NUCLEAR ENERGY INSTITUTE

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June 10, 2002

Mr. Eugene V. Imbro
Chief, Mechanical Engineering Branch
Office of Nuclear Reactor Regulation
Mail Stop O9-D3
U. S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: Additional Responses to Questions on EPRI Report 110779 "Addendum 2 to EPRI TR-103237-R2 Thrust Uncertainty Method"

PROJECT NUMBER: 689

Dear Mr. Imbro,

In two letters dated January 5 and December 6, 2001, NEI responded to NRC questions on the Thrust Uncertainty Method (TUM) described in EPRI Report 110779, "Addendum 2 to EPRI TR-103237 "Thrust Uncertainty Method", which was submitted in September 8, 1999. During a March 26th telephone conference call, the staff raised additional questions. Representatives from the industry met with your staff on May 1st to address these comments. Enclosure 1 documents our responses. The information in Enclosure 1 is not proprietary.

Based on our discussions with the staff at the May 1st meeting, it is our understanding that if the information provided in Enclosure 1 responds fully to your staff's comments, the safety evaluation on the TUM would be published before the end of July.

EPRI has already revised the TUM Report in accordance with the responses in Enclosure 1. The final report will be published one month after the staff's safety evaluation. The document will be designated EPRI Report 1003279 "Addendum 2 to EPRI MOV Performance Prediction Program Topical Report TR-103237-R2 - Thrust Uncertainty Method - Revision 1". The NRC should use this designation in its safety evaluation. A pre-publication copy will be provided to you upon request.

We believe any NRC staff review of the PPM reports is exempt from the fee recovery provision contained in 10 CFR Part 170. This submittal provides information that might be helpful to NRC staff when evaluating licensee submittals

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provided in response to Generic Letter 89-10. Such reviews are exempted under §170.21, Schedule of Facility Fees. Footnote 4 to the Special Projects provision of §170.21 states, "Fees will not be assessed for requests/reports submitted to the NRC...[a]s means of exchanging information between industry organizations and the NRC for the purpose of supporting generic regulatory improvements or efforts."

If you have any questions regarding these enclosures, please contact Mr. John Hosler of EPRI at 530-672-0878.

The NEI contact for MOV issues is Jim Riley. He can be reached at 202-739-8137, jhr@nei.org.

Sincerely,

Alex Marion

Alexander Marion

JHR/maa
Enclosure

c: Mr. Thomas G. Scarbrough, U. S. Nuclear Regulatory Commission
Mr. Peter C. Wen, U. S. Nuclear Regulatory Commission
Mr. Leonard Olshan, U. S. Nuclear Regulatory Commission
Mr. John Hosler, EPRI
Mr. Gary Vine, EPRI
Mr. Tom Walker, MPR Associates

Enclosure 1

Responses to March 2002 NRC Comments on Addendum 2 to EPRI TR-103237-R2

Responses to NRC Comments on EPRI Supplemental Response Dated December 6, 2001 on Thrust Uncertainty Method

NRC Question #1. Is there any flow loop data between 100°F and 150°F, or other information, to support EPRI view of no effect on average prediction ratio (APR)?

EPRI Response. As discussed in Reference (2), EPRI proposes to eliminate "hot water" strokes from the applicability of the TUM, based on the limited data at high temperatures. To ensure that the TUM can be used to evaluate nominally ambient temperature strokes, EPRI proposes to extend the temperature limit above 100°F (which was based on the test data used to calculate the average prediction ratio). A limit of 150°F is proposed based on the discussion in Reference (2). There is no EPRI flow loop test data between 100°F and 150°F; however, as discussed in the addendum, the PPM's friction algorithm indicates that the variation in friction coefficient from 100°F to 150°F is very small (approximately 0.02). Since the PPM's friction algorithm is based on a variety of sources, including laboratory testing at 200°F, this result supports extending the temperature limit to 150°F.

In addition, EPRI flow loop test data does exist at 550°F. These data indicate that at this temperature, the average prediction ratio is 0.775. Interpolation between 100°F and 550°F results in an average prediction ratio of about 0.708, which is considerably less than the 0.74 average prediction ratio proposed by EPRI for the TUM (see response to NRC Comment #3 below).

NRC Question #2. The basis for the "high margin" assumption with respect to motor-operated valves (MOVs) in the Joint Owners' Group program (RAI Question 3) set up using the Thrust Uncertainty Method was not clear.

EPRI Response. As discussed in the response to NRC Comment #3, EPRI proposes to revise the TUM report to require that strokes set up per the TUM have at least 5% or 10% margin, depending on the valve's risk significance. With the addition of this requirement, all valves set up per the TUM will be able to apply the longest static test frequency in the JOG program. Accordingly, there is no need for a "high margin" exemption for the TUM.

NRC Question #3. The concerns with statistical validity of 95/95 analysis need to be resolved.

EPRI Response. Based on a desire to deterministically increase confidence in the conservatism of the method, EPRI proposes to revise the TUM to use an average prediction ratio of 0.74 and an upper tolerance limit of 1.014. The effect of this change to the method is that the "nominal" required thrust is set to 74% of the PPM thrust prediction and the "bounding" required thrust is set to 101.4% of the PPM thrust prediction. Statistical analysis of the prediction ratio data provides additional confidence in this approach. Specifically:

- The deterministically selected average prediction ratio is 0.74, which is higher than the mean of the data (0.7) and is nearly identical to the median. A median value higher than the mean value indicates that the prediction ratio data is not perfectly normal and is skewed toward higher values. Therefore, use of an average prediction ratio close to the median, rather than at the mean, is appropriate.

- If the upper tolerance limit (UTL) of the prediction ratio data is evaluated using a one-sided tolerance limit approach for a non-normal distribution, we can say there is 95% confidence that 95% of the data is bounded by the highest data point, which is 1.014. This result suggests that even if the data were not close to normal, there is a sufficient number of prediction ratio data points (62) to justify an UTL of 1.014. The prediction ratio data used for the TUM has more of a "tail" on the left side of the prediction ratio histogram. However, a cumulative distribution function (CDF) curve with a mean value of 0.74 and a standard deviation of 0.115 fits the prediction ratio data that are higher than the median of the data set (0.74). See Figure 1. Applying a 95/95 analysis to a normal distribution with a mean of 0.74 and a standard deviation of 0.115, we can say with 95% confidence that 95% of the data is bounded by a prediction ratio of less than one.

EPRI further proposes to revise the TUM report as follows.

- Valve strokes set up using the TUM must have at least 5% margin for valves with low risk significance and at least 10% margin for valves with medium or high risk significance. The evaluation of risk significance for MOVs shall be conducted in accordance with accepted risk evaluation methods that include input from an expert panel, e.g., methods implemented in applying the JOG PV Program.

  Margin is defined as the difference between the measured thrust at TST and the minimum allowable thrust at TST predicted by the TUM, divided by the minimum allowable thrust at TST predicted by the TUM. These minimum margins are required for design purposes and for "operability" evaluations. These minimum margin requirements are meant to be coincident with (not in addition to) existing administrative margins.

- The following paragraphs will be added to the report.

  If differential pressure (DP) test data are available for an MOV to be set up per the TUM, or if DP test data is obtained for an MOV that was set up per the TUM, plant-specific procedures should be applied to ensure that the setup of the MOV based on the TUM is consistent with or bounds the setup based on test data.

  Users of the TUM shall consider plant-specific and industry experience and applicable MOV service conditions to have confidence that the performance of the MOV to be evaluated is consistent with the justification basis for the TUM, e.g. the valve factor and ROL are not both expected to be high.

NRC Question #4. In the discussion of RAI Question 2, the NRC staff suggested that EPRI supplement the Appendix C discussion in Addendum 2 of the topical report. Clarify EPRI's response to this comment.

EPRI Response. In EPRI's response to the NRC's RAI question #2, a significant amount of additional validation of the TUM was performed. This additional validation is provided in Appendix B of Reference (1). The results of this validation provide additional assurance that TUM predictions are bounding. EPRI proposes to incorporate this additional validation into the TUM report to provide additional support that TUM predictions are reliable.

NRC Question #5. EPRI's response does not provide additional information on the population of tested gate valves (26) versus the number of valves (14) used to determine the APR.

EPRI Response. Of the 28 flow loop gate valves, 14 are included in the APR evaluation. Results from GATM validation were used to calculate prediction ratios; therefore, only valves covered by GATM validation were included. Therefore, the 3 blind valves (#5, 26 and 30), the 4 multi-piece disk valves (#15, 21, 41 and 43), the one Westinghouse valve (#34) and Valve #61 (data not available at time of GATM validation) were not included (9 valves total). The four Borg-Warner valves (#7, 8, 9 and 10) were excluded because they are not covered by the TUM. Valve #2 was excluded because it had very low friction.

Note that data for Valves #5 and #30 are included in Figure 3, which shows the results of additional validation of the TUM. The calculated prediction ratios for the strokes of these two valves are less than the mean and median of the prediction ratio data set.

NRC Question #6. Where is EPRI's response to RAI Question 6 discussion on probability of an MOV exhibiting both a high valve factor and rate-of-loading effect?

EPRI Response. Valve factor and rate-of-loading (ROL) are independent of each other, i.e., there is no technical reason that one would be high because the other is high. Further, ROL data in the EPRI MOV Program was reasonably "normal," and bias (5.6%) and random (26.4%) values were justified for ROL. Prediction ratio (which is related to valve factor) has been shown to be reasonably "normal" above the median. Therefore, the likelihood that these two independent variables would both be at extreme high values for the same valve stroke is very low. Indeed the joint probability of such an occurrence is equal to the product of the individual probabilities, i.e., the product of two very small numbers, which equals an extremely small number. This conclusion is supported by the additional validation documented in Appendix B of Reference (1). In this appendix, the prediction ratio is plotted versus ROL for 83 valve strokes from the EPRI MOV program. Lines are drawn representing the maximum allowable ROL as a function of prediction ratio for the TUM to be conservative. As shown in Figure B-3 of that appendix (see Figure 3), all 83 data points are below the lines, indicating that the TUM would be conservative for all 83 strokes.

NRC Question #7. Did EPRI respond to RAI Question 8 discussion on use of rate-of-loading uncertainty for low loop test population and provide guidance for application of the rate-of-loading uncertainty based on plant-specific data?

EPRI Response. In Reference (2), EPRI added lines to Figure B-3 (see Figure 3) that represent implementation of the TUM using ROL values of 3% bias/21% random, which are applicable for only the 83 data points in Figure B-3. The results indicate that the TUM would be bounding using these values for all valve strokes. The TUM report provides users with guidance on determining ROL values for use with the TUM. Users are required to use the EPRI ROL values (5.6% bias, 26.4% random uncertainty) or uncertainty values that are justified statistically using plant test data. EPRI proposes to revise the TUM report to require that any statistical evaluation of plant ROL data meet a 95/95 statistical analysis for upper tolerance limit.

NRC Question #8. Do the prediction ratios support EPRI's view that a differential pressure effect is not present?

EPRI Response. Figure 2 is a plot of prediction ratio versus contact stress for the 62 strokes used to determine the average prediction ratio. As shown, other than the four low prediction ratios at low contact stress and the four data points at the upper right of the plot, there is no apparent trend of prediction ratio with contact stress. The low prediction ratios at low contact stress are attributable to the method used to calculate prediction ratio. For these strokes, the test DP was relatively low, resulting is a relatively small DP load. When the DP load is adjusted for packing and stem rejection loads to calculate prediction ratio, small variations in packing load can result in high uncertainty in the calculated prediction ratio. The four data points at the upper right of the plot are all for Valve #3, which exhibited relatively high seat friction during flow loop testing. Note for this valve, prediction ratios are unaffected by DP (contact stress). This observation suggests that contact stress does not significantly affect prediction ratio.

However, as there is insufficient prediction ratio data at contract stresses greater than approximately 15,000 psi, EPRI proposes to restrict the applicability of the TUM to strokes for which the calculated contact stress is no more than 15,000 psi.

NRC Question #9. Discuss the resolution of comments on Figure B-3 that compares thrust prediction ratios to rate-of-loading effects.

EPRI Response. The resolution of comments on Figure B-3 is covered in Reference (2). Figure 3 is a new revised version that includes a line representing use of the PPM without the TUM. This new version also reflects an average prediction ratio of 0.74 and an upper tolerance limit of 1.014. EPRI would like to clarify the following two items related to the NRC's meeting report for the October 18, 2002 meeting

1. In item #13, NRC indicates that "EPRI found the TUM to predict at least the thrust requirement predicted by the PPM...for all cold water strokes and all (but one) hot water strokes." This sentence is incorrect and should read "EPRI found the TUM to provide a conservative *prediction of minimum allowable thrust at torque switch trip*...for all cold water strokes and all (but one) hot water strokes." It should be noted that the TUM **always** predicts a minimum required thrust at torque switch trip at least as high as the PPM prediction. For example, if there are no uncertainties other than the thrust prediction uncertainty, the TUM will predict a minimum allowable thrust at torque switch trip equal to the PPM thrust prediction. As uncertainties are added (ROL, TSR, diagnostic equipment uncertainty, etc.), the TUM prediction of minimum allowable thrust at torque switch trip increases above the PPM thrust prediction. It is noted that for the one hot water stroke for which the TUM was not bounding, the PPM thrust prediction was also not bounding.

2. In item #13, NRC indicates "The staff noted that EPRI could demonstrate its assumed conservatism of the EPRI MOV PPM by applying the actual test valve factor in the EPRI MOV PPM, and comparing the predicted thrust requirement to the actual measured dynamic thrust requirement." This calculation would result, by definition, in a prediction ratio very near one. If the PPM is implemented using valve factors back calculated from the test data (input as seat COFs), the conservatism in the PPM's Stellite friction coefficient would be essentially eliminated and the resulting thrust predictions would be very close to the measured thrust. EPRI does not consider this comparison to provide any insights into the acceptability of the TUM since the TUM is intended to account for the conservatism in the Stellite friction coefficients in the PPM. EPRI agrees to revise the TUM report to clarify that the TUM can only be applied if the PPM prediction on which the TUM is based uses default friction coefficients.

NRC Question #10. Discuss how the slides in the EPRI response on MOV reliability provide confidence that Thrust Uncertainty Method will continue to provide the reliability assumed in probabilistic safety assessments.

EPRI Response. The slides summarize statistical methods to support the conclusion that the reliability provided by the TUM is *consistent with* the reliabilities used in plant PRAs. The information on the slides #2 and #3 is summarized below.

Slide #2 (shown below): The table is interpreted as follows. The % values shown in the body of the table are the probability that the number of failures in 83 trials would be equal to the value shown in the first column, if the reliability of the TUM is as shown in the column heading. For example, if the reliability of the TUM were 95%, there is a 1% probability that there would be zero failures in 83 trials. This result suggests that the reliability of the TUM is greater than 95% since there were zero failures in 83 trials (Appendix B of Reference 1). If the reliability of the TUM is 99.63% (the average from plant PSAs), the probability of zero failures in 83 trials is 74%. The point of this table is that obtaining zero failures in 83 trials is *consistent with* a reliability of 99% or greater.

TUM and MOV Reliability Used in PSAs

# Failures in 83 Trials	Reliability				
	99.63%	99.5%	99%	97.5%	95%
0	74%	66%	43%	12%	1%
1	23%	28%	36%	26%	6%
2	3%	6%	15%	27%	13%

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Slide #3 (shown below): This slide presents the results of a statistical evaluation that also suggests that the reliability of the TUM is 99% or greater. Given 83 successes in 83 trials, the probability that the reliability is 99% (or greater) is 57%. The conclusion on this slide is that these two statistical evaluations (on slides #2 and #3) is that the results of the additional TUM validation (83 successes in 83 trials) are *consistent with* the reliabilities typically used in plant PSAs.

TUM and MOV Reliability Used in PSAs

- For a population of 10,000, if 83 trials are performed with 83 successes, the probability that the reliability is:
  - 99% is 57%
  - 99.5% is 34%
  - 99.63% is 27%
  - These values are the maximum possible for 83 trials)
- Conclusion
  - The results from TUM validation are consistent with the MOV reliabilities used in plant IPEs

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References

1. NEI (D.J. Modeen) letter to NRC (E.V. Imbro), dated January 5, 2001, "Response to Questions on Addendum 2 to EPRI Performance Prediction Methodology Software, Version 2.0"

2. NEI (A. Marion) letter to NRC (E.V. Imbro), dated December 6, 2001, "Additional Responses to Questions on Addendum 2 to EPRI Performance Prediction Methodology Software, Version 2.0"

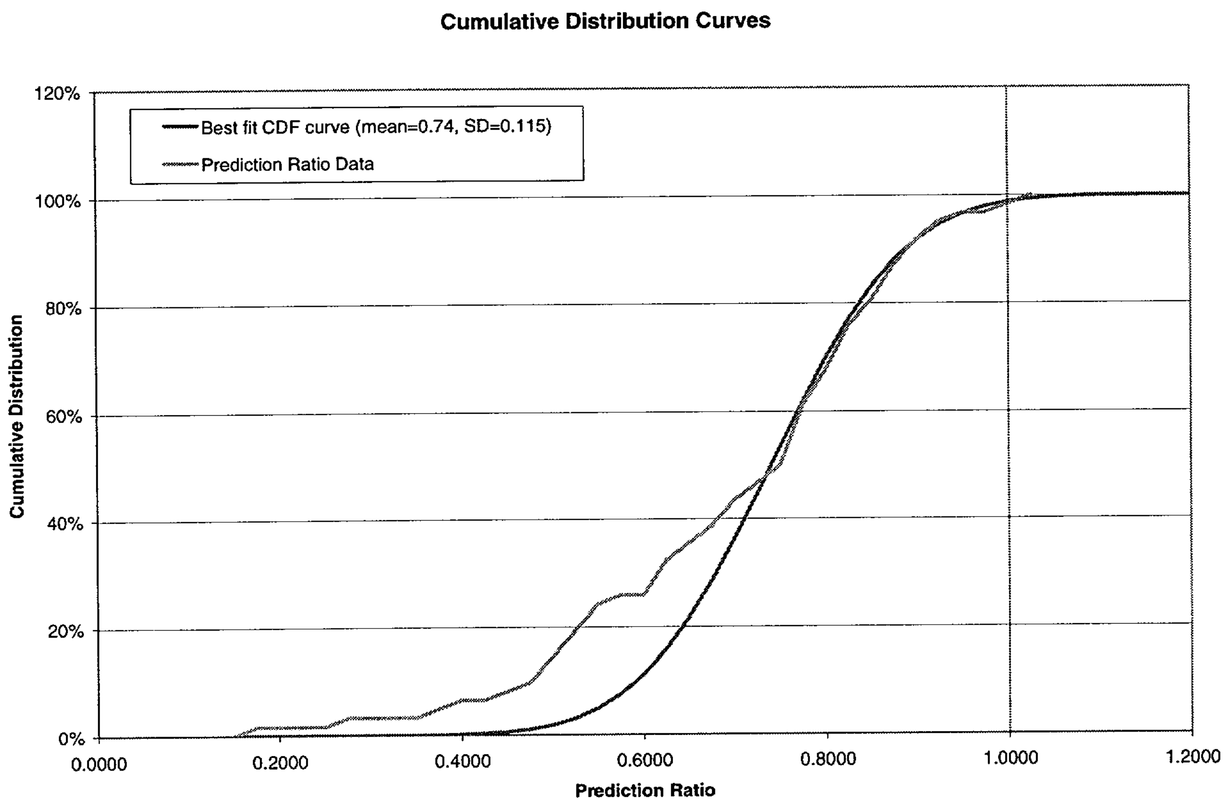

Figure 1. Cumulative Distribution Function Fit to Prediction Ratio Data

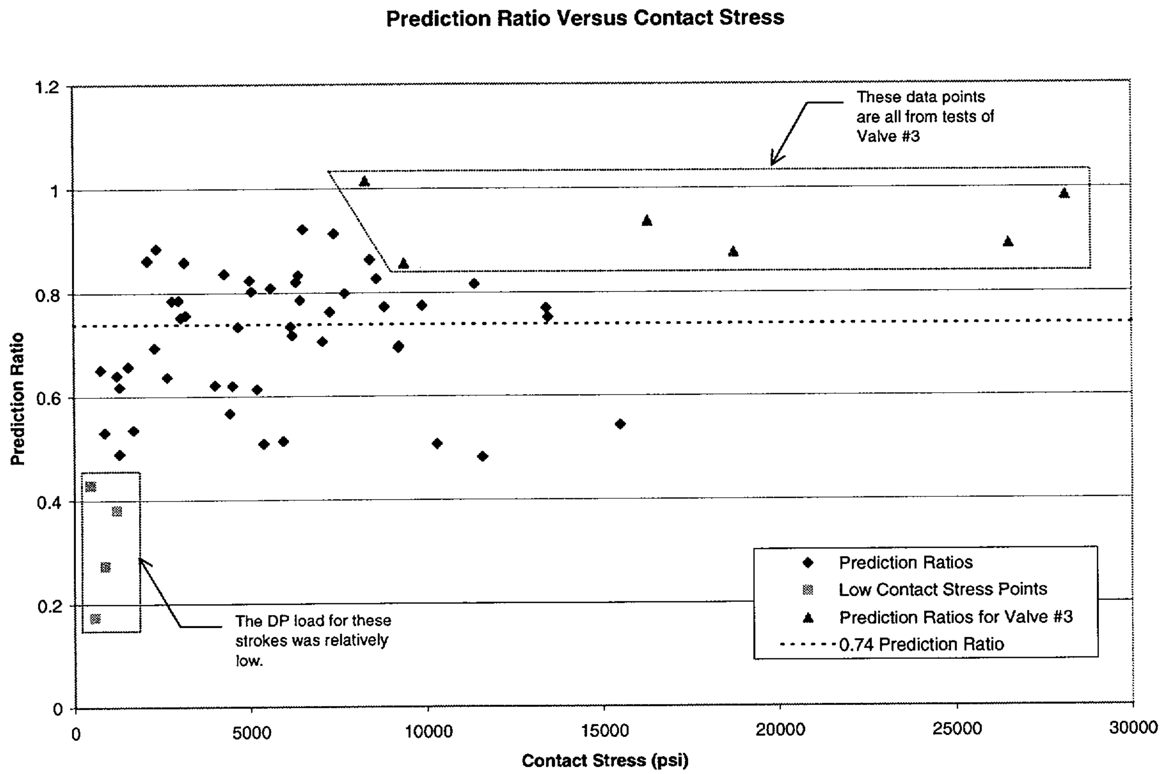

Figure 2. Prediction Ratio versus Contact Stress

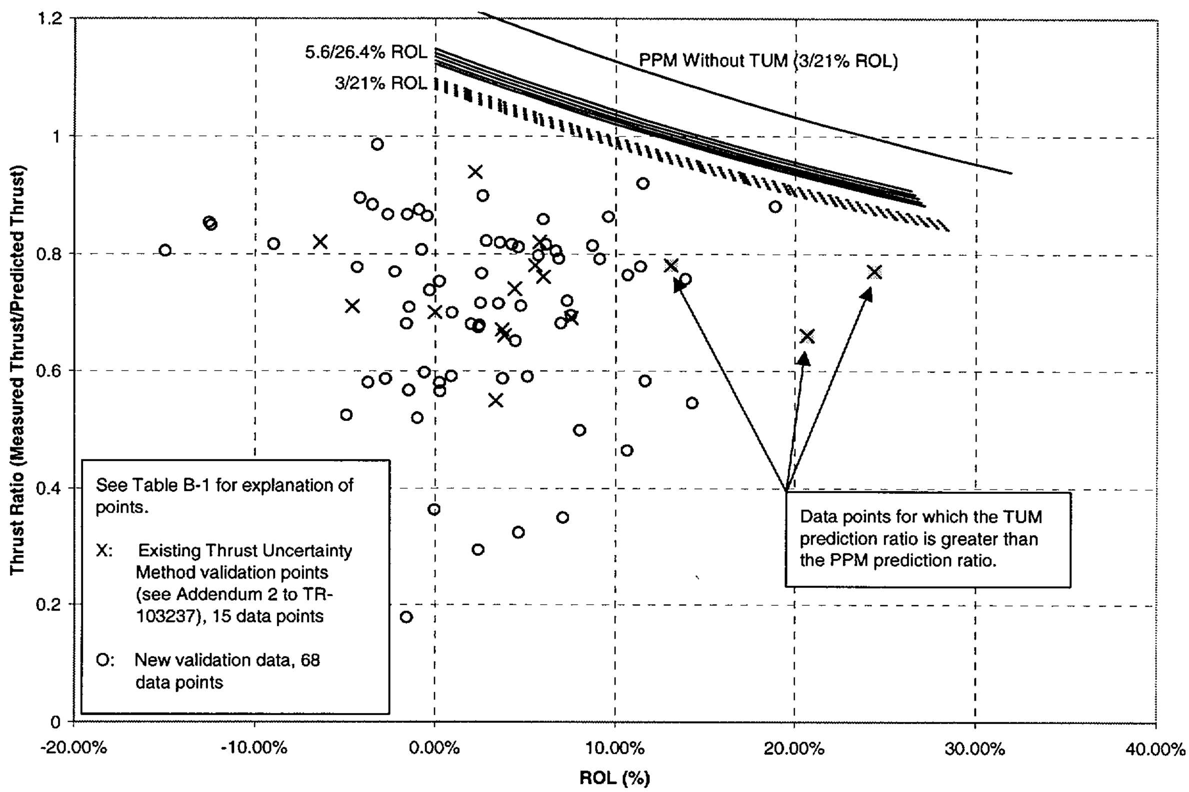

Figure 3. Revised Figure B-3 from Previous EPRI Comment Responses