UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555

June 23, 1988

NRC INFORMATION NOTICE NO. 88-43: SOLENOID VALVE PROBLEMS

Addressees:

All holders of operating licenses or construction permits for nuclear power reactors.

Purpose:

This information notice is being provided to alert addressees to a series of solenoid valve failures that have occurred at several nuclear power plants. It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this information notice do not constitute NRC requirements; therefore, no specific action or written response is required.

Description of Circumstances:

On October 29, 1987, at Perry Unit 1, during performance of stroke time testing, three of eight MSIVs failed to fast close as designed. The stroke time testing was being performed in accordance with a startup test procedure. Two of the three affected valves were inboard and outboard MSIVs in the same main steam line, which would be a significant safety problem in the event of a failure of that main steam line. Subsequently, on November 3, 1987, at Perry Unit 1, during performance of stroke time testing, two out of eight MSIVs again failed to fast close as designed. The stroke time testing was being performed as the result of the previous failures in preparation for performing the full reactor isolation startup test. The affected valves were the inboard and outboard MSIVs in the same main steam line and were the same valves that had failed on October 29. Details may be found in Augmented Inspection Team (AIT) Report No. 50-440/87024.

The licensee's investigation isolated the cause for the MSIV failures to the Automatic Switch Company (ASCO) Model NP-8323A20E dual solenoid operated valves (SOVs) that serve them. The failure mechanism could not be positively identified, but the most likely cause was determined to be degradation of the Ethylene Propylene Diene Monomer (EPDM) elastomer seats due to exposure to a high temperature environment. The high temperature environment was the result of several

steam leaks in the vicinity of the failed SOVs. Although the degradation of the EPDM seat also was considered to have been possibly caused by hydrocarbon contamination, this possibility was later discounted (see "Discussion"). Inspection of the SOVs indicated that an annular impression had been cut in the exhaust port seat material resulting in part of the seat material being extruded into the exhaust orifice. This, together with the deteriorated state of the seat material, indicated that the exhaust seat could be held in an "energized" position, even though the solenoids had de-energized. This would prevent the control air from being exhausted to atmosphere and thus prevent the MSIV from closing. The licensee subsequently replaced three of the SOVs and rebuilt the remaining five SOVs.

The third event also occurred at Perry. On November 29, 1987, the licensee was performing a MSIV special operability check when it was found that one inboard MSIV did not function properly. The licensee was performing the special operability checks as the result of commitments made in response to the previously discussed problems with MSIV closure. The operability check consisted of depressing the slow closure "test" pushbutton and allowing the MSIV to fully close. The control switch was then placed in the "close" position and the "test" pushbutton released. During this operability check, one MSIV did not remain shut when the test pushbutton was released. If the fast closure SOV shifts state per design, the MSIV will remain closed; if it fails to shift state, the MSIV will reopen. Subsequent attempts to close the MSIV by placing the control switch in the "close" position also failed. Following plant shutdown, licensee personnel and the Senior Resident Inspector made a drywell entry to observe the MSIV during a closure attempt. During this test, the valve stayed in the open position until the SOV was gently tapped. The MSIV responded by closing with a normal stroke time. Details may be found in Augmented Inspection Team (AIT) Report No. 50-440/87027.

The licensee's investigation isolated the cause for the MSIV failure to the ASCO Model NP-8323A20E SOV. Inspection of the SOV revealed the presence of a sliver of foreign material and two smaller particles of foreign material in the "B" solenoid housing assembly. The material was later identified as EPDM from one of the O-rings in the SOV that was replaced as part of the corrective action to the event of November 3, 1987. No other signs of SOV degradation were evident. The licensee concluded that the root cause of the failure of the MSIV to close was mechanical binding of the ASCO SOV by the sliver of EPDM material. The mechanical binding resulted in the exhaust seat being held in an "energized" position even though the solenoids had been de-energized. This prevented the control air from being exhausted to atmosphere and prevented the MSIV from closing. Subsequently, the licensee replaced all eight MSIV SOVs.

A fourth event involving an MSIV failure occurred at LaSalle Unit 1 on December 17, 1987. The plant was in hot shutdown following a reactor scram resulting from a feedwater transient. The licensee was in the process of closing the MSIVs to allow repair work on balance-of-plant equipment. The

method being used to close the MSIVs was the same as discussed above for Perry's fast closure operability check. During the course of closing the MSIVs, one of the outboard MSIVs reopened. Examination of the SOV internals revealed that the interfacing surfaces of the core assembly and the plugnut assembly of the "B" solenoid had a thin layer of a yellowish/amber, sticky substance coating them. When the interfacing surfaces of these components were pressed together (as they would be when energized) and then released, the core assembly would hang from the plugnut assembly with no support. The licensee concluded that the film between the core assembly and the plugnut assembly acted like an adhesive and prevented the core assembly from shifting to the de-energized position. This failure mode is very similar to MSIV failures that occurred at Grand Gulf in 1985 (reported in Information Notices 85-17 and 85-17, Supplement 1, "Possible Sticking of ASCO Solenoid Valves") in which a similar appearing substance was found in the same locations.

In response to the failure, the licensee and ASCO inspected the other SOVs. A thin layer of a similar appearing substance to that found in the failed SOV was found on the interfacing surfaces of the "B" solenoid core assembly and plugnut assembly in all cases. The licensee collected samples of the substance and had it analyzed. This analysis determined that the substance was primarily silicon in nature. Further investigation by the licensee revealed that ASCO routinely lubricates the core assembly/plugnut assembly interfaces with Dow Corning 550 silicon based lubricant to reduce noise and wear associated with 60 Hz hum (the SOVs environmental qualification did not explicitly consider the use or non-use of the lubricant). Their analysis stated that the thin film substance closely resembled the Dow 550 lubricant. Additional investigation by the licensee found that the Dow Corning product literature indicated that Dow 550 begins to gel after 14 months at 200°C. The time for Dow 550 to gel appears to lessen exponentially as the temperature increases. A Dow Corning Technical Service representative also indicated that, while Dow 550 is clear when new, it turns an amber color and becomes tacky when baked long enough.

The adverse effect of a solenoid valve failure is not limited to MSIV failure, even though this IN focuses on MSIVs. For example, on January 2, 1988, two redundant containment isolation valves on the drywell drain systems line at Brunswick Unit 2 failed to close; these isolation valves utilize solenoid valve design ASCO Model 206-832. Even though the licensee was not able to determine the root cause of failure with certainty, there appears to have been a mechanical sticking problem. The solenoid valve was in a closed position for an extended period of time, and would not vent when first called upon to open. Details may be found in Augmented Inspection Team (AIT) Report Nos. 50-325/8803, 50-324/8803.

Discussion:

As a result of the failure at Perry on November 3, 1987, the licensee began a detailed physical and chemical testing program in an attempt to pinpoint the

failure mechanism. In conjunction with this, the licensee instituted an environmental testing program. The environmental testing program consisted of baking ASCO Model NP-8323A20 SOVs (both with Viton and EPDM elastomers) in three ovens with each oven at a different temperature. SOVs within each oven were cycled at varied frequencies. The purpose of this environmental testing was to further confirm the root cause of the failures experienced, to establish a threshold temperature of EPDM degradation and to perform a comparison with Viton material. Results of the physical and chemical testing substantiated the previous conclusion of heat degradation as the root cause of the failures and eliminated hydrocarbon degradation of the EPDM as a possible cause. In addition, the chemical analyses revealed the presence of stearate compounds on the surface of the EPDM material.

The independent laboratory retained by the licensee to perform the analyses indicated that the stearate had migrated from the EPDM as a result of heat degradation. They postulated that the presence of the stearate compounds on the surface would probably act like glue and further increase the force necessary to separate the seat and exhaust port during SOV deenergization. Results to date from the environmental testing program have been several failures of the SOVs to cycle per design with less than 30 days in the highest temperature oven (temperature high enough to obtain a SOV body temperature of 284°F). The SOVs that have failed have had both EPDM and Viton elastomers. The analysis of the failed SOVs is not yet complete; however, evidence from this testing and from other failures that have occurred, as discussed in this IN, indicates that the failure mechanism for some failures is temperature dependent.

There have been a multitude of solenoid valve failures at U.S. nuclear power plants over the past 15 to 20 years, especially with regard to solenoid valves used for MSIV closure, where there have been several dozen failures. At various times the NRC has issued several forms of communications to alert the industry to these potentially significant failures. A selection of these include: IE Circular 81-14, "Main Steam Isolation Valve Failures to Close," November 5, 1981, which described 17 different PWR and BWR units that have experienced anywhere from one to nine fast closure solenoid valve failures on MSIVs; IN 85-17, "Possible Sticking of ASCO Solenoid Valves," March 1, 1985, which described a February 10, 1985 event at Grand Gulf in which three MSIV fast closure solenoid valves failed; and IN 86-57, "Operating Problems With Solenoid Operated Valves at Nuclear Power Plants," July 11, 1986, which described a September 27, 1985 event at Brunswick 2 in which three MSIVs (2 in 1 line) failed to close due to failure of their ASCO fast closure valves.

Addressees may wish to review past NRC generic communications as well as vendor and other industry information concerning solenoid valve problems to ensure that their maintenance, repair, and replacement practices have effectively utilized available knowledge from solenoid valve operating experience.

No specific action or written response is required by this information notice. If you have any questions about this matter, please contact one of the technical contacts listed below or the Regional Administrator of the appropriate regional office.

Charles E. Rossi

Charles E. Rossi, Director
Division of Operational Events Assessment
Office of Nuclear Reactor Regulation

Technical Contacts: Roger D. Lanksbury, RIII
(815) 357-8611

T. Jerrell Carter, Jr., NRR
(301) 492-1194

Attachment: List of Recently Issued NRC Information Notices

LIST OF RECENTLY ISSUED
NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
88-42	Circuit Breaker Failures Due to Loose Charging Spring Motor Mounting Bolts	6/23/88	All holders of OLs or CPs for nuclear power reactors.
88-41	Physical Protection Weaknesses Identified Through Regulatory Effectiveness Reviews (RERs)	6/22/88	All holders of OLs or CPs for nuclear power reactors.
88-40	Examiners' Handbook for Developing Operator Licensing Examinations	6/22/88	All holders of OLs or CPs for nuclear power reactors.
88-39	LaSalle Unit 2 Loss of Recirculation Pumps With Power Oscillation Event	6/15/88	All holders of OLs or CPs for BWRs.
88-38	Failure of Undervoltage Trip Attachment on General Electric Circuit Breakers	6/15/88	All holders of OLs or CPs for nuclear power reactors.
88-37	Flow Blockage of Cooling Water to Safety System Components	6/14/88	All holders of OLs or CPs for nuclear power reactors.
88-36	Possible Sudden Loss of RCS Inventory During Low Coolant Level Operation	6/8/88	All holders of OLs or CPs for PWRs.
88-35	Inadequate Licensee Performed Vendor Audits	6/3/88	All holders of OLs or CPs for nuclear power reactors.
88-34	Nuclear Material Control and Accountability of Non-Fuel Special Nuclear Material at Power Reactors	5/31/88	All holders of OLs or CPs for nuclear power reactors.
87-61, Supplement 1	Failure of Westinghouse W-2-Type Circuit Breaker Cell Switches	5/31/88	All holders of OLs or CPs for nuclear power reactors.

OL = Operating License
CP = Construction Permit

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It should be noted that I deleted a portion of the material originally included by the authors in this information notice because I believed it was too preemptive. This part and my reasons were discussed with Hub Miller in Region 3 on 6/22/88. I did not consider it necessary to ask for Region 3 to concur in my decision.
C.E. Rossi
6/22/88

Transmitted by memo from Edward G. Greenman to C. E. Rossi, "Proposed NRC Information Notice on ASCO Solenoid Operated Valve Failures," dated March 22, 1988.

*SEE PREVIOUS PAGE FOR CONCURRENCE

useful draft IN even though contained more material info.

EAB:NRR	EAB:NRR	*TECH:ED	C:EAB:NRR	C:GCB:NRR	D:DOEA:NRR
JCarter:db	PBaranowsky		WLanning	CHBerlinger	CERossi
6/21/88	6/21/88	4/19/88	6/21/88	6/ /88	6/22/88

Specific items to be inspected to determine the root cause should include, but not be limited to: hardening of the elastomer material; distortions such as annular impressions being cut into the seat elastomer (note - minor seat impressions are normal); swelling and softening of the elastomer material; flaking of the body gaskets (o-rings); a yellowish/amber, tacky substance on the core assembly/plugnut assembly interface; and/or deposits of foreign materials on valve internals. In addition to the above, the air from the air system feeding the SOV should be analyzed for dew point, particulate matter and hydrocarbons. The rebuild should be complete (i.e., use of all components included in the rebuild kit). Care should be taken to ensure that no foreign material is introduced into the SOV and that all portions of the SOV internals not being replaced are thoroughly cleaned.

Since one of the failure mechanisms postulated by licensees indicated that use of the ASCO supplied lubricant (Dow 550) may be involved in causing the SOV to fail, licensees may not which to use it during the rebuild except for judicial use on the body gaskets (o-rings). If a new SOV is installed, cleaning the internal moving parts to remove the lubricant may be beneficial.

No specific action or written response is required by this information notice. If you have any questions about this matter, please contact the technical contact listed below or the Regional Administrator of the appropriate regional office.

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