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Dr. Thomas E. Murley, Director
United States Nuclear Regulatory Commission
Office of Inspection and Enforcement, Region I
6331 Park Avenue
King of Prussia, PA 19406

Reference: 1. Possible 10CFR21 Report, Valve Operators Manufactured by Paul-Munroe Hydraulics dated October 30, 1984.

2. Possible 10CFR21 Report, Valve Operators Manufactured by Paul-Munroe Hydraulics dated November 15, 1984.

Dear Dr. Murley:

This is the final report regarding the potential 10CFR21 first reported on October 30, 1984 on the Valve Operators manufactured by Paul-Munroe Hydraulics and installed in the Limerick Generation Station, Unit 1, for Philadelphia Electric Company. That 10CFR21 report was prepared because it had been observed that the valve operators cycled more frequently than that specified by the Paul-Munroe Operations Manual. It was reported then that similar valve operator designs were delivered to:

1. Commonwealth Edison plant: Byron, Units 1 and 2.
2. Commonwealth Edison plant: Braidwood, Units 1 and 2.
3. Washington Public Power Supply: WNP, Units 1 and 2.

At that time it was postulated that loss of accumulator pressure would result in frequent cycling of the valve operators and that three components within the system would cause the accumulators to lose pressure. These components were:

1. The solenoid operated, directional control valve.
2. The piston seals in the valve actuator.
3. The gas precharge in the accumulator.

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Results of investigations by Paul-Munroe with respect to these components are summarized as follows:

1. Control valve failures were the result of hydraulic fluid contamination and improper maintenance procedures which allowed the hydraulic fluid to become aerated.

2. Piston seal-failures in the Valve Actuators were primarily the result of misalignment of the Valve Operator to the plant line valves or dampers.

3. Accumulator leakage was the result of imperfections in the application of chrome plating to the accumulator cylinder.

A detailed discussion of the Paul-Munroe study follows:

1. Solenoid operated, directional control valve. The first phase of the study involved the examination of valves which had failed and had been returned to Paul-Munroe from the Limerick plant. It was determined that the valve failure occurred at the valve sealing surface or the valve seat. Two causes of valve seat failure were evident: hydraulic fluid contamination and valve seat erosion as a result of contamination.

   Prior to completion of a test program to define the failure modes of the valve seat, Paul-Munroe recommended that the hydraulic fluid in the valve operator units be cleaned by flushing the fluid through a cleaning unit and adding a higher level of filtration to the systems to minimize contamination as a cause for failure. Further, maintenance procedures were recommended to ensure that the valve operators were initialized with the specified accumulator precharge pressures and the hydraulic fluid reservoirs filled to the required level. As a result of this maintenance program, valve failures due to contamination or erosion were eliminated.

   To ensure that the postulated causes for valve seat failure were correct, Paul-Munroe constructed a test apparatus to test the control valves in an hydraulic circuit having the following features:

   a. Ability to test two valves at one time, and in various port inlet/outlet conditions.

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b. Zero leak check valves and ball valves to allow selection of various test modes and check for leakage of the valve seats without having to move the valves to another test set-up. Also, to isolate accumulators when desired.

c. An accumulator to allow generation of high instantaneous flow rates.

d) Adjustable (0-5 GPM) pressure compensated flow control valves (PC FCV) to control flow through the valves and to provide some initial surge flow due to the PC FCV being a normally open device.

e. A pressure compensated variable volume pump with adjustable maximum volume stops driven by a 5 hp. motor. This unit is capable of 5 GPM at 1500 psi and 2.5 GPM at 3000 psi.

f. A two-micron absolute filter with condition indicator and full differential elements without a bypass.

g. A heat exchange to keep fluid temperatures at reasonable values during extended cycle tests.

h. Two methods to measure leakage, i.e. pressure drop-off method and from a bleed-off valve that has a check valve to air entering the circuit during leakage tests.

i. A method to inject nitrogen into the supply line to simulate air in the system.

j. Two cycle timers, i.e. a fast cycle unit (18 CPM) and a slow cycle unit that is adjustable from 4 CPM and slower.

k. Indicator lights to show solenoid energization and switches to allow selection of various test valves, timers, etc.

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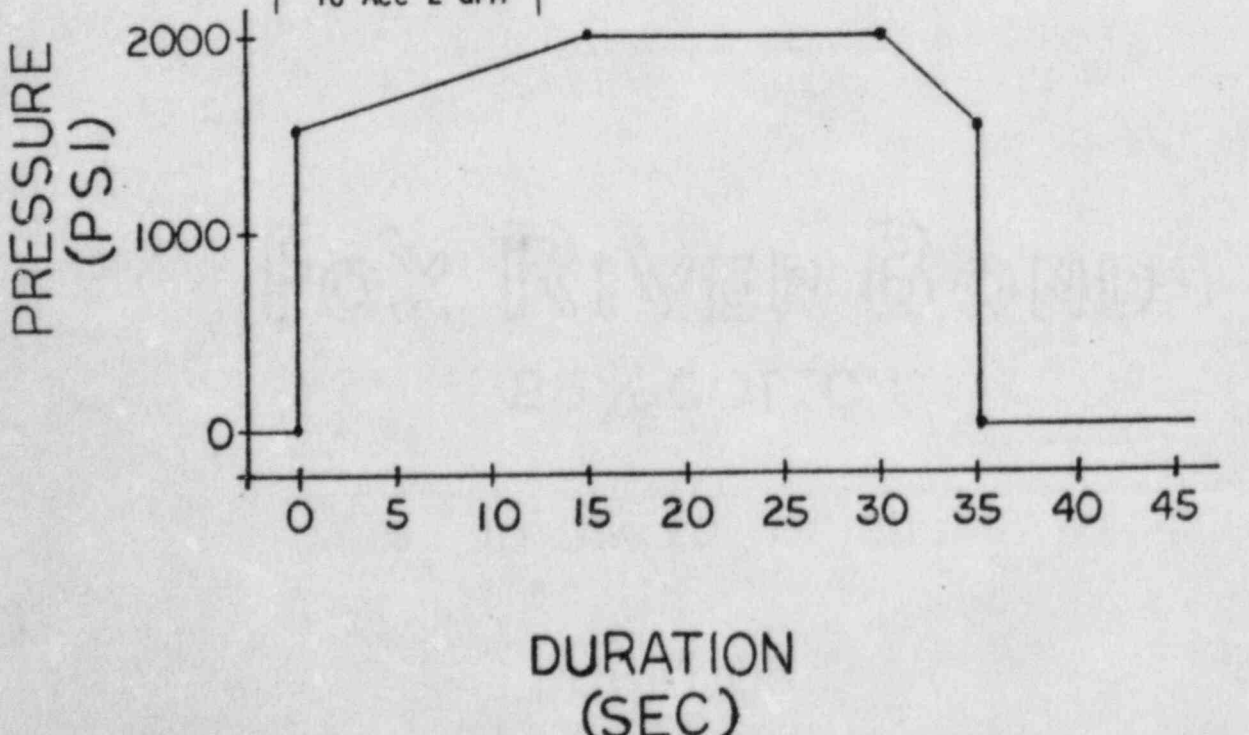
Control valves tested in this apparatus did not exhibit failures even though they were tested in excess of 12,000 cycles. This performance indicates that control valves, operating with clean hydraulic fluid, can be expected to have an operating life far in excess of the plant requirements of 2,000 cycles in 40 years.

To evaluate valve performance under conditions which could cause cavitation, nitrogen (GN_2) was injected into the test loop and the valves were tested through the test cycle profile shown below:

KEANE VALVE
N_2 INJECTION TEST
(CYCLE PROFILE)

Charging Accumulator	Constant Pressure	Acc. Dis. Charge	GN_2 Injection
Flow Rates Pump 3 GPM FCV 1 To Acc 2 GPM	1 GPM thru FCV	5 GPM	Pump Flow 3 GPM



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Two valves have been tested in this mode to date. The valve having 12,000 cycles was subjected to GN_2 injection and evidenced failure at 13,500 cycles. This valve was refurbished with new internal components and retested. Failure reoccurred at 1,700 cycles. Both valve seats evidenced the same characteristic erosion or cavitation failure exhibited by the valves returned to Paul-Munroe from the Limerick Station.

On the basis of test results and the positive effect of the recommended maintenance routines to date, we conclude that the control valves are suitable for the intended application.

2. Piston seals in the valve actuators. In the Paul-Munroe letter of November 15, 1984, we reported that design modifications to the piston and cylinder barrel had been implemented and that these modification were expected to minimize seal wear experienced during testing. As a result of continuing study of job site conditions it was noted that all actuator failures occurred on units which were suspected of misalignment of the valve operator to the damper or of misadjustment of the valve actuator to accommodate this misalignment.

   Paul-Munroe has recommended that improved alignment of valve operator to damper be effected and has clarified the procedure for adjustment of the valve actuator. These alignment and adjustment considerations, in addition to the above mentioned design modifications, will extend significantly the operating service of these units. We are confident that the valve actuator units as they are now installed in the Limerick Generating Station, are configured to achieve long term reliable operation.

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3. The November 15, 1984 letter suggested that accumulators in the valve operator units which lost pre-charge pressure were not repairable. The Paul-Munroe recommendation then was to replace faulty accumulators with new ones. This has been accomplished and no further problems have been experienced, other plants cited in this report will not require accumulator replacement.

   As a result of studies conducted to date on the valve operator units installed in the Limerick Generating Station, Paul-Munroe concludes that these systems are fully operational. Routine, periodic maintenance performed in accordance with the Installation, Operation and Maintenance Manual will result in long-term, reliable performance of the valve operator units.

Respectfully submitted,

PAUL-MUNROE, INC.
Energy Products Division

Frank U. Erlach
Vice President/General Manager

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