AEOD/S503

EVALUATION OF RECENT VALVE OPERATOR MOTOR BURNOUT EVENTS

Special Study Report

Office for Analysis and Evaluation of Operational Data

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NOTE: This report documents results of studies completed to date by the Office for Analysis and Evaluation of Operational Data with regard to particular operating events. The findings, conclusions and recommendations contained in this report are provided in support of other ongoing NRC activities concerning these events. Since the studies are ongoing, the report is not necessarily final, and the findings and recommendations do not represent the positions or requirements of the responsible program office of the Nuclear Regulatory Commission.

TABLE OF CONTENTS

EVALUATION OF RECENT VALVE OPERATOR MOTOR BURNOUT EVENTS

SUMMARY

AEOD has been monitoring operating events pertaining to motor operated valves since the issuance of AEOD Case Study C203 in May, 1982, which reviewed events during 1978, 1979, and 1980. One issue covered by that report was a recommendation addressing valve operator motor burnout. Because of recent events, AEOD conducted a limited review and evaluation of a few events.

Based on the limited review, it has been concluded that valve operator motor burnout continues to pose a potential safety problem. The data corroborates the original AEOD recommendation in C203 relative to a reassessment of Regulatory Guide 1.106 concerning bypassing of thermal overload (TOL) devices. Although only a few events were reviewed and analyzed, additional search techniques have identified more than 180 events subsequent to the original 19 events in C203. These additional events cover the time frame from 1981 to early 1985. Accordingly, it is recommended that the Office of Nuclear Reactor Regulation use this report as a basis to expedite implementation of the NRR proposed plan to address valve operator motor burnout and a reassessment of Regulatory Guide 1.106.

BACKGROUND

A previous AEOD study issued in May, 1982 (Reference 1, AEOD/C203) provided recommendations addressing several deficiencies pertaining to valve assembly inoperability. One of those recommendations involved reassessment of the guidance in Regulatory Guide 1.106 (Reference 2) concerning bypassing thermal overload devices because of valve operator motor burnout events experienced from 1978 through 1980. This recommendation has been under consideration in NRR and would be addressed by the proposed task action plan that was developed in July, 1984 (References 3 and 4) to resolve Generic Issue II.E.6.1. This proposed action plan, however, has not yet been approved.

The primary purpose of the thermal overload (TOL) device is to protect the valve operator motor from damage and degradation due to overheating and to provide an alert of an off normal situation by tripping and stopping operation of the motor. In contrast, the underlying concern of Regulatory Guide 1.106 was to prevent valve inoperability due to spurious tripping of the thermal overload device by guidance to bypass the device and/or use conservative sizing with respect to motor current. Therefore, the intent for both the presence of the TOL device and the guidance in the Regulatory Guide is to ensure that the valve operator motor is capable of operating when needed. But, in practical terms, operating plants have experienced premature valve operator motor burnout which illustrates a lack of motor protection.

DISCUSSION

Since the issuance of AEOD study C203, AEOD has been monitoring operating events involving motor burnout. This monitoring indicated that these events were continuing and increasing in frequency. As a result, we initiated a limited evaluation of data accumulated subsequent to that used for the study in

Reference 1 which covered the years 1978, 1979, and 1980. Data involving TOL devices associated with motor burnout that was obtained from the Sequence Coding and Search System (SCSS) is presented in Appendix A. The data, consisting of 14 events, is arranged by plant docket number, LER number, and a brief description based on a review of each LER and all attached documents. One event, item 14, was obtained from an inspection report rather than SCSS (the event was not reported by LER). Since the purpose of the valve operator motor TOL device is to protect the motor and alert plant staff of potential valve operability problems, the event description concentrates on available information concerning motor protection, nature of damage, TOL bypass features, and control room alarms.

Whereas past studies had identified valve motor burnout as predominantly occurring at BWRs, the recent data covers both BWRs and PWRs. Additionally, a recent AEOD study on valve operator hammering (Reference 5) identifies 17 events that involved motor burnout (five events are also part of Appendix A). Also, Reference 6 identifies four motor burnout events that involve premature degradation of motors due to oversized TOL devices. Hence, the data in Appendix A, and References 5 and 6 represent 30 new valve operator motor burnout events since the initial 19 failures analyzed in the 1982 Case Study (Reference 1).

These recent events continue to support questions concerning the effectiveness of the TOL device in providing protection to the valve operator motor. Most of the events in Appendix A indicate that the TOL device was not providing protection because it did not trip prior to motor damage. In fact, several of the event reports identify concurrent TOL trip or TOL burnout and discovery of motor burnout. Also, several of the events indicate the valve operator motor continued to run after completion of the intended operation which culminated with eventual motor burnout without TOL protection or alarm in the control room.

The events in Appendix A corroborate the previous conclusion that valve operator motors continue to burn out and are not being protected and failures can be undetected. The burnout events include situations in which the TOL device was always in the valve circuit or there was permanent bypass of the TOL device or bypass of the TOL device at some time. In particular, item 12 is an example of undetected motor burnout shortly after a surveillance test (a few seconds or minutes) even though the explicit guidance in Regulatory Guide 1.106 was utilized; i.e., the TOL device was continuously bypassed and only placed in force during periodic or maintenance testing. The reason for lack of detection was that there was no TOL alarm in the control room with the test/bypass switch in the bypass position prior to actuation of the TOL device.

The other items in Appendix A appear to indicate lack of TOL protection because either the TOL device was oversized (such as 300% of full load current) or the TOL devices were routinely reset after the trip without an attempt to determine the root cause of the TOL trip. In addition to lack of TOL protection, item 14 illustrates a potentially serious side effect of the motor burnout mode of failure. In that event, the closing torque switch did not stop the motor when the valve reached the fully closed position. Also, the TOL device was sized at 300% of the full load current and did not trip to stop the motor. The motor housing was found cracked open (see Figure 1) and dislocated sufficiently to cause the internal mechanism to jam which also prevented manual operation of

the valve. Hence, motor burnout resulted in loss of both motor and manual operational modes of the valve. This aspect could have serious implications involving several safety systems that have valves outside containment where valve operability may have been presumed assured by manual means (although possibly delayed) even if the valve operator motor was damaged. Therefore, this event appears to represent a potential generic failure mechanism which could prohibit both remote and manual valve operation.

The operating experience reviewed and analyzed in AEOD reports (References 1, 5, 6, and this report) represents approximately 50 events (19 during 1978 to 1980 and about 30 during 1981 to early 1985) associated with valve operator motor damage or burnout. Although these approximately 50 events provide a sufficient basis to draw conclusions and raise safety concerns, they do not and were never intended to represent a comprehensive list of such events. In order to identify other motor burnout events, additional data searches were conducted and resulted in an additional 150 burnout events. These searches covered the time period 1981 to early 1985 and utilized data sources as follows:

(1) Events reported by LER as retrieved from SCSS and RECON, and a limited review of LER abstracts for four plants in the DCS (see Appendix B for a list of events);

(2) Limited search of the NPRDS.

Thus, the more than 200 motor burnout events clearly indicate a lack of valve operator motor protection which illustrates that TOL devices are not being used effectively to provide protection against motor overheating. This situation, therefore, suggests that the failure mechanism (burnout) is potentially a common mode failure for a given plant because it appears related to an overall attitude or modus operandi concerning the design and operation of MOVs, and the valves' TOL sizing, bypassing of TOL devices, alarms, and surveillance procedures in use at the plant. The apparent increasing rate of burnout events suggests a need to at least determine the primary root causes of valve operator motor burnout even though it would seem unlikely that licensees could identify and correct all causes of failure. Therefore, available devices that protect against valve operator motor burnout should be correctly utilized as a means to reduce the number of burnout events.

Burnout of valve operator motors is a potentially significant safety concern for the following reasons: (a) Motor operated valves are used extensively in safety systems; (b) motor failure can be a common mode mechanism for a given plant based on their overall philosophy covering TOL devices and surveillance procedures; (c) the failed motors can remain undetected for long periods of time; and (d) motor burnout has resulted in damage to the valve operator that prevented valve operability by both motor and manual drive mechanisms.

FINDINGS AND CONCLUSIONS

The total number of events (200) reviewed in this report provide conclusive evidence that valve motor burnout is a serious problem. The motor burnout events illustrate that ineffective utilization of TOL devices has resulted in situations that (a) remove or severely limit TOL protection for the valve operator motor or (b) prohibit detection of failed valve operator motors. The following findings are provided:

(1) Valve operator motor burnout is still occurring and it appears to occur more frequently (180 events identified for the most recent 4 years compared to 19 events for the 3 year span 1978, 1979, and 1980).

(2) Motor burnout is a potentially significant safety concern because: (a) Motor operated valves are used extensively in safety systems; (b) for a given plant, the mechanism can be common mode failure; (c) failure can be undetected for long periods of time; and (d) the failure could prevent both motor and manual operation of the valve. This also suggests a need to determine the root cause of motor burnout.

(3) Although the root cause (or causes) of motor burnout may be complex and not fully understood, it is evident there is a lack of valve operator motor protection. Hence, there is a need to further address motor burnout including reassessment of Regulatory Guide 1.106 as recommended in AEOD Case Study C203 (Reference 1).

In view of this situation, we recommend that NRR consider the findings of this report to expedite implementation of the NRR proposed plan to address valve operator motor burnout, including reassessment of Regulatory Guide 1.106.

REFERENCES

1. NRC, E. J. Brown and F. S. Ashe, "Survey of Valve Operator Related Events Occurring During 1978, 1979, and 1980," AEOD/C203, May 1982.

2. NRC, Regulatory Guide 1.106, "Thermal Overload Protection for Electric Motors on Motor-Operated Valves," Revision 1, March 1977.

3. NRC, R. J. Bosnak to W. Minners, "Status of Potential Generic Issue 54, Valve Operated Related Events Occurring During 1978, 1979, and 1980." March 26, 1984.

4. NRC, J. P. Knight to R. H. Vollmer, "MEB Task Action Plan for Resolution of Generic Issue II.E.6.1, In Situ Testing of Valves," July 30, 1984.

5. NRC, M. Chiramal, "Motor Operated Valve Failures Due to Hammering Problem," AEOD/E501, January 17, 1985.

6. NRC, E. J. Brown and F. S. Ashe, "Inoperable Motor Operated Valve Assemblies Due to Premature Degradation of Motors and/or Improper Limit Switch Torque/Switch Adjustment," AEOD/E305, April 18, 1983.

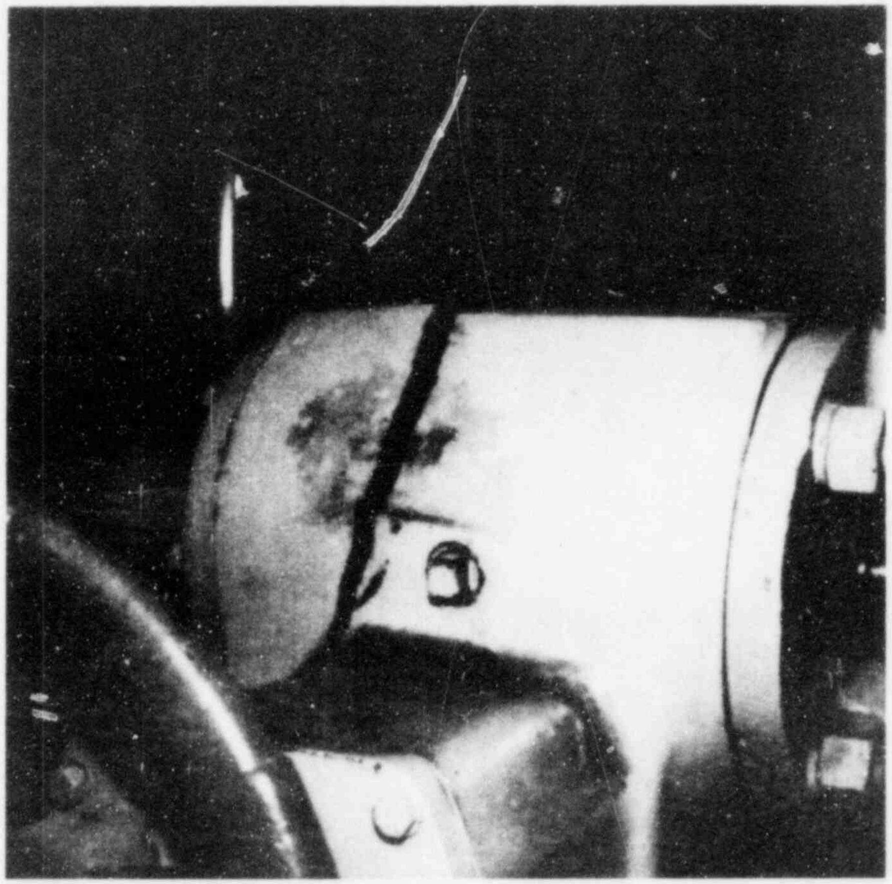

Fig. 1 Failed SMB-0 Motor Operator For Valve 39A

Appendix A

MOTOR OPERATED VALVE EVENTS INVOLVING THERMAL OVERLOAD DEVICES AND MOTOR BURNOUT

Docket and Plant	LER No.	Event Description
1. 237 Dresden 2	83-024	Core spray valve failed to open. After several attempts TOLS tripped. Motor was found burned out.
2. 245 Millstone 1	84-015	While restoring valve lineup after an Isolation Condenser Functional and Calibration Test, the isolation condenser isolation valve, 1-IC-3, motor TOL and 125 volt dc ground alarms annunciated in the control room. Out-of-adjustment limit switch caused motor to run after disc reached full closed position and motor was extensively damaged, and subsequently failed in full closed position.
3. 245 Millstone 1	84-018	Operation of outboard isolation condenser condensate return valve, 1-IC-3, became erratic. Subsequently, the motor overloaded and the circuit breaker began to smoke. Out-of-adjustment limit switch caused motor to run beyond the full closed position with extensive motor damage and the valve failed in full closed position.
4. 271 Vermont Yankee	82-014	Outboard RWCU system isolation valve, V12-18, would not open. The TOL was found tripped. Valve was manually lifted off the seat. One half hour later the TOL was reset and the valve opened electrically. About 10 minutes later there was loss of indication on V12-18 and an RWCU pump trip. The valve breaker was tripped and the motor had failed.
5. 272 Salem 1	84-021	Containment isolation valve received close signal but would not reopen on operator demand (open light did not come on). The TOL device was jumpered in the control circuit which implied no TOL protection. The stem nut was not staked such that valve never closed and motor kept running and burned out.

Docket and Plant	LER No.	Event Description
6. 293 Pilgrim	82-042	During a surveillance timing test, HPCI torus suction valve, MO-2301-35 did not operate. An open field winding was found on the operator motor. Due to its required service, the motor has no TOL or torque switch protection.
7. 298 Cooper	81-003	During surveillance test on 2/23/81, the outboard drywell spray isolation valve, RHR-MO-26B, motor current increased and remained high when the valve reached the closed position. If the motor breaker had not been manually tripped, the motor would have overheated and failed in the closed position. (Test procedure appears to have detected high current before TOL tripped.) Similar event occurred on 11/3/80.
8. 302 Crystal River	83-009	During surveillance testing on 2/22/83, the emergency feedwater pump failed to start because the steam supply valve, ASV-5, failed to open. The cause was reported as motor burnout due to a failed torque switch. Discussions with the licensee revealed that subsequent investigation determined the TOL was sized for continuous duty which was a misapplication, the torque switch was set incorrectly, and the TOL is not alarmed on a trip (see LER 83-042 also).
9. 302 Crystal River	83-042	During surveillance testing on 9/27/83, the motor on steam supply valve, ASV-5, for EFW pump 2 burned up. The cause was initially reported as a faulty torque switch. A subsequent LER revision 1 identified the cause as a stuck contactor believed to be caused by a sticky substance such as cable pulling lubricant.
10. 369 McGuire 1	81-152	Steam Generator 1C main feed to AFW nozzle isolation valve would not operate and was manually shut. Both the motor and TOL device were found burned out. The motor was replaced and a functional verification performed. After completion of the timing test, a TOL alarm was received. The second failure involved a mechanical latch malfunction causing internal components to fail and the actuator hammered until it broke.

Docket and Plant	LER No.	Event Description
11. 387 Susquehanna 1	83-111	With the unit at 100% power, it was found that the cooling water supply valve, HV-156F059, to the HPCI lube oil cooler and barometric condenser would not cycle. The valve motor was burned out due to insulation breakdown.
12. 387 Susquehanna 1	83-129	Motor operated valve, HV-156F059, would not operate from the control room. The torque switch failed to open at the specified torque. The motor continued to run and burned up on over torque with a locked rotor. The TOL bypass circuit design was found to give an erroneous indication in the control room in that if the MOV test/bypass switch were to be returned to the bypass position prior to actuation of the TOL, then no alarm would occur. (IE IN 84-13 was issued on this event.)
13. 387 Susquehanna 1	83-140	Valve which controls cooling water flow to the HPCI lube oil cooler and barometric condenser would not operate. This is additional information about LER 83-129. TOL, motor windings, armature and brushes were burned. Torque switch failed to open due to grease, one spring pack Belville washer was installed backwards, and the thrust washer/sleeve gap was too small.
14. 271 Vermont Yankee	Inspection Report 50-271/84-08	Torus cooling was secured by closing upstream isolation valve V10-39A. Approximately one minute after closing, a 125% overload condition was annunciated in the control room and the circuit breaker tripped open. Torque switch had not stopped motor when valve closed. Motor circuit shorted and caused magnetic overcurrent trip. The TOL was set at 300% and did not actuate to de-energize the motor to provide protection. Motor operator housing was cracked and prevented both motor and manual operation of the valve.

Appendix B

ADDITIONAL VALVE OPERATOR MOTOR BURNOUT EVENTS

(LER NUMBER BY DOCKET NUMBER)

237/83-052, Rev. 1

237/83-052

245/84-014

245/81-040

259/80-072

263/82-017, Rev. 1

271/81-023

278/81-018

280/81-075

281/81-052, Rev. 1

281/81-052

291/83-026

293/80-044

293/81-008

315/81-004

320/80-048

321/82-088

321/82-041

324/81-013

324/81-082

324/81-029

324/81-019

325/81-014

325/81-013

328/81-115

334/80-011

361/82-103, Rev. 2

361/82-103

362/83-022, Rev. 1

362/83-022

366/79-086

366/80-109, Rev. 1

366/80-109

366/80-089

366/80-101

366/81-074

366/81-088

366/81-117

366/81-114

366/79-114, Rev. 1

366/81-142

368/81-026

369/81-159

369/81-150

369/81-121

369/81-120

416/83-168