Pennsylvania Power & Light Company
Two North Ninth Street • Allentown, PA 18101 • 215 / 770-5151

Bruce D. Kenyon
Vice President-Nuclear Operations
215/770-7502

NOV 19 1984

Mr. Richard W. Starostecki, Director
Division of Project and Resident Programs
U.S. Nuclear Regulatory Commission-Region I
631 Park Avenue
King of Prussia, PA 19406

SUSQUEHANNA STEAM ELECTRIC STATION
T-ASCO SCRAM PILOT SOLENOID VALVES
ER 100450/100508 FILE 841-4
PLA-2361

Docket Nos. 50-387
50-388

Reference: (1) CAL No. 84-18 dated 10/17/84
(2) PLA-2360 dated 11/19/84

Dear Mr. Starostecki:

This letter provides a portion of the response requested under reference (1). Attached for your review are the following:

1. A description of the events and actions to date regarding the resolution of all concerns associated with the scram pilot solenoid valves

2. An itemized response to reference (1)

3. Results to date of an evaluation of scram pilot valves by Franklin Research Center

4. A description of the surveillance program for the scram pilot solenoid valves.

The evaluation results of the scram pilot solenoid valves by General Electric have been designated proprietary by GE and will be submitted under separate cover (Reference (2)).

I E35

Our investigation of this issue is continuing and we expect to submit a final report on this issue by January 9, 1985. We trust the attached information will be satisfactory.

Very truly yours,

B. D. Kenyon
Vice President-Nuclear Operations

Attachment 1: Description of Events & Actions to Date
Attachment 2: Itemized Response to CAL No. 84-18 dated 10/17/84
Attachment 3: Franklin Research Center Scram Pilot Valve Evaluation Program
Attachment 4: Scram Pilot Valve Surveillance Program

cc: R. H. Jacobs - NRC Susq. SES

ATTACHMENT 1

DESCRIPTION OF EVENTS
AND ACTIONS TO DATE

On October 6, 1984 during the normal 120 day scram time surveillance test, of Unit 1 four control rods did not scram, and several control rods showed hesitation. The four failures were determined to be due to failure of the scram pilot solenoid valves to actuate and vent air from the scram valves. On October 8, 1984 a task force was established to analyze the failure and determine the cause of failure. In accordance with this task, one of the failed valves was sent to General Electric (GE) and another to Franklin Research Center for analysis. In parallel with this, PP&L began researching past maintenance history of the valves; past control rod scram times; as well as, searching for the cause of failure. On October 12, 1984 GE indicated that they believed the failure mode was sticking of the polyurethane disc holder subassembly (DHS) to the exhaust part. This was consistent with NPE's suspected failure mode, at that time. GE believed that the sticking could be caused by temperature, and that a seat temperature as low as 160°F could cause sticking. Based on this, and the information that sticking could occur rapidly, the decision was made to shutdown both units and change out the polyurethane DHS with Viton-A material. PP&L also recommended that the Unit 1 SDV Vent & Drain Valve Pilot solenoid valves and the backup scram valves in both Units be reworked since they also contained a DHS. Since that time, the Unit 1 SDV vent and drain isolation Pilot Solenoid valves were replaced with a different valve design for other unrelated reasons.

On October 16, 1984 Unit I was restarted and all 185 Control Rod Drives were scram time tested with satisfactory results. The test was modified due to a problem discovered with the test switch. The problem involved a delay between the signal given to the SPSV to de-energize and the signal sent to the control room for scram test signal initiation. This makes all previous testing done by using the test switches suspect, and only previous data which was obtained from GETARS is valid. The modified test corrects for the test switch delay time by measuring the difference (plus or minus) between SPSV de-energization and the scram test signal initiation, and then adding it to the times recorded in the control room.

PP&L has performed a statistical analysis of the available scram time data between 3/22/84 and 10/18/84 and has made the following observations:

- For the 9 full core scrams prior to the 10/6/84 failures, the four rods that failed had a history of being slower than the normal distribution of scram insertion times (for all measured rods) to position 45. None of these rods have failed to fully insert in the 7 second full stroke scram time requirement for individual rods.

- Other CRD's also showed a history of slowness to position 45, but did not fail on 10/6/84.

- The average time to position 45 is getting longer as time goes on, indicating slight CRD wear. The longest average time occurred on 10/18/84, following change-out to Viton-A material. The observed slower average scram times is an anticipated condition due to drive mechanism wear which forms the basis for the 120 day scram time testing requirement.

PP&L has reviewed work authorizations (WA) for the Hydraulic Control Units which have been worked since August of 1981. This review has turned up a significant number of WA's concerning SPSV's which failed to operate properly. This investigation is continuing, but it appears at this time that valve failures of unspecified nature have occurred in past surveillance testing prior to the October 6, 1984 failures. The results of this investigation will be contained in PP&L's final report on this subject.

The task force investigation has established the following possible causes of failure for all credible failure modes based on an analysis of valve design, materials of construction, and operating conditions:

A. Bad batch of ASCO valves supplied to Susquehanna I & II.

   1. Weak Spring on the "A" solenoid not unseating DHS.

   2. Improper Machining/tolerances causing binding on stem or DHS.

   3. Improper coils causing excessive heating of valve.

   4. Improper polyurethane composition causing lower temperature resistance.

   5. "A" Solenoid Coil Spring in backwards causing bending or inadequate unseating force.

B. Improper use of cast Polyurethane in DHS.

   1. Inadequate temperature resistance for T-ASCO valve.

   2. Poor contamination resistance.

   3. Humming/chatter of coils cause heat-up that exceeds temperature resistance of polyurethane.

   4. Polyurethane cannot withstand compressive forces inherent in T-ASCO design.

   5. Improper voltage causes excessive heating.

C. Disc Holder Sub-assembly contamination.

   1. Silicone grease contamination.

   2. Contamination from Instrument Air System.

   3. Contamination from maintenance activities.

D. Diaphragm contamination.

   1. Silicone grease contamination

   2. Contamination from Instrument Air System

3. Contamination from maintenance activities

E. Improper use of BUNA-N in diaphragm

The above possible causes are currently being investigated through PP&L Engineering analysis and through the GE and Franklin test programs; however the most probable cause at this time appears to be contamination in combination with time and temperature. It has been determined that the only contaminant which would affect both Viton-A and polyurethane is acetone. Since acetone was not used on SPSV's or the air piping, there is no reason to suspect that the same contaminant that effected the polyurethane could effect the Viton-A material if the contaminant is still present in the instrument air system.

Evidence has been established of contamination on the seat by a synthetic ester oil. This oil matches the oil used in oil misters in the Instrument Air System. Synthetic ester oil is a known degradant of polyurethane.

This information represents a description of the SPSV failure problem as we understand it to date. The final report on this issue will contain detailed information on the resolution of the Scram Pilot Solenoid Valve failures.

ATTACHMENT 2

ITEMIZED RESPONSE TO CONFIRMATORY ACTION
LETTER 84-18 DATED 10/17/84

This attachment provides an item by item response to your Confirmatory Action Letter 84-18 concerning T-ASCO Scram Pilot Solenoid Valves (SPSV). This letter stated that the following actions have or would be taken by PP&L:

A. All scram solenoid valves in Units 1 and 2 have been rebuilt with disk holder subassemblies fabricated with Viton-A material in place of those fabricated from polyurethane. In the case of Unit 2, it has been confirmed via physical inspection that some of the valves already had internals fabricated from the Viton-A material. We further understand that the scram discharge volume vent and drain valves, and the back-up scram valves, have been rebuilt with the Viton-A material.

B. The scram insertion times of all the control rods in both Units 1 and 2, will be demonstrated acceptable as required by Section 4.1.3.2.b of the Technical Specifications. This means that scram-time testing of all the control rods in Units 1 and 2 is to be performed at approximately 50% to 60% power during power accession.

C. Pennsylvania Power and Light Company (PP&L) will develop a surveillance program for the scram pilot valves. This surveillance program will include procedures for valve operability testing, valve response time testing and data trending analyses to identify precursors. Valves surveillance is to be performed at a frequency of every four to six weeks during plant operations. The program plan will include acceptance criteria for the surveillance tests performed and criteria for returning to normal surveillance requirements. This program will be submitted within the next three to four weeks to the NRC Region I Office (Region I) for NRC review and approval.

D. Any failures to meet the surveillance test acceptance criteria established in the surveillance program developed in C above, any anomalies in surveillance program test results that could impact control rod operability, or any control rod failures or anomalies that occur during operation will be reported to NRC via the ENS phone network within four hours of identification. This reporting requirement will exist until return to the normal surveillance requirements as determined by the criteria established in C above.

E. Descriptions of the General Electric (GE) and Franklin Research Center (FRC) scram pilot valve evaluation programs will be provided to Region I within the next three to four weeks. Results of short term evaluations conducted by GE and FRC will also be submitted to Region I at that time.

In response to the above actions, PP&L has taken or will be taking the following actions:

Response to Item A: All Scram Pilot Solenoid Valves in Units I and II have disc holder subassemblies fabricated with Viton-A seating material. The Back-up scram valves disc holder subassemblies have been changed to Viton-A material on Both Unit I and II. The SDV Vent and Drain Pilot

Solenoid Valves have been changed out to a Valcor Valve which does not contain a disc holder subassembly, and operates in a different manner than the "T-ASCO" type solenoid valve. The Unit II SDV Vent and Drain Pilot Solenoid Valves were originally installed as Valcor valves and did not require rework. A detailed discussion of the chain of events concerning the SPSV failure and Actions taken to correct the problem is contained in attachment 1 to this letter.

Response to Item B: Scram insertion time tests were performed on all the control Rods in Unit I and II and found to be acceptable per Section 4.1.3.2b of the Technical Specifications.

Response to Item C: PP&L has developed a program for monitoring SPSV operability and response time; as well as acceptance criteria for returning to normal surveillance requirements. Details on the program are contained in attachment 4 of this letter.

Response to Item D: PP&L will comply with the requirements of this item.

Response to Item E: A description of the General Electric (GE) SPSV evaluation program and results of their short term evaluation is contained in PLA-2360 dated 11/19/84 (designated proprietary by GE). A description of the Franklin Research Center (FRC) SPSV evaluation rogram and results of their short term evaluation is contained in attachment 3.

The results of GE's and FRC's long term evaluation program are expected to be available to PP&L by December 7, 1984. At that time, it is anticipated that the exact cause(s) of failure will be known and the necessary actions will be taken to return both Units to a normal surveillance mode.

ATTACHMENT 3

FRANKLIN RESEARCH CENTER SCRAM PILOT VALVE EVALUATION PROGRAM

Franklin Research Center (FRC) scram pilot valve evaluation program is proceeding independently from the GE effort. FRC has had significant relevant experience with analysis of ASCO solenoid valves in general, and has conducted many analyses of systems and components related to safety for both PP&L and the NRC.

FRC has been given the general charter of performing an evaluation of credible valve failure modes, and then to identify the cause of the observed failures. Their program is neither guided by nor limited to the list of failure modes and causes in Attachment 1, thereby assuring that their effort is an independent verification of the GE test program.

FRC's evaluation from an examination of the failed valve's internal components supports the preliminary evaluation by PP&L engineering which attributes the observed failures to an adhesion of the disk holder assembly to the pilot valve scram vent port.

FRC will continue with operability tests and chemical analysis of critical components, per their program action plan as follows this Attachment.

FRANKLIN RESEARCH CENTER
DIVISION OF ARVIN/CALSPAN

November 2, 1984

Mr. D. Bockstanz
Pennsylvania Power & Light
2 North Ninth Street
Allentown, PA 18101

Reference: 1. PP&L Service Order No. 4-49271-S

2. Letter, V. P. Bacanskas (FRC) to D. Bockstanz (PP&L) dated October 19, 1984

Subject: Preliminary Evaluation of Failed Scram Pilot Solenoid Valve

Dear Mr. Bockstanz:

Since the transmittal of Reference 2, FRC has conducted additional testing of the solenoid valves with the following results:

1. Microscopic Analysis of Internal Parts

The polyurethane discs were examined under a microscope along with their mating pilot orifices from the valve body. Although there was some evidence of material transfer from the core disc to the brass pilot orifice on the valve body, the deposits were limited and only discernible under the microscope. The disc holder subassembly had a substantial amount of the polyurethane material in a roughened state with sufficient irregularities to indicate that some of the material had torn away from the seat. Microscopic examination of the exhaust pilot orifice in the valve body revealed pieces of the seat material had adhered to the area surrounding the pilot orifice. As depicted in Figure 1, the seat material had not adhered at the initial point of contact with the pilot orifice, but rather around the edges. This indicates that the bonding of the disc holder subassembly to the pilot orifice occurs only after either a compressive set a or significant softening of the seat has occurred.

2. Puff Tests

After completion of the microscopic examination, the valves were reassembled and subjected to puff tests. Puff tests were defined by PP&L as follows: with both the A and B solenoid coils energized and the valve pressurized, the A solenoid coil is deenergized causing the core spring to attempt to seat the core disc; the motion of the core assembly momentarily unseats the disc holder subassembly allowing a puff of air to exhaust. After a period of energization of only a few minutes, both the failed solenoid valve and the solenoid valve from PP&L stock successfully completed the puff tests.

3. Seat Temperature Rise Tests

The two solenoid valves were then arranged in a test setup allowing longer term continuous energization and instrumented with thermocouples connected to a digital temperature recorder. Thermocouples were placed at the following locations in each of the two solenoid valves.

A - between solenoid coil A and the solenoid base subassembly
B - between solenoid coil B and the solenoid base subassembly
C - near the core assembly disc through port no. 2
D - near the disc holder subassembly through port no. 3
E - near the diaphragm assembly through the "out" port
F - ambient room temperature (away from the solenoid coils)

The solenoid valves were energized and the temperature recorder was initialized. The solenoid valves were pressurized with nitrogen at approximately 50 psig. After approximately 36 hours of continuous energization, the following temperatures were recorded.

Thermocouple Location	Temperature (°F)					
	A	B	C	D	E	F
Failed Valve	179.0	191.0	143.2	135.2	126.2	77.1
New Valve	229.4	238.8	142.2	140.2	119.4	77.1

The differences in temperatures in the coils of the new and old solenoid valves are most likely attributable to the slight difference in location of the thermocouples. The thermocouples on the new coils are near the coil mid-plane where the temperature would be greater. The thermocouples on the old coils are nearer to the base of the coil where heat transfer would reduce the temperature.

The temperature recorded near the disc holder subassembly appears to be the most significant with respect to the failure mode noted for the valves. During discussions with Mr. William Brown of Asco, it was learned that the polyurethane seats will begin to soften at 180° to 190°F under normal use and at approximately 140°F if exposed to water. Since indications of fluid contamination were found during inspection of the failed valve internals, and the maximum temperature of the disc holder subassembly during the temperature tests was near 138°F, the presence of water in the air system and the high temperature may have induced the failure observed at the Susquehanna plant. After approximately 22 hours of continuous energization of the solenoid valves, a puff test was attempted. The new valve exhausted a puff of air as expected; however, the valve that had failed in service did not exhaust any air. Both solenoid coils on each of the two valves were then deenergized to determine if the solenoid valve failure had been replicated. The new valve and the valve that had failed in service promptly exhausted. The solenoid valves were renergized and will remain in an energized state for a period of 2 weeks (approximately equal to PP&L periodic test intervals) before performance of further puff tests and exhaust verification. In addition, the temperature in the room in which the test is performed was adjusted to provide an ambient temperature nearer that experienced in plant service. The higher ambient temperature is expected to result in higher temperatures at the valve internals.

4. Plan for Additional Testing

The present plan includes allowing the solenoid valves to be pressurized and energized for a period of approximately 2 weeks before deenergization. At that time, puff tests and deenergization of the solenoid valves will be performed to determine if any sticking occurs.

Following completion of these tests, the valves will be disassembled and Shore "A" durometer tests will be performed to determine the relative hardness of the polyurethane discs. The discs will then be subject to evaluation under an electron microscope to identify any material deformities, abrasions, or adhesions.

The exhaust timing tests and gas chromatograph/mass spectrometry chemical analysis discussed by Mr. Bockstanz (PP&L) and Mr. Bacanskas (FRC) are not within the scope of the present purchase orders; however, they can be performed under a modification to the existing purchase order.

FRC has included three color photographs of the solenoid valve internals marked as Figures 2, 3, and 4. All three photographs are of components from the solenoid valve that had failed in service. Figure 2 is a photograph of the disc holder subassembly with its polyurethane seat. The compressive set and the roughness outside the diameter of the compressive set should be noted. The roughness is a result of tearing of the polyurethane seat due to adhesion to the exhaust pilot orifice. Matching patterns of polyurethane were found adhered to the exhaust pilot orifice. Figure 3 is a photograph of the core disc seat with a similar compressive set evident. The black ring at the mating surface may be the result of either heat or contaminates in the air supply and further testing would be required for a determination. Figure 4 shows the stem and disc holder subassembly. Although it may not be evident in the photograph, the disc holder subassembly is being supported by the stem. The stem had firmly adhered to the polyurethane at the base of the disc holder subassembly. The photographs depict the as-found condition of these components.

FRC is continuing testing of the solenoid valves. Should you have any questions concerning this interim report, please contact the undersigned (215/448-1096) or Mr. G. Toman (215/448-1336).

Very truly yours,

Vincent P. Bacanskas

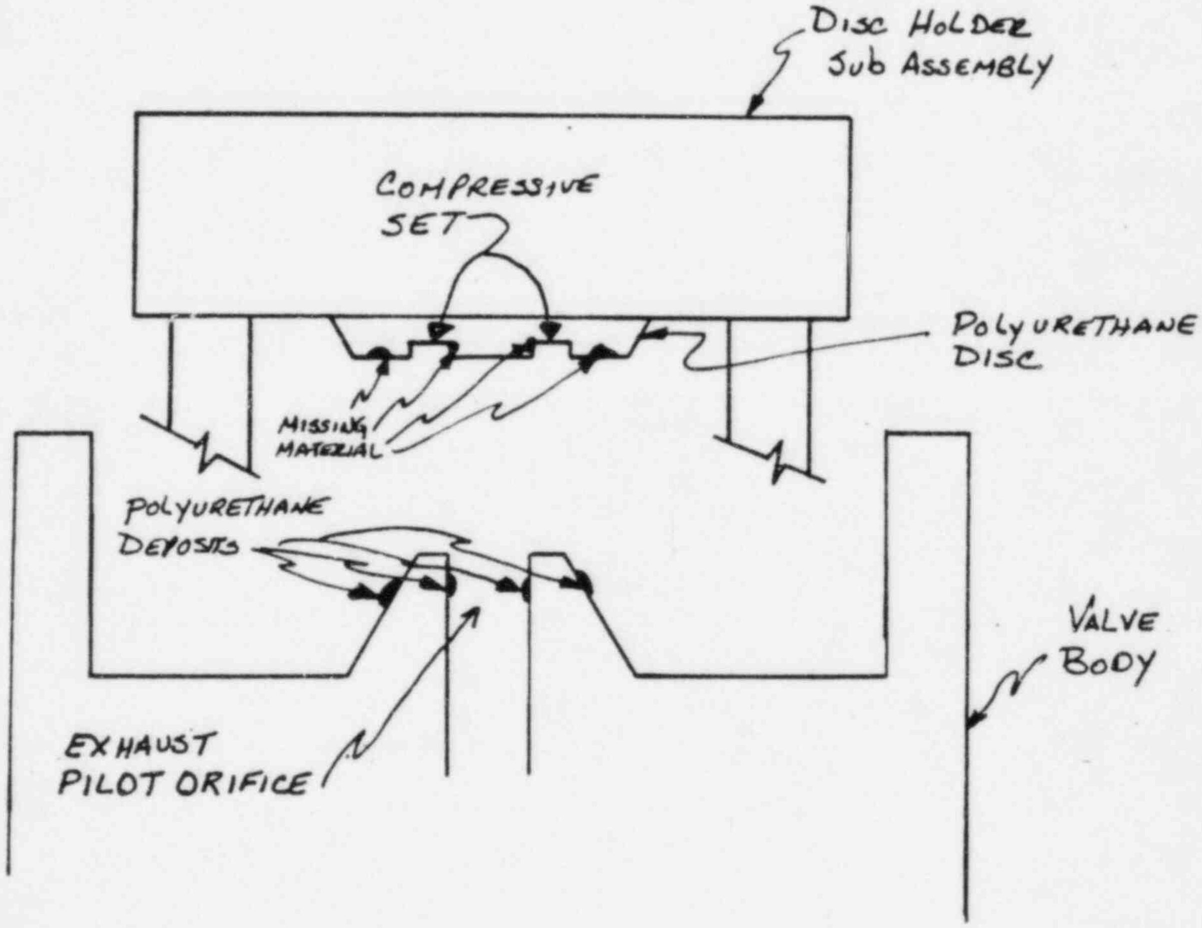
Vincent P. Bacanskas
Associate Engineer
Systems and Equipment
Engineering Section
Nuclear Engineering Department

VPB:sf
Enclosures

Franklin Research Center A Division of The Franklin Institute The Benjamin Franklin Parkway, Phila., Pa. 19103	Project 503-6052-001 PP&L NO. 4-49271-S		Page 1 of 1
	By V.P. Baranskas Date 11/2/84	Ch'k'd Date	Rev. Date

Title

SKETCH OF DISC HOLDER SUBASSEMBLY AND EXHAUST PILOT ORIFICE



FORM CS-FRC-81

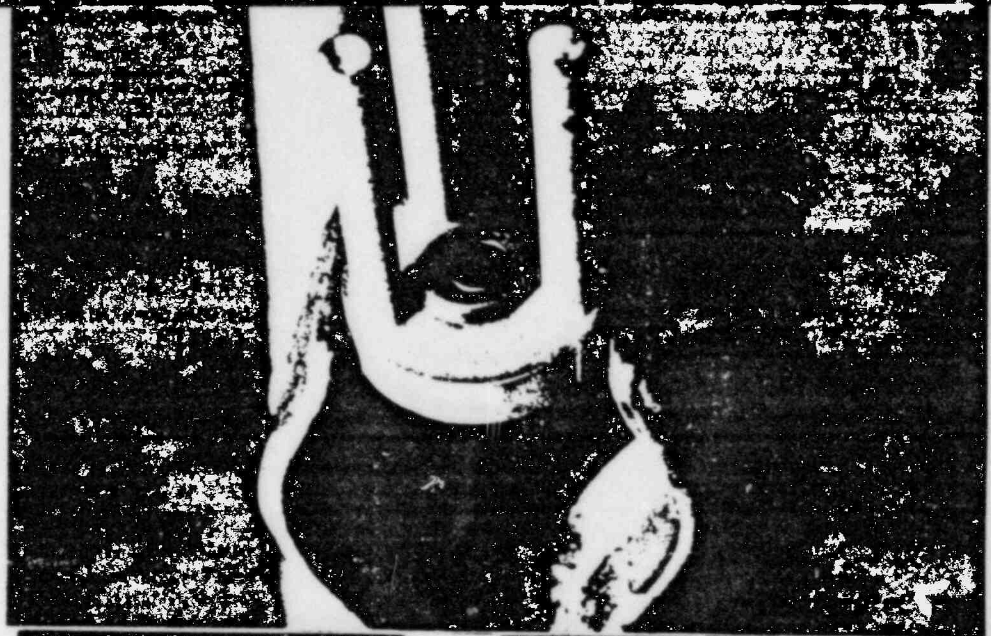


FIG. 2

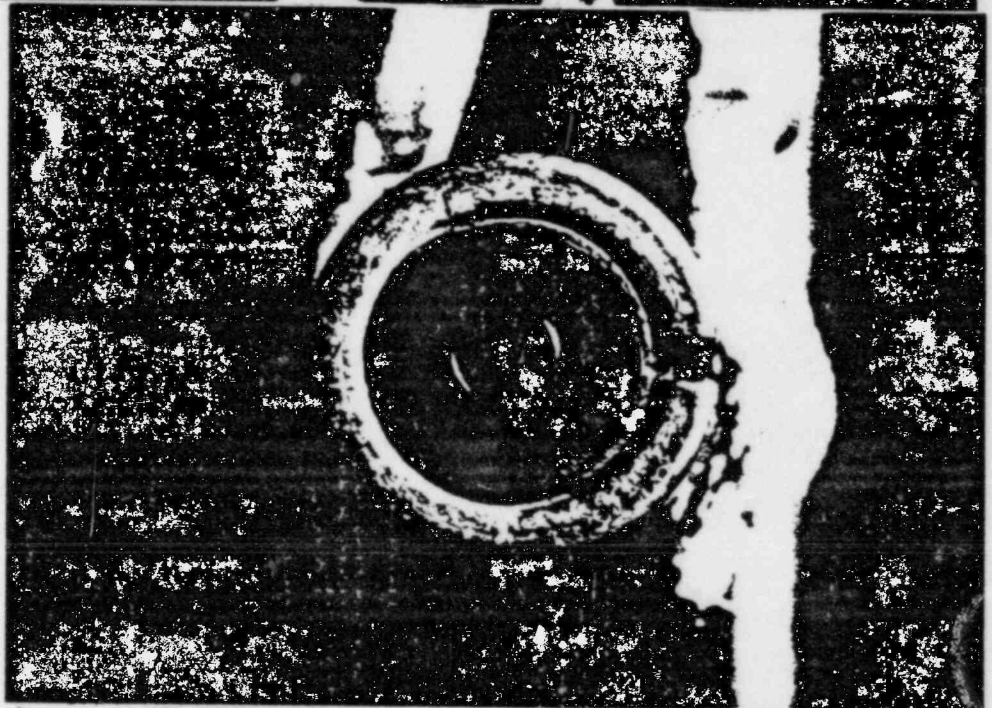


FIG. 3

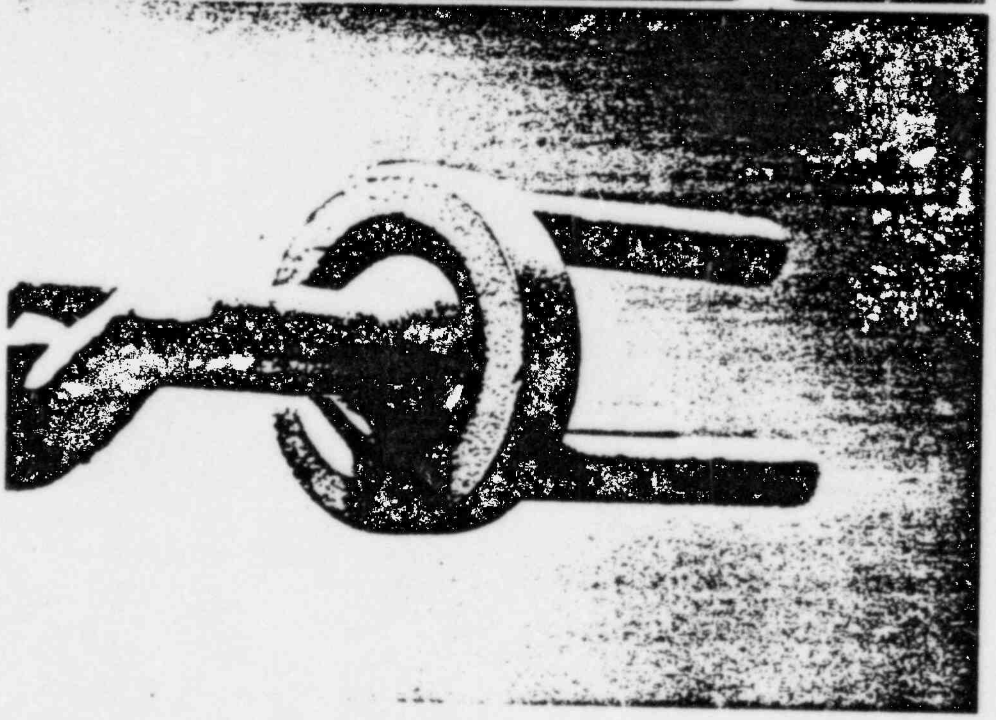


FIG. 4

FRANKLIN RESEARCH CENTER
DIVISION OF ARVIN/CALSPAN

October 19, 1984

Mr. D. Bockstanz
Pennsylvania Power & Light
2 North 9th Street
Allentown, PA 18101

Reference: PP&L Service Order No. 4-49271-S

Subject: Preliminary Evaluation of Failed Scram Pilot Solenoid Valves

Dear Mr. Bockstanz:

FRC has completed a preliminary evaluation of the scram pilot solenoid valves including receipt inspection, disassembly and internal inspection, and diaphragm assembly lift pressure tests. The results of these tests are reported below:

1. Receipt Inspection:
   Both solenoids were given an external visual examination to determine the condition in which they were received. No significant findings were identified.

2. Disassembly and Internal Inspection:
   For the solenoid valve that had failed in service, the following observations were made:

   - both seats were red (polyurethane)
   - the seat in the disc holder subassembly had taken a compressive set and was rough around the edges of the compressive set (indicating possible tearing)
   - the stem had adhered to the lower end of the disc holder sub-assembly
   - the diaphragm assembly had hardened as compared to the new valve diaphragm
   - the elastomers housed on the solenoid B side of the valve body had hardened more than those on the A side.

   For the new solenoid valve (SV-3) the following observations were made:

20TH & RACE STREETS PHILADELPHIA, PA 19103 TWX 710-670-1889 TEL. (215) 448-1000

- o the seat contained in the core assembly was black indicating Viton per PP&L
- o the seat in the disc holder sub-assembly was reddish indicating polyurethane.

3. Diaphragm Assembly Lift Pressure Tests:
As a result of the finding during the internal inspection that the diaphragm from SV-1 had hardened significantly, pressure testing was performed to determine the diaphragm lift-off pressure. The diaphragms lifted from their seats at approximately 2-4 psig. This alleviated any concern that the diaphragm aging was the cause of the inservice failures.

The preliminary cause of the failures in service appear to be a result of the disc holder sub-assembly adhering to the exhaust pilot.

Should you have any questions, please contact the undersigned at 215/448-1096.

Sincerely,

Vincent P. Bacanskas

Vincent P. Bacanskas
Systems & Equipment Engineering,
Nuclear Engineering Dept.

VPB/ih

ATTACHMENT 4

SURVEILLANCE PROGRAM

1. Basis

Tech Spec surveillance requirements 4.1.3.2.c form the basis for the special surveillance to demonstrate scram pilot valve operability and to monitor scram pilot valve response times for trending analysis. The special surveillance will accelerate the Tech Spec surveillance frequency to approximately every six weeks of power operation at a time which coincides with Rod Sequence Exchanges. The sample size will also be increased to at least 30 control rods per testing period. In addition, the acceptance criteria has also been changed per item 3.a. below. Surveillance procedures SR-155-003 and SR-255-003 will continue to be used for this testing.

Control rod scram time performance is a direct indication of scram pilot valve performance; scram valve performance and control rod drive mechanism performance cannot conceal a scram pilot valve failure or precursor to failure if adequate information is available for an evaluation. False scram pilot valve failures or precursors may be observed due to anticipated variations in control rod drive mechanism performance. When necessary, as per the operability and response time testing acceptance criteria, the scram pilot valve will be tested independently from the action of the CRD hydraulic system.

2. Surveillance Procedure - Independent Scram Pilot Valve Testing

Response times for the scram pilot solenoid valves will be measured by the time required to initiate venting of the scram valve air actuators following receipt of the scram signal at the pilot solenoid coils. These events constitute the scram action of the pilot solenoid valves and, when measured directly, remove all uncertainties which may be introduced when measuring control rod scram times. The HCU is isolated from its respective drive mechanism during this surveillance so that no rod motion is induced by this action.

The scram pilot valve solenoid B coil voltage provides the initiation signal. Scram valve air actuator venting is monitored by a pressure transducer placed over the pilot valve exhaust port. Note that no rod motion is required, or is possible, during this surveillance, so the scram valve actuators need not displace their air loads. The rod will be fully inserted for the duration of the test. Since some scram valve motion will occur, the HCU accumulator will be drained to lessen hydraulic loads on the HCU piping and on the control rod. Procedures TP-155-005 and TP-255-05 are under development for this testing.

3. Pilot Valve Operability Acceptance Criteria

   a. The scram insertion time for each tested control rod from the fully withdrawn position, based on de-energization of the scram pilot valve solenoids at time zero, to position 45 shall not exceed 0.43 second.

b. The response time of each independently tested scram pilot valve, based on de-energization of the scram pilot valve solenoids at time zero, shall not exceed 25msec.

4. Pilot Valve Response Time Trending

Response times for each control rod drive in the surveillance will be compiled on a frequency diagram to assess trends and precursors to pilot valve failure. Precursors will be identified from their distribution on the frequency diagram. This identification will be established by engineering judgment based on expected behavior and on historical data. Precursors will show as a significant departure from the normal curve which bounds the frequency diagram.

5. Reporting

Failure to meet the operability acceptance criteria will be reported within four hours of identification. The occurrence of any precursors to failure will be reported also within four hours of identification. The test results will be evaluated within 72 hours of the completion of the surveillance.

6. Criteria for Returning to Normal Surveillance Requirements

Special surveillances will be continued until the failure evaluation programs identify a credible failure mode and demonstrate its cause, at which time the NRC will be notified of the corrective actions to be taken and of the schedule for their implementation. An application for relief from special testing or for a revised testing schedule or for revised procedure requirements, if any are desired, will be submitted to the Commission at that time. Return to normal surveillance will occur when the above corrective actions are implemented if relief has not been granted before that time.

If special and normal surveillance testing demonstrates pilot valve operability and shows no precursors to failure over three full special surveillance cycles for both units 1 and 2 combined, the need for continued special surveillance testing will be evaluated. Application for relief from special testing or for a revised testing schedule or for revised procedure requirements, if any are desired, will be submitted to the Commission at that time.