

Survey of Valve Operator-Related Events Occurring During 1978, 1979, and 1980

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ABSTRACT

The survey approach was to analyze several events and identify trends or patterns. The primary data source was licensee event reports (LERs) and consisted of 444 total valve operator events with 193 motor operator events which served as the basis for this study. The investigation revealed that motor-operated events could be grouped in three major categories which are torque switches, limit switches, and motors. The major findings are:

- (1) Torque switches do not appear to be a dominant cause of valve assembly inoperability. The reported information suggests torque switch events are an indication of symptomatic change with time in valve operability characteristics rather than a root cause of valve inoperability.
- (2) Repetitive problems are occurring with valve operators. It may occur on the same valve, a valve in similar service in a similar system, or a valve in similar service in a redundant train of the same system.
- (3) The plant operating staff objective appears to be a mode of finding measures to return inoperable equipment to operational status rather than to determine root causes of inoperability.
- (4) Motor burnout of valve motor operators has occurred quite frequently in High Pressure Coolant Injection (HPCI) and Reactor Core Isolation Cooling (RCIC) systems of BWR units.

The major conclusions offered to address the observed valve operator-related problems are as follows:

- (1) The existing recommendation or guidance in Regulatory Guide 1.106 to bypass thermal overload protective devices associated with safety-related valve motor operators should be reassessed.
- (2) Improved methods and procedures for the setting of torque switches should be developed and evaluated relative to valve operability and functional qualification under accident conditions.
- (3) Signature tracing techniques should be developed and tried on selected motor-operated valves as part of the periodic inservice testing program. The objectives of such methods should be to utilize them as an indicator of changes in operability characteristics (aging, inadequate adjustment or maintenance, etc.) and a predictor of the remaining margin to failure.

1. BACKGROUND

The primary thrust of this study was to review and assess operating experience relative to its applicability or implications for valve operability during performance of a safety function. The approach was to analyze licensee event report (LER) data to identify possible trends or patterns. Operating experience involving valve and valve operators has resulted in several reviews and recommendations by both NRC and industry groups. Some of the relatively recent topics are identified in references 1-9. The complete results of this study, including several tables with event descriptions, are provided in AEOD report C203, reference 10.

2. OVERVIEW OF VALVE OPERATOR EVENTS

The initial search of LER files covered events on all types of valve operators (motor, air, hydraulic, etc.) for the three-year span 1978, 1979, and 1980. The total number of valve operator events identified was 444 and of these, 193 were motor operator events.

From information obtained during the search, applicable events relating to motor operated valves were grouped into three categories for corrective action. These categories were torque switches, limit switches and motors. Of the 193 events, 46 involved corrective actions relating to torque switches. Typical corrective actions were replacement of the switches, cleaning of the associated switch contacts, or adjustment of the setpoint. The dominant corrective action for this set of events was the adjustment of torque switches.

For the remaining two categories, 24 events involved corrective actions associated with limit switches and 19 involved motors. Corrective actions for the limit switches were replacement of the switches, cleaning of switch contacts, or switch position adjustments. For the motors, corrective action was the replacement of the motor in nearly all cases.

Regarding the remaining 104 events, 23 were attributed to unknown causes, 9 were attributed to personnel error and the remaining 72 were attributed to a multitude of causes (such as blown fuse in control circuit, loose pinion gear, worn shaft clutch and clutch gear, broken or loose wiring, inoperable brake mechanism, frozen motor bearing, loose set-screw on motor pinion, loose packing gland and so on) but the number of events for each cause was not enough to explicitly identify a separate category. The 23 events attributed to unknown causes were not identified as a category since they provided no specific item or items as areas of concern, either directly or indirectly.

Based on a review of the reported information, it is highly questionable as to whether any of the three categories identified above indicates a dominant root cause or causes of inoperable motor operator valve occurrences. For example, it is questionable as to whether adjustments in torque switch settings indicate a change in the actual torque switch setting (i.e., the torque switch itself is the problem) or a change in the amount of torque required by the valve assembly due to changes in physical condition of the valve assembly or a change due to the fluid process which it controls. Similar reasoning may be offered for the limit

switch and motor corrective actions.

Accordingly, no dominant root cause of motor operator valve inoperability could be definitely established. However, the survey did establish that the categories identified, and possibly related items or factors, are excellent candidates for further study and may yet lead to a dominant root cause or causes for the valve inoperability concern.

3. FINDINGS AND EVALUATION

3.1 Motor Operator Events in General

The significant findings from the AEOD analysis and evaluation are listed below:

- (1) Motor operator events represent approximately 45% of all reported valve operator events and range as high as 77% of all valve operator events on some plants. This indicates that motor operators represent the greatest single category of LER reports on valve operators.
- (2) Corrective actions associated with torque switches represent approximately 23% of all reported events and are the largest single corrective action group. These corrective actions consist of replacing the torque switch, cleaning the associated switch contacts or adjusting the torque switch setpoint.
- (3) In 1980, adjustment was the largest single corrective action associated with torque switches.
- (4) Although torque switches are cited most frequently for corrective actions, they do not appear to be a dominant cause of valve assembly inoperability. However, the adjustment range inherent in the torque switch makes it amenable for use as a corrective measure to restore operability to an inoperable valve. Event reports show that torque switch adjustments (increasing or decreasing the settings) are frequently used to overcome the cited operability problem.
- (5) The manner in which the torque switch is referenced, and its adjustment as a corrective action, suggests torque switch events are an indication of symptomatic change in valve operability characteristics rather than a root cause of valve inoperability.
- (6) The event data indicates only five plants had three or more events related to torque switches. Thus, the data appear marginal for defining a trend or pattern for the group as a whole and are clearly insufficient for individual plant trends or patterns.
- (7) There are indications that the problem discussed in IE Circular 77-01 of inadequate adjustment of the limit switch to bypass the torque switch with subsequent failure of the valve to open, may still exist. In a related manner, LERs from two BWR plants reported that bypass wiring associated with the torque switches had not been installed as indicated on wiring diagrams (see Reference 11).
- (8) Most malfunctions are detected by a failure to perform during a required test.

3.2 Five Plants with Most Torque Switch Events

The five plants with the greatest number of torque switch-related events were selected for additional study. These plants are Arkansas 1, Hatch 2, Davis Besse 1, D.C. Cook 2, and Oconee 3. The LERs for these plants were reviewed for additional information to identify the problem, corrective action, and affected system. These five plants, which repre-

sent about 8% of the approximately 65 operating plants, were the only plants identified in the survey data to report more than three torque switch-related events in three years. Although there is the potential to observe some trends or patterns from these plants, it would seem unreasonable to expect individual plants in general to have sufficient information to perform such tasks.

The significant findings are:

- (1) Repetitive and similar problems are occurring with valve operators. The problem may be on the same valve or a valve in similar service in a similar system or a valve in similar service in a redundant train of the same system.
- (2) There is strong evidence that changes in valve operating characteristics are developing with time in service. This has resulted in adjustment of torque switches to higher settings and appears to be a possible basis for utility maintenance personnel to conclude that a torque switch is faulty or defective.
- (3) The plant operating staff objective appears to be a mode of finding corrective measures to return inoperable equipment to operational status rather than determine root cause of inoperability; i.e., a valve failed to perform correctly during a required operability test and actions were performed which resulted in the valve assembly passing the test. (Note: This is not intended to impugn an approach that may very well be the most effective use of the plant resources.)
- (4) Torque switch adjustment is frequently used to return an inoperable valve to operable status.
- (5) Initial motor, operator and valve component selections do not appear to take into consideration incremental changes in required operational characteristics for a valve assembly due to characteristic changes in related items such as increased leakage of an upstream check valve or temperature and other variations in process conditions.

3.3 Other Operator Events

One other item reported concerning torque switch-related problems is that of cleaning of contacts. Approximately 20% of torque switch events mention cleaning of contacts as part of the corrective action. There generally is insufficient discussion in the LER to draw conclusions in this area. Since only selected operators are provided with heaters, it may be possible that contact problems are related to moisture and/or contaminant accumulation.

Limit switch events are another item reported frequently under motor operated valves. There were 24 events over the three-year study period. Limit switch adjustments were the corrective action in 17 (about 71%) of the 24 events. Cleaning of contacts was reported in four events as the corrective action. Although there are several limit switch events, the total is only about 50% of the number of torque switch events and effectively is a much lower percentage because the population of limit switches is a factor of two or more greater than torque switches. Also, the limit switch is a position indicator and does not provide the same significance about changes in thrust requirements

as does the torque switch. Therefore, limit switch adjustments were not reviewed in detail.

There were 19 motor burnouts or failures reported under operator events for the three-year period. Most of the events were concentrated in HPCI and RCIC systems of BWR plants. The survey data contained only one such event which occurred at a PWR plant. In view of this concentration of events and the potential negative consequences if this were to occur during or following an accident, an additional review was conducted of this category. This review included both discussions with licensee personnel concerning this category and a limited search for motor burnout events subsequent to 1980 from which eight additional events were identified. The objective of this additional study was to establish a reason(s) for these occurrences. Some factors under consideration were undersized motors, bypassing of torque switches, bypassing of motor thermal overload protective devices, actuation repeatability of thermal overload protective devices, improper application or usage of motor operators, and inadequate valve assembly maintenance and surveillance test procedures and practices. Based on further review of specific motor burnout events and discussions with licensee and other technical personnel concerning these events, the only factors that appear related to motor burnout are: 1) bypassing of torque switches (for the complete opening stroke distance of the valve), 2) bypassing of motor thermal overload protective devices, 3) inadequate or inappropriate actual surveillance test practices, and 4) improper usage of the motor operator.

Although this review does not establish that bypassing of motor thermal overload devices is the sole reason for motor damage or burnout, it is clear that many of the burnout occurrences could have been precluded if properly sized motor thermal overload protective devices (see references 12 and 13) were installed in the attendant circuitry. Also, improper usage of the motor operator with particular regard to duty cycle appeared to be a contributor to motor damage or burnout. Further, selected stations that bypass motor thermal overload protective devices (even during surveillance testing) do not experience a lower rate of reported valve motor operator events. This tends to suggest that, based on actual field experience, bypassing of thermal overload protective devices would not increase operability of the valve assembly on demand for surveillance testing or accident conditions.

Another aspect that surfaced in this review concerns bypassing of the motor thermal overload device and its effect on the circuit breaker rating. Reference 14 indicates that "Overload relays should be included to provide the necessary impedance to maintain short-circuit ratings and to protect cable." It should be noted, however, that operating experience to date includes several events with circuit breaker trips in which the motor thermal overload protective device bypassed the attendant control circuitry and in such events we are not aware of any instances where the circuit breaker failed to provide the intended protection. However, Regulatory Guide 1.106 could be modified to clarify that bypassing of motor overload protective devices should not include bypassing their associated heating elements, since bypassing of these elements could lead to exceeding short

circuit ratings of the attendant circuit breakers with resulting unacceptable circuit and other types of damages.

Finally, regarding actuation repeatability of the bimetallic thermal overload devices, the review of this area indicated these devices are repeatable for practical application purposes provided their upper temperature limit has not been exceeded and their surrounding ambient temperature remains essentially constant. However, if the motor current increases significantly, the upper temperature limits of these devices can be exceeded and the trip actuation setpoint will tend to increase due to the associated thermal stresses which the device will experience. Therefore, if the trip actuation setpoint of the bimetallic overload relay changes (increases) and motor terminal voltage along with the surrounding ambient temperature of the device has remained essentially constant, it would indicate that motor current has increased significantly to permit the motor to overcome increased mechanical load including aging mechanisms.

The significant findings are:

- (1) Most of the motor burnout events which occurred at BWR stations are in the HPCI and RCIC systems. Some failures were reported to be caused by electro-mechanical failures of other parts and perhaps moisture. There may be a relationship between recommendation number one in Regulatory Guide 1.106 concerning bypass of thermal overload devices and the relatively large number of motor burnouts reported. Also, there appears to be a relationship between permanent bypassing of torque switches, improper usage of motor operators, and motor burnout occurrences.
- (2) Actual operating plant experience with motor operators indicates that bypassing motor thermal overload protective devices during surveillance testing has not resulted in an increased operability of the valve assembly on demand. This tends to suggest that bypassing motor thermal overload protective devices during accident conditions would not increase the operability of the valve assembly on demand.
- (3) The review of selected nuclear units which are bypassing protective devices on motor operators shows that this recommendation is being implemented by removal of the protective device contacts from the associated control circuitry while retaining the heater elements within the motive power circuit. If bypassing of the protective devices on motor operators is to be implemented, then the practice just mentioned is desirable since complete bypassing of the protective devices could result in exceeding the short circuit rating of the attendant circuit breaker with resulting unacceptable circuit and other types of damages.

4. CONCLUSIONS

The findings and evaluations of this study suggest there are two general aspects that can contribute to resolution of the inoperability problem of valve motor operators. One aspect pertains to approaches or methods to aid in identification and definition of valve motor operator-related problems and the other pertains primarily to technical issues that can be addressed by definitive action.

For identification and definition, reported information should be explicit and factual.

In particular, it should identify the component, explain what happened, determine and discuss why it happened, identify implications for operability of the component within the system, and state corrective actions. Also, since each plant has only a few reported events, it is most likely that data analysis for trends and patterns is not feasible for individual licensees. However, it would seem that a single group (national, industry, etc.) with overview cognizance could perform a valuable service with additional detailed review and evaluation of operational data on valve motor operator events. Such a review could be limited to events involving torque switches, limit switches and motors together with related factors. The objective of this review could be to explicitly identify root cause(s) of events related to these three areas and recommend specific solutions to eliminate them. Such a group could consist of individuals possessing detailed knowledge of valve motor-operated designs, specific nuclear plant operational experience with these designs, specific surveillance and maintenance practices and procedures for these designs when they are used in a nuclear power station, and particular usage of given designs in a given nuclear power plant application. Our perception of this group is that it would concentrate on positive actions and recommendations to solve or correct problems in contrast to a response of a study group.

Some specific technical conclusions are as follows:

- (1) The existing USNRC recommendation or guidance in Regulatory Guide 1.106 to bypass thermal overload protective devices associated with safety-related valve motor operators should be reassessed.
- (2) Improved methods and procedures for the setting of torque switches should be developed and evaluated relative to valve operability and functional qualification under accident conditions.
- (3) Signature tracing techniques (such as measurement of electrical current and voltage applied to the motor or the measurement of the actual valve stem torque or thrust during valve operation) should be developed and tried on selected motor-operated valves as part of the periodic inservice testing program. The objectives of such methods should be to utilize them as an indicator of changes in operability characteristics (aging, inadequate adjustment or maintenance, etc.) and a predictor of the remaining margin to failure.
- (4) Positive steps should be taken to assure that adequate consideration is given to aging and margin requirements for valve assembly qualification and inservice operability.
- (5) Additional action is warranted on the problem discussed in IE Circular 77-01 of inadequate adjustment of the limit switch to bypass the torque switch because similar events continue to be reported.

REFERENCES

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