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TWR-19794

SPACE SHUTTLE

Solid Rocket Motors
Morton Thiokol, Inc.

RSRM FIELD JOINT VOLUME NO. 4 (V_4) PRESSURIZATION TEST RESULTS - FINAL REPORT

SEPTEMBER 1989

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RSRM FIELD JOINT VOLUME NO. 4 (V_4) PRESSURIZATION TEST RESULTS - FINAL REPORT

SEPTEMBER 1989

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1.0 INTRODUCTION

Inspection of test data from the TPTA and JES test series revealed inconsistencies in the measured pressure increase in the cavity between the primary and secondary seals (V_4) of the field joint (see Figure 1). These inconsistencies are significant, since they indicate the position of the O-rings prior to pressurization ("seated" versus "unseated"). Subscaled testing was performed to explain that the differences seen in the V_4 pressure increases can be attributed to O-ring movement caused by joint axial motion occurring during the motor ignition transient and prior to experiencing pressurization. The purpose of this report is to document test results and compare it to the analysis contained in TWR-18791 (Reference 1).

2.0 SUMMARY

Tests were conducted according to the procedure outlined in ETP-0417 (Reference 2) and performed at Thiokol Corp. M-15 laboratory. The test matrix is shown in Table 1.

The test objective, to determine if the O-rings become "unseated" during SRM motor ignition due to joint axial displacement, was accomplished. Test results are contained in Appendix A and summarized in Tables 2 through 5. Those tests labeled with the same test number were performed using the same fixture assembly. Calculations to determine initial V_4 volume are contained in Appendix B and the predictions for V_4 pressure increase are in Appendix C. Testing concludes that joint axial displacement does have a significant affect on O-ring positioning prior to pressurization. The analysis reported in TWR-18791 concluded that on the JES and TPTA tests some secondary seal movement occurs and it is highly probable that some primary seal movement also occurs. Testing and analysis concur with each other.

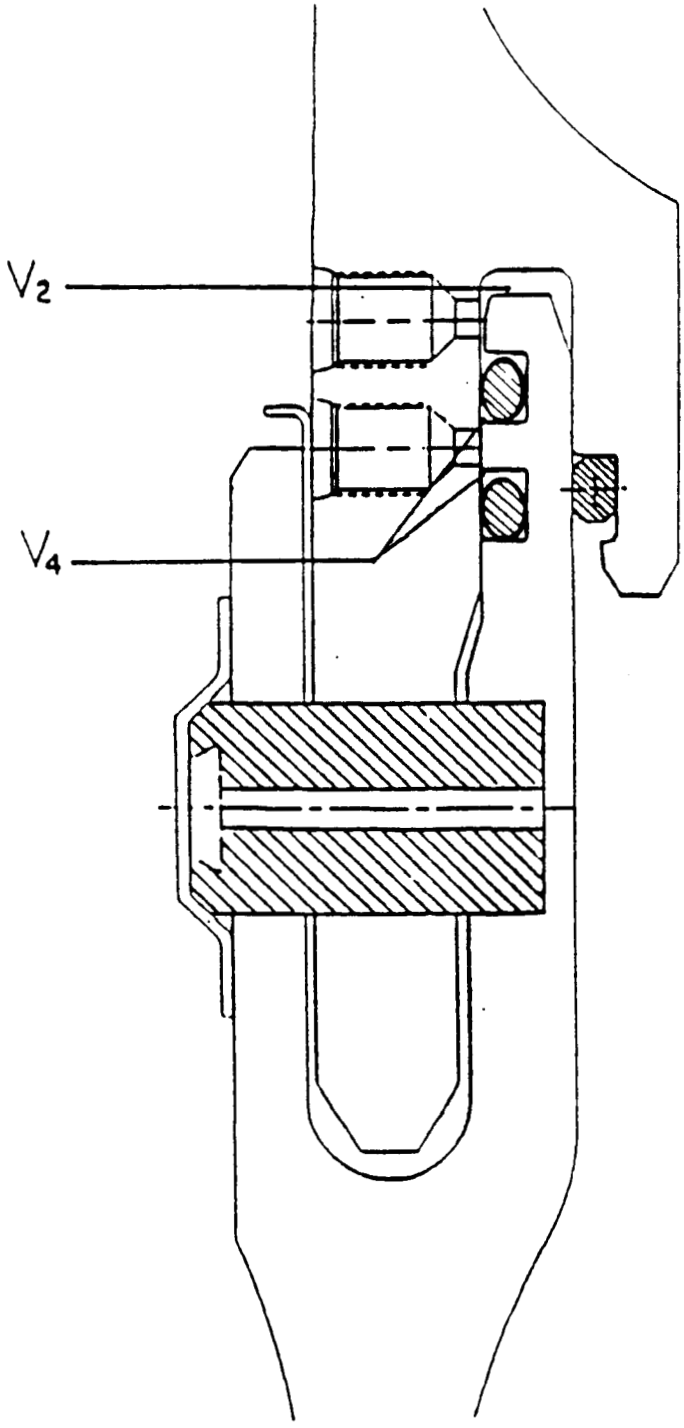


Figure 1
Field Joint Volumes

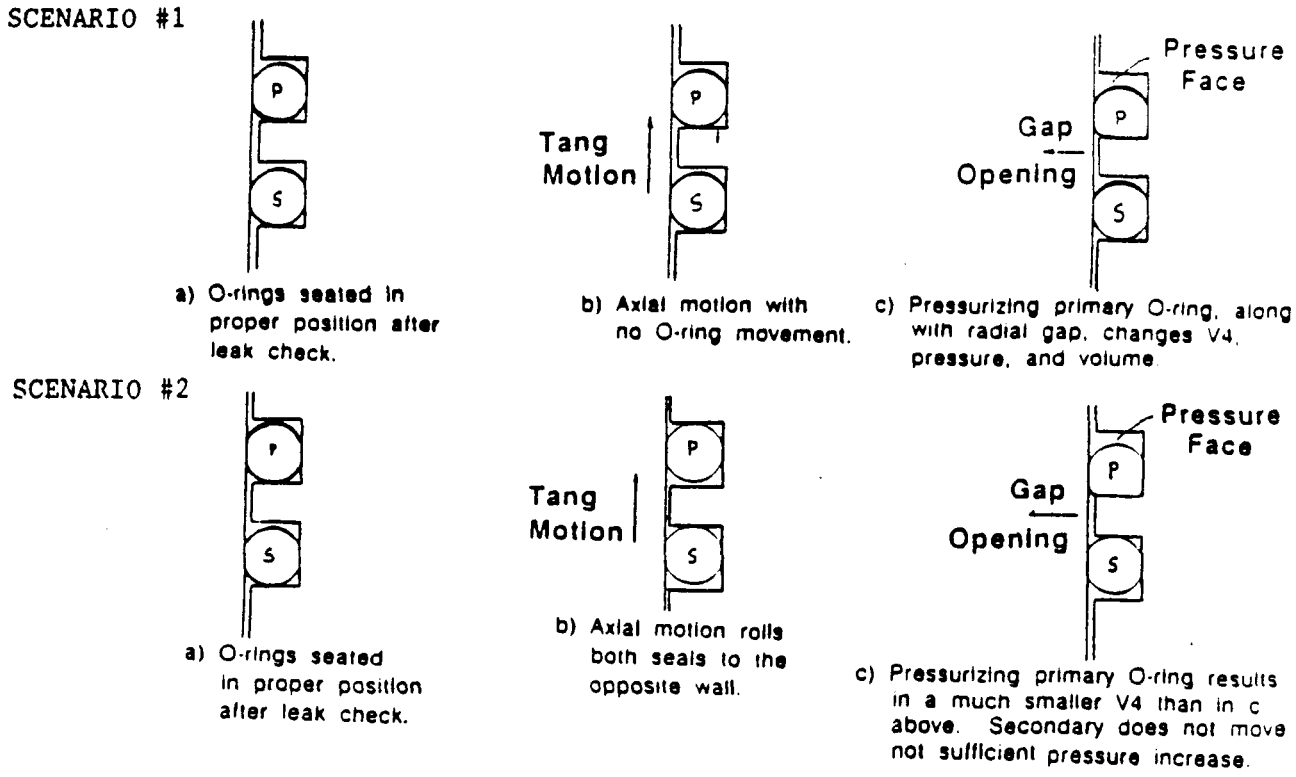


Figure 2

V_4 Pressurization Scenarios

Two V_4 pressurization scenarios were tested and are described in Figure 2. The minimum pressure increase is seen when both primary and secondary O-rings remain in their "seated" position through axial motion and primary O-ring pressurization, at which time the primary is deformed against the aft wall (see Figure 2; Scenario #1: a, b and c). This results in the largest possible final V_4 cavity volume, thus the minimum pressure increase. The maximum pressure increase is seen when both "seated" O-rings roll or slide across the grooves, coming in contact with their respective forward wall, followed by primary O-ring pressurization (Figure 2; Scenario #2: b and c). This results in the smallest possible final V_4 cavity volume, thus the maximum pressure increase.

Table 1- V_4 Pressurization Test Matrix

	NUMBER OF TESTS	SQUEEZE TARGET RANGE (%)	AXIAL GROWTH TARGET RANGE (INCHES)	TEMPERATURE (DEGREES FAHRENHEIT)
SCENARIO #1				
	8	24.0-27.0	0.020-0.025	75
	13	24.0-27.0	0.030-0.035	75
	20	24.0-27.0	0.0	75
SCENARIO #2				
	4	24.0-27.0	0.020-0.025	75
	4	24.0-27.0	0.030-0.035	75
	4	24.0-27.0	0.0	75
TOTAL =	53			

SCENARIO #1: WITH BOTH O-RINGS IN THE PROPER, "SEATED" POSITION
SCENARIO #2: WITH BOTH O-RINGS IN THE IMPROPER, "UNSEATED" POSITION

TEST ITEMS DESCRIPTION :
- D6AC Steel
- Parker's V1115-75 molded O-ring, scarf-joint splice by Hydra-Pak
- Test O-ring Size: 0.290 inch cross-section, 9.338 inch inner diameter

Testing consisted of dynamic pressurization tests, including both axial and radial joint displacements. Testing was performed using the Eccentric Shaft, Variable Gap Dynamic Test Fixture (see Figures 3 and 4) which allows independent control of joint axial displacement, radial displacement, and pressurization. Testing allowed for 3/10ths of a second delay between axial movement and pressure initiation (imitating test data from the TPTA and JES test series). Test fixture pressurization simulated the SRM motor ignition transient, following the 3-SIGMA pressure rise rate (11,500 psi/sec) reaching 1004 psig in 0.6 seconds using nitrogen gas as a constant source (see Figure 5, Reference 3). The displacement versus time curves are also based on the 3-SIGMA pressure rise curve (see Figure 6). In an effort to narrow in on the effect of axial displacement, tests were

conducted both with and without axial movement on both pressurization scenarios, noting the difference in pressure rise in the V_4 cavity.

3.0 DISCUSSION

Test results are summarized in Tables 2 through 5. Primary and secondary O-ring squeeze were determined based on the average O-ring and test fixture dimensions. Axial displacement is based on the average of the two axial LVDT measurements. The measured pressure rise in the V_4 cavity is compared to the predicted value for each test. The percent difference between predictions and measured pressure rise is given by:

$$\frac{\text{Prediction - Measured}}{\text{Measured}} \times 100$$

The predictions account for the individual O-ring dimensions used for each test, but assume the same initial V_4 volume (V_i), for each scenario, as later discussed in Section 3.5.2 and calculations contained in Appendix B. Appendix C contains pressure rise prediction calculations for one individual test for illustrative purposes only.

Additional tests were added to the initial test matrix to show test repeatability and compare the V_4 pressure increase with and without axial movement. A total of 53 tests were performed. Ease of O-ring positioning for Scenario #1 allowed more testing than for Scenario #2 (discussed further in Section 3.5.1). Pressure, radial displacement, O-ring squeeze, temperature, and fixture conditioning remained constant while axial growth varied. Although, the targeted O-ring squeeze was not met due to limitations in the test fixture (i.e. cylinder inner diameter too large), the O-ring squeeze remained relatively constant.

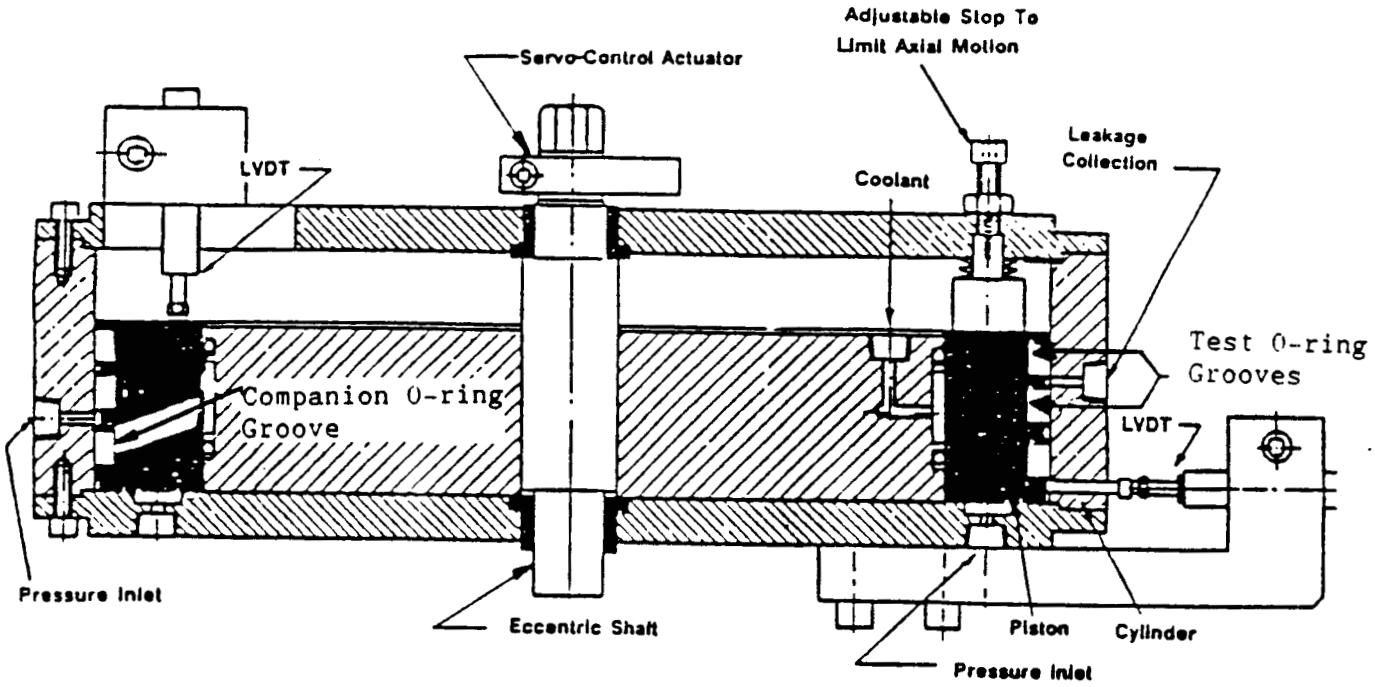
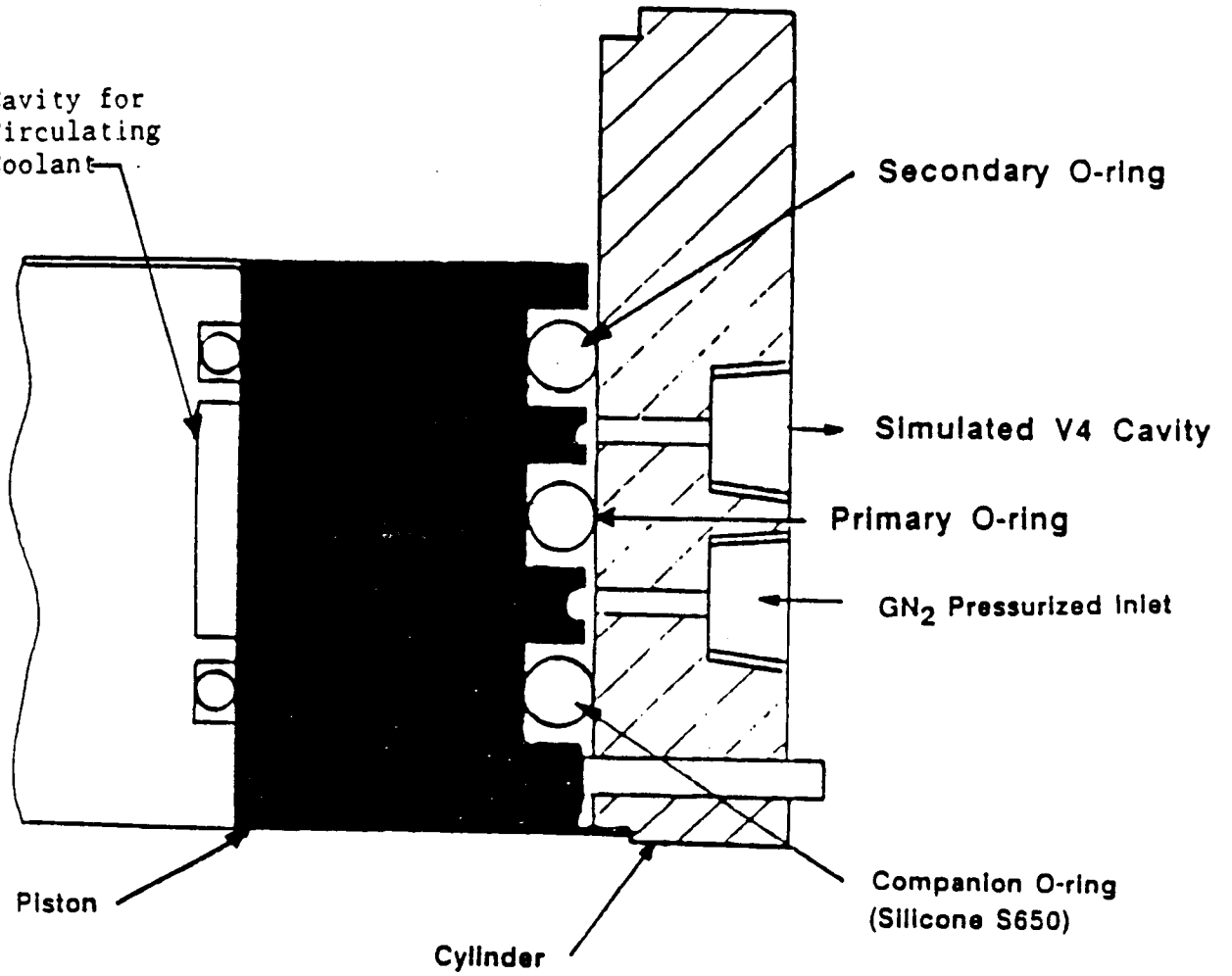


Figure 3

Cross Section of Eccentric, Variable Gap Test Rig



Primary Groove Dimensions:	Secondary Groove Dimensions:
0.215 inch depth	0.208 inch depth
0.359 inch width	0.351 inch width

Figure 4

Test Groove Configuration

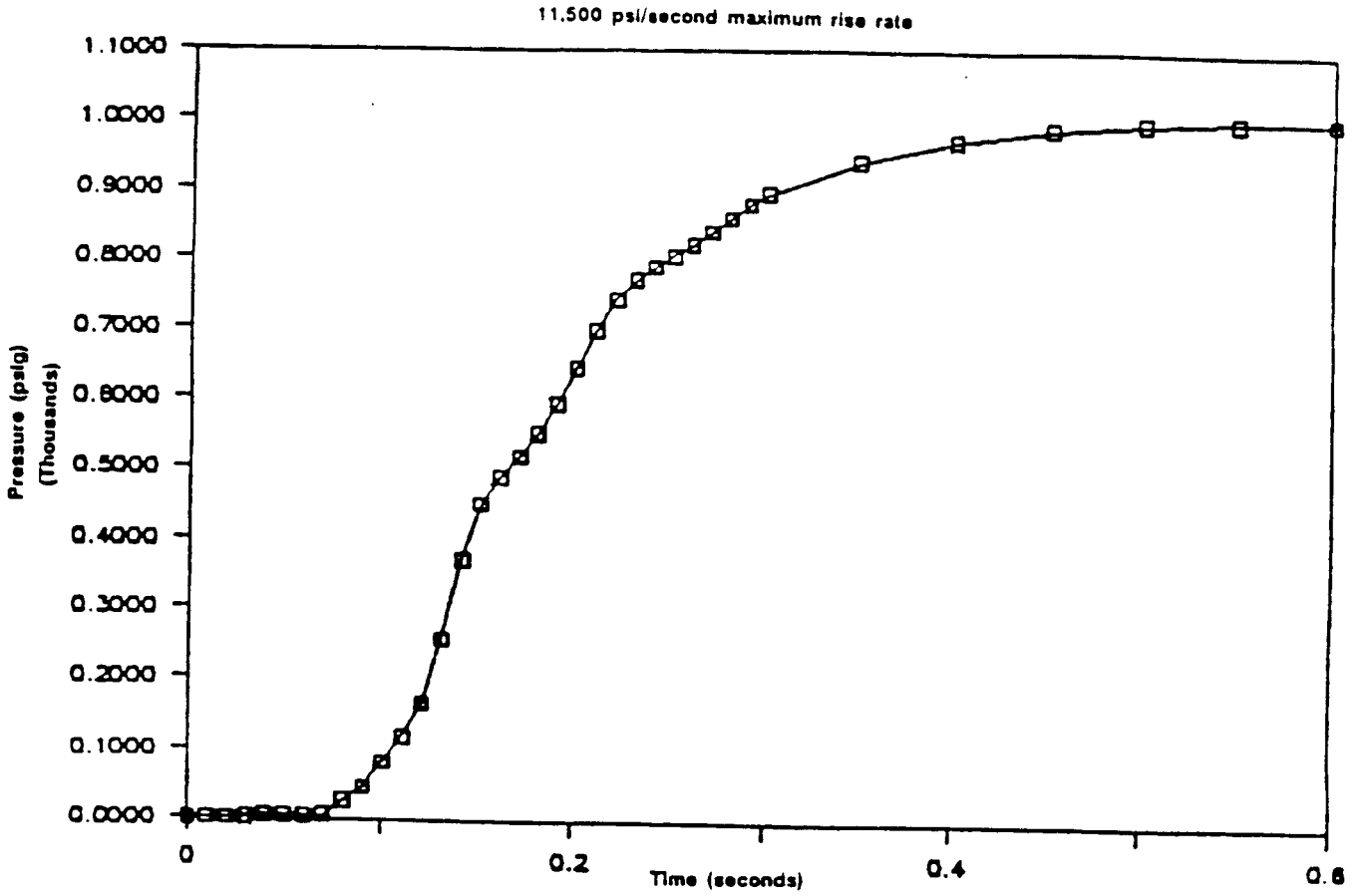
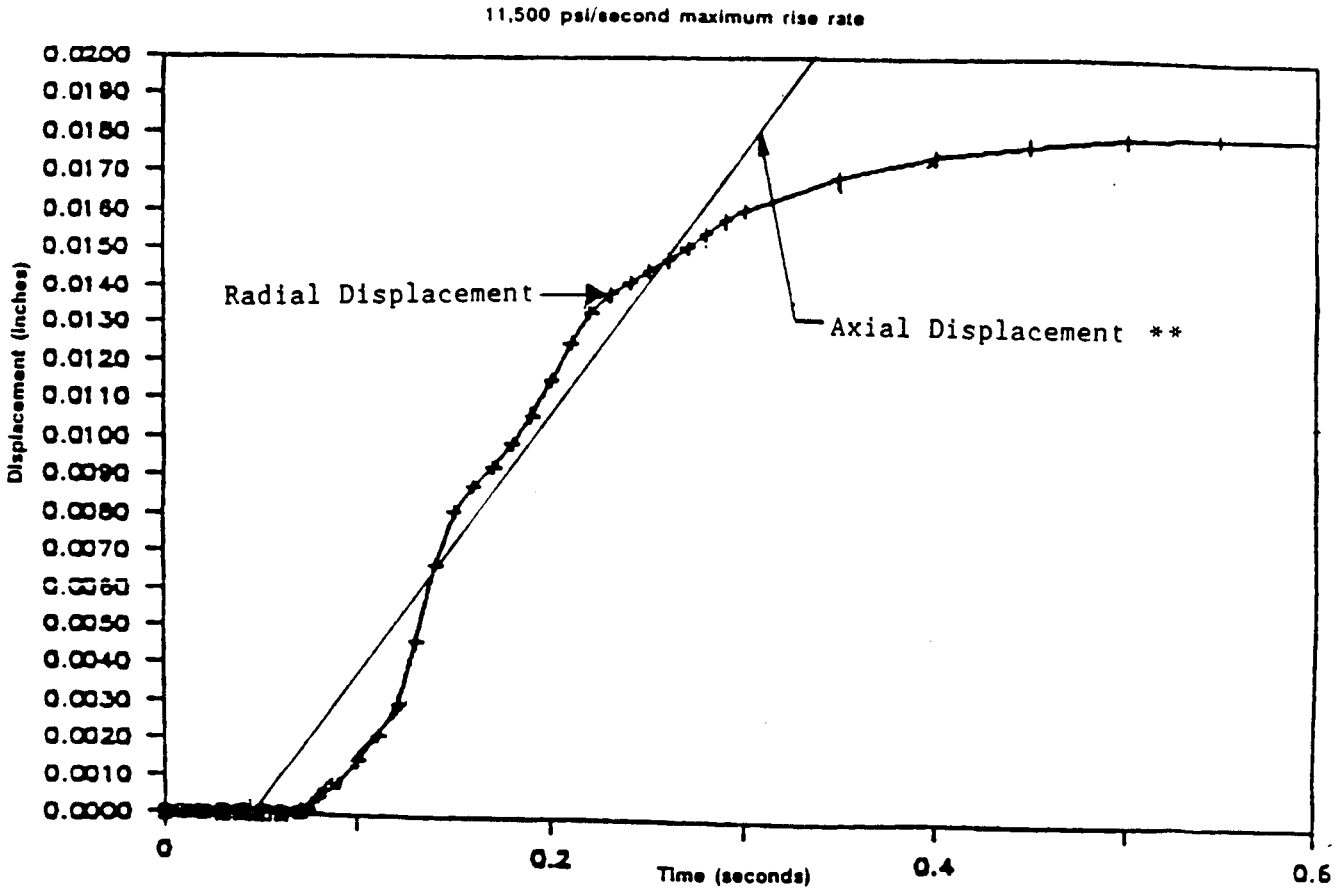


Figure 5
Pressure Versus Time Curve



**NOTE: Maximum Axial Displacement varies depending on test goal (see Test Matrix).

Figure 6

Displacement Versus Time Curve

Table 2: Test Results Summary Table
Scenario #1 - Without Axial Displacement

TEST NO.	AVG INITIAL PRIMARY O-RING SQUEEZE (%)	AVG INITIAL SECONDARY O-RING SQUEEZE (%)	AVG. AXIAL DISPLACEMENT (MILS)	TOTAL TIME ASSEMBLED (HOURS:MINS)	V4 PRESSURE RISE (PSIG)	PREDICTED V4 PRESSURE RISE (PSIG)	DIFF IN PRESS RISE (%) DIFF	V4 TEST TEMP (°F) START / 1 MIN / 2 MIN
1A	17.1	19.1	0.0	22:30	0.80	0.82	2.5	77.0 / 77.0 / 77.0
2A	17.5	19.7	2.4	24:40	0.86	0.81	-5.8	77.2 / 77.2 / 77.2
3A	17.1	19.7	0.0	18:45	0.86	0.80	-7.0	75.9 / 75.9 / 75.9
4A	17.5	19.4	0.0	20:35	0.81	0.81	0	76.3 / 76.3 / 76.3
4B	17.5	19.4	0.0	20:35	0.80	0.81	1.3	76.3 / 76.3 / 76.3
6A	17.4	19.6	0.4	23:45	0.97	0.83	-14.4	75.5 / 75.5 / 75.5
6B	17.4	19.6	0.2	23:45	0.95	0.83	-12.6	75.1 / 75.1 / 75.1
7A	17.2	18.9	0.1	21:00	0.89	0.79	-11.2	76.7 / 76.7 / 76.8
7B	17.2	18.9	0.3	21:00	0.87	0.79	-9.2	76.4 / 76.4 / 76.4
8A	17.4	19.2	0.3	20:55	0.92	0.82	-10.9	75.9 / 75.9 / 75.9
8B	17.4	19.2	0.2	20:55	0.94	0.82	-12.8	75.9 / 76.0 / 76.0
9A	17.3	19.2	0.1	19:30	0.89	0.79	-11.2	76.2 / 76.2 / 76.2
9B	17.3	19.2	0.1	19:30	0.88	0.79	-10.2	76.2 / 76.2 / 76.2
10A	17.4	19.7	0.5	19:45	0.93	0.83	-10.8	76.3 / 76.4 / 76.4
10B	17.4	19.7	0.5	19:45	0.93	0.83	-10.8	76.3 / 76.3 / 76.3
11A	17.1	19.9	0.4	19:40	0.84	0.83	-1.2	75.3 / 75.4 / 75.4
11AA	17.1	19.9	0.6	19:40	0.95	0.83	-12.6	76.2 / 76.2 / 76.3
11B	17.1	19.9	0.4	19:40	1.12	0.83	-25.9	75.9 / 76.0 / 76.0
12A	16.6	18.6	0.0	21:20	1.00	0.81	-19.0	76.0 / 76.0 / 76.1
12B	16.6	18.6	0.0	21:20	1.01	0.81	-19.8	76.7 / 76.7 / 76.7
		AVERAGE =	0.3	20:56	0.91	0.81	-10.5	

Table 3: Test Results Summary Table

Scenario #1 - With Axial Displacement

TEST NO.	AVG INITIAL PRIMARY O-RING SQUEEZE (%)	AVG INITIAL SECONDARY O-RING SQUEEZE (%)	AVG. AXIAL DISPLACEMENT (MILS)	TOTAL TIME ASSEMBLED (HOURS:MINS)	V4 PRESSURE RISE (PSIG)	PREDICTED PRESSURE RISE (PSIG)	DIFF IN PRESS RISE (%) DIFF	V4 TEST TEMP (°F) START / 1 MIN / 2 MIN
1	17.1	19.1	20.8	22:30	1.72	2.45	42.4	76.9 / 76.9 / 77.0
2	17.5	19.7	23.3	24:40	1.90	2.25	18.4	77.7 / 77.6 / 77.6
3	17.1	19.7	25.0	18:45	2.02	2.18	7.9	76.2 / 76.2 / 76.2
4	17.5	19.4	24.8	20:35	1.91	2.34	22.5	75.9 / 75.9 / 75.9
4C	17.5	19.4	24.7	20:35	1.87	2.34	25.1	76.5 / 76.5 / 76.5
5	17.2	19.4	24.4	22:00	1.90	2.37	24.7	76.4 / 76.5 / 76.5
6	17.4	19.6	23.9	23:45	2.22	2.32	4.5	76.4 / 76.4 / 76.4
6C	17.4	19.6	22.6	23:45	2.19	2.32	5.9	76.7 / 76.7 / 76.8
		AVERAGE =	23.7	22:04	1.97	2.32	18.9	
6D	17.4	19.6	33.3	23:45	2.87	2.32	-19.2	78.4 / 78.4 / 78.4
7	17.2	18.9	30.5	21:00	2.60	2.46	-5.4	75.6 / 75.7 / 75.8
7C	17.2	18.9	31.3	21:00	2.70	2.46	-8.9	76.3 / 76.4 / 76.5
8	17.4	19.2	34.0	20:55	2.70	2.48	-8.1	75.8 / 75.9 / 75.9
8C	17.4	19.2	33.9	20:55	2.76	2.48	-10.1	76.1 / 76.1 / 76.1
9	17.3	19.2	32.0	19:30	2.72	2.39	-12.1	74.7 / 74.8 / 74.8
9C	17.3	19.2	32.6	19:30	2.71	2.39	-11.8	75.4 / 75.5 / 75.5
10	17.4	19.7	30.6	19:45	2.66	2.26	-15.0	76.3 / 76.3 / 76.3
10C	17.4	19.7	33.7	19:45	3.05	2.26	-25.9	76.3 / 76.3 / 76.3
11	17.1	19.9	27.0	19:40	2.46	2.19	-11.0	75.9 / 75.9 / 75.9
11C	17.1	19.9	27.5	19:40	2.50	2.19	-12.4	75.7 / 75.7 / 75.6
12	16.6	18.6	35.9	21:20	2.96	2.66	-10.1	76.2 / 76.2 / 76.2
12C	16.6	18.6	36.0	21:20	3.17	2.66	-16.1	75.5 / 75.5 / 75.5
		AVERAGE =	32.2	20:37	2.76	2.40	-12.8	

Table 4: Test Results Summary Table
Scenario #2 - Without Axial Displacement

TEST NO.	AVG INITIAL PRIMARY O-RING SQUEEZE (%)	AVG INITIAL SECONDARY O-RING SQUEEZE (%)	AVG. AXIAL DISPLACEMENT (MILS)	TOTAL TIME ASSEMBLED (HOURS:MINS)	V4 PRESSURE RISE (PSIG)	PREDICTED PRESSURE (PSIG)	DIFF IN PRESS RISE (%) DIFF	V4 TEST TEMP (°F) START / 1 MIN / 2 MIN
1	17.1	19.1	0.0	21:45	4.22	2.17	-48.6	75.8 / 75.9 / 75.9
10	17.4	19.7	0.2	19:30	5.05	2.11	-58.2	75.9 / 75.9 / 76.0
11	17.1	19.9	0.2	19:25	6.49	2.16	-66.7	75.5 / 75.5 / 75.5
12	16.6	18.6	0.0	21:00	3.89	2.31	-40.6	76.0 / 76.0 / 76.0
		AVERAGE =	0.1	20:25	4.91	2.19	-53.5	

Table 5: Test Results Summary Table
Scenario #2 - With Axial Displacement

TEST NO.	AVG INITIAL PRIMARY O-RING SQUEEZE (%)	AVG INITIAL SECONDARY O-RING SQUEEZE (%)	AVG. AXIAL DISPLACEMENT (MILS)	TOTAL TIME ASSEMBLED (HOURS:MINS)	V4 PRESSURE RISE (PSIG)	PREDICTED PRESSURE (PSIG)	DIFF IN PRESS RISE (%) DIFF	V4 TEST TEMP (°F) START /1 MIN /2 MIN
2	17.5	19.7	22.5	21:30	6.50	7.74	19.1	76.5 / 76.5 / 76.6
3	17.1	19.7	25.1	18:30	6.61	7.65	15.7	76.2 / 76.2 / 76.2
4	17.5	19.4	24.3	20:35	4.17	7.86	88.5	75.9 / 75.9 / 75.9
5	17.2	19.4	25.1	21:55	4.70	7.90	68.1	75.7 / 75.8 / 75.8
		AVERAGE =	24.3	20:38	5.50	7.79	41.6	
6	17.4	19.6	36.3	23:30	6.73	7.84	16.5	75.9 / 75.9 / 76.0
7	17.2	18.9	39.0	21:30	7.90	8.03	1.7	75.2 / 75.3 / 75.3
8	17.4	19.2	36.9	20:45	7.17	8.06	12.4	75.6 / 75.6 / 75.6
9	17.2	19.2	34.4	21:25	7.53	7.93	5.3	74.2 / 74.2 / 74.2
		AVERAGE =	36.7	21:48	7.33	7.97	8.7	

The test fixture design is such that the radial gap opening is initiated by rotating the eccentric shaft 180 degrees, moving the piston away from the cylinder along a three inch circumferential test region (i.e. a floating radial gap). Therefore, radial displacement alone does not change the V_4 cavity volume, so it was not necessary to include these measurements in the test summary tables. Volume change in the V_4 cavity is directly attributed to the sliding/deformation of the O-rings. Three stoppers located on top of the piston were manually adjusted to limit axial movement. A more detailed description of the test fixture is contained in TWR-17065 (Reference 4).

3.1 Test Items Description

3.1.1 Piston/Cylinder

The test rig components were fabricated out of stock D6AC steel. A description of the test grooves are as follows:

PRIMARY GROOVE:	SECONDARY GROOVE:
0.215 inch deep	0.208 inch deep
0.359 inch wide	0.351 inch wide
Includes a 63 Ra single point surface finish in hoop direction.	Includes a smooth finish.

See TWR-17065 (Reference 4) for a more detailed groove and surface finish description.

3.1.2 O-rings

The test O-rings were fabricated from Parker's fluorocarbon (V1115-75)

compound per STW9-3315 (Reference 5), and spliced by Hydra-Pak (one splice per STW9-3319; Reference 6). The test O-ring dimensions were as follows:

9.33 - 9.42 inch Inner Diameter
0.290 ± 0.004 inch Cross-Section

The silicone S650 companion O-ring was of the same dimensions as that stated above for the fluorocarbon O-rings.

3.2 Heating/Cooling System

A 50/50 water/antifreeze solution was circulated from a temperature control unit to inside a piston sleeve to heat or cool the test O-rings and surrounding regions.

3.3 Data Acquisition

Dynamic motion, pressure, and temperature conditions were measured using the instrumentation listed in the following table.

Table 6: Test Instrumentation Gages

PARAMETER	MEASURING METHOD	RANGE, RESOLUTION, ACCURACY
Radial Gap	One Linearly Variable Displacement Transformer (LVDT) (located on cylinder O.D. at center of test section)	Range- 0.0 to 0.05 inch Resolution- 0.00005 inch Accuracy- 0.0001 inch
Axial Motion	Two LVDTs (located on top of piston 180° apart)	
Temperature	Thermocouple (located in V_4 cavity, adjacent to O-rings)	Range- undefined Resolution- 0.2° F Accuracy- unknown over whole test range; 2° F estimated
Dynamic Test Pressure to Primary O-ring	Pressure Transducer	Range- 0 to 1500 psig Resolution- 0.1 psig Accuracy- 10 psig
V_4 Pressure Rise	Pressure Transducer	Range- 0 to 15 psig Resolution- 0.06 psig

Pressure transducer and LVDT data, taken every millisecond for the entire two minute test, was acquired by a Data Acquisition computer. Instrumentation was available at Thiokol Corp. M-15 lab.

3.4 Test Data Requirements

The data sheets contained in the test plan were modified and completed for each test. All computer printouts and pressure and displacement traces are included with the data sheets (see Appendix A).

3.5 Test Implementation

3.5.1 Test Procedure

Testing investigated two possible O-ring scenarios for the primary and secondary O-rings immediately prior to experiencing pressurization, as previously described in the Summary Section. To achieve Scenario #2 positioning of the O-rings ("unseated"), the piston was assembled into the bottom of the cylinder and inserted upwards. This assembly rolled the O-rings into the "unseated" position (see Figure 7).

The fixture was then heated to 120° Fahrenheit and maintained for a minimum 16 hour dwell time to allow for compression set in the O-rings (Reference Appendix D in TWR-17065). The fixture was cooled to the desired test temperature of 75°F, -1/+3 and maintained for a minimum of 1.5 hours prior to testing.

Pressurization to the servo-control actuator initiated rotation of the eccentric shaft which triggered two switches to employ axial movement and motor ignition pressurization to the primary O-ring. The switches were synchronized to delay primary O-ring pressurization 3/10ths of a second behind axial movement. Nitrogen gas was used as a constant source for

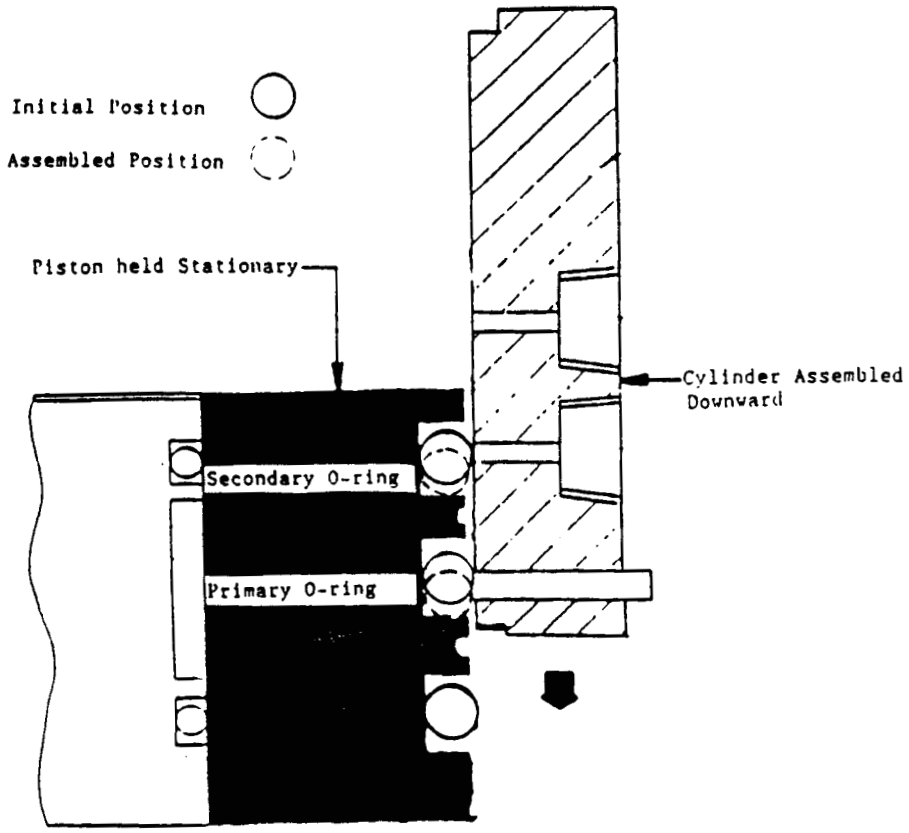


Figure 7
Fixture Assembly

O-ring pressurization. The 15 psig pressure transducer, located downstream of the primary O-ring in the V_4 cavity, measured the pressure rise.

Scenario #1 testing followed Scenario #2. To position the test O-rings in the "seated" Scenario #1 position, 100 psig $\pm$ 25 pressure was applied in the V_4 cavity for two minutes. The forward face of the primary O-ring was subsequently pressurized the same. Testing was then initiated as previously described. Because Scenario #1 tests could be performed without fixture disassembly, numerous tests were performed for repeatability. Tests identified with the same test number were performed using the same fixture assembly (see Test Results Summary Tables).

For each test series (those with the same test number), the test fixture was cleaned using lint-free cloth soaked in methyl chloroform, lightly greased per STW7-2999B (Reference 7) and reassembled using new test O-rings. The two test O-rings and silicon companion O-ring were cleaned using a lint-free cloth soaked in isopropyl alcohol and lightly greased per STW7-2999B.

3.5.2 Determining Initial V_4 Volume (V_i)

The initial volume in the V_4 cavity (V_i) was determined to be as follows:

O-rings positioned in the Scenario #1 position = 2.345 in^3
O-rings positioned in the Scenario #2 position = 3.206 in^3

Calculations on determining these volumes are contained in Appendix B. The following steps were performed on one test assembly to determine the initial volume (V_i) in the V_4 cavity.

a. The line system was assembled per Figure 8 located in Appendix B.

b. Valves No.1 and No.2 were opened.

c. Nitrogen gas, approximately 8 psig, was supplied to the system from the supply source.

d. Valve No.2 was closed while Valve No.1 remained open. Using a 15 psig pressure transducer, a leak proof system was verified.

e. Once the pressure stabilized, Valve No.1 was closed, Valve No.2 was opened and vented. The system stabilized for 15 minutes, then Valve No.2 was closed. Pressure and temperature were noted.

f. Valve No.1 was slowly opened. Following the complete opening of Valve No.1, pressure drop and temperature were immediately noted. Pressure and temperature were continually noted every thirty seconds for ten minutes. Because the system consisted of a very small volume, stabilization occurred within the first minute.

g. Using Boyle's Law the initial V_4 volume (V_i) was determined. To use Boyle's Law, in this application, there must be a known volume. The volume of the lines, indicated by the broken circle in Figure 8, was determined by measuring the volume of isopropyl alcohol needed to completely fill the lines. Isopropyl alcohol was used because of its low coefficient of surface friction.

3.5.3 Determining Final V_4 Volume and Pressure Rise

The final V_4 volume calculations, based on Boyle's Law, are contained in Appendix C. The equation follows:

$$V_f = [(P_{atm} * V_i * T_f)/((P_f + 12.7) * T_i)] - 12.7$$

where,

P_{atm} = atmospheric pressure = 12.7 psi
P_f = pressure rise in the V_4 cavity
V_i = initial volume in V_4 cavity (as determined in Section 3.5.2)
T_i = initial temperature in V_4 cavity
T_f = final temperature in V_4 cavity

4.0 RESULTS

Results on Table 2 show that the measured pressure rises for Scenario #1 tests, without axial movement, are close to predictions. The highest percentage difference in pressure rise is 19.8 (test 12B), the lowest is 0 (test 4A), and the average is 10.5. These values assure confidence in the prediction calculations for Scenario #1. Errors in these calculations can be attributed to one or more of the following; assuming the same initial volume for each test assembly, no O-ring extrusion and right angles on the bottom of the grooves when they are actually rounded. If the rounded angles were taken into account, the predicted V_a (primary) volume would be slightly larger, resulting in a smaller V_4 final volume and subsequently a larger V_4 pressure rise. O-ring extrusion would also contribute to a smaller V_4 final volume. This is shown in Table 2 where the majority of predictions are smaller than the measured pressure rises.

A comparison of Table 2 with Table 3 (tests with same test number) undoubtedly show the secondary O-ring rolling in its groove as a result of axial movement. An average axial displacement of 23.7 mils more than doubles the pressure rise in the V_4 cavity. Further review of Table 3 shows that an average 23.7 mil axial movement did not fully roll the secondary O-ring forward to the "unseated" position. An average axial displacement of 32.2 mils resulted in a higher V_4 pressure rise than the tests with 23.7 average axial displacement, which indicates that the amount of secondary O-ring sliding action is dependent on the degree of axial movement.

Prediction calculations assume the secondary O-ring becomes fully "unseated" (to the forward groove wall), which as previously stated, is not the case. This explains why predictions for tests with an average 23.7 mil displacement are higher than the actual. Predictions for tests with an average 32.2 mil displacement are smaller than the actual due to some

inherent errors in the calculations.

A comparison of Tables 4 and 5 (Scenario #2) also point to secondary O-ring motion as a result of axial displacement. A difference in V_4 pressure rise between tests with axial displacement versus those without, is not as eminent in Scenario #2 as in Scenario #1. This is so because the secondary O-ring is already in the "unseated" position, allowing less volume for the O-ring to roll.

Scenario #2 O-ring positioning was achieved solely by test fixture assembly, not by pressurizing the cavities between the O-rings as in Scenario #1. Predictions in Table 4 (without axial displacement) were based on the assumption that the initial position of the O-rings were ideally situated as depicted in Figure 2b. The discrepancy between the predicted pressure rises versus the actual indicates that the O-rings were positioned somewhere in between figures 2b and 2c. Because the V_4 volume is small, not knowing the exact initial positioning of the O-rings and subsequently the final V_4 volume, significantly diminishes the accuracy of the calculations.

Predictions in Table 5 (with axial displacement) were based on the assumption that the initial position of the O-rings is unknown, but the final position is identical to the final O-ring position in Scenario #1 (with axial displacement). Comparing the predicted pressure rise to the actual indicates a more realistic scenario. See Appendix C for more details.

The V_4 pressure rise plots (contained in Appendix A) basically follow the test initiation pressure curve. Because the data is jumpy during the initial 1.8 milliseconds of testing and test data readings were recorded only every millisecond, it is not feasible to determine the rolling effect of the primary O-ring due to axial displacement prior to experiencing

pressurization. Since the displacement of the secondary O-ring due to axial motion is so obvious, the primary O-ring most probably also becomes "unseated" prior to pressurization.

In conclusion, the subscaled test data concurs with the analysis presented in TWR-18791. In the RSRM application, it is highly likely that both the primary and secondary O-rings roll in their grooves upon motor ignition pressurization. This O-ring rolling phenomena is dependent on the amount of axial displacement which occurs in the joint.

5.0 REFERENCES

1. St.Aubin, B. K., "RSRM Field Joint Volume No. 4 (V_4) Analysis", Morton Thiokol, Inc. Specification TWR-18791, 27 September 1988.

2. Kerrigan, T. A., "RSRM O-ring Field Joint Volume No. 4 (V_4) Pressurization Tests", Morton Thiokol, Inc., Specification ETP-0417, October 1988.

3. "Nitrogen, Technical", Federal Specification BB-N-411, 3 January 1973.

4. Kerrigan, T. A., "Metal O-ring and Surface Finish Test Results", Morton Thiokol, Inc. Specification TWR-17065, 10 November 1987.

5. "Preformed Packing (O-rings) Fluorocarbon, Fabrication of", Morton Thiokol, Inc. Specification STW9-3315, 11 April 1988.

6. "Preformed Packing (O-rings), Fluorocarbon, Splicing of, Process HP", Morton Thiokol, Inc. Specification STW9-3319, 10 June 1988.

7. "Calcium Grease Field Joint, Factory Joint, Nozzle Joints Assembly Application of, and Component Installation, Space Shuttle SRM", Morton Thiokol, Inc. Specification STW7-2999B, 8 March 1988.

Appendix A

Data Sheets, Pressure Transducer and LVDT Traces

Appendix A contains the data sheets, pressure transducer and LVDT traces for each test. The data was plotted for both the initial second of testing and the total 120 seconds. In some instances the data is jumpy due computer malfunctions.

Appendix A
Index to Subscaled Test Results

Scenario #1:

Test #1 ..... A-1
Test #2 ..... A-7
Test #3 ..... A-13
Test #4 ..... A-19
Test #5 ..... A-31
Test #6 ..... A-34
Test #7 ..... A-49
Test #8 ..... A-61
Test #9 ..... A-73
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Test #12 ..... A-112

Scenario #2:

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Test #2 ..... A-127
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Test #7 ..... A-142
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Test #9 ..... A-148
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Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
ASSEMBLY DATE: 2/14/89

TEST #: 1
TEST TECHNICIAN: H. Gardner
TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16

PISTON NO.: 63/63

PRIMARY O-RING
O-RING NO.: #3
O-RING INNER DIAMETER: 9.374 in.
O-RING X-SECTION DIAM: 0.2876 in.
O-RING SQUEEZE: 17.1% (AVG.)
ADJUSTED X-SECTION: 0.2848 in.

SECONDARY O-RING
O-RING NO.: #4
O-RING INNER DIAMETER: 9.374 in.
O-RING X-SECTION DIAM: 0.2886 in.
O-RING SQUEEZE: 19.1% (AVG.)
ADJUSTED X-SECTION: 0.2836 in

O-RING CONDITIONING
CONDITIONING TEMP.: 112.0 °F
CONDITIONING START TIME: Noon, 2/14/89 CONDITIONING STOP TIME: 7AM 2/15/89

FIXTURE CONDITIONING FOR TEST
START DATE & TIME OF TEST CONDITIONING: 2/15/89 9:10 AM
CONDITIONING TEMP.: 75.0 °F
DATE & TIME OF TEST: 2/15/89 10:30 AM
FIXTURE TEMEPERATURE AT END OF TEST: 77.0 °F

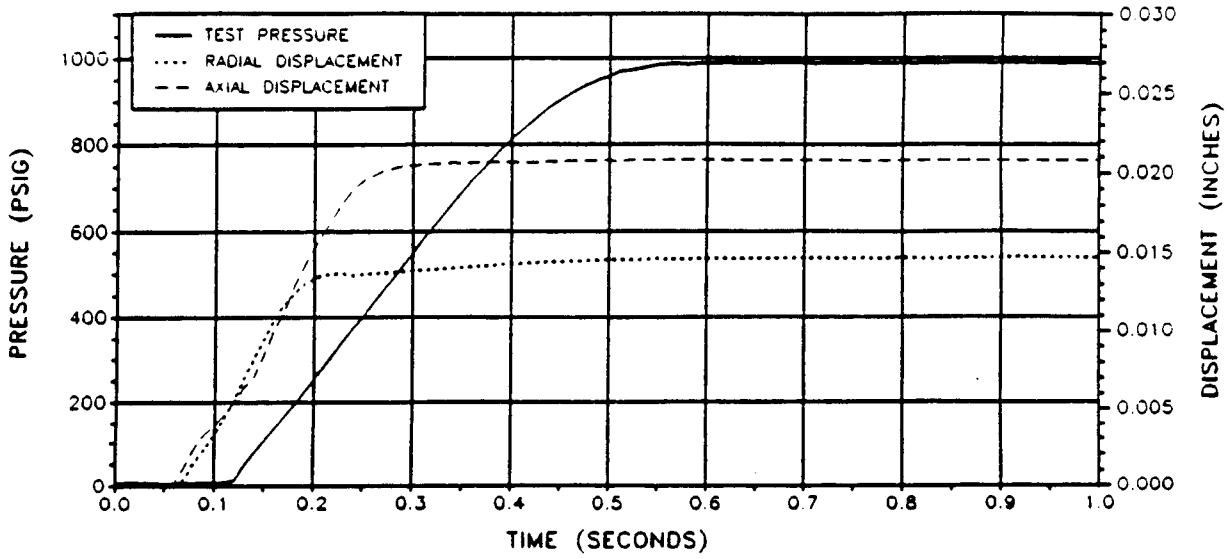
CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3
P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 14.42 psia
T_1 = 76.9 °F T_2 = 76.9 °F (at 60 seconds)
Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$
V_f = 2.0669 in^3
$\Delta V = V_i - V_f$
ΔV = 0.2799 in3

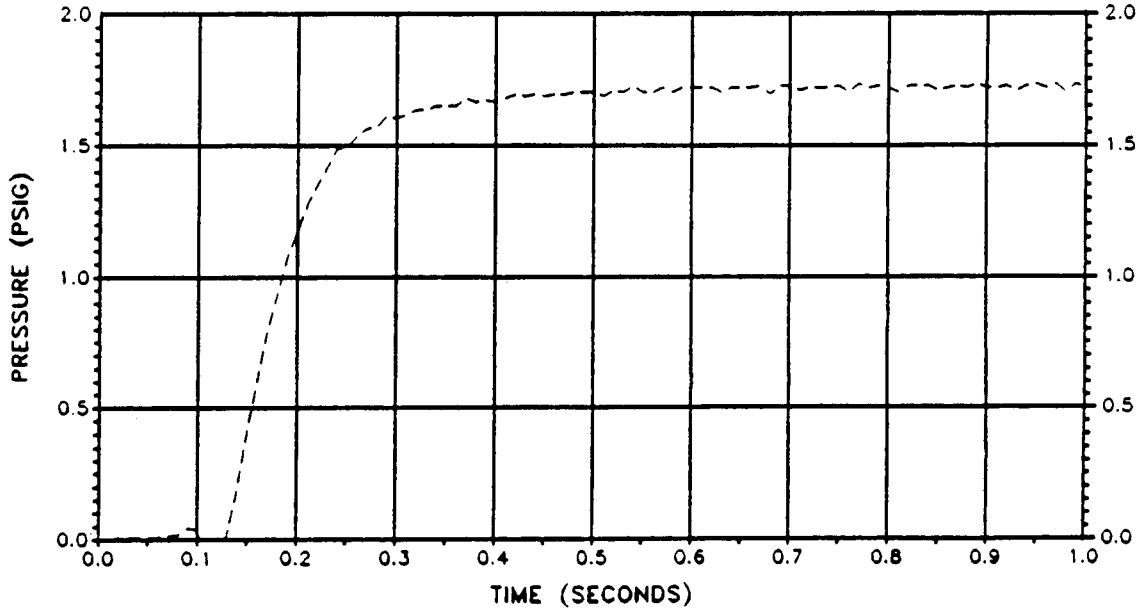
ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #1 (Test Date 2/15/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

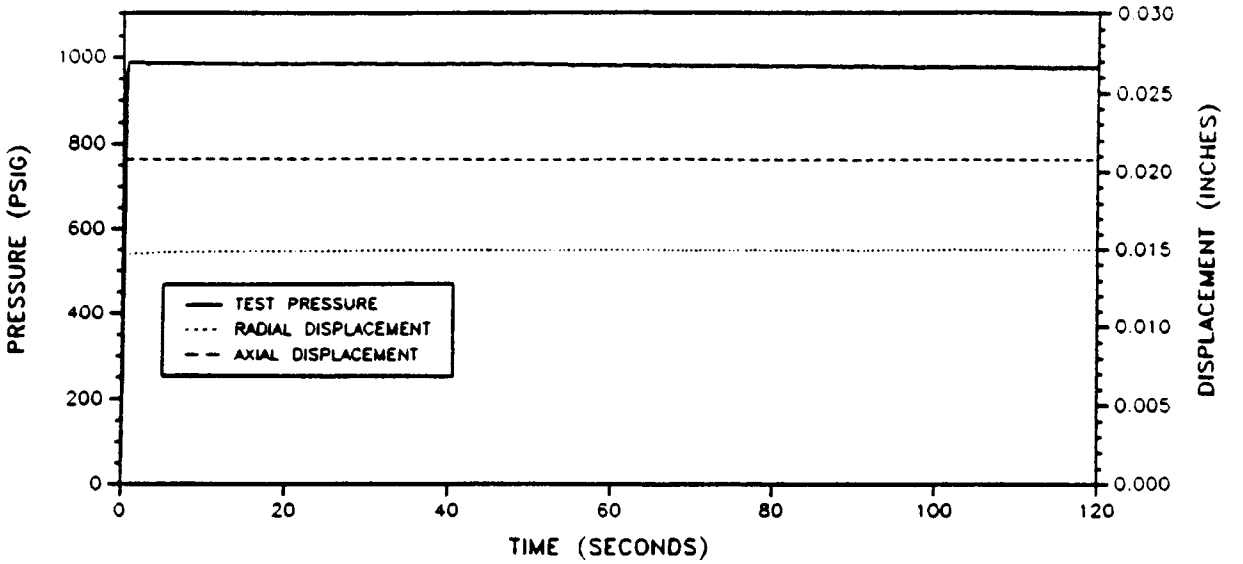


V-4 Cavity Pressure Vs. Time (1 Second Plot)

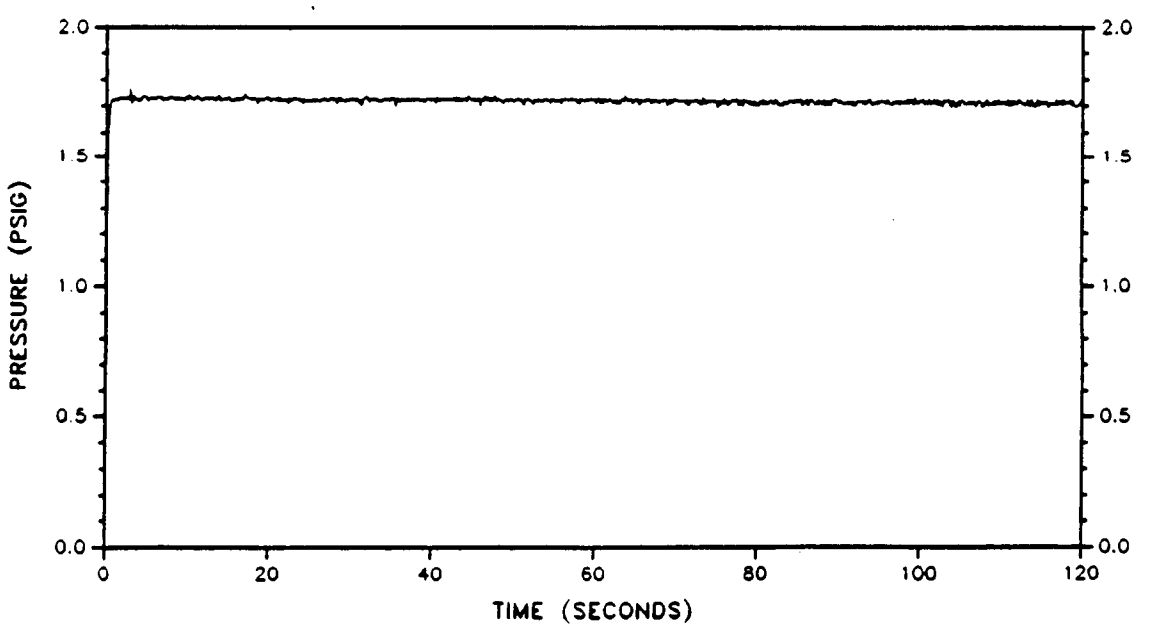


SCENARIO #1, TEST #1 (Test Date 2/15/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
ASSEMBLY DATE: 2/14/89

TEST #: 1A
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/63

PRIMARY O-RING
O-RING NO.: #3
O-RING INNER DIAMETER: 9.374 in
O-RING X-SECTION DIAM: 0.2896 in
O-RING SQUEEZE: 17.1% (AVG.)
ADJUSTED X-SECTION: 0.2848 in.

SECONDARY O-RING
O-RING NO.: #4
O-RING INNER DIAMETER: 9.374 in
O-RING X-SECTION DIAM: 0.2886 in
O-RING SQUEEZE: 19.1% (AVG.)
ADJUSTED X-SECTION: 0.2836 in.

O-RING CONDITIONING
CONDITIONING TEMP.: 112.0 °F
CONDITIONING START TIME: NOON, 2/14/89 CONDITIONING STOP TIME: 7AM 2/15/89

FIXTURE CONDITIONING FOR TEST
START DATE & TIME OF TEST CONDITIONING: 2/15/89 9:10 AM
CONDITIONING TEMP.: 75.0 °F
DATE & TIME OF TEST: 2/15/89 10:30 AM
FIXTURE TEMEPERATURE AT END OF TEST: 77.0 °F

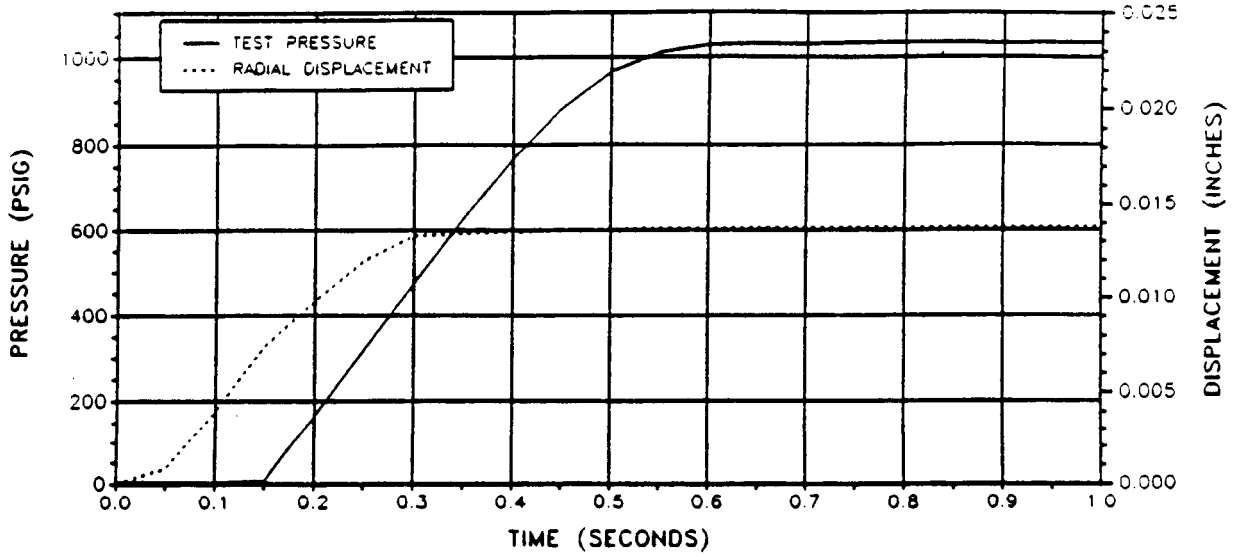
CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3
P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 13.5 psia
T_1 = 77.0 °F T_2 = 77.0 °F (at 60 seconds)
Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$
V_f = 2.2077 in^3
$\Delta V = V_i - V_f$
ΔV = 0.1391 in3

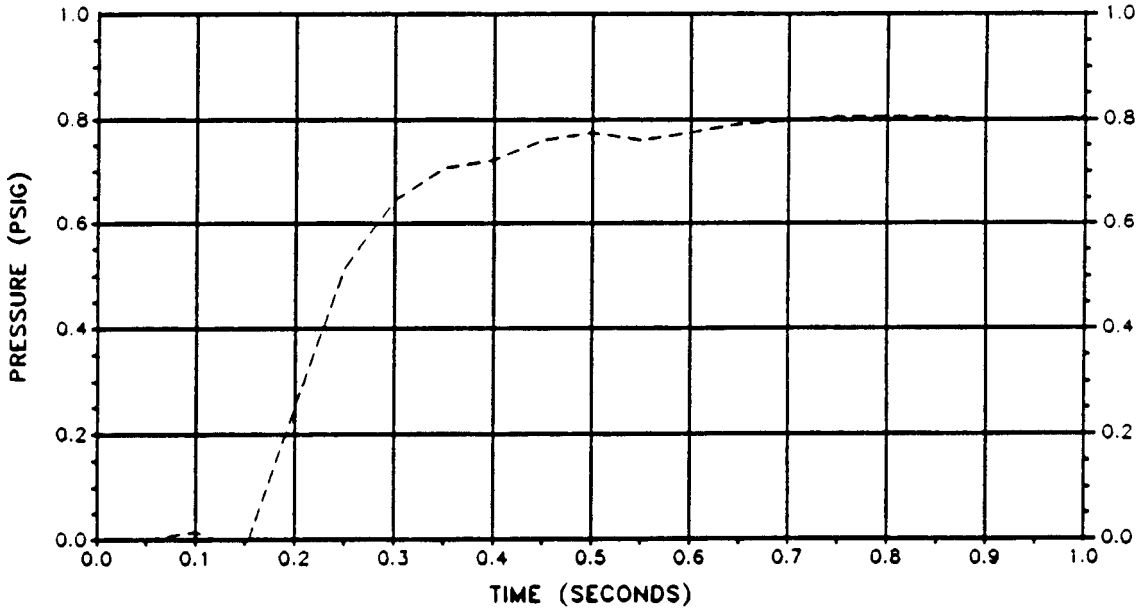
ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #1A (Test Date 2/15/89)

Test Pressure and Radial Displacement Vs. Time (1 Second Plot)

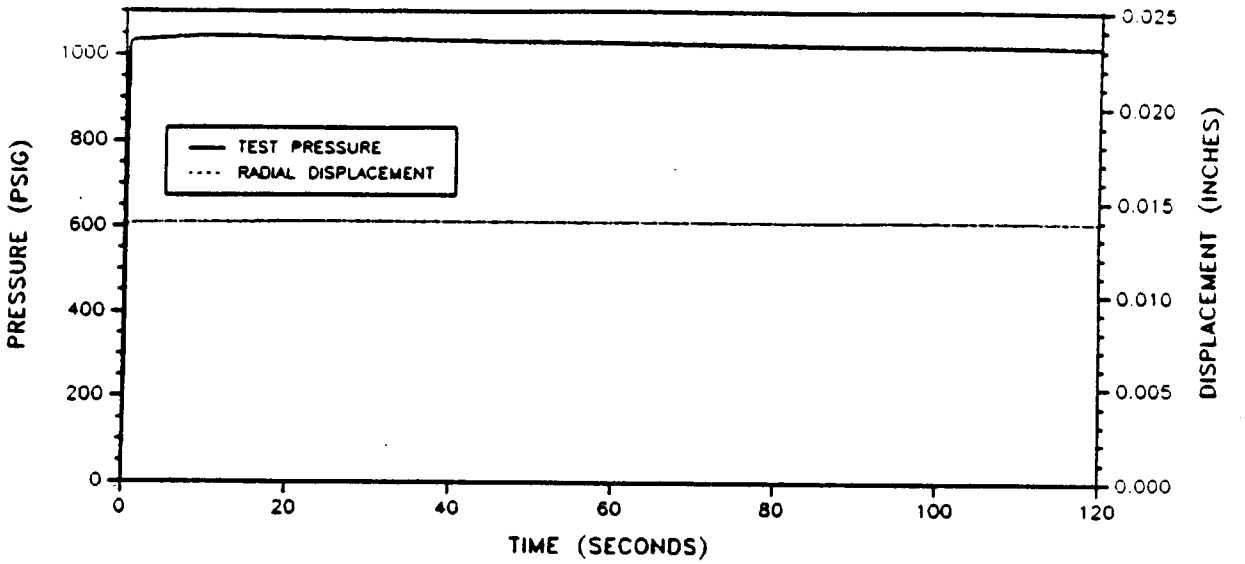


V-4 Cavity Pressure Vs. Time (1 Second Plot)

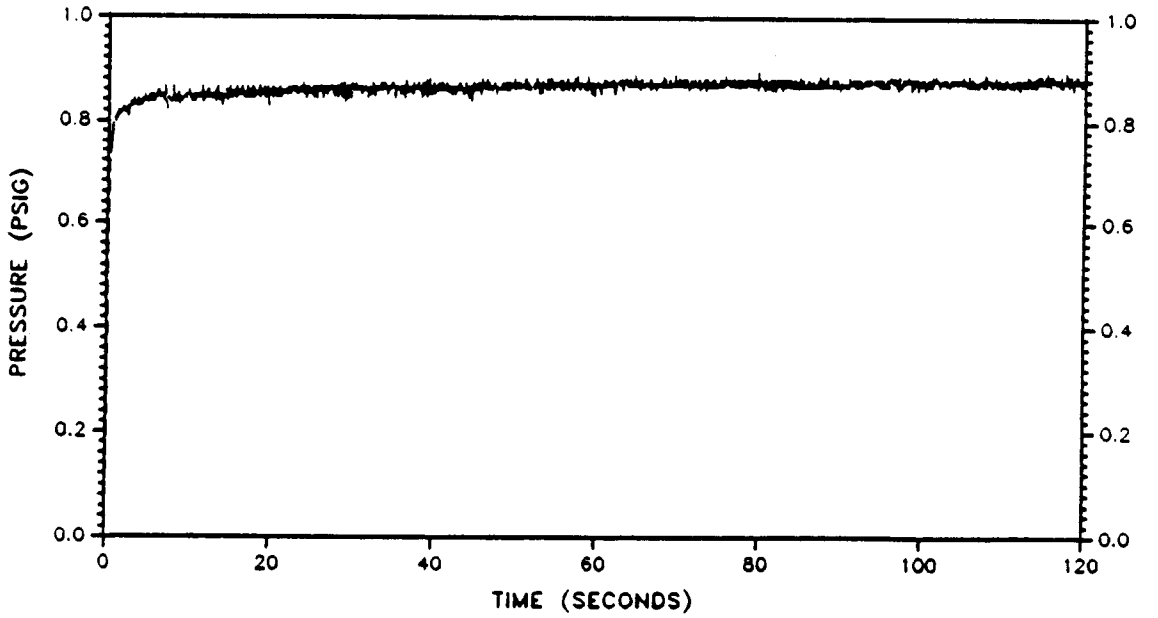


SCENARIO #1, TEST #1A (Test Date 2/15/89)

Test Pressure and Radial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
ASSEMBLY DATE: 2/20/89

TEST #: 2
TEST TECHNICIAN: Mike Gardner
TEST SUPERVISOR: Theresa Morrison

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16

PISTON NO.: 63/63

PRIMARY O-RING
O-RING NO.: #5
O-RING INNER DIAMETER: 9.368 in.
O-RING X-SECTION DIAM: 0.2911 in.
O-RING SQUEEZE: 17.5% (AVG.)
ADJUSTED X-SECTION: 0.2862 in.

SECONDARY O-RING
O-RING NO.: #6
O-RING INNER DIAMETER: 9.360 in.
O-RING X-SECTION DIAM: 0.2913 in
O-RING SQUEEZE: 19.7% (AVG.)
ADJUSTED X-SECTION: 0.2859 in.

O-RING CONDITIONING
CONDITIONING TEMP.: 112.0 °F
CONDITIONING START TIME: 1:00 PM, 2/20/89 CONDITIONING STOP TIME: 7AM 2/21/89

FIXTURE CONDITIONING FOR TEST
START DATE & TIME OF TEST CONDITIONING: 2/21/89, 9:00 AM
CONDITIONING TEMP.: 77.7 °F
DATE & TIME OF TEST: 2/21/89, 1:40 PM
FIXTURE TEMEPERATURE AT END OF TEST: 77.6 °F

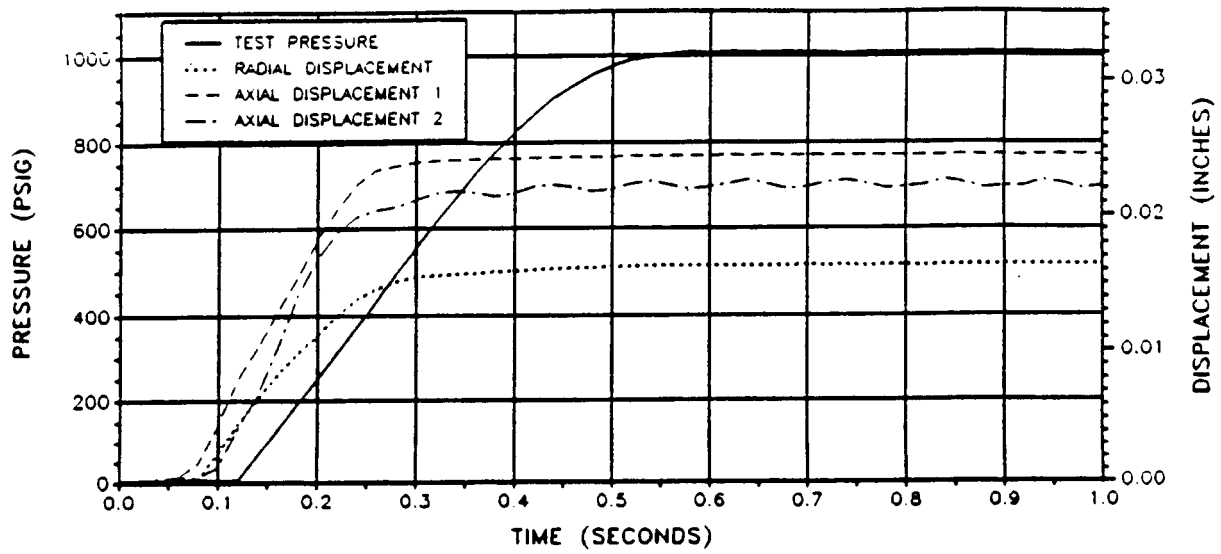
CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3
P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 14.6 psia
T_1 = 77.7 °F T_2 = 77.6 °F (at 60 Seconds)
Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$
V_f = 2.0388 in^3
$\Delta V = V_i - V_f$
ΔV = 0.308 in3

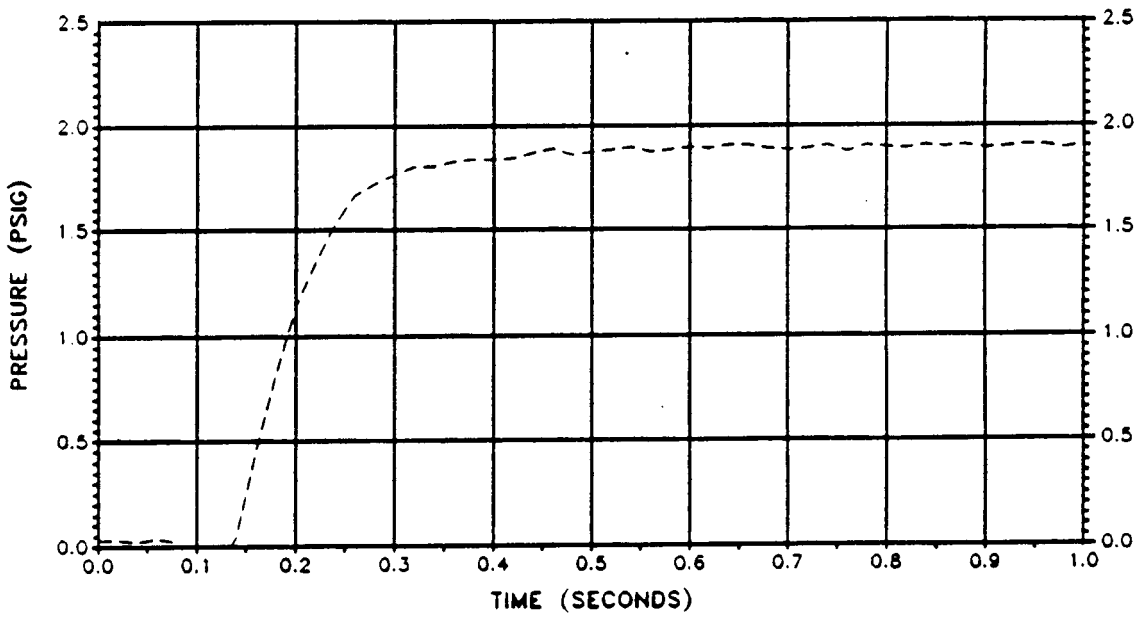
ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #2 (Test Date 2/21/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

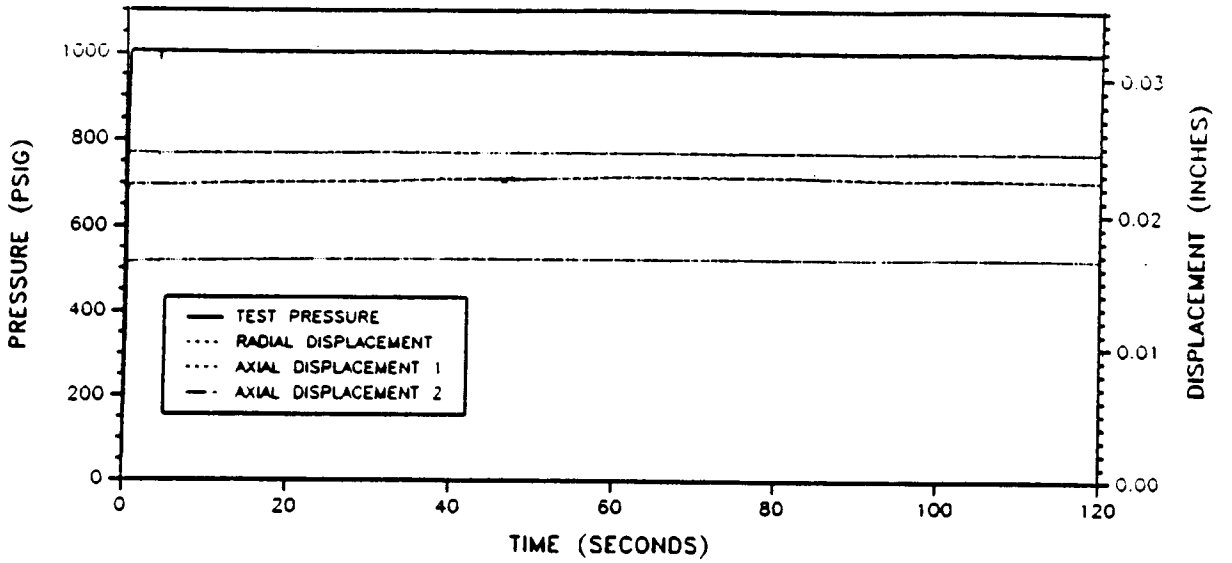


V-4 Cavity Pressure Vs. Time (1 Second Plot)

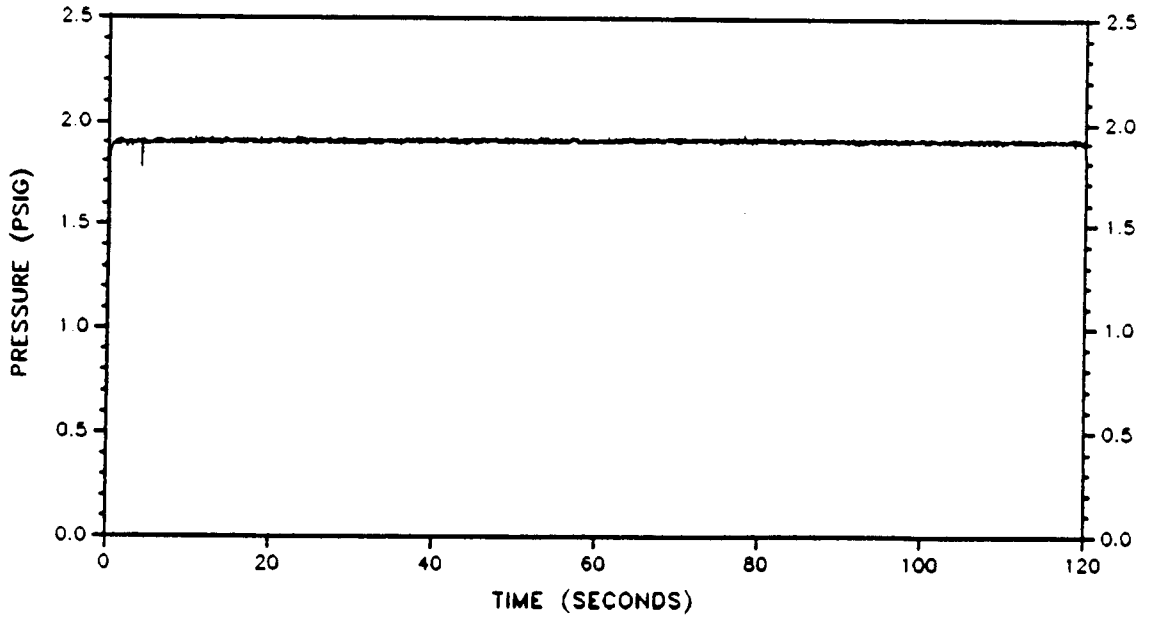


SCENARIO #1, TEST #2 (Test Date 2/21/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I

TEST #: 2-A

ASSEMBLY DATE: 2/20/89

TEST TECHNICIAN: M. Gardner

TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16

PISTON NO.: 63/63

PRIMARY O-RING

O-RING NO.: #5

O-RING INNER DIAMETER (inch): 9.368

O-RING X-SECTION DIAM (inch): 0.2911

O-RING SQUEEZE (%): (AVG.) 17.5

ADJUSTED X-SECT (inch): 0.2862

SECONDARY O-RING

O-RING NO.: #6

O-RING INNER DIAM (inch): 9.360

O-RING X-SECT DIAM (inch): 0.2913

O-RING SQUEEZE: (AVG.) 19.7

ADJUSTED X-SECT (inch): 0.2859

O-RING CONDITIONING

CONDITIONING TEMP.: 112.0 °F

CONDITIONING START TIME: 1:00 pm 2/20/89

CONDITIONING STOP TIME: 7AM 2/21/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 2/21/89 9:00 AM

CONDITIONING TEMP.: 77.2 °F

DATE & TIME OF TEST: 2/21/89 2:45 PM

FIXTURE TEMEPERATURE AT END OF TEST: 77.2 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 13.56 psia

T_1 = 77.2 °F T_2 = 77.2 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.1980 in^3

$\Delta V = V_i - V_f$

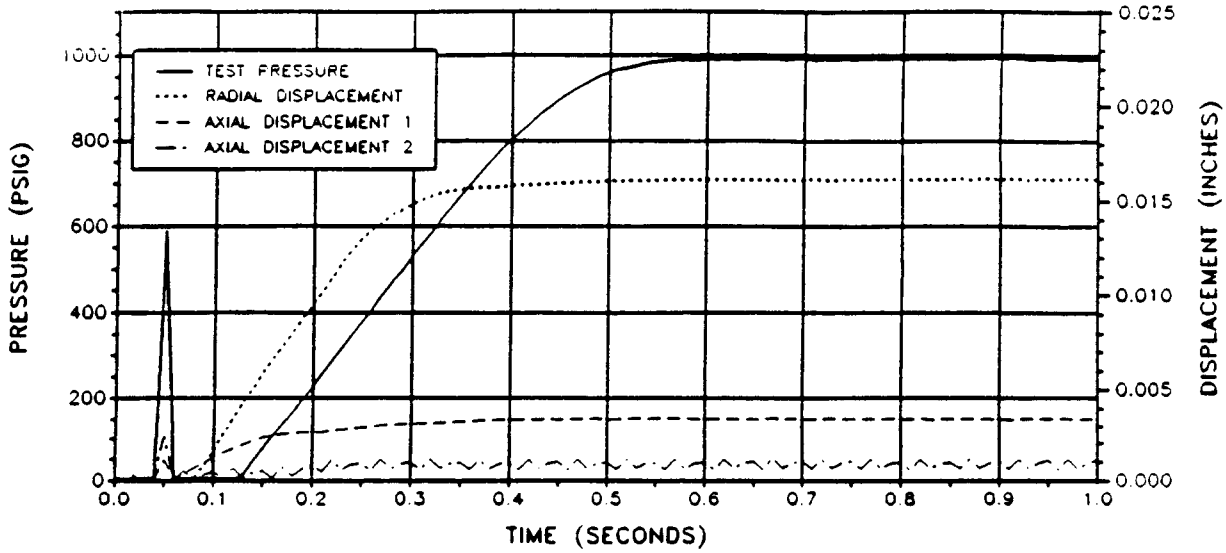
ΔV = 0.1488 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

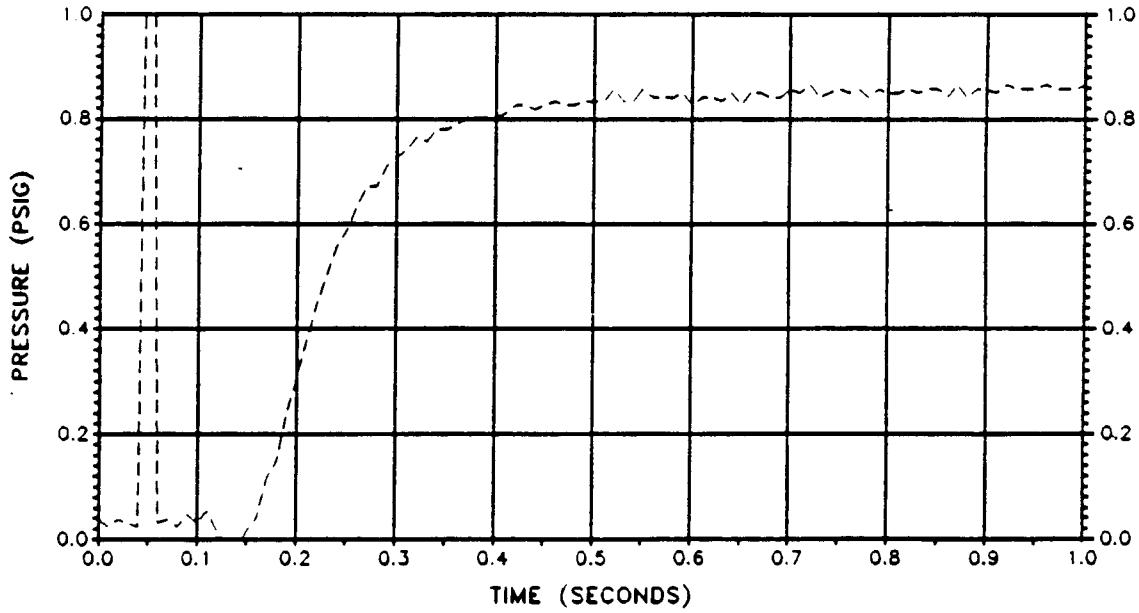
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #2A (Test Date 2/21/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

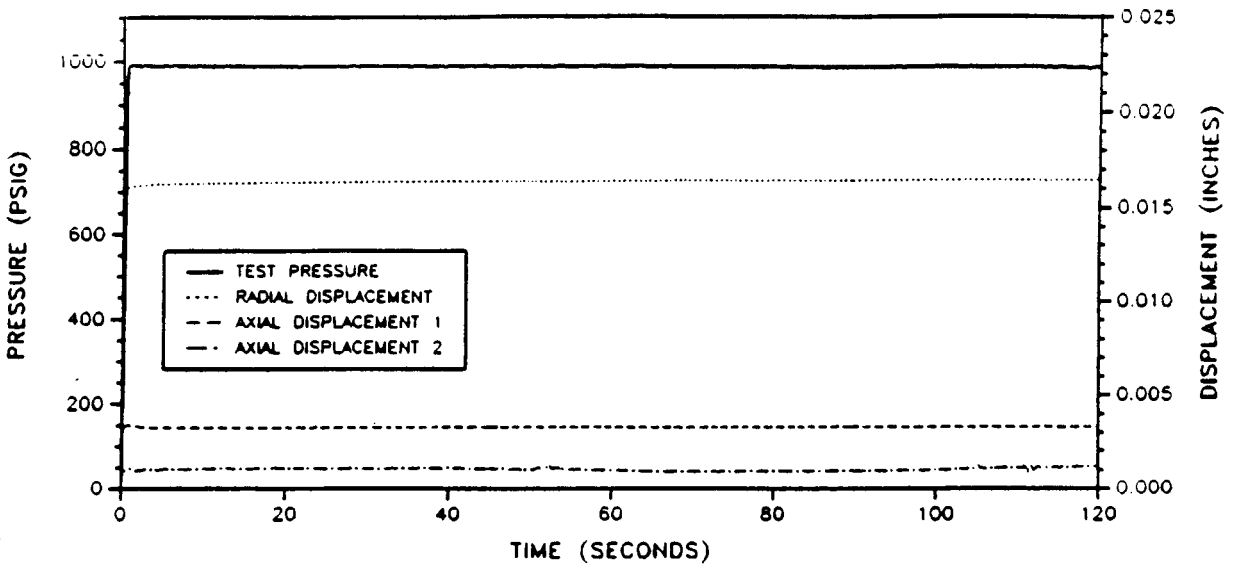


V-4 Cavity Pressure Vs. Time (1 Second Plot)

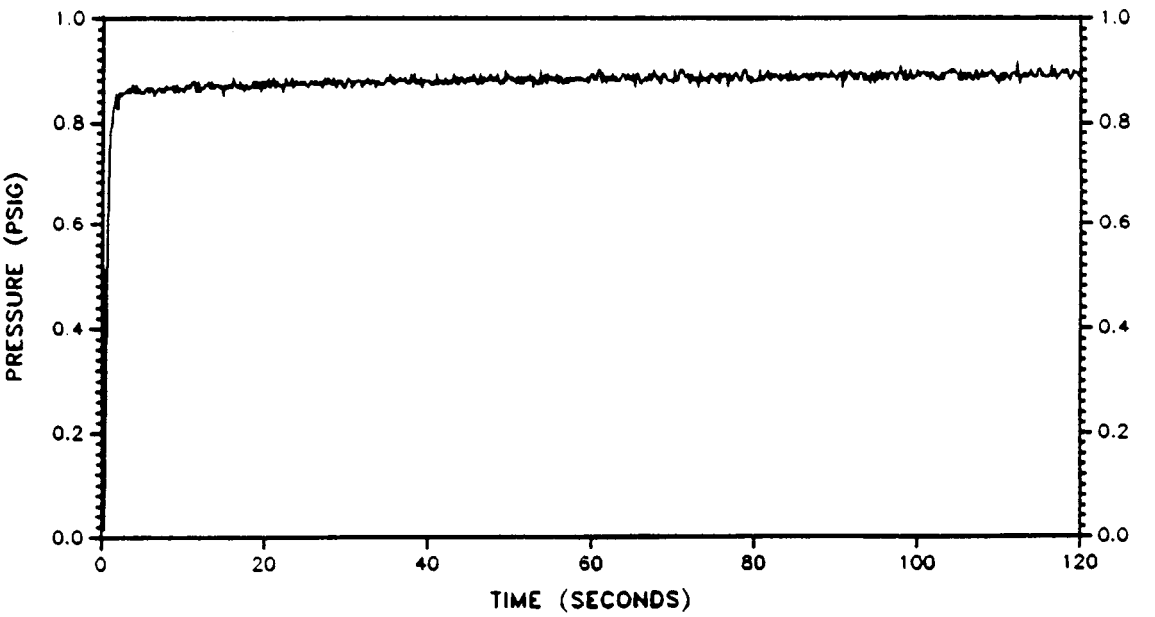


SCENARIO #1, TEST #2A (Test Date 2/21/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
TEST #: 3
ASSEMBLY DATE: 2/21/89
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. [illegible]

ASSEMBLY DETAILS:

CYLINDER NO.: 63/116
PISTON NO.: 63/63

PRIMARY O-RING

O-RING NO.: #7
O-RING INNER DIAMETER (inch): 9.351
O-RING X-SECTION DIAM (inch): 0.2900
O-RING SQUEEZE (%): (AVG.) 17.1
ADJUSTED X-SECT (inch): 0.2847

SECONDARY O-RING

O-RING NO.: #8
O-RING INNER DIAM (inch): 9.391
O-RING X-SECT DIAM (inch): 0.2906
O-RING SQUEEZE: (AVG.) 17.7
ADJUSTED X-SECT (inch): 0.2859

O-RING CONDITIONING

CONDITIONING TEMP.: 110.3 °F
CONDITIONING START TIME: 3:30 PM 2/21/89
CONDITIONING STOP TIME: 7 AM 2/22/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 2/22/89 8:45 AM
CONDITIONING TEMP.: 76.0 °F
DATE & TIME OF TEST: 2/22/89, 10:15 AM
FIXTURE TEMEPERATURE AT END OF TEST: 76.2 °F

CALCULATE V_4 FINAL VOLUME (V_f)

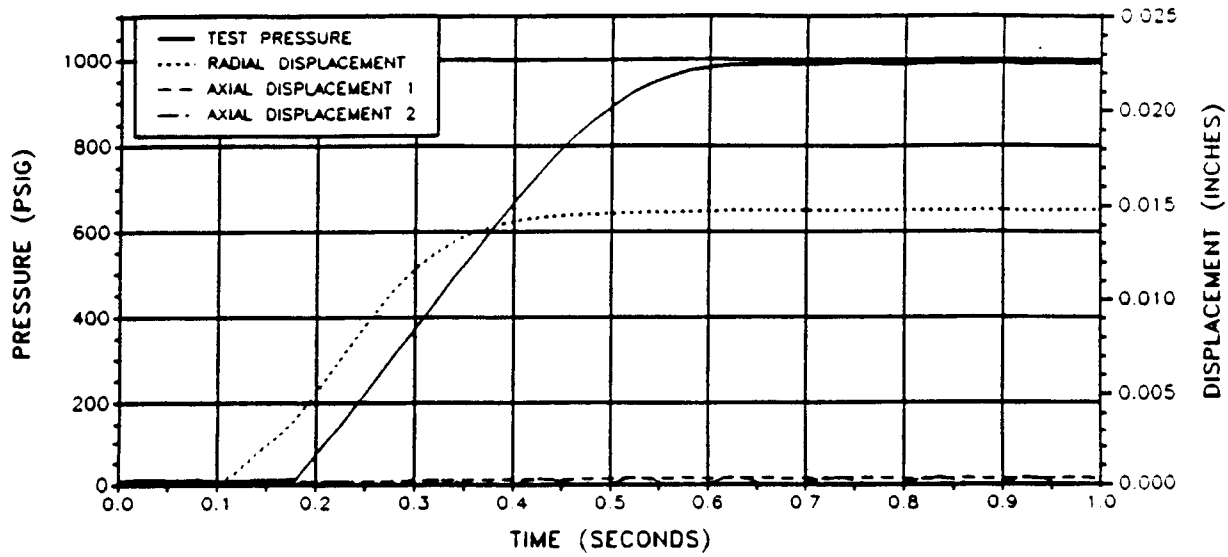
Known initial volume in system (calculated from Boyle's Law (V_i)): 2.3468 in^3
P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 14.72 psia
T_1 = 76.2 °F T_2 = 76.2 °F (at 60 seconds)
Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$
V_f = 2.0248 in^3
$\Delta V = V_i - V_f$
ΔV = 0.322 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

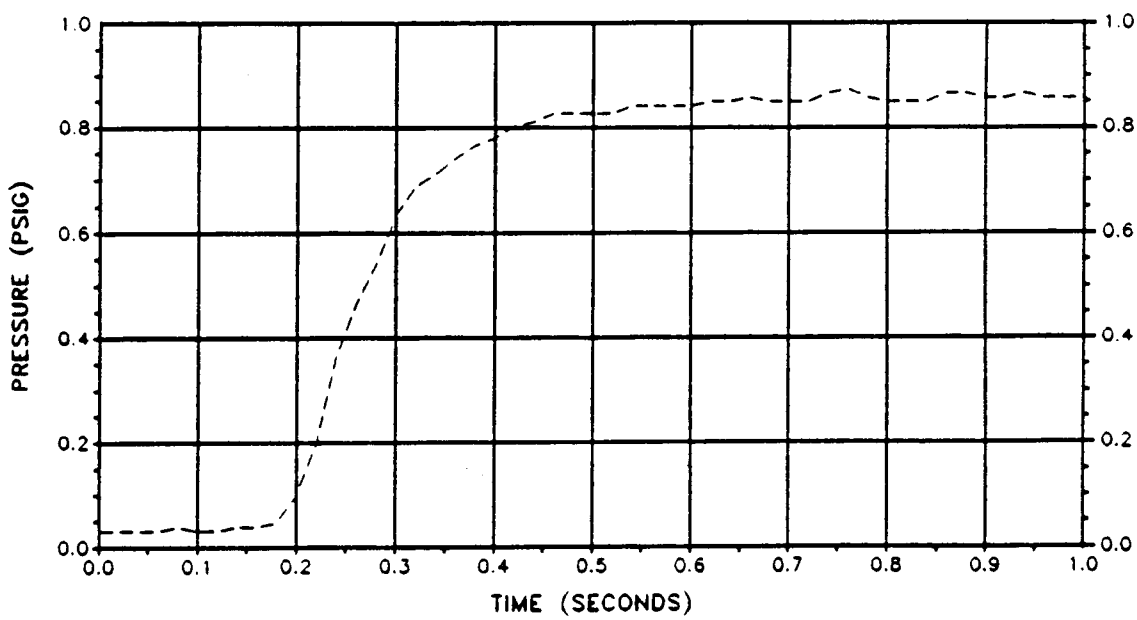
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #3 (Test Date 2/22/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

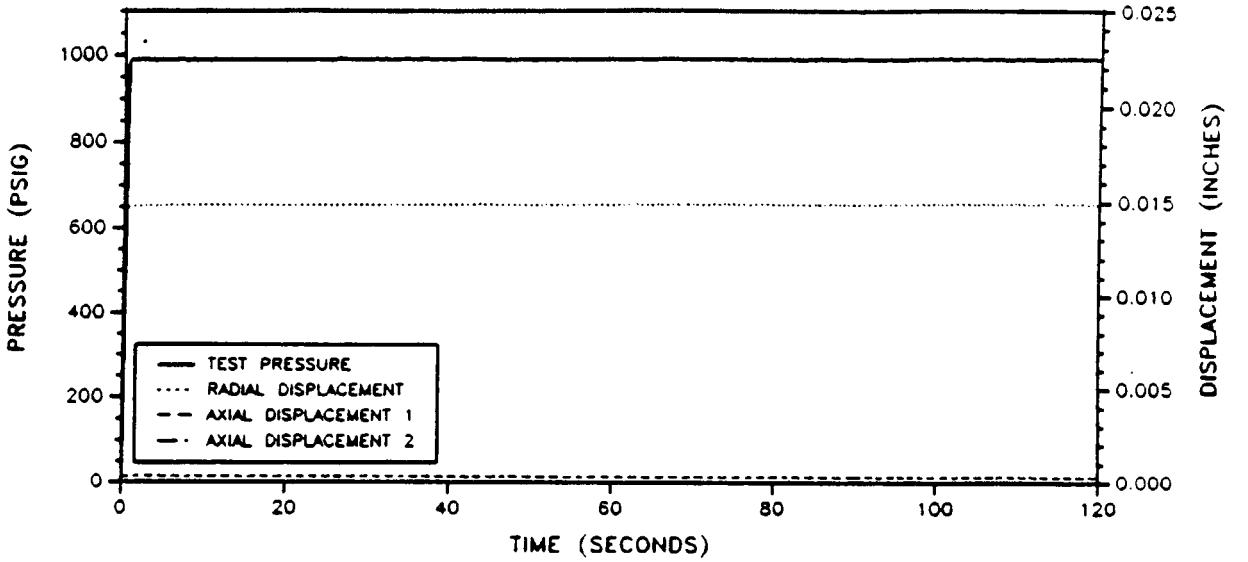


V-4 Cavity Pressure Vs. Time (1 Second Plot)

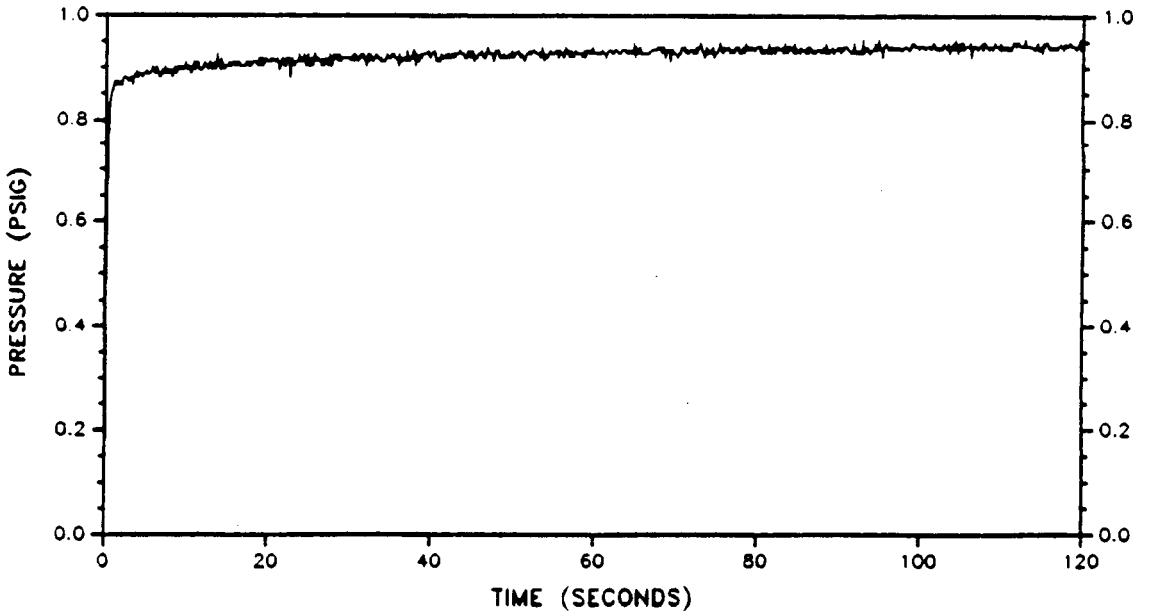


SCENARIO #1, TEST #3 (Test Date 2/22/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I

ASSEMBLY DATE: 2/21/89

TEST #: 3-A

TEST TECHNICIAN: M. Gardner

TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16

PISTON NO.: 63/63

PRIMARY O-RING		SECONDARY O-RING	
O-RING NO.:	#7	O-RING NO.:	#8
O-RING INNER DIAMETER (inch):	9.351	O-RING INNER DIAM (inch):	9.391
O-RING X-SECTION DIAM (inch):	0.2900	O-RING X-SECT DIAM (inch):	0.2906
O-RING SQUEEZE (%): (AVG.)	17.1	O-RING SQUEEZE: (AVG.)	19.7
ADJUSTED X-SECT (inch):	0.2847	ADJUSTED X-SECT (inch):	0.2859

O-RING CONDITIONING

CONDITIONING TEMP.: 110.3 °F

CONDITIONING START TIME: 3:30 PM 2/21/89

CONDITIONING STOP TIME: 7 AM 2/22/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 2/22/89 8:45 AM

CONDITIONING TEMP.: 76.3 °F

DATE & TIME OF TEST: 2/22/89, 10:30 AM

FIXTURE TEMEPERATURE AT END OF TEST: 75.9 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 13.56 psia

T_1 = 75.9 °F T_2 = 75.9 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.1980 in^3

$\Delta V = V_i - V_f$

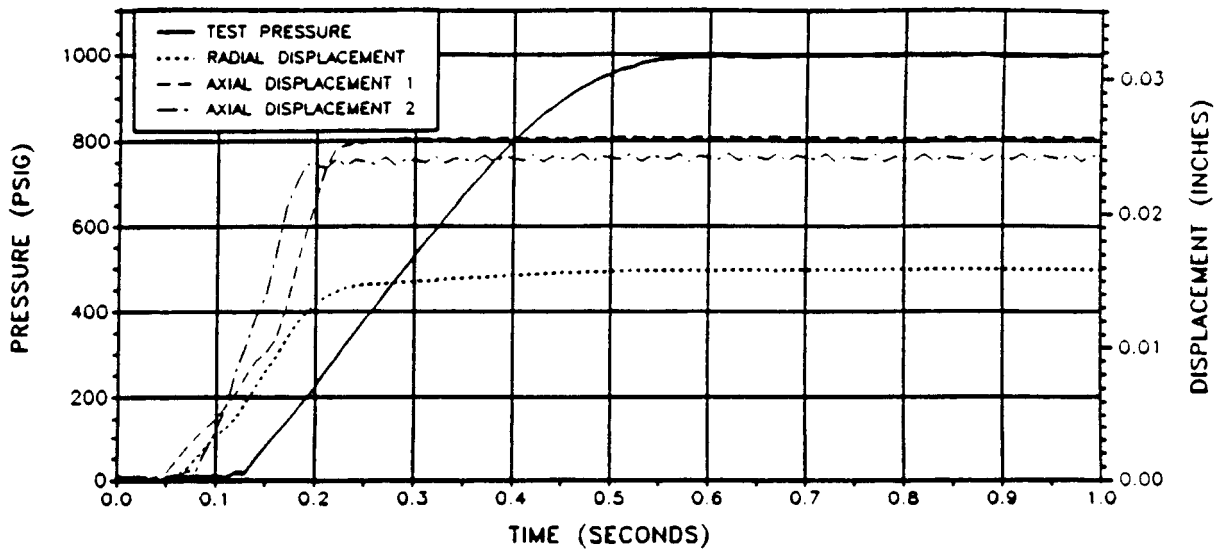
ΔV = 0.1488 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

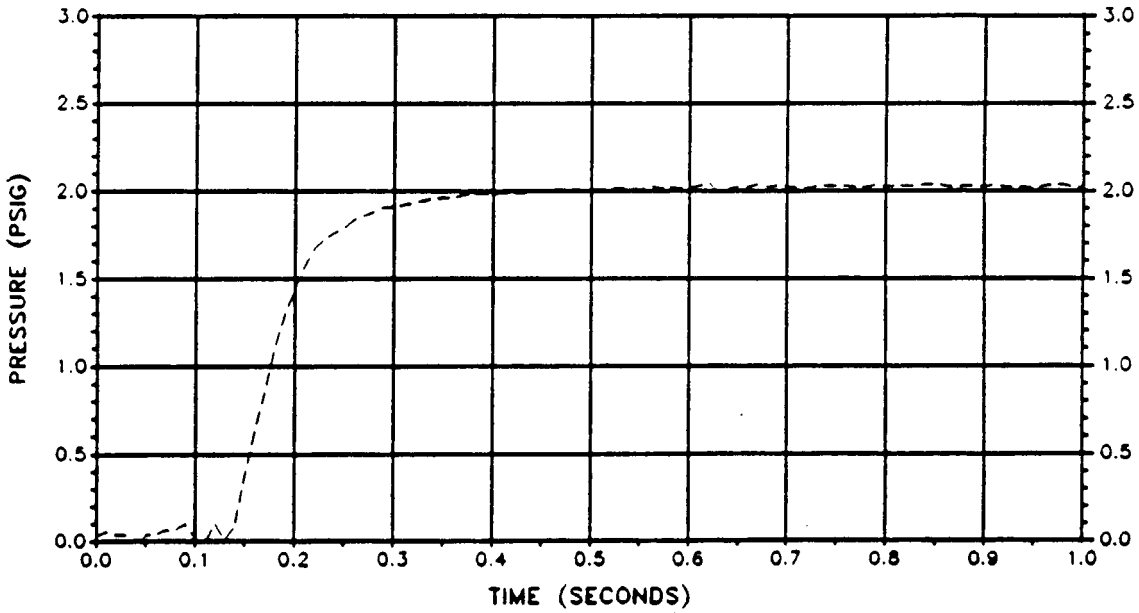
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #3A (Test Date 2/22/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

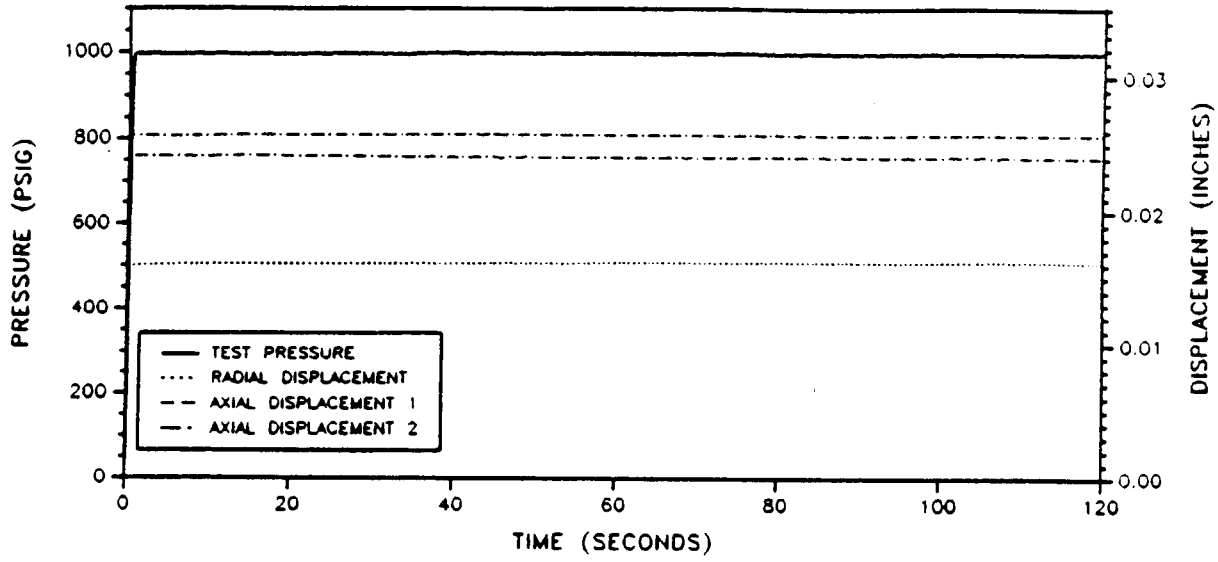


V-4 Cavity Pressure Vs. Time (1 Second Plot)

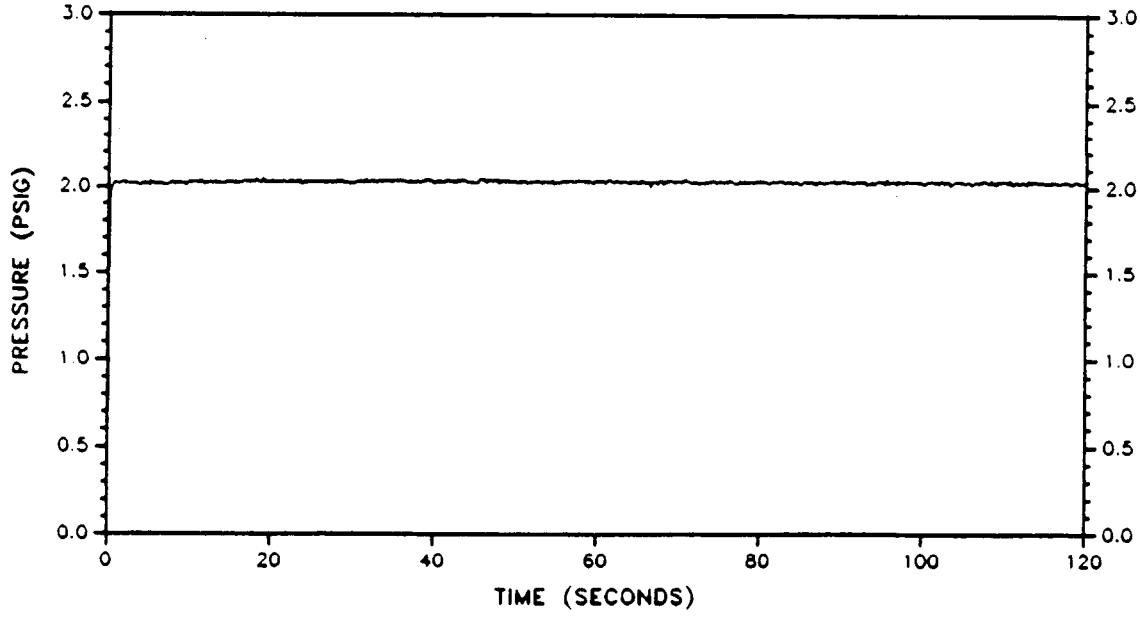


SCENARIO #1, TEST #3A (Test Date 2/22/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
ASSEMBLY DATE: 2/22/89

TEST #: 4
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16

PISTON NO.: 63/63

PRIMARY O-RING

O-RING NO.: #9
O-RING INNER DIAMETER (inch): 9.368
O-RING X-SECTION DIAM (inch): 0.2911
O-RING SQUEEZE (%): (AVG.) 17.5
ADJUSTED X-SECT (inch): 0.2862

SECONDARY O-RING

O-RING NO.: #10
O-RING INNER DIAM (inch): 9.374
O-RING X-SECT DIAM (inch): 0.2817
O-RING SQUEEZE: (AVG.) 19.4
ADJUSTED X-SECT (inch): 0.2846

O-RING CONDITIONING

CONDITIONING TEMP.: 113.2 °F
CONDITIONING START TIME: 1:15 PM 2/22/89 CONDITIONING STOP TIME: 7 AM 2/23/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 2/23/89, 8:50 AM
CONDITIONING TEMP.: 76.0 °F
DATE & TIME OF TEST: 2/23/89, 10:10 AM
FIXTURE TEMEPERATURE AT END OF TEST: 75.9 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 14.61 psia

T_1 = 75.9 °F T_2 = 75.9 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.0400 in^3

$\Delta V = V_i - V_f$

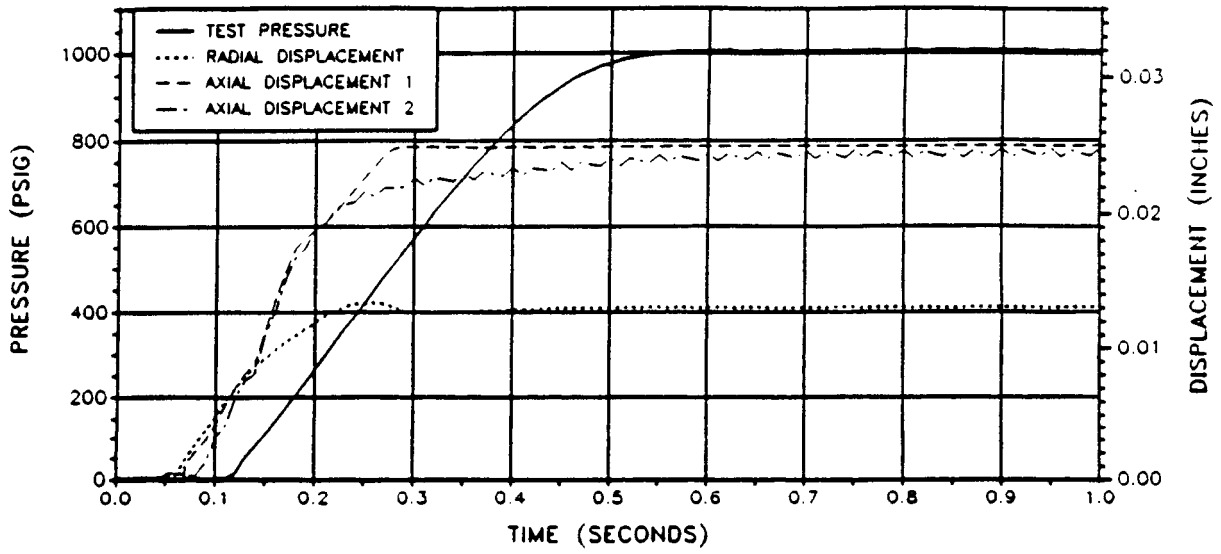
ΔV = 0.3068 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

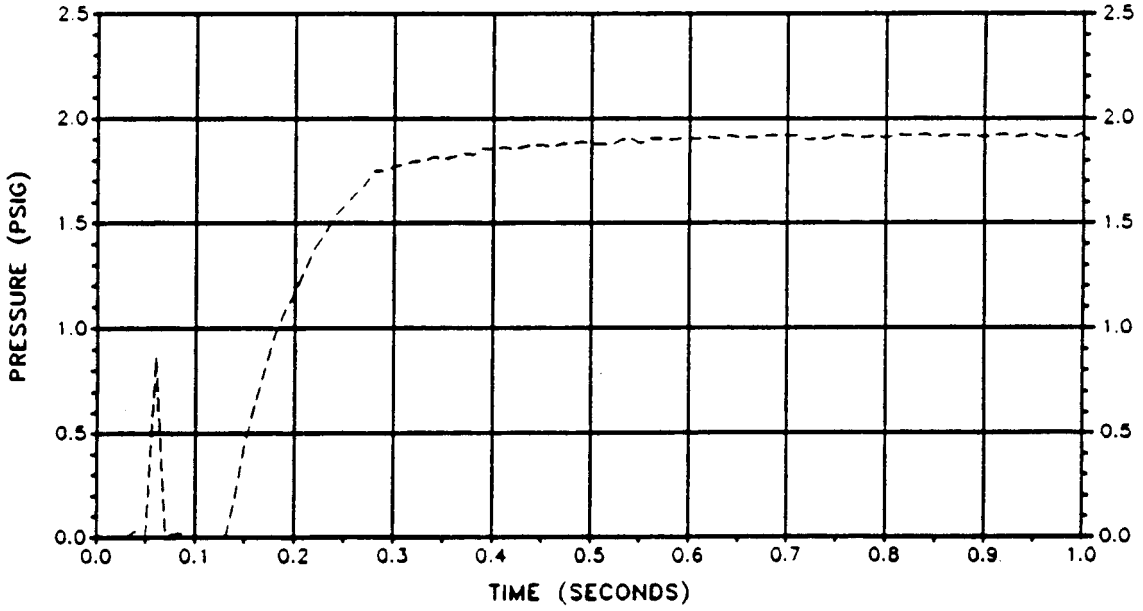
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #4 (Test Date 2/23/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

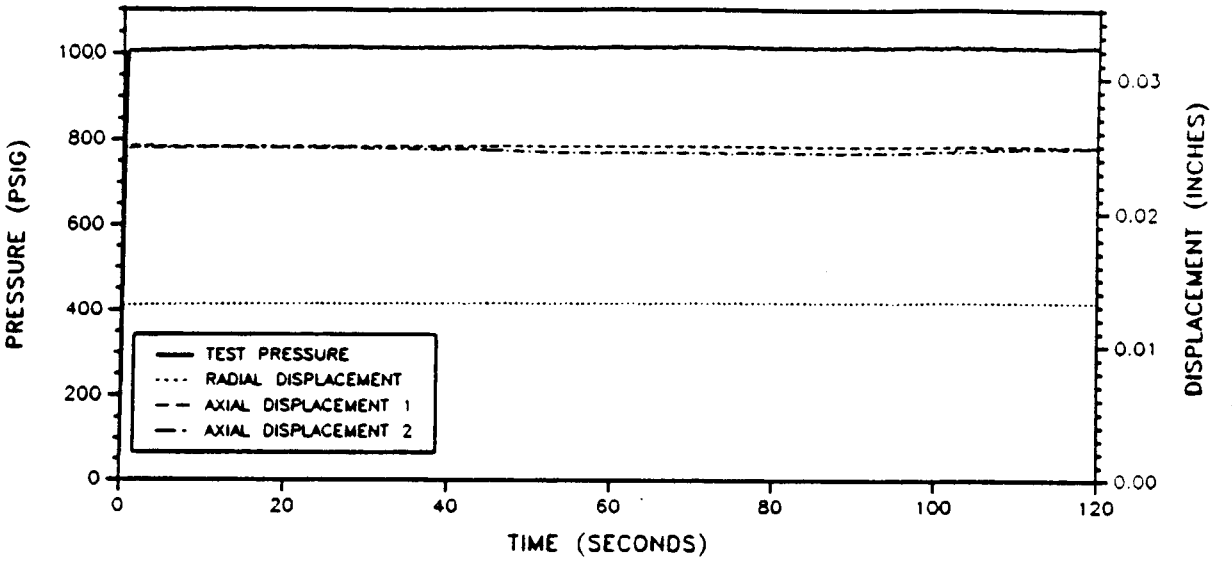


V-4 Cavity Pressure Vs. Time (1 Second Plot)

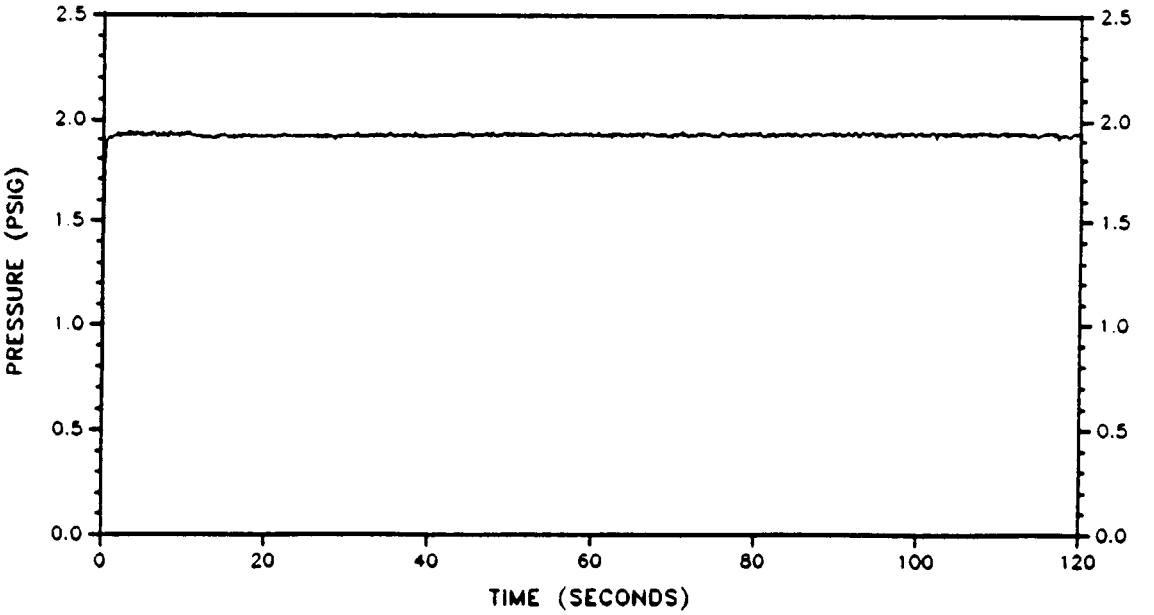


SCENARIO #1, TEST #4 (Test Date 2/23/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
ASSEMBLY DATE: 2/22/89

TEST #: 4-A
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16

PISTON NO.: 63/63

PRIMARY O-RING

O-RING NO.: #9
O-RING INNER DIAMETER (inch): 9.368
O-RING X-SECTION DIAM (inch): 0.2911
O-RING SQUEEZE (%): (AVG.) 17.5
ADJUSTED X-SECT (inch): 0.2862

SECONDARY O-RING

O-RING NO.: #10
O-RING INNER DIAM (inch): 9.374
O-RING X-SECT DIAM (inch): 0.2877
O-RING SQUEEZE: (AVG.) 19.4
ADJUSTED X-SECT (inch): 0.2846

O-RING CONDITIONING

CONDITIONING TEMP.: 113.2 °F
CONDITIONING START TIME: 1:15 PM 2/22/89
CONDITIONING STOP TIME: 7 AM 2/23/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 2/23/89, 8:50 AM
CONDITIONING TEMP.: 76.0 °F
DATE & TIME OF TEST: 2/23/89, 10:20 AM
FIXTURE TEMEPERATURE AT END OF TEST: 76.3 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 13.51 psia

T_1 = 76.3 °F T_2 = 76.3 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.2061 in^3

$\Delta V = V_i - V_f$

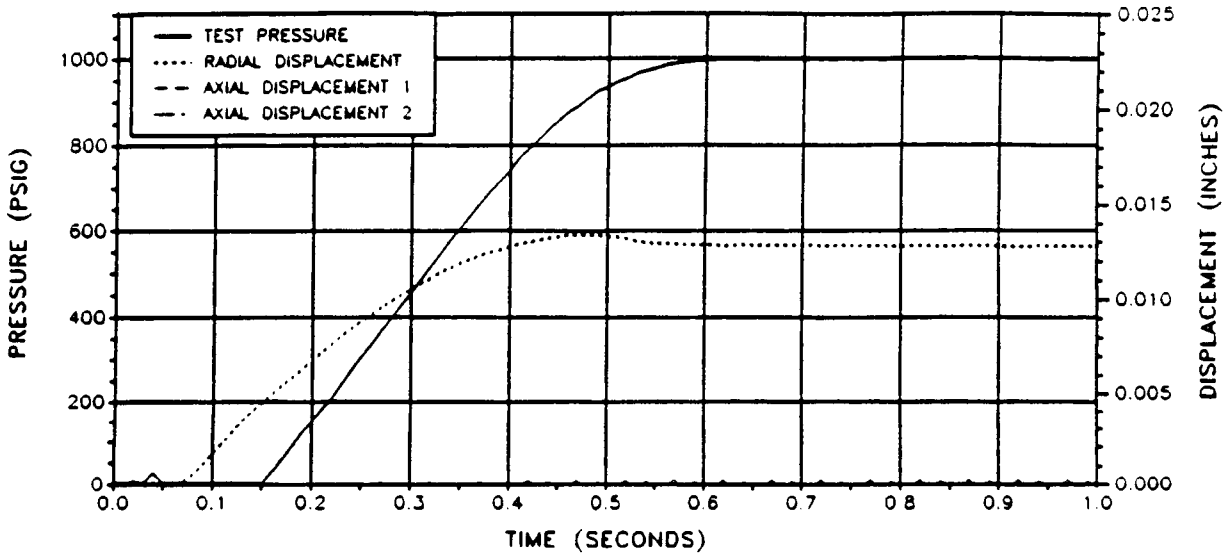
ΔV = 0.1407 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

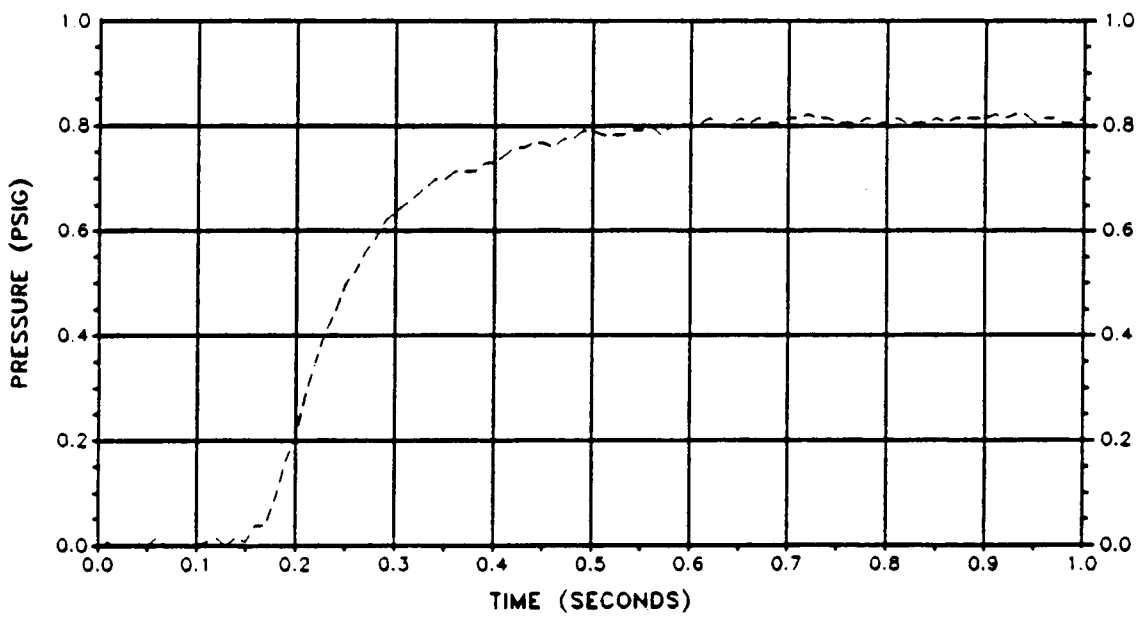
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #4A (Test Date 2/23/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

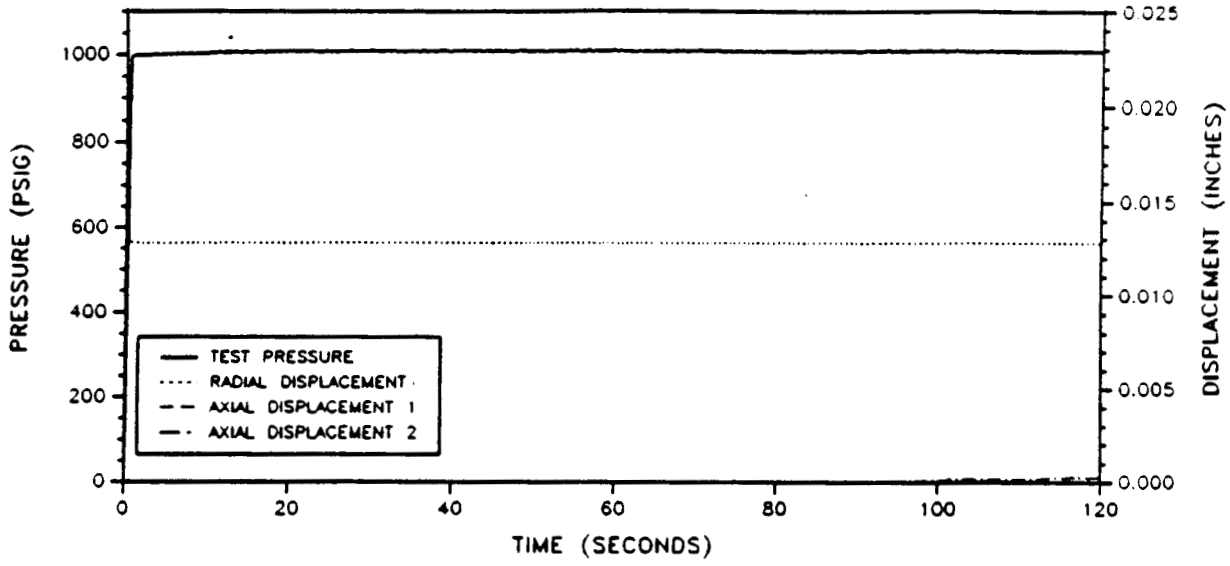


V-4 Cavity Pressure Vs. Time (1 Second Plot)

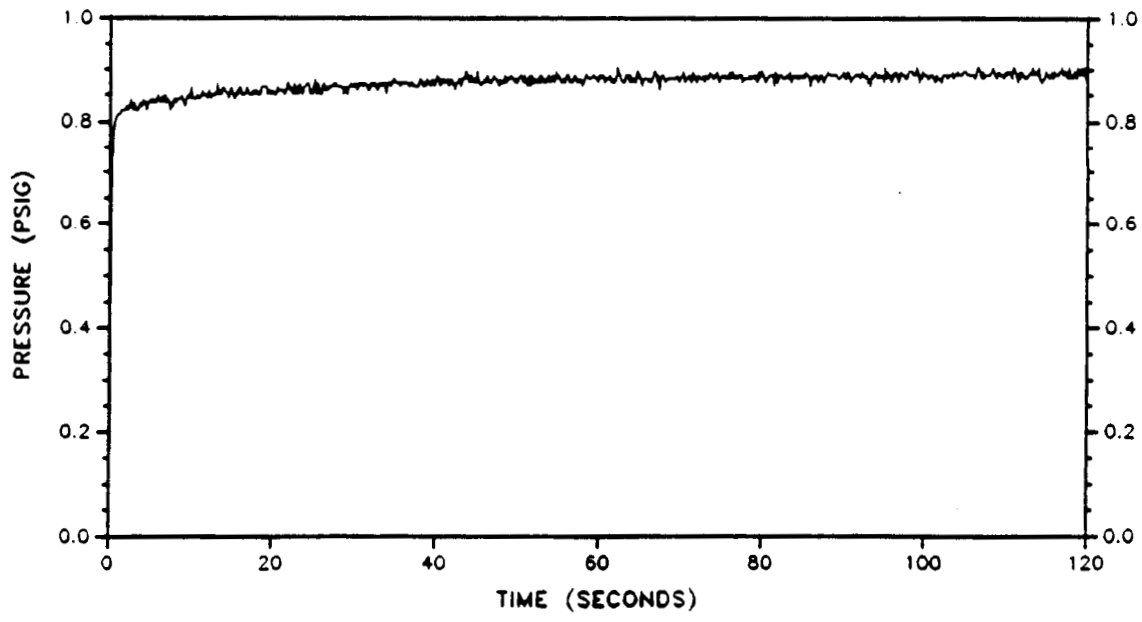


SCENARIO #1, TEST #4A (Test Date 2/23/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
ASSEMBLY DATE: 2/22/89

TEST #: 4-B
TEST TECHNICIAN: M. Gardiner
TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 13/[illegible]
PISTON NO.: 63/63

PRIMARY O-RING

O-RING NO.: #7
O-RING INNER DIAMETER (inch): 9.368
O-RING X-SECTION DIAM (inch): 0.2911
O-RING SQUEEZE (%): (AVG.) 17.5
ADJUSTED X-SECT (inch): 0.2862

SECONDARY O-RING

O-RING NO.: #10
O-RING INNER DIAM (inch): 9.374
O-RING X-SECT DIAM (inch): 0.2897
O-RING SQUEEZE: (AVG.) 17.4
ADJUSTED X-SECT (inch): 0.2816

O-RING CONDITIONING

CONDITIONING TEMP.: 113.2 °F
CONDITIONING START TIME: 1:15 PM 2/22/89
CONDITIONING STOP TIME: 7 AM, 2/23/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 2/23/89, 8:50 AM
CONDITIONING TEMP.: 76.0 °F
DATE & TIME OF TEST: 2/23/89, 9:50 AM
FIXTURE TEMEPERATURE AT END OF TEST: 76.3 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 13.47 psia

T_1 = 76.3 °F T_2 = 76.3 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.2094 in^3

$\Delta V = V_i - V_f$

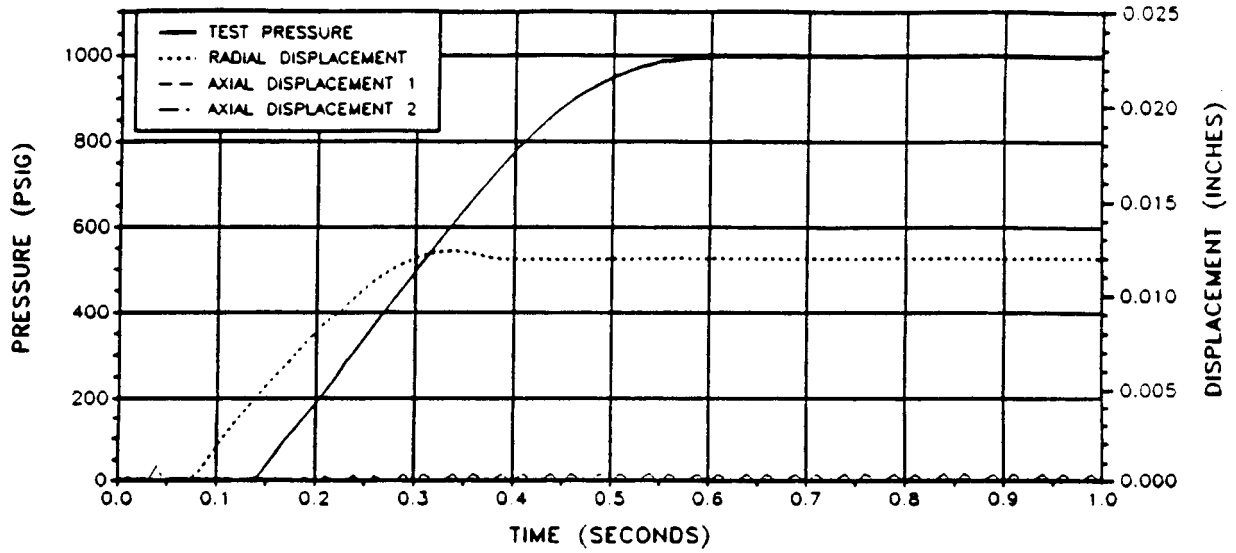
ΔV = 0.1374 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

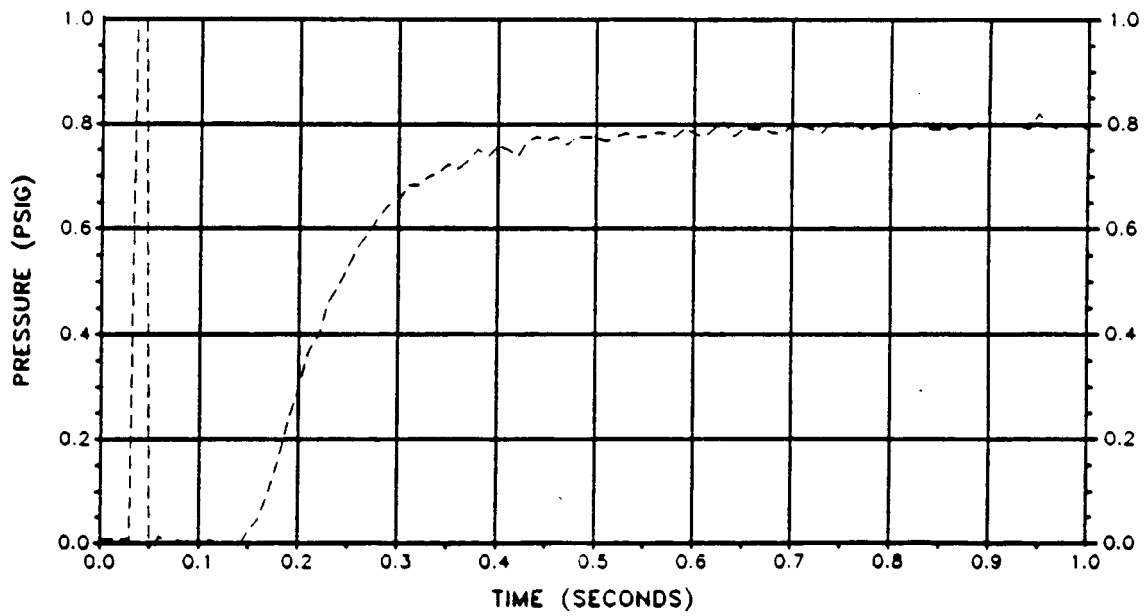
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #4B (Test Date 2/23/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

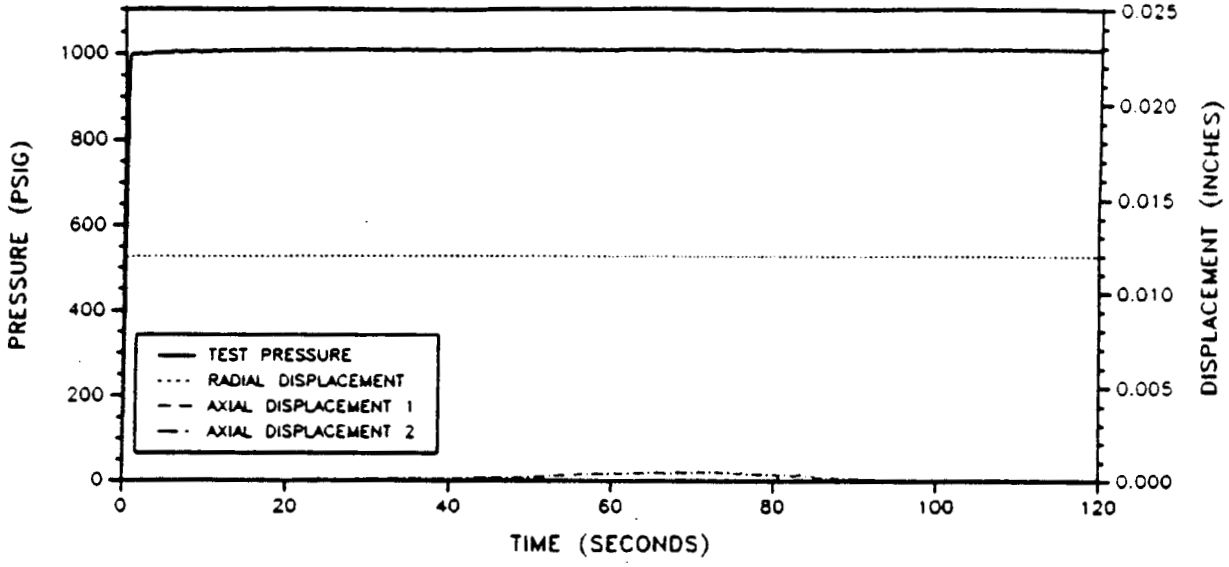


V-4 Cavity Pressure Vs. Time (1 Second Plot)

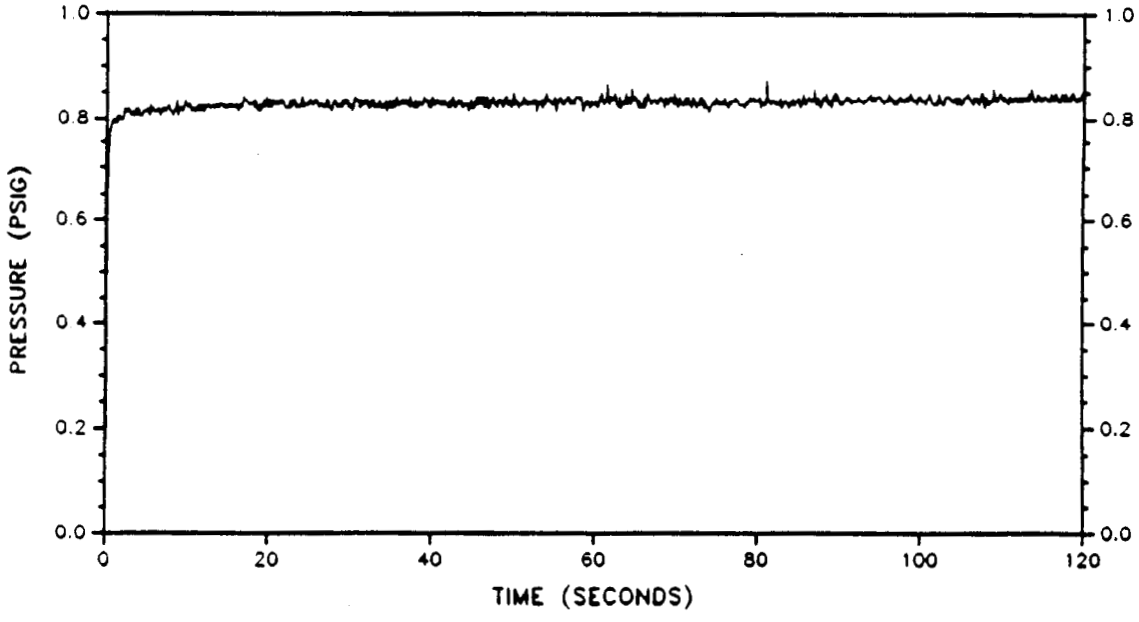


SCENARIO #1, TEST #4B (Test Date 2/23/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
TEST #: 4-C
ASSEMBLY DATE: 2/22/89
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Ferrigno

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/63

PRIMARY O-RING

O-RING NO.: #9
O-RING INNER DIAMETER (inch): 9.368
O-RING X-SECTION DIAM (inch): 0.2911
O-RING SQUEEZE (%): (AVG.) 17.5
ADJUSTED X-SECT (inch): 0.2862

SECONDARY O-RING

O-RING NO.: #10
O-RING INNER DIAM (inch): 9.374
O-RING X-SECT DIAM (inch): 0.2877
O-RING SQUEEZE: (AVG.) 17.4
ADJUSTED X-SECT (inch): 0.2846

O-RING CONDITIONING

CONDITIONING TEMP.: 113.2 °F
CONDITIONING START TIME: 1:15 PM 2/22/89
CONDITIONING STOP TIME: 7 AM 2/23/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 2/23/89, 8:50 AM
CONDITIONING TEMP.: 76.0 °F
DATE & TIME OF TEST: 2/23/89, 10:15 AM
FIXTURE TEMEPERATURE AT END OF TEST: 76.5 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 14.57 psia

T_1 = 76.5 °F T_2 = 76.5 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.0456 in^3

$\Delta V = V_i - V_f$

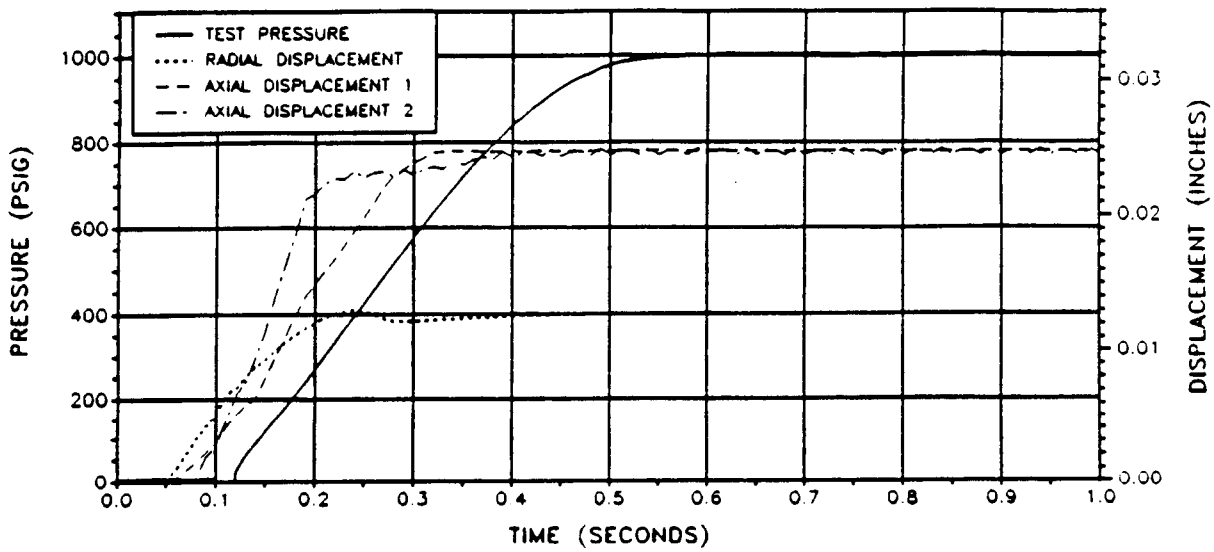
ΔV = 0.3012 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

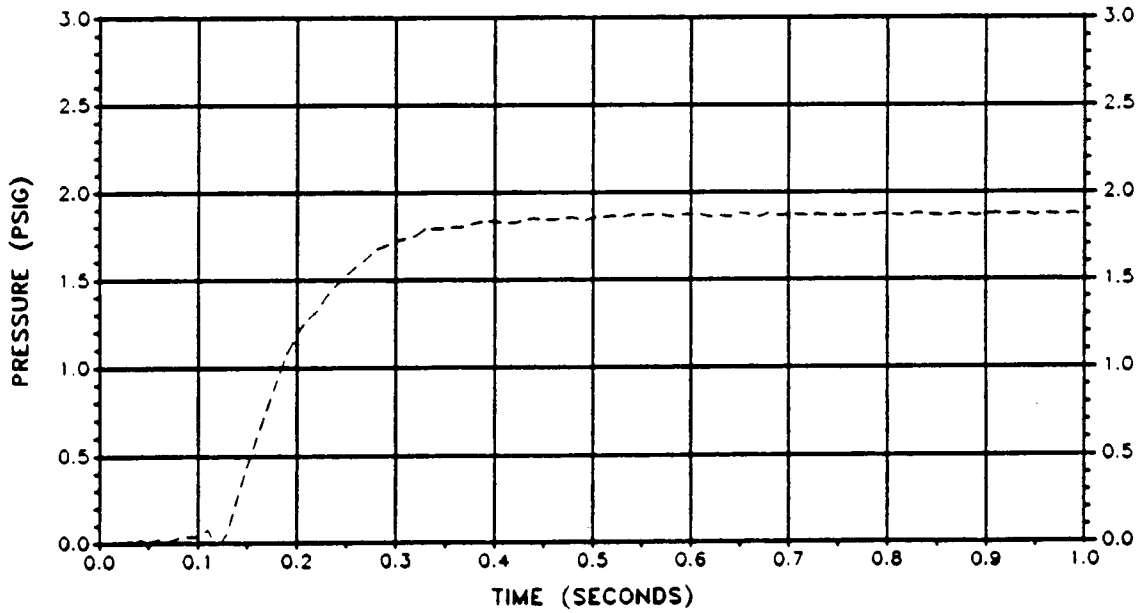
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #4C (Test Date 2/23/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

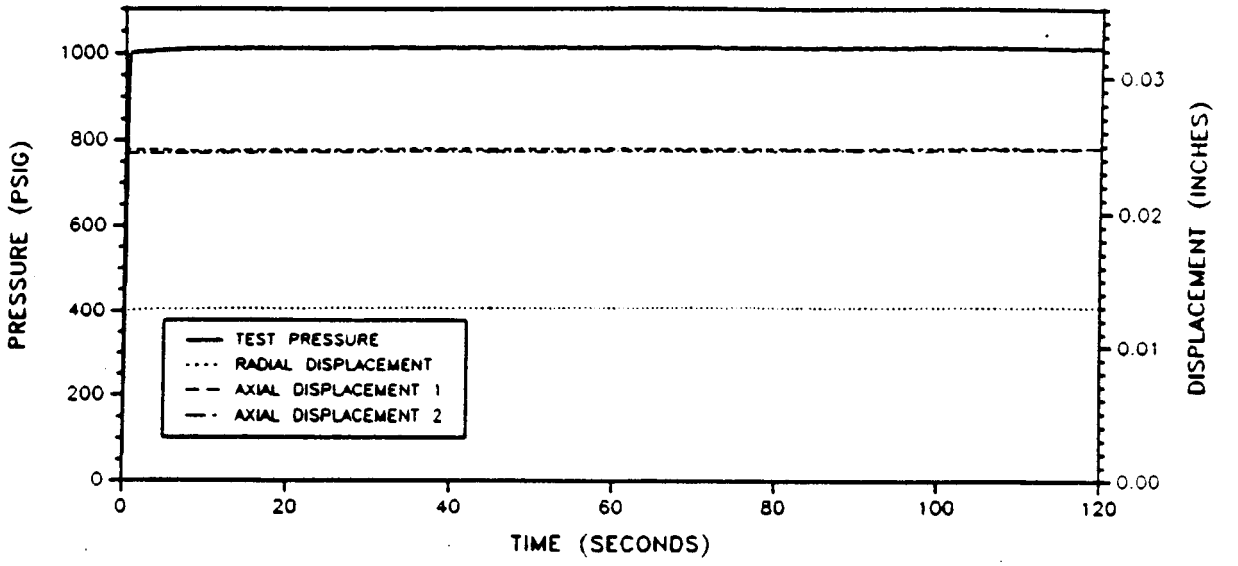


V-4 Cavity Pressure Vs. Time (1 Second Plot)

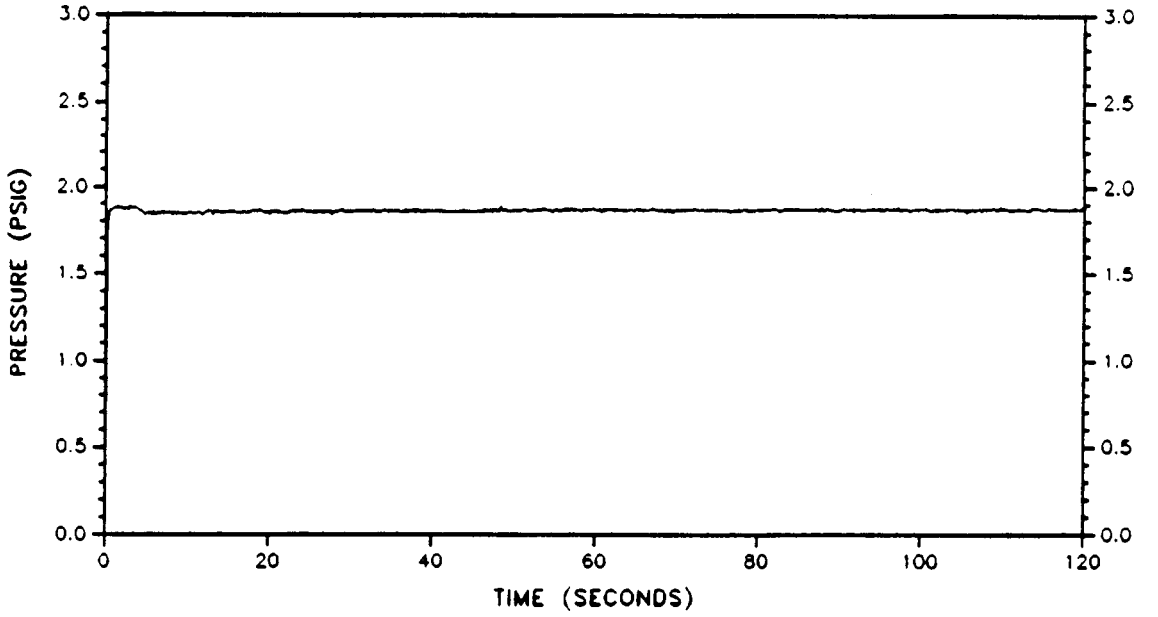


SCENARIO #1, TEST #4C (Test Date 2/23/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
ASSEMBLY DATE: 2/23/89

TEST #: 5
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/62

PRIMARY O-RING		SECONDARY O-RING	
O-RING NO.:	#11	O-RING NO.:	#12
O-RING INNER DIAMETER (inch):	9.352	O-RING INNER DIAM (inch):	9.351
O-RING X-SECTION DIAM (inch):	0.2902	O-RING X-SECT DIAM (inch):	0.2901
O-RING SQUEEZE (%): (AVG.)	17.2	O-RING SQUEEZE: (AVG.)	17.4
ADJUSTED X-SECT (inch):	0.2849	ADJUSTED X-SECT (inch):	0.2846

O-RING CONDITIONING

CONDITIONING TEMP.: 112.2 °F
CONDITIONING START TIME: NOON 2/23/89
CONDITIONING STOP TIME: 7 AM 2/24/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 2/24/89, 9:00 AM
CONDITIONING TEMP.: 76.0 °F
DATE & TIME OF TEST: 2/24/81,
FIXTURE TEMEPERATURE AT END OF TEST: 76.5 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 14.60 psia

T_1 = 76.4 °F T_2 = 76.5 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.0441 in^3

$\Delta V = V_i - V_f$

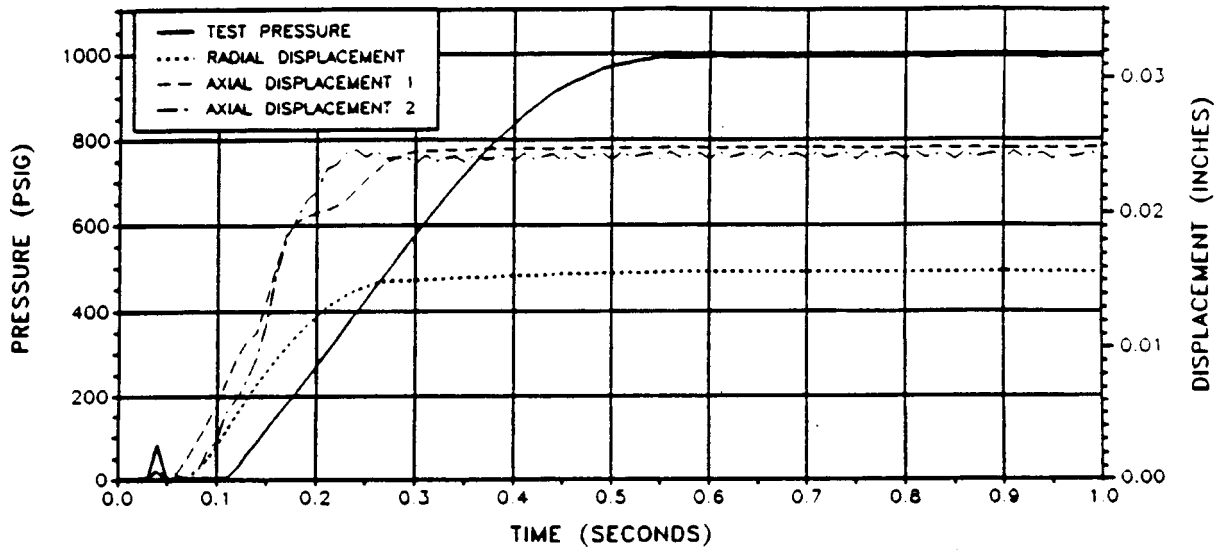
ΔV = 0.3027 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

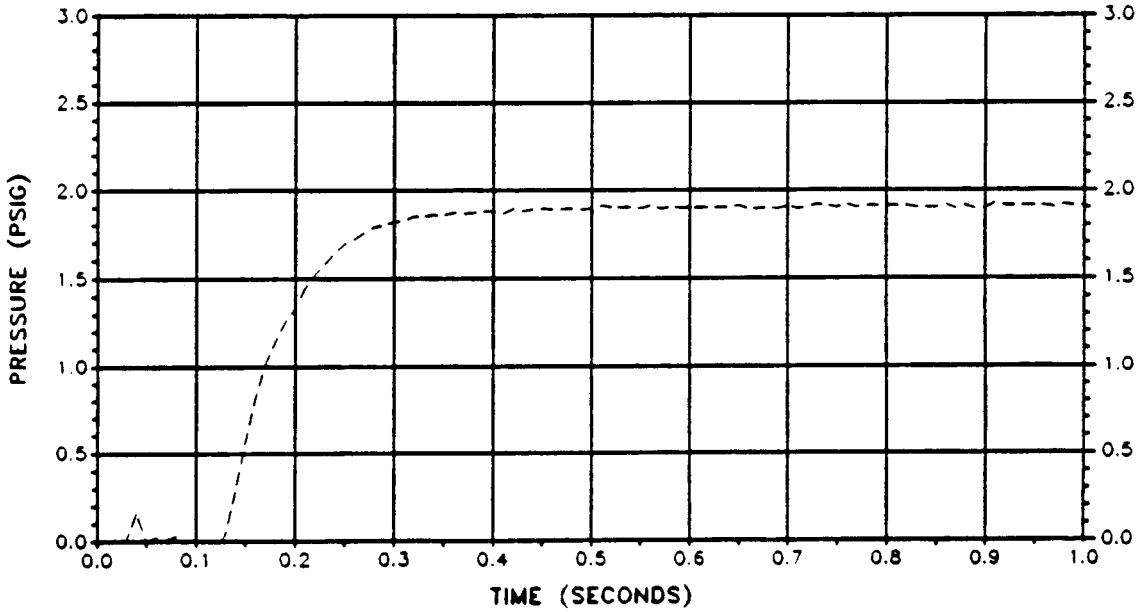
COMMENTS ON DISSASSEMBLED CONDITION: Leaked due to string under primary O-ring. Initial 1-second test is still valid. (NOTE: Constant Pressure will cause leakage.)

SCENARIO #1, TEST #5 (Test Date 2/24/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

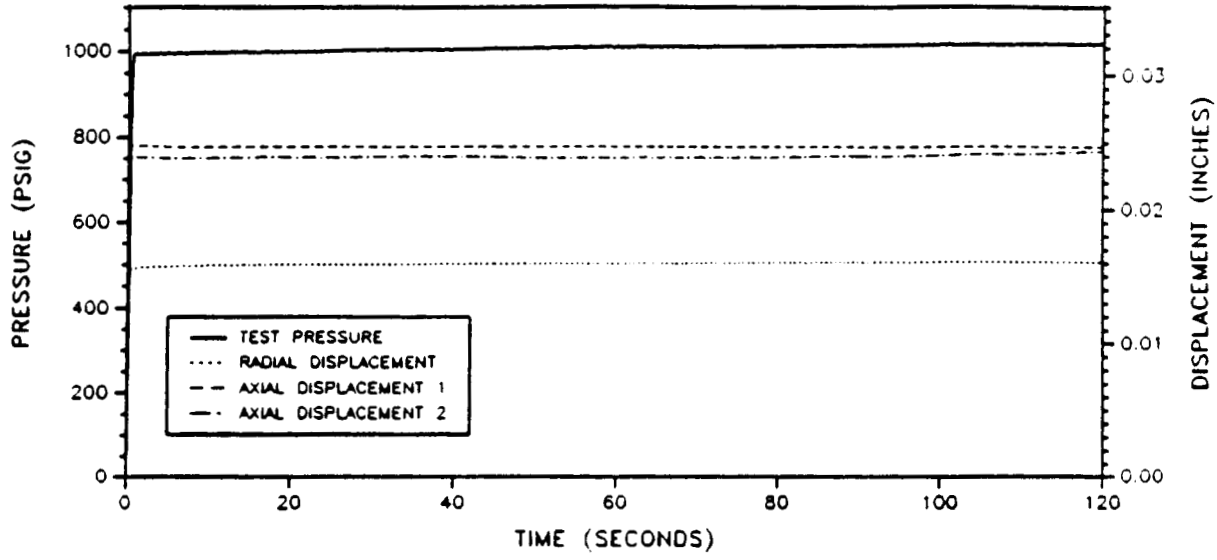


V-4 Cavity Pressure Vs. Time (1 Second Plot)

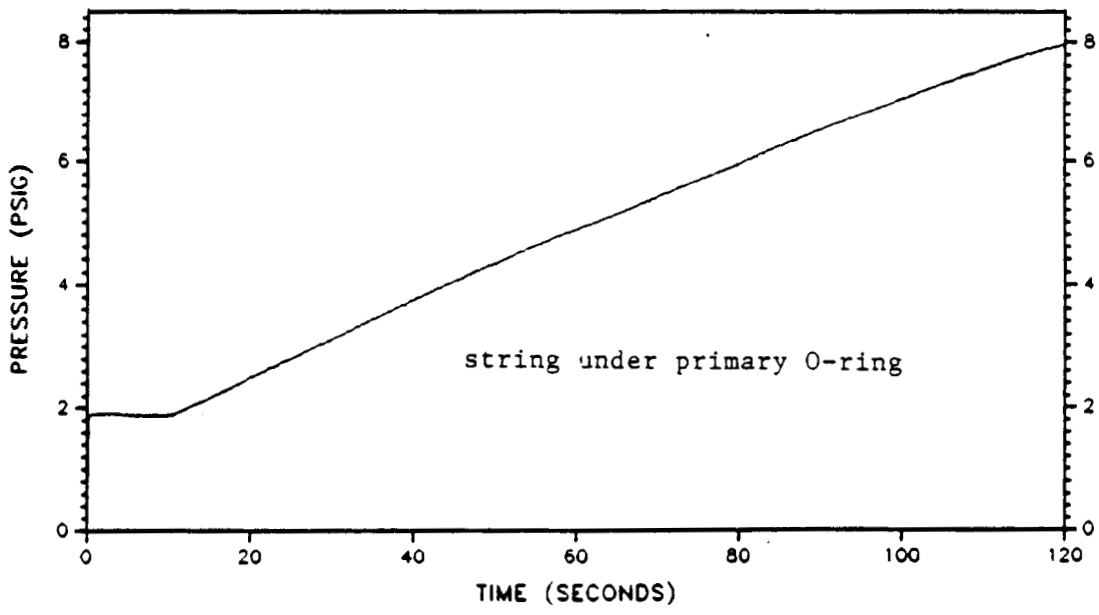


SCENARIO #1, TEST #5 (Test Date 2/24/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
TEST #: 6
ASSEMBLY DATE: 2/27/89
TEST TECHNICIAN: M Gordon
TEST SUPERVISOR: T. [illegible]

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/63

PRIMARY O-RING		SECONDARY O-RING	
O-RING NO.:	#13	O-RING NO.:	#1
O-RING INNER DIAMETER (inch):	9.383	O-RING INNER DIAM (inch):	9.351
O-RING X-SECTION DIAM (inch):	0.2902	O-RING X-SECT DIAM (inch):	0.29[illegible]
O-RING SQUEEZE (%): (AVG.)	17.4	O-RING SQUEEZE: (AVG.)	19.6
ADJUSTED X-SECT (inch):	0.2856	ADJUSTED X-SECT (inch):	0.2855

O-RING CONDITIONING

CONDITIONING TEMP.: 108.8 °F

CONDITIONING START TIME: 10:30 AM 2/27/89
CONDITIONING STOP TIME: 7 AM

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 2/28/89, 9 AM

CONDITIONING TEMP.: 75.0 °F

DATE & TIME OF TEST: 2/28/89, 10:15 AM

FIXTURE TEMEPERATURE AT END OF TEST: 76.4 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 14.9 psia

T_1 = 76.4 °F T_2 = 76.4 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.0003 in^3

$\Delta V = V_i - V_f$

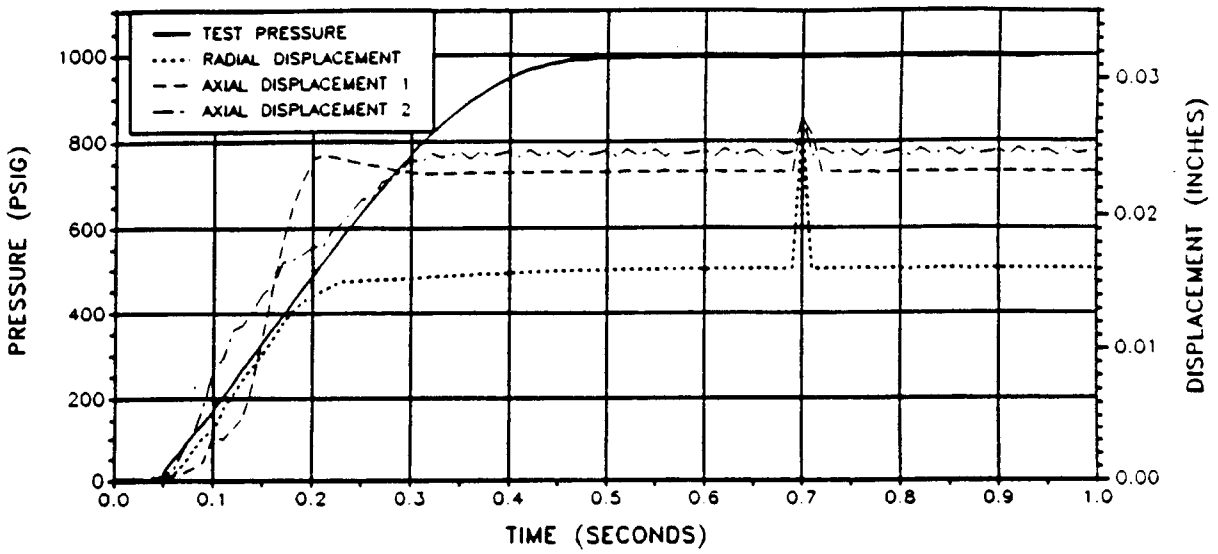
ΔV = 0.3465 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

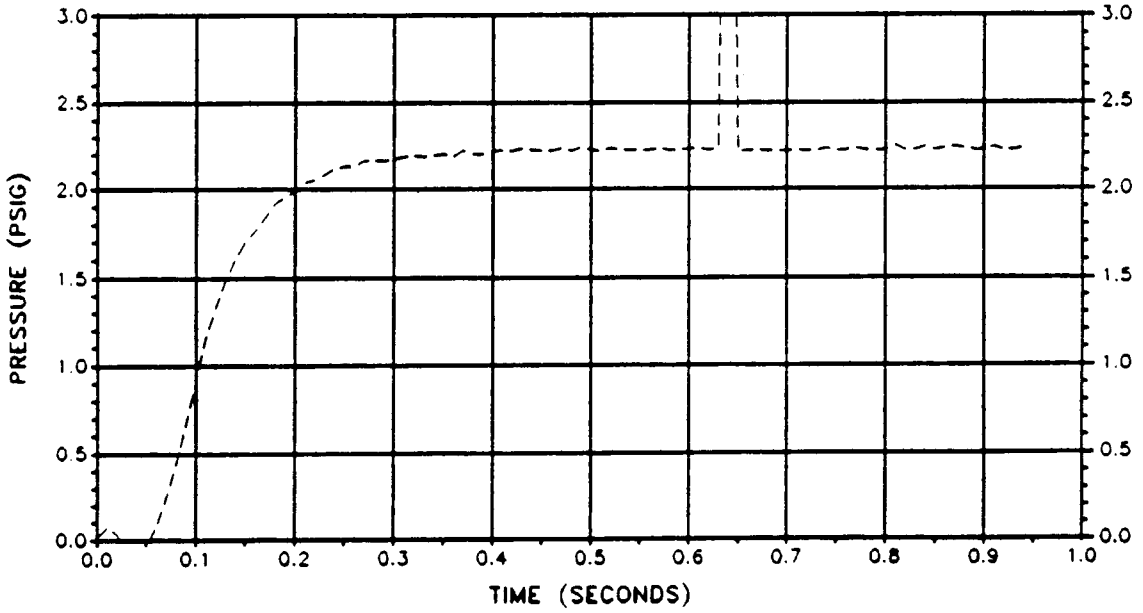
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #6 (Test Date 2/28/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

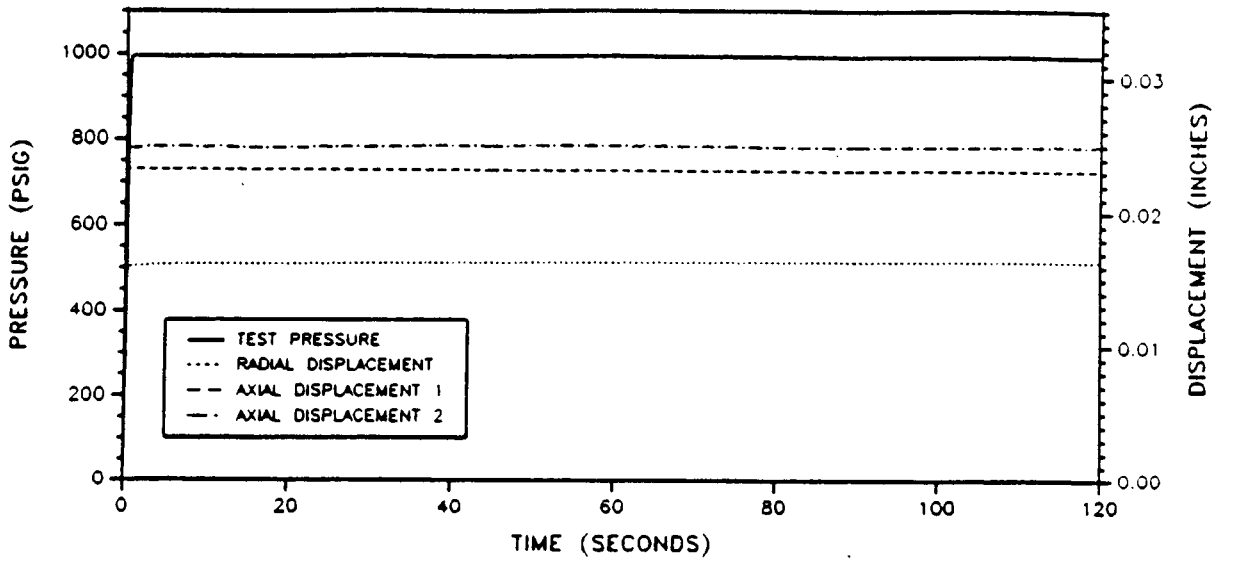


V-4 Cavity Pressure Vs. Time (1 Second Plot)

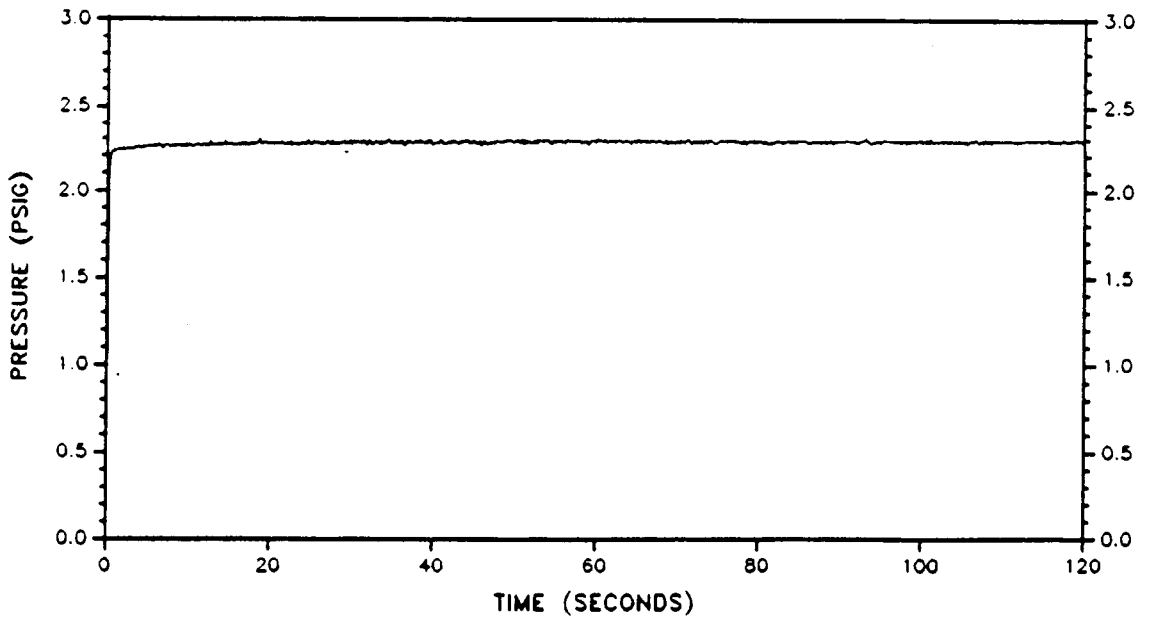


SCENARIO #1, TEST #6 (Test Date 2/28/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
TEST #: 6-A
ASSEMBLY DATE: 2/27/89
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/63

PRIMARY O-RING		SECONDARY O-RING	
O-RING NO.:	#13	O-RING NO.:	#4
O-RING INNER DIAMETER (inch):	9.383	O-RING INNER DIAM (inch):	9.351
O-RING X-SECTION DIAM (inch):	0.2902	O-RING X-SECT DIAM (inch):	0.2910
O-RING SQUEEZE (%): (AVG.)	17.4	O-RING SQUEEZE: (AVG.)	17.6
ADJUSTED X-SECT (inch):	0.2856	ADJUSTED X-SECT (inch):	0.2855

O-RING CONDITIONING

CONDITIONING TEMP.: 108.8 °F
CONDITIONING START TIME: 10:30 AM 2/27/89
CONDITIONING STOP TIME: 7 AM

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 2/28/89, 9 AM
CONDITIONING TEMP.: 75.0 °F
DATE & TIME OF TEST: 2/28/89, 10:45 AM
FIXTURE TEMEPERATURE AT END OF TEST: 75.5 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 13.67 psia

T_1 = 75.5 °F T_2 = 75.5 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.1803 in^3

$\Delta V = V_i - V_f$

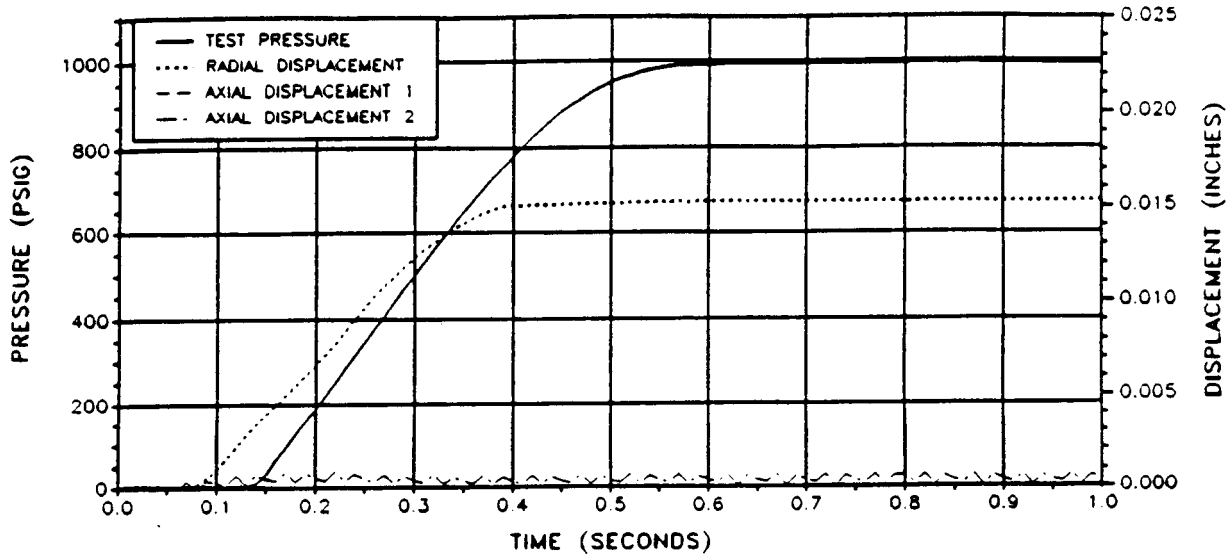
ΔV = 0.1665 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

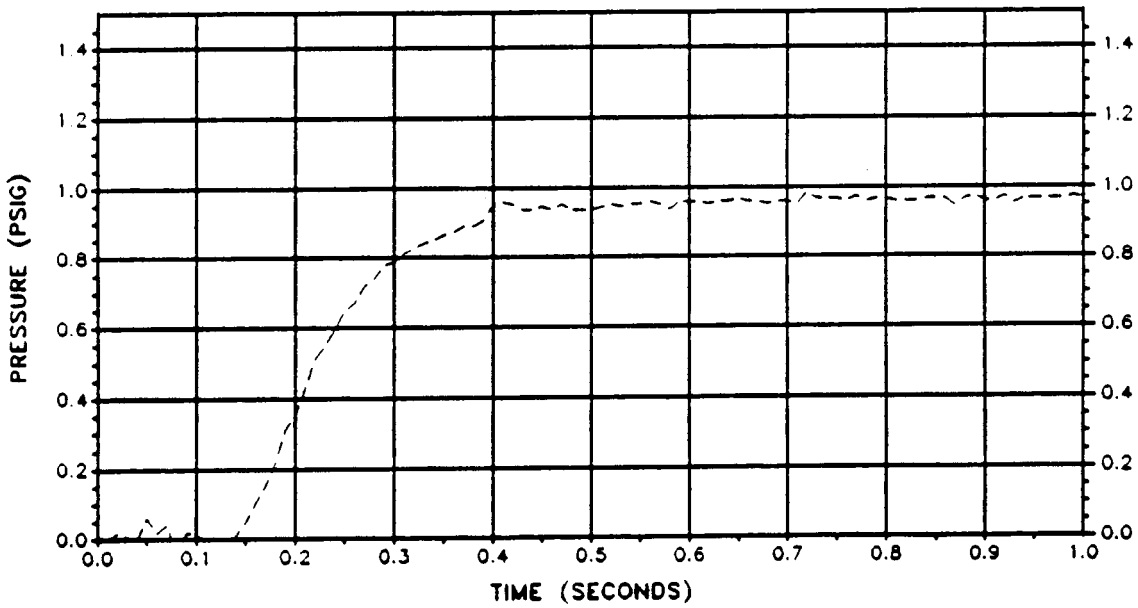
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #6A (Test Date 2/28/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

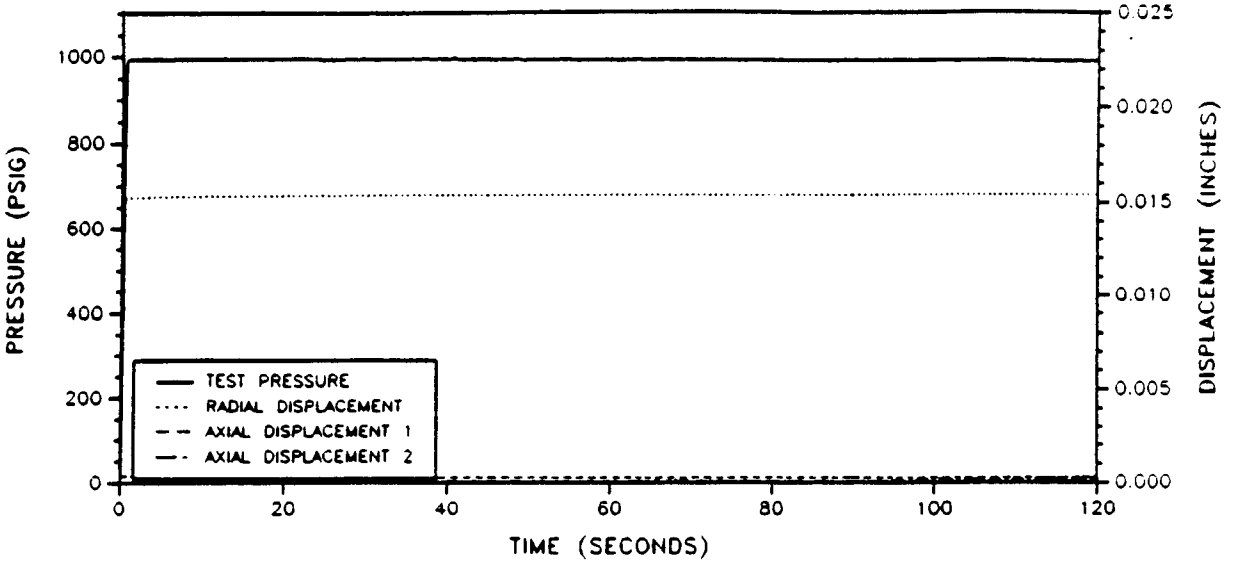


V-4 Cavity Pressure Vs. Time (1 Second Plot)

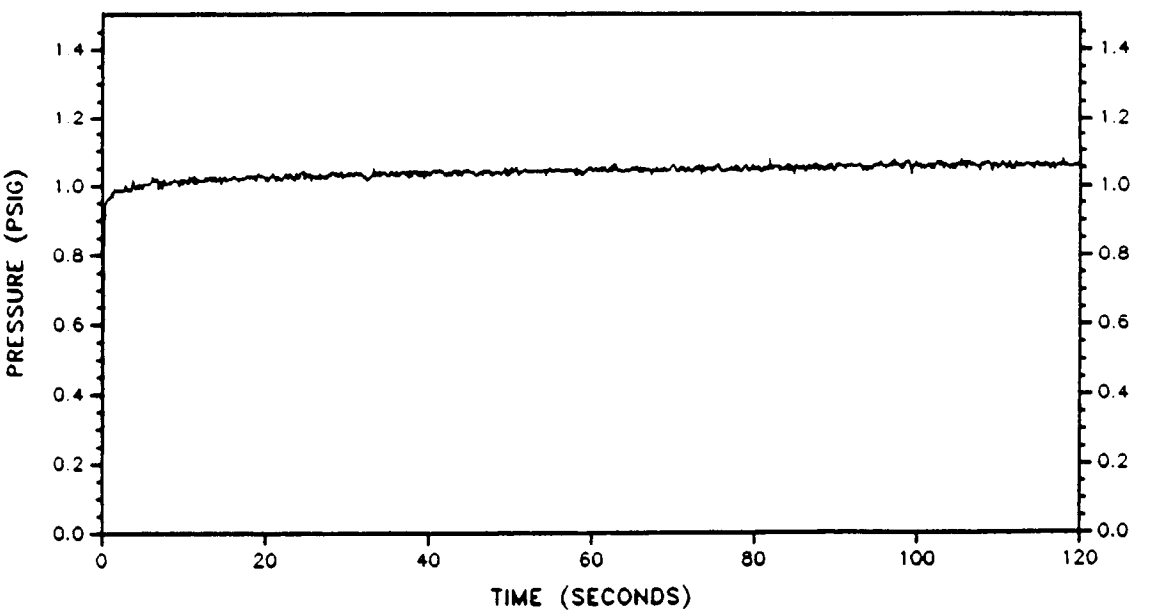


SCENARIO #1, TEST #6A (Test Date 2/28/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
TEST #: 6-B
ASSEMBLY DATE: 2/27/89
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/63

PRIMARY O-RING		SECONDARY O-RING	
O-RING NO.:	#13	O-RING NO.:	#14
O-RING INNER DIAMETER (inch):	9.383	O-RING INNER DIAM (inch):	9.351
O-RING X-SECTION DIAM (inch):	0.2902	O-RING X-SECT DIAM (inch):	0.2910
O-RING SQUEEZE (%): (AVG.)	17.4	O-RING SQUEEZE: (AVG.)	17.6
ADJUSTED X-SECT (inch):	0.2856	ADJUSTED X-SECT (inch):	0.2855

O-RING CONDITIONING

CONDITIONING TEMP.: 108.8 °F

CONDITIONING START TIME: 10:30 AM 2/27/89
CONDITIONING STOP TIME: 7 AM

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 2/28/89, 9 AM

CONDITIONING TEMP.: 75.0 °F

DATE & TIME OF TEST: 2/28/89, 10:30 AM

FIXTURE TEMEPERATURE AT END OF TEST: 75.1 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 13.65 psia

T_1 = 75.1 °F T_2 = 75.1 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.1835 in^3

$\Delta V = V_i - V_f$

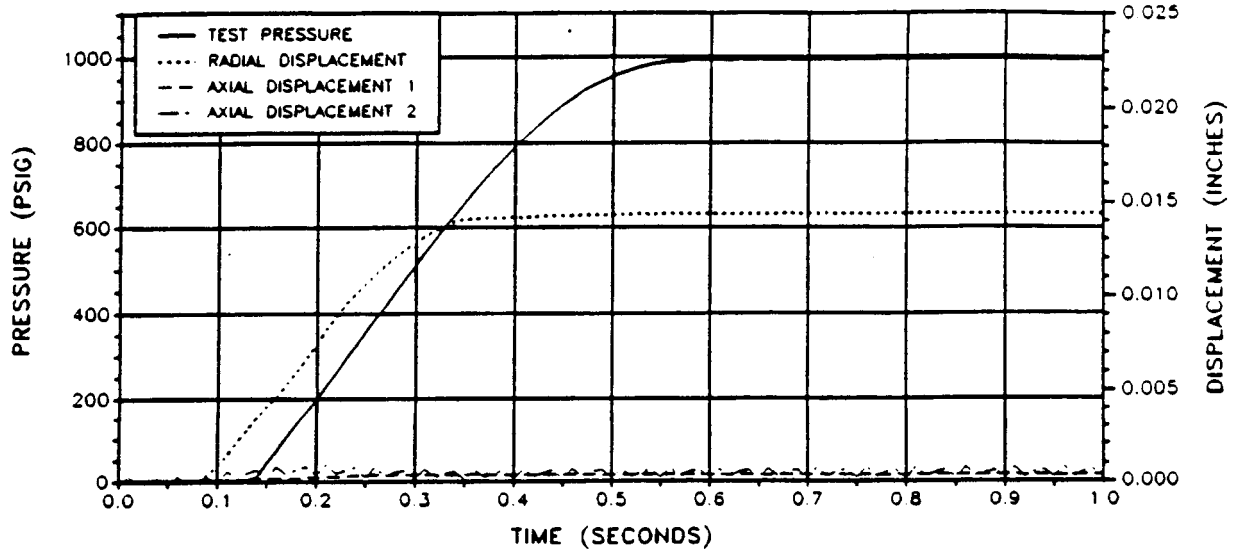
ΔV = 0.1633 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

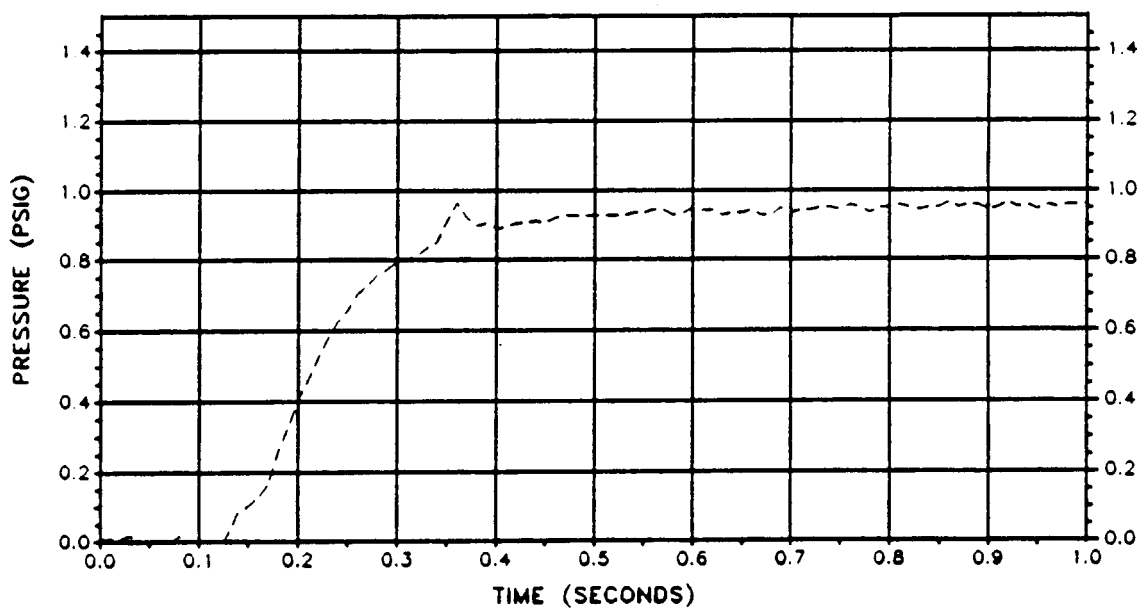
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #6B (Test Date 2/28/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

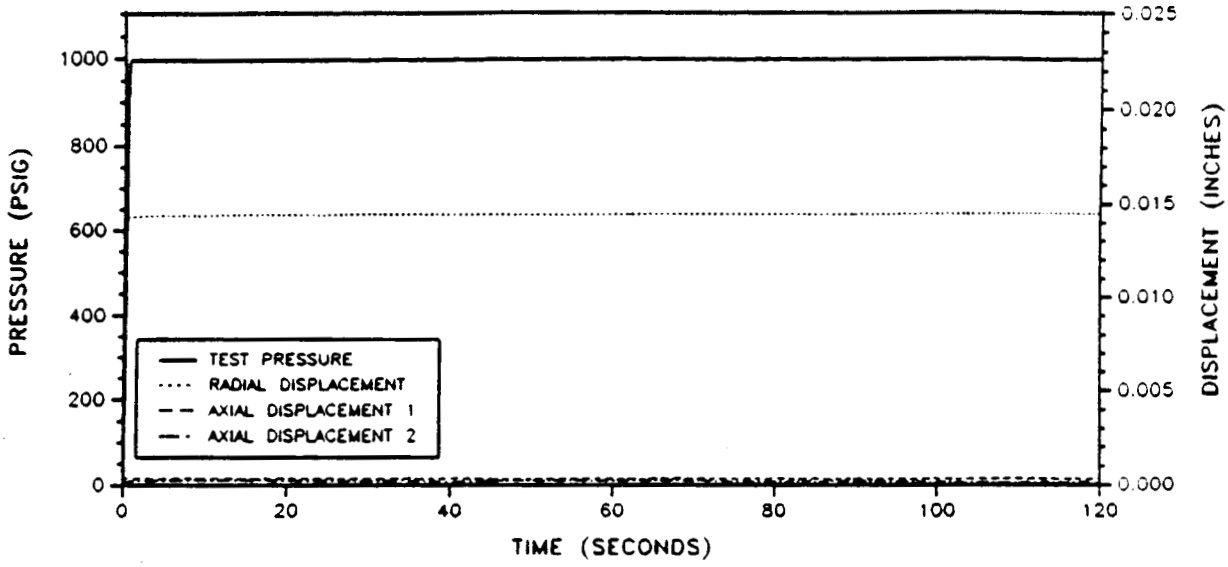


V-4 Cavity Pressure Vs. Time (1 Second Plot)

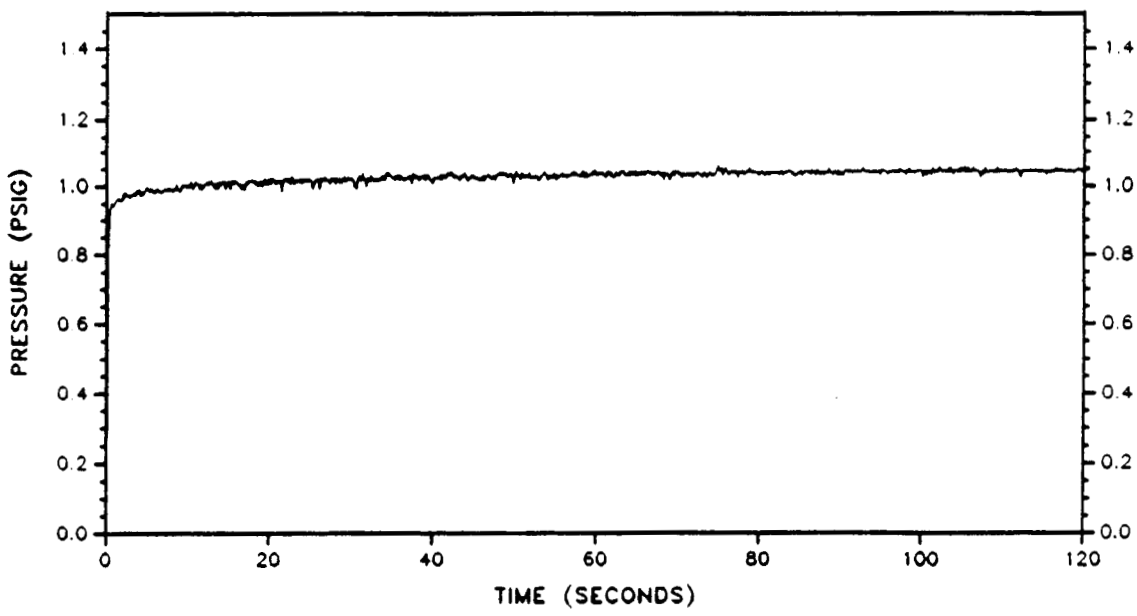


SCENARIO #1, TEST #6B (Test Date 2/28/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
TEST #: 6-C
ASSEMBLY DATE: 2/27/89
TEST TECHNICIAN: M [illegible]
TEST SUPERVISOR: T. [illegible]

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/63

PRIMARY O-RING

O-RING NO.: #13
O-RING INNER DIAMETER (inch): 9.383
O-RING X-SECTION DIAM (inch): 0.2902
O-RING SQUEEZE (%): (AVG.) 17.4
ADJUSTED X-SECT (inch): 0.2956

SECONDARY O-RING

O-RING NO.: #14
O-RING INNER DIAM (inch): 9.251
O-RING X-SECT DIAM (inch): 0.2910
O-RING SQUEEZE: (AVG.) 19.6
ADJUSTED X-SECT (inch): 0.2855

O-RING CONDITIONING

CONDITIONING TEMP.: 108.8 °F
CONDITIONING START TIME: 10:30 AM 2/27/89
CONDITIONING STOP TIME: 7 AM

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 2/28/89, 9 AM
CONDITIONING TEMP.: 75.0 °F
DATE & TIME OF TEST: 2/28/89, 10:30AM
FIXTURE TEMEPERATURE AT END OF TEST: 76.8 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 14.89 psia

T_1 = 76.7 °F T_2 = 76.7 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.0016 in^3

$\Delta V = V_i - V_f$

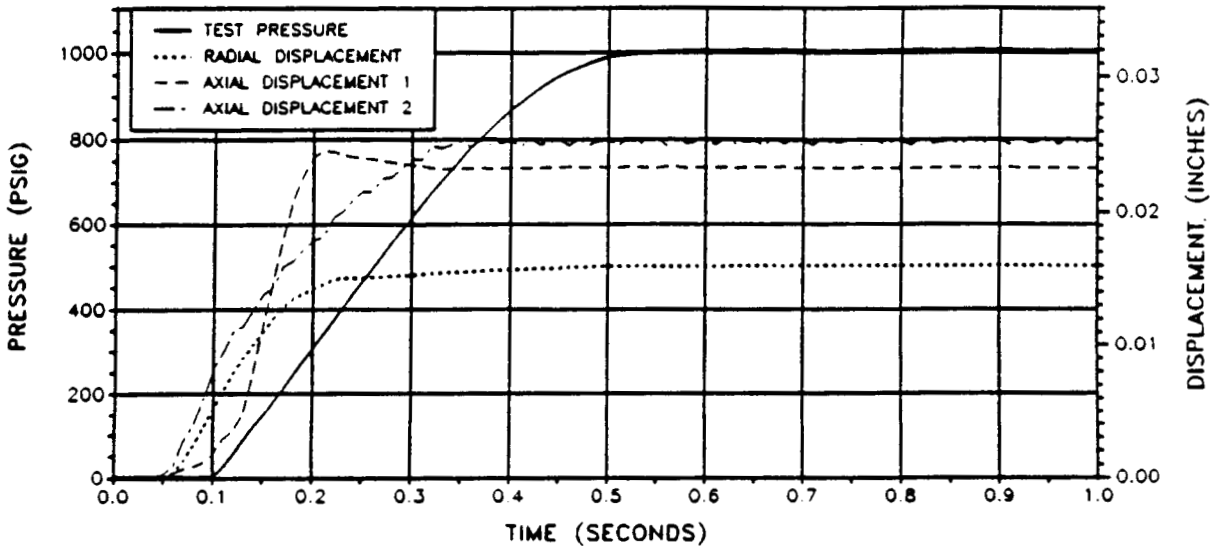
ΔV = 0.3452 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

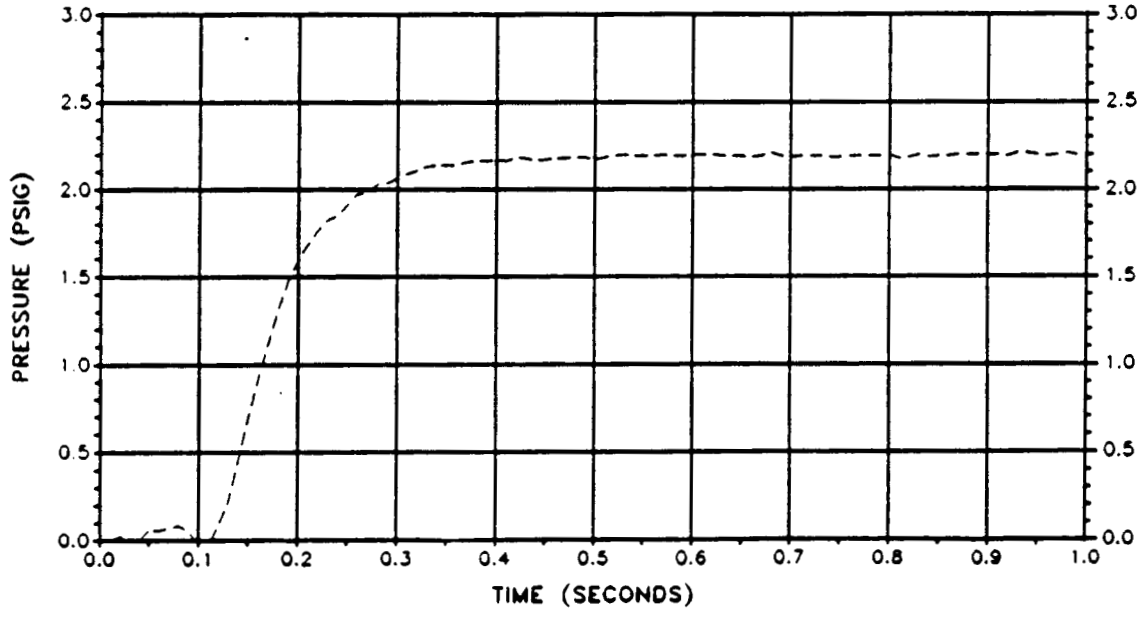
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #6C (Test Date 2/28/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

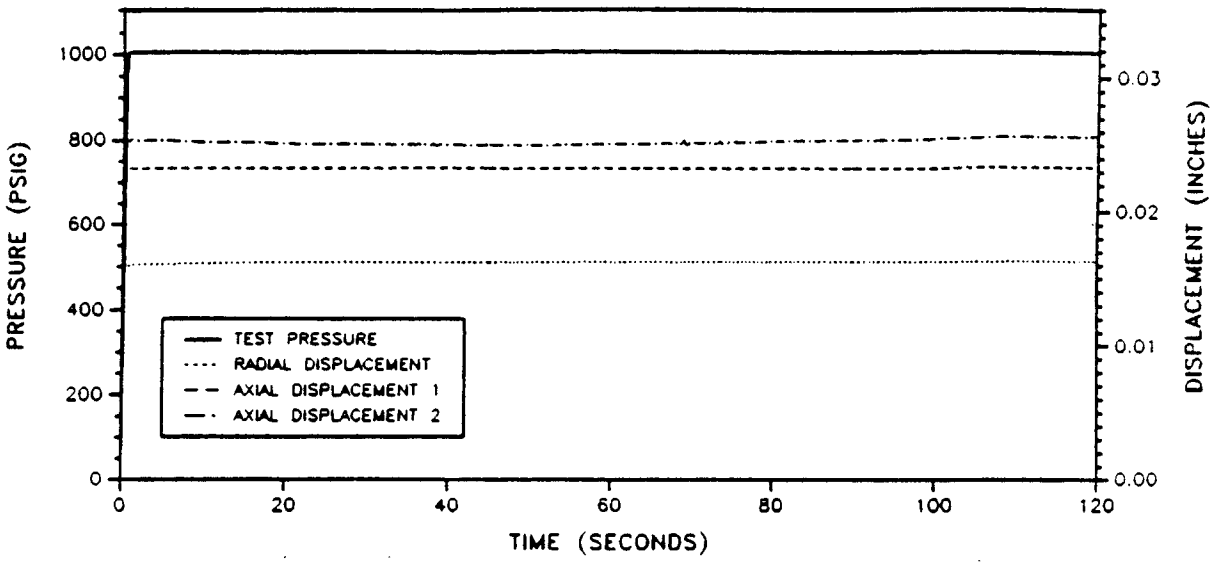


V-4 Cavity Pressure Vs. Time (1 Second Plot)

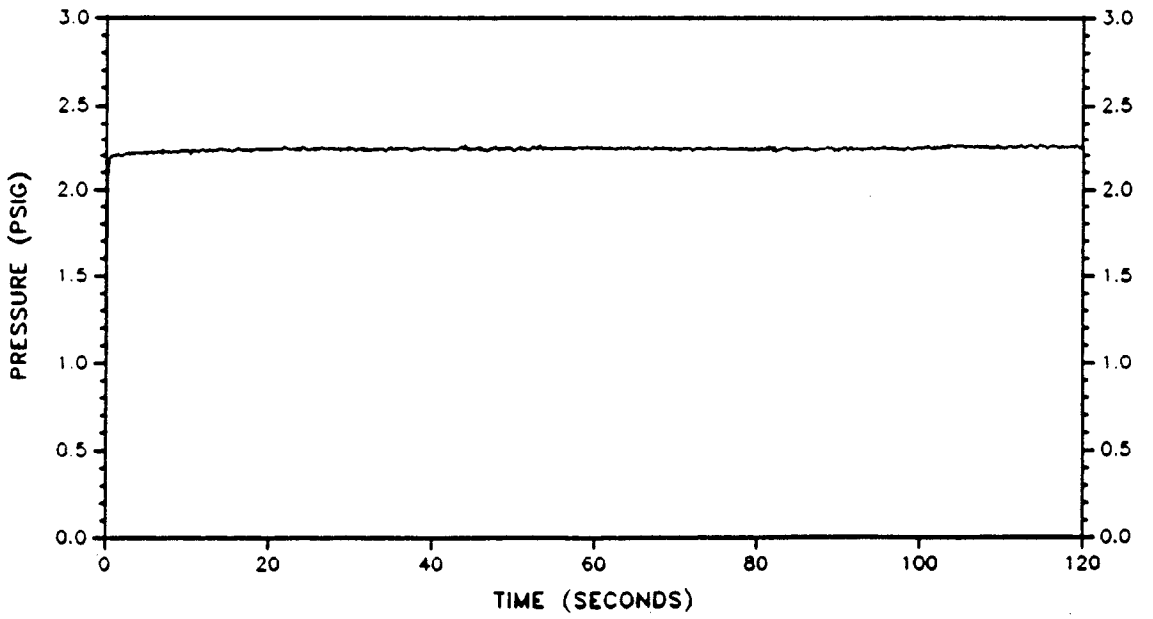


SCENARIO #1, TEST #6C (Test Date 2/28/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I

TEST #: 6D

ASSEMBLY DATE: 2/27/89

TEST TECHNICIAN: M. Gardner

TEST SUPERVISOR: T. [illegible]

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16

PISTON NO.: 63/63

PRIMARY O-RING		SECONDARY O-RING	
O-RING NO.:	#13	O-RING NO.:	#[illegible]
O-RING INNER DIAMETER (inch):	9.383	O-RING INNER DIAM (inch):	9.35[illegible]
O-RING X-SECTION DIAM (inch):	0.29[illegible]	O-RING X-SECT DIAM (inch):	0.29[illegible]
O-RING SQUEEZE (%): (AVG.)	17.4	O-RING SQUEEZE: (AVG.)	17.6
ADJUSTED X-SECT (inch):	0.2856	ADJUSTED X-SECT (inch):	0.2855

O-RING CONDITIONING

CONDITIONING TEMP.: 108.8 °F

CONDITIONING START TIME: 10:30 AM 2/27/89

CONDITIONING STOP TIME: 7 AM 2/28/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 2/28/89, 9 AM

CONDITIONING TEMP.: 75.0 °F

DATE & TIME OF TEST: 2/28/89, 1:20 PM

FIXTURE TEMEPERATURE AT END OF TEST: 78.4 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 15.57 psia

T_1 = 78.4 °F T_2 = 78.4 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 1.9142 in^3

$\Delta V = V_i - V_f$

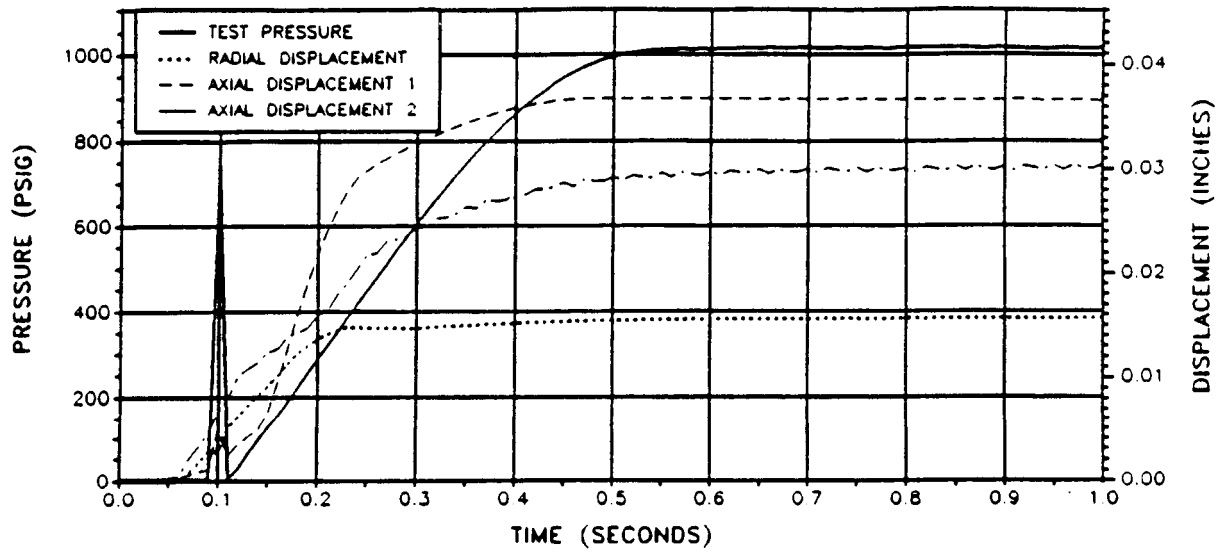
ΔV = 0.4326 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

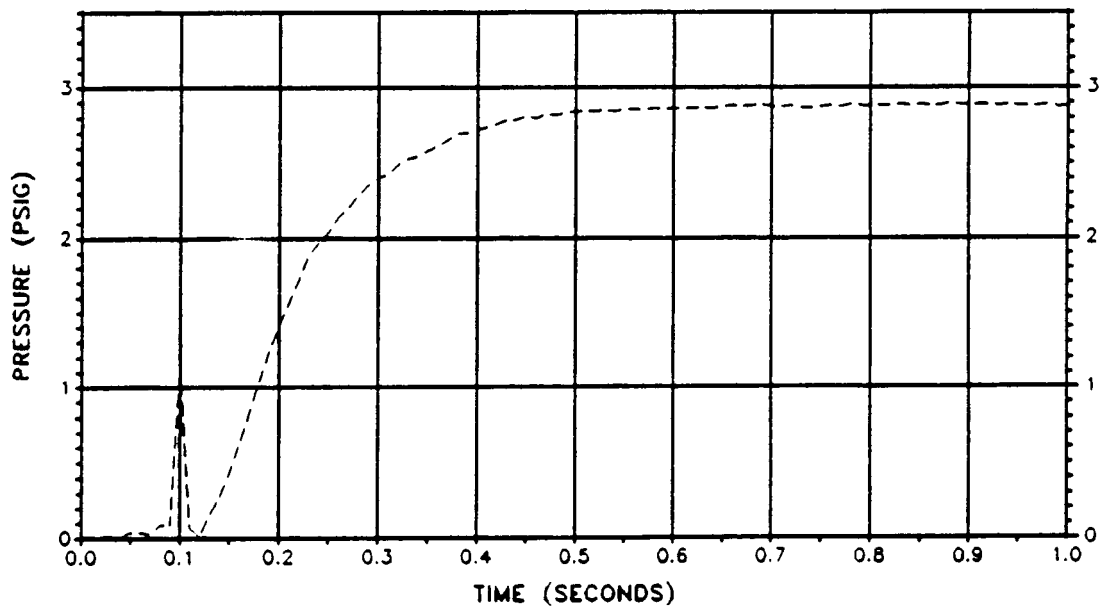
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #6D (Test Date 2/28/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

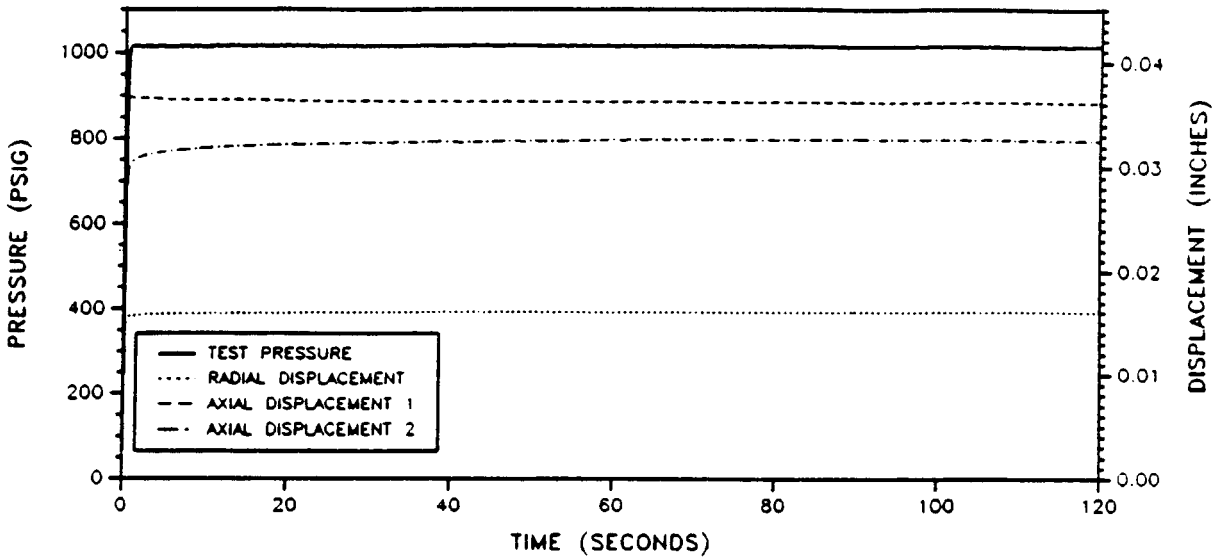


V-4 Cavity Pressure Vs. Time (1 Second Plot)

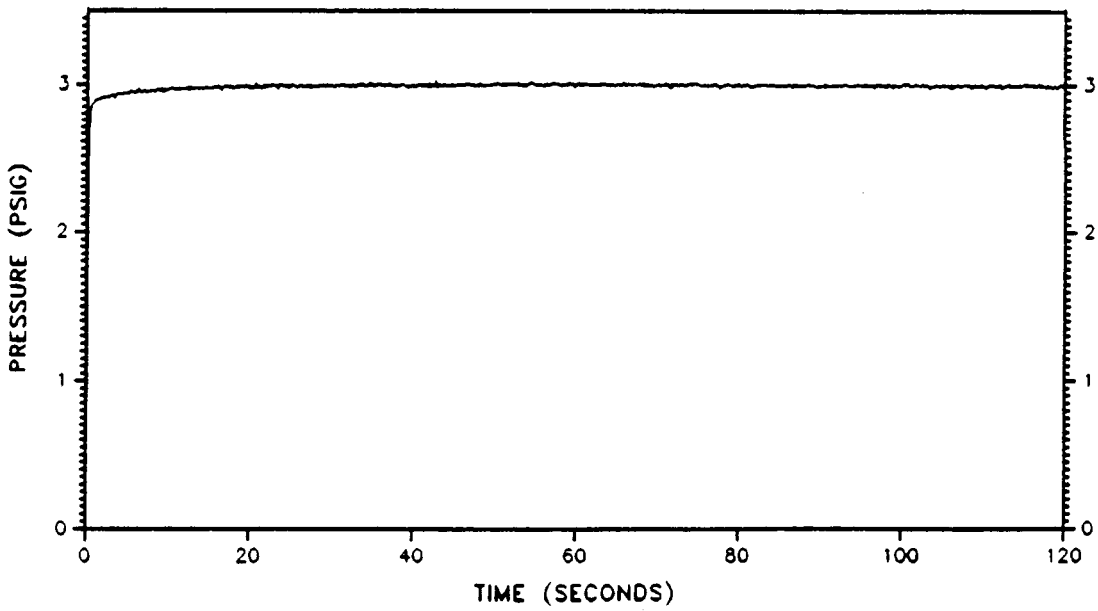


SCENARIO #1, TEST #6D (Test Date 2/28/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
TEST #: 7
ASSEMBLY DATE: 2/28/89
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/63

PRIMARY O-RING		SECONDARY O-RING	
O-RING NO.:	#15	O-RING NO.:	#16
O-RING INNER DIAMETER (inch):	9.351	O-RING INNER DIAM (inch):	9.383
O-RING X-SECTION DIAM (inch):	0.2904	O-RING X-SECT DIAM (inch):	0.2879
O-RING SQUEEZE (%): (AVG.)	17.2	O-RING SQUEEZE: (AVG.)	18.9
ADJUSTED X-SECT (inch):	0.2851	ADJUSTED X-SECT (inch):	0.2831

O-RING CONDITIONING

CONDITIONING TEMP.: 113.3 °F

CONDITIONING START TIME: 1:30 pm 2/28/89
CONDITIONING STOP TIME: 7 AM, 3/1/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/1/89, 10:00 AM

CONDITIONING TEMP.: 75.0 °F

DATE & TIME OF TEST: 3/1/89,

FIXTURE TEMEPERATURE AT END OF TEST: 75.8 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3168 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 15.30 psia

T_1 = 75.6 °F T_2 = 75.7 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 1.9506 in^3

$\Delta V = V_i - V_f$

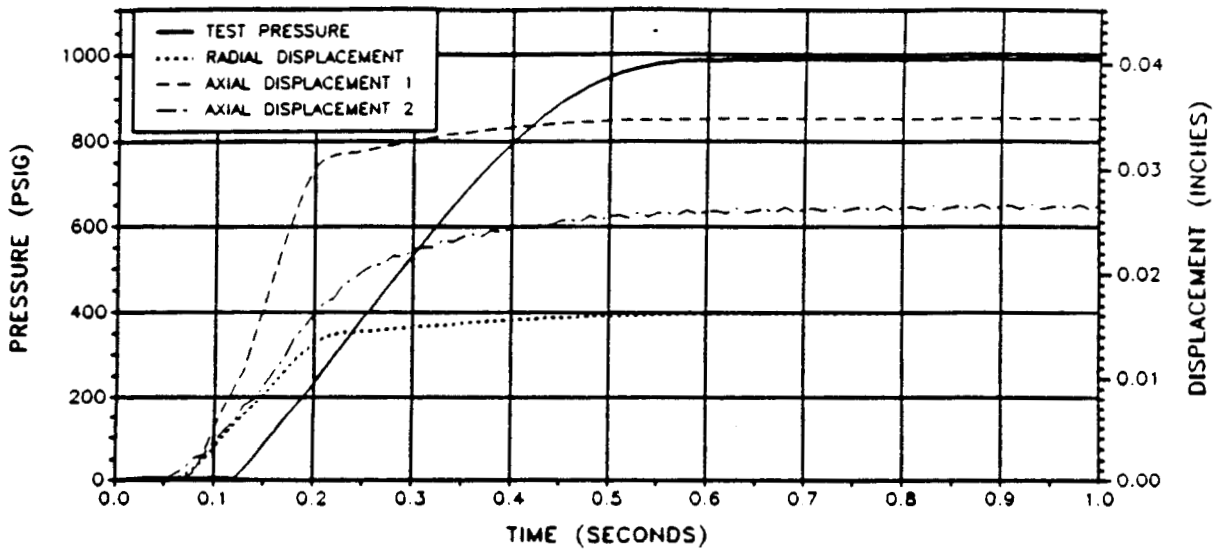
ΔV = 0.3962 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

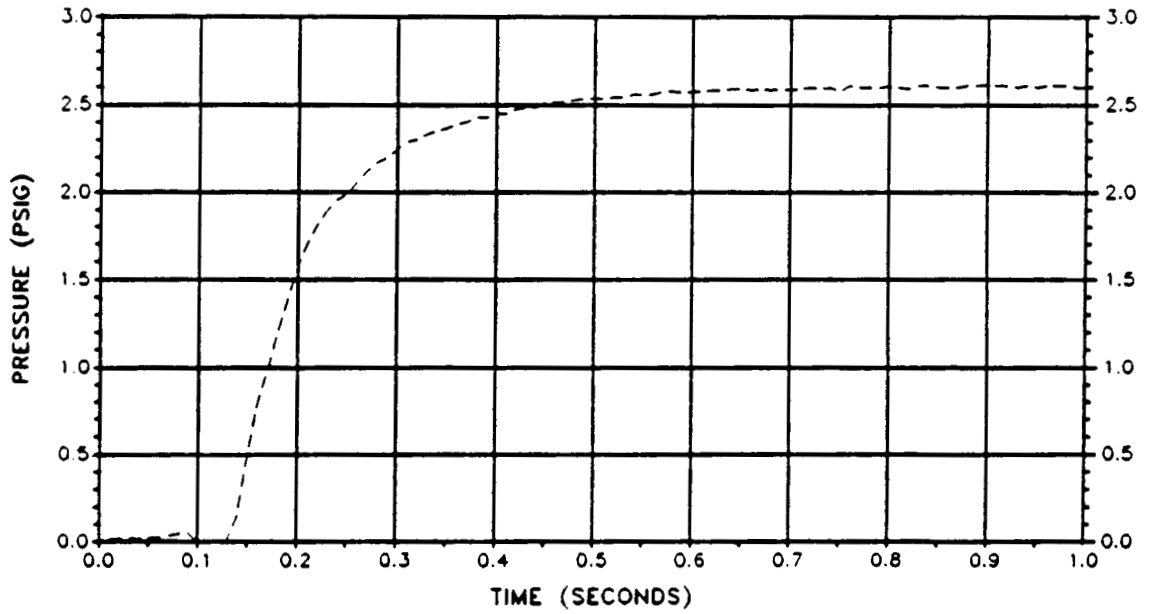
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #7 (Test Date 3/01/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

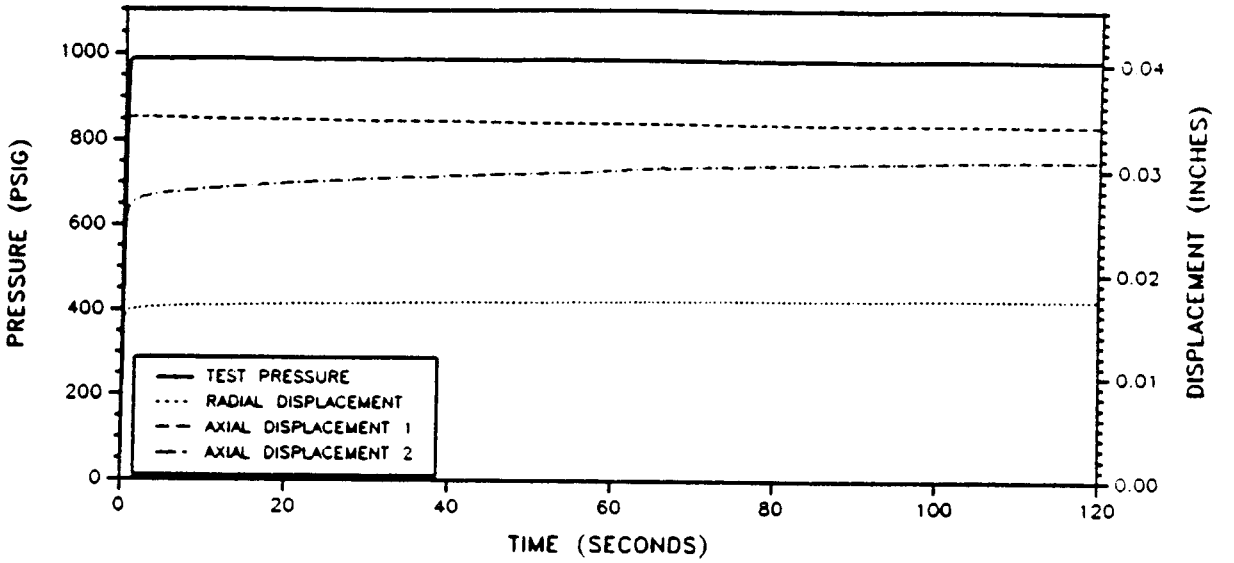


V-4 Cavity Pressure Vs. Time (1 Second Plot)

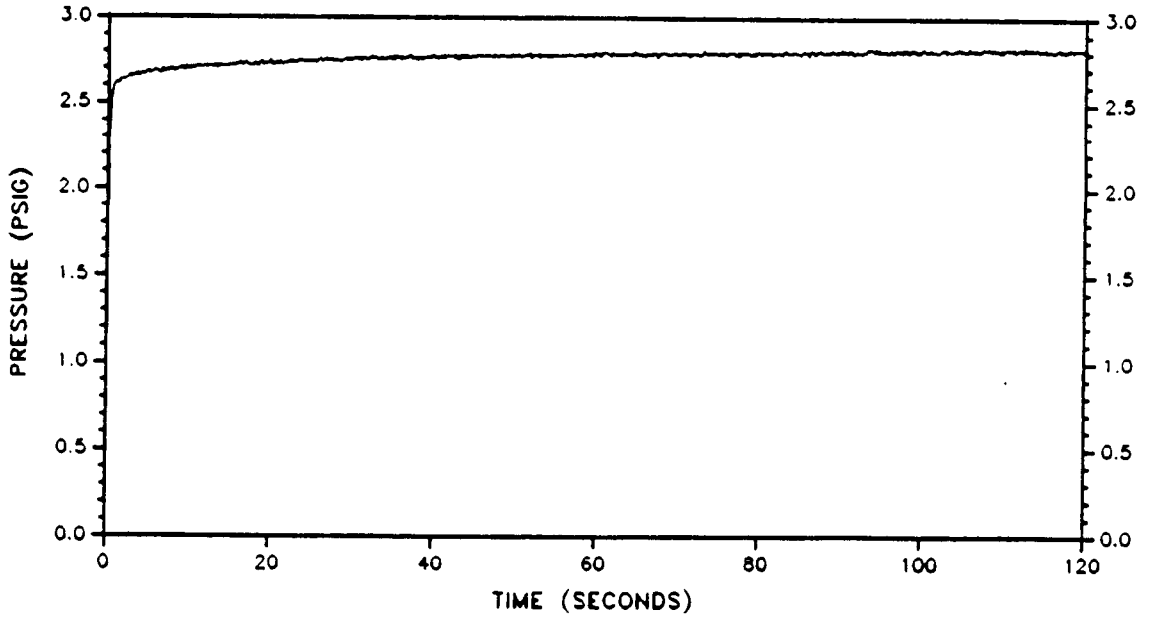


SCENARIO #1, TEST #7 (Test Date 3/01/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
ASSEMBLY DATE: 2/28/89

TEST #: 7-A
TEST TECHNICIAN: M. [illegible]
TEST SUPERVISOR: T. [illegible]

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/63

PRIMARY O-RING		SECONDARY O-RING	
O-RING NO.:	#15	O-RING NO.:	[illegible]
O-RING INNER DIAMETER (inch):	9.351	O-RING INNER DIAM (inch):	[illegible]
O-RING X-SECTION DIAM (inch):	0.2904	O-RING X-SECT DIAM (inch):	0.2779
O-RING SQUEEZE (%): (AVG.)	17.2	O-RING SQUEEZE: (AVG.)	18.9
ADJUSTED X-SECT (inch):	0.2851	ADJUSTED X-SECT (inch):	0.2831

O-RING CONDITIONING

CONDITIONING TEMP.: 113.3 °F

CONDITIONING START TIME: 1:30 pm 2/28/89 CONDITIONING STOP TIME: 7 AM 3/1/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/1/89, 10:00 AM

CONDITIONING TEMP.: 75.0 °F

DATE & TIME OF TEST: 3/1/89

FIXTURE TEMEPERATURE AT END OF TEST: 76.8 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 13.59 psia

T_1 = 76.7 °F T_2 = 76.7 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.1931 in^3

$\Delta V = V_i - V_f$

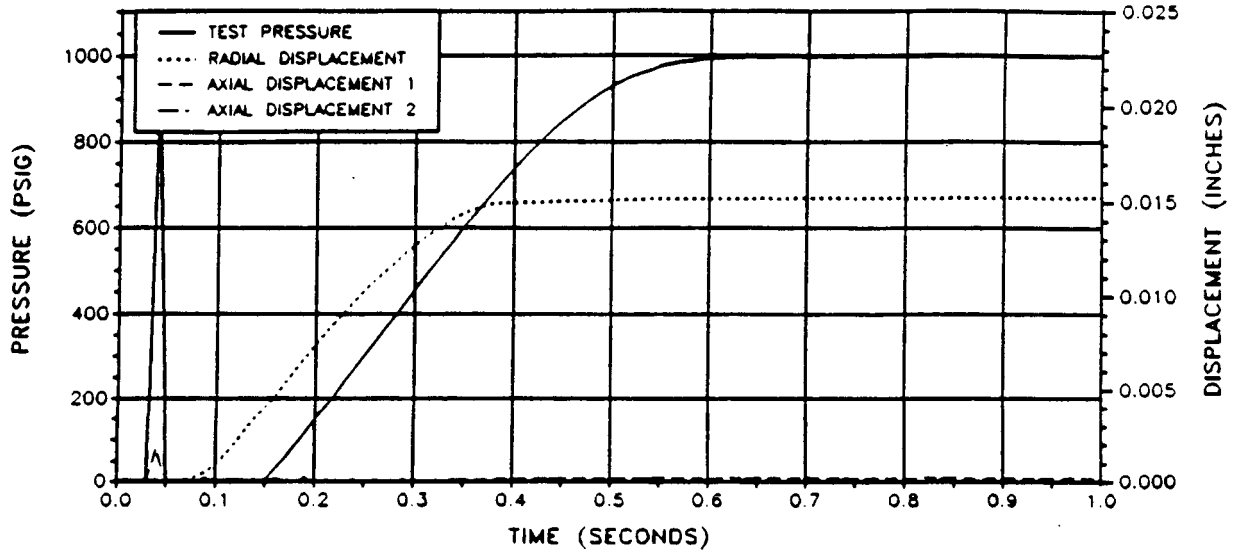
ΔV = 0.1537 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

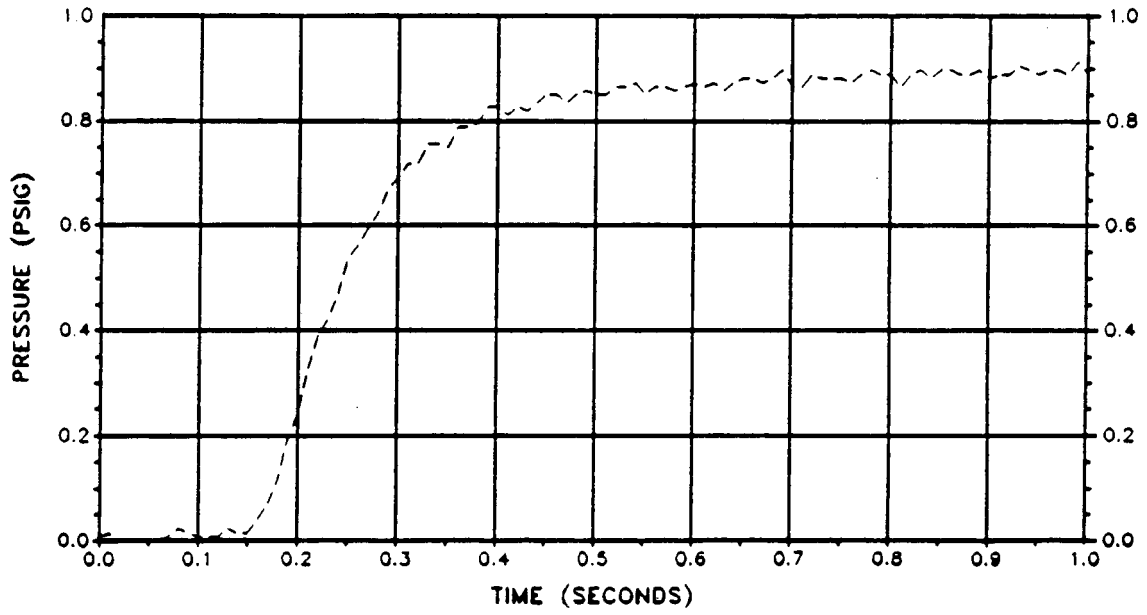
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #7A (Test Date 3/01/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

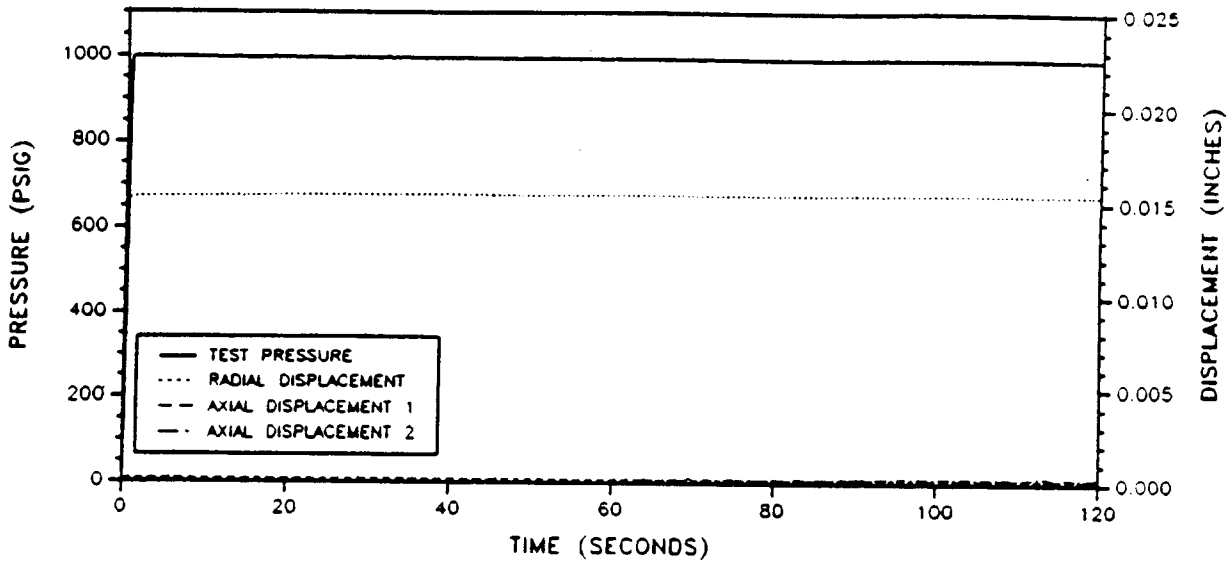


V-4 Cavity Pressure Vs. Time (1 Second Plot)

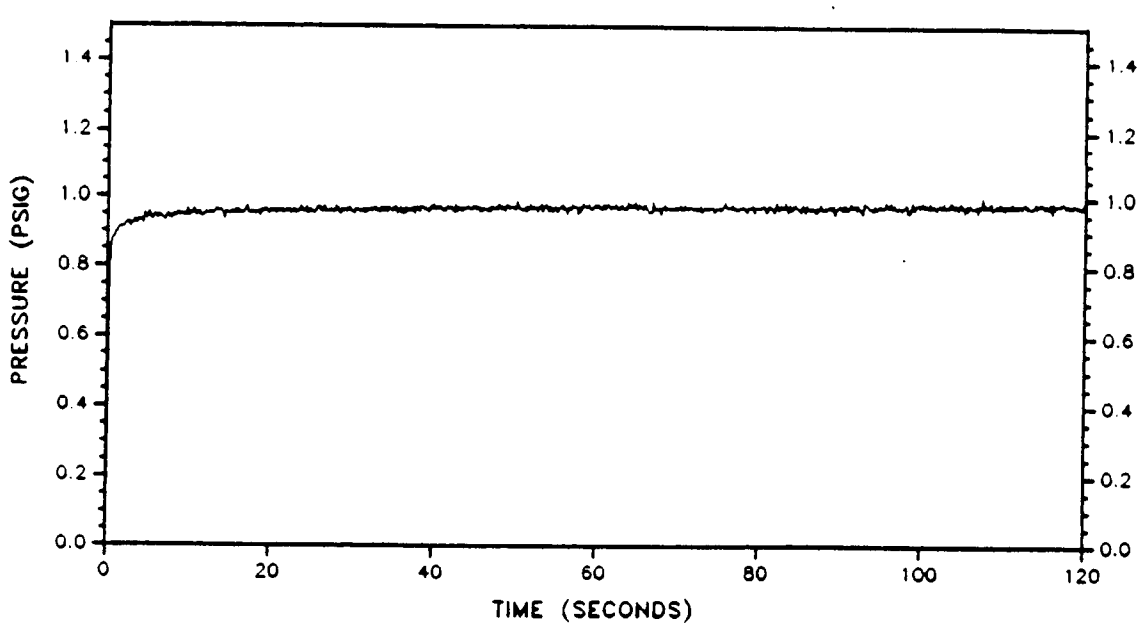


SCENARIO #1, TEST #7A (Test Date 3/01/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
ASSEMBLY DATE: 2/28/89

TEST #: 7-B
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Harrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/63

PRIMARY O-RING		SECONDARY O-RING	
O-RING NO.:	#15	O-RING NO.:	#16
O-RING INNER DIAMETER (inch):	9.351	O-RING INNER DIAM (inch):	9.283
O-RING X-SECTION DIAM (inch):	0.2904	O-RING X-SECT DIAM (inch):	0.2879
O-RING SQUEEZE (%): (AVG.)	17.2	O-RING SQUEEZE: (AVG.)	18.9
ADJUSTED X-SECT (inch):	0.2851	ADJUSTED X-SECT (inch):	0.2831

O-RING CONDITIONING

CONDITIONING TEMP.: 113.3 °F
CONDITIONING START TIME: 1:30 pm 2/28/89
CONDITIONING STOP TIME: 7AM, 3/1/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/1/89, 10 AM
CONDITIONING TEMP.: 75.0 °F
DATE & TIME OF TEST: 3/1/89, 11 AM
FIXTURE TEMEPERATURE AT END OF TEST: 76.4 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 13.57 psia

T_1 = 76.4 °F T_2 = 76.4 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.1963 in^3

$\Delta V = V_i - V_f$

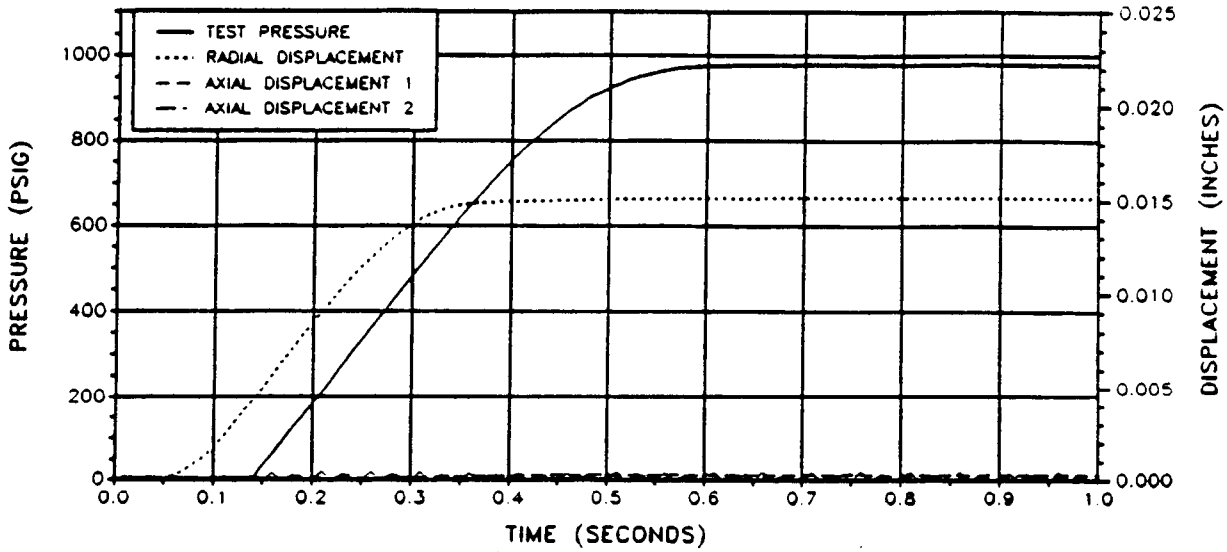
ΔV = 0.1505 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

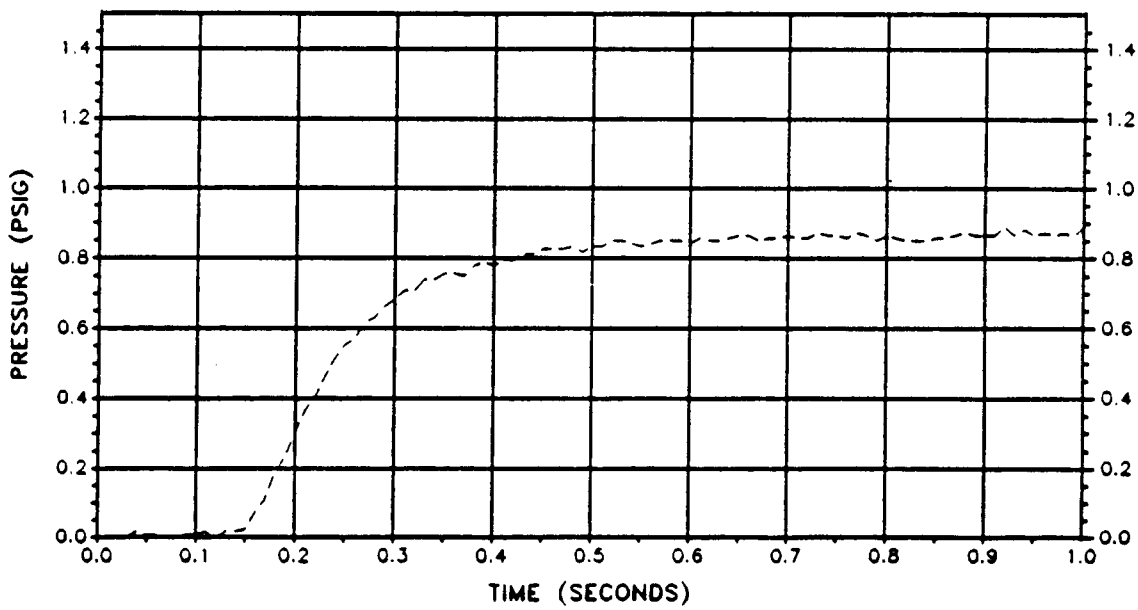
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #7B (Test Date 3/01/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

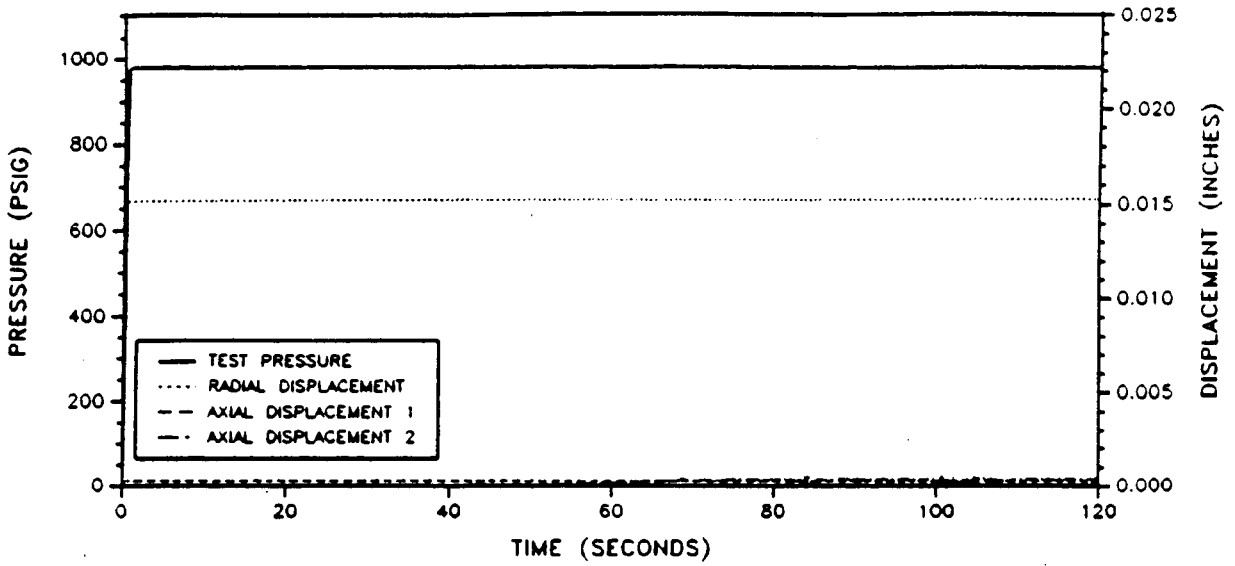


V-4 Cavity Pressure Vs. Time (1 Second Plot)

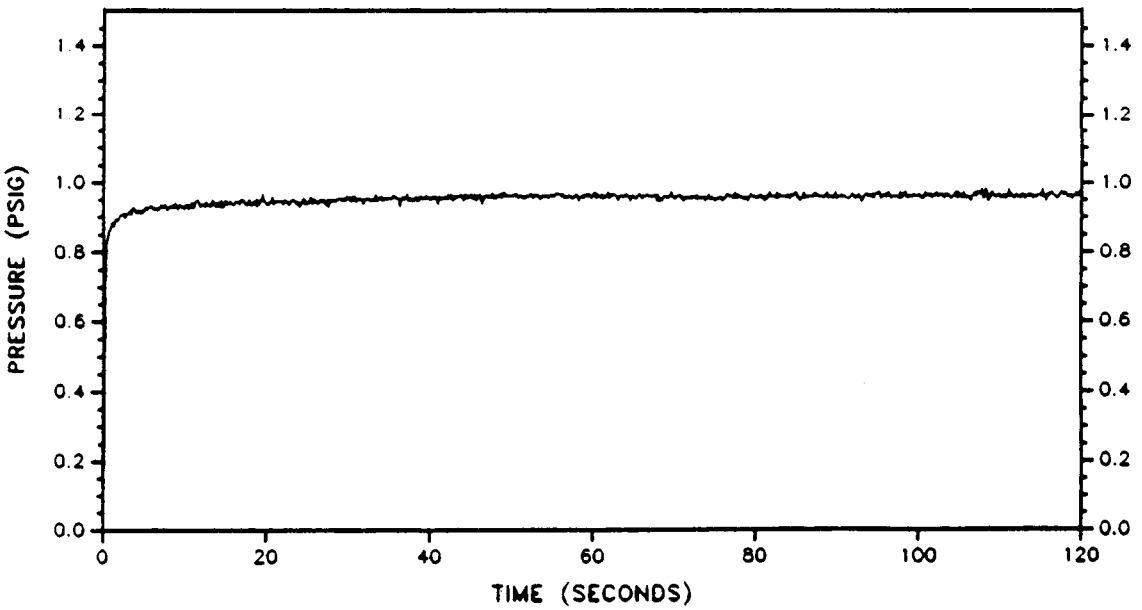


SCENARIO #1, TEST #7B (Test Date 3/01/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
ASSEMBLY DATE: 2/28/89

TEST #: 7-C
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/63

PRIMARY O-RING

O-RING NO.: #15
O-RING INNER DIAMETER (inch): 9.351
O-RING X-SECTION DIAM (inch): 0.2904
O-RING SQUEEZE (%): (AVG.) 17.2
ADJUSTED X-SECT (inch): 0.2851

SECONDARY O-RING

O-RING NO.: #16
O-RING INNER DIAM (inch): 9.383
O-RING X-SECT DIAM (inch): 0.2879
O-RING SQUEEZE: (AVG.) 18.9
ADJUSTED X-SECT (inch): 0.2831

O-RING CONDITIONING

CONDITIONING TEMP.: 113.3 °F
CONDITIONING START TIME: 1:30 PM 2/28/89
CONDITIONING STOP TIME: 7 AM, 3/1/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/1/89, 10:00 AM
CONDITIONING TEMP.: 75.0 °F
DATE & TIME OF TEST: 3/1/89
FIXTURE TEMEPERATURE AT END OF TEST: 76.5 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 15.40 psia

T_1 = 76.3 °F T_2 = 76.4 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 1.9379 in^3

$\Delta V = V_i - V_f$

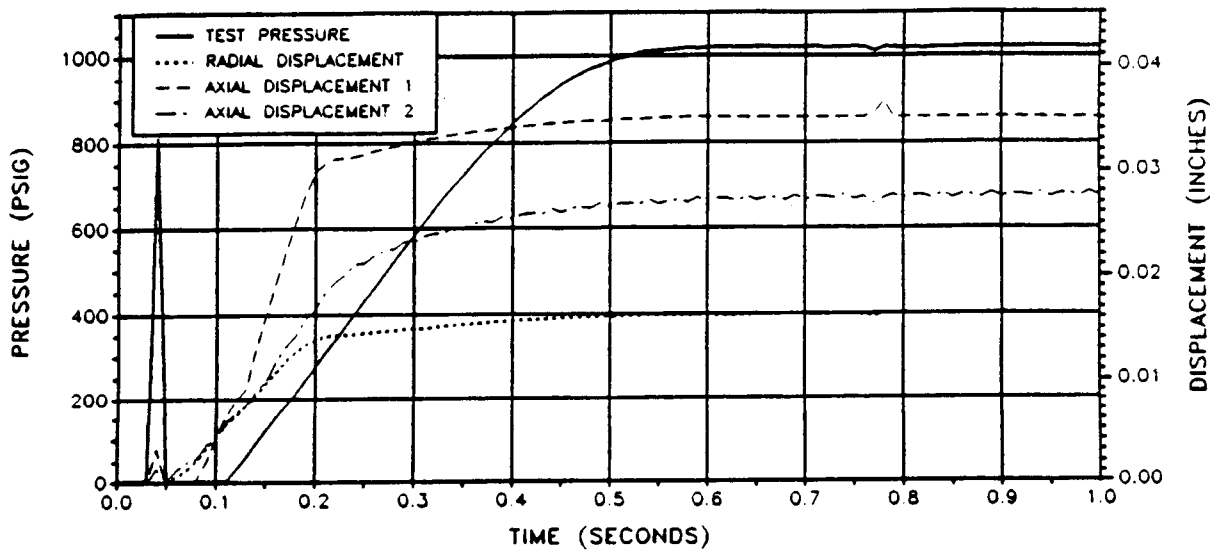
ΔV = 0.4089 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

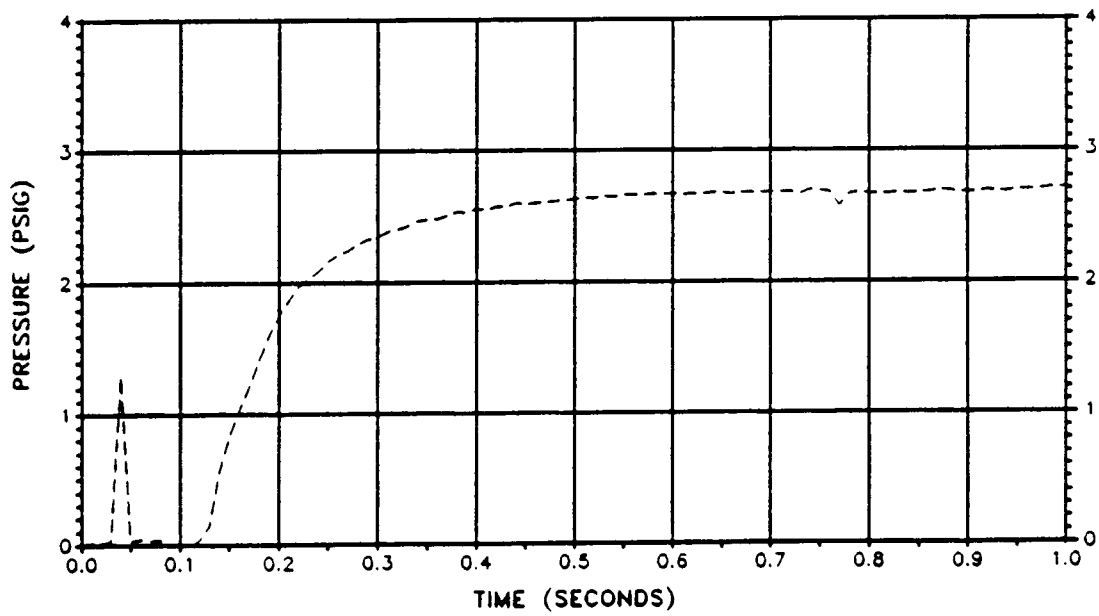
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #7C (Test Date 3/01/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

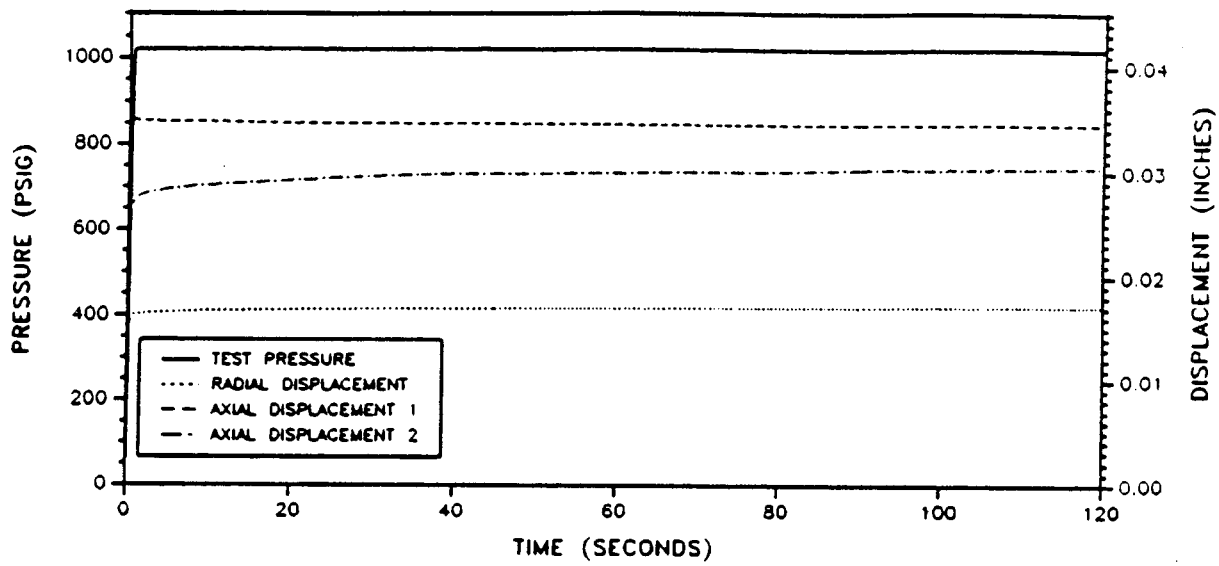


V-4 Cavity Pressure Vs. Time (1 Second Plot)

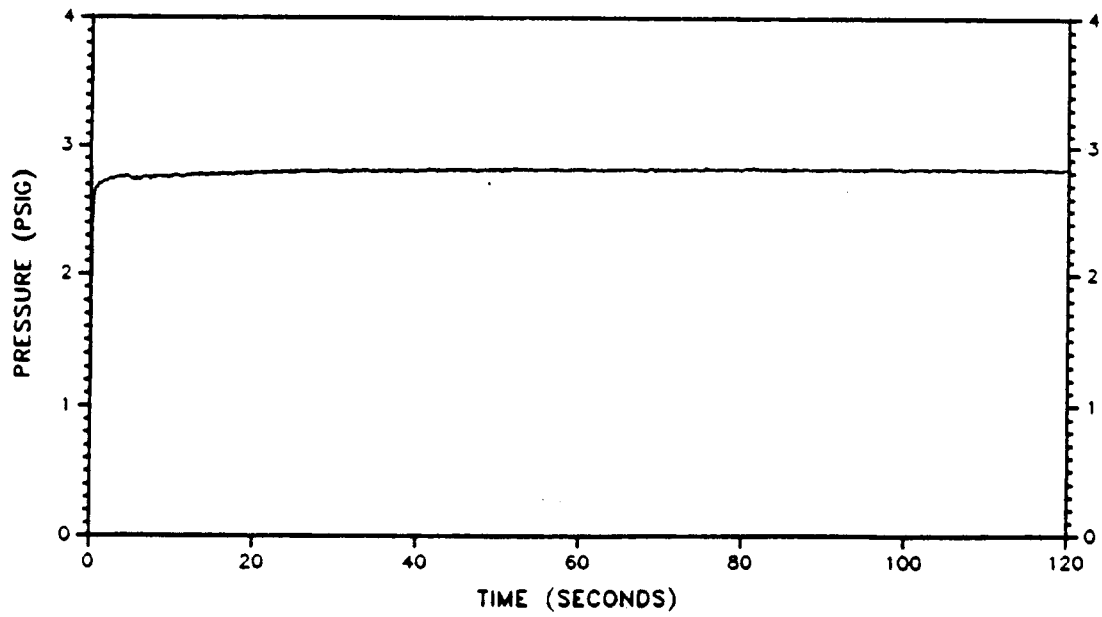


SCENARIO #1, TEST #7C (Test Date 3/01/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I

TEST #: 8

ASSEMBLY DATE: _____

TEST TECHNICIAN: M. Gardner

TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16

PISTON NO.: 63/63

PRIMARY O-RING		SECONDARY O-RING	
O-RING NO.:	#17	O-RING NO.:	#17
O-RING INNER DIAMETER (inch):	9.374	O-RING INNER DIAM (inch):	9.327
O-RING X-SECTION DIAM (inch):	0.2904	O-RING X-SECT DIAM (inch):	0.2901
O-RING SQUEEZE (%): (AVG.)	17.4	O-RING SQUEEZE: (AVG.)	17.2
ADJUSTED X-SECT (inch):	0.2856	ADJUSTED X-SECT (inch):	0.2841

O-RING CONDITIONING

CONDITIONING TEMP.: 113.3 °F

CONDITIONING START TIME: 2:30pm, 3/1/89 CONDITIONING STOP TIME: 7 AM 3/2/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/2/89, 11 AM

CONDITIONING TEMP.: 76.0 °F

DATE & TIME OF TEST: 3/2/89, 11:25 AM

FIXTURE TEMEPERATURE AT END OF TEST: 75.9 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 15.4 psia

T_1 = 75.8 °F T_2 = 75.9 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 1.9379 in^3

$\Delta V = V_i - V_f$

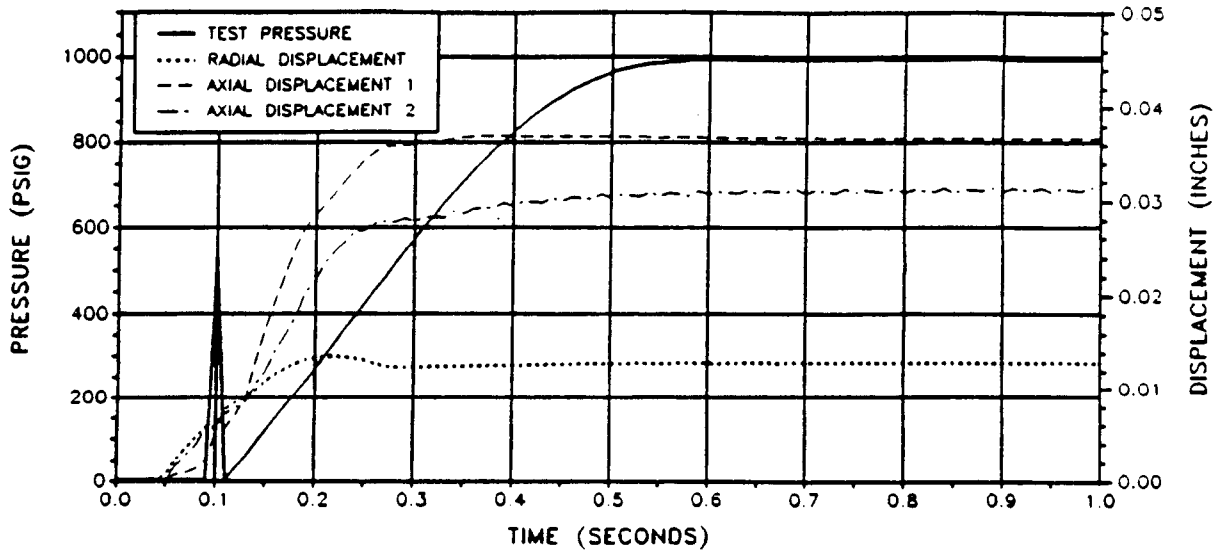
ΔV = 0.4089 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

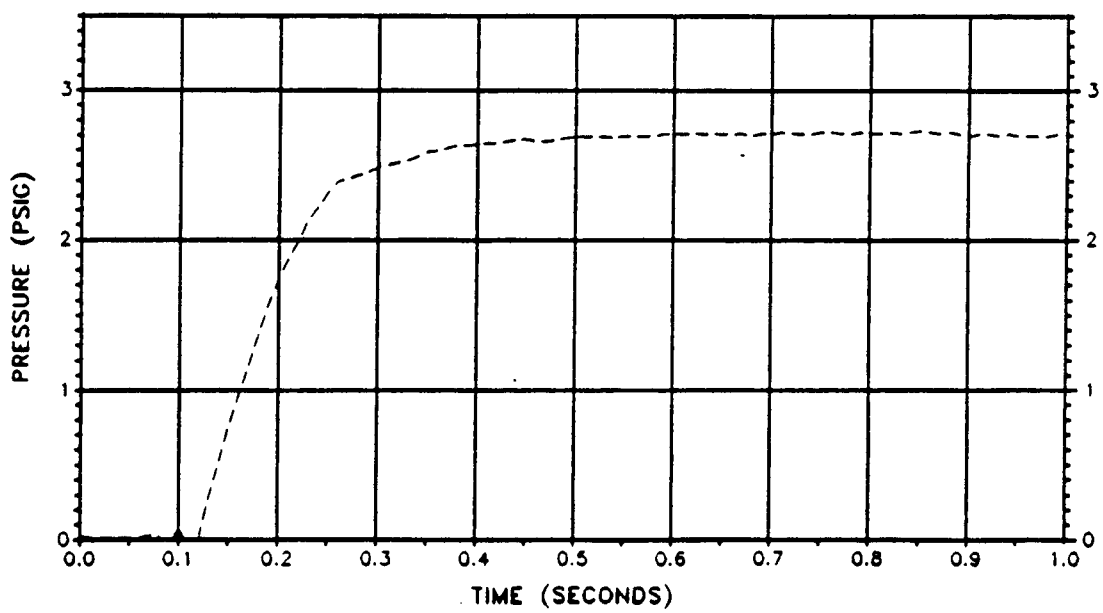
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #8 (Test Date 3/02/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

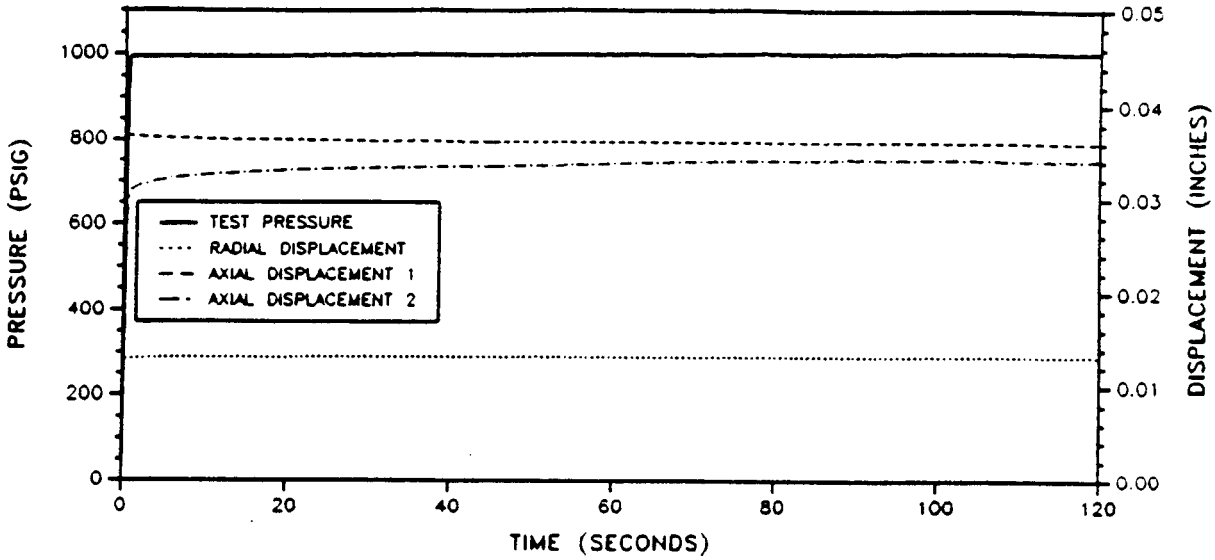


V-4 Cavity Pressure Vs. Time (1 Second Plot)

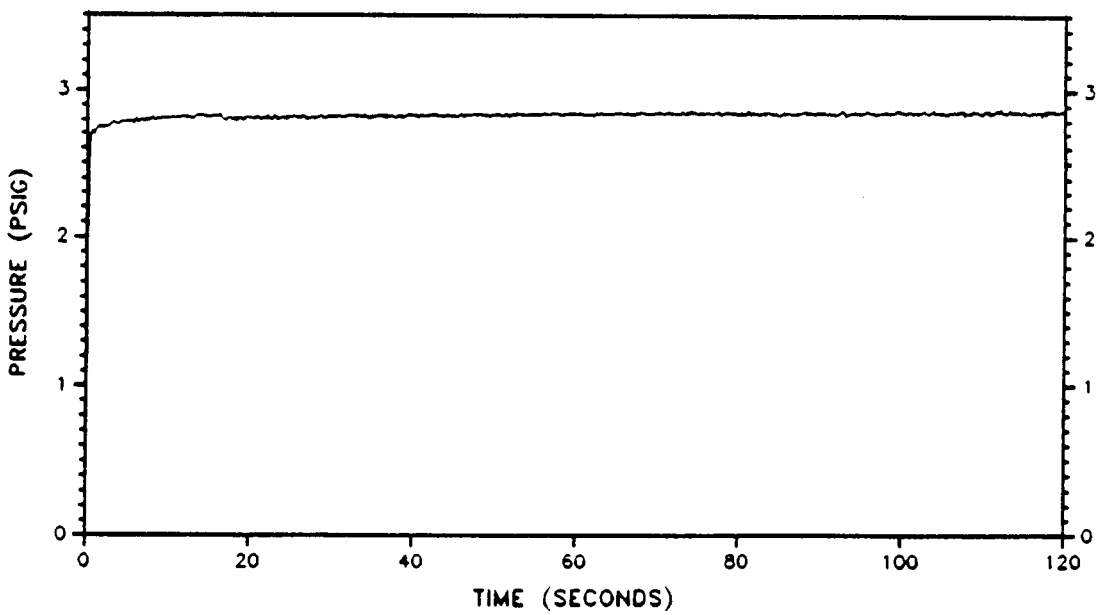


SCENARIO #1, TEST #8 (Test Date 3/02/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
TEST #: 8-A
ASSEMBLY DATE: 3/1/89
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Harrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/63

PRIMARY O-RING

O-RING NO.: #17
O-RING INNER DIAMETER (inch): 9.374
O-RING X-SECTION DIAM (inch): 0.2904
O-RING SQUEEZE (%): (AVG.) 17.4
ADJUSTED X-SECT (inch): 0.2856

SECONDARY O-RING

O-RING NO.: #18
O-RING INNER DIAM (inch): 1.327
O-RING X-SECT DIAM (inch): 0.2901
O-RING SQUEEZE: (AVG.) 19.2
ADJUSTED X-SECT (inch): 0.2841

O-RING CONDITIONING

CONDITIONING TEMP.: 113.3 °F
CONDITIONING START TIME: 2:30 PM 3/1/89
CONDITIONING STOP TIME: 7 AM, 3/2/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/2/89, 11:00 AM
CONDITIONING TEMP.: 76.0 °F
DATE & TIME OF TEST: 3/2/89, 11:55 AM
FIXTURE TEMEPERATURE AT END OF TEST: 75.9 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 13.62 psia

T_1 = 75.9 °F T_2 = 75.9 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.1883 in^3

$\Delta V = V_i - V_f$

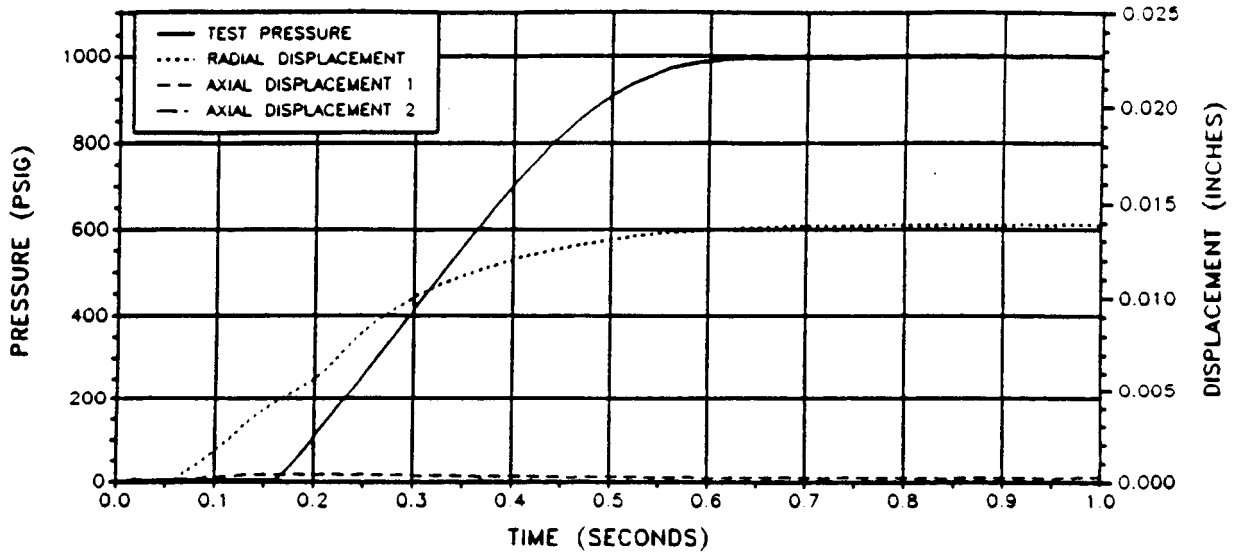
ΔV = 0.1585 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

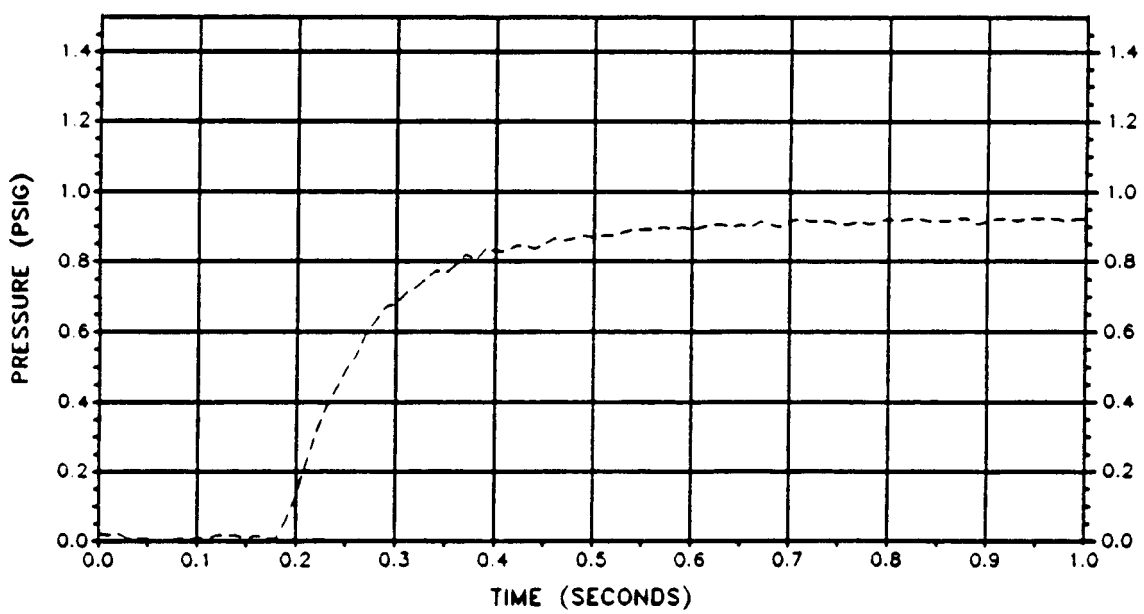
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #8A (Test Date 3/02/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

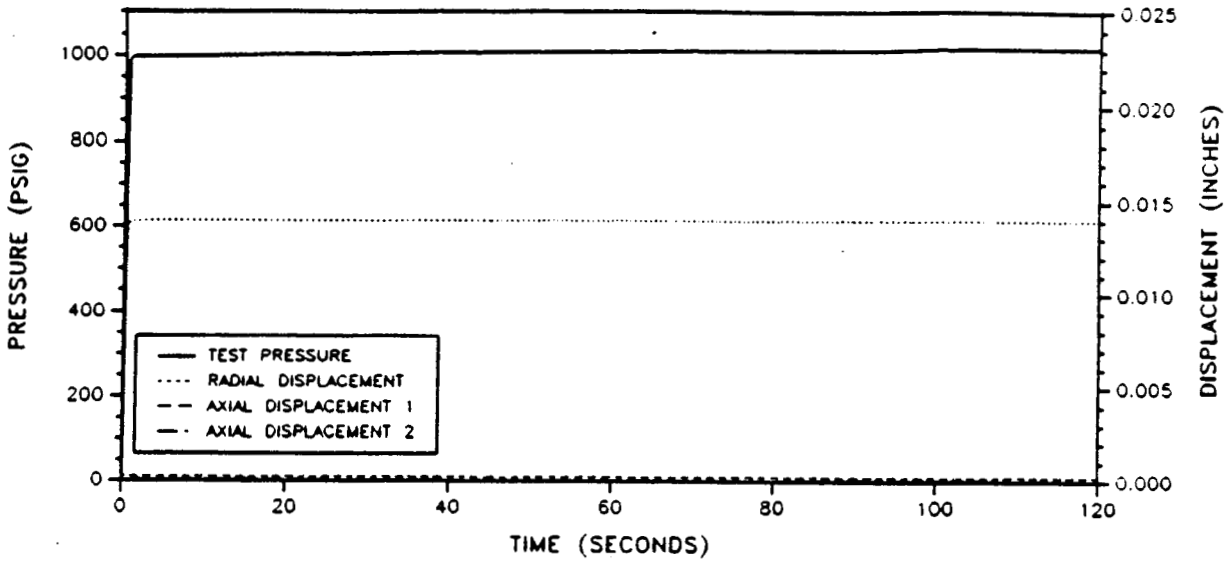


V-4 Cavity Pressure Vs. Time (1 Second Plot)

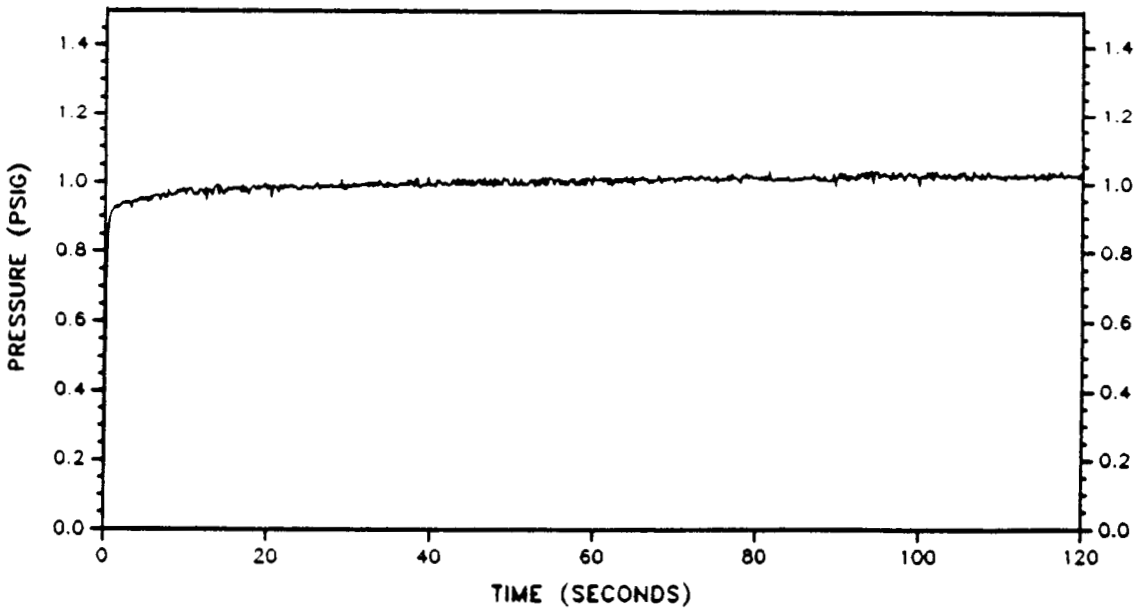


SCENARIO #1, TEST #8A (Test Date 3/02/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: 1 TEST #: 8-B

ASSEMBLY DATE: 3/1/89 TEST TECHNICIAN: M. Gardner

TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16 PISTON NO.: [illegible]

PRIMARY O-RING		SECONDARY O-RING	
O-RING NO.:	#17	O-RING NO.:	#19
O-RING INNER DIAMETER (inch):	9.374	O-RING INNER DIAM (inch):	9.327
O-RING X-SECTION DIAM (inch):	0.2904	O-RING X-SECT DIAM (inch):	0.2901
O-RING SQUEEZE (%): (AVG.)	17.4	O-RING SQUEEZE: (AVG.)	19.2
ADJUSTED X-SECT (inch):	0.2856	ADJUSTED X-SECT (inch):	0.2841

O-RING CONDITIONING

CONDITIONING TEMP.: 113.3 °F

CONDITIONING START TIME: 2:30pm, 3/1/89 CONDITIONING STOP TIME: 7AM 3/2/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/2/89, 11 AM

CONDITIONING TEMP.: 76.0 °F

DATE & TIME OF TEST: 3/2/89, 12:05pm

FIXTURE TEMEPERATURE AT END OF TEST: 76.0 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 23468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 13.64 psia

T_1 = 75.9 °F T_2 = 76.0 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.1879 in^3

$\Delta V = V_i - V_f$

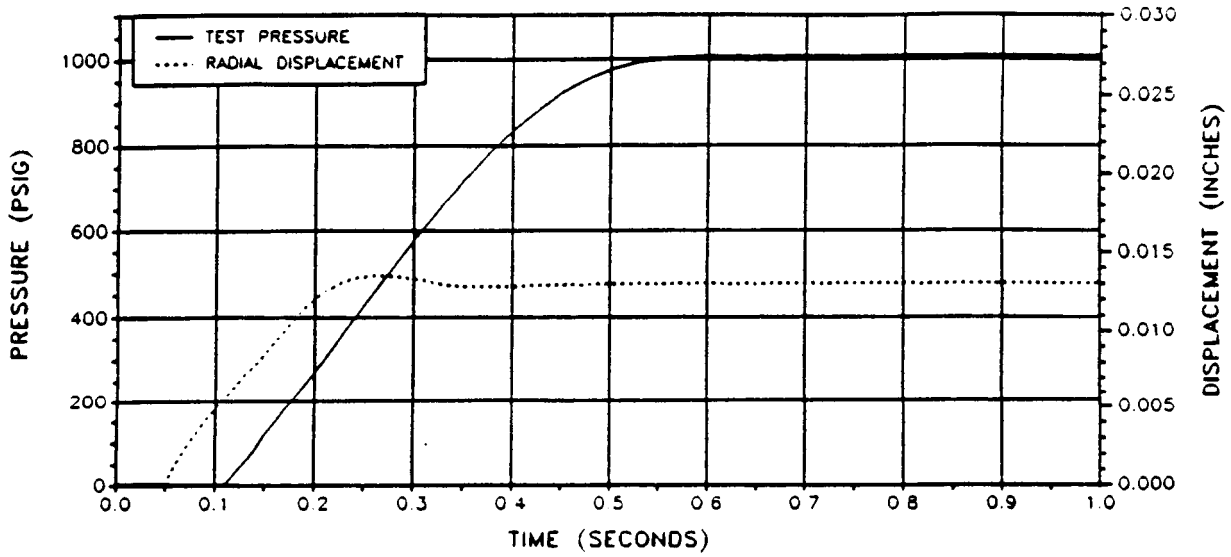
ΔV = 0.1589 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

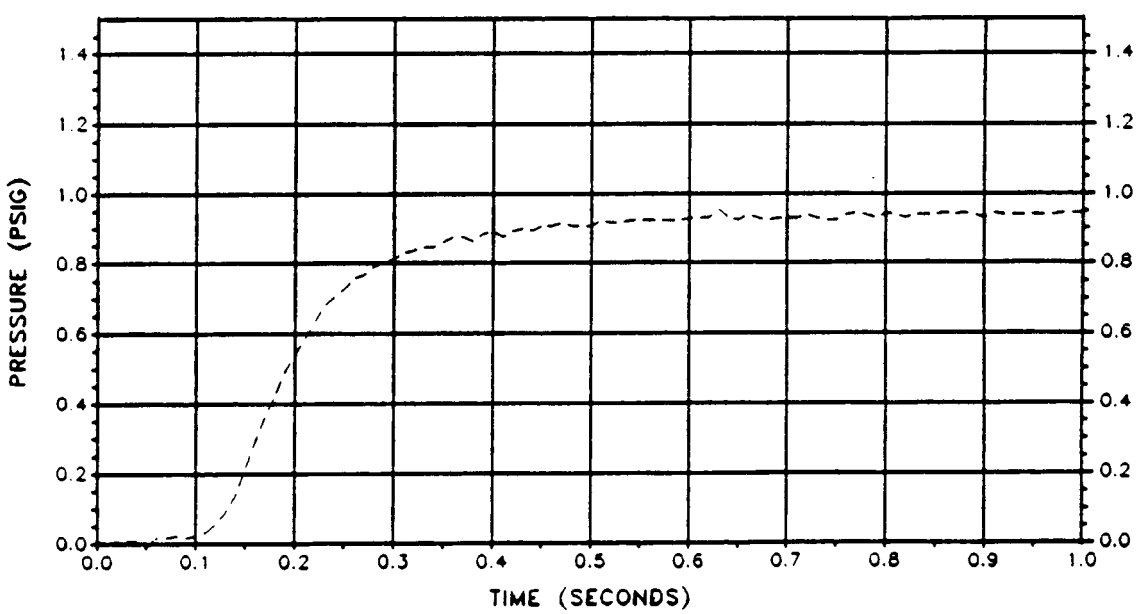
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #8B (Test Date 3/02/89)

Test Pressure and Radial Displacement Vs. Time (1 Second Plot)

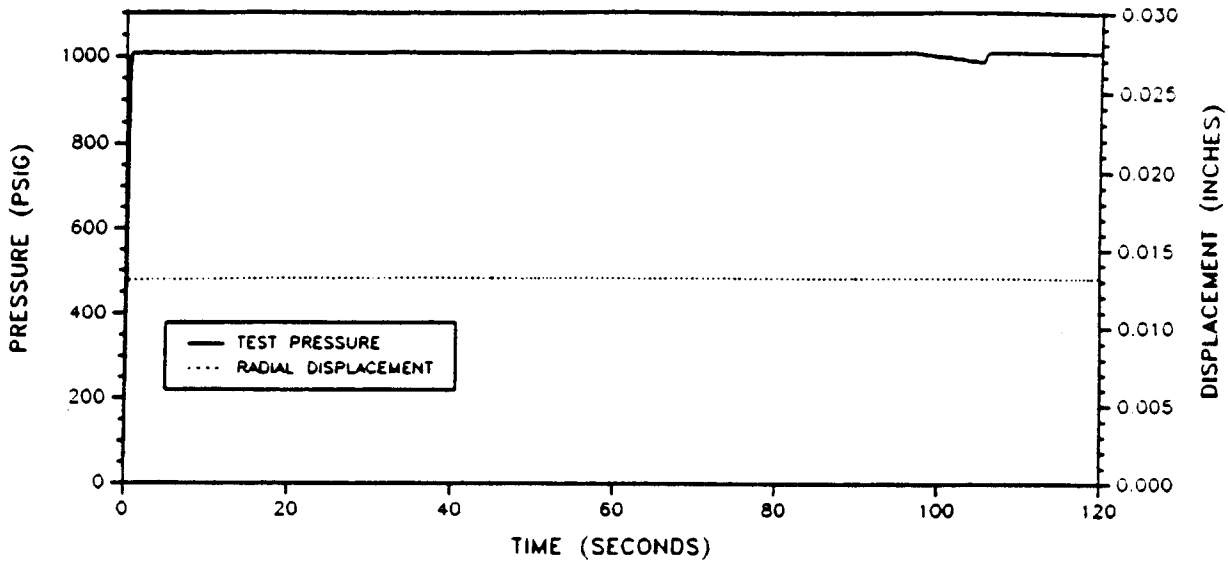


V-4 Cavity Pressure Vs. Time (1 Second Plot)

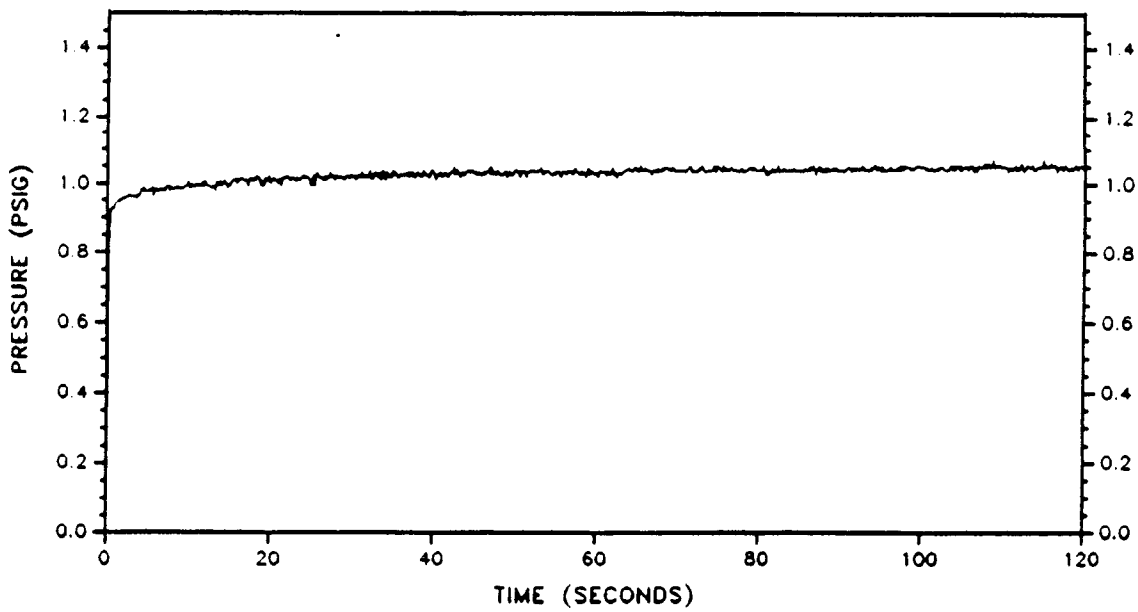


SCENARIO #1, TEST #8B (Test Date 3/02/89)

Test Pressure and Radial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
TEST #: 8-C
ASSEMBLY DATE: 3/1/89
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/63

PRIMARY O-RING		SECONDARY O-RING	
O-RING NO.:	#17	O-RING NO.:	#18
O-RING INNER DIAMETER (inch):	9.374	O-RING INNER DIAM (inch):	9.327
O-RING X-SECTION DIAM (inch):	0.2904	O-RING X-SECT DIAM (inch):	0.2901
O-RING SQUEEZE (%): (AVG.)	17.4	O-RING SQUEEZE: (AVG.)	19.2
ADJUSTED X-SECT (inch):	0.2856	ADJUSTED X-SECT (inch):	0.2841

O-RING CONDITIONING

CONDITIONING TEMP.: 113.3 °F

CONDITIONING START TIME: 2:30 PM 3/1/89
CONDITIONING STOP TIME: 7 AM, 3/2/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/2/89 11:00 AM

CONDITIONING TEMP.: 76.0 °F

DATE & TIME OF TEST: 3/2/89, 11:40 AM

FIXTURE TEMEPERATURE AT END OF TEST: 76.1 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 15.46 psia

T_1 = 76.1 °F T_2 = 76.1 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 1.9278 in^3

$\Delta V = V_i - V_f$

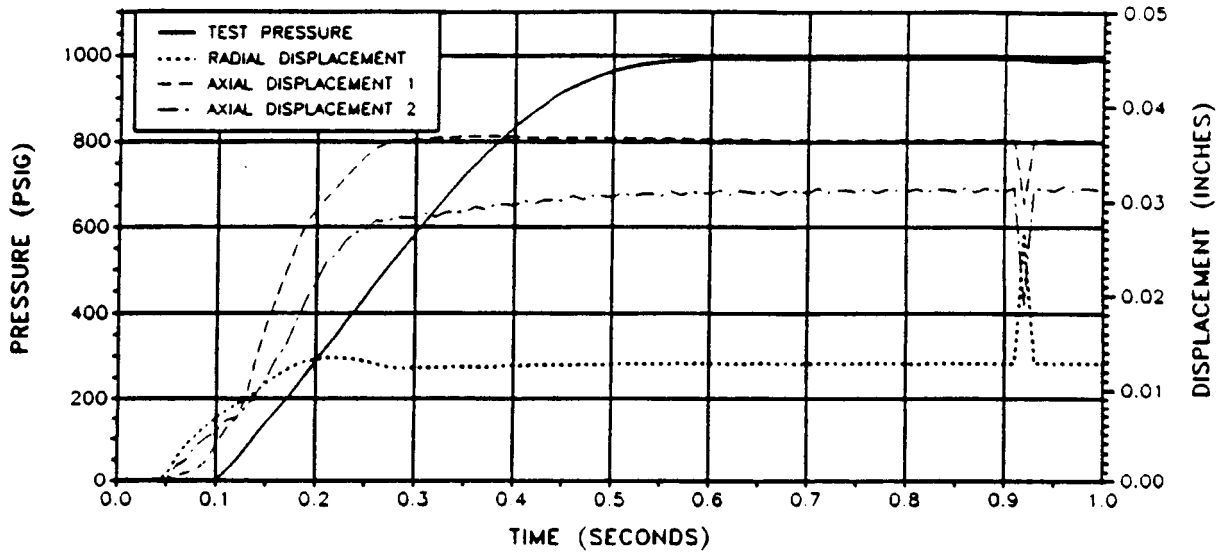
ΔV = 0.4190 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

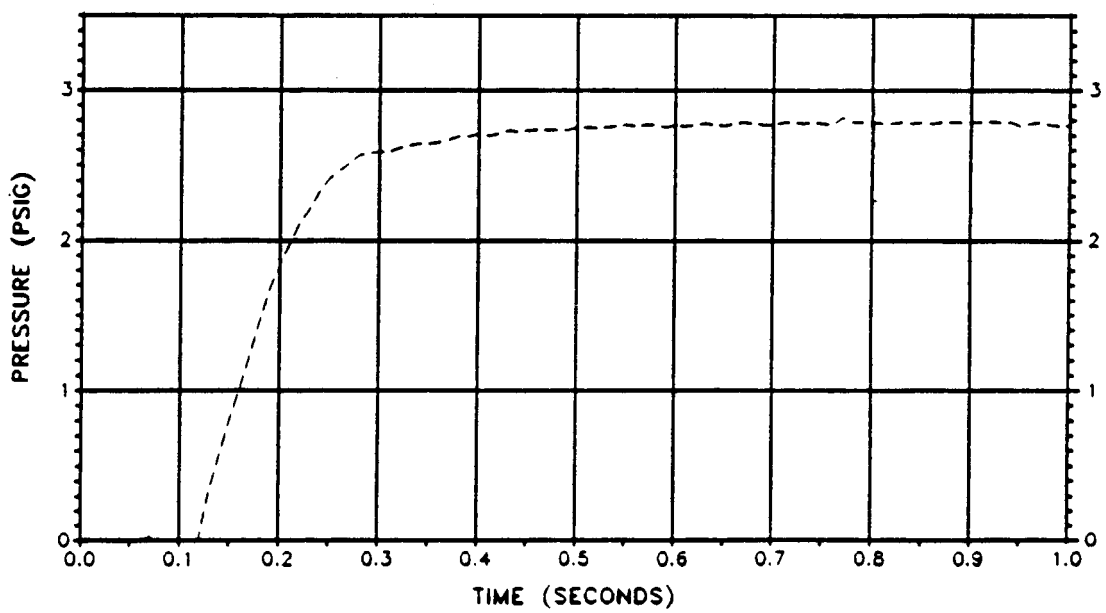
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #8C (Test Date 3/02/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

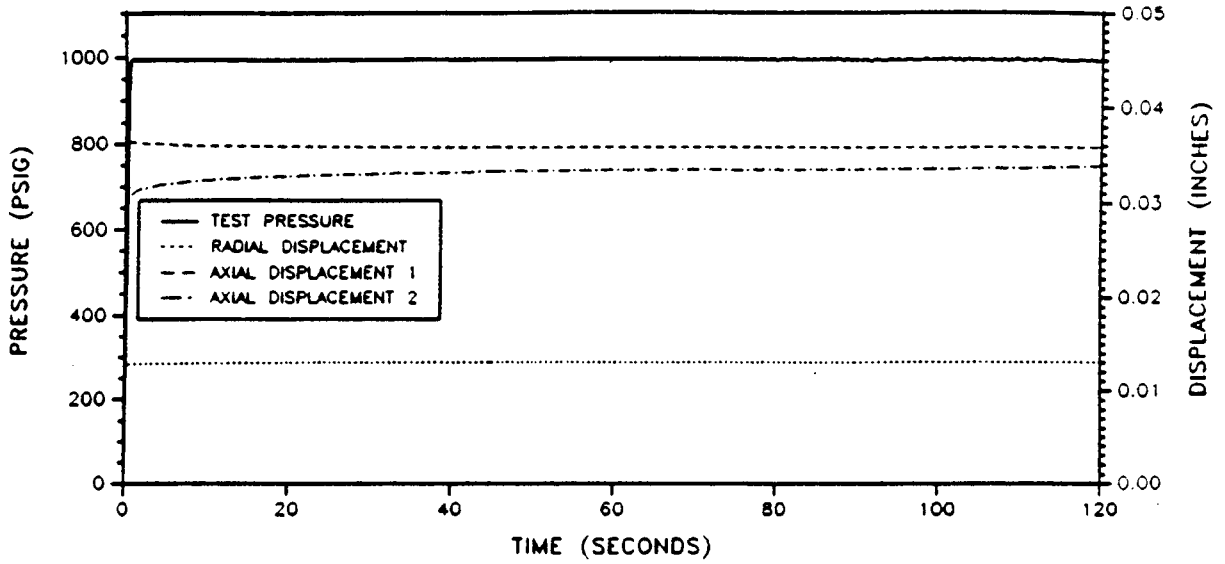


V-4 Cavity Pressure Vs. Time (1 Second Plot)

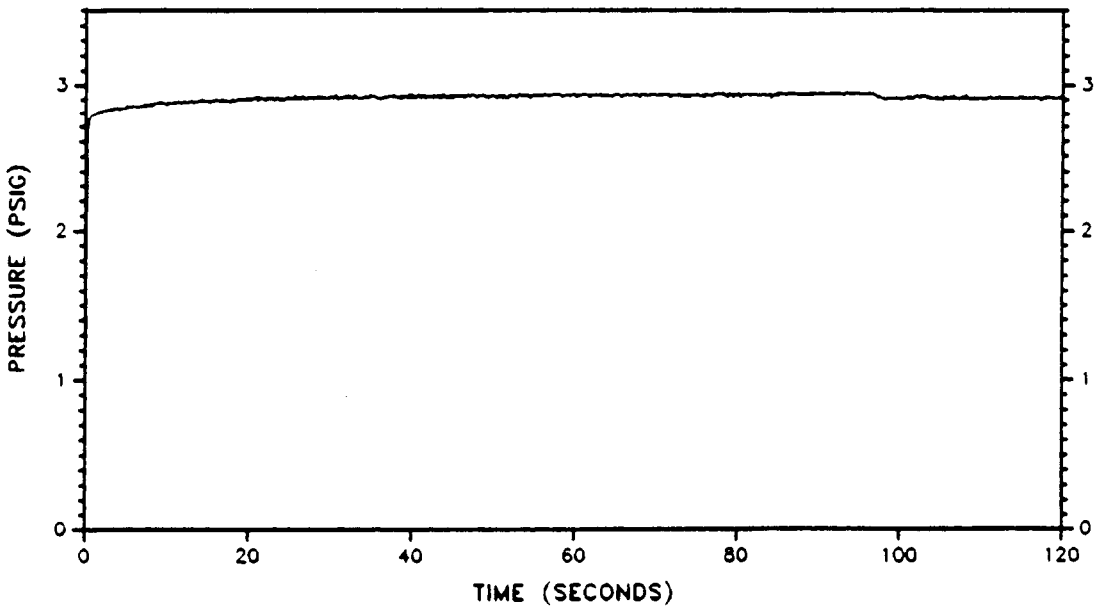


SCENARIO #1, TEST #8C (Test Date 3/02/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
TEST #: 9
ASSEMBLY DATE: 3/6/89
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Korrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: _____

PRIMARY O-RING		SECONDARY O-RING	
O-RING NO.:	#21	O-RING NO.:	#22
O-RING INNER DIAMETER (inch):	9.351	O-RING INNER DIAM (inch):	9.367
O-RING X-SECTION DIAM (inch):	0.2907	O-RING X-SECT DIAM (inch):	0.2893
O-RING SQUEEZE (%): (AVG.)	17.3	O-RING SQUEEZE: (AVG.)	19.2
ADJUSTED X-SECT (inch):	0.2854	ADJUSTED X-SECT (inch):	0.2841

O-RING CONDITIONING

CONDITIONING TEMP.: 114.1 °F
CONDITIONING START TIME: 1pM 3/7/89
CONDITIONING STOP TIME: 7 AM, 3/8/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/8/89, 8:30 AM
CONDITIONING TEMP.: 75.0 °F
DATE & TIME OF TEST: 3/8/89, 10:45 AM
FIXTURE TEMEPERATURE AT END OF TEST: 74.8 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 15.42 psia

T_1 = 74.7 °F T_2 = 74.8 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 1.9328 in^3

$\Delta V = V_i - V_f$

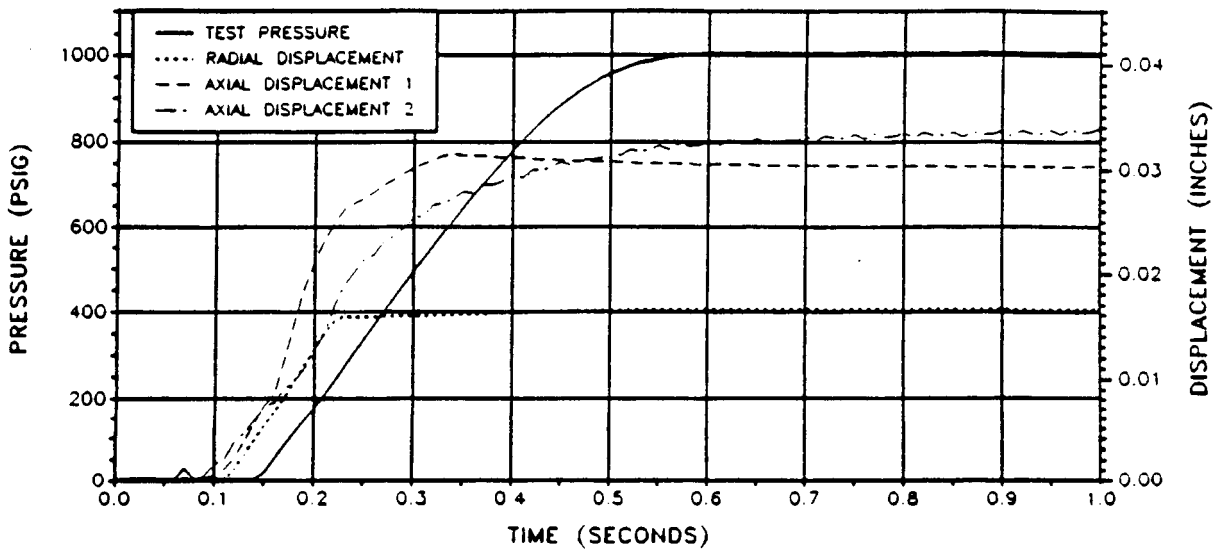
ΔV = 0.4140 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

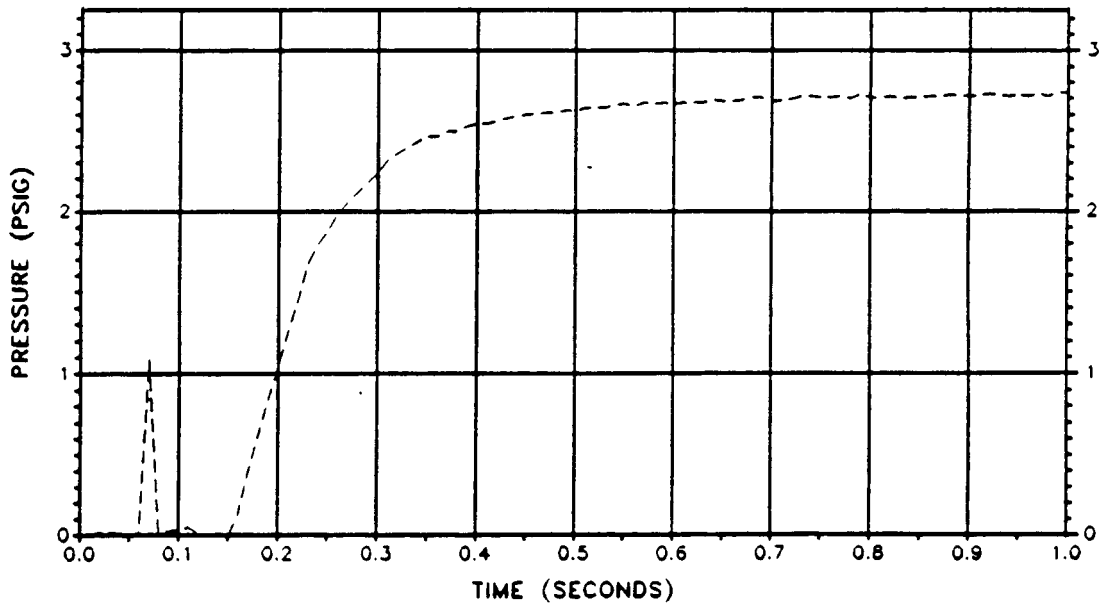
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #9 (Test Date 3/08/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

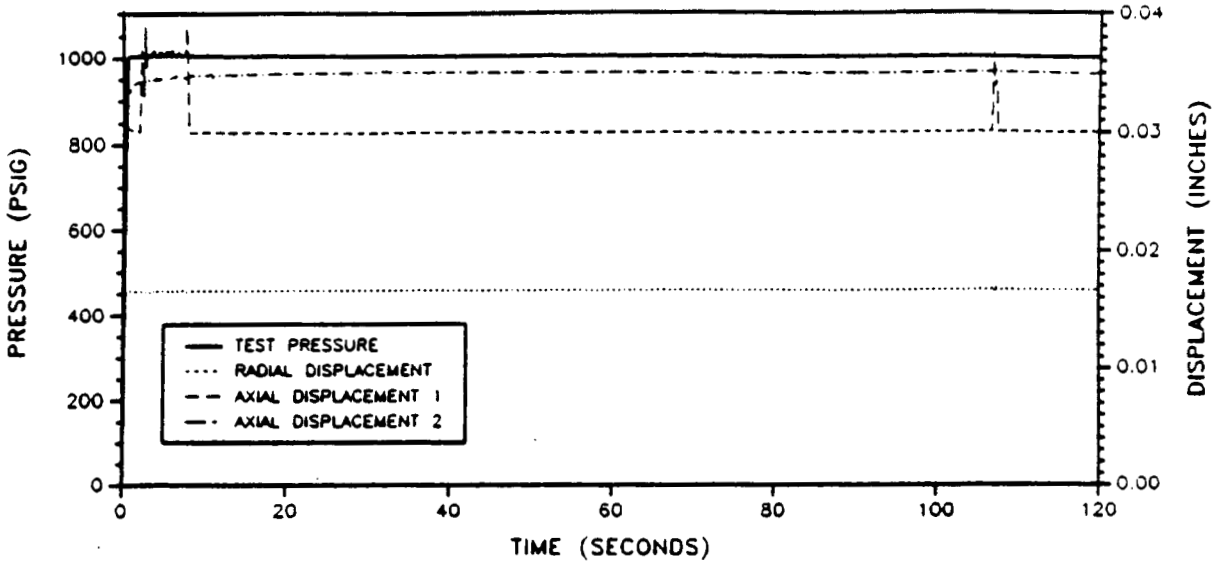


V-4 Cavity Pressure Vs. Time (1 Second Plot)

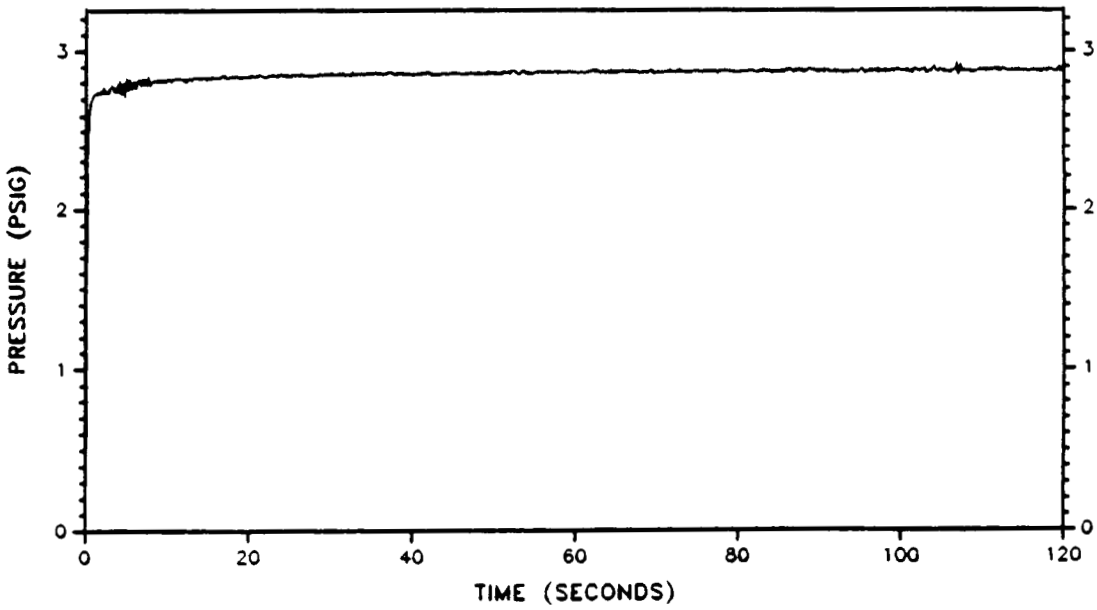


SCENARIO #1, TEST #9 (Test Date 3/08/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I

TEST #: 9-A

ASSEMBLY DATE: 3/6/89

TEST TECHNICIAN: M. Gallier

TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16

PISTON NO.: 63/63

PRIMARY O-RING

O-RING NO.: #21

O-RING INNER DIAMETER (inch): 9.351

O-RING X-SECTION DIAM (inch): 0.2907

O-RING SQUEEZE (%): (AVG.) 17.3

ADJUSTED X-SECT (inch): 0.2854

SECONDARY O-RING

O-RING NO.: #22

O-RING INNER DIAM (inch): 9.367

O-RING X-SECT DIAM (inch): 0.3823

O-RING SQUEEZE: (AVG.) 19.2

ADJUSTED X-SECT (inch): 0.3841

O-RING CONDITIONING

CONDITIONING TEMP.: 114.1 °F

CONDITIONING START TIME: 1 pm 3/7/89 CONDITIONING STOP TIME: 7AM 3/8/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/8/89, 8:30 AM

CONDITIONING TEMP.: 75.0 °F

DATE & TIME OF TEST: 3/8/89, 11:15AM

FIXTURE TEMEPERATURE AT END OF TEST: 76.1 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 13.59 psia

T_1 = 76.2 °F T_2 = 76.2 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.1931 in^3

$\Delta V = V_i - V_f$

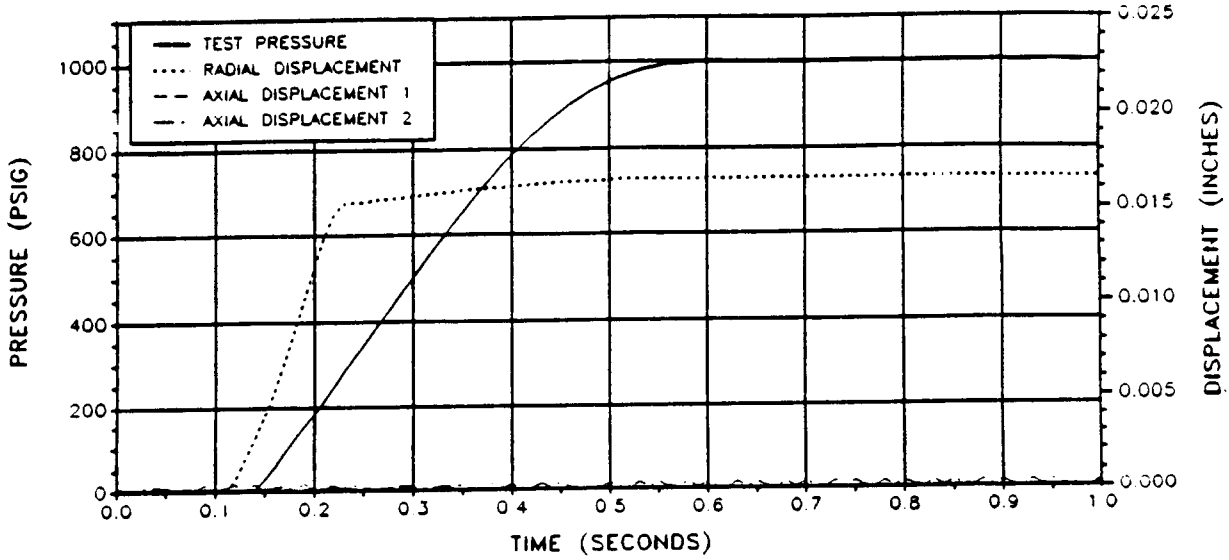
ΔV = 0.1537 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

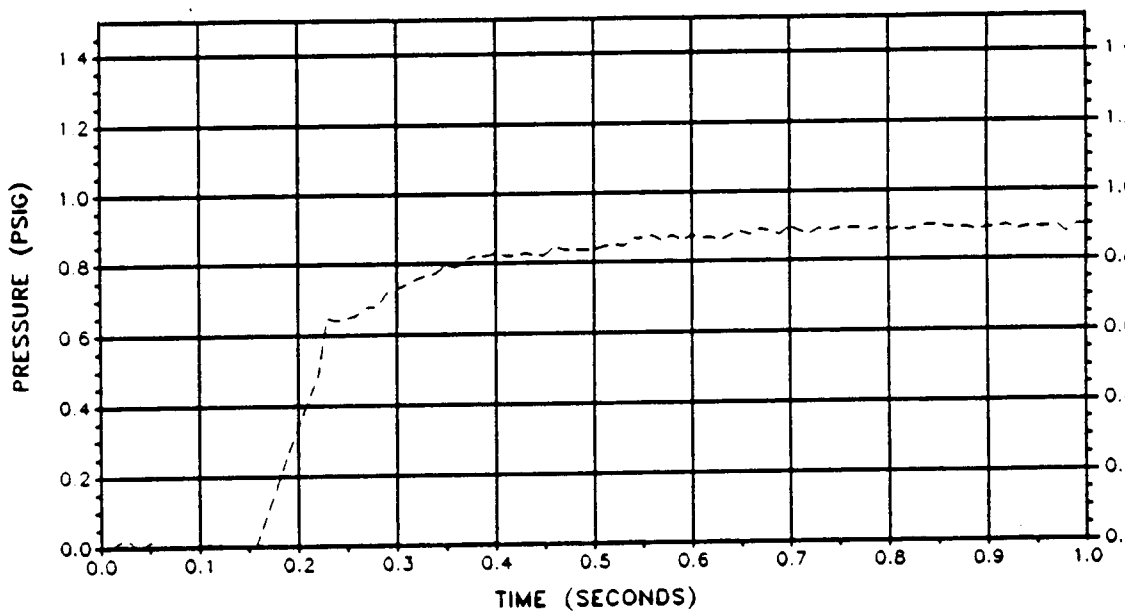
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #9A (Test Date 3/08/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

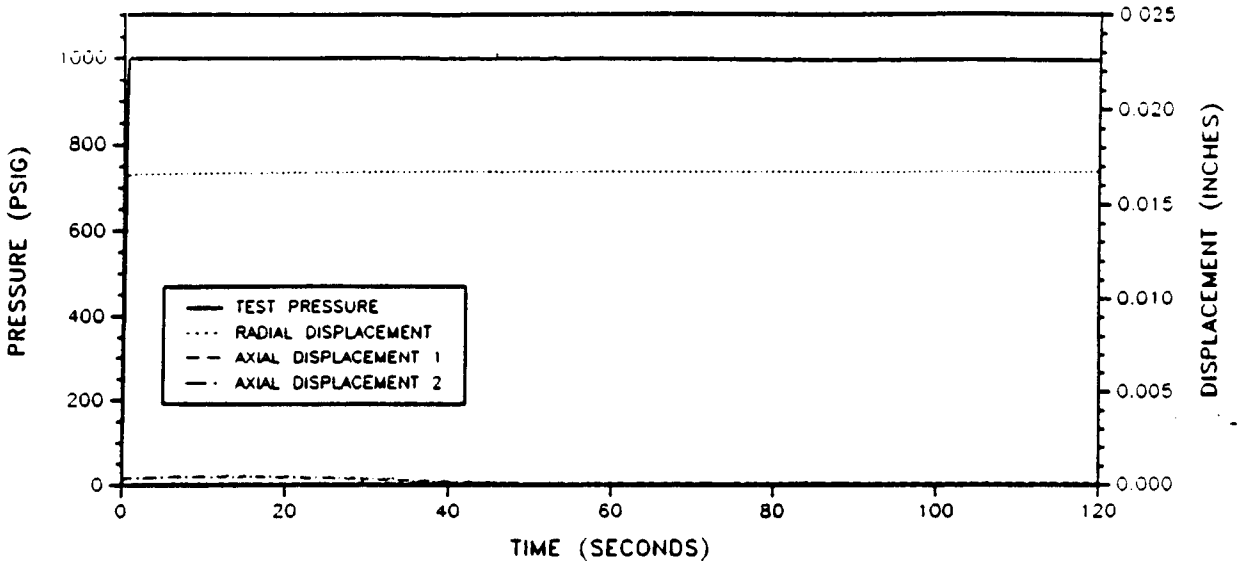


V-4 Cavity Pressure Vs. Time (1 Second Plot)

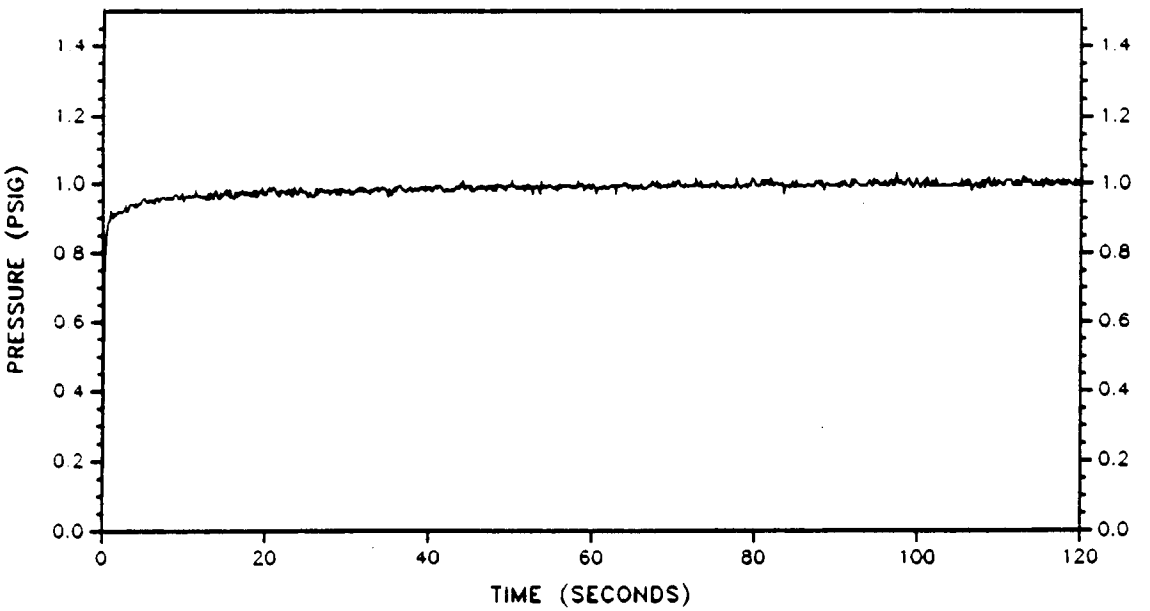


SCENARIO #1, TEST #9A (Test Date 3/08/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
TEST #: 9-B
ASSEMBLY DATE: 3/6/89
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/23

PRIMARY O-RING		SECONDARY O-RING	
O-RING NO.:	#21	O-RING NO.:	#22
O-RING INNER DIAMETER (inch):	9.351	O-RING INNER DIAM (inch):	9.367
O-RING X-SECTION DIAM (inch):	0.2907	O-RING X-SECT DIAM (inch):	0.2893
O-RING SQUEEZE (%): (AVG.)	17.3	O-RING SQUEEZE: (AVG.)	1[illegible].2
ADJUSTED X-SECT (inch):	0.2854	ADJUSTED X-SECT (inch):	0.2841

O-RING CONDITIONING

CONDITIONING TEMP.: 114.1 °F
CONDITIONING START TIME: 1pm 3/7/89
CONDITIONING STOP TIME: 7AM, 3/7/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/8/89, 8:30 AM
CONDITIONING TEMP.: 75.0 °F
DATE & TIME OF TEST: 3/8/89, 11:30 AM
FIXTURE TEMEPERATURE AT END OF TEST: 76.2 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 13.58 psia

T_1 = 76.2 °F T_2 = 76.2 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.1947 in^3

$\Delta V = V_i - V_f$

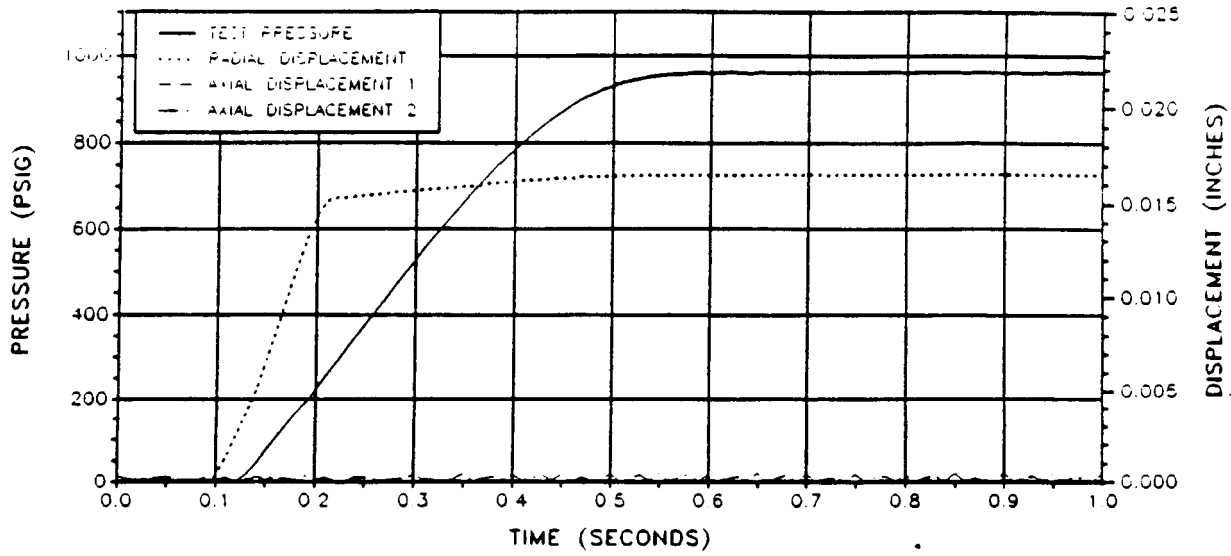
ΔV = 0.1521 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

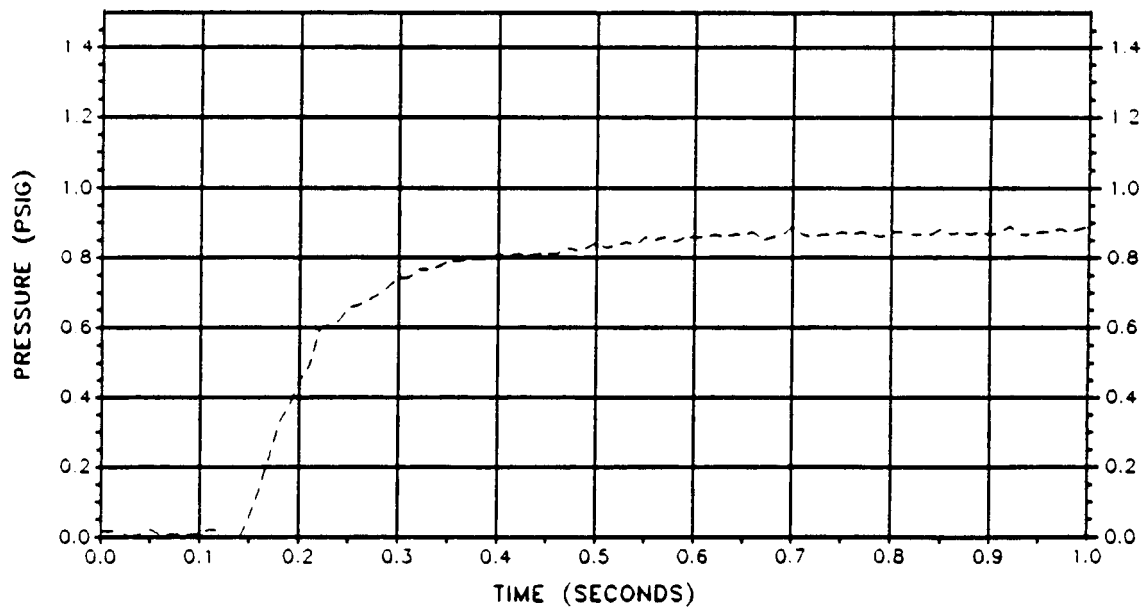
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #9B (Test Date 3/08/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

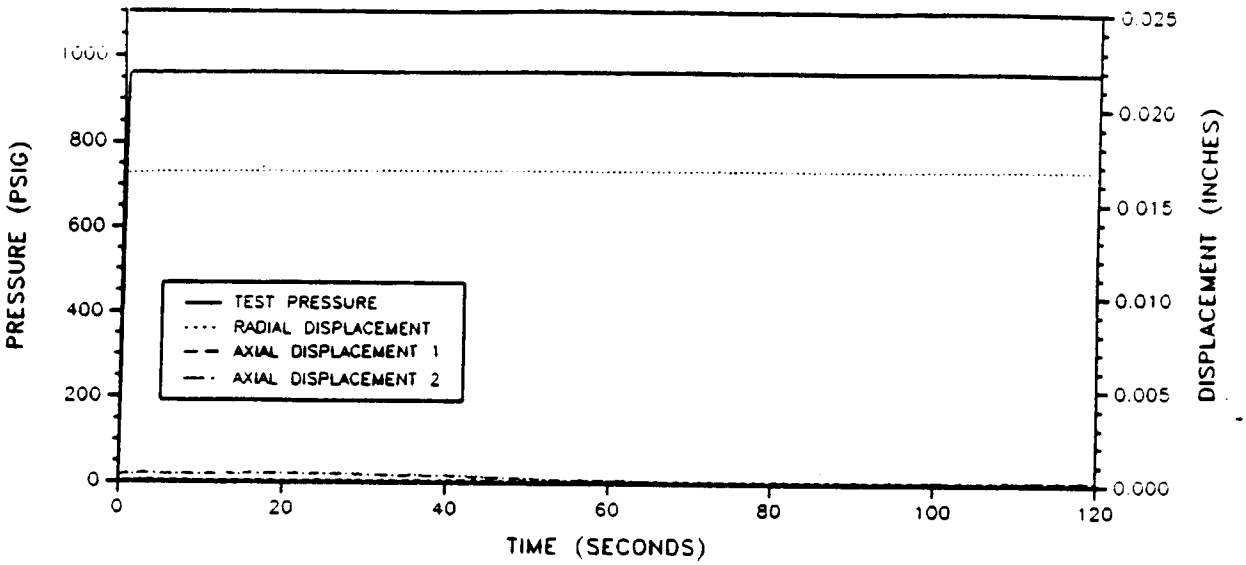


V-4 Cavity Pressure Vs. Time (1 Second Plot)

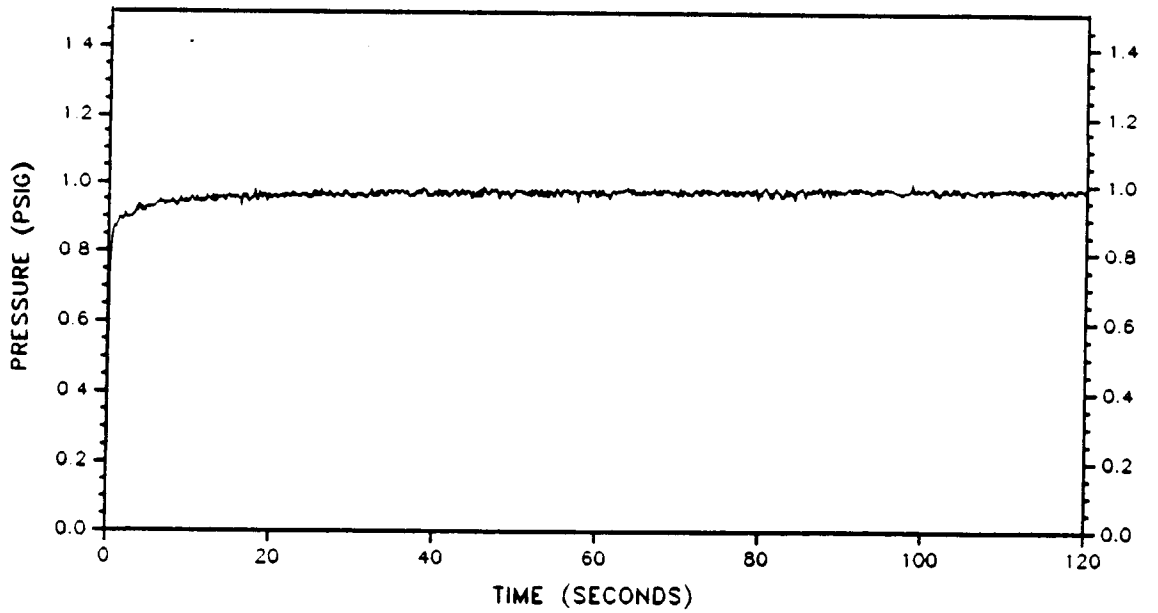


SCENARIO #1, TEST #9B (Test Date 3/08/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
TEST #: 9-C
ASSEMBLY DATE: 3/6/89
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/63

PRIMARY O-RING

O-RING NO.: #21
O-RING INNER DIAMETER (inch): 9.351
O-RING X-SECTION DIAM (inch): 0.2907
O-RING SQUEEZE (%): (AVG.) 17.3
ADJUSTED X-SECT (inch): 0.2854

SECONDARY O-RING

O-RING NO.: #22
O-RING INNER DIAM (inch): 9.367
O-RING X-SECT DIAM (inch): 0.2893
O-RING SQUEEZE: (AVG.) 19.2
ADJUSTED X-SECT (inch): 0.2841

O-RING CONDITIONING

CONDITIONING TEMP.: 114.1 °F
CONDITIONING START TIME: 1 pm 3/7/89
CONDITIONING STOP TIME: 7 AM, 3/8/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/8/89, 8:30 AM
CONDITIONING TEMP.: 75.0 °F
DATE & TIME OF TEST: 3/8/89, 8:30 AM
FIXTURE TEMEPERATURE AT END OF TEST: 75.5 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 15.42 psia

T_1 = 75.4 °F T_2 = 75.5 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 1.9328 in^3

$\Delta V = V_i - V_f$

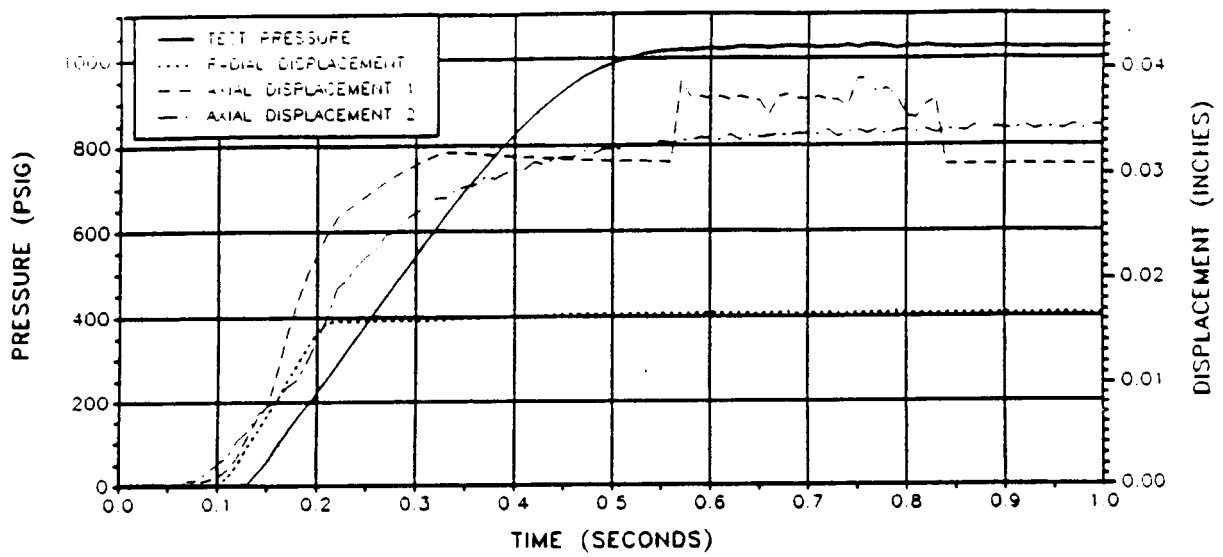
ΔV = 0.4140 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

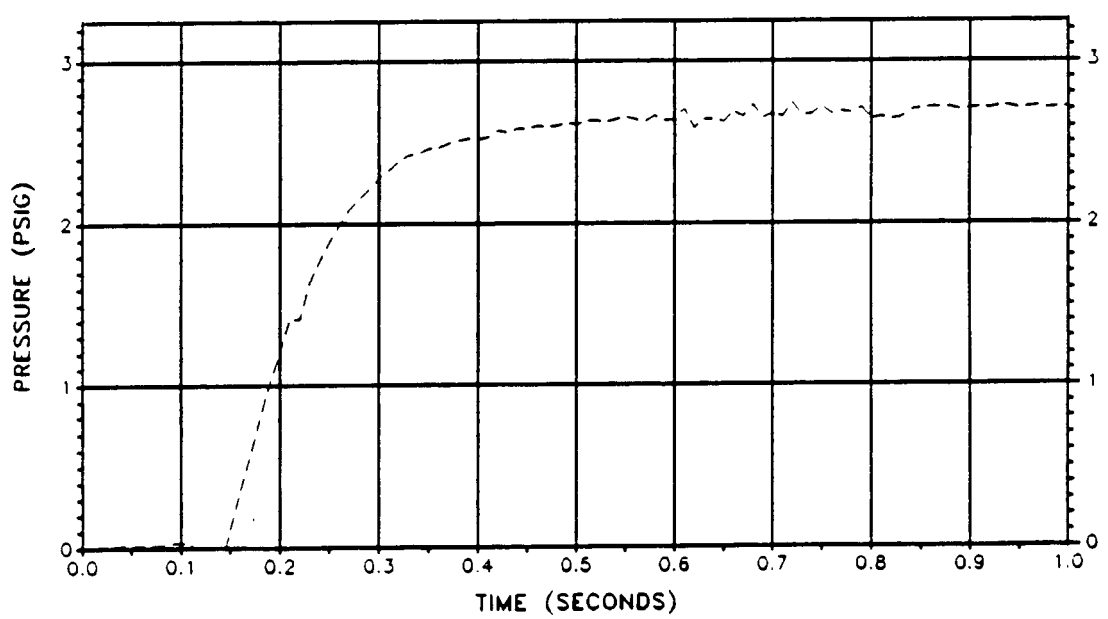
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #9C (Test Date 3/08/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

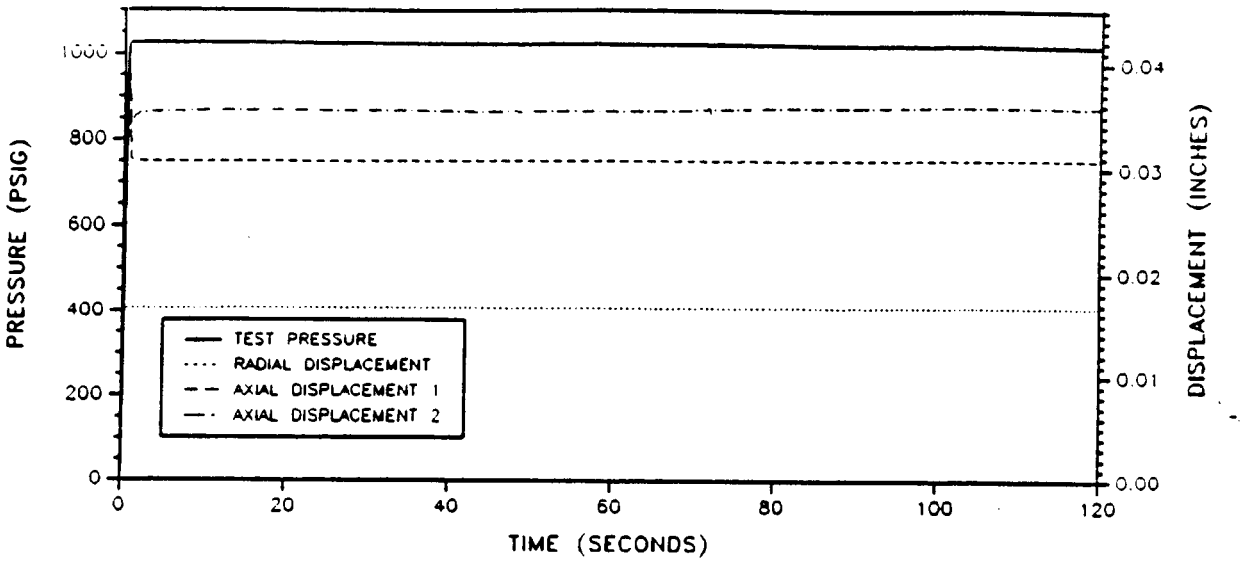


V-4 Cavity Pressure Vs. Time (1 Second Plot)

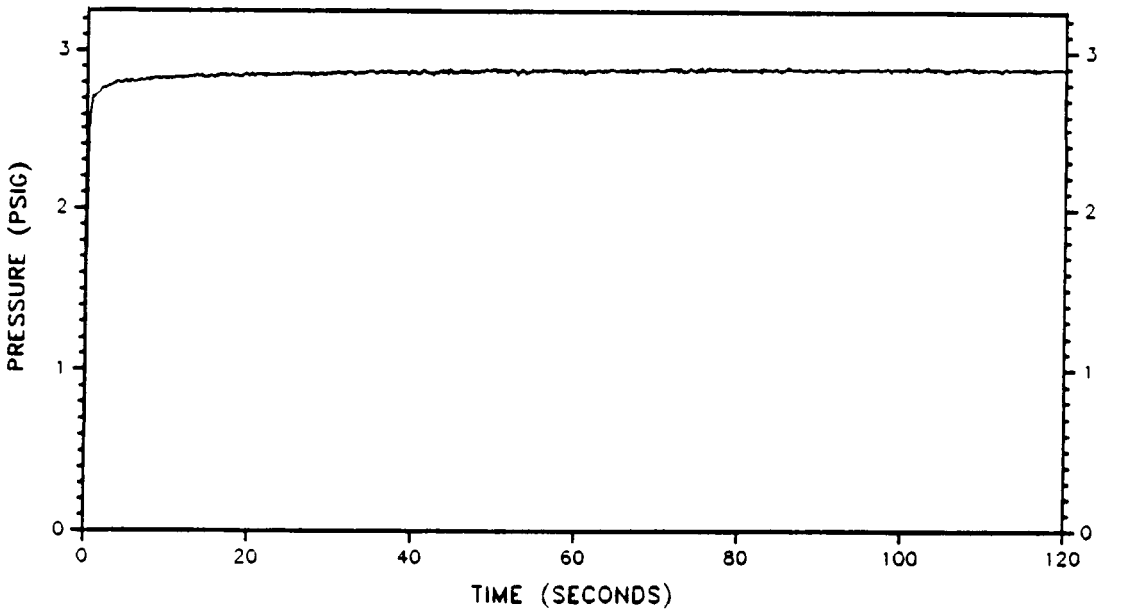


SCENARIO #1, TEST #9C (Test Date 3/08/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
TEST #: 10
ASSEMBLY DATE: 3/9/89
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/63

PRIMARY O-RING		SECONDARY O-RING	
O-RING NO.:	#25	O-RING NO.:	#56
O-RING INNER DIAMETER (inch):	9.385	O-RING INNER DIAM (inch):	9.379
O-RING X-SECTION DIAM (inch):	0.2901	O-RING X-SECT DIAM (inch):	0.2906
O-RING SQUEEZE (%): (AVG.)	17.4	O-RING SQUEEZE: (AVG.)	19.7
ADJUSTED X-SECT (inch):	0.2856	ADJUSTED X-SECT (inch):	0.2856

O-RING CONDITIONING

CONDITIONING TEMP.: 112.2 °F
CONDITIONING START TIME: 2:30 pm 3/9/89
CONDITIONING STOP TIME: 7 AM, 3/10/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/10/89, 8:30 AM
CONDITIONING TEMP.: 76.0 °F
DATE & TIME OF TEST: 3/10/89, 10:45 AM
FIXTURE TEMEPERATURE AT END OF TEST: 76.3 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 15.36 psia

T_1 = 76.3 °F T_2 = 76.3 °F (at 60 Seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 1.9404 in^3

$\Delta V = V_i - V_f$

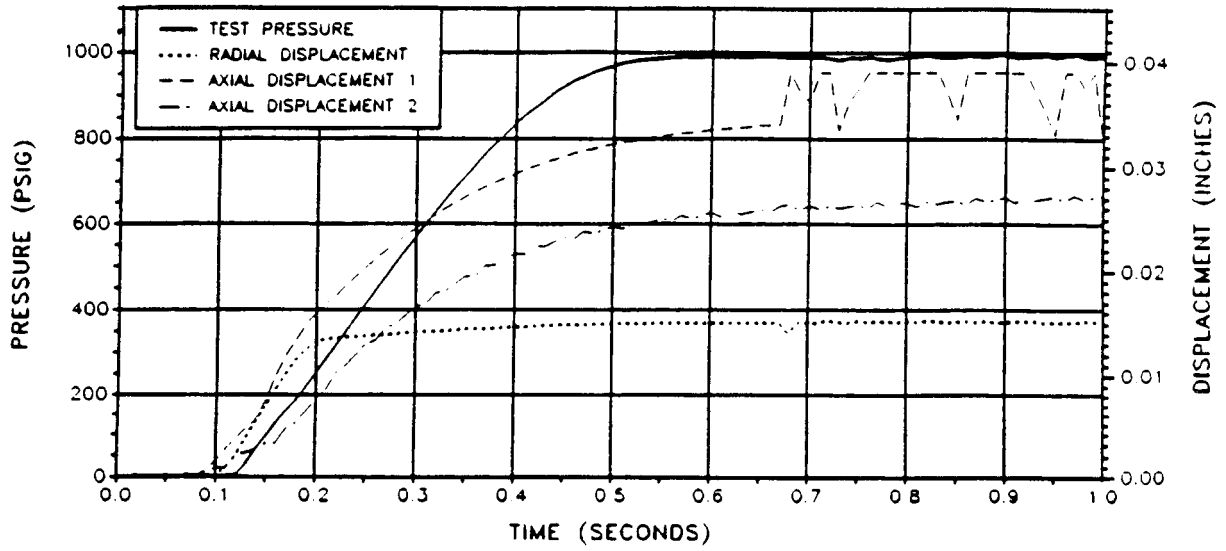
ΔV = 0.4064 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

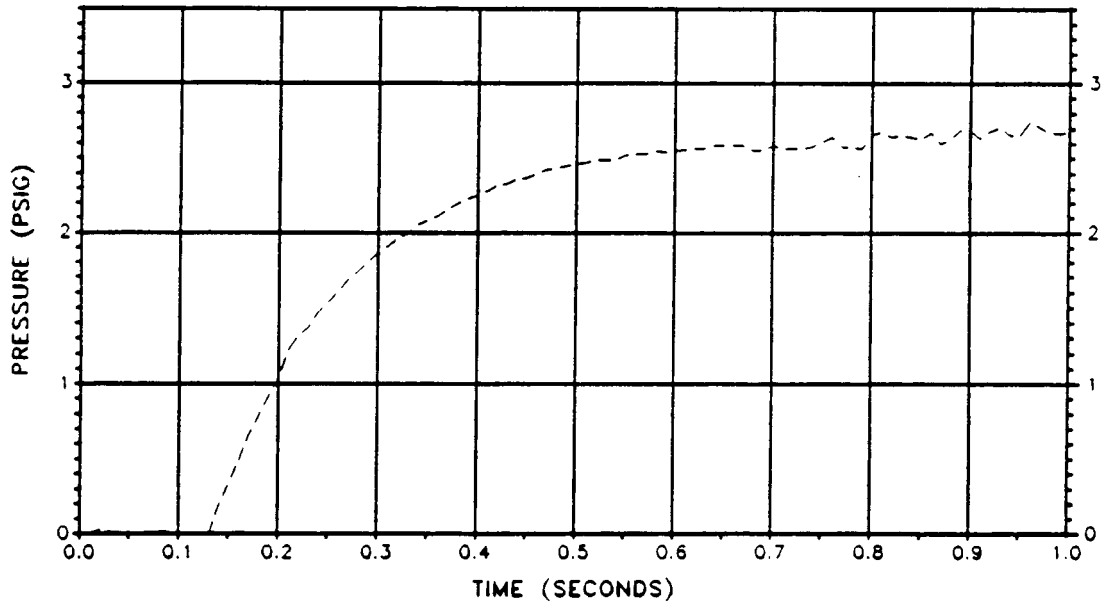
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #10 (Test Date 3/10/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

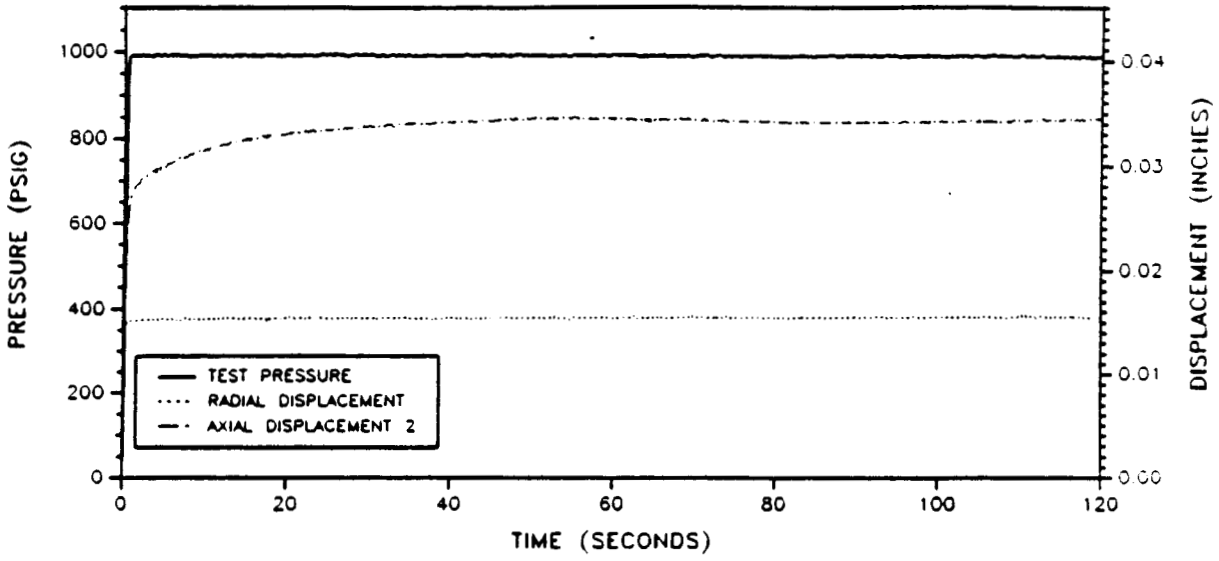


V-4 Cavity Pressure Vs. Time (1 Second Plot)

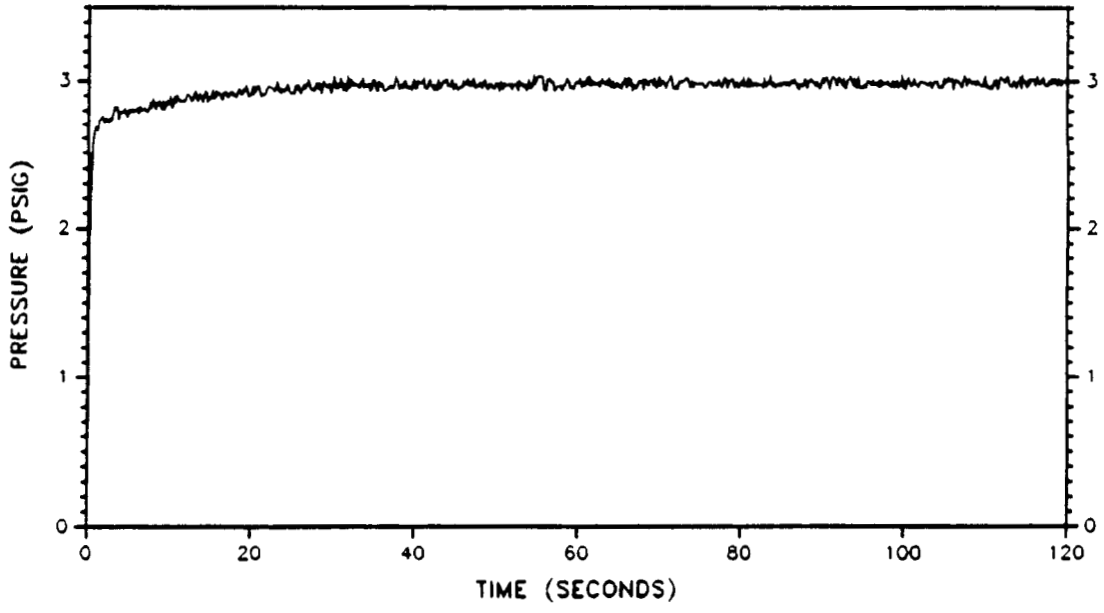


SCENARIO #1, TEST #10 (Test Date 3/10/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
TEST #: 10-A
ASSEMBLY DATE: 3/9/89
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/63

PRIMARY O-RING		SECONDARY O-RING	
O-RING NO.:	#25	O-RING NO.:	#26
O-RING INNER DIAMETER (inch):	9.385	O-RING INNER DIAM (inch):	9.379
O-RING X-SECTION DIAM (inch):	0.2901	O-RING X-SECT DIAM (inch):	0.2906
O-RING SQUEEZE (%): (AVG.)	17.4	O-RING SQUEEZE: (AVG.)	19.7
ADJUSTED X-SECT (inch):	0.2856	ADJUSTED X-SECT (inch):	0.2856

O-RING CONDITIONING

CONDITIONING TEMP.: 112.2 °F
CONDITIONING START TIME: 1:30 pm 3/9/89
CONDITIONING STOP TIME: 7 AM, 3/10/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/10/89, 8:30 AM
CONDITIONING TEMP.: 76.0 °F
DATE & TIME OF TEST: 3/10/89, 10:15 AM
FIXTURE TEMEPERATURE AT END OF TEST: 76.4 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 13.63 psia

T_1 = 76.3 °F T_2 = 76.4 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.1895 in^3

$\Delta V = V_i - V_f$

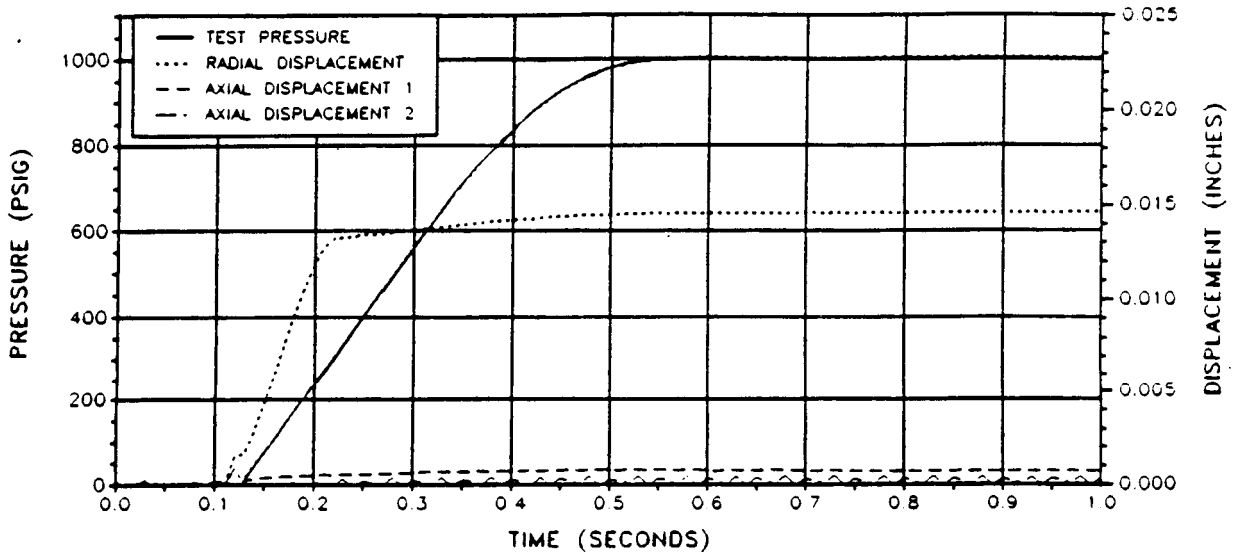
ΔV = 0.1573 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

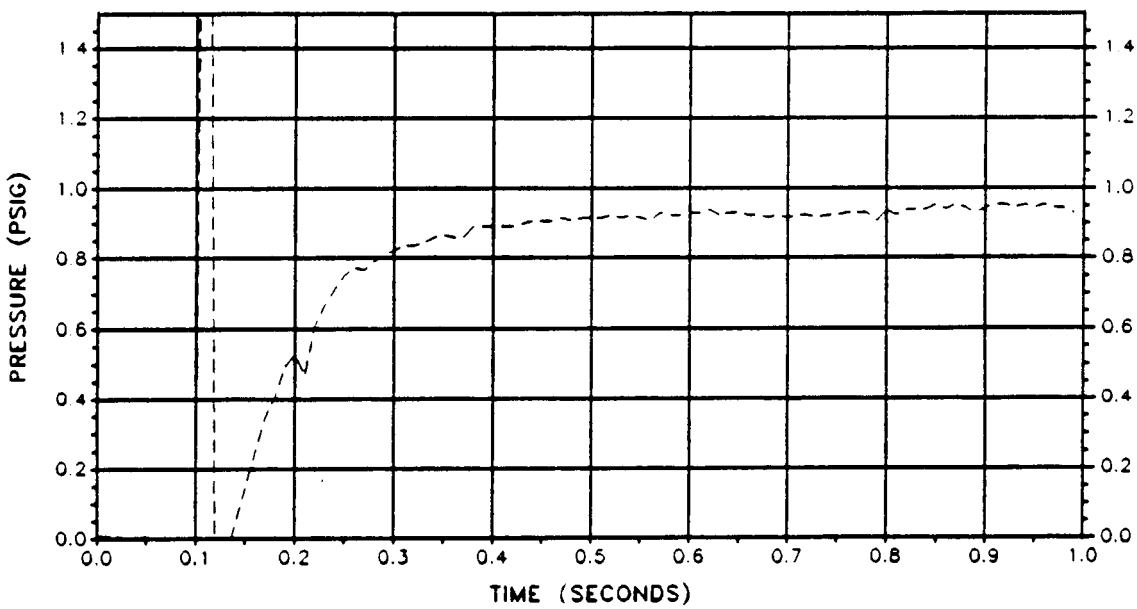
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #10A (Test Date 3/10/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

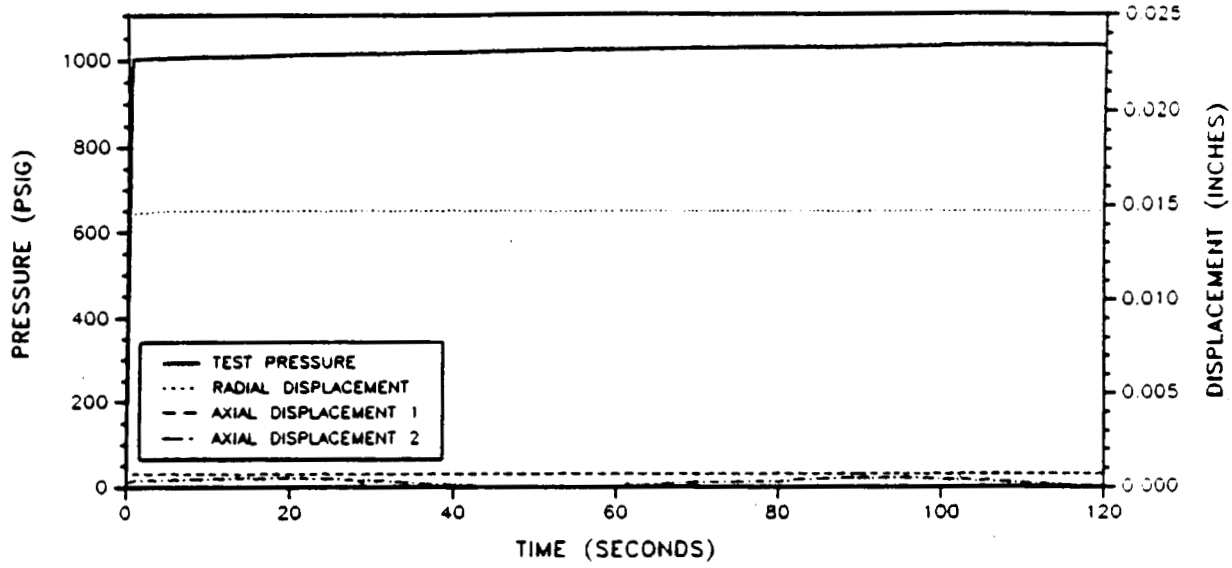


V-4 Cavity Pressure Vs. Time (1 Second Plot)

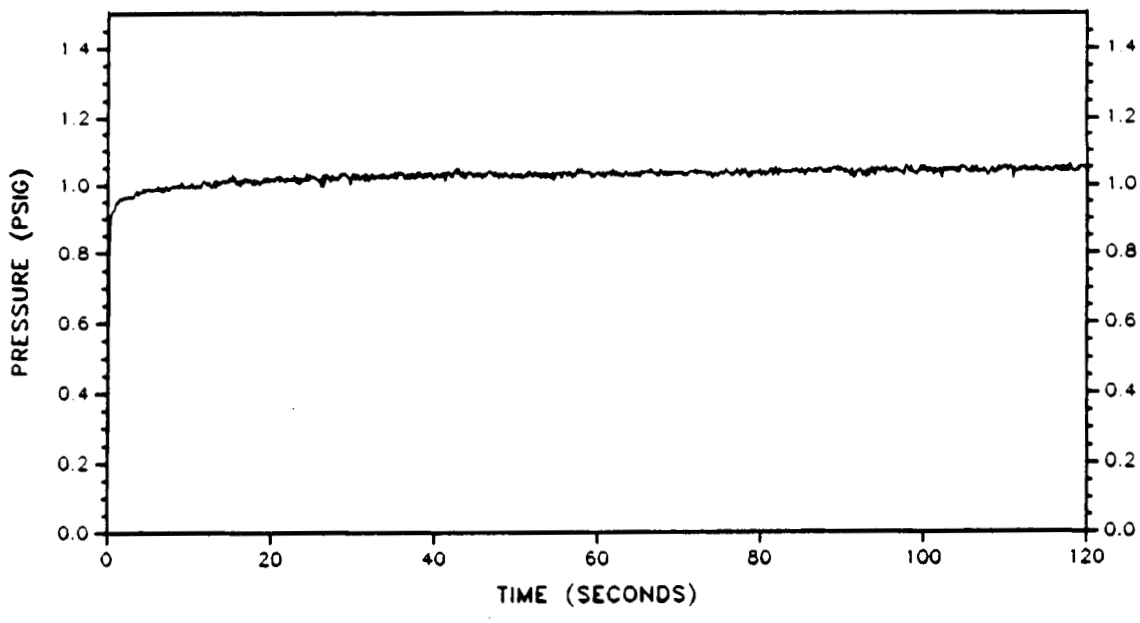


SCENARIO #1, TEST #10A (Test Date 3/10/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
TEST #: 10-B
ASSEMBLY DATE: 3/9/89
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/63

PRIMARY O-RING		SECONDARY O-RING	
O-RING NO.:	#25	O-RING NO.:	#26
O-RING INNER DIAMETER (inch):	9.385	O-RING INNER DIAM (inch):	9.379
O-RING X-SECTION DIAM (inch):	0.2901	O-RING X-SECT DIAM (inch):	0.2906
O-RING SQUEEZE (%): (AVG.)	17.4	O-RING SQUEEZE: (AVG.)	19.7
ADJUSTED X-SECT (inch):	0.2856	ADJUSTED X-SECT (inch):	0.2856

O-RING CONDITIONING

CONDITIONING TEMP.: 112.2 °F

CONDITIONING START TIME: 2:30 pm 3/9/89
CONDITIONING STOP TIME: 7 AM, 3/10/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/10/89, 8:30 AM

CONDITIONING TEMP.: 76.0 °F

DATE & TIME OF TEST: 3/10/89,

FIXTURE TEMEPERATURE AT END OF TEST: 76.3 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 13.63 psia

T_1 = 76.3 °F T_2 = 76.3 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.1867 in^3

$\Delta V = V_i - V_f$

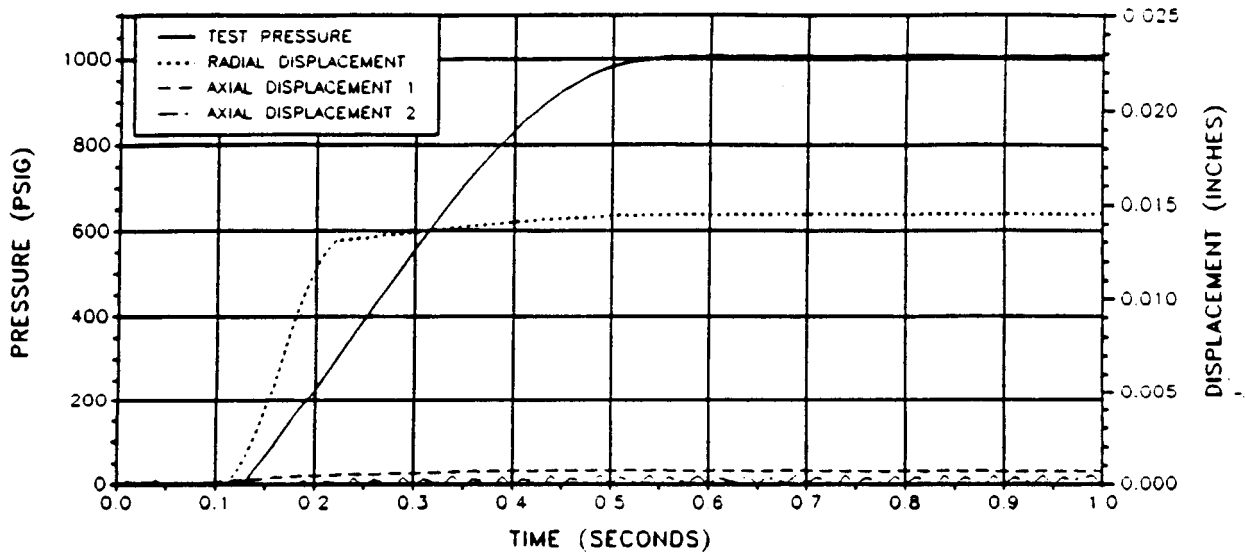
ΔV = 0.1601 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

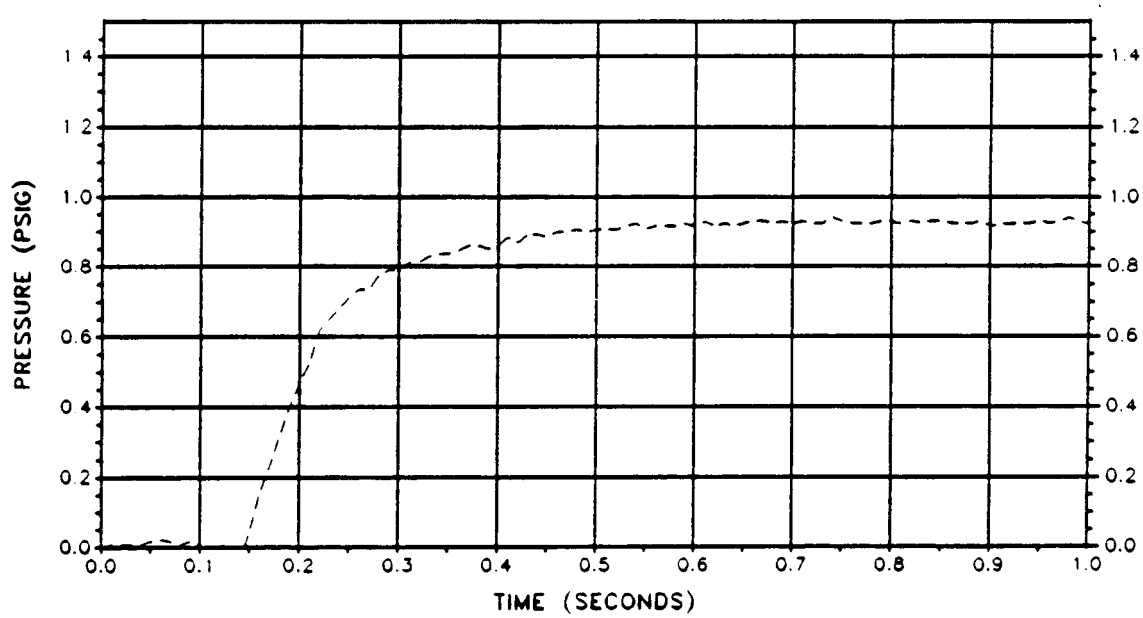
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #10B (Test Date 3/10/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

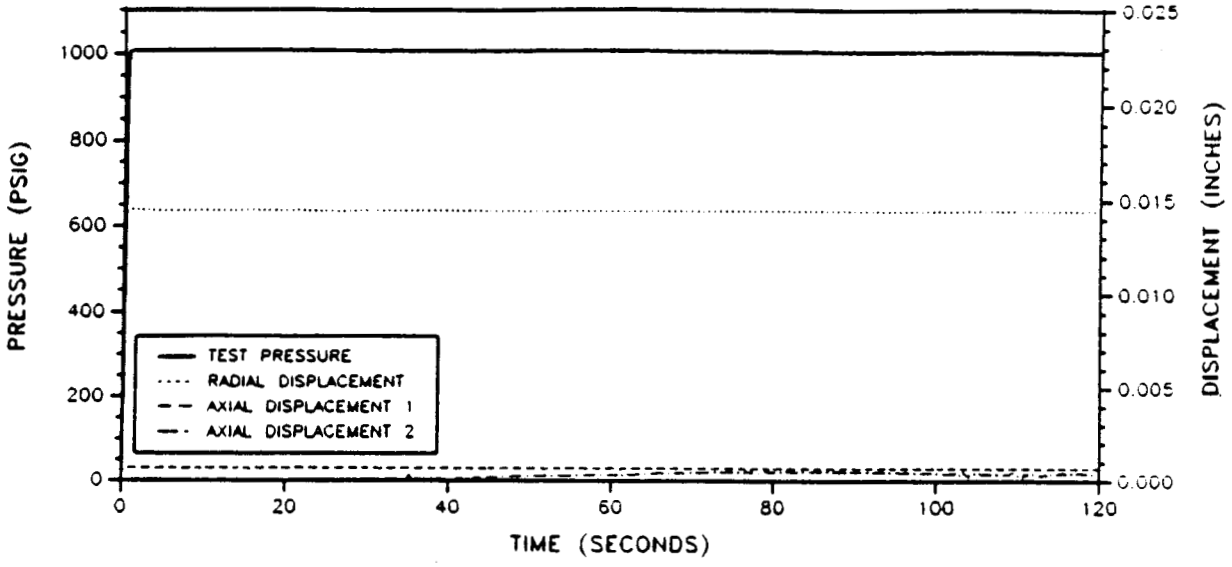


V-4 Cavity Pressure Vs. Time (1 Second Plot)

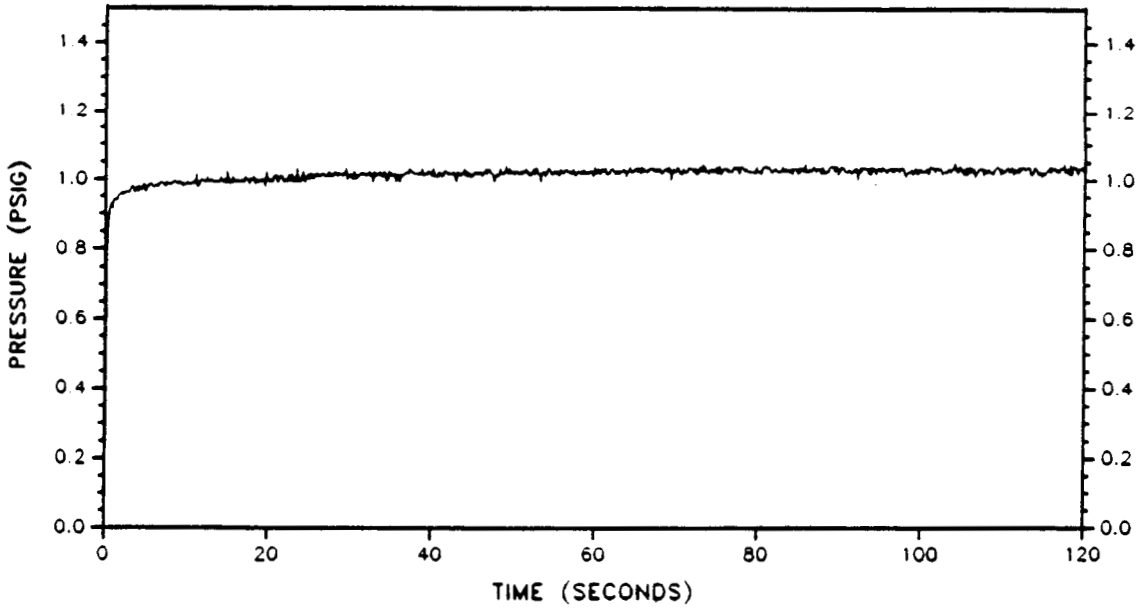


SCENARIO #1, TEST #10B (Test Date 3/10/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
TEST #: 10-C
ASSEMBLY DATE: 3/9/89
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Harrison

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/16

PRIMARY O-RING

O-RING NO.: #25
O-RING INNER DIAMETER (inch): 9.385
O-RING X-SECTION DIAM (inch): 0.2901
O-RING SQUEEZE (%): (AVG.) 17.4
ADJUSTED X-SECT (inch): 0.2756

SECONDARY O-RING

O-RING NO.: #26
O-RING INNER DIAM (inch): 9.379
O-RING X-SECT DIAM (inch): 0.2906
O-RING SQUEEZE: (AVG.) 17.7
ADJUSTED X-SECT (inch): 0.2756

O-RING CONDITIONING

CONDITIONING TEMP.: 112.2 °F
CONDITIONING START TIME: 2:30pm 3/9/89
CONDITIONING STOP TIME: 7 AM, 3/10 89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/10/89, 8:30 AM
CONDITIONING TEMP.: 76.0 °F
DATE & TIME OF TEST: 3/10/89,
FIXTURE TEMEPERATURE AT END OF TEST: 76.3 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 15.75 psia

T_1 = 76.3 °F T_2 = 76.3 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 1.8923 in^3

$\Delta V = V_i - V_f$

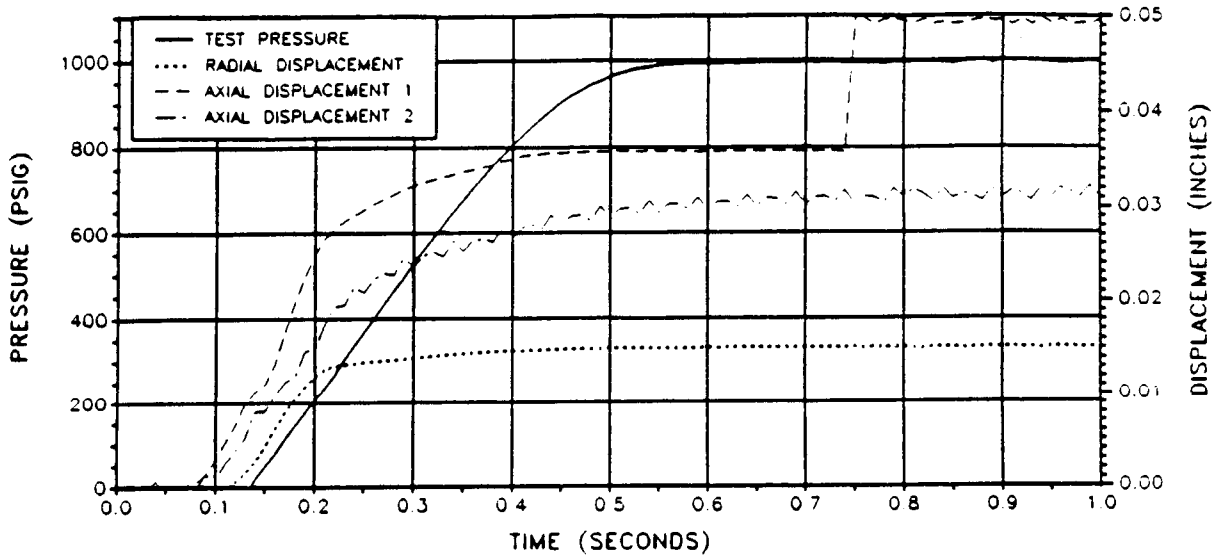
ΔV = 0.4545 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

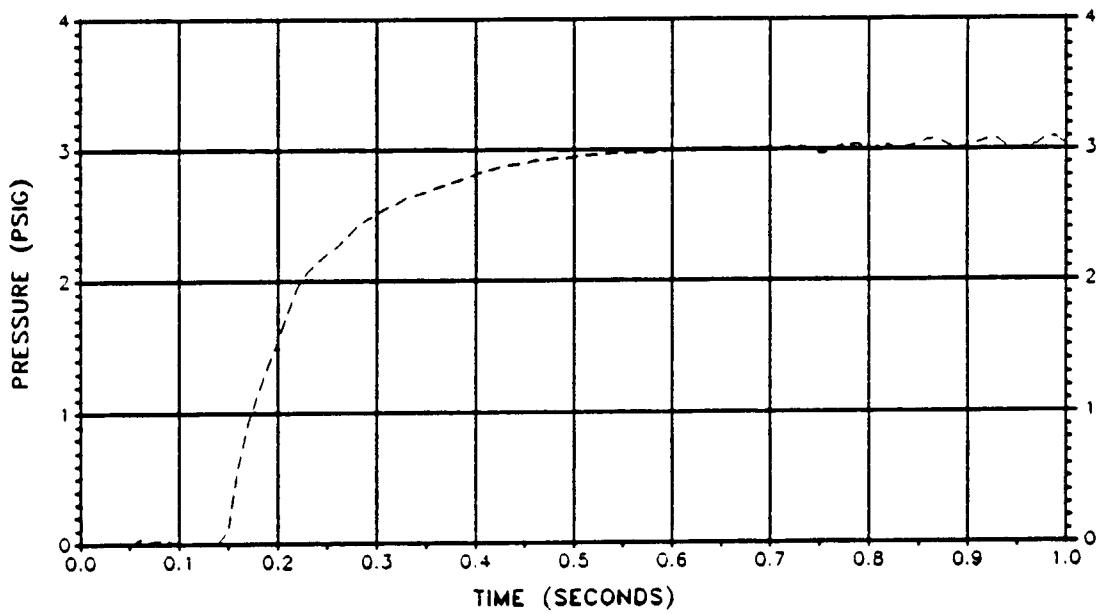
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #10C (Test Date 3/10/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

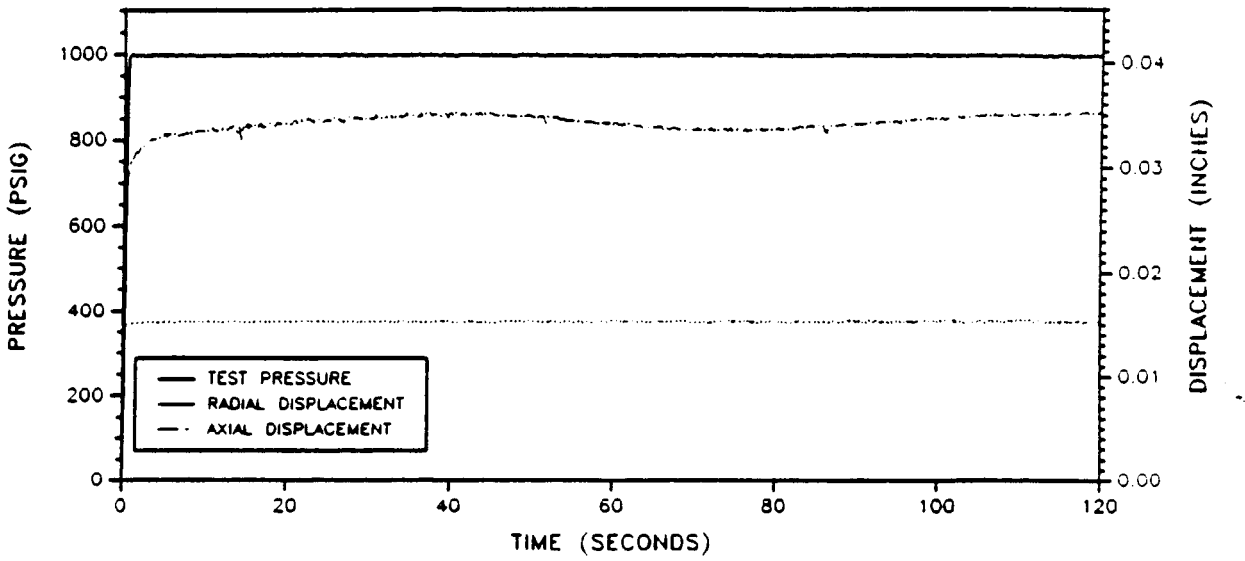


V-4 Cavity Pressure Vs. Time (1 Second Plot)

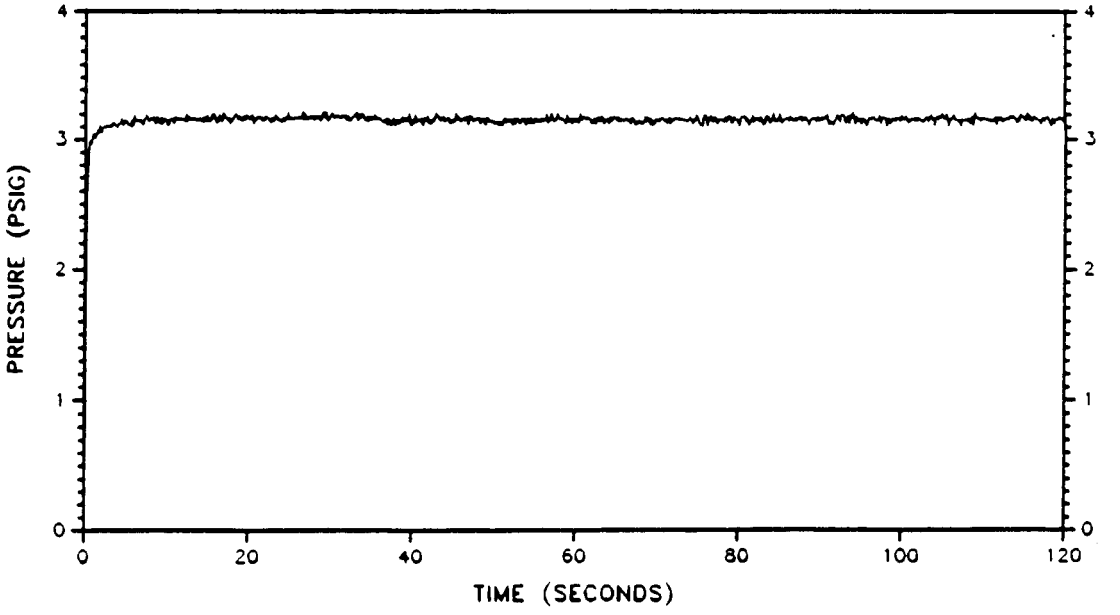


SCENARIO #1, TEST #10C (Test Date 3/10/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
TEST #: 11
ASSEMBLY DATE: 3/13/89
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/62

PRIMARY O-RING		SECONDARY O-RING	
O-RING NO.:	#27	O-RING NO.:	#28
O-RING INNER DIAMETER (inch):	9.391	O-RING INNER DIAM (inch):	9.374
O-RING X-SECTION DIAM (inch):	0.2892	O-RING X-SECT DIAM (inch):	0.2917
O-RING SQUEEZE (%): (AVG.)	17.1	O-RING SQUEEZE: (AVG.)	19.9
ADJUSTED X-SECT (inch):	0.2848	ADJUSTED X-SECT (inch):	0.2866

O-RING CONDITIONING

CONDITIONING TEMP.: 112.3 °F

CONDITIONING START TIME: 3pm, 3/13/89 CONDITIONING STOP TIME: 7 AM, 3/14/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/14/89, 8:30AM

CONDITIONING TEMP.: 76.0 °F

DATE & TIME OF TEST: 3/14/89, 11:40 AM

FIXTURE TEMEPERATURE AT END OF TEST: 75.9 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 23468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 15.16 psia

T_1 = 75.9 °F T_2 = 75.9 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 1.9660 in^3

$\Delta V = V_i - V_f$

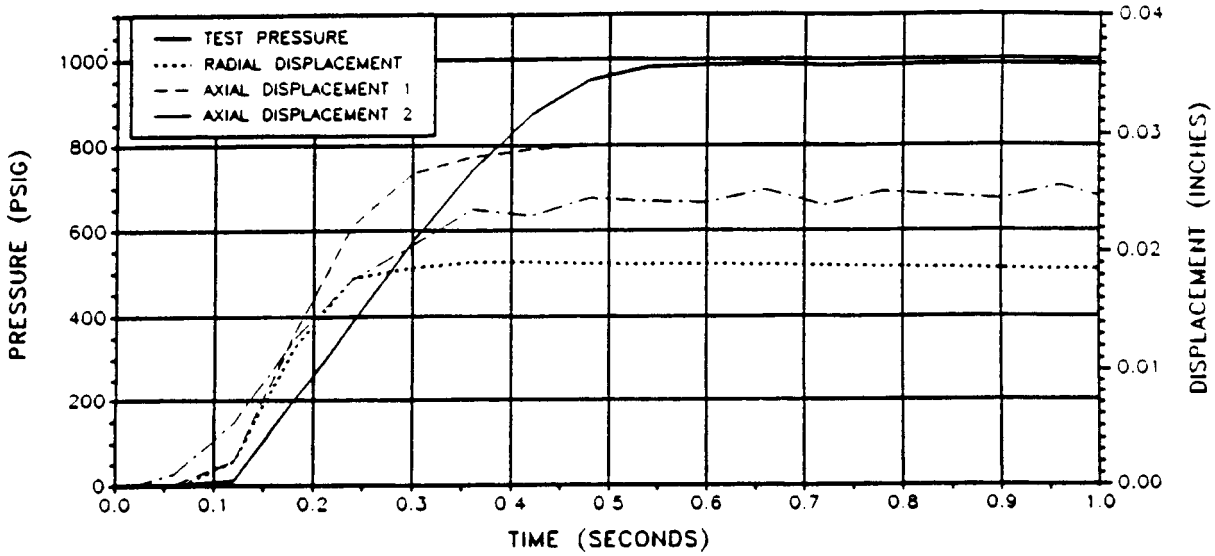
ΔV = 0.3809 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

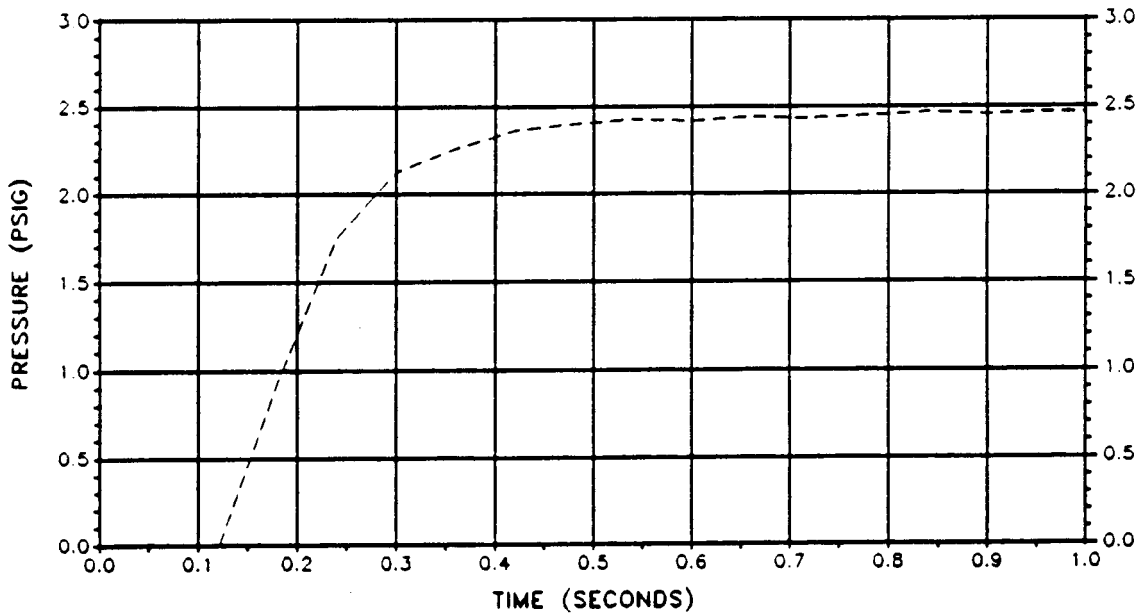
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #11 (Test Date 3/14/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

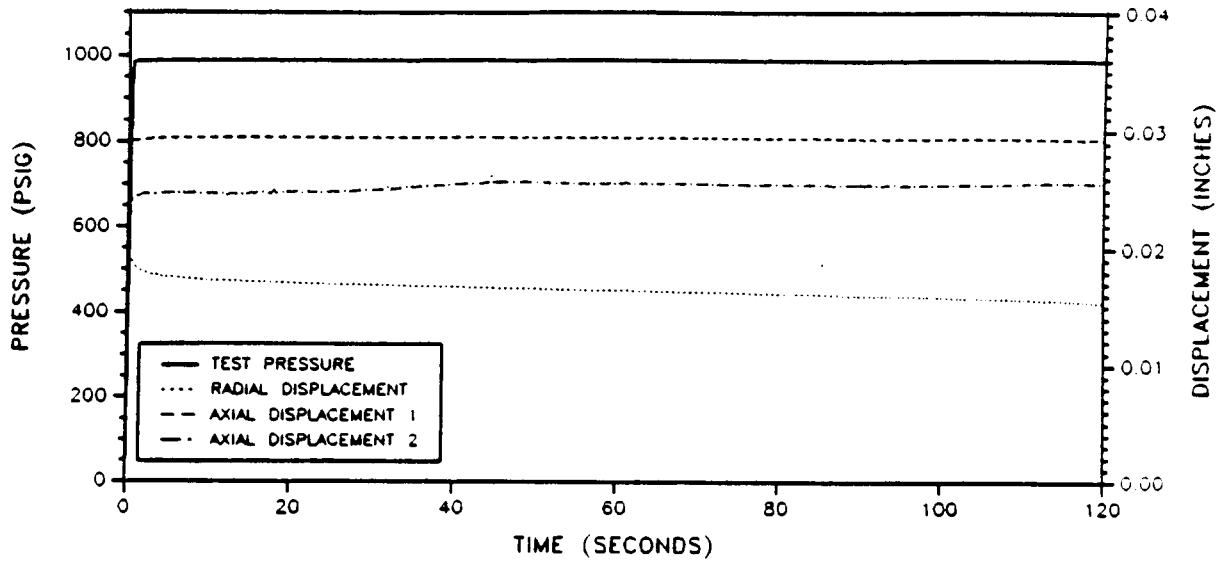


V-4 Cavity Pressure Vs. Time (1 Second Plot)

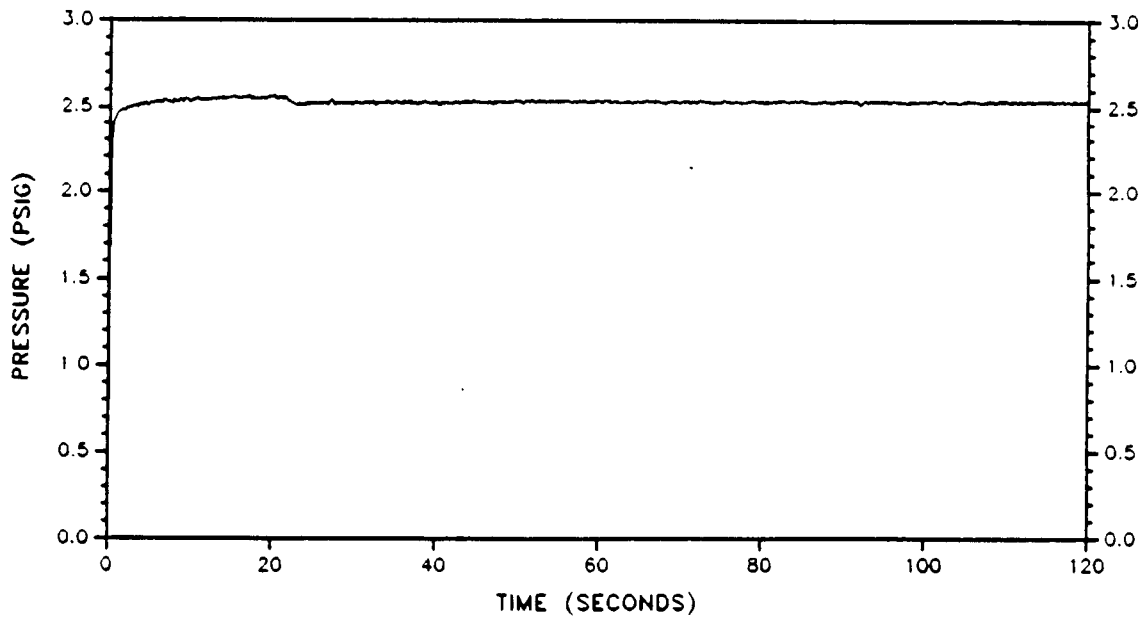


SCENARIO #1, TEST #11 (Test Date 3/14/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
TEST #: 11-A
ASSEMBLY DATE: 3/13/89
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: [illegible]3

PRIMARY O-RING

O-RING NO.: #27
O-RING INNER DIAMETER (inch): 9.391
O-RING X-SECTION DIAM (inch): 0.2872
O-RING SQUEEZE (%): (AVG.) 17.1
ADJUSTED X-SECT (inch): 0.2848

SECONDARY O-RING

O-RING NO.: #28
O-RING INNER DIAM (inch): 9.374
O-RING X-SECT DIAM (inch): 0.2917
O-RING SQUEEZE: (AVG.) 19.9
ADJUSTED X-SECT (inch): 0.2866

O-RING CONDITIONING

CONDITIONING TEMP.: 112.3 °F
CONDITIONING START TIME: 3:00 PM 3/13/89
CONDITIONING STOP TIME: 7 AM 3/14/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/14/89, 8:30 AM
CONDITIONING TEMP.: 76.0 °F
DATE & TIME OF TEST: 3/14/89, 10:40 AM
FIXTURE TEMEPERATURE AT END OF TEST: 75.4 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 13.54 psia

T_1 = 75.3 °F T_2 = 75.4 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.204 in^3

$\Delta V = V_i - V_f$

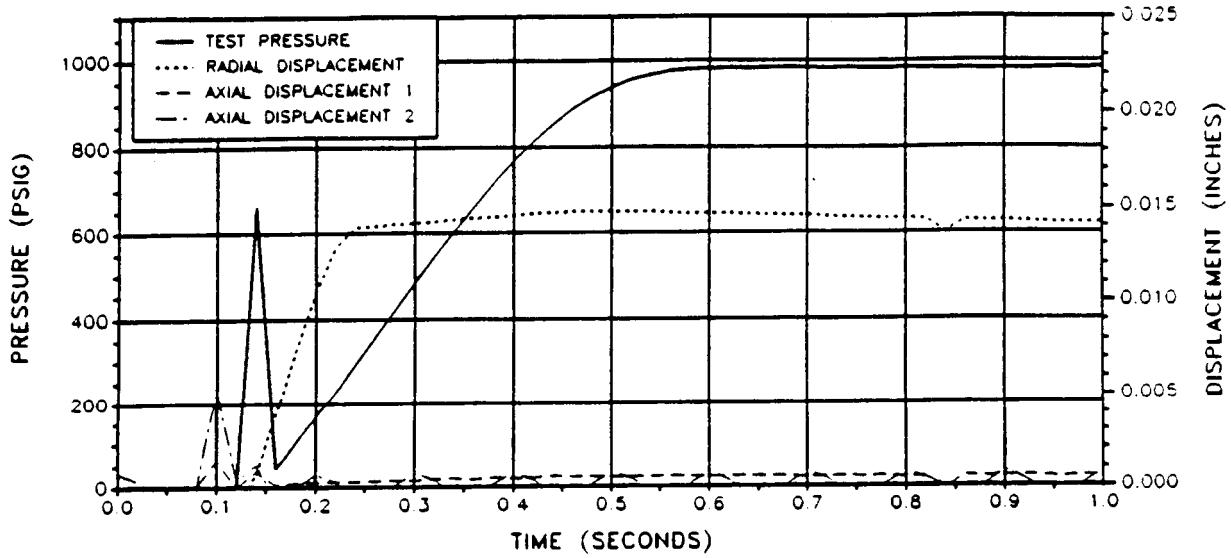
ΔV = 0.1428 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

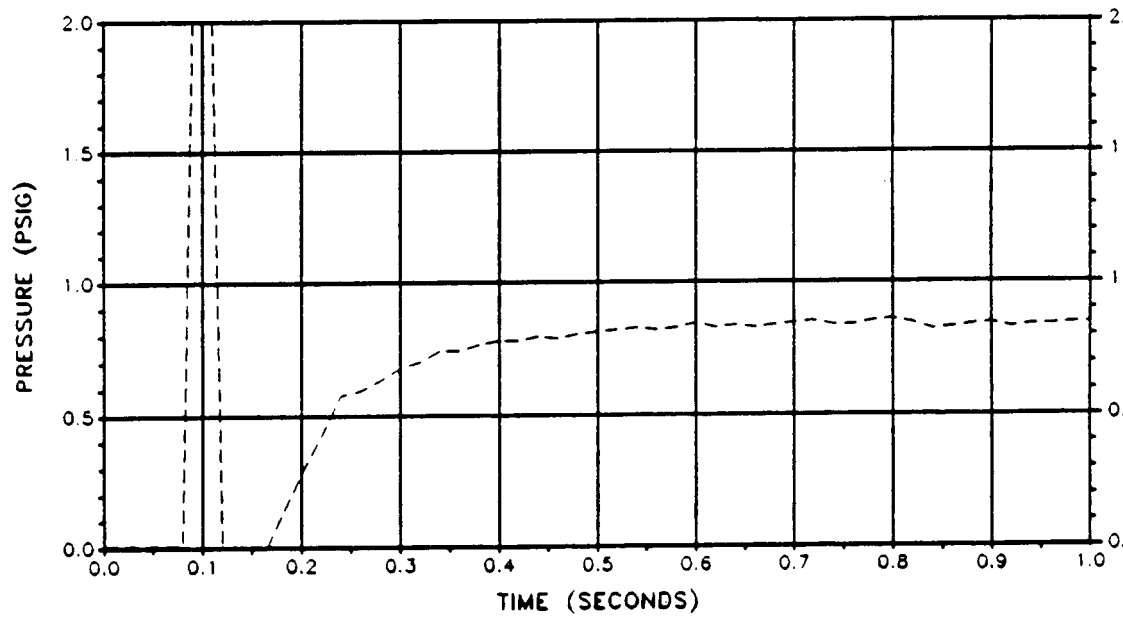
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #11A (Test Date 3/14/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

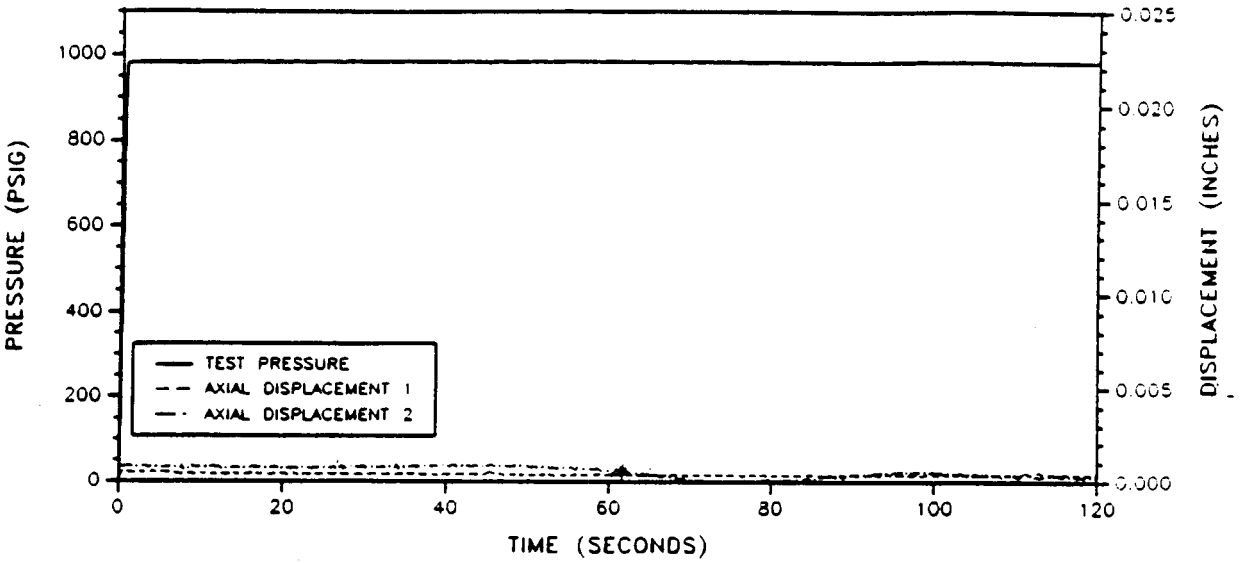


V-4 Cavity Pressure Vs. Time (1 Second Plot)

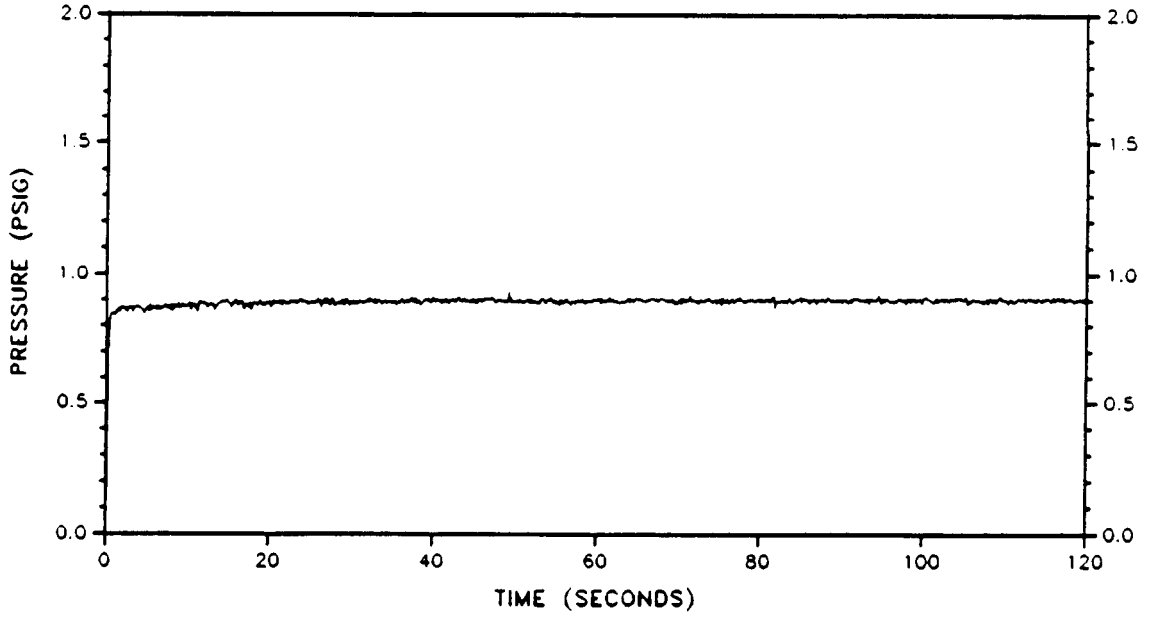


SCENARIO #1, TEST #11A (Test Date 3/14/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
TEST #: 11-AA
ASSEMBLY DATE: 3/13/89
TEST TECHNICIAN: M [illegible]
TEST SUPERVISOR: T. [illegible]

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 6[illegible] 63

PRIMARY O-RING		SECONDARY O-RING	
O-RING NO.:	#27	O-RING NO.:	#28
O-RING INNER DIAMETER (inch):	9.391	O-RING INNER DIAM (inch):	9.374
O-RING X-SECTION DIAM (inch):	0.2892	O-RING X-SECT DIAM (inch):	0.2917
O-RING SQUEEZE (%): (AVG.)	17.1	O-RING SQUEEZE: (AVG.)	19.9
ADJUSTED X-SECT (inch):	0.2848	ADJUSTED X-SECT (inch):	0.2866

O-RING CONDITIONING

CONDITIONING TEMP.: 112.3 °F
CONDITIONING START TIME: 3 PM 3/13/89
CONDITIONING STOP TIME: 7AM 3/14/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/14/89, 8:30 AM
CONDITIONING TEMP.: 76.0 °F
DATE & TIME OF TEST: 3/14/89, 11:15 AM
FIXTURE TEMEPERATURE AT END OF TEST: _____ °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 13.54 psia

T_1 = 75.3 °F T_2 = 75.4 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.1835 in^3

$\Delta V = V_i - V_f$

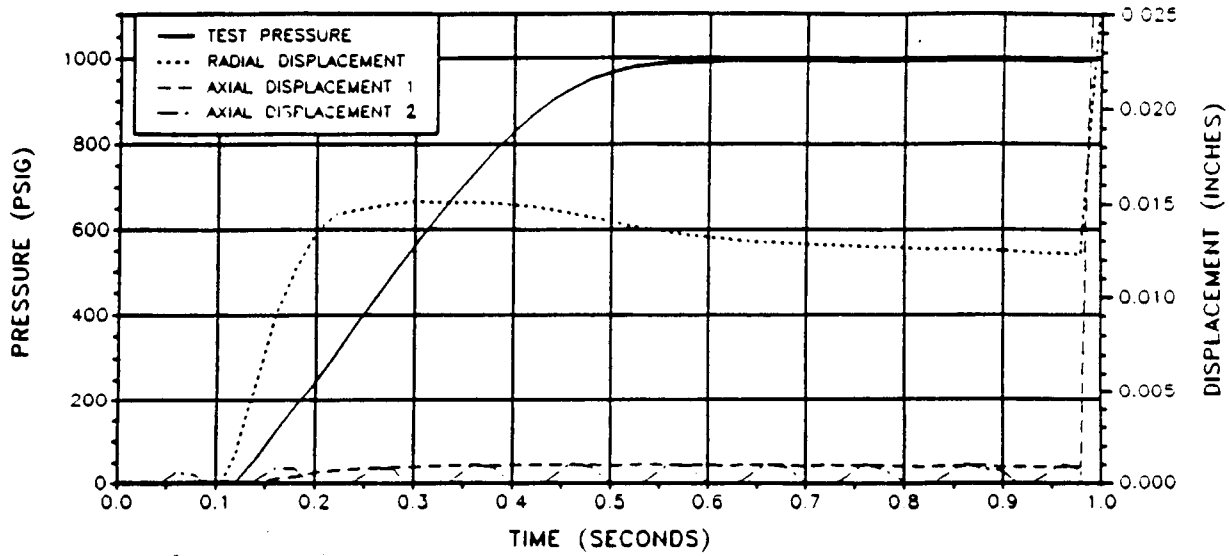
ΔV = 0.1633 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

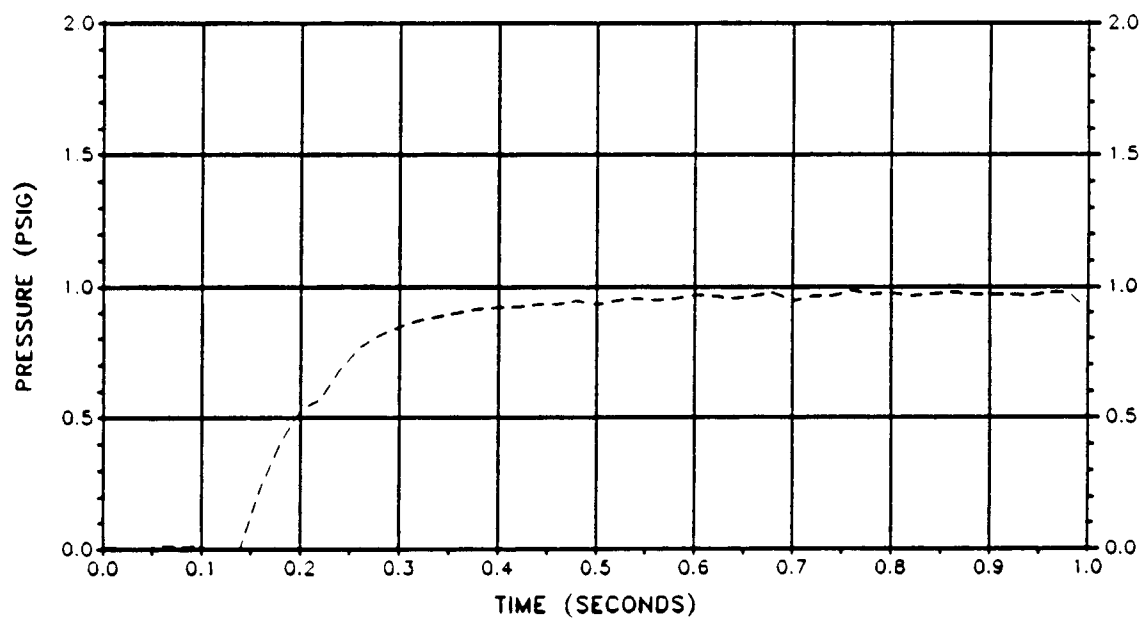
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #11AA (Test Date 3/14/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

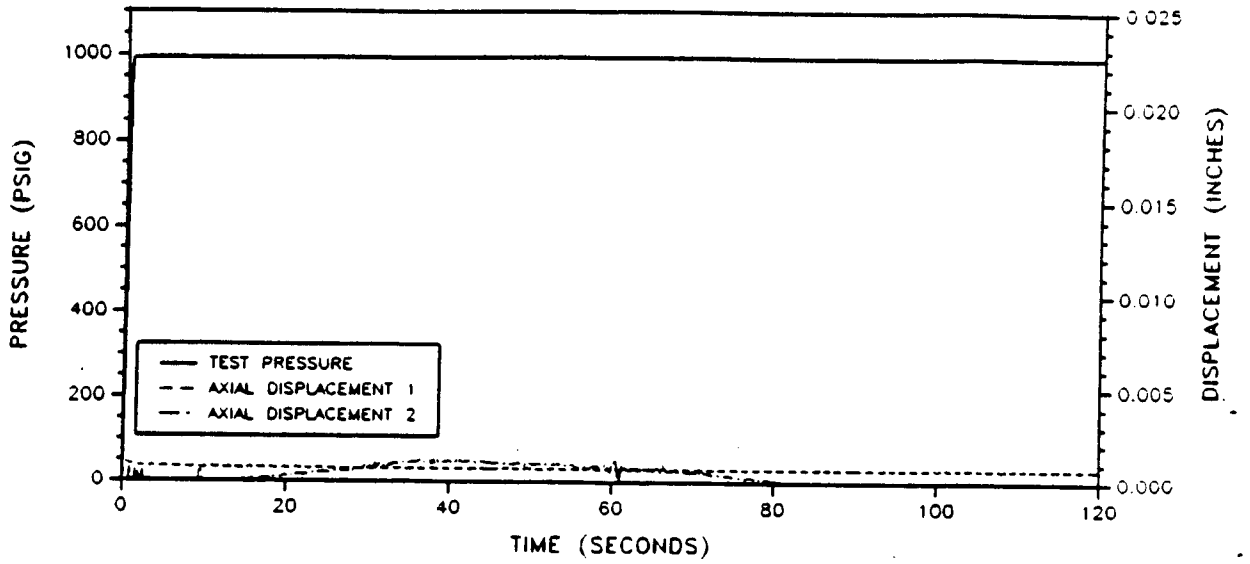


V-4 Cavity Pressure Vs. Time (1 Second Plot)

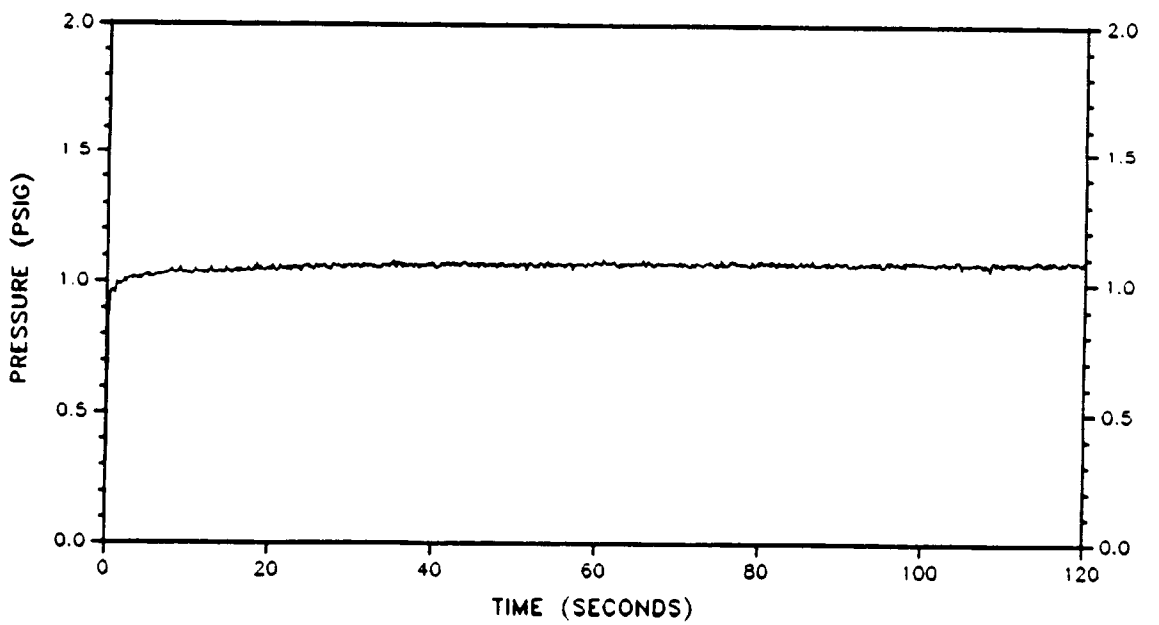


SCENARIO #1, TEST #11AA (Test Date 3/14/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I

TEST #: 11-B

ASSEMBLY DATE: 3/13/89

TEST TECHNICIAN: M. Gardner

TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16

PISTON NO.: 63/63

PRIMARY O-RING		SECONDARY O-RING	
O-RING NO.:	#27	O-RING NO.:	#28
O-RING INNER DIAMETER (inch):	9.391	O-RING INNER DIAM (inch):	9.374
O-RING X-SECTION DIAM (inch):	0.2892	O-RING X-SECT DIAM (inch):	0.2917
O-RING SQUEEZE (%): (AVG.)	17.1	O-RING SQUEEZE: (AVG.)	17.7
ADJUSTED X-SECT (inch):	0.2848	ADJUSTED X-SECT (inch):	0.2866

O-RING CONDITIONING

CONDITIONING TEMP.: 112.3 °F

CONDITIONING START TIME: 1:30 PM 3/13/89

CONDITIONING STOP TIME: 3/14/89 7 AM

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/14/89 7:30 AM

CONDITIONING TEMP.: 76.0 °F

DATE & TIME OF TEST: 3/14/89 8:30 AM

FIXTURE TEMEPERATURE AT END OF TEST: 75.7 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 13.82 psia

T_1 = 75.7 °F T_2 = 76.0 °F (at 60 Seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.1566 in^3

$\Delta V = V_i - V_f$

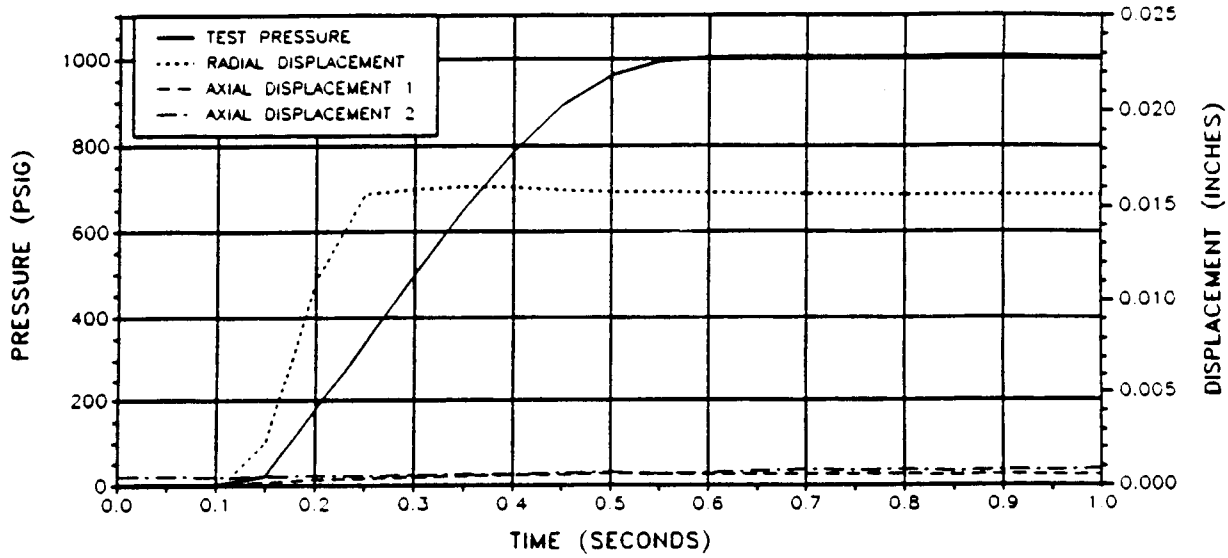
ΔV = 0.1902 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

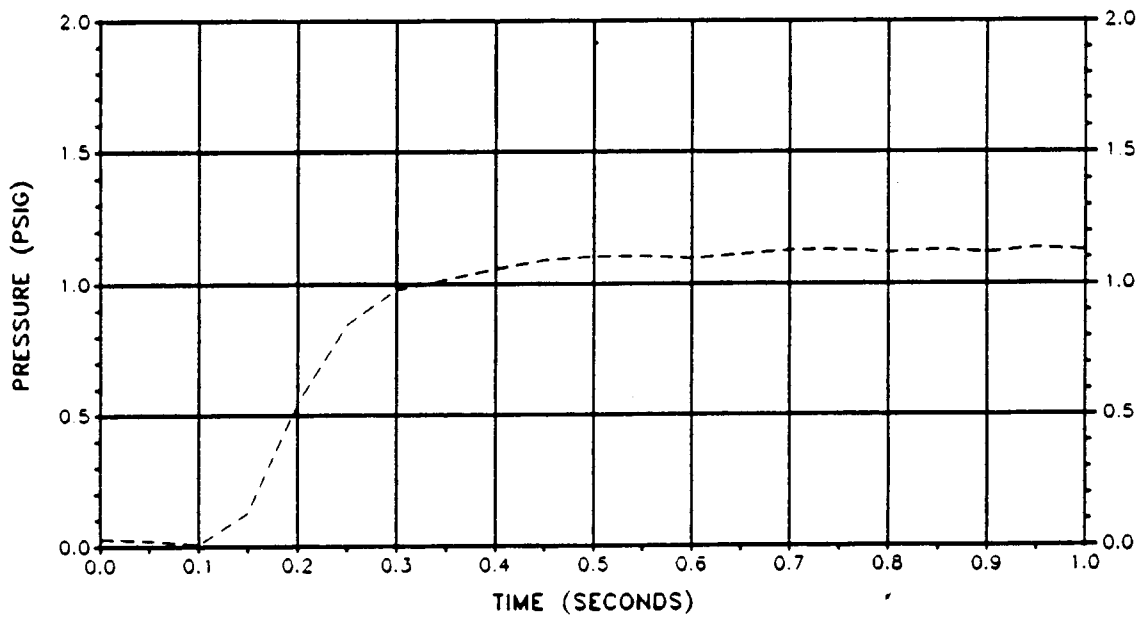
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #11B (Test Date 3/14/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

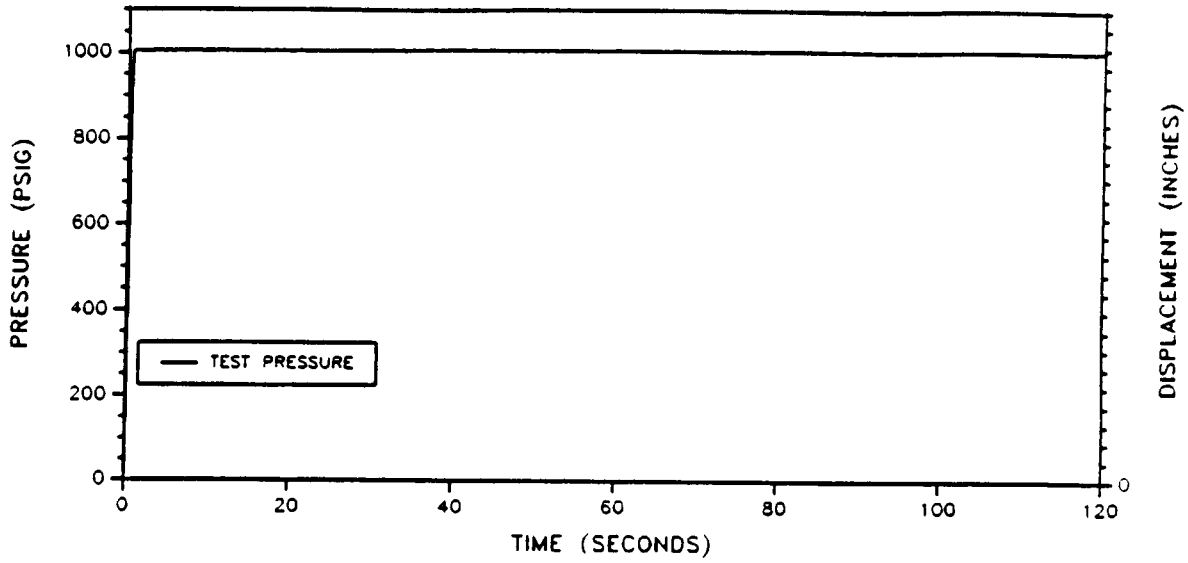


V-4 Cavity Pressure Vs. Time (1 Second Plot)

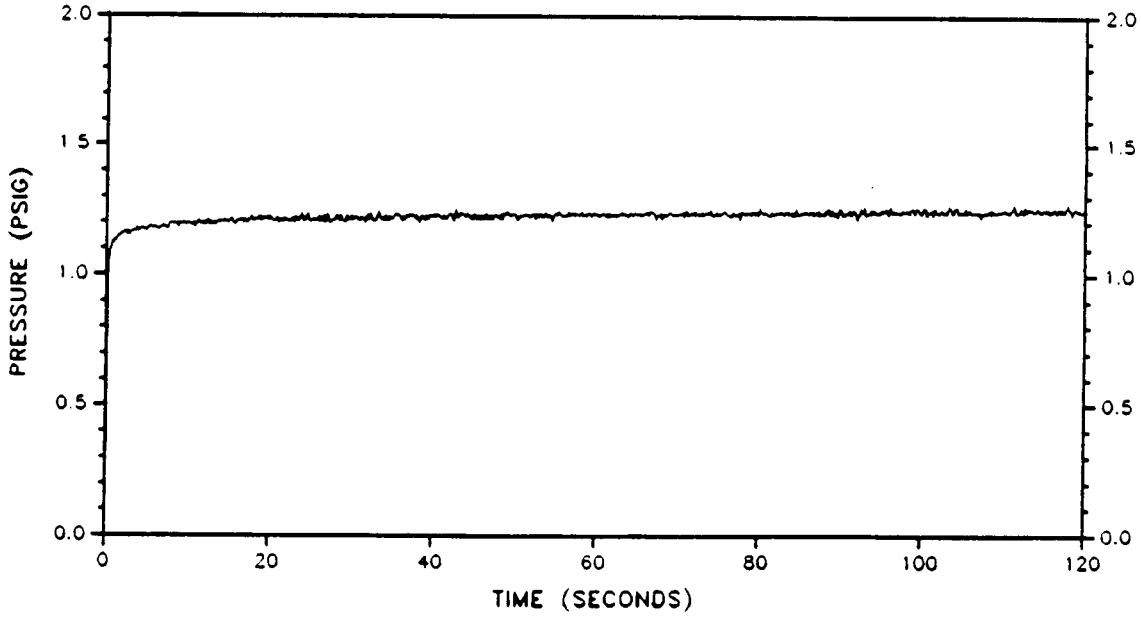


SCENARIO #1, TEST #11B (Test Date 3/14/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
ASSEMBLY DATE: 3/13/89

TEST #: 11-C
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Korrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/63

PRIMARY O-RING

O-RING NO.: #27
O-RING INNER DIAMETER (inch): 9.391
O-RING X-SECTION DIAM (inch): 0.2892
O-RING SQUEEZE (%): (AVG.) 17.1
ADJUSTED X-SECT (inch): 0.2848

SECONDARY O-RING

O-RING NO.: #28
O-RING INNER DIAM (inch): 9.374
O-RING X-SECT DIAM (inch): 0.2917
O-RING SQUEEZE: (AVG.) 19.9
ADJUSTED X-SECT (inch): 0.2866

O-RING CONDITIONING

CONDITIONING TEMP.: 112.3 °F
CONDITIONING START TIME: 3pm 3/13/89 CONDITIONING STOP TIME: 7AM, 3/14/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/14/89, 8:30AM
CONDITIONING TEMP.: 76.0 °F
DATE & TIME OF TEST: 3/14/89, 11:50AM
FIXTURE TEMEPERATURE AT END OF TEST: 75.6 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 15.20 psia

T_1 = 75.7 °F T_2 = 75.7 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 1.9608 in^3

$\Delta V = V_i - V_f$

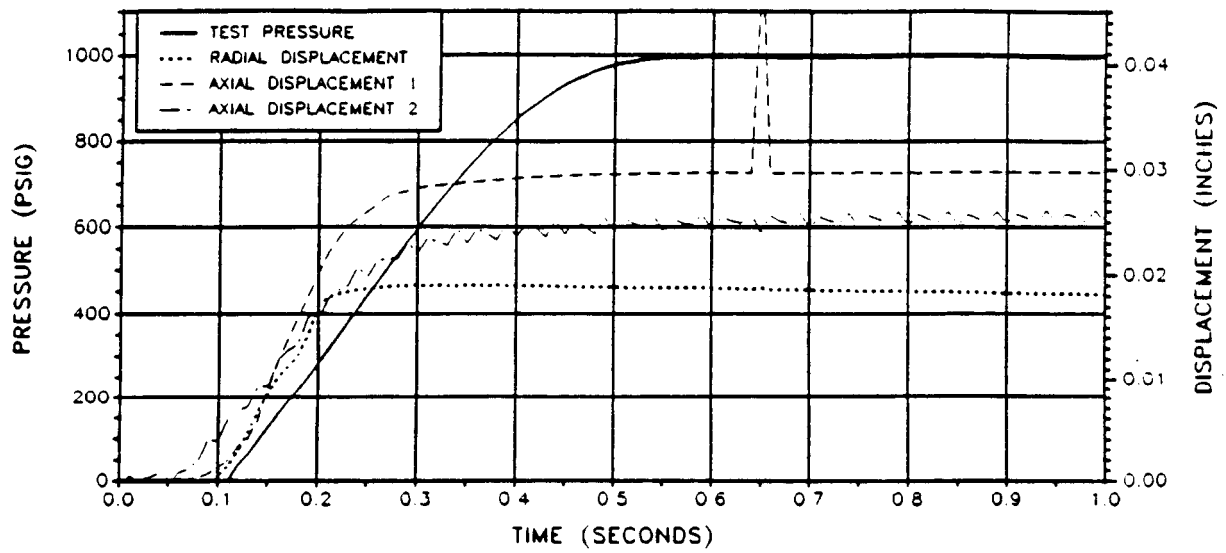
ΔV = 0.3860 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

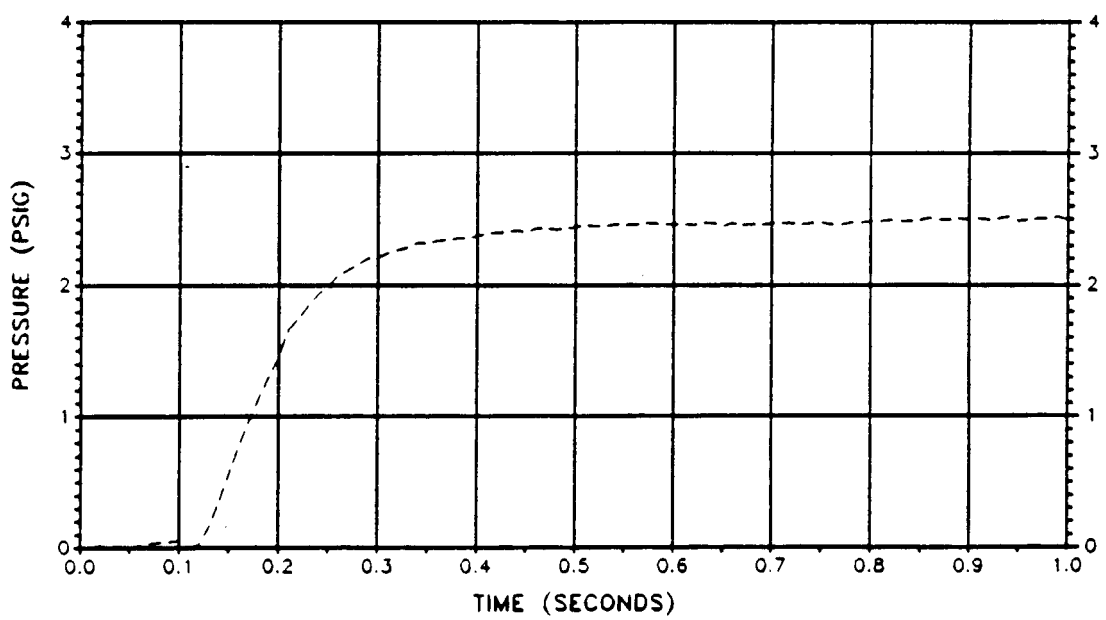
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #11C (Test Date 3/14/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

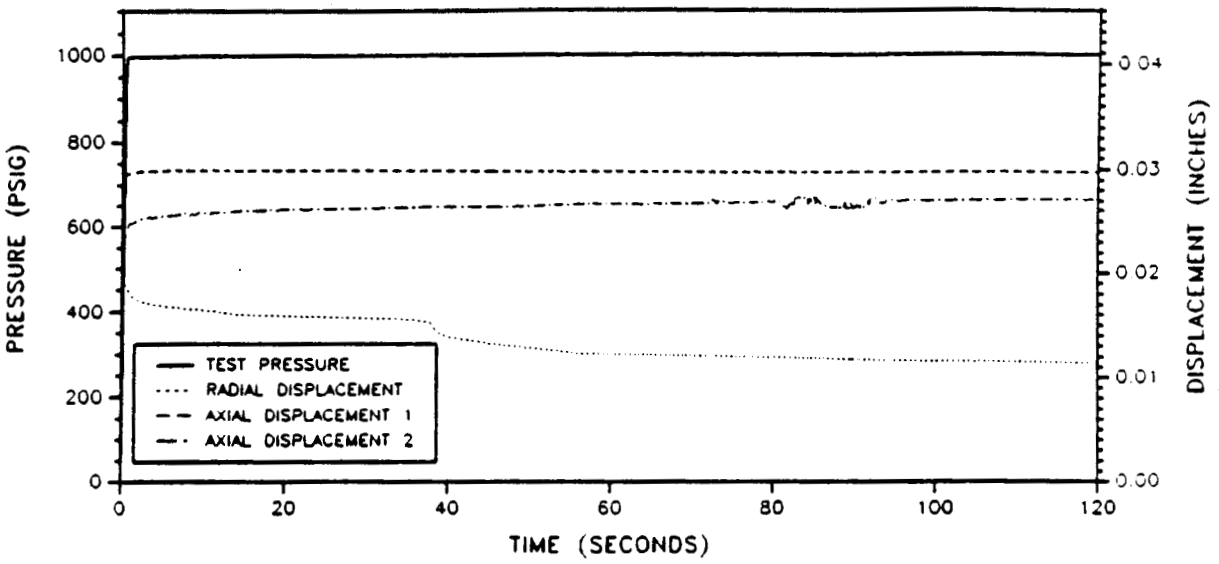


V-4 Cavity Pressure Vs. Time (1 Second Plot)

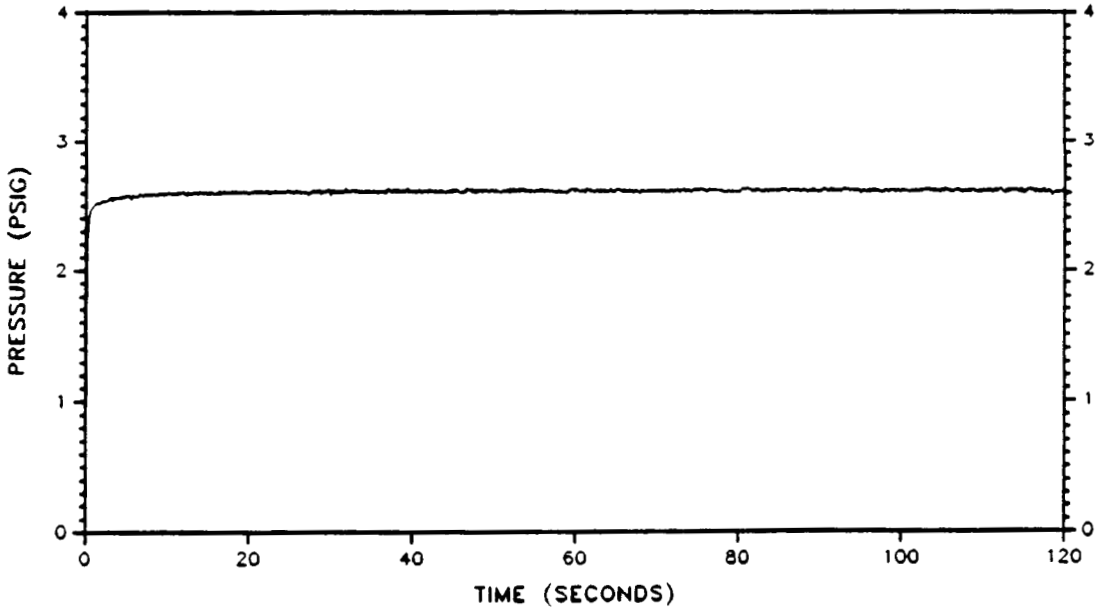


SCENARIO #1, TEST #11C (Test Date 3/14/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
TEST #: 12
ASSEMBLY DATE: 3/20/89
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Kerr

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/62

PRIMARY O-RING		SECONDARY O-RING	
O-RING NO.:	#29	O-RING NO.:	#30
O-RING INNER DIAMETER (inch):	9.351	O-RING INNER DIAM (inch):	9.332
O-RING X-SECTION DIAM (inch):	0.2882	O-RING X-SECT DIAM (inch):	0.2876
O-RING SQUEEZE (%): (AVG.)	16.6	O-RING SQUEEZE: (AVG.)	18.6
ADJUSTED X-SECT (inch):	0.2830	ADJUSTED X-SECT (inch):	0.2819

O-RING CONDITIONING

CONDITIONING TEMP.: 110.2 °F

CONDITIONING START TIME: 1pm, 3/20/89 CONDITIONING STOP TIME: 7 AM, 3/21/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/21/89, 8:45 AM

CONDITIONING TEMP.: 77.0 °F

DATE & TIME OF TEST: 3/21/89, 11:10AM

FIXTURE TEMEPERATURE AT END OF TEST: 76.2 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Lav (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 15.87 psia

T_1 = 76.2 °F T_2 = 76.2 °F (at 60 seconds)

Final Volume in V_4 (V_f) = (P_{atm} * V_i * T_2)/(P_f * T_1)

V_f = 1.8780 in^3

$\Delta V = V_i - V_f$

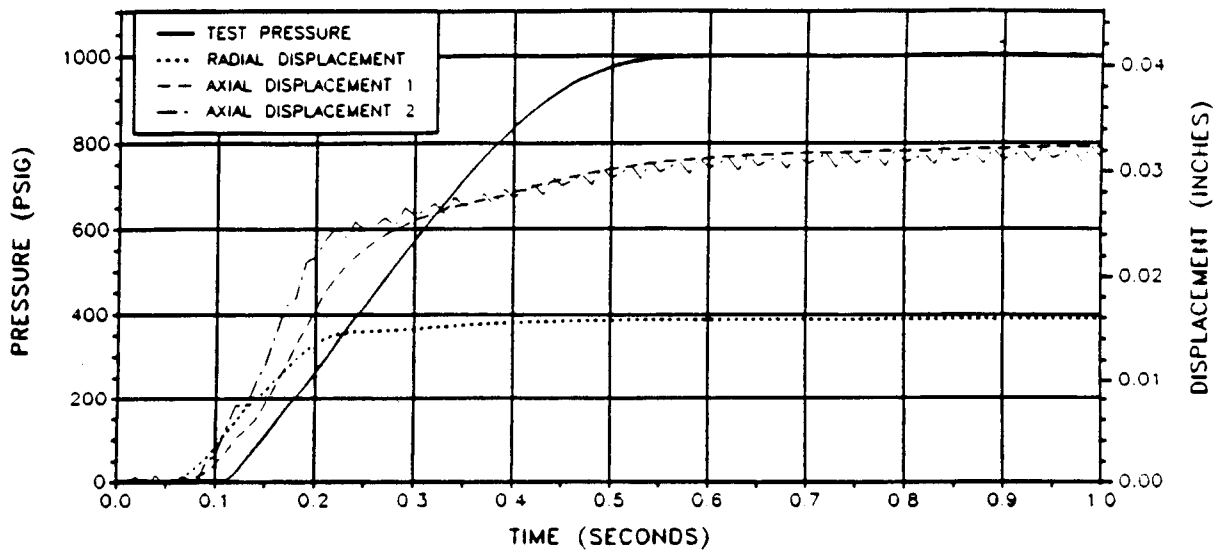
ΔV = 0.4688 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

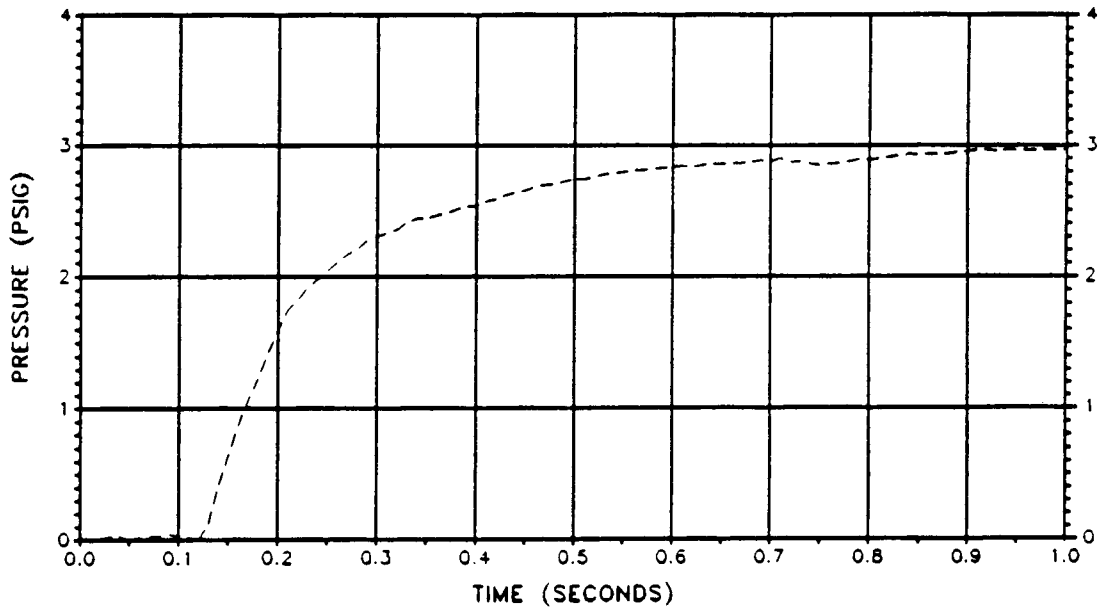
COMMENTS ON DISSASSEMBLED CONDITION: Axial stoppers were released after seating O-rings; thus O-rings were displaced by ≈ 2 mils.

SCENARIO #1, TEST #12 (Test Date 3/21/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

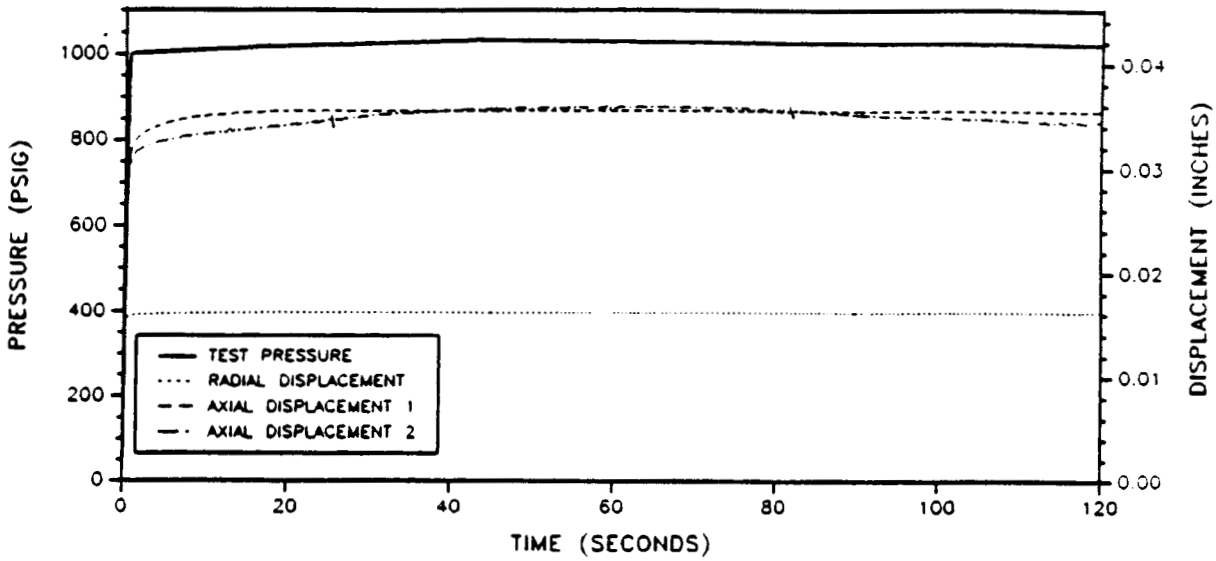


V-4 Cavity Pressure Vs. Time (1 Second Plot)

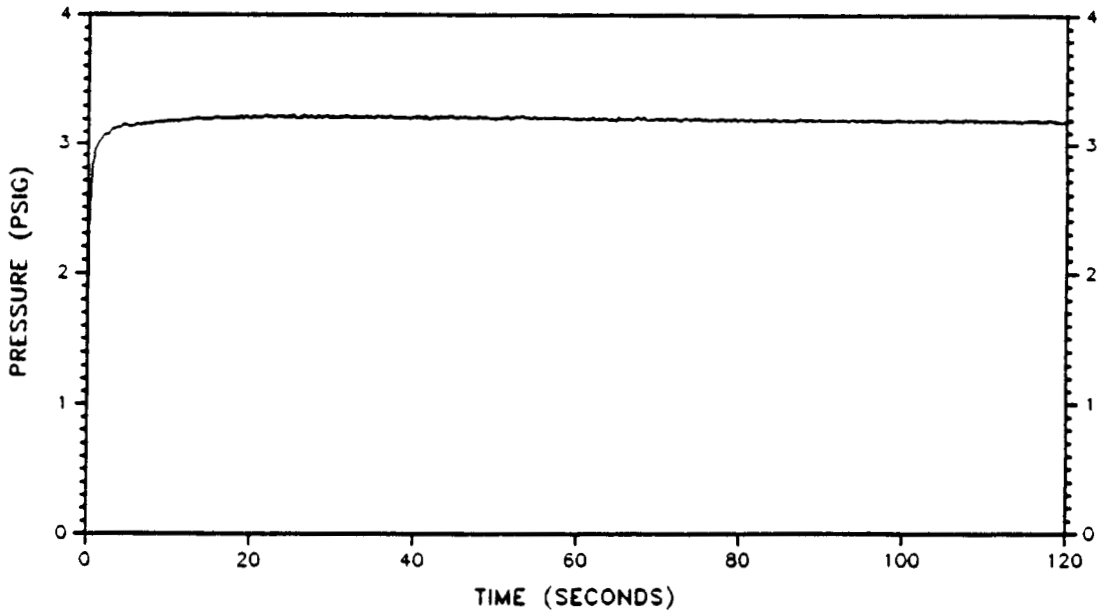


SCENARIO #1, TEST #12 (Test Date 3/21/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I

TEST #: 12-A

ASSEMBLY DATE: 3/20/89

TEST TECHNICIAN: M. [illegible]

TEST SUPERVISOR: T. Kerr[illegible]

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16

PISTON NO.: 63/63

PRIMARY O-RING		SECONDARY O-RING	
O-RING NO.:	#29	O-RING NO.:	#30
O-RING INNER DIAMETER (inch):	9.351	O-RING INNER DIAM (inch):	9.338
O-RING X-SECTION DIAM (inch):	0.2882	O-RING X-SECT DIAM (inch):	0.2876
O-RING SQUEEZE (%): (AVG.)	16.6	O-RING SQUEEZE: (AVG.)	16.6
ADJUSTED X-SECT (inch):	0.2830	ADJUSTED X-SECT (inch):	0.2817

O-RING CONDITIONING

CONDITIONING TEMP.: 110.2 °F

CONDITIONING START TIME: 1pm 3/20/89 CONDITIONING STOP TIME: 7AM 3/21/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/21/89, 7:45 AM

CONDITIONING TEMP.: 77.0 °F

DATE & TIME OF TEST: 3/21/89, 10:20 AM

FIXTURE TEMEPERATURE AT END OF TEST: 76.1 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 13.79 psia

T_1 = 76.0 °F T_2 = 76.0 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.1613 in^3

$\Delta V = V_i - V_f$

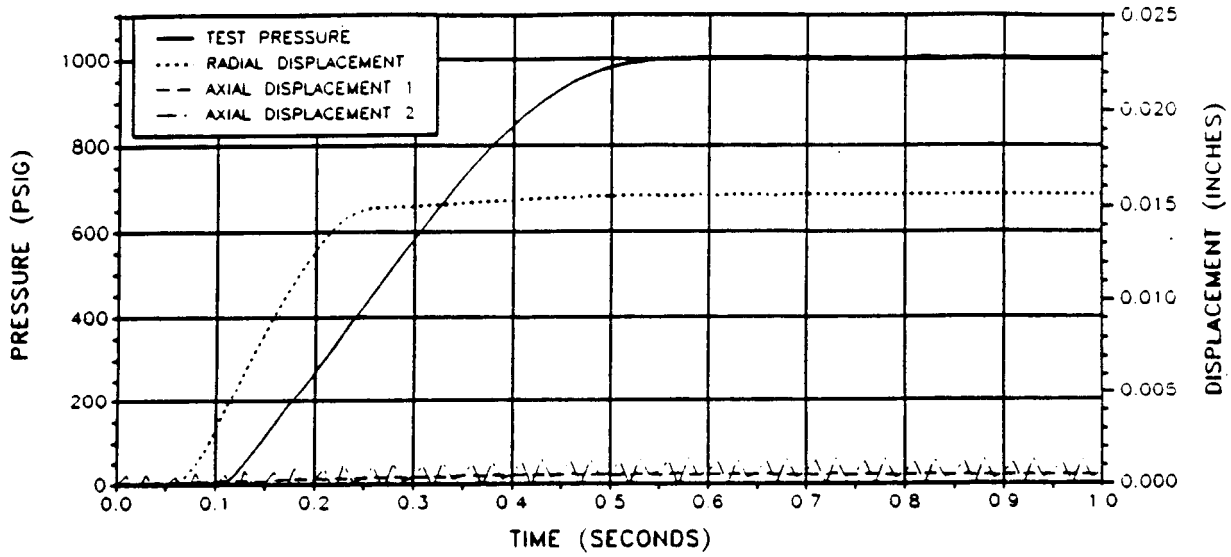
ΔV = 0.2152 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

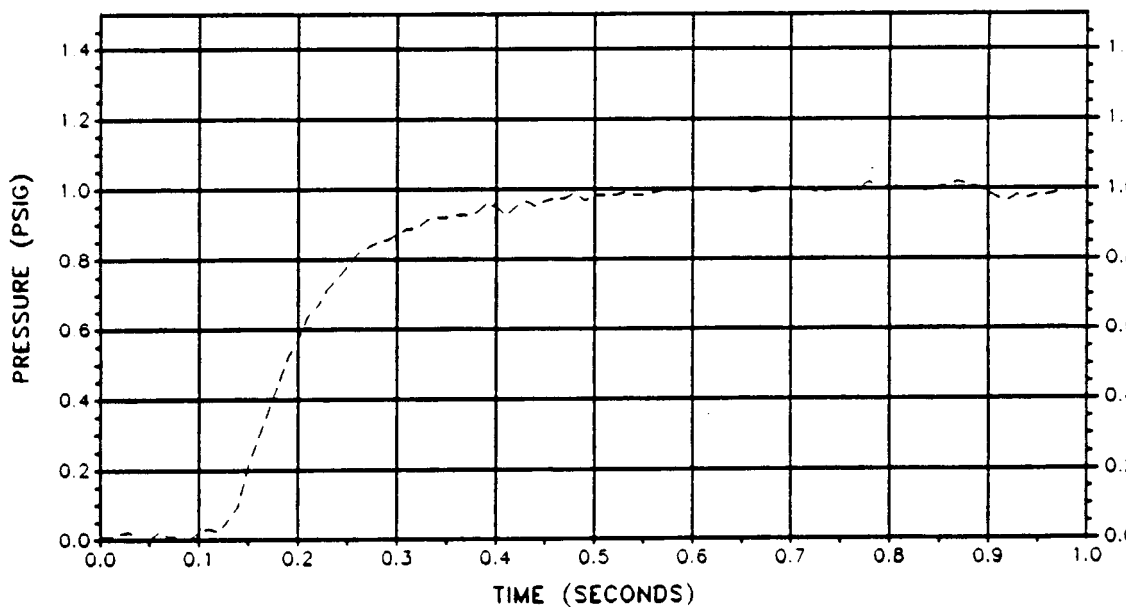
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #12A (Test Date 3/21/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

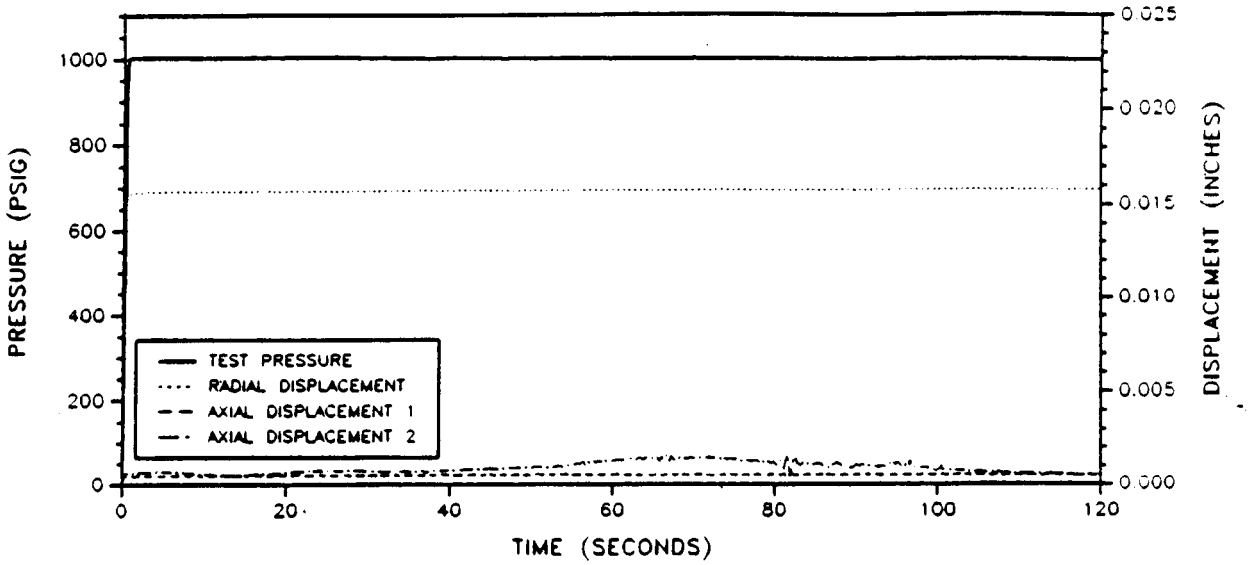


V-4 Cavity Pressure Vs. Time (1 Second Plot)

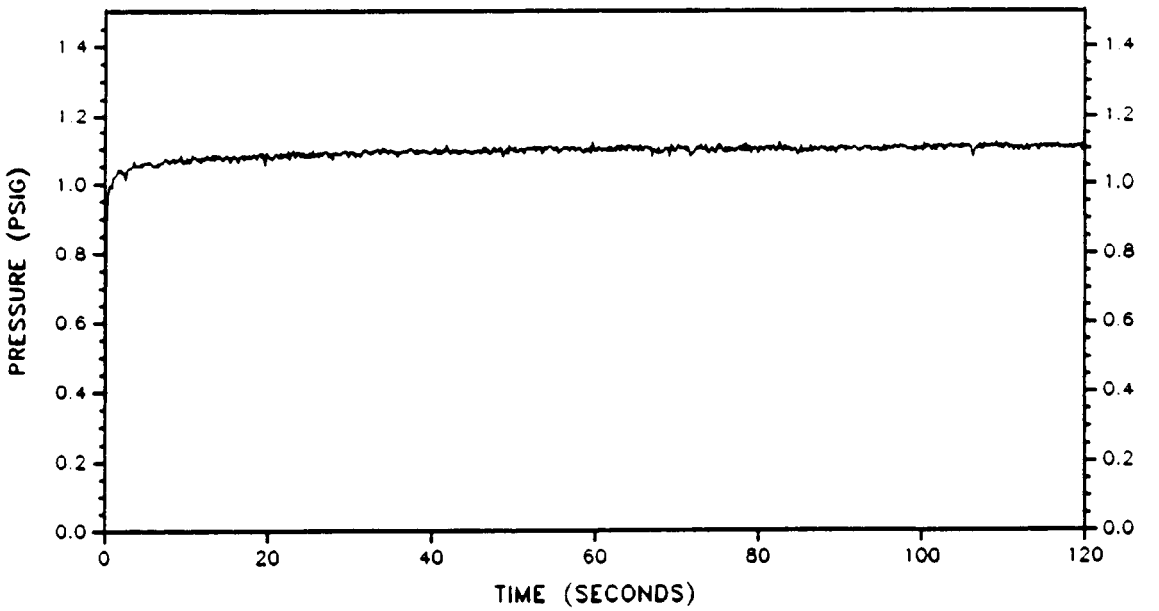


SCENARIO #1, TEST #12A (Test Date 3/21/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I
ASSEMBLY DATE: 3/20/89

TEST #: 12-B
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/63

PRIMARY O-RING

O-RING NO.: #29
O-RING INNER DIAMETER (inch): 9.351
O-RING X-SECTION DIAM (inch): 0.2882
O-RING SQUEEZE (%): (AVG.) 16.6
ADJUSTED X-SECT (inch): 0.2830

SECONDARY O-RING

O-RING NO.: #30
O-RING INNER DIAM (inch): 9.338
O-RING X-SECT DIAM (inch): 0.2876
O-RING SQUEEZE: (AVG.) 18.6
ADJUSTED X-SECT (inch): 0.2819

O-RING CONDITIONING

CONDITIONING TEMP.: 110.2 °F
CONDITIONING START TIME: 1pm, 3/20/89 CONDITIONING STOP TIME: 7AM 3/21/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/21/89, 8:45AM
CONDITIONING TEMP.: 77.0 °F
DATE & TIME OF TEST: 3/21/89, 10:40AM
FIXTURE TEMEPERATURE AT END OF TEST: 76.7 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 13.8 psia

T_1 = 76.7 °F T_2 = 76.7 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.1597 in^3

$\Delta V = V_i - V_f$

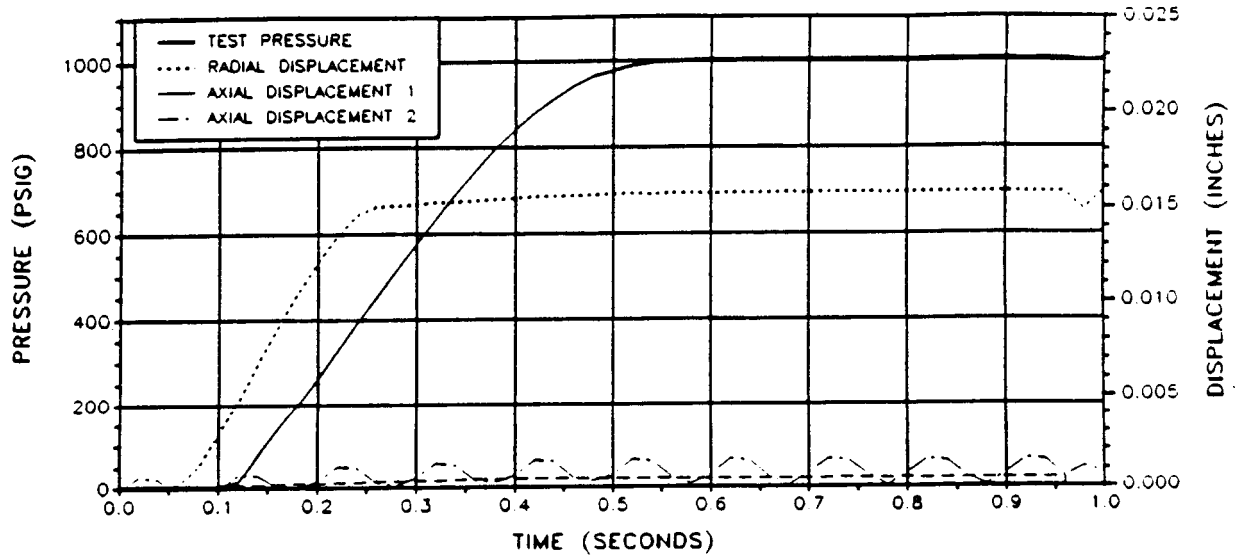
ΔV = 0.1871 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

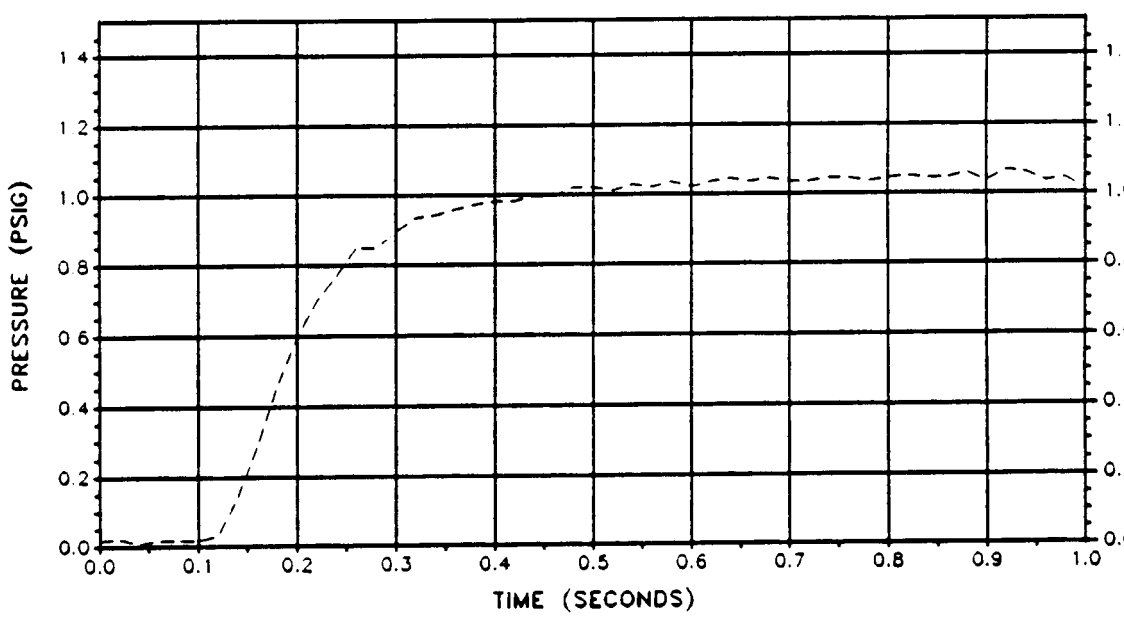
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #12B (Test Date 3/21/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

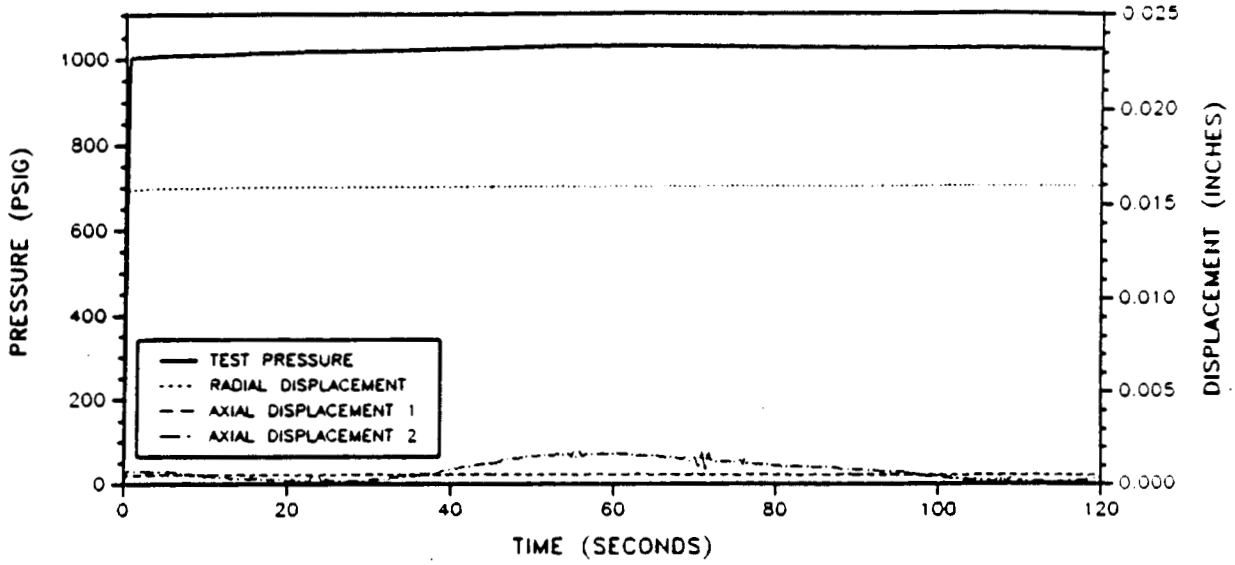


V-4 Cavity Pressure Vs. Time (1 Second Plot)

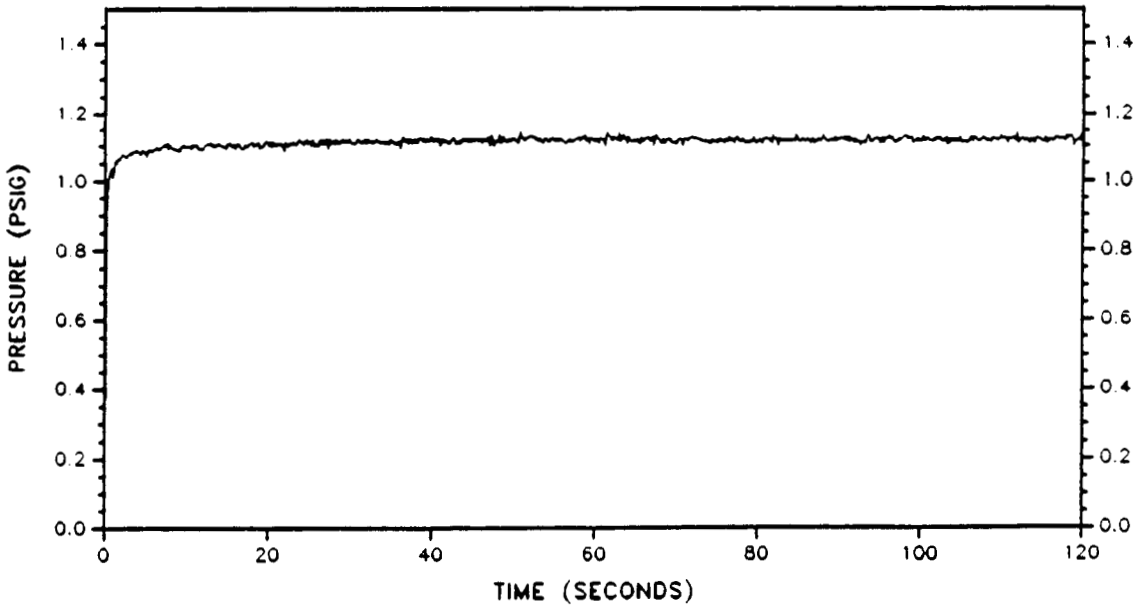


SCENARIO #1, TEST #12B (Test Date 3/21/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: I

TEST #: 12-C

ASSEMBLY DATE: 3/20/89

TEST TECHNICIAN: M. Gardner

TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16

PISTON NO.: 63/63

PRIMARY O-RING

O-RING NO.: #29

O-RING INNER DIAMETER (inch): 9.351

O-RING X-SECTION DIAM (inch): 0.2782

O-RING SQUEEZE (%): (AVG.) 16.6

ADJUSTED X-SECT (inch): 0.2830

SECONDARY O-RING

O-RING NO.: #30

O-RING INNER DIAM (inch): 9.357

O-RING X-SECT DIAM (inch): 0.2776

O-RING SQUEEZE: (AVG.) 17.6

ADJUSTED X-SECT (inch): 0.2819

O-RING CONDITIONING

CONDITIONING TEMP.: 110.2 °F

CONDITIONING START TIME: 1pm 3/20/89 CONDITIONING STOP TIME: 7 AM 3/21/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/21/89, 8:45 AM

CONDITIONING TEMP.: 77.0 °F

DATE & TIME OF TEST: 3/21/89

FIXTURE TEMEPERATURE AT END OF TEST: 75.5 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 2.3468 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 15.93 psia

T_1 = 75.5 °F T_2 = 75.5 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 1.8710 in^3

$\Delta V = V_i - V_f$

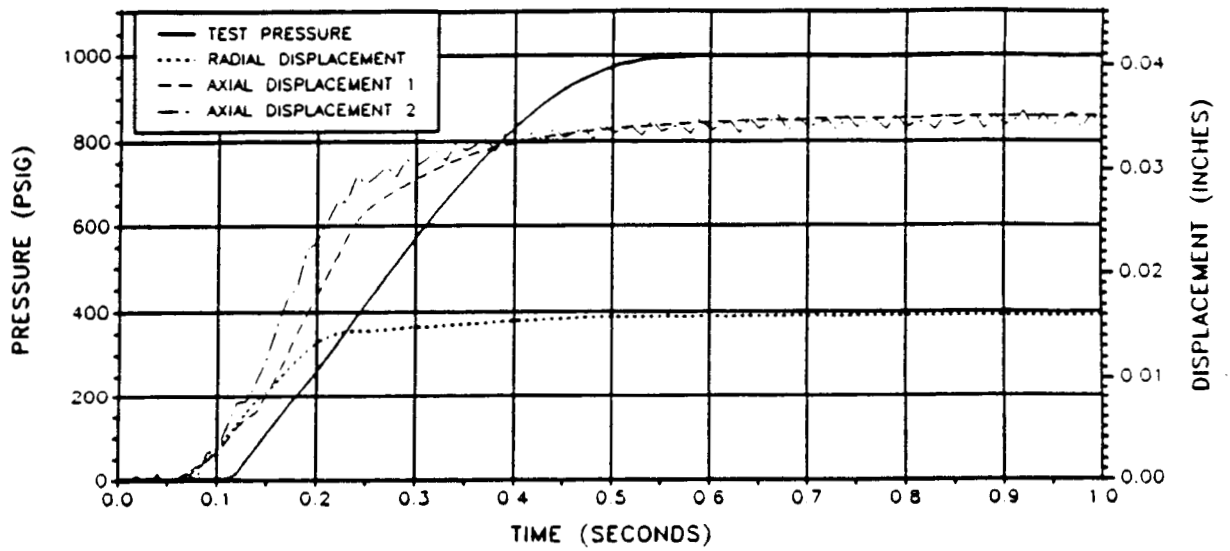
ΔV = 0.4758 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

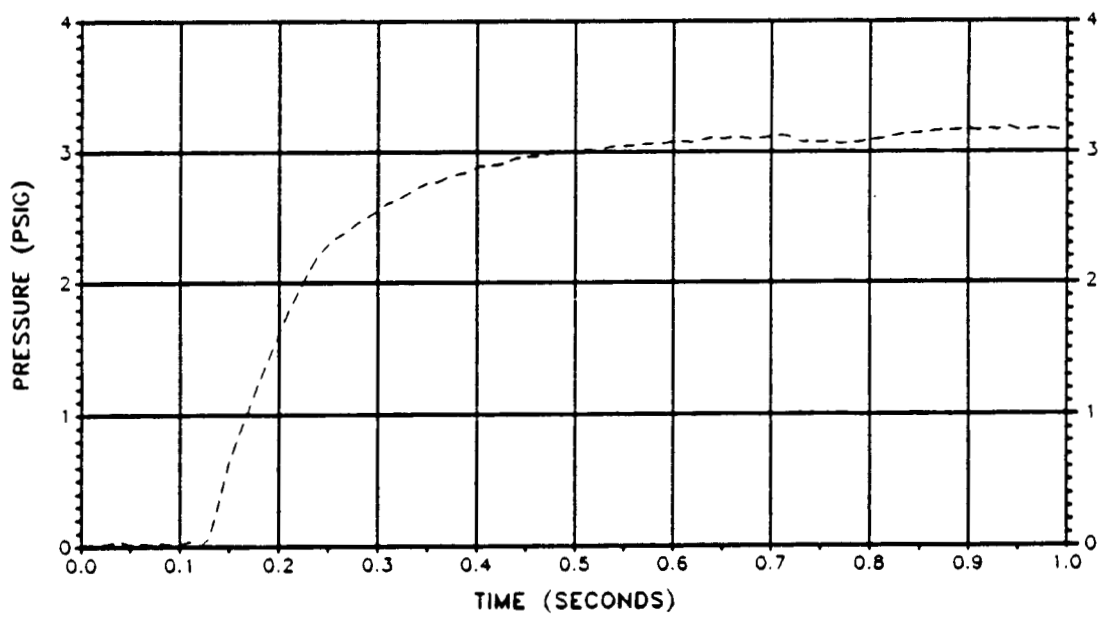
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #1, TEST #12C (Test Date 3/21/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

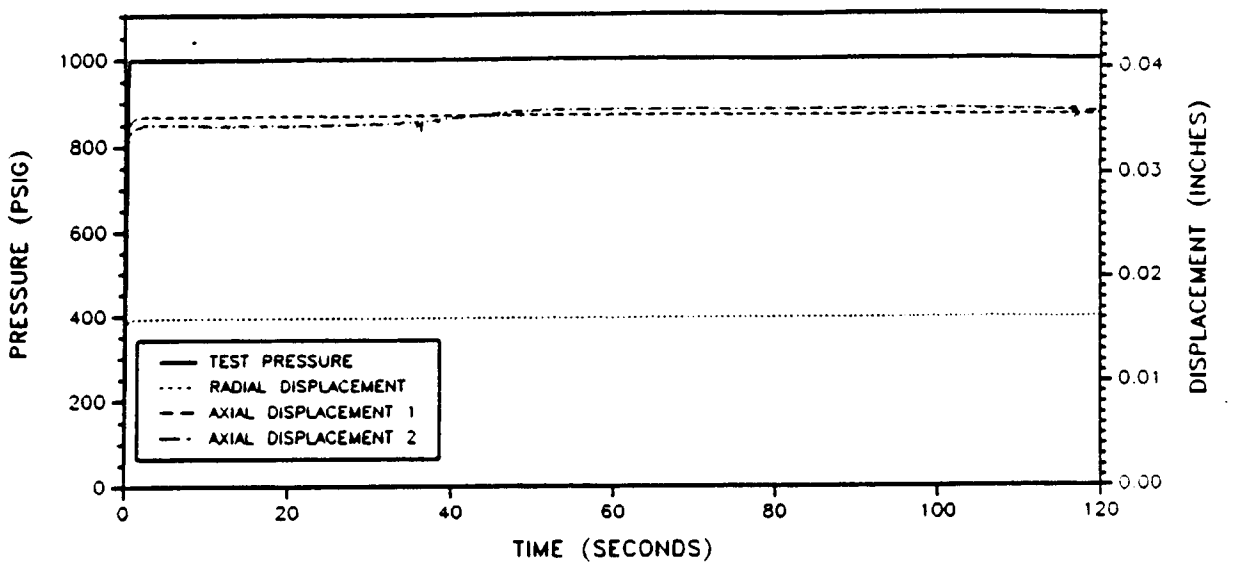


V-4 Cavity Pressure Vs. Time (1 Second Plot)

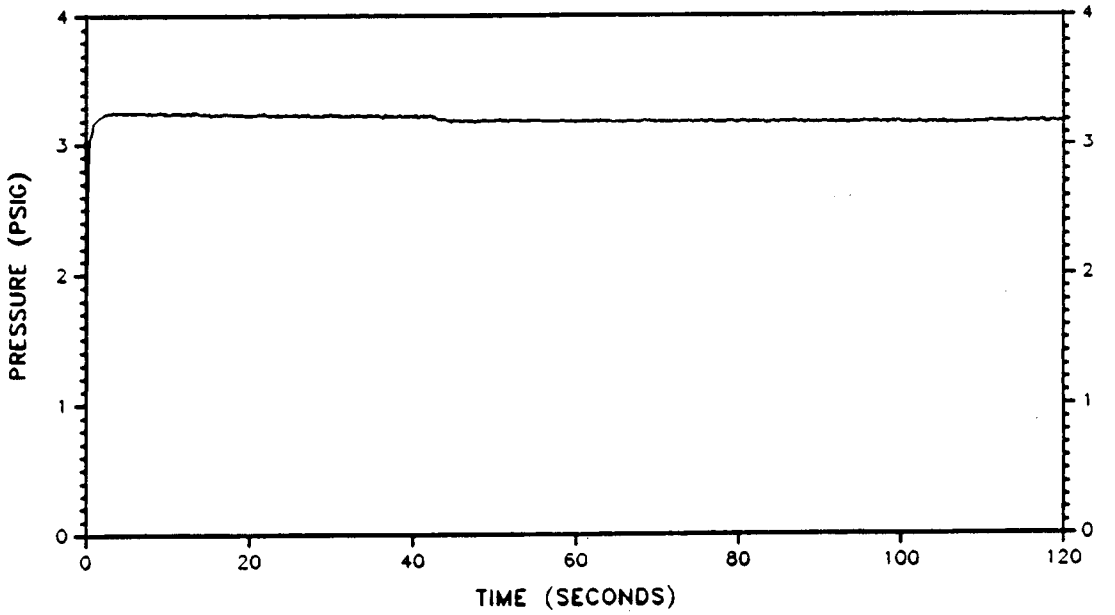


SCENARIO #1, TEST #12C (Test Date 3/21/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: II
ASSEMBLY DATE: 2/14/89

TEST #: 1
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Kennan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/63

PRIMARY O-RING		SECONDARY O-RING	
O-RING NO.:	#3	O-RING NO.:	#4
O-RING INNER DIAMETER (inch):	9.374	O-RING INNER DIAM (inch):	9.374
O-RING X-SECTION DIAM (inch):	0.2886	O-RING X-SECT DIAM (inch):	0.2886
O-RING SQUEEZE (%): (AVG.)	17.1	O-RING SQUEEZE: (AVG.)	19.1
ADJUSTED X-SECT (inch):	0.2848	ADJUSTED X-SECT (inch):	0.2836

O-RING CONDITIONING

CONDITIONING TEMP.: 112.0 °F

CONDITIONING START TIME: NOON 2/14/89 CONDITIONING STOP TIME: 7AM 2/15/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 2/15/89, 9:10 AM

CONDITIONING TEMP.: 76.0 °F

DATE & TIME OF TEST: 2/15/89, 9:45 AM

FIXTURE TEMEPERATURE AT END OF TEST: 75.9 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 3.2216 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 16.92 psia

T_1 = 75.8 °F T_2 = 75.9 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.4213 in^3

$\Delta V = V_i - V_f$

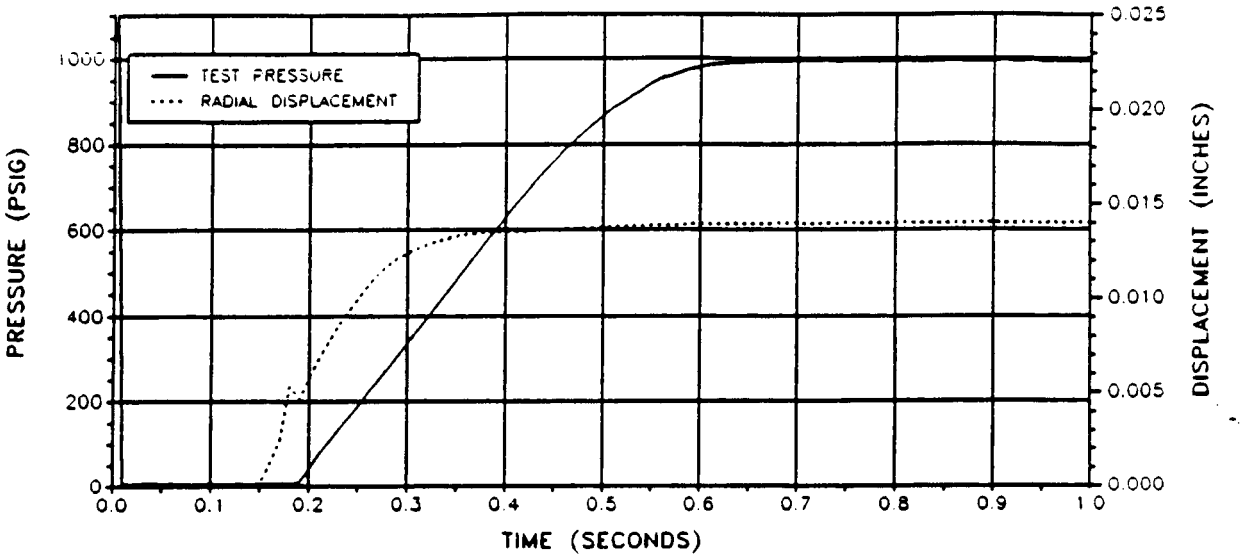
ΔV = 0.8003 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

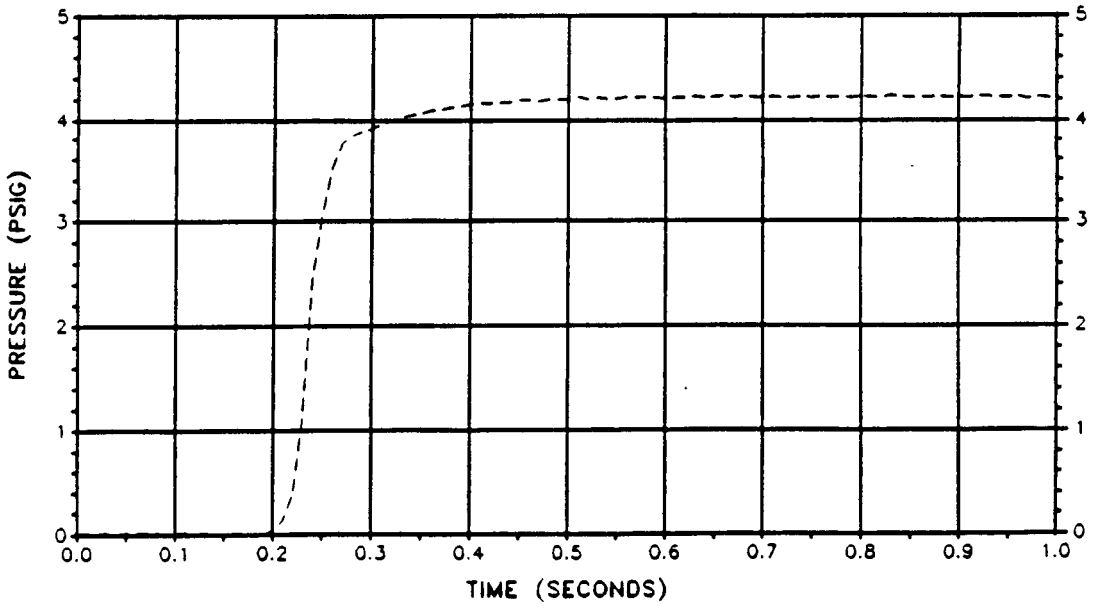
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #2, TEST #1 (Test Date 2/15/89)

Test Pressure and Radial Displacement Vs. Time (1 Second Plot)

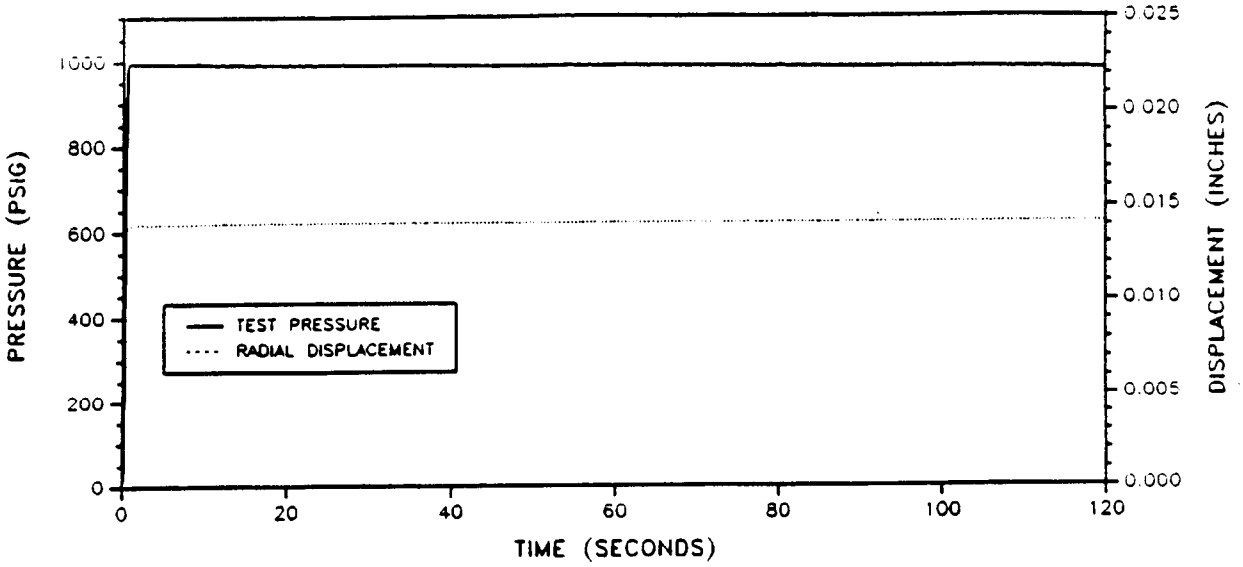


V-4 Cavity Pressure Vs. Time (1 Second Plot)

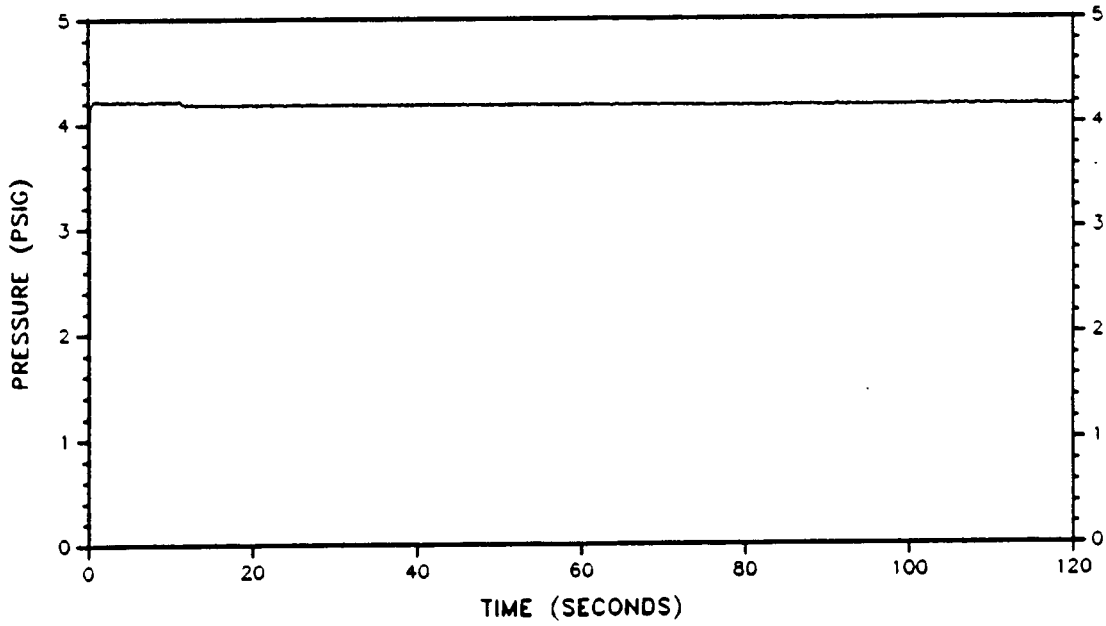


SCENARIO #2, TEST #1 (Test Date 2/15/89)

Test Pressure and Radial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: II
TEST #: 2
ASSEMBLY DATE: 2/20/89
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/63

PRIMARY O-RING
O-RING NO.: #5
O-RING INNER DIAMETER (inch): 9.368
O-RING X-SECTION DIAM (inch): 0.2911
O-RING SQUEEZE (%): (AVG.) 17.5
ADJUSTED X-SECT (inch): 0.2862

SECONDARY O-RING
O-RING NO.: #6
O-RING INNER DIAM (inch): 9.360
O-RING X-SECT DIAM (inch): 0.2913
O-RING SQUEEZE: (AVG.) 19.7
ADJUSTED X-SECT (inch): 0.2859

O-RING CONDITIONING
CONDITIONING TEMP.: 112.0 °F
CONDITIONING START TIME: 1:30 PM 2/20/89
CONDITIONING STOP TIME: 7:00 AM, 2/21/89

FIXTURE CONDITIONING FOR TEST
START DATE & TIME OF TEST CONDITIONING: 2/21/89, 10:50 AM
CONDITIONING TEMP.: 76.7 °F
DATE & TIME OF TEST: 2/21/89, 11:00 AM
FIXTURE TEMEPERATURE AT END OF TEST: 76.6 °F

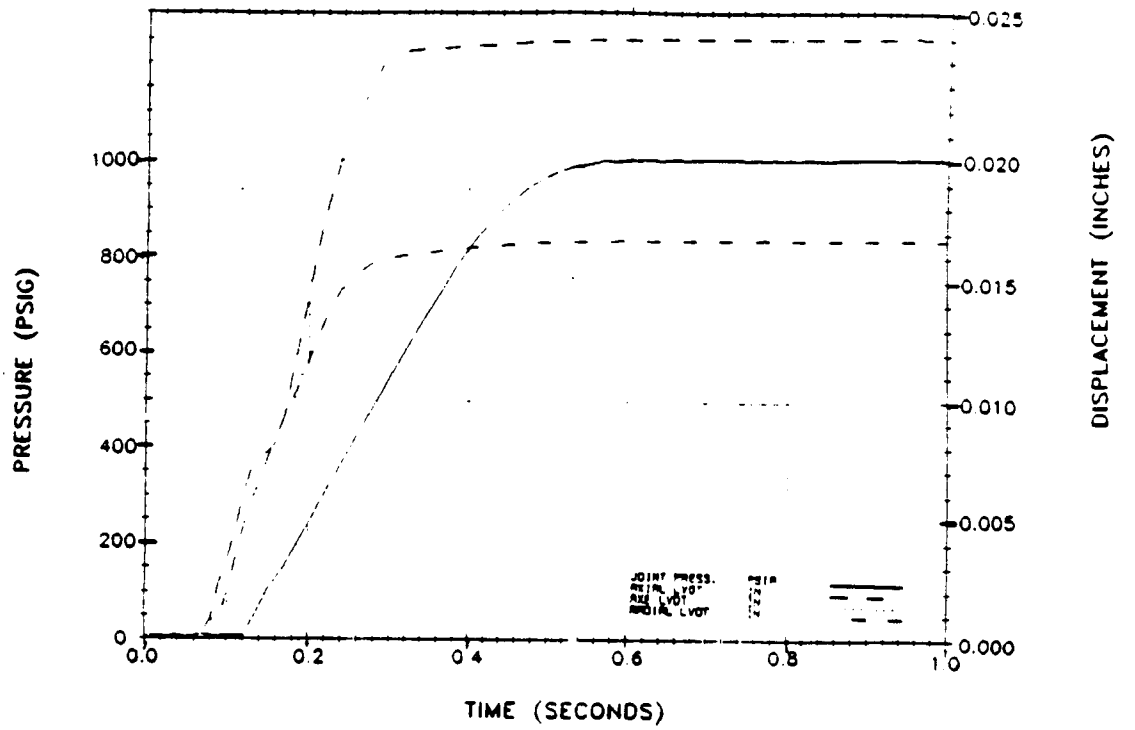
CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 3.2216 in^3
P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 19.20 psia
T_1 = 76.5 °F T_2 = 76.5 °F (at 60 seconds)
Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$
V_f = 2.1310 in^3
$\Delta V = V_i - V_f$
ΔV = 1.0906 in3

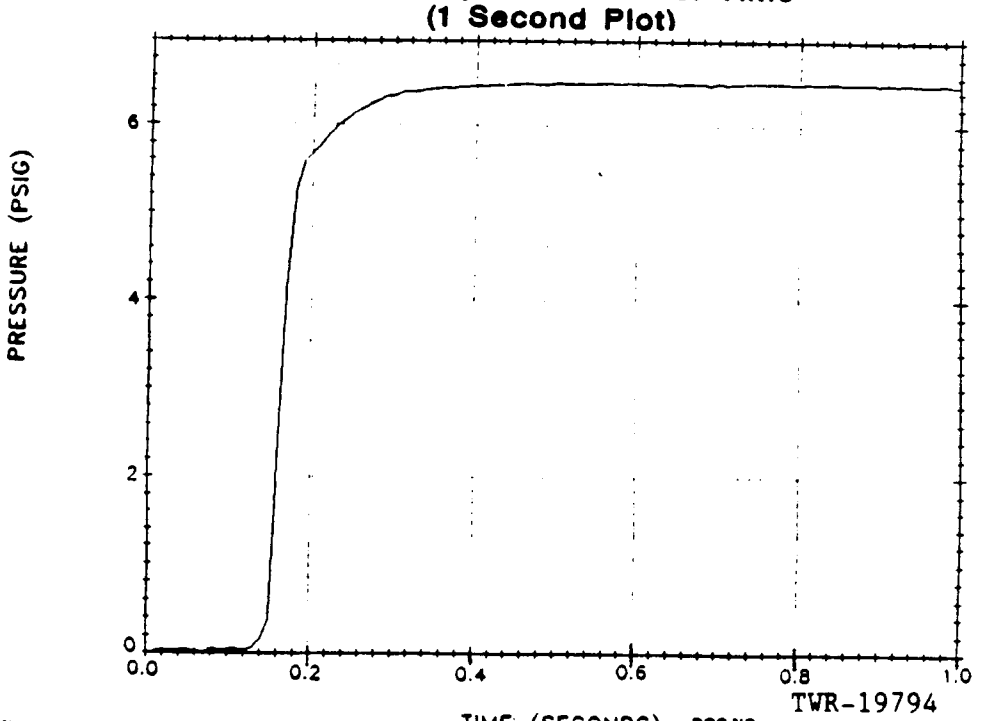
ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS
COMMENTS ON DISSASSEMBLED CONDITION: Temperature was not totally stabilized prior to testing for the 3 tests.

SCENARIO #2, TEST #2 (Test Date 2/21/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

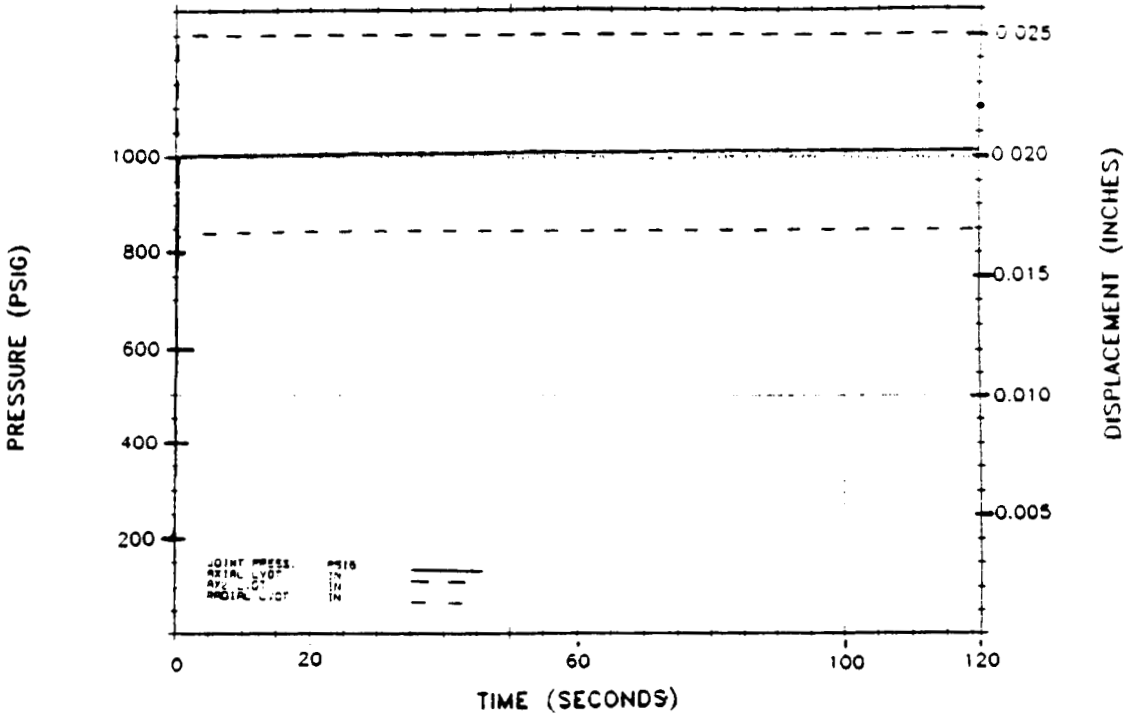


V-4 Cavity Pressure Vs. Time (1 Second Plot)

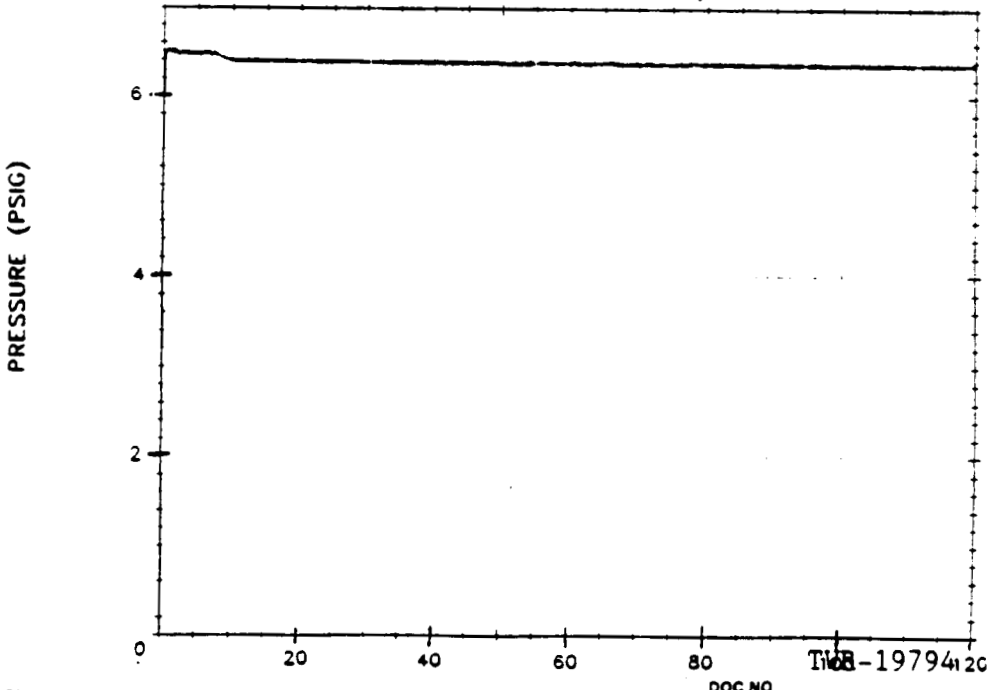


SCENARIO #2, TEST #2 (Test Date 2/21/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: II
TEST #: 3
ASSEMBLY DATE: 2/21/89
TEST TECHNICIAN: M. Gordier
TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/63

PRIMARY O-RING

O-RING NO.: #7
O-RING INNER DIAMETER (inch): 9.351
O-RING X-SECTION DIAM (inch): 0.2900
O-RING SQUEEZE (%): (AVG.) 17.1
ADJUSTED X-SECT (inch): 0.2847

SECONDARY O-RING

O-RING NO.: #8
O-RING INNER DIAM (inch): 9.371
O-RING X-SECT DIAM (inch): 0.2906
O-RING SQUEEZE: (AVG.) 19.7
ADJUSTED X-SECT (inch): 0.2859

O-RING CONDITIONING

CONDITIONING TEMP.: 110.3 °F
CONDITIONING START TIME: 3:30 pm 2/21/89
CONDITIONING STOP TIME: 7:00 AM 2/22/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 2/22/89 8:45 AM
CONDITIONING TEMP.: 76.3 °F
DATE & TIME OF TEST: 2/22/89, 10 AM
FIXTURE TEMEPERATURE AT END OF TEST: 76.2 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 3.2216 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 19.31 psia

T_1 = 76.2 °F T_2 = 76.2 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.1188 in^3

$\Delta V = V_i - V_f$

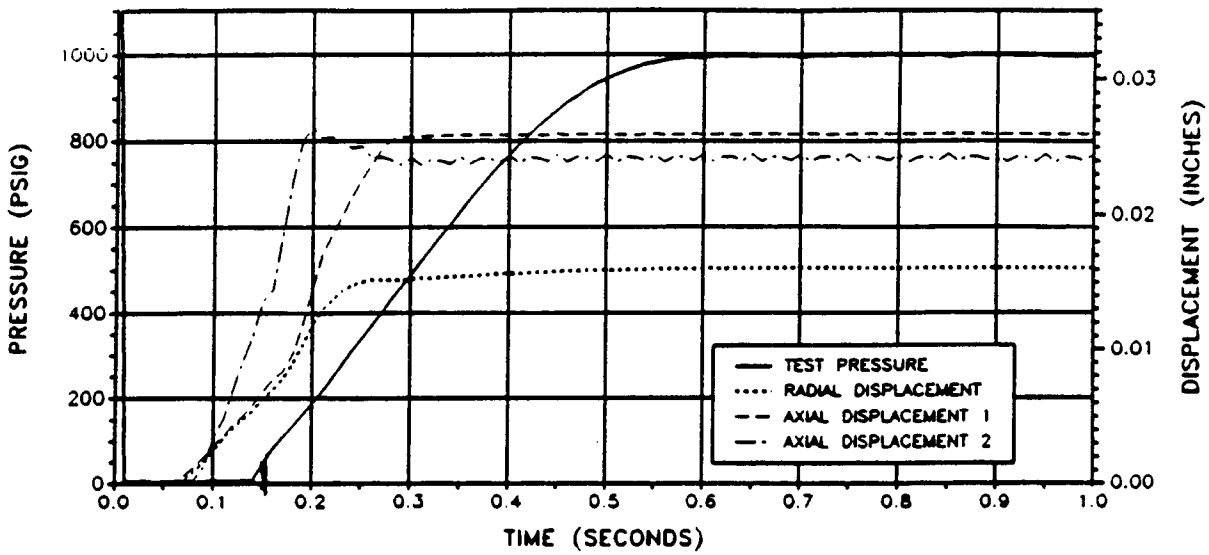
ΔV = 1.1028 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

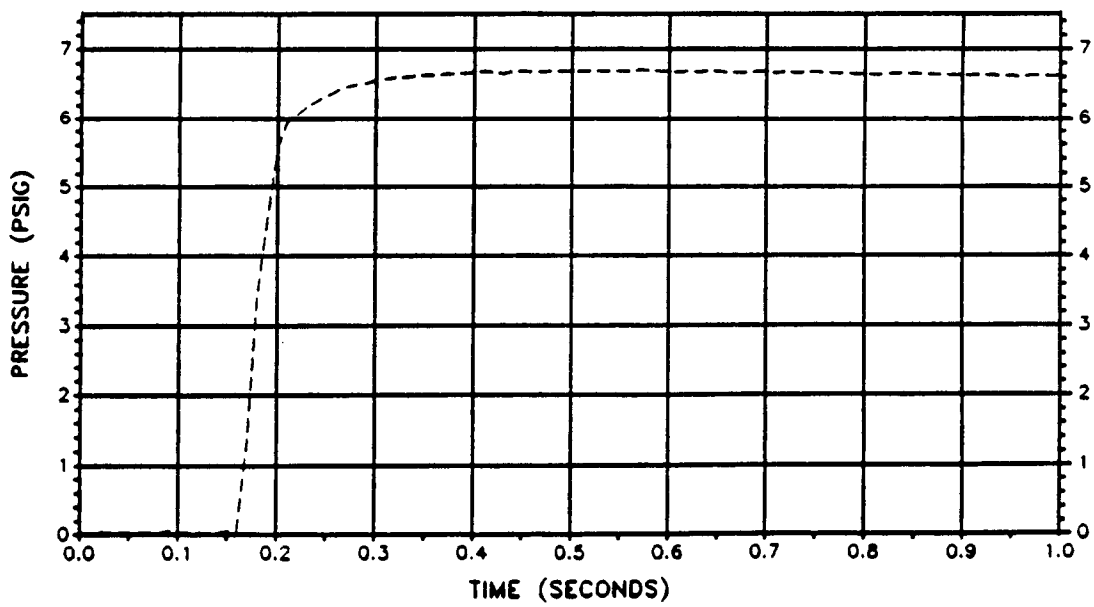
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #2, TEST #3 (Test Date 2/22/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

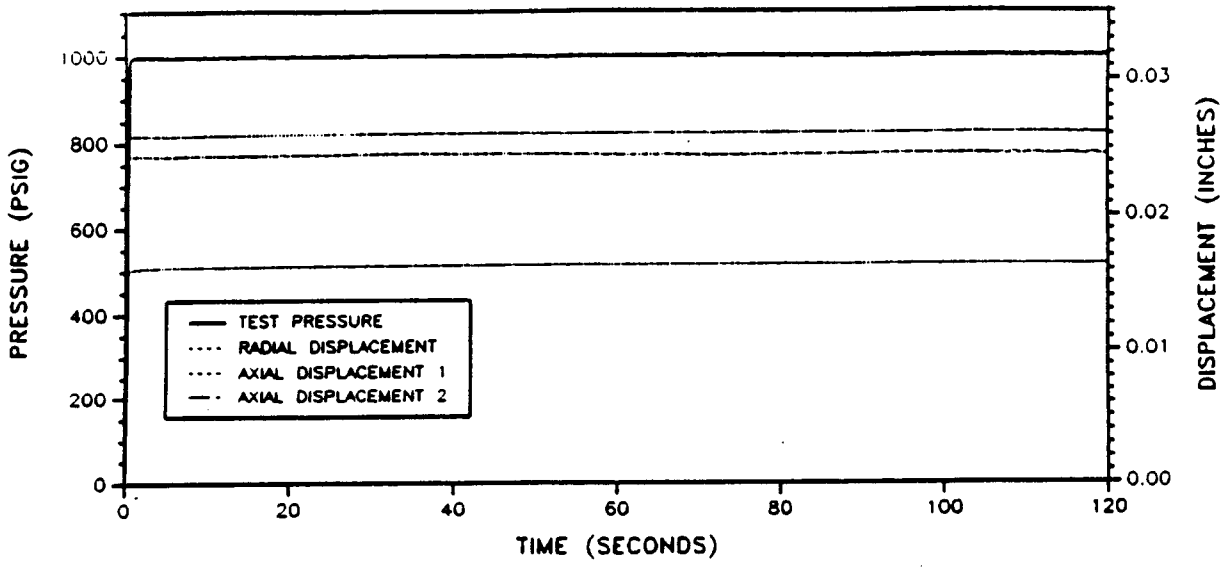


V-4 Cavity Pressure Vs. Time (1 Second Plot)

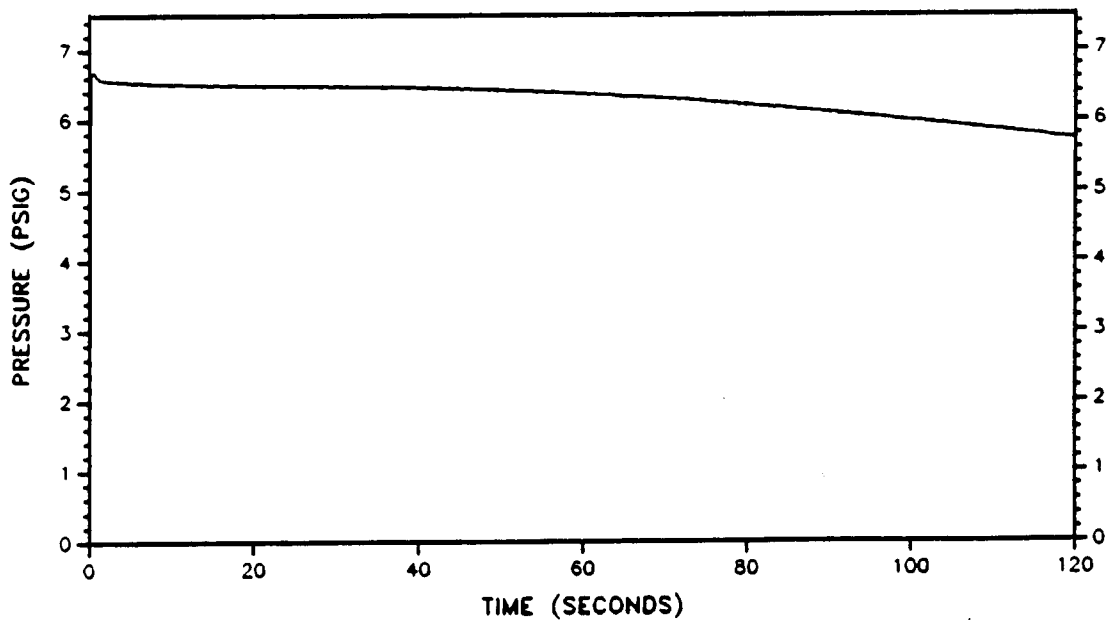


SCENARIO #2, TEST #3 (Test Date 2/22/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: II
TEST #: 4
ASSEMBLY DATE: 2/22/89
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/63

PRIMARY O-RING

O-RING NO.: #9
O-RING INNER DIAMETER (inch): 9.368
O-RING X-SECTION DIAM (inch): 0.2911
O-RING SQUEEZE (%): (AVG.) 17.5
ADJUSTED X-SECT (inch): 0.2862

SECONDARY O-RING

O-RING NO.: #10
O-RING INNER DIAM (inch): 9.374
O-RING X-SECT DIAM (inch): 0.2897
O-RING SQUEEZE: (AVG.) 19.4
ADJUSTED X-SECT (inch): 0.2846

O-RING CONDITIONING

CONDITIONING TEMP.: 113.2 °F
CONDITIONING START TIME: 1:15pm 2/22/89
CONDITIONING STOP TIME: 7AM, 2/23/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 2/23/89, 8:50 AM
CONDITIONING TEMP.: 76.0 °F
DATE & TIME OF TEST: 2/23/89, 9:50 AM
FIXTURE TEMEPERATURE AT END OF TEST: 75.9 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 3.2216 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 16.87 psia

T_1 = 75.9 °F T_2 = 75.9 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.4253 in^3

$\Delta V = V_i - V_f$

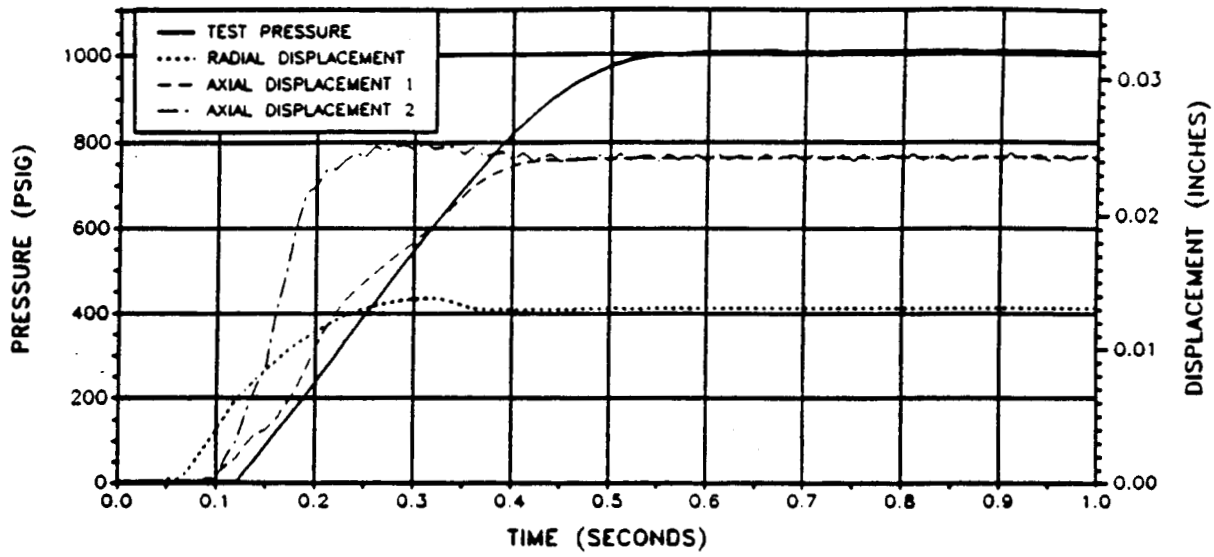
ΔV = 0.7963 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

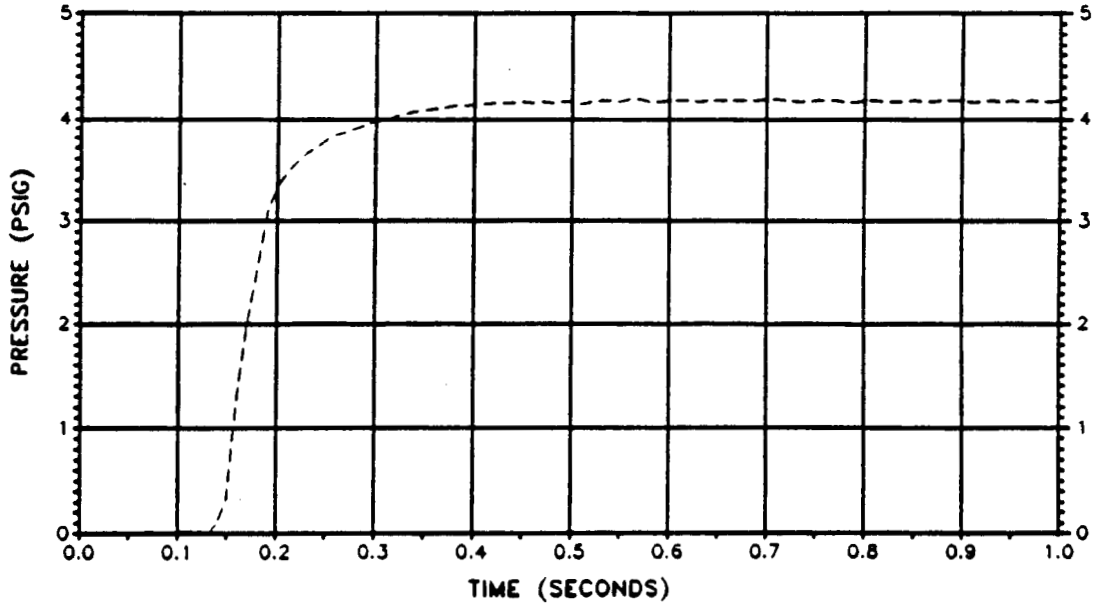
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #2, TEST #4 (Test Date 2/23/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

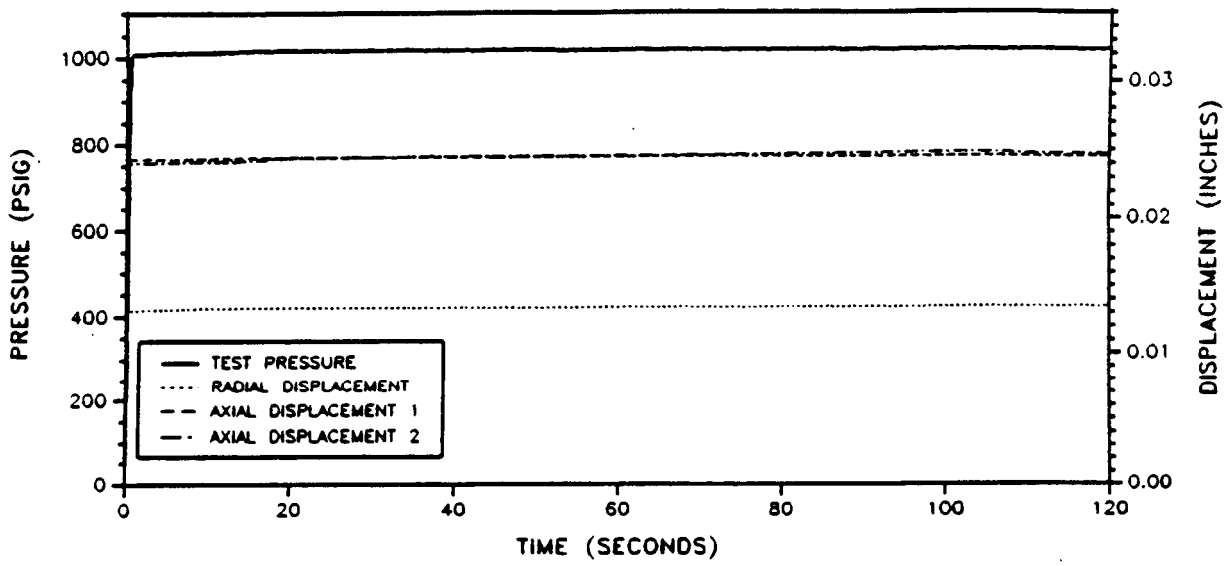


V-4 Cavity Pressure Vs. Time (1 Second Plot)

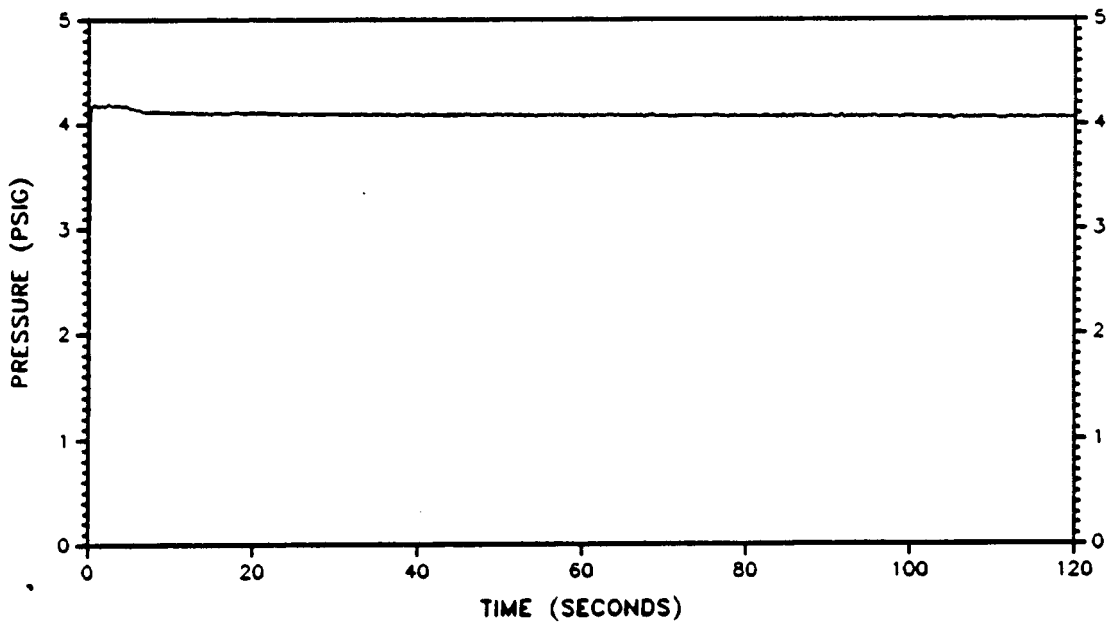


SCENARIO #2, TEST #4 (Test Date 2/23/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: II
TEST #: 5
ASSEMBLY DATE: 2/23/89
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/62

PRIMARY O-RING

O-RING NO.: #11
O-RING INNER DIAMETER (inch): 9.352
O-RING X-SECTION DIAM (inch): 0.2902
O-RING SQUEEZE (%): (AVG.) 17.2
ADJUSTED X-SECT (inch): 0.2849

SECUNDARY O-RING

O-RING NO.: #12
O-RING INNER DIAM (inch): 9.351
O-RING X-SECT DIAM (inch): 0.2901
O-RING SQUEEZE: (AVG.) 19.4
ADJUSTED X-SECT (inch): 0.2846

O-RING CONDITIONING

CONDITIONING TEMP.: 112.2 °F
CONDITIONING START TIME: NOON, 2/23/89 CONDITIONING STOP TIME: 7 AM, 2/24/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 2/24/89, 9 AM
CONDITIONING TEMP.: 76.7 °F
DATE & TIME OF TEST: 2/24/89, 9:55 AM
FIXTURE TEMEPERATURE AT END OF TEST: 75.8 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 3.2216 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 17.40 psia

T_1 = 75.7 °F T_2 = 75.8 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.3545 in^3

$\Delta V = V_i - V_f$

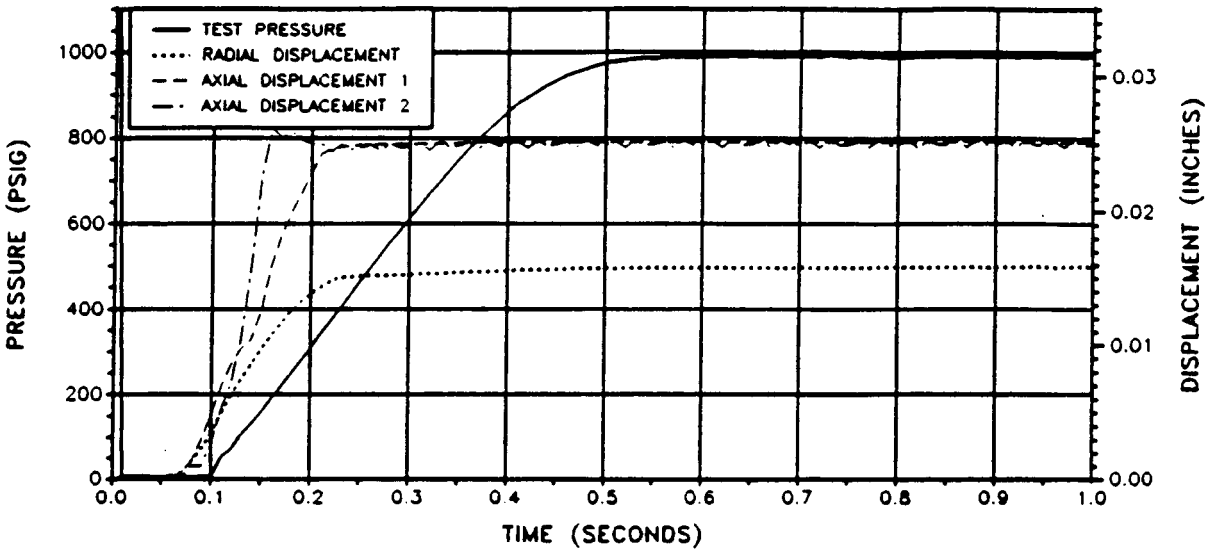
ΔV = 0.8671 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

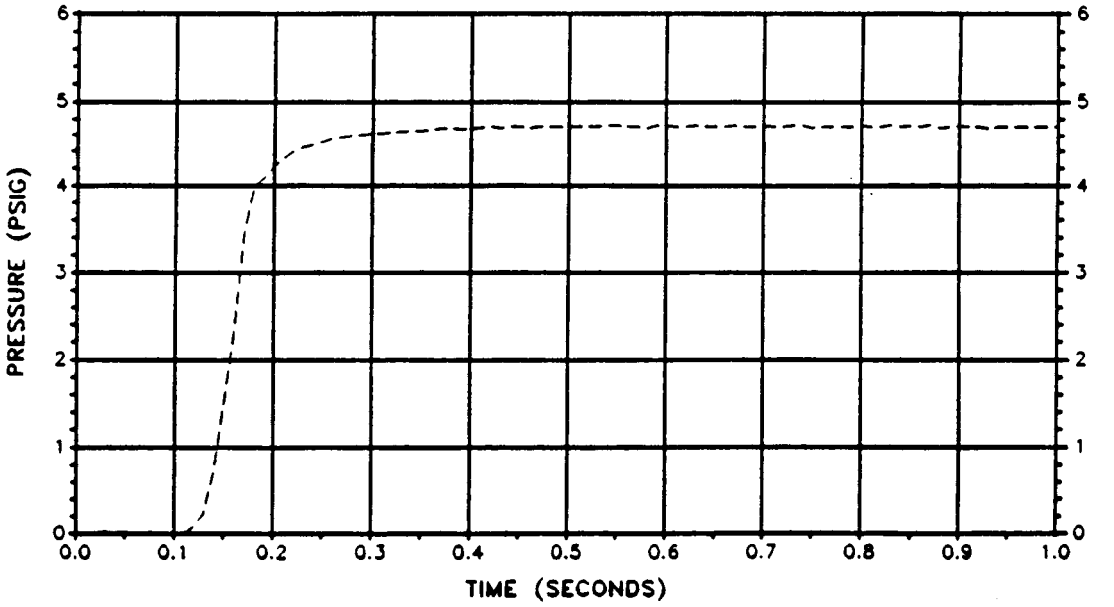
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #2, TEST #5 (Test Date 2/24/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

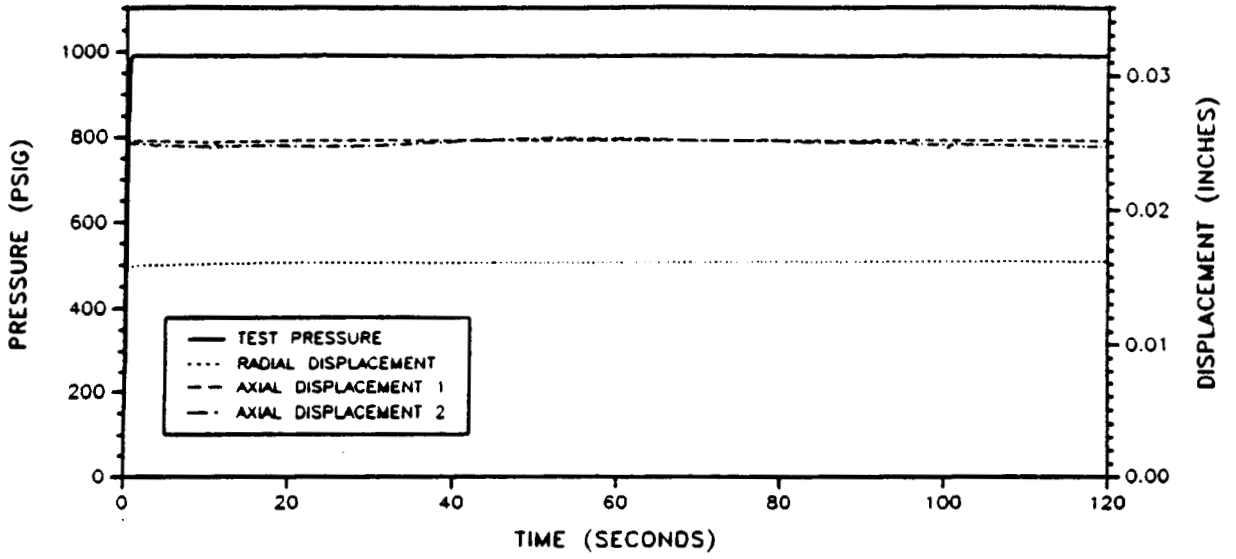


V-4 Cavity Pressure Vs. Time (1 Second Plot)

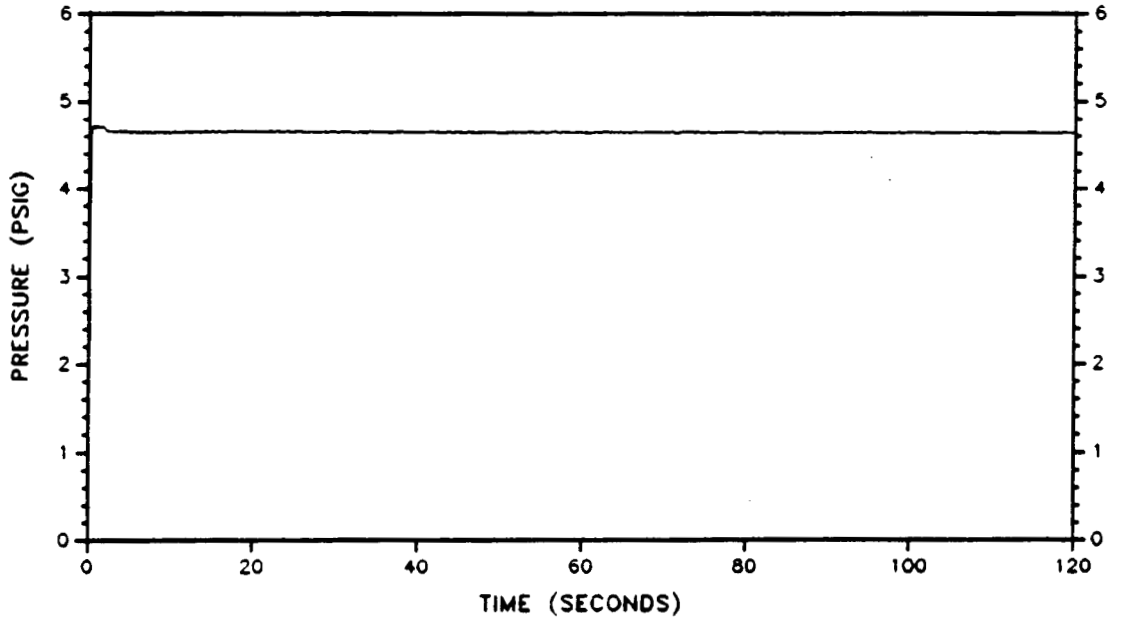


SCENARIO #2, TEST #5 (Test Date 2/24/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: II
TEST #: 6
ASSEMBLY DATE: 2/27/89
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/63

PRIMARY O-RING		SECONDARY O-RING	
O-RING NO.:	#13	O-RING NO.:	#14
O-RING INNER DIAMETER (inch):	9.383	O-RING INNER DIAM (inch):	9.351
O-RING X-SECTION DIAM (inch):	0.2902	O-RING X-SECT DIAM (inch):	0.2910
O-RING SQUEEZE (%): (AVG.)	17.4	O-RING SQUEEZE: (AVG.)	19.6
ADJUSTED X-SECT (inch):	0.2856	ADJUSTED X-SECT (inch):	0.2855

O-RING CONDITIONING

CONDITIONING TEMP.: 108.8 °F
CONDITIONING START TIME: 10:30 AM, 2/27/89
CONDITIONING STOP TIME: 7 AM, 12/28/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 2/28/89, 9 AM
CONDITIONING TEMP.: 75.0 °F
DATE & TIME OF TEST: 2/28/89, 10 AM
FIXTURE TEMEPERATURE AT END OF TEST: 76.0 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 3.2216 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 19.43 psia

T_1 = 75.9 °F T_2 = 75.9 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.1057 in^3

$\Delta V = V_i - V_f$

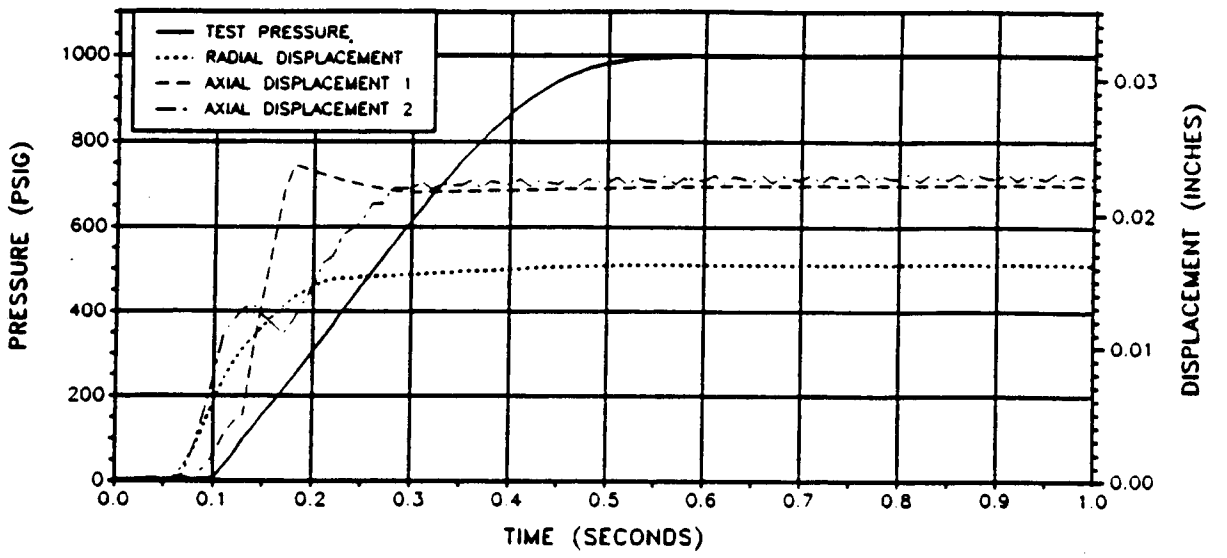
ΔV = 1.1159 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

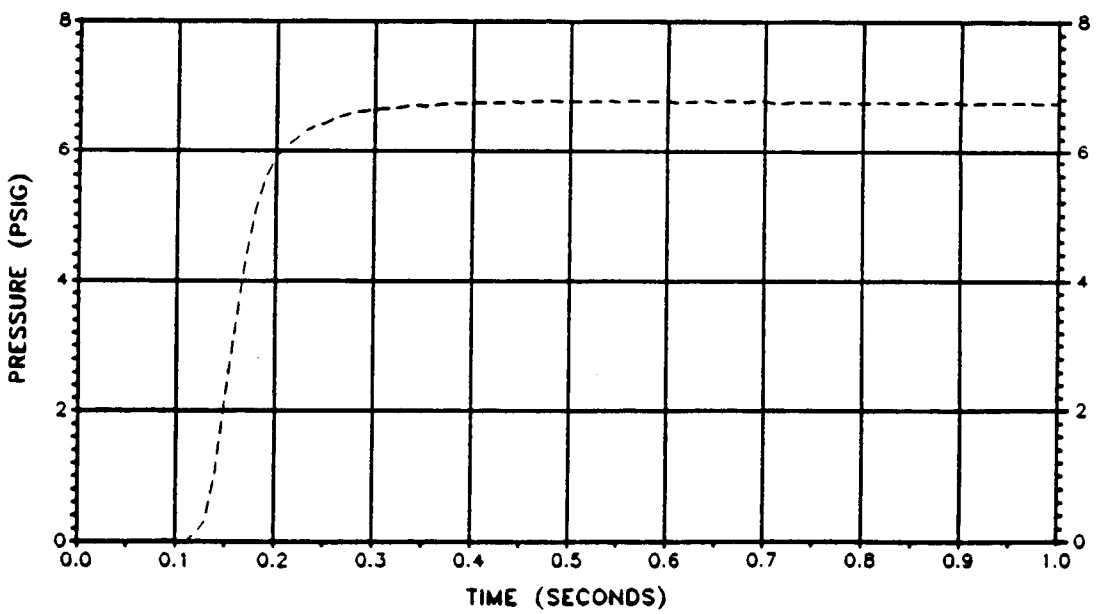
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #2, TEST #6 (Test Date 2/28/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

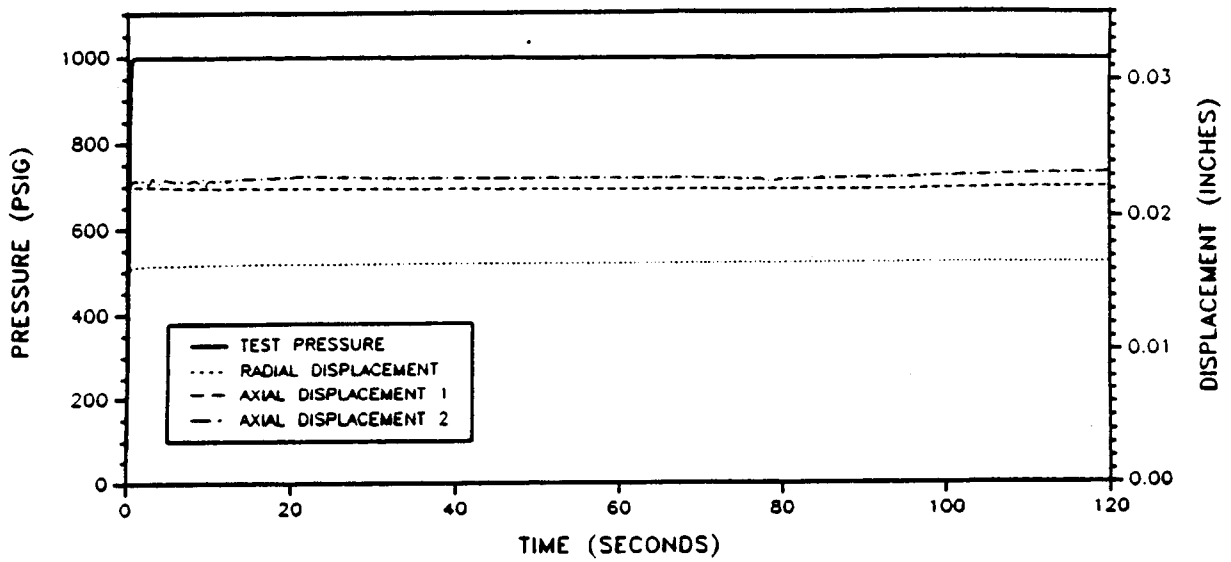


V-4 Cavity Pressure Vs. Time (1 Second Plot)

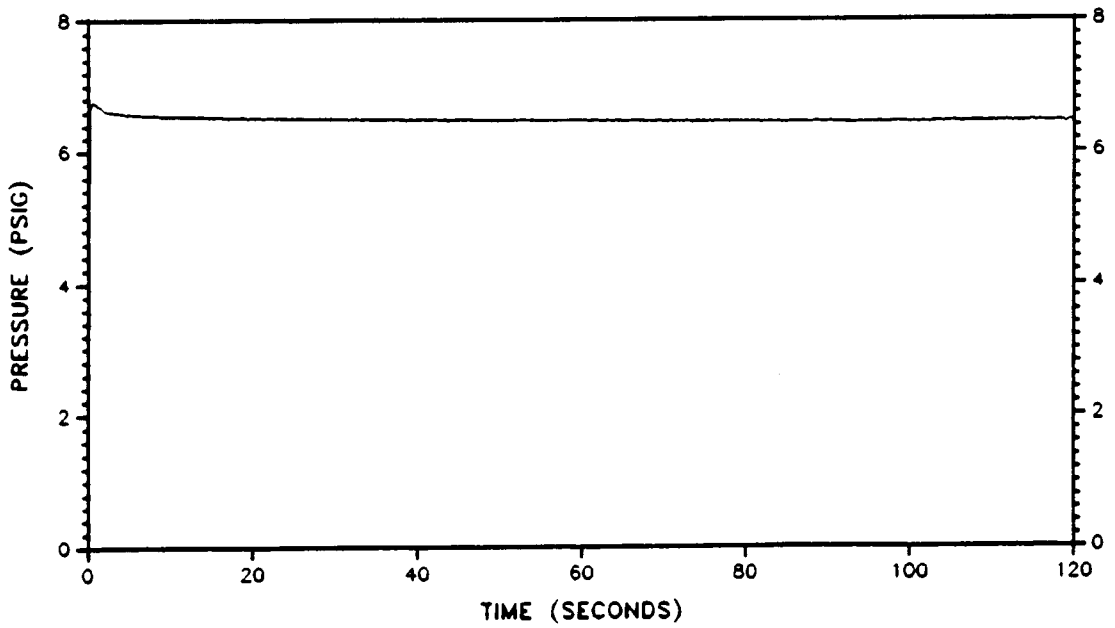


SCENARIO #2, TEST #6 (Test Date 2/28/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: II
ASSEMBLY DATE: 2/28/89

TEST #: 7
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: J. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16

PISTON NO.: 63/63

PRIMARY O-RING

O-RING NO.: #16
O-RING INNER DIAMETER (inch): 9.351
O-RING X-SECTION DIAM (inch): 0.2904
O-RING SQUEEZE (%): (AVG.) 17.2
ADJUSTED X-SECT (inch): 0.2851

SECONDARY O-RING

O-RING NO.: #17
O-RING INNER DIAM (inch): 9.383
O-RING X-SECT DIAM (inch): 0.2879
O-RING SQUEEZE: (AVG.) 18.9
ADJUSTED X-SECT (inch): 0.2831

O-RING CONDITIONING

CONDITIONING TEMP.: 113.3 °F
CONDITIONING START TIME: 1:30 PM 2/28/89
CONDITIONING STOP TIME: 7 AM, 2/29/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 2/29/89, 10 AM
CONDITIONING TEMP.: 75.0 °F
DATE & TIME OF TEST: 2/29/89,
FIXTURE TEMEPERATURE AT END OF TEST: 75.3 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 3.2216 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 20.6 psia

T_1 = 75.2 °F T_2 = 75.3 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 1.9888 in^3

$\Delta V = V_i - V_f$

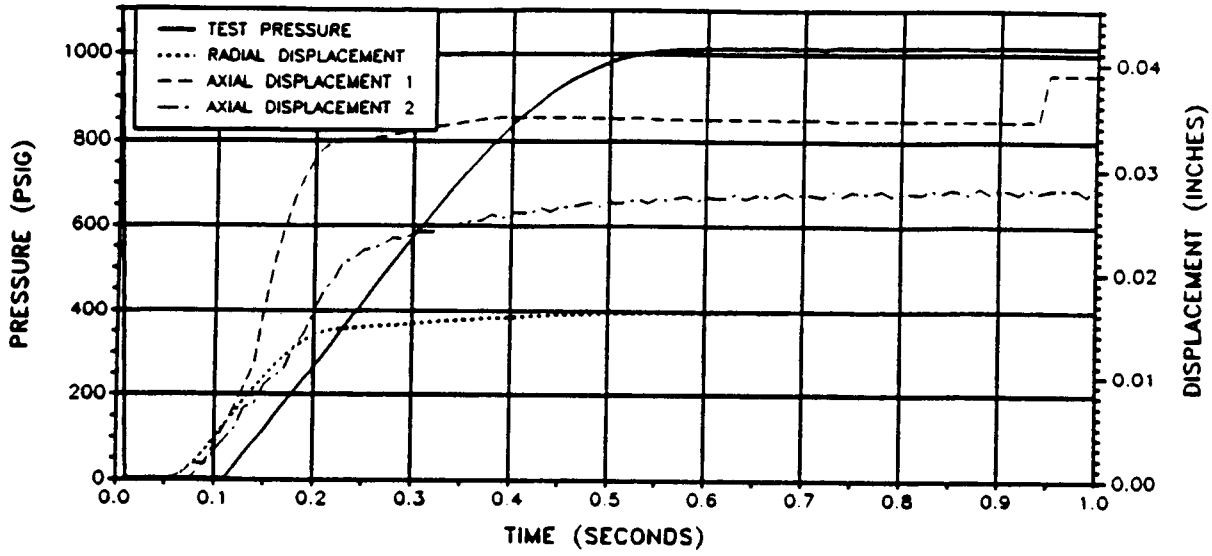
ΔV = 1.2328 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

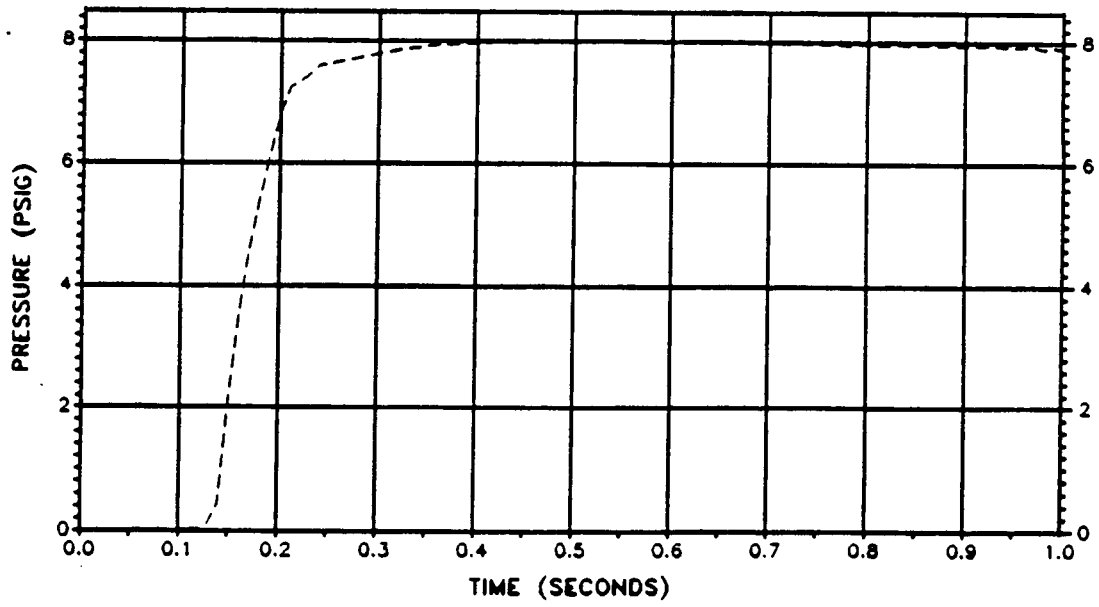
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #2, TEST #7 (Test Date 3/01/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

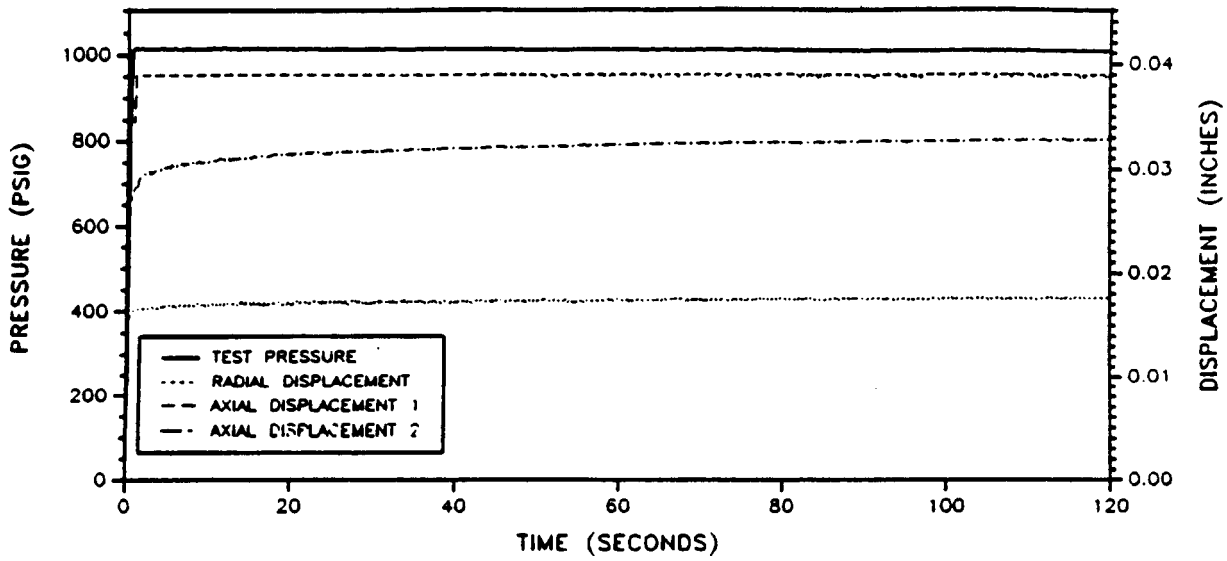


V-4 Cavity Pressure Vs. Time (1 Second Plot)

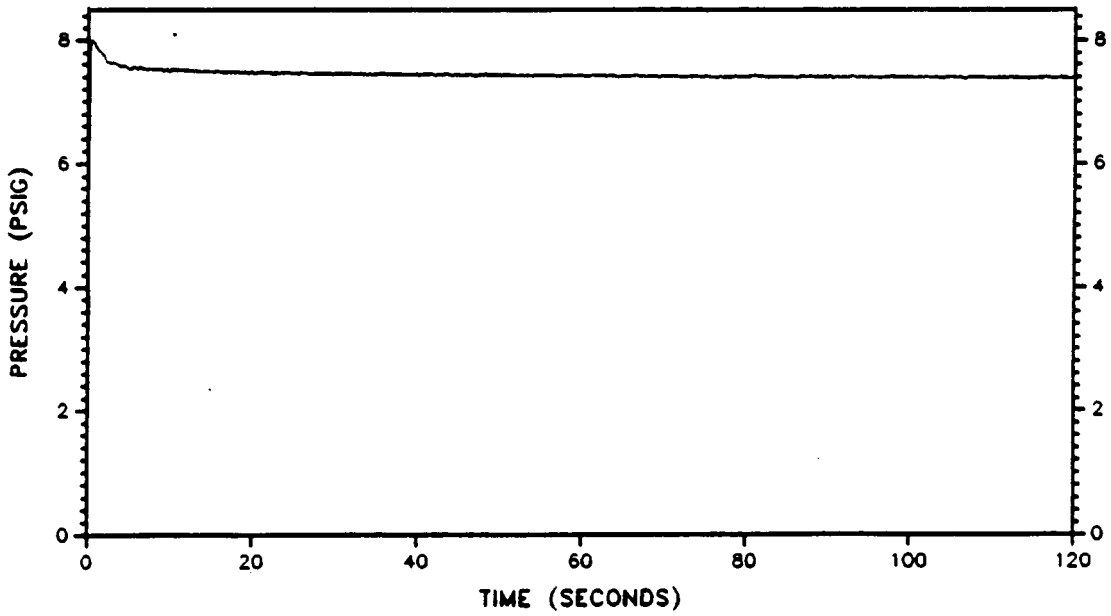


SCENARIO #2, TEST #7 (Test Date 3/01/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: II
TEST #: 8
ASSEMBLY DATE: 3/1/89
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/63

PRIMARY O-RING		SECONDARY O-RING	
O-RING NO.:	#17	O-RING NO.:	#18
O-RING INNER DIAMETER (inch):	9.374	O-RING INNER DIAM (inch):	9.327
O-RING X-SECTION DIAM (inch):	0.2904	O-RING X-SECT DIAM (inch):	0.2901
O-RING SQUEEZE (%): (AVG.)	17.4	O-RING SQUEEZE: (AVG.)	19.2
ADJUSTED X-SECT (inch):	0.2856	ADJUSTED X-SECT (inch):	0.2841

O-RING CONDITIONING

CONDITIONING TEMP.: 113.3 °F
CONDITIONING START TIME: 2:30 pM 3/1/89
CONDITIONING STOP TIME: 7 AM, 3/2/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/2/89, 11 AM
CONDITIONING TEMP.: 76.0 °F
DATE & TIME OF TEST: 3/2/89, 11:15 AM
FIXTURE TEMEPERATURE AT END OF TEST: 75.7 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 3.2216 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 19.87 psia

T_1 = 75.6 °F T_2 = 75.6 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.0591 in^3

$\Delta V = V_i - V_f$

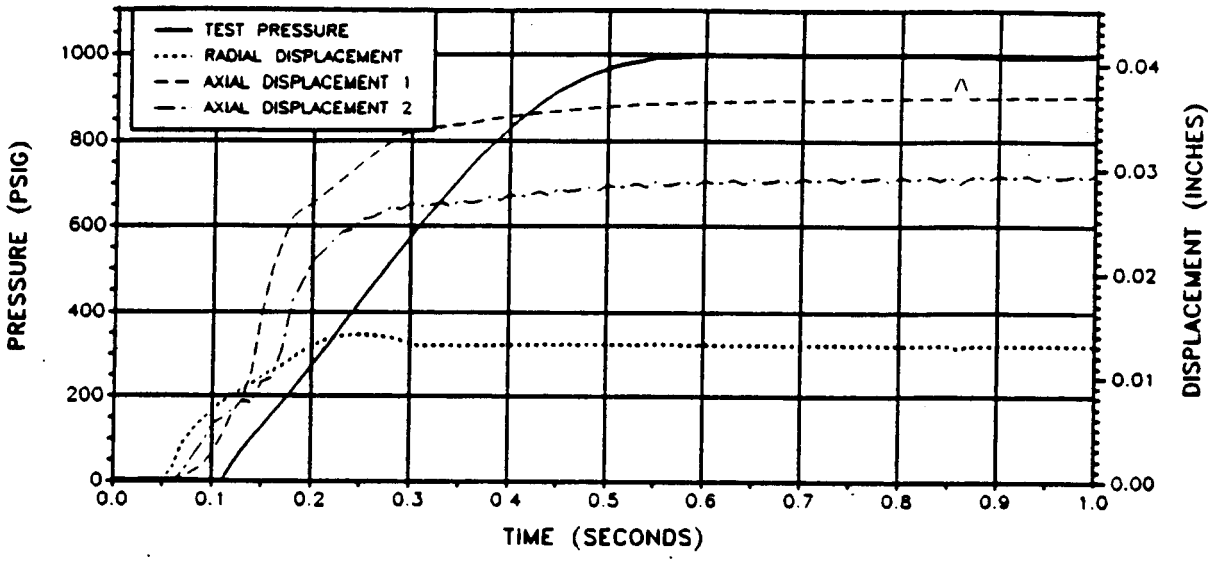
ΔV = 1.1625 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

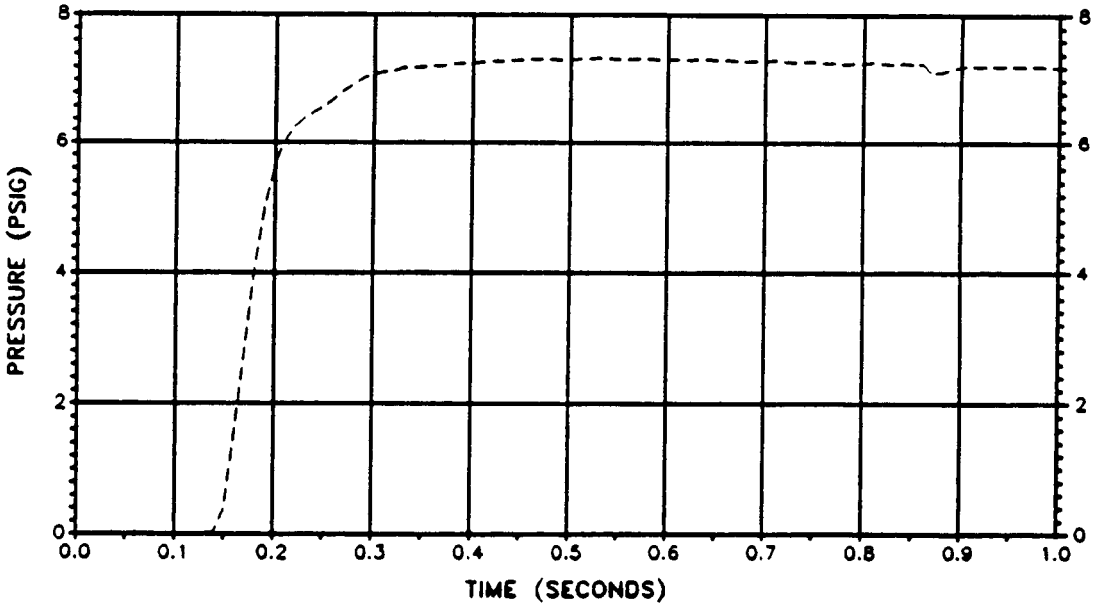
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #2, TEST #8 (Test Date 3/02/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

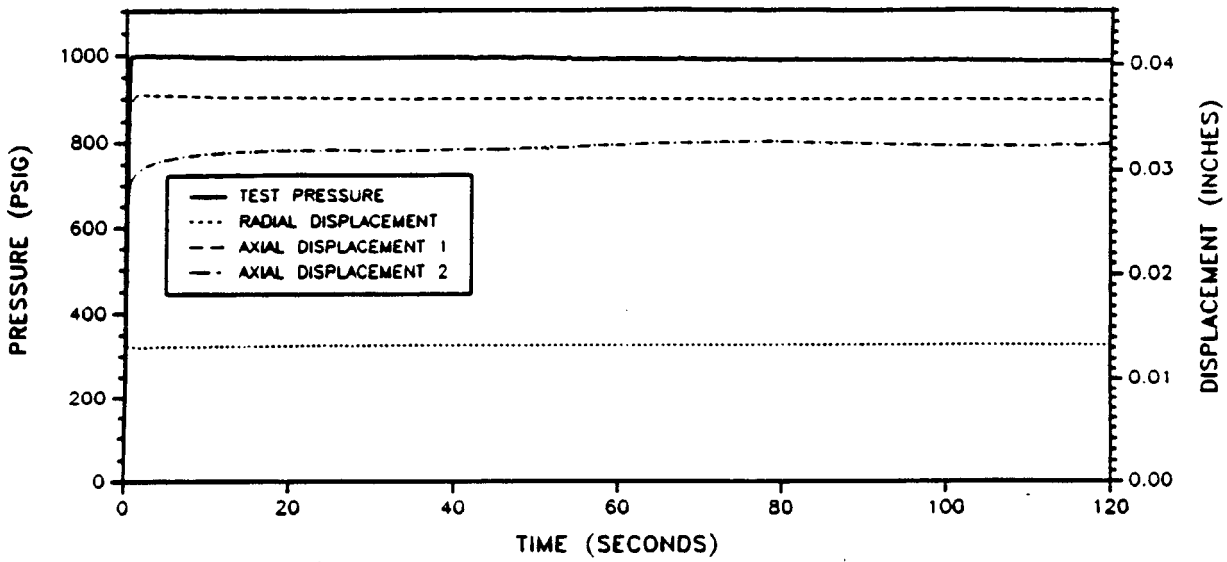


V-4 Cavity Pressure Vs. Time (1 Second Plot)

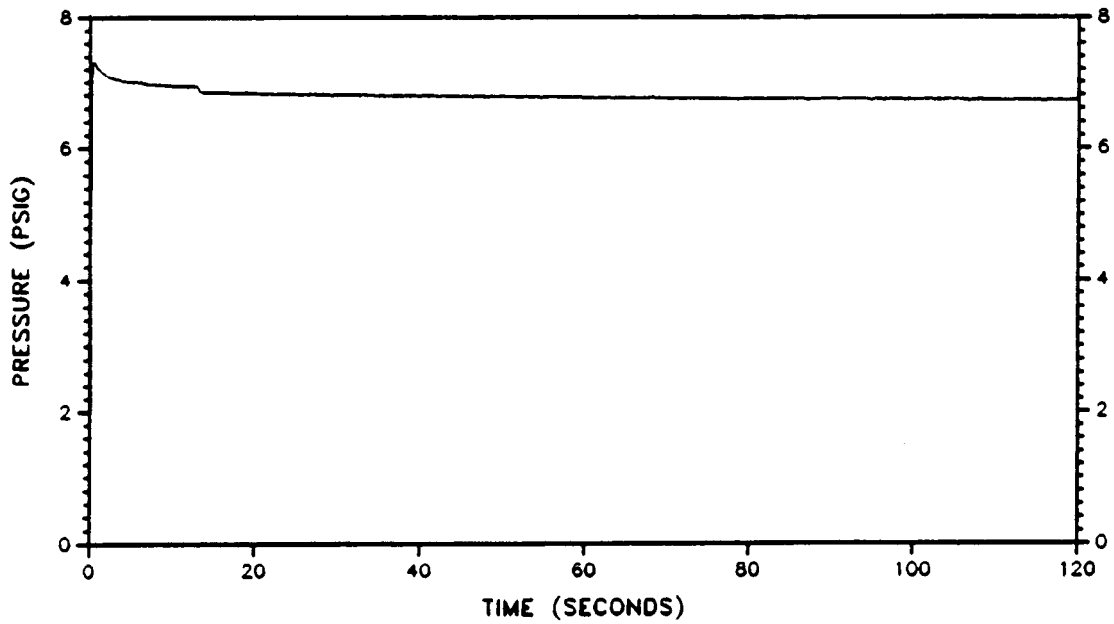


SCENARIO #2, TEST #8 (Test Date 3/02/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: II
TEST #: 9
ASSEMBLY DATE: 3/6/89
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/63

PRIMARY O-RING		SECONDARY O-RING	
O-RING NO.:	#21	O-RING NO.:	#22
O-RING INNER DIAMETER (inch):	9.351	O-RING INNER DIAM (inch):	9.367
O-RING X-SECTION DIAM (inch):	0.2907	O-RING X-SECT DIAM (inch):	0.2893
O-RING SQUEEZE (%): (AVG.)	17.3	O-RING SQUEEZE: (AVG.)	19.2
ADJUSTED X-SECT (inch):	0.2854	ADJUSTED X-SECT (inch):	0.2841

O-RING CONDITIONING

CONDITIONING TEMP.: 114.1 °F
CONDITIONING START TIME: 1 pm, 3/7/89 CONDITIONING STOP TIME: 7 AM, 3/7/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/8/89, 8:30 AM
CONDITIONING TEMP.: 75.0 °F
DATE & TIME OF TEST: 3/8/89 10:25 AM
FIXTURE TEMEPERATURE AT END OF TEST: 74.4 °F

CALCULATE V_4 FINAL VOLUME (V_f)

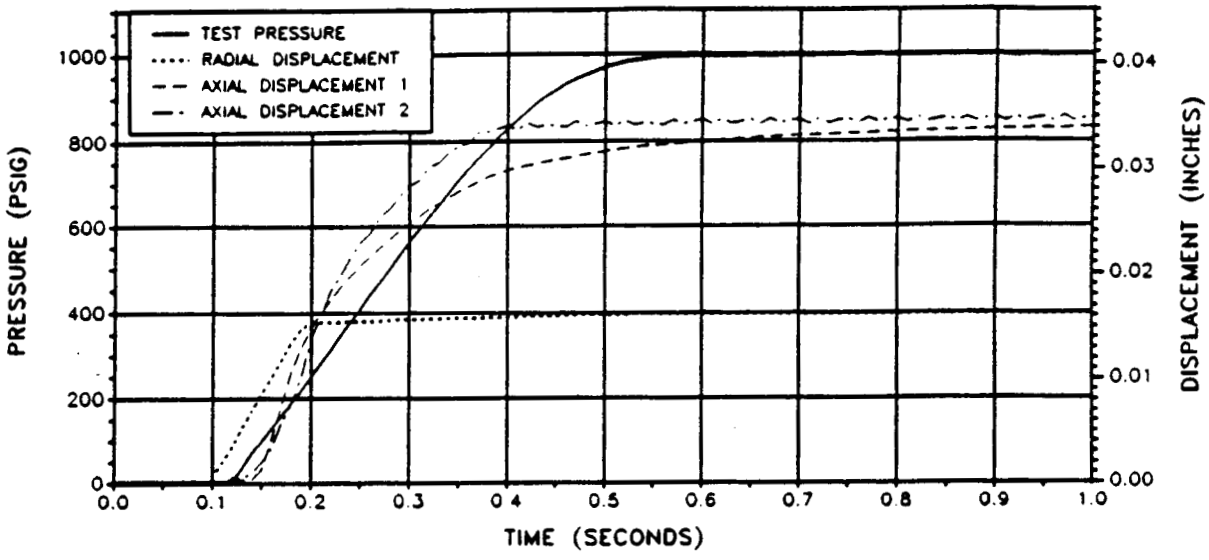
Known initial volume in system calculated from Boyle's Lav (V_i): 3.2216 in^3
P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 20.23 psia
T_1 = 74.2 °F T_2 = 74.2 °F (at 60 seconds)
Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$
V_f = 2.0225 in^3
$\Delta V = V_i - V_f$
ΔV = 1.1991 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

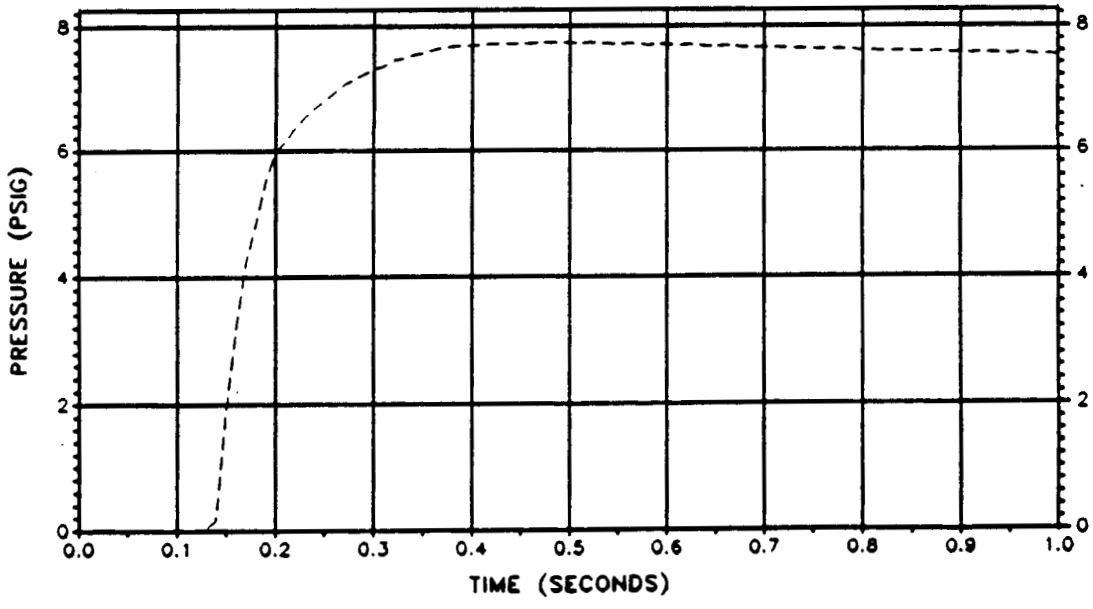
COMMENTS ON DISSASSEMBLED CONDITION: Too much pressure to initiate radial shaft. The technician greased shaft lucratively for this assembly.

SCENARIO #2, TEST #9 (Test Date 3/08/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

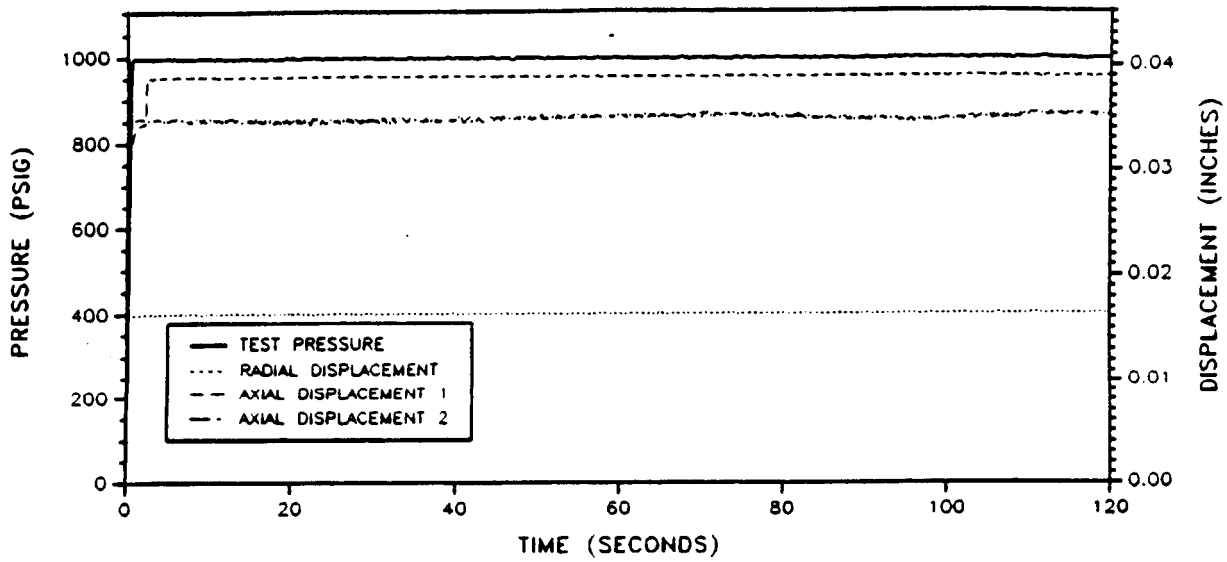


V-4 Cavity Pressure Vs. Time (1 Second Plot)

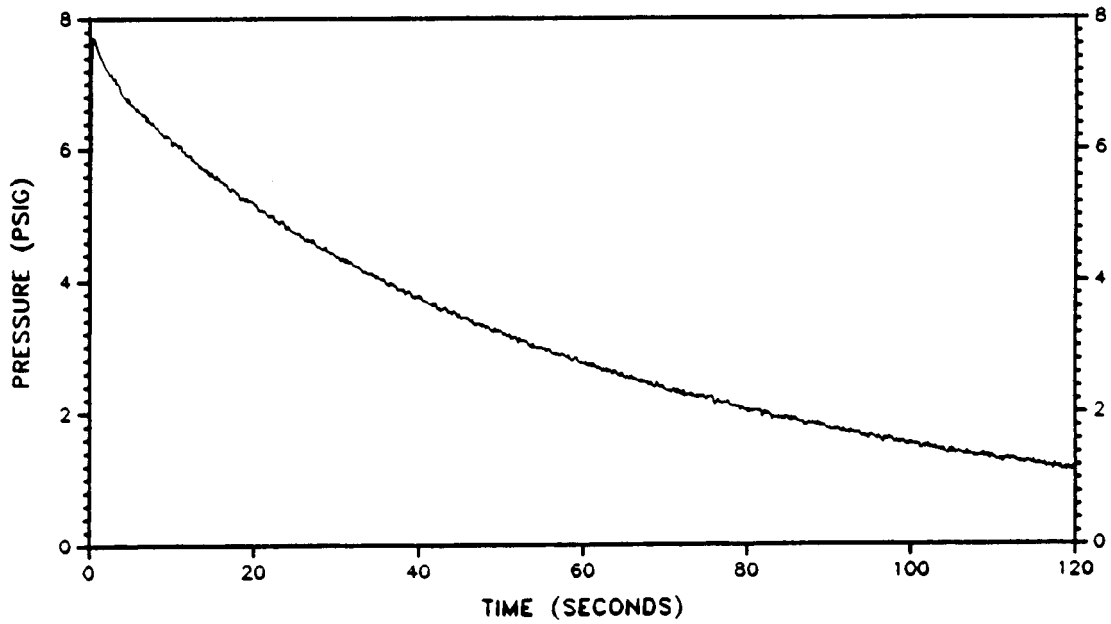


SCENARIO #2, TEST #9 (Test Date 3/08 /89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: II
TEST #: 10
ASSEMBLY DATE: 3/9/89
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/63

PRIMARY O-RING

O-RING NO.: #25
O-RING INNER DIAMETER (inch): 9.385
O-RING X-SECTION DIAM (inch): 0.2901
O-RING SQUEEZE (%): (AVG.) 17.4
ADJUSTED X-SECT (inch): 0.2856

SECONDARY O-RING

O-RING NO.: #26
O-RING INNER DIAM (inch): 9.379
O-RING X-SECT DIAM (inch): 0.2906
O-RING SQUEEZE: (AVG.) 19.7
ADJUSTED X-SECT (inch): 0.2856

O-RING CONDITIONING

CONDITIONING TEMP.: 112.2 °F
CONDITIONING START TIME: 2:30 pm 3/9/89
CONDITIONING STOP TIME: 7 AM, 3/10/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/10/89, 8:30 AM
CONDITIONING TEMP.: 76.0 °F
DATE & TIME OF TEST: 3/10/89, 10 AM
FIXTURE TEMEPERATURE AT END OF TEST: 76.0 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Lav (V_i): 3.2216 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 17.75 psia

T_1 = 75.9 °F T_2 = 75.9 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.3050 in^3

$\Delta V = V_i - V_f$

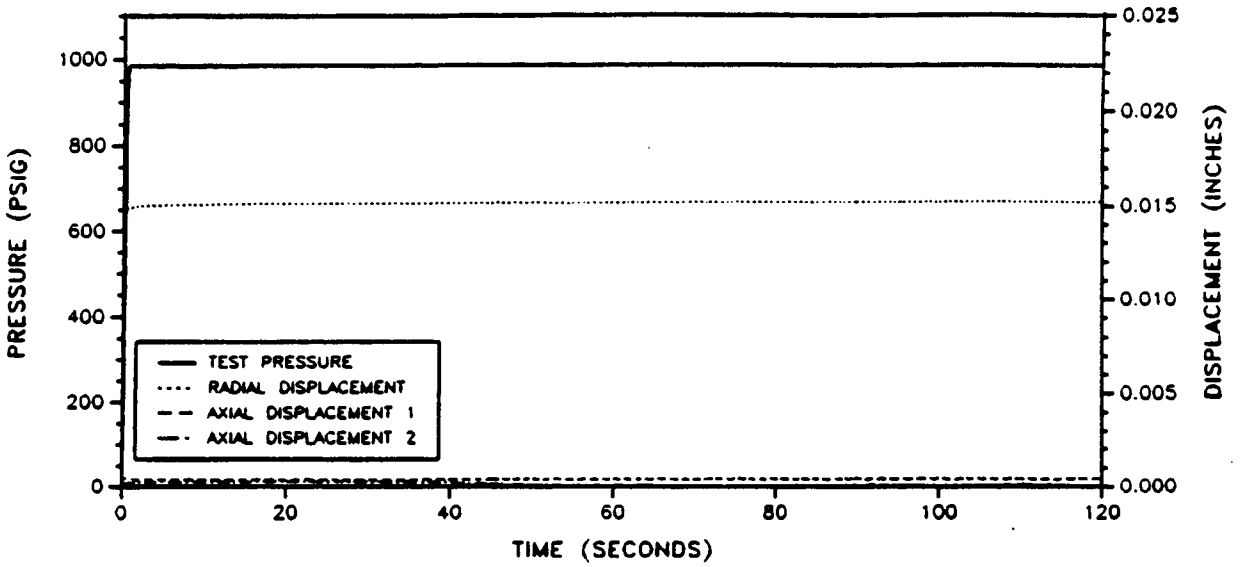
ΔV = 0.9166 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

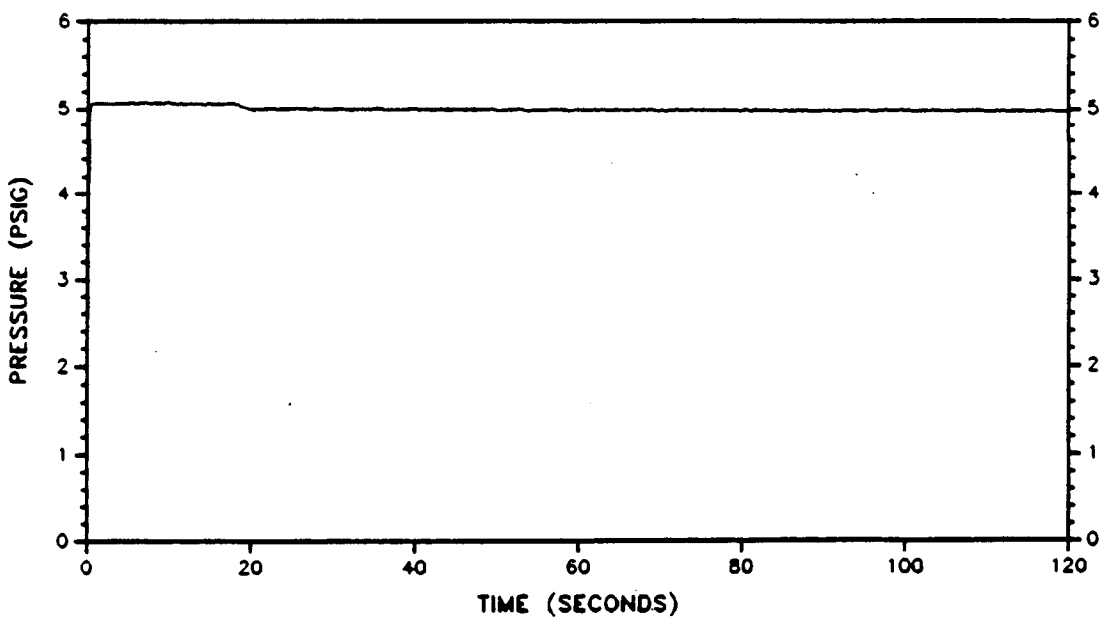
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #2, TEST #10 (Test Date 3/10/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)

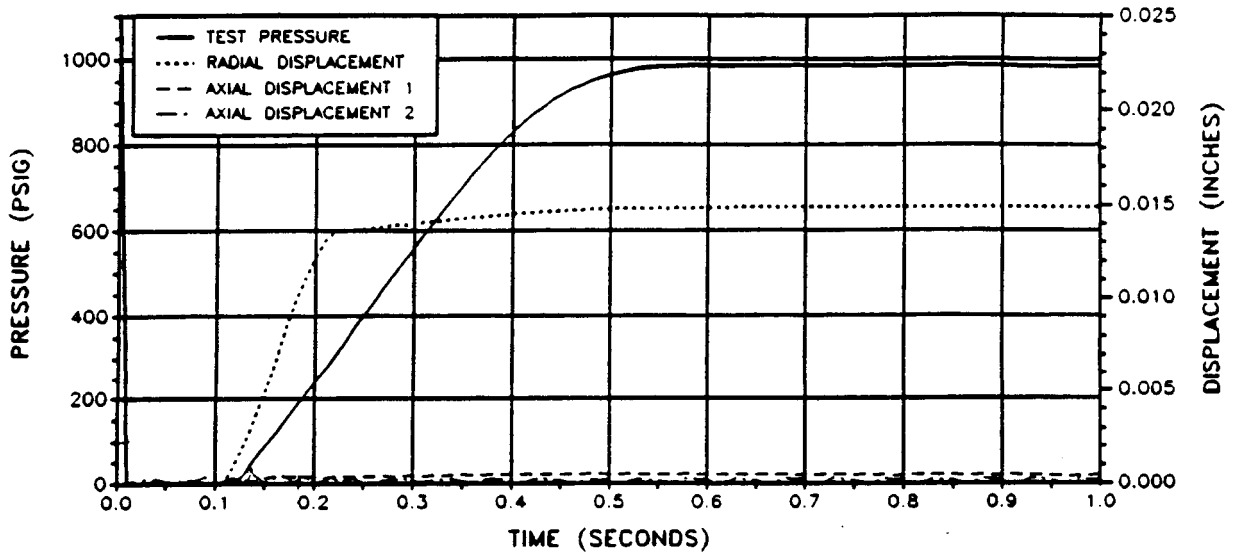


V-4 Cavity Pressure Vs. Time (120 Second Plot)

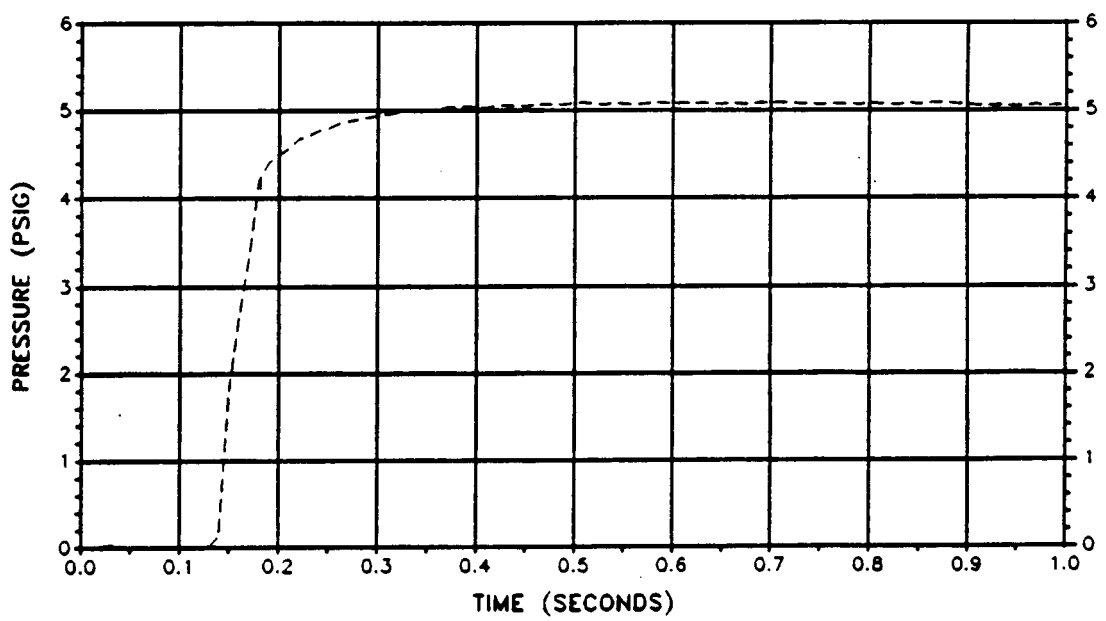


SCENARIO #2, TEST #10 (Test Date 3/10/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)



V-4 Cavity Pressure Vs. Time (1 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: II
ASSEMBLY DATE: 3/13/89

TEST #: 11
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/63

PRIMARY O-RING

O-RING NO.: #27
O-RING INNER DIAMETER (inch): 9.391
O-RING X-SECTION DIAM (inch): 0.2892
O-RING SQUEEZE (%): (AVG.) 17.1
ADJUSTED X-SECT (inch): 0.2848

SECONDARY O-RING

O-RING NO.: #28
O-RING INNER DIAM (inch): 9.374
O-RING X-SECT DIAM (inch): 0.2917
O-RING SQUEEZE: (AVG.) 19.9
ADJUSTED X-SECT (inch): 0.2866

O-RING CONDITIONING

CONDITIONING TEMP.: 112.3 °F
CONDITIONING START TIME: 3 pm, 3/13/89 CONDITIONING STOP TIME: 7 AM, 3/14/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/14/89, 8:30 AM
CONDITIONING TEMP.: 76.0 °F
DATE & TIME OF TEST: 3/14/89, 10:25 AM
FIXTURE TEMEPERATURE AT END OF TEST: 75.5 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 3.2216 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 19.19 psia

T_1 = 75.5 °F T_2 = 75.5 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.1321 in^3

$\Delta V = V_i - V_f$

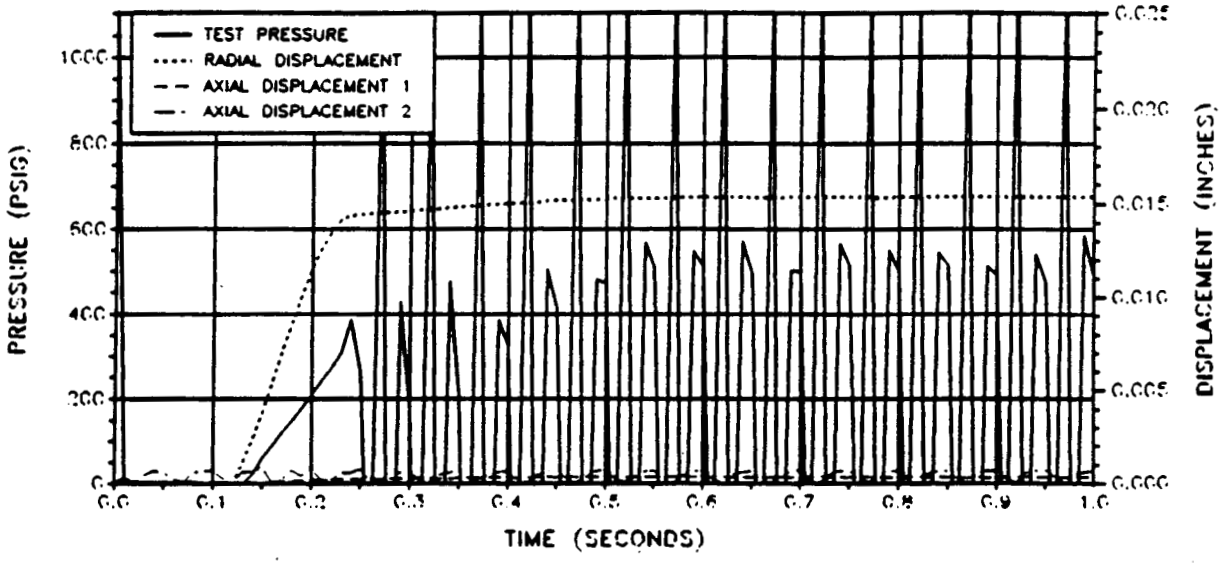
ΔV = 1.0895 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

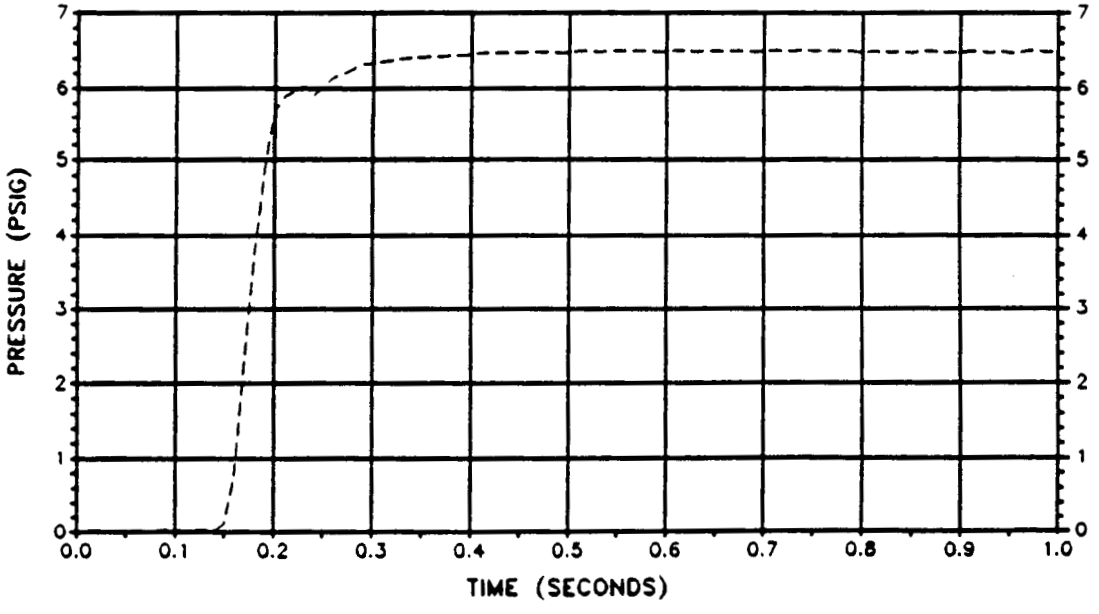
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #2, TEST #11 (Test Date 3/14/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

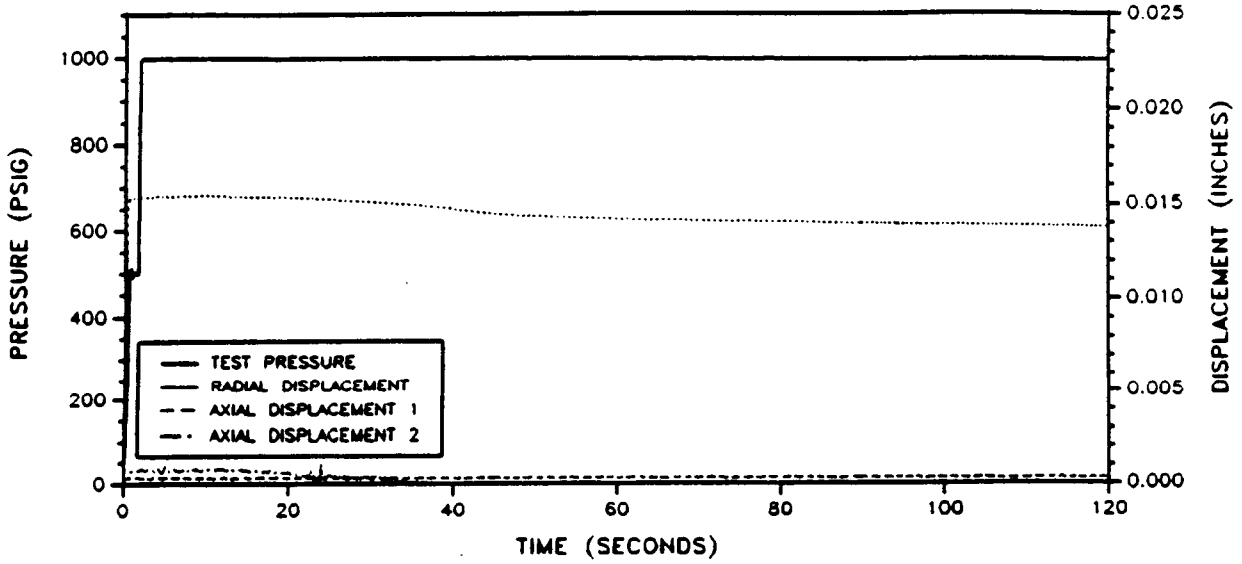


V-4 Cavity Pressure Vs. Time (1 Second Plot)

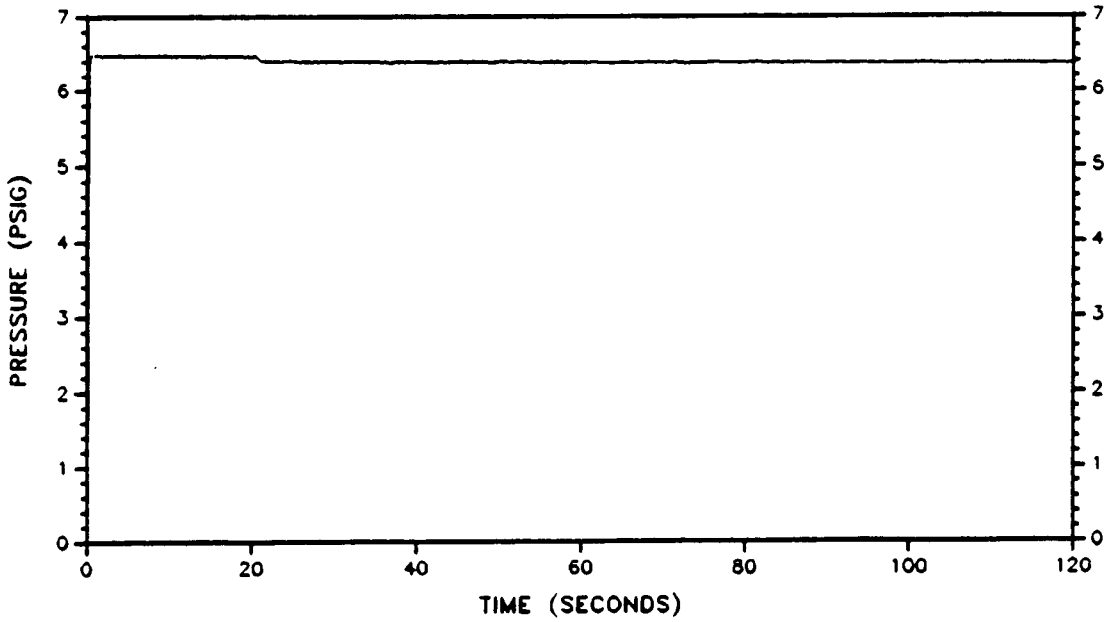


SCENARIO #2, TEST #11 (Test Date 3/14/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Thiokol CORPORATION
SPACE OPERATIONS

V_4 PRESSURIZATION TESTS - TEST DATA SHEETS

SCENARIO #: II
TEST #: 12
ASSEMBLY DATE: 3/20/89
TEST TECHNICIAN: M. Gardner
TEST SUPERVISOR: T. Kerrigan

ASSEMBLY DETAILS:

CYLINDER NO.: 63/16
PISTON NO.: 63/63

PRIMARY O-RING		SECONDARY O-RING	
O-RING NO.:	#29	O-RING NO.:	#30
O-RING INNER DIAMETER (inch):	9.351	O-RING INNER DIAM (inch):	9.338
O-RING X-SECTION DIAM (inch):	0.2882	O-RING X-SECT DIAM (inch):	0.2876
O-RING SQUEEZE (%): (AVG.)	16.6	O-RING SQUEEZE: (AVG.)	18.6
ADJUSTED X-SECT (inch):	0.2830	ADJUSTED X-SECT (inch):	0.2819

O-RING CONDITIONING

CONDITIONING TEMP.: 110.2 °F

CONDITIONING START TIME: 1 pm, 3/20/89 CONDITIONING STOP TIME: 7 AM, 3/21/89

FIXTURE CONDITIONING FOR TEST

START DATE & TIME OF TEST CONDITIONING: 3/21/89, 8:45 AM

CONDITIONING TEMP.: 76.8 °F

DATE & TIME OF TEST: 3/21/89, 10 AM

FIXTURE TEMEPERATURE AT END OF TEST: 76.0 °F

CALCULATE V_4 FINAL VOLUME (V_f)

Known initial volume in system calculated from Boyle's Law (V_i): 3.2216 in^3

P_{atm} = 12.7 psia P_f (at end of 1 min. from gage) + 12.7 = 16.59 psia

T_1 = 76.0 °F T_2 = 76.0 °F (at 60 seconds)

Final Volume in V_4 (V_f) = $(P_{atm} * V_i * T_2)/(P_f * T_1)$

V_f = 2.4662 in^3

$\Delta V = V_i - V_f$

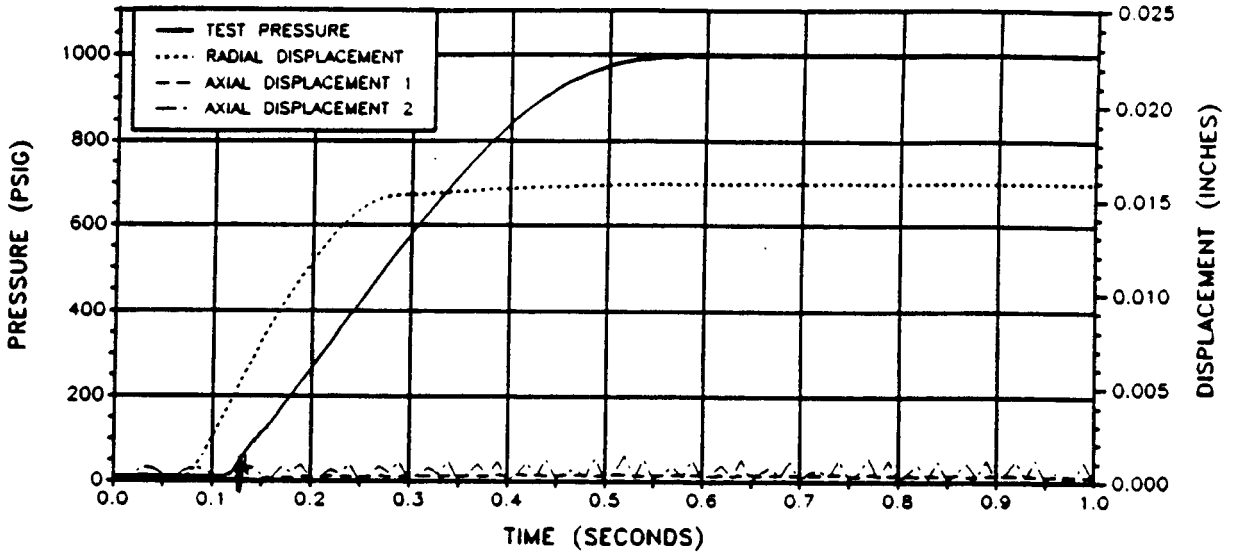
ΔV = 0.7554 in3

ATTACH ALL COMPUTER PRINTOUTS AND PRESSURE AND DISPLACEMENT TRACES FOR ABOVE TESTS

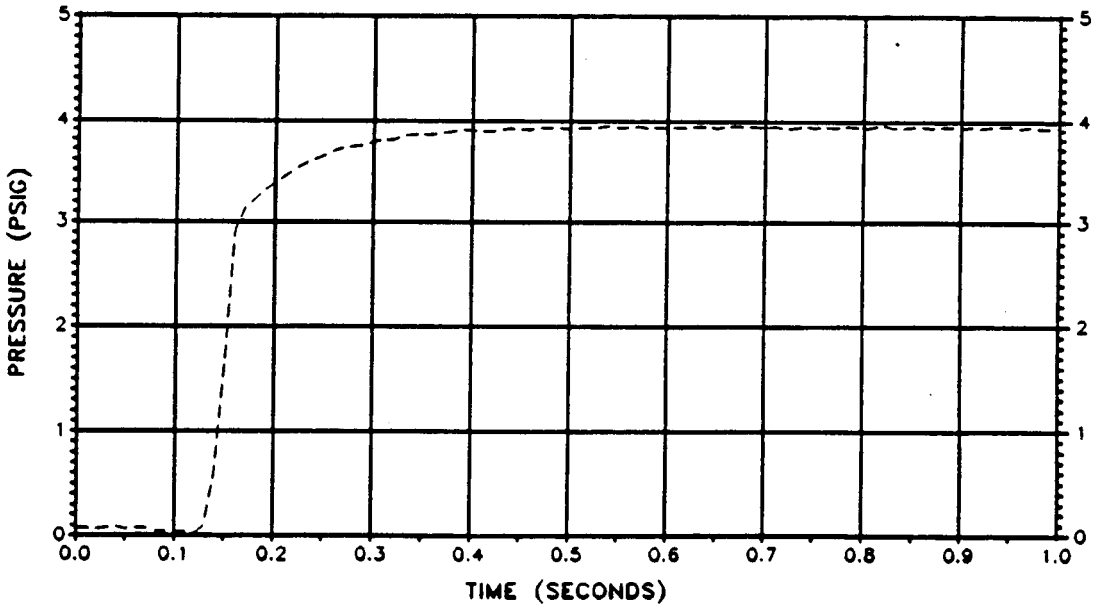
COMMENTS ON DISSASSEMBLED CONDITION: _____

SCENARIO #2, TEST #12 (Test Date 3/21/89)

Test Pressure, Radial and Axial Displacement Vs. Time (1 Second Plot)

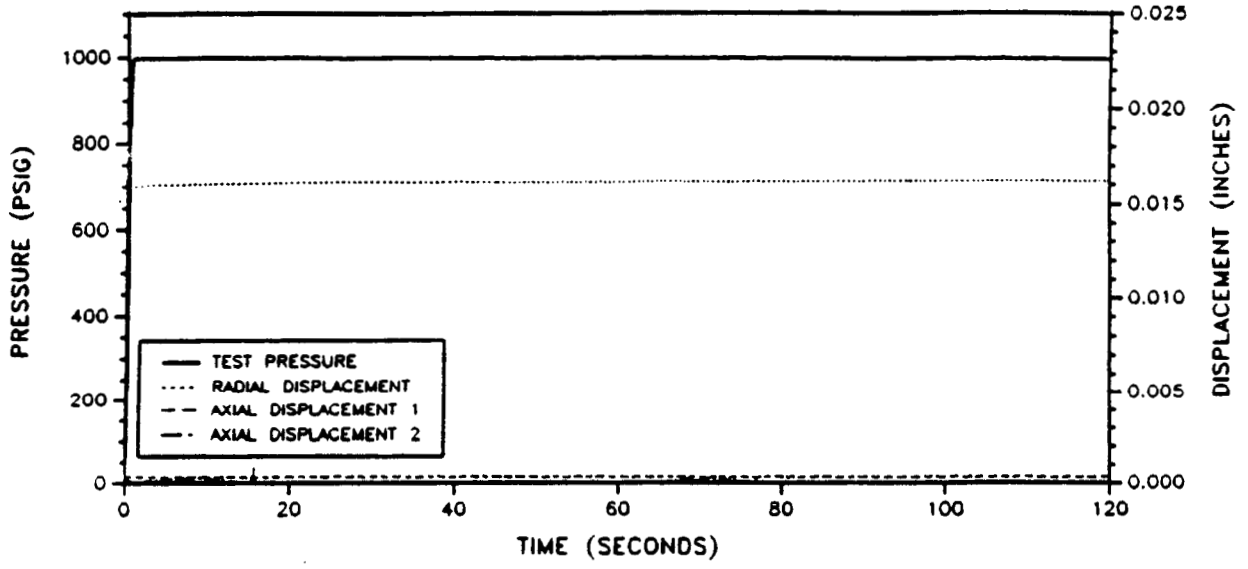


V-4 Cavity Pressure Vs. Time (1 Second Plot)

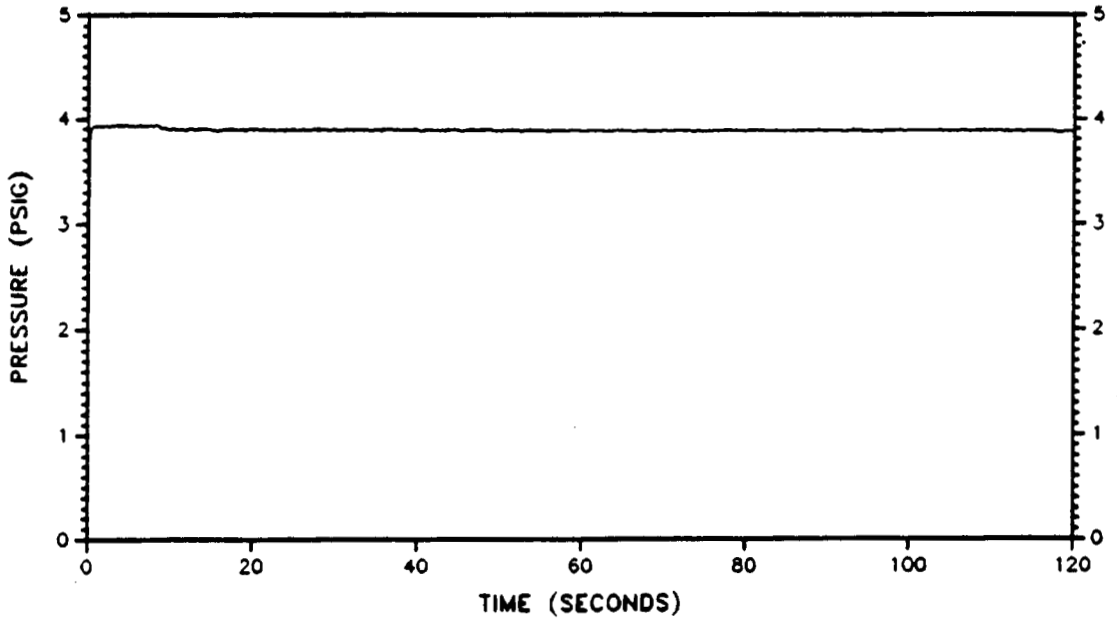


SCENARIO #2, TEST #12 (Test Date 3/21/89)

Test Pressure, Radial and Axial Displacement Vs. Time (120 Second Plot)



V-4 Cavity Pressure Vs. Time (120 Second Plot)



Appendix B
Determining Initial V_4 Cavity Volume (Test Fixture)
Scenarios #1 & #2

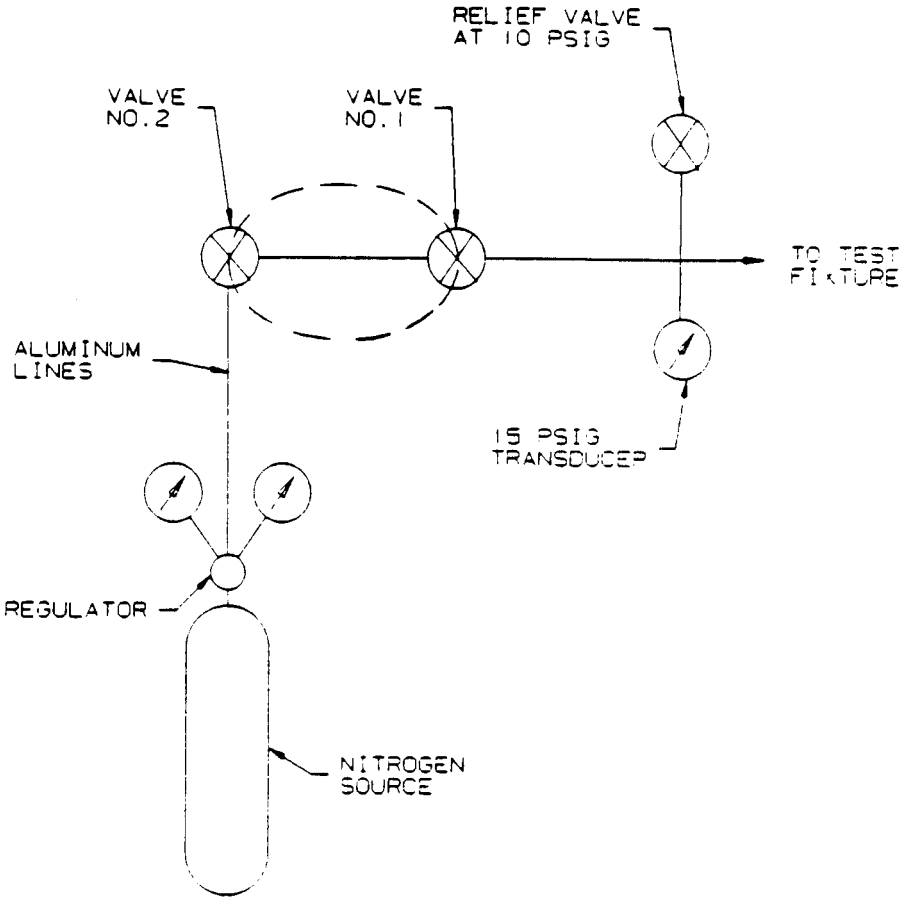


FIGURE 8

Known Volume measured with isopropyl alcohol and determined as described in Section 3.5.2.

Volume in lines + Valve No.2	=	3.0 cc.
Volume in left half of Valve No.1	=	0.5 cc.
Total Known Volume	=	3.5 cc.

SCENARIO #1

Try #1:

T_1 = 76.4° F, P_1 = 8.20 psig + 12.7 atm. = 20.90 psi (absolute)

T_2 = 76.4° F, P_2 = 6.46 psig + 12.7 atm. = 19.16 psi (absolute)

$$P_1 * V_1 = P_2 * V_2$$

$$V_1 = \frac{P_2}{P_1} * (3.5 + V_1)$$

$$V_1 = \frac{19.16}{20.90} * (3.5 + V_1)$$

$$V_1 = 3.209 + 0.917 * V_1$$

$$V_1 = 38.663 \text{ cc.} = 2.359 \text{ cu.in.}$$

Try #2:

T_1 = 77.0° F, P_1 = 8.24 psig + 12.7 atm. = 20.94 psi(absolute)

T_2 = 77.0° F, P_2 = 6.49 psig + 12.7 atm. = 19.19 psi(absolute)

$$P_1 * V_1 = P_2 * V_2$$

$$V_1 = \frac{P_2}{P_1} * (3.5 + V_1)$$

$$V_1 = \frac{19.19}{20.94} * (3.5 + V_1)$$

$$V_1 = 3.207 + 0.916 * V_1$$

$$V_1 = 38.179 \text{ cc.} = 2.330 \text{ cu.in.}$$

$$\text{AVERAGE VOLUME} = \frac{2.359 + 2.330}{2} = \mathbf{2.345\ cu.in.}$$

SCENARIO #2

Try #1:

$T_1 = 78.6°$ F, $P_1 = 5.25$ psig + 12.7 atm. = 17.95 psi(absolute)

$T_2 = 78.6°$ F, $P_2 = 4.16$ psig + 12.7 atm. = 16.86 psi(absolute)

$$P_1 * V_1 = P_2 * V_2$$

$$V_1 = \frac{P_2}{P_1} * (3.5 + V_1)$$

$$V_1 = \frac{16.86}{17.95} * (3.5 + V_1)$$

$$V_1 = 3.287 + 0.939 * V_1$$

$$V_1 = 53.885 \text{ cc.} = 3.288 \text{ cu.in.}$$

Try #2:

$T_1 = 78.2°$ F, $P_1 = 5.67$ psig + 12.7 atm. = 18.37 psi(absolute)

$T_2 = 78.2°$ F, $P_2 = 4.50$ psig + 12.7 atm. = 17.2 psi(absolute)

$$P_1 * V_1 = P_2 * V_2$$

$$V_1 = \frac{P_2}{P_1} * (3.5 + V_1)$$

$$V_1 = \frac{17.20}{18.37} * (3.5 + V_1)$$

$$V_1 = 3.277 + 0.936 * V_1$$

$$V_1 = 51.203 \text{ cc.} = 3.124 \text{ cu.in.}$$

$$\text{AVERAGE VOLUME} = \frac{3.288 + 3.124}{2} = \mathbf{3.206 \text{ cu.in.}}$$

Appendix C

Determining Final V_4 Volume and Pressure Rise

NOTE:

Appendix C contains one iteration of calculations for pressure rise predictions. These are only example calculations used to support the predictions listed in Tables 2 through 5 in the document.

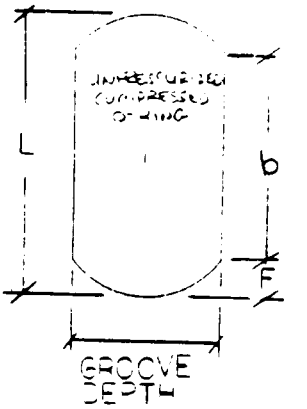
O-RING GEOMETRIC RELATIONSHIPS (using Molari Equations)

$$\frac{L}{D} = 0.9938\ e^{0.6837c}$$

$$\frac{b}{D} = 1.5\ (c)^{2/3}$$

c = Squeeze

D = Adjusted O-ring Cross Section



Solve for L, b, and F for both Primary and Secondary O-rings

O-ring Dimensions

	Primary	Secondary
ID	= 9.383"	9.374"
CS	= 0.2903"	0.2908"
ADJ CS	= 0.2857"	0.2857"
SQ	= 17.4%	19.7%

Groove Dimensions

	Primary	Secondary
ID	= 9.551"	9.564"
OD	= 9.979"	9.979"
DEPTH	= 0.215"	0.208"
WIDTH	= 0.360"	0.351"
GAP	= 0.0215"	0.0215"

Primary O-ring

$$\frac{L}{D} = 0.9938\ e^{0.6837c} = 1.1193$$

$$\frac{b}{D} = 1.5\ (c)^{2/3} = 0.4675$$

$$F = \frac{L-b}{2}$$

L = 0.320 in.

b = 0.134 in.

F = 0.093 in.

Secondary O-ring

$$\frac{L}{D} = 0.9938\ e^{0.6837c} = 1.1371$$

$$\frac{b}{D} = 1.5\ (c)^{2/3} = 0.5078$$

$$F = \frac{L-b}{2}$$

L = 0.325 in.

b = 0.145 in.

F = 0.090 in.

Primary O-ring Volume

$$V_{O\text{-}ring} = (\text{X-sec Area})*(\text{Length})\pi$$

$$= \left(\frac{0.2903}{2}\right)^2 \pi * (9.383 + 0.2903)\pi$$

$$= 2.011 \text{ cu.in.}$$

Secondary O-ring Volume

$$V_{O\text{-}ring} = (\text{X-sec Area})*(\text{Length})\pi$$

$$= \left(\frac{0.2908}{2}\right)^2 \pi * (9.374 + 0.2908)\pi$$

$$= 2.017 \text{ cu.in.}$$

Primary Groove Volume

$$V_{groove} = (\text{X-sec Area})*(\text{Length})\pi$$

$$= (0.360)*(0.215 + 0.0215)*(9.551 + 0.215 + 0.0215)\pi$$

$$= 2.618 \text{ cu.in.}$$

Secondary Groove Volume

$$V_{groove} = (\text{X-sec Area})*(\text{Length})\pi$$

$$= (0.351)*(0.208 + 0.0215)*(9.564 + 0.208 + 0.0215)\pi$$

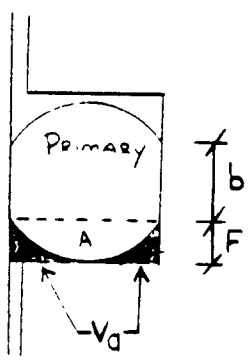
$$= 2.478 \text{ cu.in.}$$

Determining V_a Primary

$$\text{Rectangular Area} = F*(\text{Groove Depth})$$

$$= (0.093)*(0.215 + 0.0215)$$

$$= 0.022 \text{ sq.in.}$$



$$A = [\text{O-ring Area} - b*(\text{Groove Depth})] \div 2$$

$$= \left[\frac{\pi(0.2903)^2}{4} - (0.134) * (0.215 + 0.0215)\right]$$

$$A = 0.017 \text{ sq.in.}$$

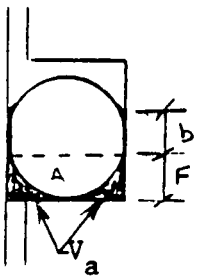
$$V_a = (\text{Rectangular Area} - A)*(\text{Length of } V_a \text{ c.g.})$$

$$V_a = (0.022 - 0.017) * (9.551 + 0.215 + 0.0215)\pi$$

$$V_a = 0.154 \text{ cu.in.}$$

Determining V_a Secondary

Rectangular Area = F(Groove Depth)
= 0.090 * (0.208 + 0.0215)
= 0.021 sq.in.



A = [O-ring Area - b(Groove Depth)] ÷ 2

$$A = \left[\frac{\pi(0.2908)^2}{4} - (0.1451) * (0.208 + 0.0215) \div 2 \right]$$

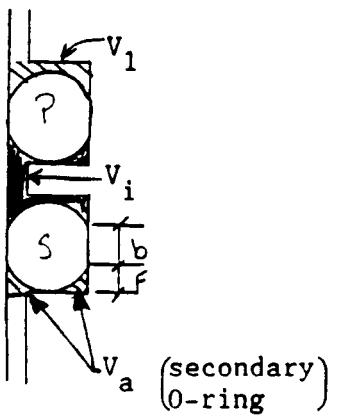
A = 0.017 sq.in.

V_a = (Rectangular Area - A) * (Length of V_a c.g.)

V_a = (0.021 - 0.017) * (9.564 + 0.208 + 0.0215)π

V_a = 0.123 cu.in.

Determining V_1 Primary



V_1 = [V_{groove} - $V_{0\text{-}ring}$ - V_a] primary

V_1 = 2.618 - 2.011 - 0.154

V_1 = 0.453 cu.in.

Determining V_1 Secondary

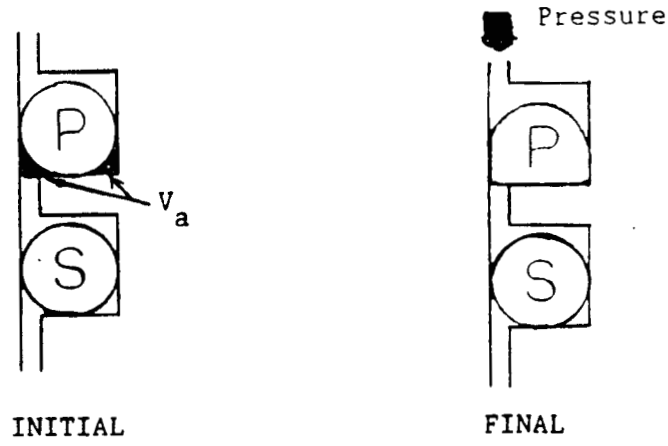
V_1 = [V_{groove} - $V_{0\text{-}ring}$ - V_a] secondary

V_1 = 2.478 - 2.017 - 0.123

V_1 = 0.338 cu.in.

SCENARIO #1

FINAL V_4 VOLUME AND PRESSURE RISE
WITHOUT AXIAL DISPLACEMENT



$V_f = V_i - V_a$; ==> V_i - Calculations contained in Appendix B

==> $V_i = 2.345$ cu.in.

==> $V_a = 0.154$ cu.in.

$V_f = 2.345 - 0.154$
$V_f = 2.191$ cu.in.

$$P_f = \frac{P_i * V_i}{V_f} - 12.7 \text{ psia} = (\text{psig});$$

==> $P_i = 12.7$ psia

==> $V_i = 2.345$ cu.in.

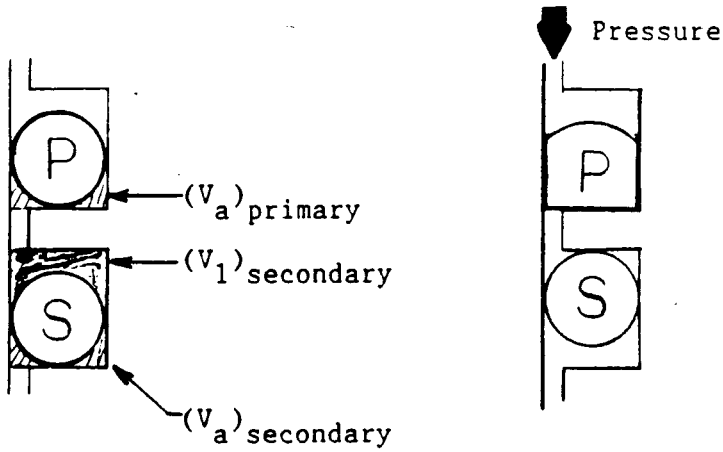
==> $V_f = 2.191$ cu.in.

$$P_f = \frac{(12.7 \text{ psia}) * (2.345 \text{ cu.in.})}{2.191 \text{ cu.in.}} - 12.7 \text{ psia}$$

$P_f = 0.893$ psig

SCENARIO #1

FINAL V_4 VOLUME AND PRESSURE RISE WITH AXIAL DISPLACEMENT



Axial motion will roll the secondary O-ring from the "seated" to the "unseated" position.

INITIAL FINAL

$V_f = V_i - (V_1 - V_a)_{sec} - (V_a)_{pri};$ ==> $(V_a)_{pri} = 0.154$ cu.in.

==> $(V_a)_{sec} = 0.123$ cu.in.

==> $(V_1)_{sec} = [V_{groove} - V_{O\text{-}ring} - V_a]_{sec}$

==> $(V_1)_{sec} = 2.478 - 2.017 - 0.123$

==> $(V_1)_{sec} = 0.338$ cu.in.

$V_f = 2.345 - (0.338 - 0.123) - 0.154$

$V_f = 1.976$ cu.in.

$$P_f = \frac{P_i * V_i}{V_f} - 12.7 \text{ psia} = (\text{psig});$$

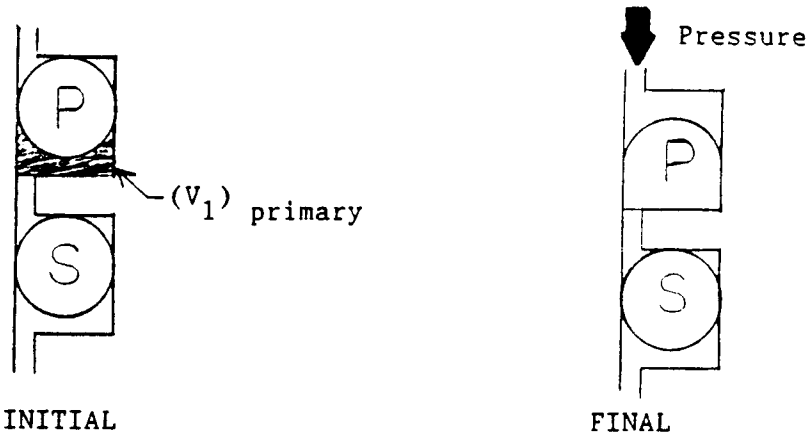
$P_i * V_i = P_f * V_f;$ ==> $P_f = 12.7$ psia
==> $V_i = 2.345$ cu.in.
==> $V_f = 1.976$ cu.in.

$$P_f = \frac{(12.7 \text{ psia}) * (2.345 \text{ cu.in.})}{1.976 \text{ cu.in.}} - 12.7$$

$P_f = 2.372$ psig

SCENARIO #2

FINAL V_4 VOLUME AND PRESSURE RISE
WITHOUT AXIAL DISPLACEMENT



$V_f = V_i - (V_1)_{pri}$; ==> V_i - Calculations contained in Appendix B

==> $V_i = 3.206$ cu.in.

==> $(V_1)_{pri} = 0.453$ cu.in.

$V_f = 3.206 - 0.453$
$V_f = 2.753$ cu.in.

$$P_f = \frac{P_i * V_i}{V_f} - 12.7 \text{ psia} = (\text{psig});$$

==> $P_i = 12.7$ psia

==> $V_i = 3.206$ cu.in.

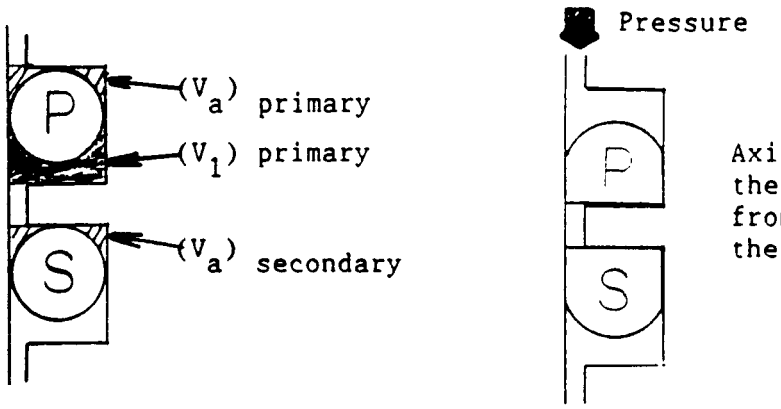
==> $V_f = 2.753$ cu.in.

$$P_f = \frac{(12.7 \text{ psia}) * (3.206 \text{ cu.in.})}{2.753 \text{ cu.in.}} - 12.7 \text{ psia}$$

$P_f = 2.090$ psig

SCENARIO #2

FINAL V_4 VOLUME AND PRESSURE RISE WITH AXIAL DISPLACEMENT



Axial motion will roll the secondary O-ring from the "seated" to the "unseated" position.

INITIAL FINAL

$V_f = V_i - (V_1)_{pri} - (V_a)_{sec}$; ==> $V_i = 3.206$ cu.in.

==> $(V_1)_{pri} = 0.453$ cu.in.

==> $(V_a)_{sec} = 0.123$ cu.in.

$V_f = 3.206 - (0.453 + 0.123)$

$V_f = 2.630$ cu.in.

$$P_f = \frac{P_i * V_i}{V_f} - 12.7 \text{ psia} = (\text{psig});$$

$P_i * V_i = P_f * V_f$; ==> $P_f = 12.7$ psia
==> $V_i = 3.206$ cu.in.
==> $V_f = 2.630$ cu.in.

$$P_f = \frac{(12.7 \text{ psia}) * (3.206 \text{ cu.in.})}{2.630 \text{ cu.in.}} - 12.7$$

$P_f = 2.781$ psig

SCENARIO #2

FINAL V_4 VOLUME AND PRESSURE RISE
(CALCULATIONS #2)

EXPLANATION:

Due to limitations in the test fixture, Scenario #2 positioning of the O-rings was achieved by fixture assembly. Therefore the exact position of the O-rings prior to experiencing pressurization is unknown. Because of this unknown, the pressure rise predictions are not even close to the actuals produced from testing. This is obviously shown in Table 4 comparing predictions to actuals. These prediction calculations are on pages 6 & 7 of Appendix C.

To understand the movement of the O-rings due to axial displacement under Scenario #2 configuration, a second set of calculations were necessary. The second calculations assume the final position of the O-rings is identical to the final position of the O-rings in Scenario #1 with axial displacement. Hence, Calculations #2 use the initial volume determined in Appendix B and the final volume of Scenario #1 determined on page 5 of Appendix C. i.e.==>

$$V_i = 3.206 \text{ cu.in.}$$
$$V_f = 1.976 \text{ cu.in.}$$

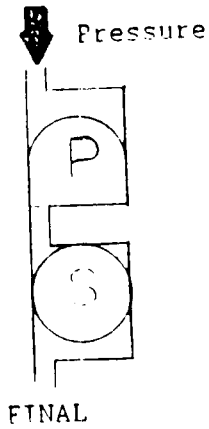
Calculations #2 are shown on the next page. These calculations were used to predict the final pressure rise for Scenario #2 with axial displacement only and are listed in Table 5.

SCENARIO #2

FINAL V_4 VOLUME AND PRESSURE RISE WITH AXIAL DISPLACEMENT

(CALCULATIONS #2)

* Initial O-ring positioning is unknown. Final O-ring positioning is assumed to be identical to final positioning of Scenario #1 with axial displacement.



$V_f = V_{f(\text{Scenario } \#1)} = 1.976$ cu.in.

$$P_f = \frac{P_i * V_i}{V_f} - 12.7 \text{ psia} = (\text{psig});$$

$P_i * V_i = P_f * V_f;$ ==> $P_f = 12.7$ psia
==> $V_i = 3.206$ cu.in.

$$P_f = \frac{(12.7 \text{ psia}) * (3.206 \text{ cu.in.})}{1.976 \text{ cu.in.}} - 12.7$$

$P_f = 7.905$ psig