U.S. NUCLEAR REGULATORY COMMISSION

REGION III

Report No. 50-346/87017(DRS)

Docket No. 50-346 License No. NPF-3

Licensee: Toledo Edison Company
Edison Plaza, 300 Madison Avenue
Toledo, OH 43652

Facility Name: Davis-Besse 1

Inspection At: Oak Harbor, Ohio

Inspection Conducted: June 24-26 and December 11-17, 1987

Inspectors: P. R. Wohld 1/15/88
Date

Approved By: M. P. Phillips, Chief 1/15/88
Operational Programs Section Date

Inspection Summary

Inspection on June 24-26 and December 11-17, 1987 (Report No. 50-346/87017(DRS))
Areas Inspected: Special safety inspection of the licensee's activities with respect to Inspection and Enforcement Bulletin 85-03, "Motor-Operated Valve (MOV) Common Mode Failures During Plant Transients Due to Improper Switch Settings."
Results: No violations or deviations were identified.

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DETAILS

1. Persons Contacted

*E. Caba, Station Performance Supervisor
*P. N. Carr, Design Engineer
+*R. C. Elfstromb, Performance Engineer
*G. Honma, Licensing Compliance Supervisor
*R. W. Schrauder, Licensing Manager
+ B. Shingleton, Licensing Engineer
*S. J. Smith, Assistant Plant Manager
*A. G. Weedman, Manager, Engineering Assurance
*B. A. Welch, Licensing Engineer

*Denotes those present at the June 26, 1987 interim exit meeting.

+Denotes those participating in the exit telephone conference held on December 17, 1987.

Additional plant technical and administrative personnel were contacted by the inspector during the course of the inspection.

2. IE Bulletin Followup

(Open) IEB 85-03: Motor-Operated Valve (MOV) Common Mode Failures During Plant Transients Due to Improper Switch Settings.

a. Toledo Edison Response Dated May 15, 1986

Action Item (a) of the bulletin requested a review and documentation of the design basis for the operation of each valve addressed including an evaluation of limiting differential pressure conditions; Action Items (b) through (d) required actions to assure that the MOV switches were set, tested, and maintained properly; and Action Item (e) required a 180 day report of the results of Item (a) and a program to accomplish (b) through (d).

While additional information had been requested from the licensee (NRC letter dated August 11, 1987) and Toledo Edison had responded (letter dated September 18, 1987), final approval of the licensee's response was still pending NRR review. However, Region III has inspected the implementation and completion of the licensee's program. The inspector found that the licensee had properly completed commitments made in the bulletin response and was continuing to address issues raised with respect to MOV operability.

Many inspections covered the licensee's activities in this area during the recovery process from the June 9, 1985 loss of feedwater

event. The following summarizes the detailed inspection findings from which the satisfactory resolution of bulletin concerns were evaluated.

b. Limitorque-Operated, Rising Stem, Gate and Globe Valve Switch Setting Evaluation

The concern expressed by IE Bulletin 85-03 is about the proper setting of switches that control the operation of motor-operated valves. Action Item (b) of the bulletin requires that correct switch settings be established; Item (c) requires differential pressure testing, preferably, or other justification to demonstrate operability with the settings from Item (b).

Because of prevalent industry practice, most valves covered by the bulletin are Limitorque-operated, rising stem, gate or globe valves. This is the case for 22 of 24 Davis Besse valves addressed in their bulletin response. Below is a list of the switches involved and concerns for their proper setting, typical setting approaches that have been taken in the industry, and the resolution adopted at Davis-Besse. The switches discussed are named:

- Thermal overload relay
- Torque switch

  Open torque switch
  Close torque switch

- Geared limit switch

  Open limit
  Open indication
  Open torque switch bypass

  Close limit
  Close indication
  Close torque switch bypass

(The two other valves addressed by the bulletin are butterfly valves and are addressed in Paragraph 2.c.)

(1) Thermal Overload Relay

Discussion: Thermal overloads are sometimes used to protect motor winding insulation from breakdown. Devices used appear to uniformly consist of heaters at the motor control center which trip a heat sensitive relay, the contacts of which either interrupt current to the contactor closure coil (which stops the motor) or initiate an overload alarm, or both. Where thermal overload relays stop operator motor rotation on tripping, the

heaters must either be sized to prevent inadvertently stopping the motor or bypassed when motor operation is important to safety, and, they should be sized to protect the motor windings from thermal damage.

Designs that are being used at this time to eliminate the threat of inadvertent motor trips include: (1) removing the heaters or relay contacts from use, (2) using the relay contacts for alarm only, (3) bypassing the relay contacts during all operating modes except when a valve is being exercised for testing, (4) bypassing the relay contacts only during the presence of an automatic safety actuation signal and (5) oversizing the thermal overloads. Problems noted with the above designs (with respect to preventing inadvertent trip) include inadequate surveillance of the bypass function (No. 3 and 4), failure to protect the remote manual operation function (No. 4), error in determining proper heater size and failure to install the heater specified (No. 4 and 5), and failure to consider actual running loads which often exceed rated values during valve closure at high system pressures (No. 4 and 5), or when valve packing is too tight. No problems have been noted with designs 1 and 2.

With respect to protecting the motor windings from thermal damage, the remote location of the thermal overload relay (at the motor control center) prevents it from sensing actual winding temperature. Also, the motor has a long thermal decay time in comparison to the relay. These two factors prevent thermal overload protection of the windings during valve setup and testing when frequent stroking at unknown motor current levels can result in exceeding the motor duty cycle. The solution to this is to be knowledgeable of valve running currents and stroke times and to limit the frequency of valve stroke cycles accordingly.

Site Specifics: Valve motor running currents were recorded and evaluated for acceptability as part of the valve diagnostic test program performed on all safety-related MOVs, although thermal overloads were not used at Davis-Besse. With respect to motor duty cycle, the licensee's staff indicated that instructions and training were provided to both operations and maintenance personnel to observe the valve motor duty cycles. This approach was acceptable, and there was no concern for inadvertant tripping of the motor control circuit.

(2) Open Torque Switch

Discussion: This switch is normally used as a mechanical fuse to limit the mechanical thrust applied to a valve or operator when stroking the valve in the open direction. It generally

provides no normal control function and is a backup for some other failure.

Because this switch is always bypassed during initial valve unseating, which is the most challenging portion of the open valve stroke, failure to set it (or its bypass) properly can cause valve failures. In fact, this was the cause of the Davis-Besse event that led to IEB 85-03. Plant designs have evolved such that some use the open torque switch (primarily PWRs) and others do not (primarily BWRs).

If the switch is used, it must be set properly (in conjunction with the associated bypass switch) to enable the valve operator to apply adequate thrust on the valve stem to operate the valve against the limiting differential pressure (dp). Some licensees have tested valve opening against dp but using a hydro pump as the pressure source. Unfortunately, the low pump capacity allows the pressure to decay before the torque switch becomes "unbypassed" and the results are inconclusive with respect to torque switch setting adequacy. A process pump can be used to sustain the dp and overcome this weakness. With either technique; however, diagnostic capabilities are available to assess the results and to better determine both setting adequacy and setting margin.

Diagnostic testing can determine the valve thrust available at torque switch trip without any existing dp; however, previously used standard calculations for thrust requirements may be inadequate. If testing without dp is used to provide the only assurance of valve thrust capability, the burden is on the licensee to show the adequacy of the calculated requirement against which it is compared.

When the open torque switch is used, low voltage considerations require a torque switch setting upper limit to assure that the operator motor is capable of tripping the torque switch under reduced plant voltage conditions. This is provided in recent plants by an appropriately sized torque switch limiter plate. (A negative aspect of this is that the thrust limit from the operator will still be thus limited by the upper torque switch setting when nominal voltage is available).

Site Specifics: All of the rising stem, bulletin valves used the open torque switch. MOVATS, Inc., diagnostic equipment was used to assure that adequate thrust was available on the open direction at torque switch trip. This included testing a representative sample of valves at full differential pressure while simultaneously recording thrust signature traces for subsequent evaluation.

To further assure that the torque switch would not inadvertently trip, the licensee: (1) set the available thrust at torque switch trip as high as possible within the limits that would not damage the valve or operator, and (2) assured that the open torque switch bypass remained closed for at least the first 20% of valve disk motion in the open direction. The use of this approach adequately addressed the inspector's concerns.

(3) Closed Torque Switch

Discussion: The close torque switch is normally used to stop motor rotation on the completion of valve travel in the close direction. Since it provides a normal control function and is exercised on every closure stroke, setting generally needs more careful consideration than for the open torque switch. The limiting requirement for closure is at the end of travel when the thrust requirements are highest, the affect on flow control is most significant, and when the switch is almost never bypassed. Hence, it is very important that the thrust at torque switch trip equal the most limiting closure thrust requirement and that margin be available to allow for valve and operator degradation between retests, refurbishment, etc.

Differential pressure testing, using system process pumps, with appropriate data gathering and diagnostic evaluation is a positive means of assuring adequacy with margin. Other approaches may be considered adequate. One would be to periodically test against full dp without diagnostics. Another might be to do an opening dp test (using a hydro pump and diagnostics) and extrapolate that data to closing by adding two times the "stem area times system pressure" to determine a ballpark closing thrust requirement; then, use diagnostics to assure that the "closure thrust at torque switch trip" matches that number with margin.

The upper end of stem thrust is limited by valve and operator design. It happens that the Limitorque operator can exceed its own rating if the design is not proper or if the torque switch is set too high. After the torque switch trips, the motor continues to run at full speed until the motor contactor opens, continuing to thrust load the stem beyond that required for valve operation. Then, inertial affects continue to add load until the motor is at rest. The final load must be less than that resulting in damage to the valve or operator. If the design is improper, the final stem thrust load may exceed upper limits even if the torque switch is set for a thrust trip point below that required for proper operation. Normally, however, there should be an acceptable range within which both upper and lower thrust limits can be met.

Undervoltage considerations can have an important impact on the close torque switch setting. Since the torque switch must open to stop motor rotation in the close direction, any time low voltage is present such that enough motor torque cannot be developed to trip the torque switch, the motor will cook at locked rotor conditions. This will trip a thermal overload or cause motor winding burnout. Hence, it is important that (1) the torque switch limiter plate be sized properly with consideration for low voltage qualification of the valve operator, (2) that the limiter plate remain installed and is not modified to allow higher switch settings, and (3) that the voltage at the valve (not the motor control center or main bus) be guaranteed at stall torque (or locked rotor) conditions to be equal to or greater than that for which the operator is qualified.

Other factors in assuring an adequate torque switch setting are valve and valve operator mechanical conditions. Gate valve seat friction factors being determined lately appear to be anywhere from half to twice that assumed in the past using previously accepted calculational formulas; field measurements of stem thrust show that the valve stem thread lubrication may impact thrust values by a factor of two; stem packing tightening has been shown to be a significant factor, actually causing motor burnout in more severe cases of overtightening. These concerns have to be addressed by maintenance, surveillance, and post maintenance test programs, not only to assure that the torque switch setting will correspond to an acceptable thrust, but to assure that all other operability factors are maintained as well.

Plant Specifics: All 22 rising stem valves close on torque with the close torque switch limiting torque for essentially the entire valve closure stroke. Again, as for the open torque switch, MOVATS, Inc. diagnostic equipment was used to assure that adequate thrust was available in the close direction at torque switch trip. Similar differential pressure testing with signature recording and evaluation was performed.

Problems were encountered by the licensee in assuring that adequate torque was available without unduly overstressing the valves on each closure. To overcome this, an engineering evaluation was done for each valve and the final torque switch setting determined from this evaluation. Corrective action was necessary in a number of cases to complete the program.

Undervoltage was evaluated in the program. The licensee indicated that the valves were purchased to operate at 70% voltage and that there was no problem in this area based on evaluations done. Based on the licensee's engineering evaluations, the inspector's concerns were adequately addressed.

(4) Open Limit Switch

Discussion: The open limit switch is normally taken from the No. 4 contacts on the Limitorque geared limit switch "open" rotor. It provides the control function of determining the upper limit of valve stem travel in the open direction and stops motor rotation by opening the circuit to the associated motor contactor coil. The setting of this switch must assure an adequate valve stroke but, normally, must prevent backseating.

Valve backseats are normally to provide a seal that is redundant to the valve packing in order to allow packing replacement without the need to drain down the process system. They are not normally used otherwise and inadvertent or deliberate backseating using the power of the motor-operator, or motor inertia, can and has caused valve stem shearing, stem thread twisting, and valve bonnet metal working until stem scoring and packing blowout occur. Hence, it is important to set the open limit switch away from the backseat and with enough margin to allow for motor contactor dropout time and inertia. Independent verification (test, etc.) should follow any setting of the switch to assure it is done properly.

This is also the switch that some licensees adjust to meet Plant Technical Specification stroke time limits. While this practice should be discouraged, no problems are known to have been identified from this practice.

Plant Specifics: Diagnostic testing was completed to assure that the valves, as left, were not backseating. Further, maintenance procedures have been written and post maintenance testing specified to assure that future activities affecting this switch setting will not result in backseating. This approach adequately addressed the inspector's concerns.

(5) Open Indication

Discussion: Open indication is usually identified by the presence of a light that goes out only when the valve is fully closed. Common practice has been to derive on/off contacts for this light from the Limitorque geared limit switch, "closed" rotor.

In the past, the "closed" rotor was set to turn (or switch) very close to the end of valve closure. The open torque switch bypass (when used) often uses this same rotor which results in the setting of the point where the rotor turns having conflicting requirements for these two functions. In setting for ideal position indication, there is not adequate bypass of the torque

switch to assure valve operability; conversely, changes to satisfy the bypass requirements have resulted in false valve position indication. Hence, resetting of the "close" rotor to address open torque switch bypass concerns must be accompanied by an evaluation of the affect on position indication and other switches on the same rotor as necessary.

Plant Specifics: Davis-Besse has the indication problem caused by setting the open torque switch bypass because the valves have two rotor limit switches. The licensee's staff has recognized the problem, and in the interim, training has been provided to the operators to assure that they understood the indication anomaly. The licensee was planning on adding the necessary switch rotors to re-establish accurate position indication and was proceeding with this activity under Field Change Request No. 86-0031. This approach adequately resolved the indication anomaly.

(6) Open Torque Switch Bypass

Discussion: When an open torque switch is used, the bypass switch is required to bypass it during the initial portion of the open stroke so that the torque switch will not prematurely stop valve travel due to high torque conditions required for initial valve movement. There is no clear answer on where to set the bypass; but, if the valve disk (not the stem) has moved 20% of its total travel distance away from the seat when the bypass opens, this has been accepted as adequate.

Note in earlier discussion, Item (2) that the open torque switch is not a requirement. When it is used, however, it requires the bypass which has conflicted in use with the setting of the switch used for open valve indication. Hence, the use of any of these switches cannot be considered independently of the others.

Plant Specifics: The open torque switch bypass was set to assure at least 20% of disk motion was accomplished in the open direction before the torque switch was unbypassed. Diagnostic testing was performed to assure the setting adequacy. There are no further questions on this switch setting.

(7) Close Limit

Discussion: The close limit switch is not often used on rising stem valves. When it is, it is usually related to addressing a special valve problem or application and takes the place of the closure torque switch in opening up the motor circuit at the end of valve closure. The close limit switch may be used with a close torque switch in parallel. This provides torque switch backup for the limit switch. (The same switch in parallel with the torque switch would be called a close torque switch bypass).

While special considerations (particularly setting precision and repeatability) are involved, there are no known problems occurring with this application to be concerned about. This is probably due to the special attention this type of application receives, the fact that it may be a more reliable design than with the torque switch, and because the valve population using this feature is small.

Plant Specifics: None of the bulletin valves were wired to "close on limit." Motor rotation in all cases was stopped by actuation of the close torque switch.

(8) Close Indication

Discussion: Close indication is usually identified by the presence of a light that goes out only when the valve is fully open. Common practice has been to derive on/off contacts for this light from the Limitorque geared limit switch "open" rotor. This rotor turns 90° at the end of the open stroke to turn out the light, leaving the open indication light on to show a fully open condition. While concern exists for the point of setting for the open indication light, as indicated earlier, there has been no problem identified with the setting of the closed indication light switch.

Plant Specifics: There was nothing unusual nor any concern for the setting of this switch based on the inspection of the valve schematic diagrams or discussions with the licensee's staff

(9) Close Torque Switch Bypass

Discussion: The close torque switch bypass acts in the same manner as the open torque switch bypass; however, contrary to its counterpart's function, it normally bypasses the torque switch during the lightest duty portion of the stroke. It is not normally required to get the valve stroke started unless, perhaps, the valve has been backseated prior to the close stroke.

Some designs do not incorporate a close torque switch bypass while others use up to a 95% to 98% bypass to eliminate uncertainties with the close torque switch for as much of the valve stroke as reasonably possible. There appears to be merit to the extended bypass, especially if surveillance testing, maintenance, etc. are less than fully adequate in assuring torque switch setting accuracy.

Plant Specifics: The licensee used a close torque switch bypass which opened early in valve travel. Since the valves were properly guarded against backseating there was no concern with respect to this switch setting.

c. Butterfly Valves

Bulletin Valves No. 1382 and No. 1383 were butterfly valves which used torque switch protection in both the open and closed directions. Valve motion was stopped using limit switches in both directions.

Because the forces were balanced for the butterfly design involved, differential pressure was not a major concern. Nevertheless, differential pressure testing was performed and no problems were identified.

d. Maintenance of Correct Switch Settings

Action Item (d) of the bulletin required plant procedures be developed that would assure the maintenance of correct switch settings throughout plant life. To some extent, this involves all programmatic activities that assure long term valve operability because wear and degradation of either the valve or operator affect the adequacy of the torque switch settings. Also, maintenance and surveillance activities must properly consider all switch settings.

The licensee had initiated a long term program for assuring valve operability and was continuing to review this area to optimize its implementation. Appropriate maintenance procedures have been issued and post maintenance test requirements specified to assure that quality was maintained.

e. Toledo Edison Final Report Dated February 27, 1987

Toledo Edison's final report, as required by Action Item (f) of the bulletin was submitted February 25, 1987. Closeout of the bulletin is pending NRC review of this response.

3. Exit Interview

The inspectors met with licensee representatives (denoted in Paragraph 1) on June 26, 1987, to discuss the scope and interim findings of the inspection. The licensee acknowledged the statements made by the inspectors with respect to items discussed in the report. The inspectors also discussed the likely informational content of the inspection report with regard to documents or processes reviewed by the inspectors during this inspection. The licensee did not identify any such documents/ processes as proprietary. Further information was also requested to be evaluated in the Region III office. On December 17, 1987, the inspectors held a conference telephone exit with the licensee representatives, denoted in Paragraph 1, to present the results of this additional evaluation and summarize the results of the full inspection.