CATEGORY 1

REGULAT Y INFORMATION DISTRIBUTION YSTEM (RIDS)

ACCESSION NBR:9611060052 DOC.DATE: 96/11/01 NOTARIZED: NO DOCKET #
FACIL:50-305 Kewaunee Nuclear Power Plant, Wisconsin Public Servic 05000305
AUTH.NAME AUTHOR AFFILIATION
MARCHI,M.L. Wisconsin Public Service Corp.
RECIP.NAME RECIPIENT AFFILIATION
Document Control Branch (Document Control Desk)

SUBJECT: Submits rev to NDE uncertainty for HEJ sleeved tubes delta D criteria.Basis & technical justification for change attached

DISTRIBUTION CODE: A001D COPIES RECEIVED:LTR 1 ENCL 1 SIZE: 16
TITLE: OR Submittal: General Distribution

NOTES:

	RECIPIENT ID CODE/NAME	COPIES LTTR	COPIES ENCL	RECIPIENT ID CODE/NAME	COPIES LTTR	COPIES ENCL
	PD3-3 LA	1	1	PD3-3 PD	1	1
	LAUFER,R	1	1			
INTERNAL:	ACRS	1	1	FILE CENTER 01	1	1
	NRR/DE/EMCB	1	1	~~NRR/DRCH/HICB~~	1	1
	NRR/DSSA/SPLB	1	1	NRR/DSSA/SRXB	1	1
	NUDOCS-ABSTRACT	1	1	OGC/HDS2	1	0
EXTERNAL:	NOAC	1	1	NRC PDR	1	1

C A T E G O R Y 1 D O C U M E N T

NOTE TO ALL "RIDS" RECIPIENTS:
PLEASE HELP US TO REDUCE WASTE. TO HAVE YOUR NAME OR ORGANIZATION REMOVED FROM DISTRIBUTION LISTS OR REDUCE THE NUMBER OF COPIES RECEIVED BY YOU OR YOUR ORGANIZATION, CONTACT THE DOCUMENT CONTROL DESK (DCD) ON EXTENSION 415-2083

TOTAL NUMBER OF COPIES REQUIRED: LTTR 13 ENCL 12

WPSC (414) 433-1598
TELECOPIER (414) 433-5544

NRC-96-118

WISCONSIN PUBLIC SERVICE CORPORATION

600 North Adams • P.O. Box 19002 • Green Bay, WI 54307-9002

November 1, 1996

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

Ladies/Gentlemen:

Docket 50-305
Operating License DPR-43
Kewaunee Nuclear Power Plant
Eddy Current Measurement Uncertainty for HEJ Sleeved Tubes ΔD Criteria

References: 1) Letter from M.L. Marchi (WPSC) to U.S. Nuclear Regulatory Commission (NRC) dated August 14, 1996.

2) Letter from Richard J. Laufer (NRC) to Wisconsin Public Service Corporation (WPSC) dated September 12, 1996.

3) Letter from Richard J. Laufer (NRC) to M.L. Marchi (WPSC) dated September 25, 1996.

By letter dated August 14, 1996, Wisconsin Public Service Corporation (WPSC) responded to a NRC staff request for additional information (RAI) by describing the abilities and qualification of the eddy current technique that was used to locate parent tube indications in Westinghouse hybrid expansion joint (HEJ) sleeved tubes. In this response, WPSC committed to using a non-destructive examination (NDE) uncertainty value of 0.004 inch. As presented at a meeting with the NRC staff on August 20, 1996, the 0.004 inch uncertainty is very conservative based a statistical analyses of the data from a number of HEJ sleeve/tube samples. Specifically, 99% of the errors in the ΔD measurement will be less than 0.004 inch with 95% confidence. Reference 2 is a summary of the information presented at the September 20th meeting.

Subsequent to this meeting, the NRC staff approved the Technical Specification amendment request for relocating the HEJ pressure boundary; reference 3. The safety evaluation report for the TS discusses the 0.004 inch NDE uncertainty value for application of the ΔD criteria. Based on the inspection results from the 1996 HEJ sleeved tube inspection, WPSC would like to revise the NDE uncertainty value from 0.004 inch, to 0.0026 inch. Attachment 1 to this submittal

A001/1

discusses the basis for this change and provides technical justification. In summary, both nonparameteric and parametric statistical reviews of the data demonstrate that a NDE uncertainty value of 0.0026 inch satisfies a 95%/95% confidence bound using the raw data from the HEJ samples.

We would like to discuss this proposed revision to the NDE uncertainty with the NRC staff in the very near future. Please contact a member of my staff if you have any questions or require additional information.

Sincerely,

M. L. Marchi
Manager - Nuclear Business Group

SLB

Attach.

cc - US NRC Region III
US NRC Senior Resident Inspector

ATTACHMENT

Letter from M. L. Marchi (WPSC)

To

Document Control Desk (NRC)

Dated

November 1, 1996

UNCERTAINTY IN THE MEASUREMENT OF ΔD (PTI TO SLEEVE INTERFERENCE)

R. F. Keating
Nuclear Services Division
Westinghouse Electric Corp.

1.0 Introduction

In April of 1994, crack-like indications were detected in hybrid expansion joint (HEJ) sleeved steam generator (SG) tubes at the Kewaunee Nuclear Power Plant (KNPP) of the Wisconsin Public Service Company (WPSC). Later that year, parent tube indications (PTIs) were also found at the Point Beach Unit 2 plant. In subsequent years, PTIs were detected at Zion 1, and again at Kewaunee and Point Beach 2. Removed tube examinations confirmed the indications to be stress corrosion cracking initiating on the inside surface of the tube in the sleeve/tube joint bottom transition. A structural/leakage acceptance criterion was developed for use in the disposition of PTIs in HEJ sleeved tubes, Reference 1. The criterion was presented to the NRC at a meeting in April, 1996, Reference 2, and subsequently accepted for application at the KNPP.

Simply put, if there is no less than 3 mils of diametral interference, ΔD, between the inside diameter of the sleeve at the elevation of the PTI and the maximum inside diameter of the sleeve at the elevation of the sleeve/tube upper hardroll joint, the sleeved tube should be permitted to remain in service. The use of the ΔD criterion has been demonstrated by test to allow sleeve/tube joints which meet the structural requirements of RG 1.121 during normal and accident conditions to remain in service. In addition, the application of the criterion results in sleeve/tube joints which restrict primary-to-secondary leakage during a postulated steam line break (SLB) event to the extent that the exposure dose requirements of 10 CFR 100 are met.

It is noted that the criterion does not rely on limiting the size of the crack indication nor does it rely the determination of crack growth rates. The structural testing performed to determine the tube/ sleeve overlap necessary to meet RG 1.121 loads demonstrated that a diametral interference of 3 mils results in a joint integrity on the order of 7 to 8 times the normal operating pressure differential. In addition, interpolation of the data indicates that an interference of 2 mils results in separation resistance on the order of 6 times the normal operating pressure differential.

Following the Reference 2 meeting, a testing program was conducted to ascertain the accuracy with which the ΔD of sleeved tubes could be measured using eddy current test (ECT) technology. The purpose of this report is to describe the analysis of the test data to establish a limiting ΔD value which should be observed in order to have a high level of confidence that the required interference is present in HEJ sleeved tubes with PTIs. Almost all of the information contained herein was presented to NRC staff members at a meeting on August 20, 1996 (Reference 3).

2.0 Reliability of Measuring ΔD

The test specimens used for the structural integrity program consisted of sleeved tubes with the tube severed in the transition. The ΔD measurement was taken on the outside diameter of the tube to minimize measurement error.

Measuring the hardroll diameter is generally considered to be both easy and accurate using standard bobbin coil probe technology. The elevation of the PTI must be determined using the +Point probe, and then the bobbin information corresponding to that elevation must be evaluated. The results of the test program, discussed in later sections, demonstrate that a 2.6 mil allowance for ECT uncertainty is sufficient and conservative.

3.0 Test Program

Ten (10) HEJ sleeve/tube specimens, fabricated to be typical of Kewaunee field installations, were examined with a +Point/bobbin coil probe assembly prototypic of the field probe. Each of the specimens had a machined circumferential slit in the HEJ lower transition. Five of the specimens were typical of having little or no rolldown, and five were typical of having significant rolldown. Overall, the transition lengths ranged from 0.29" to 1.05".

Two probes were used for the measurements, each with one +Point and two bobbin coils and five (5) replicates of each measurement were made. Two analysts and a resolution analyst were employed as for the field evaluation process. A total of twenty (20) data points were thus obtained per specimen, i.e., one final call per each examination of the specimen for each probe. By doing the evaluation in this manner, analyst to analyst variability is not significant, only the final value after resolution, if any resolution is required.

Mechanical measurements were made on the OD of the specimens for comparison with the NDE measurements made on the ID of the specimens. Thinning of the material during the expansion processes causes the ΔD on the ID to be slightly larger than the ΔD measured on the OD. This would be expected to amount to about 2 mils hardroll (HR) to hydraulic expansion (HE) diameter difference of 36 mils. The magnitude of the difference would be expected to exhibit a somewhat linear behavior with distance along the transition. For example, about 1 mil at the center of the transition, and a negligible difference near the top of the HR/HE transition. Thus, there is no adjustment to the data needed to account for the ID/OD variation in the measurement for small values of ΔD. For large PTI/HR diameter differences, the adjustment would still be small enough as to not affect any conclusion regarding the structural efficacy of the HEJ.

In order to minimize an potential error which might be associated with the physical measurements of the test specimens the mechanical measurements were repeated by the Westinghouse engineer using both calipers and an optical comparitor. In addition, the dimensions were independently confirmed by the vendor that machined the slits in the specimens.

4.0 Test Data Analysis

The ΔD measurement errors[1] for each specimen are illustrated on Figure 1 (note that there were

[1] The measurement error is calculated as the ECT diameter minus the actual diameter. Thus, a negative error, indicating that the true diameter is being underestimated, is conservative, while a positive error is nonconservative.

two specimens each with actual ΔD's of 3 and 3.5 mils). The visual examination of the data indicates that it is bounded by an extreme value of slightly less than 4 mils and independent of the actual ΔD up to about 10 mils. The error in measurement as a function of roll transition length is illustrated on Figure 2. It appears that there is somewhat less error with longer roll transition lengths and that the error is bounded by slightly less than 3 mils for transitions which are ≥ 0.7 inch long. In order to ascertain whether or not a measurement bias was being introduced by repeating the measurements using the same analysts, the error as a function of measurement number was plotted, Figure 3. Examination of the figure indicates that the measurement error is independent of measurement number. For example, the error range was essentially unchanged regardless of replicate number. This indicates that measurement bias was not having a significant affect on the ECT measurement results.

A detailed examination of the data indicated that the results were generally independent of the probe used. In addition, appeared that the trailing coil exhibited lower error, i.e.,, more negative (conservative), and a smaller standard deviation than the leading coil. Moreover, while the resolution process resulted in a reduction of the absolute error, it also resulted in an increase in the standard deviation of the data.

The aim of the analysis of the data was to calculate a confidence bound on the ΔD error as measured by the ECT in order to establish an acceptable lower limit on the ECT measured ΔD. The acceptable ECT measured ΔD is obtained as the structurally acceptable ΔD, i.e., 3 mils, plus the eddy current uncertainty. The approach to establishing the ECT uncertainty consisted of nonparametric and parametric statistical analysis of the data.

For the nonparametric analysis the distribution of the data is considered to be unknown. The results apply regardless of the actual distribution and are therefore bounding, within a specified level of confidence, with respect to the results that are obtained if the distribution form is known. The first calculation considers the sorted array of the errors. The methodology of calculating a confidence value for a portion of the population of errors is described in Section 5.5 of Reference 4. In this case, the 200 measurements are considered to be a random sample from the population of errors. The 196^{th} value is a 95% confidence estimate for the 95^{th} percentile of the population. The 196^{th} ordered error is 2.6 mils.

Binomial distribution ranks were also used to estimate an upper bounds to the error with a 95% level of confidence. In the Reference 3 meeting with the NRC staff, it was presented that the median or 50% rank on the 95^{th} percentile is 2.7 mils, a 5% rank on the 95^{th} percentile is 3.2 mils, and a 5% rank on the 98.5^{th} percentile is 4.0 mils. These results were calculated after binning or grouping the data for the purpose of plotting a histogram of the distribution, see Figure 4 for the density function and Figure 5 for the cumulative distribution function. This has the effect of smearing the detail results because of the bin size contains a range of results values. Using the raw data, the actual median rank on the 95^{th} percentile is the 191^{st} value or 2.3 mils and the 5% rank is 2.6 mils as above, and the 5% rank on the 98.5^{th} percentile is the 200^{th} value or 3.8 mils.

Two checks were performed to verify the above results. The first was a simple estimate of the confidence or probability, P, that at least a portion β of the populations is included between the smallest and the largest results from a sample of size n. The standard expression for P is,

$$P = 1 - n\beta^{n-1} + (n-1)\beta^{n}. \qquad (1)$$

Solving for the value of β to obtain a confidence value of 95% for the sample size of 200 yields 97.7%. Thus, with 95% confidence, 97.7% of the population of errors would be expected to be between -4.7 mils and 3.8 mils inclusive. Thus, only about 1^{+}% would be expected to be greater than 3.8 mils. This is in agreement with the above calculations.

For the second check, Chebyshev's inequality was used to estimate an upper bound, k, to the error using the following formula,

$$P\left\{\frac{|x-\mu|}{\sigma} \leq k\right\} > 1 - \frac{1}{k^2} \qquad (2)$$

For the error data, the probability that the error is ≤ 4 mils was found to be > 92.3%. This is also considered to verify the prior calculations. All of the prior approaches are conservative because they apply independent of the distribution of the data and provide upper bound estimates. Thus, the value obtained from the used of Chebyshev's inequality is not used because a lower upper bound value is obtained from an alternative calculations.

For the parametric analysis it was noted from the examination of the data that the distribution of errors appears to follow a Gaussian form, Figure 4. Thus, a bound on the ΔD error was also calculated based on the assumption of a Gaussian distribution using the formulation for a tolerance bounds, i.e., the confidence that a specified portion of the population is less than the bounding value. Using a conservative approximation based on the Bonferroni inequality[2], a 95%/95% upper bound is 2.7 mils, which is high because it is based on the binned data. The 95%/99% upper bound was also calculated to be 4.0 mils. The 95%/95% tolerance bound from the normal distribution agrees very well with the 5% rank from the binomial distribution.

A summary of the ΔD upper bounds is illustrated on Figure 6. Using the ranks of the raw data, the 95% confidence bound on 95% of the population is between 2.5 and 2.6 mils, and 3 mils represents a 95% confidence bound on about 97% of the population. These results are strongly supported by the 95%/95% tolerance limits from the normal distribution approximation.

5.0 Review of Structural Capability

Test data demonstrating the structural capability of HEJ sleeved tubes with PTIs was documented in References 1 and 2. Figure 4-3 from Reference 1 is included as Figure 7. The figure has been

[2] For a 95% confidence, both the mean and standard deviation estimates of the population parameters are simultaneously taken at a 97.5% level.

modified for this report in that the data (not conditioned) from the 1994 testing program presented in References 1 and 2 has been included for illustration. This illustrates that the projection of a >4000 lbs load for a ΔD of 2 mils from the 2nd order regression of the 1996 data provided a reasonably accurate estimate of the actual test load (4100 lbs) for the 1994 specimen. In addition, a 2nd order regression of the combined 1996 and 1994 data results in a solution curve that is not significantly different for that using the 1996 data only for an interference value as low as 1 mil. This difference is solely due to the inclusion of a data point obtained from a specimen with a 0.8" interference length and no diametral interference. The reason for including this discussion is to demonstrate that there is also significant structural margin for ΔD values as low as 1 mil. Thus, additional small error in the sizing would not be expected to lead to joint configurations which would not meet the structural requirements of RG 1.121 or the leak requirements of 10 CFR 100.

6.0 Conclusions

The examination of the data leads to the following conclusions:

1) The NDE error is generally independent of probe used, the coil used, and whether or not the data is taken to resolution.

2) The NDE error is expected to be ≤ 2.6 mils with a 95% level of confidence, based on using both nonparametric and parametric statistical evaluations.

3) There is sufficient structural margin to accommodate extreme errors that might occur during the evaluation of the PTIs in the SGs.

In summary, the use of an ECT error of 2.6 mils for evaluating the ΔD's for parent tube indications is justified. Therefore, the lower bound limit of acceptance for ΔD's by ECT using the combination probe is justified to be 5.6 mils. It is noted that this is 1.4 mils less than the limit reported in the Reference 3. However, the conclusion presented at that time was based on arbitrarily selecting a 99% confidence bound and on limits obtained from analyzing the binned data. The evaluation performed herein demonstrates that a 95% confidence bound is sufficient and is based on the raw data.

7.0 References

1. WCAP-14641, "HEJ Sleeved Tube Structural Integrity Criteria: "ΔD" Diametral Interference at PTIs," Westinghouse Electric Corporation (April 1996).

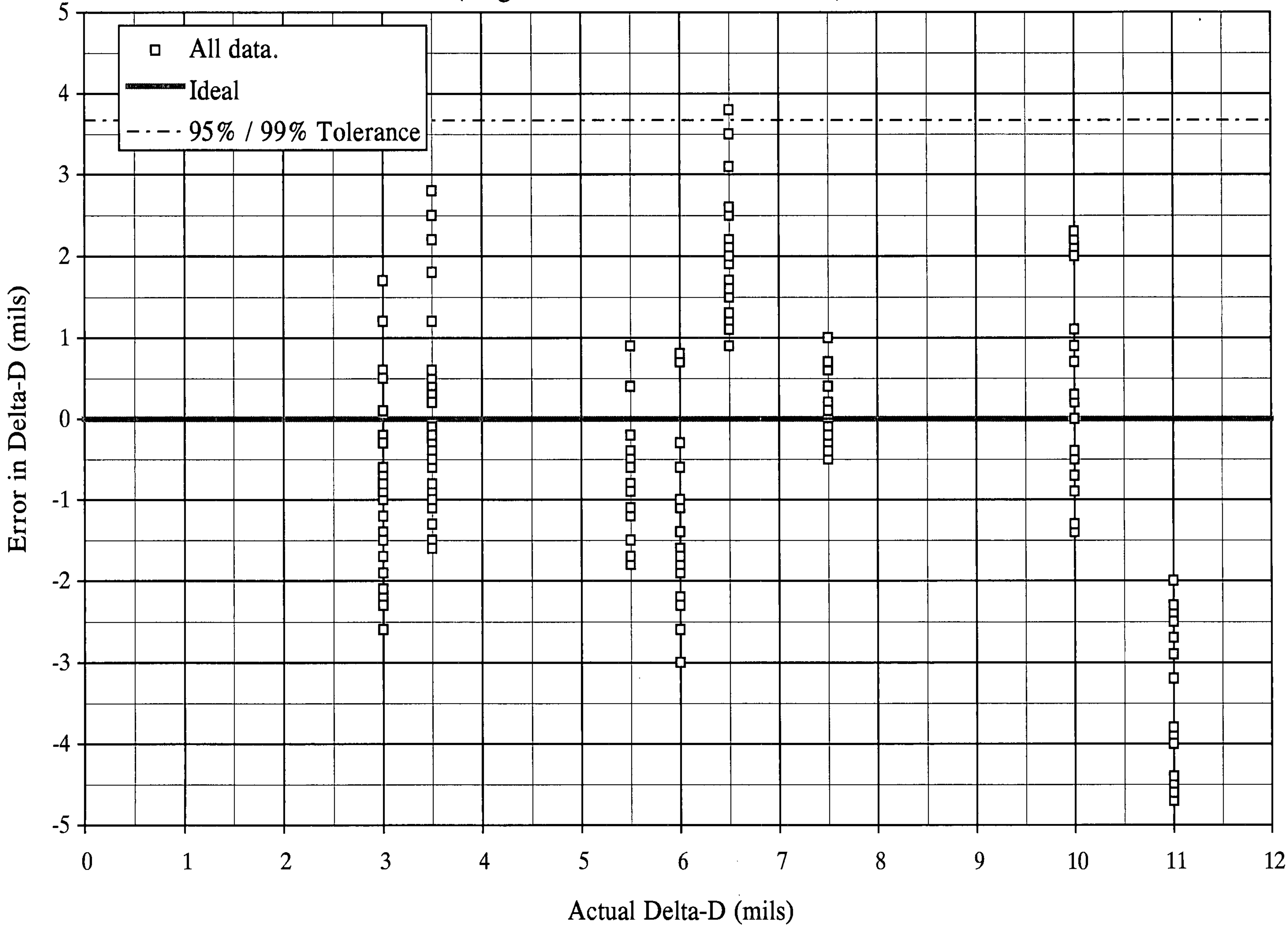
2. Meeting, "WPSC/Westinghouse/NRC Meeting on Redefinition of Pressure Boundary for HEJ Sleeves," April 25, 1996.

3. NSD-RFK-96-018, "WPS/NRC Meeting on August 20, 1996," R. Keating, Westinghouse Electric Corporation (August 21, 1996).

4. WCAP 14277, "SLB Leak Rate and Tube Burst Probability Analysis Methods for ODSCC at TSP Intersections," Westinghouse Electric Corporation (January 1995).

Figure 1: Error in Measuring Delta-D for HEJ PTIs

(Negative Error is Conservative)



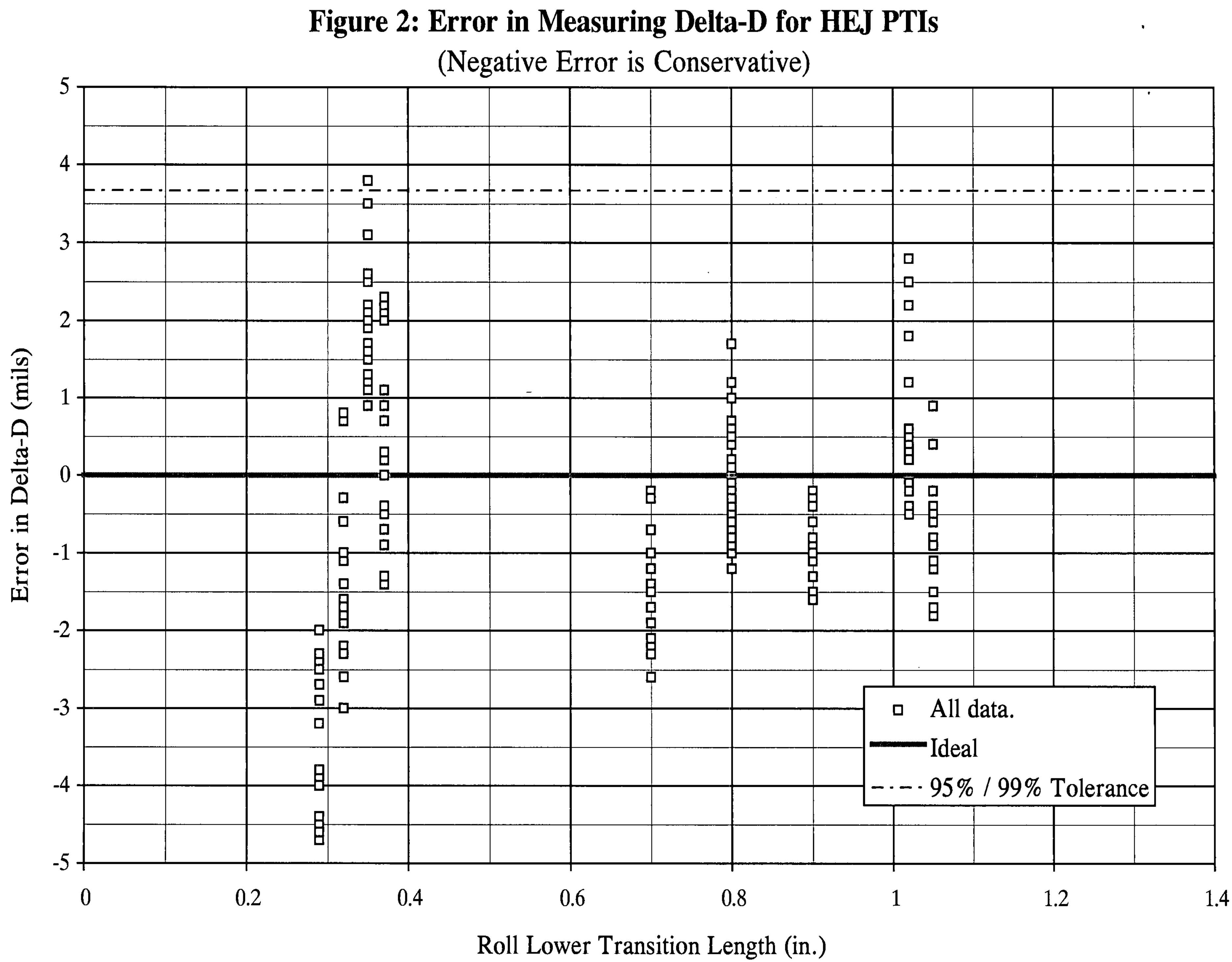


Figure 2: Error in Measuring Delta-D for HEJ PTIs
(Negative Error is Conservative)
Error in Delta-D (mils)
5
4
3
2
1
0
-1
-2
-3
-4
-5
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Roll Lower Transition Length (in.)
All data.
Ideal
95% / 99% Tolerance

Figure 3: Delta-D Error vs. Measurement Number

(Negative Error is Conservative)

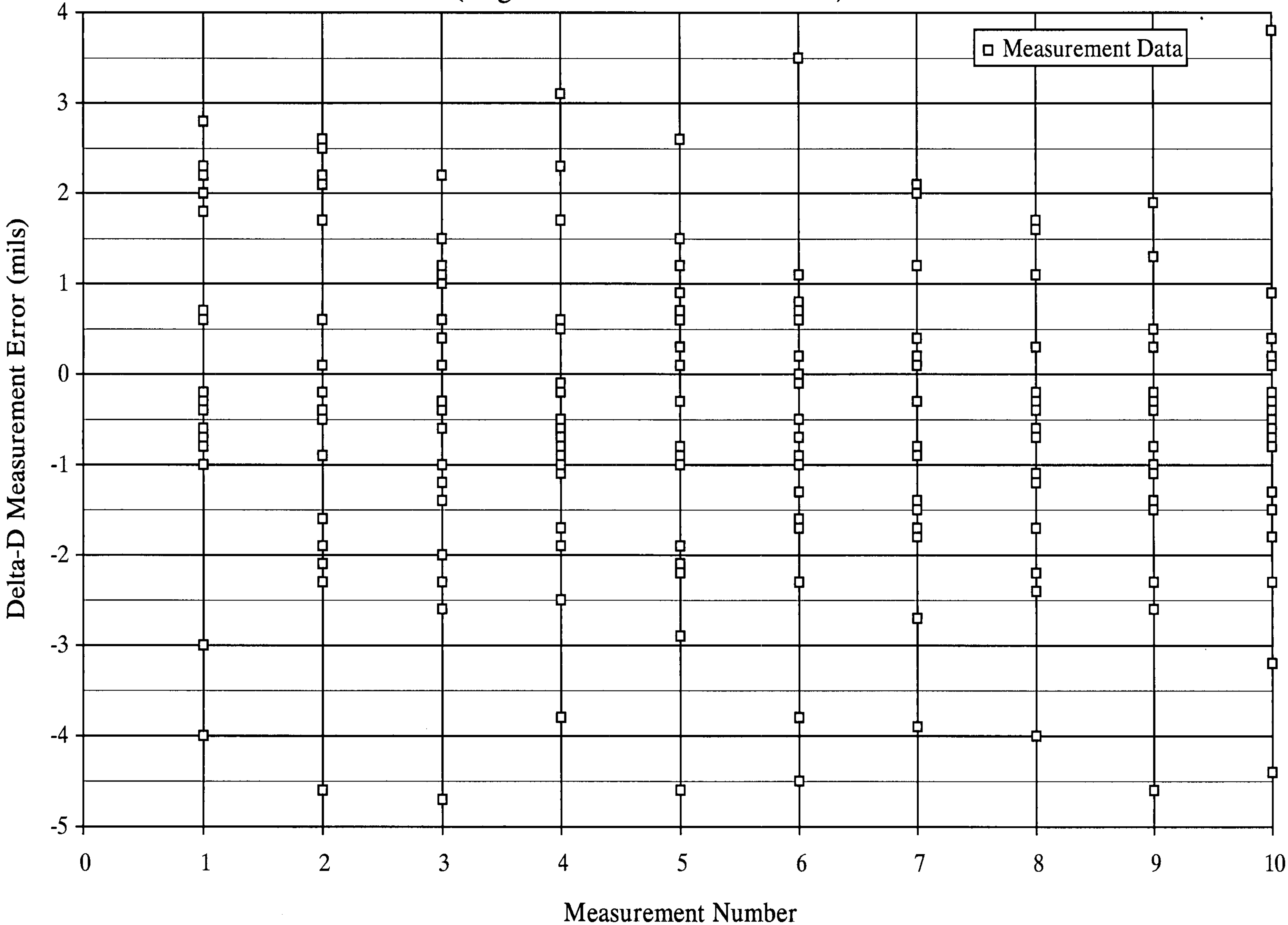


Figure 4: Probability Density of Delta-D Measurement Errors

(Negative Error is Conservative)

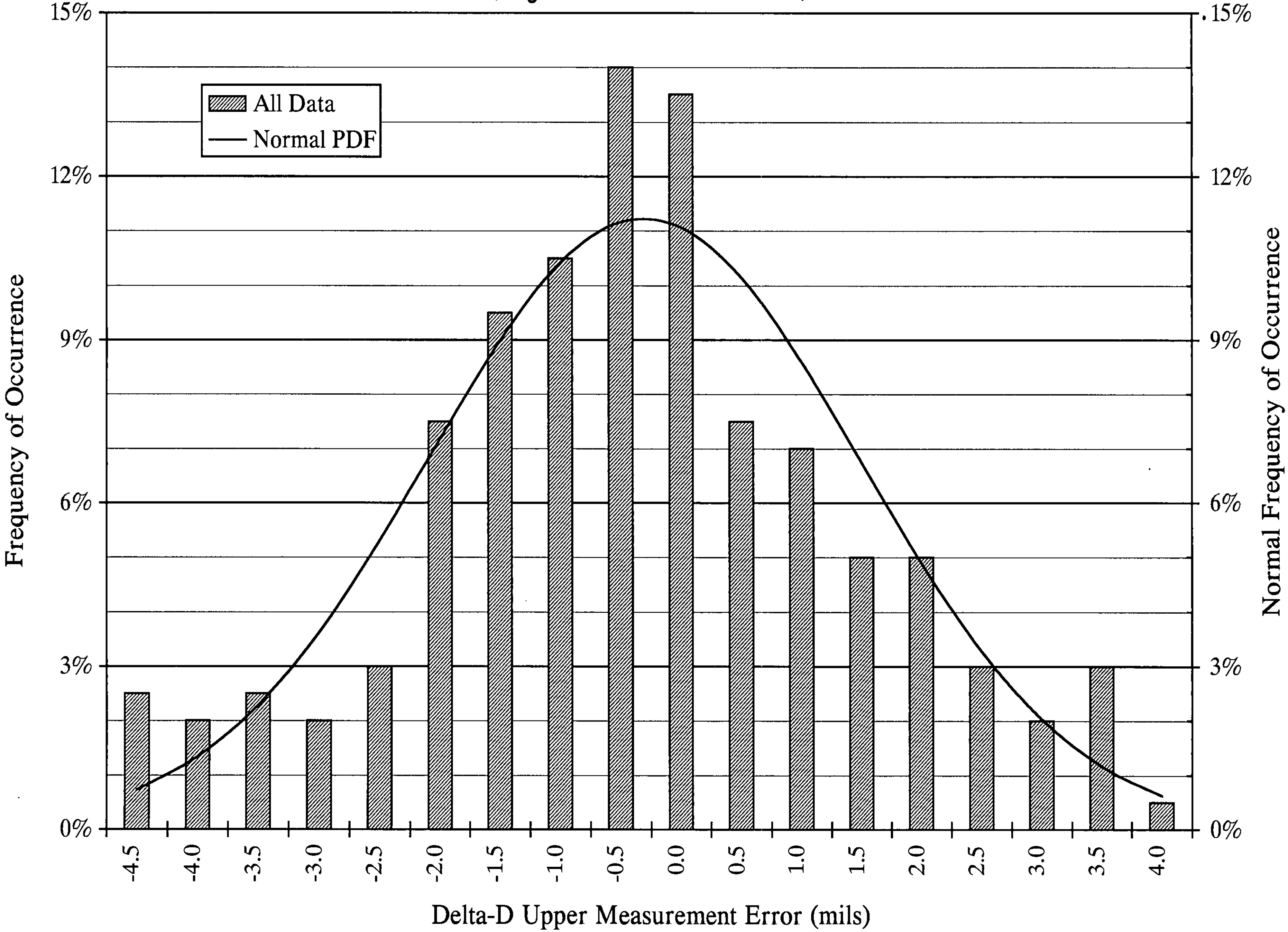


Figure 5: Distribution of Delta-D Measurement Errors

(Negative Error is Conservative)

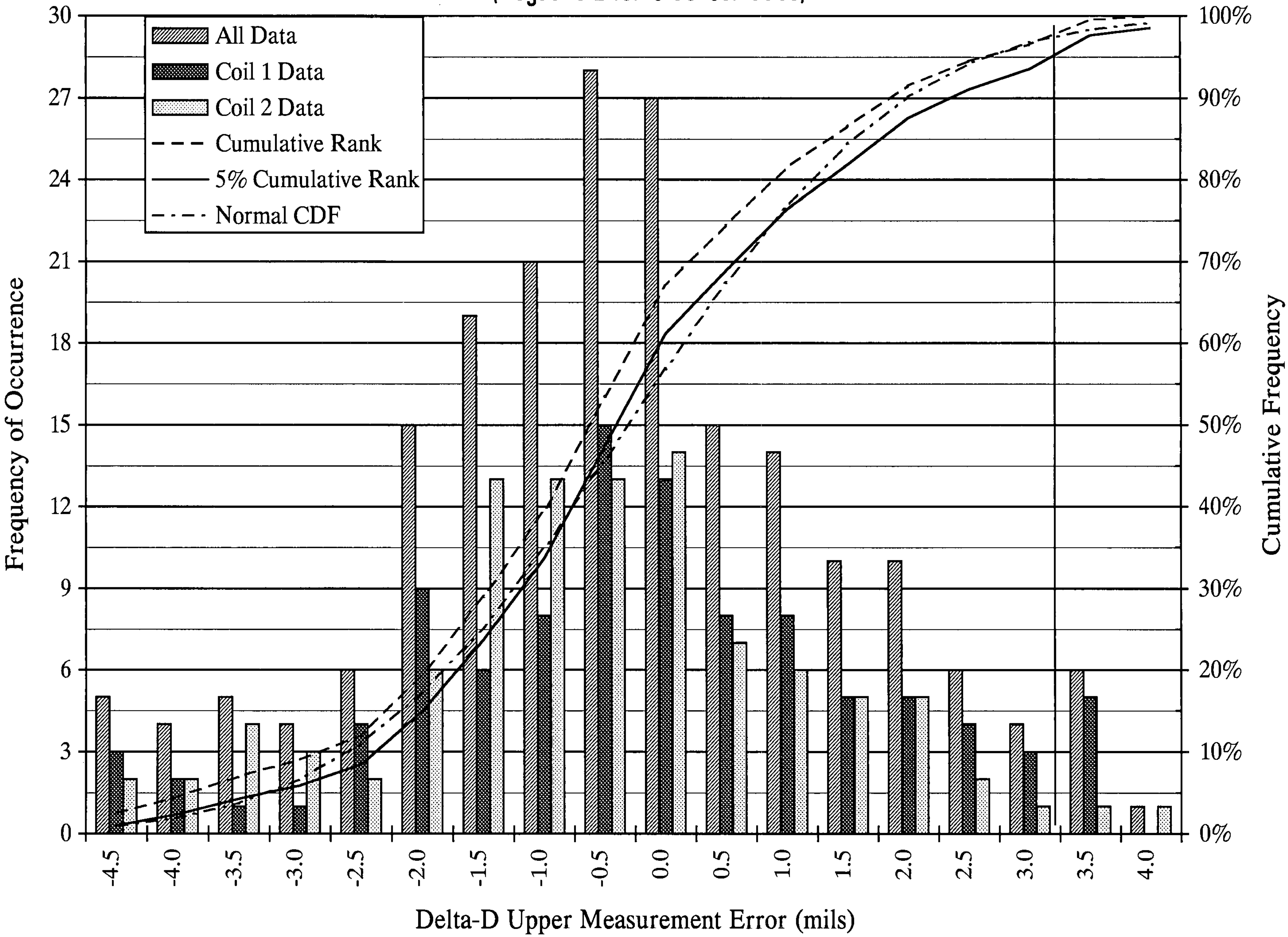


Figure 6: Summary of ΔD Upper Bounds

Nonparametric and Normal Distributions

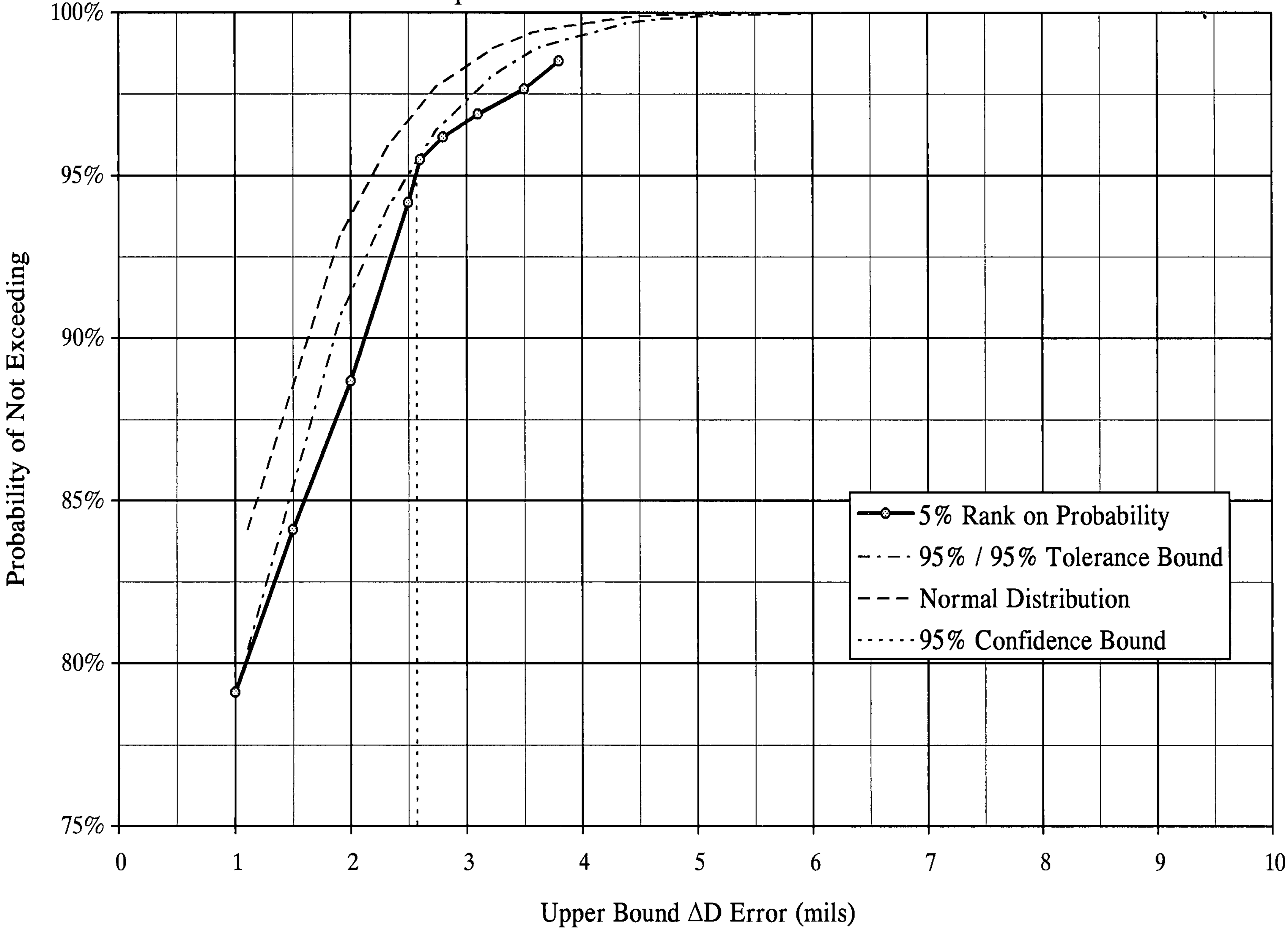


Figure 7: Peak Load vs Diametral Interference
of Elevation of PTI to HR in HEJ Sleeved Tubes