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Al Kaplan
VICE PRESIDENT
NUCLEAR GROUP

February 12, 1988
PY-CEI/OIE-0303 L

Mr. A. Bert Davis
Regional Administrator, Region III
U.S. Nuclear Regulatory Commission
799 Roosevelt Road
Glen Ellyn, Illinois 60137

Perry Nuclear Power Plant
Docket No. 50-440
MSIV Solenoid Testing Update

Dear Mr. Davis:

This letter provides an update on the results of the physical and chemical testing of the MSIV solenoid elastomer materials as well as an interim report on the progress of environmental testing. Conclusions drawn from this data to date support the root cause evaluations performed for the recent solenoid failures documented in our letter dated December 30, 1987 (PY-CEI/OIE-0297 L).

Both the chemical and environmental testing re-substantiates the conclusion of heat degradation as the root cause for the November 3 event. Additionally, the recent information is considered to have no impact upon the conclusion of mechanical binding for the November 29 event. Completion of the physical and chemical analyses of the EPDM components concludes all investigations associated with both the November 3 and November 29 events. The only testing remaining is the Environmental qualification testing (EQ), as well as the solenoid inspection currently planned for October, will continue as originally scoped. A final report detailing the EQ results is expected to be submitted in April 1988.

Very truly yours,

M. D. Lyster for

Al Kaplan
Vice President
Nuclear Group

AK:cab

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K. Connaughton
Document Control Desk

I. Main Steam Isolation Valve Stroke Testing

In accordance with our commitments following the November 29, 1987 event as documented in our letter dated December 30, 1987 (PY-CEI/NRR-0297 L), the modified monthly slow closure surveillance was performed weekly on a staggered basis until the January 1988 outage. Each test was completed satisfactorily. The modified surveillance verified proper operation of the dual solenoid by fully closing each Main Steam Isolation Valve (MSIV) utilizing the test solenoid, followed by taking the control switch to close. Stroke testing will be performed once every two weeks on a staggered basis until February 28, 1988 at which time the testing frequency will return to monthly, and continue until the first refueling outage.

II. Physical and Chemical Testing

Analysis of the MSIV elastomers taken from those failed solenoids in the November 3 event was completed on January 29, 1988 by a local contractor laboratory, Ricerca Incorporated. Attachment 1 is the final report detailing the testing performed and conclusions drawn concerning the failure mechanism of the MSIV solenoid valves.

This report summarizes the analytical investigation of the MSIV Pilot Solenoid failure, which caused the MSIV's to fail a fast closure test on November 3, 1987. The purpose of the investigation was to determine the reason the Ethylene Propylene Diene Monomer (EPDM) exhaust port seats did not release from the exhaust port when the pilot solenoids were de-energized.

Elastomer parts from failed, nonfailed, and "never used" pilot solenoid valves were examined. Two components, o-rings and elastomer exhaust port seats, from each of the solenoid valves were examined. The instrument air supply to the containment building, to the solenoid and to the two MSIV solenoid inch actuator line were analyzed for the presence of hydrocarbons.

The o-rings and the exhaust port seats are composed of EPDM, and were both in contact with brass valve components. They were exposed to the same instrument air and at the same temperature. The investigation focused on the o-rings (vs. the elastomer seats) because of their accessibility and advanced degree to degradation. Changes occurring at the o-ring are considered comparable to changes occurring to the elastomer seats.

Two hypotheses were proposed as causes for the MSIV failure. The first hypothesis proposed that a hydrocarbon contaminant in the instrument air supply affected the o-rings and seats. The second hypothesis proposed that excessive heat caused degradation of the EPDM which changed its properties and caused the failure of the valve.

A. Analysis Plan

The approach to determining the cause of the failure included both nondestructive and destructive tests.

All nondestructive tests were performed first to minimize loss of limited sample size. These tests included:

1) Optical Microscopy to record the appearance of the components,
2) Gas Chromatography analysis of the air supply,
3) Hardness and Compression Set of the o-rings and/or seats to record physical changes in the samples.

Once these results were reviewed, the destructive tests were performed. These included:

1) Infrared Spectroscopy of the o-rings to identify chemical changes,
2) Scanning Electron Microscopy and Energy Dispersive X-ray microanalysis to record physical and elemental differences between the o-rings and seats, and
3) Thermal analysis of a control o-ring to determine the effects of temperature.

Differences between the failed, nonfailed and "never used" valve components were compared.

B. Observations

Physical Changes

The compression set and hardness of the o-rings and seats progressively increased from control to nonfailed to failed valve components. This indicated that the EPDM components became less elastic. The indentations in the energized solenoid elastomer seats were deeper in the failed MSIV valves than in the nonfailed valve. The outside (100-150 micrometers) layer of the failed o-ring had changed and appeared more porous than the outside layer of either the nonfailed or control o-ring.

Chemical Changes

Several (3) failed o-rings showed evidence of a stearate material on their surface (an additive utilized in manufacturing EPDM to allow the molecules to be mobile against each other [rubber characteristic]). Copper and oxygen were present on the surface and 100-150 micrometers into the interior of the failed o-rings. Copper was also present on the surface of the failed seats.

C. Conclusions

Heat degradation of the EPDM caused the valve seats to deform, extruding the seat into the valve port. This provided additional seat-to-port surface area which increased the force necessary to separate the two when the valves were actuated. In addition, stearate compounds were found on the surface of the EPDM material inside the failed valves. Ricerca postulates that the presence of stearate compounds would probably act like glue and further increase the force necessary to separate the seat and port during valve actuation. The stearate had migrated as a result of the heat degradation of the EPDM.

The second possible cause, hydrocarbon degradation of the EPDM material, was discounted because no condensable hydrocarbons were found in the valves' air supply and the EPDM did not exhibit a "spongy" appearance. Hydrocarbon attack of EPDM would typically produce swelling of the EPDM. Instrument air analysis for hydrocarbons indicated only trace levels, far below concentrations considered to be harmful to EPDM material. Further, analysis of the EPDM materials from the pilot solenoids provided no indication that high levels of hydrocarbons were present to attack the o-rings and elastomer seats.

III. Environmental Testing

A. Background

The environmental testing of the ASCO dual coil solenoids began on December 30, 1987. The purpose of this testing at various oven temperatures is to further confirm the root cause of the failures experienced, establish a threshold temperature for EPDM degradation and perform a comparison with Viton material. The test procedure is proprietary in nature and is available for review upon request.

The environmental testing is conducted by thermally aging ASCO solenoid valves with EPDM components both with and without the Dow Corning 550 lubricant added as well as Viton components.

These valves are aged in three separate ovens at varied temperatures, 140°F, 225°F and one at a temperature to obtain a valve body temperature of 284°F (hottest oven). The solenoids are cycled at various intervals of 30, 42 and 92 days. This frequency was chosen to best represent the current monthly testing as well as the original Technical Specification quarterly frequency. The parameters monitored during the test are pressure decay (upon de-energization), voltage and current, and in-rush current during cycling and air leakage.

Test Configuration

Group #	Sample Number	Seat	Oven Temp	Cycle (Days)
1	20226-02-01-14	EPDM	140°F	0,30,60,90,92
	20226-02-02-14	EPDM	140°F	0, 92
	20026-02-03-14	VITON	140°F	0,30,60,90,92
	20226-02-04-14	VITON	140°F	0, 92
2	20226-02-05-14	EPDM (Dow Corning 550 removed)	284°F Body	0,30,60,90,92
	20226-02-06-14	EPDM	284°F Body	0, 42,84,92
	20226-02-07-14	EPDM	284°F Body	0,30,60,90,92
	20226-02-08-14	EPDM (Dow Corning 550 removed)	284°F Body	0, 42,84,92
	20226-02-09-14	VITON	284°F Body	0,30,60,90,92
	20226-02-10-14	VITON	284°F Body	0, 42,84,92

3	20226-02-11-14	EPDM	225°F	0,30,60,90,92
	20026-02-12-14	EPDM	225°F	0, 92
	20226-02-13-14	VITON	225°F	0,30,60,90,92
	20226-02-14-14	VITON	225°F	0, 92

Acceptance criteria is based upon the satisfactory operation of the valves upon demand without sticking or binding. When de-energized, the valves are monitored and required to vent a 27 cubic inch air tank from 90 to 30 psig in 2.0 seconds or less. These conditions simulate those required in the plant in order to achieve a satisfactory MSIV closure time.

B. Test Progress

Test preparation was completed on December 28, 1987 with actual test initiation on December 30. This included the collection of baseline data such as visual inspection and functional tests. The test configurations were finalized and ovens brought up to temperature to begin the thermal soak. Data collection continued with no problems until January 22, 1988 when it was noted that the air supply to the test specimens had been depleted. The air supply was immediately restored with pressure decay closely monitored. On January 25, the ovens were shutdown in order to determine the location of apparent leakage. All of the solenoids remained energized throughout this evolution. No leaks were identified in the 140°F oven. In the oven with the 284°F solenoid body temperature, leaks were identified through the exhaust port on specimen numbers 5 and 6. A leak at the junction between coil A and the valve body was also discovered on specimen 11 in the 225°F oven.

To monitor the leakage, the exhaust port effluent for specimens 5 and 6 were piped to the exterior of the test oven and flow elements installed. The ovens were the re-energized and testing continued. The total lost time was approximately 24 hours. Following the thermal cycle and with the exhaust port effluent directed outside of the oven, the total leakage was measured to be 95 milliliters per minute for specimen 5 and 1 milliliter per minute for specimen 6. These leakages are considered minimal and would not affect the functional operation of the valve.

On February 1, 1988, the first 30 day cycle of the required solenoid valves was performed. All test specimens operated upon demand with the exception of numbers 5 and 7 (both from the hottest oven).

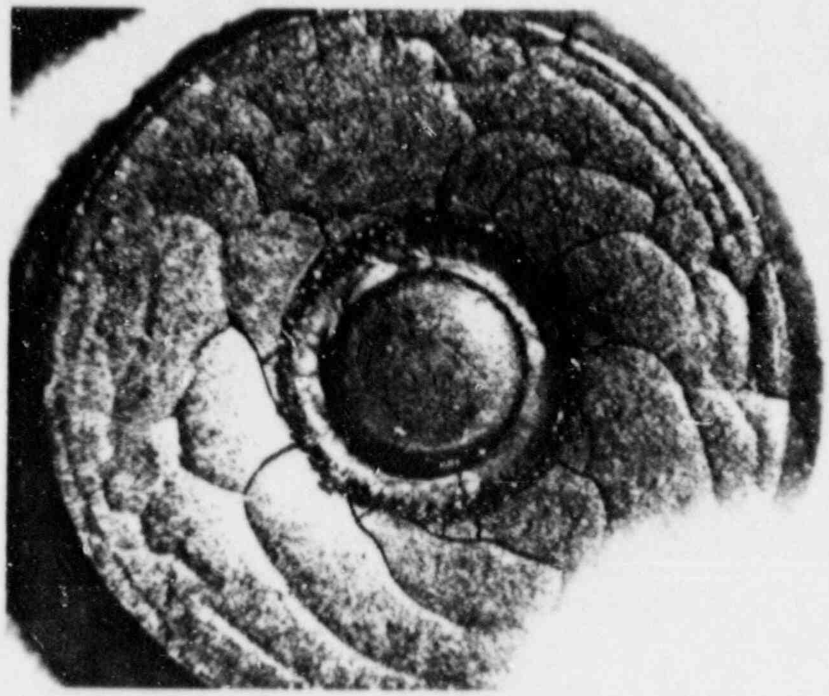
Test specimen 5 was cycled twice. During the first cycle, it failed to operate until approximately 30-60 seconds after de-energization. During the second cycle, test specimen 5 operated on demand and vented the air tank in 1.56 seconds. Considering the above, the test specimen remained in the test program for further analysis.

Three attempts were made to cycle test specimen 7. Test specimen 7 failed to operate and did not vent the air tanks. As a result, different combinations of de-energizing/energizing the two solenoid coils were tested, and radiographs were taken to determine where the sticking or binding of the solenoid may be occurring. However, during the last mode when both solenoid coils were de-energized, test specimen 7 operated and vented the air tank as required. Test specimen 7 was then removed from the test program for analysis of parts.

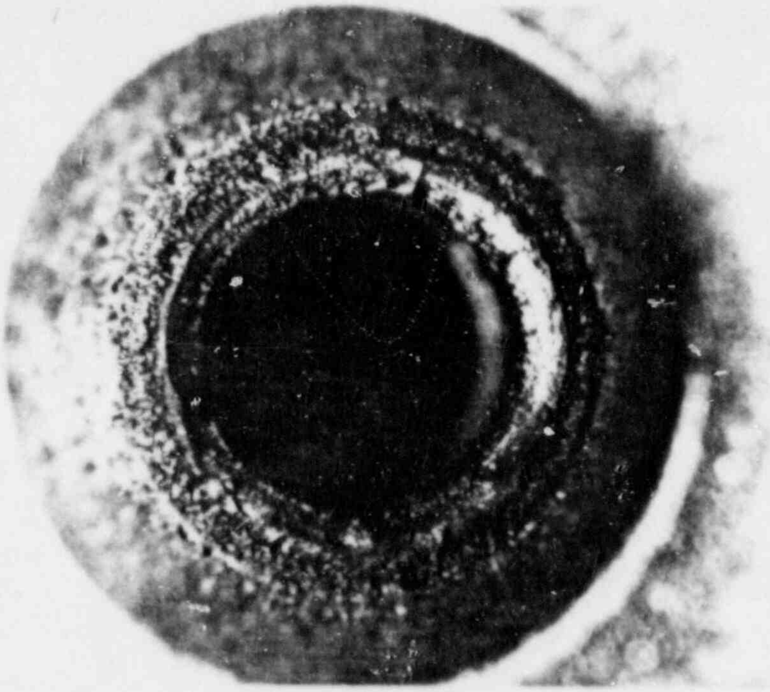
The radiographs from test specimen 7 ("A" coil was energized and "B" coil de-energized) indicated sticking or binding had occurred on the core to the solenoid base sub-assembly. Visual inspection during disassembly was conducted at Ricerca utilzing the troubleshooting work order previously developed and microscopic photos indicates that sticking may have occurred on the disc holder seat to the "B" side port hole of the solenoid body (See attached photos of the solenoid internals). Further evaluation/anlaysis is planned for the solenoid elastomers and results will be included in a future update or the final report.

C. Conclusions

Both failures are considered to be the result of degradation due to the elevated test temperature. The temperatures at which the anomalies occurred are at the threshold of EPDM material and are considered to have no operability impact upon the valves in the plant. The temperature in the plant is significantly cooler than this test temperature (as monitored under our temporay temperature element program. All tests performed at representative temperatures of the plant (140°F) successfully operated upon demand. In addition, the samples that are not functioning properly are being tested at more severe conditions than the qualification test conducted by GE.



DISC HOLDER SEAT
"B" SIDE



SOLENOID PORT HOLE
"B" SIDE