PAP-304

BUTTERFLY VALVE TESTS

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GE & Dresser
Offset Discs

I. GENERAL SECTION

PURPOSE

The tests were undertaken to determine operating characteristics of commercial butterfly valves equipped with air cylinder operators, solenoid control valves, and speed control devices. The need for such information arose because numerous service lines were to be built within the Grand Coulee Third Powerplant complex, and relatively simple, inexpensive, reliable control valves up to about 30 inches were needed. Pneumatically controlled butterfly valves were believed to offer these characteristics. Applications included service on both compressed air lines and cold waterlines. The valves were to generally conform to Specification AWWA C504-66, AWWA Standard for Rubber-Seated Butterfly Valves, Class 150B, with exceptions described and justified by the manufacturer.

BUTTERFLY VALVE PERFORMANCE REQUIREMENTS

The following operating conditions and valve properties were investigated:

1. The serviceability of the seat material after 30 days closed and dry with ambient air on either side of the leaf and air pressure of 70 to 90 psig[1] on the cylinder operator.

2. Condition of the seat after repeated opening and closing with 70-90-psig air pressure in the 8-inch pipe and 70-90-psig air on the cylinder operator.

3. Tightness of shutoff with water at 150 psig across the valve and 70-90-psig air pressure on the cylinder operator.

4. Condition of seat after repeated opening and closing with waterflow at about 16 feet per second line velocity and 43.3 psi differential pressure. Above to be repeated at higher differential pressures up to failure or 150 psi.

5. Relation between total cylinder stroke closing time and maximum water hammer pressure with about 16 feet per second waterline velocity and 70-90-psig air pressure to the cylinder. Also, similar relations when opening the valve.

6. Any other performance characteristics displayed during the tests which would be significant in relation to use of the valves

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[1] See Appendix 1 for frequently used metric equivalents.

for on-off service in powerplant auxiliary waterlines, or throttling service in powerplant air lines.

ACKNOWLEDGEMENTS

The valve study was performed through the cooperative efforts of the valve manufacturers, local manufacturers representatives; Messers. B. G. Seitz and D. C. Erickson, retired employees of the Engineering and Research Center, Division of Design; and the Division of General Research. Photography was by Mr. W. M. Batts of the General Services Branch.

DESCRIPTION OF VALVE TESTS

The valves were tested in two phases. Phase I was conducted with air in contact with the leaf. The air pressure was either at atmospheric or at 70-90 psig. Phase II was with water in contact with the leaf. Line water pressure varied up to 150 psig. For both phases, air pressure to the cylinder operator solenoid valve was maintained at between 70 and 90 psig. The air used in the tests was from reciprocating compressors and contained sizable amounts of oily condensate.

Steps Performed in Phase I

1. Valves were photographed and inspected.

2. Valves were placed on test rack to investigate seat serviceability after 30 days closed and dry with 70-90-psig air holding the leaf closed (Figure 1G).

3. Valves were again photographed and inspected.

4. Valves were individually mounted on an 8-inch pipe section supplied by a 1-1/2-inch shop air line.

5. Valve seats were tested for tighness with 70-90-psig air on one side of the leaf and atmospheric air on the other. The butterfly valve cylinder operator was supplied with 70-90-psig air to maintain the leaf in the closed position. A soap solution was brushed onto the downstream side of the leaf to test for air leakage (Figure 2G).

6. Valves were individually subjected to 1,000 cycles of opening and closing with 70-90-psig air in the 8-inch pipe section, and 70-90-psig air supplied to the cylinder operator. To speed up the tests and to conserve air and minimize noise, the butterfly valves were only opened enough to cause a rapid decompression

to near ambient pressure in the 8-inch pipe section. This was accomplished by energizing the solenoid for a preset time interval. At the end of the set time, the valve closed. (Figure 3G).

7. After the cycling tests the valves were again individually tested for tightness with 70-90-psig air in the 8-inch pipe section. As before, the cylinder operator was supplied with 7-90-psig air to maintain the leaf in the closed position and a soap solution was used to test for air leaks.

Steps Performed in Phase II

1. The butterfly valves were individually placed on the laboratory high head test facility (Figure 4G).

2. Shutoff tests were performed on the butterfly valves for three waterline pressure levels (43.3, 86.6, and 150 psig) with 70-90-psig air on the cylinder operator. The valve was exposed on the downstream end so any leakage that might occur could be easily seen. An additional downstream flange was necessary on some of the valves to insure proper seating. Each test lasted 45 minutes. Leakage (if any) was measured with a stop watch and beaker.

3. After the addition of downstream piping, cycling tests of 500 events each were performed at a waterline pressure of 43.3 psig

with 70-90-psig air on the cylinder operator. A complete cycle from fully open to fully closed to fully open was accomplished in 80 seconds.

4. Shutoff tests as in 2. above followed the 43.3-psig cycling tests.

5. Cycling tests as in 3. above were performed at a waterline pressure of 86.6 psig.

6. Shutoff tests as in 2. above followed the 86.6-psig cycling tests.

7. Cycling tests as in 3. above were performed at a waterline pressure of 150 psig.

8. Shutoff tests as in 2. above followed the 150-psig cycling tests.

9. Water hammer tests were performed on the individual valves after the cycling tests had been completed. The tests were performed at waterline pressures of 43.3 and 86.6 psig.

10. Valves were individually tested to obtain head loss values for the fully opened valves.

At the completion of Phase II, the valves were tested for bubble tightness at pressures up to 150 psig. For this test, a short 8-inch pipe section was attached to one side of the butterfly valve. The pipe was pressurized by a portable air compressor. The other side of the valve was turned upward and filled with water. Any air leaking past the seat could be readily observed.

Additional tests were performed on some valves to obtain further information. These tests will be described in the section pertaining to the valve they were performed on.

INSTRUMENTATION

Phase I. - For the cycling tests with air in contact with the leaf, an adjustable electronic timer was used to limit the solenoid valve activation time to restrict the butterfly leaf travel and minimize the quantity of compressed air consumed. Bourdon-type pressure gages were used to measure air pressure. A hand operated counter was used to record the number of cycles on the valves.

Phase II. - A precision 10-turn potentiometer and gear system was built to convert the valve rotation into an electrical signal which could be recorded on an oscillograph (Figure 5G A-B). The potentiometer system also contained a direct current power supply and a direct-current amplifier. The valve position was recorded simultaneously with hydraulic line pressure (8-inch (20.32 cm) waterline) and air pressure on each side of the piston in the butterfly valve cylinder operators. A time mark was generated at 1-second intervals on the oscillograph chart. Additional instrumentation consisting of an industrial timer and relay was used to alternately activate the solenoid valve for automatic timed cycling of the butterfly valves. Electronic pressure transducers were used to measure the air and hydraulic pressure.

Adapters were made so that the basic gear system could be used on all valves. The adapter was connected directly to the butterfly shaft or position indicator. By adjusting the amplifier sensitivity, total valve travel (including seat compression) was set to 45 mm of stylus deflection on the oscillograph. This provided an index mark every 2° (90° total travel), from fully closed to fully open.

TEST LIMITATIONS

The pipeline in the high head test facility was far too short to obtain reliable water hammer pressures. It was, however, the only available facility capable of supplying the valves with water at

150 psig. The pump characteristics were such that when a shutoff head was set with the valve closed, opening the valve produced head losses equivalent to a pipe length of approximately 4,000 feet. This limitation was not considered too serious because as the valve approached the seat, the discharge decreased, reducing the head losses. Considering the type of valve operation (fully opened to fully closed in a short time interval), the most critical condition was when the leaf was approaching or just leaving the seat. Also, it was not considered practical, possible, or safe to make adjustments to the pump speed control to compensate for any portion of the head losses while opening or closing the valve the full travel in intervals as short as 1 or 2 seconds. To prevent damage to the laboratory high head test facility, water hammer pressures were limited to approximately 40 percent of the shutoff head. This 40 percent value was approximate and was chosen after successive closures of the valve at decreasing speeds left the operator with the feeling that a higher closing speed might result in damage to the test facility.

Head loss data are comparative only, due to the lack of adequate length for recovery of head between a Venturi meter and the measuring station upstream of the valve. To obtain the most accurate data possible, 8-inch-diameter spools of the same length as the butterfly valve body were installed in the line in place of the butterfly valve and comparative data obtained of head loss between the upstream and downstream stations. The difference between the head loss obtained when the individual valves were installed and losses obtained when the spool was installed was attributed to the valve.

Throttling characteristics of the valves were not obtained. The valves were not equipped with controls capable of setting partial openings. Cavitation tests were not performed on the valve as a rather extensive program would be necessary with each valve. Cavitation was, however, quite apparent in the cycling of each of the valves. The downstream metal pipe showed considerable cavitation damage as a result of the tests. A typical photograph showing cavitation occuring downstream of a butterfly valve closing against a shutoff head of 150 psig is shown in Figure 6G.

Appendix 1

Metric equivalents for values which reoccur in this report are as follows:

English Unit	Metric Unit
70 to 90 psig	4.92 to 6.33 Kg/cm^2
43.3 psig	3.04 Kg/cm^2
75 psig	5.27 Kg/cm^2
86.6 psig	6.09 Kg/cm^2
150 psig	10.55 Kg/cm^2
8 inch	20.32 cm
1.5 inch	3.81 cm
16 ft/sec	4.88 m/s

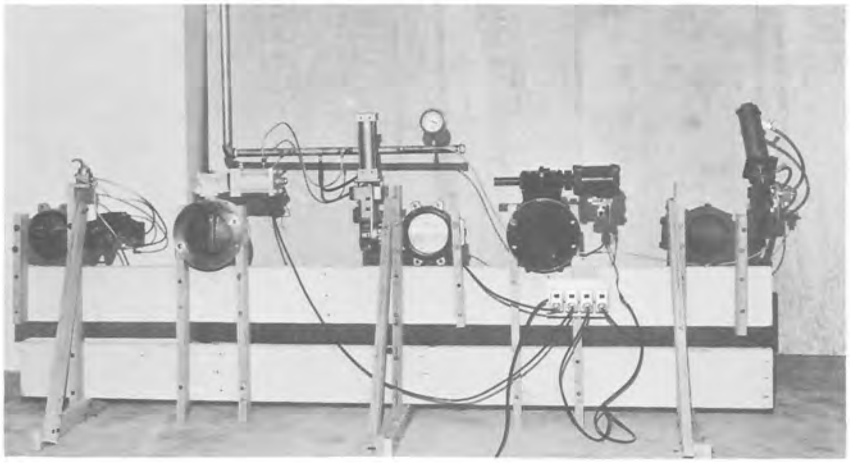


Figure 1G. Butterfly valves on rack for 30-day closed and dry test. Cylinder operator pressure - 76 psig. Valves from left to right: Crane, Pratt, Centerline, Dresser, and Allis-Chalmers. Photo P801-D-74490

Figure 2G. Soap solution being applied to seal area to help locate air leakage if present. Photo P801-D-74491

Figure 3G. Typical photo of a valve being opened with 70 to 90 psig air on the upstream side. Photo P801-D-74492

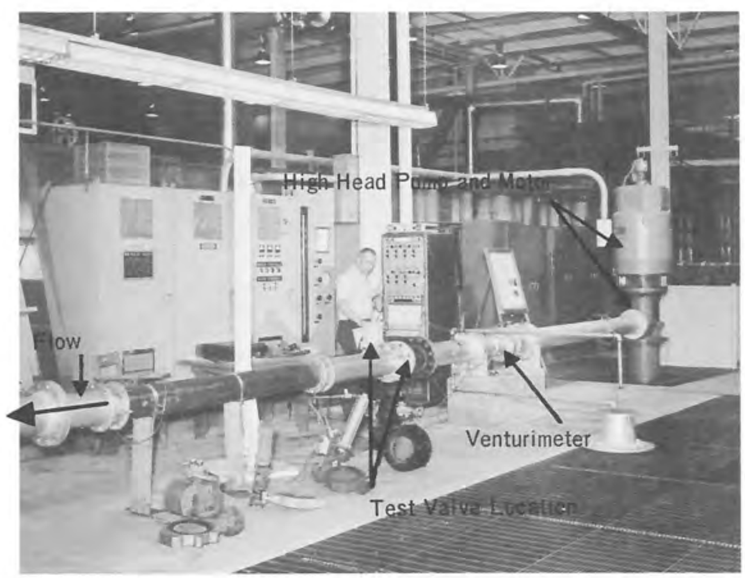


Figure 4G. Arrangement of high head test facility showing butterfly valve location. Photo P801-D-74493

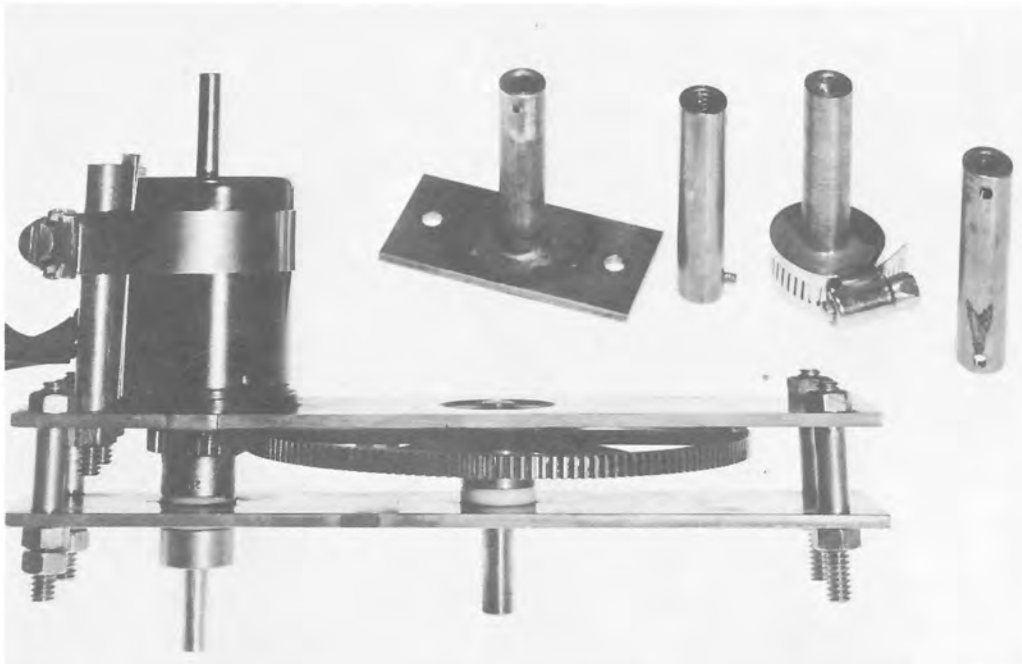


Figure 5GA. Potentiometer-gear system used to record butterfly leaf position. Attachments at upper right connect to different valves. Photo P801-D-74494

Figure 5GB. Potentiometer-gear system attached to Centerline valve. Photo P801-D-74495

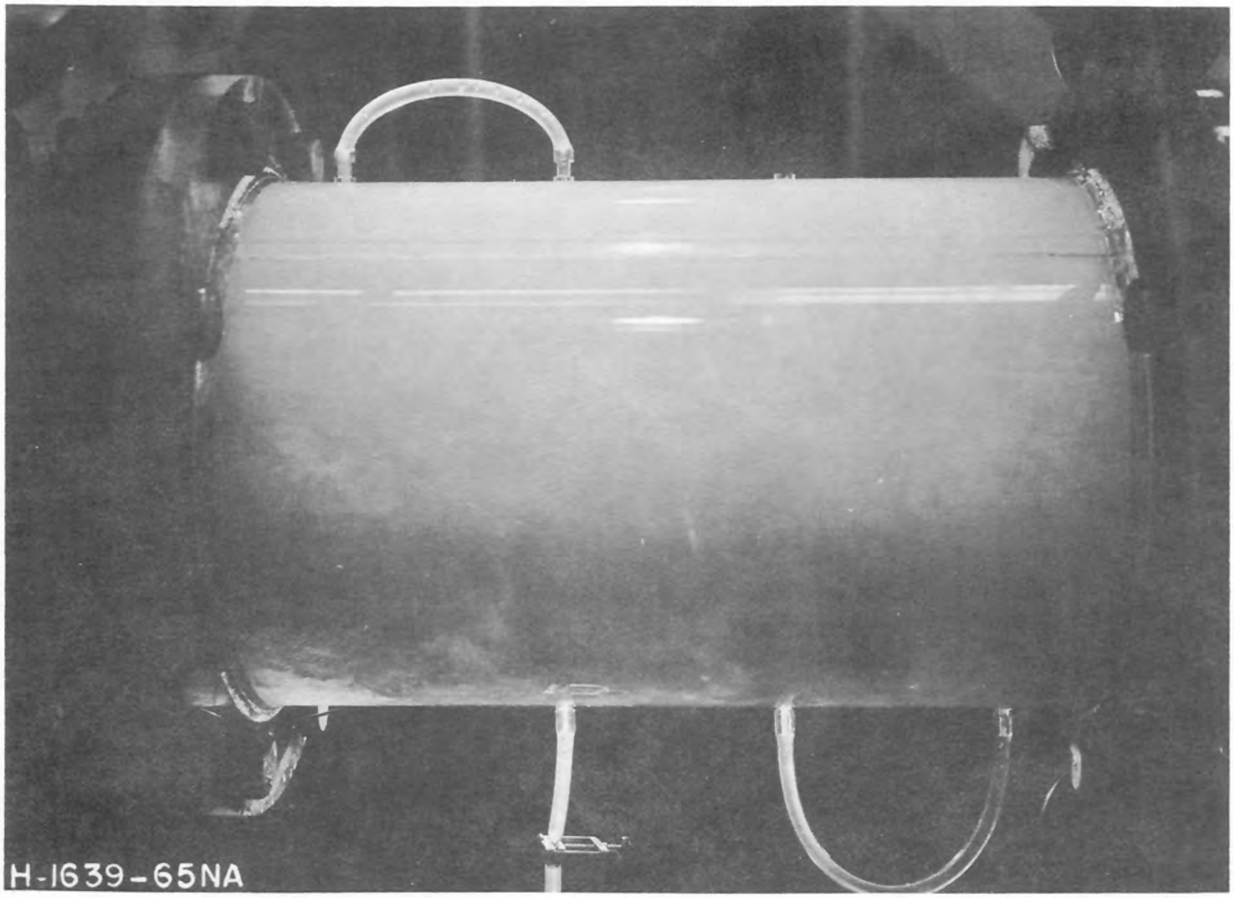


Figure 6G. Typical cavitation downstream of a butterfly valve closing against 150-psig pressure. Photo P801-D-74496

II. PRATT VALVE SECTION

GENERAL DESCRIPTION OF PRATT VALVE

The Pratt valve (Figure 1-P) was a flanged design, quite compact, with no external moving parts to interfere with adjacent equipment. The butterfly leaf (disk) was a modified lenticular shape and sealed on a rubber seat. The seat was factory bonded to the inside of the valve body and could not be replaced in the field.

The valve was opened or closed by unbalanced pressure on the cylinder operator. A lever and slider mechanism converted the linear travel of the piston shaft to rotation of the butterfly shaft. A position indicator was attached to one end of the butterfly shaft. The indicator was mounted on the outside of the slider box and contained a rotating pointer with index marks at open and closed.

The cylinder operator was equipped with a four-way "Versa" solenoid valve designed for pneumatic service. The valve contained adjustable air bleeds for metering air on either side of the cylinder operator piston. These bleeds provided excellent control of opening and closing rates of the butterfly.

PRATT VALVE - Phase I
(Air in Contact With Valve Leaf)

1. The Pratt valve was photographed, inspected, and found to be in good working order.

2. The valve was placed on the test rack and left for 30 days in the closed position with 70-90-psig air holding the leaf closed.

3. The valve was again photographed and inspeced. No permanent set or damage to the seal was observed as a result of the closed and dry test.

4. The valve was mounted on an 8-inch pipe section supplied by a 1-1/2-inch shop air line.

5. Shutoff tests with atmospheric air on one side of the leaf and 75 psig air on the other were made. The cylinder operator was supplied with 75 psig air to control the leaf. No air leakage was observed around the seat or shaft area of the valve when brushed with a soap solution.

6. The valve was subjected to 1,000 cycles of opening and closing. The valve operation during the cycling tests was excellent. Leaf movement away from the seat was quite uniform, allowing a steady

reduction in pressure in the 8-inch pipe section, without the explosive sound associated with jerky leaf travel.

7. At the completion of the cycling tests, shutoff tests were again performed. No air leakage was observed around the seat or shaft area of the valve when brushed with the soap solution. Both cylinder operator and 8-inch pipe section were pressurized with air at 75 psig.

The overall performance of the Pratt valve during Phase I tests (air in contact with the leaf) was excellent. The valve control was superior to any of the other valves tested during this phase. This superiority in control may result at least in part from the solenoid valve selected by Henry Pratt Company for use on their butterfly valve.

PRATT VALVE - Phase II
(Water in Contact With Valve Leaf)

1. The Pratt valve was bolted to an 8-inch pipe on the laboratory high head test facility. The downstream side of the valve was exposed for visual checking and measurement of leakage, if present.

2. Shutoff tests were performed for three waterline pressure levels (43.3, 86.6, and 150 psig) with 83 psig (5.84 Kg/cm^2) air on the cylinder operator. Each test lasted 45 minutes. Results of the test were:

43.3 psig - No leakage

86.6 psig - No leakage

150 psig - 0.037 ml/sec

3. The valve was cycled 500 times at shutoff pressure of 43.3 psig. The leaf travel characteristics were considered excellent. No difficulties were encountered in the 43.3 psig cycling test.

4. Shutoff tests following 500 cycles of opening and closing at 43.3 psig were performed for waterline pressures of 43.3, 86.6, and 150 psig with 78 (5.48 Kg/cm^2) psig air on the cylinder operator. Each test lasted 45 minutes. Results were:

43.3 psig - No leakage

86.6 psig - No leakage

150 psig - 0.037 ml/sec

5. The Pratt valve was cycled 500 times at a shutoff pressure of 86.6 psig. Leaf travel characteristics were considered excellent and no difficulties were encountered in the 86.6 psig cycling tests.

6. Shutoff tests following 500 cycles of opening and closing at 86.6 psig were performed for waterline pressures of 43.3, 86.6,

and 150 psig with 78 psig (5.48 Kg/cm^2) air on the cylinder operator. Each test lasted 45 minutes. Results were:

43.3 psig - No leakage

86.6 psig - No leakage

150 psig - 0.128 ml/sec

7. The valve was cycled 500 times at a shutoff pressure of 150 psig. Leaf travel was considered excellent and no difficulties were encountered in the 150 psig cycling test. Typical valve travel characteristics are shown in Figure 2-P.

8. Shutoff tests following 500 cycles of opening and closing at 150 psig were performed for waterline pressures of 43.3, 86.6, and 150 psig with 84 psig (5.91 Kg/cm^2) air on the cylinder operator. Each test lasted 45 minutes. Results were:

43.3 psig - No leakage

86.6 psig - No leakage

150 psig - 0.111 ml/sec

9. Water hammer tests were performed at shutoff pressures of 43.3 and 86.6 psig. Portions of the oscillograph charts for these tests

are shown in Figures 3-P and 4-P for the respective shutoff pressures. Events on the charts are arranged in order of increasing leaf speed moving to the right.

10. Head losses for the fully opened valve were obtained for a wide range of line velocities. These losses are shown in Figure 5-P.

The valve was then tested for bubble tightness and leakage photographed (Figure 6-P). The major portion of the leakage occurred between the seal and leaf, about 80° clockwise from the shaft. The remainder occurred at the shaft-seal point. The leakage began at 95 psig (6.68 Kg/cm^2) and increased up to the 150 psig test limit. Also, a slight leak was found in the seal from the shaft to the outside of the valve (arrow on Figure 6-PA). The cover was removed from the slider box to see if any water had leaked into the mechanism, but none was found.

The seal leakage was a result of cracking of the factory bonded rubber seal (Figure 7-P). A local Pratt Company representative requested we return the valve to the manufacuturer, where a new seal could be installed and the valve returned for further testing. The valve was shipped to the factory on May 11, 1970. No further word was received from Pratt Company regarding the valve.

SUMMARY

The Pratt valve possessed the smoothest action of all valves tested. The solenoid valve with air bleeds provided excellent control of valve opening and closing times. Head losses were lower for the Pratt valve than for any of the other valves tested. The factory bonded rubber seal developed cracks and was not bubble tight at 150 psig. Minor shaft seal leakage occurred on the side opposite the slider housing. No deviations from specifications AWWA C504-66 were listed by Henry Pratt Company for their valve.

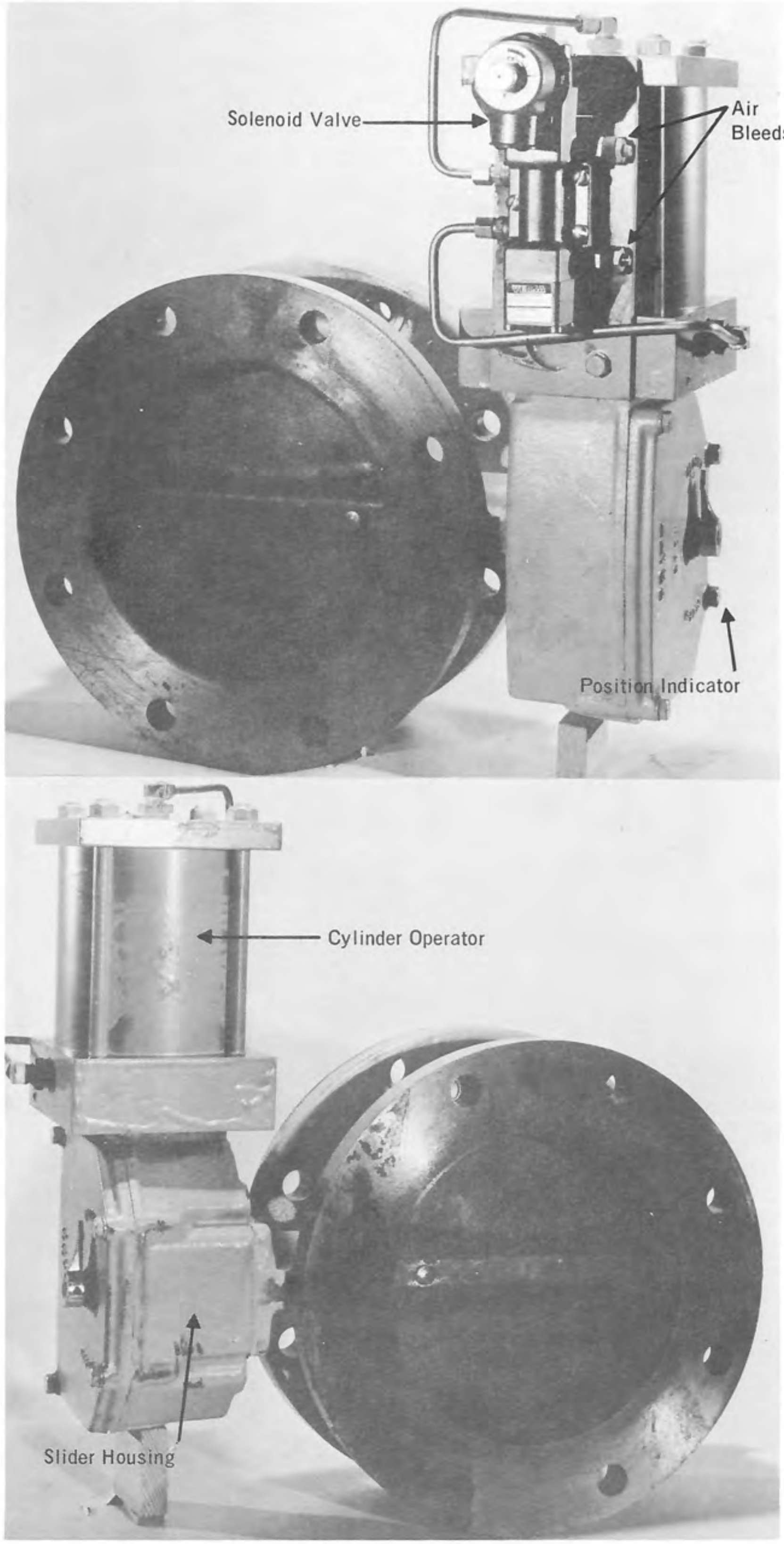
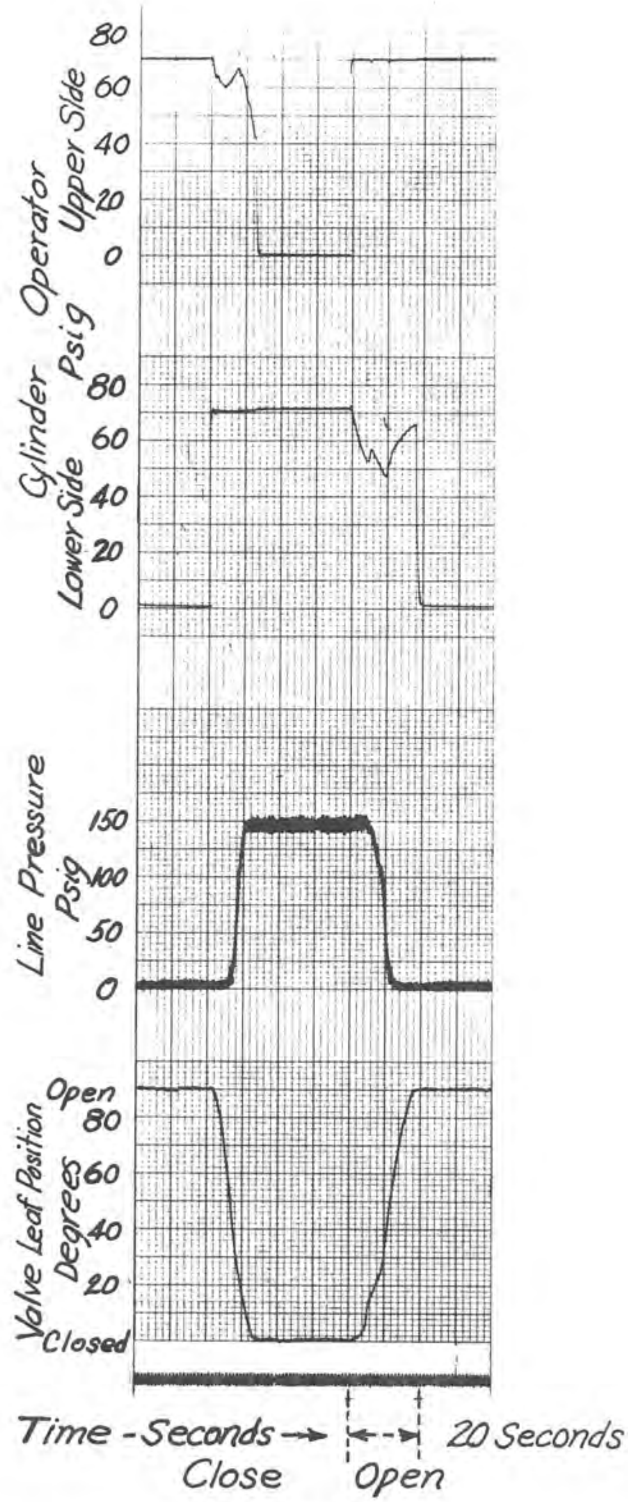


Figure 1P. Pratt valve with components labeled.
Photos P801-D-74498 (upper), P801-D-74497 (lower)

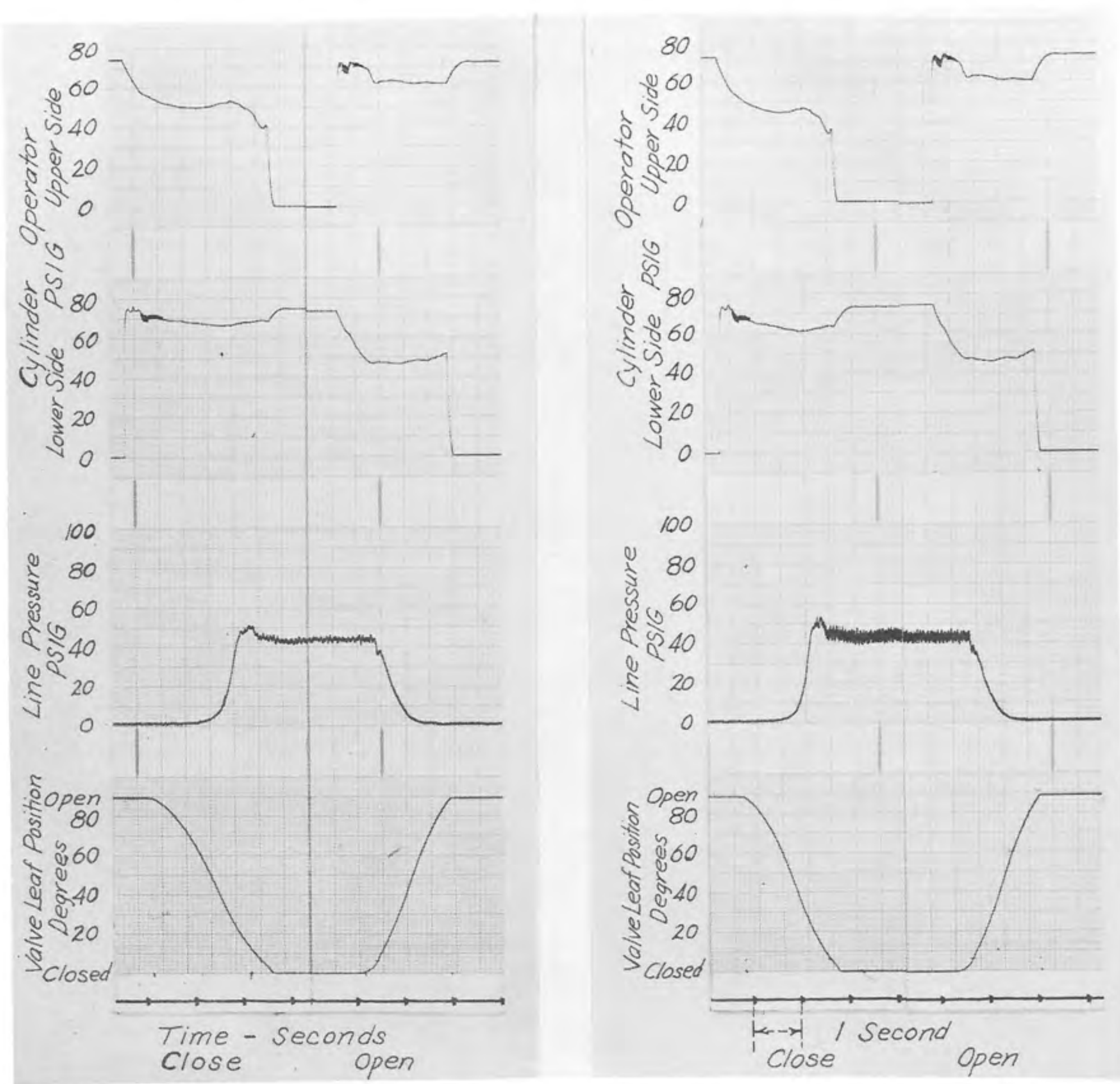
Figure 2P



Symmetrical Leaf

Valve Cycled at Line Pressure of 150 psig

GRAND COULEE THIRD POWERPLANT - BUTTERFLY VALVE TEST
PRATT VALVE

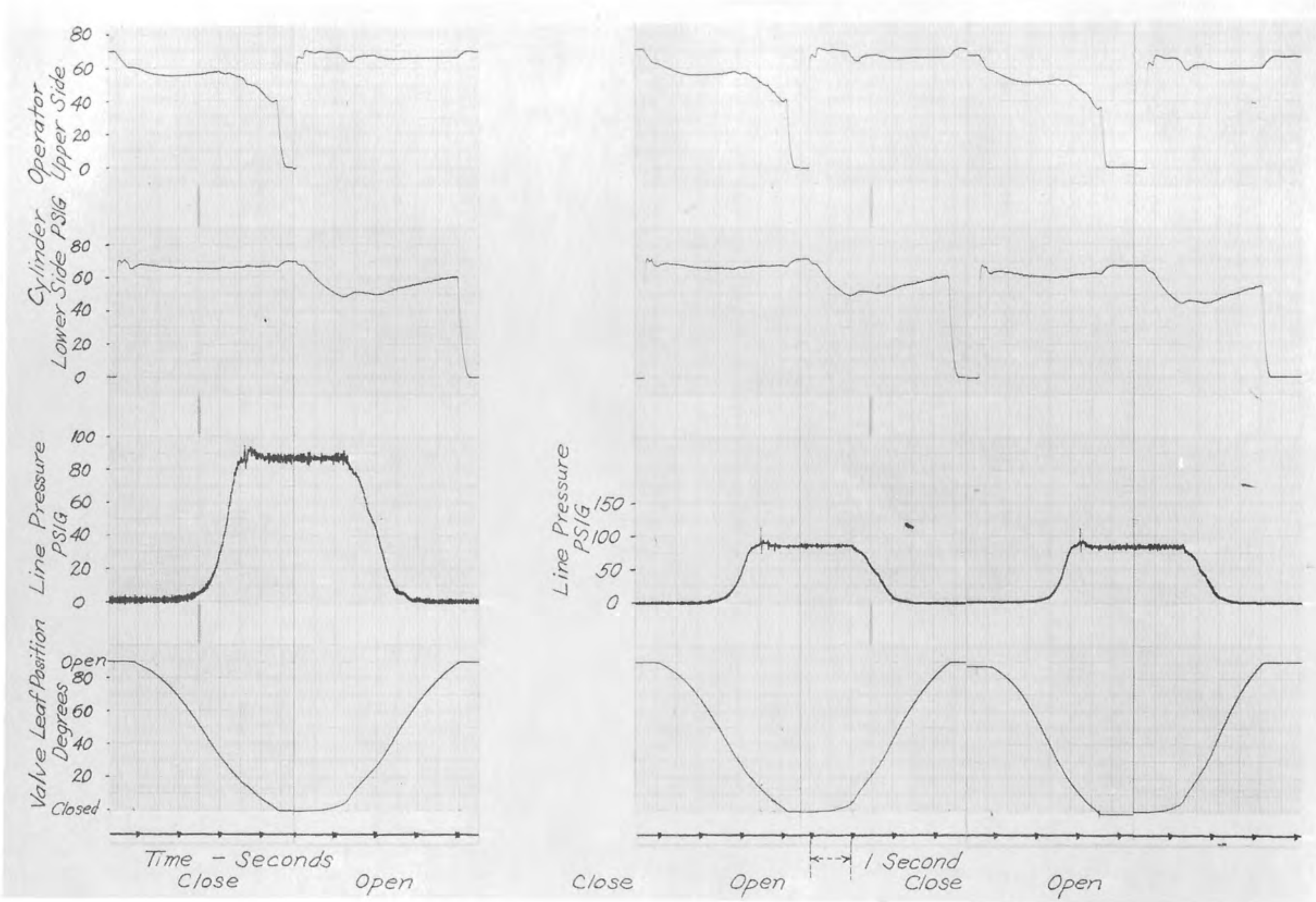


WATER HAMMER TESTS

43.3 psig Shut-off

GRAND COULEE THIRD POWERPLANT - BUTTERFLY VALVE TESTS

PRATT VALVE



WATER HAMMER TESTS

86.6 psig Shut-off

GRAND COULEE THIRD POWERPLANT - BUTTERFLY VALVE TESTS

PRATT VALVE

Figure 4P

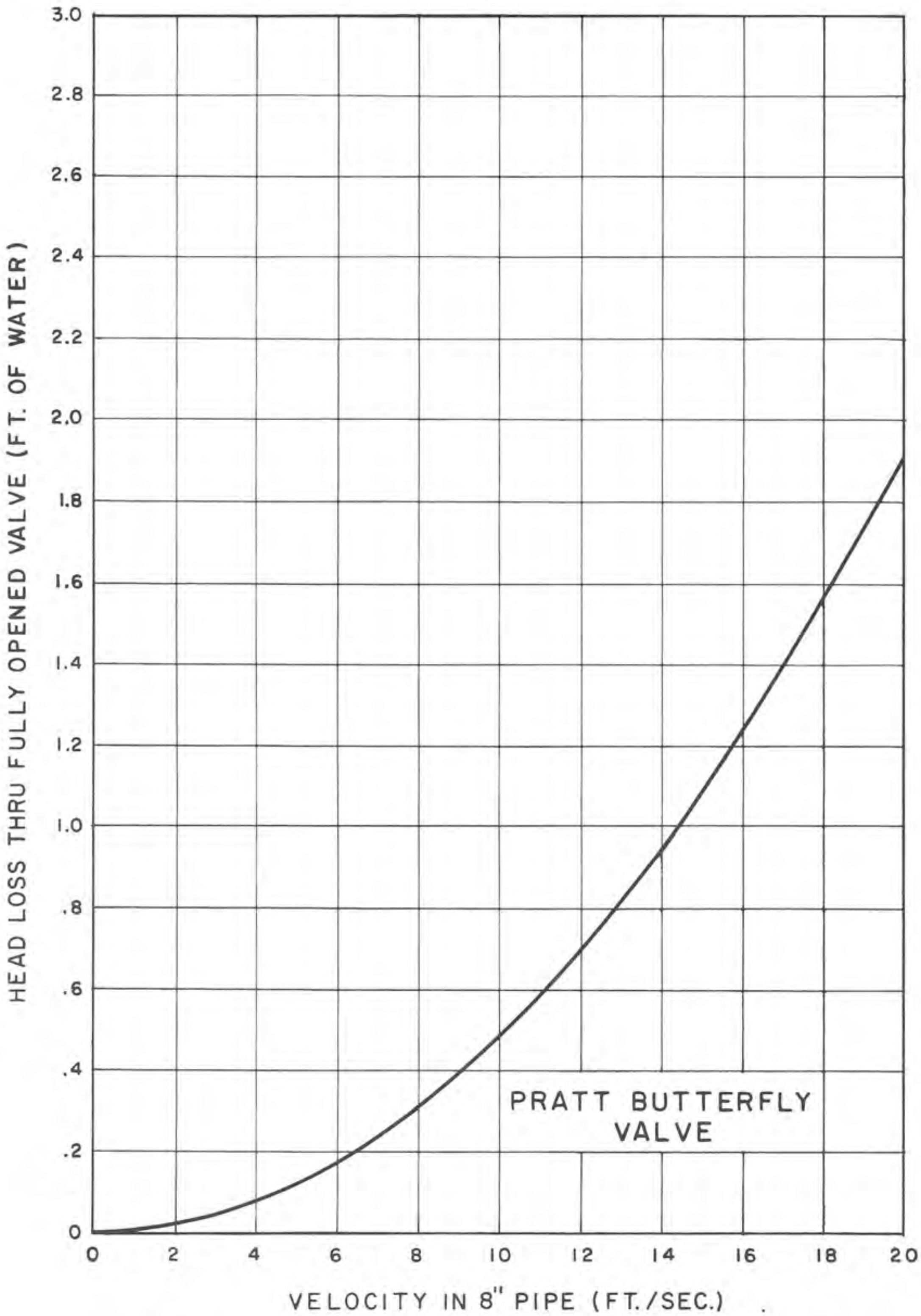
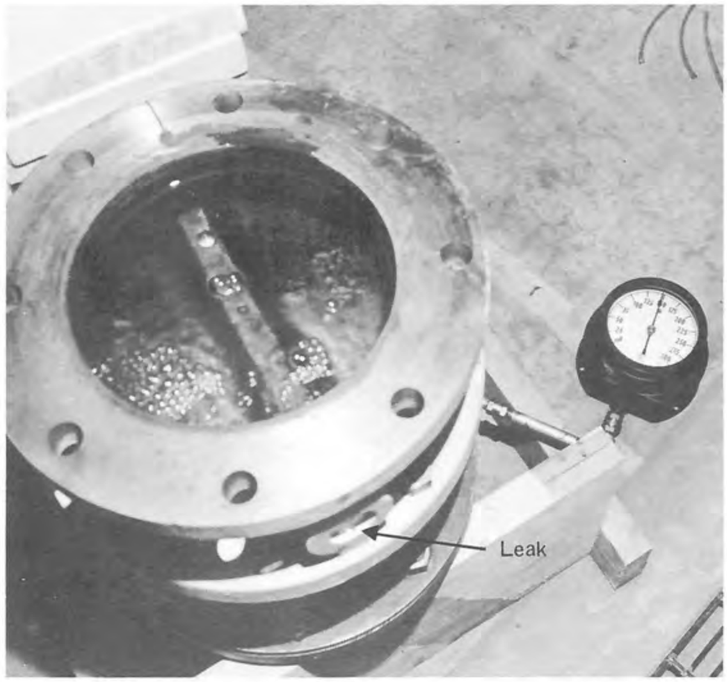


Figure 5P. Head loss through fully opened Pratt valve.

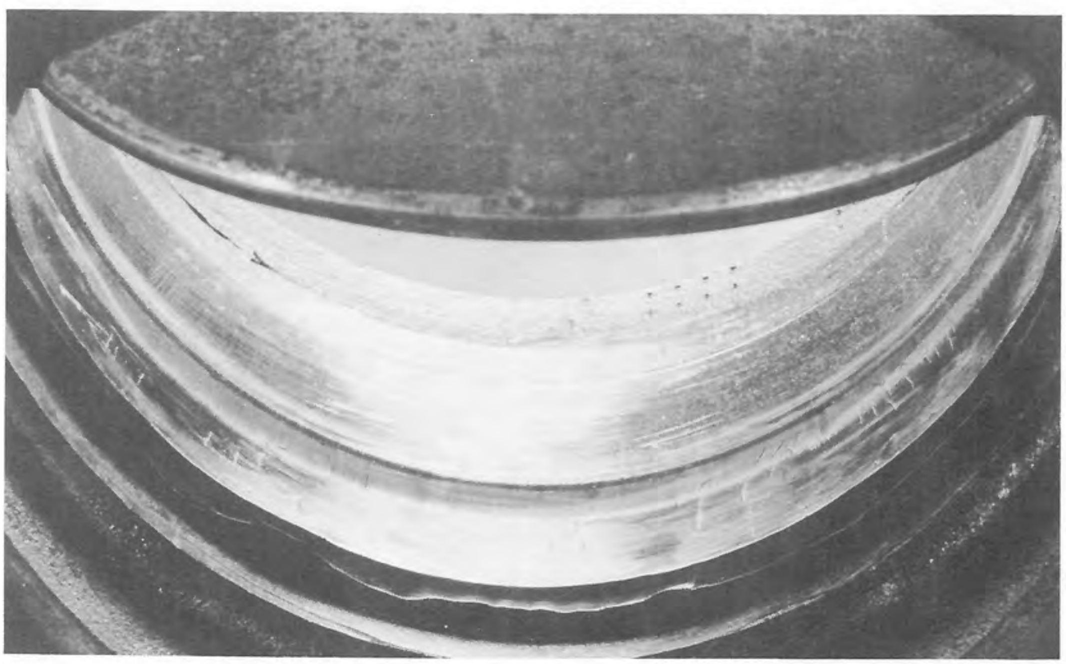


A. Leakage at 150 psig. Also note arrow showing leakage around shaft seal. Photo P801-D-74499

B. Location of shaft seal leakage. Photo P801-D-74500

Figure 6P. Bubble tightness test on Pratt valve. Air at 150 psig under water. Leakage began at 95 psig (6.68 kg/cm^2). Photo P801-D-47500

Upper portion of seat. Photo P801-D-74501



Lower portion of seat. Photo P801-D-74502

Figure 7P. Cracks in factory-bonded rubber seat of the Pratt valve.

II. DRESSER VALVE SECTION

GENERAL DESCRIPTION OF DRESSER VALVE

The Dresser valve (Figure 1-D) was a flanged design, compact, with no external moving parts to interfere with adjacent equipment. The butterfly leaf (disk) was an unsymmetrical shape with one side flat and the other raised over the shaft area (offset disk). The flat side contained the field renewable continuous rubber seal ring. The seal is composed of rubber vulcanized to a stainless steel ring. The ring was held in place by 12-1/4-inch (0.64-cm) button head cap screws (Figure 2-D). Once the valve was removed from the line, approximately 15 minutes was required to remove and replace the seal.

The valve was opened or closed by unbalanced pressure on the cylinder operator. A lever and slider mechanism converted the linear travel of the piston shaft to rotation of the butterfly shaft. A position indicator was attached to the end of the butterfly shaft. The indicator was mounted on the outside of the slider box and contained a rotating pointer with index marks at open and shut.

The cylinder operator was equipped with a four-way ASCO solenoid valve with 1/8-inch (0.32-cm) needle valves for controlling the rate of travel of the leaf.

A subsequent valve was supplied with an oil cylinder on the opposite end of the piston shaft from the air cylinder. This addition was made after all phases of testing were complete on the original valve.

DRESSER VALVE - Phase I

1. The Dresser valve was photographed, inspected, and found to be in good working order.

2. The valve was placed on the test rack and left for 30 days in the closed position with 70-90-psig air maintaining that position.

3. The valve was again photographed and inspected. No permanent set or damage was observed as a result of the closed and dry test.

4. The valve was mounted on an 8-inch pipe section supplied by a 1-1/2-inch shop air line.

5. Shutoff tests with atmospheric air on one side of the leaf and 75 psig air on the other were made. The cylinder operator was supplied with 75 psig air to control the leaf. No leakage was observed around the seat when brushed with a soap solution.

6. The valve was subjected to 1,000 cycles of opening and closing. The valve operation appeared to be inconsistent, indicating difficulty either in the solenoid valve or in the Dresser valve itself. This inconsistent operation was noted when a fixed energized time increment was set on an electronic timer and the valve was not opened to the same degree for the set time increment on successive cycles. The exact nature of the inconsistent travel was not determined. The valve travel was smooth and gradual when the leaf moved away from the seat, preventing an explosive sounding decompression.

7. After the cycling tests, shutoff tests were again performed. No leakage was observed around the seat when brushed with a soap solution. Both the cylinder operator and 8-inch pipe section were pressurized with air at 75 psig.

The overall performance of the valve during Phase I tests (air in contact with the leaf) was good, with the exception of the inconsistent leaf travel.

DRESSER VALVE - Phase II

(Water in Contact with Valve Leaf)

(a) Flat of leaf (seal side) downstream when closed

1. The valve was bolted to an 8-inch pipe section on the laboratory high head test facility. The downstream side of the valve

was left exposed for visual checking and measurement of leakage if present.

2. Shutoff tests were performed for three waterline pressures (43.3, 86.6, and 150 psig) with 76 psig (5.34 Kg/cm^2) air on the cylinder operator. Results of the tests were:

43.3 psig - No leakage
86.6 psig - No leakage
150 psig - No leakage

3. The valve was cycled 500 times with a shutoff pressure of 43.3 psig after the piston and barrel of the cylinder operator had been changed. The difficulties with the barrel and piston will be discussed at the end of this section.

The action of the valve at 43.3 psig was excellent, with good leaf control, and no rapid accelerations. The most rapid leaf travel occurred when near the half-open point, with gradual acceleration and deceleration at the beginning and end of travel. (Figure 3-D). This type of movement was due to the design of the operating mechanism.

4. Shutoff tests following 500 cycles of opening and closing at 43.3 psig were performed for water pressures of 43.3, 86.6, and

150 psig, with cylinder operator pressure at 78 psig (5.48 Kg/cm^2). Each test lasted 45 minutes. Results were:

43.3 psig - No leakage

86.6 psig - No leakage

150 psig - No leakage

5. The valve was cycled 500 times with a shutoff head of 86.6 psig. The valve began to show some effects of the hydrodynamic forces on the leaf on the opening cycle. The closing cycle was essentially as before, with gradual acceleration, maximum speed, and gradual deceleration. The opening cycle displayed an additional acceleration at near the 20° to 30° open position. This acceleration was apparently the result of a hydrofoil action of the leaf tending to open the valve. Examination of the cylinder operator pressures (Figure 4-D) showed a decrease in pressure on the active side of the operator and an increase on the inactive side at the valve position where the acceleration was encountered. This pressure reversal could only occur from a hydraulic force on the leaf.

6. Shutoff tests following 500 cycles of opening and closing at 86.6 psig were performed for water pressures at 43.3, 86.6, and

150 psig, with 76 psig (5.34 Kg/cm^2) air on the cylinder operator. Each test lasted 45 minutes. Results were:

43.3 psig - No leakage

86.6 psig - No leakage

150 psig - No leakage

7. The valve was cycled 500 times with a shutoff head of 150 psig. The valve performance remained similar to the 86.6 psig tests in that the closing cycle was well controlled with gradual acceleration, maximum speed, and gradual deceleration. The opening cycle had a much higher rate of acceleration at near the 25° to 30° open position of the valve. At this pressure a metalic knock could be heard when the leaf reached this opening. This knock was not located; however, it could have occurred because of play being taken up rapidly in a number of places, such as, between the leaf and hexagonal shaft, or between the shaft and slider, or between the slider and piston shaft, or a combination of all three. The play would result from a rapid change in hydraulic forces on the leaf.

8. Shutoff tests following 500 cycles of opening and closing at 150 psig were performed for water pressures of 43.3, 86.6, and

150 psig with 72 psig (5.06 Kg/cm^2) air on the cylinder operator. Each test lasted 45 minutes. Results of the tests were:

43.3 psig - No leakage
86.6 psig - No leakage
150 psig - No leakage

9. Water hammer tests were performed on the valve at shutoff pressures of 43.3 and 86.6 psig. Portions of oscillograph charts recorded during these tests are shown in Figures 3-D and 4-D for the respective pressures.

10. Head losses for the fully opened valve were obtained for a wide range of line velocities. These losses are shown in Figure 5-D. As mentioned earlier, these losses are comparative because of the short length of pipe between a Venturi meter upstream of the test valve and the valve. Curve A was obtained when the flat of the leaf (seal side) was facing downstream when closed. Curve B was obtained when the valve was turned end for end. In either case, the head losses are higher for the Dresser valve than for any of the other valves for which losses were measured.

Problems encountered in operation of the Dresser valve were first noted in the Phase I tests when inconsistent travel resulted with set times of energization of the solenoid. These difficulties could be attributed in part to three components of the valve. These were the solenoid, piston, and the cylinder operator barrel and seals.

Initially, cross leakage was noted in the solenoid valve. After several attempts to locate the trouble internally, the local ASCO representative found sections in the casting that were preventing proper piston travel. These difficulties were corrected. With the solenoid valve seating properly, leakage was noted past the piston in the 5-inch (12.7-cm) diameter cylinder operator. After disassembly, no visible difficulties were observed. On reassembly, it was found that on slight overtorquing of one of the four tie bolts, the total quantity of supplied air was able to leak past the piston and not cause piston movement. Subsequently, Mr. Dave Hokenson from the Bradford, Pennsylvania, Dresser Factory, came to the laboratory to repair the valve. The first attempt was to change the piston. One hundred and five cycles of opening and closing were obtained on the new piston before cross leakage forced stoppage of the tests. Mr. Hokenson then changed the operator barrel. The barrel was held between two end plates with grooves machined to fit the ends of the cylinder barrel. Each groove contained a Buna "N" seal which, when compressed, sealed the barrel to the end plates. When the tie bolts were tightened, the Buna "N" flowed, with part going to the inside and part to the outside of the groove. This had a tendency to distort the barrel, resulting in play occurring between the round piston and distorted barrel. The following day a brass cylinder barrel was installed in place of the second fiber glass one. The Buna "N" seals were omitted from the brass barrel and instead the cylinder was sealed with silicone rubber. This provided an adequate seal between the end plate and cylinder barrel. No further difficulty was encountered with cross leakage past the piston.

DRESSER VALVE - Phase II

Water in Contact with Valve Leaf

(b) Flat of leaf (seal side) upstream when closed

A complete series of tests consisting of 500 cycles of opening and closing at shutoff pressures of 43.3, 86.6, and 150 psig were performed on the valve. Following each cycling test series, shutoff tests were performed. No leakage was found during any of the shutoff tests. Water hammer tests at shutoff pressures of 43.3 and 86.6 psig were performed after completion of cycling and shutoff tests (Figures 6-D and 7-D). It should be noted that this valve had in excess of 4,000 cycles of opening and closing at the completion of this series (about 3,000 cycles wet and 1,000 cycles dry).

The performance of the valve at 43.3 psig was excellent. The leaf travel was smooth and positive with no rapid accelerations or decelerations associated with hydraulic forces on the leaf.

The performance of the valve at 86.6 psig was excellent. The leaf travel was smooth and positive with no rapid accelerations or decelerations associated with hydraulic forces on the leaf.

At 150 psig the valve performed quite well. Smooth leaf travel still existed for opening cycles and only minor effects from hydraulic forces occurred during the closing cycle. These effects produced only slight variations in leaf closure speeds, however, at no time was leaf control affected (Figure 8-D). Also, a slight leak was observed in the slider box (Figure 9-D). This leak occurred only when the valve was in an intermediate position on an opening or closing cycle. The factory inspection after the valve was returned for modification revealed a metal shaving had damaged the shaft seal. The shaving apparently had been in the valve since the initial assembly.

Bubble tightness tests were performed on the valve after 4,000 cycles of opening and closing. The seal and seat were absolutely bubble tight at a pressure of 154 psig (10.83 Kg/cm^2) (Figure 10-D). The cylinder operator pressure was maintained at 76 psig (5.34 Kg/cm^2) for the tightness tests.

The valve was crated and returned to the factory on January 2, 1970. The valve was to be modified by the addition of a second cylinder to act as a damper to eliminate poor leaf control when leaf flat was downstream when seated.

DOUBLE-CYLINDERED DRESSER VALVE

The modified valve equipped with two 5-inch (12.7-cm) diameter cylinders (Figure 11-D) was received on February 10, 1970. The lower cylinder contained oil on either side of the piston. The oil was throttled through a needle valve to eliminate the jerkiness of the leaf travel.

The valve was placed on the high head test facility with the flat of the leaf downstream. After shutoff tests where no leakage was noted at 150 psig, 500 cycles of opening and closing were performed on the valve at shutoff heads of 43.3 and 86.6 psig without difficulty. As before, dynamic forces on the leaf caused nonuniform leaf movement, but control was not seriously affected. When the shutoff head was raised to 150 psig problems occurred. After 330 cycles of opening and closing, the valve was observed to fail to open completely after every third to sixth cycle. The valve would open to between 20° and 30° and remain in that position until the timer recycled the valve (Figure 12-D).

The tests were terminated and Mr. W. C. Gilmore of Dresser Manufacturing, Bradford, Pennsylvania, was notified. Subsequently, Mr. Gilmore called and stated he had made torque calculations on the valve and found maximum torque of 1,280 inch-pounds (14.75 m-Kg) to occur at the 12° open position, but that required torque remained at or above 1,200 inch-pounds (13.83 m-Kg) from 2 to 26 degrees open. He felt the addition of the oil cylinder was overloading the pneumatic cylinder and stalling the valve. The alternatives were to replace the 5-inch (12.7-cm) pneumatic cylinder operator with a 6-inch (15.2-cm) unit, or to specify the direction of flow for the valve.

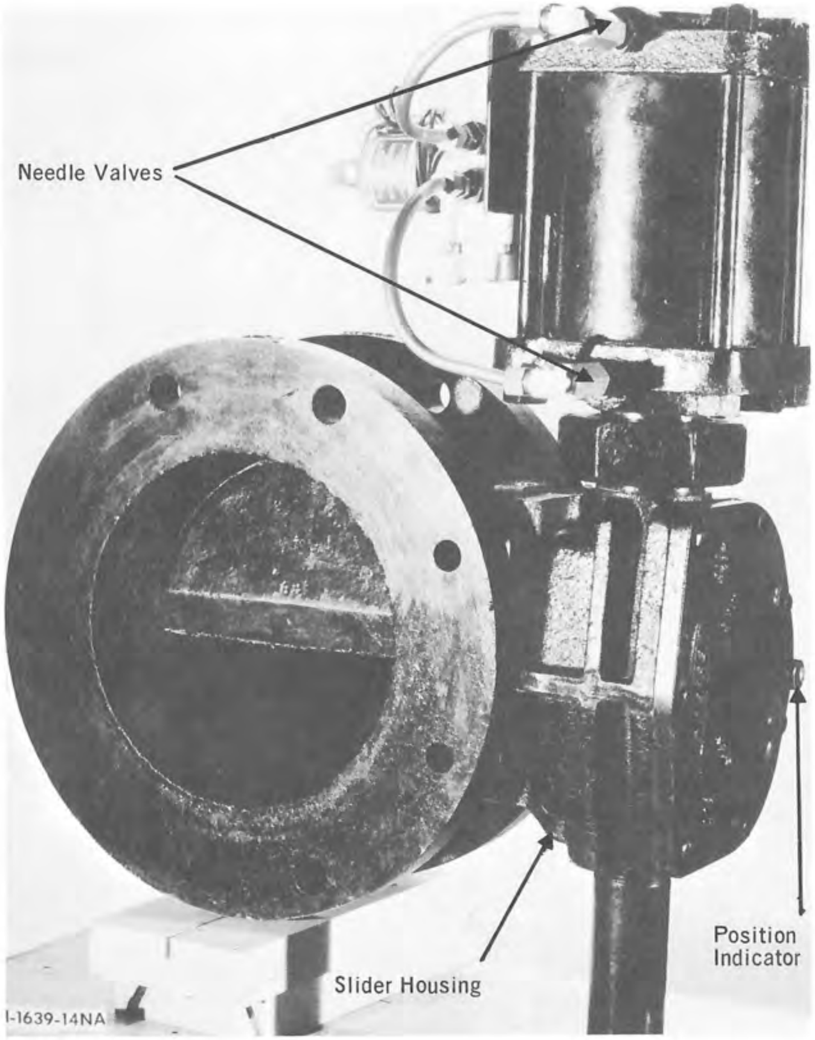
With the flat of the leaf upstream, operating torque requirements are measurably reduced. Specification of flow direction was not considered to be too restrictive and the decision was made to test the double-cylindered valve with the flat of the leaf upstream. The remainder of the tests, consisting of 500 cycles of opening and closing at 43.3, 86.6, and 150 psig were performed on the valve with the flat of the leaf upstream. The performance for these tests was excellent. Leaf travel was quite uniform and speed of opening and closing could be controlled from several seconds up to in excess of 6 minutes by simply adjusting the needle valve on the oil cylinder.

One item to be considered on the Dresser valve was the material used for the cylinder operator barrel. The barrels were made of a glass fiber reinforced epoxy resin. While some difficulties were encountered with the cylinder operator as mentioned earlier, it is not felt that the material used was unsatisfactory, but only the method of alining and holding the barrel was at fault. A sample barrel supplied by Dresser was examined in the laboratory, and found to posses a very hard, smooth inner surface. The barrel appeared to be very resistive to deformation from an impact blow. The sample barrel was struck a number of blows to the side with the pointed end of a tinners hammer in an attempt to dent the barrel. Inspection of the barrel revealed no dents, however the smooth inner coating had developed shatter cracks. These cracks were so fine that they could not be felt with the finger. Cracks this fine are not expected to cause piston wear and should not affect cylinder operator performance. Similar hammer blows to a brass barrel would result in a dent in the surface which could render the barrel inoperative. The glass fiber epoxy material has a number of advantages over brass which may result in increased service life and lower maintenance costs.

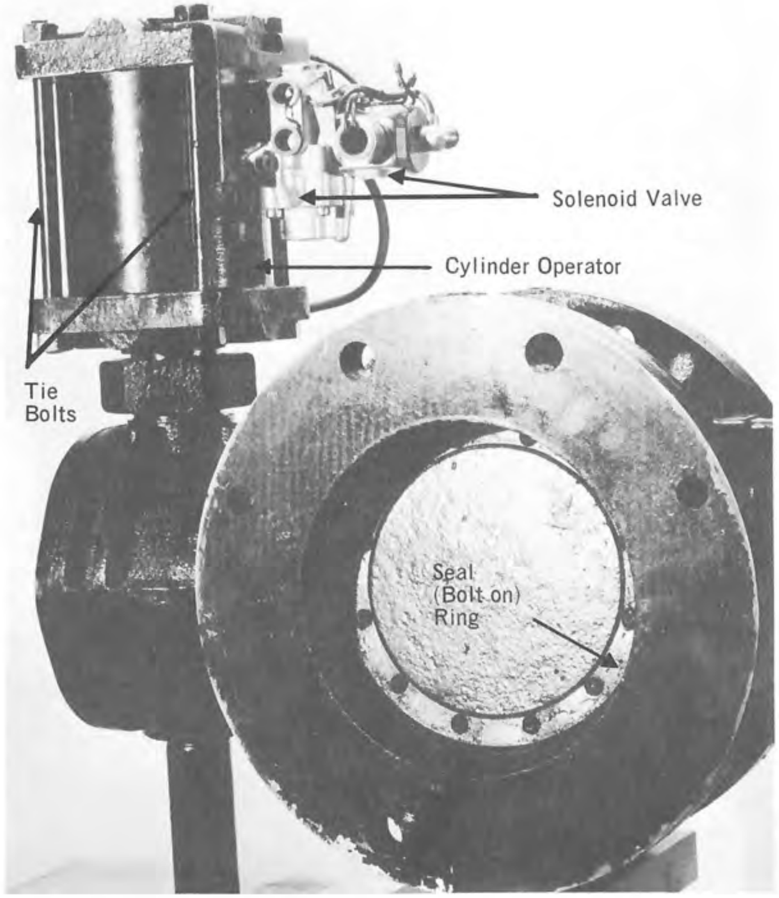
SUMMARY

The control problems encountered with the Dresser valve resulted only when the valve was mounted with the flat of the leaf downstream when seated. The other problems were mechanical and were satisfactorily corrected. With restrictions on flow direction,

the valve operation is satisfactory. With the addition of the oil cylinder, control of valve leaf movement was excellent. A fluid level gage and a means of replenishing lost fluid would be needed to insure that air accumulations did not enter the oil system. The field renewable rubber seal withstood more cycles of opening and closing than any other valve and still provided an absolutely tight seal at 150 psig. Head losses for the Dresser valve were higher than for other valves tested. Dresser provided a list of deviations to AWWA Specification C504-66 for their valve. The list is attached as supplied.



Offset side of leaf (shaft side). Photo P801-D-74503



Flat side of leaf (seal side). Photo P801-D-74504

Figure 1D. Dresser valve with components labeled.

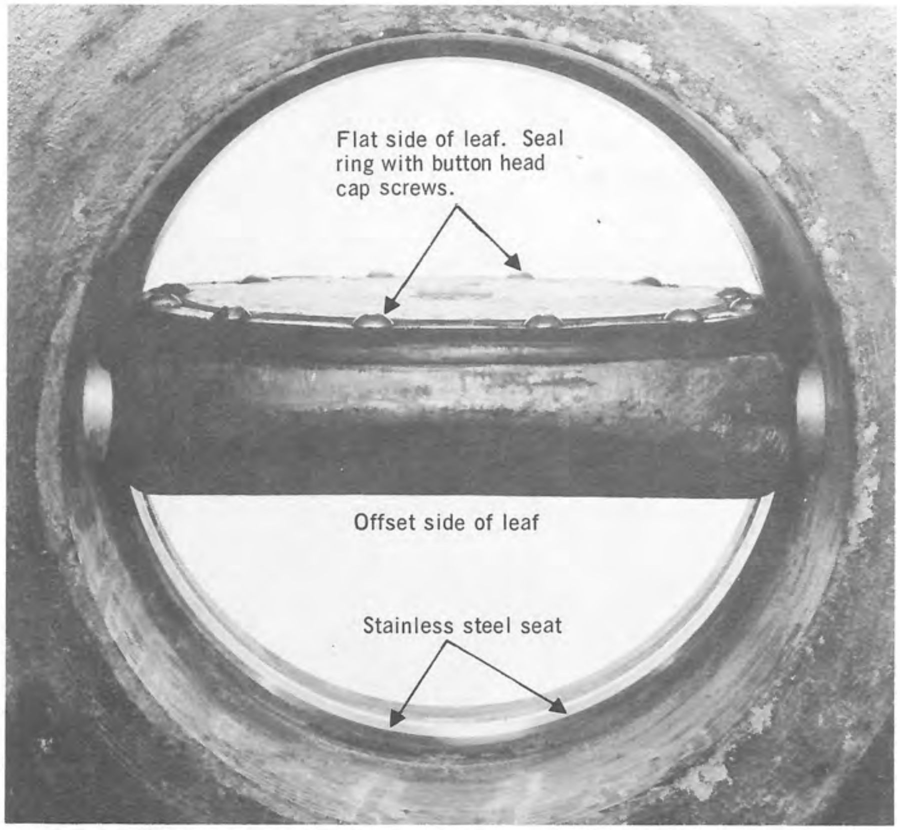
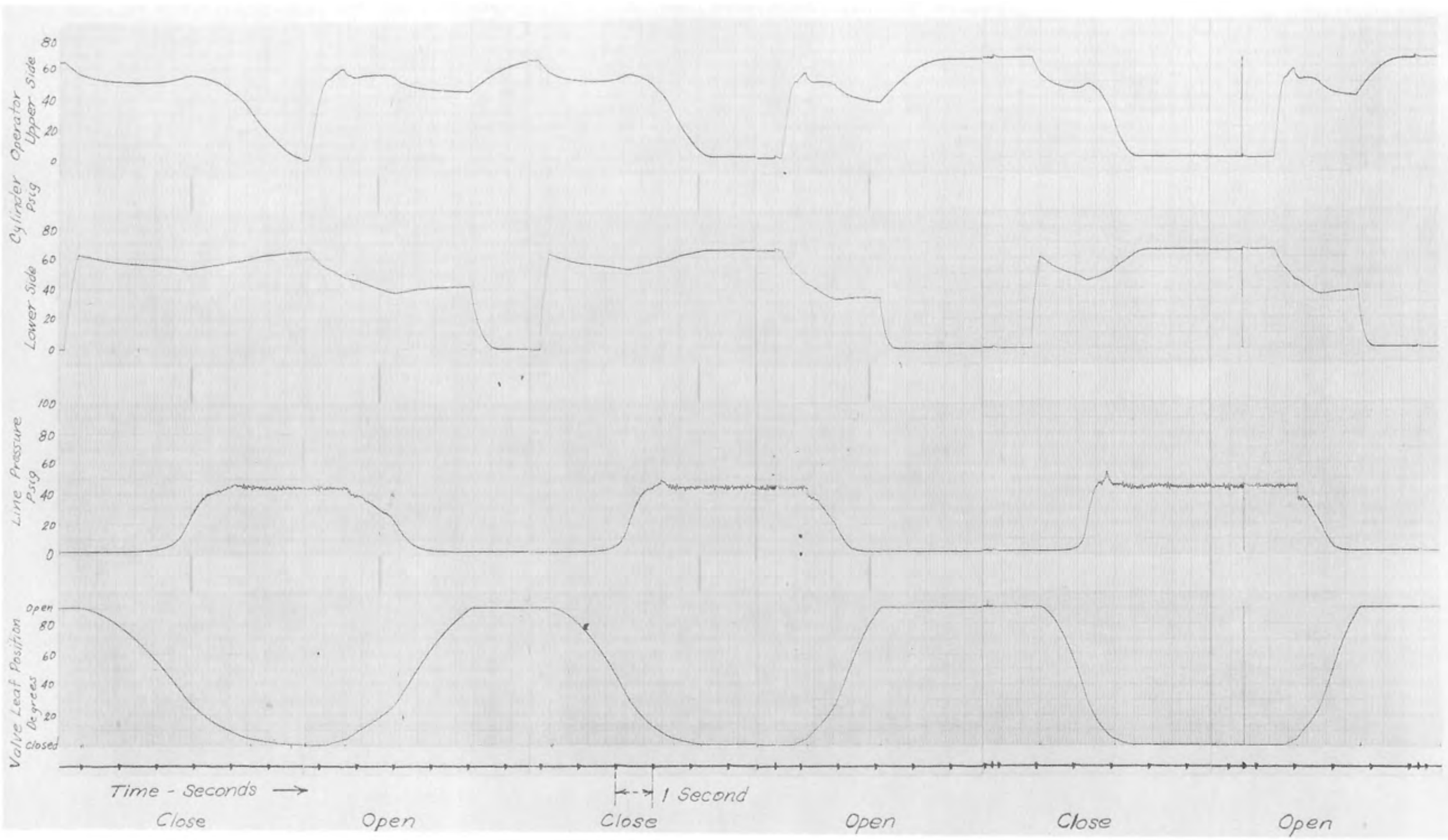


Figure 2D. Dresser valve leaf-seal-seat arrangement. Photo P801-D-74505



Flat Side of Leaf Downstream

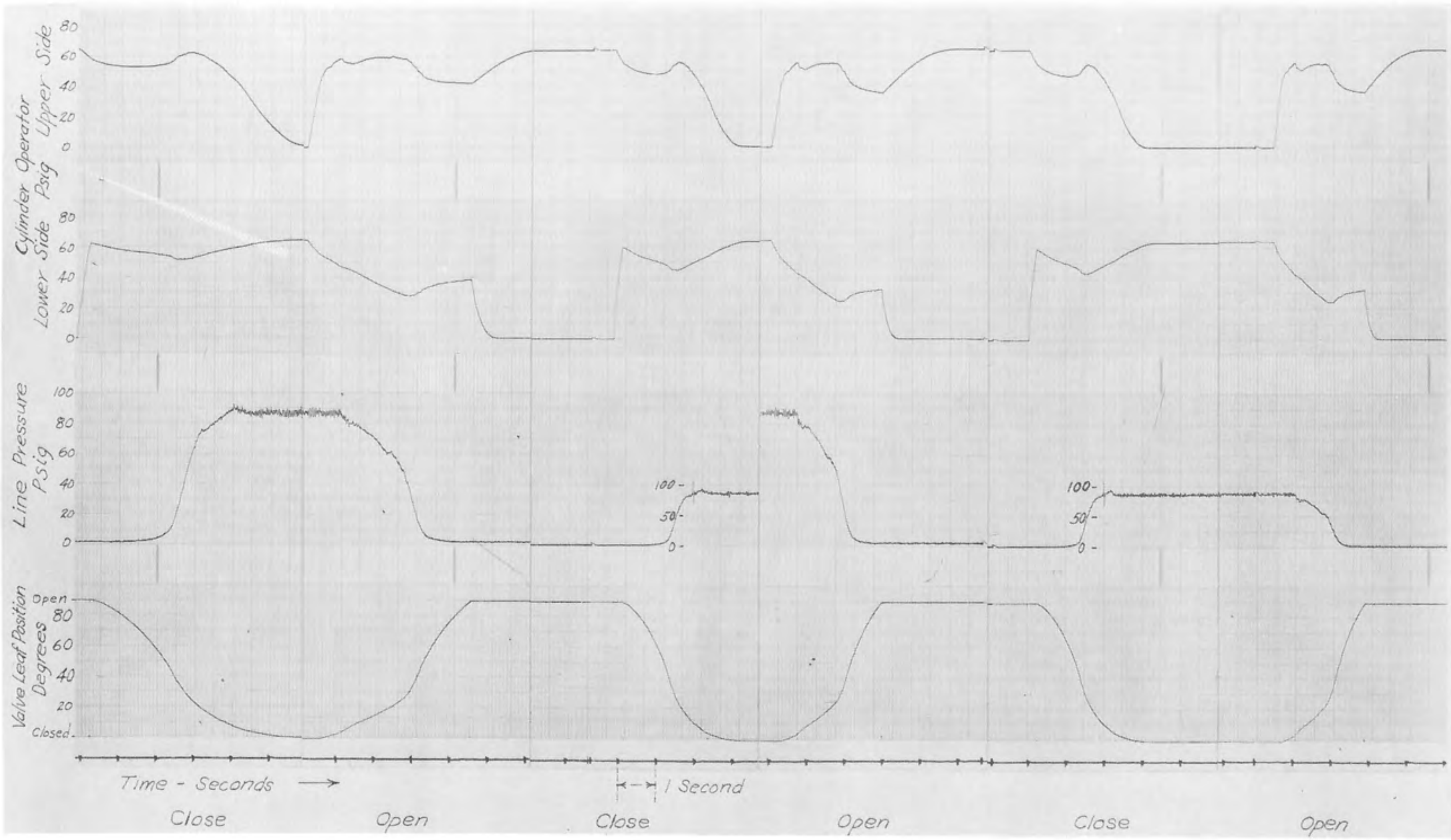
WATER HAMMER TESTS

43.3 psig Shut-off

GRAND COULEE THIRD POWERPLANT - BUTTERFLY VALVE TESTS

DRESSER VALVE

Figure 3D



Flat Side of Leaf Downstream

WATER HAMMER TESTS

86.6 psig Shut-off

GRAND COULEE THIRD POWERPLANT - BUTTERFLY VALVE TESTS

DRESSER VALVE

Figure 4D

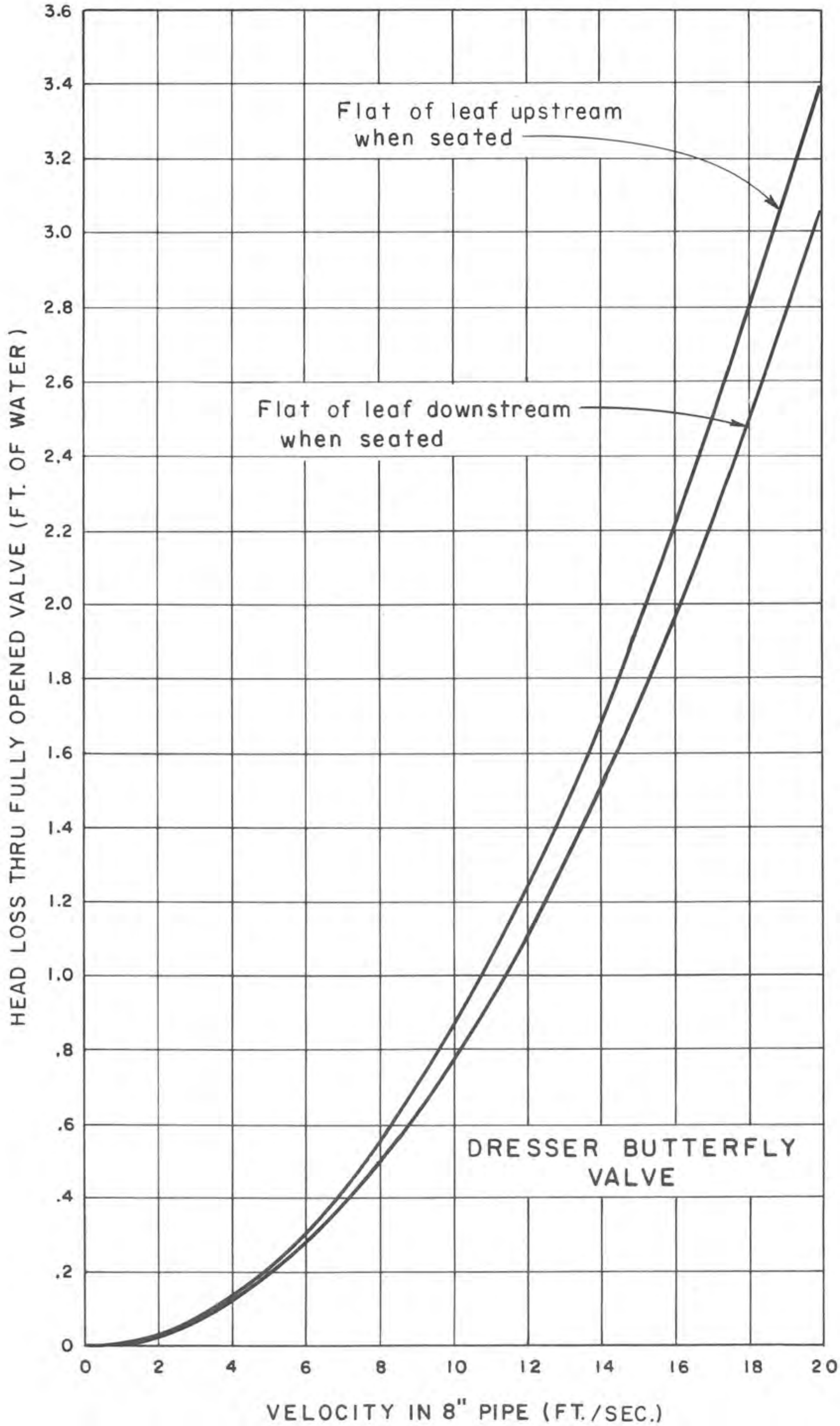
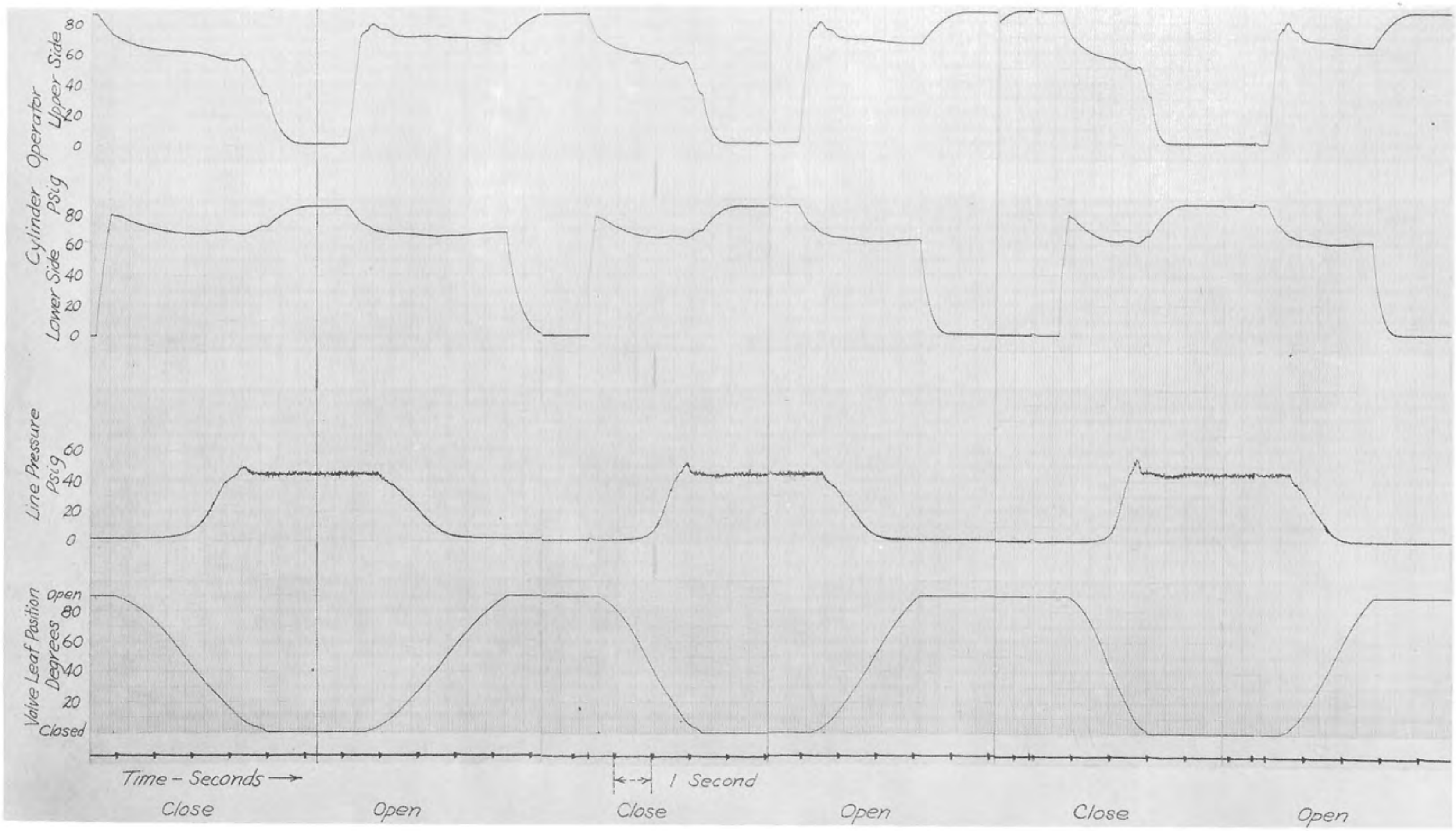


Figure 5D. Head loss through fully opened Dresser valve.



Flat Side of Leaf Upstream

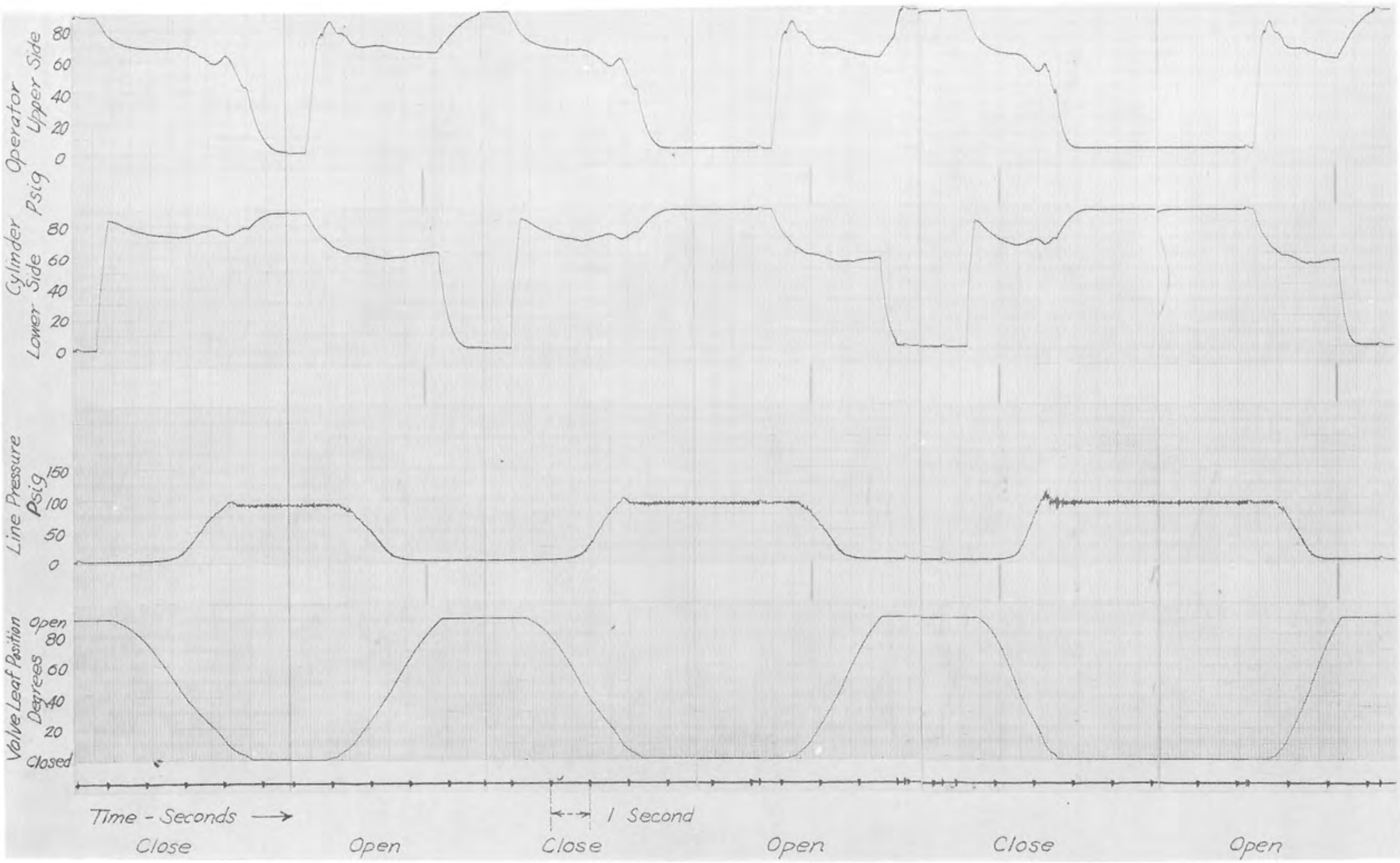
WATER HAMMER TESTS

43.3 psig Shut-off

GRAND COULEE THIRD POWERPLANT - BUTTERFLY VALVE TESTS

DRESSER VALVE

Figure 6D



Flat Side of Leaf Upstream

WATER HAMMER TESTS

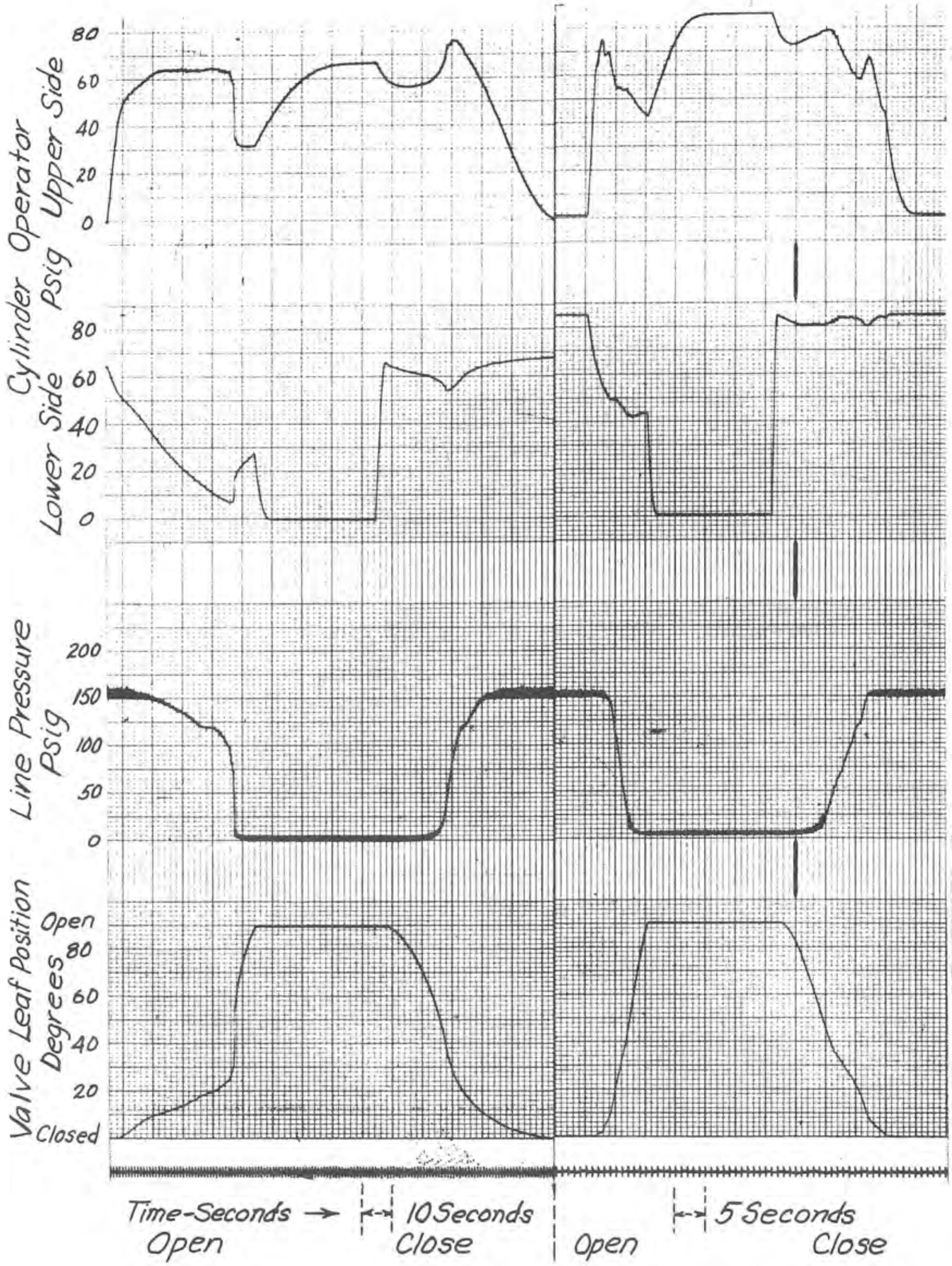
86.6 psig Shut-off

GRAND COULEE THIRD POWERPLANT - BUTTERFLY VALVE TESTS

DRESSER VALVE

Figure 7D

Figure 8D



Leaf Flat Downstream **Leaf Flat Upstream**

Valve Cycled at Line Pressure of 150 psig

GRAND COULEE THIRD POWERPLANT - BUTTERFLY VALVE TESTS

DRESSER VALVE

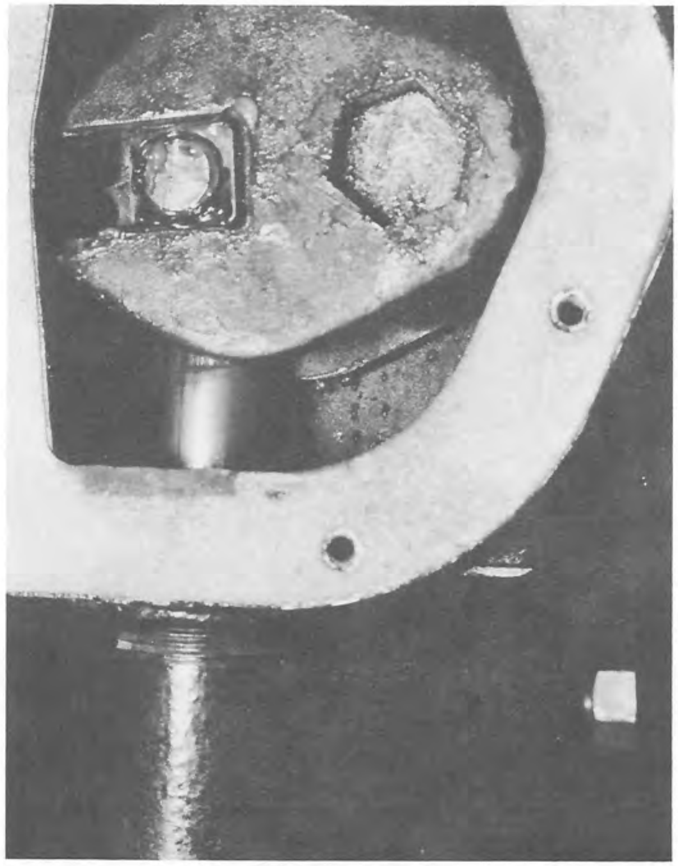


Figure 9D. Shaft seal leak developed from wear due to a metal shaving which was not removed during assembly. Leak occurred only when valve was in an intermediate position. Photo P801-D-74506

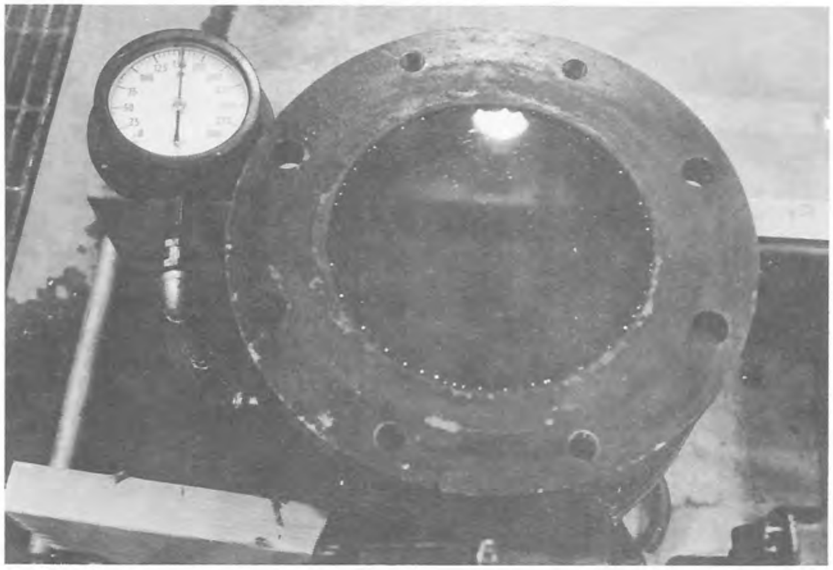


Figure 10D. Bubble tightness tests on Dresser valve after over 4,000 cycles of opening and closing. Air at 154 psig (10.83 kg/cm^2) under leaf. Photo P801-D-74507

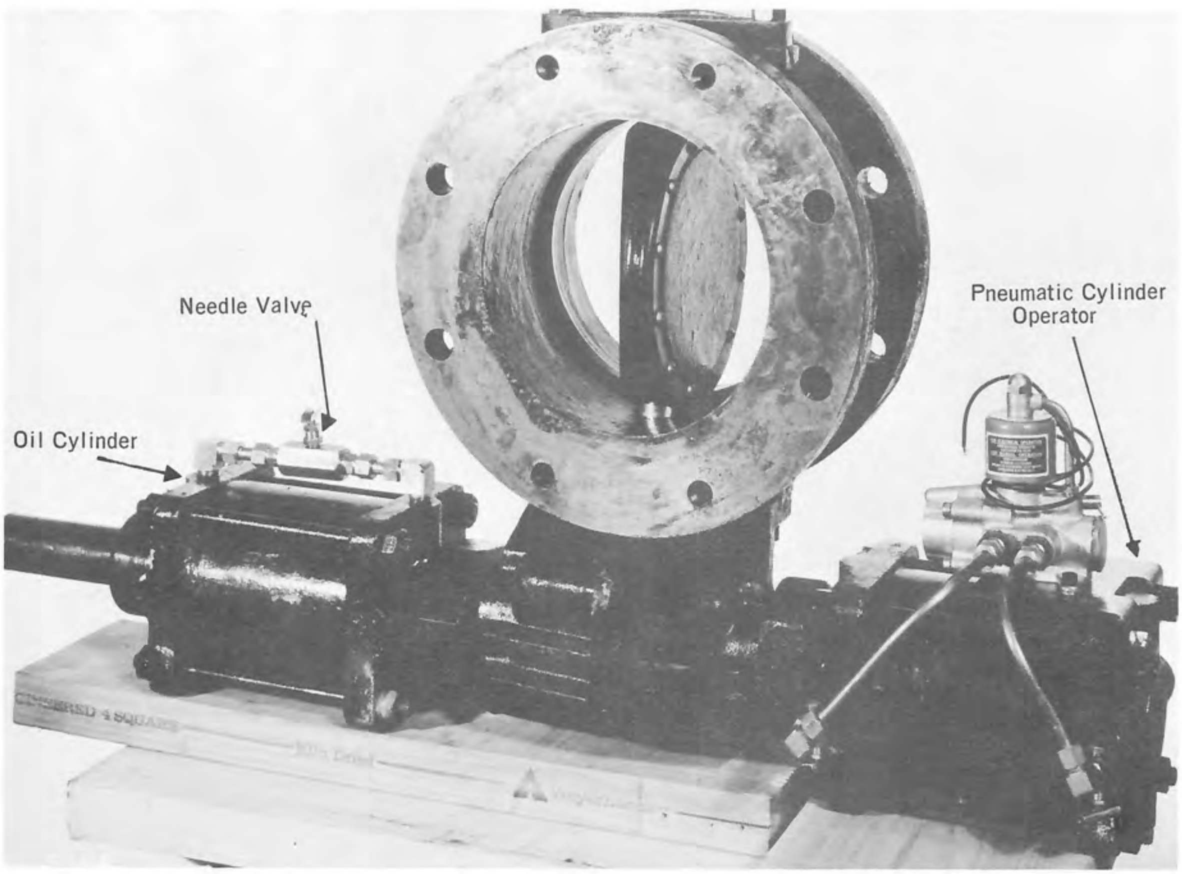
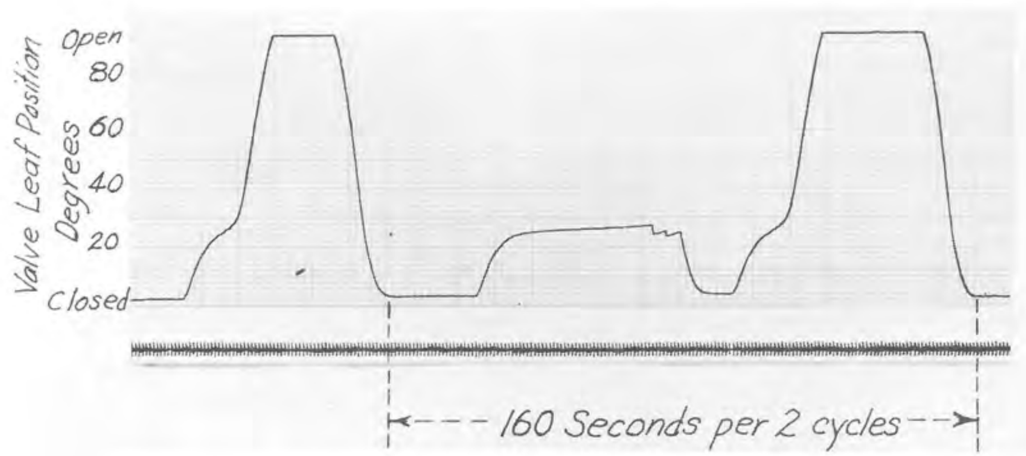


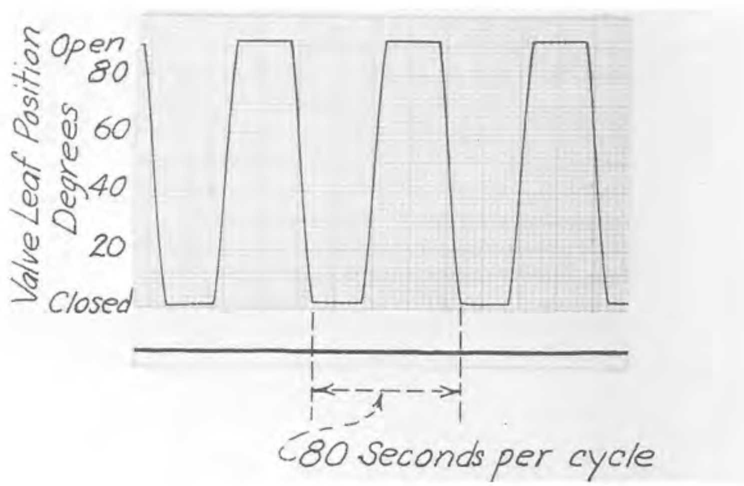
Figure 11D. Double cylindered Dresser valve. Oil cylinder added to eliminate unsteady leaf movement. Photo P801-D-74508

Figure 12D



A. Leaf Flat Downstream

Note leaf failing to completely open on second cycle. Also, note nonuniform travel during opening. Line pressure 150 psig.



B. Leaf Flat Upstream

Note near constant leaf speed. Line pressure - 150 psig.

Comparison of leaf travel with an oil cylinder added to eliminate jerky movement.

GRAND COULEE THIRD POWERPLANT - BUTTERFLY VALVE TESTS

DRESSER VALVE

DRESSER "450" BUTTERFLY VALVES
(4" thru 20" - Class 150B)

Deviations to AWWA Specification #C504-66

A. VALVE SHAFTS

1. SPECIFICATION

Section 7.3 - "Valve shafts shall be securely attached to the valve disc by means of keys, dowel pins, taper pins, or any combination of the three."

Section 7.5 - "All valve shafts shall be of 18-8 stainless steel, Type 302, 303, 304, 316, or Monel. Any deviation from these materials shall be only at the specific request of the purchaser."

2. DRESSER

Uses oversize 304 Stn. Stl. journals on a one-piece, full-size, high-tensile steel hexagon drive shaft, with permanent static rubber seals, to obtain a unique high-strength corrosion-free drive. Line content cannot contact drive shaft or vane interior.

3. CUSTOMER BENEFITS

Entire Dresser drive line is far stronger than AWWA requires:

(a) High-tensile drive shaft has a 45,000-70,000 psi yield point as compared to allowable 35,000.

(b) Dresser hexagon drive eliminates vane (disc) and shaft breakage caused by high stress concentrations at pin holes or keyways.

(c) Dresser shaft extends as one solid piece thru entire valve and operator with no neckdowns.

(d) Dresser uses 40,000 psi minimum tensile cast iron vane with rubber seat, as compared to allowed 25,000 psi minimum tensile Ni-Resist.

(e) Dresser hexagon drive assembly incorporates journals having 304 Stn. Stl. thrust bearing faces to allow valve installation in any position, and to prolong life of rubber seat by positive centering.

B. RUBBER SEATS

1. SPECIFICATION

Section 9.6 - "...The minimum dimensions of rubber seats mounted on the disc (vane) edge shall be (as specified in Table 5):"

Valve Size	Thickness	Radial Width
4" thru 14"	1/4"	1/2"
16" thru 20"	3/8"	3/4"

2. DRESSER

Valve Size	Thickness	Radial Width
4" thru 6"	3/16"	3/4"
8" thru 12"	1/4"	3/4"
14" thru 20"	5/16"	1"

3. CUSTOMER BENEFITS

(a) Dresser seat design was determined by one parameter - performance. For example, a Dresser 6" butterfly valve, under test at 175 psi, exceeded 100,000 cycles without seat leakage. AWWA required only 10,000 leak-free cycles.

(b) Total rubber area of the Dresser seat design exceeds AWWA requirements. The total area is the most meaningful determinant of sealing ability for otherwise similar rubbers.

Valve Size	Minimum Rubber Area Req'd - AWWA	Area, Dresser Rubber
4" thru 6"	1/8 sq.in.	9/64 sq.in.
8" thru 12"	1/8 sq.in.	3/16 sq.in.
14"	1/8 sq.in.	5/16 sq.in.
16" thru 20"	9/32 sq.in.	5/16 sq.in.

(c) Dresser offset seat design offers full circle 360° seating (not penetrated by valve shaft), and low cost, easy replacement if ever required. (Valve need not even be disassembled to replace seat.)

(d) Dresser valve is rated at 175 psi thru 12" size (150 psi above), tight shut-off, rather than the allowed 150 psi, or less.

C. CYLINDER OPERATORS

1. SPECIFICATION

Section 12.5.1 - "Cylinder bodies shall be of a low zinc content...bronze..."

Section 12.5.5 - "Cylinders shall be equipped with a dirt wiper to clean the piston rod before it enters the cylinder."

Section 12.6.1 - "Cylinder bodies shall be of hard-drawn brass or centrifugally-cast bronze..."

Section 12.6.6 - "Cylinders shall be equipped with a dirt wiper to clean the piston rod before it enters the cylinder."

2. DRESSER

(a) Uses one cylinder for all service. The cylinder body (barrel) is made of molybdenum-disulfide lined glass-reinforced epoxy tubing.

(b) Dresser cylinder operators neither use nor require a rod wiper, as our entire operator is totally enclosed. The piston rod is never exposed to outside contaminants.

3. CUSTOMER BENEFITS

(a) Dresser barrel is totally corrosion-free in water service and permanently self-lubricated in air service. Its ultra-smooth surface and inherent lubricity greatly extends the life of the piston cup.

(b) It is obviously far better to totally eliminate exposure to contaminants than it is to wipe the rod clean after such exposure.

(c) Dresser cylinder offers additional benefits of:

(1) Powerful, yet compact, due to big-bore short-stroke design.

(2) Cylinder does not swing, so installation is simplified and rubber hoses are not required.

D. TESTING

1. SPECIFICATION

Section 13.1 - Performance Tests - "Each valve shall be shop-operated three times from the fully-closed to the fully-opened position, and the reverse, under a no-flow condition, to demonstrate that the complete assembly is workable."

Section 13.2 - Leakage Tests - "...With the disc in the closed position, air pressure shall be supplied to the lower face of the disc for the full test duration, as follows:

Class 25A and 25B ------------ 25 psi
Class 75A and 75B ------------ 75 psi
Class 150A and 150B -----------150 psi

...The length of test shall be at least five minutes and there shall be no evidence of leakage past the valve disc (visible in the form of bubbles in the water pool on top of the disc) during the test period. As an alternative to this test procedure, Class 150A and 150B valves may be given a 150 psi hydrostatic test. During this test the valves shall be drop-tight."

Section 13.3 - Hydrostatic Test - "With the valve disc in a slightly open position, internal hydrostatic pressure equivalent to two times the specified shutoff pressure shall be applied to the inside of the valve body of each valve for a period of ten minutes. During the specified hydrostatic test, there shall be no leakage through the metal, the end joints, or the valve shaft seal; nor shall any part be permanently deformed. While undergoing testing, the valve body shall be struck with a hammer several times."

Section 13.4.1 - Proof-of-Design Tests - "One prototype valve of each size and class of a manufacturer's design shall be hydrostatically tested with twice the specified shutoff pressure applied to one side of the disc and zero pressure on the other side. This test is to be made in each direction across the disc. Under this hydrostatic test, the manufacturer may make special provisions to prevent leakage past the seats. No part of the valve or disc shall be permanently deformed by this test."

2. DRESSER

(a) Each valve is shop-operated at least once from the fully-open to the fully-closed position, and the reverse.

(b) Each valve is leak-tested at 175 psi thru 12" size (150 psi above) air-under-water, regardless of customer-specified class, but for a period of 15 seconds minimum.

(c) Each valve is hydrostatically tested at 300 psi across the closed disc regardless of customer-specified class, but for a period of two minutes minimum. We do not "strike the body with a hammer several times".

(d) Note that each and every production valve is given the severe 300 psi hydrostatic test across the closed disc, rather than performing this test only once on a prototype valve, as required by Section 13.4.1.

3. CUSTOMER BENEFITS

(a) Dresser valve and operator is a standardized, thoroughly proven design. One full-operating cycle test of each production assembly proves that that individual unit fully conforms to Dresser Specifications, or the unit is rejected. Operating valve two more times before rejection is unnecessary.

(b) Dresser leak test at 175 psi air for 15 seconds displays any shortcoming by immediate bubbling. A longer test would show nothing more. A valve that doesn't leak under 175 psi air-under-water in 15 seconds will not leak at 150 psi water test, even though the water test be continued for an hour. We consider the Dresser test to be more severe than AWWA requirement.

(c) Dresser hydrostatic test of 300 psi displays any flaw long before two minutes. Valve is not struck with a hammer as no magnitude of forces were specified by AWWA, so this requirement has no effective meaning.

(d) 300 psi hydrostatic test across the disc of every production valve reconfirms inherent ruggedness of the Dresser valve.

E. PAINTING

1. SPECIFICATION

Section 16 - "Unless otherwise specified by the purchaser, all interior and exterior steel or cast-iron surfaces of each valve, except finished or bearing surfaces, shall be shop-painted with two coats of zinc-chromate, conforming to Federal Specification TT-P-645; or, in the case of valves for buried service, with two coats of asphalt varnish conforming to Federal Specification TT-V-51c."

2. DRESSER

All valves are coated with asphalt varnish conforming to Federal Specification TT-V-51c prior to assembly, and after assembly spray-coated with black enamel.

3. CUSTOMER BENEFITS

Dresser paint system protects all valves with asphalt varnish and then gives them a hard enamel topcoat. This system allows customer painting after installation for all in-plant valves.

II. ALLIS-CHALMERS VALVE SECTION

GENERAL DESCRIPTION OF ALLIS-CHALMERS VALVE

The Allis-Chalmers valve (Figure 1-AC) was a wafer design with attached cylinder operator. The valve required mounting between 150-pound flanges. A continuous rubber seal seat was contained in the valve body. The butterfly leaf (disk) was an unsymmetrical shape, with one side flat and the other raised over the shaft area (offset disk) (Figure 2-AC). The operator was attached through a lever arm to the butterfly leaf shaft. During installation, care was required to insure adequate clearance between the valve and adjacent equipment for movement of the operator and shaft lever. A four-way ASCO solenoid valve and two micrometer adjustable needle valves controlled airflow for the 3 x 12-inch (7.6 x 30.5-cm) cylinder operator. A position indicator was indexed at open and shut positions. The valve was actuated by unbalanced pressure on the cylinder operator.

ALLIS-CHALMERS VALVE - Phase I

1. The Allis-Chalmers valve was photographed, inspected, and found to be in good working order.

2. The valve was placed on the test rack and left for 30 days in the closed position with 70-90-psig air on the cylinder operator (solenoid deenergized).

3. The valve was again photographed and inspected. No permanent set or damage was observed as a result of the closed and dry test.

4. The valve was mounted on an 8-inch pipe section supplied by a 1-1/2-inch shop air line. The leaf flat was placed on the upstream side (shaft downstream).

5. Shutoff tests with atmospheric air on one side of the leaf and 75 psig air on the other were made on the valve. The cylinder operator was supplied with 75 psig air to control the leaf. No leakage was observed around the seat when brushed with a soap solution.

6. The valve was subjected to 1,000 cycles of opening and closing. The valve operation appeared very rough. The leaf moved away from the seat in jerky fashion causing an explosive sound.

7. At the completion of the cycling tests, the valve was again checked for tightness with soap solution. Air pressures were maintained as in Step 5. No leaks were found.

The overall performance of the valve for these tests was marginal. Very poor control of the leaf results when movement is jerky. The seal, however, appeared to be excellent from a tightness standpoint. When considering the Allis-Chalmers valve for control, the effects of lack of uniformity of travel should be evaluated. For on-off service (guard valve), satisfactory performance should result.

ALLIS-CHALMERS VALVE - Phase II

(Water in Contact with Valve Leaf)

(a) Flat of leaf facing upstream when closed

1. The Allis-Chalmers valve was bolted to an 8-inch pipe section on the laboratory high head test facility. A separate flange was added on the downstream side so that the valve could be held in place while the downstream side was exposed for observing any leakage.

2. Shutoff tests were performed on the valve for three water pressures (43.3, 86.6, and 150 psig with 70 psig (4.92 Kg/cm^2)) on the cylinder operator. Each test lasted 45 minutes. The results were:

43.3 psig - No leakage
86.6 psig - No leakage
150 psig - No leakage

3. After removing the flange and connecting downstream piping, the valve was cycled 500 times with a shutoff pressure of 43.3 psig.

Eighty seconds were required for a complete cycle. The solenoid was alternately energized for 40 seconds and deenergized for 40 seconds. The type of control which resulted can be generalized from Figure 3-AC. For an opening cycle approximately 10 percent of the total travel time resulted in nearly 40 percent of the leaf movement, with the remaining 90 percent of the travel time required for the remaining 60 percent of leaf movement.

4. Shutoff tests following 500 cycles of opening and closing at 43.3 psig were performed on the valve for water pressures of 43.3, 86.6, and 150 psig with 76 psig (5.34 Kg/cm^2) air on the cylinder operator. Each test lasted 45 minutes. The results were:

43.3 psig - No leakage

86.6 psig - No leakage

150 psig - No leakage

5. The valve was cycled 500 times with a shutoff pressure of 86.6 psig. The valve performance for these tests remained similar to that of Step 3.

6. Shutoff tests following 500 cycles of opening and closing at 86.6 psig were performed. Again each test lasted 45 minutes. The results were:

43.3 psig - No leakage

86.6 psig - No leakage

150 psig - No leakage

7. The valve was cycled 500 times with a shutoff pressure of 150 psig. The valve performance again remained as in Step 3.

8. Shutoff tests following 500 cycles of opening and closing at 150 psig were performed on the valve. The results were:

43.3 psig - No leakage

86.6 psig - No leakage

150 psig - No leakage

9. Water hammer tests were performed on the valve at shutoff pressures of 43.3 and 86.6 psig. Portions of the oscillograph charts are shown in Figures 3-AC and 4-AC for shutoff pressures of 43.3 and 86.6 psig respectively.

10. Head losses for the fully opened valve were obtained for a wide range of line velocities. These losses are shown in Figure 5-AC. Curve A was obtained with the valve positioned so that the flat of the leaf was facing upstream when seated. Curve B was obtained when the valve was turned end for end.

ALLIS-CHALMERS VALVE - Phase II

(Water in Contact with Valve Leaf)

(b) Flat of leaf facing downstream when closed

A complete series of tests consisting of 500 cycles of opening and closing at pressures of 43.3, 86.6, and 150 psig were performed on the valve. Following each cycling test, shutoff tests were performed. No leakage was noted during any of the shutoff tests.

Leaf travel and valve action were very similar to what had been noted when the valve was oriented with the flat of the leaf upsteam. Also, as before, there are areas where the valve leaf is not well controlled. These critical areas can be seen in Figures 6-AC and 7-AC which show water hammer tests for the valve at 43.3 and 86.6 psig and in Figure 8-AC which shows the results of the valve operating with a shutoff head of 150 psig with the flat of the leaf both upstream and downstream when seated.

Bubble tightness tests were performed after 4,000 cycles of opening and closing. The seal and seat were absolutely bubble tight at pressures of 150 psig (Figure 9-AC). The cylinder operator pressure was maintained at 76 psig (5.34 Kg/cm^2) for the tightness tests.

SUMMARY

The control problems encountered with the Allis-Chalmers valve existed whether the valve was being closed or opened, whether the leaf movement was rapid or slow, and whether the valve was placed in the line with the flat at the leaf upstream or downstream when seated. The seal appeared to be excellent. The control problems could be minimized by providing a larger diameter cylinder operator on the valve or by switching from air to water as the control media. No deviations from Specifications AWWA C504-66 were listed by Allis-Chalmers for their valve.

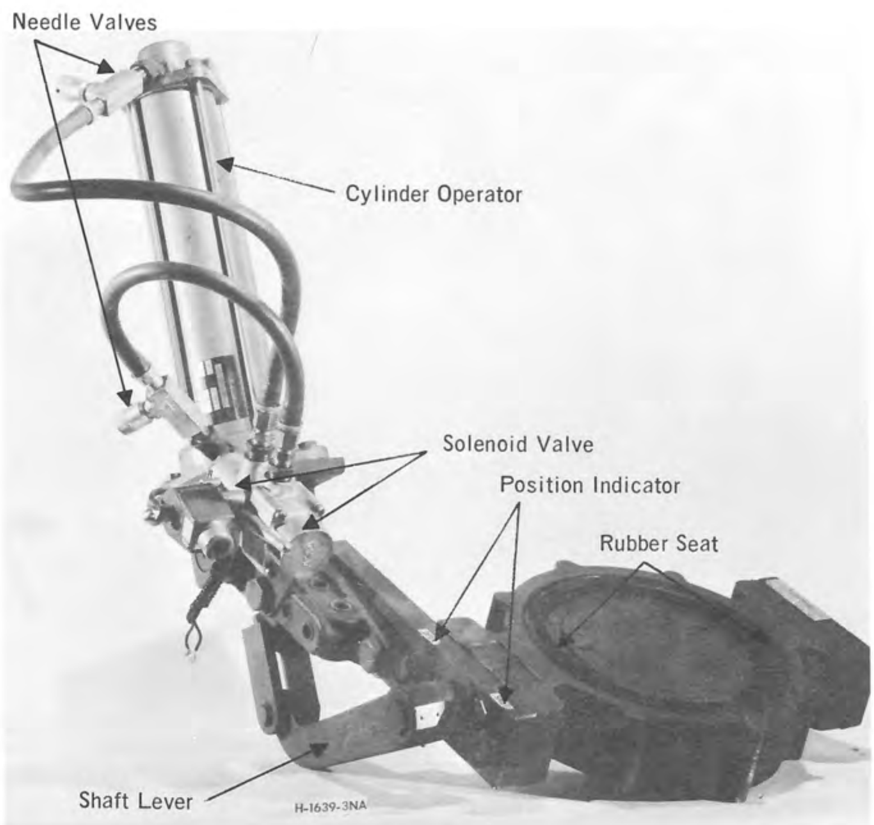


Figure 1AC. Allis-Chalmers wafer-type butterfly valve. Flat side of leaf is up. Photo P801-D-74509

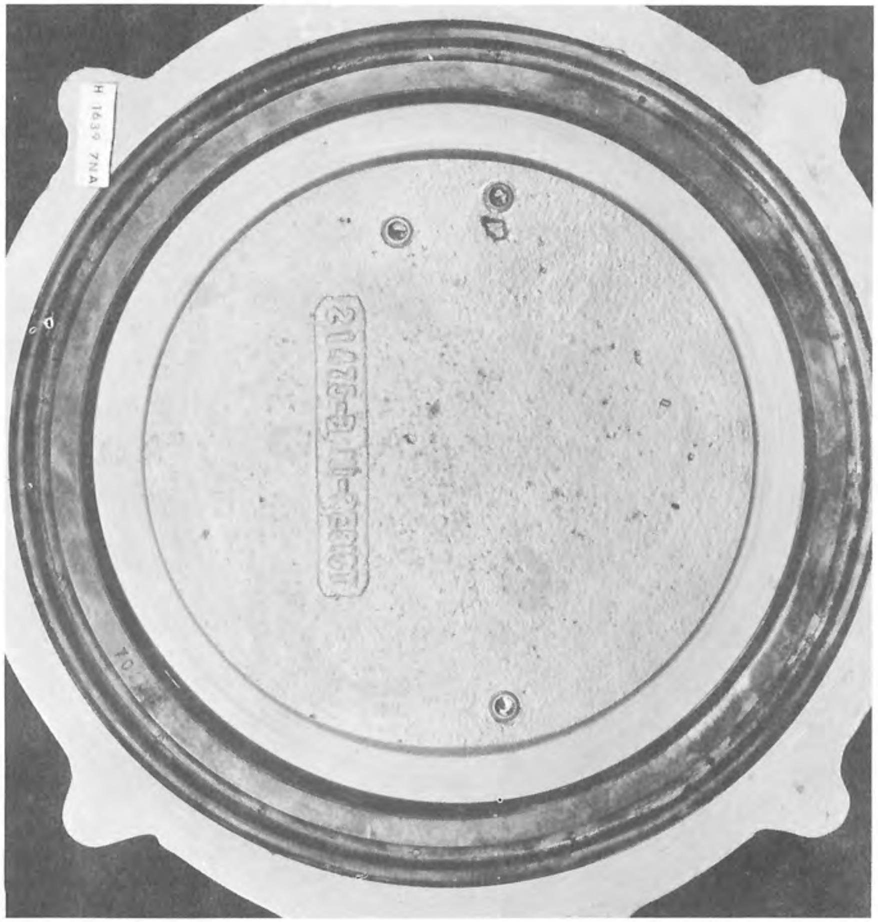


Figure 2AC-A. Flat side of leaf (seal side) of Allis-Chalmers valve. Photo P801-D-74510

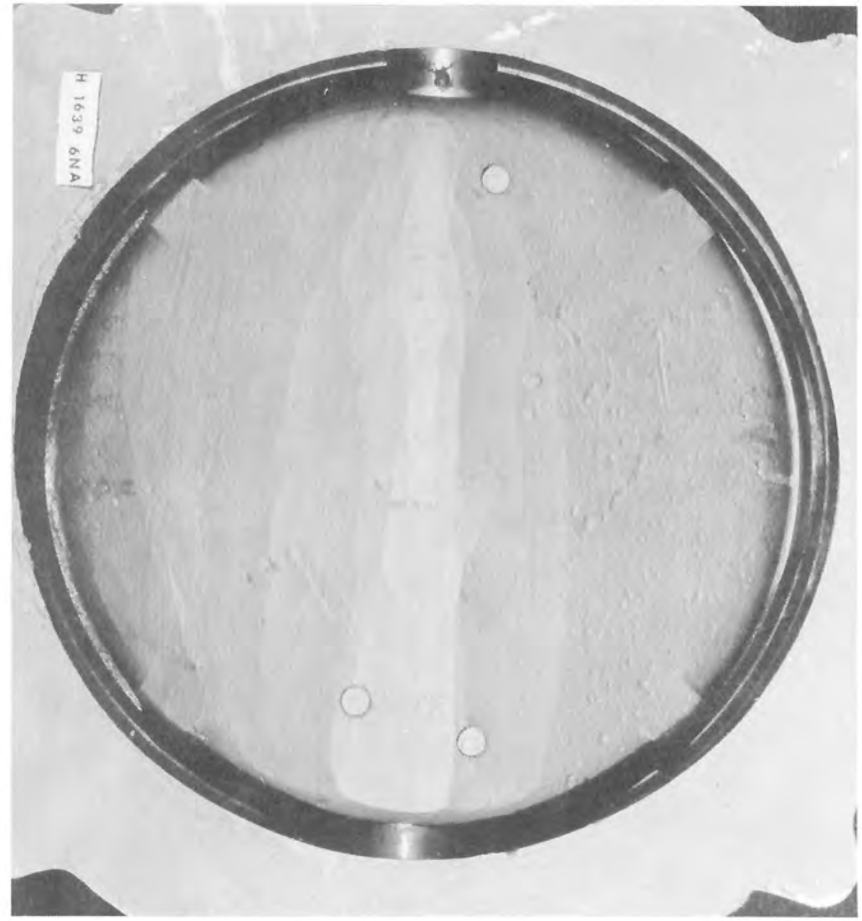
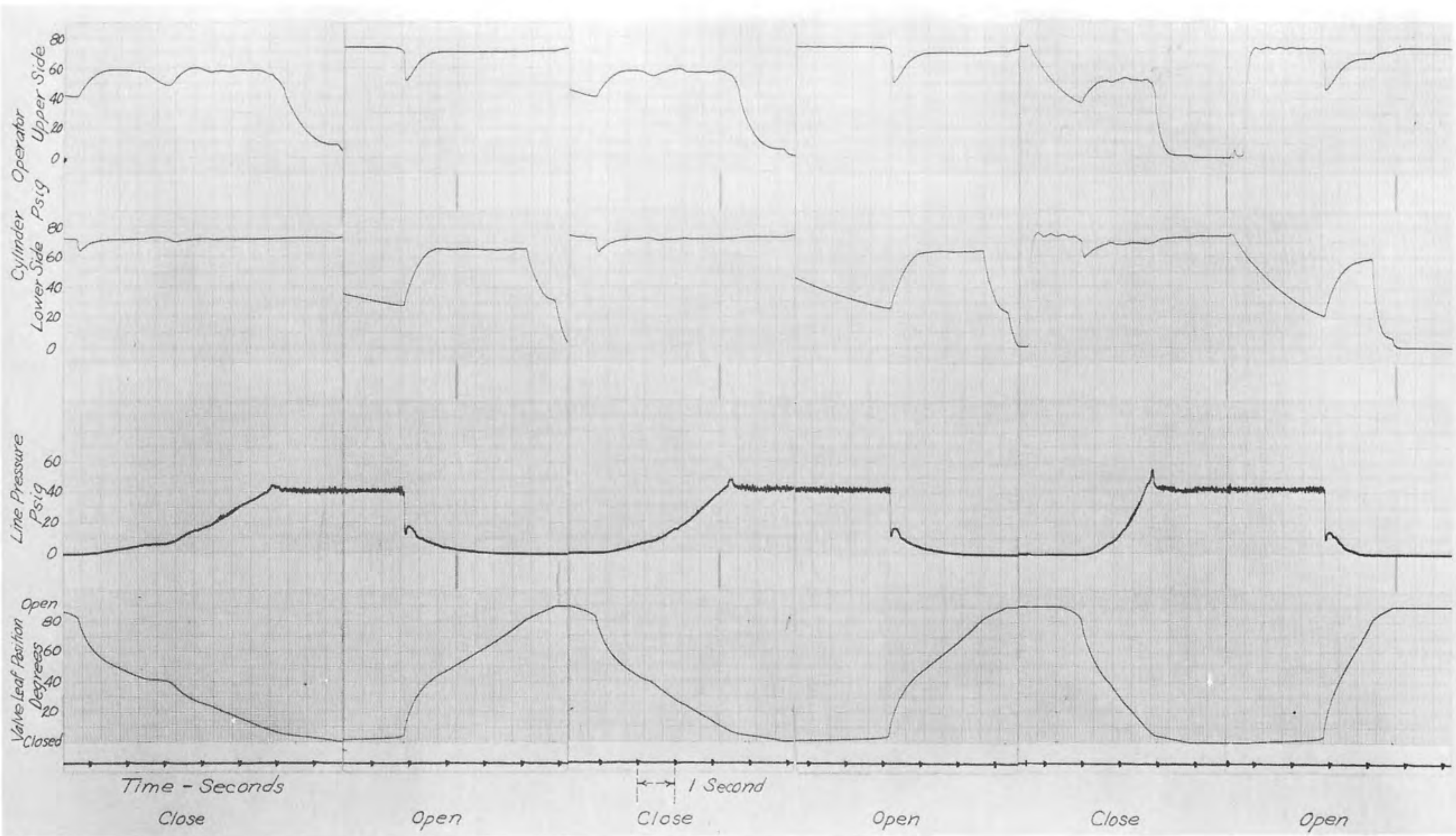


Figure 2AC-B. Shaft side of leaf (off-set side) of Allis-Chalmers valve. Photo P801-D-74511



Flat Side of Leaf Upstream

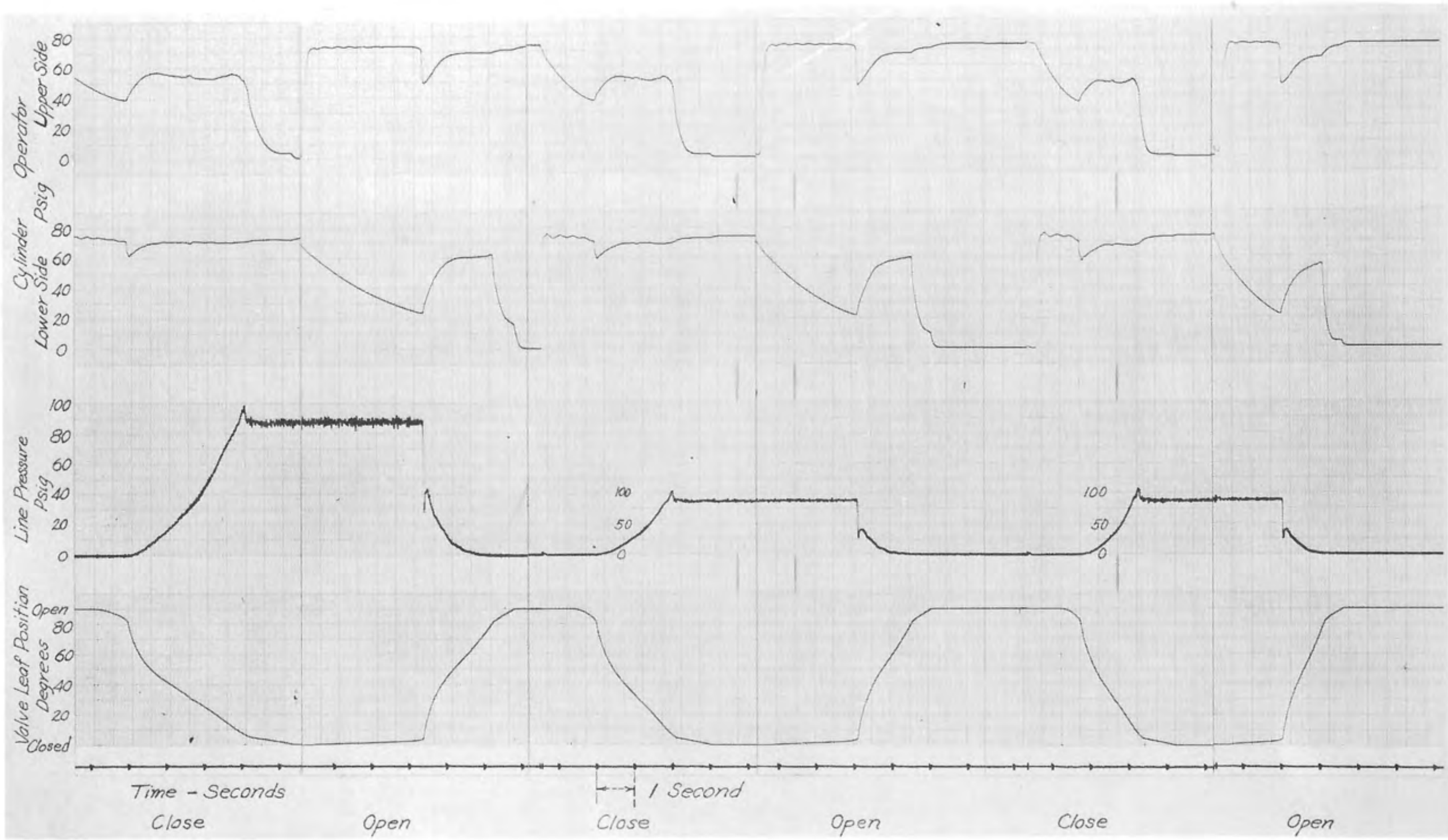
WATER HAMMER TESTS

43.3 psig Shut-off

GRAND COULEE THIRD POWERPLANT - BUTTERFLY VALVE TESTS

ALLIS-CHALMERS VALVE

Figure 3AC



Flat Side of Leaf Upstream

WATER HAMMER TESTS

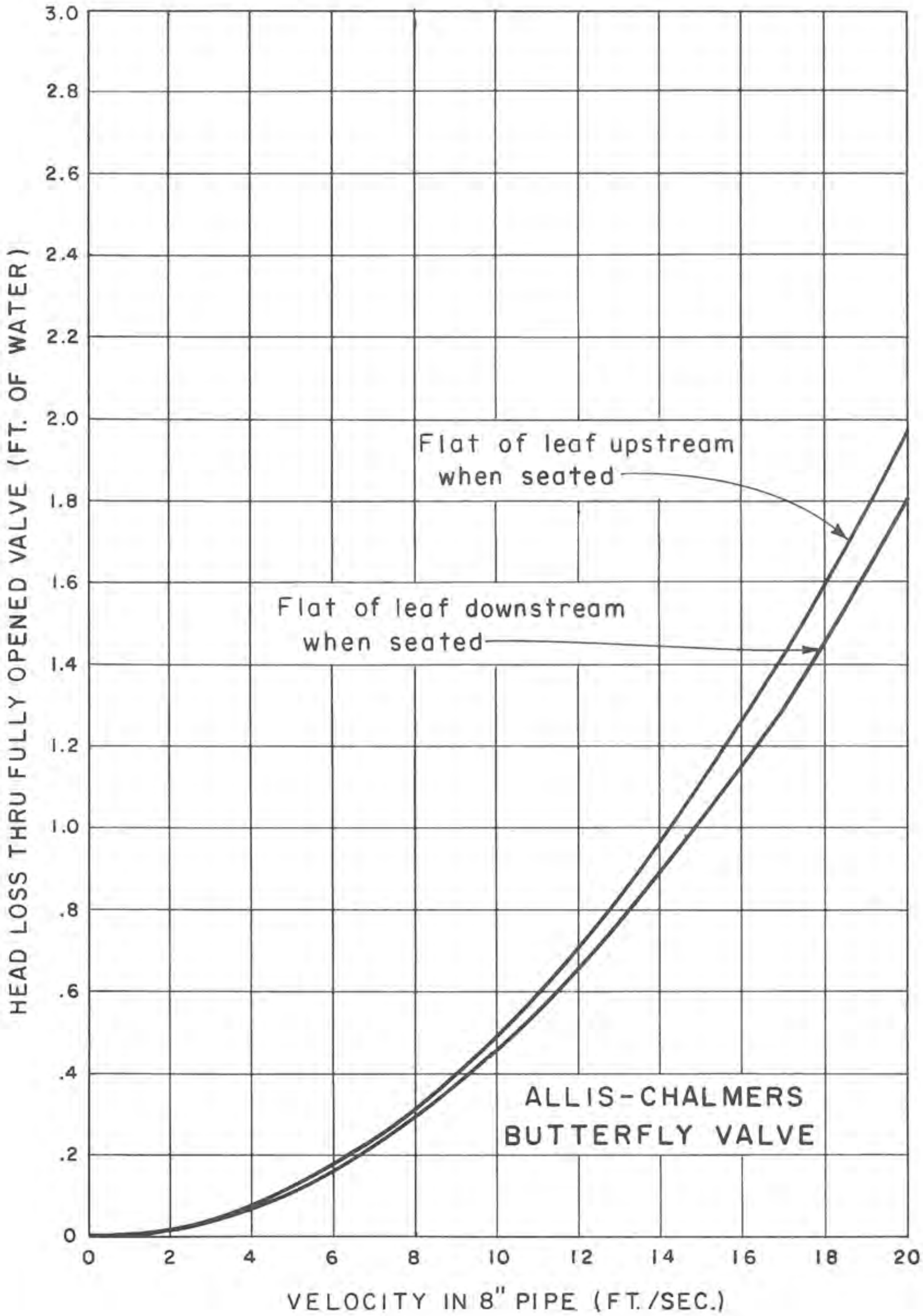
86.6 psig Shut-off

GRAND COULEE THIRD POWERPLANT - BUTTERFLY VALVE TESTS

ALLIS-CHALMERS VALVE

Figure 4AC

Figure 5AC



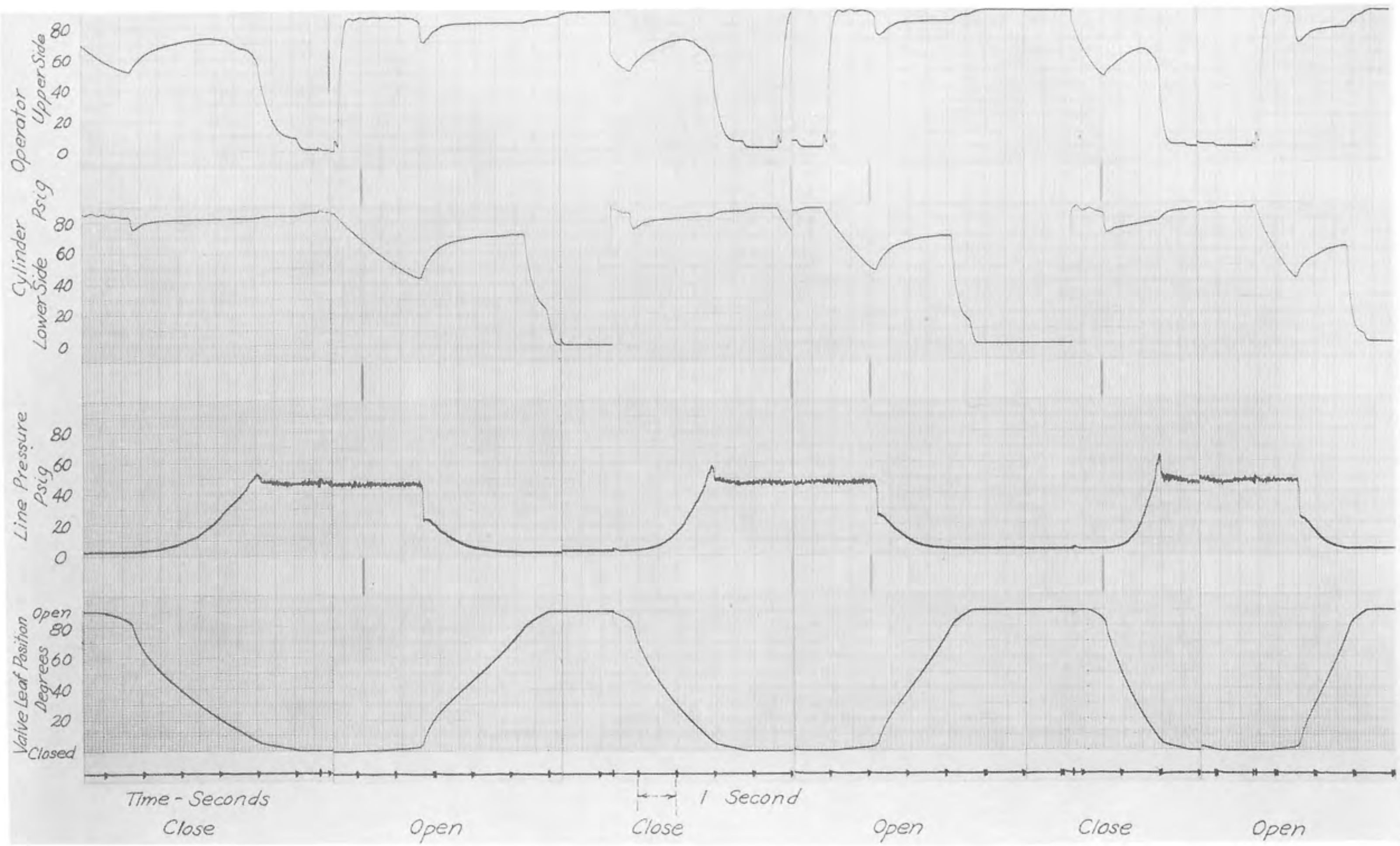
Flat Side of Leaf Downstream

WATER HAMMER TESTS

43.3 psig Shut-off

GRAND COULEE THIRD POWERPLANT - BUTTERFLY VALVE TESTS

ALLIS-CHALMERS VALVE



Flat Side of Leaf Downstream

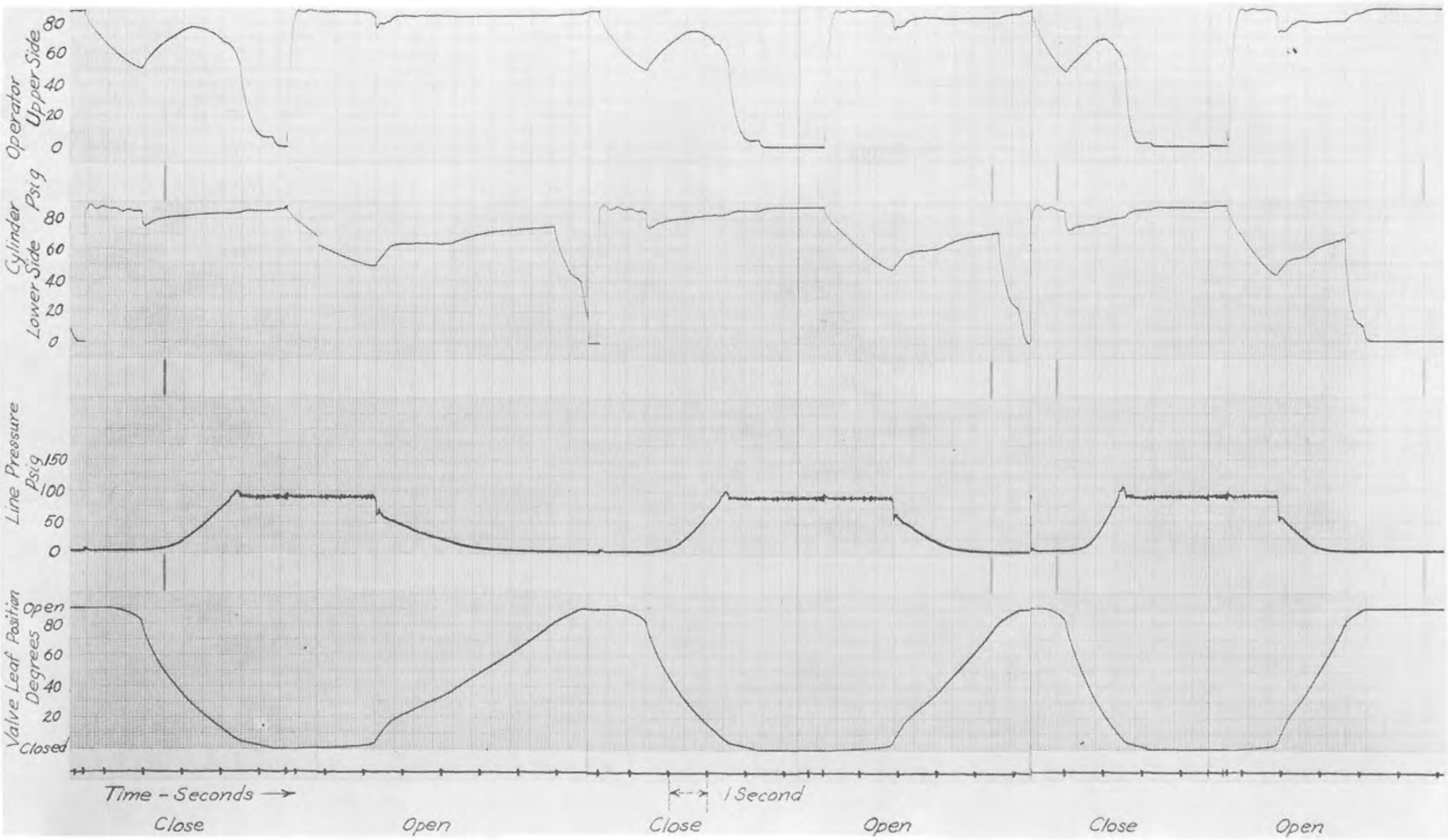
WATER HAMMER TESTS

43.3 psig Shut-off

GRAND COULEE THIRD POWERPLANT - BUTTERFLY VALVE TESTS

ALLIS-CHALMERS VALVE

Figure 6AC



Flat Side of Leaf Downstream

WATER HAMMER TESTS

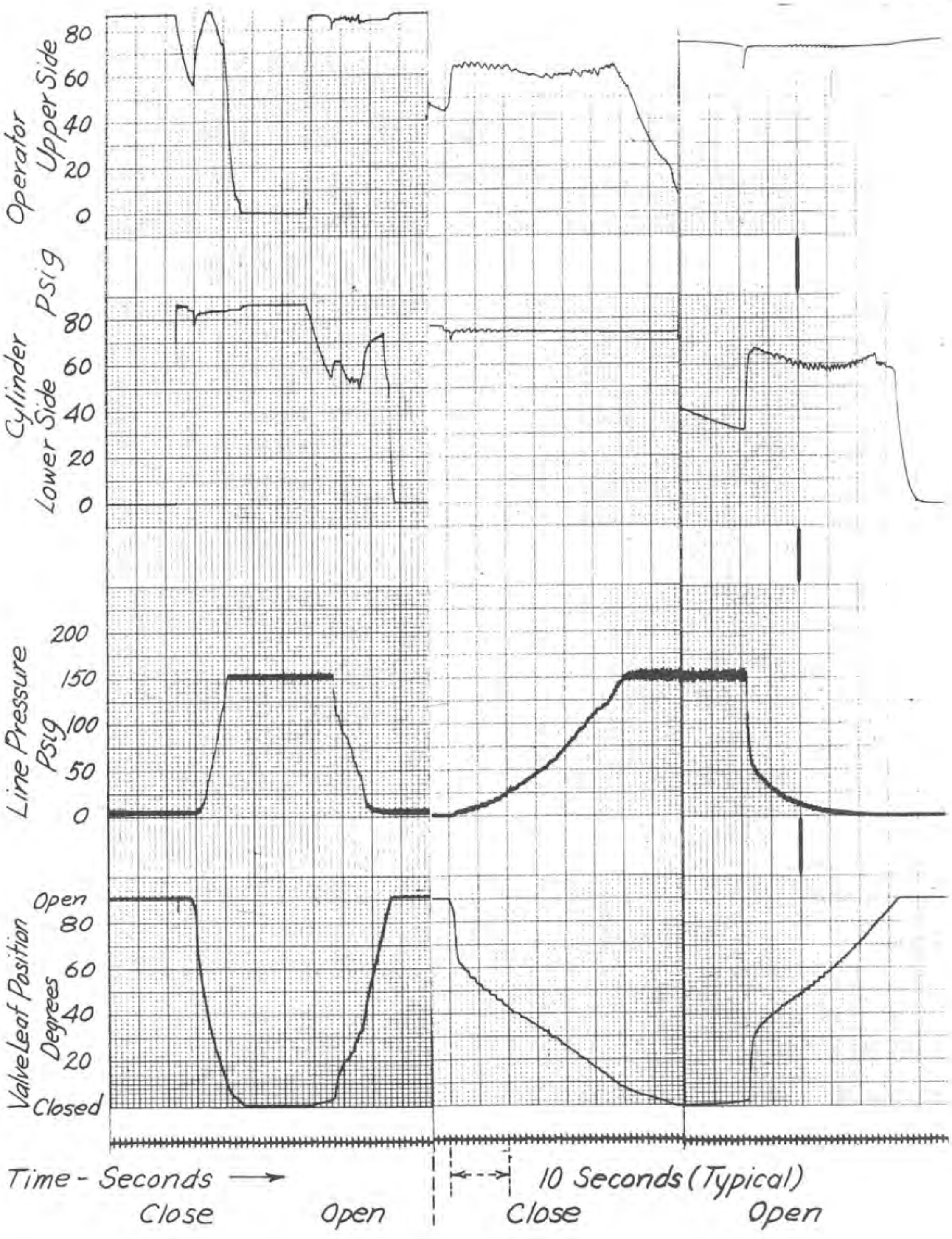
86.6 psig Shut-off

GRAND COULEE THIRD POWERPLANT - BUTTERFLY VALVE TESTS

ALLIS-CHALMERS VALVE

Figure 7AC

Figure 8AC



Leaf Flat Downstream **Leaf Flat Upstream**

Valve Cycled at Line Pressure of 150 psig

GRAND COULEE THIRD POWERPLANT - BUTTERFLY VALVE TESTS

ALLIS-CHALMERS VALVE

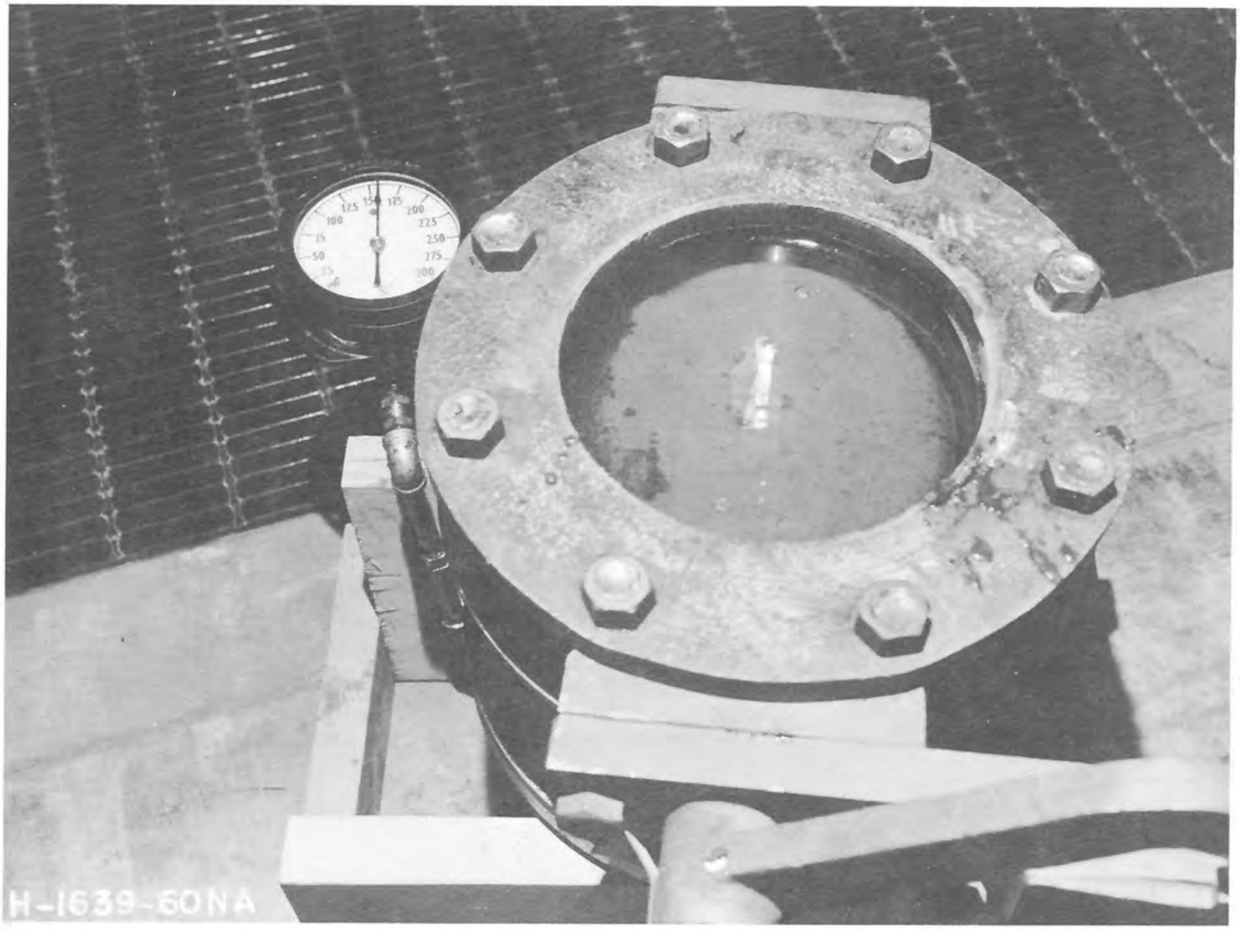


Figure 9AC. Bubble tightness tests on Allis-Chalmers valve after 4,000 cycles of opening and closing. Air at 156 psig (10.97 kg/cm^2) under the leaf. Photo P801-D-74512

II. CRANE VALVE SECTION

GENERAL DESCRIPTION OF CRANE VALVE

The Crane valve was a wafer design with attached cylinder operator (Figure 1-CR). The valve body was tapped for bolting between 150-pound flanges. The leaf (disk) was a modified lenticular shape and sealed on a continuous rubber seat bonded to the valve body.

The valve was opened or closed by unbalanced pressure on the cylinder operator. The cylinder operator pivoted as the valve was opened or closed. Clearance to accommodate this movement must be provided in the installation. Also, precautions must be taken so that a safety hazard is not created by the cylinder operator movement.

CRANE VALVE - Phase I

1. The Crane valve was photographed, inspected, and found to be in good working order.

2. The valve was placed on the test rack and left for 30 days in the closed position with 70-90-psig air on the cylinder operator.

3. The valve was again photographed and inspected. No permanent set or damage was observed as a result of the closed and dry test.

4. The valve was mounted on an 8-inch pipe section supplied by a 1-1/2-inch shop air line.

5. Shutoff tests with atmospheric air on one side of the leaf and 75 psig air on the other were made. The cylinder operator was supplied with 75 psig air to control the leaf. No leakage was observed around the seat.

6. The valve was subjected to 1,000 cycles of opening and closing. The valve operation appeared to be rather jerky when seating or unseating the leaf, resulting in an explosive sounding decompression. After about 300 cycles of opening and closing the rubber seat began to show signs of wear from contact with the roughly machined leaf edges (Figure 2-CR).

7. At the completion of the cycling tests, the valve was tested for tightness with a soap solution. Air pressure was maintained as in Step 5. No leaks were found.

The overall performance of the Crane valve for these tests was satisfactory although leaf movement was rather jerky, the valve sealed tightly against air at a pressure of 75 psig after 1,000 cycles of opening and closing.

CRANE VALVE - Phase II
(Water in Contact with Valve Leaf)

1. The Crane valve was bolted to an 8-inch pipe section on the laboratory high head test facility. A separate flange was added on the downstream end so that the rubber seat was adequately compressed while exposing the downstream side of the leaf for observing any leakage.

2. Shutoff tests were performed on the valve for three water pressures (43.3, 86.6, and 150 psig) with 70 psig (4.92 Kg/cm^2) air on the cylinder operator. Each test lasted 45 minutes. Results were:

43.3 psig - No leakage

86.6 psig - No leakage

150 psig - Dampness noted around the lower portion of the leaf. No measurable leakage in 45 minutes of operation.

3. After removing the downstream flange and connecting downstream piping, the valve was cycled 500 times with a shutoff pressure of 43.3 psig. The type of control which resulted can be generalized from Figure 3-CR. A rapid change in valve position results when the pressurized fully-closed leaf moves off the seat. This results in poor control when the leaf is near the seat.

4. Shutoff tests following the 500 cycles of opening and closing at 43.3 psig were performed on the valve for water pressures of 43.3, 86.6, and 150 psig, with 76 psig (5.34 Kg/cm^2) air on the cylinder operator. Each test lasted 45 minutes. Results were:

43.3 psig - No leakage
86.6 psig - No leakage
150 psig - 0.008 ml/sec

5. The valve was cycled 500 times with a shutoff pressure of 86.6 psig. The valve performance for these tests remained similar to that of Step 3.

6. Shutoff tests following 500 cycles of opening and closing at 86.6 psig (6.09 Kg/cm^2) were performed. Again each test lasted 45 minutes. The results were:

43.3 psig - 0.028 ml/sec
86.6 psig - 0.114 ml/sec
150 psig - 0.657 ml/sec

All leakage appeared to be coming from the shaft seal on the side nearest the cylinder operator.

7. The valve was cycled 500 times with a shutoff pressure of 150 psig. The valve performance again remained essentially as in Step 3.

8. Shutoff tests following 500 cycles of opening and closing at 150 psig were performed on the valve. The results were:

43.3 psig - No measurable leakage

86.6 psig - 0.078 ml/sec

150 psig - 0.643 ml/sec

Maximum leakage was very nearly the same as in pervious run. Reduced leakage at lower two pressures cannot be accounted for. Heaviest leakage occurred on the operator side of shaft seal with a lighter amount on the opposite side.

9. Water hammer tests were performed on the valve at shutoff pressures of 43.3 and 86.6 psig. Portions of the oscillograph charts are shown in Figures 3-CR and 4-CR for the respective tests.

10. Head losses for the fully opened Crane valve were obtained for a wide range of line velocities. These losses are shown in Figure 5-CR.

Bubble tightness tests were performed on the valve after 2,500 cycles of opening and closing (Figure 6-CR). A large amount of air leaked from around the shaft seal closest to the cylinder operator with a lesser amount coming from the opposite side. As seen in Figure 6-CR, leakage began with about 12 psig air in the lower pipe section and increased as the pressure was raised to higher levels. The leakage was apparently due to wear resulting from movement of the leaf hub against the rubber seat adjacent to the hub in the valve body.

SUMMARY

The control problems encountered with the Crane valve were not severe when the valve was being closed; however, when opening, the lack of leaf control could produce severe pressure conditions in some pipelines. Also, as the seal is not bubble tight, the valve does not appear suited to guard gate service. No deviations from AWWA Specification C504-66 were received in the laboratory regarding the Crane valve.

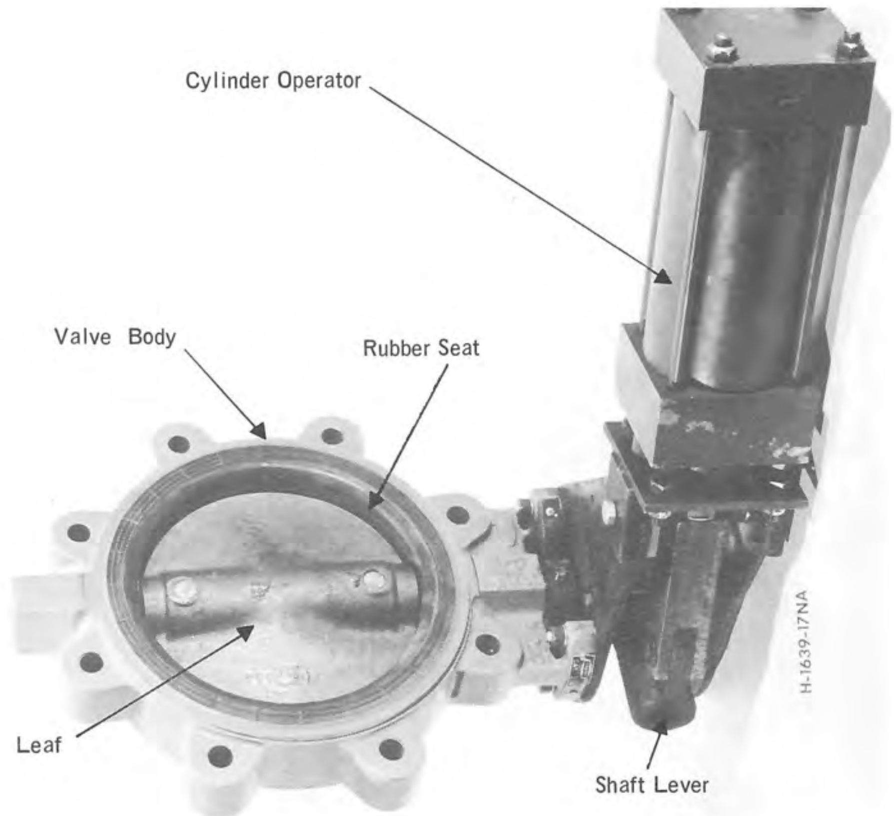


Figure 1CR. Crane wafer-type butterfly valve. Photo P801-D-74513

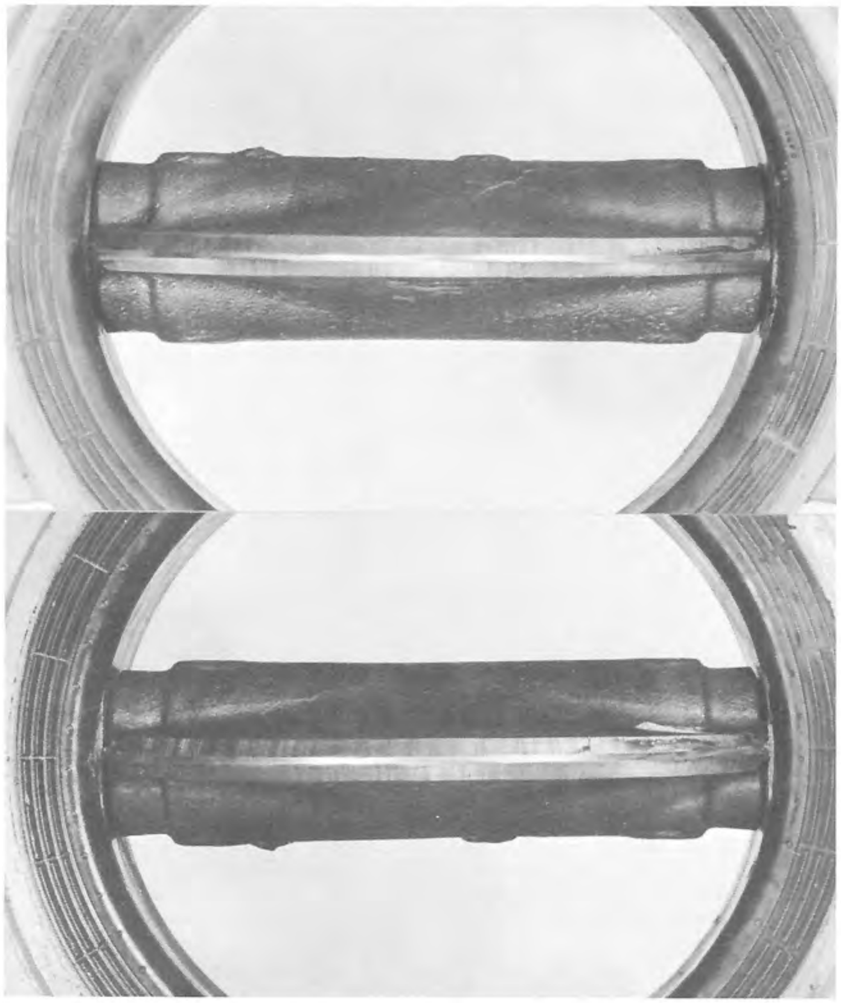
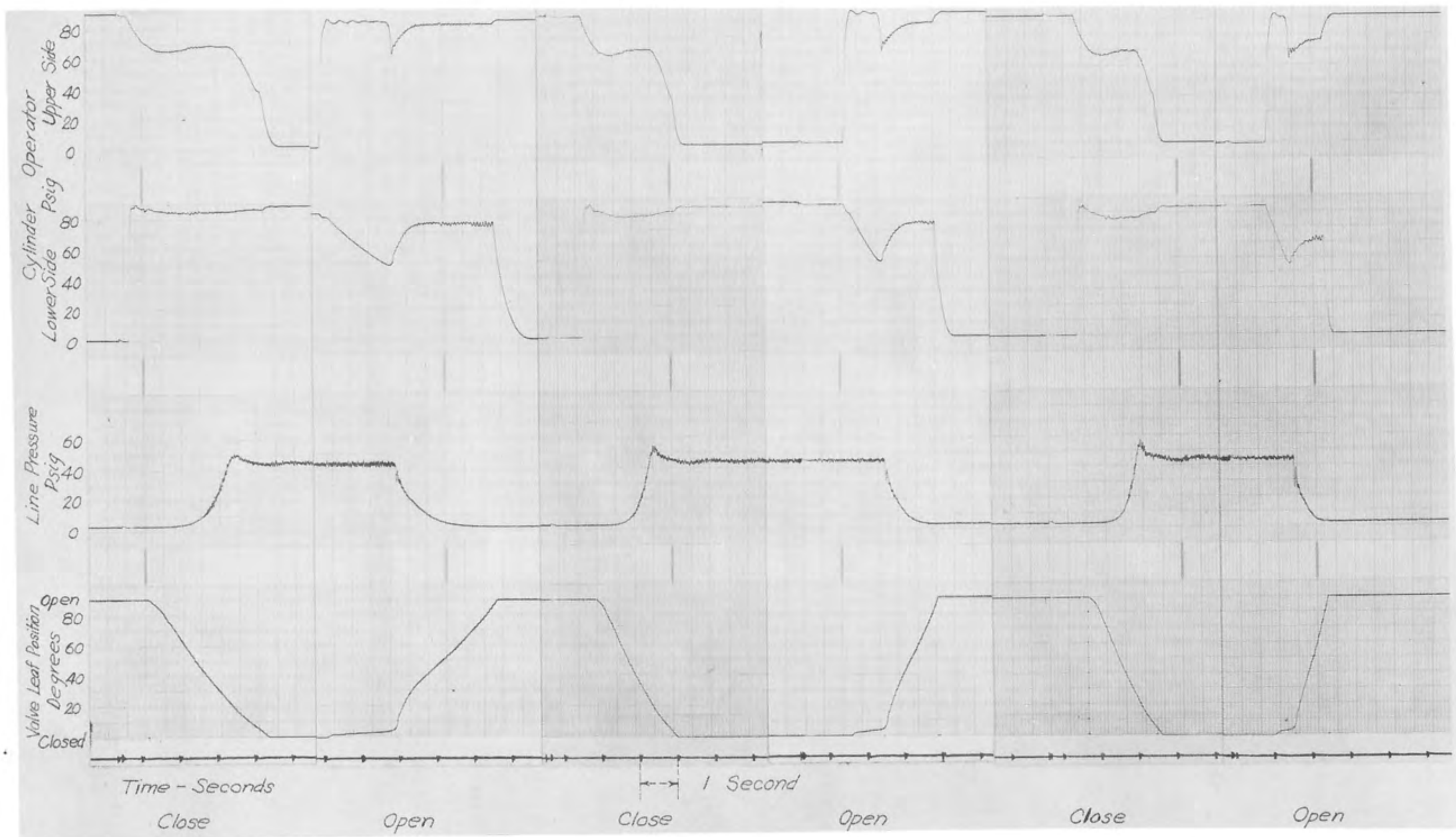


Figure 2CR. View of opposite ends of the butterfly leaf. Note rough machining on surface which contacts rubber seat. Photos P801-D-74514 (upper), P801-D-74515 (lower)



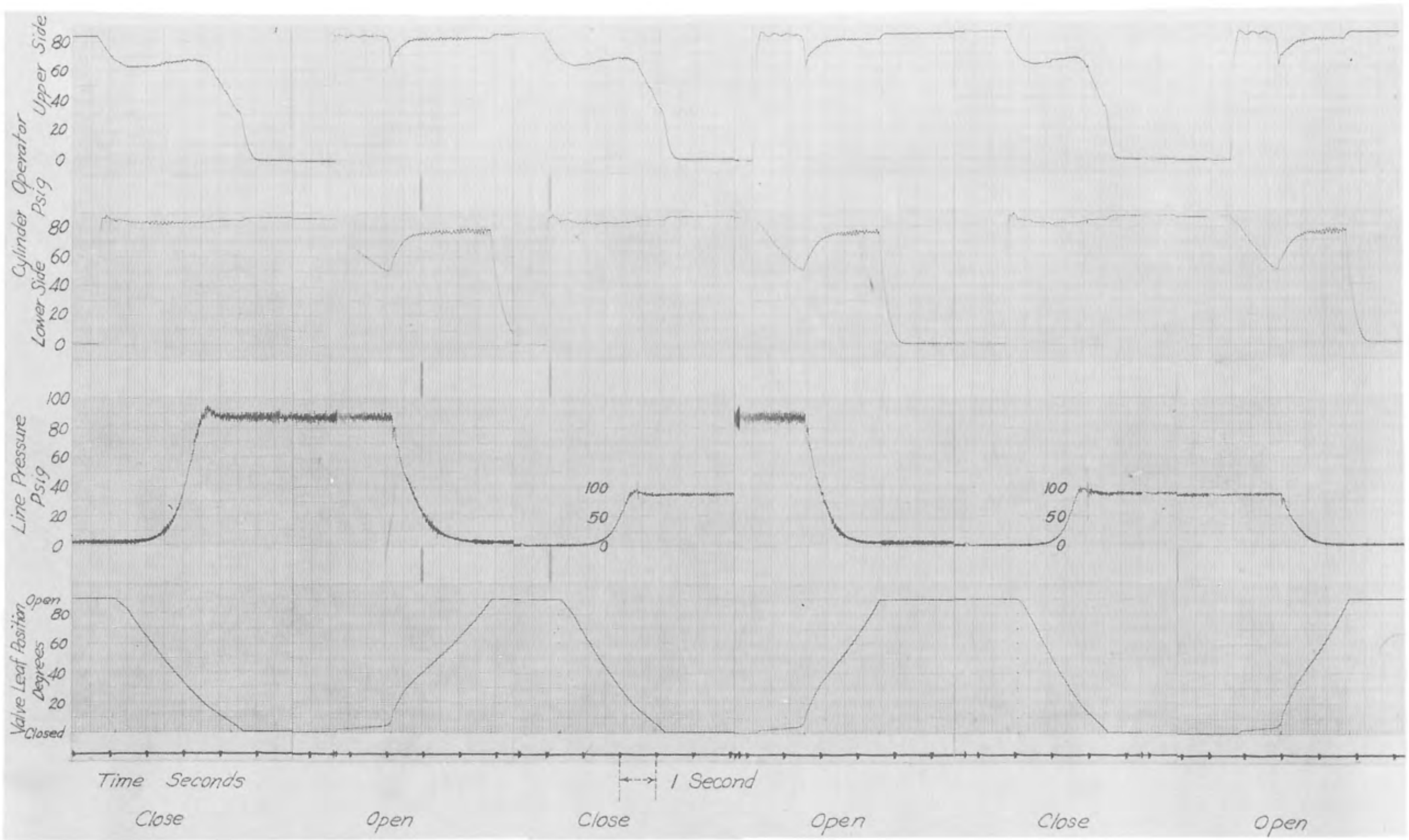
WATER HAMMER TESTS

43.3 psig Shut-off

GRAND COULEE THIRD POWERPLANT - BUTTERFLY VALVE TESTS

CRANE VALVE

Figure 3CR



WATER HAMMER TESTS

86.6 psig Shut-off

GRAND COULEE THIRD POWERPLANT - BUTTERFLY VALVE TESTS

CRANE VALVE

Figure 4CR

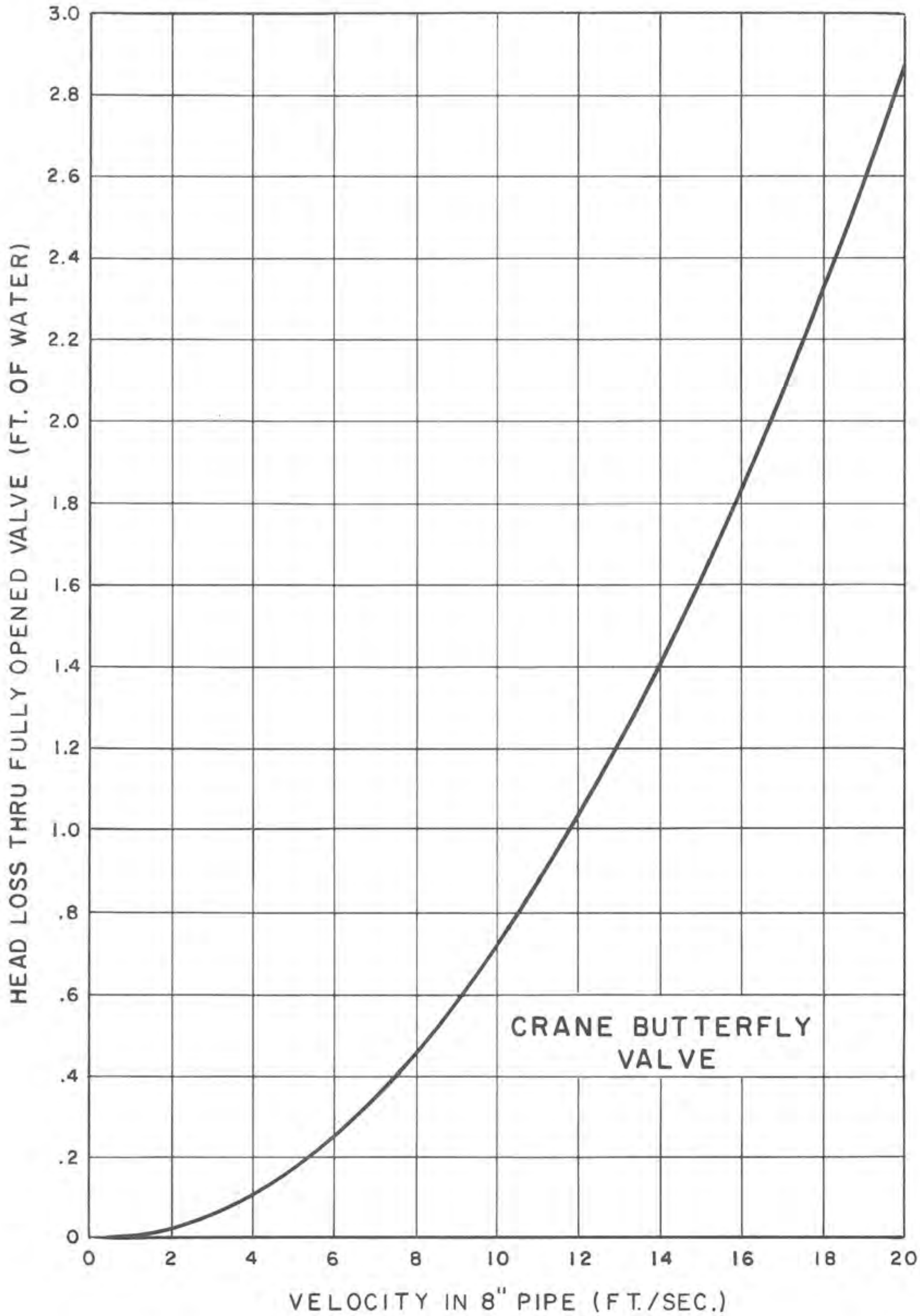


Figure 5CR. Head loss through fully opened Crane valve.

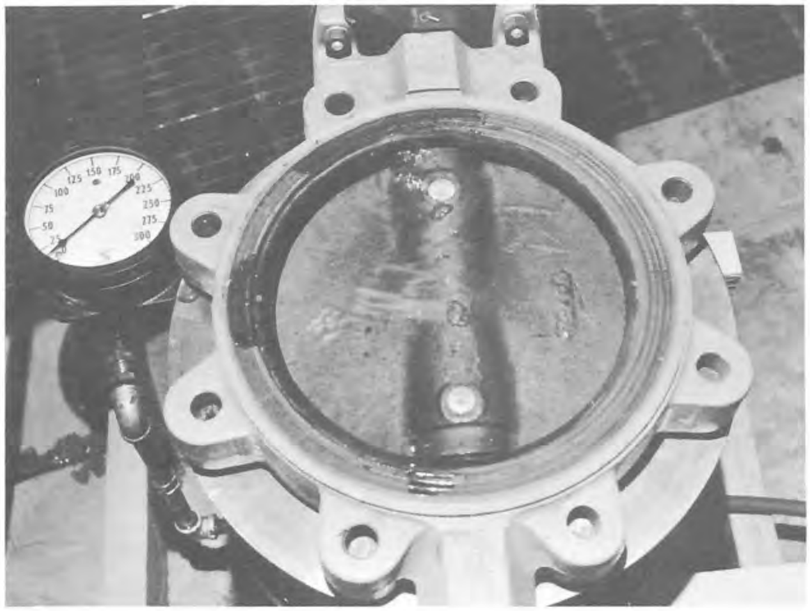


Figure 6CR-A. Bubble tightness tests on Crane valve after 2,500 cycles of opening and closing. Air at 12 psig (0.84 kg/cm^2) under leaf. Photo P801-D-74516

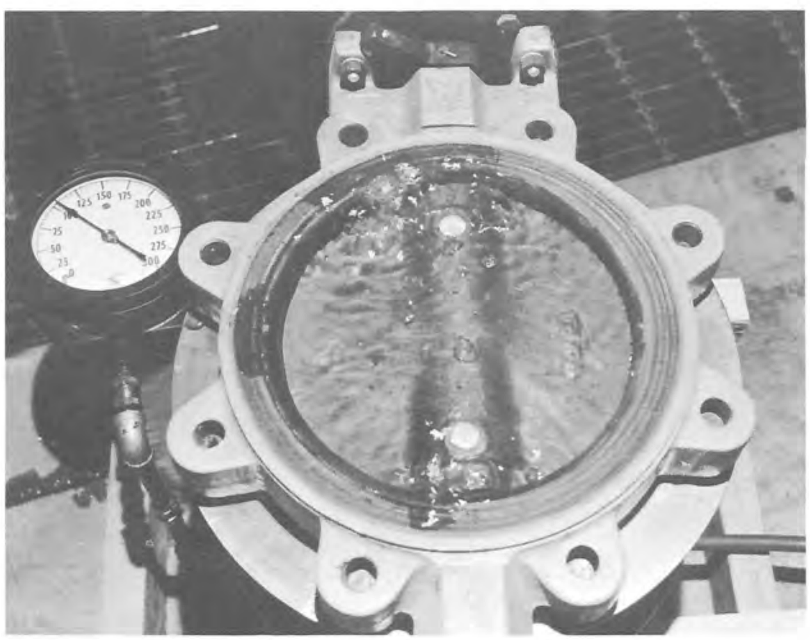


Figure 6CR-B. Bubble tightness on Crane valve after 2,500 cycles of opening and closing. Air at 106 psig (7.45 kg/cm^2) under leaf. Photo P801-D-74517

II. CENTER LINE VALVE SECTION

GENERAL DESCRIPTION OF CENTER LINE VALVE

The Center Line valve was a wafer design with attached cylinder operator Figure 1-CL. The valve body was tapped for bolting between 150-pound flanges. The leaf (disk) was a modified lenticular shape, and sealed on a continuous rubber seat which was placed in the valve body. The seat was formed as a cylindrical insert which could be renewed in the field (Figure 2-CL).

The valve was opened or closed by unbalanced pressure on the cylinder operator. The cylinder operator pivoted as the valve was opened or closed. Clearance to accommodate this movement must be provided in the installation. Also, precautions must be taken so that a safety hazard is not created by the cylinder operator movement.

CENTER LINE VALVE - Phase I
(Air in contact with valve leaf)

1. The Center Line valve was photographed, inspected, and found to be in good working order.

2. The valve was placed on the test rack and left for 30 days in the closed position with 70-90-psig air holding the leaf closed.

3. The valve was again photographed and inspected. No permanent set or damage was observed as a result of the closed and dry test.

4. The Center Line valve was mounted on an 8-inch pipe section supplied by a 1-1/2-inch shop air line.

5. Shutoff tests with atmospheric air on one side of the leaf and 75 psig air on the other were made. The cylinder operator was supplied with 75 psig air to control the leaf. No air leakage was observed around the seat or shaft area of the valve when brushed with a soap solution.

6. The valve was subjected to 1,000 cycles of opening and closing. The valve operation during the cycling tests was quite smooth and uniform.

7. At the completion of the cycling tests, shutoff tests were again performed. Leaks were found around the operating shaft, on both the side nearest the cylinder operator where the heaviest leakage was noted and on the opposite side (Figure 3-CL).

The local sales representative of Center Line valves was notified of the leakage and visited the laboratory to examine the valve. The local representative contacted the factory and obtained a second valve. The second valve was not tested on the rack with the leaf closed and dry for 30 days as the initial valve was; however, the remainder of the Phase I tests were performed. At the beginning of the tests, and after 500, 750, and 1,000 cycles, tightness tests were performed with a brushed on soap solution. As before, the air behind the leaf was maintained at a pressure of 75 psig. No leakage was detected on any of the tests and the valve performance was considered quite good. There appeared to be slightly more interference between the leaf and the molded rubber flats on the second valve than was noted on the initial valve (Figure 3-CL).

CENTER LINE VALVE - Phase II
(Water in Contact with Leaf)

1. The valve was bolted to an 8-inch pipe section on the laboratory high head test facility.

2. Shutoff tests prior to cycling tests were not performed on the valve. The valve was the first one placed on the waterline and initial shutoff tests were not included as a part of the criterion until the next valve was tested.

3. The valve was cycled 500 times at a shutoff pressure of 43.3 psig. Much slower travel rates were used with the valve on the waterline than had been used when the valve was attached to the

air line. With the slower travel, the cylinder operator motion became quite jerky (Figure 4-CL). Poor control characteristics occur with the jerky movement because fairly large increments of leaf travel can result almost instaneously. The local representative again came to the laboratory to observe the jerky movement. Under the local representative's direction, the cylinder operator was disassembled and inspected to determine if any areas of excessive wear were visible. The piston was lubricated with silicone grease and the cylinder reassembled. No improvement was noted in the jerky piston travel. Subsequently, the local representative returned to the laboratory stating that Center Line, Inc., did not recommend the silicone grease as it has a tendency to harden and dry out. They recommended a preparation called Moly Dry Film, which the local representative had obtained. The piston and cylinder were cleaned and sprayed with the recommended lubricant. Only a very slight improvement was noted in the operation of the valve. The local representative stated that Center Line, Inc., felt the jerky travel was typical of air operated cylinders and could not be entirely eliminated. They recommended the use of a larger diameter piston to minimize the jerky travel.

4. A shutoff test following 500 cycles of opening and closing at 43.3 psig was performed on the valve. The test lasted 45 minutes with the following results:

150 psig - 0.799 ml/sec

5. The valve was cycled 500 times with a shutoff pressure of 86.6 psig. The performance for these tests remained essentially as in item 3 above. No further attempts to eliminate the jerky travel were made.

6. A shutoff test following 500 cycles of opening and closing at 86.6 psig was performed on the valve. The test lasted 45 minutes with the following results:

150 psig - 0.924 ml/sec

7. The valve was cycled 500 time with a shutoff pressure of 150 psig. The valve performance remained as described in item 3 above (Figure 4-CL).

8. A shutoff test following 500 cycles of opening and closing at 150 psig was performed on the valve. The test lasted 45 minutes with the following results:

150 psig - 0.21 ml/sec

(Note reduced leakage rate from that of two previous runs.) No cause for the reduced leakage was found.

9. Water hammer tests were performed on the valve at shutoff pressures of 43.3 and 86.6 psig. Portions of the oscillographs obtained during these tests are shown in Figures 5-CL and 6-CL for shutoff pressures of 43.3 and 86.6 psig respectively.

10. Head loss measurements were not obtained for the Center Line valve as additional modifications were planned. These included the installation of a new valve seat and an 8-inch diameter pneumatic controller.

The old valve seat was photographed and inspected. Figure 7-CL shows the damaged seat which had been subjected to 2,500 cycles of opening and closing since the valve was received. The molded rubber flats showed rather extensive damage where the ends of the leaf had torn and worn into the flat. The seat itself showed very light wear around the entire circumference.

The valve was reassembled in the laboratory with a new rubber seat and an 8-inch pneumatic cylinder operator. The local Center Line representative was present during the disassembly and reassembly and performed the majority of the work. After some linkage difficulties were corrected the seat was tested for tightness and the following leakage noted:

110 psig - 0.278 ml/sec

118 psig - 5.00 ml/sec

128 psig - 15.38 ml/sec

138 psig - 31.25 ml/sec

150 psig - 47.62 ml/sec

The areas where leakage occurred became more numerous with increasing pressure. The leakage was considered too great and further testing of the valve was considered impractical. The valve was then returned to the factory by the local representative. No word was received regarding the status of the valve until 8-1/2 months had elapsed. At that time a third valve was received which was never tested. The valve was subsequently returned to the local representative.

SUMMARY

The replaceable rubber seat of the Center Line valve appears to be an excellent idea, however, leakage from the seat and molded flat area must be eliminated before the design would be acceptable. The travel of the leaf which appeared quite smooth for rapid operation became very jerky at slower speeds. Improvement would be required to eliminate water hammer pressures in long pipelines. A portion of the jerkiness could have been eliminated by reversing the tiny speed controlling needle valves. As installed, the valves restricted air flow into the cylinder operator and allowed free flow out of the cylinder operator. Smoother operation results when the air flow into the cylinder operator is unrestricted and outflow restricted to produce the desired speed. The advantage of this arrangement was not learned until after the valve had been tested. The only deviation listed to Specifications AWWA C504-66 for the Center Line valve was that the valve contained a compression shaft seal instead of an external adjustable packing.

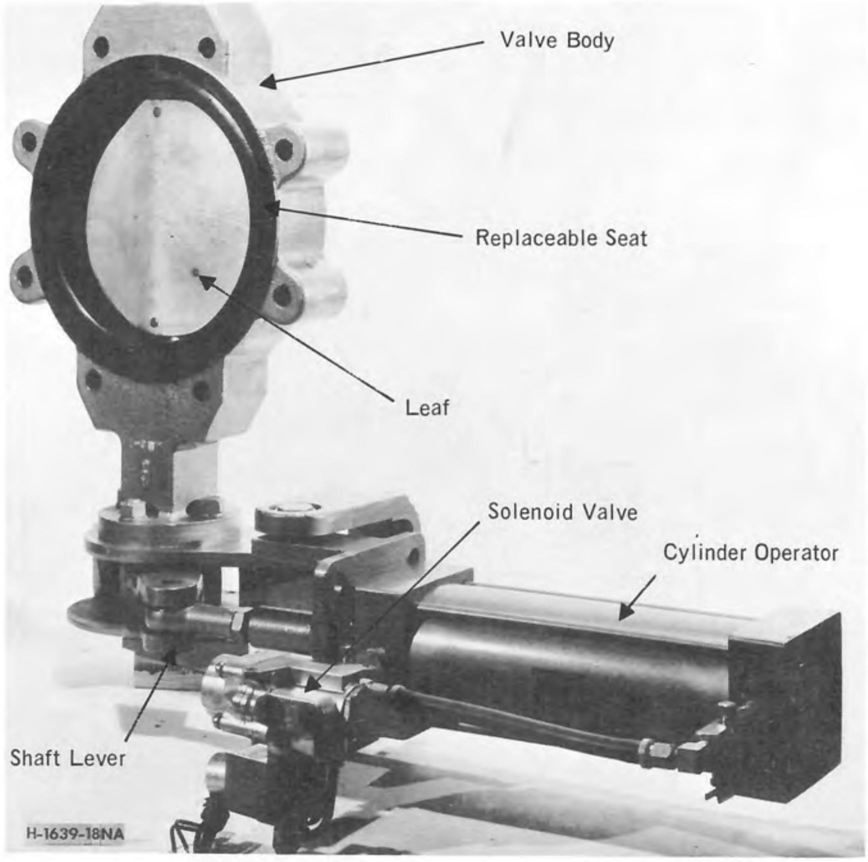


Figure 1CL. Centerline wafer-type butterfly valve, with replaceable seat. Photo P801-D-74518

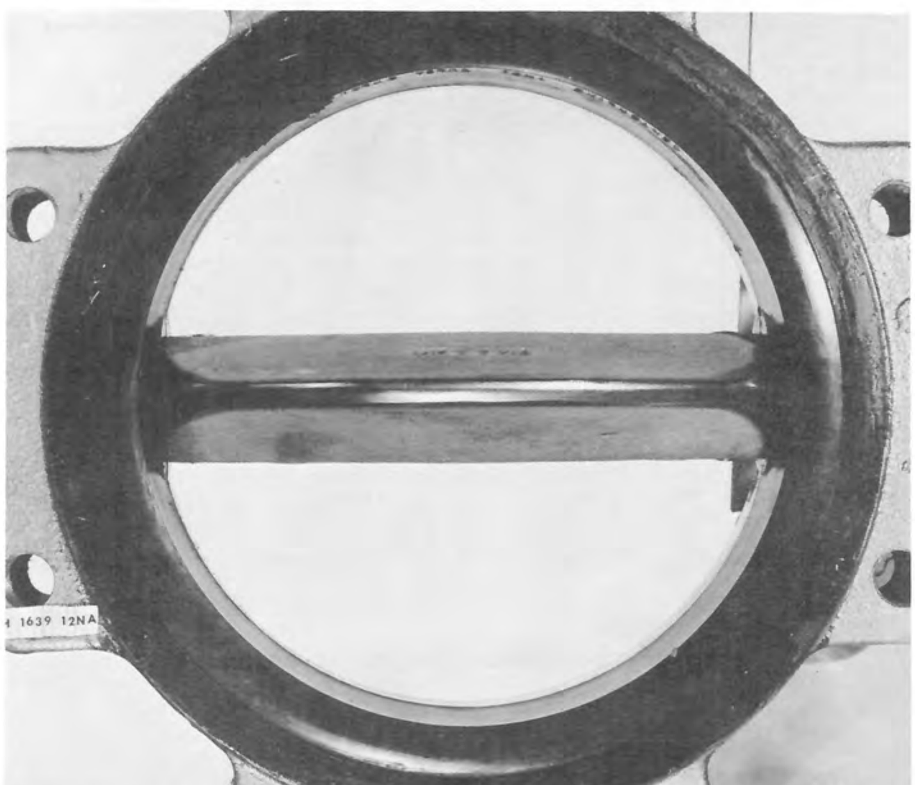


Figure 2CL. View looking into the Centerline valve with leaf fully opened. Photo P801-D-74519

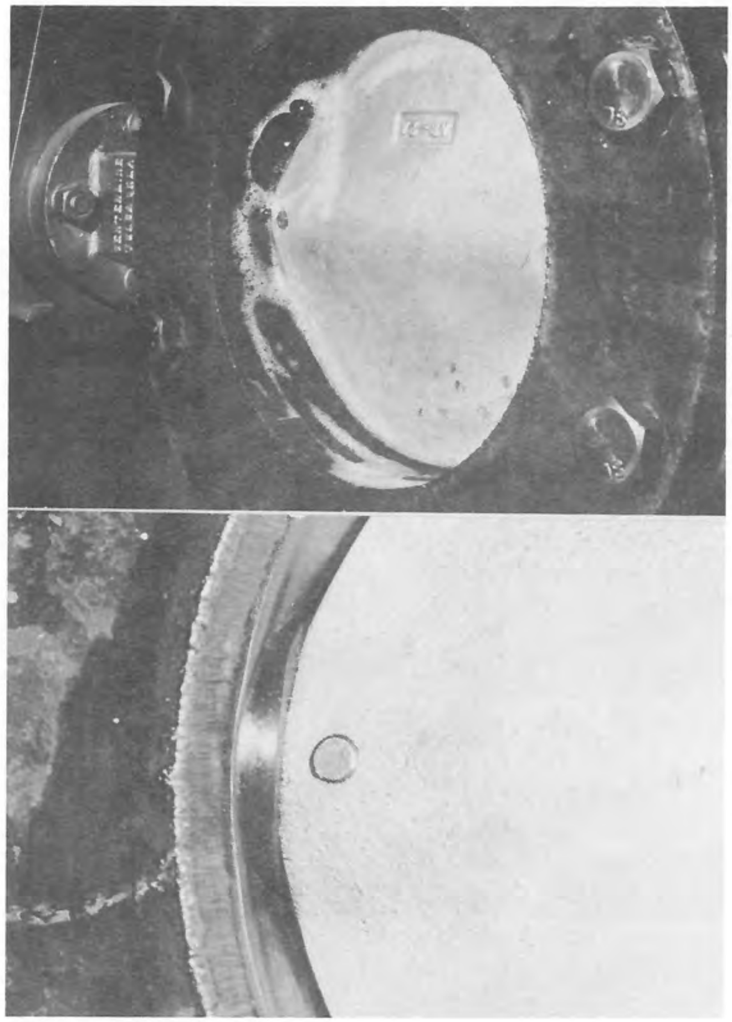
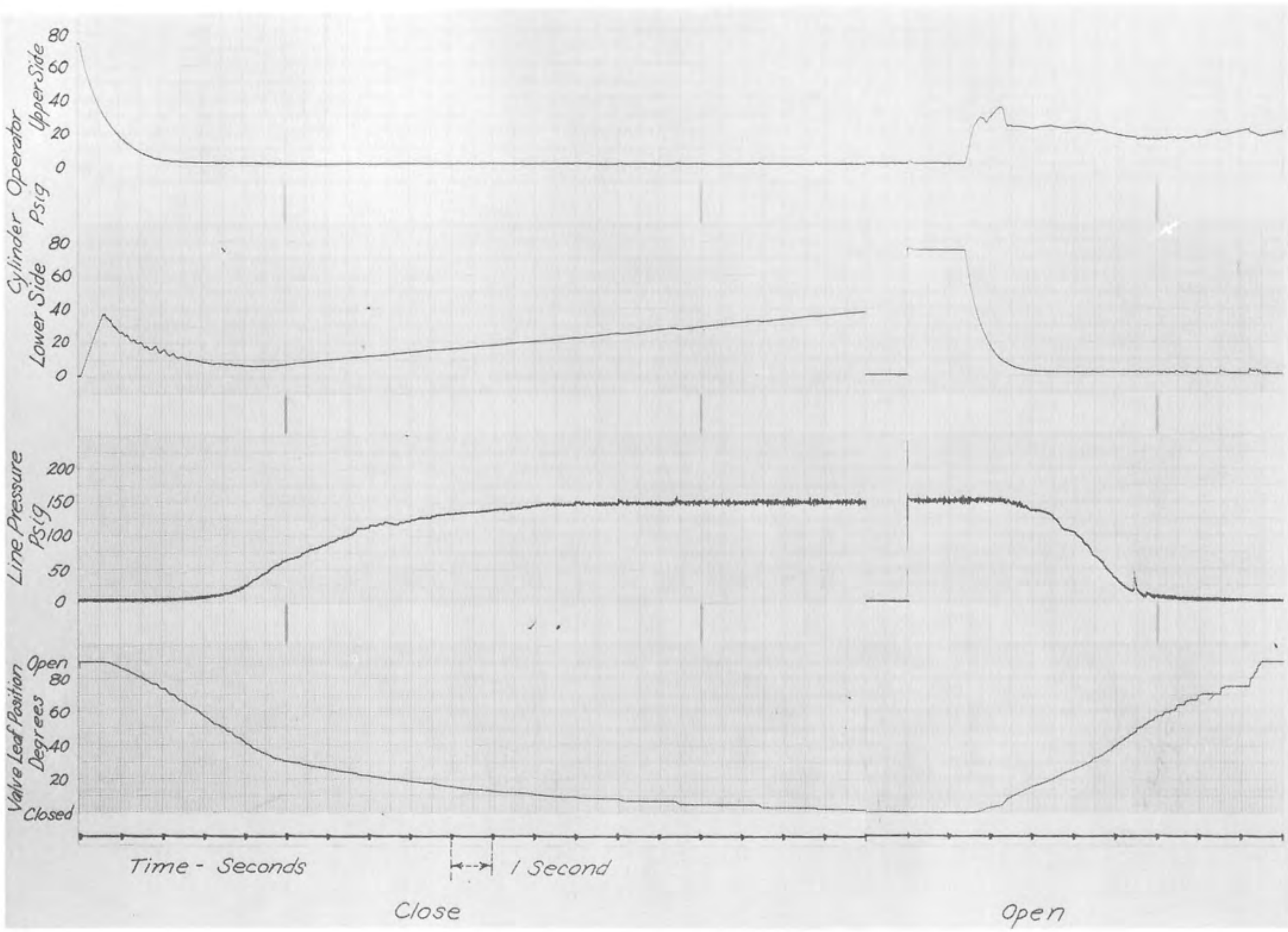


Figure 3CL. Air leakage from around the shaft seal area. The valve had been opened and closed 1,000 times with air at 75 psig against the leaf. Lower photo shows molded flats where stem passes through the rubber seat. Photos P801-D-74520 (upper), P801-D-74521 (lower)



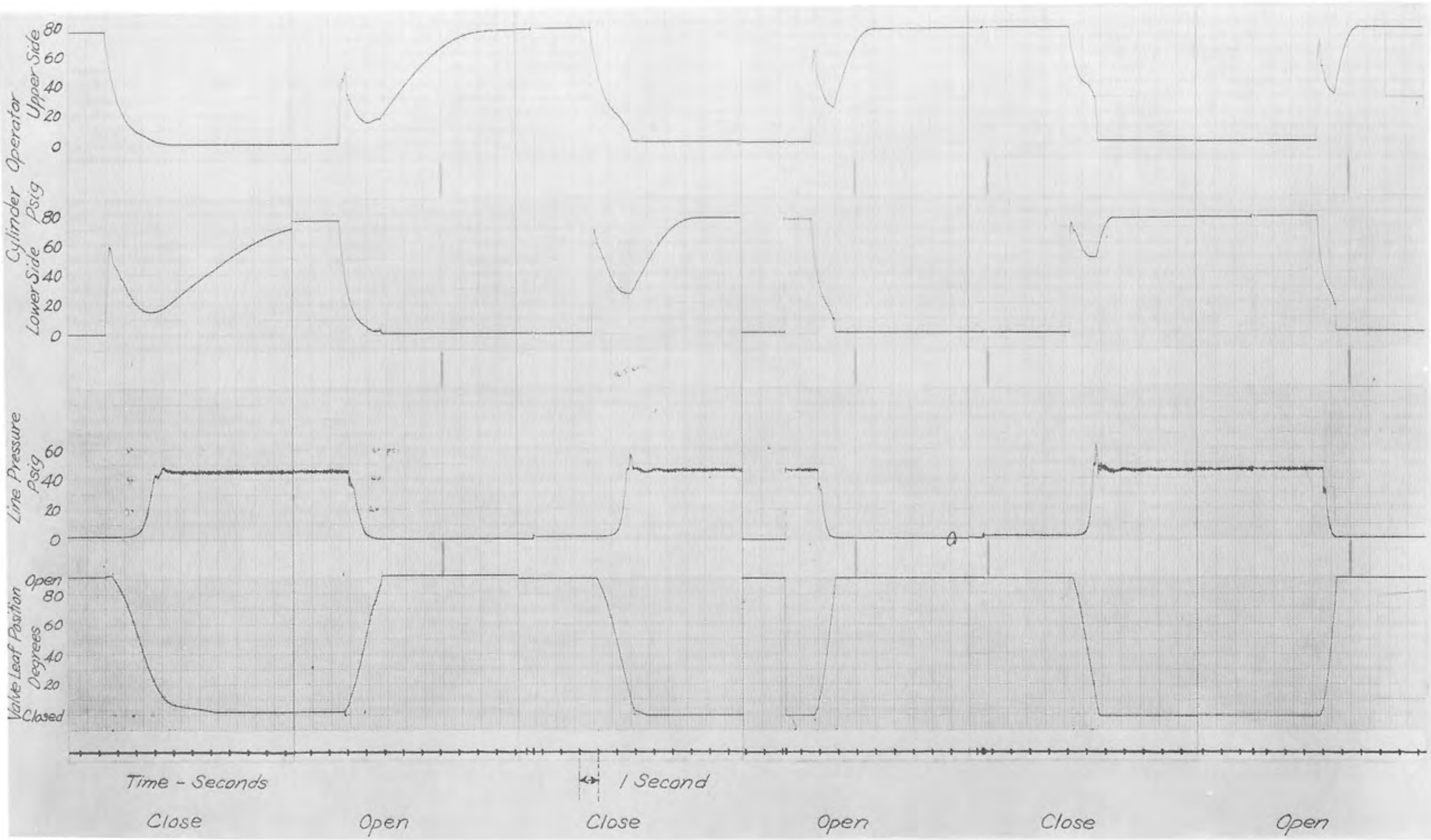
Symmetrical Leaf

Valve Cycled at Line Pressure of 150 psig

GRAND COULEE THIRD POWERPLANT - BUTTERFLY VALVE TESTS

CENTERLINE VALVE

Figure 4CL



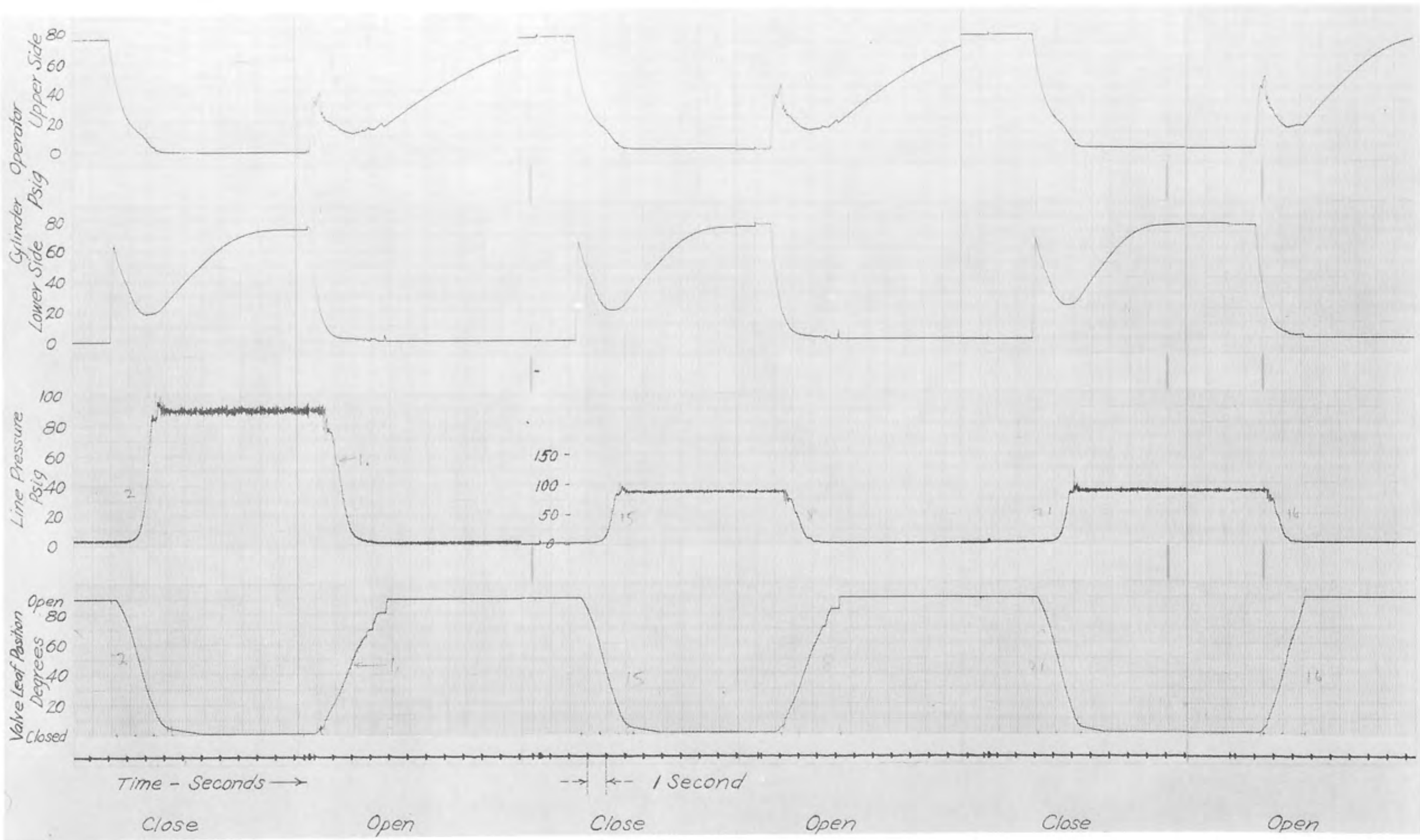
WATER HAMMER TESTS

43.3 psig Shut-off

GRAND COULEE THIRD POWERPLANT - BUTTERFLY VALVE TESTS

CENTERLINE VALVE

Figure 5CL



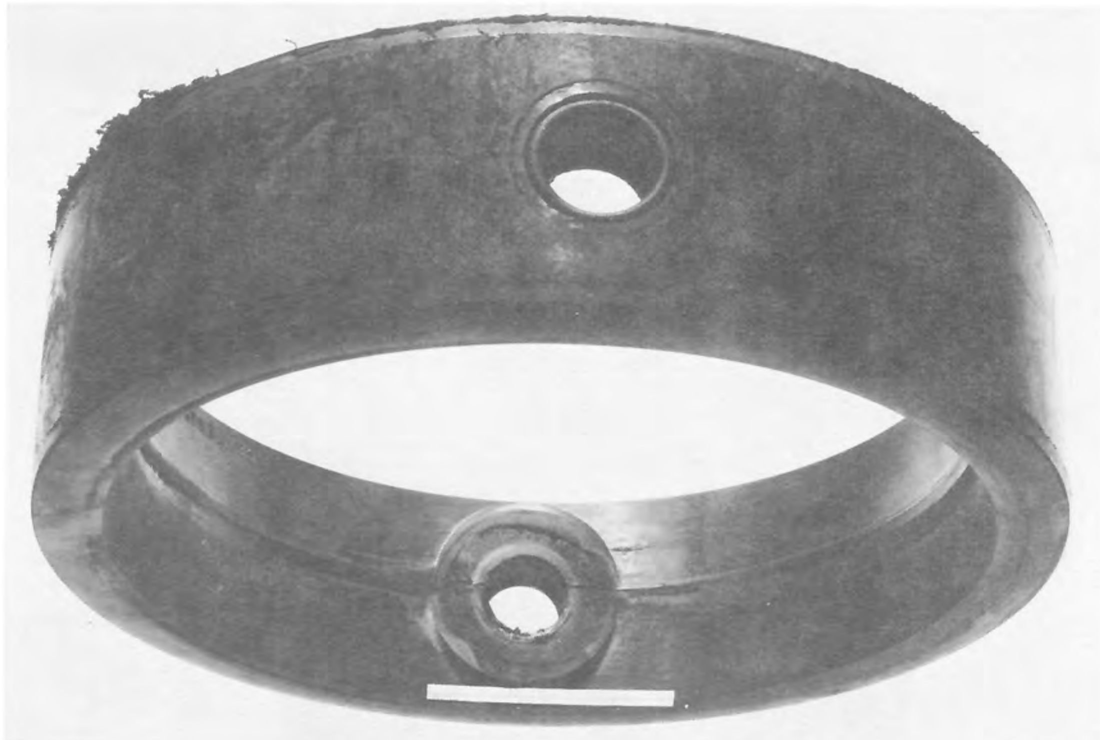
WATER HAMMER TESTS

86.6 psig Shut-off

GRAND COULEE THIRD POWERPLANT - BUTTERFLY VALVE TESTS

CENTERLINE VALVE

Figure 6CL



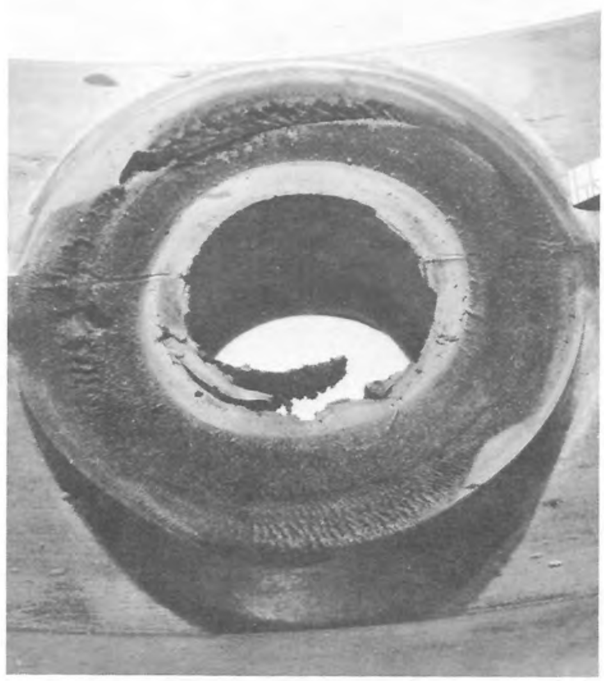


Figure 7CL. Damaged replaceable rubber seat removed from valve body. Closeup shows damage to opposite end. Major damage was to molded rubber flats. Photos P801-D-74522 (upper), P801-D-74523 (lower)