UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

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MEMORANDUM FOR: Joseph A. Murphy, Acting Director
Division of Safety Issue Resolution
Office of Nuclear Regulatory Research

FROM: Eric S. Beckjord, Director
Office of Nuclear Regulatory Research

SUBJECT: GENERIC ISSUE NO. 158, "PERFORMANCE OF SAFETY-RELATED POWER-OPERATED VALVES UNDER DESIGN BASIS CONDITIONS"

The prioritization of Generic Issue No. 158, "Performance of Safety-Related Power-Operated Valves Under Design Basis Conditions," shows that the issue has a MEDIUM priority ranking. This memorandum approves RES/DSIR taking appropriate actions, within current resource allocations, to resolve the issue. The evaluation of the subject issue is provided in Enclosure 1.

In accordance with RES Office Letter No. 1, "Procedure for Identification, Prioritization, and Tracking of the Resolution of Generic Issues," the resolution of this issue will be monitored by the Generic Issue Management Control System (GIMCS). The information needed for this system is indicated on the enclosed GIMCS information sheet (Enclosure 2). As stated in the Office Letter, the information needed should be provided within 6 weeks.

The enclosed prioritization evaluation will be incorporated into NUREG-0933, "A Prioritization of Generic Safety Issues," and is being sent to the regions, other offices, the ACRS, and the PDR, by copy of this memorandum, to allow others the opportunity to comment on the evaluation. Any changes as a result of comments will be coordinated with you. However, the schedule for the resolution of this issue should not be delayed to wait for these comments. The information requested should be sent to the Engineering Issues Branch, DSIR, RES (Mail Stop NL/S-314). Should you have any questions pertaining to the contents of this memorandum, please contact Ronald Emrit (301-492-3731).

Eric S. Beckjord

Eric S. Beckjord, Director
Office of Nuclear Regulatory Research

Enclosures:
1. Prioritization Evaluation
2. GIMCS Information Sheet

DF05

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ENCLOSURE 1

PRIORITIZATION EVALUATION

Issue 158: Performance of Safety-Related Power-Operated Valves Under Design Basis Conditions

ISSUE 158: PERFORMANCE OF SAFETY-RELATED POWER-OPERATED VALVES UNDER DESIGN BASIS CONDITIONS

DESCRIPTION

Historical Background

This issue was identified[1481] by NRR after reactor operating experience and research results on motor-operated valves (MOVs), solenoid-operated valves (SOVs), air-operated valves (AOVs), and hydraulic-operated valves (HOVs) indicated that testing under static conditions does not always reveal how these valves will perform under design basis conditions. A number of failures of power-operated valves have occurred as a result of inadequate design, installation, and maintenance. Operating events involving observed or potential common mode failures of AOVs, SOVs, and MOVs have been documented in NUREG-1275,[1079] NUREG/CP-0123, and AEOD/C603. Events that specifically involved AOVs and SOVs were identified in Volumes 2 and 6 of NUREG-1275.[1079]

Concerns regarding the performance of MOVs were resolved in Issue II.E.6.1, "In Situ Testing of Valves - Test Adequacy Study," and resulted in the issuance of Generic Letter 89-10[1217] which required licensees to establish programs to ensure the operability of MOVs in safety-related systems. In addition, the reliability of PORVs and SVs was addressed in the resolution of Issue 70, "PORV and Block Valve Reliability." Although no study is available on HOVs that highlights significant events involving observed or potential common mode failures or degradation, HOVs are used in many plants as MSIVs and in the auxiliary feedwater (AFW) system at PWRs and the service water system (SWS) at BWRs. The use of power-operated valves in safety systems is sufficiently widespread to raise concerns similar to those addressed on MOVs in the implementation of Generic Letter No. 89-10.[1217] Therefore, this analysis focuses on power-operated valves other than MOVs.

Safety Significance

Appendix A to 10 CFR 50 requires that components important to safety be designed and tested to quality standards commensurate with the importance of the safety function to be performed. Based on the experience gained by the staff in the resolution of issues concerning MOVs, malfunctioning of other power-operated valves could create unacceptable results on overall reliability of these valves or failure to operate under design basis conditions such as blowdown to vital areas, or pump failure due to deadheading or loss of NPSH. Such failures could jeopardize other systems required to cool the core.

Possible Solutions

A possible solution involves a combination of design reviews, improved surveillance/maintenance programs, valve testing, and actuation setpoint adjustments, with particular emphasis on the design basis of each power-operated valve.

PRIORITY DETERMINATION

Assumptions

The Surry, Oconee, and Sequoyah PRAs were used to model PWR AOVs and SOVs in SARA 4.0.[1456] The Grand Gulf and Peach Bottom PRAs were used to model BWR AOVs and SOVs.

Frequency Estimate

NPRDS was used to obtain values of AOV and SOV unreliability. The results for SOVs are documented in NUREG-1275,[1079] Vol. 6, where a demand failure probability for SOVs of either 7.1×10^{-3} or 8.7×10^{-3} is given compared to a NUREG-1150[1081] value of 10^{-3}; 8.7×10^{-3} was chosen for conservatism. An AEOD analysis for AOVs of NPRDS determined a demand failure probability of 1.1×10^{-2} for AOVs in risk significant systems and 4.2×10^{-2} for all AOVs, compared to a NUREG-1150[1081] value of 10^{-3} to 2×10^{-3}. Because of the ambiguity in the modifier "risk significant," 4.2×10^{-2} was chosen as the preferred value.

If a valve did not occur in one of the dominant cutsets for its PRA, it was assumed for these small changes in valve demand failure probability that the change in core-melt frequency would be negligible. This would seem to follow from the work done previously in the afore-mentioned PRAs which calculated the dominant cutsets.

The effect of the safety issue resolution (SIR) would be to improve the reliability that the valves operate as designed. To reflect this, it was assumed that the SIR will reduce the probability for a failure of an AOV or SOV to NUREG-1150 values and thus bring the core-melt frequency to the values predicted by the plant-specific PRAs. As a result, in SARA the base case core-melt frequency value represents the value after SIR implementation, and the adjusted case core-melt frequency represents the increased risk from including the effects of AOV and SOV unreliability. Therefore, the change in core-melt frequency computed in SARA gives the result of improving AOV and SOV reliability. The changes in core-melt frequency for the AOVs in various PRAs for both PWRs and BWRs are summarized in Table 3.158-1. However, the changes in Oconee and Surry were negligible because none of the AOVs occurred in a dominant cutset. Likewise, the changes for the SOVs in all the PRAs were negligible because none of the SOVs occurred in a dominant cutset.

Based on these findings, the Sequoyah and Peach Bottom results were chosen to be representative of all plants. Although Oconee and Surry's results were negligible and the Grand Gulf results were much less than that of Peach Bottom, choosing these two plants will lead to a prioritization more representative of the group of plants that could be vulnerable. Therefore, the change in core-melt frequency for PWRs is 1.236×10^{-5}/RY and for BWRs is 1.202×10^{-5}/RY.

Consequence Estimate

The containment failure probabilities and base consequences were taken from NUREG/CR-2800[64] for similar accident sequences. It was assumed that these results could be used for calculations of risk for the Sequoyah and Peach Bottom plants. The results from the per-plant calculations for the changes in public risk, and also the changes in core-melt frequency, are shown in Table 3.158-2. The total public risk reduction is 88,000 person-rem with a lower bound estimate of 0 person-rem and an upper bound estimate of 2.6×10^6 person-rem.

TABLE 3.158-1
Change in Core-Melt Frequency from AOV Failure Probability Changes for Various PRAs

PRA	Change in Core-Melt Frequency
PWRs	
Sequoyah, Unit 1	1.236E-05
Oconee, Unit 3	-
Surry, Unit 1	-
BWRs	
Peach Bottom, Unit 2	1.202E-05
Grand Gulf, Unit 1	1.606E-07

TABLE 3.158-2
PWR and BWR Results for Changes in Core-Melt Frequency and Public Risk

	Change in Core-Melt Frequency (per RY)	Change in Public Risk (person-rem/RY)
PWR	1.236E-05	3.4E+01
BWR	1.202E-05	3.4E+01

Cost Estimate

Based on recent experience observed in the MOV program described in Generic Letter 89-10,[1217] the average cost for the MOV implementation is estimated to be $6M/plant. With an estimate of approximately 100 MOVs per plant, this cost is $60,000/valve. It is assumed for this prioritization that a POV improvement program limited only to those AOVs, SOVs, and HOVs that contribute most to CDF would keep costs down. Based on the number of POVs observed to be involved in the dominant sequences in the prioritization calculation (20), the total industry cost (OLs and CPs) is estimated at (20)($60,000)(111 plants) = $133M.

NRC resources will be needed to support this POV research and possible implementation. A study of AOVs, HOVs, and SOVs was estimated to require approximately 2 years of contractor time. NRC support of implementation of the possible solution was estimated to require additional resources. The total NRC cost was estimated to be $3.7M.

The total cost associated with the possible solution was estimated to be $(133 + 3.7)M or $137M.

Impact/Value Assessment

Based on an estimated cost of $137M for the possible solution and a potential public risk reduction of 88,000 person-rem, the impact/value ratio is given by:

$$R = \frac{\$137M}{88,000 \text{ person-rem}}$$

$$= \$1,557/\text{person-rem}$$

CONCLUSION

Based on observed escalating costs associated with the ongoing MOV program, the actual cost to implement this issue could be higher than that estimated. However, a valve improvement program limited only to those AOVs, SOVs, and HOVs that contributed the most to risk could keep costs close to the level assumed in this analysis. In addition, threshold prioritization criteria show that, for CDF > 10^{-5}, a medium priority is appropriate, regardless of cost trade-off. Therefore, based on the impact/value ratio and the potential risk reduction, this issue has a MEDIUM priority ranking.

REFERENCES

64. NUREG/CR-2800, Guidelines for Nuclear Power Plant Safety Issue Prioritization Information Development," U.S. Nuclear Regulatory Commission, February 1983, (Supplement 1) May 1983, (Supplement 2) December 1983, (Supplement 3) September 1985, (Supplement 4) July 1986.

1079. NUREG-1275, "Operating Experience Feedback Report," U.S. Nuclear Regulatory Commission, (Vol. 1) July 1987, (Vol. 2) December 1987, (Vol. 3) November 1988, (Vol. 4) March 1989, (Vol. 5) March 1989, (Vol. 5, Addendum) August 1989, (Vol. 6) February 1991, (Vol. 7) September 1992, (Vol. 8) December 1992, (Vol. 9) March 1993.

1081. NUREG-1150, "Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants," U.S. Nuclear Regulatory Commission, (Vol. 1) December 1990, (Vol. 2) December 1990, (Vol. 3) January 1991.

1217. NRC Letter to All Licensees of Operating Plants and Holders of Construction Permits for Nuclear Power Plants, "Safety-Related Motor-Operated Valve Testing and Surveillance (Generic Letter No. 89-10) - 10 CFR 50.54(f)," June 28, 1989, (Supplement 1) June 13, 1990, (Supplement 2) August 3, 1990, (Supplement 3) October 25, 1990, (Supplement 4) February 12, 1992.

1481. Memorandum for E. Beckjord from T. Murley, "Potential New Generic Issues," September 25, 1991.

1456. NUREG/CR-5303, "System Analysis and Risk Assessment System (SARA) Version 4.0," U.S. Nuclear Regulatory Commission, (Volume 1) February 1992, (Volume 2) January 1992.

Managment and control indicators used in GIMCS are defined as follows:

1. Issue No. - Generic Issue Number

2. Title - Generic Issue Title

3. Identification Date - Date the issue was identified

4. Prioritization Date - The date that the prioritization evaluation was approved by the RES Director

5. Type - Generic Safety (GSI), Licensing (LI), or Regulatory Impact (RI)

6. Priority - High (H) or Medium (M)

7. Task Manager - Name of assigned individual responsible for resolution

8. Office/Div/Br - The Office, Division, and Branch of the Task Manager who has lead responsibility for resolving the issue.

9. Action Level - Active - Technical assistance funds appropriated for resolution and/or Task Manager actively pursuing resolution

   Inactive - No technical assistance funds appropriated for resolution, Task Manager assigned to more important work, or no Task Manager assigned

   Resolved - All necessary work has been completed and no additional resources will expended

10. Status - Coded summary as follows:
    NR - (Nearly-Resolved);
    3A - (Resolved with requirements);
    3B - (Resolved with No requirements);
    5 - (Licensing or Regulatory Impact issued that should be assigned resources for completion)

11. TAC Number - Task Action Control (TAC) number assigned to the issue

12. Resolution Date - Scheduled resolution date for the issue

13.	<u>Work Authorization</u>	-	Who or what authorized work to be done on the issue
14.	<u>FIN</u>	-	Financial identification number assigned to contract (if any) for technical assistance
15.	<u>Contractor</u>	-	Contractor name
16.	<u>Contract Title</u>	-	Contract Title (if contract issued)
17.	<u>Work Scope</u>	-	Describes briefly the work necessary to technically resolve and complete the generic issue
18.	<u>Status</u>	-	Describes current status of work
19.	<u>Affected Documents</u>	-	Identifies documents into which the technical resolution will be incorporated
20.	<u>Problem/Resolution</u>	-	Identifies problem areas and describes what actions are necessary to resolve them
21.	<u>Milestones</u>	-	Selected significant milestones: (a) the "original" scheduled dates reflect the original Task Action Plan plus additional milestone dates added during task resolution; (b) changes in the the original scheduled dates are listed under "Current"; (c) actual completion dates are listed under "Actual"