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FROM: James E. Richardson, Director
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SUBJECT: GUIDANCE FOR INSPECTIONS OF PROGRAMS IN RESPONSE TO GENERIC LETTER 89-10

On June 28, 1989, the NRC staff issued Generic Letter (GL) 89-10, "Safety-Related Motor-Operated Valve Testing and Surveillance," which requested nuclear power plant licensees and construction permit holders to establish programs to provide for the testing, inspection, and maintenance of motor-operated valves (MOVs) in safety-related systems. The staff finalized Temporary Instruction (TI) 2515/109, "Inspection Requirements for Generic Letter 89-10, Safety-Related Motor-Operated Valve Testing and Surveillance," on January 14, 1991. Part 1 of TI 2515/109 provided guidance for the performance of region inspections to review the programs developed by licensees in response to GL 89-10. Part 2 of TI 2515/109 provides guidance for the performance of region inspections to evaluate the implementation of those licensee programs.

The staff has completed inspections under Part 1 of TI 2515/109 at each nuclear power plant (with the exception of Millstone which received an audit in late 1990). Through a series of meetings with the regions, NRR has revised TI 2515/109 to reflect the results of these inspections and to provide updated guidance for the performance of inspections of the implementation of GL 89-10 programs.

In the enclosure to this memorandum, I am forwarding information on various aspects of GL 89-10 prepared jointly by the regions and NRR to provide assistance in performing inspections of the implementation of the generic letter. As we have discussed, NRR and the regions plan to update this information on a periodic basis.

If you have any questions on the enclosed information, please contact me at 301-504-2722, or James A. Norberg, Chief, Mechanical Engineering Branch, at 301-504-3288.

Original Signed By:
James E. Richardson

James E. Richardson, Director
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April 30, 1993 ENCLOSURE

DESIGN-BASIS REVIEWS

In Generic Letter 89-10, the staff recommends that licensees review and document the design basis for the operation of each MOV. The generic letter states that 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 extent that these MOV operations and events are included in the existing approved design basis. The staff discussed the performance of design basis reviews in response to Questions 14 to 18 in Supplement 1 to GL 89-10. For example, the staff stated that, in evaluating the design basis for each MOV in the generic letter program, licensees should review the Final Safety Analysis Report and other safety analyses to determine the applicable design-basis events. The staff stated that, to determine the conditions under which the MOV must perform its safety function, the licensee should consider all relevant factors that may affect the capability of the MOV to perform its function. For normal operations (from power operation to cold shutdown) and each accident scenario described in the design basis of the system, the staff stated that the licensee should calculate the differential pressure and flow conditions that will be present at the time that the MOV is required to change position.

The results of the design-basis reviews will be used in the calculations to verify the adequacy of MOV sizing and switch settings and in establishing conditions for design-basis testing. As a consequence, the results of the design-basis reviews may ultimately be used to identify MOV deficiencies, and to determine available margin in MOV capability. Therefore, the design-basis reviews should not yield overly conservative bounding values, but should provide meaningful input for the other portions of the generic letter program. For example, for an MOV with one or more check valves separating it from a high pressure source, the licensee would only need to consider the potential high pressure across the valve at initial opening (because check valves do not completely seal pressure), but would not need to consider any effects that would be prevented by the check valves.

PWR and BWR nuclear steam suppliers have prepared guidelines for determining the design-basis differential pressure for many MOVs within the scope of GL 89-10. For example, the BWR guidelines specify the lowest safety relief valve setpoint for the steam line isolation valves in the High Pressure Coolant Isolation and Reactor Core Isolation Cooling systems. The BWR nuclear steam system supplier has stated in a letter to the staff that a differential pressure lower than this safety relief valve setpoint may be assumed for the supply isolation valves for the Reactor Water Cleanup (RWCU) system where the licensee's analysis demonstrates that the main steam isolation valves will not close in the event of an RWCU line break. Licensees will be expected to justify their design-basis parameters.

PRESSURE LOCKING AND THERMAL BINDING OF GATE VALVES

The NRC Office for Analysis and Evaluation of Operational Data (AEOD) has completed AEOD Special Study AEOD/S92-07 (December 1992), "Pressure Locking and Thermal Binding of Gate Valves." The staff issued the AEOD report in NUREG-1275, Volume 9 (March 1993), "Operating Experience Feedback Report - Pressure Locking and Thermal Binding of Gate Valves." In its report, AEOD concludes that licensees have not taken sufficient action to provide assurance that pressure locking and thermal binding will not prevent a gate valve from performing its safety function. The NRC regulations require that licensees design safety-related systems to provide assurance that those systems can perform their safety functions. In Generic Letter 89-10, the staff requested licensees to review the design bases of their safety-related MOVs.

The licensee will be expected to have evaluated the potential for pressure locking and thermal binding of gate valves and taken action to ensure that these phenomena do not affect the capability of MOVs to perform their safety-related functions. If a licensee identifies a potential for pressure locking and thermal binding of gate valves, the NRC regulations require that the licensee take action to resolve that problem. The licensee will be expected to have performed the following two actions:

1. Documented its evaluation of the gate valves within the scope of GL 89-10 as having operational configurations with a potential for pressure locking or thermal binding.

   The evaluation should include the basis for determining whether the valves (a) are susceptible to pressure locking or thermal binding, or (b) can be removed from further consideration.

   The licensee may eliminate valves from consideration that (a) have only a safety function to close, or (b) are always open during plant operation, closed during plant shutdown, and then reopened to start the plant. For example, solid wedge disc gate valves might not be susceptible to pressure locking. Double disc gate valves are not likely to be susceptible to thermal binding.

   Licensees will be expected to consider the potential for an MOV to undergo pressure locking or thermal binding during surveillance testing. For example, the inboard containment isolation MOV in the reactor core isolation cooling (RCIC) system steam line at a plant recently failed in the closed position following closure for routine surveillance testing. The cause was believed to be pressure locking.

   The licensee will be expected to review generic evaluations for site-specific applicability. For example, the licensee will be expected to review the generic evaluation to determine if it addresses pressure locking as a consequence of either thermal effects or design-basis depressurization.

   Examples of unacceptable reasons from eliminating valves from consideration of pressure locking or thermal binding are (1) leakage rate, (2) engineering judgment without justification, and (3) lack of event occurrence at the specific plant.

The AEOD study indicated that safety-related gate valves involved in pressure locking events were:

- low pressure coolant injection (LPCI) and low pressure core spray (LPCS) system injection valves;
- core spray (CS) valves;
- residual heat removal (RHR) shutdown cooling (SDC) isolation valves;
- RHR hot leg crossover isolation valves;
- RHR containment sump and suppression pool suction valves;
- high pressure coolant injection (HPCI) steam admission valves;
- RHR heat exchanger outlet valves; and
- emergency feedwater isolation valves.

The AEOD study indicated that safety-related gate valves involved in thermal binding events were:

- reactor depressurization system isolation valves;
- RHR inboard suction isolation valves;
- HPCI steam admission valves;
- power-operated relief valve (PORV) block valves;
- reactor coolant system letdown isolation valves;
- RHR suppression pool suction valves;
- containment isolation valves (sample line, letdown heat exchanger inlet header);
- condensate discharge valves; and
- reactor feedwater pump discharge valves.

A recent event at a plant involving possible pressure locking of a RCIC valve indicates that MOVs in steam lines also are susceptible to pressure locking.

General Electric also provided guidance on pressure locking and thermal binding in its Nuclear Services Information Letter (SIL) 368 and its Supplement 1.

2. Documented its analysis of the safety-related gate valves (identified in 1 above) with the potential for either pressure locking or thermal binding to ensure all such valves can be opened to perform their safety function under all modes of plant operation. Credit for bonnet pressure decay within the valve response time might not be acceptable unless operation of the actuator motor at locked-rotor conditions would not degrade motor torque capability.

   Specific modifications or actions to prevent pressure locking or thermal binding are listed on page 7 of NUREG/CR-1275. The staff considers the modifications and actions discussed in the AEOD report to be acceptable.

   The licensee will be expected to have performed an analysis under 10 CFR 50.59 for any valve modifications and to have established adequate postmodification and inservice testing of any valves installed as part of the modification.

Where reliance is placed on actions by plant personnel, the licensee will be expected to have established training for plant personnel to perform the actions and to have incorporated specific procedural precautions/revisions into the existing plant operating procedures. For example, licensees might require plant personnel to periodically stroke certain valves to reduce the potential for thermal binding.

If an MOV is found to be susceptible to pressure locking or thermal binding, the licensee will be expected to justify any reliance on the capability of the MOV to overcome pressure locking or thermal binding because of the uncertainties surrounding the prediction of the required thrust to overcome these phenomena.

MOV CALCULATIONS

Thrust and Torque Requirements

In validating the size and setting of an MOV, the licensee will be expected to determine the required thrust and torque to open and close the valve to perform its safety function under its design-basis differential pressure and flow conditions. As discussed later under Torque Switch Settings, the licensee will be expected to ensure that the torque and thrust requirements do not exceed the structural or operating capability of the MOV including applicable uncertainties. The most common industry equation for predicting the thrust required to close a gate valve is as follows:

Required thrust = DP load + Stem load + Packing load
where
DP load = VF x DP x Ad
with VF = valve factor
DP = differential pressure
Ad = area of valve disc

Stem load = P x As
with P = system pressure
As = stem cross-sectional area

Packing load = vendor supplied, assumed or measured thrust

To obtain the predicted thrust requirement for opening the valve, the stem load is subtracted (rather than summed) or simply assumed to be zero.

Required torque = Required thrust x Stem Factor
where Stem Factor is determined based on physical parameters (stem diameter, pitch and lead) and the Stem Friction Coefficient.

Differential Pressure:
The licensee will be expected to determine an appropriate differential pressure from its design basis reviews in response to GL 89-10.

Valve Factor:
The licensee will be expected to assume a realistic valve factor/disc area combination in MOV calculations. For example, based on MOV test information from individual licensees, EPRI and INEL, a valve factor of 0.3 for gate valves in the range of 6 inches (and larger) under blowdown conditions is not considered realistic and should be more in the 0.4 to 0.6 range. The licensee will be expected to justify its assumption for various parameters (such as valve factor and stem friction coefficient) considering best available MOV test data. The staff considers best available MOV test data (in order of reliability) to be valve specific data, plant specific data, EPRI test data, and industry test data. Where several tests are considered, the licensee would not be expected to bound every datapoint. (See enclosure on grouping.)

Licensees assume various diameter dimensions in calculating area for use with the valve factor (such as mean seat diameter or outside diameter). The licensee will be expected to consistently apply the diameter dimensions in its calculations and to be aware of the diameter dimension used to derive valve factors obtained from other sources.

Stem Friction Coefficient:
The licensee will be expected to select a stem friction coefficient (SFC) for dynamic conditions that is supported by plant-specific dynamic test data. (See enclosure on grouping.)

Most licensees will probably not plan to conduct as-found dynamic tests. If the licensee is assuming a stem friction coefficient of 0.20 or greater, the licensee will eventually need to validate that assumption, but should be allowed flexibility in its plans for obtaining that verification. Where the licensee is assuming a lower stem friction coefficient and as-found dynamic testing will not be conducted, the licensee will be expected to develop a plan to justify its stem friction coefficient assumptions.

Load Sensitive Behavior (rate of loading):
Load sensitive behavior is the reduction in thrust output of the actuator under dynamic conditions compared to thrust output under static conditions. Initial INEL testing suggests that most of the reduction in thrust output is caused by an increase in the stem friction coefficient. Typically, load sensitive behavior is estimated by subtracting the thrust at torque switch trip under dynamic conditions from the thrust at torque switch trip under static conditions. Load sensitive behavior could be addressed by using a stem friction coefficient based on dynamic test data in MOV sizing calculations and also setting the torque switch sufficiently high to accommodate the reduction in thrust at torque switch trip from static to dynamic conditions.

Licensees will be expected to determine an appropriate margin to account for load sensitive behavior based on testing at its facility or other justifiable applicable data. Based on test data from INEL and other sources, it appears reasonable at this time for licensees to use the load sensitive behavior (in terms of percent) observed under partial design basis testing for design basis capability evaluations. Licensees will be expected to justify the extrapolation of load sensitive behavior. (See enclosure on Nonconformance and Operability of MOVs.)

ITI-MOVATS Thrust Requirement Database:
ITI-MOVATS established a database from results of testing MOVs under differential pressure conditions using its TMD spring pack displacement diagnostic equipment. During inspections, the staff found that the database does not always adequately predict the thrust required to operate the valve. From an inspection at ITI-MOVATS, the staff found that the database was unreliable because it combined MOVs of various sizes, valve types, and differential pressure conditions.

MOV Output Capability

After determining a predicted thrust and torque requirement, the licensee will be expected to evaluate the capability of the MOV to deliver the required thrust and torque. The standard Limitorque equation for determining MOV output capability is as follows:

Output torque capability = MT x OAR x EFF x AF x (DV)^n

where
- MT = nominal rated motor starting torque
- OAR = overall actuator ratio
- EFF = actuator efficiency
- AF = application factor
- DV = ratio of minimum voltage at motor terminals to rated motor voltage.

If DV is greater than or equal to 0.9, then n = 0 and (DV)^n = 1. If DV is less than 0.9, then n = 1 for dc motors and 2 for ac motors. Limitorque has stated that this relationship reliably applies down to a 0.7 DV.

Output thrust capability = Output torque capability / Stem Factor

Licensees have found from MOV testing that more thrust and torque are required to operate many valves than predicted by the valve vendor when sizing and setting the motor actuators. Therefore, to compensate for this design inadequacy and to better predict the actual capability of these MOVs, licensees are attempting to remove some of the conservatism assumed to be present in the standard Limitorque equation.

The following is a discussion of some of the parameters in the output equation:

Actuator Efficiency:
Limitorque provides three sets of efficiencies for its actuators. In Technical Update 92-02, Limitorque states that pullout efficiency is representative of the actuator overcoming inertial loads at startup. In a letter dated September 17, 1992, to Cleveland Electric, Limitorque states that run efficiency can be substituted for pullout efficiency where the application involves a close safety function with no potential of the actuator stopping at any point during the closing stroke.

In its September 17 letter and Maintenance Update 92-1, Limitorque indicates that the stall torque equation is to be used for overload analysis only and not for reliable actuator output. In Maintenance Update 92-1, Limitorque states that stall efficiency is not a true efficiency because it has been increased above actual efficiency to envelope inertial effects. Limitorque provides stall efficiency to be used in the stall torque equation along with motor stall torque (110% of nominal motor torque or from the motor curve). EPRI Application Guide NP-6660D on page 6-15 also indicates that the stall equation cannot be used to estimate actuator output capability.

In the evaluation of inadvertent stall events, some industry testing has revealed that Limitorque actuators might deliver greater than 100% of their nominal motor torque under static stall conditions and damage structural components in the MOV.

Application Factor:
In Technical Update 92-02, Limitorque states that the application factor takes into account variances of the motor start torque and the pullout efficiency at varying voltage levels and various actuator speeds and conditions. The application factor is 0.9 in most cases and 0.8 if the motor is 900 rpm or the actuator is an SB sized for high line temperatures. In its September 17, 1992, letter to Cleveland Electric, Limitorque states that it does not recommend removing the application factor for the actuator capability calculation. The application factor is removed from the equation for stall calculations.

Ambient Temperature Effects:
Limitorque is studying the effects of high ambient temperature on ac motor output which might reduce the motor output. The significance of these effects is not currently known.

Degraded Voltage:
See enclosure on degraded voltage.

Torque Switch Settings

After evaluating the size of the motor actuator, the licensee will be expected to determine an appropriate window for setting the torque switches. The allowable torque switch setting must not exceed the structural limits of the MOV or the motor capability under degraded voltage conditions (where the valve must change position to perform its safety function or where mispositioning is applicable), including consideration for inertia, torque switch repeatability, and test equipment accuracy. The minimum torque switch setting must exceed the required thrust to operate the valve to perform its design-basis safety function, including consideration of torque switch repeatability, test equipment accuracy, load sensitive behavior (rate of loading), and stem factor degradation until the next lubrication.

Among the considerations in setting torque switches are:

Spring pack limits:
Spring packs are limited by torque and displacement. If a licensee expresses the limit for the spring pack in terms of thrust, the licensee will be expected to use a realistic stem friction coefficient for dynamic conditions because, if the SFC is greater than assumed, then the torque limit of the spring pack might be exceeded.

Torque Switch Repeatability:
In a May 10, 1990, letter, Limitorque stated that torque switch repeatability was +/- 10% for actuator torque less than 50 ft lbs and +/- 5% for actuator torque greater than 50 ft lbs.

In Maintenance Update 92-2, Limitorque changes torque switch repeatability to the following:

Torque switch	actuator torque	torque switch repeatability
>1	>50 ft lbs	+/- 5%
>1	<50 ft lbs	+/- 10%
at 1	>50 ft lbs	+/- 10%
at 1	<50 ft lbs	+/- 20%

If a licensee sets the torque switch greater than the Limitorque maximum setting, the licensee will be expected to perform an engineering evaluation in accordance with Criterion III of 10 CFR Part 50, Appendix B.

In its initial evaluation of MOV capability, the licensee might assume high values for valve factor (or coefficient of friction), stem friction coefficient, and load sensitive behavior. By combining several such assumptions, the calculation might incorrectly predict that the MOV is incapable of performing its design-basis function. For example, one licensee has stated that it will assume a 0.5 valve factor and 0.2 stem friction coefficient for all MOVs in its GL 89-10 program. This may be conservative for many MOVs. However, if the MOV calculation and parameters are realistic or non-conservative for a valve based on test information, the licensee will be expected to evaluate the operability of the MOV in accordance with NRC regulations and plant Technical Specifications.

DEGRADED VOLTAGE

In Question 36 of Supplement 1 to GL 89-10, the staff provided guidance on the consideration of degraded voltage in MOV calculations. In a memorandum dated December 31, 1992, the Electrical Engineering Branch of NRR offered a clarification of the response as follows: "Degraded voltage determinations should include voltage drop due to impedances of cable at its maximum operating temperature, overload relay (if present), and the motor inrush (starting) current of the MOV from the worst case bus (MCC, distribution panel, etc.) voltage (refer to Branch Technical Position PSB-1 or diesel generator voltage profile). PSB-1 requires that the voltage at the equipment terminals shall never be less than the minimum allowable equipment voltage required to perform its intended function [even under sustained degraded grid conditions]. The allowable minimum voltage for an MOV motor is defined as the voltage at which the motor torque at the highest motor temperature is always greater than minimum required for valve actuation." The staff does not consider this clarification to differ from the guidance provided in Supplement 1.

For 480-Vac motors, the licensee determines minimum voltage at the motor terminals considering cable size and length, temperature, and thermal overload resistance. The licensee will be expected to consider the worst-case postulated motor control center (MCC) voltage based either on the lower of the voltage supplied from the diesel generator or the offsite supply. Where the offsite supply is the limiting case, as is typical, the licensee will be expected to use the degraded grid relay set point as the starting point for determining the minimum voltage at the motor terminals for ac motors. The appropriate set point to be used is for the degraded grid relay which provides for separation from the offsite supply, and connection to the emergency diesel generator, with or without a specific time delay or concurrent accident signal. In addition to the degraded grid voltage relays, some plants use an additional alarm relay (set higher than the degraded grid voltage relays) to alert the operator to a sustained degraded grid condition. The licensee should not use the alarm relay setting to calculate the voltage required at the MOVs. Likewise, taking credit for administrative procedures and operator response (to separate from the offsite supply) is not acceptable unless these actions have been accepted generically for all safety equipment. For dc motors, the licensee will be expected to use the worst-case battery voltage profile (including aging and temperature factors). The licensee will be expected to properly account for voltage drops from the battery to the MCC.

After determining the minimum voltage at the motor, the degraded voltage factor is calculated. The degraded voltage factor is then multiplied by the rated motor output torque and compared to the torque required. In Technical Update 92-02, Limitorque states that the degraded voltage factor is applied if motor terminal input voltage is less than 90 percent of the motor rated voltage at any time during the valve stroke. For ac-powered MOVs, the degraded voltage factor is equal to the square of the ratio of the minimum motor terminal voltage to the motor rated voltage. However for motor terminal voltages less than or equal to 70 percent, motor performance to this approximation would need to be justified by the licensee because Limitorque has only approved this approximation for motor voltages over 70 percent. For dc-powered MOVs, the degraded voltage factor is equal to the minimum motor terminal voltage divided by the motor rated voltage. In Technical Update 92-02, Limitorque states that, between 90 and 99 percent of rated voltage, the degraded voltage factor is equal to one and that the application factor makes allowances for motor torque loss up to 90 percent voltage.

For ac motors, there are essentially two methods for calculating the expected motor terminal voltage at degraded bus voltage conditions. The following is a summation of these two methods.

Method One: A motor circuit one-line diagram is constructed consisting of the known cable and overload heater impedances. The motor impedance is calculated by the following formula:

$$Z(m) = \frac{V(r)}{[\mathrm{SQRT}\ 3] \times I(lr)}$$

where Z(m) = motor impedance
V(r) = motor nominal voltage
I(lr) = rated locked rotor current

Then, a voltage divider calculation is performed with the result being the calculated motor terminal voltage under worst-case bus voltage conditions.

Method Two: A motor current value, representative of worst-case conditions, is assumed. Some licensees assume nominal locked rotor current, which should be the most conservative. Other licensees are assuming alternate values such as current at torque switch trip, which may not be conservative because the current at torque switch trip may depend on the applied voltage and consequently may be higher under degraded voltage conditions. Additionally, current at torque switch trip is not always the worst case because unseating current could be higher in some cases. Also, if the current was derived from a test at less than full differential pressure, the current at torque switch trip also might be underestimated as a result of differences in inertial forces. Therefore, licensees will be expected to provide justification for using any current value less than that of nominal locked-rotor current. Motor terminal voltage is then calculated by multiplying the assumed motor current times the cable and overload impedances and subtracting this value from the worst-case bus voltage.

Power factor:
Licensees will be expected to use the power factor specified in a table provided by Limitorque for locked-rotor conditions.

DC MOTORS:
For dc motors, the calculation to determine the worst-case motor torque is more straightforward. The locked rotor resistance of the motor is calculated from actual locked-rotor current test data. Then, appropriate values are assumed for cable, overload heater, and starting resistor resistances. The licensee will be expected to account for uncertainties in the generic motor curves. An example calculation for calculating dc motor torque is shown in a

Limitorque Maintenance Update dated August 17, 1988.

For more detailed explanation of the methods for performing voltage drop calculations, see the memorandum dated March 31, 1993, from Carl H. Berlinger, Chief, Electrical Engineering Branch, NRR, to James A. Norberg, Chief, Mechanical Engineering Branch, NRR.

MOV TESTING

MOV Testing Where Practicable

In GL 89-10 and its supplements, the NRC staff requested that licensees test MOVs within the scope of the generic letter under maximum achievable differential pressure and flow up to design-basis conditions, where practicable. The staff is not requesting that licensees test MOVs in nuclear power plants under dynamic conditions at degraded voltage because equipment damage might result. Testing an MOV under design-basis differential pressure and flow conditions with nominal voltage would require only the extrapolation of actuator capability to degraded voltage conditions. Where design-basis differential pressure and flow conditions cannot be achieved, the licensee will need to justify its method of extrapolating the test results to design-basis conditions. The licensee might not be able to fully demonstrate design-basis capability by its extrapolation method at this time because of the uncertainties that exist in MOV performance. However, the licensee might be able to use the extrapolated test data as the best test data available in the first stage of the two-stage approach described in GL 89-10 for demonstrating MOV capability.

In Supplement 1 to GL 89-10, the NRC staff discussed the practicability of MOV testing in terms of the physical capability of performing the test. The staff also recommended testing at maximum achievable conditions up to design-basis conditions to obtain information on valve and stem friction. The staff does not recommend that licensees place the plant in an unsafe condition in performing MOV tests. If the test can only be conducted by challenging safety systems, the licensee has a good argument for stating that the test is not practicable.

Some licensees have defined practicable to include whether the licensee considers the test data to be meaningful. Licensees may show that static running loads are as significant as dynamic running loads for MOVs with low design-basis differential pressure conditions. Where an MOV has sufficient margin, the staff is not concerned with lack of testing. (See enclosure on Nonconformance and Operability of MOVs.)

MOV Test Procedures

Licensees will be expected to determine the parameters that will be necessary to apply the test results in demonstrating design basis capability. Licensees will be expected to ensure the quality of the data being collected. EPRI Report NP-7078, "In Situ Test Guide for Motor Operated Valves," provides recommended parameters to be monitored during MOV tests. These parameters include system pressure, differential pressure, torque switch bypass, voltage related to the motor terminals, fluid temperature, system flow, and motor current. Parameters such as differential pressure must be accurately measured to allow test results to be applied to MOVs that cannot be dynamically tested or to be used in a national database. For example, differential pressure measurements must accurately reflect the actual differential pressure across the valve as reasonably as possible rather than general upstream and downstream system pressures. Some parameters, such as flow, can be determined less precisely. The licensee will be expected to justify the parameters monitored and not monitored, and to justify the appropriate accuracy of measuring each parameter.

The licensee will be expected to demonstrate that the development of test procedures, collection of test data, and evaluation of test data were performed in accordance with its QA procedures under Criteria III and XI of 10 CFR Part 50, Appendix B. For example, the licensee will be expected to have a process to independently verify its quantitative analyses of test data to obtain valve factors and stem friction coefficients for feedback into its MOV methodology or for input into a national database. For example, the licensee will be expected to have test data analyses checked by a licensee technical individual other than the individual performing the analyses. (See Criterion III, Design Control, of 10 CFR Part 50, Appendix B.)

MOV Test Acceptance Criteria

NRC regulations in Appendix B to 10 CFR Part 50 require that tests of safety-related MOVs be evaluated. Licensees will be expected to develop acceptance criteria for MOV testing, which must be satisfied before returning the MOV to service. The staff's views on minimum criteria and evaluation of test data are described below.

STATIC TEST ACCEPTANCE:

1. Available thrust and torque is within the window defined by the licensee's design-basis calculations and margins.

2. Diagnostic traces do not indicate significant abnormalities or anomalies.

3. Valve stroke times do not violate the requirements of Section XI of the American Society of Mechanical Engineers (ASME) Code and the applicable technical specifications.

DIFFERENTIAL PRESSURE TEST ACCEPTANCE:

1. The valve must fully open with appropriate open torque switch bypass indication and must fully close with diagnostic indication of hard seat contact and control room indication.

2. The control switch settings must provide adequate thrust margin to overcome design-basis requirements, including consideration of diagnostic equipment inaccuracy, control switch repeatability, load sensitive behavior, and margin for degradation until the next test.

3. The motor output capability at degraded voltage must be in excess of the control switch setting including consideration of diagnostic equipment inaccuracy, control switch repeatability, load sensitive behavior, and

margin for degradation until the next test.

4. The maximum thrust and torque achieved by the MOV including diagnostic equipment inaccuracy and control switch repeatability must not exceed the allowable structural capability limits for the individual parts of the MOV.

5. The diagnostic traces must not indicate any significant abnormalities or anomalies.

The following is an example o: specific acceptance criteria for differential pressure tests:

Open Stroke Evaluation

1. Determine the pullout thrust and torque (corrected for diagnostic equipment inaccuracy).

2. Determine Differential Pressure (DP) thrust for test from peak thrust (after pullout) minus running load.

3. Determine Design Basis (DB) thrust requirement by either:

   a. Determining open valve factor (VF) from test DP thrust divided by orifice area and DP (corrected for pressure measurement equipment inaccuracy and line losses). Then, use open VF in Limitorque equation (with actual packing load or the typical assumption for packing load); or

   b. Determining DBDP thrust by multiplying open test DP thrust by ratio of DBDP to test DP. Then, use DBDP thrust in Limitorque equation.

4. Determine DB torque requirement by extrapolating test DP torque (corrected for pressure measurement inaccuracy). If torque not directly measured, stem friction coefficient must be determined to be consistent with licensee assumptions (including evaluation for load sensitive behavior).

5. Ensure that adequate margin exists from structural limits and actuator degraded voltage capability to DB thrust and torque requirements corrected for diagnostic equipment inaccuracy and torque switch (TS) repeatability.

Close Stroke Evaluation

1. Determine DP test thrust from maximum DP thrust minus average running load and calculated stem rejection load (from actual DP corrected for inaccuracy and line losses).

2. Determine close VF from DP test thrust divided by orifice area and DP (corrected for pressure measurement inaccuracy and line losses).

3. Determine stem friction coefficient (SFC) from stem factor (torque/thrust) at flow cutoff. If the licensee does not obtain measurements that allow a determination of stem friction coefficient, the licensee will need to develop a plan to justify its stem friction coefficient assumption based on plant specific data.

4. Determine load sensitive behavior (LSB) from thrust at torque switch trip (TST) for static test minus thrust at TST for test, and extrapolate to design basis conditions.

If LSB, VF, and SFC are bounded by licensee assumptions in MOV calculations, then acceptance criteria met. If not, then continue:

5. Determine DB thrust requirement by either:

   a. Determining close valve factor (VF) from test DP thrust divided by orifice area and DP (corrected for pressure measurement equipment inaccuracy). Then, use close VF in Limitorque equation; or

   b. Determining DBDP thrust by multiplying close test DP thrust by ratio of DBDP to test DP. Then, use DBDP thrust in Limitorque equation.

6. Compare DP thrust requirement to TST thrust minus TS repeatability and LSB and diagnostic equipment inaccuracy.

7. Determine DB torque requirement by extrapolating test DP torque (corrected for diagnostic equipment and pressure measurement inaccuracy). If toroue not directly measured, stem friction coefficient must be determined to be consistent with licensee assumptions.

8. Ensure that adequate margin exists from structural limits and actuator degraded voltage capability to DB thrust and torque requirements corrected for diagnostic equipment inaccuracy and TS repeatability.

After returning the MOV to service, the licensee will be expected to perform a more detailed followup evaluation of test data for such items as the following:

1. In the event of greater-than-predicted thrust or torque requirements, evaluate other applicable MOVs (such as parallel train valves) before plant startup. If plant is operating, evaluate promptly in accordance with Generic Letter 91-18.

2. Perform a detailed evaluation of the diagnostic trace for such items as bent stem, spring pack gap, and stem/stem nut interface problems. Training for the VOTES diagnostic equipment for MOVs recommends comparing in-rush motor current to running current for magnesium rotor degradation.

3. Incorporate valve factors and stem friction coefficients into the MOV sizing and switch setting methodology to ensure thrust windows are correct.

Extrapolation of Differential Pressure Thrust Data

In Supplement 1 to GL 89-10, the staff requests that, where an MOV cannot be practicably tested under design-basis differential pressure and flow conditions, the licensee test the MOV under maximum achievable conditions. If the test conditions are sufficiently close to design conditions, the licensee might be able to reliably use the test results to demonstrate design-basis capability. Because of the uncertainties in extrapolating test data, the licensee might have to use the two-stage approach for MOVs that cannot be tested sufficiently near design-basis conditions.

Some licensees are linearly extrapolating the thrust required to overcome differential pressure from test conditions to design basis conditions. Currently, there is not sufficient information to state definitively how close a test needs to be to design basis differential pressure to reliably extrapolate linearly. The licensee will be expected to verify its method of extrapolation of test data. One possible method of verifying the reliability of linear extrapolation for a particular MOV would be for the licensee to test the MOV at various pressures and show that the results confirm the linearity of the test data.

MOV Diagnostic Equipment

The commercial vendors of MOV diagnostic equipment have published the accuracy of their equipment. Licensees with their own diagnostic systems will be expected to demonstrate the accuracy of their systems. The region should contact NRR for assistance in evaluating a diagnostic system developed by a particular licensee.

MOV Overhaul

It is important to have the MOV in a known condition before establishing baseline diagnostic data. For example, at one plant, an MOV failed as a result of stem nut wear without advance indications of degradation even though the licensee was using diagnostic equipment to monitor thrust delivered by the actuator. The staff does not require licensees to overhaul actuators before beginning the GL 89-10 program. Licensees will be expected to justify the method used to periodically verify MOV design basis capability.

As-Found MOV Tests

Licensees were not required to perform an as-found test of each MOV at the outset of the GL 89-10 program. As part of their GL 89-10 programs, licensees will be expected to justify assumptions for factors (such as stem friction coefficient) in their MOV calculations. Therefore, licensees will be expected to justify those assumptions by subsequently conducting as-found tests to some extent before planned maintenance. Each licensee will be expected to demonstrate that the extent of its as-found tests is sufficient to justify its assumptions. The staff would not expect licensees to perform as-found tests, when actuator repairs are needed, that might cause damage to the MOV.

Butterfly Valve Testing

Many licensees are delaying testing of butterfly valves because of the uncertainties with available diagnostic equipment and the belief that these MOVs may not have as many problems as gate valves. GL 89-10 includes butterfly valves among the MOVs that should be tested where practicable. The staff has not prescribed how licensees should establish priorities for testing MOVs (for the most part) and many licensees have placed butterfly valves at the end of their GL 89-10 test programs. However, some licensees have identified problems with sizing and setting butterfly valves. Therefore, the staff is not currently planning to modify the GL 89-10 recommendation to test butterfly valves where practicable. The staff will consider licensee proposals to group butterfly valves, where justified. (See enclosure on grouping.)

Overthrust and Overtorque

If the licensee finds that it has overthrusted or overtorqued an MOV, the licensee will be expected to take action to determine the safety significance of the overstress event. The licensee will be expected to consider the MOV to be degraded and to perform an operability evaluation as described in Generic Letter 91-18.

Several licensees contracted Kalsi Engineering to evaluate the structural thrust capability of Limitorque actuators. Limitorque has endorsed the Kalsi study to specific thrust limits above the published structural ratings of the actuators, but at this time has not increased the structural ratings of its actuators. Licensees that rely on contractor studies are responsible for justifying their use. For example, licensees using the Kalsi overthrust report will be expected to implement the provisions of that report and to periodically inspect the actuators to identify any adverse effects from the increased thrust above the structural ratings. Licensees that rely on contractor studies are responsible for evaluating any subsequent MOV problems that might be attributable to the contractor study and taking corrective action to address the problem for all MOVs whose setup is based on the contractor study. The staff would consider any such failure to indicate that the licensee may not have met the NRC regulations for design control.

NRC inspection report 99900404/92-01 provides the results of an inspection of Westinghouse regarding that company's reports on structural overthrust capability of MOVs.

MOV GROUPING

In Generic Letter 89-10 and its supplements, the NRC staff requests that licensees test each MOV under design-basis differential pressure and flow conditions where practicable. It is not practicable to test each MOV within the scope of GL 89-10 in situ under dynamic conditions. Therefore, if a licensee does not perform prototype testing for each MOV that is not practicable to test insitu, the licensee will have to group MOVs that are not practicable to test in a manner that provides adequate confidence that the MOVs are capable of performing their design-basis function. In addition, some licensees are attempting to group MOVs to reduce the number of MOVs to be dynamically tested under their GL 89-10 programs.

The staff recognizes that grouping data from design-basis differential pressure testing of similar MOVs at or near design-basis test conditions may be an acceptable option to establish design-basis valve setup conditions. Verification of design adequacy of the grouped MOVs can be accomplished through a review and analysis of both industry and plant-specific data. Use of this data should be benchmarked using differential pressure test data from testing at or near plant-specific design basis conditions. The benchmark sample size should be nominally 30 percent (no less than two MOVs) of the group. In addition, all MOVs in the group should be diagnostically tested under at least static conditions. To the extent practicable, valves chosen for dynamic testing in the group should be selected on a prioritization scheme that considers greatest safety-significance or least performance margin. Design-basis assumptions for all MOVs in the group should be based on valid benchmarked data. In assessing group feasibility, licensees will be expected to consider and document such similarities as valve manufacturer, model and size; valve flow, temperature, pressure, hydraulics, and installation configuration; valve material condition; and performance during static and dynamic testing as evidenced by full-stroke diagnostic traces. The licensee will be expected to document the justification for grouping. Licensees using data from tests performed under an approved program (for example, other licensee data) in accordance with Appendix B of 10 CFR Part 50 need not verify or audit the suppliers' procedures or processes because the program is subject to NRC inspection. If an MOV in a group fails or reveals adverse performance during testing or operations, the licensee will be expected to evaluate the applicability of that information to each MOV in the group.

LIMIT-CLOSED MOVs

In the past, licensees set most gate and globe valves to close based on torque switch trip. Some licensees are currently modifying safety-related MOVs to close based on valve disc position as measured by the limit switch. Although the staff does not object to this method of closure control, licensees will be expected to exercise caution in setting the MOV to close on limit. The licensee will be expected to set the limit switch to stop the motor actuator at a point where flow is isolated consistent with the plant safety analysis, but before the point where the MOV motor, actuator, or valve is stressed beyond the qualified rating. There have been cases where licensees have damaged motors because of inadequate limit switch settings. Motor damage has been more prevalent in those cases where the torque switch has been electrically isolated from the MOV control circuit and has not been available as backup protection.

There may be some differences between limit- and torque-closed valves in the analysis of diagnostic test results. Testing a limit-closed MOV under static conditions allows the inertia of the MOV to seat the valve following limit switch trip. The same amount of inertia may not be available for valve seating under dynamic conditions.

When limit switches were relied on for minimal torque switch bypass and indicating lights, licensees would typically use handwheel turns to set the limit switch. Licensees might need to develop a more accurate method of setting limit switches where these switches will be used in lieu of torque switches. For example, a licensee might use diagnostic equipment data to more precisely indicate valve position at limit switch trip.

Some licensees have set MOV limit switches such that, during static tests, the measured stem thrust (corrected for uncertainties) at limit switch trip is less than the calculated thrust required to close the valve under design basis conditions. This practice would not be acceptable for a torque-closed MOV. For limit-closed MOVs, in which the full capability of the actuator and motor is available to close the valve, it is considered acceptable for the thrust at limit switch trip to be less than the design-basis thrust requirement as long as the licensee has ensured that the MOV can close under design basis conditions at degraded voltage and meet all applicable leakage limits.

Some licensees have assumed that load sensitive behavior (rate of loading) effects need not be considered for calculating the design basis capability of a limit-closed MOV. The basis for this assumption is that the loss in efficiency of torque to thrust conversion between static and dynamic conditions will not result in a loss of applied thrust to the valve stem as long as the motor is capable of delivering the extra increment of torque required to overcome the higher stem factor. This assumption is valid from the point of view of the traditional definition of load sensitive behavior. However, some test results have indicated the presence of a torque load sensitive behavior effect that, if validated, would need to be considered in the evaluation of the capability of limit-closed MOVs to close under the design basis condition.

PERIODIC VERIFICATION AND POST-MAINTENANCE TESTING

Generic Letter 89-10 requested that licensees periodically verify the design basis capability of safety-related MOVs. Some licensees have indicated that they will attempt to meet their commitment to GL 89-10 through periodic static testing of MOVs. No licensee has as yet provided justification for demonstrating design basis capability on a periodic basis through extrapolation of static test data.

In response to the periodic verification recommendation in GL 89-10, the licensee will be expected to demonstrate that the MOV in the as-found condition can perform its design-basis function. Where a licensee attempts to justify design basis capability based only on static test data, the licensee will be expected to evaluate the margin available to account for the uncertainties (such as load sensitive behavior) between static and design basis conditions. In the long term, NRR will develop guidance for evaluating licensee justification for design-basis capability based on periodic verification testing.

The licensee will be expected to have maintenance procedures for step-by-step instruction to maintenance personnel that address guidance provided by valve vendors, actuator and motor manufacturers, diagnostic equipment vendors, and other applicable sources. The licensee will be expected to have procedures that do not allow maintenance personnel to omit steps of the procedure without concurrence of the licensee's engineering staff.

The licensee will be expected to justify its method to demonstrate that each safety-related MOV remains capable of operating under design-basis conditions following packing replacement or adjustment. Over the years, some licensees have replaced or adjusted valve stem packing without verifying that the MOV remains capable of operating under design basis conditions. Some licensees have simply stroked the valve following packing maintenance. Other licensees have monitored motor current or power during valve stroking in an effort to identify significant packing load changes. The MOV diagnostic equipment vendors have not expressed confidence in these motor parameters in monitoring packing load changes. Commonwealth Edison has developed a method for using motor current for post-maintenance testing where a specific amount of margin is available. The staff will be discussing this method with the licensee in the near future.

TRENDING

In Generic Letter 89-10, the staff requested licensees to trend MOV problems. In Supplement 1 to GL 89-10, the staff stated that the evaluation of MOV data for trends could assist the licensee in identifying the effects of aging, managing maintenance activities, and supporting plant life extension. The staff referred to Attachment A to GL 89-10 with respect to trending. For example, the licensee could trend problems associated with such parameters as

(1) thrust required to close or open the valve,
(2) thrust delivered at torque switch trip,
(3) torque switch settings,
(4) pullout and running motor current,
(5) stem friction coefficient over the lubrication interval,
(6) spring pack relaxation,
(7) packing load,
(8) motor replacements, and
(9) overthrusting or overtorquing.

There are no specific regulations regarding trending. However, if an MOV problem occurred repeatedly, the licensee would not have satisfied the NRC regulations for adequate corrective action in Criterion XVI of 10 CFR Part 50, Appendix B. The NRC regulations require that licensees take appropriate corrective action in response to deficiencies found regarding the performance of safety-related MOVs. Such action includes determination of the root cause of the problem and the applicability of the problem to other safety-related MOVs.

SCHEDULE

In Generic Letter 89-10, the NRC staff requested nuclear power plant licensees to develop a program to verify the capability of safety-related MOVs to perform their safety function by June 28, 1994, or three refueling outages after December 28, 1989 (whichever is later). Some licensees justified longer schedules. From its inspections of GL 89-10 programs, the staff found some licensees to have made insufficient progress toward completing their GL 89-10 programs in a timely manner. The staff is preparing a proposed supplement to GL 89-10 that would provide information on the staff's review of licensee justification for extension of GL 89-10 schedule commitments. The staff would consider a failure of an MOV as a result of insufficient torque or thrust capability after the licensee's schedule originally committed to in response to GL 89-10 to constitute inadequate corrective action by the licensee if best available test data were not used in sizing and setting the MOV.

In GL 89-10, the staff stated that nuclear power plant licensees must notify the staff of any changes to their schedule commitments to GL 89-10 but should retain the justification on site for NRC staff review. Before the proposed supplement is issued, some licensees might notify the staff of intentions to modify their schedule commitments. Until then, when a licensee notifies the staff of an intention to change its schedule commitment, the following information will be necessary to allow the staff to determine the need to perform an audit or inspection in the near future to evaluate the licensee's justification for extending the GL 89-10 test program and to establish appropriate inspection plans and schedules:

1. the completion status of the licensee's GL 89-10 program as of the program commitment date, including the valve type, size, safety function, and risk significance of the MOVs not yet set up under the program by the schedule completion date;

2. the basis used for confirming the operability of each MOV not set up under the program by the scheduled completion date; and

3. the schedule for completing MOV testing and any modifications for those MOVs not set up by the schedule completion date.

In addition to reviewing the above information, the staff will consider the following factors in assessing the licensee's justification for schedule extensions:

1. the extent of completed MOV testing under dynamic conditions;

2. the extent that plant and industry data have been used to establish the sizing and setting methodology;

3. the maintenance and modification activities to improve the performance of the MOVs and to provide assurance that marginal and deficient MOVs have been addressed; and

4. the justification for any grouping methods including design-basis test

data and comparison with industry data.

NONCONFORMANCE AND OPERABILITY OF MOVs

Technical guidance on ensuring the functional capability of a system or component (operability) and resolution of degraded and nonconforming conditions is contained in NRC Inspection Manual Part 9900 (see Generic Letter 91-18). Where an MOV is found not to be capable of performing its design-basis function, the licensee will be expected to resolve the nonconformance in a timely manner. Licensees need not demonstrate margin beyond the design-basis capability plus uncertainties (such as diagnostic equipment inaccuracy). If the nonconformance is such that the operability of the MOV is in question, the licensee will be expected to evaluate the operability of the MOV. Where the MOV is determined to be inoperable, the licensee must take action as required by the NRC regulations and plant Technical Specifications. GL 91-18 provides guidance for determining the promptness required for this action.

Licensees are finding that many MOVs currently installed in nuclear plants do not satisfy the Limitorque typical sizing equation because thrust and torque requirements are greater than assumed during the original sizing and setting of the MOVs. Therefore, many licensees are modifying the parameters used in the Limitorque equation to remove some of the conservatism in the equation. The staff believes that the Limitorque guidelines provide margin in the design of actuators, but the extent of that margin is not well known. Therefore, licensees will be expected to justify any removal of conservatism to ensure that the MOV remains capable of performing its design-basis function.

Based on current MOV test data and operating experience, the regions and NRR have prepared their current views on various parameters used in MOV sizing and setting calculations. The parameters listed below cannot be considered independently, but rather must be addressed in combination in the MOV sizing calculations. For example, a licensee might assume a greater motor torque but a lower application factor than presented in the table, but the licensee's overall calculation may be acceptable. NRR and the regions will update the information as necessary.

Stem factor	0.15 where consistent with plant-specific dynamic data
Load sensitive behavior	valve-specific data or applicable plant-specific data
Efficiencies	pullout for opening or throttling, or run for closing
Application factor	1
Motor torque	nominal rating
Motor current	based on locked rotor motor impedance
Packing load	valve specific

The combination of the above parameters is consistent with the guidance provided by Limitorque in its September 17, 1992, letter to Cleveland Electric (110% nominal motor torque, 0.9 application factor, and run efficiency for closing). Nevertheless, each licensee will be expected to justify its selection of parameters in light of plant and industry data. For example, during a recent inspection, the licensee presented the results of its torque stand testing of motor actuators which supported its assumption of nominal motor torque, run efficiency (for closing), and a 0.9 application factor in the Limitorque motor actuator output equation. A licensee might justify a combination of parameters (different from those in the above table) that would predict greater actuator capability based on its own test data.

In light of Supplement 4 to GL 89-10, BWR licensees do not need to address mispositioning. NRR will provide guidance on the consideration of inadvertent MOV operation in PWR plants when the ongoing contractor study is complete.