NRC MOV Course

MOV Regulatory Issues

Mark R. Holbrook

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Outline

- ***Regulatory Issues Covered***
  - ***IE Bulletin 85-03***
  - ***GL 89-10***
  - ***GL 89-10 Supplements***
  - ***Use of Performance Prediction Model (PPM)***

Early Research Programs

- EPRI/Marshall power-operated relief valve (PORV) block valve tests (1980)
  - Post TMI action
  - Several block valves failed with standard settings
- Generic Issue 87 Test Program (1987-1989)
  - USNRC was concerned that boiling water reactor (BWR) containment isolation valves may not isolate a steam line pipe break outside containment (i.e., HPCI, RCIC & RWCU)
  - Industry equations were found to be non-conservative

IE Bulletin 85-03

Motor-Operated Valve Common Mode Failures During Plant Transients Due to Improper Switch Settings

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IE Bulletin 85-03

- First attempt by USNRC to get the US nuclear industry to look at MOV design-basis performance; licensee's were required to review MOV switch settings and perform limited dynamic testing
- Driven by two events:
  - Davis-Besse loss of main and auxiliary feedwater
    - Valves were mispositioned closed
    - Inadequate open torque switch bypass
  - Sequoyah Unit 2 loss of main feedwater
    - Stems separated from valve disc - caused by incorrect open limit switch settings

IE Bulletin 85-03 (continued)

- ***Scope was limited to the following systems:***
  - ***High pressure coolant injection***
  - ***Core spray***
  - ***Emergency feedwater***
  - ***BWR - reactor core isolation cooling (RCIC)***
- ***Actions:***
  - ***Review design-basis conditions***
  - ***Establish correct switch settings***
  - ***Test the valve at maximum differential pressure (or justify an alternative)***
  - ***Maintain new switch settings***
  - ***Report results to USNRC***

IE Bulletin 85-03 (continued)

- ***Results:***
  - ***The USNRC conducted little on-site review of the licensee's activities***
  - ***In general, the licensees' actions were not effective***
    - ***Little dynamic testing was performed***
    - ***Poor diagnostic systems existed at that time***
    - ***Issues related to disc factor and stem factor changes were unknown at that time***

IE Bulletin 85-03 Supplement 1

- Clarified scope issues for BWRs.
  - Includes all safety-related MOVs in the selected systems
- Addressed inadvertent valve operation (or mispositioning) to address concerns related to the Davis-Besse loss of main and auxiliary feedwater incident
  - Include any MOVs in the affected systems that are not blocked from inadvertent operation
  - Include the differential pressure conditions for mispositioning scenarios

GL 89-10

Safety-Related Motor-Operated Valve Testing and Surveillance

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Purpose of GL 89-10

- ***Expand the scope implemented by IE Bulletin 85-03***
- ***Add additional measures to ensure that failures of safety-related MOVs to operate under design-basis conditions will not occur more often than had been previously estimated***

Scope of GL 89-10

- *The scope of the generic letter was originally intended to include all safety-related MOVs and position-changeable MOVs in safety-related systems*
- *Through Supplement 1, the definition of "position-changeable" in the generic letter has been limited to any MOV in a safety-related piping system that is not blocked from inadvertent operation from the control room*
- *MOVs in hard-piping ventilation systems with low design-basis differential pressure can be removed from the program scope*
- *In Supplements 4 and 7 to GL 89-10, the NRC removed the recommendation that BWR & PWR licensees address inadvertent MOV operation as part of their GL 89-10 programs*

GL 89-10 Item A

Review and document the design basis for the operation of each MOV. This documentation should include the maximum differential pressure expected during both the opening and closing of the MOV for both normal operations and abnormal events, to the extend that these MOV operations and events are included in the existing approved design basis.

- ***Should use reasonably bounding differential pressure values***
- ***System relief valve setpoints may be considered***
- ***Design-basis documents, such as the Final Safety Analysis Report (FSAR), emergency operating procedures, and normal operating procedures should be reviewed to determine each valve's safety functions***
- ***System flowrate and fluid temperature for the design-basis conditions should be identified***

GL 89-10 Item B

Using the results from item a., establish the correct switch settings. This should include establishing a program to review and revise, as necessary, the methods for selecting and setting all switches (i.e., torque, torque bypass, position limit, overload) for each valve operation (opening and closing). One purpose of this letter is to ensure that a program exists for selecting and setting valve operator switches to ensure high reliability of safety-related MOVs.

- ***Disc diameter measurement methods should be consistent (for example, based on the disc's mean seat diameter)***
- ***Adequate bases must exist for the disc factors, stem factors, load sensitive behavior, actuator efficiencies, and other assumed parameters so that each is adequately justified***
- ***Industry test data should be considered***

GL 89-10 Item B (continued)

- Initially, best available MOV test data is used when sizing and setting MOVs. However, when program is complete, all "best available data" should be verified (or supplemented as necessary) to be considered applicable data
- The motor sizing calculations must consider degraded voltage conditions
- Torque switch bypass settings should be based on analysis of the characteristics of the MOV
- The limit switch settings should be determined by analysis of the MOV characteristics and verified through actual operation of the valve
- Instrument inaccuracies must be taken into account

GL 89-10 Item B (continued)

- *If realistic values are assumed based on test data for all parameters, actions should be taken where the calculation predicts MOV capability problems*
  - *Operability assessment is performed*
  - *If the valve's operability status is questionable, or if the valve is determined to be inoperable, the requirements of the facility's Technical Specifications are followed*

GL 89-10 Item C

Individual MOV switch settings should be changed, as appropriate, to those established in response to item b. Whether the switch settings are changed or not, the MOV should be demonstrated to be operable by testing it at the design-basis differential pressure and/or flow determined in response to item a. Testing MOVs at design-basis conditions is not recommended where such testing is precluded by the existing plant configuration. An explanation should be documented for any cases where testing with the design-basis differential pressure or flow cannot practicably be performed. This explanation should include a description of the alternatives to design-basis differential pressure testing or flow testing that will be used to verify the correct settings.

- ***Should test all MOVs under maximum achievable differential pressure and flow up to design basis conditions, where practicable***
- ***Operate the necessary number of pumps to replicate the accident configuration***

GL 89-10 Item C *(continued)*

- *Ensure that pressure instruments adequately measure differential pressure across the valve*
- *Extrapolate test results to design-basis conditions*
- *Personnel should undertake prompt evaluation of test results to determine capability under design-basis conditions prior to declaring the MOV operable and returning it to service*
- *Ensure traces are marked correctly (especially flow isolation for closing direction)*
- *The utility should have justification for the accuracy of its MOV diagnostic equipment*

GL 89-10 Item D

Prepare or revise procedures to ensure that correct switch settings are determined and maintained throughout the life of the plant. These procedures should include provisions to monitor MOV performance to ensure the switch settings are correct. This is particularly important if the torque or torque bypass switch setting has been significantly raised above that required.

It may become necessary to adjust MOV switch settings because of the effects of wear or aging. Therefore, it is insufficient to merely verify that the switch settings are unchanged from previously established values. The ASME Code Section XI stroke-timing test required by 10 CFR Part 50 is not oriented toward verification of switch settings. Therefore, additional measures should be taken to adequately verify that the switch settings ensure MOV operability. The switch settings need not be verified each time the ASME Code stroke-timing test is performed.

GL 89-10 Item D (continued)

- Periodic verification of design-basis capability will continue throughout the operating life of the plant
- In 1996, the USNRC issued GL 96-05, "Periodic Verification of Design-Basis Capability of Safety-Related Motor-Operated Valves," requesting utilities to establish a program, or to ensure the effectiveness of the current program, to verify on a periodic basis that safety-related MOVs continue to be capable of performing their safety functions
- GL 96-05 provided more detailed guidance than GL 89-10

GL 89-10 Item E

Regarding item a., no change to the existing plant design basis is intended and none should be inferred. The design-basis review should not be restricted to a determination of estimated maximum design-basis differential pressure, but should include an examination of the pertinent design and installation criteria that were used in choosing the particular MOV. For example, the review should include the effects on MOV performance of design-basis degraded voltage, including the capability of the MOV's power supply and cables to provide the high initial current needed for the operation of the MOV.

- ***Worst-case voltage at the motor terminals should be used***
- ***Degraded voltage calculations should use the degraded grid relay setting as a starting point***
- ***Voltage dips during the first 5 seconds of an accident can be ignored if analysis shows that stall conditions for that duration will not impact valve operability***

GL 89-10 Item E (continued)

- ***Dc-powered MOV calculations should use the battery's end-of-life voltage profile as a starting point***
- ***Cable lengths should be considered when determining circuit resistance***
- ***Accident temperature conditions for electrical cables should be evaluated***
- ***The effect of thermal overload resistance should be included in total circuit resistance***
- ***Worst-case current conditions should be considered***

GL 89-10 Item F

Documentation of explanations and the description of actual test methods used for accomplishing item c. should be retained as part of the required records for the MOV. It is also recognized that it may be impracticable to perform in situ MOV testing at design-basis degraded voltage conditions. However, the switch settings established in response to item b. should at least be established to account for the situation where the valves may be called on to operate at design-basis differential pressure, or flow, and under degraded voltage conditions. If the licensee failed to consider degraded voltage, power supply, or cable adequacy for MOVs in systems covered by Bulletin 85-03, the design review and established switch settings for those MOVs should be reevaluated.

GL 89-10 Item F *(continued)*

Alternatives to testing a particular MOV in situ at design-basis pressure or flow, where such testing cannot practicably be performed, could include a comparison with appropriate design-basis test results on other MOVs, either in situ or prototype. If such test information is not available, analytical methods and extrapolations to design-basis conditions, based on the best data available, may be used until test data at design-basis conditions become available to verify operability of the MOV. If this two-stage approach is followed, it should be accomplished within the schedule outlined in item i. and would allow for MOV testing and surveillance to proceed without excessive delay.

Testing of MOVs at design-basis conditions need not be repeated unless the MOV is replaced, modified, or overhauled to the extent that the licensee considers that the existing test results are not representative of the MOV in its modified configuration.

GL 89-10 Item F (continued)

- May use a two-stage approach:
  - Use "best available data" to establish the initial switch settings
  - Verify the applicability of these data as more test information is obtained
- Evaluation of test results from other similar MOVs should use statistical methods to ensure that reasonably bounding values are applied to the non-dynamically tested MOVs. Mean values are not acceptable
- Data analysis should include a statistically significant number of test results
- "Students-t" analysis methods using a 95% confidence level is acceptable for analyzing small data sets

GL 89-10 Item H

Each MOV failure and corrective action taken, including repair, alteration, analysis, test, and surveillance, should be analyzed or justified and documented. The documentation should include the results and history of each as-found deteriorated condition, malfunction, test, inspection, analysis, repair, or alteration. All documentation should be retained and reported in accordance with plant requirements.

It is suggested that these MOV data be periodically examined (at least every 2 years or after each refueling outage after program implementation) as part of a monitoring and feedback effort to establish trends of MOV operability. These trends could provide the basis for a licensee revision of the testing frequency established to periodically verify the adequacy of MOV switch settings.

GL 89-10 Item H (continued)

- Ensure that each MOV failure is analyzed and the resulting corrective action (including repair, alteration, analysis, test, and surveillance) is justified
- Failure analysis and justification of the corrective action should be documented, including the results and history of each as-found deteriorated condition, malfunction, test, inspection, analysis, repair, or alteration
- MOV failure data and corrective actions should be examined at least every 2 years or after each refueling outage as part of a monitoring and feedback effort to establish trends of MOV performance

GL 89-10 Supplements

- **Supplement 1**
  - Provided the NRC staff responses to questions presented by the US nuclear industry during three public workshops held in September 1989 that discussed GL 89-10
- **Supplement 2**
  - Revised the schedule for availability of GL 89-10 program descriptions

GL 89-10 Supplements (continued)

- Supplement 3
  - Discussed the importance of the results obtained from Generic Issue 87 testing (as documented in Information Notice 90-40)
  - Testing focused on the HPCI, RCIC and RWCU containment isolation valves at BWR plants
  - Information obtained from the NRC-sponsored tests indicated that the priorities being established by BWRs for implementing their generic letter programs should be reassessed

GL 89-10 Supplements (continued)

- Supplement 3 Requested Actions
  - BWRs were to assess the applicability of the INL testing to MOVs in the affected systems (e.g., HPCI, RCIC, and RWCU)
  - Perform a plant-specific safety assessment to ensure that the generic assessment (developed by NRC and BWROG) was applicable
  - Consider implementation of short-term corrective actions
  - Accomplish these actions as part of an accelerated response to GL 89-10 (fix problems within 18 months or next refueling outage)

GL 89-10 Supplements (continued)

- Supplement 4
  - The Boiling Water Reactors Owners' Group (BWROG) submitted a backfit appeal on the recommendations for position-changeable valves
  - The NRC reviewed and evaluated the issues concerning mispositioning of valves from the control room and determined that the recommendations in GL 89-10 should be changed for BWRs
    - Beyond design-basis because it assumes multiple failures
    - Safety studies did not provide a strong technical basis for retaining the requirement

GL 89-10 Supplements (continued)

- Supplement 5
  - There was a generic concern regarding the reliability of the data provided by MOV diagnostic equipment (MUG validation testing)
  - The MOVATS thrust measuring device (TMD) and the VOTES force sensor were determined to have higher than published inaccuracies in some cases
  - NRC requested that licensees reevaluate their MOV programs using the new diagnostic equipment uncertainties

GL 89-10 Supplements (continued)

- Supplement 6
  - Provided the NRC staff responses to questions presented by the US nuclear industry during a public workshop held in February 1993 that discussed GL 89-10
  - Provided factors to consider when requesting a schedule extension
    - All valves must be setup with "best available data"

GL 89-10 Supplements (continued)

- Supplement 6 (continued)
  - Guidance for Grouping
    - Review and analyze both industry and valve-specific data
    - Flow test 30% of population (no less than 2)
    - Perform static tests on all valves in group
    - Select test valves based on low margin and safety significance
    - Validate assumptions for group with benchmarked data
    - Consider valve and system characteristics for group
    - Consider adverse information for all valves in the group

GL 89-10 Supplements (continued)

- Supplement 7
  - The NRC reviewed and evaluated the issues concerning mispositioning of valves from the control room and determined that the recommendations in GL 89-10 should be changed for pressurized water reactors (PWRs)
  - Although PWRs tend to have a higher core damage frequency (CDF) than BWRs, PWRs typically have a lower conditional containment failure probability, which tend to balance the overall risk to the public

NRC Guidance on Use of EPRI Performance Prediction Model (PPM)

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PPM Objectives

- The EPRI MOV Performance Prediction Program, focused on the development and validation of improved methods for bounding MOV performance
- The objective was to develop a methodology to be used in demonstrating the design-basis capability of MOVs when valve-specific design-basis test data are not available
  - Hierarchy for application of test data
    - Valve-specific in-plant dynamic test data
    - Valve-specific data from other tested valves at plant
    - Valve-specific data from another plant
    - PPM
- EPRI integrated the individual models and methods into an overall methodology including a computer program and implementation guide

PPM Components

- Gate Valve Model
- Globe Valve Model
- Butterfly Valve Model
- Hand Calculation Models
  - Anchor/Darling Double-Disc Gate Valve.
  - Westinghouse Flex-Wedge Gate Valve.
  - WKM Parallel-Expanding Gate Valve.
  - Aloyco Split-Wedge Gate Valve.

Separate Effects Testing

- ***EPRI performed separate effects testing to determine friction coefficients and damage threshold levels for a range of material pairs, contact geometries and stresses, fluid media, and temperatures typical of nuclear plant fluid systems***
- ***EPRI conducted testing at 4 flow loop facilities and conducted in-situ at nuclear plants to supplement the flow loop test data***

Gate Valve Model

- ***EPRI developed the gate valve model using equations describing thrust components acting on the gate valve stem (similar to INL gate valve equation)***
- ***The required thrust is based on:***
  - ***Differential pressure load***
  - ***Stem rejection load***
  - ***Valve packing load***
  - ***Torque reaction load***
  - ***Disk and stem weight***
- ***EPRI validated the gate valve model by comparing data from its flow-loop tests, tests performed at power plants, and tests performed for the NRC by the INL***

Globe Valve Model

- ***The stem thrust for a globe valve is calculated by summing the various force components acting along the axis of the valve stem:***
  - ***Disk differential pressure load***
  - ***Friction force between the disk guides and valve body,***
  - ***Stem rejection load***
  - ***Valve packing load***
  - ***Torque reaction load***
  - ***Disk and stem weight***
- ***EPRI used test data from five globe valves manufactured by different vendors under ambient temperature and various flow conditions***

Butterfly Valve Model

- The stem torque predictions are calculated from the torque components acting on the valve stem, including:
  - Bearing torque
  - Packing torque
  - Seat torque
  - Hydrostatic torque
  - Hub seal torque, and
  - Hydrodynamic torque
- The torque required to operate the valve is the larger of the total required dynamic torque and the total required seating/unseating torque