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SUMMARY TEST REPORT
MASONEILAN CAMFLEX II VALVE
METC SOA TEST VALVE NO. A-15 AND TEST VALVE NO. A-15R
STATE-OF-THE-ART
LOCKHOPPER VALVE-TESTING AND DEVELOPMENT PROJECT

April 1981

UNITED STATES DEPARTMENT OF ENERGY
Morgantown Energy Technology Center
Morgantown, West Virginia

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Morgantown, West Virginia

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Morgantown, West Virginia 26505

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J.F. Gardner[1], T.R. Gayheart[2], R.A. Griffith[3],
R.C. Hall[4], R.G. Hornbeck[3], D.A. Maxfield[5],
T.M. Nutter[3], and R.B. Sgamma[2]

ABSTRACT

The 8-inch ANSI Class 600 Masoneilan "Camflex II" Valve (METC SOA Test Valve No. A-15) accumulated 306 cycles in the Valve Static Test Unit (VSTU) and 901 cycles in the Valve Dynamic Test Unit (VDTU). METC SOA Test Valve No. A-15R accumulated 848 cycles in the VSTU and 5,070 cycles in the VDTU. The test valve satisfactorily completed the ambient, 300°F, and 600°F static tests. The valve leakage rates exceeded the maximum allowable leakage rates during dynamic testing using limestone as the test medium. Excessive leakage occurred due to improper clearances between the valve parts and degradation of the valve sealant. The sealing surfaces showed minimal degradation as a result of exposure to solids. This—plus the design's similarity to other valves that have performed well in lockhopper testing—suggests that with appropriate modifications the Camflex II could have potential for use in solids-feeding lockhopper service.

ACKNOWLEDGMENTS

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Work performed by the various support groups at METC is also sincerely appreciated. Without their combined efforts, this work would not be possible.

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INTRODUCTION

Coal will play a key role in meeting our country's energy needs. Most processes, such as pressurized fluidized-bed combustion and advanced coal gasifiers, operate at high temperatures and pressures. The availability of reliable lockhopper valves for handling solids at pressures to 1,000 psig and temperatures to 1200°F is a critical problem. Valve failures have been encountered in most pilot-plant operations. These failures are typically caused by abrasion, erosion, jamming, or other solids-related problems.

The Lockhopper Valve Testing and Development Projects personnel at the Morgantown Energy Technology Center (METC) are cooperating with valve manufacturers to develop solutions to these problems. The State-of-the-Art (SOA) Lockhopper Valve-Testing and Development Project is targeted to provide commercially available lockhopper valves for pilot and early-demonstration commercial coal-conversion plants. The project's approach is as follows:

1. Survey valve manufacturers for candidate lockhopper-valve designs.
2. Develop a test program and the facilities required to evaluate the capability of existing valve designs to meet the requirements of lockhopper applications.
3. Conduct tests of candidate valves in cooperation with the valve manufacturers.
4. Compile data on valve life and failure modes experienced in the test program. Use this information to generate design improvements and establish maintenance and reliability criteria.
5. Retest valves to verify design modifications.
6. Establish a strong mechanism for transferring the technology developed to manufacturers, architects/engineers, and plant operators.
7. Verify valve usage in pilot/demonstration plants.

As a result of the valve survey, 15 valves were selected and procured for testing. An additional 14 valves were obtained through no-cost cooperative agreements with manufacturers or long-term loans.

To perform the required developmental testing, four lockhopper vlave-test units, a computer-controlled data-acquisition system, and a metrology laboratory have been constructed. Additional information on these facilities is provided in the Appendix.

STATE-OF-THE ART LOCKHOPPER VALVE-TESTING AND DEVELOPMENT PROJECT

At the start of the State-of-Art Lockhopper Valve-Testing and Development Project (circa 1976), the service life of a typical lockhopper valve in a pilot plant was approximately 500 cycles, at which time a major rebuild was normally required to return it to service. The maximum process conditions that a lockhopper valve could be used at were 600°F and 500-psig differential pressure. This represents the baseline with which to gauge improvements in service conditions and life for lockhopper valves.

To determine the requirements for successful lockhopper-valve service, several processes and pilot plants were surveyed. Based on this survey, valves were classified according to their application (e.g., solids feed, dry-solids removal, wet-ash or slag-slurry removal, etc.). Overall State-of-the-Art Lockhopper Valve-Testing and Development Project goals have been established as:

- Lockhopper valve life of 25,000 cycles with maximum allowable leakages of 3 scfm per inch of nominal pipe diameter internal and 0.1 scfm external.
- Maximum actuation time of 30 seconds for either opening or closing.
- Design pressure range of 20-1,600 psig.
- Design temperature range of 60-1600°F.

To date, 29 valves have entered the test program. Over 60 valve failures have been recorded and seven valves have been deleted from the project as a result of the failures.

TEST VALVE DESCRIPTION

METC SOA Test Valve No. A-15 is an 8-inch ANSI Class 600 Masoneilan Camflex II Valve with actuator manufactured by Masoneilan International, Inc., Norwood, Massachusetts 02062. Specifications for the valve include:

Valve Body: Wafer-type, cast ASTM A-216, Grade WCB, carbon steel, ANSI Class 600
Valve Seat Ring: Type 316 stainless steel hard-faced with Stellite No. 6
Retainer: Type 316 stainless steel
Valve Shaft Bearings: Stellite No. 6

- **Valve Plug:** Type 316 stainless steel hardfaced with Stellite No. 6
- **Valve Shaft:** Type 17-4 PH stainless steel
- **Valve Packing:** Teflon/asbestos
- **Valve Actuator:** Masoneilan, Spring-Diaphragm, Pneumatic Actuator; maximum supply pressure 40 psig
- **Design Operating Parameters:** 600 psig at up to 600°F maximum

Figure 1 is a schematic of the test valve and Figure 2 shows its component parts. The valve is fitted with a Masoneilan, spring-diaphragm, pneumatic actuator that is designed for air-to-open and spring-to-close operation.

The operation of the valve involves the rotation of the plug through an angle of 50° by a lever linked to the spring-diaphragm actuator. A positive seal between the plug and seat is maintained by the elastic deformation of the flexible plug arms.

METC SOA Test Valve No. A-15R is identical to Test Valve No. A-15. During dynamic testing, some manufacturing defects were discovered in Test Valve No. A-15. The manufacturer rebuilt the test valve to repair these defects. Because the body, plug, seat ring, and retainer ring had been replaced, the rebuilt valve was designated METC SOA Test Valve No. A-15R.

OVERVIEW OF TESTING

The normal sequence for the METC SOA Lockhopper Valve-Testing and Development Project is acceptance testing, static testing, initial inspection, dynamic testing, and final inspection, as shown in Figure 3. Table 1 summarizes the testing performed on METC SOA Test Valve Nos. A-15 and A-15R.

Acceptance testing verifies that the proper valve has been shipped, that the valve is operable, and that it meets the manufacturer's specifications for initial leakage. Leakage testing is performed on a work bench using blind flanges, bottled nitrogen gas, and a rotameter. The initial valve received was returned because the valve body was the wrong ANSI class construction. When the proper valve was received, it was designated METC SOA Test Valve No. A-15. The acceptance leakage testing results are provided in Table 2.

The next step is static testing, which is performed in the Valve Static Test Unit (VSTU). Its purpose is to establish baseline operating data for the test valve. Leakage rates, operating forces, and actuation times are measured. The valve is tested in clean, inert gas over a range of pressures and valve-body temperatures. Test Valve No. A-15 successfully completed static testing.

After static testing, the test valve is then reassembled and a bench test or a brief static test (reestablishment of baseline test) is performed to verify that the valve has been properly reassembled. This provides the opportunity to assess the maintainability of the valve and the quality and completeness of the assembly instructions. The static testing and reestablishment of baseline testing results for Test Valve No. A-15 are provided in Tables 3, 4, and 5.

The dynamic testing is performed in the Valve Dynamic Test Unit (VDTU). Its purpose is to evaluate the test valve under simulated lockhopper operating conditions of varying pressure, valve-body temperature, and ambient-temperature solids media of varying particle-size distribution. Although an ambient-temperature test media is used, an induction heater heats the valve to typical operating temperatures. The evaluation is based on measurement of the actuation operating times, forces, and leakage rates. Due to test-equipment problems, actuation times and operating forces were not reported for VDTU Test Run No. D-2.

Test Valve No. A-15 was installed in the upper test-valve position (TV-1). In this position, the valve experiences a test cycle that simulates the initial valve in a lockhopper system feeding solids into a high-pressure reactor. Dynamic testing of Test Valve No. A-15 was interrupted twice due to excessive leakage, once after 244 cycles and again after 866 cycles. Test data is presented in Table 6. The first time the test valve was removed, the sealant between the valve body and the seat was replaced and the actuator was repaired. The second time the test valve was removed, it was inspected and, after discussion with the manufacturer, it was determined that the leakage was due to manufacturing defects. The manufacturer requested that the valve be returned for repair.

Most of the key parts of the valve were replaced, including the body, plug, shaft, seat, and retainer ring. After an initial inspection to verify that all of the defects had been repaired, the test valve was entered into the test sequence as METC SOA Test Valve No. A-15R. The data from static testing of Test Valve No. A-15R is presented in Tables 7, 8, and 9. The initial inspection was performed and the valve was reassembled for reestablishment of baseline testing. The seat and actuator had to be readjusted before the test valve could complete the reestablishment test. The final leakage data is presented in Table 10.

For dynamic testing, Test Valve No. A-15R also was installed in the TV-1 position. The specific test conditions for VDTU Test Run No. D7 are presented in Table 11. Test Valve No. A-15R was removed for maintenance after 3,453 cycles on the VDTU, and testing was terminated after 5,700 cycles due to repeated excessive leakage. Test data is presented in Tables 12 and 13. When removed for maintenance, the test valve had excessive internal leakage and the actuator was not functioning properly. The actuator was repaired and the seat and actuator were readjusted. Several attempts were made before the plug seated properly. When the valve was inspected after testing was terminated, the seat was found to have slipped out of adjustment.

TEST DESCRIPTION AND RESULTS

A test series in the VSTU consists of a series of 25 to 60 test-valve cycles at specified conditions with a leakage test series before and after it. The measurements performed during a leakage test series include operating-force, actuation-time, external-leakage, and internal-leakage measurements. Internal leakage (i.e., seat leakage) is measured at seven test pressures (50, 100, 200, 300, 400, 500, and 600 psig). The test valve is cycled between each measurement to establish a new contact between the plug and seat for each test. The leakage data reported is obtained from a flowmeter installed on the outlet of the unpressurized side of the valve.

External leakage (e.g., stem and body-joint leakage) is measured using a pressure-decay technique. The test valve is pressurized in the open position and isolated for 5 minutes. The initial and final pressures are recorded. The external-leakage rate is calculated from the pressure loss, using the Ideal Gas Law. A qualitative check (SNOOP[1] liquid) of the test system is made before each test to insure that the test-system connections are leak tight. An inert gas (88% N_2 and 12% CO_2 or 99+%N_2) was used for pressurizing the valve and as a leak-testing medium.

Actuation time is recorded by an automatic timer that uses limit switches on the actuator to sense the full-open and full-closed positions. The supply pressure to the pneumatic actuator is used as an indication of the operating force. Both the pressure at which movement starts and the pressure required to complete the travel are reported. Since the actuator on this valve is "spring to close," only the force to open is reported.

VSTU Test Run No. 20 included test series with the valve body at ambient temperature (70°F) and heated to 300° and 600°F. The changes in the valve-body temperature and test-valve cycle count at which leakage test series are performed are reported in Table 3. At all times, the test valve was cycled with a balanced pressure across the plug (either atmospheric or 600 psig). Each time the test valve was in the closed position (except during the test series and during miscellaneous adjustment cycles) a differential pressure of 600 psi was placed across the plug. These operations simulate the various conditions of pressure and actuation that occur in a valve in a lockhopper system.

Figure 4 shows METC SOA Test Valve No. A-15 installed in the VSTU. The measurements made during VSTU Test Run No. 20 are presented in Tables 3 and 4.

The external-leakage rate was low (0.01-0.05 scfm). Opening force as measured by actuator supply pressure was relatively constant. The valve lifted off the seat at 7-10 psig and opened fully at 27 psig. These supply pressures convert to forces of 270-390 and 1,000 pounds, respectively. It is a relatively fast operating valve, opening in 2.7 seconds and closing in 3.3 seconds. The operating time remained nearly constant during static testing.

The most outstanding feature of the valve internal-leakage data is the sudden drop in leakage rate as temperature is increased (see Figure 5). The drop occurs over too small a number of cycles to be explained by any kind of a wearing-in process. In light of the improper clearances later found between the body and the seat retainer ring, the most likely explanation is differential thermal expansion. The differential thermal expansion (approximately 0.004 inch radially and 0.001 inch axially) expected in a 530°F temperature rise between the carbon-steel body and the 316 stainless-steel seat ring and retainer ring may have seated the seat ring tighter, reducing the leakage bypassing the seat/plug seal.

Test Valve No. A-15 was next disassembled for inspection. The sealing surfaces of the seat and plug appeared to be in excellent condition. The bench-leakage test was performed after reassembly (Table 5) and showed that the valve had been properly reassembled.

The next step is dynamic testing. Dynamic testing is organized into a series of subruns with a measurement series initially and at the completion of each subrun. The actuation time and operating force are measured the same as in static testing, except op-

[1]Manufacturers' names on products described herein are given only for technical completeness and do not constitute endorsement by the U.S. Government, its agencies, employees, or contractors.

erating-force measurements were obtained only when the valve body was at ambient temperature.

Leakage measurements are complicated by the presence of solids and the fact that there are two test valves, one at each end of a test section (see Figure I-4 in the Appendix). During the leakage tests, the test valves are cycled without solids flow. Measurements are made of the flow required to maintain constant pressure in the test section. During the leakage-test series, a blind flange and rotameter are installed so that the flow out of the lower test valve (TV-2) can be measured. Internal leakage is reported directionally for the lower test valve and calculated (flow in minus flow out of TV-2) for the upper test valve. A liquid leakage detector (SNOOP[1]) is used periodically to qualitatively check the packing and body joint for leakage.

Test Valve No. A-15 was mounted in the top position (TV-1) of the VDTU, as shown in Figure 6, and METC SOA Test Valve No. A-12 was mounted in the bottom position (TV-2). The test conditions for the initial subrun were valve body at ambient temperature, 200-psig lockhopper pressure, and ¼-inch x 10-mesh limestone solids. The companion valve, Test Valve No. A-12, was replaced by METC SOA Test Valve No. A-11 after approximately 300 cycles. After almost 500 cycles, an increase in the internal leakage of Test Valve No. A-15 was noted. The test valve was removed and inspected. The inspection revealed that the seal between the seat and the valve body had failed. It appeared that the sealant had been damaged by exposure to high temperatures. However, there is no record of the valve being tested at temperatures above ambient since reassembly after the initial inspection.

The sealant was replaced by an alternate recommended by the manufacturer and testing was continued. After a total of 848 test-valve cycles during dynamic testing, the internal leakage rate exceeded the range of the flowmeter (10.4 scfm). With the assistance of a representative from the manufacturer, a detailed inspection of the valve was performed. This inspection showed:

- Excessive play in the splined connection between the shaft and the plug, which could have resulted in the valve not closing properly.
- Excessive clearances between the threads of the body and the seat/ring retainer ring.

The manufacturer requested that the valve be returned for repair at their expense.

The returned valve was redesignated METC SOA Test Valve No. A-15R. During acceptance inspection, it was noted that most of the parts–including the body, retainer ring, seat ring, plug, and shaft–had been replaced.

Static testing (VSTU Test Run No. 26) totalled 873 cycles. METC SOA Test Valve No. A-15R performed acceptably in VSTU Test Run No. 26 (Tables 7, 8, and 9) except for 600°F testing. The testing was successfully completed after replacing the sealant between the seat and retainer ring. Following static testing, the valve was disassembled for metrology inspection. Inspection found all mating parts to be within a good working tolerance of design specification.

In the first attempt at the reestablishment of baseline testing, leakage was excessive. Inspection revealed that the retainer ring was loose. After the retainer ring was tightened, another set of test data again revealed excessive seat leakage. Cleaning and an application of fresh sealant to the seal ring enabled Test Valve No. A-15R to finally pass the reestablishment test (Table 10). Test Valve No. A-15R had experienced a total of 904 cycles prior to dynamic testing.

For dynamic testing, Test Valve No. A-15R also was installed in the TV-1 position on the VDTU. Baseline data was established successfully, and dynamic cycling began. The test conditions for VDTU Test Run No. D7 are described in Table 11, and the test data is presented in Tables 12 and 13. The valve successfully completed 2,273 cycles before severe internal leakage was observed. Manual cycling corrected the problem. The leakage again appeared after 3,433 cycles. The valve was removed from the VDTU and carefully examined. Leakage was observed all around the plug/seat-ring area. A 0.003-inch gap was observed between the plug and seal ring when the valve was in a fully closed position.

A bent actuator shaft and guide for the coil spring were found to be the problem. Repairs were made, but the 0.003-inch gap still existed in the reassembled valve. Several attempts were made to reassemble the valve before a tight seal was achieved.

The test valve was remounted in the TV-1 position of the VDTU. After 5,059 test-valve cylces in the VDTU, excessive leakage was again observed. The valve was removed from the VDTU, disassembled, inspected, and returned to the manufacturer. Complete data from dynamic testing is presented in Tables 11 and 12.

The ambient-temperature internal leakage for Test Valve No. A-15R was indeed lower than for Test

[1]Manufacturers' names on products described herein are given only for technical completeness and do not constitute endorsement by the U.S. Government, its agencies, employees, or contractors.

Valve No. A-15. However, Test Valve No. A-15R was not able to complete dynamic testing. The seat was very difficult to adjust properly and tended to be displaced easily.

The reestablishment of baseline testing was stopped once and dynamic testing was stopped twice due to excessive leakage that required seat adjustment. Normally, several adjustment attempts were necessary to achieve a tight seal. The seat slipping and recentering could have been the cause of the high leakage that was correctable by cycling the valve a few times. It also is possible that the high internal leakage was the result of solids being trapped between the seat and plug. However, METC SOA Test Valve No. A-15R experienced over 5,000 cycles with limestone solids with minimal effect on the sealing surfaces (i.e., scoring or impact pits). Because of the good condition of the seating surfaces, it would be worthwhile to correct the seat-ring problems.

CONCLUSIONS

1. METC SOA Test Valve No. A-15 did not function to its full potential due to manufacturing deficiencies. The manufacturer concurred and refurbished the valve at their own expense.

2. METC SOA Test Valve No. A-15R successfully completed static testing.

3. METC SOA Test Valve No. A-15R did not complete dynamic testing due to an inability to maintain the seat ring and plug in proper adjustment.

4. The current seat-ring design is difficult to adjust and becomes misaligned easily when the valve is operated in the presence of solids.

5. The current design's operating temperature is limited by the compound used to seal the seat ring to the valve body.

6. Minimal wear was observed on the sealing surfaces of the seat ring and plug.

7. The Camflex II valve with the incorporation of recommended design changes offers good potential as a feed-side lockhopper valve.

RECOMMENDATIONS[1]

1. Evaluate alternate seat designs to overcome the alignment and loosening problems experienced in testing with solids. A first attempt might be the use of a pin to limit the movement of the seat ring. If a new design approach is taken, consideration should be given to one in which the seat can be replaced without removing the valve from the line.

2. Consideration should be given to designs for seat-to-body seals that can be used at higher temperatures. If a sealant is still used, screening tests should be performed to select candidates for high-temperature service (600°F and up).

3. The current full-port design has the plug partially in the solids flow. Consideration should be given to a reduced-port design (i.e., 6-inch internals in a 8- or 10-inch body). This would allow the plug to move back out of the solids flow and allow sufficient room to prevent solids from becoming trapped between the plug and the valve body.

4. Submit the modified valve for testing.

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[1] These recommendations were reviewed with Masoneilan representatives at a meeting on April 3, 1981. They agreed to make the necessary modifications and submit a valve for further testing.

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METC SOA
TEST VALVE NOS. A-15 AND A-15R
SUMMARY TEST REPORT

TABLES

Table 1. Test Summary—METC SOA Test Valve Nos. A-15 and A-15 R

Date	Activity/Test	Cumulative Test-Valve Cycles	Remarks/Results
5-23-78	Received wrong class of body.		
6-15-78	Received correct valve.		
7-11-78	Prepared Test Valve No. A-15 for acceptance tests and performed acceptance tests.		Passed satisfactorily.
7-19-78 to 7-31-78	VSTU (Valve Static Test Unit) Test Run No. 20		Internal leak decreased drastically as valve-body temperature in-increased.
9-5-78	Valve disassembled—parts measured in metrology lab., photographs taken.	296	
9-25-78	Reassembled valve. Reestablished baseline leak. Performed rate test.	306	
11-27-78	Commenced dynamic testing. Testing was halted after 117 cycles.	423	Leakage exceeds measurement range.
1-18-79	Valve removed from VDTU for inspection and repair.		Determined the sealant between the seat ring and body had deteriorated.
1-24-79	Received alternate sealant (Turbo No. 1471 Grade 50).		
	Noticeable movement of the seat ring and movement between the shaft and plug body.		
	Tested for external leakage. Tested for seat leakage.		Passed successfully. Passed successfully.
	Halted dynamic test.	559	Valve leaked in excess of 10.4 scfm.
2-6-79	Halted dynamic testing and removed valve from VDTU and disassembled for inspection.	1,154	Failure to seat may be due to "play" between the splines of stem to the splines of plug. Leaked completely around threaded seat retainer ring (outside of ring, through threads).

Table 1. Test Summary—METC SOA Test Valve Nos. A-15 and A-15R (Continued)

Date	Activity/Test	Cumulative Test-Valve Cycles	Remarks/Results
2-12-79	Masoneilan representative agreed that "play" in the splines of stem to the plug and with the threads of the threaded seal ring was too great.		
5-9-79	Began static testing on Test Valve No. A-15R—performed total of 863 cycles on rebuilt valve in static testing.	863	
8-8-79	Disassembled valve for metrology inspection and reassembled.	867	
8-14-79	Reestablish baseline test was performed after valve was reassembled.		Bad leak at the plug and around the threads of the seal ring.
8-21-79	Reestablishment of baseline test.	901	Excessive leakage.
8-27-79	Valve taken to storage area to be installed on VDTU.	904	Reestablishment testing completed after several attempts and careful alignment of the seat.
11-1-79	Installed A-15R on VDTU in TV-1 position.		
12-20-79		3,177	Severe leakage observed during 400-psi leak test. Series of manual cycling corrected the problem.
1-3-80	Continued testing.	4,340	Valve again leaked severely during first part of leak test but sealed for second half.
1-4-80	Removed valve from VDTU	4,357	Inspection revealed 0.003-inch gap on one side of seating area when valve was fully closed. Actuator shaft was bent and one guide for coil spring was bent.
	Machine shop made repairs to bent parts.		
	Examined valve again for measurements.		Valve still had the 0.003-inch clearance to one side.
1-10-80 to 1-11-80	Made several attempts to reassemble valve prior to a successful sealing of the valve's plug to seat.		
1-16-80	Reinstalled Valve A-15 R on VDTU.		
1-21-80	Restarted Test Run No. D7.	5,063	
1-23-80	Removed valve from VDTU for disassembly and inspection.	5,974	Discovered that seat ring had moved.

Table 2. Acceptance Test Data—METC SOA Test Valve No. A-15

Test Pressure (psig)	Internal Leakage (scfm)
50	0.27
100	0.04
200	0.038
300	0.065
400	0.38
500	1.27
600	2.30
Valve Temperature: Ambient (73°F)	

Table 3. Internal Leakage Data for VSTU Test Run No. 20—METC SOA Test Valve No. A-15

Leak Test No.	Cumulative Test-Valve Cycles	Test Pressure (psig)	Internal Leakage (scfm)
Valve-Body Temperature: 80°F ± 10°F			
1	8	52	0.08
2	9	105	0.05
3	10	202	10.09
4	11	297	0.04
5	12	397	1.8
6	13	487	2.6
7	14	590	3.2
8	72	60	0.07
9	73	104	0.95
10	74	200	0.28
11	75	293	1.3
12	76	390	2.5
13	70	484	3.1
14	71	600	3.7
15	127	52	0.03
16	128	107	0.048
17	129	205	0.2
18	130	300	1.8
19	131	395	2.3
20	132	494	3.2
21	133	584	3.8
Valve-Body Temperature: 276°F ± 4°F			
22	141	55	0.08
23	142	105	0.07
24	143	209	0.055
25	144	307	0.05
26	145	407	0.035
27	147	502	0.065
28	148	604	0.12
29	154	56	0.012
30	176	102	0.012
31	177	202	0.017
32	178	307	0.026
33	180	406	0.04
34	181	502	0.07
35	182	605	0.16
36	208	55	0.011
37	209	106	0.012
38	210	203	0.016
39	211	306	0.024
40	212	408	0.04
41	213	503	0.09
42	214	608	0.18
Valve-Body Temperature: 555°F ± 5°F			
43	222	54	0.024
44	223	104	0.03
45	224	205	0.035
46	225	304	0.03
47	226	408	0.035
48	227	511	0.04

Table 3. Internal Leakage Data for VSTU Test Run No. 20—METC SOA Test Valve No. A-15 (Continued)

Leak Test No.	Cumulative Test-Valve Cycles	Test Pressure (psig)	Internal Leakage (scfm)
Valve-Body Temperature: 555°F ± 5°F (Continued)			
49	228	603	0.04
50	255	53	0.022
51	256	100	0.027
52	257	206	0.03
53	258	304	0.03
54	259	406	0.03
55	260	505	0.035
56	261	602	0.035
57	287	53	0.15
58	289	103	0.19
59	290	206	0.02
60	291	310	0.025
61	292	407	0.025
62	293	508	0.03
63	294	610	0.035

Table 4. External Leakage, Valve Actuation Force, and Operating Time Data for VSTU Test Run No. 20—METC SOA Test Valve No. A-15

Approximate Test-Valve Cycles	Valve Body Temp. (°F)	Actuation Force[1]		Operating Times		External Leakage (scfm)[2]
		Breaking (lb)	Full (lb)	Opening (sec)	Closing (sec)	
5	84	390	1,000	2.7	3.3	0.0084
133	82	390	1,000	2.9	3.2	0.0059
141	274	310	1,000	2.6	3.3	0.008
214	280	310	1,000	2.6	3.4	0.055
222	560	270	1,000	2.6	3.4	0.0135
294	551	310	1,000	2.6	3.4	0.010

[1] Force is to open only. Actuator is spring actuated for closing.

[2] Calculated from the pressure drop observed on the Test Section Inlet Pressure Transducer, PT-1 over a 5-minute interval. The volume was 537 in^3.

Table 5. Reestablishment of Baseline Data—METC SOA Test Valve No. A-15

Internal Leakage	
Test Pressure (psig)	Internal Leakage (scfm)
50	0.57
100	0.98
200	1.80
300	2.60
400	3.75
500	3.98
585	4.60

External Leakage			
Initial Pressure (psig)	Final Pressure (psig)	Net Pressure Decay (psig)	External Leakage[1] (scfm)
600.0	595.0	5.0	0.10

[1] This calculation uses a volume of 488 in^3 and a decay time of 5 minutes.

Table 6. Total Leakage Data for VDTU Test Run No. D2—METC SOA Test Valve No. A-15

Cumulative Test-Valve Cycles	Pressure (psig)	Total Leakage[1] (scfm)
310	600	4.04
312	500	3.19
314	400	2.68
316	300	3.13
318	200	2.39
320	100	1.24
322	50	0.74
790	50	2.41
792	100	1.18
794	200	>2.42
796	300	>2.42

[1] Calculated from total test-section leakage minus internal leakage through companion valve.

Table 7. Internal Leakage Data for VSTU Test Run No. 26—METC SOA Test Valve No. A-15R

Leak Test No.	Cumulative Test-Valve Cycles	Test Pressure (psig)	Internal Leakage (scfm)
Valve-Body Temperature: 70°F ± 10°F			
1	22	62	0.16
2	25	112	0.14
3	28	213	0.95
4	31	315	1.58
5	34	413	2.00
6	37	509	2.40
7	40	554	2.4
8	190	64	0.50
9	103	114	0.18
10	196	213	0.99
11	202	414	2.20
12	202	414	2.20
13	205	515	2.70
14	208	552	2.85
15	358	65	0.53
16	361	112	0.29
17	364	213	0.92
18	367	309	1.90
19	370	410	2.25
20	373	505	2.70
21	376	552	2.90
Valve-Body Temperature: 300°F ± 25°F			
22	384	64	0.37
23	387	115	0.08
24	390	216	0.10
25	393	316	0.12
26	396	415	0.15
27	399	515	1.07
28	402	566	1.21
29	480	64	0.25
30	483	115	0.09
31	486	215	0.12
32	489	315	0.21
33	492	414	0.66
34	495	514	1.13
35	498	556	1.26
36	576	75	0.28
37	579	116	0.08
38	582	216	0.12
39	585	317	0.21
40	588	416	0.63
41	591	513	1.10
42	594	558	1.24
Valve-Body Temperature: 600°F ± 25°F			
43	598	65	1.00
44	601	115	0.22
45	604	218	0.06
46	607	316	0.03
47	610	416	0.02
48	613	513	0.01
49	616	559	0.01
50	694	75	3.95
51	697	116	0.62
52	700	217	0.08
53	703	316	0.04
54	706	417	0.04
55	709	515	0.03
56	512	560	0.03
57	778	66	3.60
58	781	116	0.35
59	784	216	0.06
60	787	316	0.06
61	790	415	0.06
62	793	513	0.06
63	796	559	0.06
Valve-Body Temperature: 70°F ± 10°F			
64	804	62	0.74
65	807	113	0.82
66	810	215	1.15
67	813	314	1.20
68	816	415	1.34
69	819	513	1.42
70	822	557	1.44
71	855	64	0.53
72	858	114	0.63
73	861	213	0.86
74	864	314	1.03
75	867	413	1.20
76	870	511	1.35
77	873	561	1.42

Table 8. External Leakage Rate for VSTU Test Run No. 26—METC SOA Test Valve No. A-15R

Cumulative Test-Valve Cycles	Initial Pressure (psig)	Pressure Decay[1] (psi)	Valve Temperature (°F)	External Leakage (scfm)[2]
21	571.0	2.0	70	0.009
377	589.0	4.0	75	0.018
383	592.0	1.0	300	0.003
595	595.0	5.0	300	0.016
597	594.0	5.0	600	0.011
797	605.0	6.0	600	0.014
803	584.0	25.0	70	0.113

[1] A test time of 5 minutes was used.

[2] This rate calculation used a volume of 586.13 in^3 for the volume of the valve in the open position including test sections and hoses.

Table 9. Actuation Force and Operating Time for VSTU Test Run No. 26—METC SOA Test Valve No. A-15R

Cumulative Test-Valve Cycles	Valve-Body Temp. (°F)	Ambient Pressure				600-psig Pressure			
		Opening		Closing		Opening		Closing	
		Time (sec)	Force[1] Break/Open	Time (sec)	Force[2]	Time (sec)	Force[1] Break/Open	Time (sec)	Force[2]
21	70	2.3	10/33	2.5	—	2.0	9/27	2.6	—
377	75	2.2	8/27	2.6	—	2.2	12/28	2.6	—
383	300	2.2	8/28	2.6	—	2.3	8/27	2.6	—
595	300	2.3	9/28	2.5	—	2.3	8/26	2.5	—
597	600	2.3	8/26	2.5	—	2.2	9/26	2.5	—
797	600	2.2	8/26	2.5	—	2.2	8/26	2.5	—
803	70	2.2	8/27	2.6	—	2.3	9/27	2.7	—

[1] The supply pressure, psig, to the actuator required to break and fully open the valve is used as an indication of actuation force.

[2] Spring-loaded closing, no measurement taken.

Table 10. Reestablishment of Baseline Test Following Metrology Inspection—METC SOA Test Valve No. A-15R

Internal Leakage		
Total Cycles	Test Pressure (psig)	Internal Leakage (scfm)
895	50	0.15
896	100	0.13
897	200	0.14
898	300	0.16
899	410	0.22
900	505	0.24
901	600	0.26

External Leakage				
Total Cycles	Initialized Pressure (psig)	Pressure Decay (psi)	Test Time (min)	External Leakage (scfm)
901	590.0	2.0	5.0	0.009

Table 11. Test Conditions for VDTU Test Run No. D7—METC SOA Test Valve No. A-15R

Subrun No.	Cumulative Test-Valve Cycles	Limestone Particle Size (mesh)	Pressure (psig)[1]	Temperature (°F)[2]
D7-1	1,050-2,141	5/16" x 1/8"	100	Ambient
D7-2	2,142-3,201	-8	100	Ambient
D7-3	3,402-5,963	-8	600	Ambient

[1] Pressure Tolerance — ± 25 psig.

[2] Temperature Tolerance — ± 25°F.

Table 12. Internal Leakage Data for VDTU Test Run No. D7—METC SOA Test Valve No. A-15R

Date	Cumulative Test-Valve Cycles	Test Pressure (psig)	Internal Leakage (scfm)
137 cycles required to seat plug on seat ring properly before run.			
12-13-79	1,042	52	0.92
	1,043	103	0.64
	1,044	205	0.82
	1,047	300	0.39
	1,048	407	2.00
	1,049	504	2.00
	1,050	567	1.40
Subrun D-7-1: 1,092 cycles; ambient valve-body temperature; 5/16" x 1/8" limestone.			
12-18-79	2,142	51	9.20
	2,143	109	11.6
	2,145	206	9.46
	2,146	316	7.20
	2,148	407	3.14
	2,151	505	1.92
	2,152	569	1.40
Subrun D7-D: 934 cycles; ambient valve-body temperature; -8 limestone.			
12-20-79	3,186	57	5.48
	3,189	103	7.20
	3,191	201	7.70
	3,193	303	7.11
	3,198	399	4.43
	3,201	504	6.16
Subrun D7-3.1: 1,134 cycles; ambient valve-body temperature; -8 limestone.			
1-3-80	4,335	55	14.0
	4,338	97	>23.3
	4,339	210	>33.0
	4,340	320	>40.4
	4,341	406	>45.2
	4,342	506	>50.3
	4,343	523	>51.
Subrun D7-3.2: 65 cycles; ambient valve-body temperature; -8 limestone.			
1-17-80	4,408	54	1.24
	4,409	105	1.88
	4,410	288	2.61
	4,411	311	1.15
	4,412	398	1.10
	4,413	500	1.22
	4,414	570	1.42

Subrun D7-3.2: 65 cycles; ambient valve-body temperature; -8 limestone.

Table 13. Actuation Force and Operating Time Data for VDTU Test Run No. D7—METC SOA Test Valve No. A-15R

Test-Valve Cycles	Actuator[1] Supply Pressure (psi) Break/Open	Operating Times		Valve Body Temp. (°F)
		To Open (sec)	To Close (sec)	
912	5/23	3.00	4.70	58
1,051	4/24	3.00	4.50	36
2,139	4/22	2.60	4.60	22
2,153	10/22	2.70	4.20	38
2,665	6/24	2.60	4.10	44
3,203	14/28	3.20	4.20	36
3,716	8/28	2.86	4.19	36
4,344	8/28	3.00	4.20	30
4,415	2/18	4.00	4.00	47
4,420	5/22	3.00	4.30	420
4,944	5/23	3.75	4.00	500
5,451	2/24	3.00	3.90	500
5,961	24/30	3.00	4.10	500

[1] The supply pressure, psig, to the actuator required to break and fully open the valve is used as an indication of actuation force. Spring-loaded closing, no measurement taken.

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SUMMARY TEST REPORT

FIGURES

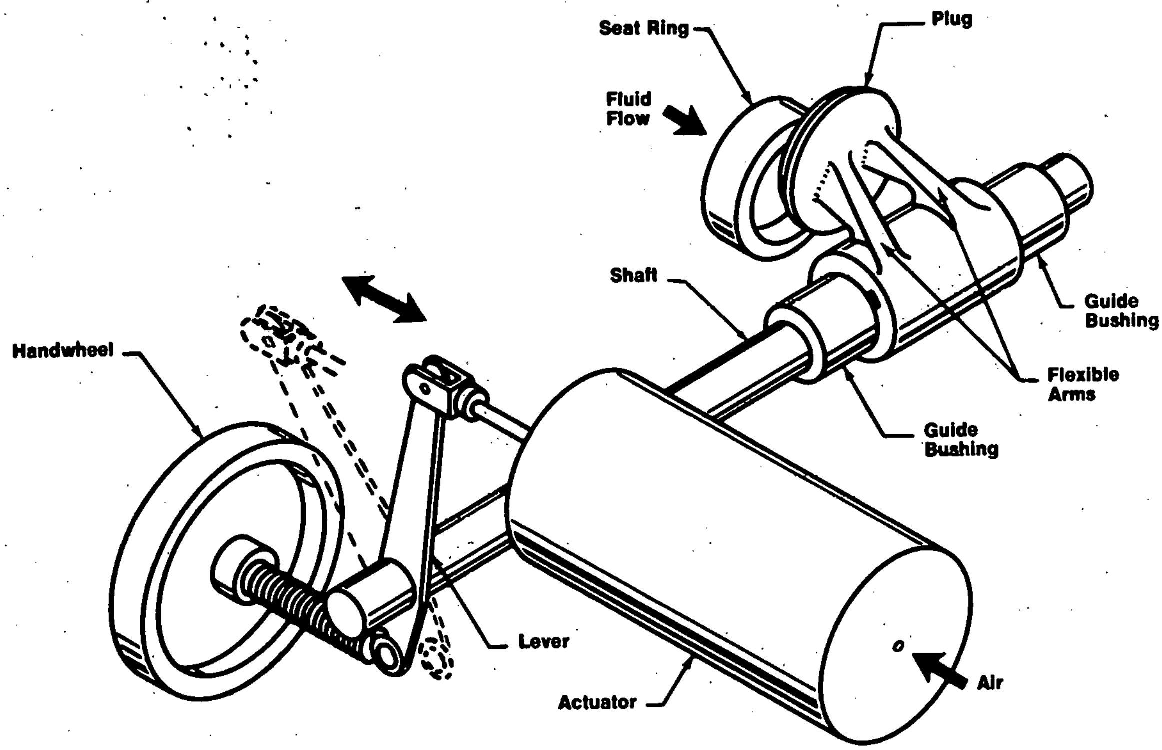

Figure 1. Schematic, 6-Inch Masoneilan Camflex II Valve–METC SOA Test Valve No. A-15

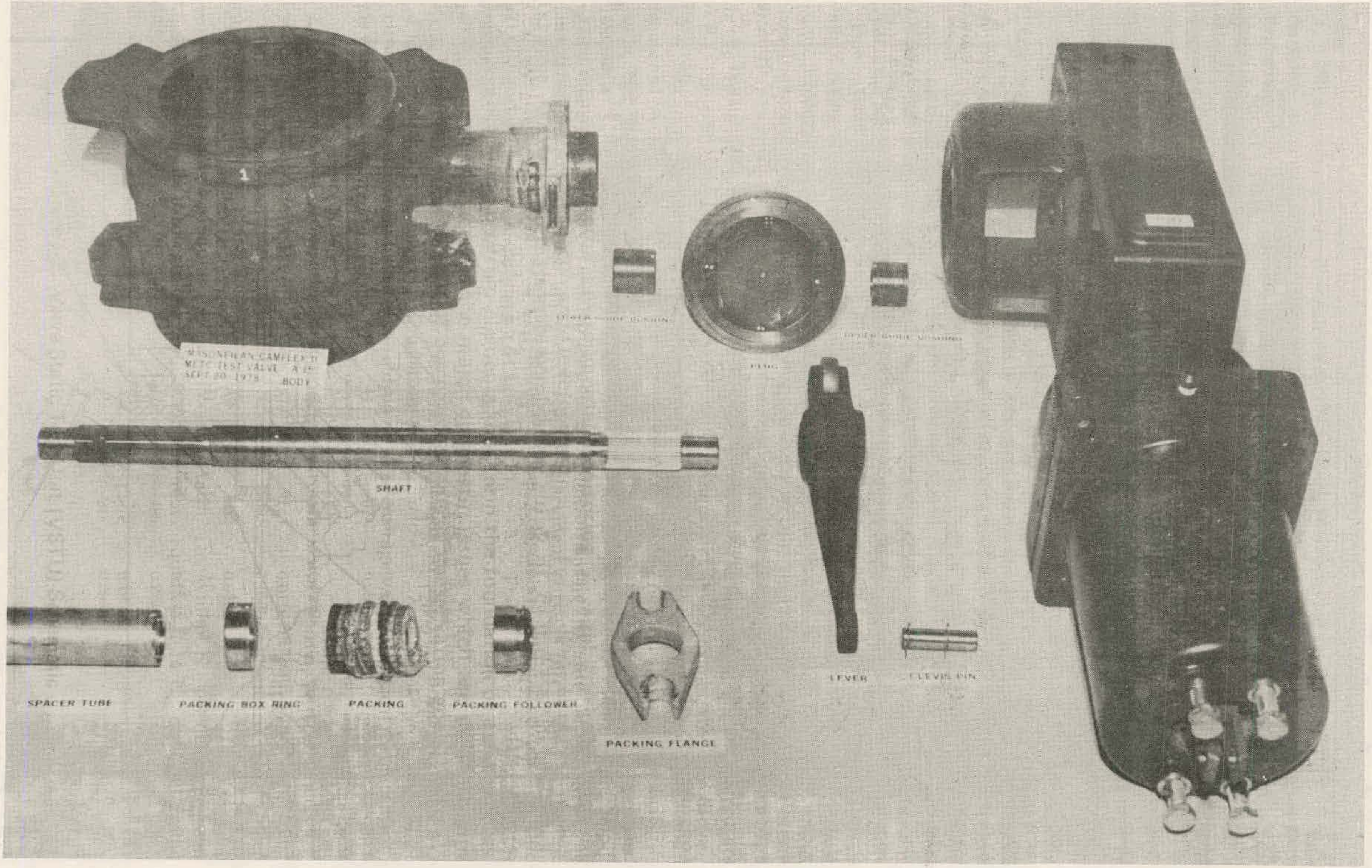

Figure 2. Component Parts of Masoneilan Camflex II Valve--METC SOA Test Valve No. A-15

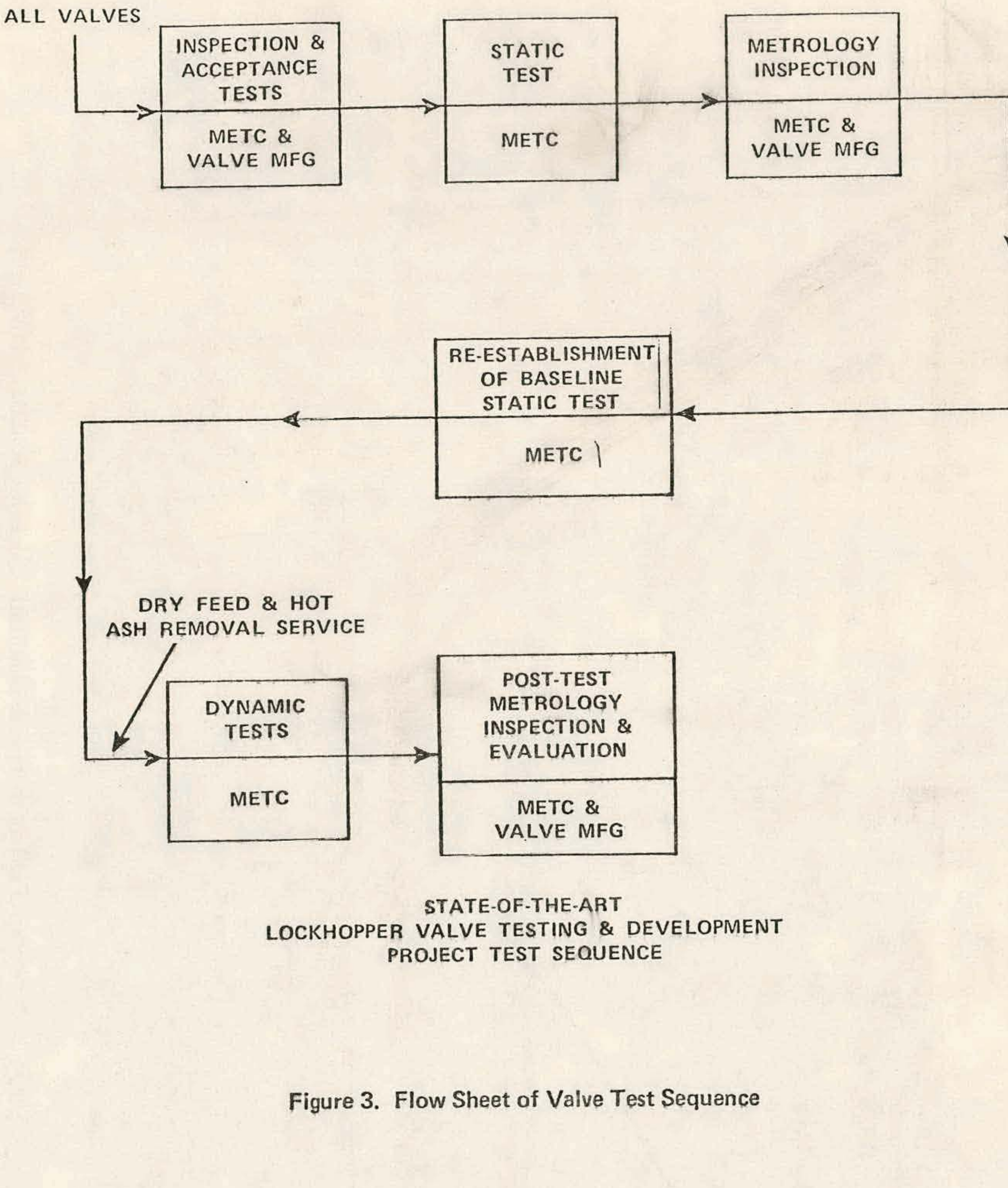

Figure 3. Flow Sheet of Valve Test Sequence

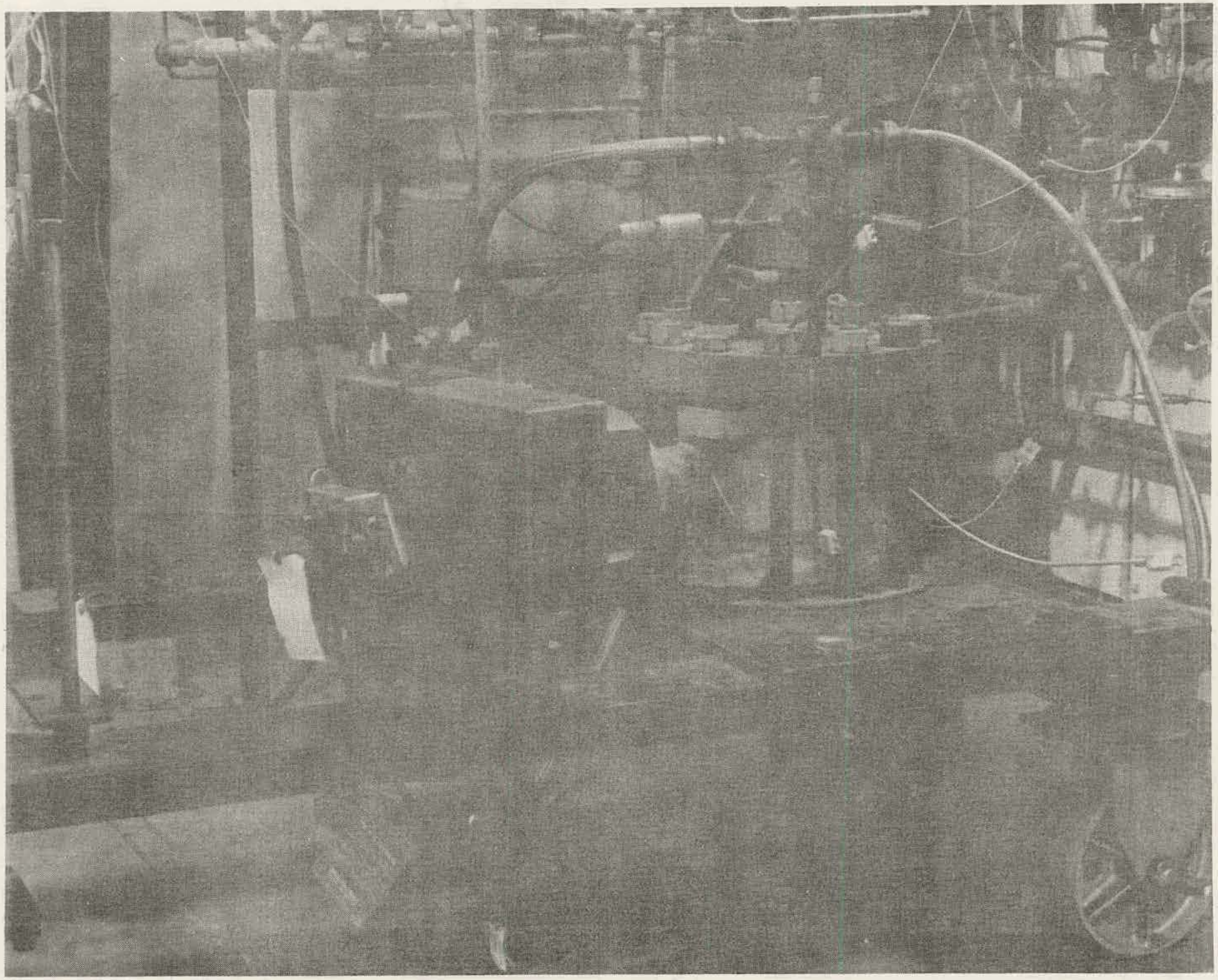

Figure 4. VSTU Installation—METC SOA Test Valve No. A-15

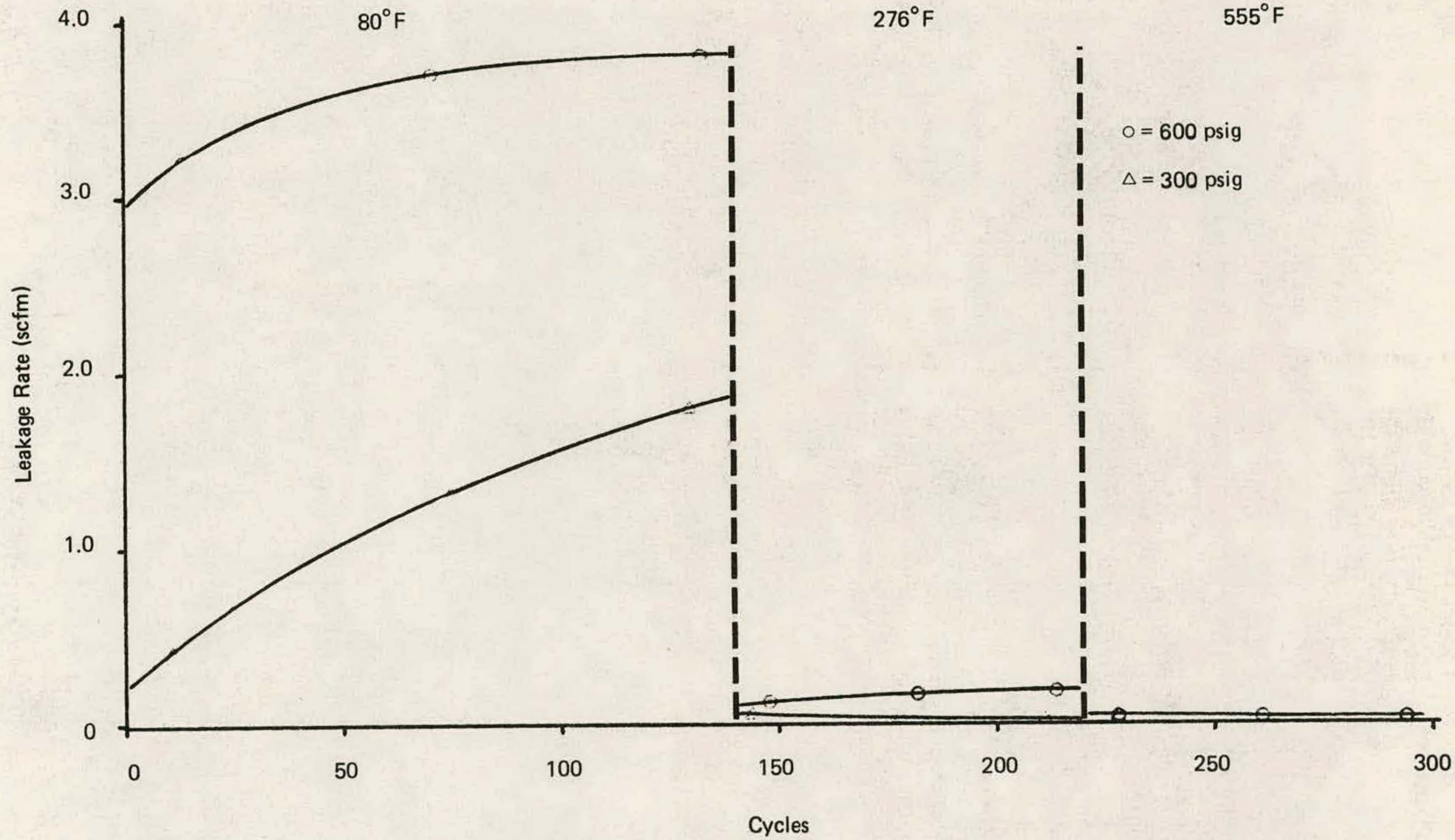

Figure 5. Internal Leakage Versus Cycles at Various Pressures and Temperatures for VSTU Test Run No. 20—METC SOA Test Valve No. A-15

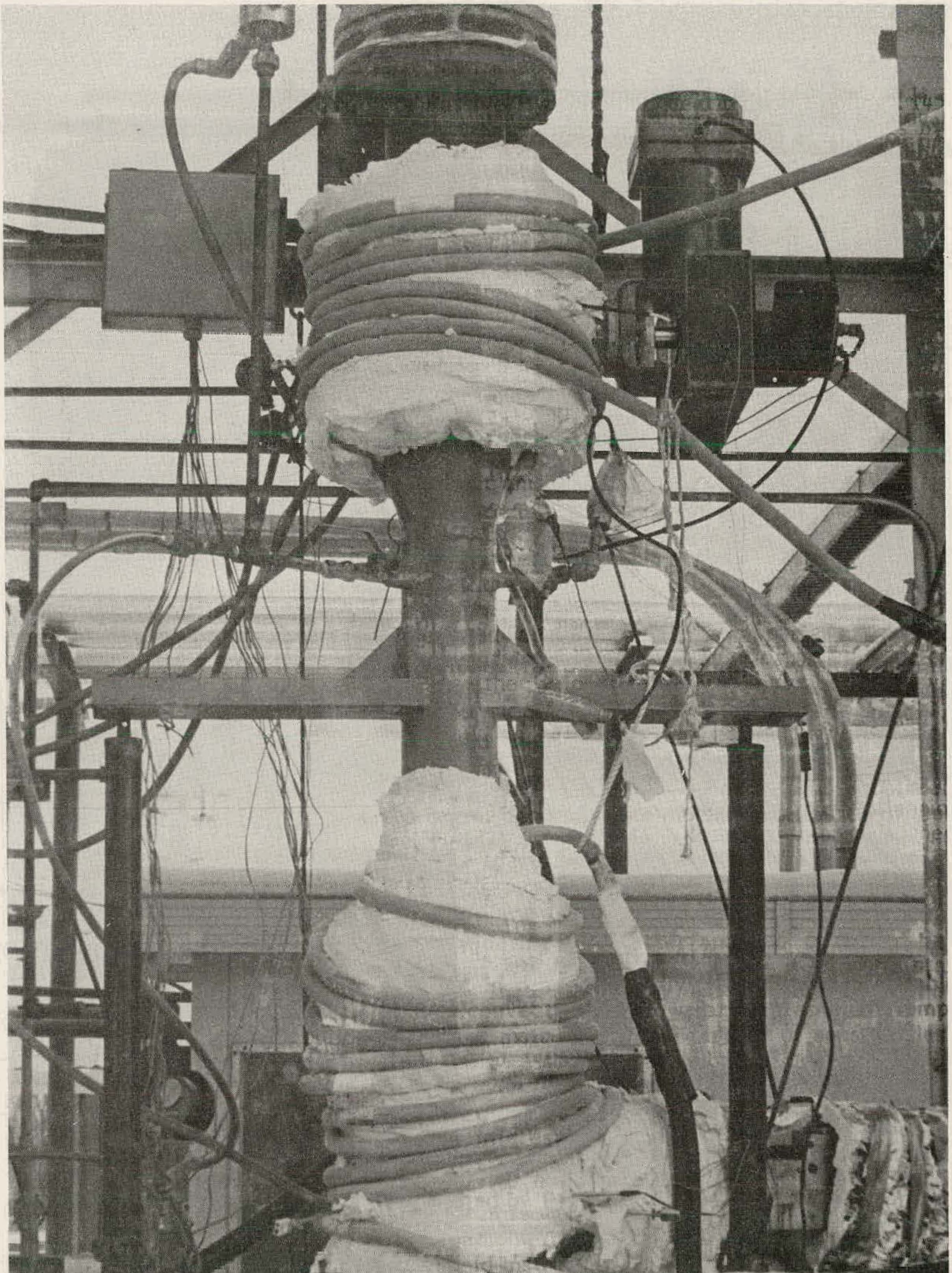

Figure 6. VDTU Installation—METC SOA Test Valve No. A-15

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SUMMARY TEST REPORT

APPENDIX

APPENDIX–METC VALVE TEST FACILITIES

The Morgantown Energy Technology Center has constructed four test units for the evaluation of valves for coal-conversion service. The capabilities of these test units are summarized on Figure I-1. These facilities are supplemented by a computerized Automatic Data-Acquisition and Control System (ADACS), an extensive metrology laboratory, and a staff of highly-trained operating technicians.

The Valve Static Test Unit (VSTU) evaluates the valve's performance (operating force, operating time, stem leakage, and seat leakage) with dry gas at ambient and elevated temperatures. The purpose is to provide baseline data for comparison with the results of testing with solids. A schematic is shown on Figure I-2.

The Valve Dynamic Test Unit (VDTU) operates the valve in a simulated lockhopper mode. Ambient-temperature solids flow in batches through the vertical test train. Two or three valves are in series and the sections between them are alternately pressurized and vented. A typical operating sequence is provided on Figure I-3. The test valves can be heated by an external induction heater to evaluate the effects of elevated temperatures. A schematic is shown on Figure I-4.

The Valve Hot Solids Test Unit (VHSTU) operates much like the VDTU. The difference is that the solids being lockhoppered through the test train are at an elevated temperature. The fluidized-bed-solids heater in the unit can provide solids at up to 2000°F. A schematic is shown on Figure I-5.

The Valve Slurry Test Unit (VSLTU) is designed to test valves to be used for aqueous-slurry rather than dry-solids service. A schematic is shown on Figure I-6.

The ADACS facility is dedicated solely to the valve-testing program. It provides automatic control of the test units, real-time monitoring of valve operation, data acquisition, and display of the test results.

The metrology laboratory has a wide range of equipment running from Weber Gauge Blocks to a Boice C-201 CMM 3-dimensional measuring machine to provide extensive capabilities for physical measurements. These capabilities are supplemented by equipment for surface finish characterization, hardness determination (both for metals and elastomers), and alloy verification. Cameras and lighting systems are available for documenting the disassembly of a valve and the condition of each part.

Parameter	Valve Static Test Unit (VSTU)	Valve Dynamic Test Unit (VDTU)	Valve Hot Solids Test Unit (VHSTU)	Valve Slurry Test Unit (VSLTU)
PRESSURE (PSIG):	← 0-1600 →			
PRESSURIZING MEDIA:	← Air or Nitrogen →			
TEST MEDIA	Dry Gas	Non-Flammable Solids up to 4 Mesh	Non-Flammable Solids up to 4 Mesh	Water Slurry up to 50% Solids
MEDIA TEMPERATURE	Ambient	Ambient	100-2000°F	100-200°F
EXTERNAL HEATERS FOR VALVE BODY	100-850°F	100-850°F	None	None

Figure I-1. METC Valve Testing Facilities

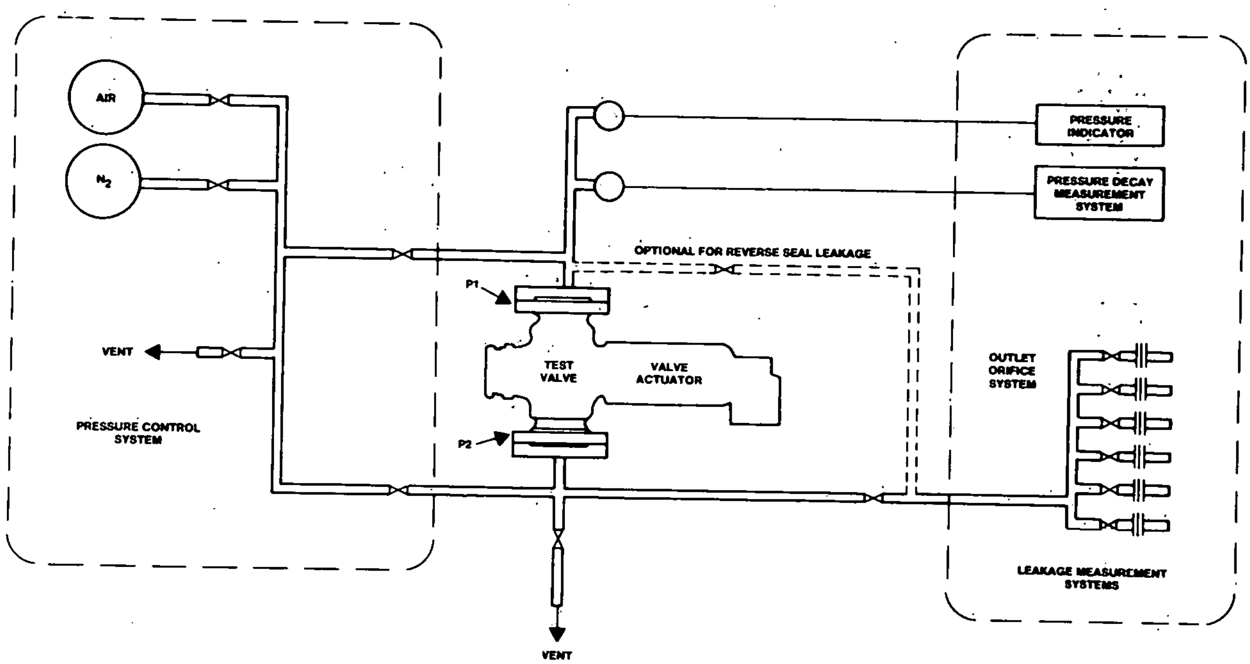

Figure I-2. Valve Static Test Unit (VSTU) Schematic

EVENT		ESTIMATED TIME SECONDS
1.	Open Test Unit Feed Valve	15
2.	Solids Flow to Upper Test Valve	15
3.	Close Test Unit Feed Valve	15
4.	Open Upper Test Valve	5 - 30
5.	Solids Flow into Test Section	30
6.	Close Upper Valve	5 - 30
7.	Pressurize Test Section	60 - 200
8.	Gross Leak Test	60 - 200
9.	Depressurize Test Section	60 - 200
10.	Open Lower Test Valve	5 - 30
11.	Solids Flow from Test Section	30
12.	Close Lower Test Valve	5 - 30
	Total Time Per Cycle	305 to 825

Note: Pressure decay leak test is available as option.

Figure I-3. Dynamic Test Sequence—Two-Valve Test Train

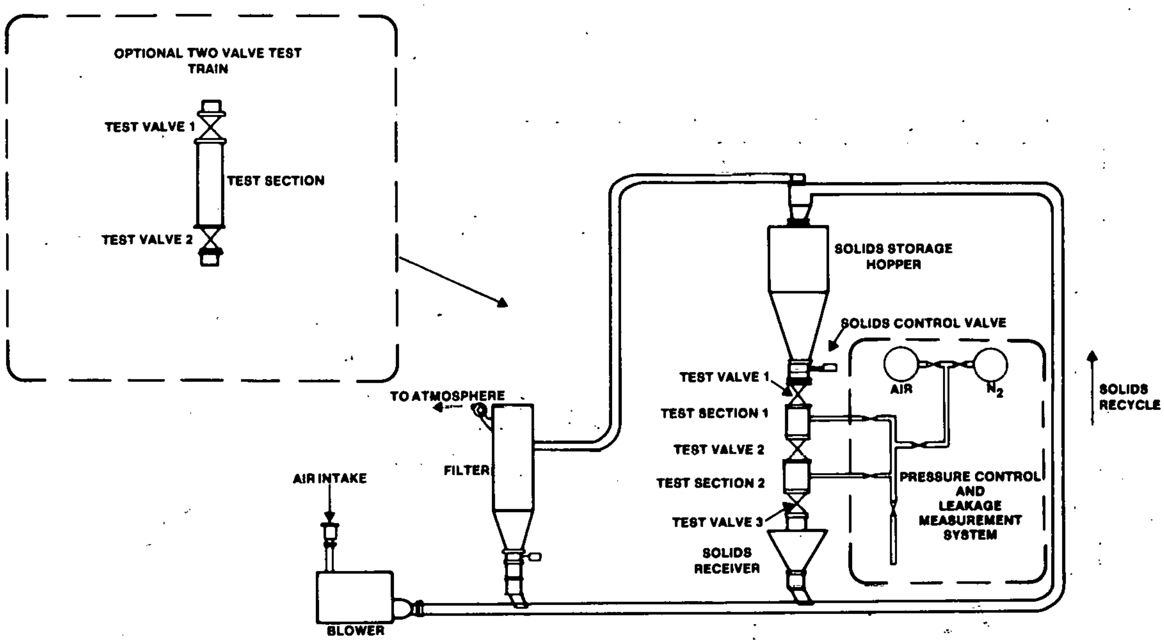

Figure I-4. Valve Dynamic Test Unit (VDTU) Schematic

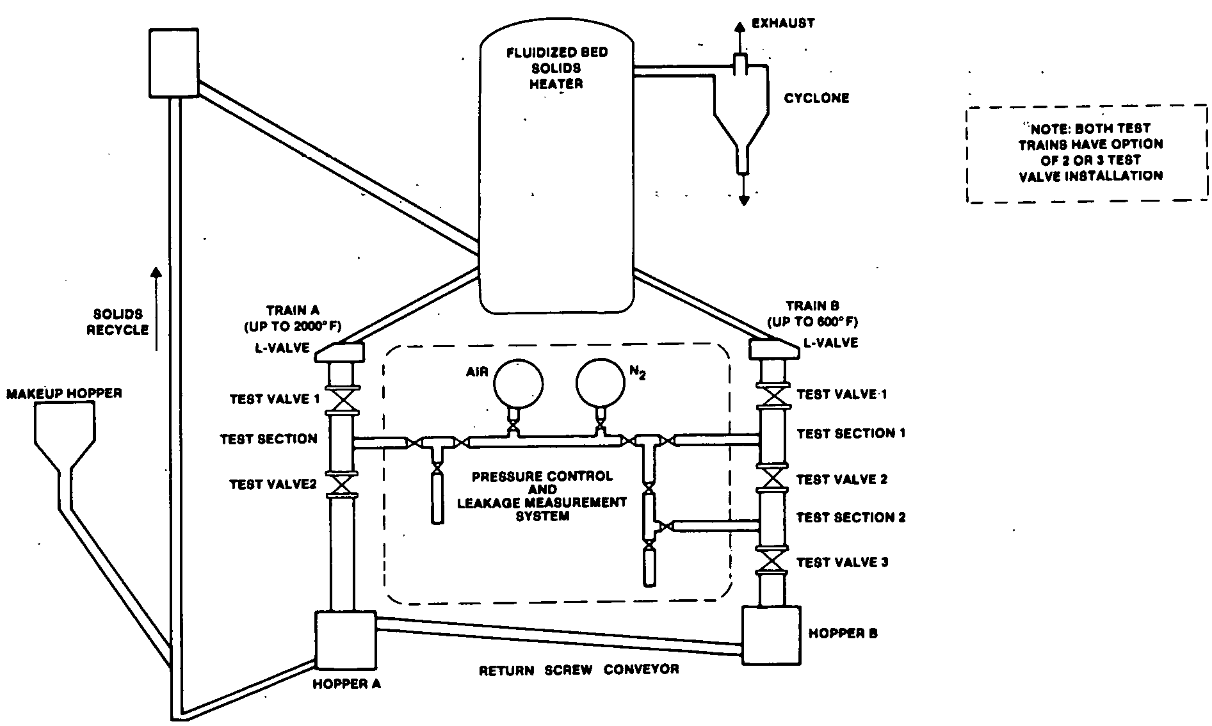

Figure I-5. Valve Hot Solids Test Unit (VHSTU) Schematic

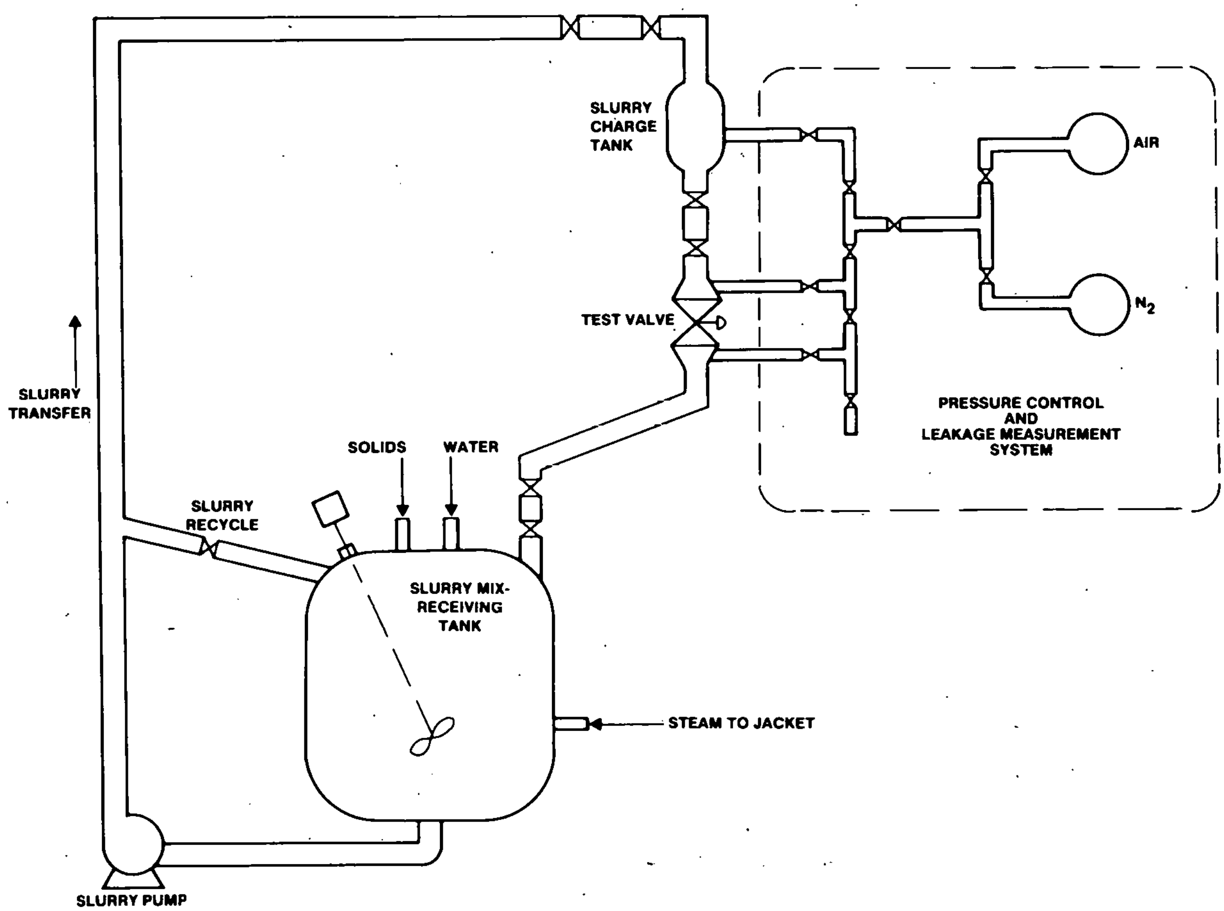

Figure I-6. Valve Slurry Test Unit (VSLTU) Schematic

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