NUCLEAR ENERGY INSTITUTE

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December 6, 2001

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: Addendum to Responses to Questions on Addendum 2 to EPRI Performance Prediction Program Topical Report TR-103237-R2 Thrust Uncertainty Method

PROJECT NUMBER: 689

Dear Mr. Imbro,

On January 5, 2001, NEI submitted a letter to the NRC, which responded to NRC questions on the Thrust Uncertainty Method described in Addendum 2 to the EPRI Performance Prediction Methodology (PPM). A meeting was held with your staff on October 18th to address their comments on the January 5 letter. Enclosure 1 documents the results of the discussion and updates the information in the January 5 letter in accordance with your staff's comments. We believe this provides the staff with sufficient information to prepare a Safety Evaluation of the Thrust Uncertainty Method (EPRI Report AD-110779).

The information in Enclosure 1 is not proprietary.

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 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.

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

Sincerely,

Alex 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. Thomas Walker, MPR Associates
Mr. Chad Smith, Duke Energy

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

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

Purpose

This document is an addendum to EPRI responses to NRC comments on Addendum 2 to EPRI TR-103237-R2, which documents a Thrust Uncertainty Method (TUM) for the EPRI PPM. The following items are addressed.

1. Applicability of the TUM to hot water applications.
2. Temperature limit for cold water applications.
3. Consideration of MOVs set up per the TUM in nuclear plant periodic verification programs in response to NRC Generic Letter (GL) 96-05.
4. The consistency of the MOV reliability achieved with the TUM compared to assumptions in plant Probabilistic Safety Assessments (PSAs).
5. The average prediction ratio (APR) used in the TUM for cold water applications.
6. Figure B-3 from the original comment responses, adjusted based on NRC comments.

Discussion

Applicability of the TUM to Hot Water Applications

Consistent with discussions between NRC, EPRI and NEI, we conclude that there is insufficient data to apply the TUM to hot water gate valve applications at this time.

Temperature Limit for Cold Water Applications

Addendum 2 to EPRI TR-10327-R2 classifies "cold water" strokes as strokes with a maximum design basis temperature of 100°F or less. With the elimination of hot water strokes from the TUM, we consider that extending the temperature limit for cold water strokes is appropriate so that the TUM can be used for most in-plant "low temperature" applications. We consider a temperature limit of 150°F to be appropriate for "cold water." Per EPRI TR-103229, this temperature limit extension has a small effect on the coefficient of friction (COF) used in the PPM (Stellite-on-Stellite in water). Per Table 2-3 of TR-103229, the COF difference between 100°F and 150°F is about 0.02. Determination of the COF values used in the PPM is documented in Appendix E of TR-103229, which evaluates test data from EPRI's separate effects testing at Battelle (TR-103119) and other test programs (e.g., NRC/INEL testing). The range of data used in determining COFs for use in the PPM provides a good basis for the small effect of extending from 100°F to 150°F.

Plant Periodic Verification Programs

Consistent with discussions between NRC, EPRI and NEI, we consider that the reliability achieved with the TUM is such that nuclear plants should be able to consider MOVs set up per the TUM in the same way MOVs set up based on PPM predictions are considered in plant periodic verification (PV) programs. Specifically, MOVs set up per the TUM should be allowed to be classified as "high margin" valves in the JOG interim PV program, regardless of the calculated margin. The JOG final report should be used as the vehicle to document a final approach in this regard.

Consistency of TUM Method Reliability with Plant PSAs

Attachment 1 to this document contains the slides from a recent presentation by EPRI to the NRC. These slides summarize work that indicates that the reliability achieved with the TUM is *consistent with* MOV reliability values used in plant PSAs.

TUM Average Prediction Ratios (APRs)

Consistent with discussions between NRC, EPRI and NEI, the median prediction ratio, rather than the mean prediction ratio, should be used as the APR in the TUM since the prediction ratio data is not normal. Attachment 2 to this document is an evaluation of the data used to develop the TUM for cold water strokes to determine if there is 95% confidence that 95% of the valve population (i.e., safety-related gate valves in nuclear power plants) would be bounded by a prediction ratio of 1. In this evaluation, an APR of 0.7435, corresponding to the median of the data, is used.

Revised Figure B-3 from Original Comment Responses

During a recent meeting between NRC, EPRI and NEI, NRC requested that Figure B-3 from the original comment responses be revised as follows.

- The TUM "threshold lines" should be adjusted to reflect an APR of 0.7435 rather than 0.697.
- Additional threshold lines should be added for implementation of the TUM with a rate-of-loading (ROL) bias of 3% and an uncertainty of 21%, which are applicable for the 83 data points in Figure B-3.
- The data points for the three cold water strokes for which the Thrust Uncertainty Method prediction ratio is greater than the thrust prediction ratio (from PPM validation) are highlighted.

The revised Figure B-3 is Attachment 3.

Presentation Slides

TUM and MOV Reliability Used in PSAs

- From NUREG-1715, Vol. 4 (Sept 2001), the average MOV reliability used in plant IPEs is 99.63%
  - Based on 6 PWRs systems and 6 BWR systems
  - Corresponds to a failure on-demand of 3.7×10^{-3}
- For cold water conditions, application of the TUM yielded positive margin (success) on 83 of 83 trials (validation tests)

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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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Presentation Slides

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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TUM and MOV Reliability Used in PSAs

- Reliability considered from TUM validation is a design basis reliability (confluence of worst case conditions such as voltage, temperature, DP, etc)
- Reliability appropriate for PSA is an as-demanded reliability (conditions existing in the fault tree path evaluated in PSA)
- In general, reliability in PSA is greater than the design basis reliability
- Conclusion
  - There is good confidence that use of the TUM will not constrain MOV reliability values less than those used in PSAs

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Evaluation of Thrust Uncertainty Method Reliability

Background

The EPRI MOV Thrust Uncertainty Method (TUM) is documented in Reference (1). For cold water applications, the TUM uses an average prediction ratio (APR) of 0.697 to convert bounding PPM thrust predictions to nominal thrust predictions. The difference between the nominal and bounding predictions is then converted to an uncertainty, which is combined statistically with other uncertainties related to valve setup. The APR of 0.697 was derived from the results of valve testing in the EPRI MOV program. The value of 0.697 is the average prediction ratio (ratio of measured DP thrust to predicted DP thrust) for 62 gate valve closing strokes in ambient water. The 62-point data are not a precisely normal distribution, as evidenced by the fact that the median value is 0.7435. The distribution has a longer "tail" at low prediction ratios. The predictions ratios are shown in the first column of Table 1.

In this attachment, the "valve population" is the set of safety-related gate valves in nuclear power plants.

Purpose

The purpose of this attachment is to answer the following question. Is there 95% confidence that a prediction ratio of 1.0 bounds 95% of the valve population, given the data in the first column of Table 1 but adjusting its lower half to be like its upper half, so that the mean equals the median (0.7435)?

Results and Recommendations

There is <u>more than</u> 95% confidence that a prediction ratio of 1.0 bounds 95% of the valve population, given the data set in the first column of Table 1 but adjusted so that its mean is 0.7435.

Discussion

Using the procedure in Section 2-5.3 of Reference (2), a one-sided upper tolerance limit for a data set consistent with the actual prediction ratios but with a mean of 0.7435 is calculated as follows.

- For 95% confidence that 95% of the data is bounded by a given value, both the Proportion (P) and the confidence coefficient (() are set to 0.95.

Evaluation of Thrust Uncertainty Method Reliability

- The average (X) of the population is set to 0.7435. Since it would not be appropriate to calculate a standard deviation of the actual prediction ratios about the median value, the following approach is used to calculate a standard deviation.
  - All actual prediction ratios in the first column of Table 1 that are less than the median are eliminated from the population. The median is indicated by the bold horizontal line in Table 1.
  - New data points (that are less than the median value) are added to the population to create a "mirror" image of the values above the median. For each value greater than the mean (by an amount *x*), a new value is added to the population that is *x* less than the median. The data set created in this way, which has both an average and a mean equal to 0.7435, is shown in the second column of Table 1. Figure 1 shows histograms of the actual prediction ratio data and the prediction ratios "mirrored" around the median.
  - The standard deviation (s) of the new data set is calculated to be 0.1151.
- A K-value of 2.01 is calculated, with $z_{(}$ equal to 1.645 (from Table A-2 of Reference 2), z_P equal to 1.645 (from Table A-2 of Reference 2) and n equal to 62 (the number of data points). The equations are shown below.

$$a = 1 - \frac{z_\gamma^2}{2 \cdot (n-1)} = 1 - \frac{1.645^2}{2 \cdot (62-1)} = 0.9778$$

$$b = z_P^2 - \frac{z_\gamma^2}{n} = 1.645^2 - \frac{1.645^2}{62} = 2.6624$$

$$K = \frac{z_P + \sqrt{z_P^2 - a \cdot b}}{a} = \frac{1.645 + \sqrt{1.645^2 - 0.9778 \cdot 2.6624}}{0.9778} = 2.010$$

- The upper tolerance limit (UTL) is:

$$UTL = X + K \cdot s = 0.7435 + 2.01 \cdot 0.1151 = 0.975$$

Since this value is less than 1.0, there is more than 95% confidence that a prediction ratio of 1.0 bounds 95% of the valve population, given the data set in the second column of Table 1.

References

1. EPRI AD-110779, *EPRI MOV Performance Prediction Program: Addendum 2 to EPRI TR-103237-R2: Thrust Uncertainty Method*, November 1998

Evaluation of Thrust Uncertainty Method Reliability

2. Natrella, Mary G., *Experimental Statistics, National Bureau of Standards Handbook 91*, August 1, 1963

Evaluation of Thrust Uncertainty Method Reliability

Table 1. Prediction Ratios for Cold Water Closing Strokes (62 Strokes)

Actual Prediction Ratios	Prediction Ratios "Mirrored" Around the Median Value
1.014	1.014
0.984	0.984
0.936	0.936
0.922	0.922
0.914	0.914
0.892	0.892
0.885	0.885
0.876	0.876
0.863	0.863
0.862	0.862
0.859	0.859
0.856	0.856
0.837	0.837
0.834	0.834
0.827	0.827
0.824	0.824
0.821	0.821
0.817	0.817
0.809	0.809
0.803	0.803
0.799	0.799
0.786	0.786
0.786	0.786
0.785	0.785
0.775	0.775
0.773	0.773
0.77	0.77
0.763	0.763
0.757	0.757

Evaluation of Thrust Uncertainty Method Reliability

Actual Prediction Ratios	Prediction Ratios "Mirrored" Around the Median Value
0.753	0.753
0.752	0.752
0.735	0.473
0.735	0.503
0.718	0.551
0.706	0.565
0.697	0.573
0.694	0.595
0.693	0.602
0.658	0.611
0.652	0.624
0.641	0.625
0.637	0.628
0.621	0.631
0.62	0.65
0.618	0.653
0.613	0.66
0.567	0.663
0.543	0.666
0.535	0.67
0.53	0.678
0.513	0.684
0.508	0.688
0.507	0.701
0.491	0.701
0.489	0.702
0.482	0.712
0.461	0.714
0.429	0.717
0.381	0.724

Evaluation of Thrust Uncertainty Method Reliability

Actual Prediction Ratios	Prediction Ratios "Mirrored" Around the Median Value
0.366	0.73
0.274	0.734
0.174	0.735

Evaluation of Thrust Uncertainty Method Reliability

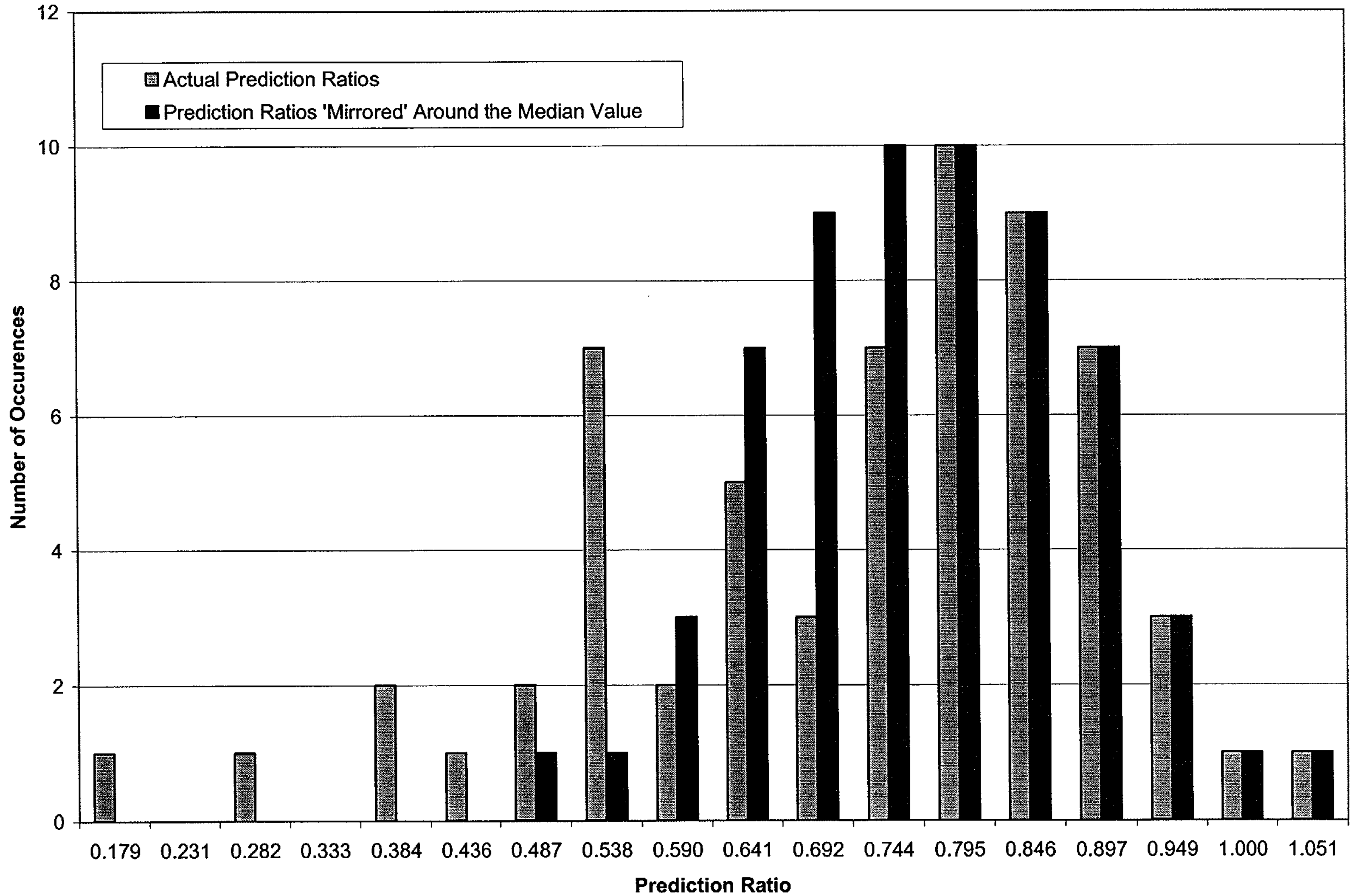

Figure 1. Histogram of Prediction Ratios (Actual and "Mirrored")

Figure B-3. Prediction Ratio (PR) versus Rate-of-Loading (ROL) for Cold Water Strokes