Duquesne Light Company Beaver Valley Power Station
P.O. Box 4
Shippingport, PA 15077-0004

SUSHIL C. JAIN
Division Vice President
Nuclear Services
Nuclear Power Division

(412) 393-5512
Fax (412) 643-8069

March 27, 1996

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

Subject: **Beaver Valley Power Station, Unit No. 1**
Docket No. 50-334, License No. DPR-66
Steam Generator Tube Pull Data (Supplemental)
Supporting Alternate Tube Plugging Criteria Implementation

Attached is a copy of the industry steam generator tube pull data in support of our proposed Operating License Change Request 229. This data is proprietary and replaces that previously provided by our letter dated March 7, 1996, identified as Table 1 and Table 2, with supporting text. This data supports the upper voltage repair limit calculation for the Unit 1 eleventh refueling outage as presented in Enclosure 1 of our March 7, 1996, submittal. This data is provided in response to a request from our NRC Sr. Project Manager to clarify the basis for exclusion of proprietary information since the March 7 submittal was not specific. An affidavit is provided as an attachment pursuant to 10 CFR 2.790(a)(4) from the Electric Power Research Institute (EPRI), the owner of the information, which sets forth the basis on which the information may be withheld from public disclosure.

On March 25, 1996, it was agreed to docket an earlier verbal commitment regarding the reporting of the fraction of rotating pancake coil no detectable degradation (RPC NDD) indications included in the beginning of cycle distribution. Therefore, the Duquesne Light Co. will include the fraction of RPC NDD applied in the beginning of cycle voltage distribution and the RPC NDD confirmation rate from the inspection data in the 90 day report following steam generator inspections. (Ref: Generic Letter 95-05, Attachment 1, item 6.b).

If you have any questions regarding this submittal, please contact Mr. G. S. Sovick at (412) 393-5211.

Sincerely,

Sushil C. Jain

010080

c: Mr. L. W. Rossbach, Sr. Resident Inspector
Mr. T. T. Martin, NRC Region I Administrator
Mr. D. S. Brinkman, Sr. Project Manager

Ltr 1 Encl 1NP

Change: NRC PDR

A001 1/1

DELIVERING QUALITY ENERGY

AFFIDAVIT

I, ARTHUR KENNY, being duly sworn, depose and state as follows:

I am a Intellectual Property Attorney of the Electric Power Research Institute ("EPRI") and I have been specifically delegated responsibility for reviewing the records, documents and information sought under this affidavit to be withheld (the "Information") and authorized to apply for their withholding on behalf of EPRI. This affidavit is submitted to the Nuclear Regulatory Commission ("NRC") pursuant to 10 CFR 2.790 (a)(4) based on the fact that the Information consists of trade secrets of EPRI owned by EPRI and that the NRC will receive the Information from EPRI under privilege and in confidence.

The Information, which EPRI requests the NRC to withhold, consists of EPRI owned Proprietary Information contained within The attached document entitled "EPRI ARC DataBase For 3/4 Inch and 7/8 Inch Diameter Tubes and Updated ARC Correlation For 7/8 Inch Diameter Tubes". The Information has been marked as PROPRIETARY AND CONFIDENTIAL.

EPRI desires to disclose the Information to the NRC for informational purposes to assist the NRC. EPRI would welcome any discussions between EPRI and the NRC related to the Information that the NRC desires to conduct.

The basis for which the Report should be withheld from the public is set forth below:

(i) The Information has been held in confidence by EPRI. EPRI intends to provide copies of the Information to EPRI members and to one or more EPRI contractors. EPRI members and contractors are bound by confidentiality agreements to preserve the confidentiality of proprietary and confidential documents received from EPRI. Receipt of the Information by such members and contractors will not impair the proprietary and confidential nature of the Information nor will such receipt impair the value of the Information as trade secrets. In addition, EPRI may license the Information to organizations that are not EPRI members.

(ii) The Information is of a type customarily held in confidence by EPRI and there is a rational basis therefor. The Information is of a type that EPRI considers to be trade secrets. Such Information is customarily held in confidence by EPRI because to disclose it would prevent EPRI from licensing the Information at fees which would allow EPRI to recover its investment. If consultants and other businesses providing services in the electric power industry were able to obtain the Information, they would be able to use it commercially for profit and avoid spending the large amount of money that EPRI was required to spend to obtain the Information. The rational basis that EPRI has for classifying information as a trade secrets is the Uniform Trade Secrets Act which California adopted in 1984 and which has been adopted by over twenty states. The Uniform Trade Secrets Act defines a "trade secret" as follows:

> "Trade secret" means information, including a formula, pattern, compilation, program, device, method, technique, or process, that:
>
> (1) Derives independent economic value, actual or potential, from not being generally known to the public or to other persons who can obtain economic value from its disclosure or use; and
>
> (2) Is the subject of efforts that are reasonable under the circumstances to maintain its secrecy.

(iii) The Information will be transmitted and received by the NRC in confidence. The purpose is to maintain the confidentiality of the Information.

(iv) The Information is not available in public sources. EPRI developed the Information only after making a determination that the Information was not available from public sources. EPRI was required to spend a large amount of money through payments to contractors. In addition, EPRI was required to use a large amount of time of EPRI employees. Finally, the Information was developed only after a long period of effort.

(v) A public disclosure of the Information would be highly likely to cause substantial harm to EPRI's competitive position. The Information can be properly acquired or duplicated by others only with an equivalent investment of time and effort.

I have read the foregoing and the matters stated therein are true and correct to the best of my knowledge, information and belief.

I make this affidavit under penalty of perjury under the laws of the United States of America and under the laws of the State of California.

Executed at 3412 Hillview Avenue, Palo Alto, being the premises and place of business of the Electric Power Research Institute:

March 22, 1996

A Kenny

Arthur Kenny

Subscribed and sworn before me this day: March 22, 1996

Tamsen Helen Gagnon, NOTARY PUBLIC

TAMSEN HELEN GAGNON
COMM. # 1016243
Notary Public — California
SANTA CLARA COUNTY
My Comm. Expires FEB 5, 1998

Attachment

EPRI Non-Proprietary

Table 1
7/8-Inch Diameter Pulled and Model Boiler Tube Leak Rate and Burst Pressure Measurements

Plant Letter & Name	Specimen No. or Row/Col.	TSP	Bobbin Coil		RPC Volts	Destructive Exam		Normal Operation Leak Rate[3] (l/hr)	SLB Leak Rate (l/hr)[3] Pressure Differential			Burst Pressure (psi)	Yield Stress S_y (ksi)	Ultimate Stress S_u (ksi)	2 × Flow Stress S_y+S_u (ksi)	Adjusted Burst Pressure[4] (psi)	Correlation Appication[5]		
			Volts[1]	Depth		Max Depth	Length[2] (in.)		2335 psi	2560 psi	2650 psi						Prob. of Leak	Leak Rate	Burst

TABLE78.WP5

Table 1
7/8-Inch Diameter Pulled and Model Boiler Tube Leak Rate and Burst Pressure Measurements

Plant Letter & Name	Specimen No. or Row/Col.	TSP	Bobbin Coil		RPC Volts	Destructive Exam		Normal Operation Leak Rate[3] (l/hr)	SLB Leak Rate (l/hr)[3] Pressure Differential			Burst Pressure (psi)	Yield Stress S_y (ksi)	Ultimate Stress S_u (ksi)	2 × Flow Stress S_y+S_u (ksi)	Adjusted Burst Pressure[4] (psi)	Correlation Application[5]		
			Volts[1]	Depth		Max Depth	Length[2] (in.)		2335 psi	2560 psi	2650 psi						Prob. of Leak	Leak Rate	Burst

TABLE78.WP5

Table 1
7/8-Inch Diameter Pulled and Model Boiler Tube Leak Rate and Burst Pressure Measurements

Plant Letter & Name	Specimen No. or Row/Col.	TSP	Bobbin Coil		RPC Volts	Destructive Exam		Normal Operation Leak Rate[3] (l/hr)	SLB Leak Rate (l/hr)[3] Pressure Differential			Burst Pressure (psi)	Yield Stress S_y (ksi)	Ultimate Stress S_u (ksi)	2 × Flow Stress S_y+S_u (ksi)	Adjusted Burst Pressure[4] (psi)	Correlation Application[5]		
			Volts[1]	Depth		Max Depth	Length[2] (in.)		2335 psi	2560 psi	2650 psi						Prob. of Leak	Leak Rate	Burst

TABLE78.WP5

Table 1
7/8-Inch Diameter Pulled and Model Boiler Tube Leak Rate and Burst Pressure Measurements

Plant Letter & Name	Specimen No. or Row/Col.	TSP	Bobbin Coil		RPC Volts	Destructive Exam		Normal Operation Leak Rate[3] (l/hr)	SLB Leak Rate (l/hr)[3] Pressure Differential			Burst Pressure (psi)	Yield Stress S_y (ksi)	Ultimate Stress S_u (ksi)	2 × Flow Stress S_y+S_u (ksi)	Adjusted Burst Pressure[4] (psi)	Correlation Application[5]		
			Volts[1]	Depth		Max Depth	Length[2] (in.)		2335 psi	2560 psi	2650 psi						Prob. of Leak	Leak Rate	Burst

TABLE78.WP5

Table 1
7/8-Inch Diameter Pulled and Model Boiler Tube Leak Rate and Burst Pressure Measurements

Plant Letter & Name	Specimen No. or Row/Col.	TSP	Bobbin Coil		RPC Volts	Destructive Exam		Normal Operation Leak Rate[3] (l/hr)	SLB Leak Rate (l/hr)[3] Pressure Differential			Burst Pressure (psi)	Yield Stress S_y (ksi)	Ultimate Stress S_u (ksi)	2 × Flow Stress S_y+S_u (ksi)	Adjusted Burst Pressure[4] (psi)	Correlation Application[5]		
			Volts[1]	Depth		Max Depth	Length[2] (in.)		2335 psi	2560 psi	2650 psi						Prob. of Leak	Leak Rate	Burst

TABLE7S WPS

Table 1
7/8-Inch Diameter Pulled and Model Boiler Tube Leak Rate and Burst Pressure Measurements

Plant Letter & Name	Specimen No. or Row/Col.	TSP	Bobbin Coil		RPC Volts	Destructive Exam		Normal Operation Leak Rate[3] (l/hr)	SLB Leak Rate (l/hr)[3] Pressure Differential			Burst Pressure (psi)	Yield Stress S_y (ksi)	Ultimate Stress S_u (ksi)	2 × Flow Stress S_y+S_u (ksi)	Adjusted Burst Pressure[4] (psi)	Correlation Application[5]		
			Volts[1]	Depth		Max Depth	Length[2] (in.)		2335 psi	2560 psi	2650 psi						Prob. of Leak	Leak Rate	Burst

TABLE78.WP5

Table 1
7/8-Inch Diameter Pulled and Model Boiler Tube Leak Rate and Burst Pressure Measurements

Plant Letter & Name	Specimen No. or Row/Col.	T S P	Bobbin Coil		RPC Volts	Destructive Exam		Normal Operation Leak Rate[3] (l/hr)	SLB Leak Rate (l/hr)[3] Pressure Differential			Burst Pressure (psi)	Yield Stress S_y (ksi)	Ultimate Stress S_u (ksi)	2 × Flow Stress S_y+S_u (ksi)	Adjusted Burst Pressure[4] (psi)	Correlation Application[5]		
			Volts[1]	Depth		Max Depth	Length[2] (in.)		2335 psi	2560 psi	2650 psi						Prob. of Leak	Leak Rate	Burst

TABLE78.WP5

Table 1
7/8-Inch Diameter Pulled and Model Boiler Tube Leak Rate and Burst Pressure Measurements

Plant Letter & Name	Specimen No. or Row/Col.	TSP	Bobbin Coil		RPC Volts	Destructive Exam		Normal Operation Leak Rate(3) (l/hr)	SLB Leak Rate (l/hr)(3) Pressure Differential			Burst Pressure (psi)	Yield Stress S_y (ksi)	Ultimate Stress S_u (ksi)	2 × Flow Stress S_y+S_u (ksi)	Adjusted Burst Pressure(4) (psi)	Correlation Application(5)		
			Volts(1)	Depth		Max Depth	Length(2) (in.)		2335 psi	2560 psi	2650 psi						Prob. of Leak	Leak Rate	Burst

TABLE78.WP5

Table 1
7/8-Inch Diameter Pulled and Model Boiler Tube Leak Rate and Burst Pressure Measurements

Plant Letter & Name	Specimen No. or Row/Col.	TSP	Bobbin Coil Volts[1]	Bobbin Coil Depth	RPC Volts	Destructive Exam Max Depth	Destructive Exam Length[2] (in.)	Normal Operation Leak Rate[3] (l/hr)	SLB Leak Rate (l/hr)[3] Pressure Differential 2335 psi	SLB Leak Rate (l/hr)[3] Pressure Differential 2560 psi	SLB Leak Rate (l/hr)[3] Pressure Differential 2650 psi	Burst Pressure (psi)	Yield Stress S_y (ksi)	Ultimate Stress S_u (ksi)	2 × Flow Stress S_y+S_u (ksi)	Adjusted Burst Pressure[4] (psi)	Correlation Application[5] Prob. of Leak	Correlation Application[5] Leak Rate	Correlation Application[5] Burst

TABLE78.WP5

Table 1
7/8-Inch Diameter Pulled and Model Boiler Tube Leak Rate and Burst Pressure Measurements

Plant Letter & Name	Specimen No. or Row/Col.	TSP	Bobbin Coil		RPC Volts	Destructive Exam		Normal Operation Leak Rate[3] (l/hr)	SLB Leak Rate (l/hr)[3]			Burst Pressure (psi)	Yield Stress S_y (ksi)	Ultimate Stress S_u (ksi)	2 × Flow Stress S_y+S_u (ksi)	Adjusted Burst Pressure[4] (psi)	Correlation Application[5]		
									Pressure Differential										
			Volts[1]	Depth		Max Depth	Length[2] (in.)		2335 psi	2560 psi	2650 psi						Prob. of Leak	Leak Rate	Burst

NOTES:
1. All voltages normalized to the recommended values of this report.
2. Crack network length for burst crack, with through wall crack length given in parentheses.
3. N.O. leak rates are adjusted to ΔP = 1450 psi per Appendix B of Reference 1. SLB leak rates are adjusted to reference ΔP's shown.
4. Normalized to 150 ksi flow stress (sum of yield and ultimate stress).
5. Column indicates application of specimen in leak rate and/or burst correlations. 0 = No, 1 = Yes
6. Data excluded from application to correlations based on EPRI data exclusion criterion 2.
7. N.R. = Not Reliable data.
8. 98% deep for 0.22"; >95% deep for 0.35".
9. N.M. = Not Measured; value of 169.8 ksi in parenthses assumed for burst pressure adjustments when measurements not available.
10. Averag- f multiple measurements.
11. Burst test conducted within TSP. Burst pressure not used in ARC database.
12. Inferred from destructive exam depth, leak test not performed. Corrosion depth too shallow leakage at SLB conditions.
13. Data excluded from application to correlations based on EPRI data exclusion criterion 1.

Table 2
3/4-Inch Diameter Pulled and Model Boiler Tube Leak Rate and Burst Pressure Measurements

Plant Letter & Name	Specimen No. or Row/Col.	TSP	Bobbin Coil Volts[1]	Bobbin Coil Depth	RPC Volts	Destructive Exam Max Depth	Destructive Exam Length[2] (in.)	Normal Operation Leak Rate[3] (l/hr)	SLB Leak Rate (l/hr)[3] Pressure Differential 2335 psi	SLB Leak Rate (l/hr)[3] Pressure Differential 2560 psi	SLB Leak Rate (l/hr)[3] Pressure Differential 2650 psi	Burst Pressure (psi)	Yield Stress S_y (ksi)	Ultimate Stress S_u (ksi)	2 × Flow Stress S_y+S_u (ksi)	Adjusted Burst Pressure[4] (psi)	Correlation Application[5] Prob. of Leak	Correlation Application[5] Leak Rate	Correlation Application[5] Burst

TABLE34 WP5-1

Table 2
3/4-Inch Diameter Pulled and Model Boiler Tube Leak Rate and Burst Pressure Measurements

Plant Letter & Name	Specimen No. or Row/Col.	TSP	Bobbin Coil		RPC	Destructive Exam		Normal Operation Leak Rate[3] (l/hr)	SLB Leak Rate (l/hr)[3] Pressure Differential			Burst Pressure (psi)	Yield Stress S_y (ksi)	Ultimate Stress S_u (ksi)	2 × Flow Stress S_y+S_u (ksi)	Adjusted Burst Pressure[4] (psi)	Correlation Application[5]		
			Volts[1]	Depth	Volts	Max Depth	Length[2] (in.)		2335 psi	2560 psi	2650 psi						Prob. of Leak	Leak Rate	Burst

TABLE34 WP5-2

Table 2
3/4-Inch Diameter Pulled and Model Boiler Tube Leak Rate and Burst Pressure Measurements

Plant Letter & Name	Specimen No. or Row/Col.	TSP	Bobbin Coil		RPC	Destructive Exam		Normal Operation Leak Rate[3] (l/hr)	SLB Leak Rate (l/hr)[3]			Burst Pressure (psi)	Yield Stress S_y (ksi)	Ultimate Stress S_u (ksi)	2 × Flow Stress S_y+S_u (ksi)	Adjusted Burst Pressure[4] (psi)	Correlation Application[5]		
									Pressure Differential										
			Volts[1]	Depth	Volts	Max Depth	Length[2] (in.)		2335 psi	2560 psi	2650 psi						Prob. of Leak	Leak Rate	Burst

TABLE34 WPS-3

Table 2
3/4-Inch Diameter Pulled and Model Boiler Tube Leak Rate and Burst Pressure Measurements

Plant Letter & Name	Specimen No. or Row/Col.	TSP	Bobbin Coil		RPC Volts	Destructive Exam		Normal Operation Leak Rate[(3)] (l/hr)	SLB Leak Rate (l/hr)[(3)] Pressure Differential			Burst Pressure (psi)	Yield Stress S_y (ksi)	Ultimate Stress S_u (ksi)	2 × Flow Stress S_y+S_u (ksi)	Adjusted Burst Pressure[(4)] (psi)	Correlation Application[(5)]		
			Volts[(1)]	Depth		Max Depth	Length[(2)] (in.)		2335 psi	2560 psi	2650 psi						Prob. of Leak	Leak Rate	Burst

TABLE34 WP5-4

Table 2
3/4-Inch Diameter Pulled and Model Boiler Tube Leak Rate and Burst Pressure Measurements

Plant Letter & Name	Specimen No. or Row/Col.	TSP	Bobbin Coil		RPC	Destructive Exam		Normal Operation Leak Rate[3] (l/hr)	SLB Leak Rate (l/hr)[3]			Burst Pressure (psi)	Yield Stress S_y (ksi)	Ultimate Stress S_u (ksi)	2 × Flow Stress S_y+S_u (ksi)	Adjusted Burst Pressure[4] (psi)	Correlation Application[5]		
									Pressure Differential										
			Volts[1]	Depth	Volts	Max Depth	Length[2] (in.)		2335 psi	2560 psi	2650 psi						Prob. of Leak	Leak Rate	Burst

TABLE34 WP5.5

Table 2
3/4-Inch Diameter Pulled and Model Boiler Tube Leak Rate and Burst Pressure Measurements

Plant Letter & Name	Specimen No. or Row/Col.	TSP	Bobbin Coil		RPC Volts	Destructive Exam		Normal Operation Leak Rate[3] (l/hr)	SLB Leak Rate (l/hr)[3] Pressure Differential			Burst Pressure (psi)	Yield Stress S_y (ksi)	Ultimate Stress S_u (ksi)	2 × Flow Stress S_y+S_u (ksi)	Adjusted Burst Pressure[4] (psi)	Correlation Application[5]		
			Volts[1]	Depth		Max Depth	Length[2] (in.)		2335 psi	2560 psi	2650 psi						Prob. of Leak	Leak Rate	Burst

TABLE34 WP5-6

Table 2
3/4-Inch Diameter Pulled and Model Boiler Tube Leak Rate and Burst Pressure Measurements

Plant Letter & Name	Specimen No. or Row/Col.	TSP	Bobbin Coil		RPC	Destructive Exam		Normal Operation Leak Rate[3] (l/hr)	SLB Leak Rate (l/hr)[3]			Burst Pressure (psi)	Yield Stress S_y (ksi)	Ultimate Stress S_u (ksi)	2 × Flow Stress S_y+S_u (ksi)	Adjusted Burst Pressure[4] (psi)	Correlation Application[5]		
									Pressure Differential										
			Volts[1]	Depth	Volts	Max Depth	Length[2] (in.)		2335 psi	2560 psi	2650 psi						Prob. of Leak	Leak Rate	Burst

TABLE34 WPS-7

Table 2
3/4-Inch Diameter Pulled and Model Boiler Tube Leak Rate and Burst Pressure Measurements

Plant Letter & Name	Specimen No. or Row/Col.	T S P	Bobbin Coil		RPC Volts	Destructive Exam		Normal Operation Leak Rate[3] (l/hr)	SLB Leak Rate (l/hr)[3] Pressure Differential			Burst Pressure (psi)	Yield Stress S_y (ksi)	Ultimate Stress S_u (ksi)	2 × Flow Stress S_y+S_u (ksi)	Adjusted Burst Pressure[4] (psi)	Correlation Application[5]		
			Volts[1]	Depth		Max Depth	Length[2] (in.)		2335 psi	2560 psi	2650 psi						Prob. of Leak	Leak Rate	Burst

NOTES:
1. All voltages normalized to the recommended values of this report.
2. Crack network length for burst crack, with through wall crack length given in parentheses.
3. N.O. leak rates are adjusted to ΔP = 1300 psi per Appendix B of NP-7480-L, Volume 2. SLB leak rates are adjusted to reference ΔP's shown.
4. Normalized to 150 ksi flow stress (sum of yield and ultimate stress).
5. Column indicates application of specimen in leak rate and/or burst correlations. 0 = No, 1 = Yes
6. Leak rate inferred from destructive examination crack morphology. Corrosion depth too shallow for leakage at SLB conditions.
7. N.R. = Not Reliable data.
8. Burst tests performed with TSP constraint; data not used in ARC burst correlation.
9. Conservatively calculated with CRACKFLO code; included per NRC directive.
10. Data excluded from application to correlations based on EPRI data exclusion criterion 2.
11. Burst test showed insignificant extension at the corrosion crack tips. Therefore, burst pressure is a minimum value since burst is defined to include crack extension.
12. Data excluded from application to correlations based on EPRI data exclusion criterion 1.
13. Data meets EPRI data exclusion criterion 3.
14. Second throughwall crack 30 degrees from burst crack.

1.0 Updated ARC Correlations for 7/8" Tubes

This section reports on the evaluations performed which utilized the results of leak rate and burst testing of tube sections removed from SGs at utility sites in the United States after the publication of the original EPRI database for 7/8" diameter SG tubes (NP-7480-L, Volume 1). The results of the destructive examinations of the tube sections were reported in utility specific reports, and will be summarized in the complete data update report to follow. The additional pulled tube data germane to the APC correlations, and the bobbin amplitudes for APC applications, will be contained in a table in the complete update report to be issued at a later date. The additional data consist of results from pulled tube sections from Beaver Valley 1 (SG-95-06-006, May 1995), Farley 2 (SG-95-07-010, July 1995), Sequoyah 1 (SG-96-01-007, January 1996), and Farley 1 (SG-96-01-003, January 1996).

The results of the leak and burst tests are compared herein to the database of similar test results for 7/8" outside diameter SG tubes, and the effect of including the new test data in the reference database is evaluated. In summary, the applicable test data are consistent with the database relative to the burst pressure, the probability of leak, and the leak rate as function of bobbin amplitude correlations for 7/8" diameter tubes. The comparisons and evaluations follow.

Suitability for Inclusion in the Database

The morphology of the degradation of each indication considered herein was reviewed relative to the EPRI guidelines for inclusion/exclusion of tube specimen data in the alternate plugging criteria (APC) database. The findings of the reviews were recorded in documents prepared for each utility as the data were obtained. The details of the reviews will be included in a comprehensive report to be issued at a later date dealing with multiple tube sizes. None of the reviews revealed information that would lead to a conclusion that the data considered in this section should not be included in the database. Therefore, the correlations reported herein should be considered applicable to the use of APC for indications in 7/8" diameter tubes in Westinghouse SGs and constitute the analyses of the updated database.

1.1 Free Span Burst Correlation

The burst pressure database used in this report for 7/8" tubes consists of the EPRI recommended database, plus test results from tube R11C60-1 removed from D.C. Cook Unit [illegible]. The results for this tube section were abnormally high, but the degradation morphology did not meet all of the exclusion criteria developed for degradation with abnormally high burst pressures, hence it was retained in the correlation database. The results from ten (10) burst tests, performed on tube specimens which exhibited a non-zero bobbin amplitude at a TSP elevation location, were considered for evaluation. A plot of the burst pressures of the additional specimens is depicted on Figure 1-1 relative to the burst pressure correlation developed using the reference database and relative to a 95% confidence band to contain 90% of the population of burst pressures.

1. A visual examination of the data relative to the EPRI database indicates that the burst pressures measured fall within the scatter band of the reference data.

2. Nine, i.e., 90%, of the data points fall within a 95%/90% tolerance interval (approximate) about the regression line (95% confident to contain 90% of the underlying normal population).

3. One, i.e., 10%, of the data points falls outside of the 95%/90% tolerance band about the regression line.

In summary, the visual examination doesn't indicate any significant departures from the reference database. Although the burst pressure is less than would have been expected for one of the indications, the appearance of one such indication in the additional ten data points is not significantly improbable. Moreover, the bobbin amplitude for this indication increased from 4 volts before removal to 12 volts after, thus, the burst pressure could have been reduced as a consequence of mechanical deformation from the tube removal activities. Since the regression line for this analysis represents the mean and median burst pressure to be expected from the parent population, it would be expected that additional data should fall about half above and half below the line. For the additional data analyzed, six (6) values were above the line and four (4) values below the line. For ten values drawn at random from the population of bursts, the probability that the split would be five above and five below is about 25%, and the probability that the results would be split six/four in either direction is 41%. Thus, distribution relative to above or below the regression line is not unusual. In addition, the average difference in the observed burst pressure relative to the predicted burst pressures is only 1.1%. Finally, although the tube data are from SGs at multiple plant sites, an examination of the normalized residuals relative to the predictions of the reference correlation equation was performed. The results of this analysis are shown on Figure 1-2 where the distribution of observed deviates is compared to those expected from a normal distribution. There doesn't appear to be any significant systematic departure from normality.

Since the additional burst pressure data were not indicated to be from a separate population from the reference data, the regression analysis of the burst pressure on the common logarithm of the bobbin amplitude was repeated with the additional data included. A comparison of the regression results obtained by including these data in the regression analysis is provided in Table 1-1. Regression predictions obtained by including these data in the regression analysis are shown on Figure 1-3. The appropriate regression equation for future ARC analyses is,

$$P_B = 7.592 - 2.370\log(\text{Volts}), \qquad \textbf{(1-1)}$$

with a SLB structural limit of 8.6 volts. The changes to the correlation are:

1. The intercept of the burst pressure, P_B, as a linear function of the common logarithm of the bobbin amplitude regression line is increased by 0.48%. This has the effect of increasing the predicted burst pressure as a function of the bobbin amplitude.

2. The absolute slope of the regression line is increased by 2.19%, i.e., the slope is more steep. This has the effect of decreasing the burst pressure as a function of bobbin amplitude for indications greater than about 3 volts.

3. There is an increase in the standard error of the residuals of 1.38%. The effect of this change would be reflected in a slightly larger deviation of the 95% prediction line from the regression line.

The net effect of the changes on the SLB structural limit ($1.43 \cdot \Delta P_{SLB}$), using 95%/95% lower tolerance limit material properties, is to decrease it by 0.2 volts, i.e., from 8.8 volts to 8.6 volts. The increase in the slope relative to the increase in the intercept, and the increase in the standard error coupled with the fact that the structural limit is also decreased indicates that the probability of burst would also increase for bobbin indications over the structural range of interest. Based on the relatively small change in the structural limit, the change in the probability of burst would also be expected to be small.

1.2 Probability of Leak Correlation

As for the burst pressure correlation, there are ten (10) additional data pairs that were considered relative to the reference database and the probability of leak (POL) correlation to the common logarithm of the bobbin amplitude. Figure 1-4 illustrates the additional data relative to the reference correlation. All of the specimens except one exhibited POL behavior commensurate with expectations indicated by the reference database and regression curve. The single exception was an indication with a bobbin amplitude of 4.03 volts that exhibited leakage, thus becoming the indication with the second lowest voltage of the indications that leaked in the database.

Based on the reference curve, the POL for the leaking indication is 0.133, thus, roughly 1 in 7 indications with an amplitude of 4.03 volts would be expected to leak. Had the expectation been 1 in 20, statistically anomalous behavior could have been suspected. The indication that leaked was the same indication that exhibited a lower than expected burst pressure. It is strongly suspected that this indication experienced ligament tearing during the tube pull as indicated by the maximum 96% corrosion depth resulting in post-pull Argon leakage at 200 psid and the increase in bobbin amplitude from 4.03 to 12.2 volts. However, since it is difficult to prove that the wall thickness ligament would not have torn during postulated SLB conditions, the indication is to be retained in the EPRI database. In conclusion, data examinations revealed no significant evidence of irregular results, i.e., outlying behavior is not indicated.

In order to assess the quantitative effect of the new data on the correlation curve, the database was expanded to include the additional data points and a *Generalized Linear Model* regression of the POL on the common logarithm of the bobbin amplitude was repeated. A comparison of the correlation parameters with those for the reference database is shown in Table 1-2. These results indicate:

1. A 9.7% increase (smaller negative value) in the *logistic* intercept parameter.

2. A 6.2% decrease in the *logistic* slope parameter.

3. The absolute values of the parameters' covariance matrix changed by 26.5% to 34.5%. These changes may have a significant impact on the POL values used during the Monte Carlo Simulations, but may not have a significant impact on the 95% confidence bound on the total estimated leak rate from a single SG.

4. The Pearson standard error decreased by 7.2% from 0.640 to 0.594. This is a negative indicator since the ideal value would be 1.0, but is not judged to be significant.

An additional evaluation was performed which demonstrated that most of the changes in the distribution parameters are a result of including the 4.03 V indication that leaked. In order to assess whether or not these changes are significant, the reference correlation and the new correlation were also plotted on Figure 1-4. An examination of Figure 1-4 reveals a moderate change in the correlation up to about 5 V, with a 31% increase at 4.03 V. A tabular summary of POL predictions before and after including the additional data point is provided as Table 1-3. For indications with amplitudes less than 1.0 volt, the POL increases by a factor of 2 to

4. The POL for indications of 3 volts increases by about 50%, while the change in the POL is not significant for indications of 8 volts and greater.

When the total leak rate is determined using the leak rate to bobbin volts correlation, the resulting value can be quite insensitive to the form of the POL function. So, the effect of the changes in the parameter values and variances would be expected to be small or insignificant relative to the calculation of the 95% confidence bound of the total leak rate from a SG. However, when the leak rate is considered as independent of the voltage, as for the current APC database, the increase in POL will more directly affect the estimated total leak rate.

1.3 Free Span SLB Leak Rate Correlation for 7/8" Tubes

As previously noted, only one of the specimens exhibited leakage at SLB operating conditions. The test leak rate value corresponded to 2.19 lph at the SLB temperature and pressure difference conditions. The correlation of leak rate to bobbin voltage exhibits a *p*-value of 6.5% for the slope parameter using the reference database, and a value of 6.4% with the additional data point. Based on the requirements stipulated in NRC Generic Letter 95-05 for voltage based plugging criteria, the use of the correlation in performing Monte Carlo simulations to estimate the total leak rate from a SG is not considered to be justified. Figure 1-5 illustrates the new data point relative to the distribution predicted mean using the reference database and relative to a lower 95% confidence limit for a predicted leak rate from the distribution. Also illustrated on Figure 1-5, is the relation of the data point to the regression fit (median of the log-normal distribution) and to the expected leak rate (mean of the log-normal distribution) based on the regression analysis of the leak rate on the bobbin amplitude.

The common logarithm (log) of the test leak rate, 0.340, is lower than the mean log leak rate for the reference database, 0.576, but is well within one standard deviation of that value. The effects of including the data point in the database on the estimated parameters of the leak rate distribution are tabulated in Table 1-4. The estimated mean and standard deviation of the population of leak rates are decreased, hence, predicted leak rates from Monte Carlo simulations and the 95% confidence bound on the total leak rate from a single SG will be reduced. For clarification, the values listed in Table 1-4 for the mean, μ, and standard deviation, σ, of the population of leak rates are derived from the sample values of the log leak rate. These are the expected leak rate parameters to result from a simulation of the log leak rates using the NRC accepted leak rate simulation method as described in WCAP-14277.

1.4 Summary/Conclusions

The review of the effect of the additional data indicates that the SLB structural limit burst pressure will not be significantly changed by the inclusion of the data. Therefore, it is likely that the conclusions relative to EOC probability of burst and based on the correlation obtained using the reference database would not be significantly affected.

The probability of leak correlation to the common logarithm of the bobbin amplitude is moderately changed by the inclusion of the data, leading to the expectation of predicting slightly larger 95% confidence bound leak rates. At the same time, the mean and standard deviation of the leak rate distribution are decreased, leading to the expectation of lower 95% confidence bound leak rates. It may be expected that the increase in the POL will be at least partially offset by the decrease in the predicted leak rates.

Table 1-1: Effect of Additional Data on the 7/8" Tube Burst Pressure vs. Bobbin Amplitude Correlation

$$P_B = \alpha_1 + \alpha_2 \log(\text{Volts})$$

Parameter	Reference Database Value	Database with additional	New / Old Ratio
α_1	7.5555	7.5919	1.0048
α_2	-2.3192	-2.3699	1.0219
r^2	82.7%	81.8%	0.9891
σ_{Error}	0.81729	0.82853	1.0138
N (data pairs)	70	80	
p Value for α_2	1.4×10^{-27}	1.3×10^{-30}	9.3×10^{-4}
Reference σ_f	68.78 ksi(1)		

Notes: (1) This is the flow stress value to which all data was normalized prior to performing the regression analysis. This affects the coefficient and standard error values. The corresponding values for a flow stress of 75.0 ksi can be obtained from the above values by multiplying by 1.0904.

Table 1-2: Effect of Additional Data on the 7/8" Tube Probability of Leak Correlation $Pr(Leak) = \left\{1 + e^{-[\beta_1 + \beta_2 \log(V)]}\right\}^{-1}$			
Parameter	Reference Database	Database with additional	Change
β_1	-6.8974	-6.2269	-9.7%
β_2	8.3507	7.7739	-6.9%
V_{11} (1)	3.4998	2.2911	-34.5%
V_{12}	-3.8459	-2.6004	-32.4%
V_{22}	4.5822	3.2955	-26.1%
DoF(2)	97	107	
Deviance	25.09	28.90	15.2%
Pearson SD	64.0%	59.4%	-7.2%

Notes: (1) Parameters V_{ij} are elements of the covariance matrix of the coefficients, β_i, of the regression equation.
(2) Degrees of freedom.

Table 1-3: Effect of Additional Data on 7/8" Tube Probability of Leak Predictions			
Bobbin Amplitude (Volts)	EPRI/NRC Database POL	w/ additional Database POL	New / Old Ratio
0.100	$2.39 \cdot 10^{-7}$	$8.31 \cdot 10^{-7}$	3.48
0.200	$2.95 \cdot 10^{-6}$	$8.63 \cdot 10^{-6}$	2.93
0.300	$1.28 \cdot 10^{-5}$	$3.39 \cdot 10^{-5}$	2.64
0.500	$8.18 \cdot 10^{-5}$	$1.90 \cdot 10^{-4}$	2.33
0.600	$1.58 \cdot 10^{-4}$	$3.52 \cdot 10^{-4}$	2.22
0.800	$4.50 \cdot 10^{-4}$	$9.29 \cdot 10^{-4}$	2.07
1.000	$1.01 \cdot 10^{-4}$	$1.97 \cdot 10^{-3}$	1.95
2.000	0.0123	0.0201	1.63
3.000	0.0515	0.0746	1.45
4.030	0.1367	0.1793	1.31
5.000	0.2572	0.3115	1.21
8.000	0.6557	0.6886	1.05
10.000	0.8105	0.8245	1.02
15.000	0.9490	0.9486	1.00
20.000	0.9814	0.9799	1.00
32.000	0.9957	0.9948	1.00
40.000	0.9985	0.9980	1.00
50.000	0.9993	0.9991	1.00

Table 1-4: Effect of Inclusion of Additional Data on the Reference Leak Rate Database for 7/8" Tube APC Applications				
Parameter	Leak Rate (lph)		Log(Leak Rate)[1]	
	Reference Database	w/ additional Database	Reference Database	w/ additional Database
Sample Size	26	27	26	27
Sample μ	13.74	13.32	0.5764	0.5696
Sample σ	21.13	20.84	0.8338	0.8188
p Value			6.5%	6.4%
The following are based on the lognormal distribution sample parameters.				
Population μ	23.9 lph	22.0 lph	These values are biassed to be higher than expected.	
Population σ	149.1 lph	128.0 lph		
Upper 95% Pred.	100.6 lph	92.5 lph	These ranges are biassed to be wider than expected.	
Lower 95% Pred.	0.143 lph	0.149 lph		
Notes: 1. It has been previously shown that a log-normal distribution can be used to describe the population of leak rates.				

Figure 1-1: Burst Pressure vs Volts for 7/8" Alloy 600 SG Tubes

Additional Data, Reference $\sigma_f = 68.8$ ksi @ 650°F

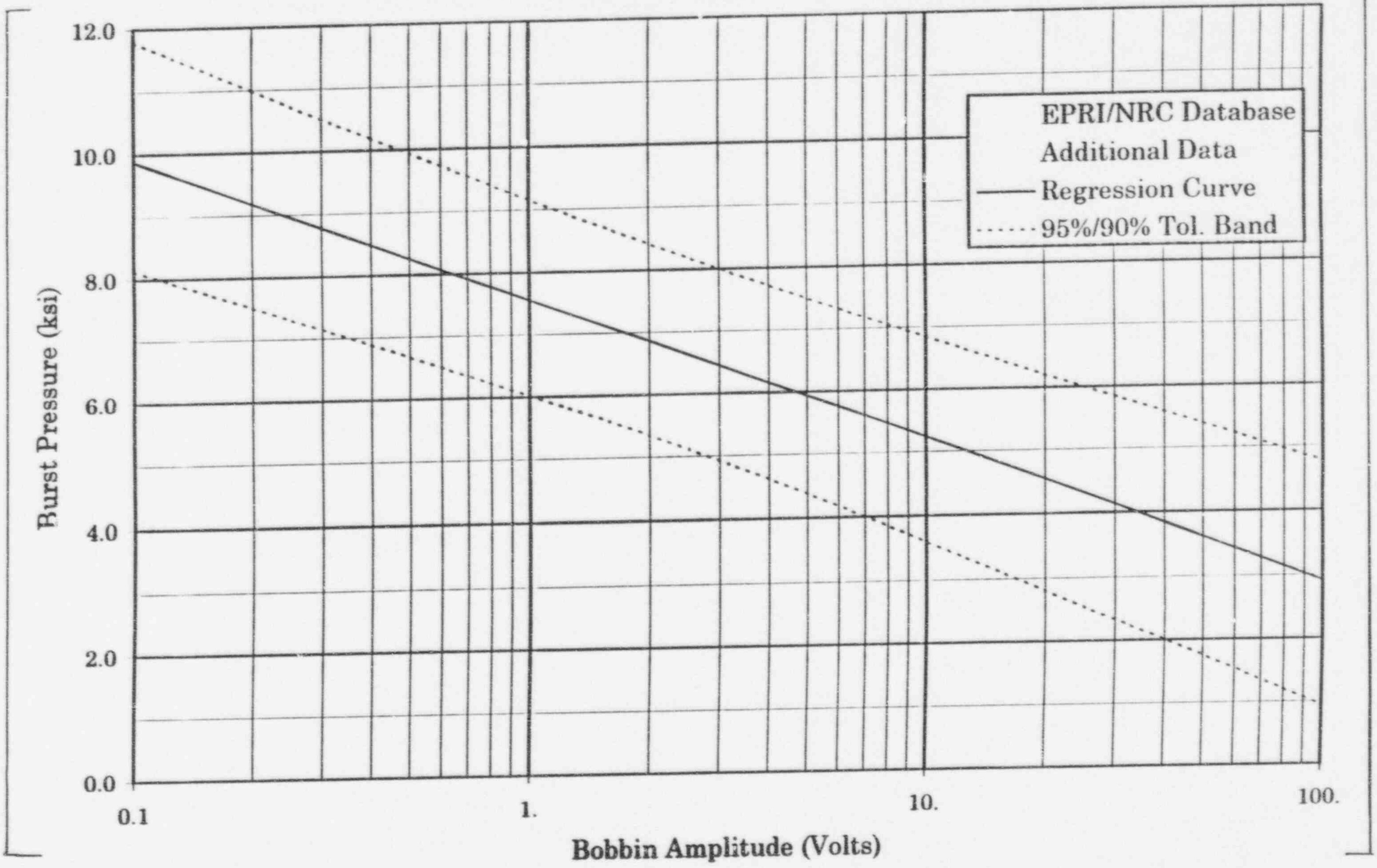
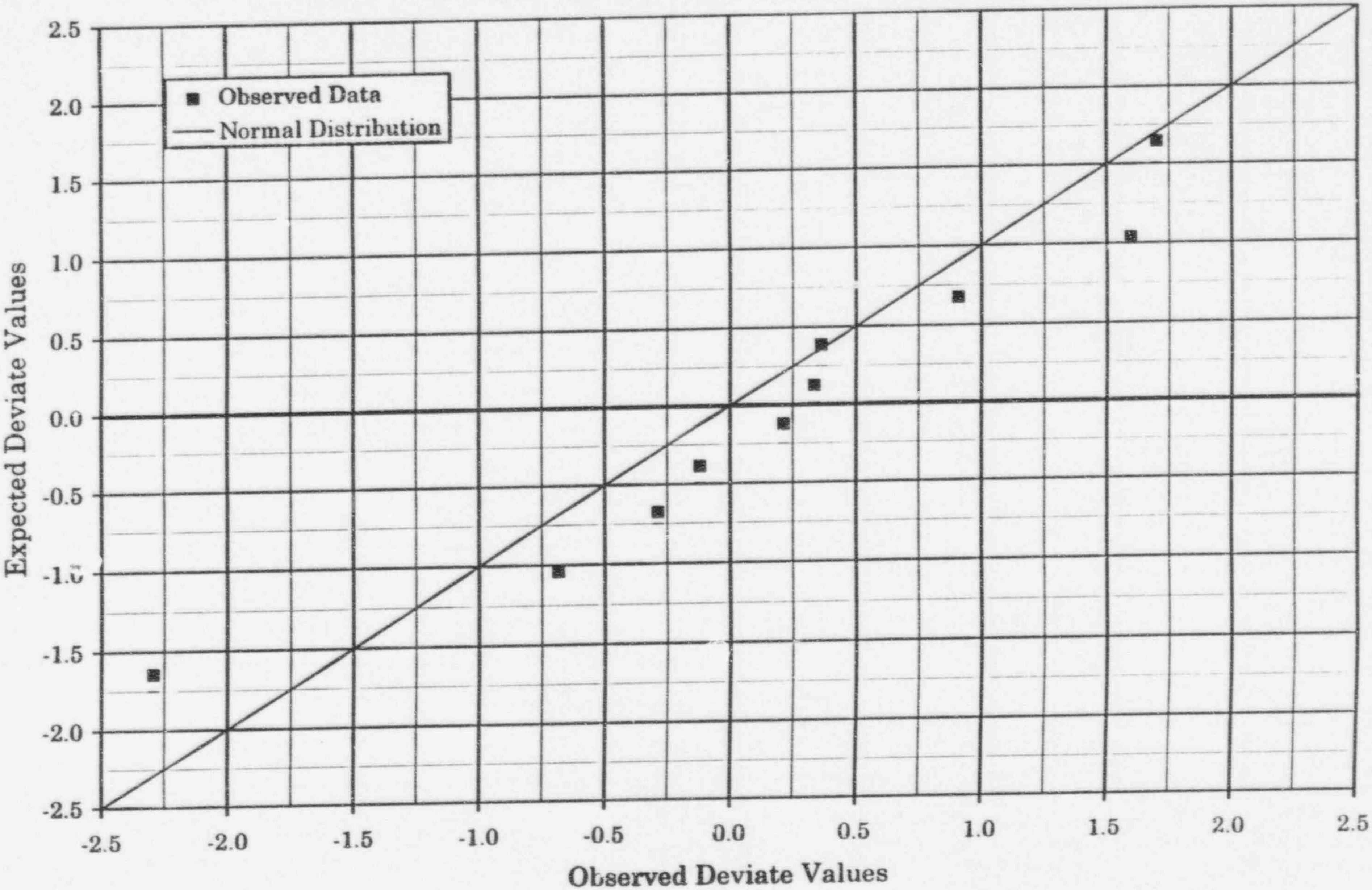


Figure 1-2: Burst Pressure for 7/8" Diameter Tubes

Deviate Analysis of Additional Data



RFK: 2/24/96, 3:23 PM

[78BV_296.xls] New.Devs

Figure 1-3: Burst Pressure vs Volts for 7/8" OD Alloy 600 SG Tubes

NRC/EPRI Database, Reference $\sigma_f = 68.8$ ksi @ 650°F

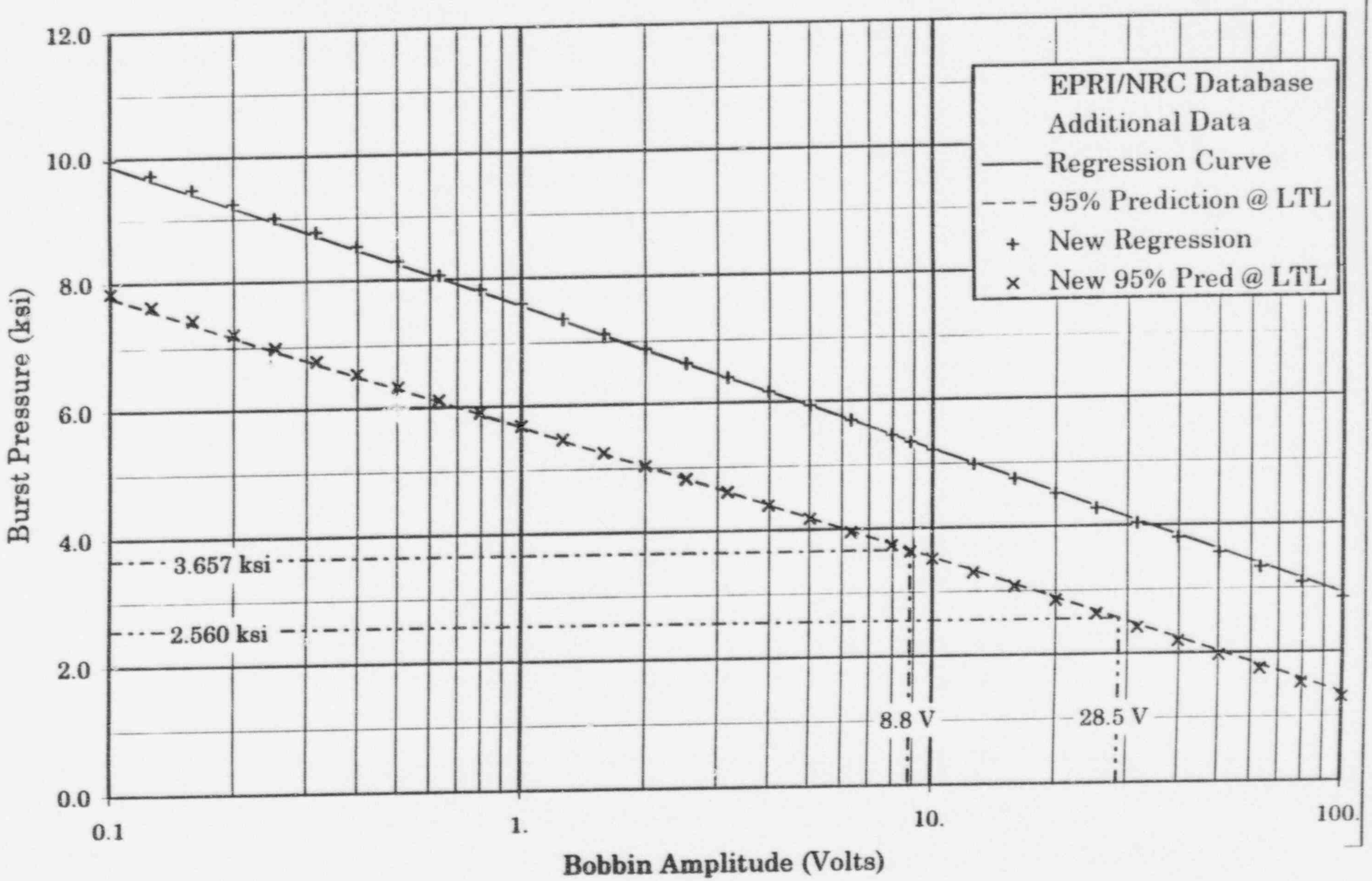
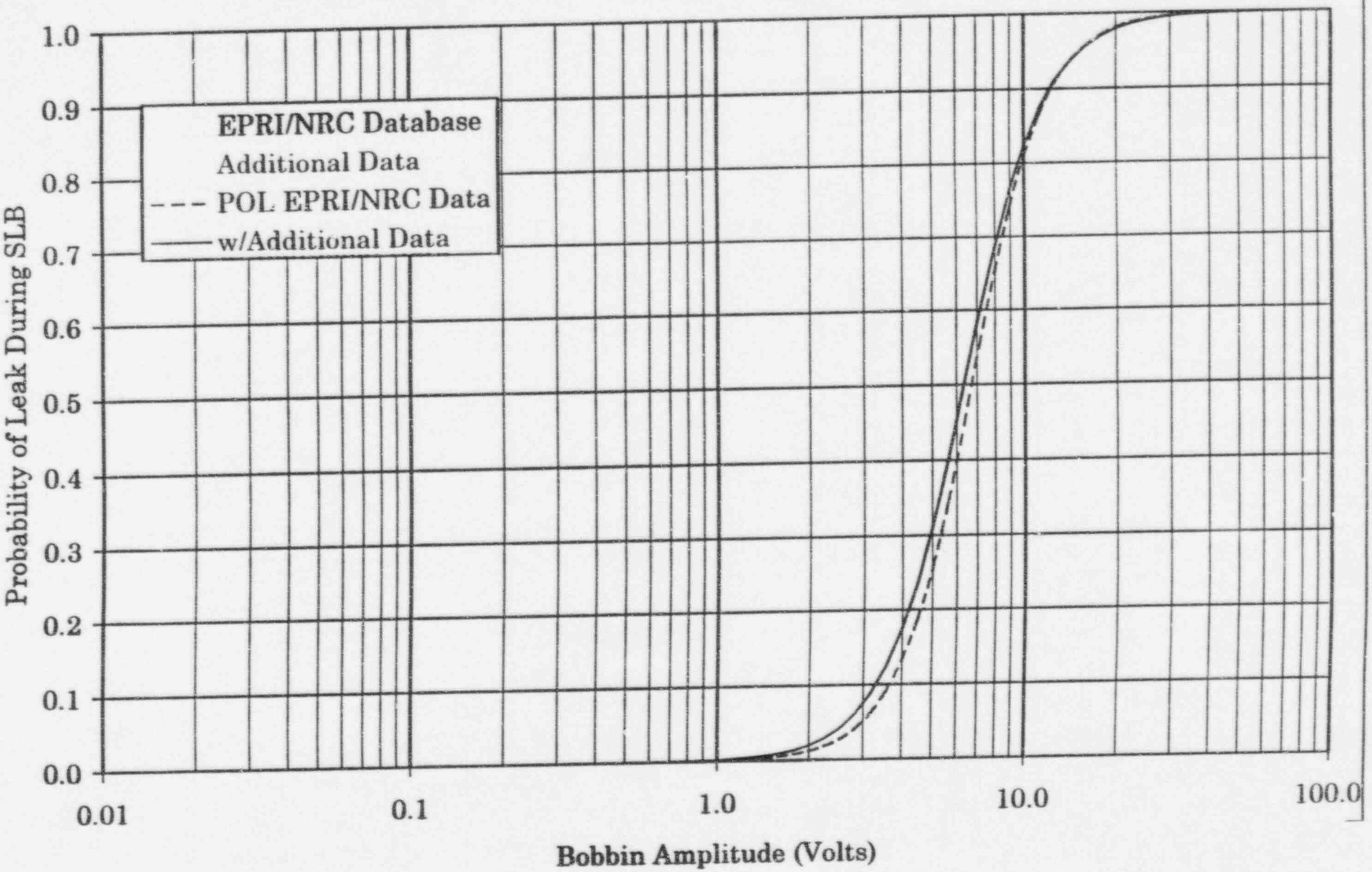


Figure 1-4: Probability of Leak for 7/8" SG Tubes
Effect of Inclusion of Additional Data



RFK: 2/24/96, 3:26 PM

[78pol_6.xls] PoL.log(V)

Figure 1-5: Leak Rate vs Bobbin Amplitude

7/8" Tube Data, All Data, NRC Correlation