April 20, 2001

Mr. Gary L. Vine
Senior Washington Representative
Electric Power Research Institute
2000 L Street, N.W., Suite 805
Washington, DC 20036

SUBJECT: SUPPLEMENT 2 TO SAFETY EVALUATION ON ELECTRIC POWER RESEARCH INSTITUTE TOPICAL REPORT TR-103237, "EPRI MOTOR-OPERATED VALVE PERFORMANCE PREDICTION PROGRAM," ADDENDUM 1 (TAC NO. MA6485)

Dear Mr. Vine:

In November 1994, the Nuclear Energy Institute (NEI) submitted for NRC review the Electric Power Research Institute (EPRI) Topical Report TR-103237, "EPRI MOV Performance Prediction Program," that describes the EPRI motor-operated valve (MOV) methodology that predicts the applicable thrust or torque required to operate gate, globe, and butterfly valves over a wide range of differential pressure, temperature, and flow conditions. On March 15, 1996, the NRC staff issued a safety evaluation (SE) documenting the staff's acceptance of the EPRI MOV Performance Prediction Methodology (MOV PPM) described in the subject topical report, with certain conditions and limitations. On February 20, 1997, the staff issued a supplement to that SE documenting its acceptance, with certain conditions and limitations, of EPRI hand-calculation models for two additional gate valve designs and highlighting other aspects of the EPRI program.

On September 8, 1999, NEI submitted for NRC review Addendum 1, "PPM Version 2.0," and Addendum 2, "Thrust Uncertainty Method," to EPRI Topical Report TR-103237-R2. Version 2.0 of the EPRI MOV PPM described in Addendum 1 to the topical report resolves several previous modeling errors and incorporates other improvements to the modeling software. The Thrust Uncertainty Method described in Addendum 2 to the topical report estimates average conservatism in the MOV PPM gate valve thrust prediction, and combines this conservatism with uncertainties in the calculations.

In the enclosed supplement to the SE on the EPRI MOV PPM, the staff describes its review of Addendum 1 to EPRI Topical Report TR-103237-R2 with the assistance of the Idaho National Engineering and Environmental Laboratory.

Based on the review of Addendum 1 to EPRI Topical Report TR-103237-R2, the staff concludes that the changes made to the EPRI MOV PPM in Version 2.0 improve the ability of the EPRI model to predict the applicable thrust or torque required to operate gate, globe and butterfly valves. As a result, the EPRI MOV PPM remains acceptable with the limitations and conditions described in the SE dated March 16, 1996, and the SE supplement dated February 20, 1997.

Pursuant to 10 CFR 2.790, we have determined that the enclosed SE does not contain proprietary information. However, we will delay placing the SE in the public document room for a period of ten (10) working days from the date of this letter to provide you with the opportunity to comment on the proprietary aspects only. If you believe that any information in the enclosure is proprietary, please identify such information line by line and define the basis pursuant to the criteria of 10 CFR 2.790.

In accordance with the procedures established in NUREG-0390, the NRC requests that EPRI publish an accepted version of the report, including the safety evaluation, within 3 months of receipt of this letter. The accepted version shall incorporate this letter, and the enclosed evaluation between the title page and the abstract. The accepted version shall include an "-A" (designating accepted) following the report identification symbol. The accepted version shall also incorporate all communications between EPRI, NEI and the staff during this review.

Should our criteria or regulations change so that our conclusions as to the acceptability of Addendum 1 to EPRI Topical Report TR-103237-R2 are no longer valid, EPRI and NEI and the licensees referencing the topical report will be expected to revise and resubmit their respective documentation, or to submit justification for the continued effective applicability of the topical report without revision of their respective documentation.

If you have any further questions regarding this review, please contact Leonard Olshan at 301-415-1419.

Sincerely,

***/RA/***

Stuart A. Richards, Director
Project Directorate IV & Decommissioning
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Project No. 669

Enclosure: Supplement to SE

cc w/encl: See next page

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# SUPPLEMENT 2 TO SAFETY EVALUATION

# BY THE OFFICE OF NUCLEAR REACTOR REGULATION

# ELECTRIC POWER RESEARCH INSTITUTE

# TOPICAL REPORT TR-103237, "EPRI MOTOR-OPERATED VALVE PERFORMANCE PREDICTION PROGRAM," ADDENDUM 1

# PROJECT NO. 669

## 1.0 INTRODUCTION

In November 1994, the Nuclear Energy Institute (NEI) submitted for NRC review the Electric Power Research Institute (EPRI) Topical Report TR-103237, "EPRI MOV Performance Prediction Program," that describes the EPRI motor-operated valve (MOV) methodology that predicts the applicable thrust or torque required to operate gate, globe, and butterfly valves over a wide range of differential pressure, temperature, and flow conditions. On March 15, 1996, the NRC staff issued a safety evaluation (SE) documenting the NRC staff's acceptance of the EPRI MOV Performance Prediction Methodology (PPM) described in the topical report, with certain conditions and limitations. The SE addressed the EPRI computer model for globe and butterfly valves and various gate valves, and EPRI hand-calculation models for Anchor/Darling double-disk gate valves and Westinghouse flexible-wedge gate valves. On February 20, 1997, the NRC staff issued a supplement to that SE documenting its acceptance, with certain conditions and limitations, of the EPRI hand-calculation models for WKM parallel-expanding gate valves and Aloyco split-wedge gate valves, and highlighting other aspects of the EPRI program.

On September 8, 1999, NEI submitted for NRC review Addendum 1, "PPM Version 2.0," and Addendum 2, "Thrust Uncertainty Method," to EPRI Topical Report TR-103237-R2. Version 2.0 of the EPRI MOV PPM, described in Addendum 1 to the topical report, addresses several modeling errors and incorporates other improvements to the modeling software. The Thrust Uncertainty Method described in Addendum 2 estimates average conservatism in the MOV PPM gate valve thrust prediction, and combines this conservatism with uncertainties in the calculations.

In this supplement to the SE on the EPRI MOV PPM, the NRC staff documents its review of Addendum 1 to EPRI Topical Report TR-103237-R2. The staff’s evaluation of Addendum 2 to the EPRI topical report will be documented in a separate SE supplement.

## 2.0 REGULATORY REQUIREMENTS

The NRC regulations require that MOVs important to safety be treated in a manner that provides assurance of their intended performance. Criterion 1 to Appendix A, "General Design Criteria for Nuclear Power Plants," to Part 50 of Title 10 of the Code of Federal Regulations (10 CFR Part 50) states, in part, that structures, systems, and components important to safety shall be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed. The quality assurance program to be applied to safety-related components is described in Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50. In Section 50.55a of 10 CFR Part 50, the NRC requires licensees to establish inservice testing (IST) programs in accordance with the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code and, in the future, the ASME Code for Operation and Maintenance of Nuclear Power Plants.

In response to concerns regarding MOV performance, the NRC staff issued Generic Letter (GL) 89-10, "Safety-Related Motor-Operated Valve Testing and Surveillance," dated June 28, 1989, which requested that nuclear power plant licensees and construction permit holders ensure the capability of MOVs in safety-related systems to perform their intended functions by reviewing MOV design bases, verifying MOV switch settings initially and periodically, improving evaluations of MOV failures and necessary corrective action, and trending MOV problems. The staff requested that licensees complete the GL 89-10 program within approximately three refueling outages or 5 years from the date of issuance of the generic letter. Permit holders were requested to complete the GL 89-10 program before plant startup or in accordance with the above schedule, whichever was later.

On September 18, 1996, the NRC staff issued GL 96-05, "Periodic Verification of Design-Basis Capability of Safety-Related Motor-Operated Valves," requesting each licensee to establish a program, or ensure the effectiveness of its current program, to verify on a periodic basis that safety-related MOVs continue to be capable of performing their safety functions within the current licensing bases of the facility. In GL 96-05, the NRC staff summarized several industry and regulatory activities and programs related to maintaining long-term capability of safety-related MOVs. For example, the staff discussed the use of the EPRI MOV PPM in establishing an effective MOV program. Many licensees are applying the EPRI MOV PPM as part of their program to provide assurance of the capability of MOVs to perform their safety functions in response to GL 89-10 and GL 96-05.

## 3.0 EPRI MOV PPM VERSION 2.0

In Addendum 1 to EPRI Topical Report 103237-R2, EPRI describes the changes to the computer software incorporated into Version 2.0 of the MOV PPM. In general, the software changes address errors found in Version 1.0 of the MOV PPM and minor improvements based on comments received from users of the software. For example, EPRI corrected an error in the MOV PPM which, under certain conditions, resulted in the system flow model not being executed prior to initiating the butterfly valve model. Also, EPRI resolved the improper prediction of thrust by the model during a valve stroke if the software calculations failed to achieve an equilibrium of the forces acting on the valve. EPRI modified the model so as not to improperly issue a Type 1 unpredictable warning when sharp edge contact on the trailing edge

of the sliding surfaces was determined to occur. EPRI revised the model to prevent improper issuance of a galling warning for guide material combinations of Stellite-on-stainless steel and Stellite-on-carbon steel if the temperature was greater than 100°F. EPRI corrected an error that caused the MOV PPM to print and plot values of zero when compressive stem thrusts were predicted to exceed 99,999 pounds of force. EPRI corrected an improper calculation for predicting hydrodynamic torque required to operate butterfly valves under compressible flow conditions. EPRI modified the model to correctly determine disk loading factors in the gate valve module. EPRI revised the user interface module to include differential pressure caused by water inertia and its effect on valve upstream pressure. EPRI also made other minor changes to the computer software including revision of various parameter descriptions to be consistent throughout the MOV PPM documentation.

EPRI assessed the changes to the gate valve model of the MOV PPM by evaluating thrust predictions for 20 EPRI flow loop gate valves for 100 percent differential pressure opening and closing strokes. EPRI also performed an assessment of the rounding of valve dimensions in MOV PPM Version 1.0 for four valves. EPRI assessed the effects of the changes in the MOV PPM on torque predictions by the butterfly valve model by evaluating two flow loop butterfly valves for 100 percent differential pressure opening and closing strokes. EPRI did not modify the globe valve module software and, therefore, the thrust predictions for globe valve performance were not affected by the MOV PPM changes.

Based on its assessment, EPRI determined that the thrust and torque predictions obtained from Version 2.0 of the MOV PPM were within about 1 percent of the Version 1.0 thrust and torque predictions. With respect to the performance of a Borg-Warner gate valve, EPRI reported that an unpredictable outcome from Version 1.0 of the MOV PPM was determined to be predictable when applying Version 2.0. However, the measured thrust required to operate that Borg-Warner gate valve slightly exceeded (by about 0.3 percent) the thrust predicted by Version 2.0 of the MOV PPM. This slight underprediction of the required thrust by the MOV PPM is within the 5 percent margin required to be included in applying the MOV PPM to Borg-Warner gate valves.

## 4.0 EVALUATION

With the assistance of the Idaho National Engineering and Environmental Laboratory (INEEL), the NRC staff has reviewed Addendum 1 to EPRI Topical Report TR-103237-R2 together with the supplemental information from EPRI provided by NEI on February 28, 2000. The staff also reviewed sample and bench-test problems to evaluate individual software changes through variations in system and valve parameters. In this review, the staff compared the predictions of MOV PPM Versions 1.0 and 2.0 for three gate valve problems and one butterfly valve problem.

Based on the sample problems, the staff determined that Version 2.0 of the MOV PPM properly performed the thrust and torque calculations to predict valve operating requirements. For example, the system flow module of the MOV PPM executed when valve inputs were changed in the sample butterfly valve problem. With followup information provided by EPRI in the February 28, 2000, submittal, thrust predictions calculated by the software following force equilibrium failures reasonably bounded the measured thrust requirements for the sample

valves. As indicated by EPRI, Version 2.0 of the MOV PPM did not issue warnings of potential galling for Stellite-on-stainless steel and Stellite-on-carbon steel guide material combinations in the identified temperature range. Version 2.0 of the MOV PPM correctly presented stem thrusts greater than 99,999 pounds. Where sample problems were not available to directly evaluate the change in the MOV PPM, the staff agreed with EPRI that the changes to the software are appropriate based on the performance of the computer model or would have minimal effect on the model predictions.

As part of the review of Addendum 1 to EPRI Topical Report TR-103237-R2, the staff obtained thrust predictions provided by Version 2.0 of the MOV PPM for positive and negative guide offsets for a 14-inch, 600# gate valve and a 2.5-inch, 2500# gate valve. In each case, Version 2.0 of the MOV PPM predicted slightly higher thrust requirements to operate the valves than predicted by Version 1.0 of the MOV PPM. The staff also obtained the torque prediction provided by Version 2.0 of the MOV PPM for a 6-inch symmetrical disk butterfly valve. In that case, the torque predictions by the two MOV PPM versions were equal although the torque traces predicted by the MOV PPM versions differed during the early part of the valve operation. The staff did not consider the trace differences to be significant in predicting the total operating requirements for butterfly valves by the MOV PPM.

In response to the identification of an incorrect date in a sample problem output report, EPRI reported in the submittal dated February 28, 2000, that the calculations performed by the MOV PPM do not rely on the date or time of the calculation. EPRI indicated that Y2K (Year 2000) testing was performed to ensure that the MOV PPM would function properly during the transition to the year 2000. However, EPRI noted that the year printed on prediction reports and plots are based on the number of years since 1900. EPRI also indicated that the date and time printed on prediction reports and plots will be incorrect beginning in the year 2038 because of limitations on software storage space. Based on sample application of the computer software in the year 2000, the staff does not consider the thrust and torque predictions provided by the MOV PPM to be adversely affected by Y2K issues although the date indicated on the reports and plots might not be accurate.

In its review, the staff questioned whether EPRI had addressed previous concerns regarding performance of the butterfly valve model in the MOV PPM for low differential pressure or downstream pressure. In the submittal dated February 28, 2000, EPRI reported that changes to address system flow model convergence had not been made in Version 2.0 of the MOV PPM. However, EPRI noted that it issued a notice to MOV PPM users in 1997 that provided guidance for addressing such concerns when applying the system flow model of the MOV PPM. The staff does not consider the absence of resolution of the performance concerns for the butterfly valve model in the MOV PPM for low differential pressure or downstream pressure to prevent the acceptance of Addendum 1 to EPRI Topical Report TR-103237-R2.

## 5.0 CONCLUSION

Based on the review of Addendum 1 to EPRI Topical Report TR-103237-R2 with INEEL assistance, the NRC staff concludes that the changes made to Version 2.0 of the EPRI MOV PPM improve the ability of the computer model to predict the thrust and torque required to operate gate, globe, and butterfly valves. As a result, the EPRI MOV PPM remains acceptable

with the limitations and conditions described in the SE dated March 16, 1996, and the SE supplement dated February 20, 1997.

Principal Contributor: T. Scarbrough

Date: April 20, 2001