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SCOPING TEST ON CONTAINMENT PURGE AND VENT VALVE SEAL MATERIAL

B.E. MILLER

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Bruce E. Miller

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Prepared by
Engineering Analysis and Human Factors Group
Department of Nuclear Energy
Brookhaven National Laboratory
Upton, Long Island, New York 11973

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Introduction/Purpose

Severe accidents in nuclear power plants result in containment environments that may accelerate the degradation of seal material used in containment purge and vent butterfly valves. This degradation may initiate valve seal leakage thus breeching containment. A scoping test was performed to gather information on the behavior of the seal material ethylene propylene when exposed to severe accident conditions, (i.e., steam at 350°F 120 psig and 400°F and 232 psig). Three separate test sequences were performed during which the test assembly was monitored for leakage. The results of these tests revealed no seal leakage, however, seal degradation was evident.

Summary of Test Results

The valve seals were tested in accordance with the enclosed procedure. For test sequences 2 and 3, the procedure was revised to include modified temperature profiles and seal testing sequence. Figures 2 and 3 show the test fixture. Figure 1 illustrates a typical purge and vent butterfly valve.

In test sequence 1, the specimen was subjected to a steam environment at 350°F and 120 psig for 11 hours in each valve direction. A minor leak was detected and monitored during the initial test run. Valve seal integrity was maintained throughout the elevated temperature portion of the procedure for both test runs. Upon cooling down from each test run, the valve seal was bubble tested. The valve seal was found to be bubble tight to at least 182 psig on the ring side of the disc and 200 psig on the shaft side.

The bubble test performed following the first test run revealed that the minor leak previously mentioned was at the disc/pin connection (Figure 8). The leak was caused by a manufacturing error in squeezing the pin and the disc together, Figures 6 and 7. The resultant leak, very minor in magnitude, had no effect on the seating or seal integrity of the valve. (Note: the manufacturer of the valve states that the valve had not been processed through final quality inspection as would be the case for all valves shipped and is not a significant concern.)

Removal and inspection of the valve seat following this test sequence revealed minor remolding of the seat material at the disc/body interface with no deformities noted. Approximately one week later, cracks had developed in the seat. The cracks were located in an area that would be compressed by the retaining ring and in no instance effected the sealing integrity of the valve. Figure 9 shows these cracks.

In test sequence 2, the test environment was revised to be steam at 400°F and 250 psig for 11 hours in each valve direction. The specimen again maintained its seating integrity throughout the elevated portion of the test in both directions. After the initial cool-down, the seat was found to be bubble tight to at least 75 psig with the pressure applied to the ring side of the disc. When the pressure was applied to the shaft side of the disc after the cool-down period, following the second test run, the seat was found to be bubble tight to at least 200 psig.

Removal and inspection of the valve seat revealed some remolding of the seat and a minor crack in the compressed retaining portion of the seat. Approximately one week after removal, the crack had propagated to about 4 inches in length and one-half the thickness of the seat. As in test sequence 1, the seat was retained in the valve and the compressive force of the seat ring minimized the growth of the crack. Figure 10 shows the crack that developed as a result of this test sequence

In test sequence 3, the temperature pressure profile was stepped with a maximum temperature of 400°F and a pressure of 232 psig. The test sequence was reversed to apply the pressure to the shaft side of the disc for the first 11 hours and to the ring side for the second 11 hours.

Upon completion of the initial 11 hours of testing and cooling, the valve was found to be bubble tight to at least 200 psig. Prior to performing this test, the pin/disc connection was repressed, resulting in no leakage.

Initial bubble testing of the valve prior to the second run or retaining ring side test, there was general seal leakage starting at 1 psig. The seat was readjusted to maintain 140 psig. There was no leakage observed or recorded during the second test run and was bubble tight to at least 83 psig upon cooling. The valve was again re-oriented such that pressure would be applied to the shafts at the disc. This resulted in a bubble tight condition to at least 200 psig.

Inspection of the seat upon removal, revealed minor circumvential cracks at the edge of the retaining ring (Figure 11). The seat profile had been remolded to conform to the mating surface.

Conclusion

The results of this scoping test revealed no seal leakage. The seal degradation, cracking, was visually evident in the compressed retaining portion of the seat. However, the result should not be construed as representing the entire ethylene propylene family. Ethylene propylene is an elastomer prepared from ethylene and propylene monomers. Varying the relationship of these monomers, effects the characteristics and their ability to withstand environmental conditions. It should also be noted that all mechanisms by which rubber deteriorates with time are attributable to environmental conditions. The Parker Seal Company states that it is environment, not age that is significant to seal life, both in storage and actual service.

SEVERE ACCIDENT TESTING PROCEDURE FOR CONTAINMENT PURGE AND VENT VALVES

SEVERE ACCIDENT TESTING PROCEDURE
FOR
CONTAINMENT PURGE AND VENT VALVES

1.0 Purpose

The purpose of this test procedure is to describe the procedure used to test a valve assembly, hereinafter called the specimen, for the Department of Energy, Brookhaven National Laboratory.

2.0 Specimen Description

One series 1200 nuclear butterfly valve to be furnished by, and remain the property of, the Henry Pratt Company.

3.0 Specimen Testing

3.1 Mounting

The specimen will be mounted to the Henry Pratt static seismic loading platform and bolted between a set of approximately sized test fixtures.

3.1.1 Specimen Orientation

The specimen shall be oriented such that the specimen mounting flanges will be in the horizontal plane (see Figure 12).

3.2 Method of Test

3.2.1 General Description

High temperature steam will be supplied against a closed valve disc in accordance with the given profile (see Figure 13).

3.2.2 Testing Schedule

3.2.2.1 Mount the specimen in the test figure in accordance with Figure 12 such that the pressure in the lower chamber is applied to the retaining ring side of the specimen disc when the disc is in the fully closed position.

3.2.2.2 Close the disc.

3.2.2.3 Apply saturated steam in accordance with the attached temperature profile.

3.2.2.4 Continuously monitor the test chamber temperature and pressure.

NOTE: The upper chamber is vented to atmosphere.

3.2.2.5 Read and record the lower chamber pressure and temperature and the valve leakage rate in the upper chamber once very hour.

3.2.2.6 Upon completion of the test duration, allow the specimen to cool below 125°F, remove the upper chamber and physically inspect the specimen.

3.2.2.7 Reorient the specimen such that the pressure in the lower chamber will be applied to the shaft side of the specimen disc when the disc is in the fully closed position.

3.2.2.8 Repeat steps 3.2.2.2 through 3.2.2.6.

3.3 Instrumentation

3.3.1 Temperature potentiometer using Type "J" thermocouple with the thermocouple extending into the lower pressure chamber.

3.2.2 Pressure gages for monitoring the pressure in the lower chamber.

3.3.3 Rotometer connected to the upper chamber to monitor the specimen leakage.

3.3.4 Auxiliary thermocouples connected to a strip chart recorder (if the recorder is available).

3.4 Data Collection

All data sheets will contain the Henry Pratt Company name, job number, date, customer name, and signatures of those personnel reading and recording data.

The data collection portion of the data sheets will have a minimum of the following headings starting from left to right:

a) Data entry number
b) Time
c) Lower chamber pressure (psig)
d) Lower chamber temperature (°F)
e) Rotometer reading and scale
f) Leakage rate
g) Initials (of person taking specific data line).

4.0 Acceptance Criteria

This test is being performed for the purpose of determining the amount of specimen leakage under the given criteria and for informational purposes only.

RESULTS TEST SEQUENCE 1.2.3.

RESULTS OF TEST SEQUENCE 1

TEST SEQUENCE 1

PROCEDURE. The procedure used was that given in the previous section of this report.

OBSERVATION. During the initial period of the test, it was observed that the rotometer ball would occassionally spike while otherwise remaining at zero.

In order to determine what was happening, a tube was connected to the rotometer input. The other side of the tube was placed in an inverted graduate and the graduate partially submerged in a beaker of water.

It was noted that the water positvely displaced a maximum of 10 mL which occurred in a six minute time interval. Further observation noted positive changes up to 16 mL above the zero mark and negative changes of 8 mL below the zero mark. Since the leakage appeared to be very small and not consistent, the test was completed. An investigation would be initiated at the end of the test run to determine this source of the leak. Ignoring the spikes of the rotometer, there was no seal leakage observed or recorded during the initial 11 hours of testing at 350°F.

Upon completion of the initial 11 hours, the valve was allowed to cool to below 125°F and leak tested with the pressure applied to the ring side of the disc. The seat was found to be bubble tight to at least 182 psig.

The bubble test performed following the first 11 hours of testing revealed a minor leak at the pin/disc connection. This leakage was caused by a manufacturing error in squeezing the pin. Since the valve had not bee processed through final quality inspection as would be the case for all valves shipped to customers, it is not a significant concern.

The fluxuation on the rotometer was caused by minute amounts of steam seeping past the pin, condensing in the cooler upper chamber, and then dropping onto the heated disc. The droplets would then flash causing an increase in pressure and a decrease in pressure as they cooled.

Since this minute leakage did not affect the sealing integrity of the valve seat, it was agreed to note the phenomenon, ignore the spikes, and continue with sequence 1 of the test.

The specimen was reoriented in accordance with paragraph 3.2.2.7 of the procedure, leak tested, and found to be bubble tight to at least 200 psig.

There was also no seat leakage observed or recorded during the second portion of the test.

On completion of the second 11 hours at 250°F, the specimen was allowed to cool below 125°F and the seat was found to be bubble tight to at least 200 psig.

INSPECTION

Removal and inspection of the valve seat following this test sequence revealed minor remolding of the seat material at the disc/body interface with no other deformities noted.

After a period of one week following the test, the seat developed cracks (Figure 9). These cracks, however, were located such that they would be compressed by the retaining ring and in no instance effect the sealing integrity of the valve.

RESULTS OF TEST SEQUENCE 2

TEST SEQUENCE 2

PROCEDURE. The procedure was revised to include the use of test profile 2. Due to the occasional spiking of the rotometer as explained in test sequence 1, the top head was raised to allow for continuous visual inspection of the valve seat throughout test sequence 2.

OBSERVATIONS. During the second test sequence, the top chamber was raised to visually monitor seat leakage, of which there was none, and to observe the pin. An occasional droplet of water would dance around the pin which substantiated the previous hypothesis regarding pin/shaft leakage.

Upon completion of the initial 11 hours of testing, the specimen was allowed to cool below 125°F and the leak tested. With the pressure applied to the retaining ring side, the specimen seat was found to be bubble tight to at least 75 psig.

Reorientating the specimen in accordance with paragraph 3.2.2.7 of the procedure and then leak testing the same with the pressure applied to the shaft side of the valve resulted in a bubble tight valve seat to at least 200 psig.

There was no seat leakage observed during the second portion of the 410°F test.

On completion of the second portion of the test, the valve was leak tested and the seat was found to be bubble tight to at least 200 psig.

INSPECTION

Removal and inspection of the valve seat following the testing sequence revealed some remolding of the valve seat and a minor crack in the compressed retaining portion of the seat.

After about one week of dormancy, the crack had propagated to about 4 inches in length and one-half the thickness of the seat (Figure 10). It should be noted that the means by which the seat is retained in the valve, the compressive force of the seat ring would minimize this condition. However, in either instance, Figure 9 or 10, location of the cracked area would not interfere with the seating integrity of the specimen.

RESULTS OF TEST SEQUENCE 3

TEST SEQUENCE 3

PROCEDURE. The procedure was revised as follows:

a. Paragraph 3.2.2.1 - mount the specimen in the test fixture in accordance with Figure 1 such that the pressure in the lower chamber is applied to the shaft side of the specimen disc when the disc is in the fully closed position.

b. Paragraph 3.2.2.7 - reorient the specimen such that the pressure in the lower chamber will be applied to the retaining ring side of the specimen when the disc is in the fully closed position.

c. Test profile 2 will be followed during the first 11 hours and test profile 3 will be followed after reorientating the specimen during the second 11 hours.

Note: There was sufficient time between test sequence 2 and 3 permitting the specimen to be sent to the manufacturing facility and the pin re-squeezed into the disk. The following leak test revealed no pin leakage.

OBSERVATION. There was no leakage observed or recorded during the first 11 hours at the elevated temperature of 400°F.

Upon completion of the initial 11 hours of testing, the specimen was allowed to cool below 125°F and leak tested.

With the pressure applied to the shaft side of the disc, the valve was found to be bubble tight to at least 200 psig. The specimen was reoriented in accordance with the revised paragraph 3.2.2.7 and leak tested.

With the pressure applied to the retaining ring side of the valve there was general seat leakage starting at 1 psig. This was due to the "set" that the seal had taken from the first test run. The seat was then adjusted to maintain 140 psig and the second portion of the testing sequence was performed using test profile 3. There was no leakage observed or recorded during the elevated portion of the testing sequence using test profile 3.

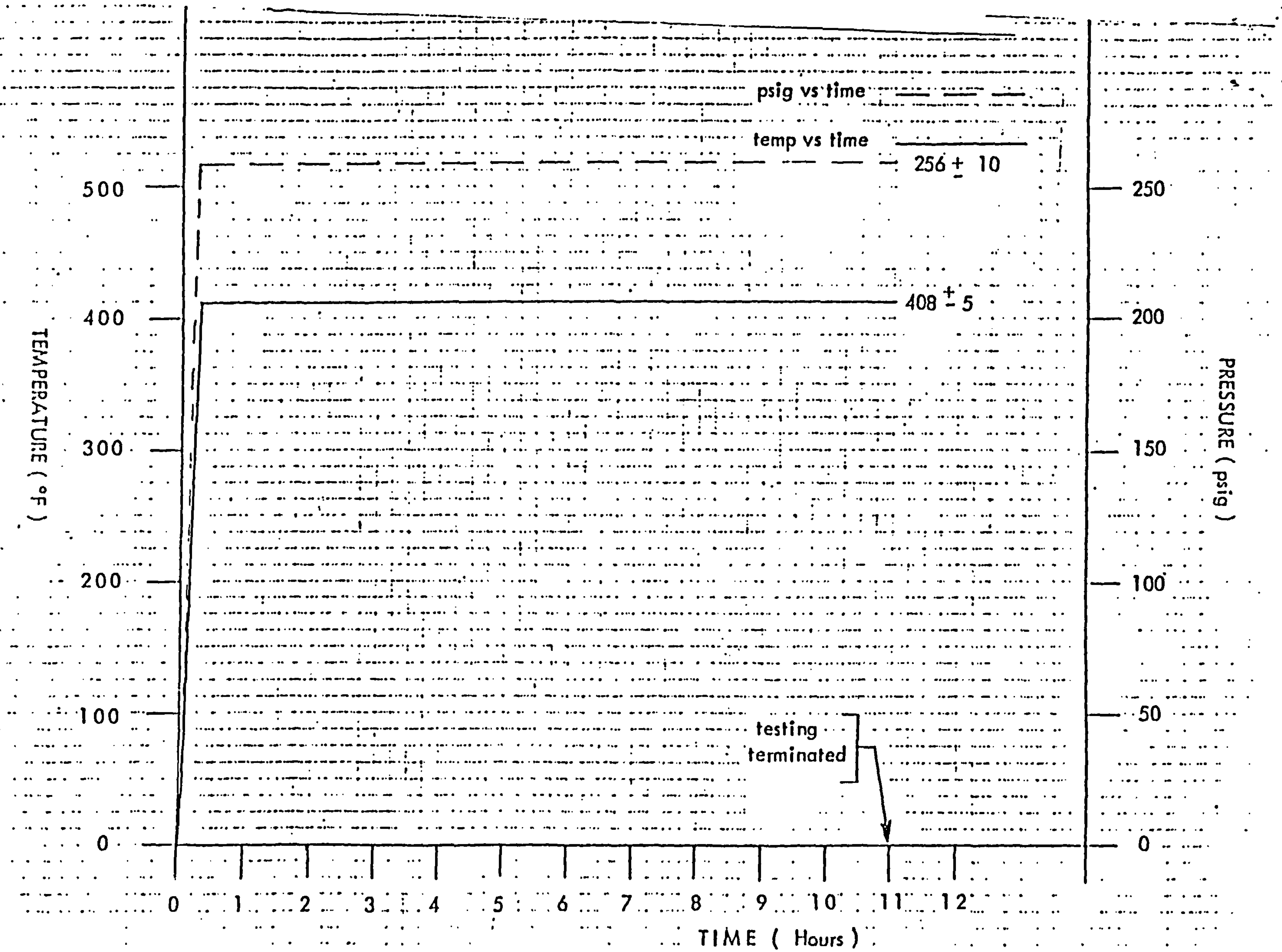
When the specimen had cooled below the 125°F, it was again leak tested. With the specimen pressurized from the retaining ring side, the specimen was found to be bubble tight to at least 83 psig.

The valve was again reoriented such that the pressure was applied against the shaft side of the disc resulting in a bubble tight condition to at least 200 psig.

INSPECTION

Inspection, upon removal of the seat, revealed minor circumferential cracks at the edge of the retaining ring. The seat profile had been remolded to conform to the mating surface.

These discrepancies do not effect the seat integrity of the valve for normal containment isolation purposes.



TEST PROFILE # 2

FIGURES

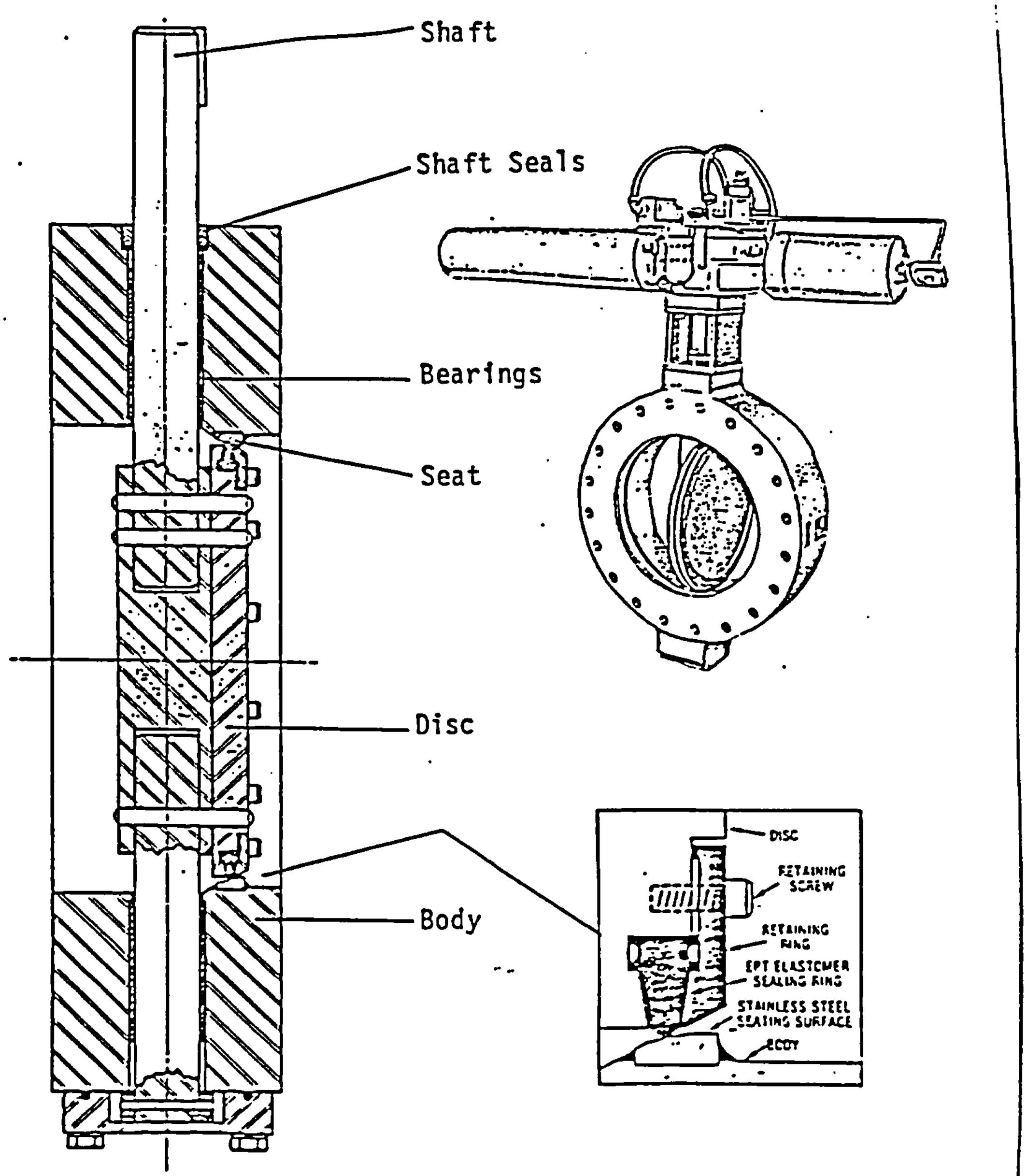


Figure 1. Typical purge and vent butterfly valve manufactured by Pratt.

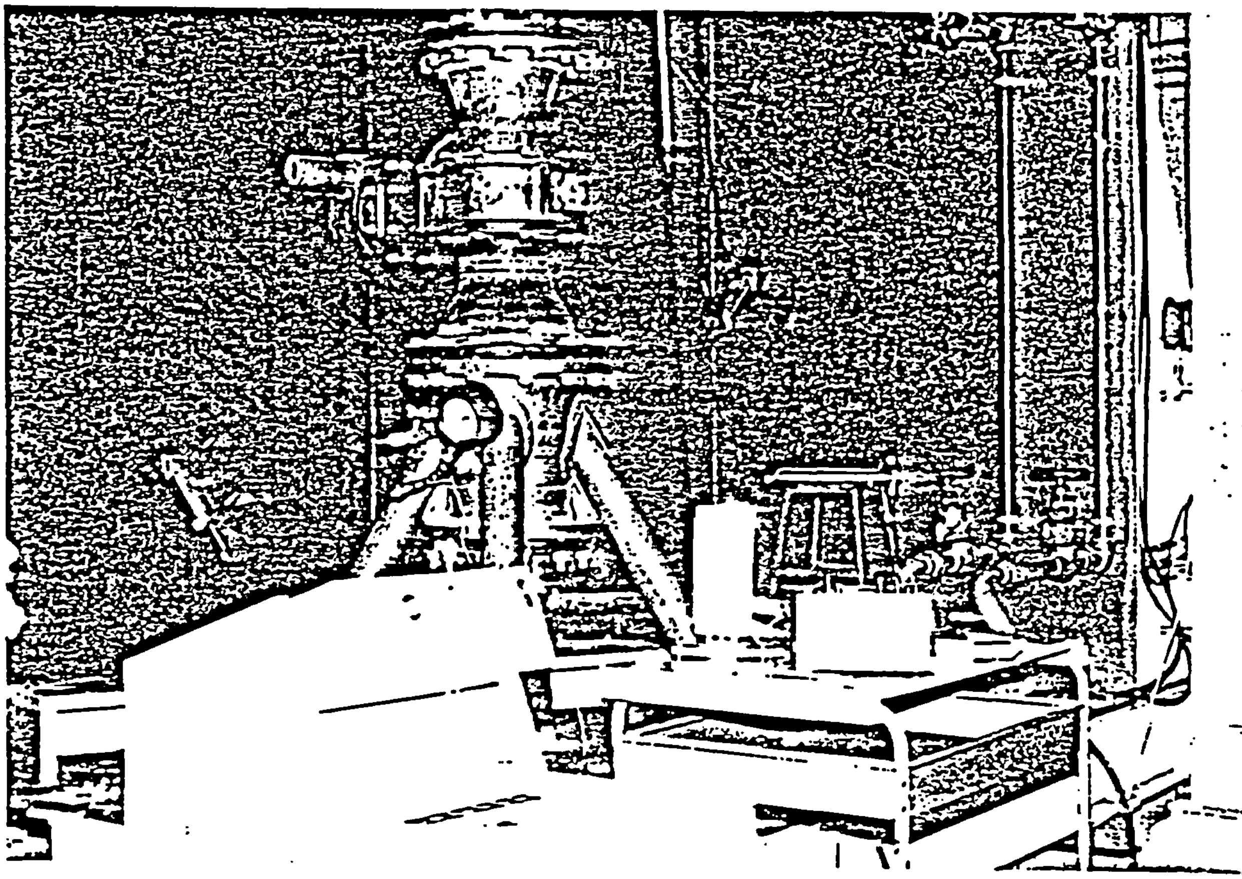


Figure 2. Testing assembly with monitoring instrumentation in foreground.

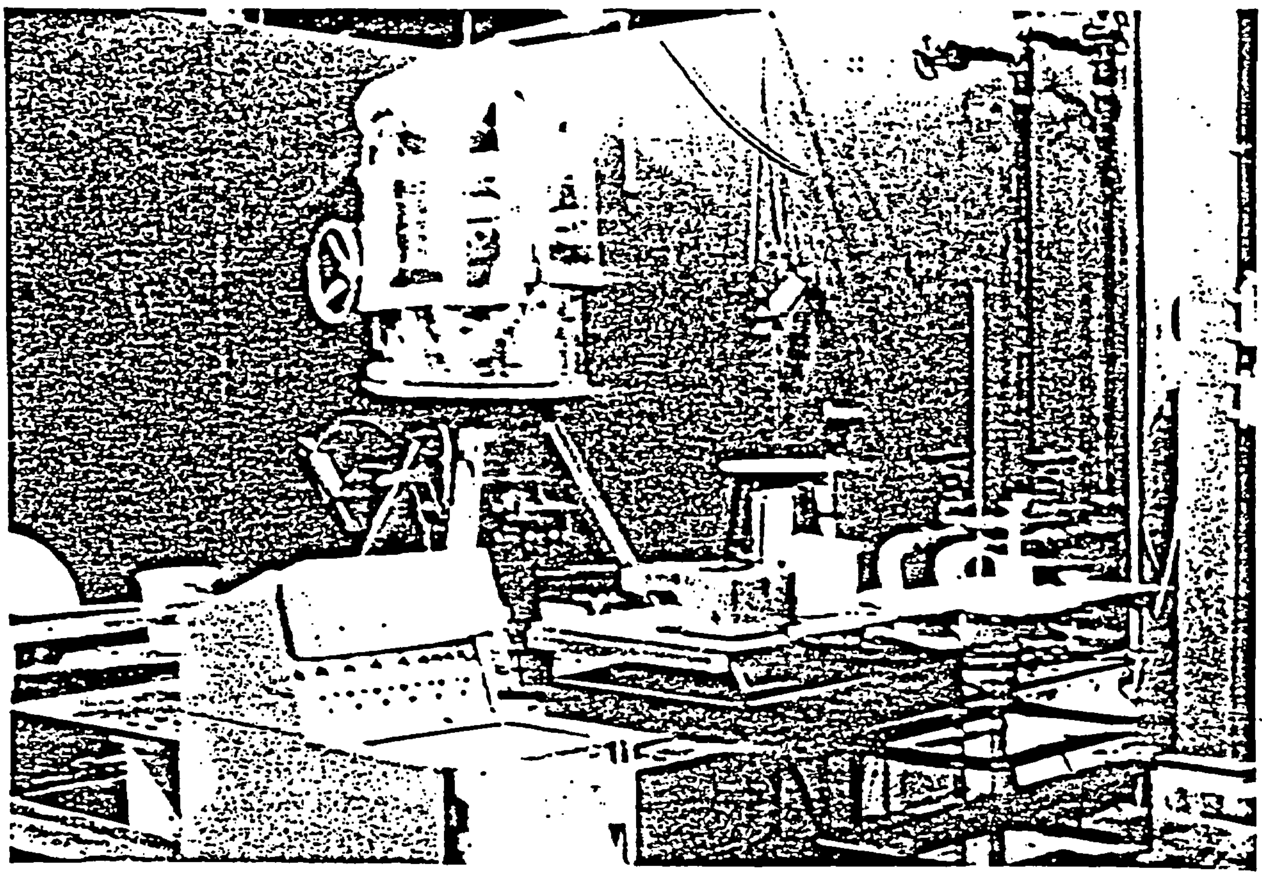


Figure 3. Testing assembly with insulation with monitoring instrumentation in foreground.

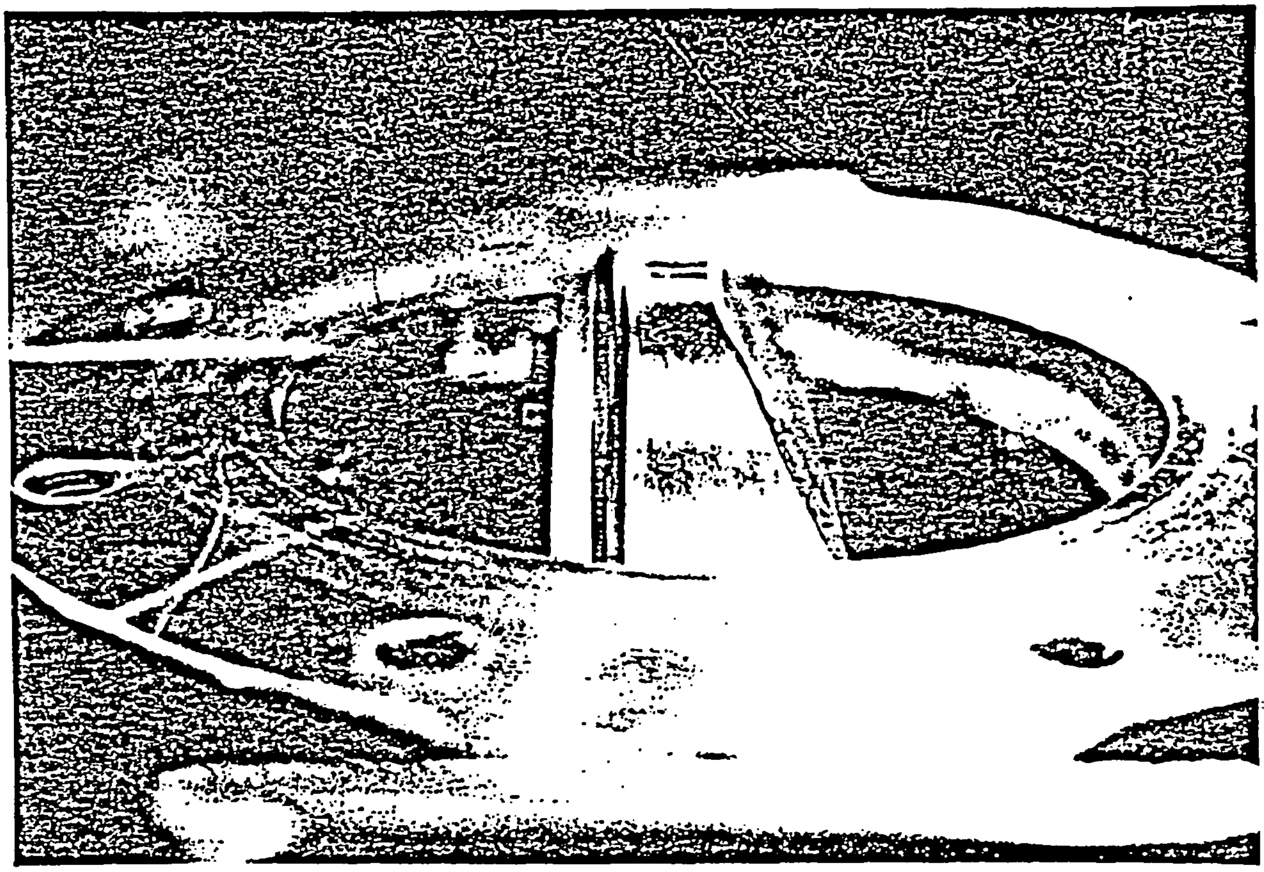


Figure 4. View of shaft side of disc and valve seal - valve open.

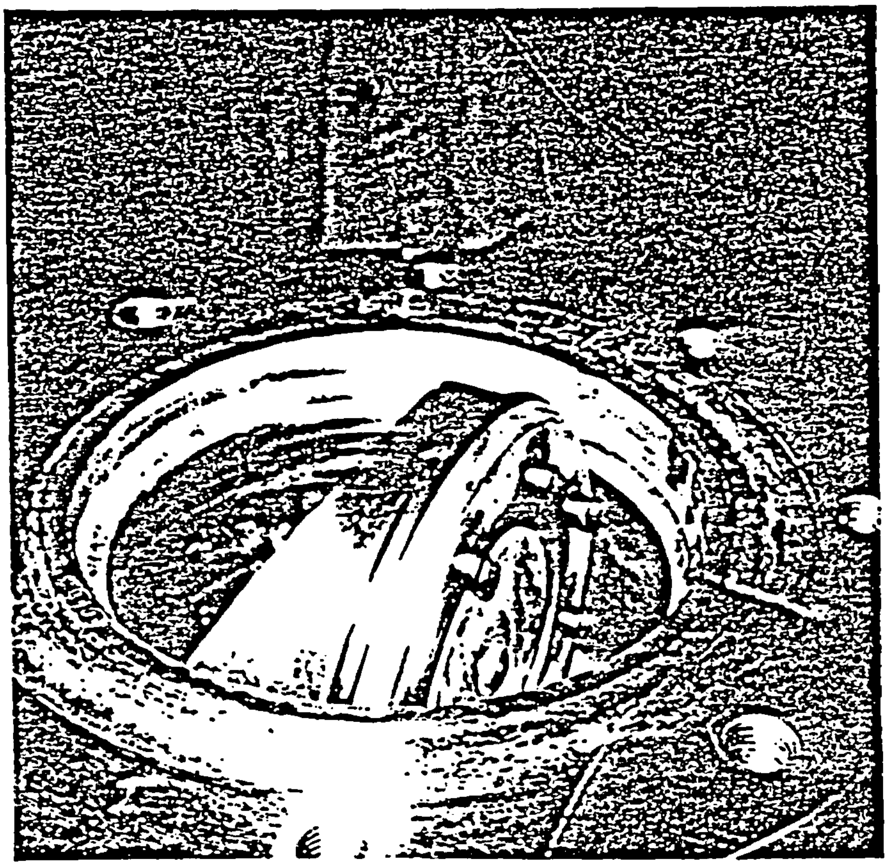


Figure 5. View of retaining ring side of disc - valve open.

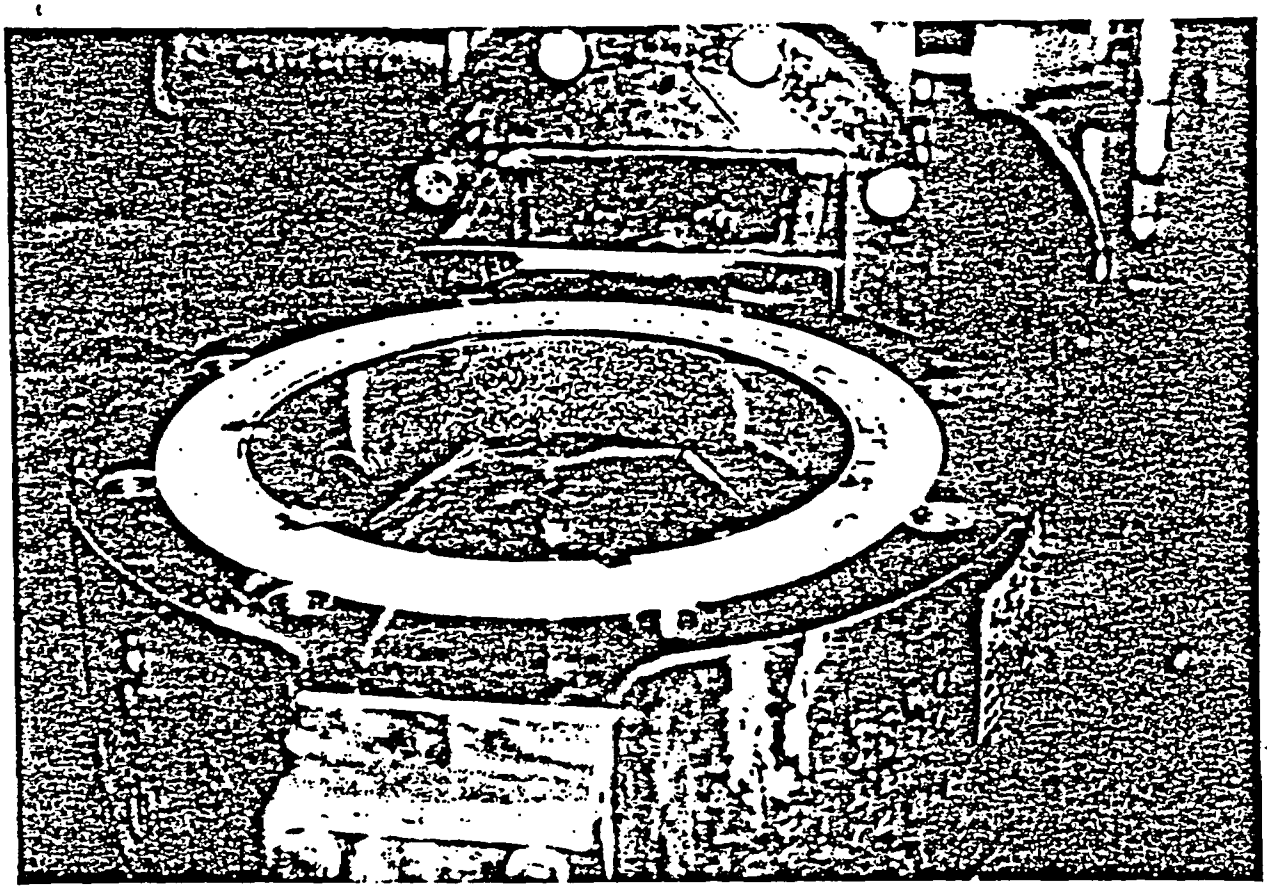


Figure 6. Valve closed - area indicated by arrow shows where pin/shaft leak defaced valve body. Leak was passed pin then down the cavity between the shaft and disc.

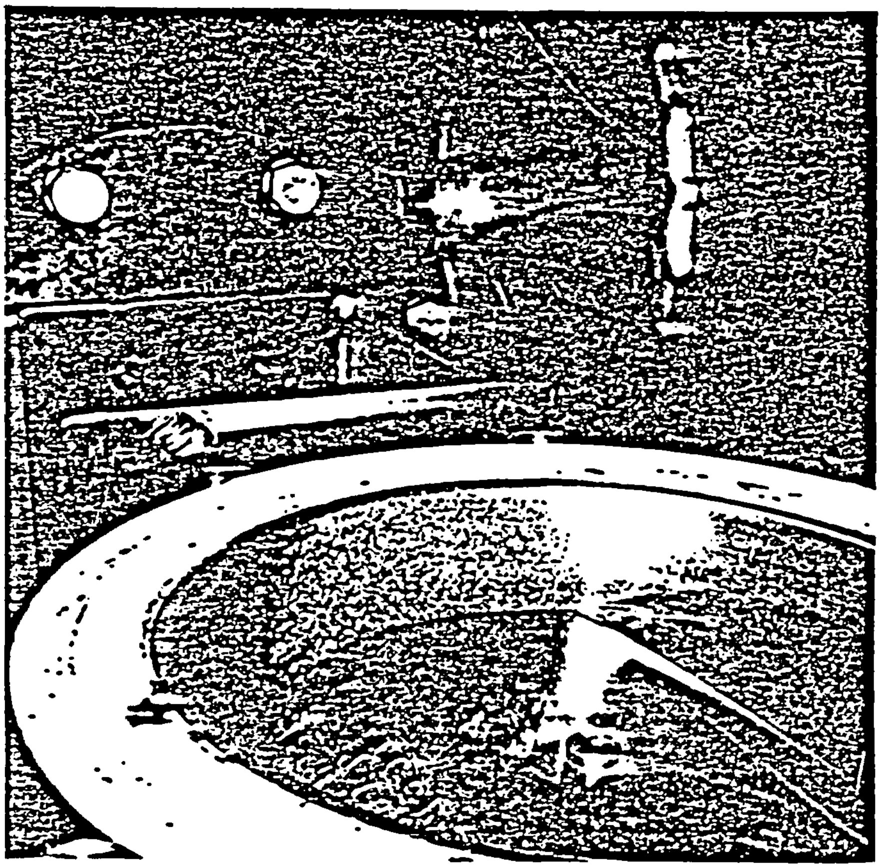


Figure 7. Valve closed - area indicated by arrow shows where pin/shaft leak defaced valve body. Leak was passed pin then down the cavity between the shaft and disc.

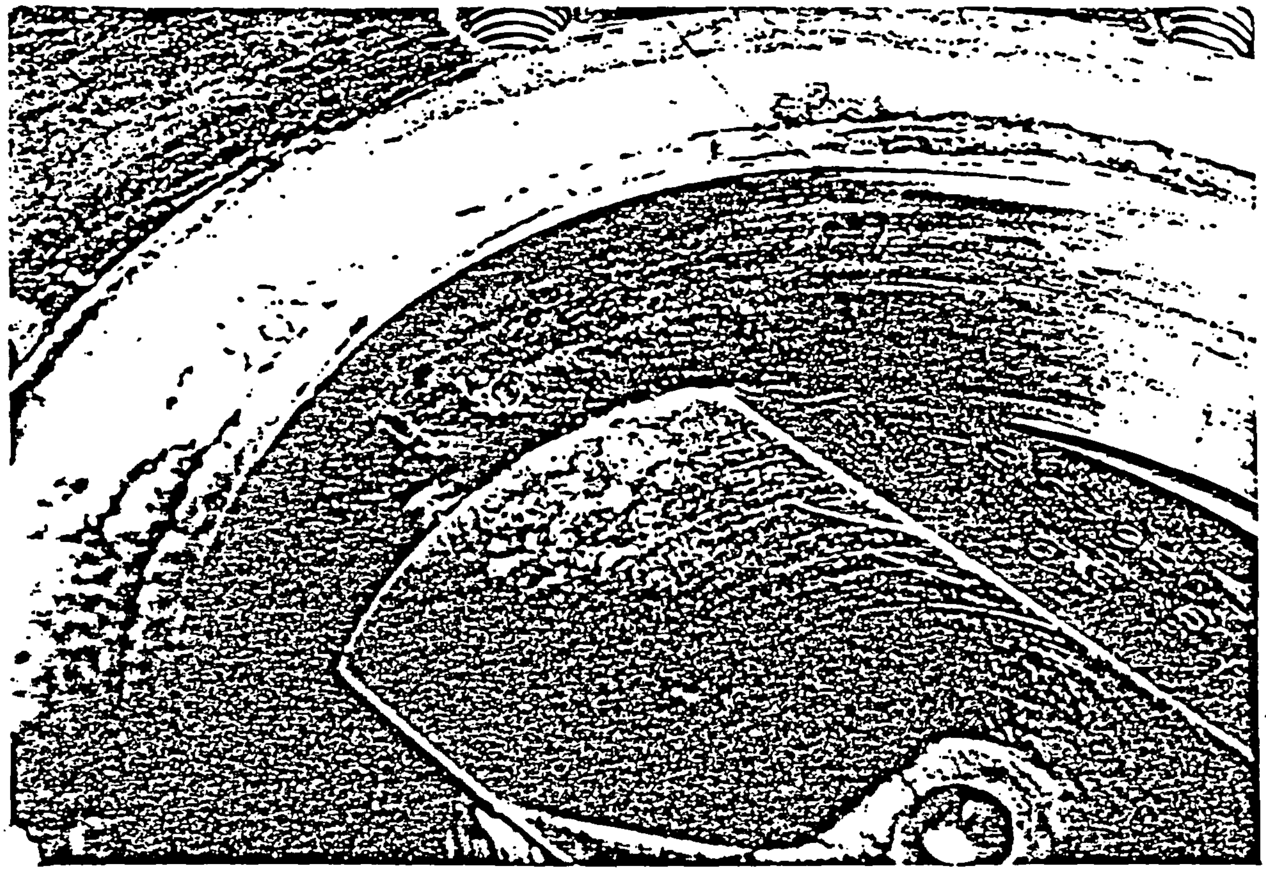


Figure 8. Arrows indicate bubbles forming, when leak test was performed, verifying pin/shaft leakage path.

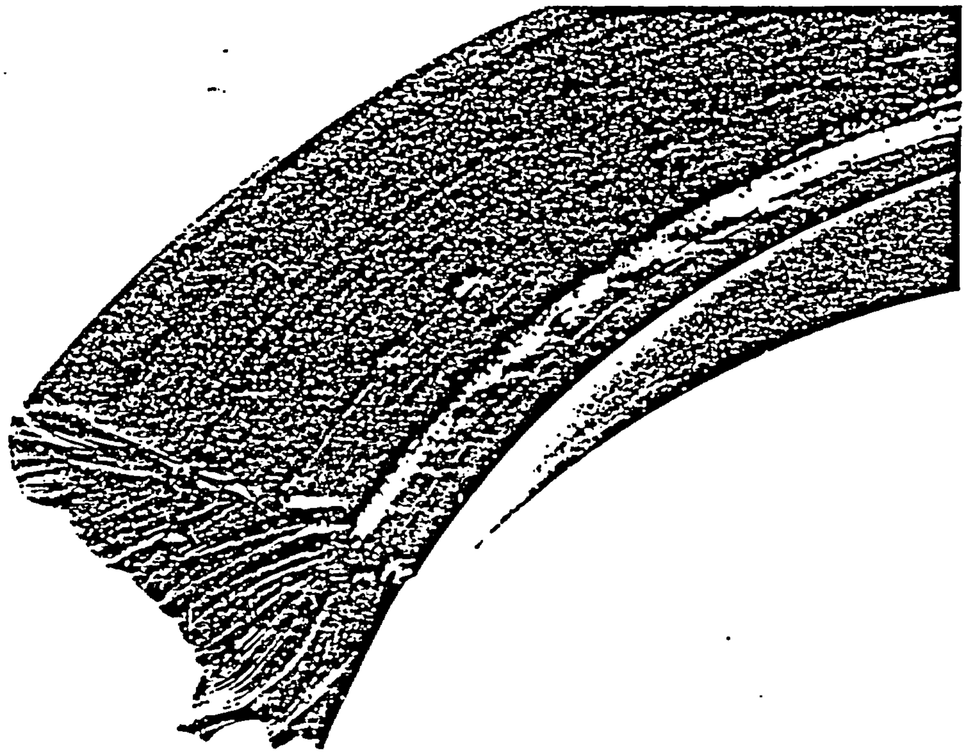


Figure 9. Degradation as a result of test sequence 1.

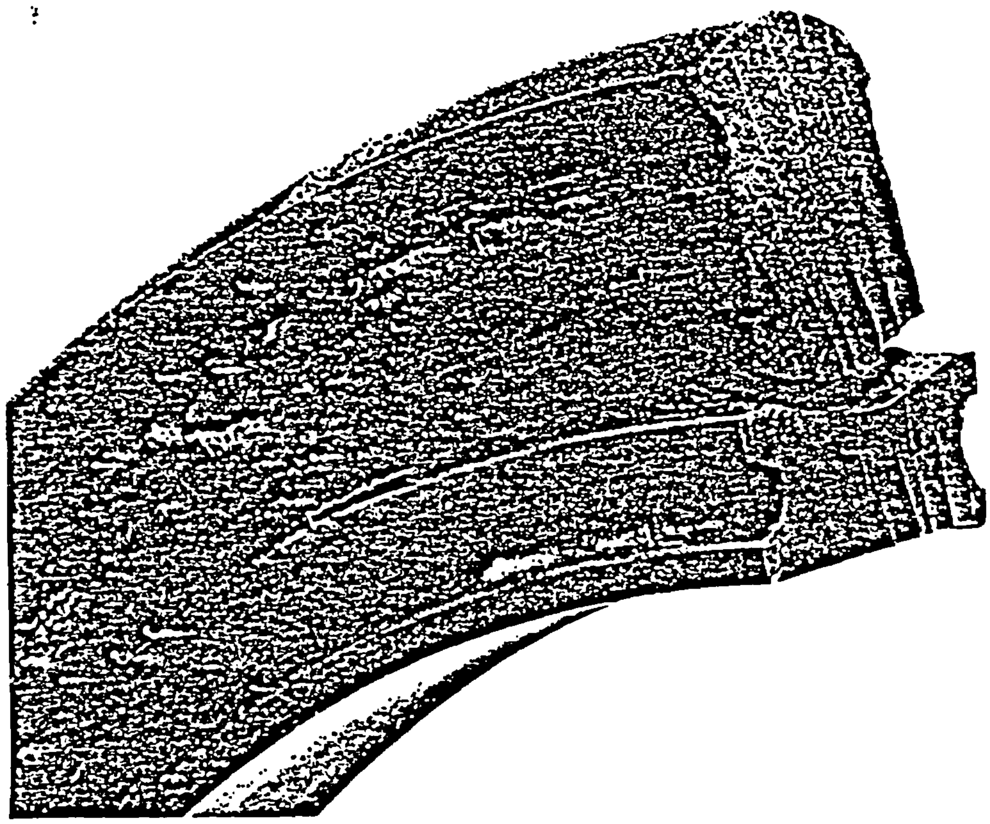


Figure 10. Degradation as a result of test sequence 2.

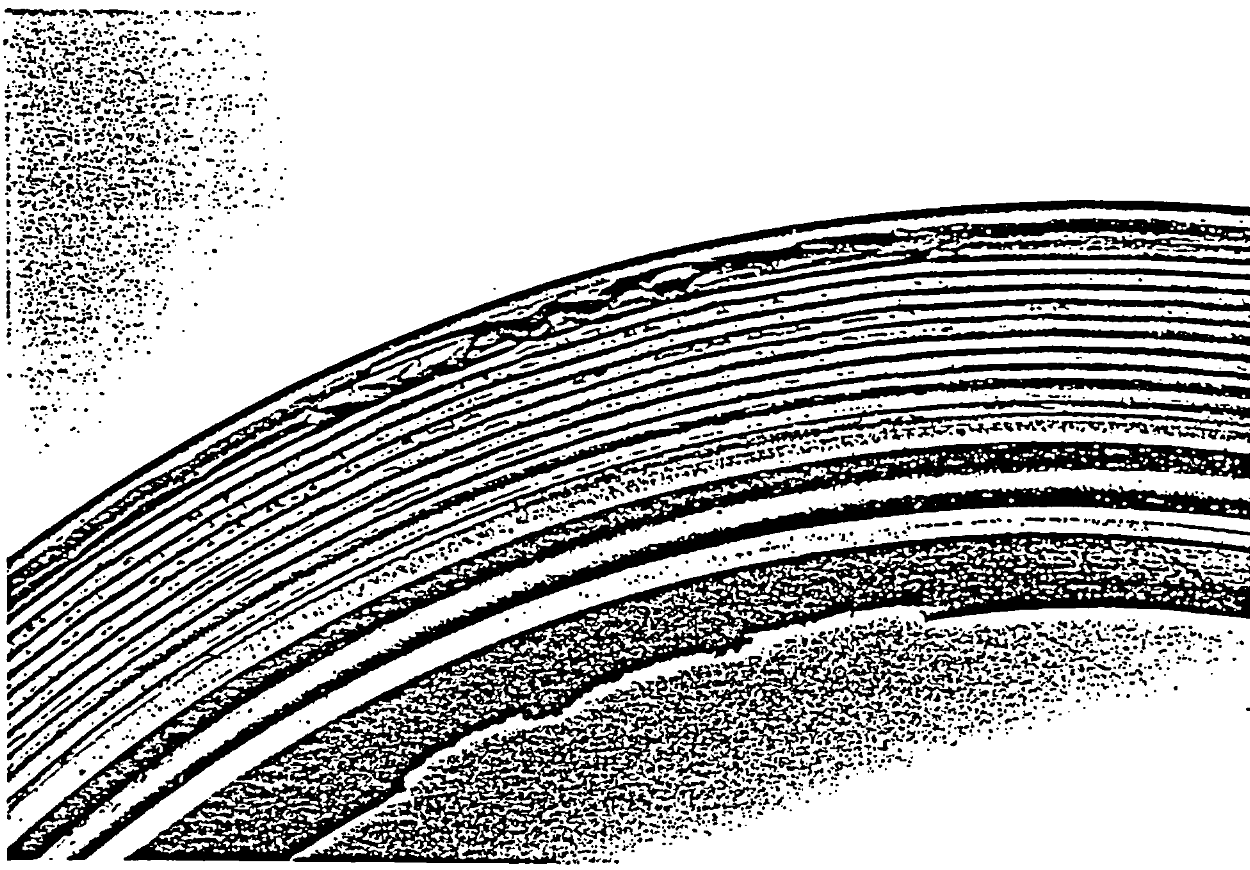


Figure 11. Degradation as a result of test sequence 3.

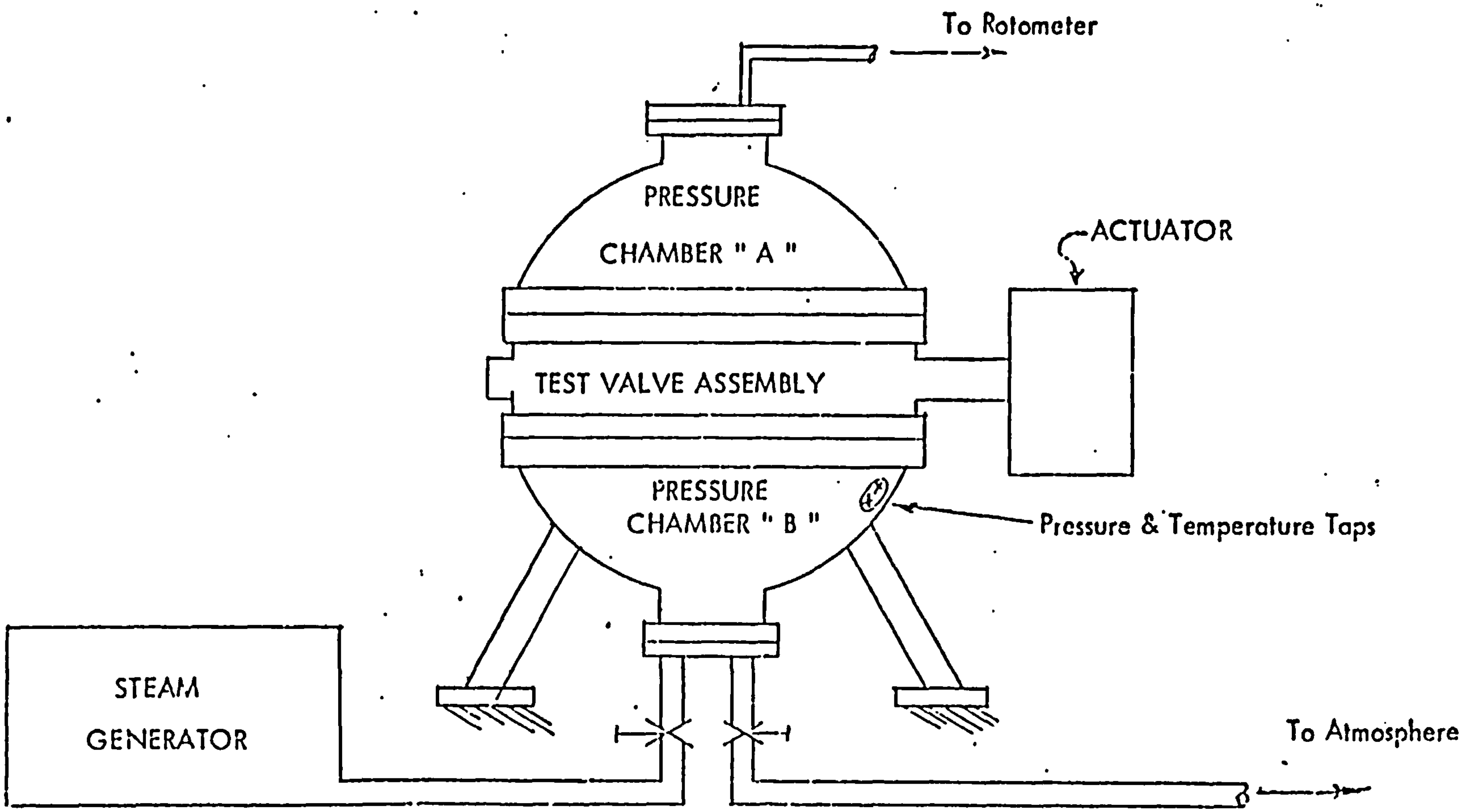

To Rotometer
PRESSURE
CHAMBER " A "
ACTUATOR
TEST VALVE ASSEMBLY
PRESSURE
CHAMBER " B "
Pressure & Temperature Taps
STEAM
GENERATOR
To Atmosphere

Figure 12

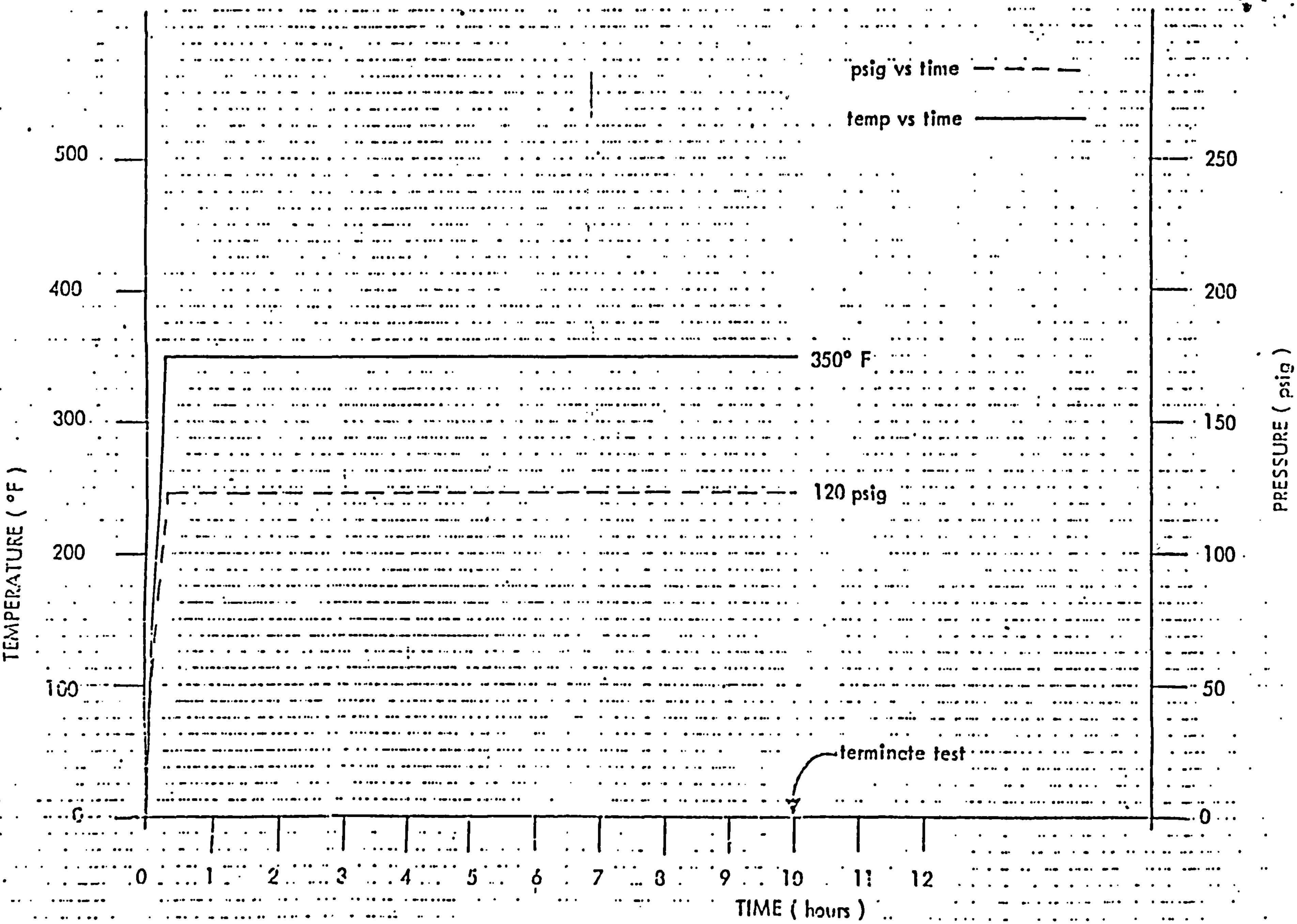


Figure 13. Test Profile.