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Title: CONTAINMENT PURGE AND VENT VALVE
PROGRAM — FINAL REPORT

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Operated for the U.S. Department of Energy
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TECHNICAL DATA RECORD

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DISTRIBUTION K. Akamine P. Archbold F. L. Fletcher D. E. Goggin R. Jassak M.W. McDowell A. Onesto R. E. Schnurstein T. L. Wells D. J. Zweng Library (15)		STATEMENT OF PROBLEM Butterfly valve actuators are required to close the valves against flow developed in the event of a design basis loss of coolant accident and concern has been raised about the ability of existing valves to close under these conditions.		
		ABSTRACT: This report describes the Test Piping System and Instrumentation used to determine the forces acting against the actuator when closing a butterfly valve against flow. Locations of the test instrumentation are shown and photos of the installation are included. The techniques for determining bearing and packing resistance, seating forces and fluid dynamic forces are described. Various problems encountered and corrective actions taken are discussed. Typical plots are included to illustrate the results obtained. Complete sets of data for each valve program were transmitted to EG&G, Idaho for detailed analysis.		
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I. INTRODUCTION AND SUMMARY

The purpose of this program was to evaluate the closing torque requirements of three butterfly valves typical of the types used in the containment purge and ventilation system of commercial nuclear facilities. The closing torques were to be measured with two upstream piping configurations and with the valves mounted in various attitudes. Leak tests were to be performed before and following torque tests and Design Basis and Severe Accident tests.

Closing torque requirements were determined against a constant upstream pressure with the valves in the various attitudes in both upstream piping configurations. Temperature, pressure, and flow parameters were measured and recorded for analysis.

The tests were performed at the Thermal Transient Facility (TTF), where nitrogen gas was used to pressurize the test piping system to the desired pressure. High pressure nitrogen from the facility bottle bank was controlled by a valve which was programmed to ramp open and then maintain a constant pressure upstream of the test valve under computer control. The test valve actuator was computer controlled to close against this pressure when the required pressure was reached. A torque meter was installed on the test valve and connected to the Data Acquisition System to record the torque required to open and close the valve. The data was recorded in core memory, then transferred to high speed disc for control room printout following each test and was recorded on tape for permanent record and off-line data recovery.

Tests were performed in accordance with ETEC test procedures 013-TP-0001, 013-TP-0002 and 013-TP-0003, and EG&G Test Request ES-50823. Tests were performed on two different designs of Butterfly valves and on two different size valves of one of the designs. After cycling each valve to "age" the seat, a leak test was performed in each direction followed by a no-flow unseating force test. The torque required to open and close the valve was then determined by stroking the valve from full open to full closed and back to full open. Torque required to close the valve against 60 psig pressure was determined in six (6) different attitudes for each valve.

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Additional tests were performed at 15, 30 and 45 psig on the 24-in. valve. A second seat leak test was performed on each valve after completion of the torque tests.

Leak tests were also performed on each valve at elevated temperatures under simulated "Design Basis Accident" and "Severe Accident" conditions.

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II. TEST DESCRIPTION

A. FACILITY

The Thermal Transient Facility (TTF) is designed to enable accelerated life tests, thermal transient tests, and thermal creep tests under mechanical loading using gaseous nitrogen as the heat transfer medium.

Structural steel members embedded in the floor are designed to react loads through interaction with test article support members bolted to these floor beams. This technique provides flexibility in the test article configurations that can be accommodated. The mechanical loads are normally provided by load struts powered by hydraulic load cylinders with load cells for load measurement. The facility maintains an inventory of different sized load cylinders. The hydraulic system is dedicated and includes a load maintainer which enables precise pressure control to twenty different supply lines, thus accommodating requirements to apply bending moments, torsional loads, and tensile or compressive loads to the desired level. Gaseous nitrogen is supplied from a 1080-ft³ (16,000-lb) bottle bank at 3200 psig.

The basic piping with control valves and safety features is in place in the two bays of the facility and is ready for connection to any test article. The exhaust stacks and associated piping are also in place and blast shields are available for equipment and personnel protection during high pressure test programs. Electric power is available for heating elements when required to provide controlled temperature distribution across a test article. The heating elements can be zoned and each zone maintained at the proper level by temperature controllers.

Both bays in the facility have patch panels which are connected to the digital data acquisition system (DDAS). Instrumentation for a test program is connected to the patch panel for monitoring and recording in the control room. Control signals are also connected through the patch panel to enable remote computer control of all high pressure tests.

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The TTF was selected for this valve program on the basis of ability to provide the necessary gas flow at the required pressures in a pipe loop which conformed to the Test Requester's configuration. The flexible feature of the support beams enabled suitable tie-down for restraint of the piping configuration during high pressure blowdowns.

The piping system for the 8-in. butterfly valve tests was installed in the high bay and was connected to the facility 4-in. nitrogen supply line through a flowmeter and a 4-in. ball-type regulating valve. From the control valve the line expanded into an 8-in. vertical U-bend arrangement with a rupture disc connection at the top of the U-bend. The horizontal test section of pipe was connected to the return leg of the U-bend through a 90° elbow. The outlet end of the test section was flared and exhausted to atmosphere through a horizontal 24-in. pipe duct. The test piping system was supported and restrained using the existing facility structural steel support members. Figure 1 shows this installation. The piping system was fully instrumented with thermocouples and pressure transducers as shown in Figures 2 and 3. All parameters required for each test were recorded by the data acquisition system and quick-look printouts and plots were available from the line printer in the control room. The ball-type pressure regulating valve was hydraulically actuated under computer control. The valve was ramped open in prescribed time by the computer until the desired upstream pressure was achieved and then operated under pressure control until closed by the computer when the test valve reached the fully closed position.

Vertical support stands were used to support the valve outside of the test loop for valve cycling and leak testing. The leak tests were performed using a portable rig which includes provisions for accurate control of the applied gas pressure, for reading low leak rates by means of positive water displacement and for reading larger leak rates by means of calibrated flowmeters of various capacities.

For the 24-in. butterfly valve test, the test loop position was located adjacent to the nitrogen bottle bank area in order to minimize line losses.

Figure 1. Installation in Thermal Transient Facility

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FIGURE 2 - INSTRUMENT LOCATIONS
STRAIGHT RUN INSTALLATION

FIGURE 3 - INSTRUMENT LOCATIONS
ELBOW INSTALLATION

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The test loop was connected to a 600-ft³, 3200-psig nitrogen storage bottle through a 6-in. block valve. From this valve the line was reduced to match the 4-in. ball type control valve and from the outlet of this valve the line expanded to 24-in. pipe which was welded to a 90° elbow, as shown in Figure 5. The straight section of pipe was fitted with a 16-in., 150-psi rupture disk. The test section of 24-in. pipe was bolted to the outlet of the 90° elbow, as shown in Figure 4. Instrumentation and controls were similar to those used for the 8-in. valve tests and the signal cables were routed to the control room to provide the necessary control and data recording. Cycling and leak testing was performed in a vertical support stand in the facility high bay. All tests were controlled remotely from the control room with visual observation of the control valve, test valve, and exhaust enabled by TV cameras with TV monitors located in the control room.

B. INSTRUMENTATION

The Thermal Transient Facility (TTF) Containment Purge Valve Test instrumentation system consisted of pressure transducers, thermocouples, RVDTs for valve angular position, and a torque sensor. Each of these measurements employs standard supporting electronics and signal conditioning components. All parameters are ultimately recorded on the TTF computer-based digital data acquisition system (DDAS). Test data is temporarily recorded in computer memory, transferred to disc, and permanently recorded on magnetic tape. By employing this special recording routine, the DDAS recording rate has been increased to 155 samples per second for these highly transient tests. Data can be retrieved from disc storage shortly after the actual tests or from magnetic tape at any time in the future.

1. Data Acquisition System

The TTF DDAS is based on a Hewlett Packard Model 21MX E series computer. This system interfaces the facility data channels with a Hewlett Packard Model HP 2313B multiplexer.

FIGURE 4. 24-INCH VALVE - STRAIGHT RUN INSTALLATION

FIGURE 5. 24-INCH VALVE - ELBOW INSTALLATION

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While this system has inherent capacity for hundreds of measurement channels, the requirements of this test program were satisfied with 48 channels. These channels were input to either a high-level (± 10.24 V fs) card or a programmable low-level (± 10 mV to ± 800 mV fs) card, depending on their signal requirements. Data can be monitored at two facility CRTs, and plots or tabulations can be made on an HP 2608A printer/plotter.

2. Pressure Transducers

The program utilized several pressure transducers of both static and differential configurations. The transducers utilized strain gage transducing techniques, were of both amplified and nonamplified configurations, and are summarized in Table 1.

3. Temperature Measurements

All temperature measurements were made with Type K (chromel-alumel) thermocouples used with 130°F heated reference junctions. The thermocouples were premium grade 1/4-in.-OD stainless steel sheathed units manufactured to RDT STD C7-6T.

4. Valve Position Measurement

Both the facility control valve V-102D and test article valve shaft position measurements were made with Schaerritz Model R30D ($\pm 40^\circ\text{F}$) rotary variable differential transformer (RVDT) transducers.

5. Torque Measurement

The test article valve shaft torque measurement was made with a Lebow Model 2112-100K 100,000 in.-lb torque sensor for the 24-in. valve and a Lebow Model 2110-5K 5,000 in.-lb torque sensor for the 8-in. valves.

TAG NUMBER	MODEL TRANSDUCER	RANGE
PT-TA-A	CEC-1000-02	100 PSIG
PT-TA-B	CEC-1000-02	100 PSIG
PT-TA-C	STATHAM PA497-100-3	100 PSIA
PT-TA-D	STATHAM PA418-100-7	100 PSIA
PT-TA-E	STATHAM PA497-100-6	100 PSIA
PT-TA-F	STATHAM PA497-100-6	100 PSIA
PT-TA-G	STATHAM PA418-100-6	100 PSIA
PT-TA-H	STATHAM PA418-100-6	100 PSIA
PT-TA-J	STATHAM PA418-100-7	100 PSIA
PT-TA-K	STATHAM PA418-100-7	100 PSIA
PDT-TA	STATHAM PM8142-100	100 PSID
FE-102A	STATHAM PM8142-300	300 PSID

TABLE 1. PRESSURE TRANSDUCER
SUMMARY

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6. Accuracy

The accuracies of all measurements were equal to or better than the Test Request requirements except for the torque measurement, where the resolution was ± 108 in.-lb and the accuracy was ± 300 in.-lb, and the nitrogen flow rate, where the accuracy was ± 2 lb/sec when the flow rate was 20 lb/sec or larger. Table 2 lists the instrument accuracies.

C. QUALITY CONTROL

The ETEC Quality Assurance department ensures that the requirements of RDT Standard F2-2, including Amendments 1-7 are met. Quality Assurance Program Index, QADD No. 9, relates ETEC procedures and directives to RDT Standard F2-2.

The ETEC Quality Assurance department participated in the program through document reviews, shop and facility surveillance, and inspection. All documents related to the program such as drawings, specifications, purchase orders, and procedures were reviewed for compliance with RDT Standard F2-2, the Test Request, and all Society codes. Surveillance of suppliers, shop facilities, contractor activities, and the facility operations and maintenance ensured that quality requirements were met. All verifications required by inspection plans, construction inspection records, and procedures were verified by Quality Assurance inspection.

D. TEST ARTICLE

The test articles for this program are butterfly valves similar to those used in nuclear power plant containment purge and vent systems. Two valves of the same size but different design were tested and two valves of different size but the same design were tested. Test Valve 1 is an 8-in. valve. Test Valves 2 and 3 are 8-in. and 24-in., respectively, and are of the same design.

	<u>Size (in.)</u>	<u>Design</u>
Valve 1	8	A
Valve 2	8	B
Valve 3	24	B

PARAMETER	RANGE	REQUIRED ACCURACY
Test Valve Inlet Pressure	0-100 psig	±2 psi
Test Valve Delta Pressure	0-100 psid	±4 psi
Nitrogen Flow		±20 cfm
Test Valve Inlet Temperature	0-1000°F	±5°F
Test Valve Torque	0-5000 in.-lb	±24 in.-lb
Test Valve Torque	-	

TABLE 2 - INSTRUMENTATION ACCURACY

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Test Valve 1 is designed with an elastomer seat installed in the valve body as shown in Figure 6. The valve disc contains a half-round metal surface which mates with the seat. The valve contains no stops and the full open and full closed positions were established by aligning the coupling so that the stops in the hydraulic actuator prevented valve travel beyond these positions.

Test Valves 2 and 3 have the elastomer seat secured to the disc and have a wedge shaped metal seat in the body. The full open and full closed positions were established by alignment of the coupling with the hydraulic actuator stops, preventing valve travel beyond these positions. Figures 7 and 8 show the general arrangement of these valves.

E. TEST METHOD

The tests performed were specified in a test matrix, Table 3, with configurations as shown in Figure 9. For each valve, a test was performed in a fixture, as shown in Figures 6, 7 and 8, to determine the unseating force prior to installation in the test pipe loop. In order to eliminate any effect due to the valve being closed against the seat for any length of time, this test was started with the valve in the full open position. The valve was then closed and immediately opened under computer control with data recorded at a rate of 100 samples per second. Since the valve was stroked from full open to closed with data recorded, the same test provided the data for the bearing and seal resistance and seating force test. A cycling test was then performed to "age" the valve seat. For this test, the valve was cycled 150 times from full open to full closed to full open under computer control. Plots of torque and valve position vs time were generated immediately after the first cycle to establish the baseline and to verify torque did not exceed the specified threshold value. The valve was then cycled (with plots generated after cycle numbers 50, 100, and 150) to determine whether any adverse conditions were developing.

FIGURE 6. VALVE 1

FIGURE 7. VALVE 2

FIGURE 8. TEST VALVE 3

FIGURE 9. Valve Positions for Test Program

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TABLE 3
TEST MATRIX

No Flow Tests			Valve "1" 8" dia.	Valve "2" 8" dia.	Valve "3" 24" dia.
Unseating Force Test			✓	✓	✓
Bearing and seal resistance and seating force test			✓	✓	✓
<u>Flow Tests</u>					
<u>Entrance Type</u>	<u>Disk Surface Facing Upstream</u>	<u>Stem Position</u>			
Straight	Flat		✓	✓	✓
Straight	Back		✓	✓	✓
Elbow	Flat	Perpendicular to plane of elbow, actuator at "a"	✓	✓	✓
Elbow	Back	Perpendicular to plane of elbow, actuator at "a"	✓	✓	✓
Elbow	Flat	Perpendicular to plane of elbow, actuator 180° from "a"	✓	✓	✓
Elbow	Back	Perpendicular to plane of elbow, actuator 180° from "a"	✓	✓	✓

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On completion of the cycling test, a gas seat leak test was performed at ambient conditions. This test consisted of mounting flanges to the inlet and outlet of the test valve with gas connections provided in each flange. Nitrogen gas pressure was then applied to one side of the valve at levels of 2 to 3 psi, 50 psi, and 125 psi, and a line from the opposite flange was installed in an inverted measuring jar suspended over a bath of water. The gas leakage was monitored for 30 minutes and then the test was repeated in the opposite direction across the test valve. If the leak rate was excessive for water displacement techniques, provisions existed for switching the outlet to a series of flowmeters.

Following the seat leakage test, the test valve was installed in the pipe loop, and flow tests were performed in the six configurations defined in Figure 9. The flow test was initiated with the test valve in the full open position. The system control valve was then ramped open at a predetermined rate, under computer control, until the line pressure upstream of the test valve reached 60 psig. At that point the computer changed to pressure control. The test valve was then closed under computer control to the full closed position at which point the computer closed the control valve and fully opened the test valve. Plots of torque, valve position, line pressure, and control valve position were generated immediately following each test for determination of initial torque, running torque, and seating torque. The tests were repeated for determination of repeatability of test results. After completion of flow tests in all six configurations, the test valve was removed from the test loop and installed in the assembly fixture. The seat leakage test was repeated in both forward and reverse directions to determine whether the flow tests caused any degradation in valve integrity. This concluded the basic test program. Data was reduced for all parameters for each configuration for all valve tests.

After completion of the basic test program, each valve was moved to a vertical support stand and subjected to Design Base Accident conditions of temperature and pressure, with leak checks at various conditions, followed by Severe Accident conditions of temperature and pressure with further leak checks. These tests were performed to procedure 013-STP-094.

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F. TEST OPERATION

In September 1983, the 8-in. pipe test loop for this program had been installed in the TTF. Nitrogen was piped to the 4-in. ball control valve which was programmed to ramp open in 5 seconds and to switch to pressure control when the downstream pressure reached 60 psig. With an open pipeline installed downstream of the control valve, a blowdown test was performed to verify operation of the control valve. The valve did not open beyond 40% of full open position and, on closing, there appeared to be an excessive leak rate through the valve. The manufacturer's field engineers replaced the seats in the valve. A new actuator was procured and installed and the blowdown test was repeated.

Subsequent to this test, seat leakage was again in evidence and the seats were removed and new aluminum-bronze rings were installed in place of the original teflon rings. As an added safeguard, a 2-in. bypass line was installed between the control valve and the test valve to prevent excess pressure buildup due to control valve leakage when the test valve was fully closed. Testing continued until control could no longer be improved without the test valve being installed. The Site Representative had arrived on site on September 2, 1983 and had agreed to performance of both cycling and leak tests in a vertical stand outside of the test loop. The actuator and valve were aligned so that, with computer control of the actuator motion, the valve could not be overclosed. Cycling tests were initiated and the torque plot was reviewed after 1 cycle, 50 cycles, 100 cycles, and 150 cycles. No significant change was observed in initial torque, running torque, or closing torque throughout the test. Figure 10 is a typical plot showing cycles 45 through 50 of the test.

The Site Representative requested a baseline seat leak test in both forward and reverse directions prior to installing test valve No. 1 in the test loop. Flanged covers with provisions for pressurization and leak connections were installed on the test valve. A portable leak detection system was set up to measure the gas leak rate. This system had provisions for precise control of the supply gas pressure, accurate small leak measurement using

FIGURE 10. VALVE 1 - CYCLING TEST

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positive water displacement, and larger leak measurement using various capacity calibrated flowmeters. The leak measurement indicated a leak rate of approximately 41.5 scfh at 2 psid in both directions and then 505 scfh at 100 psid in both directions. Examination of the valve seat showed a section from about 12 o'clock to 2 o'clock, looking into the valve, where light could be seen between the disc and the seat. The valve was opened and closed and the condition was found to be repeatable.

After discussion with the Test Requester, an attempt was made to tighten the compression ring and close the gap. This effort had no effect, and further examination led to the conclusion that the valve had in all probability been stored on its side, resting on the actuator extension, which would put the section of seat under observation at the lowest part of the valve disc. Under these conditions, it was concluded, the elastomer seat had probably taken a set. In agreement with the Test Requester, heat was applied to the segment of seat in question, using a small hand-held hot-air blower, and a further attempt was made to reshape the elastomer using the compression plate. An improvement was observed but a seal could not be achieved. The Test Requester then arranged to provide a new elastomer seat.

By October 25, 1983 a new valve seat had been supplied and installed and a leak test was performed. After adjusting the alignment between the valve and actuator, there was no measurable leak in either forward or reverse direction. The valve was originally lined up by setting the disc flat face parallel to the valve flange to assure a full closed position. The hydraulic actuator was then set to its full closed position and the coupling flanges were bolted in place. On subsequent strokes, however, the valve did not seat properly in the full closed position. Analysis of the situation indicated that after coupling in the torque transducer, when the actuator reached its closed position, part of the closing force was absorbed in "wind-up" of the torque transducer so that the valve did not reach the full closed position. The actuator mounting holes were slotted and the actuator was rotated so that in its closed position, it could accommodate this wind-up and still position the valve so that it was full closed. Tests performed in this configuration enabled the valve-actuator setting to provide full closure repeatedly.

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The valve cycling test was then repeated to "age" the new seat and the torque plots were obtained after 1, 50, 100, and 150 cycles. Figure 11 is a typical example of these plots.

Figure 11. Valve 1 - Second Cycling Test

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The test article valve was installed in the test loop in the No. 1 configuration of Figure 9. Several blowdown tests were performed with the test valve locked open to characterize the control curve for the control valve. On October 28, a test run was made with the test valve closing under computer control. The pressure upstream of the test valve only reached 50 psig with the test valve wide open and did not approach 60 psig until the test article valve was closed to the 72° open position. As soon as flow was introduced to the system, the disc tended to go more open, resulting in a negative torque indication of almost 1300 in.-lb at the valve stem, and then a steady value of approximately 1000 in.-lb until the test valve started to close. By convention, negative torque coefficients resist closure of the valve while positive torque coefficients assist closure. The negative torque results from the fluid dynamic effect which tries to open the valve more as flow is introduced. The torque value increased to -1500 in.-lb as the upstream pressure increased to 60 psig with the valve at 72° open. The torque remained at this value until the valve reached the 40° open position, when a torque reduction took place, decreasing the value to -1300 in.-lb. The valve continued to close under this applied torque until it reached the 8° open position at which point the torque increased to provide the seating force against the elastomer seat and built up to a value of about -2800 in.-lb.

When the test article valve reached the full closed position, the pressure control valve was also closed by computer control. As soon as the test article valve reached the full closed position, it was programmed to start opening. The torque value reversed and reached a level of +950 in.-lb before the upstream pressure began to decay until the test article valve was full open and both line pressure and torque were zero.

The test valve was then rotated so that the curved side of the disc was upstream in the closed position. A test was performed and a review of the resulting data indicated that some adjustment of the control valve was needed to improve the line pressure curve. Adjustments were made and two more tests run before satisfactory pressure control was achieved. It was noted that the fluid dynamic effect of the valve disc had resulted in a positive holding torque in this configuration. On the fourth attempt, the required upstream

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pressure was achieved and a review of the data plots indicated that introduction of the gas pressure resulted in the valve tending to close and the actuator exerting a positive torque to maintain the valve in the open attitude. The torque reached a value of about +1100 in.-lb just prior to start of test valve closure. There was a reduction in torque value at the instant of starting to close, but the torque then increased to a maximum of +1500 in.-lb at approximately 77° open. From this point the torque value gradually reduced to zero at a test valve position of 27° open and then went negative until it reached -700 in.-lb at about 8° open. At this point the negative torque value increased rapidly to -2300 in.-lb to effect valve closure as the disc reacted to resist closure.

The valve was programmed to open immediately on reaching the full closed position with the pressure control valve maintained closed. The torque value climbed rapidly to +750 in.-lb until the pressure decayed and then reached zero with the test valve full open. The test valve was removed from the loop and reinstalled adjacent to the 90° elbow with the flat face of the disc facing the elbow and the actuator at 90° to the axis of the elbow, as shown in position 1 of Figure 9. After verifying the calibration of the instruments, a test was performed and again it was demonstrated that the fluid dynamics effect was to force the valve to open, resulting in a negative opposing torque at the transducer. The torque at the start of valve closing was about -1300 in.-lb, then slowly increased to -1500 in.-lb at 40° open. The torque rapidly increased to a closing force -2200 in.-lb as the test valve seated. As the valve reopened, the torque value changed from -2200 in.-lb to +1350 in.-lb, then decreased to zero as the valve opened and pressure decayed.

For the next test the valve was reversed so that the flat side of the disc was facing the elbow with the actuator rotated to the opposite side at 90° to the axis of the elbow as shown in position 3 of Figure 9. In this test the torque was again negative at the start of the test and reached -1500 in.-lb as the valve started to close. The torque value gradually

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increased to -1500 in.-lb at 35° open. The torque increased rapidly to -2200 in.-lb at valve closure. The test valve was immediately reopened with torque reaching +1200 in.-lb, then decaying to zero when the valve was full open.

These two tests produced almost identical plots with only a small difference in torque values resulting from the position of the actuator.

The test valve was removed and rotated so that the curved side of the disc faced the elbow and the actuator was back in the original position at 90° to the axis of the elbow as shown in position 2 of Figure 9. As expected, the torque transducer registered a restraining torque of +1250 in.-lb against the disc which was tending to close. As the valve started closing, the torque built up to about 2100 in.-lb at 80° open, and reached -2100 in.-lb when the disc resisted closure as the valve seated. The valve immediately started to open and the torque value achieved a value of +900 in.-lb before reducing to zero as the line pressure decayed.

The valve was then installed with the curved side facing the elbow and the actuator rotated 180°, as shown in position 4 of Figure 9. At the start of the test, the torque built up to a restraining level of 1250 in.-lb and, as the valve started to close, increased to about 1800 in.-lb at 76° open. The torque reached a negative value of -2000 in.-lb as the valve seated. On opening, the torque climbed rapidly to +950 in.-lb, then decayed to zero as the valve opened fully and the line pressure decayed to zero.

Again, the torque plots for these two positions were similar, with only a small difference in torque value reflecting the change in actuator location.

Figures 12 through 17 are the plots of torque versus valve position for the tests performed on test Valve 1.

The valve was then removed from the test loop and mounted in a vertical stand for leak testing, design base, and severe accident testing. The actuator was removed for use with the second valve and flanged caps with connections for thermocouples and pressure taps were mounted on the inlet and

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outlet flanges of the test valve. The valve was wrapped with heater cable and insulated to allow temperature changes for the "accident" tests. These tests were performed in accordance with an approved procedure, 013-STP-094. The first test performed was to the severe accident conditions and at the conclusion of the test, the valve leaked at a rate of 360 scfh. The test caps were removed and a bubble test performed which indicated the leak to be around the stem at the top of the disc. Further inspection showed deformation of the seat and inside dimensions taken across the seat verified this. Figure 18 shows the readings obtained across the seat inside diameter. Subsequent to this test, a need was identified to obtain leak data for a valve which had been subjected to a design base accident. To perform this test on Valve 1, it was necessary to install a new seat and repeat baseline leak tests.

The second 8-in. valve was installed in a vertical test stand and the hydraulic actuator and torque transducer were mounted and aligned so that the valve travelled from full open to full closed with no overtravel at either end. The flanged caps were installed and a leak test performed with the pressure applied to each side of the disc and no measurable leak observed. The valve was then cycled and torque plots were obtained after 1, 50, 100, and 150 cycles with 5 or 6 of the last cycles plotted in each set of 50. Figure 19 is a typical example of the plots.

After transferring the test valve to configuration 1 of Figure 9 in the test loop, a test was performed on November 15, and the torque plot showed considerable difference between the operation of Valve 1 and Valve 2. Valve 1 required a torque of -1000 in.-lb to maintain position against the flow developed by 50 psig supply gas. Valve 2 was maintained in position by a torque of about -660 in.-lb. The valve reached a maximum torque value of -1060 in.-lb at approximately 72° open, reversed, and then increased to -790 in.-lb seating force. This value was 2010 in.-lb less than the seating force required for Valve 1. A review of the pressure plots indicated a negative pressure on the downstream side of the valve and the pressure at the outlet end of the pipe also indicated negative values. This was in contrast to the data for Valve 1 which indicated positive downstream pressure during the

8 INCH BUTTERFLY
VALVE

DIMENSIONS TAKEN ACROSS INSIDE OF
ELASTOMER SEAT

CONDITION AFTER SEVERE ACCIDENT
TEST

FIGURE 18. VALVE 1 - INSIDE DIMENSIONS
OF SEAT

FIGURE 19. VALVE 2 - CYCLING TEST

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test. Two possible causes of changes in performance were identified as the installation of a blast bucket at the end of the 24-in. exhaust duct to divert the flow, and the difference in location of the end of the downstream 8-in. pipe relative to the entrance of the 24-in. duct. These two conditions were changed to reflect the same configuration as used for Valve 1. A second test was then performed but the results were the same as obtained in the first test with negative pressures on the downstream side of the test valve and at the end of the pipe.

An analysis of the piping system and the test data by ETEC gas dynamicists concluded that, with the valve configuration and the flow rates involved, the negative pressure experienced was to be expected and no change in downstream piping arrangement would have any effect. On this basis, it was decided to run a final test in this configuration and accept the data as representative of the valve performance under the given conditions. This test was performed on November 16 and Figure 20 shows a plot of torque vs valve position while the valve closed.

The valve was rotated so that the curved side of the disc faced upstream and the test was repeated on November 17. The torque value to maintain the valve in the open position when flow was introduced to the loop was +900 in.-lb. As the test valve started to open, the torque built up to a maximum value of +1350 in.-lb with the valve 75° open, then reached -850 in.-lb as the valve seated. When the valve started to open, the torque reversed and reached a value of +350 in.-lb before dropping to zero. Figure 21 is the torque vs valve position for this test.

The test valve was removed and reinstalled adjacent to the elbow in position 3 of Figure 9. Figure 3 shows this installation schematically with instrument locations. The test was performed on November 17 in this configuration and as flow was introduced, the actuator applied a negative torque of -700 in.-lb to maintain the valve in the 90° open position. Valve closure required a seating torque of -740 in.-lb as shown in Figure 22.

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The test valve was rotated so that the curved side of the disc was facing upstream as shown in position 4 of Figure 9. A test was performed in this configuration on November 18, and as flow was introduced, the actuator exerted a torque of +950 in.-lb to maintain the valve in the 90° open position. The torque reached a maximum of +1400 in.-lb when the valve was 75° open and then reached -1000 in.-lb as the valve seated. Figure 23 is a plot of torque versus valve position during this test.

The test valve was removed, rotated, and reinstalled with the flat face of the disc facing the elbow and the actuator rotated 180° to position 5 of Figure 9. A test was performed on November 18, and the actuator imposed a negative torque of -660 in.-lb to maintain the valve disc in a full open position as flow was introduced. The negative torque value increased to a maximum of 1120 in.-lb as the valve reached 65° open position. Closing torque reached -740 in.-lb as the valve seated. The plot of torque versus valve position is shown in Figure 24.

The valve was again rotated so that the curved side of the disc was facing the elbow with the actuator on the same side as the previous test. This time the actuator torque required to maintain the valve in the full open position was a positive +950 in.-lb. As the valve started to open, the torque increased to a maximum of +1350 in.-lb at about 78° open. The torque rapidly reached -1000 in.-lb as the valve seated. (Figure 25 is a plot of torque vs valve position for this test.) The test valve was removed from the test loop and installed in the vertical stand in preparation for the Design Base Accident and Severe Accident tests. The flanged caps were mounted to the valve, heater cables were installed, and the whole assembly was insulated. These tests were performed in accordance with ETEC procedure 013-STP-094. The baseline leak test resulted in zero leakage in either direction. After performing the Design Base Accident and Severe Accident tests, the valve was allowed to cool to ambient, and on January 30, the baseline leak test was repeated with zero leak in either direction. This completed the test program on 8-in. Valve 2.

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In order to achieve the required test pressure for the 24-in. valve, the installation was moved adjacent to the facility GN₂ bottle bank to minimize line losses.

On December 5, the Site Representative and his Program Manager arrived on site, and on December 6, a seat leak test was performed on the 24-in. valve. The test was unsuccessful because of openings around the seal. The manufacturer's representative was contacted and recommended that the compression ring bolts be lubricated and torqued one at a time to 115 in.-lb to effect a seal.

On December 13, the bolts were torqued to this value and a bubble test performed. The seat still leaked. The Site Representative and the Manufacturer's Representative arrived on site on December 19, and, under guidance of the Manufacturer's Representative, the valve seal was reseated, and the thrust collar shims were adjusted to center the disc. On December 23, the leak test in both forward and reverse directions was performed with no leak observed. Testing was resumed in January 1984, and the 150-cycle test was completed by January 5. Figure 26 is a typical plot showing the cycling. A final leak test again showed no leaks. The valve was now ready for the blowdown tests. By February 17, the installation adjacent to the GN₂ bottle bank was complete, and the 24-in. test article valve was in place ready for the test. The control system was changed from closed to open loop control since the available volume of gas was limited.

On February 20, the Site Representative was on site for testing, and by February 23, thrust restraints had been positioned and secured, and a blowdown test was performed with the Test Article valve blocked open. The test data indicated that the required test pressure could be achieved, and preparations were made for a 15-psi test by setting the necessary coefficients into the program.

The 15-psig test was performed on February 24, and the maximum torque observed was -7647 in.-lb at 80° open. Closing torque reached a value of -7000 in.-lb. Instrument locations are shown schematically in Figure 27.

FIGURE 26.

VALVE 3 - CYCLING TEST

FIGURE 27. INSTRUMENT LOCATIONS

FIGURE 28. INSTRUMENT LOCATIONS

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On February 27, a 30-psig test produced a maximum torque of -16,750 in.-lb which occurred at 80° open. Closing torque was -8000 in.-lb. After adjusting the program coefficients, a 45-psig test was run, and again, the maximum torque, which reached -21,120 in.-lb, occurred at 80° open. Closing torque reached a value of -8765 in.-lb. Figures 29 and 30 show the plots of torque and pressure versus valve position for these tests.

The next test was at 60 psig, and on the first attempt the test pressure was too low. A second attempt was made after adjusting the program coefficients, and maximum torque occurred at 80° open with a value of -26,000 in.-lb. Closing torque reached a value of -10,400 in.-lb. Figure 31 is a plot of the torque and pressure versus valve position. Since the plots obtained during this series of tests looked reasonable, the valve was rotated so that the curved face of the disc faced upstream.

A test was performed on March 1, and maximum torque of +29,000 in.-lb was observed at 75° open as shown in Figure 32. Closing torque reached a value of -13,000 in.-lb. Since these results were as expected, the valve was removed from the system and reinstalled adjacent to the elbow with the flat face of the disc upstream and the actuator vertically above the valve. This changeover was accomplished by March 6, and an initial test was made, but the pressure went too high as the test valve began to close. New coefficients were derived for the program, but the second test was aborted because of a multiplexer problem in the computer. This was resolved, and a third test resulted in maximum torque of -35,000 in.-lb developing at 78° open. Closing torque reached -8850 in.-lb as the disc resisted closure. Figure 33 shows the torque and pressure plots for this test. Instrument locations are shown in Figure 28.

The valve was rotated for the next test with the curved face of the disc facing upstream and the actuator vertically above the valve. A 15-psig test was performed on March 9, resulting in a maximum torque value of 11,500 in.-lb at 70° open as shown in Figure 34. Closing torque reached a value of -4000 in.-lb as the disc resisted closure. This was followed by a 30-psig test in which the pressure reached 42 psig as the test valve

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closed. After adjusting the coefficients, a second test was performed, and maximum torque of +18,900 in.-lb was observed at 75° open. As the disc resisted closing, the torque increased to -8560 in.-lb. Figure 35 shows the plots for this test. After setting the program coefficients for 45 psig, a test was run with maximum torque reaching +26,850 in.-lb at 73° open. The torque reached a value of -11,620 in.-lb as the disc resisted closing against the seat as shown in Figure 36.

On March 9, a 50-psig test was initiated, but the pressure control was not correct, and adjustments were made to the coefficients. A second test resulted in a low pressure that peaked after valve closure. After further adjustments to the coefficients, a successful test was made on March 12, with maximum torque reaching 26,150 in.-lb at 71° open. The torque reached -8850 in.-lb as the disc resisted closure. The resulting plots are shown in Figure 37.

The test valve was rotated and reinstalled adjacent to the elbow with the flat face of the disc facing upstream and the actuator mounted vertically below the valve. A 60-psig test was performed on March 13, with maximum torque of -26,000 in.-lb at 71°. The torque then reached -8150 in.-lb as the disc seated. The torque plot exhibited heavy chatter between 90° and 71°, and since this effect had not been observed during previous tests, a second test was performed. The results were a repeat of those for the first test, and agreement was reached in a conference call between ETEC, EG&G, and the valve manufacturer that the effect was probably a result of the valve attitude with the actuator down. Except for the chatter, the data looked good as shown in the plots in Figure 38.

The valve was rotated so that the curved face of the disc faced upstream, and the actuator was vertically below the valve. On March 15, a test was run with torque peaking at 23,770 in.-lb at 71°, but both pressure and torque turned over at the same time so that it was not positive that torque had really reached a maximum. A second test was performed after adjustment was made to maintain the desired pressure level of 60 psig. The torque peaked at 23,540 in.-lb at 64.7°. As the disc resisted closing, the

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torque reached a maximum value of -12,420 in.-lb. This test concluded the scheduled series of pressure-torque tests, and the valve was removed from the test loop and set up in the hi-bay on support blocks for leak tests and Design and Severe accident tests. Typical plots for the pressure-torque tests are shown in Figure 39.

On March 22, a baseline leak test was performed on the 24-in. valve with pressure applied to the flat side of the disc. No leak was measured over a 3-hr period and the test was repeated with pressure applied to the curved side of the disc. In this test the gas leaked out of the packing gland at a rate sufficiently high to prevent a leak test. After discussion with the customer, the packing was gently blown out of the stuffing box and the shaft, gland and packing were examined for damage. No obvious damage was found and the packing was carefully replaced. A bubble test was then performed which showed a leak in one specific segment of the gland. The packing was removed again and a borescope examination of the wall of the stuffing box revealed what appeared to be a cavity in the wall of the stuffing box, just above the retaining plate, at the approximate location of the leak. A 1/8-in.-thick neoprene washer was made to fit the stuffing box and was installed on top of the retainer plate. The packing was replaced and a leak test was performed with no measurable leak observed. A complete baseline leak test was performed to the test procedure. No leak was recorded in either direction.

Heaters were formed and mounted to the valve body and blanket insulation was installed. The temperature of the valve was raised at the rate of 50°F per hour to 286°F for the design based accident test. No leak was observed with 60 psi applied to the curved side of the disc and pressure was maintained at 60 psi with a temperature of 280°F for a period of two hours in accordance with approved procedure 013-STP-94. No leak was recorded and the curved side of the disc was vented. Then 60 psi pressure was applied to the flat side of the disc. The temperature was holding at 280°F and these conditions were maintained for one hour in accordance with the procedure. The flat side of the disc was monitored for leak rate with no measurable leak observed for the hold period of one hour. The valve was then allowed to cool

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to ambient temperature and the baseline seat leak procedure was repeated. There was no measurable leak rate observed.

With 60 psig applied to the flat side of the disc, the temperature was raised to 310° while maintaining a constant pressure of 60 psig. Figure 40 is a plot of temperatures and pressure during this temperature rise and demonstrates the control exercised to maintain the delta temperature at 30° or less with a constant 60-psig pressure. Figure 41 shows the location of the instrumentation used to control the temperatures and pressure. The pressure was then increased to 90 psig and maintained there for 30 minutes while monitoring for leaks. Since no leak was measured, the pressure was removed from the flat side of the disc and 90 psig was applied to the curved side of the disc. This pressure was maintained for 30 minutes with no measurable leak and the temperature was then increased to 350°F with a constant 90 psig and no seat leakage was observed. The pressure was then increased but leakage at the packing gland was sufficient to limit the increase to 110 psig instead of the 120 psig specified. The pressure was reduced to 90 psig which the regulator could easily maintain and these conditions of temperature and pressure were maintained for three hours while monitoring seat leakage. After about 1 1/2 hours, the leak rate reached 65 scfh but by the end of the three hours, it was at a level of 49 scfh. The curved side of the valve was vented and a pressure of about 115 psig was applied to the flat side of the disc. This pressure was held for three hours with essentially no leak rate recorded. Table 4 is a copy of the actual data sheet from the test procedure used during this test. The valve was allowed to cool to ambient temperature and a baseline leakage test was performed with leak rates experienced as shown on the data sheet, Figure 42. The flange was removed, and the valve disc was checked for parallelism with the valve flange. The disc was about 0.065 in. out of parallel. An attempt was made to re-align the disc parallel to the flange, but further testing indicated leak rates were still around 320 scfh.

A new seat was installed in Valve 1 and a baseline leak test was performed. Leaks were observed coming through the tapered pins securing the disc to the shaft. By agreement with the Test Requester, the pins were carefully removed and examined. The only damage observed was a flattening of the

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PVV-1 HEATED SEAT LEAKAGE TEST			
T/C-HT NO.	TIC NO.	SEQ. NO.	LOCATION
TE-HT-1	TIC-29	31	SOUTH BODY HEATER
TE-HT-2	TIC-28	36	NORTH BODY HEATER
TE-HT-3	-----	40	DISK FLAT FACE (INTERNAL)
TE-HT-4	-----	47	DISK ROUND FACE (INTERNAL)
TE-HT-5	TIC-30	34	EAST FLANGE
TE-HT-6	TIC-31	37	WEST FLANGE
PT-TA-J	-----	10	SUPPLY PRESSURE

FIGURE 41

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DATA-SHEET 1GAS LEAKAGE RATE ACROSS VALVE SEAT1. Valve IdentificationVALVE NO
Manufacturer:

3

Type:

Butterfly

Size:

24"

2. Test Data

Barometric Pressure 15.52 psig ins. Hg.

Temperature 68 F Start of Test 67.5 F End of Test

3. Flowmeter Tube

Dwyer 1500 SCFH AIR MT 13673

Type WATER DISCONTINUOUS ML Serial No. _____

Diff. Press. Psid.	Pressure (Psig)		Seat Leakage Rate in Atmos (cc/Min at 68F)					
			1st Measurement		2nd Measurement		3rd Measurement	
	Forward	Rev.	Forward	Rev.	Forward	Rev.	Forward	Rev.
			FLAT FACE	CURVED FACE	FLAT FACE	CURVED FACE		
2-3	3	3	0	0	0	0		
50	50	50	0	38 SCFH	0	38 SCFH		
125	125	125	0	320 SCFH	0	320 SCFH		

Flange Face MeasurementsDisk Flat Face

Right Side

Left Side

.348

.341

Disk Round Face

Right Side

Left Side

FIGURE 42

DATA SHEET

VALVE IDENTIFICATION

VALVE MANUFACTURER : PRATT
 TYPE : BUTTERFLY
 SIZE : 2.0"
 TEST DATE : 4-3-84
 TEST TITLE : Heat Up Valve para 7.4.3

TIME	TEMP. HT-1	PRESSURE	CURVED SIDE PRESSURIZED FLAT SIDE LEAK RATE	FLAT SIDE PRESSURIZED CURVED SIDE LEAK RATE
1110	45	60		0
1230	97.99	60.35		0
1300	104.4	60.03		0
1330	110.43	59.83		0
1400	120.77	59.29		0
1430	130.85	59.13		0
1500	136.18	59.89		0
1530	141.91	59.65		0
1545	145.53	59.61		0
1615	150.70	59.70		0
1645	156.82	59.35		0
1715	163.84	59.18		0
1745	168.15	59.30		0
1815	174.83	59.90		0
1845	181.73	58.90		0
1915	188.00	58.7		0
1945	193.84	58.3		0
2015	199.	60.7		0
2045	205.77	60.91		0
2115	211.21	60.71		0
2145	216.45	60.51		0
2215	223.43	60.51		0
2245	229.59	60.71		0
2315	236.80	60.11		0
2345	241.77	60.53		0
2415	248.16	60.46		0
2445	254.85	60.53		0
2515	261.52	60.21		0
2545	266.24	60.35		0
2615	271.70	60.45		0
2645	277.66	60.38		0
2715	283.76	60.39		0
2745	289.46	60.47		0
2815	295.60	60.53		0
2845	301.37	60.35		0
2915	307.5	60.35		0
2945	313.75	60.20		0
2955	313.75	60.5		0
2965	312.1	60.3		0
2975	312.18	60.48		0
2985	312.15	60.96		0
2995	312.15	60.48		0
3005	314.04	60.26		0
3015	314.37	60.35		0
3025	313.88	60.46		0
3035	313.20	60.30		0
3045	313.21	60.58		0
3055	314.53	60.10		0
3065	315.31	60.22		0
3075	315.56	60.38		0
3085	315.92	60.41		0
3095	315.47	60.74		0
3105	315.83	60.15		0
3115	315.93	60.04		0
1600	353.19	90.16	23	
1615	352.84	90.56		
1700	351.84	90.16	65	
1750	351.84	90.36	47	
1800	351.62	90.16	61	
1830	351.42	90.16	49	
1850	351.4	117.21		0
1940	351.84	115.80		0
2020	351.84	115.40		0
2030	352.25	113.40		0
2100	358.02	113.80		0
2115	357.05	115.40		0
2130	360.8	115.05		0
2200	363.53	116.60		0
2230	364.45	115.80		120
2300	364.45	116.00		0
2330	364.45	115.30		0
2400	368.54	115.39		120
2415	364.58	115.29		0

back to
to 0-5
X-11

250.40
back to
water dis.
placement

END OF
TEST

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O-ring in each of the two pins. It was concluded that the O-rings most probably took a "set" when heated to 350°F for the severe accident test. The O-rings were replaced with Viton rings which were rated for at least 500°F. After replacing the pins, the leak test was repeated but leaks were observed around the inside edge of the stainless steel seating disc. After consultation with the Test Requester, the disc was removed and the O-ring seal was found to be flattened. A Viton O-ring was installed and the disc was replaced. A leak test indicated that all leaks had been stopped and the baseline leak test for Procedure 013-STP-94 was performed. Heaters were then installed and insulation added for the design basis and severe accident tests. On April 9, the design basis accident test was initiated by applying 60 psig to the curved face of the disc and raising the temperature to 250°F at 50°F per hour while maintaining 60-psig pressure. The temperature was then raised to 280°F at 30°F per hour and maintained at this temperature and 60 psig for 2 hours while monitoring for leaks. The curved side of the disc was then vented, and 60-psig pressure was applied to the flat side of the disc. The pressure and temperature were held for 1 hour while monitoring for leaks. No leaks were recorded in either of these tests. The valve was allowed to cool to ambient temperature, and a baseline leak test was performed. At 3 psig, no leak was recorded in either direction. At 50 psig, with pressure on the flat face of the disc, a leak rate of 70 scfh was recorded. At 125 psig, this leak rate increased to 470 scfh. There was no measurable leak in the opposite direction. The test was terminated at this point.

III. ADDENDUM FOR FOLLOW-ON TEST PROGRAM

Based on the review of data from low pressure tests (15, 30, and 45 psig) performed on the 24-in. valve, the Test Requester authorized a program to perform low pressure tests on Valves 1 and 2. On May 16, ETEC was asked to dismantle Valve 2, clean the old lubricant out of the bearing and packing gland cavities, repack the cavities with fresh lubricant, and replace the valve seal.

An attempt was made to press out the pin securing the disc to the shaft but eventually it had to be drilled out. The disc could not be readily separated from the shaft and a decision was made to clean out the cavities with the shaft in place. By May 31, the valve had been cleaned and lubricated and a new seat had been installed.

An effort was made to locate the leak in Valve 1 by applying pressure to the curved side of the disc. High leak rates were observed at both pins securing the disc to the shaft and at the packing gland. New O-rings were installed in the pins and the gland was tightened. Pressure was applied to the curved side of the disc and a bubble test around the seat indicated no leak.

On June 1, a request was made to install two Prandtl type pitot tubes in the loop to get some data for comparison with data taken during a program at Langley Field. A request was also made to test Valve 1 first using a seat which had previously been installed but not used during the test program. This seat was installed and Valve 1 was coupled to the actuator and an alignment made. Because of play in the bearings, perfect alignment could not be achieved since checks on the parallelism of the disc to the body were not repeatable. The valve was installed in the test loop and the pitot tubes were installed at locations specified by the Test Requester.

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Instrumentation calibrations were completed and on June 12 a 15-psig test was initiated. Some difficulty was experienced with the control valve and, after two or three diagnostic tests, the supply pressure was reduced to 1500 psig. At this pressure, control was achieved and tests were completed at 15 psig and 10 psig. Figures 1 and 2 are plots of torque vs valve position for these tests. After reviewing the data, the Test Requester asked for a 60-psig test to compare results against the previous test series to see if valve performance had changed in any way (Figure 3).

The valve was then rotated to position the curved side of the disc upstream and a 15 psig test was performed. The torque signal prior to valve closing was very noisy and testing was suspended while the system was checked out. Troubleshooting indicated a faulty power supply in the hydraulics servo loop electronics and this was replaced. A 15-psig test was performed with some improvement in the torque signal but chatter was still in evidence and was attributed to the bearing clearances. The data was accepted and tests were performed at 10 psig and 5 psig. The valve was then removed from the loop and Valve 2 was installed. Figures 4, 5, and 6 are typical plots of torque vs valve position for this series of tests.

By June 19, Valve 2 had been installed and aligned with all instrumentation calibration completed. A 15-psig test was performed and, as Figure 7 shows, the torque signal was much smoother, indicating that lubricant in the bearing cavities had indeed reduced valve chatter. Based on data obtained, tests were performed at 10 psig and 5 psig with good results and the valve was rotated to put the curved side of the disc upstream. Tests were performed at 15 psig, 10 psig, and 5 psig with consistently good data obtained. Figures 7 through 12 are typical of the plots obtained.

Copies of all data plots, including those obtained from the new pitot tubes, were provided to the Test Requester for analysis. By June 29, the Test Requester had determined that no further repeat testing was necessary and the test program was considered complete.

ETEC DATA PLOT

CONTAINMENT VALVE TEST

PVV-1X-C

START 06/13/84 10:34:30 END 06/13/84 10:34:44

SEQ 12 ZT-TAV

PLOT # 1 FROM FILE P103 ON 7/5/84 AT 14:40

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ETEC DATA PLOT

CONTAINMENT VALVE TEST PVV-1X-E

START 06/13/84 14:29:14 END 06/13/84 14:29:27

SEQ 12 ZT-TAV

PLOT # 2 FROM FILE P103 ON 7/5/84 AT 14:40

ETEC DATA PLOT

CONTAINMENT VALVE TEST PVV-1X-K

START 06/14/84 14:59:42 END 06/14/84 14:59:55

SEQ 12 ZT-TAV

PLOT # 3 FROM FILE P103 ON 7/5/84 AT 12:42

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CONTAINMENT VALVE TEST PVV-2X-A

START 06/15/84 10:05:00 END 06/15/84 10:05:14

SEQ 12 ZT-TAV

PLOT * 4 FROM FILE P103 ON 7/5/84 AT 12:42

ETEC DATA PLOT

CONTAINMENT VALVE TEST

PVV-2X-B

FIGURE 5

START 06/15/84 10:42:40 END 06/15/84 10:42:55

SEQ 12 ZT-TAV

PLOT # 5 FROM FILE P103 ON 7/5/84 AT 12:43

CONTAINMENT VALVE TEST PVV-2X-C

START 06/15/84 13:12:21 END 06/15/84 13:12:35

SEQ 12 ZT-TAV

PLOT # 6 FROM FILE P103 ON 7/5/84 AT 12:44

ETEC DATA PLOT

CONTAINMENT VALVE TEST
PVV-2-1X

START 06/19/84 13:40:12 END 06/19/84 13:40:25

SEQ 12 ZT-TAV

PLOT * 1 FROM FILE P103R ON 7/6/84 AT 12:51

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CONTAINMENT VALVE TEST
PVV-2-1XA

START 06/20/84 08:40:10 END 06/20/84 08:40:25

SEQ 12 ZT-TAV

PLOT # 2 FROM FILE P1038 ON 7/8/84 AT 12:52

ETEC DATA PLOT

CONTAINMENT VALVE TEST

PVV-2-1XB

FIGURE 9

START 06/20/84 10:48:40 END 06/20/84 10:48:55

SEQ 12 ZT-TRV

PLOT 3 FROM FILE P103R ON 7/6/84 AT 12:53

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CONTAINMENT VALVE TEST
PVV-2-2X

START 06/20/84 13:36:21 END 06/20/84 13:36:35

SEQ 12 ZT-TRV

PLOT # 4 FROM FILE P1038 ON 7/8/84 AT 12:53

ETEC DATA PLOT

CONTAINMENT VALVE TEST
PVV-2-2XA

START 06/20/84 14:04:47 END 06/20/84 14:05:00

SEQ 12 ZT-TAV

PLOT # 5 FROM FILE P103R ON 7/6/84 AT 12:54

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ETEC DATA PLOT

CONTAINMENT VALVE TEST
PVV-2-2XB

START 06/20/84 14:36:10 END 06/20/84 14:36:25

SEQ 12 ZT-TRV

PLOT # 6 FROM FILE P1038 ON 7/6/84 AT 12:55

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