ATTACHMENT 1

Consumers Power Company
Palisades Plant
Docket 50-255

INFORMATION REQUIRED BY THE NOVEMBER 9, 1989
TECHNICAL EVALUATION REPORT (TER) -
NUREG 0737, ITEM II.D.1,
"PERFORMANCE TESTING OF RELIEF AND
SAFETY VALVES, PALISADES PLANT"
TO CLOSE ITEMS NOT FULLY RESOLVED

May 30, 1990

6 Pages

OC0590-0339-NL04

ATTACHMENT 1

The following items are from Section 5.2 of the TER and refer to items listed in Section 1.2 of the TER.

ITEM 1:

Item 1, which requires conducting tests to qualify reactor coolant system relief and safety valves under expected operating conditions for design basis transients and accidents, was not met. This is because Consumers Power has not shown that tests on valves that are representative of the new valves were completed.

RESPONSE

The new PORVs and block valves must open and close under LTOP conditions, at a maximum pressure of 2100 psia (Reference 1) with either saturated steam or water or sub-cooled water as the inlet condition.

Target Rock Corporation (TRC) conducted opening and closing tests on the PORV Model 88RR with water as the inlet condition at 455 psig and 300°F and with saturated steam as the inlet condition at 2500 psig (Reference 2, Attachment 2). Both tests were conducted with the flow less than that expected at Palisades. The new TRC Model 88RR PORV is similar in operation to the TRC Model 80 tested by EPRI under conditions exceeding those required for Palisades. The Model 88RR is larger than the Model 80; therefore, the Model 88RR was computer modeled by MPR Inc. with Palisades conditions simulated (Reference 4). Based on the similarity of operation and the results obtained from the computer model which was benchmarked against the EPRI test results, the Model 88RR TRC PORV meets the criteria of NUREG 0737 II.D.1 (Reference 5, Attachment 3).

The block valve, a Rockwell Size 4 Model 1550 Equiwedge Gate Valve, was tested under static conditions by Edward Valve Co, the supplier, at 2500 psig and saturated steam inlet conditions and at 451 psig and 460°F under water inlet conditions (Reference 8). These conditions envelope, except for flow, the expected operational conditions at Palisades. The Rockwell Size 4 Model 1550 Equiwedge Gate Valve is similar in operation and size to the Rockwell Size 3 Equiwedge Gate Valve tested by EPRI (References 6, 7, and 9), therefore, this valve meets the criteria of NUREG 0737 II.D.1 (Reference 9, Attachment 4).

In summation, under design basis conditions both the block valve and the PORV have to open and close under flow and no-flow conditions with water or saturated steam inlet conditions at less than or equal to 2100 psia. The block valve, a Rockwell Size 4 Equiwedge Gate Valve, is qualified by the vendor tests and similarity to the valve model, Rockwell Size 3 Equiwedge Gate Valve, tested and qualified by the EPRI tests. The PORV is qualified by a combination of EPRI tests on a similar but much lower capacity valve, vendor tests, and a computer model, benchmarked against EPRI test results, developed and written by MPR Associates.

ITEM 2:

Item 2, which requires that valve expected operating conditions be determined through the use of analysis of accidents and anticipated operational occurrences referenced in Regulatory Guide 1.70, Rev 2, was not met. This is because the Licensee did not provide any information to demonstrate that representative valves were tested under conditions based on regulatory transients.

RESPONSE

The new valves are not required to operate under the conditions of accidents and anticipated operational occurrences referenced by Regulatory Guide 1.70 Rev 2 (References 10 & 16). Except under LTOP conditions, Palisades operates with the Block Valves closed.

ITEM 3:

Item 3, which requires the forces on the safety and relief valves to be maximized, was not met for the PORV inlet/outlet discharge piping. This is because the new PORVs to be installed at Palisades have a flow rate that is 3.4 times larger than the old PORVs for which the PORV piping was analyzed.

RESPONSE

The previously existing 2½ inch pipe in the Primary Coolant System (PCS) relief valve flowpath was replaced with 4 inch pipe (Reference 11). The entire relief valve piping flowpath has been analyzed for the new flow capacity (References 12 & 13) and meets the criteria of the Palisades FSAR. With the larger capacity PORV flowpath open, the PCS pressure would not challenge the PCS safety valves (Reference 12). As stated in the response to Item 2, the Palisades PORVs are not required to operate during any design basis accidents. According to the TER, the PORV outlet piping under LTOP conditions is not considered by the Staff to be in the scope of NUREG 0737 II.D.1 review.

ITEM 4:

The part of Item 4 that requires the highest predicted pressure be chosen for the tests was not met for the new PORVs or PORV block valves because information was not supplied to demonstrate this requirement was met for the new valves.

RESPONSE

The EPRI tests (References 3 & 6) which tested similar valves were conducted under conditions which exceed those expected at Palisades. Additionally, tests were conducted at Wyle Laboratories (References 13, 14, & 15) under conditions (?500 psia) which exceed the steam inlet conditions expected at Palisades (See Item 1 above). Reference 14 is included as Attachment 5.

ITEM 5:

Item 5, which requires the qualification of the associated control circuitry, was not met. Consumers Power has not demonstrated the control circuitry for the new PORV is environmentally qualified for the conditions possible during the accidents and transient where the PORV will operate.

RESPONSE

The limiting environmental conditions under which the new valves would be expected to operate would be during cooldown after the Main Steam Line Break

(MSLB) inside containment incident. Peak humidity and temperature during that incident are 100% humidity and 408°F.

The control circuitry for the new PORVs meets the criteria of 10CFR50.49 (References 17, 18, & 19) for those conditions.

ITEM 6

Item 6, which requires that the Licensee provide test data for NRC staff review and evaluation, was not met. The Licensee has not justified that the EPRI test results are applicable to the new valves to be installed or provided other test data for review.

RESPONSE

The Wyle test data (Reference 14) is included as Attachment 5 and was submitted by Consumers Power letter dated 2/23/90 (Reference 16). Target Rock Corporation (TRC) test data (Reference 2) is included as Attachment 2 and shows that the EPRI tests are applicable to the computer simulation of the Model 88RR PORV. Edward Valve test data (Reference 7 and 8) shows the EPRI tests are applicable to the new block valve. The response to Item 1 provides justification that the EPRI test results are applicable to the new valves.

ITEM 7

The following parts of Item 7 were not met.

a. The part of Item 7 that requires the Licensee to submit a correlation or other evidence to substantiate the valves tested in a generic test program demonstrate the functionability of as-installed primary relief and safety valves was not met for the new PORVs or PORV block valves to be installed at Palisades. The Licensee did not present sufficient information to conclude the tested valves demonstrate the operability of the valves to be installed at Palisades.

b. The part of Item 7, which requires showing that the test conditions are equivalent to those prescribed in the FSAR, was not met for the new PORVs and PORV block valves. The Licensee did not compare the test inlet conditions for the valves that would be representative of the new Palisades valves to the conditions expected at the plant. Therefore, it

cannot be assured that the test conditions bound the conditions expected at Palisades.

c. The part of Item 7 that requires consideration of the effect of as-built discharge piping on PORV operability was not met. The maximum calculated bending moment on the Palisades PORVs was not compared to the maximum testing bending moment to ensure the calculated bending moment is bounded by the test moment.

RESPONSE

a. Response to Items 1, 2, 3, 4, & 6 provides sufficient information to conclude the tested valves demonstrate the operability of the valves installed at Palisades.

b. Response to Items 1, 2, 3, 4, 5, & 6 assures that the test conditions bound the conditions expected at Palisades.

c. Response to Item 3 and CPC submittal dated March 30, 1989 assure the maximum bending moment does not exceed the maximum allowable bending moment. The maximum expected bending moment was submitted to the NRC on March 30, 1989 and is 3500 ft-lbs for new PORVs. This is within the code allowables.

ITEM 8:

Item 8, which requires qualification of the piping and supports, was not met for the PORV inlet/outlet piping and downstream of where the PORV line connects to the common header. With the new PORVs to be installed at Palisades, this portion of the piping must be reanalyzed to show it is qualified for the new loads. Because the flow rate of the new PORVs exceeds the flow rate of the Dresser 31739A safety valves at Palisades by a factor of 1.75, the Licensee should confirm the loads on the safety valve discharge piping are still bounded by a safety valve discharge.

RESPONSE

As stated in the response to Item 3, if the new PORV flowpath were to open, the safety valves would not be challenged (References 12 & 13). The PORV inlet/outlet piping, from the pressurizer to the quench tank, was analyzed (References 12 & 13) and in no case did it exceed the code allowables. The only use of the PORV flowpath within plant design bases at Palisades is for LTOP conditions and, as stated in the TER, analysis of the PORV discharge piping for LTOP conditions is not considered by the NRC Staff to be in the scope of Item II.D.1 review.

REFERENCES

1. Palisades System Operating Procedure SOP-1.

2. Target Rock Corporation Report No 5071 Rev A, January 31, 1990, "88RR Actuation/De-Actuation Times".

3. EPRI/Wyle Power Operated Relief Valve Phase III Test Report, Volume 2: Summary of Phase III Testing of the Target Rock Relief Valve, EPRI.NP - 2670-LD Vol 2 - October 1982.

4. MPR Associates, Inc; Dynamic Analysis of Target Rock Power Operated Valves, MPR.1150, February 1990. (Proprietary)

5. MPR Associates, Inc, Third Party Qualification Review of Replacement Pressurizer Power Operated Relief Valves for Palisades Nuclear Plant, MPR-1141, October 1989.

6. EPRI-Marshall Electric Motor-Operated Valve (Block Valve) Interim Test Data, EPRI NP-2514-LD July, 1982.

7. Edward Valves, Inc, "Qualification Summary Report for a Size 4 Class 1550 Equiwedge Gate Valve with a SMB-00-25 Limitorque Operator, RAL-7127, 11-10-89.

8. Edward Valve, Inc, "Qualification Testing for a Size 4 Class 1550 Equiwedge Gate Valve with a SMB-00 Limitorque Actuator, Report No RAL-7125, October, 1989.

9. MPR Associates, Inc, Third Party Qualification Review of Replacement Pressurizer Motor Operated Block Valves for the Palisades Nuclear Power Plant, MPR-1168, February 1990.

10. Palisades Final Safety Analysis Report Update (FSAR) Chapter 14.

11. Palisades Piping and Instrument Diagram, M-201, Sheet 2, Rev 21.

12. EI International, Inc, "Thermal Hydraulic Analysis of Pressurizer PORV Relief System. Prepared for Palisades Plant Pressurizer Valves Replacement Project," April 1990.

13. Consumers Power Co Palisades Facility Change File FC-791.

14 Wyle Laboratories Test Report No 57375, December 18, 1989.

15. MPR Associates letter, December 13, 1989 LEDemick to JLTopper, Consumer Power Co, "Report of the Pressurizer Valve Tests Conducted at Wyle December 5 through 8, 1989".

16. Consumers Power letter, February 23, 1990, RWSmedley to NRC, "Preliminary Response to Staff Concerns Related to PORV/Block Valve Modification (TAC 72889)".

17. Consumers Power Company Internal Correspondence letter "Summary of EEQ Evaluation, Project GWO 8304, File 120, 130" to JLTopper from DHPayne (PSE 44-90), May 24, 1990.

18. Consumers Power Company internal letter form DHPayne to RWSmedley, December 15, 1989 (DHP 42-89), "Pressurizer Valves Replacement Project, GWO 8304, Electrical Equipment Qualification".

19. Target Rock Corporation Report No 4915C "Qualification Extension Analysis Report for the Environmental Qualification of the Target Rock Corporation Project 88RR Series Power Operated Relief Valves, etc" February 27, 1989.

ATTACHMENT 2 TO THE 5/30/90 CPC RESPONSE
TO THE 11/9/89 TER ON NUREG 0737 II.D.1
COMPLIANCE

Consumers Power Company
Palisades Plant
Docket 50-255

MODEL 88RR TARGET ROCK CORPORATION REPORT
5071 REV A ACTUATION/DE-ACTUATION TIMES

OC0590-0339-NL04

REPORT NO 5071, Rev. A
PROJECT 88RR
DATED: 21 Aug 1989

88RR ACTUATION/DE-ACTUATION TIMES

CONSUMERS POWER CO.
ENGINEERING DEPARTMENT
SUPPLIER DOCUMENT [illegible]

1. [X] Work may proceed
2. [ ] [illegible] Work may proceed subject to incorporation of changes [illegible]
3. [ ] Revise and resubmit. Work may not proceed.

F/C No 791
GWO No 8304

Permission to proceed [illegible] acceptance or approval of design details selected by the [illegible] relieve Supplier from full compliance with contractual obligations or release any "holds" placed on the order.

BY [signature] DATE 5/21/90

CONSUMERS POWER CO.
PALISADES PLANT
P.O. # 2003-4152-(Q)
GWO 8304/FC 791
TRC REFERENCE 88RR

FINAL

Target Rock

Target Rock Corporation, 1966E Broadhollow Road, East Farmingdale, New York 11735

950*M/LB, Sh 48

P..ARED BY ______	TARGET ROCK CORPORATION	PAGE i OF
DATE ______	EAST FARMINGDALE LONG ISLAND, N. Y.	REPORT 5071 Rev.A
APPROVED BY ______		PROJECT 88RR
DATE ______		

REVISIONS

LETTER	DESCRIPTION	DATE	BY	APP.
--	First Issue	21Aug89	RB RB	V.L. 8/23/89
A	Incorporated customer comments; corrected flow co efficients and re-calculated; incorporated comparisons to EPRI valve & re-evaluated TRC test data	31Jan90	RB RB	V.L. 2/5/90

X = PAGE CHANGED THIS REVISION
O = NO CHANGES THIS REVISION

PG NO.	–	A	B	C	D	E	F	G	
TITLE	X	X							
i	X	X							
ii	X	X							
iii	X	X							
iv	X	X							
1	X	X							
2	X	X							
3	X	X							
4	X	X							
5	X	X							
6	X	X							
7	X	X							
8	X	X							
9	X	X							
10	X	X							
11	X	X							
12	X	X							
13	X	X							
14	X	X							
15	X	X							
16	X	X							
17	X	X							
18	X	X							
19	X	X							
20	X	X							
21	X	X							
22	X	X							
23	X	X							
24	X	X							
25	X	X							
26	X	X							
27	X	X							
28	X	X							
29	X	X							
30	X	X							
31	X	X							
32	X	X							
33	X	X							
34	X	X							
35	X	X							
36	X	X							
37	X	X							
38	X	X							
39	X	X							
40	X	X							

REVISIONS

LETTER	DESCRIPTION	DATE	BY	APP.	X = PAGE CHANGED THIS REVISION O = NO CHANGES THIS REVISION PG NO.	—	A	B	C	D	E	F	G	
					TITLE									
					i									
					41	X	X							
					42	X	X							
					43	X	X							
					44	X	X							
					45	X	X							
					46	X	X							
					47	X	X							
					48	X	X							
					49	X	X							
					50	X	X							
					51		X							
					52		X							
					53		X							
					54		X							
					55		X							
					56		X							
					57		X							
					58		X							
					59		X							
					60		X							
					61		X							
					62		X							
					63		X							
					64		X							
					65		X							
					66		X							
					67		X							
					68		X							

PREPARED BY ______ DATE ______ APPROVED BY ______ DATE ______	**TARGET ROCK CORPORATION** EAST FARMINGDALE LONG ISLAND, N. Y.	PAGE ii of REPORT 5071 Rev. A PROJECT 88RR

ADDENDA

NOTE: THE FOLLOWING IS A LIST OF ADDENDA TO THIS REPORT. REVISION OF THIS LIST DOES NOT REQUIRE REVISION OF THE BASIC REPORT.

X = PAGE CHANGED THIS REVISION
O = NO CHANGES THIS REVISION

ADDENDUM NO. (REV.)	DESCRIPTION	DATE	BY	APP.	PG NO.	–	A	B	C	D	E	F	G
I	First Issue Water Data Point #6	21Aug89	RB	8/23/89	ADD. I: 1	X	X						
					2	X	X						
					3	X	X						
IA	Deleted	31JAN90	RB RB	2/2/90									

TABLE OF CONTENTS

1.0 SUMMARY

The ensuing discussion concerns the actuation and de-actuation times of the TRC Power Operated Relief Valve 88RR.

A computer model was developed, in which the times associated with both subcooled water (flashing and non-flashing) and steam were obtained. In determining the validity of the computer model comparisons with actual test data from the EPRI test valve, 1052020-1 were conducted. These comparisons, for the initial conditions of saturated steam and (non-flashing) subcooled water, were very good; thereby establishing confidence in the computer model.

For the 88RR valve, calculations were conducted for the following thermal hydraulic conditions:

- o water at 280 psia & 212^{o}F,
- o water at 280 psia & 243.5^{o}F,
- o water at 469.7 psia & 388^{o}F, and
- o saturated steam at 2514.7 psia.

For all water calculations, the following two system pressure situations were considered:

- o the system inlet experiences a 50 psi/sec ramp and
- o the system experiences NO pressure ramp

The actuation times for all cases, except the NO ramp 469.7 psia case, were < 2.0 seconds. While the no ramp 469.7 psia case was found to be 2.701 seconds.

The de-actuation times for the 469.7 and 2514.7 psia cases were $<$ 2.0 seconds. While for all the 280 psia cases the times were found to be $>$ 2.0 seconds; with the 243.5^{O}F case experiencing the longest time of 4.476 seconds.

The most significant effect on valve actuation resulted from the .375 inch diameter pilot seat, and for any flashing situation that may occur the resulting actuation times will be within acceptable limits.

A curve of actuation/de-actuation times, for 100^{O}F water, as a function of valve ΔP was obtained for the 88RR valve and is given in Figure 7.

2.0 INTRODUCTION

Before preceding to a discussion of the mathematical model, a brief discussion of the physics is in order.

The time for the actuation of a PORV is dependent on four parameters:

1. the time to energize the coil,
2. the time to actuate the pilot,
3. the time to start slew action of the main disc, and
4. the time to slew the main disc.

If we consider that the time to actuate the pilot is instantaneous, then the time from coil energization to pilot motion is dependent on:

- o applied voltage and
- o system pressure.

It has been found[1] that the time from coil energization to pilot motion is approximately 440 msec.[2] (at 125 volts). The time required for the complete motion of the main disc is best illustrated in figure 1.

[1] From actual testing conducted at Target Rock.

[2] The time associated with coil energization is defined as that time where the magnetic force becomes > the piloting force (i.e: the pressure load plus the spring pre-load acting on the piloting mechanism plus the weight of the appropriate parts). The ≈ 480 msec given here, would not be the time associated with coil energization for the case of zero Δp. For this case, the magnetic force would have to increase to a value > the piloting force (ie: the spring pre-load plus the weight of the appropriate parts) plus the main disc spring pre-load plus the weight of main. Therefore, the coil energization time is dependent on system Δp. It should be noted that an implicited assumption, is that the valve bonnet is in the vertical direction.

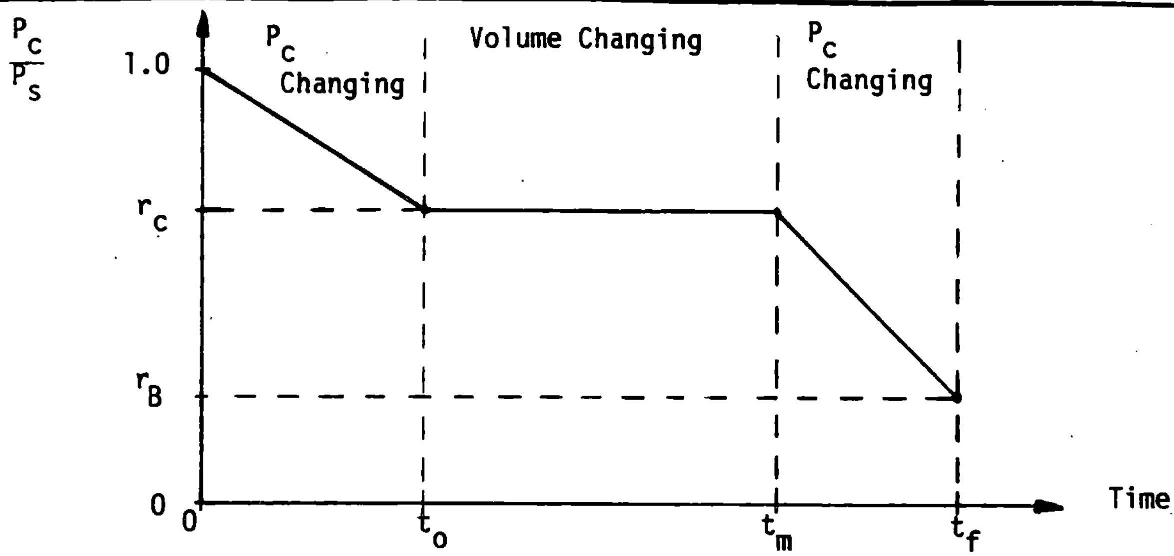


FIGURE 1: Actuation

Where r_c = pressure ratio defined from a force balance on main disc,

P_c = control pressure,

P_s = system pressure,

t_o = time to start slew action,

t_m = time for complete lift to occur,

r_B = steady state ratio defined by equal control chamber in-flow(s) and out-flow, and

t_f = time at which steady state control pressure is achieved.

Once the pilot disc is opened, the control pressure, P_c (which initially was P_s) begins decreasing. This results from the fact that the control chamber's outlet flow is greater than the inlet flow(s). This chamber pressure continues to decrease until it reaches a value of r_cP_s . Where r_cP_s is defined as the control point and is found from a summation of forces acting on the main disc; i.e.: the point at which the pressure forces, main disc spring pre-load, and weight become balance. Therefore, once this point is reached as one more molecule flows out of the chamber, a force inbalance is created in the

upward direction. Therefore, the main disc begins slewing, i.e. time t_o; from this point on, the control pressure will remain approximately constant.[3]

This constant pressure results from the fact, that though the chamber pressure wants to change; the force inbalance creates a volumetric change which tends to keep the chamber pressure constant.

Therefore, in order to maintain a constant control pressure, the control chamber volume must change, i.e.: the disc must lift. This volumetric change continues until the complete stroke is achieved, i.e.: time t_m. After t_m the control chamber pressure will decrease, until a value is reached in which the control chamber inlet and outlet flows are equal.[4]

Therefore, complete valve actuation is defined as,

$$\Delta t_{total} = t_o + \Delta t_{mo}. \quad (1)$$

[3] In reality, as the main disc moves there is an increase in the spring force acting on the main, i.e.; $F_{spring} = F_{spring\ preload} + |\Delta x|K$. Where K is the spring constant and Δx is the distance traveled from the control point. At the control point $\Delta x = 0$; thereby defining the control point (uniquely) and as motion occurs the increase in force will result in a decreased required control pressure. Thereby causing the main disc to slew even faster, in order, to "catch" the required "new" lower control point, thus defining a positive feedback situation. Therefore, from a conservative point of view we will neglect any increase in force; and assume the control point is constant and defined using $\Delta x = 0$.

[4] From a design point of view it becomes obvious that $r_C > r_B$ always.

For the de-actuation of a PORV, the following parameters must be considered:

- The time to de-energize the coil,
- the time to close pilot,
- the time to "build-up" the control chamber's pressure to start slew action, and
- the time to slew the main disc.

If we consider that the time to close the pilot is instantaneous, then the time from coil de-energization to pilot motion is primarily dependent on the switch condition.[5] An average time for de-energization of the coil is approximately ≈ 220 msec.[6] (at 125 volts). The time required for the complete motion of the main disc is best illustrated in figure 2.

[5] This became painfully clear during the 88RR de-actuation tests and was found to have considerable affect on de-actuation times.

[6] Obtain from actual testing conducted at Target Rock.

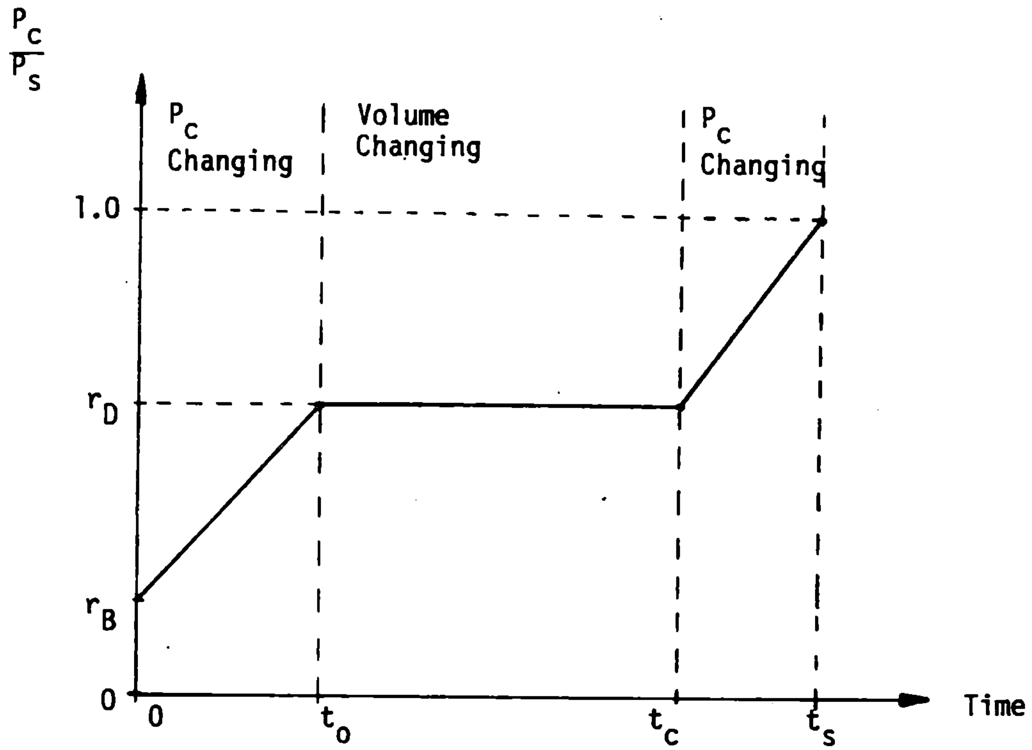


FIGURE 2: DE-ACTUATION

Where, t_s = time at which $P_c = P_s$,

t_c = time for complete closure to occur, and

r_D = pressure ratio defined from a force balance on main disc.

Once the pilot closes, there only exists inlet flow(s) into the control chamber. This flow will increase the control chamber's pressure from its minimum value to a value, that when combined with the spring preload, spring load and gravity load balances the upward system pressure load. Therefore, once this point is reached, as one more molecule flows into the chamber, a force inbalance is created in the downward direction; at which point, the main disc begins moving.

From this point on, the control chamber's pressure remains approximately constant.[7] The disc continues to move until complete closure is achieved. Once the disc is closed, the control chamber's pressure begins increasing until it finally reaches its steady state value, i.e.: the system pressure.

Before continuing, some general comments concerning the differences between, steam, non-flashing water and flashing water are in order.

Between steam and (non-flashing) water there exists some fundamental differences. First off, it can be shown that for water calculations, the actuation times are ΔP dependent, while for steam, it can be shown that actuation is pressure independent.

Furthermore, for the water calculations, the significant time is associated with the "slewing" of the main disc (i.e.: $t_m - t_o$); where as the de-pressurization time t_o, can be shown to be "fast". For steam, just the reverse is true, i.e.: t_o is the significant time segment and $t_m - t_o$ is "fast".

7 In reality, as the main disc moves the spring force will decrease from its maximum value to its pre-load value. This decrease in spring force will result in a higher required control pressure. Thereby causing the main to slew slower, thus defining a negative feedback situation. Since the difference in control pressure (between including and not including the increased force) is small, see Section 3.2, we will include the increased force and assume that the control pressure remains constant (see footnote 3).

For the case of flashing water, it must be understood that the flashing phenomena will cause an increase in control chamber pressure for an appreciable length of time, provided the outlet to inlet area ratio is not appropriately chosen. From previous Target Rock testing, it has been determined that as a minimum, the outlet to inlet area ratio should be approximately 10 to 1. For this specific design, the area ratio is greater than 10 to 1; therefore, we should not experience a pressure rise, due to flashing, within the chamber. Though the pressure will not rise, the flashing phenomena will result in a slowing down of the pressure decrease within the chamber. Therefore, there will be longer times associated with flashing water than with non-flashing water.

3.0 ANALYSIS

3.1 Pressure & Quality

Let us first consider valve actuation. As shown in Figure 1, the control chamber's pressure initially equals the system pressure. Then, with the opening of the pilot disc[8], this pressure will continually decrease with time, until the chamber pressure reaches a force balance point. (Defined from a summation of forces acting on the main disc). This balancing occurs at time $t = t_0$, and is the time at which the main disc begins slewing. Remember, during this time interval,

$$0 \leq t \leq t_0$$

the control chamber's volume remains constant.

Time $t = 0$ is defined as that time at which, the pilot is opened, but the control chamber's pressure P_c still equals the system pressure P_s. Thus at time $t = 0+$, the chamber pressure will be defined as,

$$P_c < P_s .$$

Before continuing let us define the following general assumptions:

- o the pressure within the control chamber is uniform,
- o the volume is uniform in its thermodynamic state,
- o all two phase flow is homogeneous,
- o any quality change occurs in thermodynamic equilibrium, and
- o pressure expansion and compression will be defined isentropically.

8 We will assume that the pilot opens instantaneously.

Now considering the control volume shown in Figure 3; the application of the continunity equation,

i.e.:

ROC of mass = 0, (2)

yields the following:

$$\frac{\partial}{\partial t}(\langle \rho \rangle V)_{cv} = \Sigma W_I + W_\ell - W_o \quad . (3)$$

Where $\langle \rho \rangle$ = control volume (c.v.) density,

V = c.v. volume,

ΣW_I = sum of inlet flows,

W_ℓ = leakage flow, and

W_o = outlet flow.

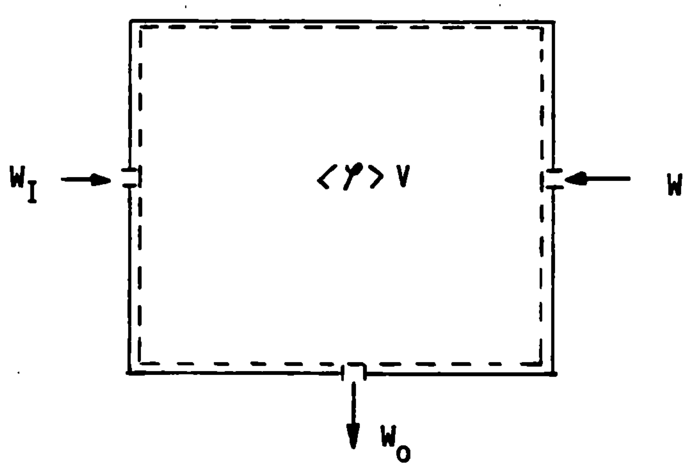


FIGURE 3: CONTROL VOLUME

REPRESENTATION OF CONTROL CHAMBER

For the case of saturated steam (assuming a homogenous equilibrium model), during the expansion process the steam will remain in thermodynamic equilibrium, as does all formed water.

Therefore, for the case of valve actuation, i.e.: V = constant, equation (3) becomes

$$\frac{\partial \langle \rho \rangle}{\partial t} = \frac{\sum W_I + W_l - W_o}{V} \quad . \qquad (4)$$

Defining the c.v. density in terms of specific volume $\langle v \rangle$; namely,

$$\langle \rho \rangle = 1/\langle v \rangle, \quad (5)$$

and defining the specific volume as:

$$\langle v \rangle = v_f + \langle x \rangle v_{fg} \; ; \quad (6)$$

where $\langle x \rangle$ = quality,

v = specific volume, and

the subscripts "f" and "g" define saturated water and steam respectively.

Furthermore, since we have defined saturated conditions, the phasic specific volumes are functions of pressure only, i.e.:

$$\left.\begin{aligned} v_f &= f(P) \text{ and} \\ v_g &= f(P); \end{aligned}\right\} \quad (7)$$

using the chain rule of differentiation; and assuming that the water is incompressible, namely:

$$\frac{\partial v_f}{\partial P} = 0 \quad .(8)$$

Equation (4) can be put into the following form,

$$\frac{-1}{\langle v \rangle^2}\left[\langle x \rangle \frac{\partial v_g}{\partial P}\frac{dP}{dt} + v_{fg}\frac{d\langle x \rangle}{dt}\right] = \frac{\Sigma W_I + W_\ell - W_o}{V} \quad . (9)$$

Where the partial derivatives have been replaced by total derivatives. Re-arranging and solving for the pressure derivative the following is obtained:

$$\frac{dP}{dt} = \left(\langle x \rangle \frac{\partial v_g}{\partial P}\right)^{-1}\left[\langle v \rangle^2 \frac{(W_o - \Sigma W_I - W_\ell)}{V} - v_{fg}\frac{d\langle x \rangle}{dt}\right] \quad .(10)$$

As stated earlier, we have defined an isentropic expanion; therefore, the quality at any given time step is defined by:

$$\langle x \rangle^i = \frac{\langle s \rangle_o - s_f(P^i)}{s_{fg}(P^i)} \quad ; \quad (11)$$

where $\langle s \rangle_0$ = system entropy = constant,

$s(P^i)$ = specific entropy at pressure P^i, where the superscript "i" defines an individual time step.

Therefore, by defining all the terms on the right side of equation (10), except $d\langle x \rangle/dt$, at the "old" time step, we are able to "march through time." Thus, the solution becomes an iterative process of solving for

$$\frac{dP}{dt} \quad \text{and} \quad \frac{d\langle x \rangle}{dt}$$

at a "new" time step, in terms of the parameters defined at the "old" time step.

From a Taylor series expansion, you can show that,

$$\frac{dP}{dt} \approx \frac{\Delta P}{\Delta t} + \ldots \text{ and}$$
$$\frac{d\langle x \rangle}{dt} \approx \frac{\langle x \rangle}{\Delta t} + \ldots \qquad (12)$$

Therefore, by assuming $\langle x \rangle^i$ you can calculate

$\left.\frac{d\langle x \rangle}{dt}\right)^i$ from equation (12) and

$\left.\frac{dP}{dt}\right)^i$ from equation (10). Now from equation (12) you calculate P^i and by using P^i you can find the "new" phasic specific entropies. Finally from equation (11), you calculate the "new" quality $\langle x \rangle^i$.

By comparing this calculated $\langle x \rangle^i$ to the assumed $\langle x \rangle^i$ you can see if closure has been achieved. The process continues until some convergence criteria is satisfied, namely:

$$\frac{|\langle x \rangle^i \text{ guess} - \langle x \rangle^i \text{ cal}|}{\langle x \rangle^i \text{ cal}} \leq \epsilon \quad . \quad (13)$$

Where ϵ is a small number.

Once the control pressure point ($r_c P_s$) has been reached the pressure within the control chamber becomes constant and the chamber volume begins changing, i.e.: the main disc slews. The disc continues to move until time t_m, i.e.: complete lift, is achieved. Therefore, from equation (3) with a constant chamber pressure and the volume varying, we obtain the following,

$$\frac{dV}{dt} = \frac{\sum W_I + W_\ell - W_o}{\langle \rho \rangle_{cv}} \quad . \quad (14)$$

By defining,

$$\frac{dV}{dt} = \frac{\Delta V}{\Delta t} + \ldots \quad (15)$$

the following result is obtained,

$$\Delta t_{mo} = \frac{\langle \rho \rangle_{cv} \ \Delta V}{W_I + W - W_o} \quad ; \quad (16)$$

Where

$$\Delta t_{mo} = t_m - t_o \quad ^{9} .$$

Now, let us consider the case of subcooled water. It will be assumed that during the expansion process, once the saturation pressure (associated with the system temperature) is reached the liquid will become and remain saturated; furthermore, any vapor formed will be defined as saturated steam. This will explicity avoid the superheating of the liquid phase; for as was stated earlier, we are assuming a thermodynamic equilibrium model.

For the case of subcooled water, with constant volume, equation (3) can be written in the form,

$$\frac{\partial v_\ell}{\partial t} = \frac{(W_O - \sum W_I - W_\ell)}{V} v_\ell^{\,2} \quad ; \quad (17)$$

[9] Equation 16 is valid for those cases where there exists NO system pressure RAMP. But for those cases where a pressure ramp does exist, the (actuation) disc slew time may be defined by:

$$\Delta t_{mo_{ramp}} = \left[\frac{F_g \Delta \ell}{6 g_c \, P_{slope} \, A_A} \right]^{1/3} . \quad (16A)$$

Where F_g = the gravity force, see eq. 29,
$\Delta \ell$ = the valve lift,
g_c = constant,
P_{slope} = the pressure ramp, and
A_A = the area on which the pressure is acting.

Thus, the (actuation) disc slew time is defined by eq. (16) for all cases where $P_{slope} = 0$ and for those cases where $P_{slope} > 0$ then:

o use eq. (16) when $\Delta t_{mo} \le \Delta t_{mo_{ramp}}$, or

o use eq. (16A) when $\Delta t_{mo} > \Delta t_{mo_{ramp}}$.

Where the subscript "ℓ" refers to subcooled liquid. Now by defining the adiabatic bulk modulus[10] B_ℓ as:

$$B_\ell \equiv -v_\ell \left[\frac{\partial P}{\partial v_\ell}\right] \quad , \quad (18)$$

and combining equation (17) and (18); we obtain the following result:

$$\frac{dP}{dt} = B_\ell \left[\frac{\sum W_I + W_\ell - W_0}{V}\right] v_\ell \quad . \quad (19)$$

Therefore, by defining the flow rates and specific volume at the "old" time we are able to solve for $\left.\frac{dP}{dt}\right)^i$ in terms of B_ℓ .

Now, by assuming that for the pressure range of interest, the bulk modulus remains constant; we therefore can define B_ℓ at the initial temperature and pressure. Thereby, obtaining an explicit expression for the pressure derivative.

Therefore, by the use of equation (19), we can now "march" forward in time from the initial conditions to the point (if applicable) where quality formation occurs. This formation point will be defined at that time where the instantaneous pressure reaches the saturation pressure (associated with the initial temperature). Thus, when

$$P^i \leq P_{sat} (T^0) \quad (20)$$

we will assume quality will form.

[10] Since the bulk modulus is defined in terms of thermodynamic properties, itself is also a thermodynamic property.

Once equation (20) is satisfied, we must now calculate the corresponding quality. This is achieved by using equations(4) and (5) to obtain,

$$\frac{d\langle v\rangle}{dt} = \langle v\rangle^2 \left[\frac{W_o - \sum W_I - W_\ell}{V}\right]; \quad (21)$$

and by defining,

$$\frac{d\langle v\rangle}{dt} = \frac{\Delta\langle v\rangle}{\Delta t} + \ldots , \quad (22)$$

we can now define the "new" chamber specific volume. Thus from equation (6) we can now define $\langle x\rangle^i$, i.e.:

$$\langle x\rangle^i = \frac{\langle v\rangle^i - v_f\,(P^i)}{v_{fg}(P^i)} \quad ; (23)$$

and by using this quality, we can now define the entropy (from which the expansion occurs) as:

$$\langle s\rangle_o = s_f\,(P^i) + \langle x\rangle^i\, s_{fg}\,(P^i) = \text{constant.} \quad (24)$$

Therefore, the solution scheme now becomes rather straight forward. For each successive time step, we first guess a pressure P^i and then solve for $\langle v\rangle^i$ using equations (21) and (22). From here the quality $\langle x\rangle^i$ is calculated from equation (23). Using the P^i and $\langle x\rangle^i$ we now calculate the instantaneous entropy from equation (24). Since the entropy is constant, closure is obtained when the calculated entropy equals the constant entropy $\langle s\rangle_o$.

The "marching" through time is continued until the control pressure point ($r_C P_s$) is reached. At this point, the solution is the same as was with saturated steam; namely, equation (16) is solved for Δt_{mo}.

Once both t_o and Δt_{mo} have been determined, the total actuation time is defined as,

$$\Delta t_{total} = t_o + \Delta t_{mo}. \quad (25)$$

Once the valve completely actuates, the pressure within the control chamber will begin decreasing from the control point to a minimum value defined as $r_B P_s$ [11], see figure 1. This minimum value is defined by that pressure in which the control chamber's inflow(s) equal the outflow. Thus, the solution of the equation:

$$\Sigma W_I + W_\ell = W_o , \quad (26)$$

will explicitly define this minimum pressure $r_B P_s$.

On de-actuation, the pilot disc[12] will close and the control chamber's

11 The actual time Δt_{fM} associated with reaching $r_B P_s$ (see figure 1) is of no interest to us and will not be considered here. The only consideration is that $r_B P_s$ is reached at some point. Though this might not be true in actual practice, the worst case scenario is associated with assuming that $r_B P_s$ has been reached. Therefore we will assume that the initial chamber pressure for de-actuation is $r_B P_s$.

12 We will assume that the pilot closes instantaneously.

pressure will increase from the minimum value, defined by equation (26), to the value defined as $r_D P_S$, see figure 2. Where $r_D P_S$ is defined by a force balance on the main disc. Once this new force balance point is reached, the main disc will begin slewing, and will continue until time = t_c ; i.e.: the time at which the main "hits" its mechanical stop (that is, the main has re-seated itself). Thus, in summarizing:

- for $0 < \text{time} < t_o$ the chamber pressure increases from its minimum value to the control point (at constant volume), and
- for $t_o \leq \text{time} \leq t_c$ the main disc slews (at constant pressure).

For the time frame t_c to t_s, the control chamber pressure will increase from the balance point $r_D P_S$ to the system pressure P_S. But, since this time frame is not pertinent to our analysis, it will not be considered here.

Time t = 0 will be defined as that time at which the pilot is closed, but the chamber pressure is still at its minimum value defined by equation (26). Thus at time = 0^+, the chamber pressure will be defined as,

$$P_c > P_{c_{min}} .$$

From all thermodynamic cases, de-actuation is defined with a closed pilot disc. Therefore the outflow flow W_O, as shown in figure 3, is always equal to zero.

For the case of a two phase mixture (which resulted from the expansion of saturated steam) the de-actuation solution is exactly as was outlined for the saturated steam valve actuation. (i.e.: equations (10) through (16)).

For the case of subcooled water, where no flashing has occurred, the solution is as defined by equations (18) and (19). But, when flashing has occurred, the solution is defined by equations (18) through (24) applied in reverse. That is, equations (21) through (24) are solved until,

$$P^i \geq P_{sat}(T^O). \quad (27)$$

At this point it is assumed that all quality disappears and as the pressure rises, the water becomes more and more subcooled. Therefore, from this time onward the solution is defined by equations (18) and (19).

It should be understood that depending on the amount of initial subcooling, it is quite possible that the de-actuation force balance point as defined by $r_D P_S$, is inside the "steam dome". Therefore, for the time segments of interest to us (see figure 2), de-actuation will always be defined within the two phase region. While, it is also

possible that the subcooling is such that, for valve actuation, $r_B P_s$ is greater than the saturation point and flashing will not occur; thereby requiring only subcooled equations.

We have now completely defined the model for both actuation and de-actuation for different thermodynamic conditions.

3.2 Force Balances

Considering the cause of valve actuation first, we will now define the pressure $r_C P_S$, inwhich the forces acting on the main disc become balanced. From figure 4, inwhich the main disc is shown in the closed position, one can see that a force balance on the disc will yield the following:

$$P_C = P_S \left[\frac{A_A}{A_{P_1}} \right] + P_{DS} \left[\frac{A_{DS}}{A_{P_1}} \right] - \frac{(F_g + F_{sp})}{A_{P_1}} \quad . \qquad (28)$$

Where P_C = control chamber pressure,

P_s = system pressure,

P_{DS} = downstream pressure,

F_g = force due to gravity,

F_{sp} = force due to spring pre-load,

A_{P_1} = Piston Area - Pilot Seat Area,

A_{DS} = Main Seat Area - Pilot seat area, and

$A_A = A_{P_1} - A_{DS}$.

One will notice that equation (28) has no friction term present. This results from the fact that we are interested in the point at which the forces balance, before motion has occurred; therefore, there is NO friction[13] present. Furthermore, this pressure P_c is in the conservative sense; because once the main "crakes" there will be a sudden increase in pressure under the disc, i.e. $P_{DS} \rightarrow P_s$. And

[13] Once the main begins motion, a frictional force would develop; but, from a review of the forces presented within this section, one can see that the inclusion of friction plays no significant role.

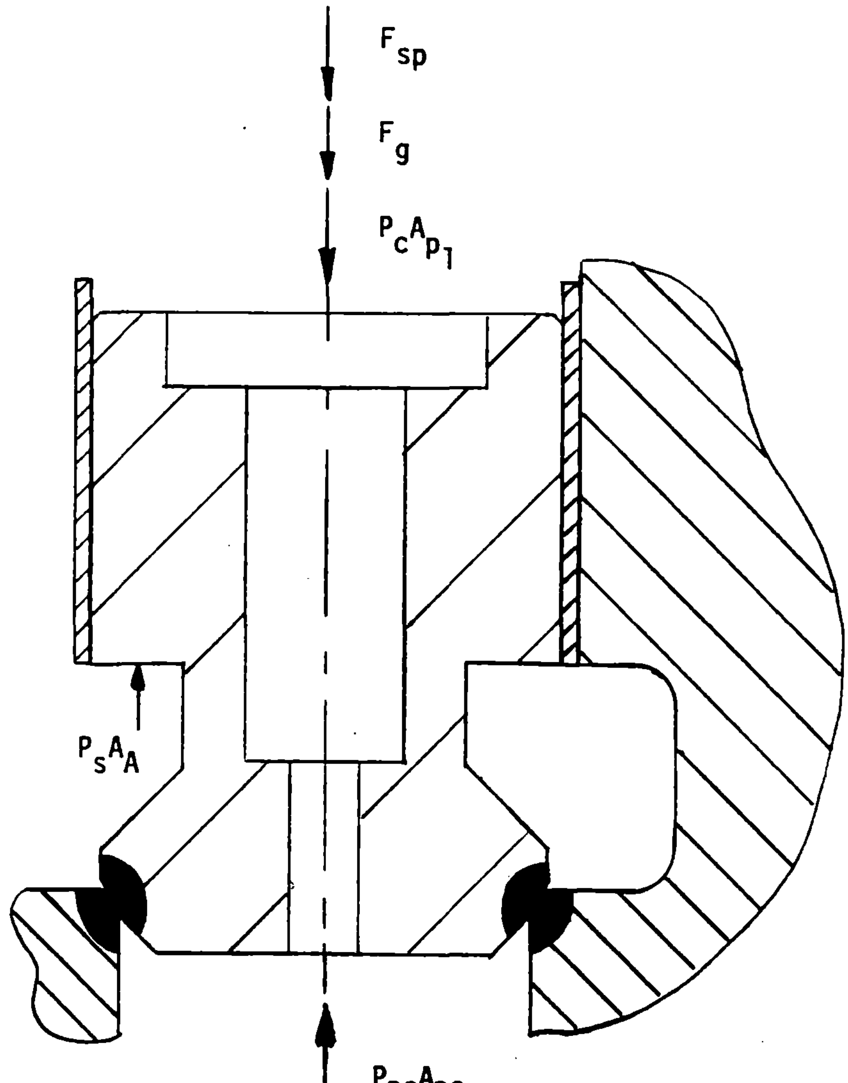


FIGURE 4: Forces acting on seated main disc.

this increase would cause a sudden "jump" in the position of the main. But, it must further be understood that once a flow begins to establish itself, the flow separation that results will result in a "low" pressure under the "nose" of the disc. Therefore, the assumption that P_{DS} is constant and defined from the closed valve position is very reasonable and conservative.

The gravity force F_g is defined by the component of the main disc weight F_{MD} ; namely

$$F_g = F_{MD} \sin \theta \quad . \quad (29)$$

Where $F_{MD} \approx 25 \ lb_f$, and

$\theta = 50^0$,

therefore, the force due to gravity is,

$$F_g \approx 19.2 \ lb_f \ .$$

The spring pre-load is defined as

$$F_{sp} = K \ | \Delta X | _{pre} \quad , \quad (30)$$

where $K = 83 \ lb_f$ /in, and

$$| \Delta X |_{pre} \approx .809 \text{ in;}$$

therefore, the spring pre-load is,

$$F_{sp} \approx 67.1 \ lb_f \ .$$

The areas are defined by,

- o Piston diameter = 5 in.,
- o Main Seat diameter = 4 in., and
- o Pilot seat diameter = .375 in..

Thus, by using the appropriate values in equation (28) the following result is obtained,

$$P_c = [.3620\ P_s + .6380\ P_{DS} - 4.420]\ \text{psi.}^{14} \quad (31)$$

Therefore, for any given system pressure we can obtain the corresponding control pressure P_c , see Table 1. As stated earlier, the downstream pressure P_{DS} will be assumed constant and will be defined as

$$P_{DS} \approx 0\ \text{psig.}$$

14 One can see that the combined effect of gravity and spring is ≈4 psi. Therefore, any inclusion of friction would have a marginal affect.

TABLE 1: Valve Actuation Control Pressure for Given System Pressures and NO pressure ramp

P_s ~ psia	P_c ~ psia	$r_c = P_c/P_s$
2514.7	915.3	.364
469.7	175.0	.373
280	106.3	.380

The valves given within Table 1 are for the case of zero system pressure ramp. For those (water) cases were the system pressure increases at a rate of 50 psi/sec, the control pressure as defined by equation (28) will become a function of time. That is, the system pressure is defined by:

$$P_s^{i} = P_s^{i-1} + 50\,\Delta t, \quad (32)$$

where the superscripts refer to the "new" and "old" times, and the "new" control pressure is defined by:

$$P_c^{i} = (.3620\, P_s^{i} + .6380\, P_{DS} - 4.420) \text{ psi}. \quad (33)$$

Therefore, for those cases where a 50 psi/sec ramp has been included the following control pressures are defined:

TABLE 2: Valve Actuation Control Pressure for Cases where the system pressure increases at a rate of 50 psi/sec.

P_s^{o} ~ psia	P_s^{i} ~ psia	P_c^{i} ~ psia	$r_c^{i} = P_c^{i}/P_s^{i}$
280	280	106.3	.380
469.7	530.73	197.1	.371

From a review of Table 2, one can see that the de-pressurization time

associated with an initial system pressure of 280 psia is so small that there is no appreciable increase in system pressure; while the 469.7 psia and 388°F case does have appreciable de-pressurization time and therefore, a corresponding increase in system pressure.

Now for valve de-actuation, see figure 5, the control pressure $r_D P_s$ is defined from a force balance on the main disc as:

$$P_c = P_s \left[1 - \frac{A_s}{A_p} \right] + P_{DS} \left[\frac{A_s}{A_p} \right] - \frac{(F_g + F_{sp} + F_{sm})}{A_p} . \quad (34)$$

Where A_p = piston area,

A_s = main seat area, and

F_{sm} = spring force due to maximum lift.

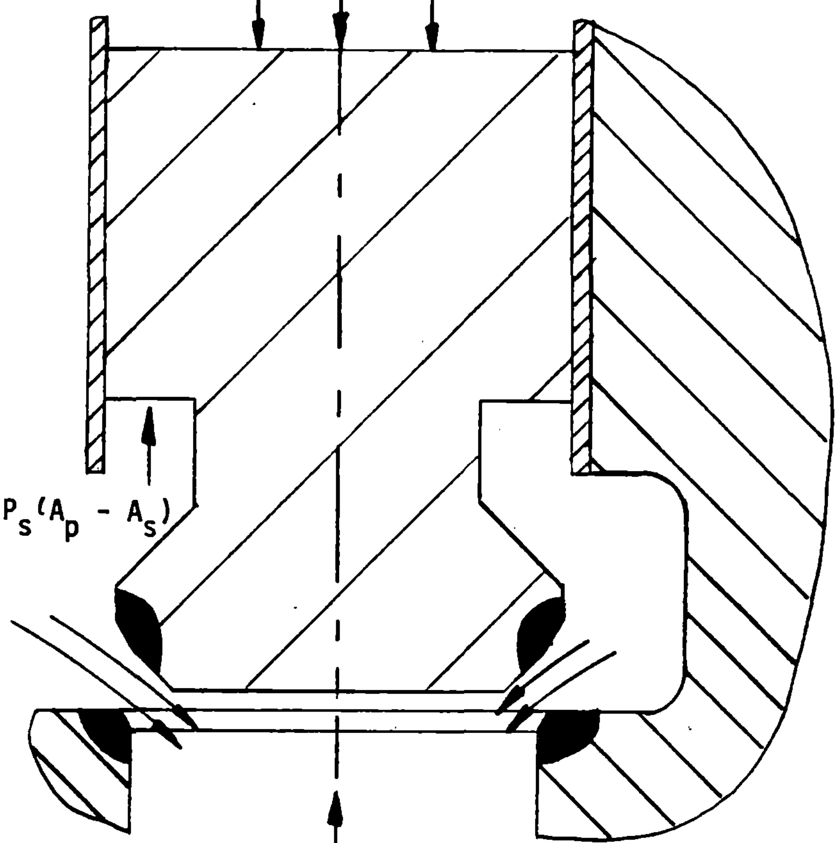


Figure 5: Forces acting on Open Main Disc

The spring load due to maximum lift is defined as,

$$F_{sm} = K \mid \Delta X \mid_{max.} \quad , (35)$$

Where $\mid \Delta X \mid_{max} \approx 1.0$ in; thus

$$F_{SM} \approx 83 \; lb_f \; .$$

Again by using the appropriate values, the following equation is obtained:

$$P_c = (.36P_s + .64P_{DS} - 8.622) \text{ psi}, \quad (36)$$

with the corresponding values listed in Table 3.

TABLE 3: Valve De-actuation Control Pressure for Given System Pressures and NO pressure ramp

$P_s \sim$ psia	$P_c \sim$ psia	$r_D = P_c/P_s$
2514.7	906.1	.360
469.7	169.9	.362
280	101.6	.363

The values given within Table 3 are for the case of zero system pressure ramp.

For those (water) cases were a 50 psi/sec ramp has been included, the control pressure as defined by equation (34) will become a function of time.

Since, we are not interested in the time from t_m to t_f, see figure 1; we will assume that the system pressure during de-actuation is defined as that value (P_s^K) associated with the end of actuation de-pressurization. That is, we will neglect any increase in system pressure during the times from t_o to t_m [15] and t_m to t_f.

Therefore, for those cases where the pressure ramp has been included the control pressures are defined by:

$$P_c^i = (.36\ P_s^K + .64\ P_{DS} - 8.622) \qquad (37)$$

and found to be:

TABLE 4: Valve De-actuation Control Pressure for cases where the system pressure increases at a rate of 50 psi/sec.

P_s^o psia	P_s^K psia	P_c^K psia	$r_D^K = P_c^K / P_s^K$
280	280	101.6	.363
469.7	530.73	191.8	.361

From Table 4, one can see that the de-pressurization time associated with P_s^o = 280 psia is small; while, that for P_s^o = 469.7 psia is not.

[15] From a review of the disc slew times associated with the inclusion of a pressure ramp, one can see that the error associated with neglecting Δt_{mo} is small.

3.3 Inlet, Leakage & Outlet Flows

We will now define the individual flow rates. For the case of subcooled water the individual flows will be defined by:

$$W_i = C_{di} \; A_i \sqrt{2g_c \rho_K \; \Delta P_K} \quad , \; (38)$$

Where W_i = individual flow rate,

C_{di} = individual flow coefficient,

A_i = individual flow area,

$g_c = 32.2 \; lb_f - ft/lb_m - sec^2$,

ρ_K = appropriate density, and

ΔP_K = appropriate pressure differential.

For the inlet (ΣW_I) and leakage (W_ℓ) flows, the appropriate density and pressure differential are:

o $\rho_K = \rho(P_s, T_s)$, and

o $\Delta P_K = P_s - P^{i}_{cv}$;

Where P_s and T_s are the respective constant system pressure and temperature and the superscript denotes a given time step.

For the outlet (W_o) flow, the appropriate parameters are:

o $\varphi_K = \varphi(P^i_{cv}, T_s)$, and

o $\Delta P_K = P^i_{cv} - P_{DS}$.

Where P_{DS} is the downstream pressure and is assumed constant.

It is possible that a given subcooled flow will choke. Therefore, whenever

$$\Delta P_K > \Delta P_{M_K} \quad (39)$$

a maximum flow rate will be defined and the respective ΔP_K will be replaced by ΔP_{M_K}.

Where, $\Delta P_{M_K} = F_L^2 \; (P_A - r_c P_{sat})$, (40)

with $P_{sat} = f(T_s)$,

P_A = inlet pressure to a given flow path,

r_c = critical pressure ratio, and

F_L^2 = the pressure recovery factor.

The critical pressure ratio will be defined by,

$$r_c = 0.96 - 0.28 \left[\frac{P_{sat}}{P_{critical}} \right]^{\frac{1}{2}}, \quad (41)$$

where $P_{critical}$ = 3208.2 psia;

It must be remembered, that since the system parameters are assumed constant, the inlet and leakage flows will always be subcooled. But due to the fact that the chamber parameters are time variant; it is quite possible that the outlet flow will not be subcooled. Thus, for these cases, W_o will be defined as:

$$W = C_{d_o} A_o \langle \rho \rangle_{cv} \sqrt{2 g_c J \left(\langle h \rangle_{cv} - \langle h \rangle \right)}, \qquad (42)$$

Where $\langle \rho \rangle_{cv}$ is the volume density,

$\langle h \rangle_{cv}$ is the volume enthalpy,

$\langle h \rangle$ is the downstream enthalpy, and

$J = 778 \; lb_f - ft/BTU$.

The control volume density and enthalpy are defined as:

$$\langle \rho \rangle_{cv} = 1/ \left(v_f(P^i) + \langle x \rangle^i v_{fg} (P^i) \right), \qquad (43)$$

and

$$\langle h \rangle_{cv} = h_f (P^i) + \langle x \rangle^i h_{fg} (P^i). \qquad (44)$$

Where the parameters are defined at a given time step. Finally the downstream enthalpy $\langle h \rangle$ is defined by an isentropic expansion from the chamber pressure to the downstream pressure. For those cases where the outlet flow is choked, equation (42) is solved for different downstream pressures until a maximum is reached.

For those cases where the system is saturated steam, the inlet and leakage flows are defined by equation (42) with the appropriate values. Again, the outlet flow is defined using equations (42) through (44).

3.4 Inlet, Leakage & Outlet Areas

The inlet to the control chamber consists of two diametrically opposed .060 inch diameter holes. But the pilot disc has a "shut off" feature; that is, once the pilot lifts, the inlet holes are partially blocked off. While in the closed position the inlet holes are completely open. This feature is shown schematically in Figure 6.

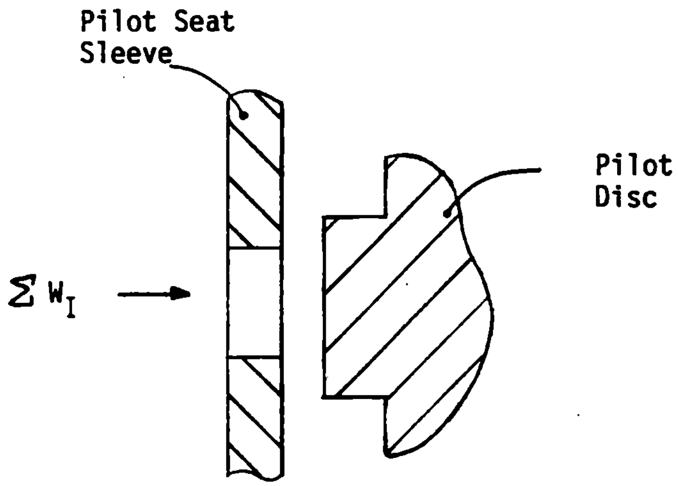


Figure 6: Pilot Disc "Shut off" Feature

Therefore, the inlet areas will be defined as follows:

- o for actuating, there are two parellel .0268" Dia.[16]. holes "feeding" the chamber, while
- o for de-actuation, there are two parallel .060" dia. holes.

The leakage into the control chamber is due to the leakage past the piston rings. From previous experience, it has been found that these rings will have an area corresponding to a .032" diameter hole. It should be understood that the inlet and leakage flows are in parallel.

The outlet flow area is defined from the geometry associated with the pilot disc and seat; thus, for a pilot lift of .158", the corresponding outlet diameter is .375 inch. Remember, this area is only defined for valve actuation, for de-actuation $A_{outlet} = 0$.

3.5 Volumes

The maximum control chamber volume is 47.57 in^3 , while the minimum volume is 27.93 in^3. Therefore, the change in volume due to the slewing of the main disc is,

$$\Delta V = 19.64 \text{ in}^3.$$

16 This is the corresponding hole diameter that results from partially blocking the .060" Dia. hole.

3.6 Initial & Boundary Conditions

For the actuating case, the following parameters, listed in Table 5, define the chamber initial conditions.

TABLE 5: Initial Conditions for Valve Actuation

Both with and without system pressure ramp.

SYSTEM			CHAMBER		
PRESSURE ~ psig	TEMP. ~ °F	QUALITY	PRESSURE ~ psig	TEMP. ~ °F	QUALITY
2500	Sat.	1.0	2500	sat.	1.0
455	388	0.0	455	388	0.0
265.3	243.5	0.0	265.3	243.5	0.0
265.3	212	0.0	265.3	212	0.0

The boundary conditions are defined as:

- Volume at t_o = 47.57 in^3. and
- Volume at t_m = 27.93 in^3..

For the case of de-actuation, Table 6 defines the chamber initial conditions.

TABLE 6: Initial Conditions for Valve De-actuation

SYSTEM			CHAMBER			
PRESSURE ~ psig	TEMP. ~ °F	QUALITY	PRESSURE ~ psig	TEMP. ~ °F	QUALITY	r_B
2500	Sat.	1.0	40.05	sat.	.660	.0218
455 (unramped)	388	0.0	.01	sat.	.165	.0313
265.37 Both ramped & unramped	243.5	0.0	.01	sat.	.020	.0525
265.3 (Both ramped & unramped)	212	0.0	.07	212	0.0	.0528
516.03 (455 psig with ramp)	388	0.0	.01	sat	.165	.0277

Note: The chamber conditions are found from the solution of equation (26).

The boundary conditions are defined as:

- Volume at t_o = 27.93 in^3 and
- Volume at t_c = 47.57 in^3.

4.0 RESULTS

For the case of saturated steam at 2500 psig, the following results were obtained, see Figures 1 and 2:

- r_C = .364,
- r_D = .360, and
- r_B = .0218

Valve Actuation:

- o t_o = .080 seconds
- o $\Delta t_{mo} = t_m - t_o$ = .031 seconds, and
- o $\Delta t_{total} = t_o + \Delta t_{mo}$ = .111 seconds.

Valve De-actuation:

- o t_o = 0.250 seconds,
- o $\Delta t_{co} = t_c - t_o$ = .189 seconds, and
- o $\Delta t_{total} = t_o + \Delta t_{co}$ = .439 seconds.

If we now define the coil energization time as ■ .480 seconds and the de-energiztion time as ■ .220 seconds [17]; the following total times defined from switch actuation to completed valve motion are:

- o Δ t actuate = .591 seconds, and
- o Δ t de-actuate = .659 seconds

[17] See footnotes 1, 2, 5, and 6.

For the case of subcooled water at 280 psia and 212^{O}F, the following results were obtained:

- o r_C = .380,
- o r_D = .363, and
- o r_B = .0528.

These ratios are identical for either the ramped or unramped cases.

For NO Pressure Ramp:

Valve actuation:

- o t_o = .0010 seconds,
- o $\Delta t_{mo} = t_m - t_o$ = .216 seconds, and
- o $\Delta t_{total} = t_o + \Delta t_{mo}$ = .217 seconds.

Valve De-actuation:

- o t_o = .0010 seconds,
- o $\Delta t_{co} = t_c - t_o$ = 2.347 seconds, and
- o $\Delta t_{total} = t_o + \Delta t_{co}$= 2.348 seconds.

Now using the coil energization and de-energization timesas previously defined, the total time from switch actuation to complete valve motion is:

- Δt actuate = .697 seconds, and
- Δt de-actuate = 2.568 seconds.

For 50 psi/sec RAMP:

Valve Actuation:

- t_o = .0010 seconds
- $\Delta t_{mo} = t_m - t_o$ = .066 seconds, and
- $\Delta t_{total} = t_o + \Delta t_{mo}$ = .067 seconds

Valve de-actuation:

- Results are the same as given for de-actuation with NO ramp.

Therefore, the total times are:

- Δt actuate = .547 seconds, and
- Δt de-actuate = 2.568 seconds

For the case of subcooled water at 280 psia and 243.5^oF, the following results were obtained:

- r_c = .380,
- r_D = .363, and
- r_B = .0525.

These ratios are identical for either the ramped or unramped cases.

For NO pressure ramp:

Valve actuation:

- t_o =.0010 seconds

- $\Delta t_{mo} = t_m - t_o$ = .263 seconds, and
- $\Delta t_{total} = t_o + \Delta t_{mo}$ = .264 seconds.

Valve De-actuation:[18]

- t_o = 1.891 seconds,
- $\Delta t_{co} = t_c - t_o$ = 2.366 seconds, and
- $\Delta t_{total} = t_o + \Delta t_{co}$ = 4.257 seconds.

Now using the coil energization and de-energization times as previously defined, the total time from switch actuation to complete valve motion is:

- Δt actuate = .744 seconds, and
- Δt de-actuate = 4.477 seconds.

For 50 psi/sec Ramp:

Valve actuation:

- t_o = .0010 seconds,
- $\Delta t_{mo} = t_m - t_o$ = .066 seconds, and
- $\Delta t_{total} = t_o + \Delta t_{mo}$ = .067 seconds

Valve de-actuation:

- Results are the same as given for de-actuation with NO RAMP.

[18] Note, the control chamber is intially in a two phase mix; but when the pressure rises to the saturation point ($\approx$26.5 psia) the chamber re-enters the subcooled region.

Therefore, the total times are:

- o Δt actuate = .547 seconds and
- o Δt de-actuate = 4.477 seconds .

For the case of subcooled water at 469.7 psia and 388^{o}F, the following results were obtained:

For NO Pressure Ramp:

- o r_c = .373,
- o r_D = .362, and
- o r_B = .0313

Valve actuation: [19]

- o t_o = 1.881 seconds,
- o $\Delta t_{mo} = t_m - t_o$ = .340 seconds, and
- o $\Delta t_{total} = t_o + \Delta t_{mo}$ = 2.221 seconds.

Valve De-actuation:[20]

- o t_o = .550 seconds,
- o $\Delta t_{co} = t_c - t_o$ = .457 seconds, and
- o $\Delta t_{total} = t_o + \Delta t_{co}$ = 1.007 seconds.

[19] Note, the control chamber is initially subcooled water, but when the pressure falls to the saturation point ($\approx$215 psia) flashing beings.

[20] The chamber is within the two phase region and the control point is $<$ the saturation point; therefore during this time segment the chamber does not re-enter the subcooled region.

Now using the coil energization and de-energization times as previously defined, the total time from switch actuation to complete valve motion is:

- Δt actuate = 2.701 seconds and
- Δt de-actuate = 1.227 seconds.

For 50 psi/sec ramp:

Remembering that the initial system pressure for actuation was 469.7 psia; while the system pressure at the end of actuation de-pressurization was 530.73 psia, thus:

- $r_C = .371$,
- $r_D = .361$, and
- $r_B = .0277$.

Valve actuation:[19]

- $t_o = 1.221$ seconds,
- $\Delta t_{mo} = t_m - t_o = .066$ seconds, and
- $\Delta t_{total} = t_o + \Delta t_{mo} = 1.287$ seconds.

Valve de-actuation:[20]

- $t_o = .77$ seconds,
- $\Delta t_{co} = t_c - t_o = .745$ seconds, and
- $\Delta t_{total} = t_o + \Delta t_{co} = 1.515$ seconds.

Therefore, the total times are:

o Δt actuate = 1.767 seconds and

o Δt de-actuate = 1.735 seconds.

For a complete summary of all results see Table 7. From a review of Table 7, one can see that the inclusion of the system pressure ramp has a significant effect on the disc slew (actuation) time, thereby decreasing the total time associated with valve actuation. Furthermore, for the 280 psia cases, the inclusion of the ramp had no appreciable effect on the force balance control pressures; therefore, these de-pressurization times were not effected in the least, while for the 469.7 psia case, the inclusion of the ramp did decrease the de-pressurization time significantly. This resulted from the fact that the control pressure was significantly raised.

When considering de-actuation, the inclusion of the ramp showed no significant effect for the 280 psia cases; while the 469.7 psia case did show a significant increase in de-actuation time. This resulted from the fact that the ramp caused a significant increase in force balance control pressure, thereby causing both increased pressurization and disc slew times.

TABLE 7: SUMMARY OF RESULTS

SYSTEM PRESSURE ~ psia	TEMP ~ °F	FORCE BALANCE CONTROL PRESSURE ~ psia		Flow Balance Control Pressure ~ psia	Medium	Actuation Time ~ seconds		De-actuation Time ~ seconds	
		Actuation	De-actuation			Disc Slew	Total	Disc Slew	Total
280	212	106.3	101.6	14.77	Subcooled Water	.216	.697	2.347	2.568
280 (with ramp)	212	106.3	101.6	14.77	Subcooled Water	.066	.547	2.347	2.568
280	243.5	106.3	101.6	14.71	Subcooled Water	.263	.744	2.366	4.477
280 (with ramp)	243.5	106.3	101.6	14.71	Subcooled Water	.066	.547	2.366	4.477
469.7	388	175.0	169.9	14.71	Subcooled Water	.340	2.701	.457	1.227
469.7(with ramp)	388	197.1	191.8	14.71	Subcooled Water	.066	1.767	.745	1.735
2514.7	Sat.	915.3	906.1	40.05	Steam	.031	.591	.189	.659

NOTE: Total times are determined using a coil energization time = .480 seconds and a coil de-energization time = .220 seconds.

52

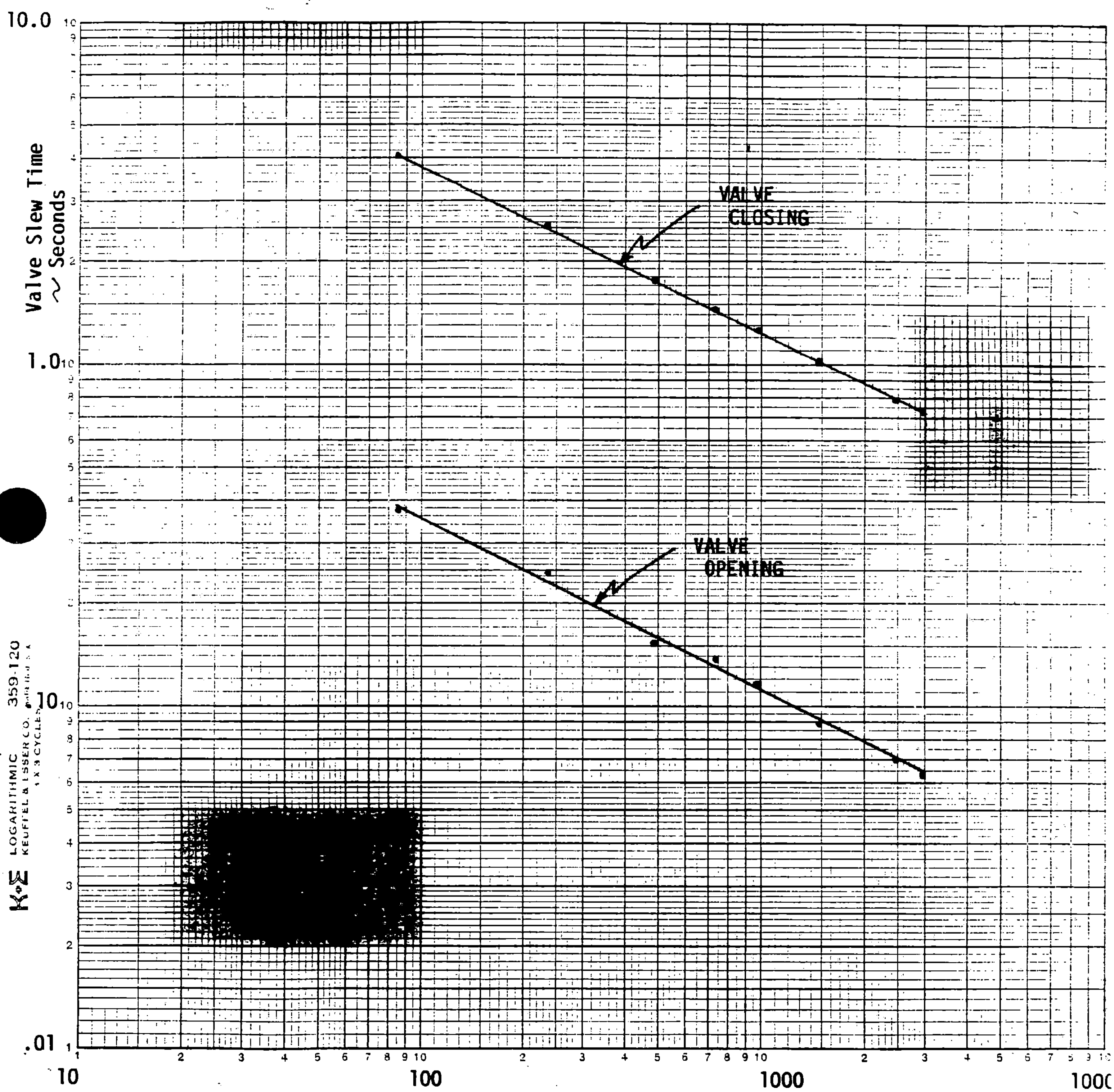
For a complete illustration of the operation of the 88RR valve, a curve of actuation/de-actuation disc slew times -vs- valve ΔP would be very informative. Thus, let us consider 100^{O}F water at different system inlet pressures, ranging from 100 to 3000 psia, and a back pressure of 14.7 psia; with the results listed in Table 8 and shown in Figure 7.

TABLE 8 Disc Slew times (for 100^{O}F water and P_{DS} = 14.7 psia) at different system pressures (No pressure ramp)

System Pressure psia	Disc Slew time Seconds Actuation	De-actuation
100	.378	4.013
250	.248	2.528
500	.153	1.784
750	.137	1.457
1000	.117	1.262
1500	.089	1.029
2500	.070	.798
3000	.064	.727

From a review of Table 8, one must appreciate the effect that the .375 inch diameter pilot has on actuating times; while during de-actuation the pilot is closed and therefore has no effect.

FIGURE 7: 88RR MAIN DISC SLEW TIME AS A FUNCTION OF VALVE ΔP, FOR 100°F WATER.



● Calculated points

5.0 TEST DATA

The 88RR valve was tested for actuation/de-actuation in the Target Rock "Blow Down" Test Facility. The test times were recorded in conjunction with valve inlet pressure, valve exit pressure, upstream temperature, and valve position. Where the valve position is recorded using a LVDT, a Linear Variable Differential Transformer.

Due to the limitations of the facility capacity in relation to the valve flow capacity, it was not possible to maintain system pressure. Therefore, during the course of each test run both the inlet and exit pressures varied. Furthermore, due to the large flow rate associated with saturated steam at 2500 psig, the flow through the valve had to be limited. This was accomplished by limiting the valve stroke, for the steam tests only, to ~ 0.25 inch (which was accomplished by the use of a spacer). Therefore as a result of this limitation, the chamber volume was changed (for steam tests only). The new values are:

- For actuation:

  $V_{initial} = 41.36\ in^3$ and

  $V_{final} = 36.45\ in^3$; and

- For de-actuation:

  $V_{initial} = 36.45\ in^3$ and

  $V_{final} = 41.36\ in^3$.

Again, these new volumes are for steam only.

Thus, for the case of saturated steam, the following test results were obtained:

TABLE 9: STEAM ACTUATION/DE-ACTUATION TIMES
(lift = 0.25 inch).
SATURATED CONDITIONS AT = 2500 psig

TEST #	ACTUATION		DE-ACTUATION	
	Disc Slew Time ~ seconds	Total Time ~ seconds	Disc slew time ~ seconds	Total time ~ sec
1	.056	1.310	.110	.436
2	.059	1.645	.085	.419
3	.046	1.860	.091	.384
AVERAGE VALUES	.054	1.605	.095	.413

Furthermore as an example, consider the following information as obtained from test "traces" for test run #1:

- o For Actuation:
  - o The Initial conditions (defined just prior to disc motion) were,

P_{Inlet} = 2550 psig and

P_{Exit} = 0 psig.

- And the final conditions (defined at the end of disc motion) were,

  $P_{Inlet} \approx$ 2075 psig and

  $P_{Exit} \approx$ 0 psig.

- For De-actuation:

  - The Initial conditions (just prior to valve motion) were,

    $P_{Inlet} \approx$ 1835 psig and

    $P_{Exit} \approx$ 120 psig.

  - And the final conditions (at end of motion) were,

    $P_{Inlet} \approx$ 2125 psig and

    $P_{Exit} \approx$ 100 psig.

Now, considering the testing that was concluded with subcooled water, the following data was obtained:

TABLE 10: WATER ACTUATION/DE-ACTUATION

TIMES (FULL LIFT)

SUBCOOLED WATER AT ■ 455 psig & 300°F

TEST #	ACTUATION		DE-ACTUATION	
	Disc Slew Time ~ seconds	Total Time ~ seconds	Disc slew time ~ seconds	Total time~sec
1	1.75	2.085	5.83	5.92
2	1.58	1.918	3.53	3.70
3	1.50	1.84	3.183	3.421
AVERAGE VALUES	1.61	1.95	4.18	4.35
Reference point[21] Test Run #6 at 455 psig & 364°F	1.540	1.872	4.503	4.696

21 For all the water tests conducted, this was the "hottest" temperature at the valve.

As an example, consider the following information as obtained from the test "traces" for test run #2 (water temperature was ~319°F):

- For actuation:
  - The initial conditions (just prior to disc motion) were:

    P_{Inlet} = 470 psig and

    P_{exit} = 0 psig
  - At ~.500 seconds after the start of disc motion:

    P_{Inlet} = 250 psig and

    P_{exit} = 100 psig.
  - And the final conditions (at the end of disc motion) were:

    P_{Inlet} = 200 psig and

    P_{exit} = 120 psig
- For De-actuation:
  - The initial conditions (just prior to disc motion) were:

    P_{Inlet} = 200 psig and

    P_{exit} = 120 psig.

    These initial conditions remain approximately constant throughout 90% of the test run.
  - And the final conditons (at the end of disc motion) were:

    P_{Inlet} = 340 psig and

    P_{exit} = 55 psig.

From a review of the information given for the steam test run #1 and the water test run #2, one can see that the variation in thermal hydraulic conditions is such that any attempt to model these tests (without a significantly more sophisticated model) is useless; thus, this information has only been provided for reference purposes.

Therfore, let us now turn out attention to a valve of similar, though smaller, design. That is, let us consider the EPRI (Electric Power Research Institute) test valve, Model 1052020-1. This valve, which was tested at Wyle Laboratories in Norco, California in April 1981, is of the dual plunger design and is the standard from which all Target Rock PORV's have derived, including the 88RR valve. Thus, listed within Table 11 is the EPRI valve test data.

TABLE 11: EPRI Test Valve (Model 1052020-1) Test Data

TEST RUN #	INLET PRESSURE ∿ psia	INLET TEMP ∿ °F	MEDIUM	TOTAL TIMES ∿ SECONDS	
				ACTUATION	DE-ACTUATION
1-TR-1S	2521	Sat.	steam	.330	.305
3-TR-3W	715	447	water	.280	.690
4-TR-5W	2536	645	water	.250	.435
5-TR-2W	690	114	water	.266	.802
6-TR-4W	2508	451	water	.271	.527
7-TR-7W	2505	113	water	.230	12.37*
8-TR-5W	2494	648	water	.390	.444
9-TR-6W	2490	645	water	.370	.413
17-TR-1S	2510	Sat.	steam	.396	.232

*This was a thermal transient test, on De-actuation the piston rings bound, therefore this is NOT a valid test point; it is for reference only.

6.0 COMPARISONS

In order to have confidence in the analytical model, it is required that there be some comparisons to actual test data. But, as was stated earlier, the tests conducted with 88RR at Target Rock would require the application of a significantly more sophisticated model; therefore, the use of this data for comparison purposes is NOT practical and has been provided only for reference purposes. Thus, in order to gain the required confidence, comparisons with the similar, though smaller, EPRI test valve (1052020-1) will be made. But, before listing the obtained model results, some pertainent geometric information is required. The chamber volumes for the EPRI valve are:

- For actuation

$$V_{Initial} = 12.987 \text{ in}^3 \text{ and}$$

$$V_{final} = 10.812 \text{ in}^3\text{; and}$$

- For de-actuation

$$V_{Initial} = 10.812 \text{ in}^3 \text{ and}$$

$$V_{final} = 12.987 \text{ in}^3.$$

The inlet to this control chamber consists of one (1) .047 inch diameter hole, which is completely open for valve de-actuation. While, for valve actuation, this hole will be partially blocked (see Figure 6) and the resulting equivalent, inlet hole diameter is .0237 inches. The control chamber outlet is a .125 inch diameter hole, which for actuation is completely open and for de-actuation completed closed. The leakage into the control chamber will be defined with an

equivalent hole diameter of .031 inches. Now that all the required geometric information has been defined, let us turn to the resulting calculated times.

TABLE 12: Valve Actuation/De-actuation times for the EPRI Test Valve, 1052020-1.

TEST RUN NO.	INLET PRESSURE ~psia	INLET TEMP ~°F	FORCE BALANCE CONTROL PRESSURE ~psia		FLOW BALANCE CONTROL CHAMBER		MEDIUM	TOTAL TIMES ~ SECONDS			
								Actuation		De-Actuation	
			Act.	De-act.	Press~psia	Quality		Measured	Calculated	Measured	Calculated
1-TR-1S	2521	Sat.	1186.1	1183.6	230.3	.691	Steam	.330	.338	.305	.571
3-TR-3W	715	447	342.0	341.3	165.5	.097	Water	.280	4.604	.690	1.133
4-TR-5W	2536	645	1193.2	1190.6	264.0	.318	Water	.250	1.012	.435	.620
5-TR-2W	690	114	330.3	329.7	20.3	0.0	Water	.266	.249	.802	.708
6-TR-4W	2508	451	1180.1	1177.6	141.5	.073	Water	.271	.198	.527	1.054
7-TR-7W	2505	113	1178.7	1176.2	35.1	0.0	Water	.230	.188	*	.475
8-TR-5W	2494	648	1173.5	1171.1	250.5	.325	Water	.390	1.007	.444	.620
9-TR-6W	2490	645	1171.7	1169.2	260.3	.318	Water	.370	1.035	.413	.620
17-TR-1S	2510	sat.	1181.0	1178.5	221.3	.691	Steam	.396	.327	.232	.570

*This was a thermal transient test, on de-actuation piston rings bound, therefore this is NOT a valid test point.

63

In calculating the total times as given in Table 12, a coil energization time of .120 seconds and a coil de-energization time of .220 seconds were used, see ref. 8.1.

Now, let us consider the results as listed in Table 12. For the saturated steam and "cold" water cases, namely runs 1-TR-1S, 5-TR-2W, 7-TR-7W, and 17-TR-1S, the comparisons between the model and test results are very good. For those cases, where the water temperatures were high, namely runs 3-TR-3W, 4-TR-5W, 6-TR-4W, 8-TR-5W, and 9-TR-6W, the comparisons are NOT good. But, a further review of these test results leads to the conclusion that the actual temperatures, of the fluid and/or valve body, were NOT as were given. Because, when one looks at the actuation times associated with these "hot" runs, one sees that these times correspond more to "colder", non-flashing, water runs. Therefore, in order to see the effect of fluid temperature on both the actuation and de-actuation times, let us re-run these five (5) data points as a function of fluid temperature. Therefore:

TABLE 13: EPRI TEST RUN 3-TR-3W
P_{Inlet} = 715 psia and Variable Temp.

Fluid Temp ~ °F	Did Quality Form During Actuation?	Flow Balance Control Chamber Quality	Total Time ~ Seconds Actuation Cal.	Actuation Measured	De-actuation Cal.	De-actuation Measured
150	No	0.0	.245	.280	.697	.690
200	No	0.0	.248	.280	.693	.690
300	No	.015	.254	.280	1.770	.690
400	No	.075	.335	.280	2.005	.690
447	Yes	.097	4.604	.280	1.133	.690

NOTE: The measured values are given for comparison only. These were NOT measured as a function of temperature.

From a review of Table 13, one can see that the test results correspond closer to a fluid temperature range of 150-200°F than to a 447°F temperature. Or, it is also possible that the fluid entered the control chamber at say 300-400°F, but upon coming in contact with a "cold" valve body the fluid was then "cooled down". Therefore, the actuation would correspond to the 300-400°F range, but the de-actuation would correspond to say the 150-200°F range.

Table 14: EPRI Test Run 4-TR-5W
P_{Inlet} = 2536 psia and variable Temp.

Fluid Temp ~ °F	Did Quality Form During Actuation?	Flow Balance Control Chamber Quality	Total Time ~ Seconds			
			Actuation		De-actuation	
			Cal.	Measured	Cal.	Measured
150	No	0.0	.187	.250	.473	.435
300	No	0.0	.187	.250	.465	.435
400	No	.038	.192	.250	1.021	.435
600	Yes	.238	1.072	.250	.791	.435
645	Yes	.318	1.012	.250	.620	.435

NOTE: The measured values are given for comparison only. There were NOT measured as a function of temperature.

From a review of Table 14, one can see that the test results correspond closer to a fluid temperature range of 150-300°F than to a 645°F temperature. Or, it is also possible that the fluid entered the chamber at around 400°F, but upon contacting the "cold" valve body the fluid then "cooled down". Therefore, the actuation would correspond to the 400°F range, but the de-actuation would correspond to say the 150-300°F range.

TABLE 15: EPRI Test Run 6-TR-4W
P_{Inlet} = 2508 psia and variable Temperature

Fluid Temp ~ ^{O}F	Did Quality Form During Actuation?	Flow Balance Control Chamber Quality	Total Time ~ Seconds: Actuation Cal.	Actuation Measured	De-actuation Cal.	De-actuation Measured
150	No	0.0	.188	.271	.473	.527
200	No	0.0	.188	.271	.472	.527
300	No	0.0	.188	.271	.467	.527
400	No	.039	.192	.271	1.033	.527
451	No	.073	.198	.271	1.054	.527

NOTE: The measured values are given for comparison only. There were NOT measured as a function of temperature.

From a review of Table 15, one can see that the test results correspond closer to a fluid temperature range of 150-300^{O}F than to a 451^{O}F temperature. Or, it is possible that the fluid entered the chamber at around 400^{O}F, but upon contacting the "cold" valve body the fluid then "cooled down". Therefore, the actuation would correspond to the 400^{O}F range, but the de-actuation would correspond to say the 150-300^{O}F range.

TABLE 16: EPRI Test Run 8-TR-5W
P_{Inlet} = 2494 psia and variable Temp.

Fluid Temp ~ °F	Did Quality Form During Actuation?	Flow Balance Control Chamber Quality	Total Time ~ Seconds: Actuation Cal.	Actuation Measured	De-actuation Cal.	De-actuation Measured
150	No	0.0	.188	.390	.474	.444
200	No	0.0	.188	.390	.473	.444
300	No	0.0	.188	.390	.468	.444
400	No	.039	.193	.390	1.034	.444
500	No	.111	.212	.390	1.053	.444
600	Yes	.239	1.098	.390	.779	.444
648	Yes	.325	1.007	.390	.620	.444

NOTE: The measured values are given for comparison only. These were NOT measured as a function of temperature.

From a review of Table 16, one can see that the test results correspond closer to a fluid temperture of 150-300°F than to a 648°F temperature. Or, it is possible that the fluid entered the chamber around 400-500°F, but upon contacting the "cold" valve body the fluid then "cooled down". Therefore, the actuation would correspond to say the 400-500°F range, but the de-actuation would correspond to say the 300°F range.

TABLE 17: EPRI Test run 9-TR-6W
P_{Inlet} = 2490 psia and variable Temp.

Fluid Temp ~ °F	Did Quality Form During Actuation?	Flow Balance Control Chamber Quality	Total Time ~ Seconds Actuation Cal.	Measured	De-actuation Cal.	Measured
150	No	0.0	.188	.370	.475	.413
300	No	0.0	.188	.370	.467	.413
400	No	.039	.193	.370	1.034	.413
500	No	.111	.212	.370	1.053	.413
600	Yes	.239	1.097	.370	.779	.413
645	Yes	.318	1.035	.370	.620	.413

NOTE: The measured values are given for comparison only. These were NOT measured as a function of temperature.

From a review of Table 17, one can see that the test results correspond closer to a fluid temperature of 150-300°F than to a 645°F temperature. Or, it is possible that the fluid entered the chamber around 400-500°F, but upon contacting the "cold" valve body the fluid then "cooled down." Therefore, the actuation would correspond to say 400-500°F range, but the de-actuation would correspond to say the 300°F range.

Finally, after a complete review of Tables 13-17, one must conclude that either the fluid temperature was "colder" than listed or the valve body temperature was such that it causes the fluid to respond as a "colder" fluid. In either case, the results are clear, the EPRI data for runs 3-TR-3W, 4-TR-5W, 6-TR-4W, 8-TR-5W, and 9-TR-6W are NOT for the temperatures that are listed, but rather for those "colder"

temperatures as listed in Tables 13-17. Thus, when one takes into account the previous arguement, it becomes quite clear that the model accurately predicts valve response.

In making these comparisons, one must keep in mind the limitations associated with this model, namely:

- First off, for water it has been assumed that the chamber is a complete "solid" water system. That is, no air, contributing to some compressibility, has been allowed. Also, in general, no internal pressure gardient within the chamber, has been allowed,
- Secondly, the model does not allow for heat transfer to the valve internals.

7.0 CONCLUSIONS

Due to the variations in the thermal hydraulic parameters associated with the 88RR test data, any attempt to model these tests (without a significantly more sophisticated model) was considered useless. Therefore, all comparisons were made with the EPRI test data obtained for the similar, though smaller, valve 1052020-1.

For all cases where comparisons with data were made, the results are all very reasonable; thereby, proving the validity of the model.

For the 88RR valve, calculations were conducted for both saturated steam and subcooled water. For the subcooled water conditions, valve actuation was considered to occur with either a system pressure ramp of 50 psi/sec or NO ramp at all.

For the 2514.7 psia saturated steam condition all calculated times were $<$ 1.0 seconds.

For the 280 psia subcooled, non-flashing, water condition the inclusion of the system pressure ramp had no appreciable effect (during actuation) on the chamber de-pressurization rate, but did have a significant effect on disc slew time. Due to the fact that the de-pressurization rate was not significantly effected, the inclusion of the pressure ramp had no calculated effect on valve de-actuation.

For all the 280 psia cases considered, all calculated actuation times were < 1.0 seconds and all calculated de-actuation times were > 2.0 seconds. For the case (namely 280 psia & 243.5^{O}F) where flashing occurred after the (actuation) force balance point but before the flow balance point, valve de-actuation was significantly lengthened. This lengthening consisted of approximately 2.0 seconds, therefore, the maximum de-actuation time occurred at 280 psia and 243.5^{O}F and was calculated to be 4.477 seconds.

For the 469.7 psia and 388^{O}F case, flashing occurred before the (actuation) force balance point and had a significant affect on valve actuation times. The maximum actuation time occurred for the case where NO pressure ramp existed and was calculated to be 2.701 seconds. But, the inclusion of the 50 psi/sec ramp resulted in an actuation time < 2.0 seconds.

For the 469.7 psia case, the inclusion of the pressure ramp had a significant effect on the (actuation) de-pressurization rate as well as the disc slew time. Therefore, the de-actuation time was adversely effected by the pressure ramp, this is due to the fact that the (de-actuation) force balance point rose. As a result, the de-actuation time associated with the 50 psi/sec ramp was the maximum value obtained and was calculated to be 1.734 seconds.

Therefore, for those cases where the saturation point (associated with the inlet temperature) is above the (actuation) force balance point,

the valve actuation times will be significantly lengthened. But then again, the inclusion of a system pressure ramp will have a significant shortening of the valve actuation times; while at the same time the ramp inclusion will lengthen the de-actuation time. The net effect being, that a pressure ramp will cause the valve to actuate significantly faster, while at the same time marginally lengthening valve de-actuation.

For any case, the most significant effect on valve actuation is the relation between the pilot seat diameter and the chamber inlet flows. The pilot seat diameter of .375 inches has resulted in the fact that any flashing situation that may occur will result in an actuation time well within acceptable limits.

For a complete review of the calculated 88RR valve actuation/ de-actuation times see Table 6. And for a curve of the 88RR valve actuation/de-actuation times, for 100°F water, as a function of valve ΔP see Figure 7.

8.0 REFERENCE

8.1 Beauman, Ron; "PORV Measurements in Actuation and De-actuation for Subcooled Water"; TRC Report 3980; November, 1983.

8.2 Beauman, Ron; "PORV Actuations and De-actuation time Analysis for Superheated Steam and Subcooled Water", TRC Report 3917; September, 1983.

8.3 Bergles, A.E., ...; "Two Phase Flow and Heat Transfer in the Power and Process Industries"; Hemisphere Publishing 1981.

8.4 Hutcherson, M.N., R.E. Henry, and D.E. Wollersheim; "Two Phase Vessel Blowdown of an intially Saturated Liquid ..."; Parts 1 & 2, ASME Transactions, November, 1983.

8.5 Lahey, R.T. Jr. and F.J. Moody; "The Thermal-hydraulics of a Boiling Water Nuclear Reactor"; ANS 1977.

ATTACHMENT 3 TO THE 5/30/90 CPC RESPONSE
TO THE 11/9/89 TER ON NUREG 0737 II.D.1
COMPLIANCE

Consumers Power Company
Palisades Plant
Docket 50-255

MPR REPORT NO 1141
THIRD PARTY QUALIFICATION REVIEW OF REPLACEMENT
PRESSURIZER POWER OPERATED RELIEF VALVES

OC0590-0339-NL04

MPR ASSOCIATES, INC.

PALISADES POWER PLANT
POWER OPERATED RELIEF VALVES

THIRD PARTY QUALIFICATION REVIEW
OF REPLACEMENT PRESSURIZER
POWER OPERATED RELIEF VALVES
FOR PALISADES NUCLEAR POWER PLANT

MPR-1141

Prepared for:

Consumers Power Company
Jackson, MI 49201

October 1989

1050 CONNECTICUT AVENUE, N.W. WASHINGTON, D.C. 20036 202-659-2320

EXECUTIVE SUMMARY

MPR Associates has performed a third party review of the technical and licensing justification for installation of the Target Rock Corporation (TRC) pressurizer power operated relief valves (PORVs) at Palisades. The PORVs are being replaced to provide a fully qualified valve and to satisfy Low Temperature Overpressure Protection (LTOP) and Once Through Cooling (OTC) requirements. The scope of this review included 1) verifying that the process used by Consumers Power Company (CPCo) in specifying the replacement valves, evaluating proposals and selecting the supplier was complete, technically sound and consistent with the classification of pressurizer systems and 2) confirming that the supplier has completed or is planning to complete all steps necessary to satisfy the requirements of the Conformed Equipment Specification with regard to valve qualification.

With respect to the CPCo process for purchase of this valve, we conclude that the valve specification and valve supplier evaluations and selection are complete and sufficient to satisfy NRC concerns on PORV functionality as stated within NUREG-0737 II.D.1. Specifically, the supplier is required to prove functional similarity between the valves to be supplied to Palisades and those functionally tested by EPRI in the Marshall and Wyle facilities. The regulatory codes and specific requirements included in the specification are also consistent with the classification of the valve as specified in the Palisades FSAR.

With respect to supplier qualification of the valve, we have concluded that seismic and environmental qualification of the valve meets specification requirements. We also conclude, on the basis of the supplier design report, that the replacement PORVs meet the structural requirements of ASME Code Section III for Class 1 components.

With respect to functional qualification we conclude that the replacement PORVs are functionally qualified within the intent of NUREG 0737 II.D.1 with one qualification. TRC bases functional qualification of the valve on a combination of basic operability testing and analysis. We consider this approach to be acceptable, however, the results of the final TRC analyses of valve performance for specified operating conditions have not been received. Our conclusion that the valve is functionally qualified is based on discussions with TRC concerning the results of preliminary analysis and on the results of independent verification analyses of valve performance performed by MPR Associates (MPR report 1150). The verification analyses demonstrated compliance with valve functional requirements over a wider range of operating conditions than specified by the CPCo Equipment Specification. These analyses were also validated by a successful comparison of the results of similar analyses with results from the EPRI tests of a similar TRC valve at Marshall and Wyle facilities. Our conclusion assumes that the results of the final TRC analyses also demonstrate the valve meets its functional requirements.

On these bases, therefore, we consider that the replacement PORV installation is acceptable from technical and licensing considerations.

TABLE OF CONTENTS

LIST OF TABLES

Section 1

INTRODUCTION

MPR Associates was requested by Consumers Power Company (CPCo) to perform a third party review of the technical and licensing justification for the replacement of the Pressurizer Power Operated Relief Valves (PORVs) at the Palisades Nuclear Power Plant. These valves are being replaced to satisfy NRC requirements of NUREG-0737 to provide fully qualified pressurizer valves. The capacity of the replacement PORVs is also larger than the existing valves to provide sufficient capacity for Low Temperature Overpressure Protection (LTOP) and Once Through Cooling (OTC).

The PORVs are being supplied by Target Rock Corporation (TRC). The TRC valves are solenoid operated piloted relief valves with a C_v of 219.

The scope of this review included 1) verifying that the process used by CPCo to purchase the replacement pressurizer valve was complete, technically sound and consistent with the classification of pressurizer systems and 2) confirming that the valve manufacturer has completed or is planning to complete all steps necessary to satisfy the requirements of the specification with regard to valve qualification. In this regard the scope of the review did not include evaluating the specified required capacities and operating fluid conditions to meet the valve functional requirements for pressure relief, LTOP and OTC. The values contained in the Conformed Equipment Specification and developed subsequent to issue of the specification of CPCo for these valves were assumed to be correct.

The objective of this review is to determine if the technical justification and documentation for these replacement valves satisfy NRC concerns.

This review has been focused on the following areas.

1. Completeness of the Valve Specification considering NRC concerns with the pressurizer valves, basic plant design requirements, and pressurizer valve classifications.
2. Functional Qualification of the replacement valves
3. Structural Design compliance with the ASME Code
4. Environmental Qualification
5. Seismic Qualification

The following sections of this report discuss the impact of each of these items on the replacement of the PORVs only and our conclusions on the technical and licensing justification for the specific replacement PORVs for Palisades.

A significant amount of documentation was reviewed as part of this task. This documentation is listed in Section 7 of the report. Specific references to some of these documents and to regulatory standards are made throughout the report.

Section 2

COMPLETENESS OF THE VALVE TECHNICAL SPECIFICATION

Conclusion

We conclude that the requirements of the valve specification including incorporation of regulatory codes and standards are complete and sufficient to satisfy NRC concerns on replacement PORVs and are consistent with the classifications of the pressurizer valves as specified in the plant FSAR.

Discussion

NUREG-0737

The NRC concern with pressurizer valves is that the valves be qualified by test to prove that they will satisfy their functional requirements for all operating conditions. This position is stated in NUREG-0737, II.D.1, "Clarification of TMI Action Plan Requirements, Performance Testing of Boiling-Water and Pressurized-Water Reactor Relief and Safety Valves (NUREG-0578, Section 2.1.2)," November 1980. This position states that PWR licensees "shall conduct testing to qualify the reactor coolant system relief and safety valves under expected operating conditions for design-basis transients and accidents."

In the clarification section the NUREG states that testing "should demonstrate that the valve will open and reclose under the expected flow conditions." The EPRI test program or other generic test program were cited as acceptable to demonstrate valve functionality. The EPRI testing was subsequently conducted at Marshall Station (Duke Power) (NP-2144-LD, February 1982) and Wyle Laboratories, Norco, California (NP-2628-SR, December 1982). The NRC does not expect every valve installed in each plant to be tested under full-scale conditions. Accordingly, the NUREG also states that "a correlation or other evidence to substantiate that the valves tested in the EPRI ... or other generic test program demonstrate the

functionality of as-installed primary relief and safety valves." Also the effect of "discharge piping on valve operability must also be accounted for, if it is different from the generic test loop piping."

The CPCo equipment specification for the replacement valves require compliance with NUREG-0737 and that the suppliers provide sufficient documentation, data or new test data to prove that the valves to be supplied for Palisades are functionally similar to those tested by EPRI (Section 3.2.1, Part 2, Technical Requirements).

The PORV specification also requires functional qualification in accordance with ANSI B16.41-1983 as modified by specific requirements in Part 2, Technical Requirements. It is noted that the scope of this standard does not include PORVs. We understand that the ASME is preparing a similar standard (QV-3) which will cover PORVs. A draft of QV-3 was reviewed by Teledyne Energy Systems (TES) as part of the review of the CPCo valve specification. TES concluded that B16.41-1983 is more restrictive in some areas than QV-3 and equivalent in others. We have not been able to obtain a draft copy of QV-3 to confirm this conclusion. However, considering that there was no equivalent standard available at the time of submittal of the valve specification and assuming that the TES conclusions on the comparison with QV-3 are accurate, we consider that use of the B16.41-1983 standard in the PORV specification is appropriate.

Finally, the CPCo specification requirements for valve capacity and fluid operating conditions, are based on calculations using the new piping system configuration in which the valves are to operate. The effect of piping is, therefore, considered in qualifying these valves as required by the NUREG.

Specification Requirements

Table 1 provides a summary of the applicable codes (e.g., NRC regulations, IEEE Standards, ASME codes and ANSI standards) along with the requirements invoked by the replacement valve specification. Requirements for functional, structural, environmental and seismic qualification are

included. In general, the code requirements derive from classification of the PORVs as Class 1 (by the equipment specification). Requirements for Class 1 equipment are covered by the Palisades FSAR requirements, NRC regulations and the Code of Federal Regulations. We consider that this table demonstrates that the equipment specification requirements are sufficient for Class 1 equipment.

Compliance of the supplier with the specification requirements is discussed in the following sections.

TABLE 1
POWER OPERATED RELIEF VALVE (PORV) QUALIFICATION REVIEW
PALISADES NUCLEAR POWER STATION

PRIMARY REQUIREMENT	APPLICABLE CODES	SPECIFICATION REQUIREMENTS
1. <u>FUNCTIONAL QUALIFICATION</u>		
NUREG-0737, II.D.1	IEEE 382 "Standard for Qualification of Actuators for Power Operated Valve Assemblies with Safety-Related Functions for Nuclear Power Plants." ANSI B16.41 - "Functional Qualification Requirements for Power Operated Active Valve Assemblies for Nuclear Power Plants"	General technical requirements (Section 3.4.6.3, page 22) state that valves shall be designed and tested in accordance with: - ANSI B16.41-1983, - Regulatory Guide 1.148, - Standard Review Plans 3.9.3, 3.9.6, 3.10 and 3.11 - ANSI N278.1 - 1975.
	ANSI N278.1 - "Self-Operated and Power-Generated Safety-Related Valves Functional Specification Standard."	Design Data Sheets (pages 28 - 35) contain data specified by ANSI N278.1.
2. <u>STRUCTURAL QUALIFICATION</u>		
FSAR Table 5.2.3	Regulatory Guide 1.26 10 CFR 50 (50.2, 50.55a) ASME Code Section III, Class 1 Components	PORVs must meet the requirements of the ASME Code Section III for Class 1 components.

TABLE 1
POWER OPERATED RELIEF VALVE (PORV) QUALIFICATION REVIEW
PALISADES NUCLEAR POWER STATION

PRIMARY REQUIREMENT	APPLICABLE CODES	SPECIFICATION REQUIREMENTS
3. ENVIRONMENTAL QUALIFICATION		
10CFR50.49 - "Environmental Qualification of Electric Equipment Important to Safety of Nuclear Power Plants"	Regulatory Guide 1.89 - "Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants." IEEE 323 "Qualifying Class 1E Equipment for Nuclear Power Generating Stations." IEEE 382 "Standard for Qualification of Actuators for Power Operated Valve Assemblies with Safety-Related Functions for Nuclear Power Plants."	PORVs must meet requirements of the following: IEEE 323-1974 (Section 3.4.3.2, page 21) IEEE 382-1985 (Section 3.4.3.2, page 21) Reg Guide 1.89 (Section 3.4.3.2, page 21) Reg Guide 1.73, "Qualification Tests of Electric Valve Operators Installed Inside the Containment of Nuclear Power Plants", (Section 3.4.3.2, page 21) Stand Rev Plan 3.11, "Environmental Qualification of Mechanical and Electrical Equipment", (Section 3.4.3.2, page 21)
4. SEISMIC QUALIFICATION		
FSAR Table 5.2.3	Regulatory Guide 1.29, Rev. 3 IEEE 323 "Qualifying Class 1E Equipment for Nuclear Power Generating Stations."	General technical requirements (Section 3.3.3, page 20) refer to Technical Specification C-175 (Q) - "Requirements for Seismic Qualifications of Electrical and Mechanical Equipment" (pages 70 - 95) which states the valves must meet the following:

TABLE 1
POWER OPERATED RELIEF VALVE (PORV) QUALIFICATION REVIEW
PALISADES NUCLEAR POWER STATION

PRIMARY REQUIREMENT	APPLICABLE CODES	SPECIFICATION REQUIREMENTS	
4. SEISMIC QUALIFICATION, CONTINUED			
	IEEE 344 "Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations."	Regulatory Guide 1.29	(Section 3.1.1, page 77)
		IEEE 323-1974	(Section 3.2.11, page 79)
		IEEE 344-1975	(Section 3.3.1.1, page 80)
	IEEE 382 "Use guide for type test of Class I Electric Valve Operators for Nuclear Power Generating Stations."	IEEE 382	(Section 3.3.2.1, page 80)
		Regulatory Guide 1.92	(Section 4.4.2, page 83)
	ANSI B16.41, Annex F "Seismic Loading Test."		

Section 3
FUNCTIONAL QUALIFICATION

Conclusion

We conclude that the replacement PORVs are functionally qualified within the intent of NUREG-0737 II.D.1 with one qualification. TRC bases functional qualification of the valve on a combination of basic operability testing and analysis. We consider this approach to be acceptable, however, the results of the final TRC analyses of valve performance for specified operating conditions have not been received. Our conclusion that the valve is functionally qualified is based on discussions with TRC concerning the results of preliminary analysis and on the results of independent verification analyses of valve performance performed by MPR Associates (MPR report 1150). The verification analyses demonstrated compliance with valve functional requirements over a wider range of operating conditions than specified by the CPCo Equipment Specification. These analyses were also validated by a successful comparison of the results of similar analyses with results from the EPRI tests of a similar TRC valve at Marshall and Wyle facilities. Our conclusion assumes that the results of the final TRC analyses also demonstrate the valve meets its functional requirements.

Discussion

The CPCo PORV specification requires qualification to NUREG-0737 II.D.1 (Section 3.2.2) and testing in accordance with ANSI B16.41-1983 (Section 3.4.6.3) as modified by Section 5.0 of the Equipment Specification. (The use of B16.41-1983 for the PORVs is discussed in Section 2, above). Table 2 provides a summary of applicable sections of the specification.

Table 2

SUMMARY OF SPECIFICATION REQUIREMENTS ON FUNCTIONAL QUALIFICATION

SPECIFICATION SECTION	REQUIREMENT	APPLICABLE CODE, IF ANY
3.2 and 3.2.1	Invoke NUREG-0737 and require the valve to be similar in design, construction, function and operational characteristics to those valves furnished by the supplier for testing by EPRI.	NUREG-0737, II.D.1
3.4.1.1	Requires the valve to be functional before and after a seismic event but not during the event.	Supercedes CPCo generic seismic specification.
3.4.6.2	Requires the valve to be operational under all combinations of operating and environmental conditions specified. Actual conditions are contained in the Design Data Sheets for the valves, Section 9.	
3.4.6.3	Invokes applicable codes for design and testing of the valve.	ANSI B16.41-1983 ANSI N278.1-1975 R.G. 1.148 S.R.P 3.9.3, 3.9.6, 3.10 and 3.11
5.0	Inspections, Examinations and Tests	
5.2	Cold Cyclic Testing	ANSI B16.41, Annex B
5.3	Hot Cyclic Testing	Annex C
5.4	Pipe Reaction End Loading Test	Annex D
5.5	Exploratory Vibration Test	Annex E
5.6	Seismic Loading Test	
5.7	Flow Interruption Test	Annex G
5.8	Endurance Test	Annex H
5.9	Similarity	Annex J
9.0	Design and functional requirements including capacity and stroke times on Design Data Sheets, DDS-3, DDS-4, DDS-7 and DDS-8	

Functional qualification of the TRC valves is documented by the following:

1. TRC Report 4913E, "Production Test Procedure, 4 X 4 Power Operated Relief Valve, Assembly No 1071240-5", January 17, 1989

2. TRC Report 4915B, "Qualification Extension Analysis, Power Operated Relief Valve 88RR-001", February 27, 1989

3. TRC Report 5071 "88RR Actuation/De-Actuation Times", August 21, 1989

<u>ANSI B16.41-1983 Testing</u>

The TRC production test procedure (TRC-4913E) includes:

- Seat Leakage Tests

- Operational Tests including an equivalent static seismic test and flow interruption tests at partial flow conditions on the TRC flow test loop. This loop does not have adequate capacity to test the valve under full flow conditions.

- High Pressure Steam and Subcooled Water Cycling Tests

The qualification report (TRC-4915B) references exploratory vibration testing.

CPCo personnel have indicated that Endurance Testing per Annex H of ANSI B16.41 as required by Section 5.8 of the specification was not required of this valve because of the operational tests that were conducted on the valve and vibration testing that was performed on a similar valve reported in TRC-4915B. Section 5.9 of the specification permits alternatives to the ANSI B16.41 tests upon CPCo approval.

The Pipe Reaction End Load Testing per ANSI B16.41, Annex D was performed on a similar valve and reported in TRC-4915B and was also considered in the design report for the valve. The loads were found to be negligible and to have no effect on valve operation.

The TRC test reports indicate that the production testing (TRC-4913E) was successfully completed for both valves. (Note the operational testing was only completed on one valve in accordance with procedure provisions). We consider that successful completion of these tests establish the replacement valves operability in the context of ANSI B16.41-1983. This satisfies the testing requirements of Section 5 of the valve specification.

<u>NUREG-0737 Testing</u>

The PORVs to be installed in Palisades -- TRC designation 88RR -- are functionally similar to the TRC valve tested by EPRI -- TRC designation 80X, but are significantly larger (a 4 X 4 valve with significantly more capacity versus the 2-1/2 X 4 valve tested). The 88RR valve has not been tested under full flow conditions and, therefore, its similarity to the smaller tested valve must be demonstrated to establish its functional qualification within the context of NUREG-0737.

TRC is performing calculations of the expected actuation and deactuation times of the PORVs for different fluid conditions at the valve inlet. The specific fluid conditions being analyzed were specified by CPCo to be consistent with final functional requirements of the valve for low temperature overpressure protection (LTOP), once through cooling (OTC), and steam relief.

The results of the final TRC analyses have not been received as of the date of this report. However, it is expected that these analyses will demonstrate compliance with valve functional requirements for these conditions for the following reasons:

1. Independent dynamic analyses of the replacement PORVs were performed by MPR Associates for operating conditions which bound those specified by CPCo (MPR report 1150). These analyses demonstrated that the valve opening and closing stroke times meet specification requirements (less than 2 seconds total stroke time) for all conditions analyzed.

These analyses were performed using a digital computer based program previously developed by MPR for predicting the response of solenoid operated valves under transient loading conditions. MPR modeled the valve using detailed drawings of valve components obtained from TRC on a proprietary basis. The model used for these analyses was more detailed than that used by TRC -- comprising all components which could affect valve performance over all operating conditions, i.e., including conditions outside those specified by CPCo. The TRC model is adequate for the conditions specified by CPCo.

The MPR analyses were validated by a successful comparison of the results of similar analyses with test data for the TRC PORV tested by EPRI at Marshall and Wyle facilities. These validation runs were made for conditions which bounded the EPRI test conditions and are similar to those specified for the Palisades PORV. The analyses were also made using the same computer program and modeling assumptions used for the Palisades PORV analysis.

2. TRC has reviewed the MPR analyses and concurs generally with the modeling approach and the results.

3. TRC has performed preliminary analyses using similar modeling data to that used in the MPR analyses and has obtained similar results. TRC has also performed analyses for the valve tested by EPRI and has obtained comparable results for several test conditions, thereby validating the TRC model.

<u>Dimensional Similarity</u>

The 88RR valve to be installed in Palisades is larger than the 80X valve which was tested by EPRI. However, the valves are functionally identical. A comparison of certain key dimensional characteristics of these valves can be used to establish similarity between the valves and augment the analyses discussed above to establish 88RR valve functional qualification.

It should be noted that the ASME Code (NB7700) and ANSI B16.41 discuss criteria for establishing valve similarity. However, the ASME code addresses similarity in capacity for certification of larger relief valves in comparison with tests of smaller valves. We also understand that the ANSI standard is concerned with physical size as it affects loads on the actuators. To check functional similarity between the TRC PORVs, other characteristics of the valve internals are of concern. These valves are similar to servo-mechanisms. The speed of response of the valve depends to varying degrees on the sizes of orifices, volumes, pistons and springs which comprise the valve internals and the rating of the solenoid.

Table 3 compares key dimensional characteristics of the Palisades replacement valve (88RR) and the EPRI tested valve (80X) along with a brief summary of the expected effect of variations in these characteristics on valve stroke time. The conclusion of this comparison is that the Palisades replacement PORV should be expected to have a faster opening stroke time and a slightly slower closing stroke on a relative basis when compared to the EPRI tested valve. This is consistent with the results of the dynamic analyses performed by TRC and MPR.

TABLE 3
COMPARISON OF KEY VALVE PARAMETERS
80X VERSUS 88RR VALVE

ITEM	EFFECT ON VALVE DYNAMICS	80X	88RR	CONCLUSIONS
Ratio of the size of the control volume and the conical gap to the pilot flow area.	This ratio affects the depressurizing time of the control volume and conical gap during the opening valve stroke. The larger this ratio, the longer the time to depressurize the control volume on valve opening.	69.9	49.3	The 88RR would be expected to have a shorter relative depressurizing time than the 80X. This difference is acceptable for the PORV.
The ratio of the size of the control volume and the conical gap to the sum of the minimum area at the supply orifice and the area of the piston ring leakage with the valve shut.	This ratio affects the time to pressurize the control volume and the conical gap during the closing valve stroke. The larger this ratio the longer it will take to pressurize the control volume on valve closing.	123.7	803.0	The 88RR would be expected to have a longer relative pressurizing time on closing than the 80X. However, there is significant margin in the closing stroke times so this is not considered a problem.
Ratio of the supply orifice and piston ring flow areas to the pilot flow area.	This ratio affects depressurizing time during valve opening stroke. The larger this ratio the longer it will take to depressurize the control volume on opening.	0.111	0.0167	This also indicates that the relative depressurization rate for the 88RR is higher than for the 80X.

TABLE 3
COMPARISON OF KEY VALVE PARAMETERS
80X VERSUS 88RR VALVE

ITEM	EFFECT ON VALVE DYNAMICS	80X	88RR	CONCLUSIONS
Ratio of the effective pressure areas above and below the piston excluding the exhaust area.	This ratio determines the net effect of the pressure forces on the main disc which affects both opening and closing stroke times.	0.47	0.35	The lower ratio for the 88RR increases the depressurizing time and adds to the opening stroke time. This is unavoidable with the size of the internals in this valve relative to the body size. The flow area ratios described above provide compensation for this difference.
Ratio of the size of the conical gap volume to the flow area between the plungers and the bonnet tube.	This affects pressure differential across the plunger which tends to retard valve motion. The larger this number the longer it takes to reach equilibrium between the conical gap and the control volume.	10.7	12.7	The retarding action of the plunger for the 88RR would be somewhat greater.
Ratio of the minimum solenoid pull force to maximum spring compression.	This affects valve stroke under low pressure differential conditions. The higher this ratio the faster the valve will stroke under zero differential pressure conditions.	2.02	1.5	The 80X would be expected to stroke a little faster under low differential conditions. This is not a major concern for PORV applications which generally involve high pressure conditions.

Section 4
DESIGN IN ACCORDANCE WITH ASME SECTION III

Conclusion

The TRC PORV design report 4914A was reviewed for compliance with ASME Code Section III for Class 1 components. We conclude that on the basis of this report, that the TRC PORV structural design meets ASME Section III and valve specification requirements for the design conditions of the Specification.

Specifically, actual wall thickness is greater than the minimum required, primary plus secondary stresses are within Code and Specification allowables and the valve is acceptable for cyclic loading conditions.

Discussion

1. In the seismic analysis of the PORV, TRC combined the stresses due to dead weight and internal pressure with the stresses due to the seismic load. Stresses were evaluated for four loading conditions as follows:

Load Condition	Load Combination	Allowable
A	$D + P_D$	Basic Stress Intensity Limits
B	$D + 1.1\ P_D + OBE$	110% of Basic Stress Intensity Limits
C	$D + 1.2\ P_D + OBE$	$2.25\ S_m$
D	$D + 1.5\ P_D + SSE$	$3.6\ S_m$

2. In the analysis, the internal pressure used by TRC for Loading Conditions B, C, and D was higher than required by Technical Specification C-175(Q). TRC assumed the internal pressure for Loading Conditions B, C, and D was equal to the maximum pressure permitted by the ASME Code. In fact, the internal pressure for Load Conditions B, C,

and D is the same as for Load Condition A, i.e., 2500 psi. Thus, the maximum combined stresses calculated by TRC for the PORV are considered conservative.

3. The maximum calculated stresses were compared by TRC with allowable stresses given in the ASME Code. However, Paragraph 4.5.1 of Technical Specification C-175(Q) specifies more restrictive allowables as follows:

Load Combination	ASME Code	Technical Specification C-175(Q)
$D + P_D + OBE$	Basic Stress Intensity Limits	Basic Stress Intensity Limits
$D + P_D + OBE$	110% of Basic Stress Intensity Limits	S_y
$D + P_D + SSE$	$3.6\ S_m$	$1.1\ S_y$

We concur that the more restrictive allowables specified in the Specification are appropriate for the PORVs since they are required to operate after an earthquake. ASME Code limits for Level D loading conditions assure structural integrity of the valve pressure boundary but permit gross yielding of the structure which may affect the valves operability.

4. In general, TRC has analyzed the PORV for more conservative conditions than required by the Specification and compared the calculated stresses to higher allowables than permitted by the Specification. However, based on a review of the calculated stresses, we conclude that the PORV meets the structural and seismic requirements of the Specification.

5. TRC used an equivalent static coefficient method for analyzing seismic load using a coefficient of 1.0. CPCo generic seismic qualification specification SP-MP-8304-002(Q), Revision B, requires the use of a static coefficient of 1.5, but does allow use of a lower coefficient

approved by the OWNER (Section 4.3.2.2). CPCo instructed TRC to use the coefficient of 1.0, [Reference: CPCo letter to MPR Associates JLT 272-89, dated October 25, 1989].

We agree that the use of a 1.0 static coefficient is appropriate because the valve can be represented structurally as a single degree of freedom system with its natural frequency outside the seismic loading range.

Section 5
ENVIRONMENTAL QUALIFICATION

Conclusion

We conclude that the replacement PORVs meet specification requirements for environmental qualification. TRC has established similarity of components between the Palisades PORVs, (TRC designation 88RR) and another valve (TRC designation 82X) which has been fully qualified by test. This approach is accepted by applicable regulatory guidance and industry standards.

Discussion

A review of the TRC environmental qualification of the replacement PORVs (TRC designation -- 88RR) was performed to verify that the methodology used and the documentation supplied by TRC are sufficient to justify installation of these valves at Palisades and satisfy the requirements of the NRC. This review was based on the following:

1. TRC Qualification Extension Analysis Report for the 88RR Series Power Operated Relief Valves, TRC Report No. 4915, Rev. B.
2. CPCo Conformed Equipment Specification, SP-MP-8304-002(Q)
3. IEEE Std 382-1980, IEEE Standard for Qualification of Safety-Related Valve Actuators.
4. USNRC Regulatory Guide 1.73, Qualification Tests of Electric Valve Operators Installed Inside the Containment of Nuclear Power Plants, January 1974.
5. IEEE Std 323-1974, IEEE Standard for Qualifying Class IE Equipment for Nuclear Power Generating Stations.
6. USNRC Regulatory Guide 1.89, Environmental Qualification of Certain Electrical Equipment Important to Safety for Nuclear Power Plants, June 1984.

The TRC environmental qualification of the replacement PORVs is based on establishing component similarity with another valve (TRC valve designation 82X), which TRC considers to be fully qualified. This approach to

qualification is a method accepted by the applicable regulatory guidance (References 4 and 6) and industry standards. The TRC analyses and comparisons between the 82X valve and the 88RR valve are contained in TR-4915 (Reference 1). The 82X valve is a one-inch DC solenoid operated globe valve weighing approximately 32 pounds. The TRC environmental qualification of the 82X is based on a type test which was performed in accordance with the Qualification Test Plant and Test Procedure which are included as Appendices to TR-4915. The type test performed on the 82X is considered an acceptable method for qualifying the 88RR PORV subject to the following clarifications.

The Target Rock part numbers for the position indicator switch and terminal board are identical for the 82X and 88RR valves. Accordingly, the qualification testing of these components in the 82X valve is directly applicable to the 88RR valve. However, the 82X test valve was designed to operate from a 120 VAC power source by using a hermetically sealed solid-state full-wave rectifier to power the DC solenoid. The 82X solenoid has a different part number than the 88RR solenoid. Although the 88RR solenoid coil is physically larger in size than the 82X solenoid coil, the conducting and insulating materials are the same in both valves and therefore the qualification tests performed on the 82X are considered adequate to qualify these materials for the 88RR.

The TR test procedure required operating the valve during simulated LOCA and MSLB at 108, 120, and 132 VAC. The DC voltage to the 82X valve solenoid was not measured during the test. The CPCo Equipment Specification (Reference 2) requires the following:

> "The valve solenoids shall incorporate a coil design for continuous operation. Coils must be capable of operating at a minimum of 90-V and a maximum of 140-V DC supply voltage."

The principal concerns associated with the voltage requirements is whether the 88RR solenoid can develop sufficient force to open the valve at the minimum specified DC voltage and will not experience significant degradation while operating at the maximum specified DC voltage. Based on

the information supplied in TR-4915 it can not be determined if the operating voltage requirements for the 88RR valve were met during the qualification testing of the 82X valve. However, information obtained through telephone conversations with TRC personnel on August 23, 1989, indicated that TRC has performed tests on the 88RR and these tests demonstrate the 88RR solenoid develops sufficient force to open the valve at the minimum specified DC voltage under the most limiting ambient and process flow conditions.

During once through cooling operation, the 88RR valve could be required to be open for considerably longer periods (e.g., up to 1 hour). The operating times for the test valve 82X are specified in the TRC qualification test plan as 15 seconds and 2 minutes. Therefore, the tests performed on the 82X valve have not demonstrated the solenoid in the 88RR will produce sufficient opening force for extended periods of time at elevated ambient temperatures. However, information obtained through telephone conversation with TRC personnel on August 23, 1989, indicate that additional tests on a solenoid similar to that on the 88RR were performed by TRC at elevated temperatures. These tests consisted of holding the solenoid at an ambient temperature of 400°F for one hour with the valve de-energized and then energizing the solenoid for one hour under the 400°F ambient conditions.

The Equipment Specification specifies a relative humidity of 0 - 100% for normal operating and test conditions. Further item C.3.b of Reg Guide 1.89 specifies:

> "Electric equipment located in an area where rapid pressure changes are postulated simultaneously with the most adverse relative humidity should be qualified to demonstrate that the equipment seals and vapor barriers will prevent moisture from penetrating into the equipment to the degree necessary to maintain equipment functionability."

During containment leak rate testing in the plant, the 88RR valve will be exposed to pressurization cycles with ambient air which could be at a high humidity level. The concern is that leakage of the moist air

part the electrical enclosure gasket could cause degradation in the electrical circuits. During the 82X valve qualification testing, the containment leak rate test cycles were simulated. However, the qualification test plan and test procedure contained TR-4915 for these tests do not specify the ambient relative humidity to be used during these pressurization aging tests. TRC personnel indicated that high relative humidity was present during the pressurization aging tests.

Section 6
SEISMIC QUALIFICATION

Conclusion

We conclude that the seismic qualification of the replacement TRC PORVs is acceptable. This seismic qualification is based on a combination of analysis and testing that meets the requirements of the CPCo equipment specification for these valves.

Discussion

A review of the TRC seismic qualification of the replacement PORVs was performed to verify the adequacy of the methodology used and documentation supplied by TRC to justify the installation of these valves at Palisades and to address NRC concerns. This review was based on the following:

1. TRC Qualification Extension Analysis Report for the 88RR Series Power Operated Relief Valves, TRC Report No. 4915, Rev. B.

2. CPCo Conformed Equipment Specification.

3. USNRC Regulatory Guide 1.29, Seismic Design Classification, Revision 3, September 1978.

4. USNRC Regulatory Guide 1.92, Combining Modal Responses and Spatial Components in Seismic Response Analysis, Revision 1, February 1976.

5. IEEE Std 323-1974, IEEE Standard for Qualifying Class IE Equipment for Nuclear Power Generating Stations.

6. IEEE Std 344-1975, IEEE Recommended Practices for Seismic Qualification of Class iE Equipment for Nuclear Power Generating Stations

7. IEEE Std 382-1980 IEEE Standard for Qualification of Actuators for Power Operated Valve Assemblies with Safety-Related Functions for Nuclear Power Plants.

The seismic qualification of the replacement TRC PORVs is based on analysis with some support testing. This approach for seismic qualification is acceptable under Section 6.0 of CPCo Technical Specification SP-MP-8304-002(Q). The calculations, data and information supporting seismic qualification are presented in TRC Reports 4914A and 4915B.

The TRC analysis and testing considers only equivalent static loading on the valve. No seismic dynamic testing is to be performed. The justification for this approach derives from the following:

1. Section 3.4.2.3 of Part 2, Technical Requirements of the Equipment Specification states that "functionality is required to be verified after a safe shutdown seismic event". This requirement is considered to supercede Section 3.1.2 of the generic seismic qualification Technical Specification SP-MP-8304-002(Q) which states "all equipment qualified under this Technical Specification are required to perform the safety function(s) during and after a series of five Operating Basis Earthquakes (OBE) and a Safe Shutdown Earthquake (SSE)".

   We consider this revision to be acceptable on the following basis:

   - The PORV does not provide the primary overpressure protection for the reactor coolant system and, therefore, does not have to be operational during the seismic event.

   - If the PORV were to open spuriously during the event the size of the opening does not present a major coolant loss path for the system in the short term and in the long term the PORV can be isolated by its block valve.

   We do not consider, therefore, that dynamic (shake table) testing at the floor response spectrum is required to prove operability during the event.

2. According to Section 4.1.1 of SP-MP-8304-002(Q), the use of analysis alone for seismic qualification is acceptable if "the necessary functional integrity of the equipment is assured by its structural integrity alone".

   TRC design report 4914A presents analyses which:

   - verify the structural integrity of the valve pressure retaining components for the maximum seismic loading,
   - indicate that the valve does not have a structural natural frequency in the seismic range (less than 33 hz).

3. TRC performed exploratory vibration tests of the valve to confirm that the valve does not have a structural natural frequency within the seismic range (less than 33 hz). The results of these tests were presented in response to CPCo questions concerning the TRC design report 4914A.

4. The valve production test series include a static seismic loading test in accordance with Annex F of B16.41-1983 to verify valve operability after an SSE (3 g loading).

   Although SP-MP-8304-002(Q) Section 3.3.2.2 prohibits the use of the static seismic test method of Annex F of B16.41-1983 for PORV qualification, as indicated above, this standard is invoked in the Technical Requirements Part 2 of the Equipment Specification. This test can be accepted as part of the seismic qualification for this valve.

5. It should be noted that TRC performed full scale shaker table tests on a smaller version of the PORV. They reported the results of these tests in TR-4915B, but have not included them in the basis for qualification of the valve bodies of the replacement PORV's for Palisades. TRC does use these test results to qualify the electrical

equipment which is common between the smaller valve and the replacement PORV's. This is appropriate.

6. Subsequent to issue of design Report 4914A, TRC recomputed the natural frequencies of the spring main systems which comprise valve internals (main and pilot discs) and the minimum internal pressure in the valve which would be required to ensure the internals will not lift under a 3g RIM SSE. These calculations indicated that the natural frequencies of the main and pilot including solenoid plungers are in the seismic range, however, at operating pressure (2200 psia) amplification factors of 40 for the pilot/plunger and of 367 for the main/disc/plunger combinations at the 3g RIM SSE would be required to exceed the closing forces and cause a momentary lift of the pilot or main. These amplification factors are not considered achievable. In addition, a momentary lifting of the pilot or the main without the solenoid energized would only produce a short burst of flow -- the valve would not slow completely open. Even under solid RCS conditions, no significant effect on system pressure would be anticipated. [Note that this type of action will likely occur each time the valve is placed into service by opening the block valves with the pressurizer solid during plant shutdown.] Accordingly, we do not consider the probability of a spurious opening of the valve under operating conditions to be of concern. Note that it is also current practice at Palisades to isolate these valves once a bubble is pulled in the pressurizer. As long as this practice is maintained, the spurious action of the valves during an SSE with the reactor at power is not a consideration.

Section 7

PROJECT FILE

LOG NUMBER	DATE	SUBJECT
98-108-01	February 1982	EPRI-Marshall Power-Operated Relief Valve Interim Test Data Report, NP-144-LD, Research Project V102, Prepared by Intermountain Technologies, Inc., 1400 Benton, Idaho Falls, Idaho 83401, Principal Authors, S.D. Kucharshi, R.K. House, G.A. Cordes, Prepared for Participating PWR Utilities and Electric Power Research Institute, 3412 Hillview Avenue, Palo Alto, CA 94304, EPRI Project Manager, J.D.E. Jeffries, PWR Safety and Relief Valve Test Program, Nuclear Power Division
98-108-03	1985	Report No. 4915B, Project 88RR, Qualification Extension Analysis Report for the Environmental Qualification of the Target Rock Corporation Project 88R Series Power Operated Relief Valves in accordance with standard Case IV Conditions (Modified) IEEE 382-1985, Prepared for Consumers Power, Palisades Nuclear Plant, GWO 8304/FC 791, P.O. 2003-4152 (Q), Prepared by Target Rock Corporation, 1966 E. Broadhollow Road, East Farmingdale, NY 11735
98-108-04	May 13, 1988	Letter: 6897-3 To: Consumers Power Company, 212 West Michigan Avenue, Jackson, MI 49201 From: James C. Tsacoyeanes and Lenin B. Semprucci, Teledyne Engineering Services, 130 Second Avenue, Waltham, Massachusetts 02254-9195 Subject: PORV Design Specification SP-MP-8304-002 (Q) Review Palisades Pressurizer Replacement Project
98-108-05	July 15, 1988	Consumers Power Company, Palisades Plant, Internal Correspondence Memo to: W. Clark, P-14-434A From: J. L. Topper, P-13-425 Subject: Pressurizer Valves Replacement Project Bid Evaluation - Replacement PORV's, GWO 8304, File: -011, -312.5, JLT 56-88

PROJECT FILE

LOG NUMBER	DATE	SUBJECT
98-108-07	September 15, 1988	Palisades Specification M1-LBA, ESS Specification SP-MP-8304-002(Q), Pressurizer Valves Replacement Project Replacement Pressure-Operated Relief Valves, GWO 8304/FC 791, Consumers Power Company, Palisades Plant, UFI No. 02330, 13107, 41
98-108-09	February, 1989	Report: 4914A, Project: 88RR, Design Report for Power Operated Relief Valve, Assembly Number 1071240-5, Rev. C, Prepared for: Consumers Power Company, Consumers Power Company, Palisades Plant, P. O. # 2003-4152-(Q), GWO 8304/FC 791, TRC Reference 88RR, Prepared by Target Rock Corporation, 1966E Broadhollow Road, East Farmingdale, NY 11735
98-108-10	November 11, 1988	Drawing 88RR-001 D, Project Control Dwg, Power Operated Relief Valve Energize to Open Size 4" X 4" Customer: Consumers Power Company, Site: Palisades Nuclear Plant, GWO8304/FC 791, Target Rock Reference 88RR, Sheet 1 of 2 and Sheet 2 of 2
98-108-11	November 14, 1988	Drawing 1071240-5, Assembly Drawing 4 inch x 4 Inch Power Operated Relief Valve, Sheet 1 of 2 and Sheet 2 of 2 Customer: Consumers Power Company, Palisades Plant, TRC Reference 88RR, Prepared by Target Rock Corporation, E. Farmingdale, NY
98-108-17A	August 11, 1989	Letter from: J. L. Topper, Project Manager Consumers Power Company Subject: Palisades Plant Pressurizer Valves Replacement Project Third-Party Qualification Review, GWO 8304, File -011, -317.0.
98-108-17B	August 14, 1989	Letter from: J. L. Topper, Project Manager Consumers Power Company, JLT 193-89 Subject: Palisades Plant Pressurizer Valves Replacement Project Third-Party Qualification Review, GWO 8304, File -011, -317.0

PROJECT FILE

LOG NUMBER	DATE	SUBJECT
98-108-17C	August 14, 1989	Letter from: J. L. Topper, Project Manager Consumers Power Company, JLT 195-89 Subject: Palisades Plant Pressurizer Valves Replacement Project Third-Party Qualification Review, GWO 8304, File -011, -317.0
98-108-17D	August 15, 1989	Letter from: James L. Topper, Project Manager, Consumers Power Company, JLT 201-89 Subject: Palisades Plant Pressurizer Valves Replacement Project Third-Party Qualification Review, GWO 8304, File -011, -317.0
98-108-17E	August 15, 1989	Letter from: James L. Topper, Project Manager, Consumers Power Company, JLT 210-89 Subject: Palisades Plant Pressurizer Valves Replacement Project Third-Party Qualification Review, GWO 8304, File -011, -317.0, transmits (3) copies of Palisades Technical Specification Sections 2.0, 3.1, and Table 3.17.4.
98-108-18	August 15, 1989	Letter from: James L. Topper, Project Manager, Consumers Power Company, JLT 207-89 Subject: Palisades Plant Pressurizer Valves Replacement Project Third-Party Qualification Review, GWO 8304, File -011, -317.0
98-108-19	August 17, 1989	Letter from: James L. Topper, Project Manager, Consumers Power Company, JLT 224-89 Subject: Palisades Plant Pressurizer Valves Replacement Project, Third-Party Qualification Review, GWO 8304, File -011, -317.0
98-108-20A	August 17, 1989	Letter from: James L. Topper, Project Manager, Consumers Power Company, JLT 218-89 Subject: Palisades Plant Pressurizer Valves Replacement Project Third-Party Qualification Review, GWO 8304, FILE -011, -317.0 Enclosures: 3 copies of Target Rock Corporation Document No. 4913, Revision E, "Production Test Procedure".

PROJECT FILE

LOG NUMBER	DATE	SUBJECT
98-108-21	August 17, 1989	Letter from: James L. Topper, Project Manager, Consumers Power Company, JLT 220-89 Subject: Palisades Plant, Pressurizer Valves Replacement Project, Third-Party Qualification Review, GWO 8304, FILE -011, -317.0 Enclosures: Uncontrolled copy of the current Palisades Nuclear Plant Technical Specification.
98-108-22	August 21, 1989	Letter from: J. L. Topper, Project Manager, Consumers Power Company, JLT 237-89 Subject: Palisades Plant, Pressurizer Valves Replacement Project, Third-Party Qualification Review, GWO 8304, File -011, -317.0.
98-108-23A	August 22, 1989	Telefax from: J. L. Topper, Project Manager, Consumers Power Company Subject: 88RR Actuation and De-Actuation Times - Preliminary Report, Pages 1 - 54.
98-108-23B	August 22, 1989	Letter: JLT 242-89 To: L. E. Demick From: James L. Topper, Consumers Power Subject: Enclosure of (3) copies of Target Rock Corporation Document No. 4946, Revision A, "Flow Test Procedure," including valve flow coefficient C_v.
98-108-24	August 22, 1989	Telefax from: J. L. Topper, Project Manager, Consumers Power Company Subject: Production Test Results for Refurbished Engineering Test Valve Body No. 258, Pages 1 - 6.
98-108-26	August 23, 1989	Letter from: J. L. Topper, Project Manager, Consumers Power Company Subject: Palisades Plant, Pressurizer Valves Replacement Project, Third-Party Qualification Review, GWO 8304, File -011, -317.0. (3) copies of Target Rock Corp. In-Process Status Sheets
98-108-27A	August 28, 1989	Telefax from: J. Topper to L. Demick Transmittal of TRC Time Comparison between 88RR and EPRI valves.

PROJECT FILE

LOG NUMBER	DATE	SUBJECT
98-108-27B	August 29, 1989	Telefax from: J. L. Topper, Project Manager, Consumers Power Company Subject: Telefax to: J. L. Topper from C. J. Ashwater, (6 pages, graphs)
98-108-28	September 8, 1989	Telefax from: J. L. Topper, Consumers Power Company Subject: LTOP Setpoints
98-108-29	September 14, 1989	Telefax from: M. S. McClintock, Target Rock Corporation Subject: 80X-006, Enclosed 4 pages of drawings
98-108-30	September 15, 1989	Licensing Correspondence Record Summary, dated September 12, 1989 Subject: Technical Specification Change Request - Low Temperature Overpressure Protection (LTOP) - Variable Setpoint (TAC No. 72889)
98-108-31	September 14, 1989	Telefax from: M. S. McClintock, Target Rock Corporation Subject: 88RR Study, Enclosed 4 pages of drawings
98-108-32	September 14, 1989	Telefax from: J. L. Topper, Consumers Power Company Subject: PORV Stroke Time Data
98-108-32A	September 19, 1989	Consumers Power Company Internal Correspondence: Y. Chan to J. Topper Subject: Palisades Plant, Pressurizer Valves Replacement Project, Third-Party Qualification Review, GWO 8304, File -011, -317.0.
98-108-33A	September 22, 1989	Licensing Correspondence, J. Topper P13-425, Subject: Technical Specification Change Request - Low Temperature Overpressure Protection (LTOP) - Variable Setpoint - Revision 1 (TAC No. 72889).
98-108-33B	September 25, 1989	Licensing Correspondence, J. Topper P13-425, Subject: Transmittal of Figures 3-1, 3-2, and 3-3, originally omitted from 9/22/89 submittal.

PROJECT FILE

LOG NUMBER	DATE	SUBJECT
98-108-35	October 25, 1989	Letter from: James L. Topper, Project Manager, Consumers Power Company, JLT 272-89 Subject: Palisades Plant, Pressurizer Valves Replacement Project, Third-Party Qualification Review, GWO 8304, FILE -011, -317.0.
98-108-34A	November 9, 1983	Report: 3980A, Project 83A-84, "PORV Measurements in Actuation and De-Actuation for Sub-Cooled Water."
98-108-35A	December 15, 1988	Document Transmittal No. 92, File 8304-106 Originator: J. Topper, P13-425 Subject: (1) ECN 8304-M-003 Affected Specification: SP-MP-8304-001(Q), Rev. 0 and (2) ECN 8304-M-005 Affected Specification: SP-MP-8304-001(Q) Rev 0. (3 copies)
98-108-37	February 1, 1989	Letter: JLT 08-89 To: Peggy Bruno, Target Rock Corporation From: James L. Topper, Consumers Power Subject: Listing of valve and expected reactions of equipment (3 copies - 2 pgs).
98-108-39	February 9, 1989	Letter: JTL 14-89 To: Peggy Bruno, Target Rock Corporation From: J. L. Topper, Consumers Power Subject: EI Services correspondence dated January 31, and February 3, 1989, providing pressure gradient for revised Palisades Pressurizer Relief system as determined by the RELAP transient analysis computer code. (6 copies)
98-108-41	April 21, 1989	Letter: JLT 77-89 To: Peggy Bruno, Target Rock Corporation From: J. L. Topper, Consumers Power Subject: Copy of valve design data sheets from Specification SP-MP-8304-002(Q). (3 copies, pages 28 - 35 of 184)

PROJECT FILE

LOG NUMBER	DATE	SUBJECT
98-108-42	April 21, 1989	Letter: JLT 78-89 To: Peggy Bruno, Target Rock Corporation From J. L Topper, Consumers Power Subject: Revised listing of valve end reaction forces to be furnished under P.O. 2003-4253(Q). (3 copies, 2 pages)

ATTACHMENT 4 TO THE 5/30/90 CPC RESPONSE
TO THE 11/9/89 TER ON NUREG 0737 II.D.1
COMPLIANCE

Consumers Power Company
Palisades Plant
Docket 50-255

MPR REPORT 1168
THIRD PARTY QUALIFICATION REVIEW OF REPLACEMENT
PRESSURIZER MOTOR OPERATED BLOCK VALVES

MPR ASSOCIATES, INC.

THIRD PARTY QUALIFICATION REVIEW OF REPLACEMENT PRESSURIZER MOTOR OPERATED BLOCK VALVES FOR PALISADES NUCLEAR POWER PLANT

MPR-1168

CONSUMERS POWER CO.

ENGINEERING DEPARTMENT

SUPPLIER [illegible] STAMP

1. [X] Work may proceed
2. [ ] [illegible] Work may proceed subject to incorporation of [illegible]
3. [ ] Revise and resubmit. Work may not proceed.

GWO 8364

FC 791

Permission to proceed [illegible] acceptance of operation of design details selected by the [illegible] relieve Supplier from full [illegible] with contractual obligations or [illegible] placed on the order.

FINAL

BY [signature] 2/7/90

Prepared for:

Consumers Power Company
Jackson, MI 49201

February 1990

1050 CONNECTICUT AVENUE, N.W. WASHINGTON, D.C. 20036 202-659-2320

EXECUTIVE SUMMARY

MPR Associates has performed a third party review of the technical and licensing justification for installation of the Edward Valves, Inc. (EVI) pressurizer motor operated block valves (MOVs) at Palisades. The MOVs were replaced in combination with new pressurizer power operated relief valves (PORVs) to provide fully qualified valves and to satisfy Low Temperature Overpressure Protection (LTOP) and Once Through Cooling (OTC) requirements. The scope of this review included 1) verifying that the process used by Consumers Power Company (CPCo) in specifying the replacement valves, evaluating proposals and selecting the supplier was complete, technically sound and consistent with the classification of pressurizer systems and 2) confirming that the supplier has completed all steps necessary to satisfy the requirements of the Conformed Equipment Specification with regard to valve qualification.

With respect to the CPCo process for purchase of this valve, we conclude that the valve specification and valve supplier evaluations and selection are complete and sufficient to satisfy NRC concerns on block valve functionality as stated within NUREG-0737 II.D.1. Specifically, the supplier is required to prove functional similarity between the valves to be supplied to Palisades and those functionally tested by EPRI in the Marshall facilities. The regulatory codes and specific requirements included in the specification are also consistent with the classification of the valve as specified in the Palisades FSAR.

With respect to supplier qualification of the valve, we have concluded that seismic and environmental qualification of the valve meet specification requirements. We also conclude, on the basis of the supplier design report, that the replacement MOVs meet the structural requirements of ASME Code Section III for Class 1 components. We noted in our review of

structural design results that the fatigue life of the valve may not extend to the end of plant life. Although it is not a safety concern, EVI should be requested to establish the allowed number of cycles for the valve stem and stem replacement should be considered as part of the long term maintenance of the valve when this number of cycles is approached. This factor should also be considered in evaluation of potential increases in torque switch settings for these valves.

With respect to functional qualification we conclude that the replacement MOVs are functionally qualified within the intent of NUREG 0737 II.D.1. This conclusion is based on 1) review of the EVI reports which base functional qualification on a combination of analysis, basic operability testing in accordance with ANSI B16.41-1983 and qualification testing by EPRI on a similar but smaller valve and 2) on the successful operability test of one Palisades block valve at Wyle, Norco, California in December 1989.

On these bases, therefore, we consider that the replacement MOV installation at Palisades is acceptable from technical and licensing considerations.

TABLE OF CONTENTS

LIST OF TABLES

Section 1
INTRODUCTION

MPR Associates was requested by Consumers Power Company (CPCo) to perform a third party review of the technical and licensing justification for the replacement of the Pressurizer Motor Operated Block Valves (MOVs) at the Palisades Nuclear Power Plant. These valves are being replaced to satisfy NRC requirements of NUREG-0737 to provide fully qualified pressurizer valves.

The MOVs are being supplied by Edward Valves, Inc. (EVI, formerly Rockwell). The Edward valves are four inch equiwedge gate valves with Limitorque SMB-00-25 motor operators.

The scope of this review included 1) verifying that the process used by CPCo to purchase the replacement pressurizer valve was complete, technically sound and consistent with the classification of pressurizer systems and 2) confirming that the valve manufacturer has completed all steps necessary to satisfy the requirements of the specification with regard to valve qualification. In this regard the scope of the review did not include evaluating the specified required capacities and operating fluid conditions to meet the valve functional requirements for pressure relief, LTOP and OTC. The values contained in the Conformed Equipment Specification and in amendments to this specification subsequently issued by CPCo were assumed to be correct.

The objective of this review is to determine if the technical justification and documentation for these replacement valves satisfy NRC concerns.

This review has been focused in the following areas.

1. Completeness of the Valve Specification considering NRC concerns with the pressurizer valves, basic plant design requirements, and pressurizer valve classifications.

2. Functional Qualification of the replacement valves

3. Structural Design compliance with the ASME Code

4. Environmental Qualification

5. Seismic Qualification

The following sections of this report discuss the impact of each of these items on the replacement of the MOVs only and our conclusions on the technical and licensing justification for the specific replacement MOVs for Palisades.

A significant amount of documentation was reviewed as part of this task. This documentation is listed in Section 7 of the report. Specific references to some of these documents and to regulatory standards are made throughout the report.

Section 2
COMPLETENESS OF THE VALVE TECHNICAL SPECIFICATION

Conclusion

We conclude that the requirements of the valve specification including incorporation of regulatory codes and standards are complete and sufficient to satisfy NRC concerns on replacement MOVs and are consistent with the classifications of the pressurizer valves as specified in the plant FSAR.

Discussion

NRC Concerns -- NUREG-0737

The NRC concern with pressurizer valves is that the valves be qualified by test to prove that they will satisfy their functional requirements for all operating conditions. This position is stated in NUREG-0737, II.D.1, "Clarification of TMI Action Plan Requirements, Performance Testing of Boiling-Water and Pressurized-Water Reactor Relief and Safety Valves (NUREG-0578, Section 2.1.2)," November 1980. This position states that PWR licensees "shall conduct testing to qualify the reactor coolant system relief and safety valves under expected operating conditions for design-basis transients and accidents." The pressurizer block valves were included under this position in Changes to Previous Requirements and Guidance of the NUREG where it is stated that "qualification of PWR block valves is a new requirement" and in Clarification where it is stated that "although not specifically listed as a short-term lessons-learned requirement in NUREG-0578, qualification of PWR block valves is required by the NRC Task Action Plan NUREG-0660 under task item II.D.1."

In the clarification section the NUREG states that testing "should demonstrate that the valve will open and reclose under the expected flow conditions." The NRC does not expect every valve installed in each plant to be tested under full-scale conditions. Accordingly, the NUREG states that "it is the understanding of the NRC that testing of several commonly

used block valve designs is already included in the generic EPRI PWR safety and relief valve testing program.... Each PWR licensee ... should provide evidence supported by test that the block or isolation valves between the pressurizer and each power-operated relief valve can be operated, closed, and opened for all fluid conditions expected under operating and accident conditions." EPRI testing of electric motor-operated block valves was subsequently conducted at Marshall Station (Duke Power) (NP-2514-LD, February 1982, Reference 1).

The CPCo equipment specification for the replacement valves requires compliance with NUREG-0737 and that the suppliers provide sufficient documentation, data or new test data to prove that the valves to be supplied for Palisades are functionally similar to those tested by EPRI (Section 3.2.1, Part 2, Technical Requirements, Reference 3).

Specification Requirements

Table 1 provides a summary of the applicable codes (e.g., NRC regulations, IEEE Standards, ASME codes and ANSI standards) along with the requirements invoked by the replacement valve specification. Requirements for functional, structural, environmental and seismic qualification are included. In general, the code requirements derive from classification of the MOVs as Class 1 (by the equipment specification). Requirements for Class 1 equipment are covered by the Palisades FSAR requirements, NRC regulations and the Code of Federal Regulations. We consider that this table demonstrates that the equipment specification requirements are sufficient for Class 1 equipment.

We note the specification is not precisely clear with regard to the valve performance requirements at minimum operator voltage. However, we also note that the supplier's hot functional test program demonstrates that the valves meet the performance requirements at minimum voltage. Accordingly, we do not consider that CPCo needs to take any action in this area. The following discusses the bases for this conclusion.

The relevant specification requirements are:

- Paragraph 3.3.2.7 of ME-13151-001-5

  "All AC equipment shall be suitable for continuous operation between 90% and 110% of rated voltage."

- Paragraph 3.3.3.6 of ME-13151-001-5

  "The operator shall provide a maximum unseating torque of 50% in excess of the required valve seating torque at the specified voltage, neglecting hammer-blow effects."

- Paragraph 3.3.4.5 of ME-13151-001-5

  "Motor windings shall be braced for across-the-line full voltage starting and shall be capable of starting and accelerating the driven equipment to rated speed at 85% of rated nameplate voltage during acceleration."

We consider that the valve/operator should be designed to meet all performance requirements at minimum voltage (in this case 85% of nominal voltage). Instead, the wording of the specification indicates only "accelerations" have to be covered at 85% voltage (a nonencompassing requirement). Further, the specification implies that the valve unseating load (50% margin over normal load) has to only be satisfied at nominal ("specified") voltage. A more appropriate approach in the specification is to require the valve performance requirements to be fully satisfied at minimum voltage. However, as mentioned above, no action is required since the test program covers the limiting conditions.

TABLE

POWER OPERATED RELIEF VALVE (PORV) QUALIFICATION REVIEW

PALISADES NUCLEAR POWER STATION

PRIMARY REQUIREMENT	APPLICABLE CODES	SPECIFICATION REQUIREMENTS
1. <u>FUNCTIONAL QUALIFICATION</u>		
NUREG-0737, II.D.1	IEEE 382 "Standard for Qualification of Actuators for Power Operated Valve Assemblies with Safety-Related Functions for Nuclear Power Plants."	General technical requirements (Section 3.4.6.3, page 22) state that valves shall be designed and tested in accordance with: - ANSI B16.41-1983, - Regulatory Guide 1.148, - Standard Review Plans 3.9.3, 3.9.6, 3.10 and 3.11 - ANSI N278.1 - 1975.
	ANSI B16.41 - "Functional Qualification Requirements for Power Operated Active Valve Assemblies for Nuclear Power Plants"	
	ANSI N278.1 - "Self-Operated and Power-Generated Safety-Related Valves Functional Specification Standard."	Design Data Sheets (pages 28 - 35) contain data specified by ANSI N278.1.
2. <u>STRUCTURAL QUALIFICATION</u>		
FSAR Section 4.2.4	ASME Code Section III, Class 1 Components.	MOVs must meet the requirements of the ASME Code Section III for Class 1 components.
	Regulatory Guide 1.26.	
	10 CFR 50 (50.2, 50.55a, Appendix A - Criterion 1).	

TABLE 1
POWER OPERATED RELIEF VALVE (PORV) QUALIFICATION REVIEW
PALISADES NUCLEAR POWER STATION

PRIMARY REQUIREMENT	APPLICABLE CODES	SPECIFICATION REQUIREMENTS
3. ENVIRONMENTAL QUALIFICATION		
10CFR50.49 - "Environmental Qualification of Electric Equipment Important to Safety of Nuclear Power Plants"	Regulatory Guide 1.89 - "Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants." IEEE 323 "Qualifying Class 1E Equipment for Nuclear Power Generating Stations." IEEE 382 "Standard for Qualification of Actuators for Power Operated Valve Assemblies with Safety-Related Functions for Nuclear Power Plants."	MOVs must meet requirements of the following: IEEE 323-1974 (Section 3.4.3.2, page 21) IEEE 382-1985 (Section 3.4.3.2, page 21) Reg Guide 1.89 (Section 3.4.3.2, page 21) Reg Guide 1.73, "Qualification Tests of Electric Valve Operators Installed Inside the Containment of Nuclear Power Plants", (Section 3.4.3.2, page 21) Standard Review Plan 3.11, "Environmental Qualification of Mechanical and Electrical Equipment", (Section 3.4.3.2, page 21)
4. SEISMIC QUALIFICATION		
10CFR50 Appendix A - Criterion 2, "Design Basis for Protection Against Natural Phenomena."	Regulatory Guide 1.29, Rev. 3. 10CFR50 (Appendix A - Criterion 2). IEEE 323 "Qualifying Class 1E Equipment for Nuclear Power Generating Stations."	General technical requirements (Section 3.3.4, page 20) refer to Technical Specification C-175 (Q) - "Requirements for Seismic Qualifications of Electrical and Mechanical Equipment" (pages 70 - 95) which states the valves must meet the following:

TABLE I
POWER OPERATED RELIEF VALVE (PORV) QUALIFICATION REVIEW
PALISADES NUCLEAR POWER STATION

PRIMARY REQUIREMENT	APPLICABLE CODES	SPECIFICATION REQUIREMENTS	
4. SEISMIC QUALIFICATION, CONTINUED			
	IEEE 344 "Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations."	Regulatory Guide 1.29	(Section 3.1.1, page 77)
		IEEE 323-1974	(Section 3.2.11, page 79)
		IEEE 344-1975	(Section 3.3.1.1, page 80)
	IEEE 382 "Use guide for type test of Class I Electric Valve Operators for Nuclear Power Generating Stations."	IEEE 382	(Section 3.3.2.1, page 80)
		Regulatory Guide 1.92	(Section 4.4.2, page 83)
	ANSI B16.41, Annex F "Seismic Loading Test."		

Section 3
FUNCTIONAL QUALIFICATION

Conclusion

We conclude that the replacement MOVs are functionally qualified within the intent of NUREG-0737 II.D.1. This conclusion is based on 1) review of the Edward Valves, Inc. reports which base functional qualification on a combination of analysis, basic operability testing in accordance with ANSI B16.41-1983 and qualification testing by EPRI on a similar valve and 2) on the successful operability test of one Palisades block valve at Wyle in December 1989 in saturated steam conditions at near full specification flow and pressure conditions.

Discussion

A review of the Edward Valves functional qualification was performed to verify that the methodology and the documentation meet CPCo specification requirements. This review was based on the following:

1. Requirements for functional qualification are covered by the CPCo specification which requires qualification to NUREG-0737 II.D.1 (Section 3.2.2) and testing in accordance with ANSI B16.41-1983 (Section 3.4.6.3) as modified by Section 5.0 of the Equipment Specification. Table 2 provides a summary of applicable sections of the specification.

2. Functional qualification of the EVI valves is documented by the following:

   - RAL-7127 (-7126), "Qualification Summary Report for a Size 4 Class 1550 Equiwedge Gate Valve Figure No.12011\CF8M) FJMNPQTYZ with a SMB-00-25 Limitorque Actuator," November 10, 1989, Revision 0.

- RAL-7125, "Qualification Testing for a Size 4 Class 1550 Equiwedge Gate Valve," October 30, 1989.

The following discusses the specific results of review of this documentation.

__ANSI B16.41-1983 Testing__

Edwards performed ANSI B16.41-1983 testing in accordance with the CPCo specification. The test procedures and the test results for each test required by the specification are summarized by the following:

1. Annex A, Valve Leakage Test and Annex B, Cold Cyclic Test were performed successfully in accordance with Edward Valves, Inc (EVI) Method Specification (MS)-7863, "Hydrostatic and Functional Test Procedure for a Size 4 Class 1550 Stainless Steel Equiwedge Gate Valve," July 13, 1989, Revision 1.

2. Annex C, Hot Cyclic Test was successfully completed in accordance with Corporate Consulting and Development Company, Inc (CCL) Test Procedure 2161-1, September 20, 1989 and EVI MS-7866, August 29, 1989, Revision 1.

3. Annex D, Pipe reaction End Loading Qualification Test and Annex F, Seismic Loading Test were successfully completed in accordance with CCL Test Procedure 2161-3, September 18, 1989, Revision 0 and EVI MS-7865, August 29, 1989, Revision 1.
4. Annex E, Exploratory Vibration Test was successfully completed in accordance with CCL Test Procedure 2161-2, September 13, 1989 and EVI MS-7864, May 15, 1989, Revision 0.

5. Annex F, Seismic Loading Test results are discussed below in Section 6, Seismic Qualification, of this report.

6. Annex G, Flow Interruption Capability Test is covered in the discussion below on NUREG-0737 testing.

7. The intent of Annex H, Endurance Testing has been met by successful completion of the operational, vibratory and seismic tests that were conducted on the valve and the actuator.

We consider that successful completion of these tests establish the replacement valves operability in the context of ANSI B16.41-1983. This satisfies the testing requirements of Section 5 of the valve specification.

NUREG-0737 Testing

EVI states in RAL-7127 (-7126) that the ability of the Palisades block valve to function under full flow conditions is verified by similarity with a functionally identical but smaller valve tested in the EPRI-Marshall Electric Motor-Operated Valve (Block Valve) Test Program reported in EPRI NP-2514 (LD), July 1982, Reference 1. The EPRI tested valve was Size 3, Class 2500 compared with the Size 4, Class 1550 valve at Palisades. EVI concludes that the valves are similar within the context of NUREG B16.41-1983 and NUREG-0737 on the following bases:

- The valves are similar in design.
- The materials used for construction and hardfacing and the required surface finish of critical mating surfaces of the valves are identical.
- The structural design of valve components and the sizing of the actuator were performed to the same design criteria.
- The gates were designed to the same stress levels and the same criteria were used for the design of the stem to gate T-head connection.

We do not consider that the EVI approach is necessarily sufficient to establish functionality of the larger Palisades valve. We do not believe that there is currently a consensus in the industry on the key factors

which establish functional similarity between motor operated gate valves of different sizes. For example, flexure of the gates under load which could increase friction in the guide rails or cause interference at the seats is not necessarily going to be the same in a four inch valve as it is in a three inch valve, even if the two gates are designed to the same stress level. The dynamic thrust characteristics of the two valves will also not necessarily be similar. We believe that more detailed comparisons than were made by EVI would be required to establish functional qualification only by similarity.

However, we consider that there are additional factors which establish the operational capabilities of the Palisades valve which are sufficient to complete the functional qualification of the valve. These are as follows:

- The EPRI tests of the smaller EVI valve demonstrated that this valve had considerable margin in meeting its functional requirements throughout the test program. This provides more confidence that the larger valve, designed to the same criteria will perform acceptably.

- One of the Palisades MOV's was cycled open and closed at near full flow and pressure conditions in saturated steam in a formal test program at Wyle laboratories Norco, California in December 1989, References 19 and 20. The capabilities of the valve were measured directly using the Consumers Power VOTES equipment. The results of these tests demonstrated that the valve is capable of interruption of full steam flow in a configuration similar to that at Palisades. The test data indicate that the margin between available and required thrust at the current actuator torque settings is small but acceptable, Reference 21. [Note the torque settings of the actuator are at the maximum allowable within the current design constraints of the valve stem as discussed in detail in Section 4.0 of this report. The margin between the required thrust and the torque setting can not be increased without changing the valve stem size.]

On these bases we conclude that the flow interruption capabilities of the Palisades MOV's have been successfully established by the EPRI tests and by the CPCo Wyle tests. We also conclude that the successful completion of these tests and the ANSI B16.41-1983 basic operability tests are sufficient to establish functional qualification of the MOV's within the intent of NUREG-0737.

Table 2

SUMMARY OF SPECIFICATION REQUIREMENTS ON FUNCTIONAL QUALIFICATION

SPECIFICATION SECTION	REQUIREMENT	APPLICABLE CODE, IF ANY
3.2, 3.2.1 and 3.2.2	Invoke NUREG-0737 and require the valve to be similar in design, construction, function and operational characteristics to those valves furnished by the supplier for testing by EPRI.	NUREG-0737, II.D.1
3.4.1.1	Requires the valve to be functional before and after a seismic event but not during the event.	Supercedes CPCo generic seismic specification.
3.4.6.2	Requires the valve to be operational under all combinations of operating and environmental conditions specified. Required operating conditions are contained in the Design Data Sheets for the valves.	
3.4.6.3	Invokes applicable codes for design and testing of the valve.	ANSI B16.41-1983 ANSI N278.1-1975 R.G. 1.148 S.R.P 3.9.3, 3.9.6, 3.10 and 3.11
5.2	Cold Cyclic Testing	ANSI B16.41, Annex B
5.3	Hot Cyclic Testing	Annex C
5.4	Pipe Reaction End Loading Test	Annex D
5.5	Exploratory Vibration Test	Annex E
5.6	Seismic Loading Test	Annex F
5.7	Flow Interruption Test	Annex G
5.8	Endurance Test	Annex H
5.9	Similarity	Annex J
9.0	Design and functional requirements including capacity and stroke times on Design Data Sheets, DDS-3, DDS-4, DDS-7 and DDS-8	

Section 4
DESIGN IN ACCORDANCE WITH ASME SECTION III

Conclusion

The Edward Valves, Inc. (EVI) MOV design report (issued as Rockwell International report RAL-2119, July 12, 1989, Revision 1) was reviewed for compliance with ASME Code Section III for Class 1 components. We conclude on the basis of this report, that the EVI MOV structural design meets part NB-3500 of the ASME Code Section III and the CPCo valve specification requirements for the design conditions of the specification.

Discussion

1. Specification requirements

   The CPCo specification for the block valves includes the following requirements on valve structural design:

Section	Requirement
Part Two - SP-MP-8304-001(Q)	
3.4.2.1,	Invokes by reference ASME Section III and CPCo Technical Specification ME-13101-001(Q), "ASME Section III, Gate Valves."
Technical Specification ME-13101-001(Q)	
3.3.3	For valves 4-inch and under this section invokes NB-3513 of the ASME Code Section III and permits the use of ANSI B16.34, "Special Class" design rules.

3.3.5 Invokes Subarticle NB-3500 and NX-3500 of the ASME Code Section III for sizing body dimensions and internal proportions.

3.3.8.1 Requires that the "valve stem shall be designed in accordance with the requirements of the Code for pressure boundary requirements."

3.3.8.3 Requires an analysis of bending stresses and buckling stresses in the valve stem for maximum operator thrust and maximum differential pressure or flow velocity through the valve.

3.4 Requires submittal of valve actuator sizing calculations and coordination between the valve operator manufacturer and valve manufacturer to ensure that the operator is adequately sized for the service.

2. Vendor Submittals

The following documentation was reviewed to establish if the valve and valve operator design meet specification requirements.

a. Design Report RAL-2119 for a Size 4 Class 1550 Equiwedge Gate Valve Figure NO. 12011 (CF8M)FJMNPQTYZ with a SMB-00-25 Limitorque Operator," July 12, 1989, Revision 1. This report presented valve body design and valve stem design calculations and calculations of the pressure seal gasket performance factor.

b. RAL-4131 Rev 1, Consumers Power - Palisades, PORV Block Valve, Actuator Sizing Calculations, Limitorque Model SMB-00-25, Rockwell Sales Order No. 36-05624," May 10, 1989, Revision 1.

3. <u>Structural adequacy of design</u>

   a. The valve body meets the minimum wall thickness requirements of NB-3543 of the Code for the design pressure/temperature conditions.

   b. By NB-3513, analysis of other valve parts (e.g., bonnet, body-to-bonnet joints, gate, etc.), are not required by the Code for valves with inlet piping connections four inches and less.

   c. The stem meets the requirements of NB-3546.3 of the Code for the assumed actuator load (13,146 lbf). However, we have concerns in the following areas of the stem analysis:

      - Nonconservative stem load used in the stem evaluation
      - Potential stem structural inadequacy and fatigue usage

      These are discussed below:

      <u>Stem Load</u>
      The stem load used in the stem calculations (13,146 pounds) is the calculated required stem load to operate the valve. However, in the tests performed on this valve at Wyle in December 1989, and in static tests, higher stem loads were measured (15,210 average), Reference 21.

      <u>Stem Adequacy</u>
      NB-3546.3 requires that the valve stem be designed so that primary stresses do not exceed S_m, if stem failure will result in a violation of the pressure boundary. We believe that the CPCo specification could be interpreted to require that the stem be designed to meet this criteria. In the EVI calculations the stem stress (41.7 ksi) is over 89% of the allowable stress (46.7 ksi) using the calculated stem load. If the measured load is used,

the calculated stem stress (48.2 ksi) just exceeds the allowable value.

The stem buckling evaluation, which showed a substantial margin, would still be acceptable.

It is noted, that the allowable value used for the maximum stress comparison (S_m) is based on assuming that the valve stem is a part of the pressure boundary. In fact the most limiting stress in the valve stem is at an undercut positioned outside the pressure boundary. This undercut is provided as the weak link in the valve actuator-stem-gate path to ensure that any failure of the stem will be outside the pressure boundary. If the stem is not considered part of the pressure boundary the maximum stress criterion would be 35_m. The stem stresses calculated for the stem loads measured in the Wyle tests meet this criterion.

<u>Stem fatigue life</u>

We also note that no fatigue analysis was performed for the valve stem. Vendor fatigue evaluation is not required based on the valve specification and code requirements. However, fatigue is pertinent to consider because of the above stated concerns with stem adequacy. On every cycle of the valve, the stem will be subjected to alternating compressive (on closing) and tensile (on opening) stresses of the nominal magnitudes discussed above. Stress concentrations at the threads and thread undercut will give rise to higher peak stresses. We believe this alternating peak stress range exceeds the endurance limit of this material. This clearly does not compromise the structural adequacy of the valve in the short term or the safety of the valve in the long term. However, the potentially limited fatigue life of the valve stem should be discussed with EVI and the number of allowable cycles for the valve should be established. This potential

limitation on the number of allowable cycles should also be considered for the following:

1) If CPCo considers an increase in the torque switch settings to address operability or NRC concerns. (For example, NRC Generic Letter 89-10 requires licensees to evaluate MOV switch settings and ensure these are maintained at values to assure operability.) Increased torque switch settings increase the maximum value of stem stresses further above S_m and reduce the fatigue life of the valve stem.

2) In the planned maintenance of the valve. A valve stem replacement may be considered as the number of allowed cycles is approached.

We do not consider these concerns compromise the safety or capabilities of the replacement MOV's and conclude that the MOV's structural design meets part NB-3500 of the ASME Code Section III and the intent of the CPCo valve specification.

Section 5
ENVIRONMENTAL QUALIFICATION

Conclusion

We conclude that the replacement MOVs with Limitorque Actuators meet specification requirements for environmental qualification. EVI has established similarity of components between the Palisades block valve Limitorque operators (SMB-00-25) and another operator (SMB-00-15) which has been fully qualified by test. This approach is accepted by applicable regulatory guidance and industry standards.

Discussion

A review of the EVI environmental qualification of the replacement MOVs was performed to verify that the methodology used and the documentation supplied by EVI are sufficient to justify installation of these valves at Palisades and satisfy the requirements of the NRC. This review was based on the following:

1. Qualification requirements are based on the following:

   - CPCo Conformed Equipment Specification, SP-MP-8304-001(Q)

   - IEEE Std 382-1980, IEEE Standard for Qualification of Safety-Related Valve Actuators.

   - USNRC Regulatory Guide 1.73, Qualification Tests of Electric Valve Operators Installed Inside the Containment of Nuclear Power Plants, January 1974.

   - IEEE Std 323-1974, IEEE Standard for Qualifying Class IE Equipment for Nuclear Power Generating Stations.

- USNRC Regulatory Guide 1.89, Environmental Qualification of Certain Electrical Equipment Important to Safety for Nuclear Power Plants, June 1984.

2. The documentation provided by EVI to support environmental qualification of the MOVs includes the following:

   - RAL-7127 Qualification Summary Report for a Size 4 Class 1550 Equiwedge Gate Valve Figure No. 12011 (CF8M)FJMNPQTYZ with a SMB-00-25 Limitorque Actuator," November 10, 1989, Revision 0.

   - Report B0212, "Nuclear Power Station, Qualification Type Test Report, Limitorque Valve Actuators with Type LR Motor for Westinghouse PWR," tested per IEEE Standards 382-1980, 323-1974 and 344-1975, tests performed June 18, 1984 to November 30, 1984, April 10, 1985, Revision 0.

3. Qualification Review

The EVI environmental qualification of the replacement MOVs is based on establishing similarity between the actuator installed in Palisades (SMB-00-25) with an actuator (SMB-00-15) which was fully qualified by Limitorque (Report B0212). This approach to qualification is a method accepted by the applicable regulatory guides and industry standards.

The EVI comparison between the SMB-00-25 and the SMB-00-15 actuators is made in RAL-7127, Reference 17. These actuators are mechanically identical except for the motor sizes. The Palisades motor is rated at 25 ft-lbs, the tested motor is rated at 15 ft-lbs. The same materials and configuration is used for both motors. Accordingly, we consider the similarity comparison to be acceptable and sufficient to establish environmental qualification of the Palisades actuator.

Section 6
SEISMIC QUALIFICATION

Conclusion

We conclude that the seismic qualification of the replacement Edward Valves, Inc. (EVI) MOVs is acceptable. This seismic qualification is based on analyses that meet the requirements of the CPCo equipment specification for these valves.

Discussion

A review of the EVI seismic qualification of the replacement MOVs was performed to verify the adequacy of the methodology used and documentation supplied by EVI to justify the installation of these valves at Palisades and to address NRC concerns. This review was based on the following:

1. The requirements for seismic qualification for the MOVs are based on the following:

   - CPCo Conformed Equipment Specification.

   - USNRC Regulatory Guide 1.29, Seismic Design Classification, Revision 3, September 1978.

   - USNRC Regulatory Guide 1.92, Combining Modal Responses and Spatial Components in Seismic Response Analysis, Revision 1, February 1976.

   - IEEE Std 323-1974, IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations.

- IEEE Std 344-1975, IEEE Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations

- IEEE Std 382-1980 IEEE Standard for Qualification of Actuators for Power Operated Valve Assemblies with Safety-Related Functions for Nuclear Power Plants.

2. EVI submitted the following documentation to support seismic qualification of the MOVs:

   - Seismic Report RAL-3221 for a Size 4 Class 1550 Equiwedge Gate Valve Figure No. 12011 (CF8M)FJMNPQTYZ with a SMB-00-25 Limitorque Actuator, June 6, 1989, Revision 0.

   - RAL-7125, "Qualification Testing for a Size 4 class 1550 Equiwedge Gate Valve," October 27, 1989, Revision 0

   - Edward Valves, Inc., Method Specification - 7864, "Modal Survey Test Procedure for a Size 4 Class 1550 Stainless Steel Equiwedge Gate Valve," May 15, 1989, Revision 0, implemented by Corporate Consulting and Development Company, Ltd (CCL) Test Procedure 2161-2, September 13, 1989, Revision 0.

   - Edward Valves, Inc., Method Specification - 7865, "Static Seismic Test Procedure for a Size 4 Class 1550 Stainless Steel Equiwedge Gate Valve," June 19, 1989, Revision 0, implemented by Corporate Consulting and Development Company, Ltd (CCL) Test Procedure 2161-3, September 13, 1989, Revision 0.

   - Limitorque Seismic Report B0037, "Seismic Qualification of Limitorque Actuators, Tests per IEEE 344-75," tests performed starting April 1, 1975, prepared by Limitorque Corporation

- Project #600457, "Nuclear Power Station Qualification Type Test Report, Limitorque Valve Actuators for PWR Service," tested per IEEE Standard 382-1972, Tests performed June 7, 1974 to November 22, 1974, prepared by Limitorque Corporation Test Laboratory, December 9, 1975.

3. Qualification Summary

The seismic qualification of the replacement MOVs is based on analysis and testing. This approach for seismic qualification is acceptable under Section 6.0 of CPCo Technical Specification SP-MP-8304-001(Q), Reference 3. The calculations, data and information supporting seismic qualification are presented in the above reports. The following summarizes the results of the qualification effort.

a. Structural Design

The seismic acceleration was taken as 3.0g. A static analysis was performed with a static coefficient of 1.5. Total load was 4.5g. Two load cases were considered; perpendicular to the flow direction and parallel with the flow direction.

The seismic loads and stresses were determined by the finite element method (ANSYS). Where the finite element model explicitly modeled the valve parts, stresses were taken directly from the finite element analysis. Where the finite element model did not explicitly model the valve parts, supplemental hand calculations were performed based on the loads obtained from the finite element analysis. Stresses due to seismic loads were combined with stresses due to the design internal pressure of 2500 psig where appropriate.

Allowable stresses were based on the Level A Service Limits of the ASME Code Section III. This is conservative. The Specification allows higher allowables: S_y for load combinations with OBE and 1.1 S_y for load combinations with SSE.

A natural frequency analysis was performed which indicates the lowest natural frequency was greater than 33 Hz, as required by the Specification.

b. Functional Qualification

Seismic functional qualification for the EVI MOV and Limitorque actuator are based on equivalent static loading on the valve. No seismic dynamic testing was performed. The justification for this approach derives from the following:

1) Section 3.4.2.3 of Part 2, Technical Requirements of the equipment specification states that "functionality is required to be verified after a safe shutdown seismic event." This requirement is considered to supercede Section 3.1.2 of the generic seismic qualification Technical Specification SP-MP-8304-002(Q) which states "all equipment qualified under this Technical Specification are required to perform the safety function(s) during and after a series of five Operating Basis Earthquakes (OBE) and a Safe Shutdown Earthquake (SSE)."

   We consider this revision to be acceptable on the following basis:

   - The MOV is normally shut with the reactor at power since the PORV does not provide the primary overpressure protection for the reactor coolant system. Neither the PORV nor the MOV have to be operational during the seismic event.

   - The MOV is only open during startup and shutdown when the PCS is solid. If the PORV were to open spuriously during a seismic event at that time the size of the

opening does not present a major coolant loss path for the system. In the long term the MOV can be closed, if necessary, to isolate the PORV.

We do not consider, therefore, that dynamic (shake table) testing at the floor response spectrum is required to prove operability during the event.

2) According to Section 4.1.1 of SP-MP-8304-002(Q), the use of analysis alone for seismic qualification is acceptable if "the necessary functional integrity of the equipment is assured by its structural integrity alone."

The EVI design report presents analyses which:

- verify the structural integrity of the valve pressure retaining components for the maximum seismic loading,

- indicate that the valve and the actuator do not have a structural natural frequency in the seismic range (less than 33 hz).

3) EVI and Limitorque performed exploratory vibration tests of the valve and the actuator to confirm that they do not have structural natural frequencies within the seismic range (less than 33 hz).

4) The valve ANSI B16.41-1983 test series included a static seismic loading test in accordance with Annex F to verify valve operability after an SSE (3 g loading). This method for establishing seismic qualification of valve operator, valve operator assembly and valve functional accessories is permitted per section 3.3.2.2 of CPCo Technical Specification C-175(Q).

Section 7
REFERENCES

1. "EPRI-Marshall Electric Motor-Operated Valve (Block Valve) Interim Test Data Report," EPRI NP-2514-LD, Project V102, Interim Report, Prepared by Intermountain Technologies, Inc., Idaho Falls, Idaho, July 1982.

2. Consumers Power Company Internal Correspondence JLT 91-88, J. L. Topper to W. Clark, "Palisades Plant Pressurizer Valves Replacement Project Bid Evaluation - Replacement PORV Block Valves, GWO 8304, File -011, -311.5," August 24, 1988

3. "Conformed Palisades Specification M-241BC, ESS Specification SP-MP-8304-001(Q), Pressurizer Valves Replacement Project, Replacement PORV Block Valves," GWO 8304/FC 791, Consumers Power Company, Palisades Plant, UFI No. 02330, 13101, 41, Revision 0, December 9, 1988.

4. Letter, J. L. Topper (CPCo) to J. Davis (Rockwell International Corporation), JLT-81-89; "Palisades Plant, Pressurizer Valves Replacement Project, P.O. 2003-4153(Q), GWO 8304, File -011, -311.0, -311.7," transmittal of valve design data sheets from Specification SP-P-8304-001(Q), dated April 24, 1989.

5. "Consumers Power - Palisades PORV Block Valve Actuator Sizing Calculations, Limitorque Model SMB-00-25, Rockwell Sales Order No. 36-05624," Report RAL-4131 Revision 1, May 10, 1989.

6. Letter, J. L. Topper (CPCo) to L. E. Demick (MPR), JLT 274-89, "Palisades Plant, Pressurizer Valves Replacement Project, Third-Party Qualification Review, GWO 8304, File -011, -317.0," transmittal of Rockwell International Corporation (Edward Valve) Report RAL 7125, "Qualification Testing," November 1, 1989.

7. "Qualification Testing for a Size 4 Class 1550 Equiwedge Gate Valve with an SMB-00 Limitorque Actuator; Report RAL-7125, October 30, 1989.

Appendix A, Test Procedures.

Appendix A-2, CCL Test Procedure 2161-3, Revision 0, and EVI Method Specification Number 7865, Revision 1.

Appendix A-3, CCL Test Procedure 2161-1, Revision 0, and EVI Method Specification Number 7866, Revision 1.

Appendix B, Description of Modal Survey Techniques and Mathematics.

Appendix C, Tabulated Mode Shapes.

Appendix D, Frequency Response Functions.

Appendix E-1, Modal Survey Test Monitor Log.

Appendix F, Records of Deviation From Test Procedure.

Appendix G, Records of Anomaly.

Appendix H, Static Seismic Test Monitor Log.

Appendix I, Hot Functional Test Monitor Log.

Appendix J, Instrumentation Sheet.

Appendix K, Photographs (3 sheets).

8. "Design Report RAL-2119 for a Size 4 Class 1550 Equiwedge Gate Valve, Figure No. 12011(CF8M)FJMNPQTYZ with an SMB-00-25 Limitorque Actuator," Revision 1, July 12, 1989.

9. "Seismic Report RAL-3221 for a Size 4 Class 1550 Equiwedge Gate Valve, Figure No. 12011 (CF8M)FJMNPQTYZ, with a SMB-00-25 Limitorque Actuator," Revision 0, June 6, 1989.

10. "Hydrostatic and Functional Test Procedure for a Size 4 Class 1550 Stainless Steel Equiwedge Gate Valve," Method Specification MS-7963, Revision 1, July 13, 1989.

11. "Modal Survey Test Procedure for a Size 4 Class 1550 Stainless Steel Equiwedge Gate Valve," Edward Valves, Inc., Method Specification, MS 7864, Revision 0, May 15, 1989.

12. "Static Seismic Test Procedure for a Size 4 Class 1550 Stainless Steel Equiwedge Gate Valve," Edward Valves, Inc., Method Specification, MS 7865, Revision 0, June 19, 1989.

13. "Hot Functional Test Procedure for a Size 4 Class 1550 Stainless Steel Equiwedge Gate Valve," Edward Valves, Inc., Method Specification, MS 7866, Revision 0, May 25, 1989.

14. "Nuclear Power Station Qualification Type Test Report, Limitorque Valve Actuators with Type LR Motor for Westinghouse PWR," Report B0212, Tested per IEEE Standards 382-1980, 323-1974 and 344-1975, Test performed 18 June 1984 to 30 November 1984, April 10, 1985.

15. "Seismic Qualification Limitorque Valve Actuators," Report B0037, Tests performed starting April 1, 1975, Prepared by Limitorque Corporation, Revision 0, November 10, 1975.

"Job 383964 Pre Seismic Torque Switch Calibration and Monitoring performed during Seismic Testing Unit SB-3-100," Test Report.

"Job 383964 - Pre Seismic Torque Switch Calibration and Monitoring performed during Seismic Testing Unit SMB-000-5," Test Report.

"Job 383964 - Pre-Seismic Torque Switch Calibration and Monitoring performed during Seismic Testing Unit SMB-9-25 (D C motor)," Test Report.

"Job 383964 - Pre-Seismic Torque Switch, Calibration and Monitoring performed during Seismic Testing SMB-3-100," Test Report.

"Job 383964 - Pre-Seismic Torque Switch Calibration and Monitoring performed during Seismic Testing Unit SB-9-25," Test Report.

"Seismic Testing of SMB-1-25/H4BC with Standard Cast Iron Adapter," Report B-0006.

"Seismic Dwell Testing on One SMB-5T Valve Control," Wyle Report 43059-02, for Limitorque Corporation, October 30, 1975.

16. "Nuclear Power Station Qualification Type Test Report, Limitorque Valve Actuators for PWR Service," Project 600456, December 9, 1975.

17. "Qualification Summary Report for a Size 4 Class 1550 Equiwedge Gate Valve, Figure No. 12011 (CF8M) FJMNPQTYZ, with a SMB-00-25 Limitorque Actuator," Report RAL-7127 (-7126), Revision 0, November 10, 1989.

18. Letter 98-108-05 L. E. Demick (MPR) to J. L. Topper (CPCo), "Interim Report, Third-Party Qualification Review of Block Valve Replacement, Palisades Nuclear Plant," August 28, 1989.

19. Letter 98-108-20, L. E. Demick (MPR) to J. L. Topper (CPCo), "Report of the Pressurizer Valve Tests Conducted at Wyle, December 5 through 8, 1989," dated December 13, 1989.

20. Test Report 57375, Wyle Laboratories, Western Operations, Norco Facility, Job No. FS-57375, December 18, 1989.

21. "MO-1042A and MO-1032A dP Test Results," Test Results of Valve MO-1042A, performed between December 6, 1989 and December 8, 1989 at Wyle Labs in Norco, California.

ATTACHMENT 5 TO THE 5/30/90 CPC RESPONSE
TO THE 11/9/89 TER ON NUREG 0737 II.D.1
COMPLIANCE

Consumers Power Company
Palisades Plant
Docket 50-255

WYLE REPORT NO 57375
REPORT OF PRESSURIZER VALVE TESTS CONDUCTED
AT WYLE, DECEMBER 5 THROUGH 8, 1989

WYLE
LABORATORIES SCIENTIFIC SERVICES & SYSTEMS GROUP
WESTERN OPERATIONS, NORCO FACILITY
1841 HILLSIDE AVENUE, NORCO, CALIF. 91760

test REPORT

TEST REPORT

WYLE LABORATORIES SCIENTIFIC SERVICES & SYSTEMS GROUP
WESTERN OPERATIONS, NORCO FACILITY

REPORT NO. 57375
OUR JOB NO. FS-57375
CONTRACT --
YOUR P. O. NO. --

Consumers Power
Palisades Nuclear Plant
27780 Blue Star Memorial Highway
Covert, Michigan 49043

60 Page Report

DATE December 18, 1989

This is to certify that the enclosed test data sheets contain true and correct data obtained in the performance of the test program as set forth in your purchase order.

Test methods, results, and equipment used are recorded on these data sheets.

Where applicable, instrumentation used in obtaining this data has been calibrated using standards which are traceable to the National Bureau of Standards.

SUMMARY:

High pressure steam tests of 4-inch MOV and PORV test valves were performed for Consumers Power Company at Wyle Laboratories, Norco facility. Wyle provided a 9-channel strip chart primarily to record steam and flow conditions. Detailed MOV data was acquired by and under the direction of Consumers Power Company engineer George L. Smith.

(continued on page 2)

STATE OF CALIFORNIA } ss.
COUNTY OF RIVERSIDE }

W.D. Peters, being duly sworn, deposes and says: That the information contained in this report is the result of complete and carefully conducted tests and is to the best of his knowledge true and correct in all respects.

W.D. Peters

SUBSCRIBED and sworn to before me this 20th day of December, 19 89

Catherine C Kelty

Notary Public in and for the County of Riverside, State of California

My Commission expires 23 July 1991, 19

OFFICIAL SEAL
CATHERINE C KELTY
NOTARY PUBLIC - CALIFORNIA
RIVERSIDE COUNTY
My comm. expires JUL 23, 1991

W-867A

DEPARTMENT FLUID SYSTEMS

DEPT. MGR. W.D. Peters

TEST ENGINEER D. Anderson

REGISTERED PROFESSIONAL ENGINEER

DCAS—QAR VERIFICATION

QUALITY ASSURANCE J. Graper

PORV actuation test number 6.3 was performed three times with the PORV installed in the test system as shown in Figure 1 of the test procedure. The orientation of the PORV actuator for all three runs was at top dead center. Limit switch signals from the PORV actuator were noisy and/or out of adjustment throughout the test program.

Run one of test 6.3 demonstrated that the PORV will lift and reseat itself when its inlet is pressurized with a 575 psig steam supply. PORV lift to reseat time was four seconds. Wyle instrumentation channels P1 and C1 were erroneously recorded as negative signals.

Run two of test 6.3 was similar to run one, except PORV lift to reseat time was longer at 21 seconds. Wyle instrument channels P1 and C1 were correctly recorded as positive signals.

Run three of test 6.3 deviated from the first two runs. Initiating this test was as both prior runs, resulting in the PORV lifting and reseating in 62 seconds. This time however the MOV was opened for 10 minutes, then closed for 10 minutes. The PORV was then electrically actuated to dump P2 pressure, then subjected to steam pressure by jogging the MOV to 10% open. Again the PORV lifted and reseated, this time in 15.5 seconds.

MOV jog test number 6.4 was performed once with the test valves installed as shown in Photograph 1. Prior to this test, the PORV valve was rotated 135^{o} from top dead center as shown in Photographs 1 and 2. It is noted that during test procedure step number 6.4.7, the PORV did not measurably lift when subjected to upstream pressure, however a few gallons of water was discharge from the outlet vent piping before complete shutoff by the PORV.

MOV leakage test number 6.5 was performed by opening a drain valve downstream of the MOV and observing any steam or condensate leakage. Another drain valve just upstream of the MOV was also opened to bring 2500 psig, dry saturated steam to the MOV inlet. No leakage past the MOV was observed during this test, nor at any other time during the test program.

The high pressure test number 6.6 was performed in accordance with the test procedure up to step number 6.6.8, which concludes the test by closing the PORV. The PORV remained open, and the test was concluded by closing the MOV.

Removal of the PORV revealed a piece of metal lodged just upstream of the valve seat and under the valve stem. Upon removing the metal, a visual inspection indicated minimal damage to the PORV and it was reinstalled in the test system. The PORV displayed normal operation and was used to control steam flow during the remaining tests.

Test numbers 6.7, 6.8 and 6.9 began with the MOV position at 60%, 25% and 100% of open respectively. In all, cases, the initial upstream total pressure was 2500 psig, and the MOV was started close immediately after initiating steam flow with the PORV. MOV upstream pressure at closure was 2500 psig for test 6.8 and 1800 psig for test 6.9. MOV closure test number 6.7 was performed twice. The MOV position indication is wrong on run one. Run one of test 6.7 had a MOV inlet pressure of 2300 psig at closure. Run two of test 6.7 had an inlet closure pressure of 2100 psig.

WYLE LABORATORIES SCIENTIFIC SERVICES & SYSTEMS GROUP

DATA SHEET

Customer CPC Job No. 57375
Date 12-5-89

Specimen MOV

RECEIVING INSPECTION

No. of Specimens Received: 1

Record identification information exactly as it appears on the tag or specimen:

Manufacturer ROCKWELL

P/N's MO-1042A
PRV BLOCK VALVE
W/ LIMITORQUE
ACTUATOR

S/N's 00724766056 2401

How does identification information appear: (name plate, tag, painted, imprinted, etc.) ATTACHED PLASTIC TAG

Examination: Visual, for evidence of damage, poor workmanship, or other defects, and completeness of identification.

Inspection Results: There was no visible evidence of damage to the specimen(s) unless otherwise noted below.

RADIOACTIVE MATERIAL RECEIVING REPORT
ON FORM SA-202

WYLE 234 12-5-89

Inspected By [signature] 12-5-89
Sheet No. ______ of ______
Approved ______ Date: ______

W-614
QA Form Approval [initials]

WYLE LABORATORIES SCIENTIFIC SERVICES & SYSTEMS GROUP

DATA SHEET

Customer CPC Job No. 57375

Date 12-5-89

Specimen PORV VALVE

RECEIVING INSPECTION

No. of Specimens Received: 1

Record identification information exactly as it appears on the tag or specimen:

Manufacturer TARGET ROCK

P/N's PRV-1042B
RELIEF VALVE
MODEL 88RR-001

S/N's

How does identification information appear: (name plate, tag, painted, imprinted, etc.) ATTACHED PLASTIC TAG

Examination: Visual, for evidence of damage, poor workmanship, or other defects, and completeness of identification.

Inspection Results: There was no visible evidence of damage to the specimen(s) unless otherwise noted below.

RADIOACTIVE MATERIAL RECEIVING REPORT ON FORM SA-702

WYLE 234 12-5-89

Inspected By [signature] 12-5-89
Sheet No. ______ of ______
Approved ______ Date: ______

W-614
QA Form Approval [initials]

DATA SHEET

Customer CPC Job No. 57375

Date 12-5-89

Specimen PIPE SPOOL PIECE

RECEIVING INSPECTION

No. of Specimens Received: 1

Record identification information exactly as it appears on the tag or specimen:

Manufacturer UNKNOWN

P/N's P-Ø47 S/N's

EW56

ØØØ4

<4' W/ FLANGE 1500 LB.
@ ONE END & PC506, PC507
VENT VALVES & PC508 & PC509 DRAIN VALVES

How does identification information appear: (name plate, tag, painted, imprinted, etc.)

Examination: Visual, for evidence of damage, poor workmanship, or other defects, and completeness of identification.

Inspection Results: There was no visible evidence of damage to the specimen(s) unless otherwise noted below.

NONE 12-5-89

RADIOACTIVE MATERIAL RECEIVING REPORT
ON FORM SA-202

WYLE 234

Inspected By [signature] 12-5-89

Sheet No. of

Approved Date:

W-614

QA Form Approval [initials]

WYLE LABORATORIES
S.S.& S. GROUP

TEST TITLE: OPERABILITY

Customer: CONSUMERS POWER COMPANY Job No.: FS57375 Date: 12-1-89

Specimen: SEE RECEIVING INSPECTION Technician:

Part No.: SEE RECEIVING INSPECTION Serial No.: SEE RECV. INSP. Engineer:

EQUIPMENT	MANUFACTURER	MODEL NO.	RANGE	WYLE NO.	CALIBRATION LAST	CALIBRATION DUE	ACCY.
DIGITAL VOLTMETER	VALIDYNE	PM212	0 TO ± 10 VDC	10251	02-08-89	02-11-90	± 1.0%
DIGITAL MULTIMETER	FLUKE	8600A	± 200 VDC	8687	03-27-89	04-01-90	± .025%
STRIPCHART RECORDER	SOLTEC	TA200-938	9 CHANNELS	11315	SYSTEM	CALIB.	N/A
CARRIER DEMODULATOR	VALIDYNE	CD-19	0 TO ± 10 VDC	8879	12-03-89	02-03-90	± 1.0%
CARRIER DEMODULATOR	VALIDYNE	CD-19	0 TO ± 10 VDC	7425	12-03-89	02-03-90	± 1.0%
CARRIER DEMODULATOR	VALIDYNE	CD-19	0 TO ± 10 VDC	7417	12-03-89	02-03-90	± 1.0%
CARRIER DEMODULATOR	VALIDYNE	CD-19	0 TO ± 10 VDC	45616	12-03-89	02-03-90	± 1.0%
PRESSURE TRANSDUCER	VALIDYNE	DP-22	0 TO 3000 PSI	S/N 19964	12-03-89	02-03-90	± 0.25%
PRESSURE TRANSDUCER	VALIDYNE	DP-22	0 TO 3000 PSI	45631	12-03-89	02-03-90	± 0.25%
PRESSURE TRANSDUCER	VALIDYNE	DP-22	0 TO 3000 PSI	45637	12-03-89	02-03-90	± 0.25%

QA FORM APPROVAL J.G.
W614D-82

Where applicable, the listed test equipment has been calibrated using standards which are traceable to the National Bureau of Standards. Certificates and reports are retained in Wyle QA files for inspection.

WYLE LABORATORIES
S.S.& S. GROUP

TEST TITLE: OPERABILITY

Customer: CONSUMERS POWER COMPANY Job No.: FS57375 Date: 12-1-89

Specimen: SEE RECEIVING INSPECTION Technician:

Part No.: SEE RECEIVING INSPECTION Serial No.: SEE RECV. INSP. Engineer:

EQUIPMENT	MANUFACTURER	MODEL NO.	RANGE	WYLE NO.	CALIBRATION LAST	CALIBRATION DUE	ACCY.
PRESSURE TRANSDUCER	VALIDYNE	DP-22	0 TO 300 PSI	47245	12-03-89	02-03-90	± 0.25%
THERMOCOUPLE AMP.	VALIDYNE	TC-243	TYPE "K" 0 TO 1000 F	45822	12-03-89	02-03-90	± 1.0F
THERMOCOUPLE AMP.	VALIDYNE	TC-243	TYPE "K" 0 TO 1000 F	45649	12-03-89	02-03-90	± 1.0F
PRESSURE GAUGE	HEISE	12 IN.	0 TO 3000 PSI	9809	09-18-89	03-18-90	± 0.1%
DEADWEIGHT TESTER	AMETEK	10-10525	0 TO 10,000PSI	45679	12-09-88	12-10-89	± 0.1%
							WYLE 234

Page No.

Report No. 5/3/5

QA FORM APPROVAL J.G.
W614D-82

Where applicable, the listed test equipment has been calibrated using standards which are traceable to the National Bureau of Standards. Certificates and reports are retained in Wyle QA files for inspection.

WYLE LABORATORIES
S.S.& S. GROUP

TEST TITLE: OPERABILITY

Customer: CONSUMERS POWER COMPANY Job No.: FS57375 Date: 12-1-89

Specimen: SEE RECEIVING INSPECTION Technician:

Part No.: SEE RECEIVING INSPECTION Serial No.: SEE RECV. INSP. Engineer:

EQUIPMENT	MANUFACTURER	MODEL NO.	RANGE	WYLE NO.	CALIBRATION LAST	CALIBRATION DUE	ACCY.
MODULE CASE	VALIDYNE	MC1-20	20 CHANNELS	9507	SYSTEM	CALIB.	N/A
A/D CONVERTER	METRABYTE	DAS-16F	± 10 V.D.C.	11258	SYSTEM	CALIB.	N/A
COMPUTER	DTK	TECH 1250	DIGITAL	11253	SYSTEM	CALIB.	N/A
MONITOR	TEKNIKA	MJ530	DIGITAL	11252	SYSTEM	CALIB.	N/A
VOLTAGE STANDARD	ANALOGIC	AN-3100	0 TO ± 11.111 DC	7977	09-14-89	03-18-90	± .005%
THERMOCOUPLE CALIB.	ECTRON	1100	TYPE "K" 0 TO 2000 F	10380	10-04-89	04-08-90	± 1.0F
DIGITAL MULTIMETER	FLUKE	77	0 TO ± 32 VDC	10012	01-15-89	01-21-90	± 0.3%
DIGITAL MULTIMETER	FLUKE	77	0 TO ± 32 VDC	10928	12-01-89	12-02-~~89~~ 90 JG	± 0.3%
DIGITAL THERMOMETER	NEWPORT	269-KF	-337 TO +2502F	45906	10-04-89	02-04-90	± 3.0F
DIGITAL VOLTMETER	DORIC	410A	0 TO 10 VDC	45678	07-13-89	07-15-90	± 0.25%

QA FORM APPROVAL J.G.
W614D-82

Where applicable, the listed test equipment has been calibrated using standards which are traceable to the National Bureau of Standards. Certificates and reports are retained in Wyle QA files for inspection.

WYLE 234

WYLE LABORATORIES SCIENTIFIC SERVICES & SYSTEMS GROUP

TEST TITLE TEST PROCEDURE #4648

CUSTOMER CONSUMERS POWER CO Job No. 57375 Date 12-06-89

Specimen 4" MOV + PORV Technician T. A. CULBERTSON

Part No. — Serial No. — Engineer [illegible]

EQUIPMENT	MANUFACTURER	MODEL NO.	RANGE	WYLE NO.	CALIBRATION LAST	CALIBRATION DUE	ACCY.
PRESSURE TRANSDUCER	VALIDYNE	DP-22	0 TO 3000	19664	12-3-89	2-3-89	
			0 TO 3000	45631			
			0 TO 3000	45637			
			0 TO 300	47245			
PRESSURE XMTR	ROSEMOUNT		0 TO 15.7 PSID				
THERMOCOUPLE AMP	VALIDYNE	TC-243	0 TO 700°F	45822			
				45649			
				45647			
GAUGE	HEISE	CMG139D	0 TO 3000 PSIG	9809	9-18-89	3-18-90	± 0.1%
I TO V CONVERT	ACTION	4300 ~~4500~~	4 TO 20 MA IN 0 TO 10 VDC OUT				
DEAD WEIGHT TESTER	AMETEK	10-10525	0 TO 10,000 PSI	45679	12-9-88	12-10-89	± 0.1% FS

QA Form Approval [illegible]
W614D-82

Where applicable, the listed test equipment has been calibrated using standards which are traceable to the National Bureau of Standards. Certificates and reports of all calibrations are retained in the Wyle Laboratories QA files and are available for inspection upon request.

WYLE LABORATORIES SCIENTIFIC SERVICES & SYSTEMS GROUP

TEST TITLE MOV/PORV OPERABILITY

CUSTOMER Consumers Power Company Job No. 57375 Date 12-06-89

Specimen 4" MOV & PORV Technician T.A. CULBERTSON

Part No. — Serial No. — Engineer

EQUIPMENT	MANUFACTURER	MODEL NO.	RANGE	WYLE NO.	CALIBRATION LAST	CALIBRATION DUE	ACCY.
BUCKET	VALIDYNE	MC1	0 - 20 CHANNEL	9507	SYSTEM	CAL	N/A
A/D CONVERTER	METRABYTE	DAS-16F	± 10 VDC	11258	SYSTEM	CAL	N/A
COMPUTER	DTK	TECH/250	DIGITAL	11253	—		
MONITOR	TEKNIKA	MJ530	DIGITAL	11252	—		
VOLTAGE STANDARD	ANALOGIC	AN3100	± 10 VDC	7927	9-14-89	3-18-90	±.005%
DVM	FLUKE	77	LABEL	10012	1-15-89	1-21-90	DATA
DVM	FLUKE	77	LABEL	10928	12-1-89	12-2-90	DATA
T.C SIMULATOR	ECTRON	1100	LABEL	10380	10-4-89	4-8-90	LABLE
DTM	NEWPORT	265-KF		45906	10-4-89	2-4-90	±3°F
DVM	DORIC	410A	± 10 VDC	45678	7-13-89	7-15-90	±.25%
DVM	VALIDYNE	DM212	± 10 VDC	10251	2-8-89	2-11-90	±1%
~~CARRIER DEMOD~~ DVM	FLUKE	8600A	± 10 VDC	8687	3-27-89	4-1-90	±.005%
STRIP CHART	SOLTEC	TA200-938-F	0 TO 8 CHANNELS	11315	SYSTEM	CAL	N/A
CARRIER DEMOD	VALIDYNE	CD-19	0 TO 10 VDC	8879	12-3-89	2-3-90	
" "	—	—	—	7425	12-3-89		
" "	—	—	—	7417	12 "		
" "	—	—	—	45616			

QA Form Approval

W614D-82

Where applicable, the listed test equipment has been calibrated using standards which are traceable to the National Bureau of Standards. Certificates and reports of all calibrations are retained in the Wyle Laboratories QA files and are available for inspection upon request.

Report No. 57375
Page No. 11

WYLE LABORATORIES — SCIENTIFIC SERVICES & SYSTEMS GROUP

Flowrate Calculation

From Test Data

Static Pressure (P1) — P1 = PSIA

Dynamic Pressure (P2) $= \left(\frac{v^2}{2g}\right)\left(\frac{\rho}{144}\right)$ — P2 = PSID; v = ft/sec; $\rho = lbm/ft^3$

Area = .0716 ft^2
(4" sch 120 SS pipe)

$$Velocity = \left[\frac{(P2)(2)(32.174)(144)}{\rho}\right]^{1/2}$$

v = ft/sec; $\rho = lbm/ft^3$

Density is at P1 Pressure

Mass Flowrate $= \rho A v$ — $\dot{m}$ = lbm/sec

$$\dot{m} = (\rho)(.0716)\left[\frac{(P2)(2)(32.174)(144)}{\rho}\right]^{1/2}$$

$$\boxed{\dot{m} = 6.892\sqrt{(\rho)(P2)}}$$

Example: Conditions 2 secs after initiating steam flow during test № 6.9 are:

Static Pressure (P1) = 2080 PSIA
$\rho = 5.6\ lbm/ft^3$
Dynamic Pressure (P2) = 120 PSID

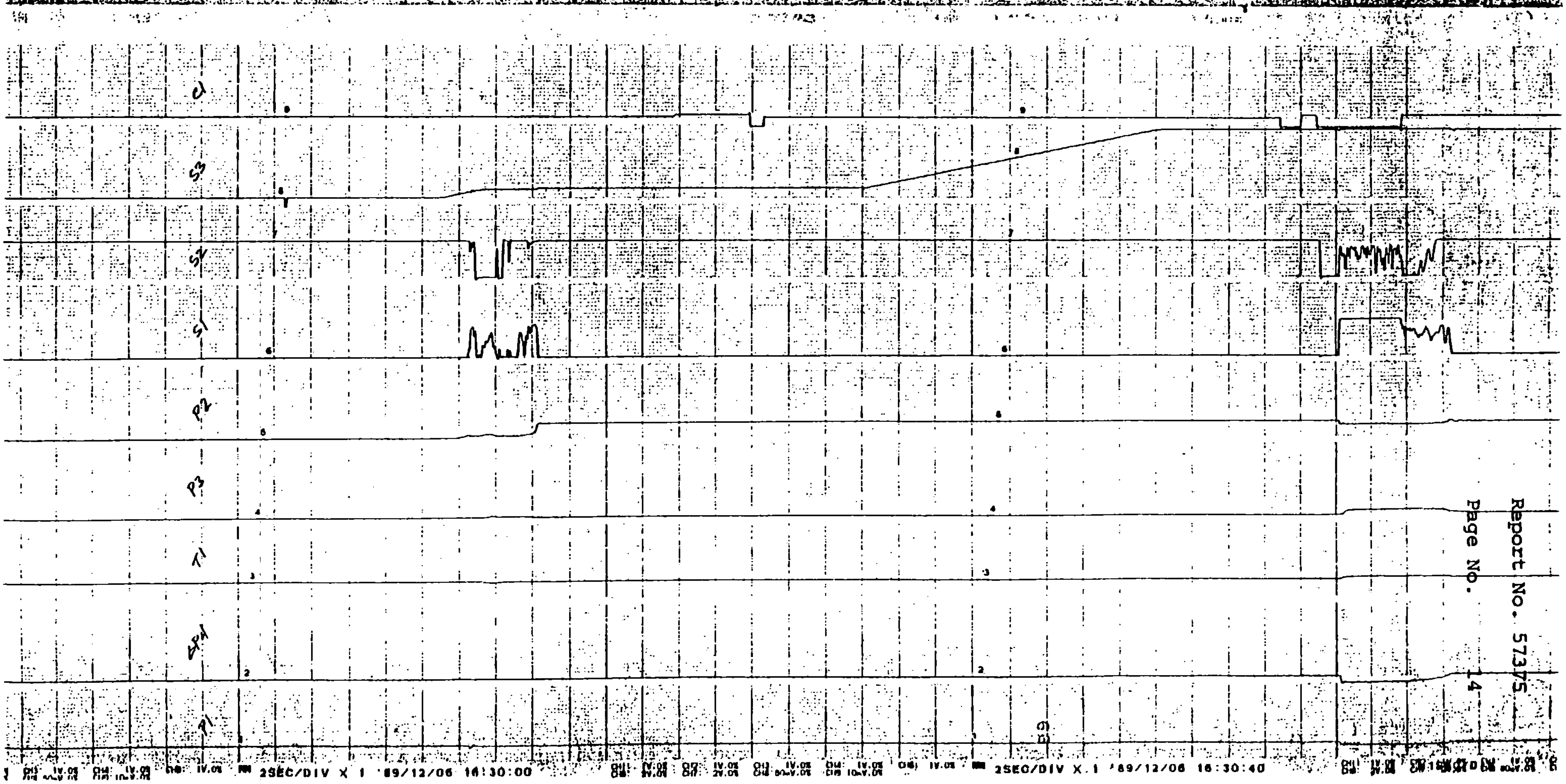
$$\dot{m} = 6.892\sqrt{(5.6)(120)} = 179\ lbm/sec$$

TABLE II - TEST PROGRAM

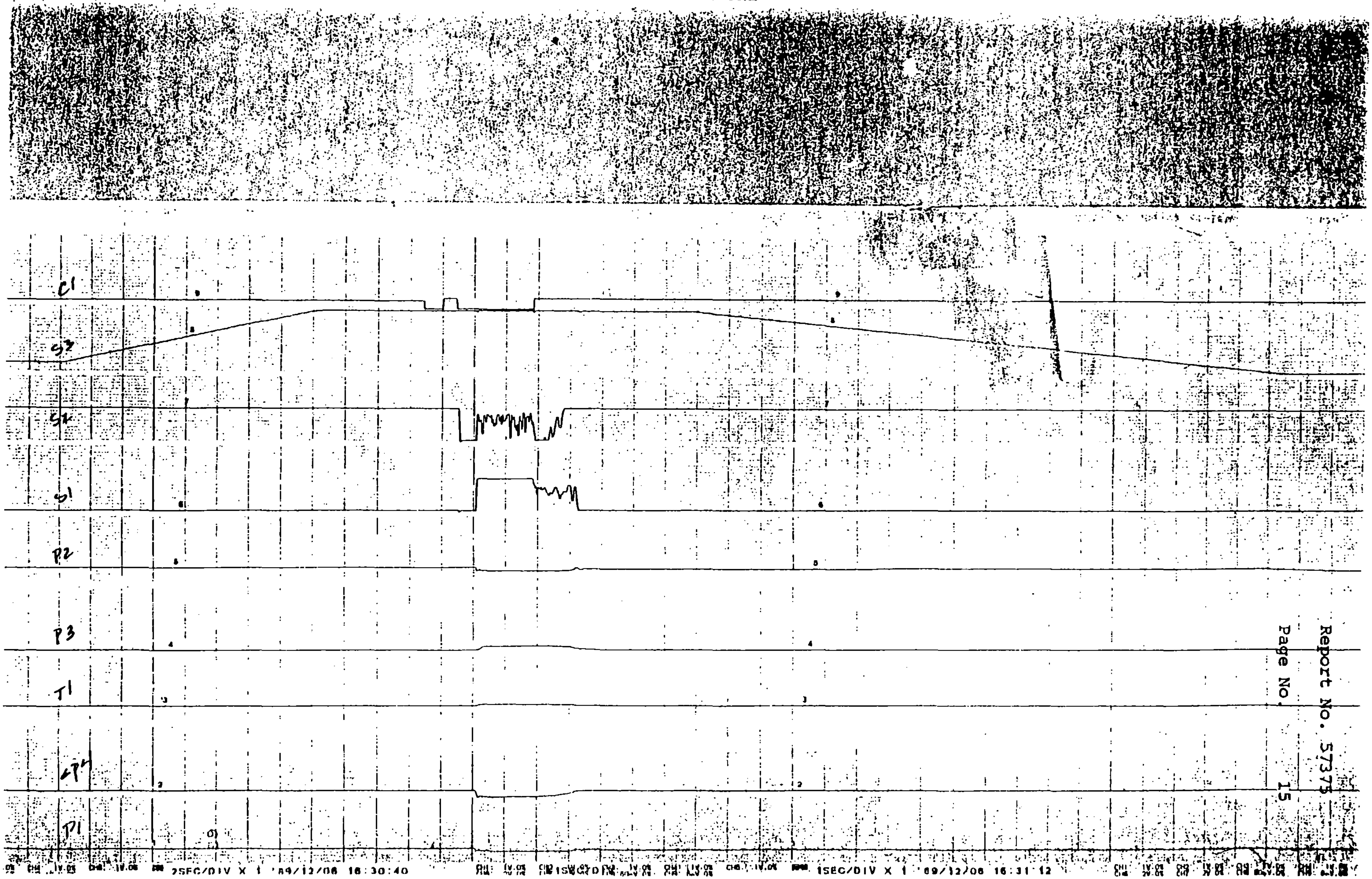
Designition	Stripchart channel number	Measurement	Range
P1	1	MOV. UPSTREAM STATIC PRESSURE	0 TO 3000 P.S.I.G.
P4	2	MOV. UPSTREAM DYNAMIC PRESSURE	0 TO 300 P.S.I.D.
T1	3	MOV. UPSTREAM TEMP.	0 TO 1000 DEG. F
P3	4	PORV. DOWNSTREAM STATIC PRESSURE	0 TO 3000 P.S.I.G.
P2	5	PORV. UPSTREAM PRESSURE	0 TO 3000 P.S.I.G.
S1	6	PORV. OPEN LIMIT SWITCH (V.D.C.)	ON/OFF
S2	7	PORV. CLOSE LIMIT SWITCH (V.D.C.)	ON/OFF
S3	8	MOV. POSITION INDICATOR	% OF FULL OPEN
C1	9	MOV./PORV. CURRENT INDICATOR	0 TO 25 AMPS. V.A.C. 0 TO 5 AMPS. V.D.C. (UNCALIBRATED)

TEST 6.3 RUN ONE

MOV JOGGED TO 10% OPEN, RESULTING IN
PORV LIFT AND RESEAT IN 4 SECONDS



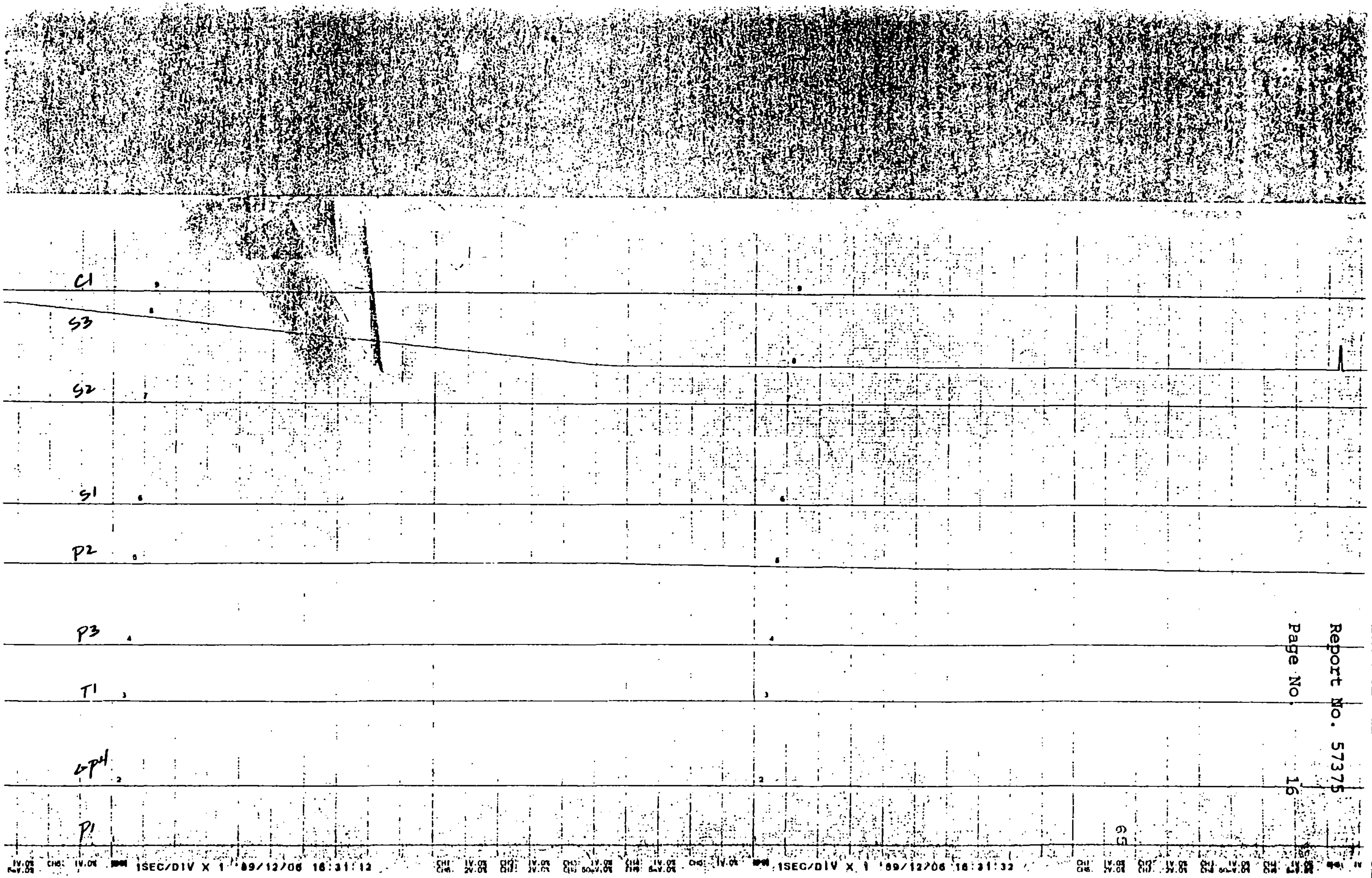
TEST 6.3 RUN ONE



Report No. 57373

Page No. 15

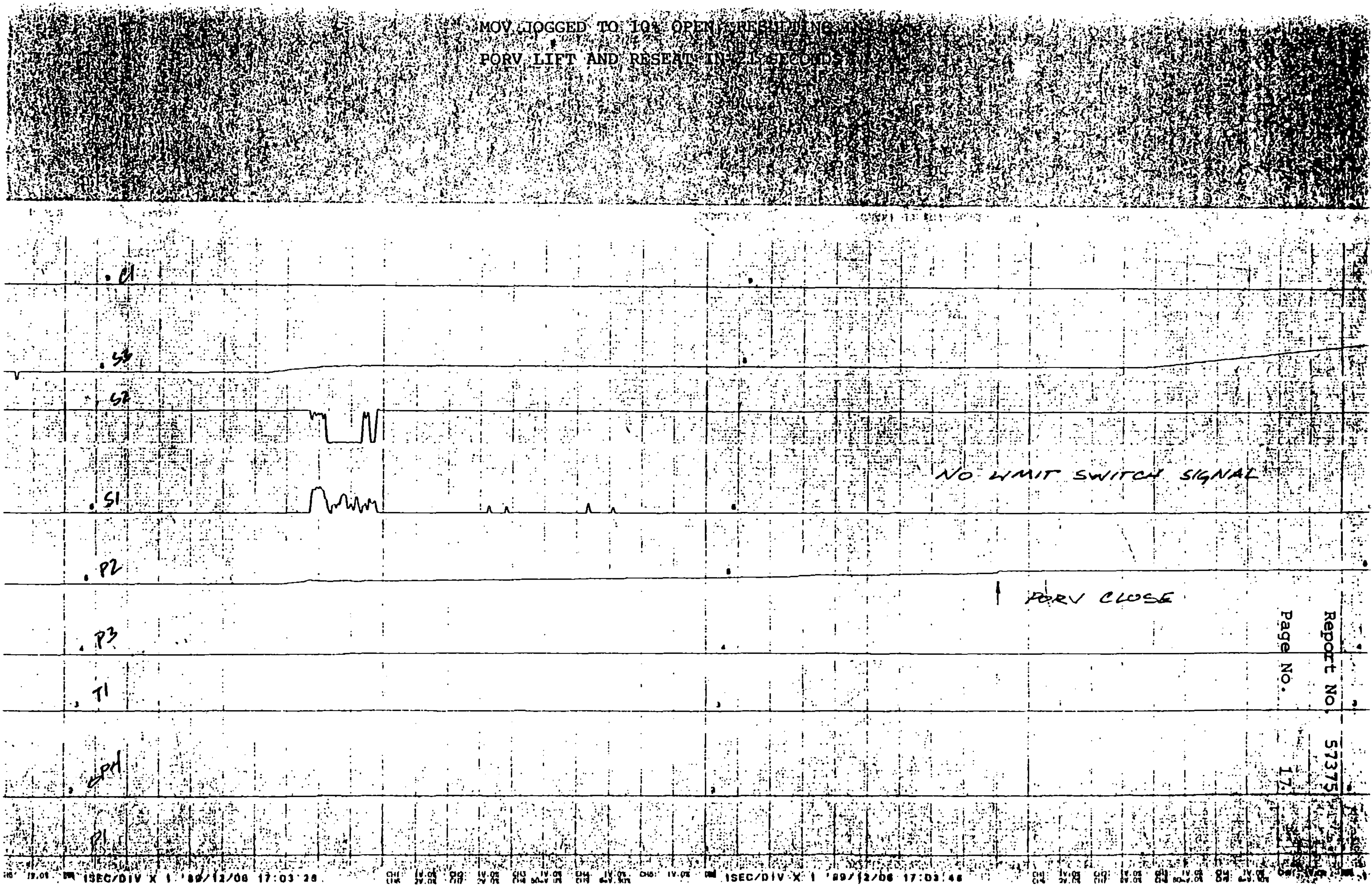
TEST 6.3 RUN ONE



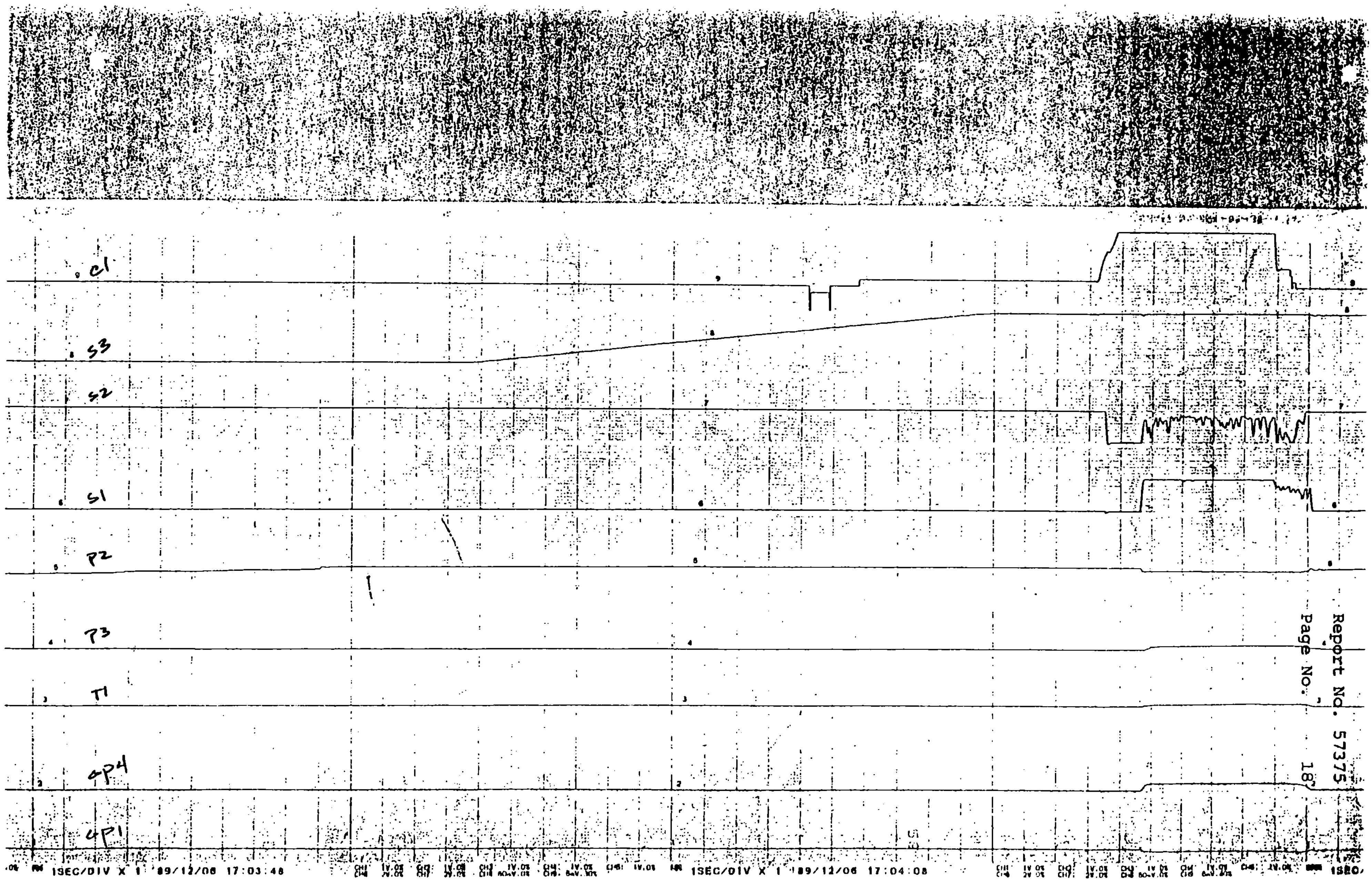
Report No. 57375

Page No. 16

TEST 6.3 RUN TWO



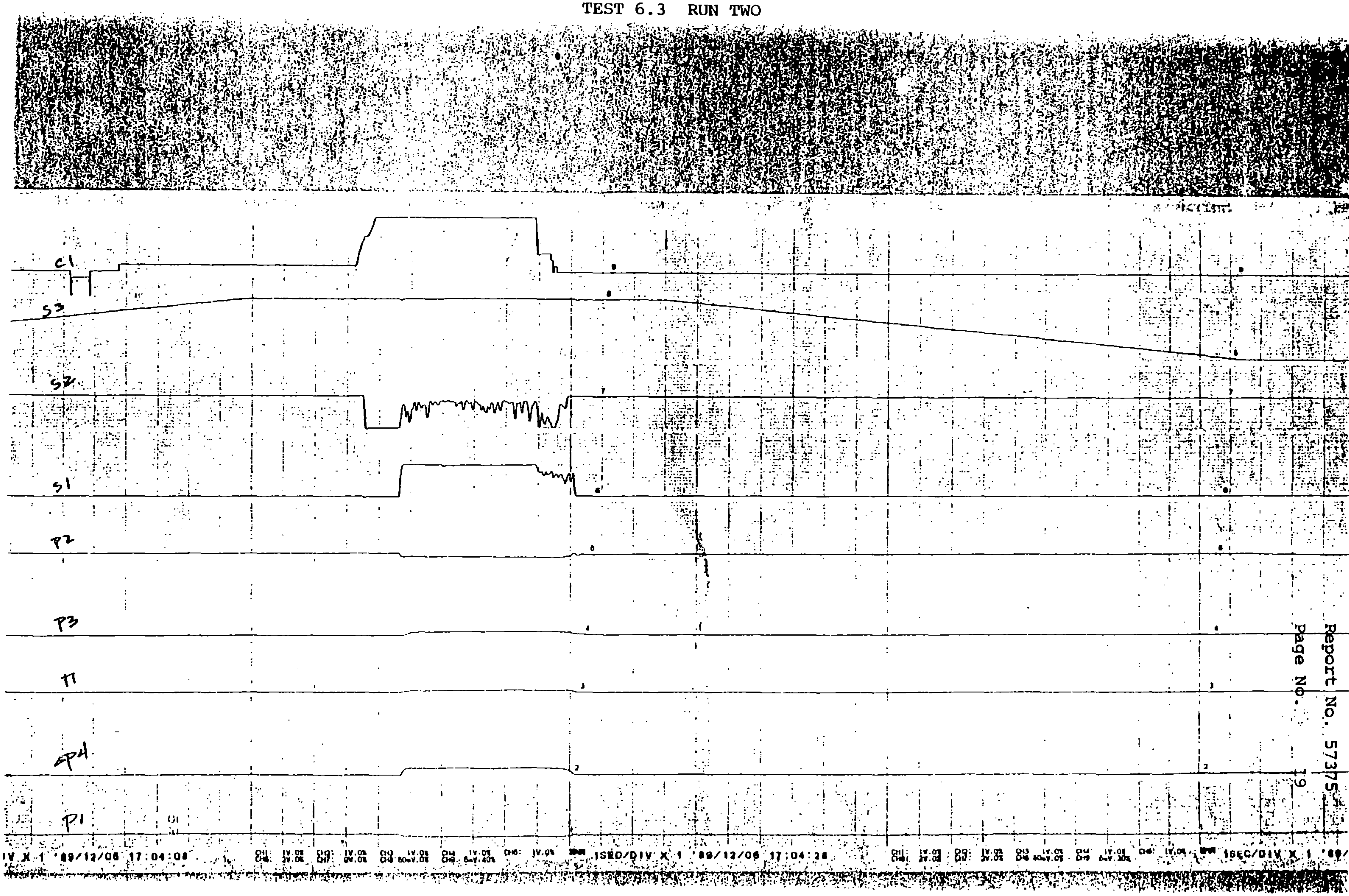
TEST 6.3 RUN TWO



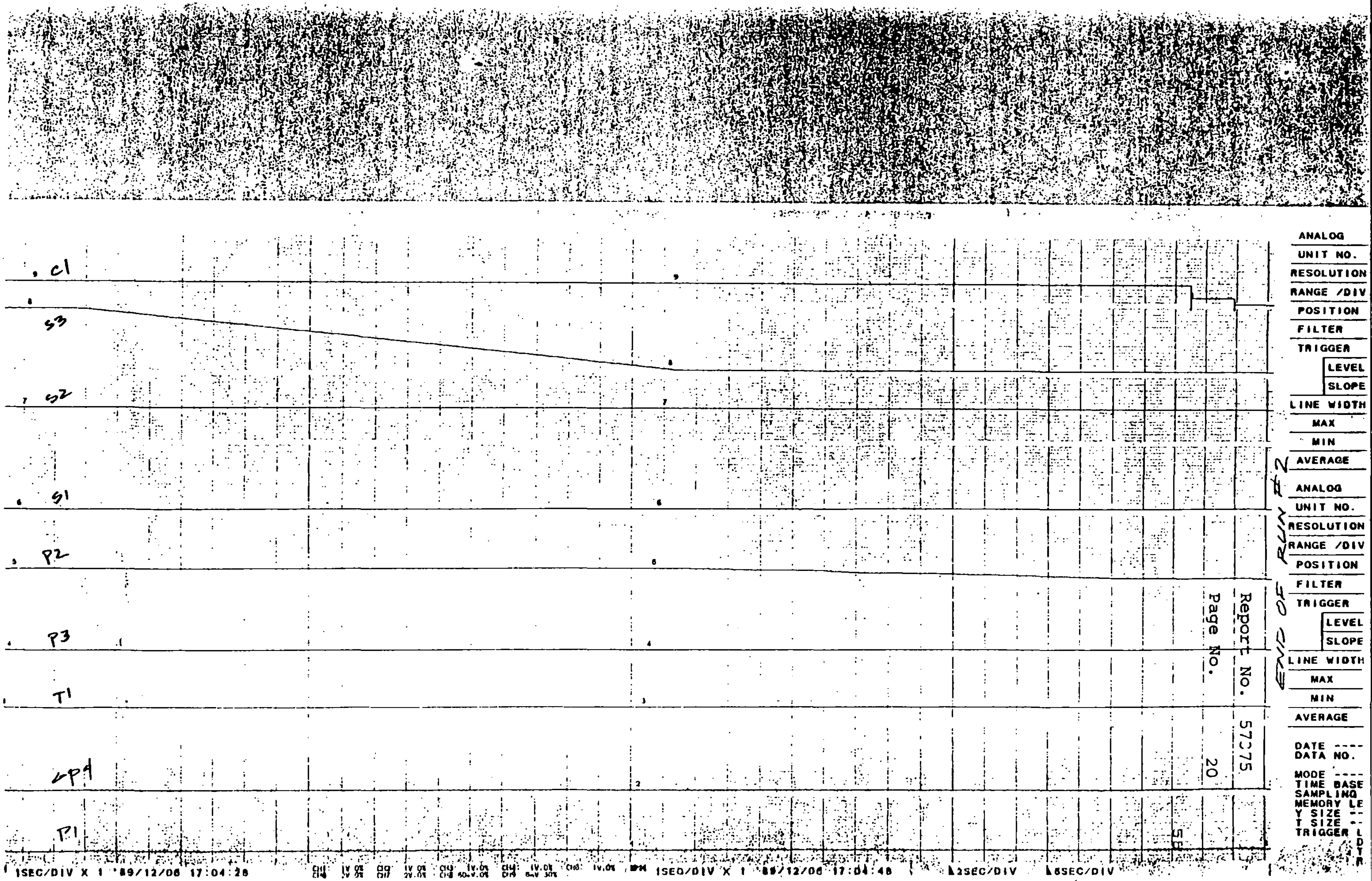
Report No. 57375

Page No. 18

TEST 6.3 RUN TWO

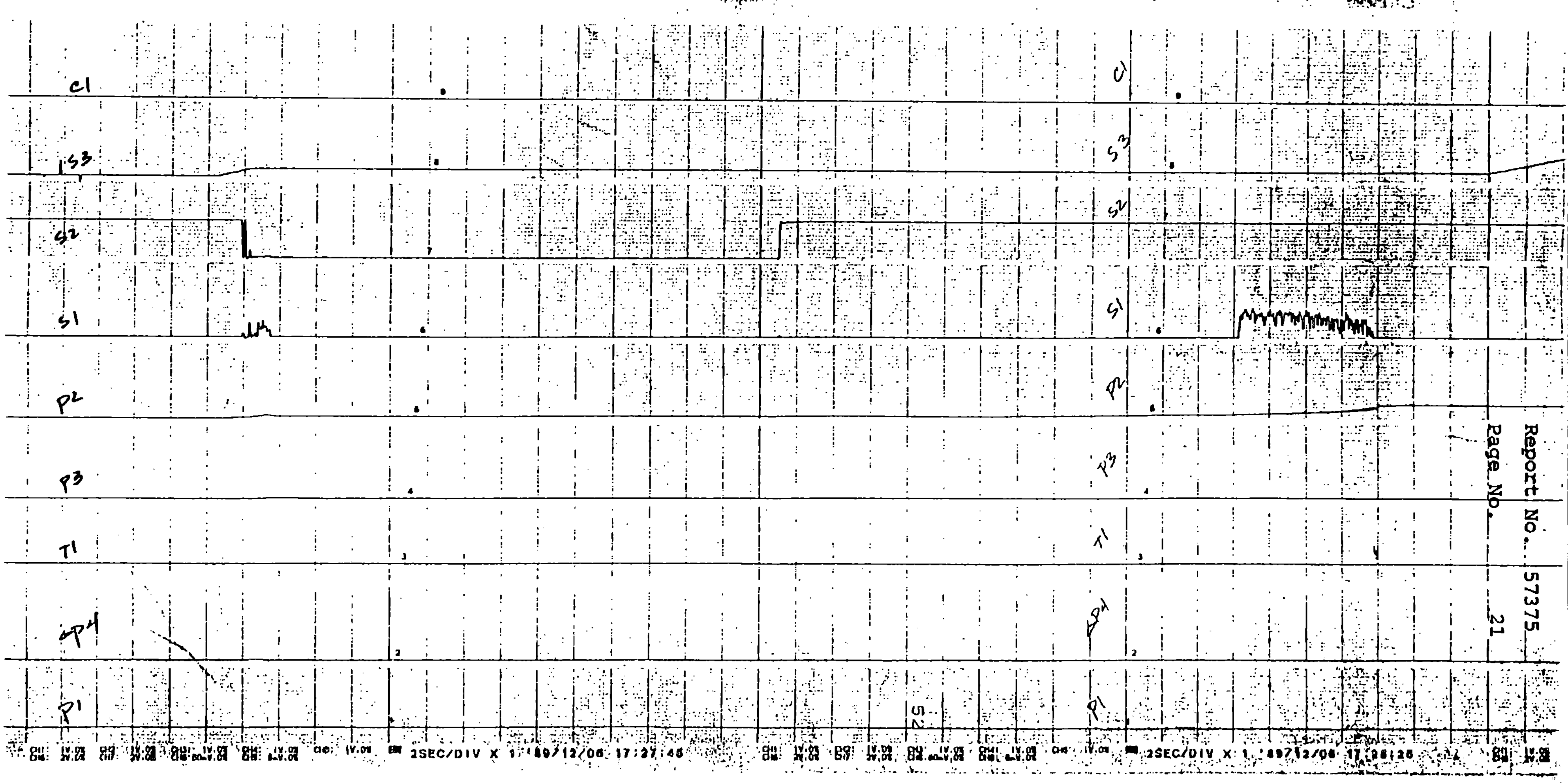


TEST 6.3 RUN TWO



TEST 6.3 RUN THREE

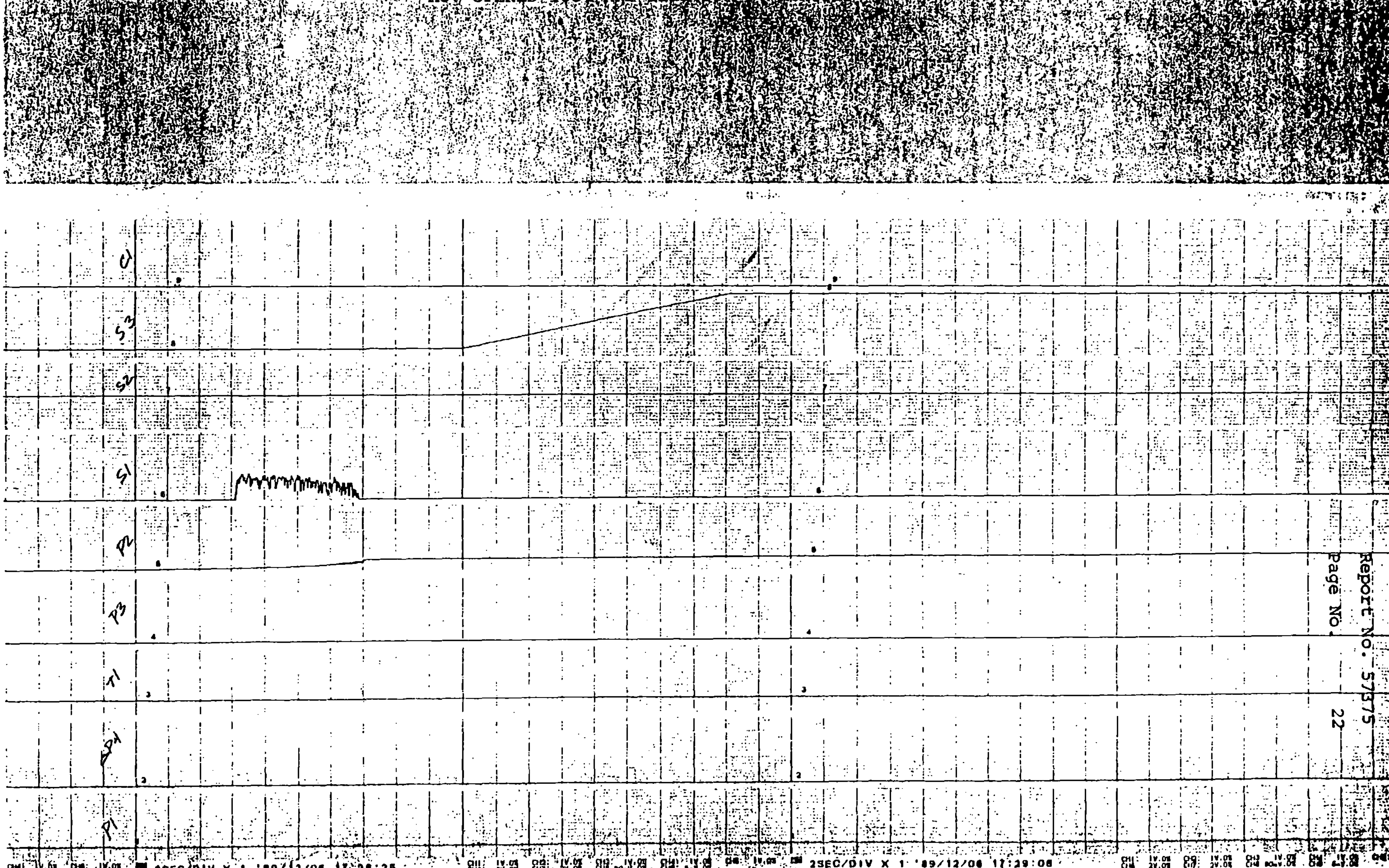
MOV JOGGED TO 10% OPEN, RESULTING IN PORV LIFT AND RESEAT IN 62 SECONDS



Report No. 57375

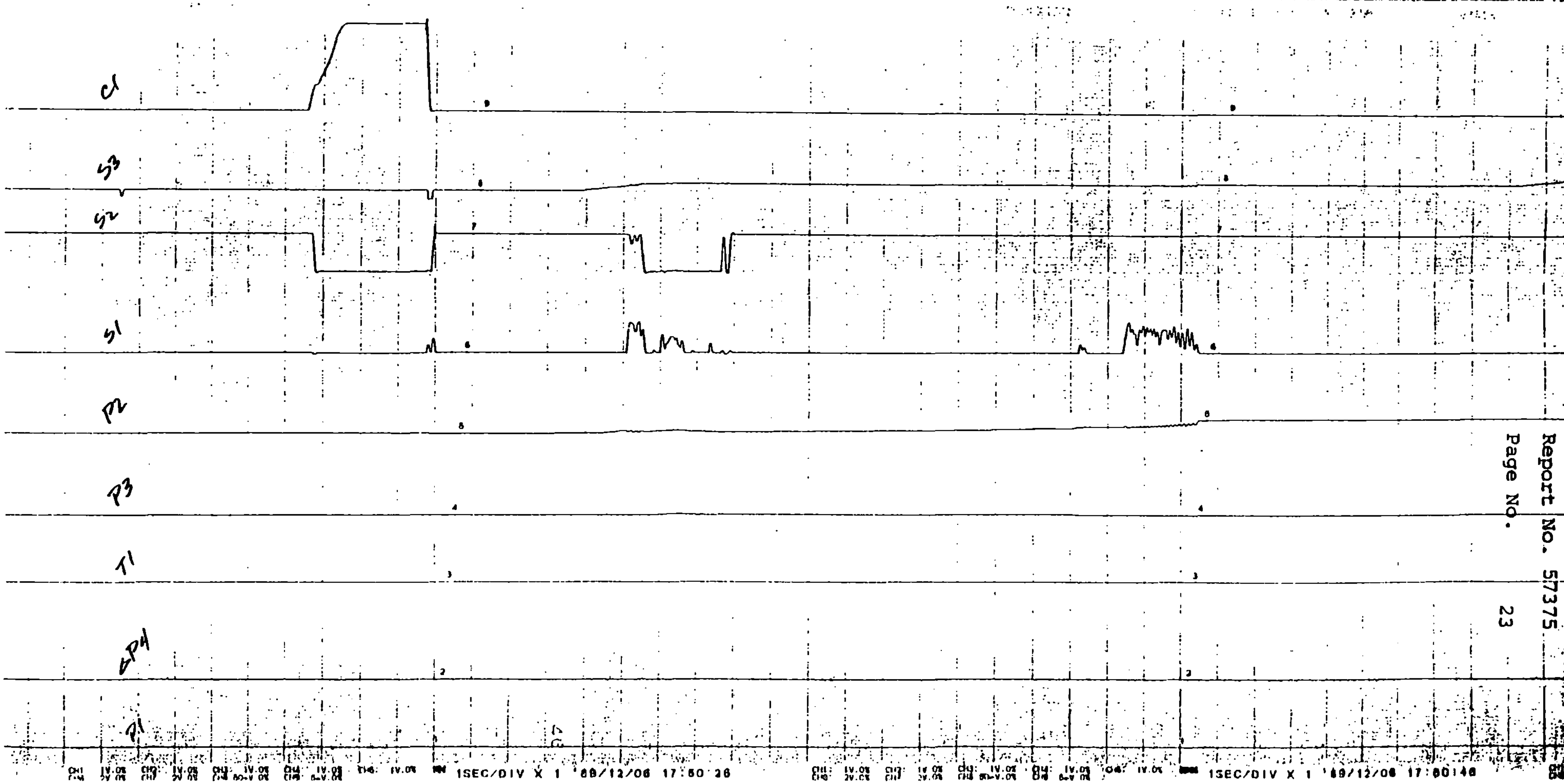
TEST 6.3 RUN THREE

MOV OPENED 100% AND HELD FOR 10 MINUTES

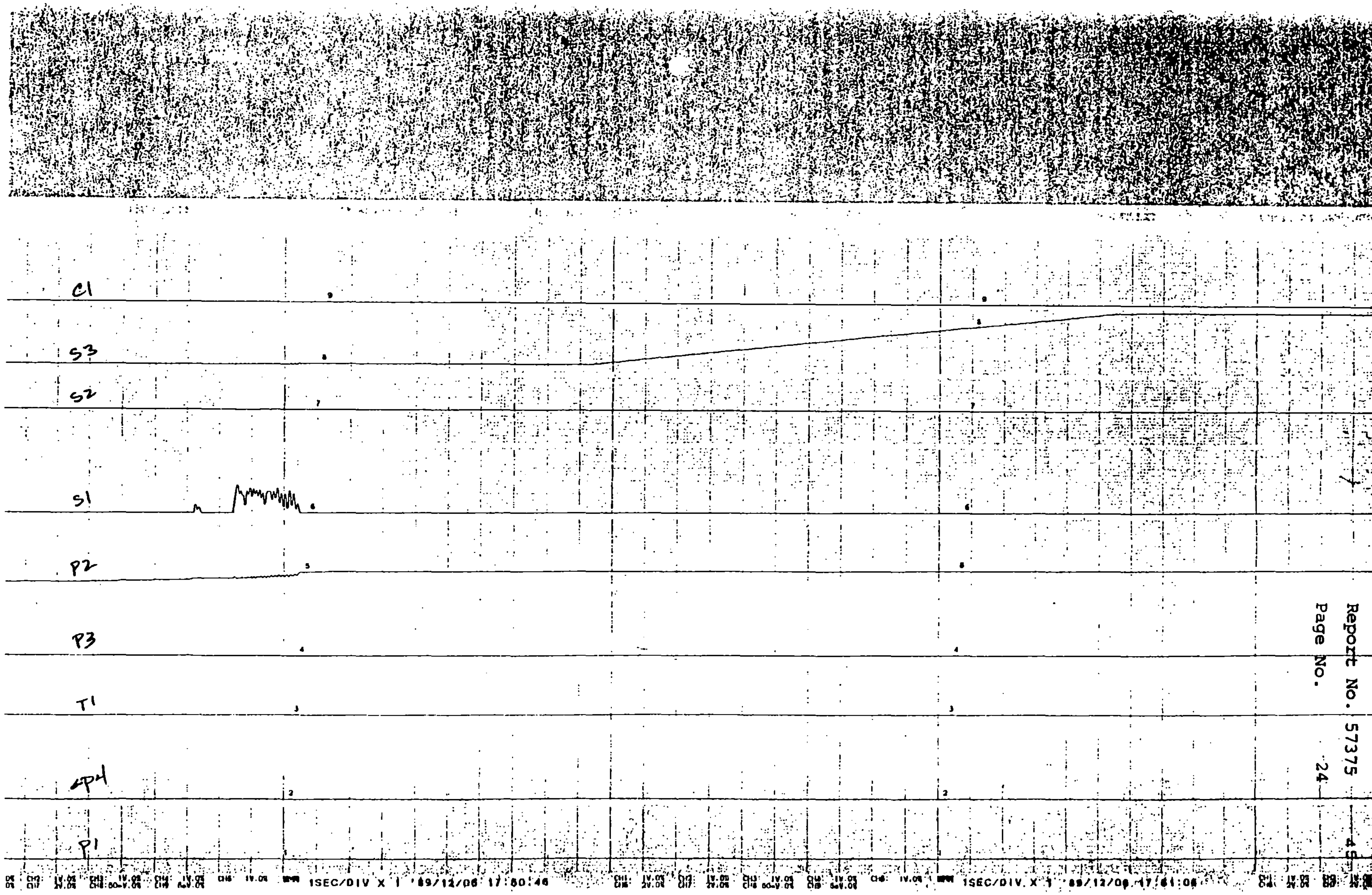


TEST 6.3 RUN THREE

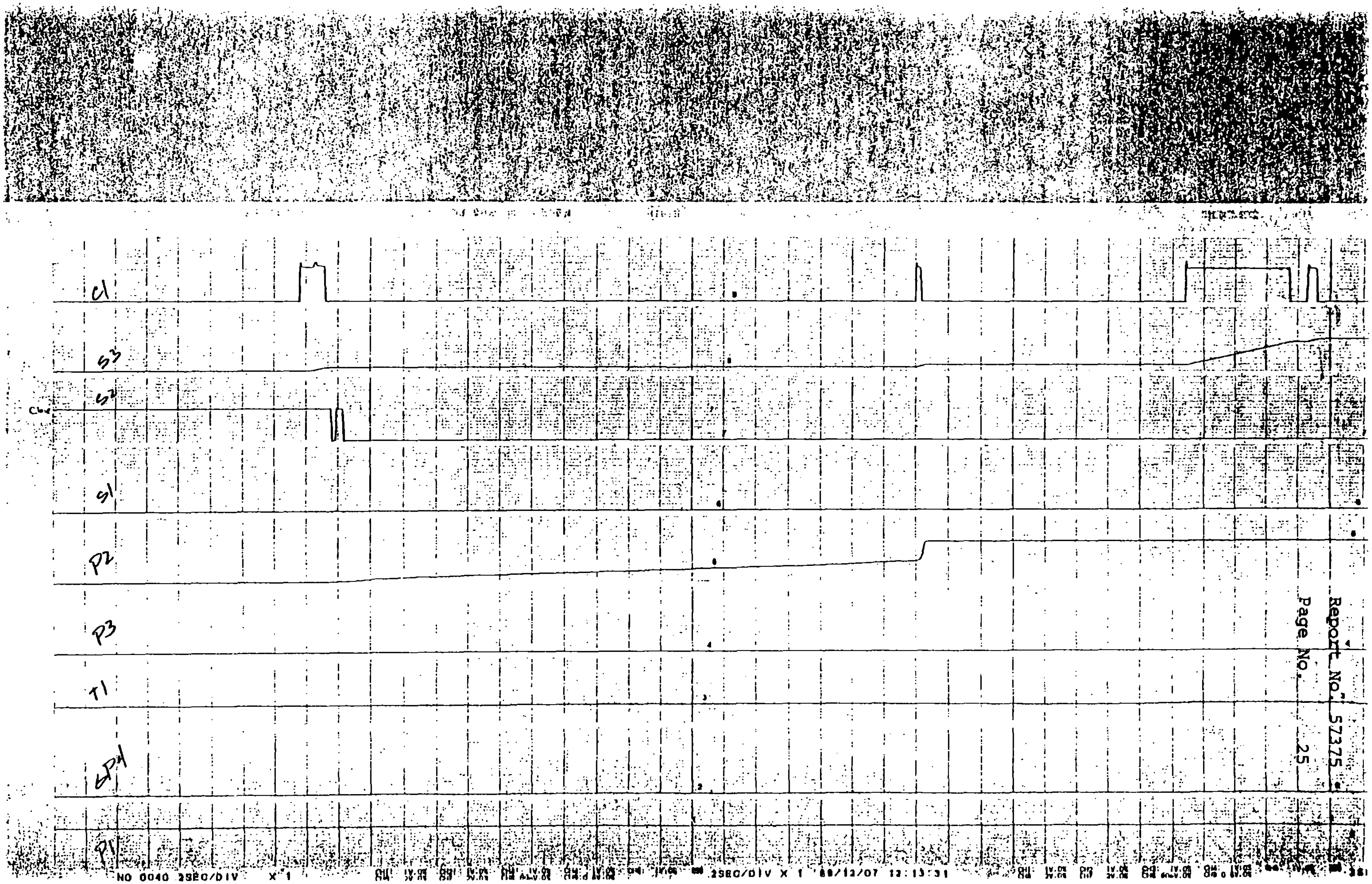
MOV CLOSED FOR 10 MINUTES, THEN JOGGED
TO 10% OPEN, RESULTING IN PORV LIFT AND
RESEAT IN 15.5 SECONDS



TEST 6.3 RUN THREE



TEST 6.4 MOV JOG TEST



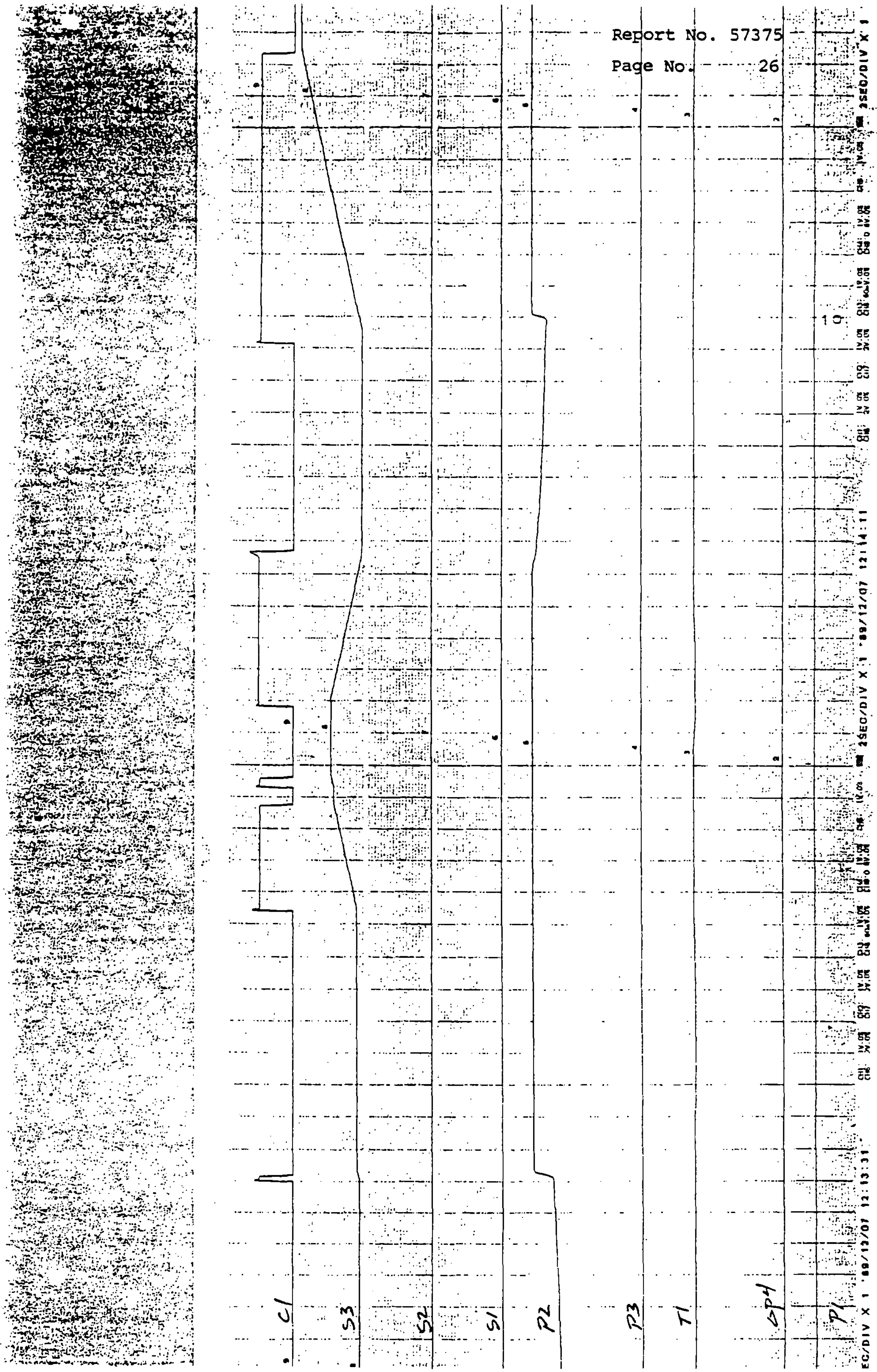
Report No. 57375

Page No. 25

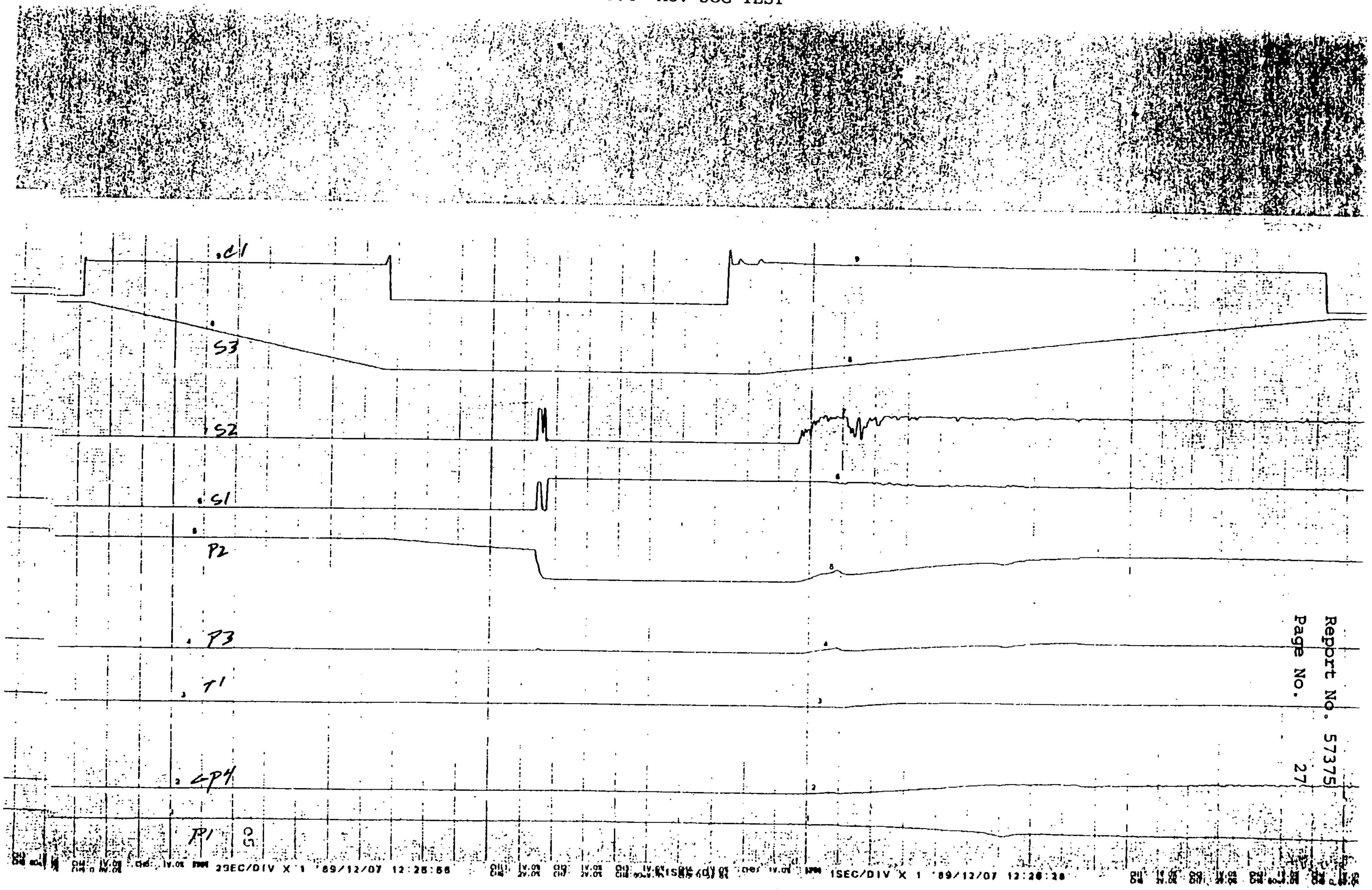
Report No. 57375

Page No. 26

TEST 6.4 MOV JOG TEST

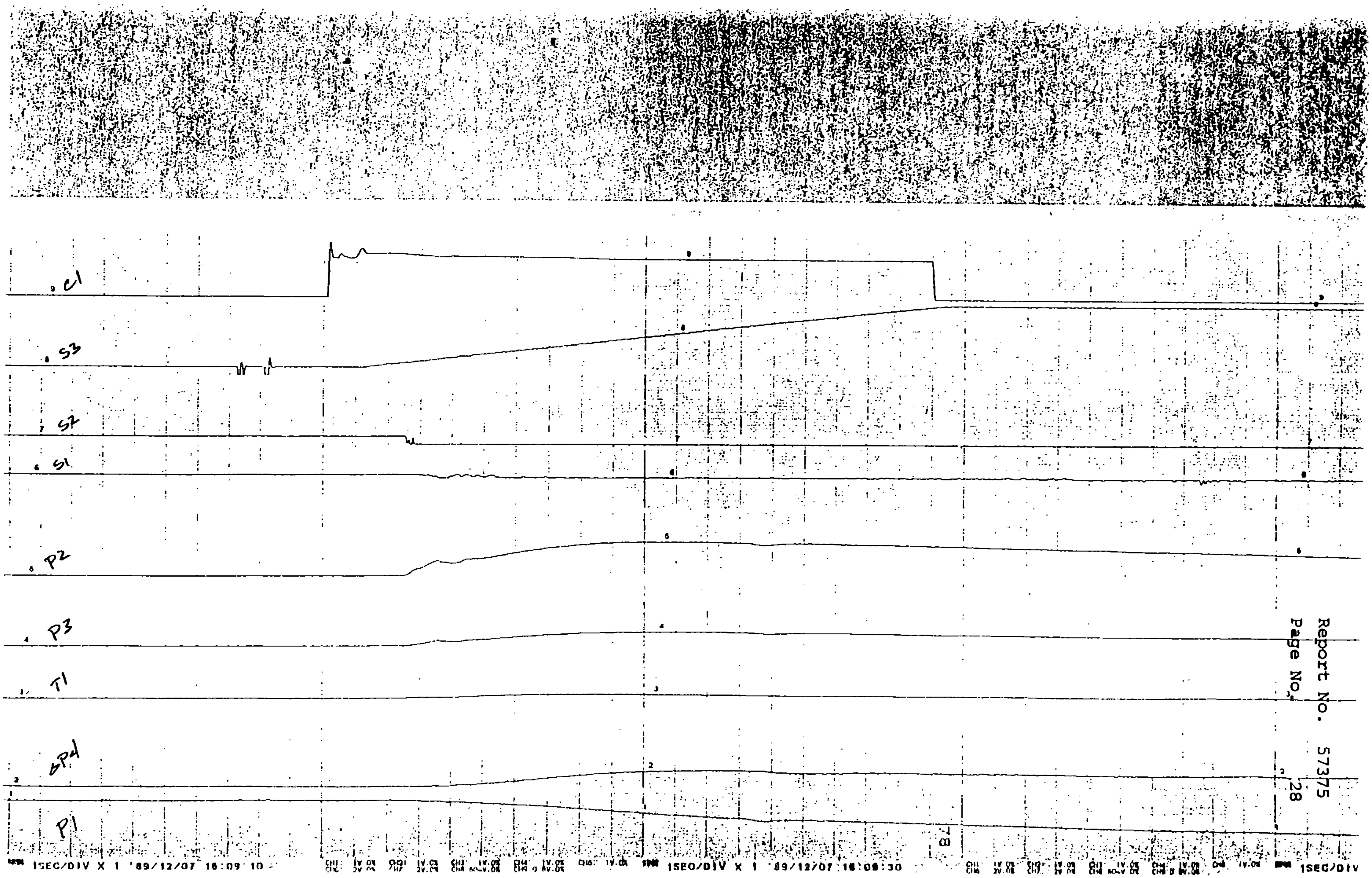


TEST 6.4 MOV JOG TEST



TEST 6.5 MOV LEAKAGE

TEST 6.6 HIGH PRESSURE

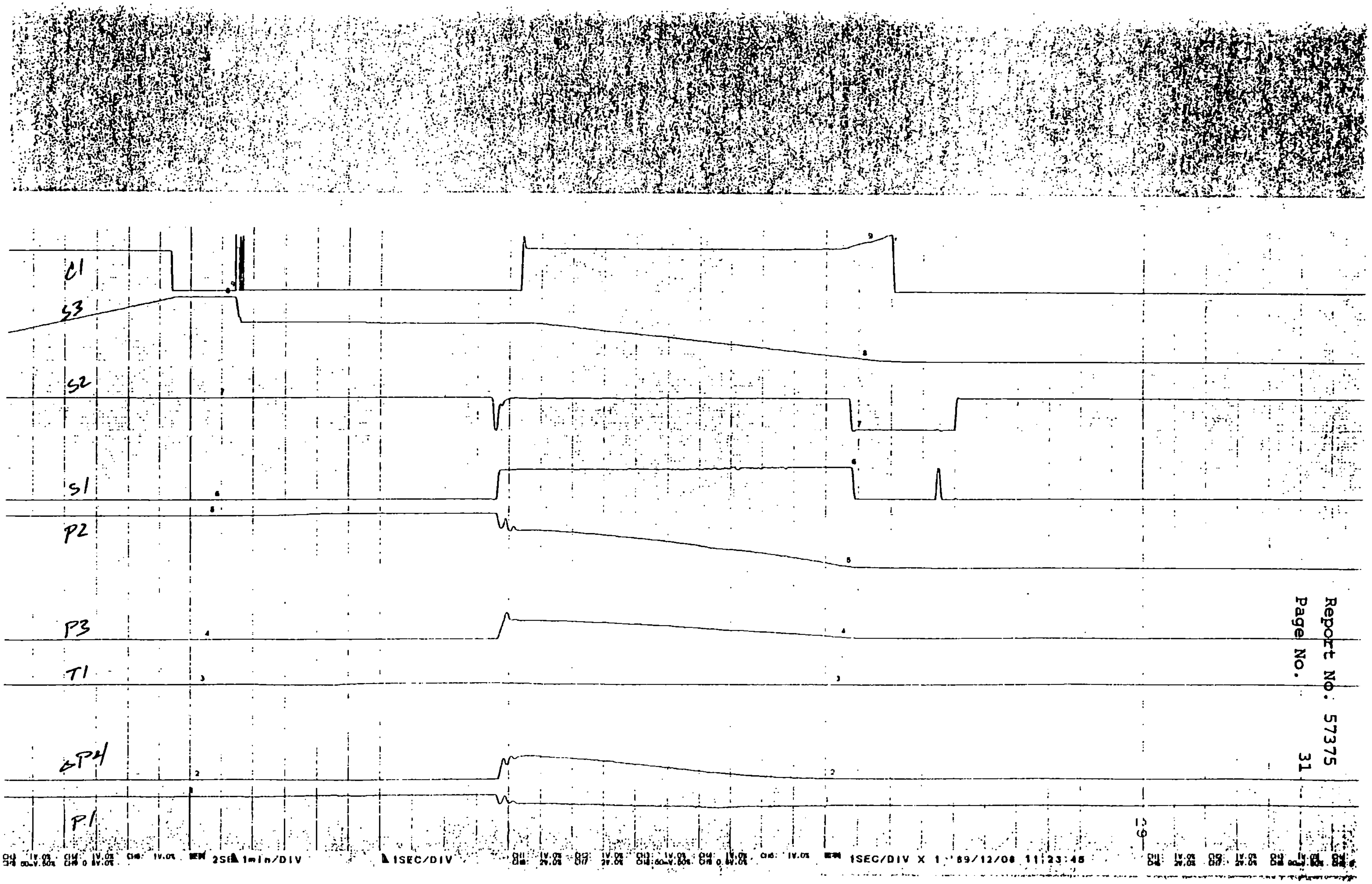


Report No. 57375
Page No. 28

TEST 6.6 HIGH PRESSURE

TEST 6.7 MOV CLOSURE RUN ONE

TEST 6.7 MOV CLOSURE RUN TWO

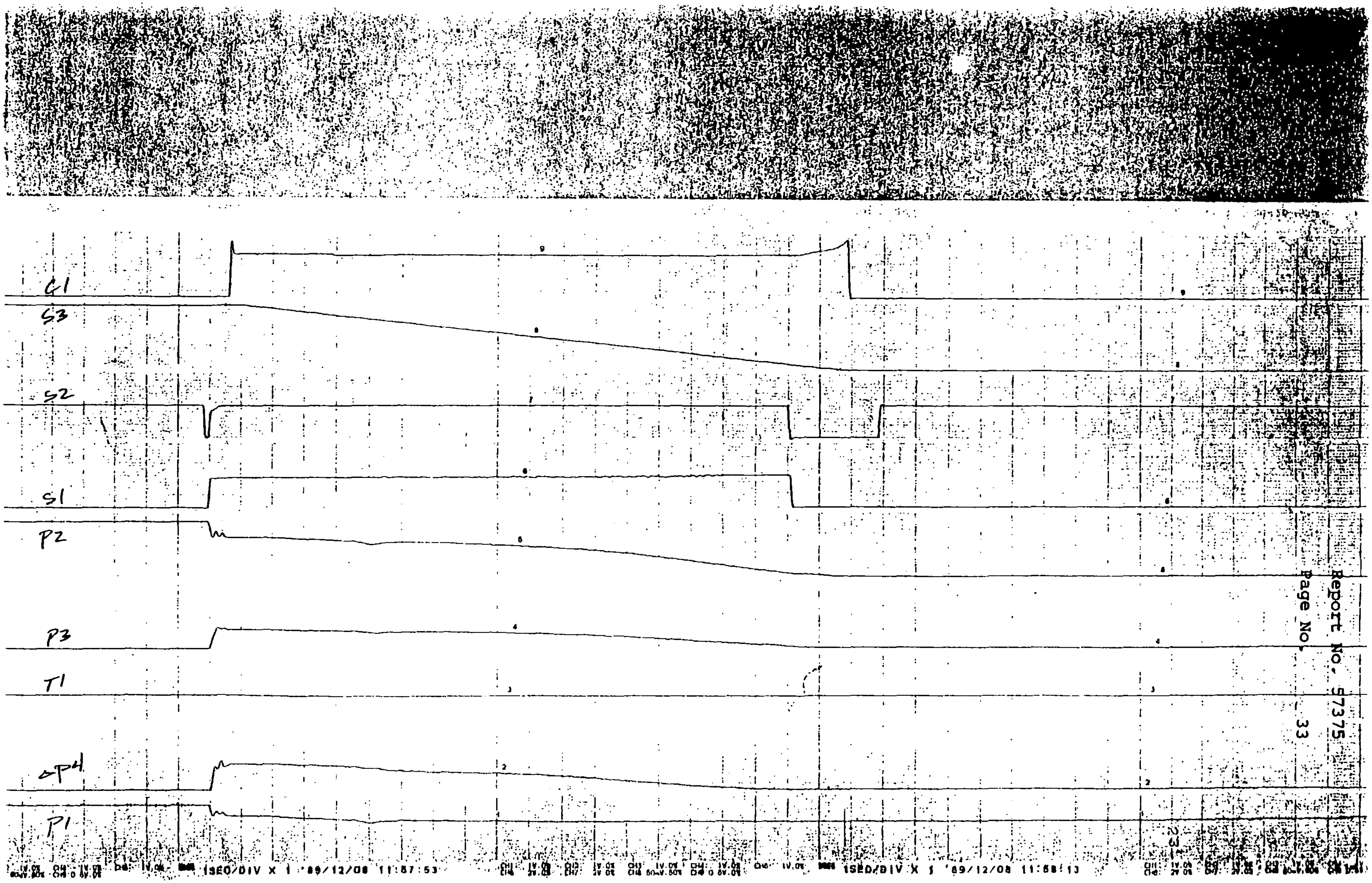


Report No. 57375
Page No. 31

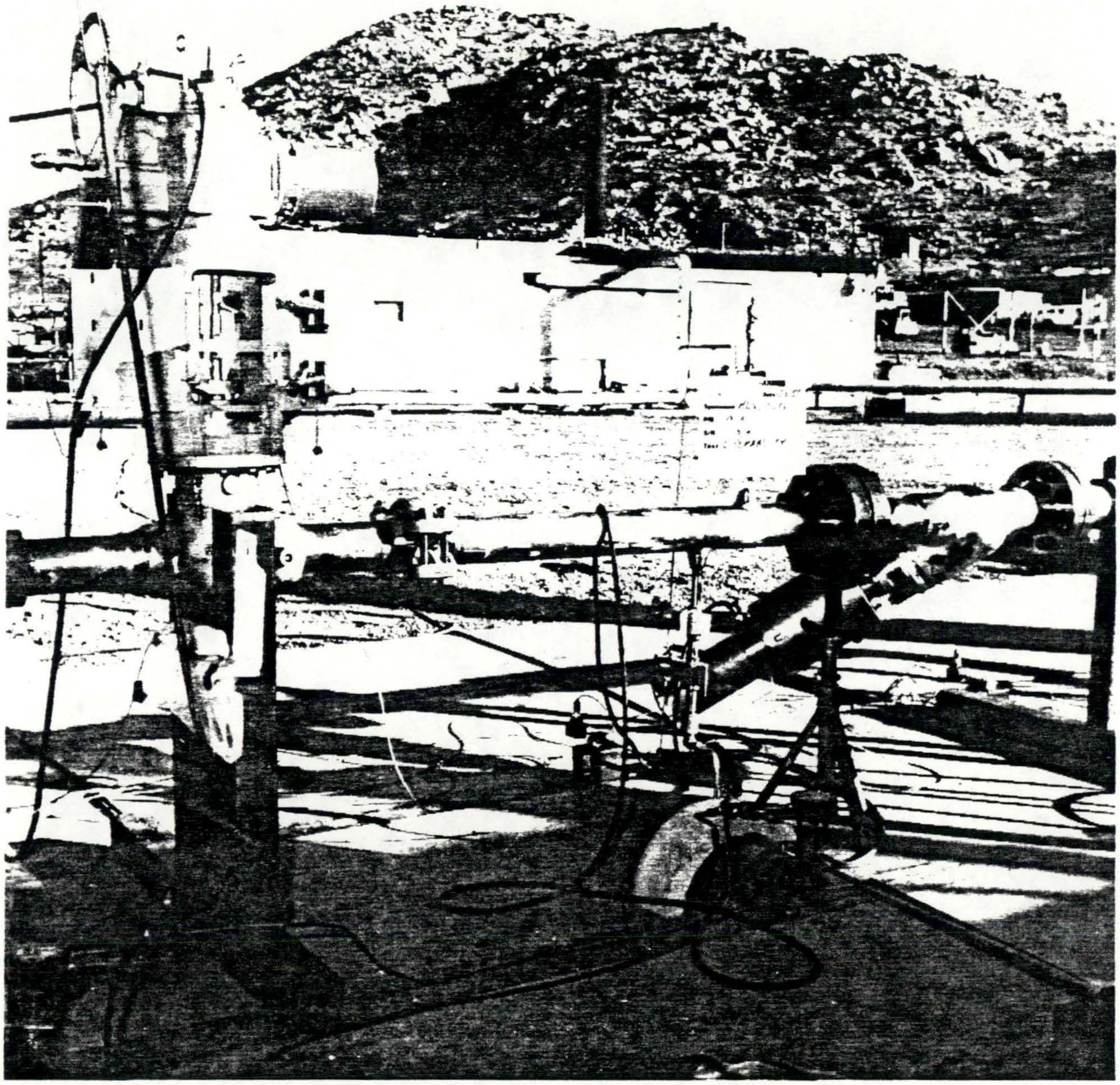
TEST 6.8 MAX THRUST

Report No. 57375
Page No. 32

TEST 6.9 MOV 100% OPEN TO CLOSE

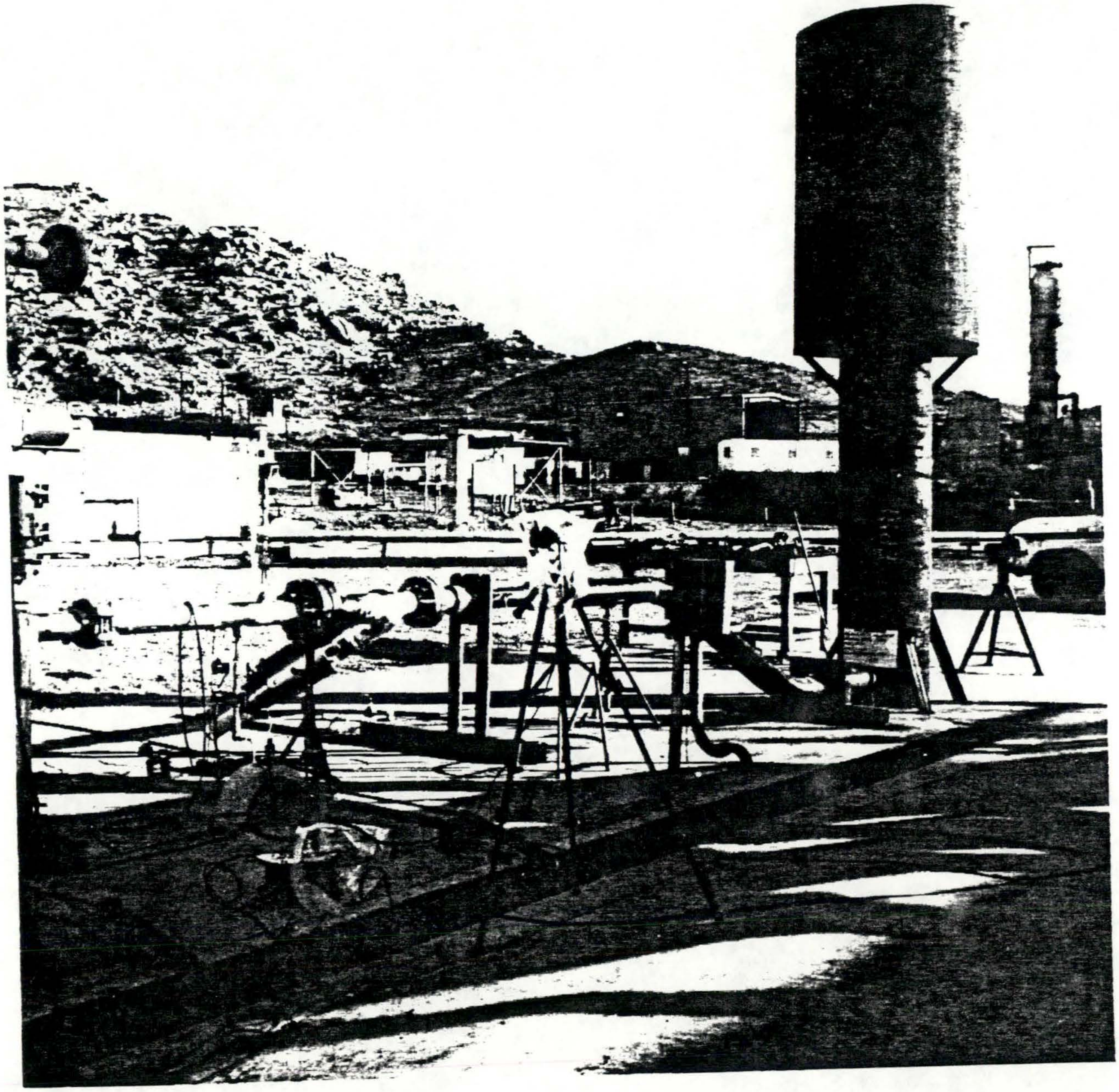


Report No. 57375
Page No. 33



PHOTOGRAPH 1

TEST VALVE INSTALLATION



PHOTOGRAPH 2

PORV TEST VALVE AND
OUTLET PIPING

NOTICE OF DEVIATION

WYLE LABORATORIES

WYLE JOB NO. 57375
NOD NO. 1
PO NO. --
DATE 12-18-89
GOV'T. CONT. NO.

TO: Consumers Power Company

ATTN: Robert Gilmore

PART NAME 4-inch valves

PART NO. MOV-1042A, PORV-1043B SERIAL NO. N/A

TEST: Steam Tests Section 6.0

SPECIFICATION TP No. 4648 PARAGRAPH NO. 6.3 thru 6.9

NOTIFIED CUSTOMER: Robert Gilmore DATE: 12-06-89 VIA: on site

NOTIFIED DCAS-QAR: DATE:

SPECIFICATION REQUIREMENTS:

Original Test Procedure Number 4648, Section 6.0.

DATE OF DEVIATION: 12-06-89 thru 12-08-89
TYPE OF DEVIATION: Procedure changes
DESCRIPTION OF DEVIATION:

Actual testing was performed under customer directed changes as documented in Test Procedure Number 4648, Rev. A.

SPECIMEN DISPOSITION: Testing completed.

COMMENTS - RECOMMENDATIONS:

TEST WITNESS:

REPRESENTING:

TEST ENGINEER [signature] D. Anderson

DEPT. MANAGER [signature] W.D. Peters

QUALITY ASSURANCE [signature] J. Graper

QC FORM APPROVAL [initials]

DISTRIBUTION:
ORIGINAL: DEPARTMENT
__COPIES: CUSTOMER
1 COPY : DEPARTMENT
1 COPY : QUALITY CONTROL
1 COPY : CONTRACTS
__COPIES: DCAS-QAR

WL-109A

TEST PROCEDURE 4648

REVISION A

WYLE LABORATORIES SCIENTIFIC SERVICES & SYSTEMS GROUP
WESTERN OPERATIONS, NORCO FACILITY

TEST PROCEDURE NO. 4648
DATE: December 6, 1989

Revision A
December 18, 1989

CONSUMERS POWER COMPANY

OPERABILITY TEST

FOR

MOTOR OPERATED VALVE MOV-1042A

AND

PRESSURE OPERATED RELIEF VALVE PORV-1043B

WYLE JOB NUMBER 57375

APPROVED BY: ______
FOR: ______

APPROVED BY: [signature] 12/6/89
FOR: Consumers Power Company

APPROVED BY: [signature] 12/6/89
FOR: Consumers Power

APPROVED BY: [signature]
FOR: WYLE LABORATORIES

APPROVED BY: [signature]
FOR: WYLE LABORATORIES

PREPARED BY: Douglas G. Anderson
WYLE LABORATORIES

REVISIONS

REV. NO.	DATE	BY	APPROVAL DEPT.	APPROVAL QA	APPROVAL CUST.	PAGES AFFECTED	DESCRIPTION OF CHANGES
A	12-18-89		WDP	[signature]		All	Customer directed procedure changes.

TABLE OF CONTENTS

1. **PURPOSE**

Pressure relief operability testing under steam conditions.

2. **REFERENCES**

2.1. Consumers Power Company telecopy dated December 2, 1989 (Appendix A).

2.2. Wyle Quality Assurance Manual Rev. H, dated July 8, 1989.

3. **DESCRIPTION OF TEST SPECIMENS**

3.1. MOV-1042A, 4-inch Edwards Valve, Figure No. 12011 (CF8M) F5MNPQTYZ

3.2. Connecting piping, Palisades piping class CC-11-4-inch (4" SCH 120 SS304).

3.3. PORV-1043B, 4-inch Target Rock M/N 100 4 X 4.

4. **PROGRAM REQUIREMENTS**

4.1. The test program will be run in accordance with this test procedure and the test plan outlined on Table I.

4.2. Wyle personnel shall perform all testing and witnessed by Wyle quality assurance and Consumers Power Company personnel.

4.3. Test failures or anomalies shall be documented per Wyle Notice of Deviation format.

4.4. Wyle Certified Data Sheet report will be submitted to Consumers Power Company following testing.

5. **TESTING CONDITIONS AND TEST EQUIPMENT**

5.1. Ambient conditions at Wyle Laboratories, Norco, California will not affect this test program.

5.2. The test tolerance for temperature measurements will be ± 5°F, for pressure measurements will be ± 1% of full scale range.

5.3. Appropriate test equipment will be calibrated and presented in the equipment list format of Section 7.0.

6. **REQUIREMENTS AND PROCEDURES**

6.1. Prerequisites

A. Demineralized water, 3,000 gallons ______

B. Propane, 2,000 gallons ______

C. Verify instrumentation is in calibration ______

D. All Wyle personnel are wearing dosimeters ______

E. Verify test personnel qualify per SOP 518-1A ______

6.2. Test Initiation Readiness

6.2.1. Verify MOV and PORV actuation circuits. ______

6.2.2. Verify MOV and PORV position indicators. ______

6.2.3. Verify SD1 and SD2 operation. ______

6.2.4. Start Wyle vapower boiler system with certified boiler operator. ______

6.2.5. Close 6" steam supply valve. ______

6.2.6. Close SD1 and SD2. ______

6.2.7. Build V2 steam vessel pressure. ______

6.2.8. Close MOV and PORV. ______

6.2.9. Open SD2, open steam supply valve. ______

6.2.10. Clear test pad area before V2 steam vessel pressure reaches 500 psig. ______

6.3. PORV Actuation Test

6.3.1. Verify MOV and PORV are closed. ______

6.3.2. Open SD1 to drain liquid from steam supply line. ______

6.3.3.	Close SD1.	______
6.3.4.	Verify V2 steam pressure is 575 psig.	______
6.3.5.	Start chart recorder.	______
6.3.6.	Open MOV for about 3 seconds, about 10% open.	______
6.3.7.	If PORV lifts, wait for PORV to reseat.	______
6.3.8.	Continue opening MOV to 100% open.	______
6.3.9.	Open, then close PORV.	______
6.4.	<u>MOV Jog Test</u>	
6.4.1.	Build V2 steam vessel pressure to 1800 psig.	______
6.4.2.	Verify MOV and PORV are closed.	______
6.4.3.	Open SD1 to drain liquid from steam supply line at MOV inlet.	______
6.4.4.	Close SD1 and SD2.	______
6.4.5.	Start chart recorder.	______
6.4.6.	Open the MOV for about 3 seconds, corresponding to about 10% open.	______
6.4.7.	If PORV opens, wait until PORV reseats.	______
6.4.8.	Continue opening MOV to 50% open.	______
6.4.9.	Close MOV.	______
6.4.10.	Open MOV to 100% open, and wait 3 minutes.	______
6.4.11.	After 3 minutes, close MOV.	______
6.4.12.	Open PORV.	______
6.4.13.	Open MOV to 100% open.	______

6.5.	<u>MOV Leakage Test</u>	
6.5.1.	Open SD2 with MOV and PORV closed.	_____
6.5.2.	Build V2 steam vessel pressure to 2500 psig.	_____
6.5.3.	Observe any leakage thru MOV at SD2 discharge.	_____
6.5.4.	Open SD1 to bring 2500 psig steam to MOV inlet.	_____
6.5.5.	Observe any leakage thru MOV at SD2 discharge.	_____
6.6.	<u>High Pressure Test</u>	
6.6.1.	Verify MOV is closed.	_____
6.6.2.	Open PORV.	_____
6.6.3.	Close SD2.	_____
6.6.4.	Open SD1 to drain liquid from the steam supply line.	_____
6.6.5.	Close SD1.	_____
6.6.6.	Start strip chart recorder.	_____
6.6.7.	Open MOV to 100% open.	_____
6.6.8.	When P1 decays to 1500 psig, close PORV.	_____
6.7.	<u>MOV Closure Test</u>	
6.7.1.	Build V2 steam vessel pressure to 2500 psig.	_____
6.7.2.	Close PORV.	_____

6.7.3.	Close SD1 and SD2.	______
6.7.4.	With MOV in open position, close MOV to 25% open.	______
6.7.5.	Wait 2 seconds and open MOV to 100% open.	______
6.7.6.	Set MOV at 60% open.	______
6.7.7.	Open SD2 to drain liquid from the steam supply line.	______
6.7.8.	Close SD1 and SD2.	______
6.7.9.	Start chart recorder.	______
6.7.10.	Open PORV to initiate steam flow.	______
6.7.11.	Close MOV.	______
6.7.12.	When MOV seats close, close PORV and open SD2.	______
6.8.	MOV Max Thrust Test	
6.8.1.	Build V2 steam vessel pressure to 2500 psig.	______
6.8.2.	Close PORV.	______
6.8.3.	Position MOV to 25% open.	______
6.8.4.	Open SD2 to drain liquid from steam supply line.	______
6.8.5.	Close SD2 amd SD1.	______
6.8.6.	Start chart recorder.	______
6.8.7.	Open PORV to initiate steam flow.	______
6.8.8.	Close MOV.	______
6.8.9.	When MOV seats close, close PORV and open SD2.	______

6.9. MOV 100% Open to Close Test

6.9.1. Build V2 steam vessel pressure to 2500 psig. ______

6.9.2. Close PORV. ______

6.9.3. Position MOV to 100% open. ______

6.9.4. Open SD2 to drain liquid from steam supply line. ______

6.9.5. Close SD1 and SD2. ______

6.9.6. Start chart recorder. ______

6.9.7. Open PORV to initiate steam flow. ______

6.9.8. Close MOV. ______

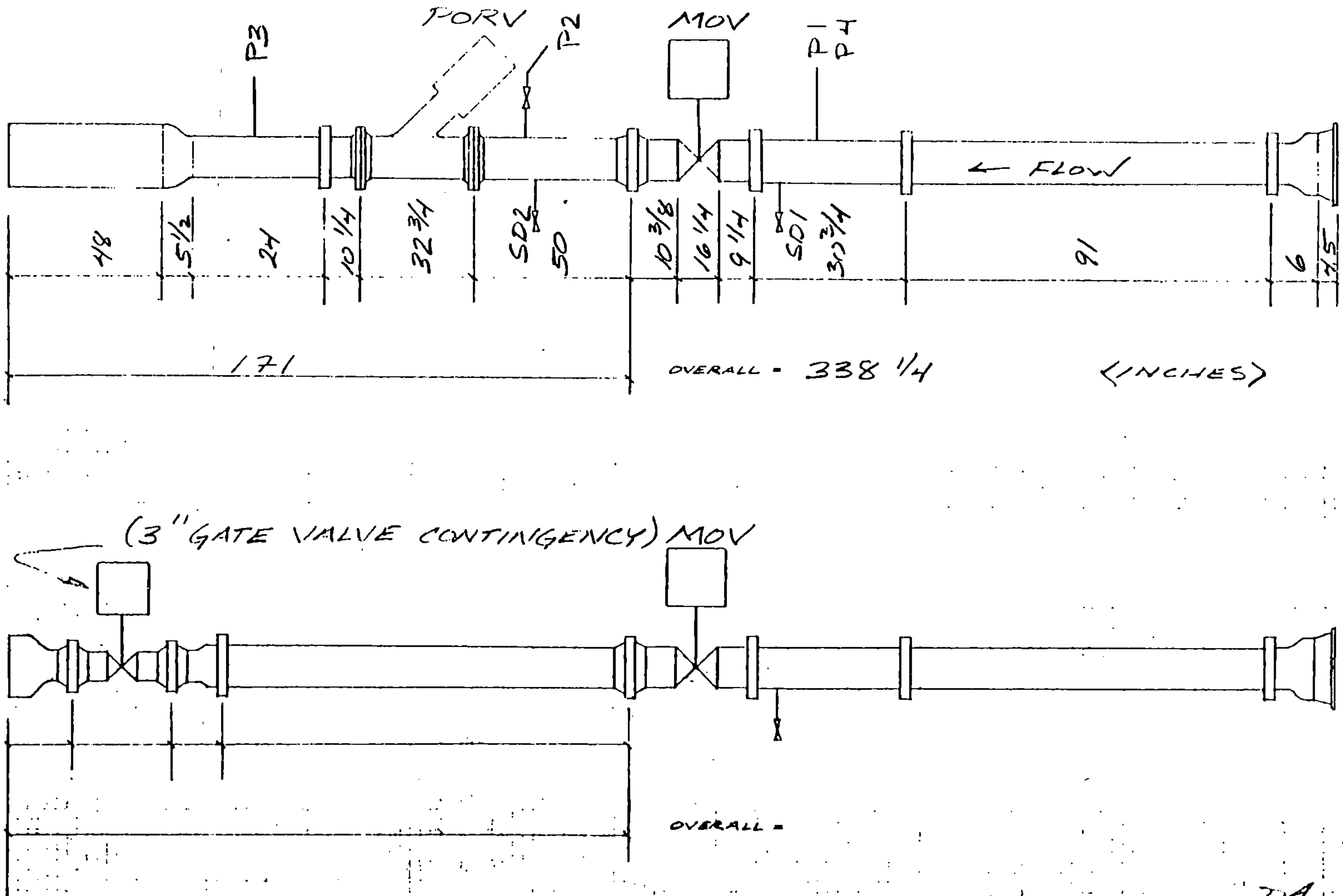
6.9.9. When MOV seats close, close PORV and open SD2. ______

TABLE I - TEST PROGRAM

Number	Test description	MOV. initial inlet pressure P.S.I.G	PORV. initial inlet pressure P.S.I.G	MOV. initial to finial % of open
6.3	PORV. Acuation Test	575	575	100 TO 0
6.4	MOV. Jog Test	1800	0	0 TO 100
6.5	MOV. Leakage Test	2500	0	0
6.6	High Pressure Test	2500	2500	100 TO 0
6.7	MOV. 60% open, Closure Test	2500	2500	60 TO 0
6.8	MOV. Max. thrust Test	2500	2500	25 TO 0
6.9	MOV. 100% open ,Closure Test	2500	2500	100 TO 0

TABLE II - TEST PROGRAM

Designition	Stripchart channel number	Measurement	Range
P1	1	MOV. UPSTREAM STATIC PRESSURE	0 TO 3000 P.S.I.G.
P4	2	MOV. UPSTREAM DYNAMIC PRESSURE	0 TO 300 P.S.I.D.
T1	3	MOV. UPSTREAM TEMP.	0 TO 1000 DEG. F
P3	4	PORV. DOWNSTREAM STATIC PRESSURE	0 TO 3000 P.S.I.G.
P2	5	PORV. UPSTREAM PRESSURE	0 TO 3000 P.S.I.G.
S1	6	PORV. OPEN LIMIT SWITCH (V.D.C.)	ON/OFF
S2	7	PORV. CLOSE LIMIT SWITCH (V.D.C.)	ON/OFF
S3	8	MOV. POSITION INDICATOR	% OF FULL OPEN
C1	9	MOV./PORV. CURRENT INDICATOR	0 TO 25 AMPS. V.A.C. 0 TO 5 AMPS. V.D.C. (UNCALIBRATED)



24

FIG. 2 TEST VALVE INSTALLATION DIMENSIONS

CONSUMERS POWER COMPANY JOB NO 57357

PIPING AND FITTING SCHEMATIC

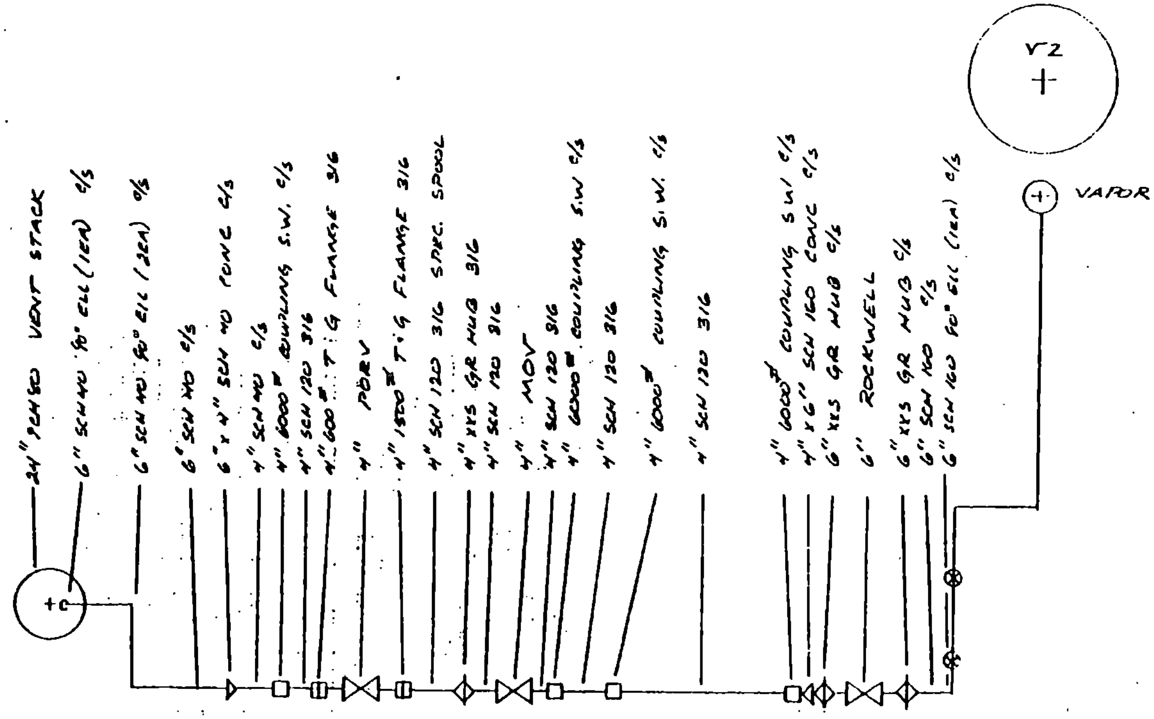
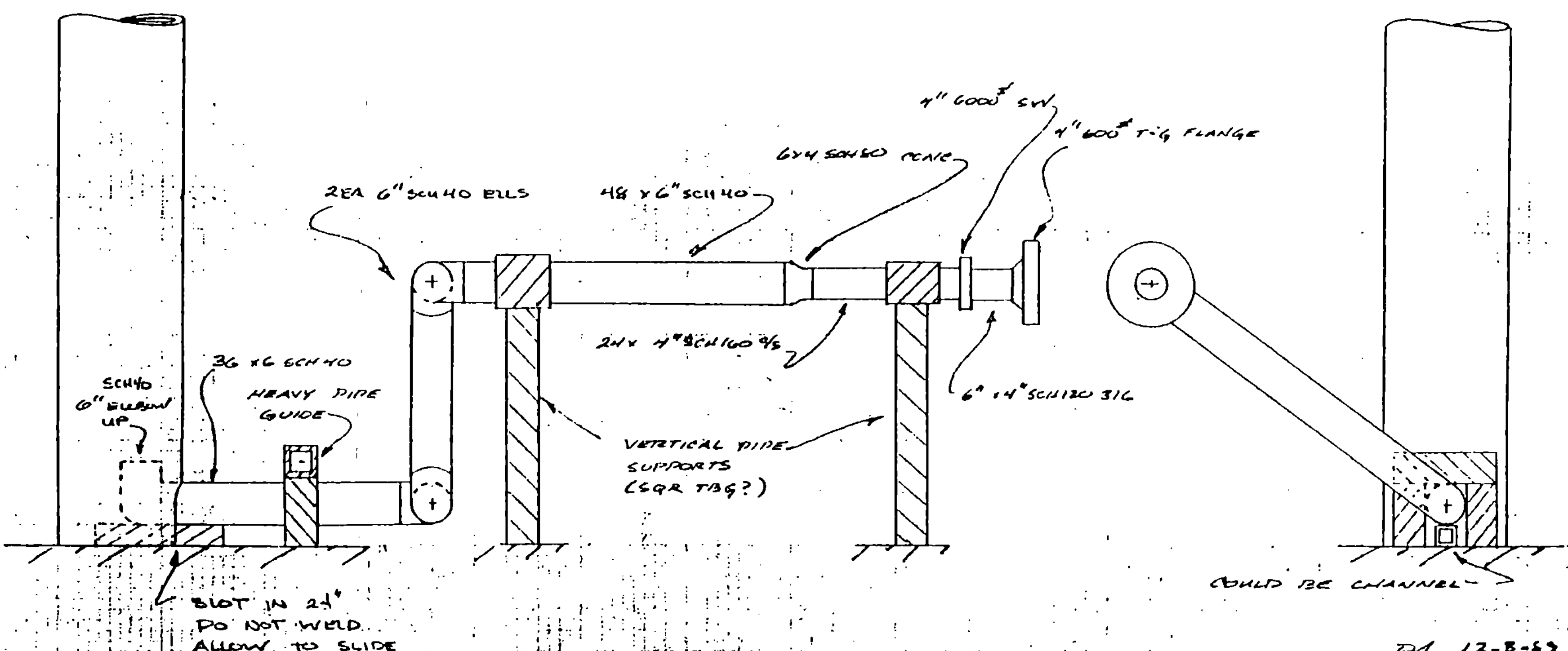


FIG 2

DK 12-2-89

PORV OUTLET AND VENT STACK PIPING



12-8-67
57375

FIG 3

INSTRUMENTATION SPOOL

HRW 2 DEC 89

INSTALLATION ORIENTATION

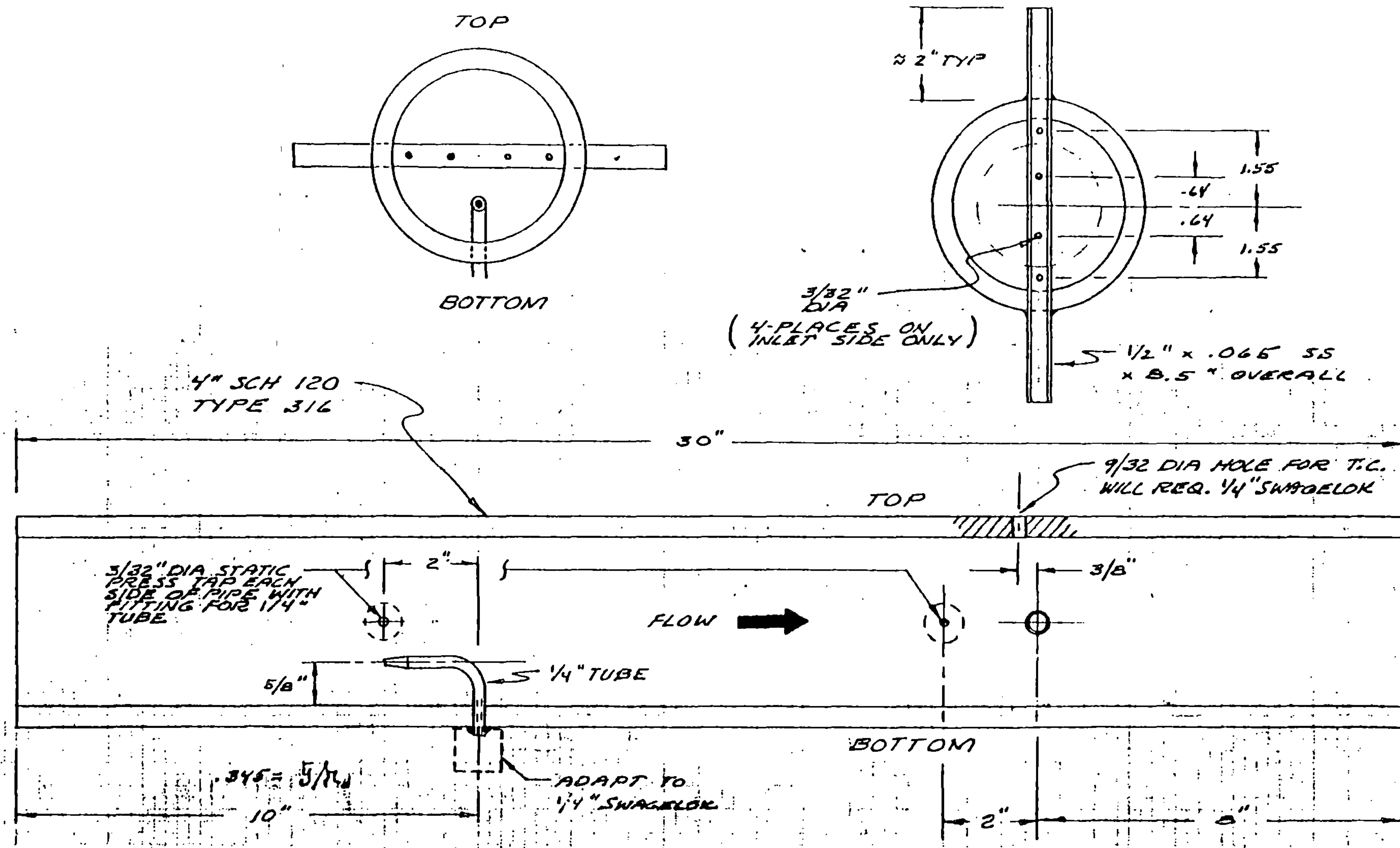


FIG 4

7. FORMS

WYLE LABORATORIES SCIENTIFIC SERVICES & SYSTEMS GROUP

DATA SHEET

Customer ______________________ Job No. ______________________

______________________ Date ______________________

Specimen ______________________

RECEIVING INSPECTION

No. of Specimens Received: ______________________

Record identification information exactly as it appears on the tag or specimen:

Manufacturer ______________________

____

P/N's ______________________ **S/N's** ______________________

How does identification information appear: (name plate, tag, painted, imprinted, etc.) ______________________

Examination: Visual, for evidence of damage, poor workmanship, or other defects, and completeness of identification.

Inspection Results: There was no visible evidence of damage to the specimen(s) unless otherwise noted below.

____

Inspected By ______________________

Sheet No. ______________ of ______________

Approved ______________ Date: ______________

W-614

QA Form Approval ______

WYLE
LABORATORIES SCIENTIFIC SERVICES & SYSTEMS GROUP

TEST TITLE ______________________

CUSTOMER ______________________ Job No. ______________ Date ______________

Specimen ______________________________________ Technician ______________

Part No. ______________ Serial No. ______________ Engineer ______________

EQUIPMENT	MANUFACTURER	MODEL NO.	RANGE	WYLE NO.	CALIBRATION		ACCY.
					LAST	DUE	

Procedure No. 4648
Page No. 17

QA Form Approval [signature]
W614D-82

Where applicable, the listed test equipment has been calibrated using standards which are traceable to the National Bureau of Standards. Certificates and reports of all calibrations are retained in the Wyle Laboratories QA files and are available for inspection upon request.

WYLE
LABORATORIES

WYLE LABORATORIES TEST LOG SHEET

Job Number ____________________ Test Title ____________________ Log Page __________ Of __________

Customer ____________________ Test Item ____________________ Test Engineer ____________________

Date ____________________ Serial No. ____________________ Test Area ____________________

USE A SEPARATE LOG SHEET FOR EACH TEST TITLE OR TEST ITEM

Time		Action and Remarks	Entered by
Start	Comp.		

W-648-B Q.C. Form Approval ____________

NOTICE OF DEVIATION

WYLE LABORATORIES

WYLE JOB NO. ______
NOD NO. ______
PO NO. ______
DATE ______
GOV'T. CONT. NO. ______

TO: ______

ATTN: ______

PART NAME ______

PART NO. ______ SERIAL NO. ______

TEST: ______

SPECIFICATION ______ PARAGRAPH NO. ______

NOTIFIED CUSTOMER: ______ DATE: ______ VIA: ______

NOTIFIED DCAS-QAR: ______ DATE: ______

SPECIFICATION REQUIREMENTS:

DATE OF DEVIATION:
TYPE OF DEVIATION:
DESCRIPTION OF DEVIATION:

SPECIMEN DISPOSITION:

COMMENTS - RECOMMENDATIONS:

DISTRIBUTION:
ORIGINAL: DEPARTMENT
__COPIES: CUSTOMER
1 COPY : DEPARTMENT
1 COPY : QUALITY CONTROL
1 COPY : CONTRACTS
__COPIES: DCAS-QAR

TEST WITNESS: ______ TEST ENGINEER ______

REPRESENTING ______ DEPT. MANAGER ______

QUALITY ASSURANCE ______

QC FORM APPROVAL ______

WL-109A

APPENDIX A

TELECOPIER MESSAGE

CONSUMERS POWER COMPANY
PALISADES - ESS
27780 BLUE STAR MEMORIAL HIGHWAY
COVERT, MICHIGAN 49043

TELECOPIER NO.: (616) 764-8913, Ext. 0601

FOR ASSISTANCE CALL: (616) 764-8913, Ext. 0621

DATE: 12/2/89

TO: NAME Doug Anderson

FIRM Wyle Laboratories

TELEPHONE 714-737-0871

TELECOPIER TELEPHONE 714-735-4030

FROM. NAME Bob Gilmore

FIRM Consumers Power

TELEPHONE 616-764-8913 ext 0669

PAGES TO FOLLOW: 2

COMMENTS: Proposed Test Conditions
Home Phone 517-782-2071

(1)

Cycle No.	Type	Operator Thrust Setting	Initial Conditions: Orifice Pressure psig	PORV Upstream Pressure psig	PORV Downstream Pressure psig	Calculated Flow Rate lb/hr	PORV Position % of Full Open	Actuation Time	Final Conditions: Orifice Pressure psig	PORV Upstream Pressure psig	PORV Downstream Pressure psig
5.3-1	Leakage Test		2500				∅				
5.4.1-1	Limitorque SMB-00-25	~~755~~ 12500	2500	0.0	0.0		0.0				
5.4.1-1A	Limitorque SMB-00-25 Jog Open	12500	2100	0.0	0.0		0.0				
5.4.2-1	Limitorque SMB-00-25	12500	2500	2500	0.0		100		2500	2500	2500
5.4.2-2	Limitorque SMB-00-25	12500	2500	2500	0.0		~~50~~ At Max Thrust and Max dP		2500	2500	2500
5.4.2-3	Limitorque SMB-00-25 Actuate/Close PORV	12500	575	575	0.0		100		575	575	~~575~~ 0.0
5.4.2-4	Limitorque SMB-00-25 Actuate/Close PORV Saturated Water	12500	~~575~~ 300	~~575~~ 300	0.0		~~50~~ 100		~~575~~ 300	~~575~~ 300	~~575~~ 0.0

Attachment A