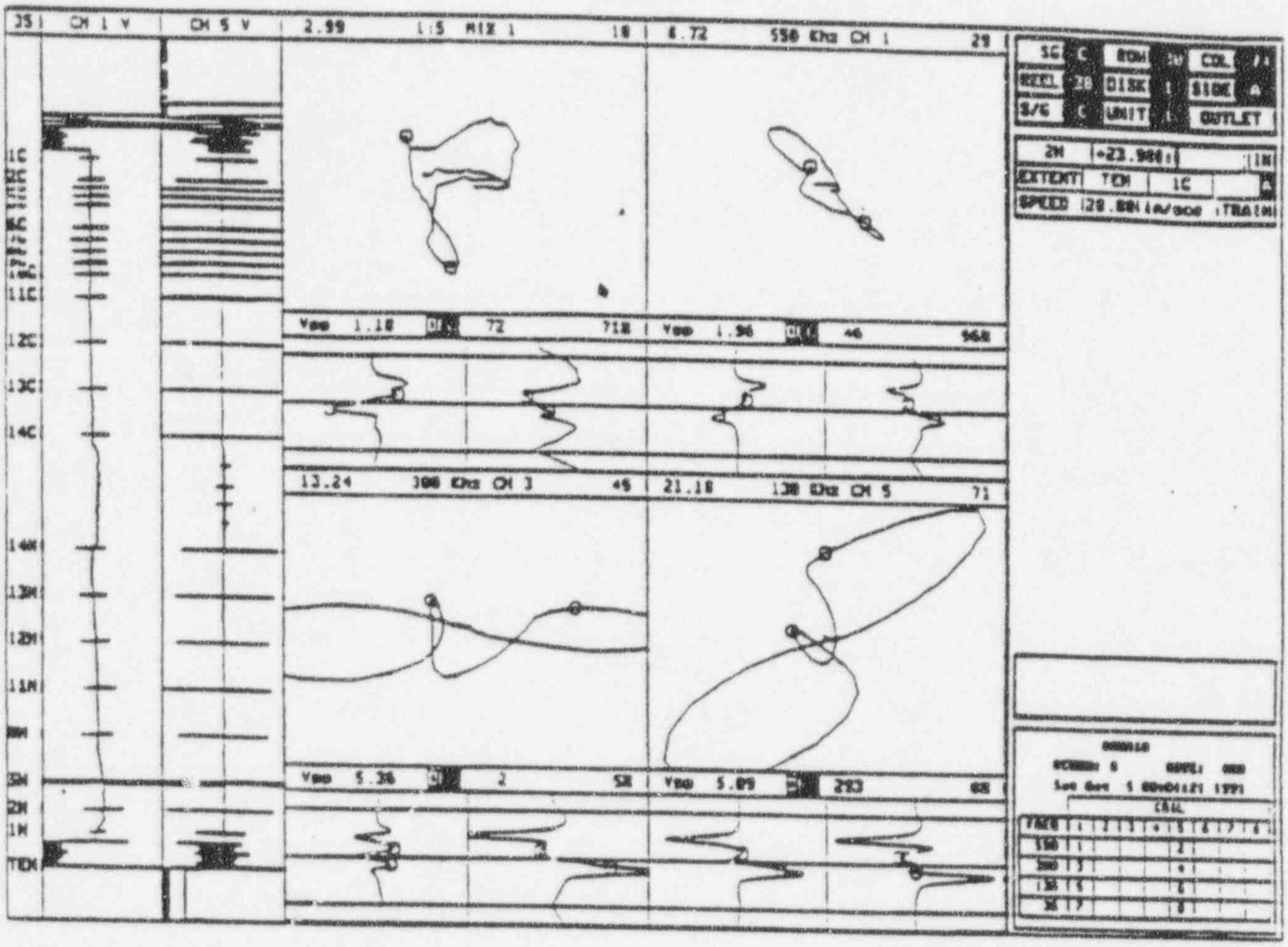


Figure A-15: Example of Bobbin Coil Field Data - Mix Residual Due to Alloy Change.

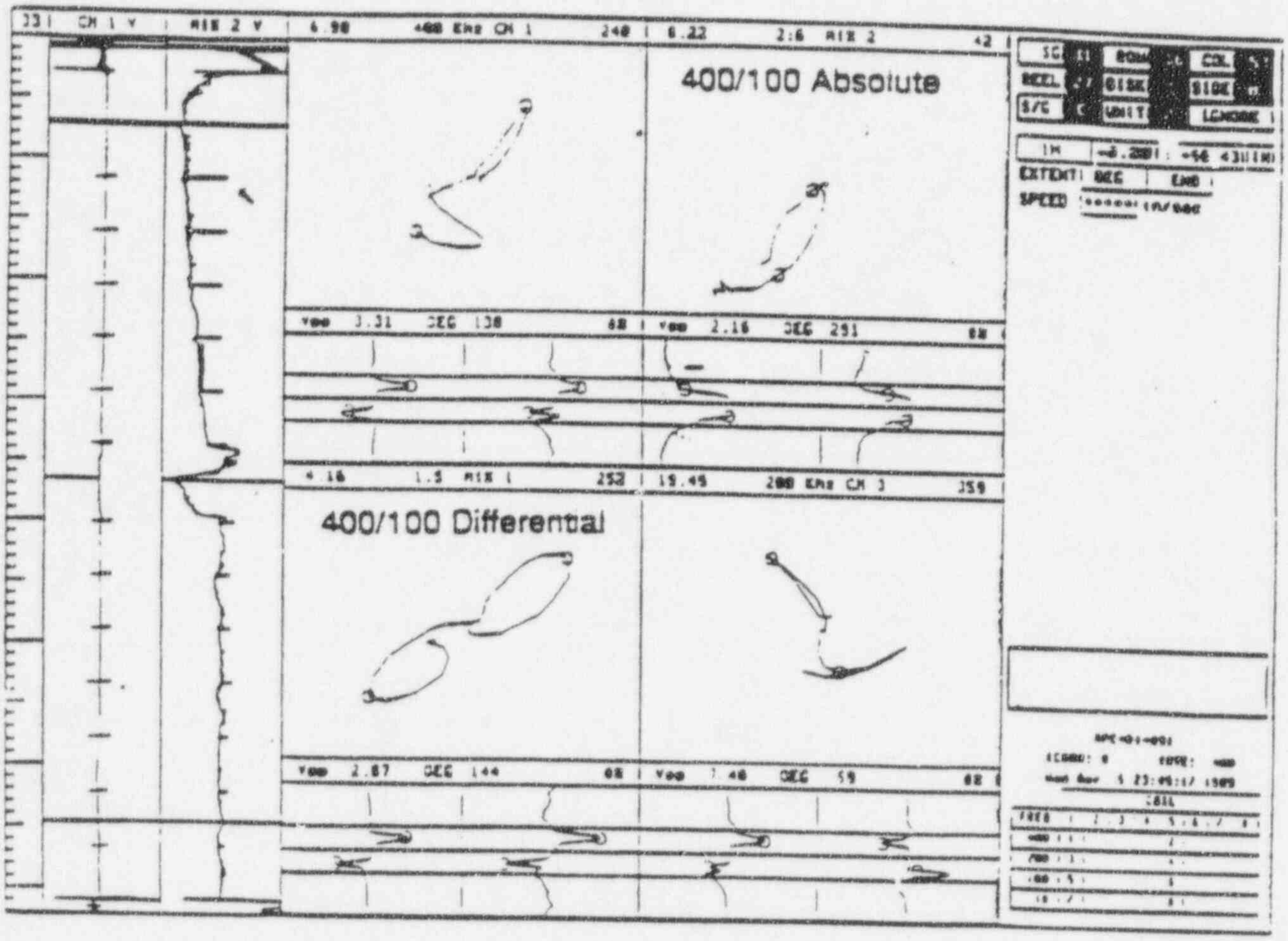


Figure A-16: Example of RPC Data for Single Axial Indication (SAI) Attributed to ODSCC - Plant S.

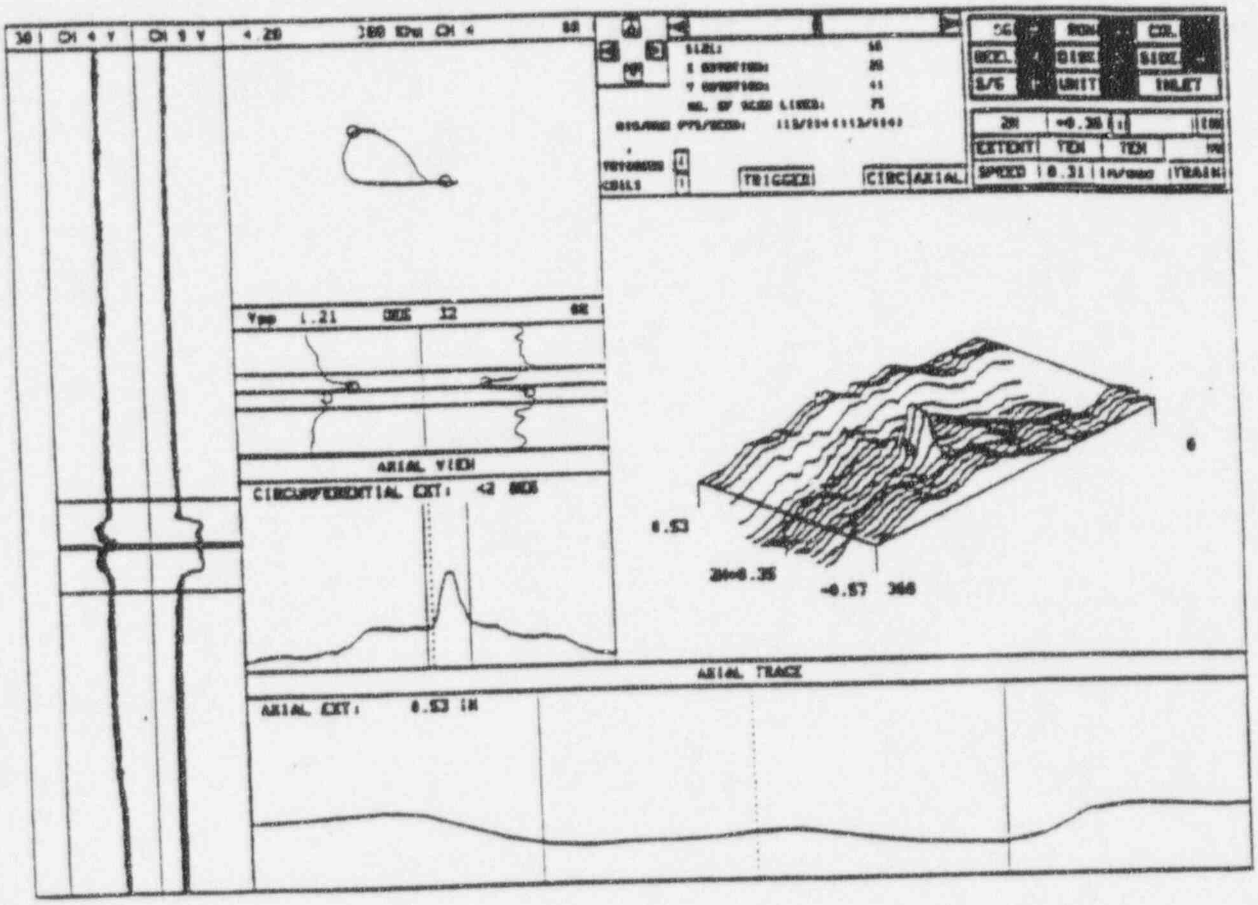


Figure A-17: RPC Data for Single Axial ODSCC Indication(SAI) - Plant S.

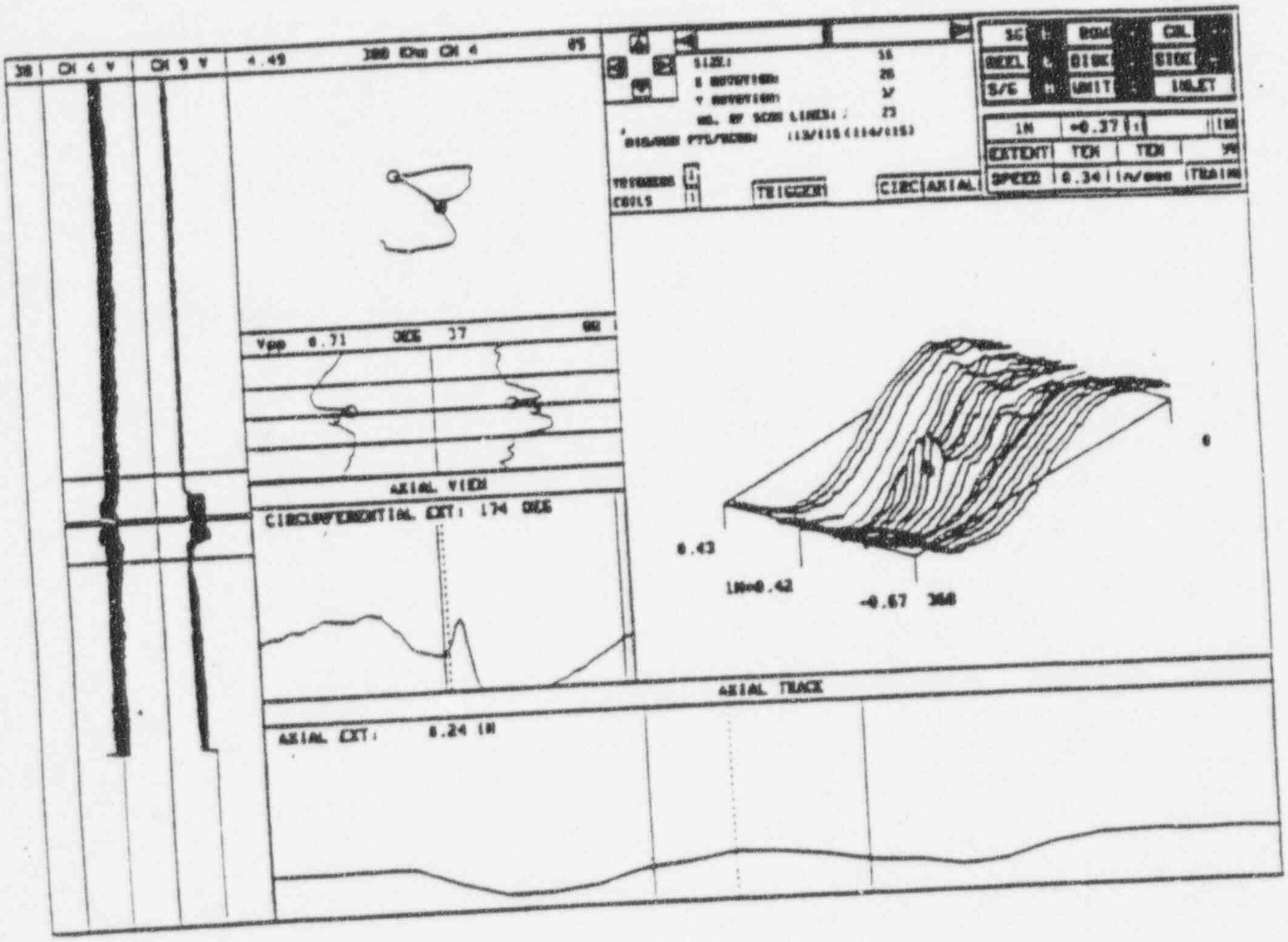


Figure A-17: RPC Data for Single Axial ODSCC Indication(SAI) - Plant S.

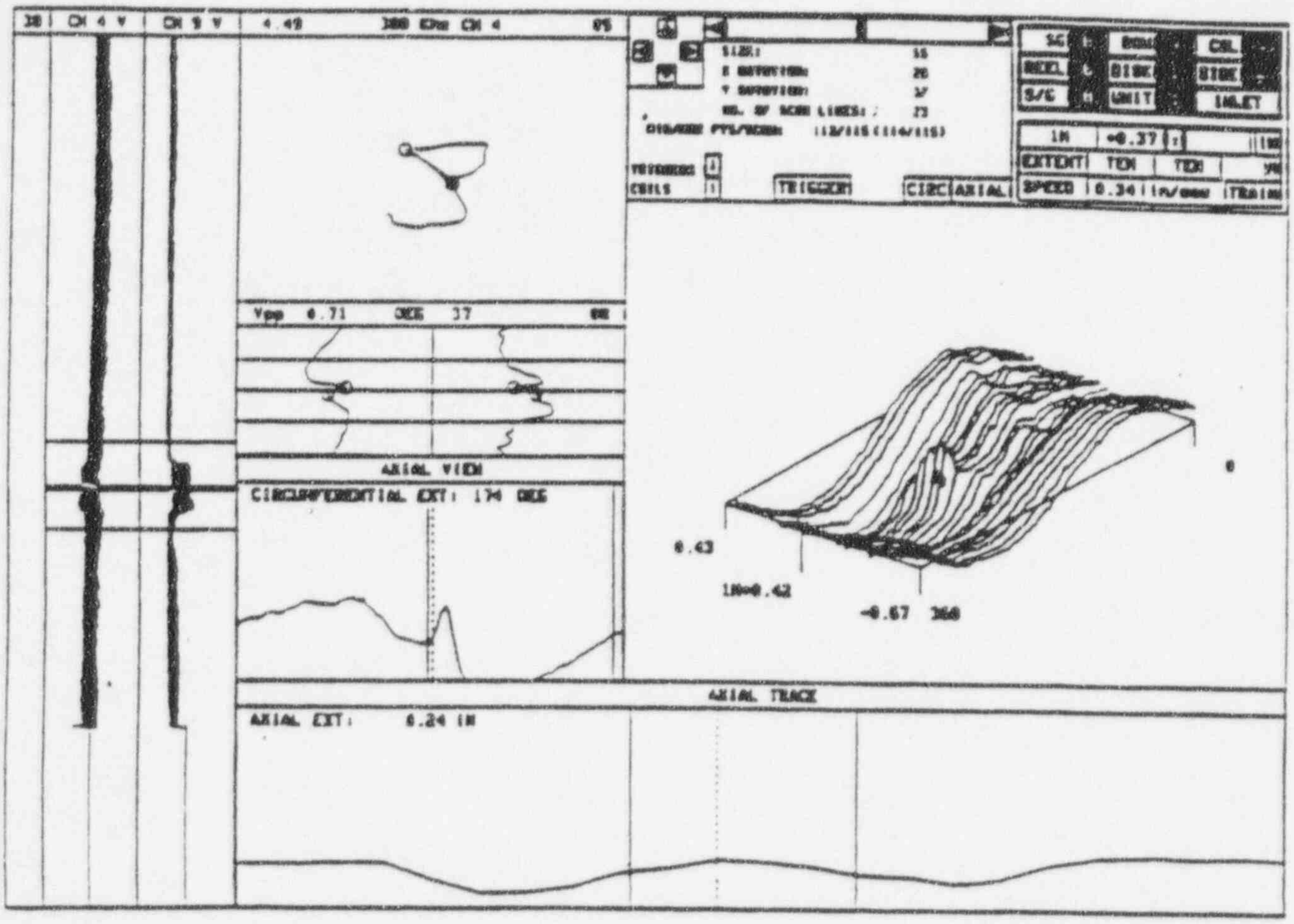


Figure A-18: RPC Data for Multiple Axial ODSCC Indications (MAI) - Plant S.

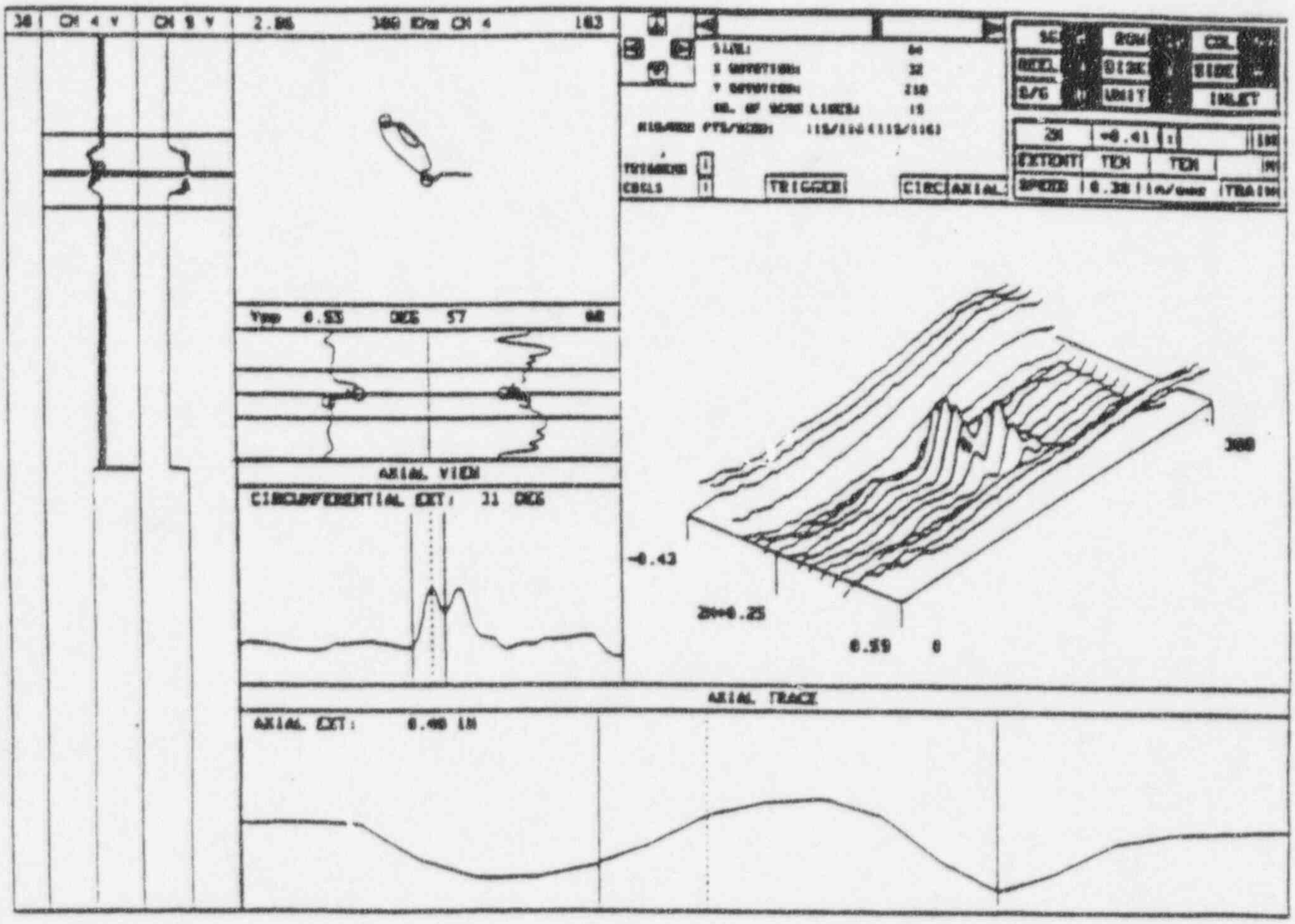


Figure A-19: RPC Data for Circumferential ODSCC Indications at Dented Upper and Lower TSP Edges.

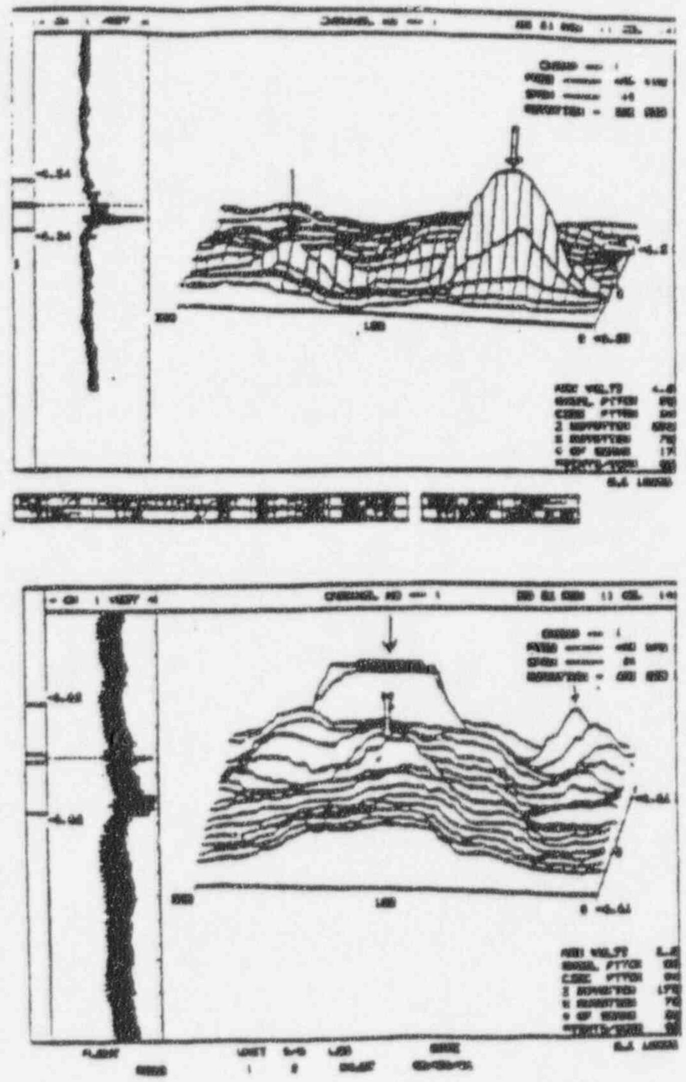


Figure A-20: Example of Bobbin Coil Field Data - Flaw Signals for ODSCC at Dented TSP Intersection from Plant A.

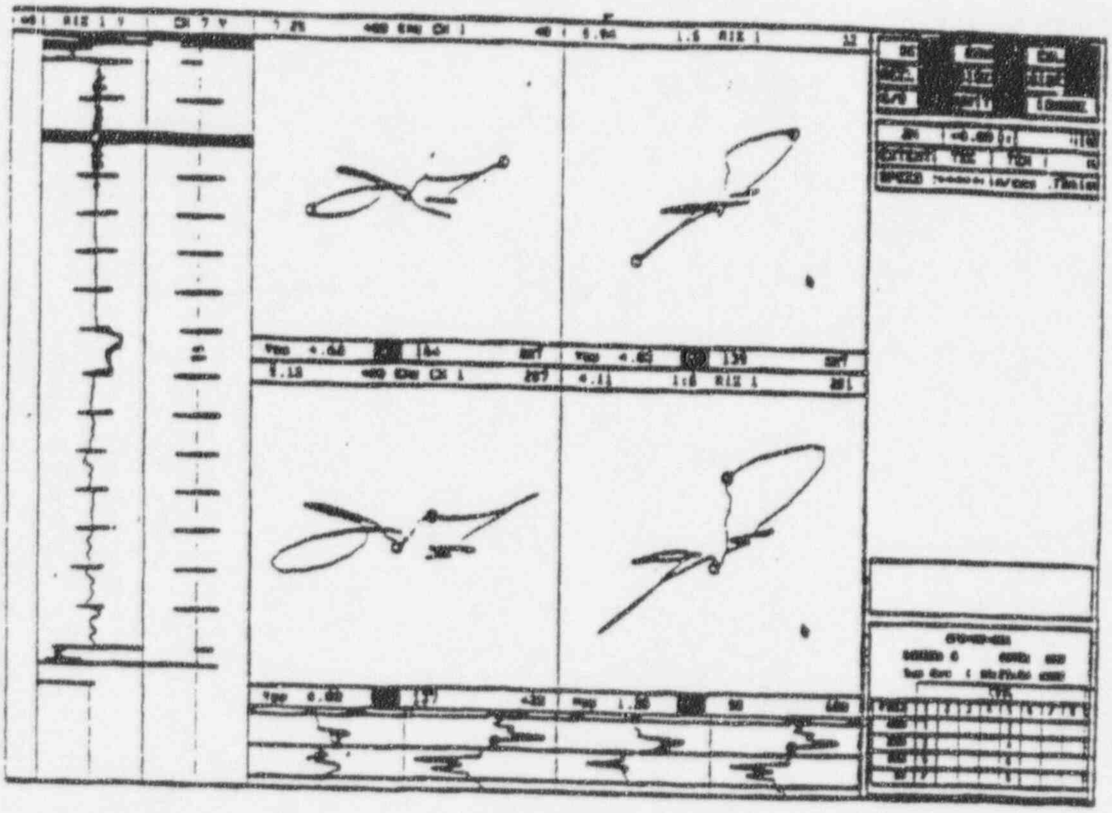


Figure A-21: Example of Bobbin Coil Field Data - Flaw Signals for ODSCC at Dented TSP Intersection from Plant A.

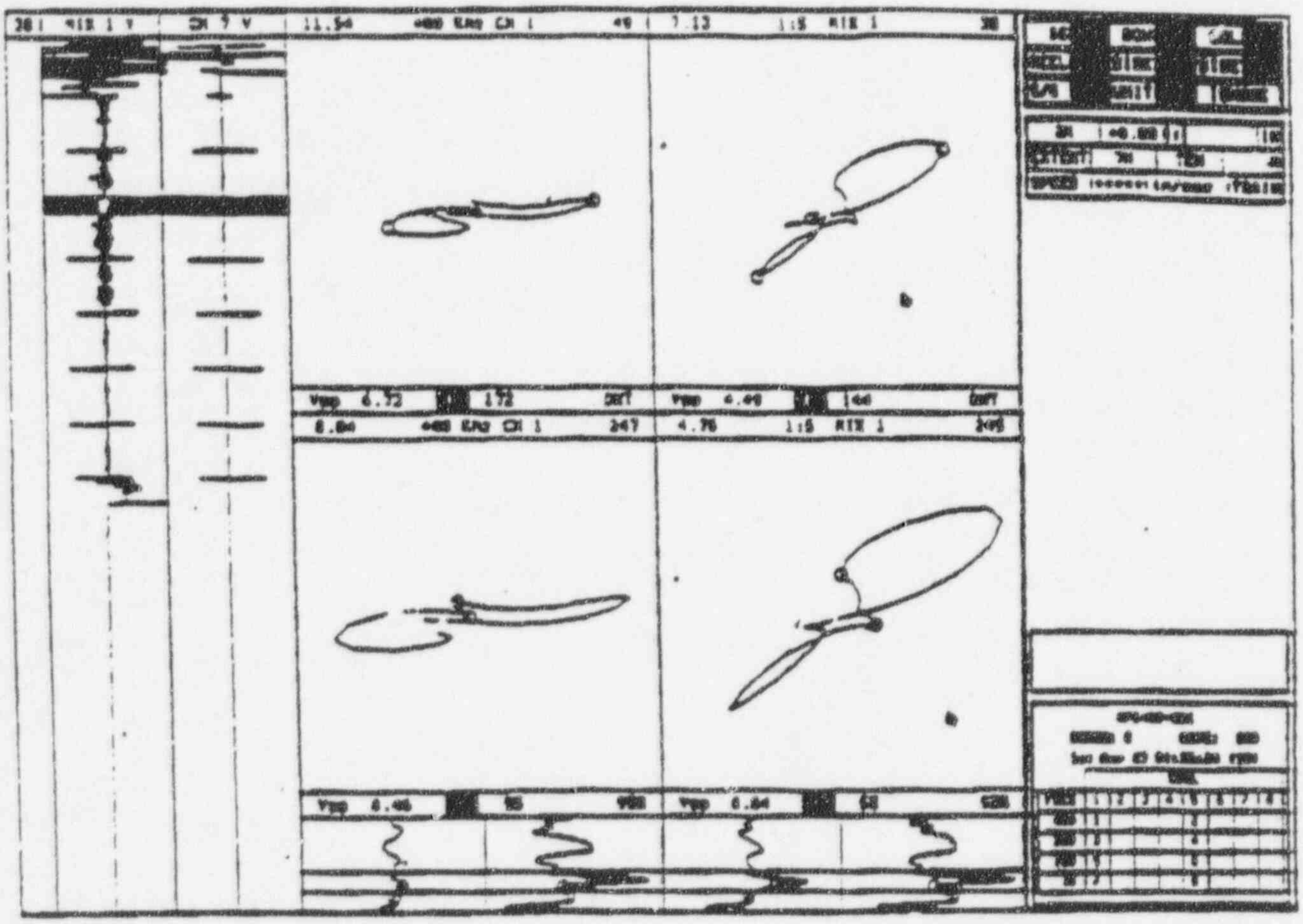


Figure A-22: Example of Bobbin Coil Field Data - Flaw Signals for ODSCC at Dented TSP Intersection from Plant A.

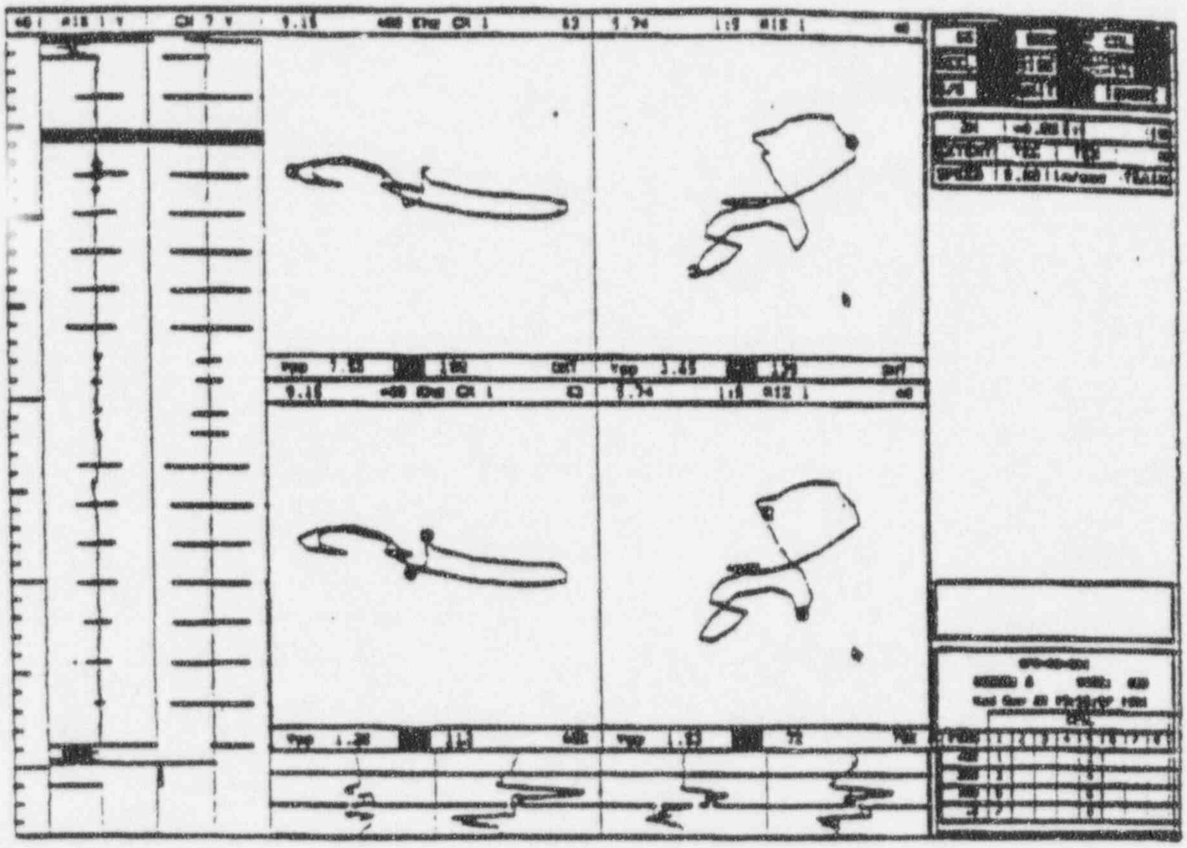


Figure A-23: Example of Bobbin Coil Field Data - Flaw Signals for ODSCC at Dented TSP Intersection from Plant A.

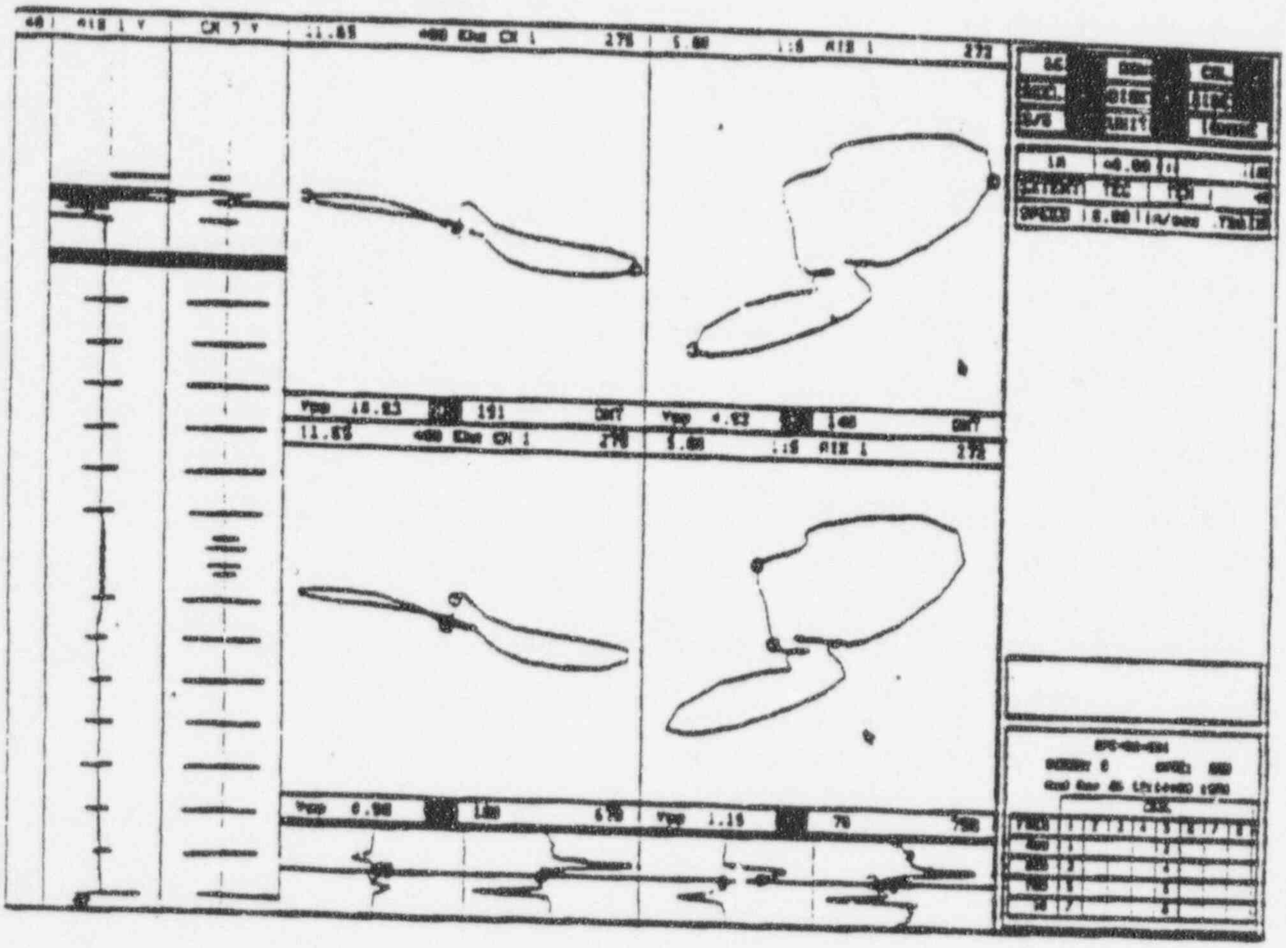


Figure A-24: Example of Bobbin Coil Field Data - Flaw Signals for ODSCC at Dented TSP Intersection from Plant A.

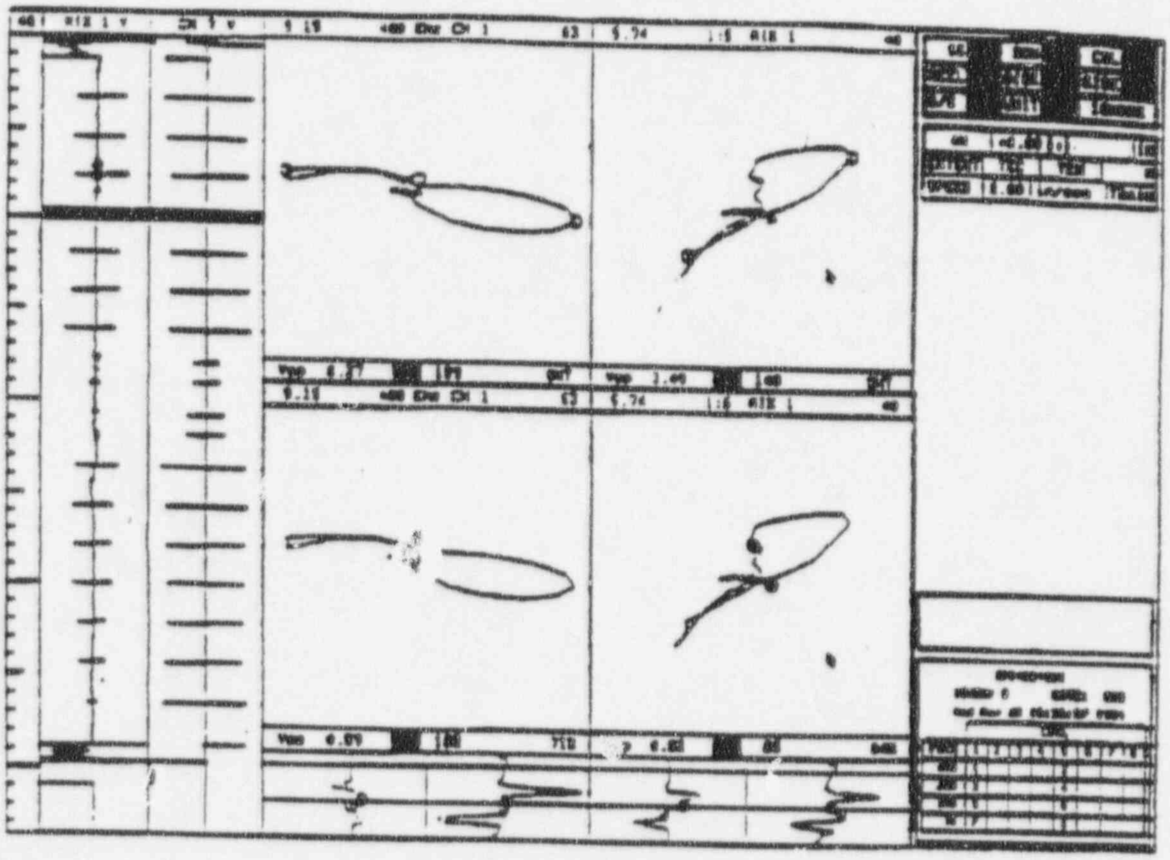


Figure A-25: Example of Bobbin Coil Field Data - Flaw Signals for ODSCC at Dented TSP Intersection from Plant A.

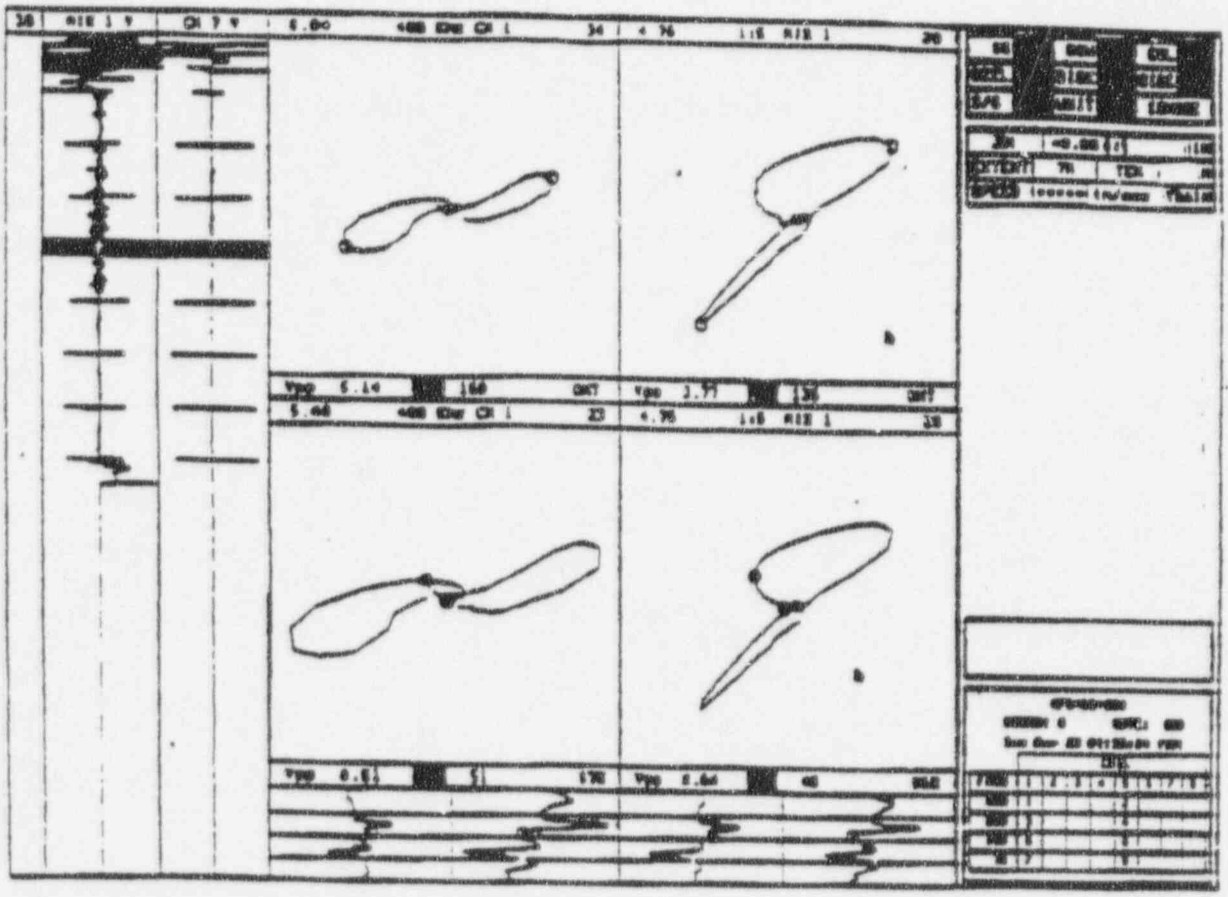
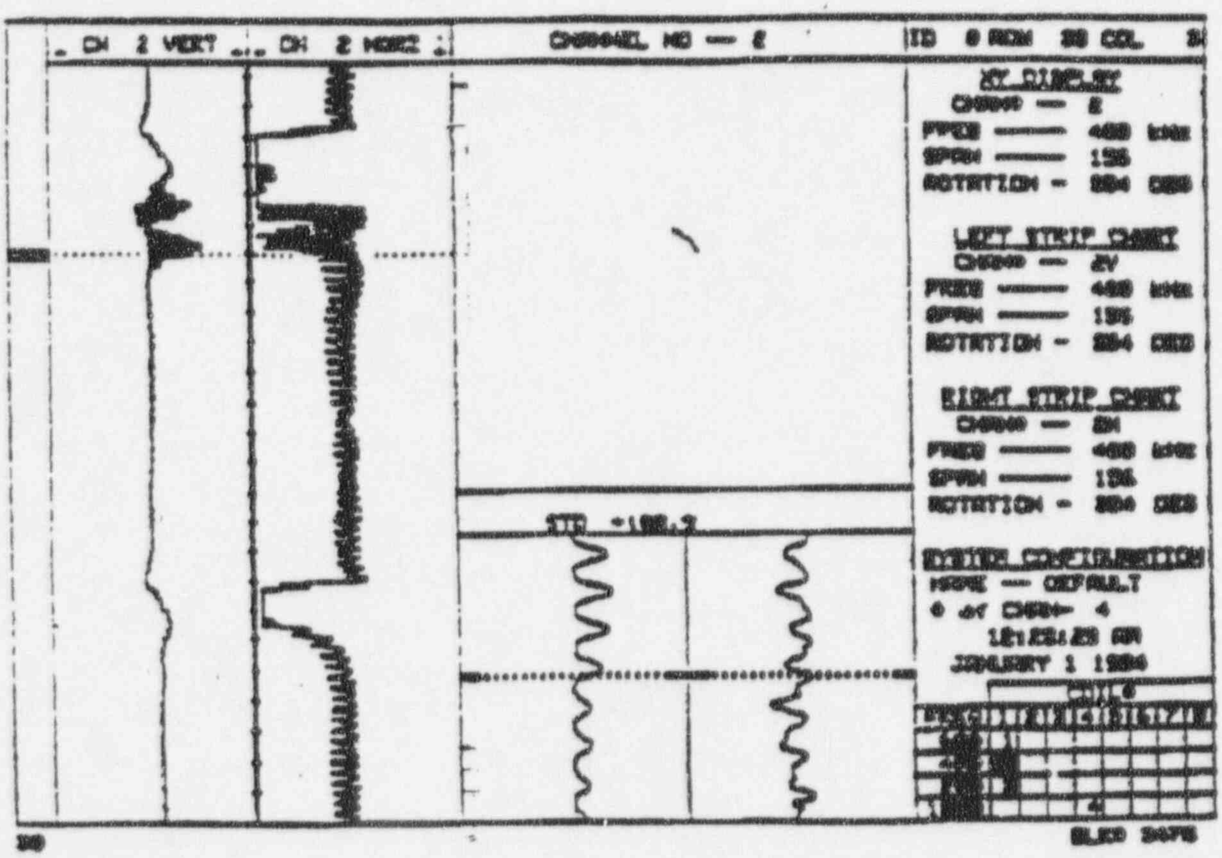


Figure A-26: Location of One End of an Indication Using an RPC Probe.



APPENDIX B
ANALYSIS GUIDELINE CHANGE FORM

ANALYSIS GUIDELINES CHANGE FORM

CHANGE FORM #:_______________

SUBJECT:

DESCRIPTION OF CHANGE:

REASON FOR CHANGE:

TECHNICAL BASIS:

EXAMINATION IMPACT:

AUTHORIZATIONS:

Lead Analyst____________________________________ Date: ____/____/____

ComEd Acknowledgment____________________________ Date ____/____/____

ANALYSIS GUIDELINES CHANGE ACKNOWLEDGMENT FORM
(Continued)

CHANGE FORM #:______________

EFFECTIVE DATE OF CHANGE ___/___/___ TIME ___/___ am/pm

Analyst Signature	Date	Time
______________	___/___/___	___:___
______________	___/___/___	___:___
______________	___/___/___	___:___
______________	___/___/___	___:___
______________	___/___/___	___:___
______________	___/___/___	___:___
______________	___/___/___	___:___
______________	___/___/___	___:___
______________	___/___/___	___:___
______________	___/___/___	___:___
______________	___/___/___	___:___
______________	___/___/___	___:___
______________	___/___/___	___:___
______________	___/___/___	___:___
______________	___/___/___	___:___
______________	___/___/___	___:___
______________	___/___/___	___:___
______________	___/___/___	___:___
______________	___/___/___	___:___
______________	___/___/___	___:___

APPENDIX C
ANALYSIS AND RETEST CODES

Analysis & Retest Codes

Category 1 - No Further Action:	Analysis	Retest
No Detectable Degradation	NDD	RND
Plugged	PLG	-----
Sleeved	SLV	RSV
Positive Indentification	PID	-----

Category 2 - Possible Flaw, Further Action Required:	Analysis	Retest
Non-Quantifiable Indication	NQI	RNQ
Absolute Drift Indication	ADI	RAD
Distorted Support Indication	DSI	RDI
Distorted Tubesheet Indication	DTI	RTI
Dent with Possible Indication	DNI	RNI
Distorted Roll Indication	DRI	RTI
Single Axial Indication	SAI	RSA
Multiple Axial Indications	MAI	RMA
Single Circumferential Indication	SCI	RSC
Multiple Circumferential Indications	MCI	RMC
Mixed Residual Indications	MRI	RMI
Free-Span Indication	FSI	RSI
Lead Analyst Resolution	LAR	RAR

Category 3 - Possible Loose Part, Further Action Required:	Analysis	Retest
Possible Loose Part	PLP	RLP

Category 4 - Further Action Required, Retest Condition:	Analysis	Retest
Bad Data	RBD	RBD
Incomplete Test	INC	RIC
Obstructed	OBS	ROB
Template Plug	TMP	RTP
Tube No Test	TNT	RNT
To Be Retested	TBR	-----
Fixture	FIX	RFX
Tube Number Check	TNC	RNC

Category 5 - No Further Action Required:	Analysis	Retest
Bulge	BLG	RBL
Copper Deposit	CUD	RCD
Dent	DNT	RDN
Deposit	DEP	RDP
Ding	DNG	RDG
Distorted Roll Transition Signal	DRT	RRT
Distorted Support Plate Signal	DSS	RDS
Distorted Tubesheet Signal	DTS	RDT
Expansion	EXP	REX
Free-span Signal	FSS	PFS
Indication Not Reportable	INR	RNR

Category 5 - No Further Action Required (Con't)	Analysis	Retest
Indication Not Found	INF	RNF
Manufacturing Burnish Mark	MBM	RBM
Manufacturing Anomaly Mark	MAM	RAM
Noisy Tube	NSY	RSY
Over Roll	OVR	RVR
Overexpansion	OXP	RXP
Partial Tubesheet Expansion	PTE	RTE
Permeability Variation	PVN	RPV
Skipped Roll	SKR	RSR
Sludge	SLG	RSG
Top Main Roll	TMR	RTM
Volumetic Indication (s)	VOL	RVL
Free-Span Differential	FSD	RSD
Shot Peening Anamoly	SPA	RPA

APPENDIX D
SUPPORT STRUCTURES
NOMENCLATURE & MEASUREMENTS

Support Structures Nomenclature and Measurements

Westinghouse Model D4 S/G
Support Structures Measurements

Level	Elevation Spacing (inches)	
	Hot Leg	Cold Leg
Tube End	0	0
Top of Tubesheet	21.2	21.2
Center of 1st support	6.4	6.4
Center of 2nd support	n/a	12
Center of 3rd support	30	18
Center of 4th support	n/a	18
Center of 5th support	36	18
Center of 6th support	n/a	18
Center of 7th support	36	18
Center of 8th support	43	43
Center of 9th support	43	43
Center of 10th support	43	43
Center of 11th support	43	43

Support Structures Nomenclature and Measurements

Westinghouse Model D5 S/G
Support Structures Measurements

Level	Elevation Spacing (Inches)	
	Hot Leg	Cold Leg
Tube End	0	0
Top of Tubesheet	21.2	21.2
Center of 1st support	8.4	8.4
Center of 2nd support	n/a	12
Center of 3rd support	28	18
Center of 4th support	n/a	18
Center of 5th support	36	18
Center of 6th support	n/a	18
Center of 7th support	36	18
Center of 8th support	43	43
Center of 9th support	43	43
Center of 10th support	43	43
Center of 11th support	43	43

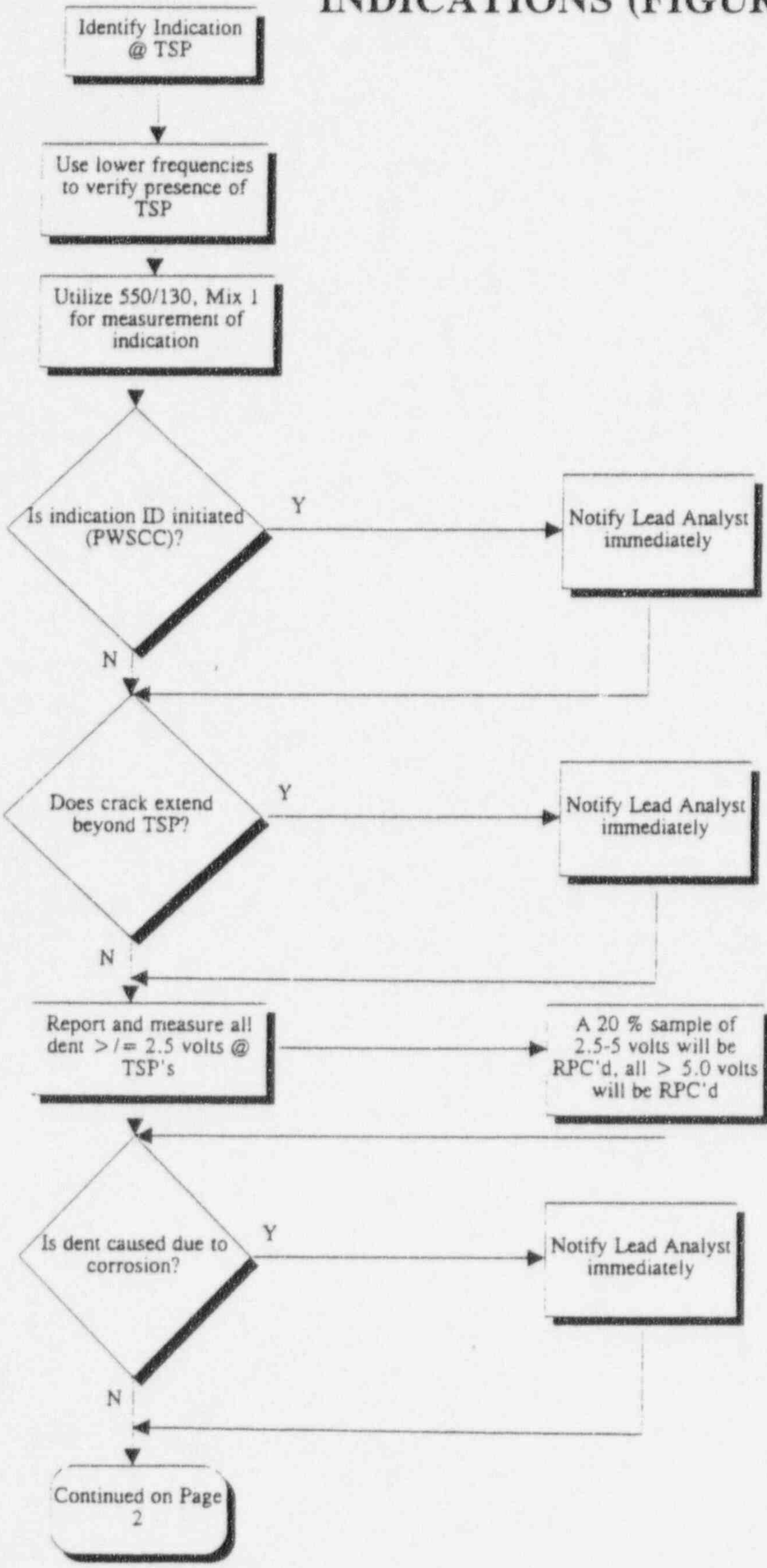
Support Structures Nomenclature and Measurements

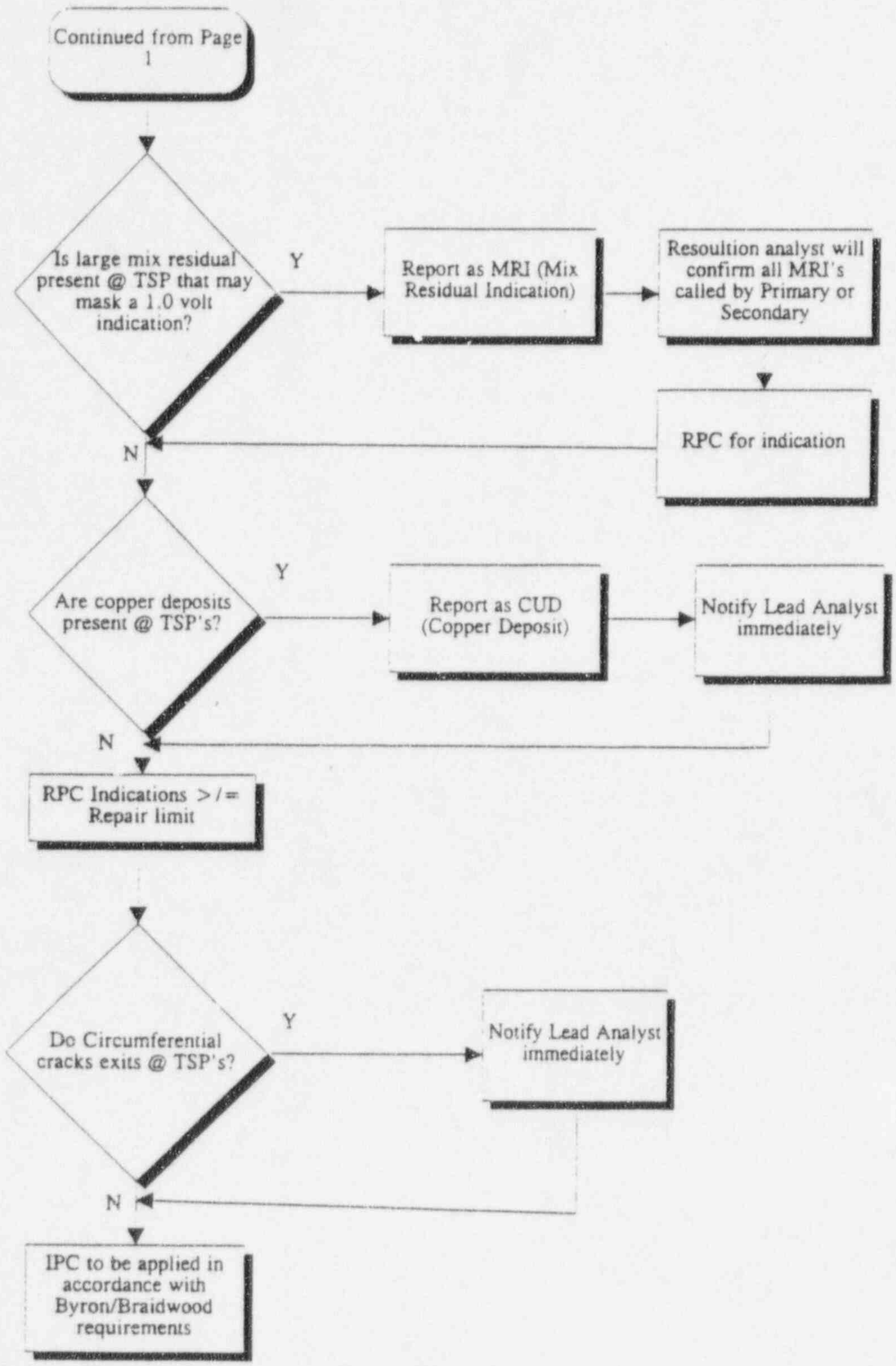
Structures Nomenclature

Notation	Description
TEH	Tube end hot
TSH	Top of tubesheet - hot leg
01H	1st support plate - hot leg
03H	3rd support plate - hot leg
05H	5th support plate - hot leg
07H	7th support plate - hot leg
08H	8th support plate - hot leg
09H	9th support plate - hot leg
10H	10th support plate - hot leg
11H	11th support plate - hot leg
AV1	1st anti-vibration bar
AV2	2nd anti-vibration bar
AV3	3rd anti-vibration bar
AV4	4th anti-vibration bar
11C	11th support plate - cold leg
10C	10th support plate - cold leg
09C	09th support plate - cold leg
08C	08th support plate - cold leg
07C	07th support plate - cold leg
06C	06th support plate - cold leg
05C	05th support plate - cold leg
04C	04th support plate - cold leg
03C	03th support plate - cold leg
02C	02th support plate - cold leg
01C	01st support plate - cold leg
TSC	Top of tubesheet - cold leg
TEC	Tube end cold

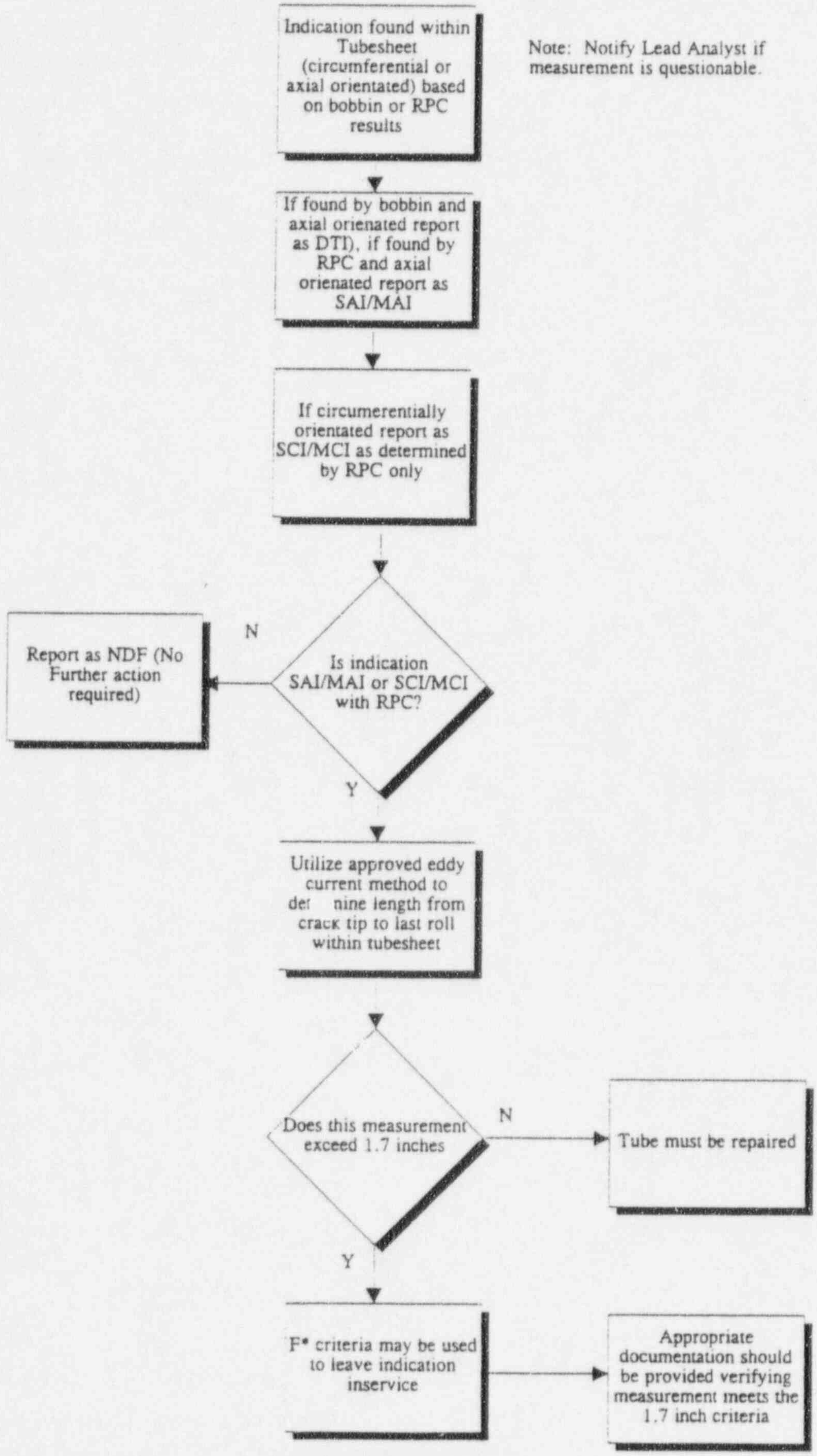
ATTACHMENT 1
(FIGURE 1, 2, 3, 4, 5 & 6)

FLOW DIAGRAM FOR TUBE SUPPORT PLATE INDICATIONS (FIGURE 1)

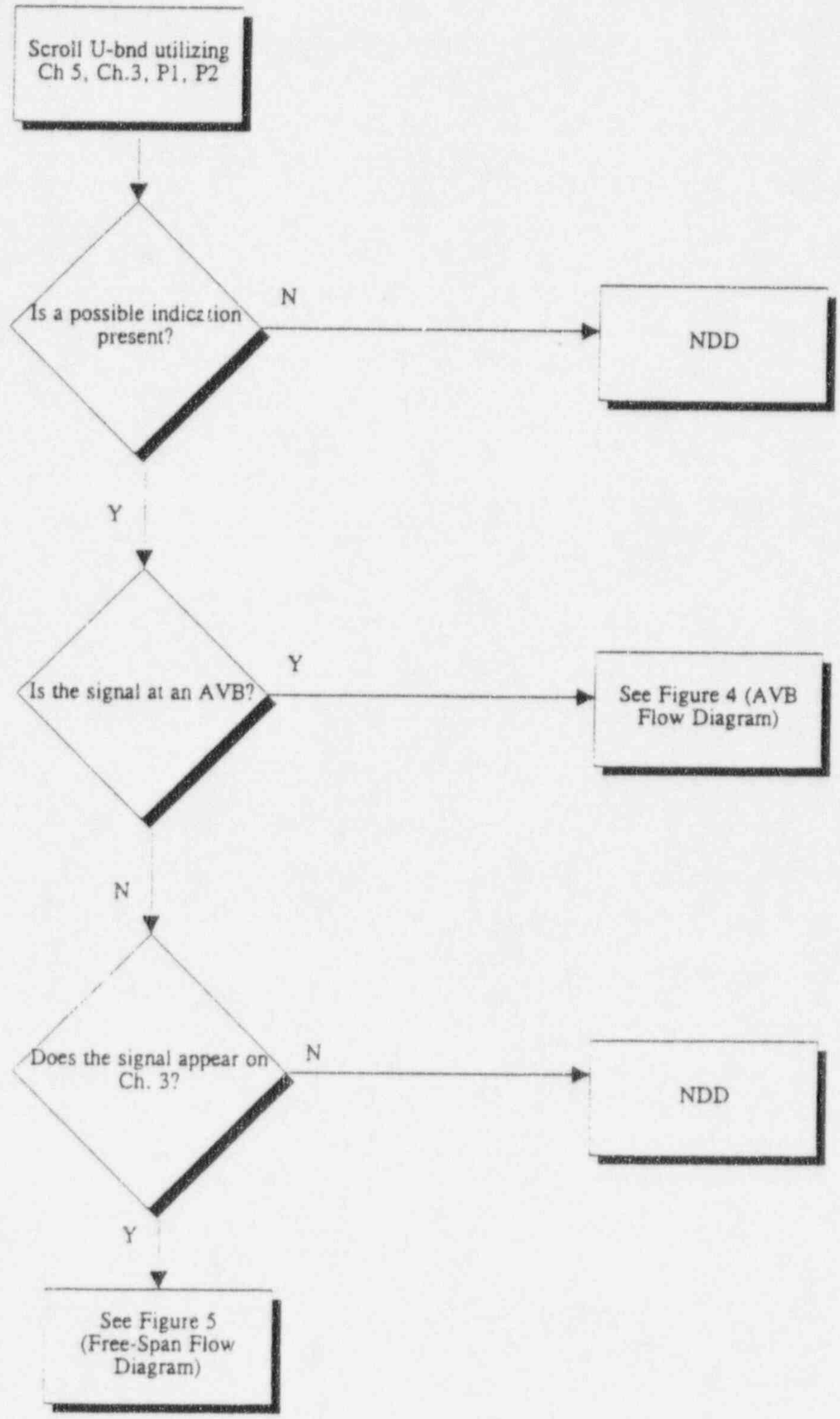



Continued from Page 1
Is large mix residual present @ TSP that may mask a 1.0 volt indication?
Y
Report as MRI (Mix Residual Indication)
Resoultion analyst will confirm all MRI's called by Primary or Secondary
RPC for indication
N
Are copper deposits present @ TSP's?
Y
Report as CUD (Copper Deposit)
Notify Lead Analyst immediately
N
RPC Indications >/= Repair limit
Do Circumferential cracks exits @ TSP's?
Y
Notify Lead Analyst immediately
N
IPC to be applied in accordance with Byron/Braidwood requirements

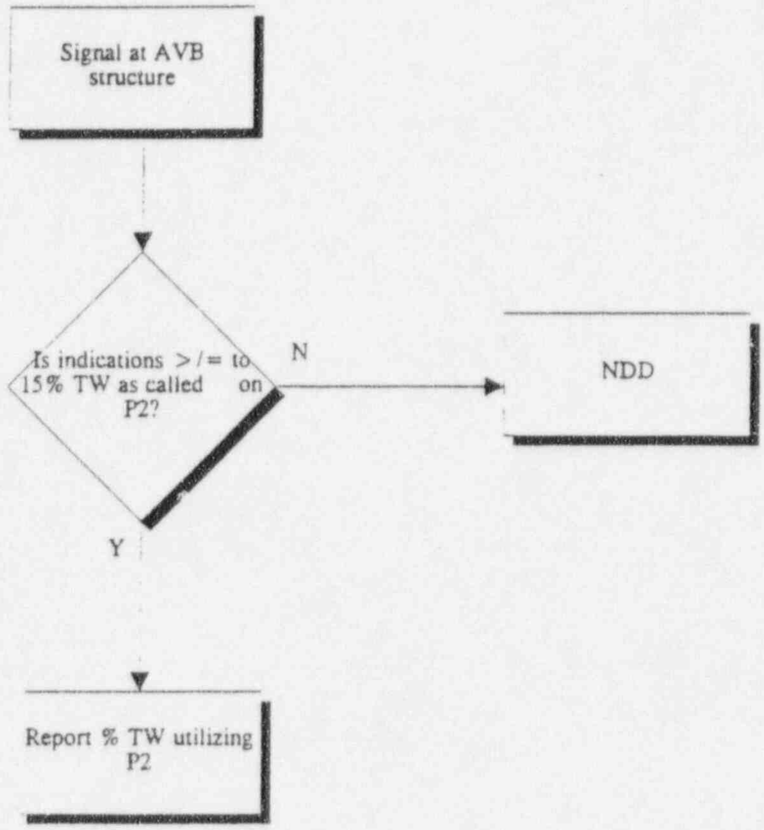
FLOW DIAGRAM FOR TUBESHEET INDICATIONS (F*)
(FIGURE 2)



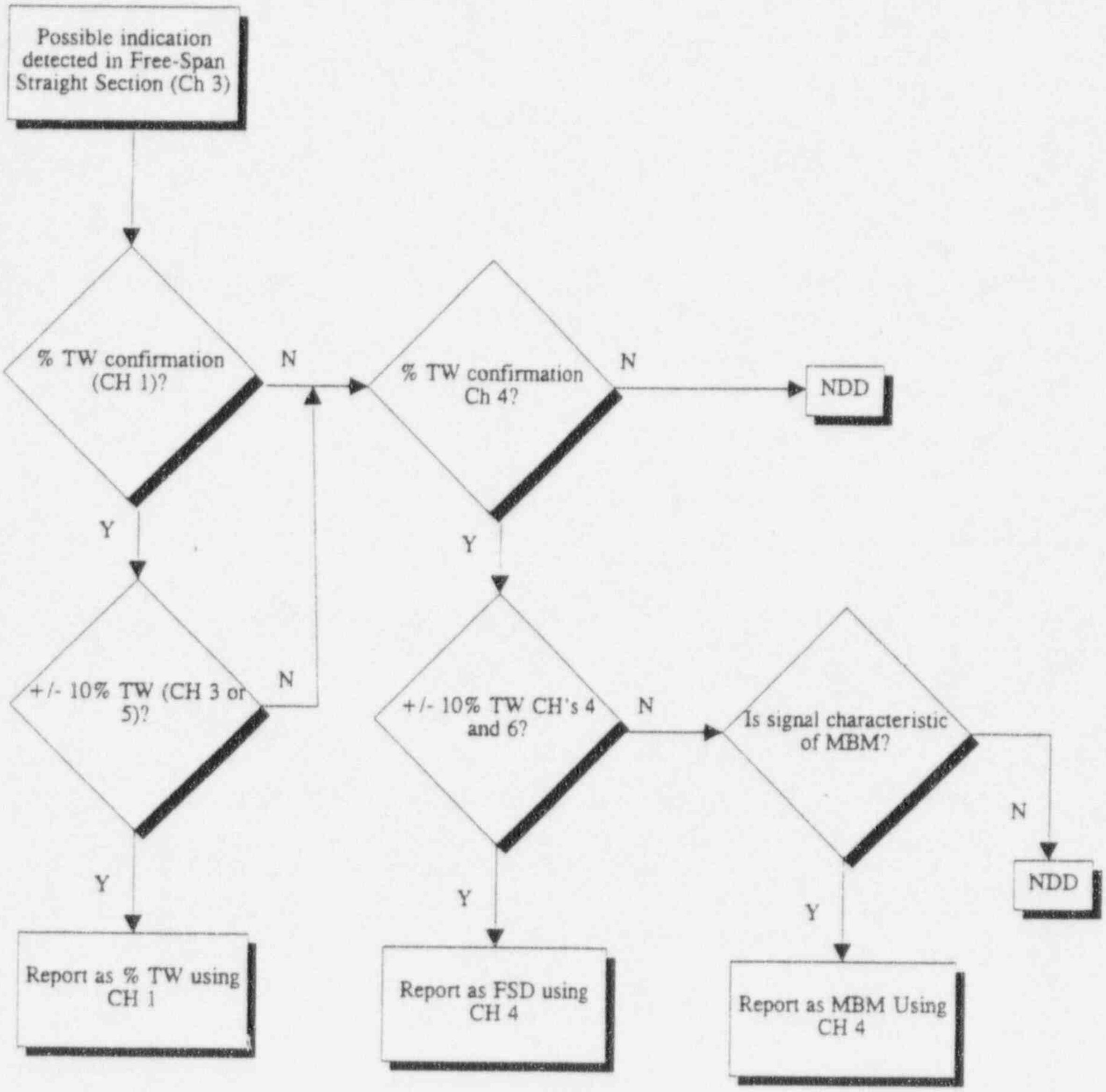
FLOW DIAGRAM FOR U-BEND REGION 11H THROUGH 11C (FIGURE 3)



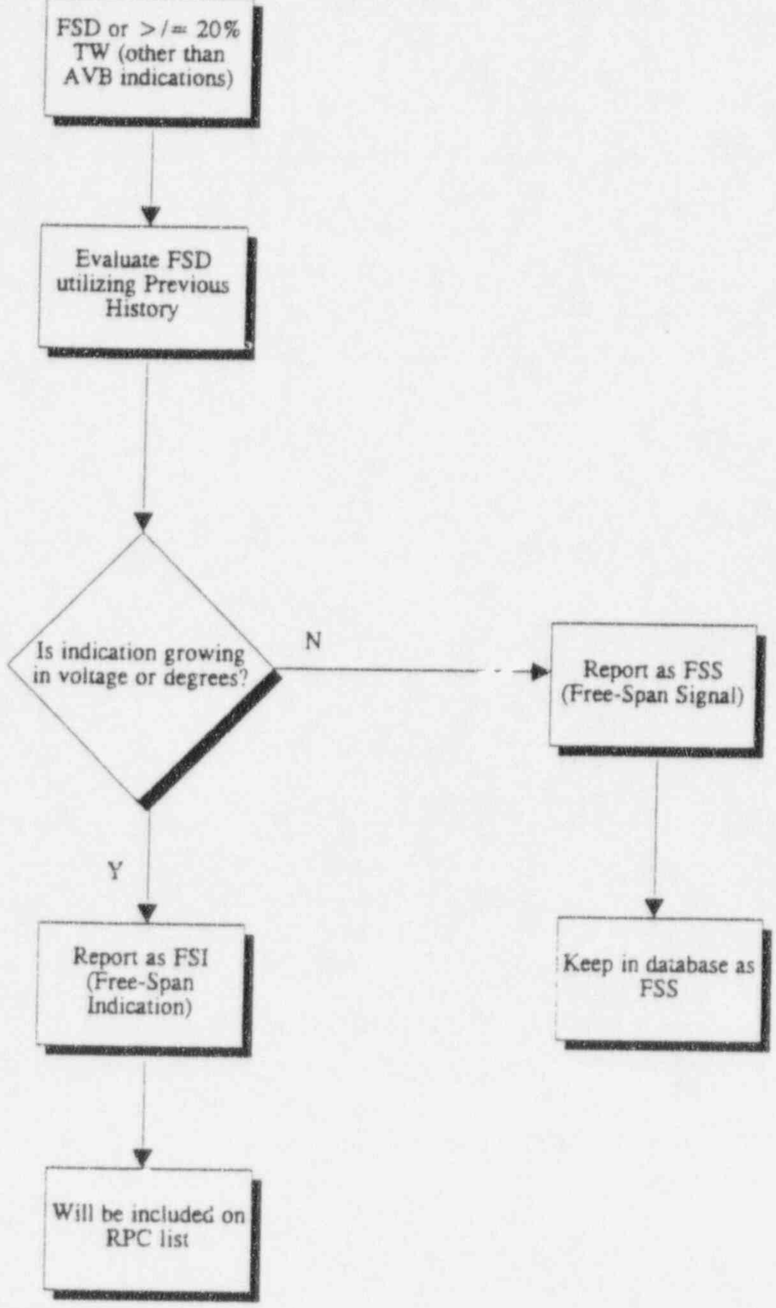
FLOW DIAGRAM FOR INDICATIONS AT AVB'S (FIGURE 4)



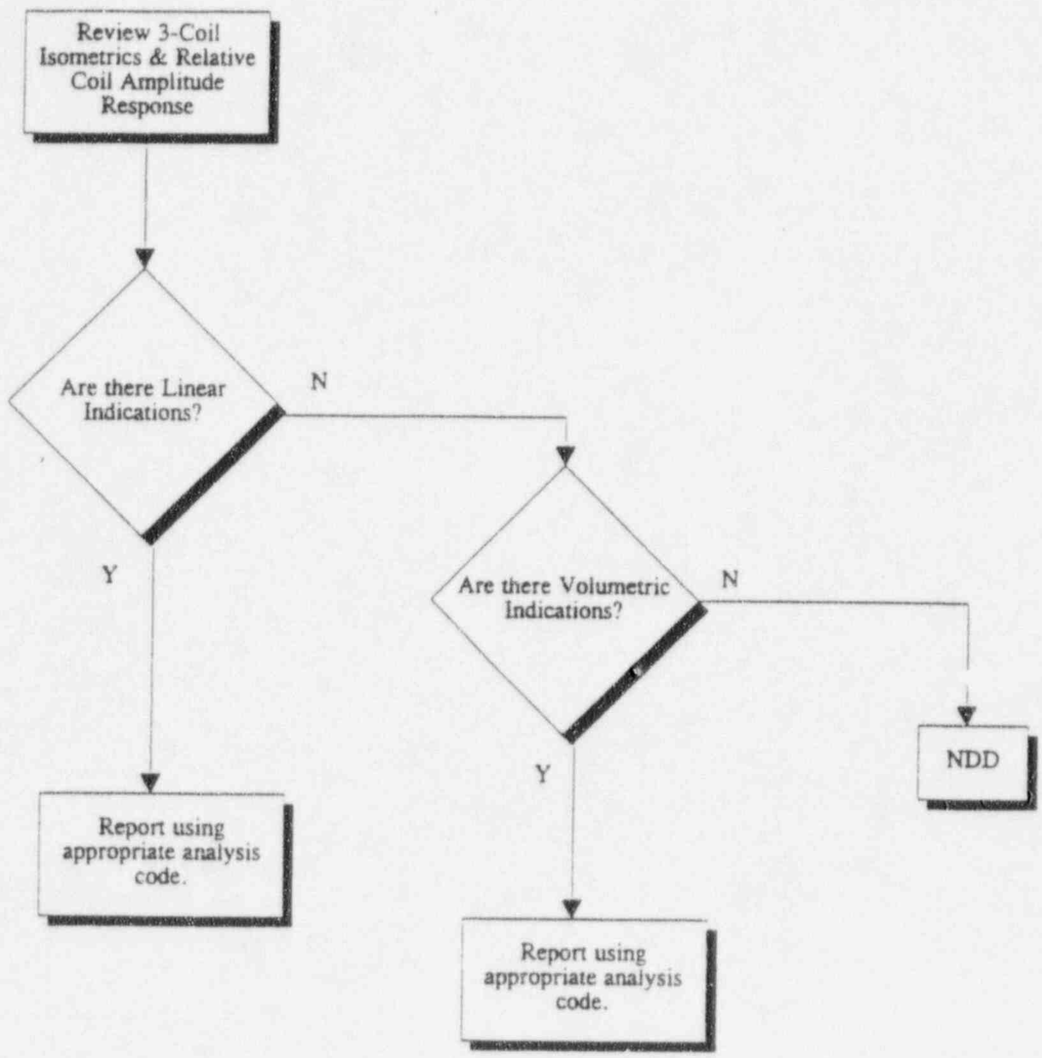
FLOW DIAGRAM FOR FREESPAN STRAIGHT SECTIONS (FIGURE 5)



FLOW DIAGRAM FOR RESOLUTION OF FREESPAN INDICATIONS (FIGURE 6)



FLOW DIAGRAM FOR ROTATING PROBE ANALYSIS (FIGURE 7)



ANALYSIS GUIDELINES CHANGE FORM

CHANGE FORM #: 1

SUBJECT:
Editonal changes to guidelines in section 6.3.3, A.3.9.1(a), Figure 1 and Figure 5 of Attachment 1 and note under A.3.3 "Alloy Property Changes"

DESCRIPTION OF CHANGE:
1) 6.3.3: "Dents or dings > *5.0* volts peak to peak.." This should read "> *2.5 volts*"
2) A.3.9.1: "Bobbin voltage indications > *1.0 volt*". This should read "*>lower repair limit*"
3) Figure 1: See attachment to this page for changes. All changes are generic and do not require any additional input from the analysts.
4) Figure 5: See attachment to this change form. All changes are generic and involve the anlayst making an FSI call rather than a % TW call.
5) Note under A.3.3: Remove the word "All" in the first sentence.

REASON FOR CHANGE:
To provide the analysts with additional information for reporting damage mechanisms.

TECHNICAL BASIS:
These changes are editorial in nature and they do not challenge the technical basis since the analsyts will already be addressing these types of damage mechanisms.

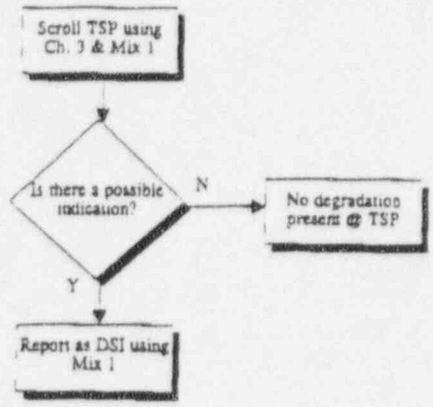
EXAMINATION IMPACT:
None

AUTHORIZATIONS:

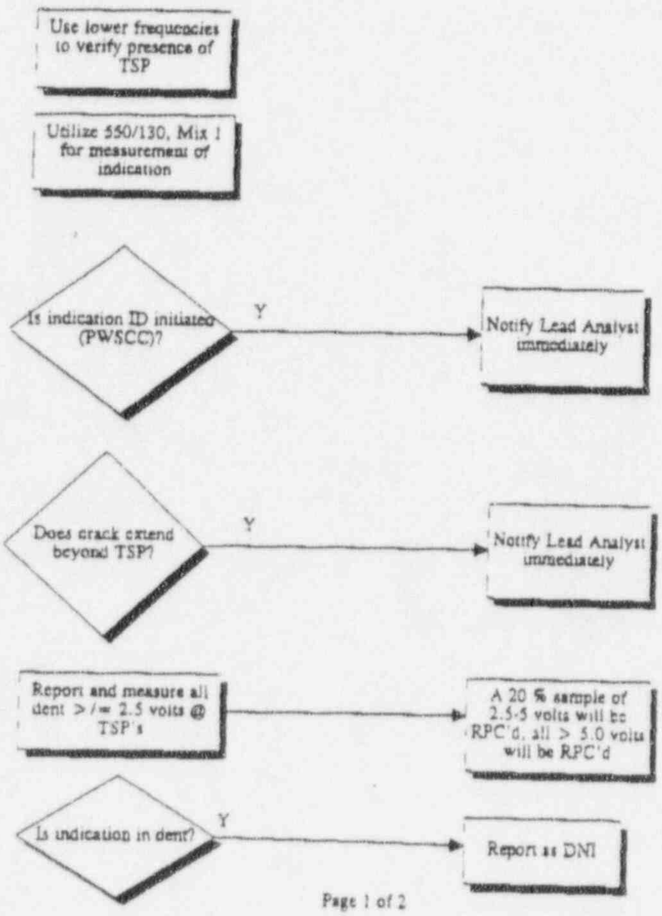
Lead Analyst [signature] Date: 10 / 3 / 95

ComEd Acknowledgment [signature] Date 10 / 3 / 95

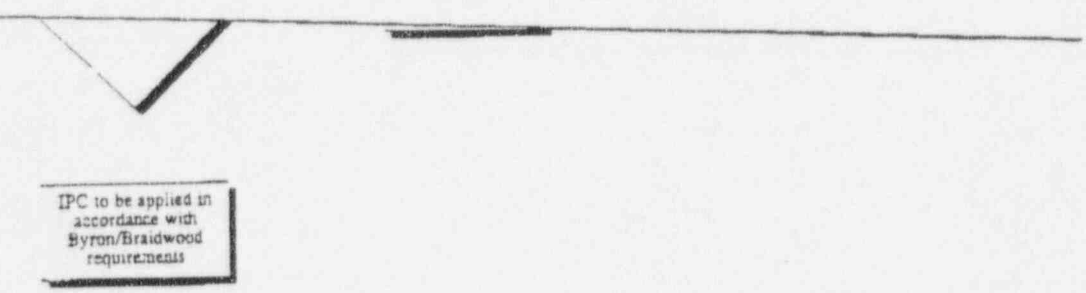
FLOW DIAGRAM FOR TUBE SUPPORT PLATE INDICATIONS (FIGURE 1)



JOB FLOW DIAGRAM

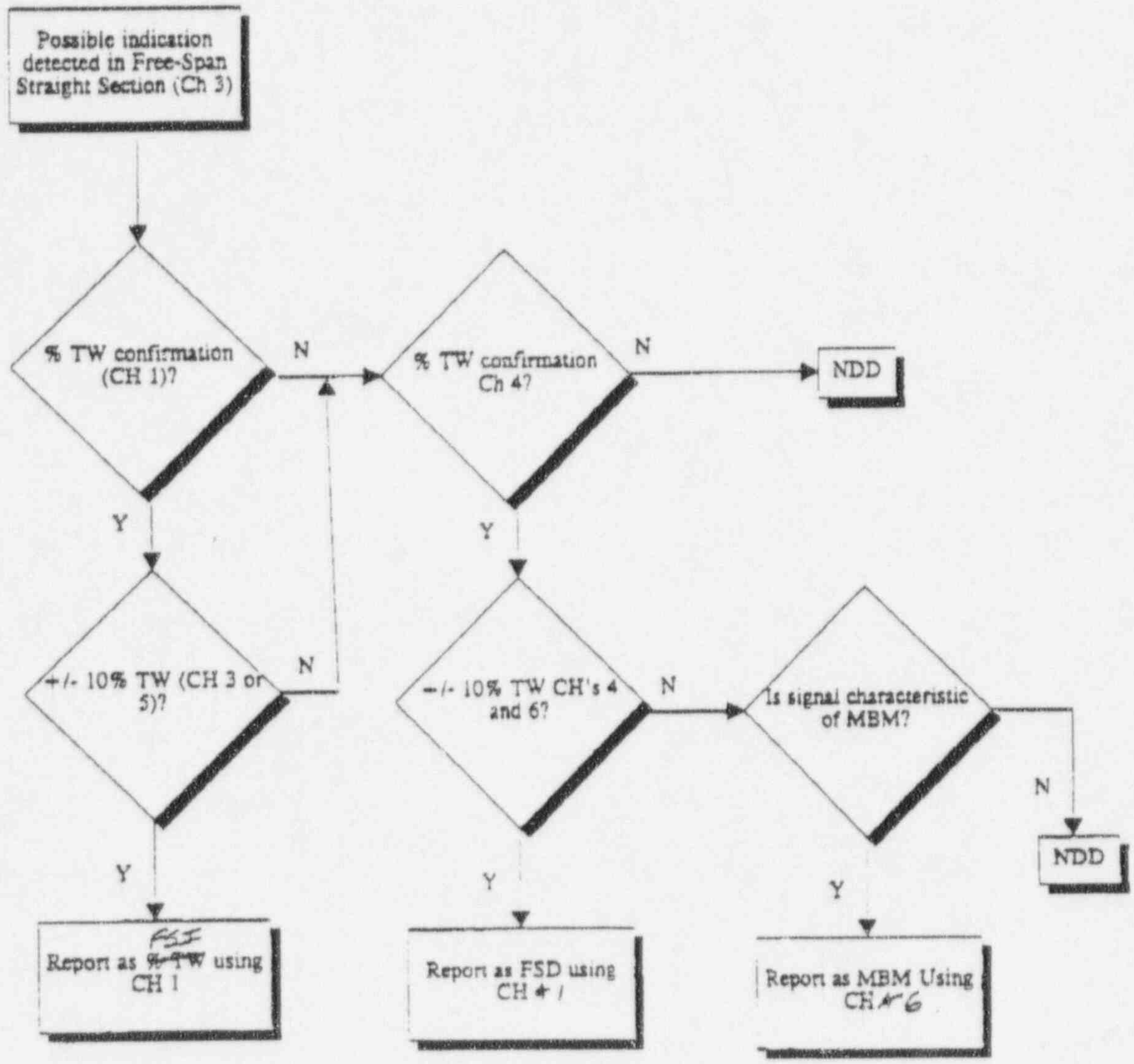


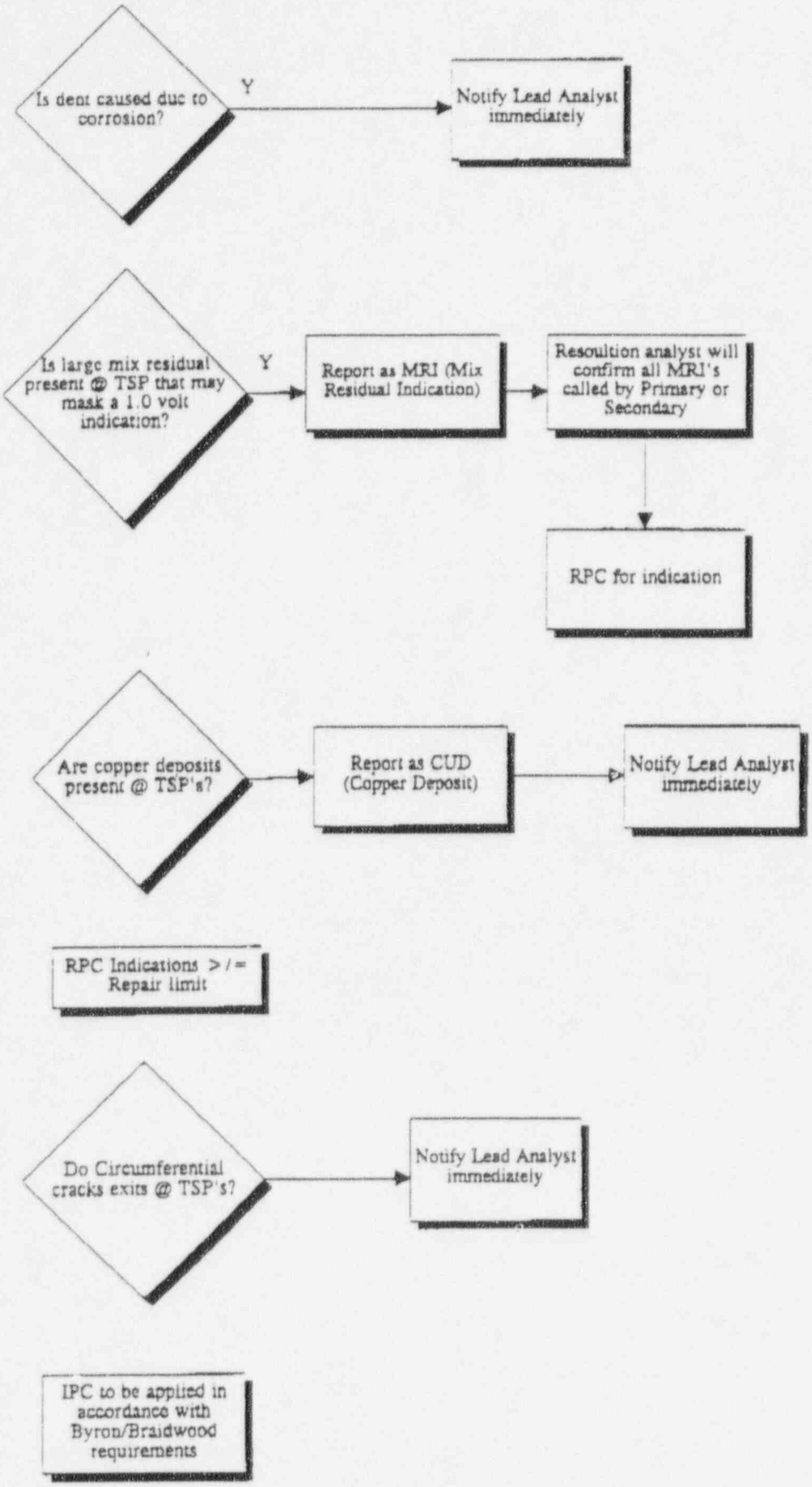
Page 1 of 2



Page 2 of 2

FLOW DIAGRAM FOR FREESPAN STRAIGHT SECTIONS (FIGURE 5)




Is dent caused due to corrosion?
Y
Notify Lead Analyst immediately
Is large mix residual present @ TSP that may mask a 1.0 volt indication?
Y
Report as MRI (Mix Residual Indication)
Resoultion analyst will confirm all MRI's called by Primary or Secondary
RPC for indication
Are copper deposits present @ TSP's?
Report as CUD (Copper Deposit)
Notify Lead Analyst immediately
RPC Indications >/= Repair limit
Do Circumferential cracks exits @ TSP's?
Notify Lead Analyst immediately
IPC to be applied in accordance with Byron/Braidwood requirements

COMED STEAM GENERATOR EDDY CURRENT GUIDELINES

Revision 9, September 1 1995

Byron and Braidwood Unit 1 and Unit 2 Appendix B

ANALYSIS GUIDELINES CHANGE ACKNOWLEDGMENT FORM

(Continued)

CHANGE FORM #: ____________

EFFECTIVE DATE OF CHANGE 10/3/95 TIME __:__ am/pm

Analyst Signature	Date	Time
Kim Soon Gon	10/04/95	10:00
Kwon, Kyung Joo	10/04/95	10:00
OH, CHANG HA	10/04/95	10:00
KO, JONG IN	10/04/95	10:00
KIM, SEOK GON	10/04/95	10:00
YOO, BYEONG YONG	10/04/95	10:00
Harry L. Smith	10/05/95	8:55
[illegible]	10/5/95	15:10
[illegible]	10/5/95	15:15
[illegible]	10/5/95	15:20
[illegible]	10/5/95	15:25
	/ /	:
	/ /	:
	/ /	:
	/ /	:
	/ /	:
	/ /	:
	/ /	:
	/ /	:
	/ /	:

ATTACHMENT 21

ACTS/ANTS
SHEETs

*** SUMMARY FORM ***

OWNER:	CECO	PLANT:	BYRON
UNIT:	1	DATE:	10/05/94
SG 1A		LEG:	HOT
DISK NO.:	BY1A15a		
OPERATOR:	B3905	LEVEL:	II
OPERATOR:		LEVEL:	
ASME S/N:		EDM. S/N:	1240923B
TUBE DIAM:	.750	WALL THICK:	.043
MATERIAL:	INCONEL 600		
PROBE TYPE:	.610 3COIL		
PROBE S/N:			
MANUFACTURE	ZETEC	PROBE LEN:	83'
PR EXT TYPE	COAXIAL		
MANUFACTURE	ZETEC	PR EXT LEN:	50

ADDITIONAL TEXT INPUT:

UNIX MIZ-18 ACQUISITION REV25 PROC. ISI-424, rev.21
COMPUTER: 5011543 DISPLAY: 5011499
HARD DRIVE: 5011590 OPTICAL DRIVE:
MIZ-18 RDAU:5001476 LAN BOX: 5009915 #60

PROBE HEAD:181359 MOTOR UNIT:183791
SLIPRING: 002

CONFIGURATION INFORMATION:

CHAN	1	2	3	4	5	6	7	8
FREQ	300	300	300	200	200	200	100	100
SPAN	18	15	25	32	22	25	23	76
ROT	277	313	326	356	67	55	173	256
COIL	1	5	7	1	5	7	1	4

CHAN	9	10	11	12	13	14	15	16
FREQ	100	100	10					
SPAN	27	15	13					
ROT	190	217	240					
COIL	5	7	1					

W.R.#950020338-01 Doc.#25 Rev.0

NUCLEAR SERVICES DIVISION | JOB DATA SHEET | NO. CAE-04-1095

HEAT EXCHANGER EDDY CURRENT INSPECTION
MULTI-FREQUENCY INSPECTION PARAMETERS, MIZ-18A SYSTEM

CUSTOMER: Commonwealth Edison Company DATE: 10/27/95

PLANT SITE: Byron UNIT: 1 SYMBOL: CAE

HX. TYPE: D-4 IDENTIFICATION AND SIDE: A H/C, B H/C, C H/C, D H/C

PART A: PRECONFIGURED TEST SETUP

NAME: N/A TYPE:

PART B: JOB SPECIFIC CONFIGURATION

NUMBER: 04 SAMPLES PER SEC: 600

NAME: + Point TTS PROBE PUSHER SPEED: .2 inches/sec.

FREQUENCY SEQUENCE		PROBE CHANNEL SELECT							
#	FREQUENCY	COIL 1	COIL 2	COIL 3	COIL 4	COIL 5	COIL 6	COIL 7	COIL 8
1	600 KHz	XXXX				XXXX		XXXX	
2	300 KHz	XXXX				XXXX		XXXX	
3	200 KHz	XXXX			XXXX	XXXX		XXXX	
4	10 KHz	XXXX				XXXX		XXXX	

COMMENTS:
1. Test configuration for top of tubesheet + point.
2. Set rotation to approximately 250 rpm's.
3. Probe pusher speed should be set to approximately .2 inches/sec..
4. Coil 4 at 200 KHZ is the trigger.

SIGNATURES: [signature] 10/28/95
WESTINGHOUSE COORDINATOR/DATE

[signature] 10/27/95
WESTINGHOUSE NDE LEVEL III/DATE

[signature]
CUSTOMER/DATE

Byron-1 B1RO7 Steam Generator Eddy Current Examinations

ACQUISITION TECHNIQUE SHEET NO. 3	Rev. 0	Date: 04/11/96	Page 3 of 8

APPLICABILITY: **TTS / ARD* PLUS POINT**

INSPECTION MATERIAL TYPE/SIZE: Inconel 600 tubing 0.750" OD X 0.043" Wall Thickness	SCAN SPEED: 0.6 IPS
INSPECTION EQUIPMENT: Zetec MIZ-30 Multi-Frequency Eddy Current Instrument	
PROBE MANUF., TYPE & SIZE: Zetec 0.610" Plus Point Probe (with 0.115" and 0.080" Mid-range Pancake Coils)	ROTATION SPEED: 900 RPM
PROBE EXT. CABLE TYPE & LENGTH: Zetec Universal Cable 945-1760 - 50 ft.	
CALIBRATION STANDARDS: ASME/EDM Guide Tube Std.	SCAN DIRECTION: PUSH
DATA RECORDING: Pinnacle Micro Sierra 1.3 Gb Optical Drive and 3M Rewritable Optical Disk 650 Mb	

SPECIAL INSTRUCTIONS: Perform examinations in accordance with Procedure 54-ISI-400-00

When a single guide tube is used deactivate boards #3 & #4, change active probes to 1

* When performing the ARD exams use a 0.080" HF pancake coil

MIZ-30

trig: off | down | configuration # : | name : | samples / sec : 1230 | rec. media = HARD DRIVE

tester = miz-30 | # of channels = 22

		board # 1 probe # 1				board # 2 probe # 1				board # 3 probe # 2				board # 4 probe # 2			
		DRIVE A	D	B	C	DRIVE A	D	B	C	DRIVE A	D	B	C	DRIVE A	D	B	C
Drive Polarity		N			N	N		N		N			N	N		N	
Group Number		1			1	1		1		2			2	2		2	
Coil Number		1			4	5		7		1			4	5		7	
FREQ #1 300 kHz	Time Slot # 1 G: x 2 16.0 V	D				D		D		D				D		D	
FREQ #2 200 kHz	Time Slot # 2 G: x 2 16.0 V	D				D		D		D				D		D	
FREQ #3 100 kHz	Time Slot # 3 G: x 2 16.0 V	D			D	D		D		D			D	D		D	
FREQ #4 20 kHz	Time Slot # 4 G: x 4 16.0 V	D								D							
FREQ #5	Time Slot # 5 G: x 2 12.0 V																
FREQ #6	Time Slot # 6 G: x 2 12.0 V																
FREQ #7	Time Slot # 7 G: x 2 12.0 V																
FREQ #8	Time Slot # 8 G: x 2 12.0 V																

		board # 5 probe # 1				board # 6 probe # 1				board # 7 probe # 1				board # 8 probe # 1			
		DRIVE A	D	B	C	DRIVE A	D	B	C	DRIVE A	D	B	C	DRIVE A	D	B	C
Drive Polarity																	
Group Number																	
Coil Number																	
FREQ #1 300 kHz	Time Slot # 1 G: x 2 16.0 V																
FREQ #2 200 kHz	Time Slot # 2 G: x 2 16.0 V																
FREQ #3 100 kHz	Time Slot # 3 G: x 2 16.0 V																
FREQ #4 20 kHz	Time Slot # 4 G: x 4 16.0 V																
FREQ #5	Time Slot # 5 G: x 2 12.0 V																
FREQ #6	Time Slot # 6 G: x 2 12.0 V																
FREQ #7	Time Slot # 7 G: x 2 12.0 V																
FREQ #8	Time Slot # 8 G: x 2 12.0 V																

END LOC CH : 1 1	DRIVE A : D = A1-A2, P = dr:A1 pu:A2, DP = dr : D1&D2 pu : A1&A2
THRESHOLD : off off	DRIVE B : D = B1-B2, A = A1-B2
(P) GAIN : x6	P = dr : B1 pu:B2, DP = dr : C1&C2 pu : B1&B2
ACTIVE PROBES 2	DRIVE C : D = C1-C2, A = D1-C2
	DRIVE D : D = D1-D2

NUCLEAR SERVICES DIVISION

JOB DATA SHEET

NO. CCE-02
REV 0

HEAT EXCHANGER EDDY CURRENT INSPECTION
MULTI-FREQUENCY INSPECTION PARAMETERS, MIZ-18A SYSTEM

CUSTOMER: Commonwealth Edison Company DATE: 2/02/95

PLANT SITE: Braidwood UNIT: 1 SYMBOL: CCE

HX. TYPE: D-4 IDENTIFICATION AND SIDE: A H/C, B H/C, C H/C, D H/C

PART A: PRECONFIGURED TEST SETUP

NAME: N/A TYPE: ______

PART B: JOB SPECIFIC CONFIGURATION

NUMBER: 02 SAMPLES PER SEC: 400

NAME: 3 Coil RPC PROBE PUSHER SPEED: .2 inches/sec.

FREQUENCY SEQUENCE #	FREQUENCY	PROBE CHANNEL SELECT: COIL 1	COIL 2	COIL 3	COIL 4	COIL 5	COIL 6	COIL 7	COIL
1	300 KHz	XXXX				XXXX		XXXX	
2	200 KHz	XXXX				XXXX		XXXX	
3	100 KHz	XXXX			XXXX	XXXX		XXXX	
4	10 KHz	XXXX							

COMMENTS:

1) Test configuration for straight length and ubend rotating pancake 3-coil inspection.
2) Set rotation to approximately 300 rpm's.
3) Probe pusher speed should be set to approximately .2 inches/sec.

SIGNATURES: Roy A. Popovich 2/14/95
WESTINGHOUSE LEVEL III / DATE

[signature] 2-22-95
WESTINGHOUSE COORDINATOR / DATE

[signature] 2-22-95
CUSTOMER / DATE

*** SUMMARY FORM ***

OWNER:	HL&P	PLANT:	STPEGS
UNIT:	I	DATE:	03/25/95
SG 1D		LEG:	HOT

CAL GRP: 166

OPERATOR:	C3697	LEVEL:	II
OPERATOR:		LEVEL:	

ASME S/N:	Z-13504	STD S/N:	N/A
TUBE DIAM:	.750"	WALL THICK:	.043
MATERIAL:	INCONEL 600		

PROBE TYPE:	.600 3-COIL MRtC		
PROBE S/N:			
MANUFACTURE	ZETEC	PROBE LEN:	83′
PR EXT TYPE	LOW LOSS PROFIL		
MANUFACTURE	ZETEC	PR EXT LEN:	50′

ADDITIONAL TEXT INPUT:
UNIX MIZ 30-4 ACQUISITION REV.27.4 PROC. ISI-510 REV.15
MIZ 30-4 RDAU:029
LIVE PROBE:
REF. PROBE:
PROBE HEAD:214913
MOTOR UNIT:215742
EXT. SHAFT:215894

CONFIGURATION INFORMATION:

CHAN	1	2	3	4	5	6	7	8	9	10	11	12	13
FREQ	300	300	300	200	200	200	100	100	100	100	10		
SPAN	153	137	121	138	59	72	126	268	32	34	44		
ROT	266	283	287	8	26	32	113	201	109	109	204		
COIL	1	[illegible]	7	1	5	7	1	4	5	7	1		

CHAN	14	15	16	17	18	19	20	21	22	23	24	25	26
FREQ													
SPAN													
ROT													
COIL													

CHAN	27	28	29	30	31	32	33	34	35	36	37	38	39
FREQ													
SPAN													
ROT													
COIL													

CHAN	40	41	42	43	44	45	46	47	48	49	50	51	52
FREQ													
SPAN													
ROT													
COIL													

CHAN	53	54	55	56	57	58	59	60	61	62	63	64
FREQ												
SPAN												
ROT												
COIL												

*** SUMMARY FORM ***

OWNER: B.G.E
UNIT: 2
SG 22

PLANT: Calvert Cliffs
DATE: 4-6-93
LEG: HOT

DISK NO.: –

OPERATOR: S.Yatabe
OPERATOR:

LEVEL: IIB
LEVEL:

ASME S/N: Z-13333
TUBE DIAM: 0.750
MATERIAL: INCONEL 600

STD S/N:
WALL THICK: 0.048

PROBE TYPE: .600 plus point
PROBE S/N:
MANUFACTURE ZETEC
PR EXT TYPE profilometry
MANUFACTURE ZETEC

PROBE LEN: 83'
PR EXT LEN: 50

ADDITIONAL TEXT INPUT:

MIZ 30 S/N 39
MU SN# 216073
EXT SN# 216336
P/H SN# 216415

CONFIGURATION INFORMATION:

CHAN	1	2	3	4	5	6	7	8	9	10	11	12	13
FREQ	300	300	200	200	100	100	100	20	20				
SPAN	187	29	103	149	39	337	36	101	36				
ROT	272	192	357	20	103	204	44	58	223				
COIL	1	5	1	5	1	4	5	1	5				

CHAN	14	15	16	17	18	19	20	21	22	23	24	25	26
FREQ													
SPAN													
ROT													
COIL													

CHAN	27	28	29	30	31	32	33	34	35	36	37	38	39
FREQ													
SPAN													
ROT													
COIL													

CHAN	40	41	42	43	44	45	46	47	48	49	50	51	52
FREQ													
SPAN													
ROT													
COIL													

CHAN	53	54	55	56	57	58	59	60	61	62	63	64
FREQ												
SPAN												
ROT												
COIL												

Eddynet Message Viewer /rod0101/raw/tape34Ccal04i/SL_000_9901000

OWNER: ENTERGY OPS.	CHAN	1	2	3	4	5	6	7	8
PLANT: ANO	FREQ	400	400	400	200	200	200	100	100
UNIT: 02 DATE:03/23/92	SPAN	64	55	129	154	74	126	48	312
S/G: B LEG:INLET	ROT	256	265	273	18	50	70	146	237
TAPE NO: 027	COIL	1	5	7	1	5	7	1	4
OPER/LVL:P5581/II /									
OPER/LVL: / /	CHAN	9	10	11	12	13	14	15	16
ASME CAL. STD:Z-10273	FREQ	10							
EDM CAL. STD:	SPAN	38							
PROFIL STD:	ROT	43							
SIZE: 0.750"OD X 0.049"WL	COIL	1							

MATERIAL: INCONEL 600

PROBE TYPE: .590 MRPC MIZ-18 ACQUISITION EDITION 18.7 REV1.0

PROBE MFG/LENGTH:ZETEC/83 FT. EXT. CABLE TYPE/LENGTH:COAX / 60 FT

EQUIPMENT SERIAL NUMBERS: MIZ-18 RDAU: 271 HPIB INTERFACE: 5000228

COMPUTER: 5005721 DISPLAY: 5003928 DATA CARTRIDGE RECORDER: 5001440

PROBE HEAD:154758 MOTOR UNIT:0151367

PROBE HEAD: MOTOR UNIT:

PROBE HEAD: ECT PROCEDURE: ISI-510, REV:11

PROBE SPEED:0.2INCHES/SEC. SAMPLE RATE: 400SAMPLES/SEC. COMMENTS:

Next Tube ... | Refresh Previous ... | Data Directory ... | Next Message ... | PRINT

ATTACHMENT 30

DATA ANALYSIS GUIDELINES

BYRON UNIT 1

STEAM GENERATOR

EDDY CURRENT LOOK-BACK ANALYSIS GUIDELINES

1.0 PURPOSE

1.1 The purpose of this guideline is to provide general instructions and to define specific requirements for the look-back analysis of the Byron Unit 1 steam generator eddy current data using the Zetec Voltage Integral software.

1.2 These look-back analysis guidelines provide a structure to ensure that data is (a) analyzed in accordance with the appropriate techniques and practices that reflect current industry experience, (b) in a consistent and repeatable manner and (c) in compliance with ComEd requirements.

1.3 Conditions encountered during the course of the look-back analysis not foreseen by this guideline are to be reported by the data analysts to the Lead Analyst and the ComEd Level III.

1.4 Referencing Documents:

1.4.1 Zetec "Voltage Integral" features operation manual.

2.0 OBJECTIVES

2.1 Determine a predicted end of cycle average voltage distribution for Byron Unit 1 circumferential indications to assess full cycle operation.

2.2 Develop voltage limit(s) for structural integrity.

3.0 WORKSCOPE

3.1 Analyze the .080" MRPC and Plus Point data for tubes with .080" MRPC indications detected during the 1995 (SG B) and 1996 (SG C) look-backs. These tubes are identified as Attachments 1 and 2 respectively. The tubes with a voltage value identified under the column 1996 volts (1996 look-back only) , 1995 volts, or 1994 volts are the tubes with detectable indications which will be included within the look-back analysis. The tubes with blanks in these columns are not within the workscope of this look-back. Look-back to previous years if an indication was detected during the original look-back.

3.2 A total of 132 circumferential indications were reported during the 1994 inspection. The indications that were identified in steam generators B and C will be reanalyzed using the voltage integral software. The tubes are identified in Attachment 3.

3.3 Report the voltage integral from the .080" pancake coil and the plus point coil for each indication using the latest revision of EddyNet95 analysis software (Patch 2.4)

3.4 The same analyst will perform the analysis for all three years.

4.0 PERSONNEL QUALIFICATIONS

4.1 Personnel performing the look-backs must be qualified to at least Level II-A, preferably a Level III and shall be qualified in accordance with SNT-TC-1A.

4.2 Per ComEd's response to Generic letter 95-03 "Circumferential Cracking of Steam Generator Tubes" all analysts who perform the look-back evaluation from the MRPC

data from the top of the tubesheet inspection will be Qualified Data Analysts (QDA's) per EPRI Guidelines Appendix G.

5.0 CALIBRATION

Calibration set-up is performed for each calibration group. The standard nearest to the first tube acquired should be used for the calibration set-up.

5.1 Set the voltage of the 100% axial EDM notch to 20.00 volts for the 0.080" pancake coil and the plus point coil in the normal lissajous window using peak to peak. Select the Set Volt Units in the Circ Liz RPC window. Choose Set Circ to Main Eddy in the Circ voltage Scale Menu popup. **NOTE:** If the data is saturated in the pancake coil use the 100% through wall hole and set to 10.00 volts.

5.2 For the 1996 and 1995 data, set the circumferential flaws going up both in the 300 kHz plus point and the 300 kHz 0.080" pancake coil with probe motion horizontal.

5.3 For the 1994 data, set the EDM notches for the 300 kHz 0.080" pancake, axial and circ. coils going up first with probe motion horizontal.

5.4 Set the span for the 300 kHz 0.080" pancake, 300kHz plus point (1996 and 1995 data) to 3 divisions on the 60% OD axial EDM notch.

5.5 Set the 300 kHz circ. coil (1994) data so that the nominal 40% circ EDM notch is at approximately 1.5 divisions.

5.6 Set the measurement scale between known indications in the calibration standard.

5.7 Set the left strip chart to display the plus point coil for the 1996 and 1995 data. Set the left strip chart to display the circ. coil for the 1994 data.

5.8 Set the right strip chart to display the 10 kHz pancake coil.

5.9 Set the lissajous display to the 300 kHz plus point coil (1996 and 1995) data and the 300 kHz circ. coil for the 1994 data.

5.10 Set the 10 kHz top of the tubesheet locator channel to a span that exhibits a clear representation of the top of the tubesheet signal.

5.11 Set up the appropriate slewing (rotate data) for each coil.

5.12 Refer to Appendix 1 for the set-up procedure to be used for the voltage integral analysis software.

6.0 DATA EVALUATION

6.1 For the look-back evaluation, display the tube for all data sets to be evaluated on the lissajous display(s) in reference to attachments 1, 2 and 3.

6.2 C-Scan the 300 kHz plus point data for the 1996 and 1995 data.

6.3 C-Scan the 300 kHz circ. coil data for the 1994 data.

6.4 Adjust the offset so that the indications are in the center of the C-Scan plot for all three years. Select the same circumferential scan line in all data sets.

6.5 All voltage measurements will be reported off of the 300 kHz 0.080" pancake coil. For the 1996 and 1995 data, all indications originally reported with the 0.080" pancake coil will also be reported with the 300 kHz plus point coil.

6.6 For the 0.080" pancake coil, the circ line filter will be used to reduce the effects of tube wall variations. The line will be applied above the tube sheet. Note: The circ line filter will not be used for the plus point coil measurements.

7.0 REPORTING REQUIREMENTS

7.1 All previous circumferential indications reported for each data set 1996, 1995 and 1994 identified in attachments 1, 2 and 3 shall be reported with the voltage integral value.

8.0 RECORDING REQUIREMENTS

8.1 The following information will be recorded in the final report section of the recording medium.

8.1.1 For each tube that has the voltage integral measurement, two entries must be made that, as a minimum, contains the S/G, ROW, COL, VOLTS, CH#, LOCATION, and EXTENT tested.

8.1.2 The report entry dialog will automatically assign the "VIR" three-letter code in the "percent" field of the final report. The "ARC" field displays the voltage integral value.

8.1.3 From the circ lissajous window, record the "voltage at cursor" using a vert max measurement. Type "MAX" in the percent field.

8.1.4 Circumferential indications that are identified as being 360 degrees will be entered on the first line entry in the degree field as "360".

8.1.5 A standard Rockridge header shall be used.

BLIND TEST DATA EVALUATION GUIDELINES FOR EXPANSION ZONE CIRCUMFERENTIAL CRACKING USING ZETEC VOLTAGE INTEGRAL ANALYSIS SOFTWARE

1.0 PURPOSE

1.1 The purpose of this guideline is to provide general instructions and to define specific requirements for the evaluation of Byron, Braidwood and Industry steam generator eddy current data using the Zetec Voltage Integral software.

1.2 These guidelines provide a structure to ensure that data is (a) analyzed in accordance with the appropriate techniques and practices that reflect current industry experience, (b) in a consistent and repeatable manner and (c) in compliance with ComEd requirements.

1.3 Conditions encountered during the course of the blind test not foreseen by these guidelines are to be reported by the data analysts to the Lead Analyst and the ComEd Level III.

1.4 Referencing Documents:

1.4.1 Zetec "Voltage Integral" features operation manual.

1.4.2 Appendix A, "Expansion Zone Circumferential Cracking Data Evaluation Guidelines Using Zetec Voltage Integral Analysis Software".

1.4.3 Zetec EddyNet MRPC User Guide.

2.0 OBJECTIVES

2.1 Determine analyst ability to evaluate the appropriate scan line.

2.2 Determine analyst ability to report the maximum and average voltage.

2.3 Determine Voltage Integral Software scan line variability.

3.0 WORKSCOPE

3.1 Analyze the 180 tube blind test which consists of Byron, Braidwood and Industry circumferential crack data. The blind test is made up of in-generator data, tube pulls and insitu pressure test data.

3.2 The probe of record is the 0.080" pancake coil for all voltage measurements.

3.3 The Voltage Integral Software shall be used to measure the maximum and average voltages for the maximum single circumferential scan line that is produced on the C-Scan display.

4.0 PERSONNEL QUALIFICATIONS

4.1 Personnel performing the analysis must be qualified to at least Level II-A and shall be qualified in accordance with SNT-TC-1A.

4.2 Per ComEd's response to Generic letter 95-03 "Circumferential Cracking of Steam Generator Tubes" all analysts who perform the blind test analysis will be Qualified Data Analysts (QDA's) per EPRI Guidelines Appendix G&H of the ISI Guidelines (PWR Steam Generator Examination Guidelines: Latest Revision EPRI NP-6201).

5.0 CALIBRATION

Calibration set-up is performed for each calibration group. Locate the ASME or EDM standard that contains the 100% through wall (TW) hole. The 100% TW hole shall be used for the calibration setup.

5.1 Set the reporting channel voltage, normally 300 kHz from the 100% TW hole to 10.00 volts peak-to-peak for the 0.080" pancake coil in the main Eddynet lissajous window. Store the voltage to the reporting frequency. Select the Set Volt Units in the Circ Liz RPC window and perform a peak-to-peak measurement. Choose Set Circ to Main Eddy in the Circ voltage Scale popup Menu. **NOTE:** for calibration groups not acquired with the 300 kHz use the 400 kHz 0.080"pancake coil as the primary reporting channel.

5.2 Set the 100% TW hole for the 300 or 400 kHz 0.080" pancake coil at 5 degrees. Set the remaining coils going up first with probe motion horizontal.

5.3 Set the spans such that the peak-to-peak response of the 60% flat bottom hole is full screen height for the 300 or 400 kHz pancake coil. Set the remaining coils from the 60% flat bottom hole to full screen height.

5.4 Set the measurement scale between known indications in the calibration standard.

5.5 Set the zoom to a value of 30.

5.6 Set the left strip chart to display the circumferential coil for the 3-coil probe. If the 3-coil probe is not used for a specific calibration group, the analyst shall use his discretion. An appropriate coil for screening of circumferential flaws shall be displayed.

5.7 Set the right strip chart to display the 10 kHz pancake coil.

5.8 Set the lissajous display to the 300 or 400 kHz pancake coil.

5.9 Set the 10 kHz top of the tube sheet locator channel to a span that exhibits a clear representation of the top of the tube sheet signal.

5.10 Set up the appropriate slewing (rotate data) for each coil. The data slewing eliminates the offset in the eddy current data caused by the physical separation of the coils.

5.11 Refer to Appendix A for the set-up procedure to be used for the voltage integral analysis software.

5.12 Filters shall be used as a minimum. If filters are used the axial average filter shall be used. The Axial average smoothes the data offsets visually represented down the axial scan lines in the C-scan plot. The filter averages all of the data point values on a given circumferential scan line and subtracts the average value from every data point on that line. The output reduces the data offsets in the axial direction similar to the axial line filter. If the axial average filter does not produce an acceptable C-scan plot to measure the voltage of the circumferential scan line the Circumferential Line Filter shall be used. The circumferential line filter lets you choose a circumferential scan line to use as a filter line. The chosen line is

subtracted from every circumferential scan line in the C-scan plot. It acts as a nulling function for all of the circumferential scans and removes unwanted signals that occur consistently in each scan line. Be sure to choose a non-flawed scan line as the filter line.

5.13 Toggle R-SLEW on. The R-Slew removes the helical effect in the C-scan plot created by the rotating probe.

6.0 DATA EVALUATION

6.1 Display the tube to be evaluated on the lissajous display. Review the strip chart data while scrolling the expansion zone using the primary frequency of 300 or 400 kHz. The 300 or 400 kHz circ. coil shall also be used for additional confirmation.

6.2 C-Scans shall be viewed and plotted for the expansion zone using each coil, (pancake, axial, circumferential or plus point).

6.3 Adjust the Trigger offset so that the indications are in the center of the C-Scan plot.

6.4 Adjust span settings as required such that proper detailed analysis is conducted on all data for the expansion zone.

7.0 REPORTING REQUIREMENTS

7.1 The voltage of an indication will be measured at the peak signal for each indication. This will typically be at the centermost "hit" of the indication using the 300 or 400 kHz 0.080" pancake coil. Vertical Maximum "VERT. MAX" shall be used for the voltage measurement.

7.2 The location of indications will be derived from the centermost "hit" point of the calling channel.

7.3 The extent tested will be TSHTSH.

8.0 RECORDING REQUIREMENTS

8.1 The following information will be recorded in the final report section of the recording medium.

8.1.1 For each tube that has the voltage integral measurement an entry must be made that, as a minimum, contains the S/G, ROW, COL, VOLTS, CH#, LOCATION, and EXTENT tested.

8.1.2 The report entry dialog will automatically assign the "VIR" three-letter code in the "percent" field of the final report. The "ARC" field displays the voltage integral value.

8.1.3 Manually report the Maximum voltage "MAX" three-letter code in the "percent" field of the final report. Manually record the vertical maximum voltage in the ARC field of the report taken from the Volts at cursor in the Voltage Integral widget.

8.1.4 Circumferential indications that are identified as being 360 degrees will be entered into the final report as 360 in the DEGREE field.

APPENDIX A

EXPANSION ZONE CIRCUMFERENTIAL CRACKING DATA EVALUATION GUIDELINES USING ZETEC VOLTAGE INTEGRAL ANALYSIS SOFTWARE

1.0 SCOPE

These guidelines provide instructions for the measurement of the integrated voltage under a single circumferential line-scan (rotating probe data) using Zetec Eddynet software.

2.0 CALIBRATION

2.1 Activate Eddynet and MRPC analysis windows.

2.2 Set the following features in the RPC User Selectables window as follows:

- Circ filter - Off
- Axial filter - Off
- Activate - On
- Crosshatch - Off
- Voltage Integral - Yes
- Circ DEG INC - 10
- Axial Filtering - No
- TUBING DIAMETER MID WALL .702"

Other features not specified should be set at values as determined by the authorized Leve III

2.2 Set the reporting channel voltage from the 100% through wall hole signal to 10.00 volts peak-to-peak in the *main* Eddynet Lissajous window.

2.3 Select the *Set Volt Units* in the *Circ Liz RPC* window. Choose *Set Circ to a Main Eddy* in the *Circ Voltage Scale* popup *Menu.*

3.0 CALIBRATION

3.1 Generate a C-Scan display for the expansion region of interest as shown in Figure 1.

3.2 Using the *Axial and Circumferential Strip Chart Cursors*, isolate the C-scan line associated with the maximum vertical channel displacement as shown in Figure 2.

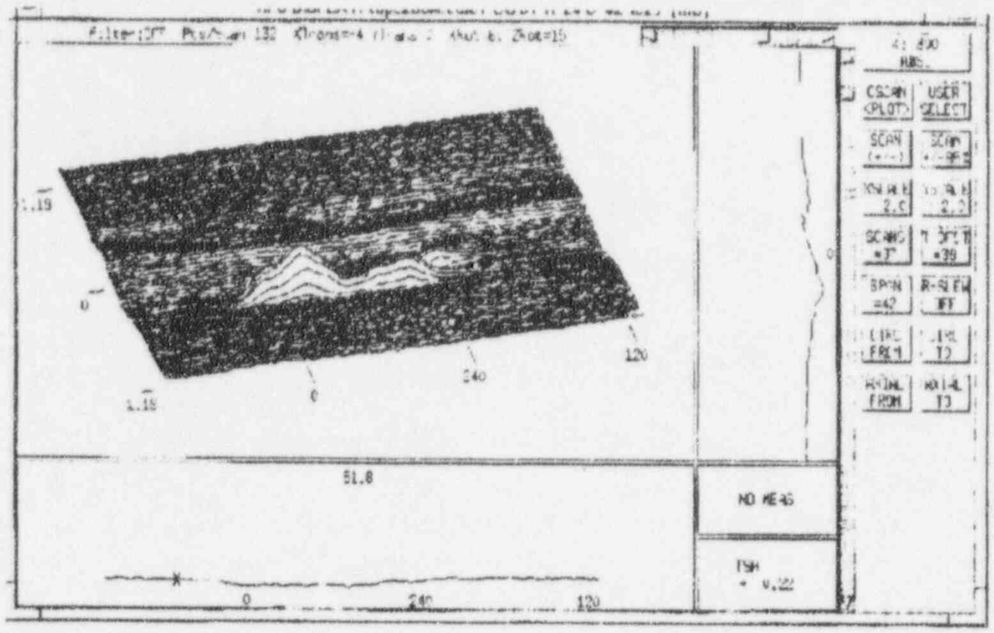


Figure 1. RPC display C-Scan showing expansion zone circumferential indications.

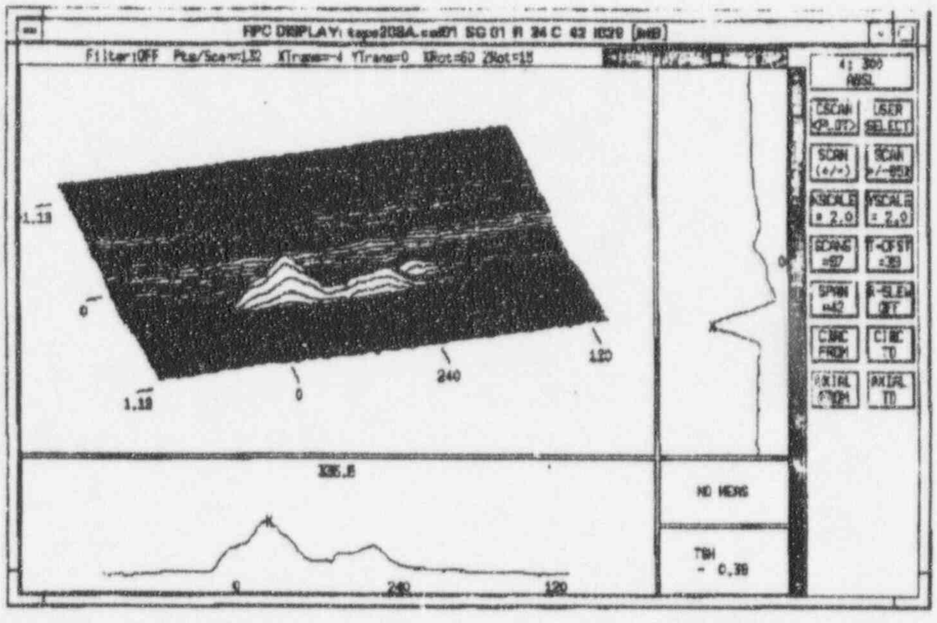


Figure 2. RPC display C-scan showing strip chart cursors located at maximum vertical channel displacement.

3.2 RPC Voltage Integral Display

3.2.1 Clicking the *Plot Cursor Scan* button in the *RPC Voltage Integral* display window replicates the circumferential line scan generated in the main RPC DISPLAY as shown in Figure 3.

Caution: A C-scan should first be generated in the main RPC display or else the system will crash!

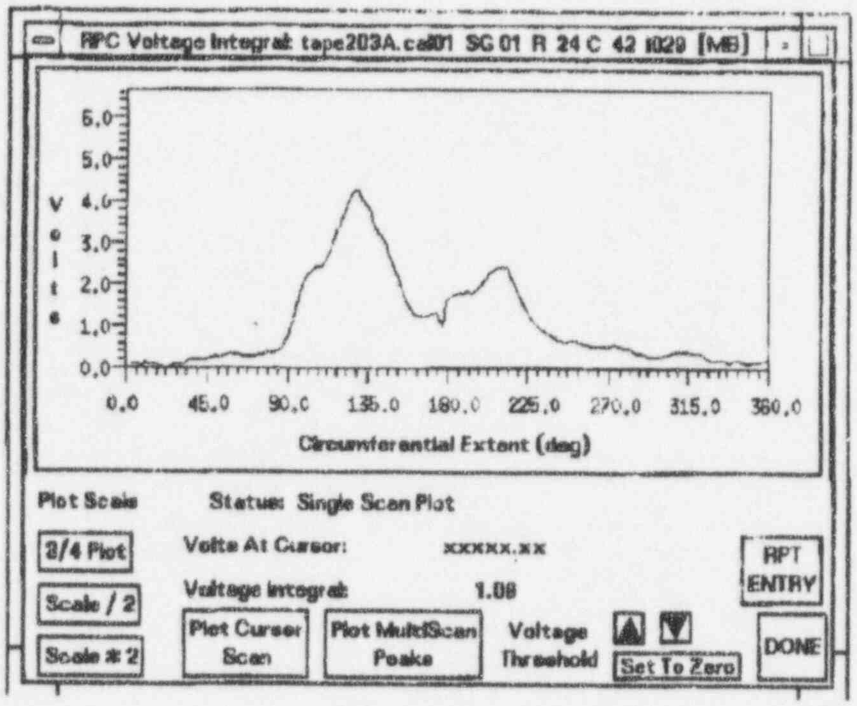


Figure 3. Circumferential line scan as displayed in the RPC Voltage Integral window.

3.2.2 Choose 3/4, /2, or *2 display values as appropriate so that the circumferential line scan is conveniently scaled in the window.

3.2.3 A numeric value appears in the *Voltage Integral* entry box while an xxxxx.xx value initially appears in the *Volts At Cursor* box.

3.2.4 Using the mouse, position the cursor to the maximum vertical displacement location as shown in Figure 4. The *Volts at Cursor* will change as the cursor is moved along the trace while the *Voltage Integral* value remains constant.

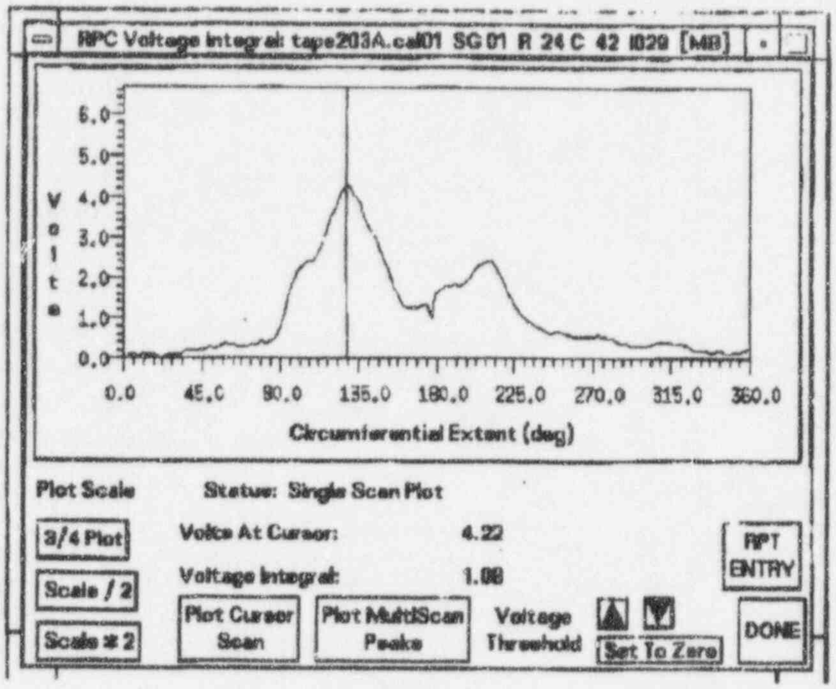


Figure 4. Circumferential line scan as displayed in the RPC Voltage Integral window with Volts at Cursor located at maximum displacement position.

3.2.5 The circumferential line-scan baseline trace determines the zero reference point for voltage measurements. This level may sometimes be influenced by local noise spikes. Adjustment of the baseline to another level can be controlled by using the *Voltage Threshold* up/down buttons. Changing the *Voltage Threshold* changes both the *Volts at Cursor* and *Voltage Integral* values. *Set to Zero* simply returns the voltage threshold to its initial value. In general, changes in voltage threshold should be done with caution under the direction of the authorized Level III.

4.0 REPORTING

4.1 Pressing the *RPT ENTRY* button activates the *Report Entry Display* with the *Voltage Integral* value automatically entered in the ARC field.

4.2 The *Volts at Cursor* value should be entered in the DEG column.

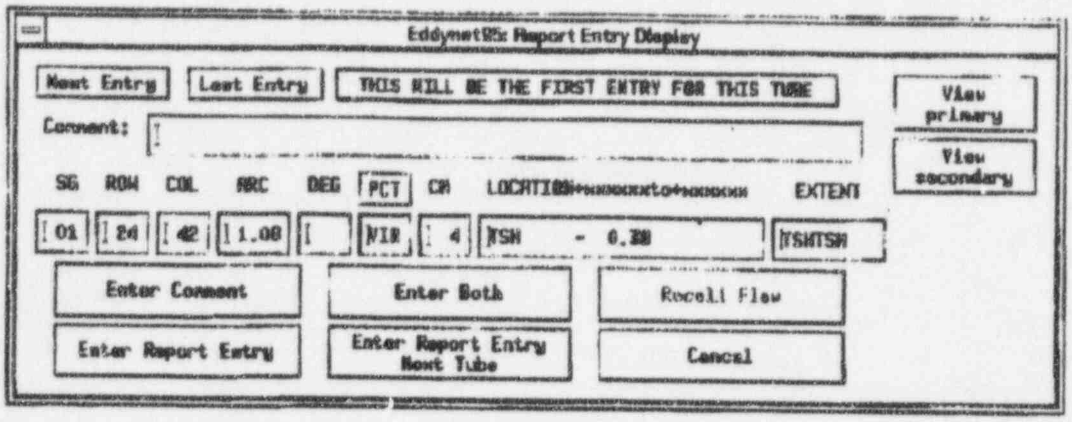


Figure 4. Report entry display showing the *Voltage Integral* numeric value entered in the ARC field.