RELIABILITY AND QUALITY CONTROL REPORT

QC & R 6-046

PREPARED FOR

JET PROPULSION LABORATORY

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PYRONETICS, INC.

A CORDON INTERNATIONAL COMPANY

REPORT NO. QC & R 6-046

EVALUATION TEST PROGRAM

FINAL REPORT

VALVE, EXPLOSIVE ACTUATED, NORMALLY CLOSED

PYRONETICS MODEL 1400

JET PROPULSION LABORATORY

PURCHASE ORDER NO. ES-536829

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INTRODUCTION AND SUMMARY

The Evaluation Test Program for the Explosive Actuated, Normally Closed Valve, Model 1400, was conducted in compliance with JPL Purchase Order Number ES-536829.

The objective of this Evaluation Test Program was to demonstrate compliance of this valve with the requirements of JPL P.O. ES-536829 by a series of operating tests applied to three (3) valves.

There was one test malfunction during actuation testing. One of the valves under actuated and caused approximately 25% obstruction of the flow passage. The ram/body bore clearance was increased and a requirement for blending of radius into the ram taper was added to the drawing.

Additionally the ram slot was elongated .020 to prevent any obstruction in flow passage (Ref. TFR 0069). Valve S/N 003 was modified and successfully tested with a 75% (under load) cartridge. All subsequent testing was successfully completed with no further anomalies encountered.

Compliance of the Explosive Actuated, Normally Closed Valve with all specification requirements was successfully demonstrated by this Test Program.

Additionally, within the testing parameters specified, the JPL cartridge P/N 10028949, demonstrated successfully its capability to properly actuate the Model 1400 valves which underwent this testing program.

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DESCRIPTION OF CARTRIDGE ACTUATED, NORMALLY CLOSED VALVE MODEL 1400

The Model 1400 is a normally closed cartridge actuated valve which will be utilized in the trajectory correction propulsion subsystem of the Thermoelectric Outer Planets Spacecraft. (TOPS).

The normally closed valve will be used to control and isolate the flow of hydrazine to a 25 pound thrust monopropellant thruster.

The Model 1400 valves will be utilized in conjunction with the Pyronetics Model 1399, Cartridge Actuated, Normally open valve in a monifold assembly to provide a multiple start-stop capability. Each assembly is normally closed in the TOPS vehicle at launch. The projected usage of the propulsion subsystem is for trajectory correction during mission duration as long as ten years in the interplantary and outer space environments within the solar system.

Upon actuation, the normally closed valves of each assembly will supply the fuel to the rocket engine assembly. Prior to actuation the propellant and pressurization fluids are isolated by the valves until engine ignition is desired. Valve actuation is accomplished by explosive energy generated when the JPL cartridges, P/N 10028049, are ignited by the application of electrical power.

The valves are mounted in the propulsion subsystem by welding the inlet and outlet ports into a manifold tubular system. In the normally closed position internal leakage is prevented by two integral nipples. Upon actuation, the nipples are sheared and retained within the valve body by a ram propelled by the pressure cartridge. A flow passage is opened through the valve by the shearing of the nipples.

EVALUATION TEST PROGRAM

EXPLOSIVE ACTUATED VALVE

MODEL 1400 NORMALLY CLOSED

1.0 TEST PROGRAM

Three (3) normally closed valves were submitted for evaluation testing in accordance with Pyronetics Test Procedure TS 1400. The objective of the test program was to verify design concept compatibility with the test requirements of JPL PO. ES-536829 for a normally closed explosive valve that will control the flow of hydrazine to a 25 pound thrust monopropellant thruster. The cartridge utilized for actuation testing (JPL P/N 10028049) was supplied by Jet Propulsion Laboratory and underwent only the actuation test.

The three valves were subjected to the following test sequences:

1. Proof Pressure and Internal Leakage Test (Body Subassembly)
2. Proof Pressure and External Leakage Test (Body Subassembly)
3. Proof Pressure and Leakage Test (Actuator Assembly)
4. Gross Leak Test (Actuator Assembly)
5. Examination of Product
6. Cleanliness Verification
7. Actuation Test
8. Post Actuation Proof Pressure
9. Flow vs Pressure Drop Test
10. Post Actuation Disassembly Inspection
11. Post Actuation Leakage (Actuator Assembly)
12. Post Actuation Leakage-Gross (Actuator Assembly)
13. External Leakage After Actuation (Valve Assembly less Actuator Assembly)
14. Burst Pressure Test

2.0 REFERENCE DOCUMENTS

The following documents comprise the criteria for this test program.

2.1 Military

MIL-C-45662A	Calibration System Requirements 9 February 1962
MIL-P-27401B	Propellant, Pressurizing Agent Nitrogen, 19 September, 1962
MIL-P-27407	Propellant, Pressurizing Agent Helium, 8 June 1965

2.2 JPL

P.O. No. ES-536829	Requirements for Fabrication, Assembly and Test of Normally Open and Normally Closed Explosive Actuated Valve
FS 504574	General Cleanliness Required for Spacecraft Systems and Support Equipment, Detail Specification for
Drawing 10028049	Squib

2.3 Pyronetics, Inc.

Drawing 1400	Valve, Normally Closed, Explosive Actuated
TS 1400	Acceptance and Evaluation Test Procedure

3.0 TEST DESCRIPTION AND RESULTS

The evaluation test requirements, descriptions and test results of the Normally Closed Valves, Pyronetics Model 1400, employed in the evaluation test program (in accordance with Pyronetics Procedure TS 1400), are described in the following paragraphs.

3.1 Proof Pressure and Internal Leakage (Body Subassembly) 3 units

Requirement

(Reference JPL P.O. ES-536829)

Each body subassembly shall be internally pressurized simultaneously through both nipple tubes to 1000 + 30/-0 psig with gaseous helium for thrity (30) minutes minimum. There shall be no evidence of leakage in excess of 1×10^{-6} scc/sec of helium. The leakage shall be measured through the cartridge port. There shall be no evidence of deformation or failure as a result of this test.

Test Description

The proof and internal leakage test was performed on the valve body subassembly during inprocess testing per TS 1400, prior to submitting the assembled valves to the functional evalution tests. The normally closed valves were subjected to a combined proof pressure and internally leakage test. (See Figure 1). Each valve was simultaneously pressurized through both nipple tubes to $1,000\ ^{+30}_{-0}$ psig with gaseous helium. A test adaptor was connected to the cartridge port which in turn was connected to a helium mass spectrometer and subsequently evacuated to 10^{-4} torr. The internal leakage was then monitored on the mass spectrometer for 30 minutes minimum for evidence of leakage in excess of 1×10^{-6} sccs of helium. Upon completion of test, the valves were removed from the test system and the nipple tubes were blown off with gaseous nitrogen to prevent any residual helium potentially entrapped in the tubes from yielding erroneous leakage rates during subsequent tests.

Test Results

None of the units tested sustained any evidence of yielding, permanent deformation or other visible damage. Additionally, the valves did not exhibit any detectable leakage in excess of 1×10^{-6} sccs. Maximum internal leakage recorded was 3.0×10^{-8} sccs. Reference test results in Appendix 1.

3.0 TEST DESCRIPTION AND RESULTS (Contd.)

3.2 Proof Pressure and External Leakage (Body Subassembly) 3 units

Requirement

(Reference JPL P.O. ES-536829)

Subject the body subassembly to an external leakage test by applying a pressure of 1000 +30/-0 psig helium gas to the actuator cavity for a period of at least thirty (30) minutes. Measure the external leakage. The leakage shall not exceed 1×10^{-6} scc/sec.

Test Description

The proof and external leakage test was performed on the valve body subassembly during inprocess testing per TS 1400 prior to submitting the assembled valves to the functional evaluation tests. The normally closed valves were subjected to a combined proof pressure and external test (see Figure 2). Each valve was individually pressurized through the cartridge port, while installed in a bell jar, to $1000\ ^{+30}_{-0}$ psig with gaseous helium. The bell jar was connected to a helium mass spectrometer and subsequently evacuated to 10^{-4} torr. The external leakage was then monitored on the mass spectrometer for 30 minutes minimum for evidence of leakage in excess of 1×10^{-6} sccs of helium. Upon completion of test, the valves were removed from the test system and the cartridge port was blown off with gaseous nitrogen.

Test Results

None of the units tested sustained any evidence of yielding, permanent deformation or other visible damage. Additionally, the valves did not exhibit any detectable leakage in excess of 1×10^{-6} sccs. Maximum external leakage recorded was 2.0×10^{-8} sccs. Reference test results in Appendix 1.

3.3 Proof Pressure and Leakage Test (Actuator Assembly) 3 Units

Requirement

(Reference JPL P.O. ES-536829)

Each actuator assembly shall be installed in a suitable holding fixture and subjected to an external pressure of 500 +10/-0 psig with gaseous helium for thirty (30) minutes minimum. Following pressurization period, actuator assembly shall be removed from the helium pressurization and subjected to a helium mass spectrometer leak test. There shall be no evidence of leakage in excess of 1×10^{-6} scc/sec helium. There shall be no evidence of deformation or damage as a result of these tests.

Test Description

The combined proof pressure and leakage test was performed on each actuator assembly prior to assembling into valve body as an in process test per TS 1400. Each actuator sub-assembly was installed in a holding fixture as shown in Figure 3 and subjected to an external pressure of $500 \begin{smallmatrix}+10\\-0\end{smallmatrix}$ psig with gaseous helium for thirty minutes. The actuator assembly was then removed from the pressure fixture and blown off with gaseous nitrogen and within sixty seconds after removal from fixture was installed in the leakage test fixture. The test fixture was evacuated to 10^{-4} torr and the leakage rate from the actuator assembly was checked with a mass spectrometer for evidence of leakage in excess of 1×10^{-6} sccs, the initial value indicated by the mass spectrometer was recorded. The bellows assembly was then visually examined for evidence of damage or deformation as a result of the proof pressure test.

Test Results

None of the units tested exhibited any evidence of yielding, permanent deformation or other visible damage. There was no evidence of leakage in excess of 1×10^{-6} sccs. Maximum leak rate recorded was 5.5×10^{-9} sccs, reference test results in Appendix 2.

3.4 Gross Leak Test (Actuator Assembly) 3 Units

Requirement

(Reference JPL P.O. ES-536829)

The actuator assembly shall be tested for gross leakage by submerging in hot deionized water at +180 ±15°F and checked for evidence of bubbles.

Test Description

The gross leak test on the actuator assembly was performed prior to assembling into valve body as an in process test per TS 1400. Each actuator assembly was immersed in hot water (+180 ±15°F) with axis in a horizontal position and the entrapped air in the bellows was removed by slightly agitating the assembly, reference Figure 4. Actuator assembly was maintained immersed in the hot water for one minute minimum while visually observing for bubble emission from the bellows of the actuator assembly as an indication of gross leakage.

Test Results

No evidence of bubble emission was detected from any of the actuator assemblies during the test. Hence, no gross leaks were found in the bellows area of the actuator assembly as recorded on the data sheet of Appendix 3.

3.5 Examination of Product (3 Units)

Requirement

(Reference JPL P.O. ES-536829)

Each valve body and components shall be visually examined for freedom from blemishes, tool marks, burrs, legibility and correctness of markings and any other characteristics which reflect the general quality of workmanship. The size, configuration and mounting dimension shall be in accordance with the dimensions noted on the appropriate drawings. These units shall be inspected with suitable gauges and/or instruments for conformance to the dimensions noted on the appropriate drawings, reference drawing 1400. The specimens shall be deemed acceptable for testing if they conform to the drawing requirements and are free from damage.

Test Description

The examination of product was performed upon completion of all the in process tests and prior to assembling the valve. Each valve body and components were visually examined for freedom from blemishes, tool marks, burrs, legibility and correctness of markings and other characteristics which reflected the general quality of workmanship. The size, configuration and mounting dimensions were inspected for conformance to the appropriate drawing.

Test Results

All of the major dimensions and characteristics were one hundred percent inspected and were per print. The requirements, results and verification of special processes are on file at Pyronetics. Appendix 4 includes the Configuration Identification Index indicating the as built configuration of the valves, and inspection buy-off records. The index indicates all documents, by revision letter, necessary for the manufacture of the parts.

3.6 Cleanliness Verification (3 Units)

Requirement

(Reference JPL P.O. ES-536829)

Units shall be cleaned and assembled in accordance with applicable drawing requirements. (Reference level D.2 of JPL Spec. FS-504574.) Units selected for Evaluation Tests shall have JPL 10028049 squib installed in the actuator assembly prior to cleaning. Installation torque shall be 300 ± 20 in-lbs.

Verify cleanliness level of completed assembly and sign off on data sheet.

Test Description

The cleaning operation was performed by Garwood Laboratories in accordance with JPL Specification FS 504574 (Level D.2). The JPL 10028049 cartridge was installed in the actuator assembly prior to cleaning with 300 ±20 in-lbs. Upon completion of cleaning operation Pyronetics personnel assembled the valves in the clean room. After the units were assembled, a final partical count was performed and the cleanliness level of FS 504574D.2 was verified. The units were again vacuum oven dried and the tube ports were sealed with nylon film and tape cleaned to the same level as the valves. Each valve was placed in a polyethylene bag; purged with gaseous nitrogen, vacuum evacuated and heat sealed.

Test Results

All applicable surfaces of the components were cleaned as specified in FS 504574and certified to a cleaning level of D.2. Reference test results in Appendix 5.

3.7 Actuation Test (3 Units)

Requirement

(Reference JPL P.O. ES-536829)

The actuation test shall be performed on a sample selected at random from the production lot. The valve shall be actuated while a water pressure of 500 psig is applied to one of the normally closed nipples. The response time shall be measured from bridgewire burnout to first indication of pressure rise on the downstream side of the valve. Response time shall not exceed 10 milliseconds.

Test Description

The valves were mounted in a holding fixture as indicated in Figure 5. A pressure transducer was connected on the downstream side of the valves to detect response time. The bridgewire resistance of each bridgewire on the 10028049 JPL cartridge was measured and recorded with an Alinco Ohmmeter. The normally closed nipple tubes were pressurized to 500 $^{+10}_{0}$ psig with water. The valves were actuated individually upon application of 5.0 amperes from a constant current power supply to one bridgewire of the cartridge while one nipple tube was pressurized to 500 psig. The response time was measured by the transducer installed on the downstream side of the valve with an oscilloscope and camera. Upon actuation of the valve, transfer of the valve to the open mode caused the pressure to rise on the downstream side as the water flowed through the valve. Hence, response time was measured from bridgewire burnout to first indication of pressure rise on the downstream side of the valve.

Test Results

The first valve tested actuated to the closed mode satisfactorily without any detectable evidence of damage to the structural integrity of the valves. However on the second firing, valve S/N 1068-002 underactuated and obstructed the flow passage by approximately 25% (Reference TFR 0069 in Appendix 14) Failure analysis conducted on the test unit (after subjecting the valve to the remaining test in TS 1400, excluding Flow vs Pressure Drop Test) revealed that leading edge of ram tap had minimum allowable radius and was not smoothly blended

3.7 Actuation Test (3 Units) (Contd.)

Test Results (Contd.)

Also the ram/body bore clearance was approximately .0010/-.0015 tighter than on other units fired successfully during DVT. Examination of the body bore indicated evidence of ram leading edge digging into mating body taper. Hence, to preclude a recurrence, the ram/body bore clearance was increased in addition to increasing the radius on leading edge of ram taper. A requirement was also added to the drawing for blending radius on ram into taper. An additional safety margin, (proper alignment of ram crosshole) was incorporated by elongating the ram slot by 0.020. The remaining test unit was then modified to incorporate the design change. At JPL's request the reworked valve was actuated with a 75% (underload) cartridge. Valve actuated successfully with no obstructions in flow flow passage. Response time ranged from 1.0 to 1.1 milliseconds for all valves. Hence all valves complied with the 10 milliseconds maximum response time requirement.

Since all the units passed the subsequent post actuation leakage and burst test, the test was deemed successful. See test data sheets in Appendix 6.

3.8 Post Actuation Proof Pressure (3 Units)

Requirement

(Reference JPL P.O. ES-536829)

Each valve assembly shall be subjected to a hydrostatic pressure of 1000 +30/-0 psig. One (1) port shall be capped and the other pressurized from 0 to 1000 psig for two (2) minutes minimum. There shall be no evidence of deformation or failure as a result of this test, nor shall the ram retract.

Test Description

The actuated valves were firmly secured in a proof test holding fixture (reference Figure 6) and one tube port was connected to a hydrostatic pressure source. The valves were placed behind a safety barricade and the tube port was slowly pressurized to 1,000 psig with water for two minutes.

3.8 Post Actuation Proof Pressure (3 Units) (Contd.)

Tests Results

None of the actuated valves proofed exhibited any visual evidence of external leakage. The test was considered successful since the valves did not reveal evidence of structural damage, nor did the ram retract. Reference test results in Appendix 7.

3.9 Flow vs Pressure Drop Test (2 units)

Requirements

(Reference JPL ES-536829)

The flow rate versus the pressure drop shall be determined across the open flowpath of each normally closed valve. The pressure drop across the unit shall not exceed 5.0 psid when a water pressure of 500 psig is applied at the inlet port and a flow of 0.15 lbs/sec of H_2O is established.

Test Description

Each valve was installed in a holding fixture (Ref. Figure 7) and the tube ports were pressurized to 500 psig with water while a regulated flow rate through the open flow path was maintained at 0.15 lbs/ sec. The pressure drop through the entire system was determined with a differential pressure gauge and recorded. The net pressure drop across the valve was determined by subtracting the tare pressure drop from the gross pressure drop. The tare pressure drop was determined by removing the valve from the system and replacing it with a tare tube and repeating the flow test. The tare tube is a straight section one half inch long and has the same I.D. and O.D. as the valve under test.

Test Results

The flow was performed on only the two valves that actuated satisfactorily. Neither of the two units exceeded the maximum pressure drop requirements of 5.0 psid. The maximum gross pressure drop of the two units was 4.45 psid with a tare value of 3.65 psid. The test was considered successfully passed since the net pressure drop was 0.80 psi with a variation in pressure drop between valves of 0.03. Actual test results are found in Appendix 8.

3.10 Disassembly Inspection (3 Units)

Requirement

(Reference JPL P.O. ES-536829)

The JPL 10028049 squib shall be removed from the actuator assembly and the actuator assembly shall be removed from the valve body. Valve and actuator assembly shall be examined for proper actuation and there shall be no evidence of abnormal deformaties, cracks, etc. on the actuator assembly bellows.

Test Description

The fired JPL 10028049 cartridge was removed from the actuator assembly first, then the actuator assembly was removed from the valve body. Examination of the actuator assembly was then performed under a 40X microscope for evidence of abnormal deformaties, cracks, etc on the bellows and all observations were recorded, the valve body was also visually examined for proper actuation.

Test Results

No cracks or other anomalies were detected on the actuator assembly bellows exterior. There was no evidence of cartridge gas blowby. No visual evidence of abnormal deformation was found in the valve bodies. The structural integrity of the actuated valves appeared sound. Reference test results in Appendix 9.

3.11 Post Actuation Leakage (Actuator Assembly) 3 Units

Requirement

(Reference JPL P.O. ES-536829)

Each actuator assembly shall be installed in a suitable holding fixture and subjected to an external pressure of 500 +10/-0 psig with gaseous helium for thirty (30) minutes minimum. Following pressurization period, actuator assembly shall be removed from the helium pressurization and subjected to a helium mass spectrometer leak test. There shall be no evidence of leakage in excess of 1×10^{-6} scc/sec helium. There shall be no evidence of deformation or damage as a result of these tests.

Test Description

The actuator assembly from each actuated valve was installed in a holding fixture as shown in Figure 3 and externally pressurized with helium to $500 \begin{smallmatrix}+10\\-0\end{smallmatrix}$ psig for 30 minutes. Upon completion of the pressurization period the actuator assembly was removed from the test fixture and within 60 seconds was blown off externally with gaseous nitrogen and subjected to a leak check. A mass spectrometer was utilized to check for evidence of leakage in excess of 1×10^{-6} sccs.

Test Results

No evidence of leakage in excess of 1×10^{-6} sccs of helium was detected on any of the actuator assemblies. Maximum leakage rate detected was 4.3×10^{-8} sccs. Reference actual test results in Appendix 10.

3.12 Post Actuation Gross Leakage (Actuator Assembly) 3 Units

Requirement

(Reference JPL P.O. ES-536829)

The actuator assemblies from the actuated valves shall be tested for gross leakage by submerging in hot deionized water at +180 ±15°F and checking for evidence of bubbles.

Test Description

Each actuator assembly that had been removed from the actuated valve was immersed in hot water (+180 ±15°F) with axis in a horizontal position and the entrapped air in the bellows was removed by slightly agitating the assembly, reference Figure 4, and checked for gross leakage. Actuator assembly was maintained immersed in hot water for one minute minimum while visually observing for bubble emission from the bellows in the actuator assembly as an indication of gross leakage.

Test Results

No evidence of bubble emission was detected in the bellows area during the time the actuator assembly was immersed in the hot water. Reference test results in Appendix II.

3.13 External Leakage After Actuation (Valve Assembly Less Actuator Assembly (3 Units)

Requirement

(Reference JPL ES-536829)

The external leakage after actuation of each valve shall be determined. The tube ports shall be pressurized to 1000 +30/-0 psig with helium gas for a minimum duration of thirty (30) minutes. The external leakage shall not exceed 1×10^{-6} scc/sec of helium. The actuator assembly shall be removed for this test.

Test Description

Following the actuation test, the actuator assembly was removed from the valve body. The actuated valves were then secured in a pressure fixture, reference Figure 8, placed in a bell jar and both tube ports were simultaneously pressurized to $1000 \, ^{+10}_{-0}$ psig with helium gas. The bell jar was connected to a helium mass spectrometer and then evacuated to 10^{-4} torr. The valves were leak checked for evidence of external leakage by monitoring a mass spectrometer for leakage in excess of 1×10^{-6} sccs of helium for 30 minutes.

Test Results

None of the valves tested exhibited any detectable external leakage in excess of 1×10^{-6} sccs during the 30 minute test period. The post actuation leakage rate recorded ranged from 7.6×10^{-8} to 9.0×10^{-8} sccs. Therefore, test was considered acceptable since no leakage in excess of 1×10^{-6} sccs was detected. Reference test results in Appendix 12.

3.14 Post Actuation Burst Pressure Test (3 Units)

Requirement

(Reference JPL ES-536829)

The valve assembly (actuator assembly removed) shall be subjected to a burst pressure test and burst pressure determined. One nipple tube shall be capped and the other pressurized with hydrostatic pressure from 0 to 10,000 psig in increments of 1000 psig. Minimum burst pressure shall be 2000 psig. If unit fails to burst at 10,000 psig pressure, discontinue test.

Test Description

The actuated valves were firmly secured in a burst test holding fixture (reference Figure 6) and one nipple tube was capped and the other was connected to a hydrostatic pressure source. The valves were placed behind a safety barricade and the nipple tube was slowly pressurized in increments of 1000 psig and maintained for 15 seconds at each level up to 10,000 psig with water. During the test valves were visually examined for evidence of leakage with the aid of a mirror.

Test Results

None of the actuated valves burst tested exhibited any visual evidence of external leakage. The test was considered successful since the valves did not burst and no evidence of structural damage was observed as a result of the burst pressure. In order to further ascertain the structural integrity of the normally closed valves, upon completion of the burst test, the nipple tube of each valve was pressurized until the ram retracted from its taper lock. The pressure required to retract the rams ranged from 12,600 to 13,500 psig for S/N 002 (under actuated unit). Reference test results in Appendix 13.

4.0 TEST PROGRAM CONCLUSIONS

Accomplishment of the evaluation tests in accordance with Pyronetics Test Procedure TS 1400 Rev A, dated 22 March 1971 signify the acceptance of the Normally Closed Explosive Actuated Valve, Pyronetics Model 1400, as having fulfilled the test requirements of JPL Purchase Order No ES-536829. The evaluation test program was conducted by Pyronetics, Inc. and witnessed and acknowledged by JPL Engineering.

Examination of the data included herein indicates excellent repeatability of all functional characteristics, i.e., ignition time, response time and flow vs pressure drop. Additionally, post actuation proof and leakage test of the actuator assembly and valve body revealed adequacy of the taper lock (metal-to-metal seal) between the ram and valve body after actuation. It should also be noted that the internal proof pressure had no effect on the integrity of the shear section of the normally closed nipple tubes.

The structural integrity of the valve assemblies was successfully demonstrated by the post actuation 10,000 psig burst test and in the fact that the pre-actuation and post-actuation leak rates detected far surpassed the 1×10^{-6} sccs requirements. The fact that no anomalies or degradation in performance was experienced with an 75% cartridge load; in addition to the fact that a minimum pressure of 12,600 psi is required to retract the ram further testifies to the soundness of the design.

Finally, it should be noted, that the Bellows which is incorporated into the valve design to positively prevent any cartridge products of combustion from entering the flow stream, performed exactly as required. Positive retention of all contamination was achieved.

Therefore, based on the data described herein, and the modification made in the ram/body bore no other changes to the valve design are recommended.

5.0 TEST EQUIPMENT AND SETUPS

The test equipment and environmental apparatus employed in the performance of the various tests described herein are listed below. All equipment was checked for reliable performance prior to initiation of specific tests. Accuracy and capability is as specified and all calibrations are traceable to the National Bureau of Standards.

5.1 Test Equipment -- Proof Pressure and Leakage

Instrument	Mass Spectrometer
Manufacturer	Consolidated Electrodynamics
Model No.	24-120B S/N 9593
Range	5×10^{-11} scc/sec
Type	Helium Detector
Calib. Frequency	Prior to use

Instrument	Sensitivity Calibrator
Manufacturer	Consolidated Electrodynamics
Model No.	25643 S/N 122G6
Range	Helium Leak Rate 8.8 x 10-7 scc/sec
Accuracy	± 10% of indicated leak rate

Instrument	Pressure Gauge
Manufacturer	Marsh Instrument Co.
Model No.	100 S/N 535
Range	0-1500 psi
Accuracy	± 0.5%
Calib. Frequency	90 days
Calib. Due	10-28-71

Instrument	Stop Watch
Manufacturer	Minerva
Model No.	136-L S/N 1355
Range	0-15 Min x .01 sec
Accuracy	±0.05 min/hr
Calib. Frequency	6 months
Calib. Due	2-5-72

5.2 Test Equipment - Gross Leakage

Instrument	Hot Plate
Manufacturer	Thermolyne Corp.
Model No.	HP-A1915B
Range	100-500°F
Accuracy	N/A
Calib. Frequency	N/A

Instrument	Thermometer
Manufacturer	Van Waters Rodgers
Model No.	--
Range	0-230°F
Accuracy	±1%

5.3 Test Equipment - Examination of Product

As examination of products consists of visual inspections, dimensional measurements, surface finish inspection measurements, all of the equipment necessary to perform these inspections will not be listed below. However, all inspection tools utilized in the accomplishment of this task were verified to be within calibration prior to use.

5.4 Test Equipment - Actuation Test

Instrument	Ignition Circuit Tester
Manufacturer	Alinco
Model No.	1015 AF S/N 501
Range	0-10, 0-20 ohms
Accuracy	±0.02 ohms
Calib. Frequency	90 days
Calib. Due	12-18-71

Instrument	Constant Current Pulse Generator
Manufacturer	E&R Development Co.
Model No.	PS-4A S/N 653
Range	0-to 10 amp; 0 to 100m' sec
Accuracy	±0.5%
Calib. Frequency	6 months
Calib. Due	9-29-71

5.4 Test Equipment - Actuation Test (continued)

Instrument	Charge Amplifier
Manufacturer	Kistler Corp.
Model No.	503 S/N 746
Type	Dial Calibration
Range	0-10 volts
Calib. Frequency	Prior to use

Instrument	Oscilloscope Camera
Manufacturer	Tektronix
Model No.	C12 S/N 003939

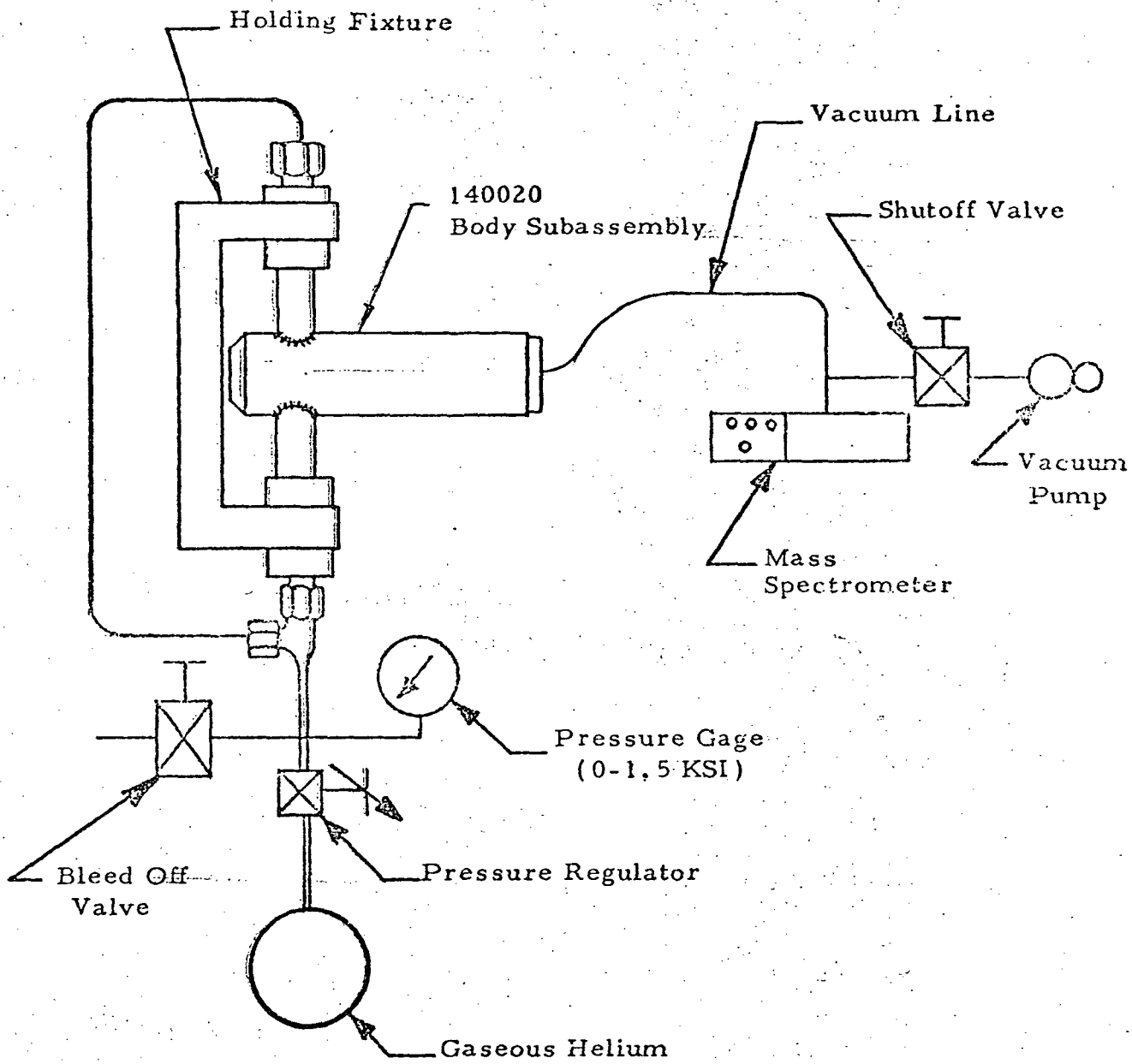
Instrument	Oscilloscope
Manufacturer	Tektronix
Model No.	502 S/N 002367
Type	Dual Beam
Range	100 μ to 20 v/centimeter
Accuracy	±3%
Calib. Frequency	90 days
Calib. Due	12-12-71

Instrument	Pressure Transducer
Manufacturer	Kistler Corp.
Model No.	603H S/N 2773
Range	0-15,000 psi
Accuracy	±1%
Calib. Frequency	Prior to use

5.5 Test Equipment - Burst Pressure

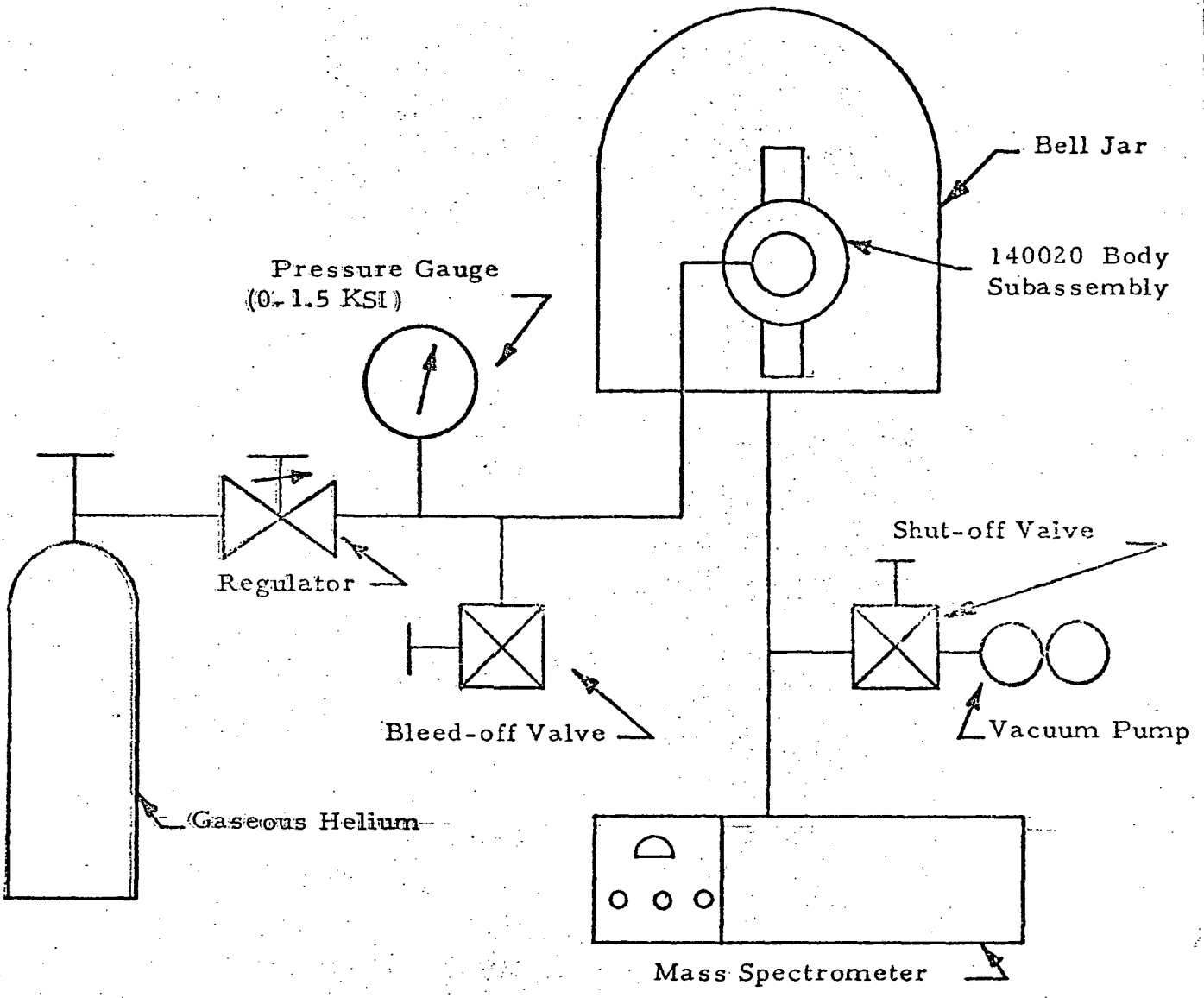
Instrument	Pressure Gauge
Manufacturer	U.S. Gauge
Model	19035, Serial No. 669
Range	0-20,000 psig
Accuracy	±0.5%
Calib. Frequency	90 days
Last Calibration	11-2-71

Instrument	Hydrostatic Test Console
Manufacturer	Pyronetics, Inc.
Model No.	N/A
Range	0-20,000 psig
Calib. Frequency	N/A



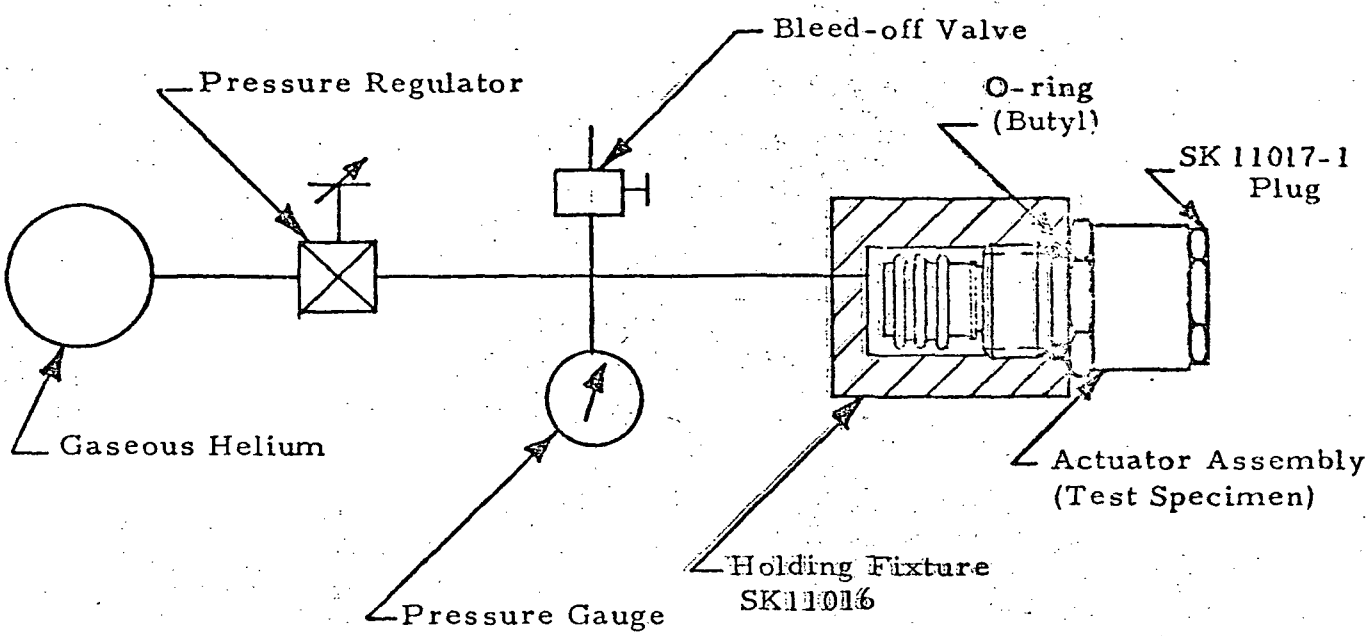
PROOF PRESSURE & INTERNAL LEAKAGE TEST SETUP

FIGURE 1.

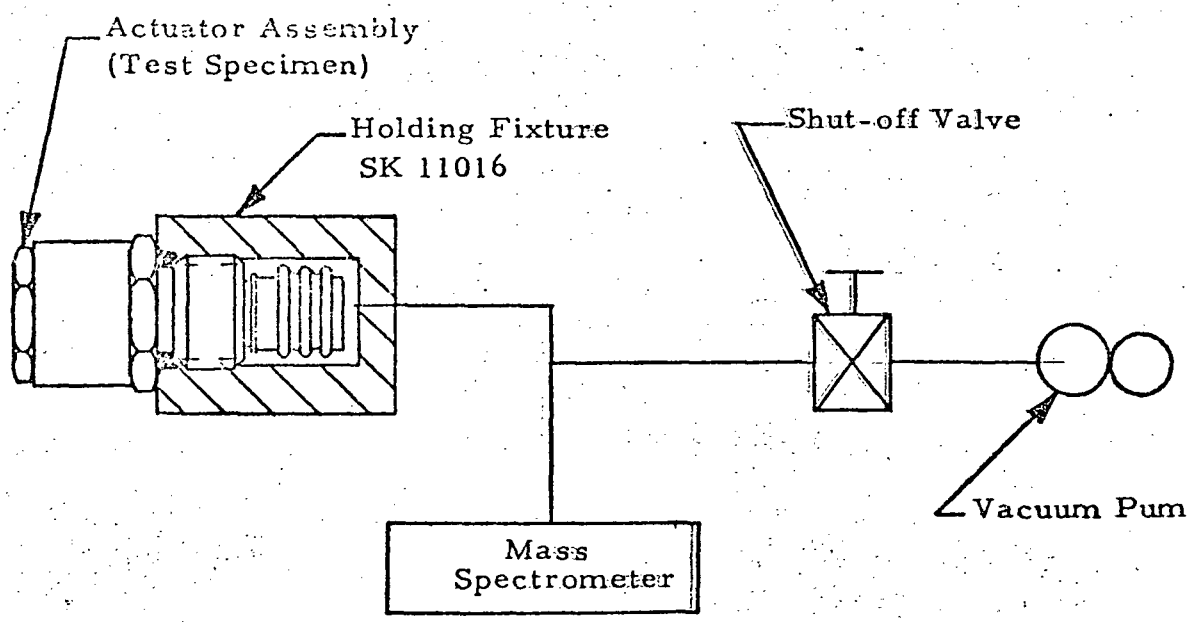


PROOF PRESSURE & EXTERNAL LEAKAGE TEST SETUP

FIGURE 2



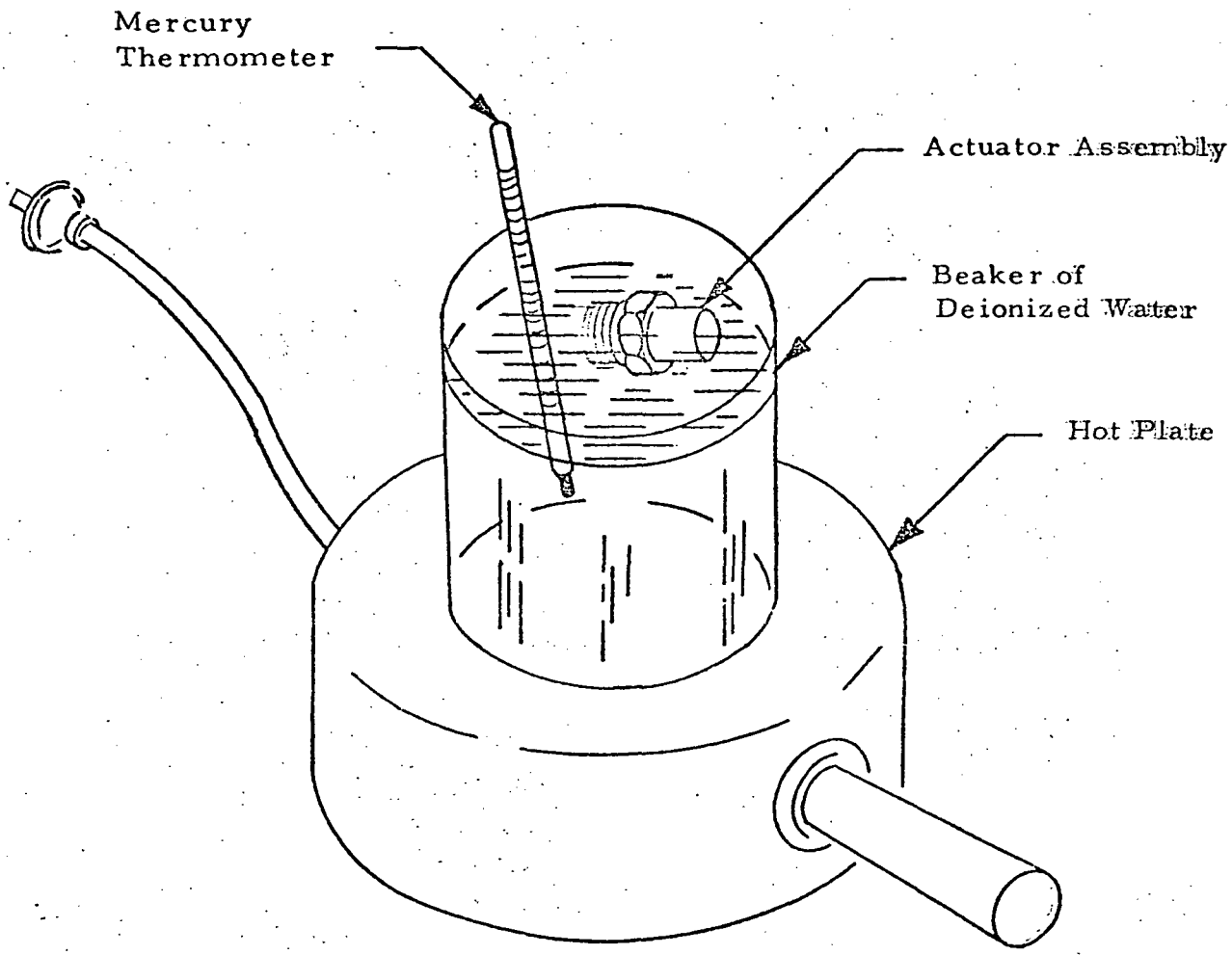
(A) PROOF PRESSURE



(B) LEAK TEST

PROOF PRESSURE & LEAK TEST SETUP
(ACTUATOR ASSEMBLY)

FIGURE 3

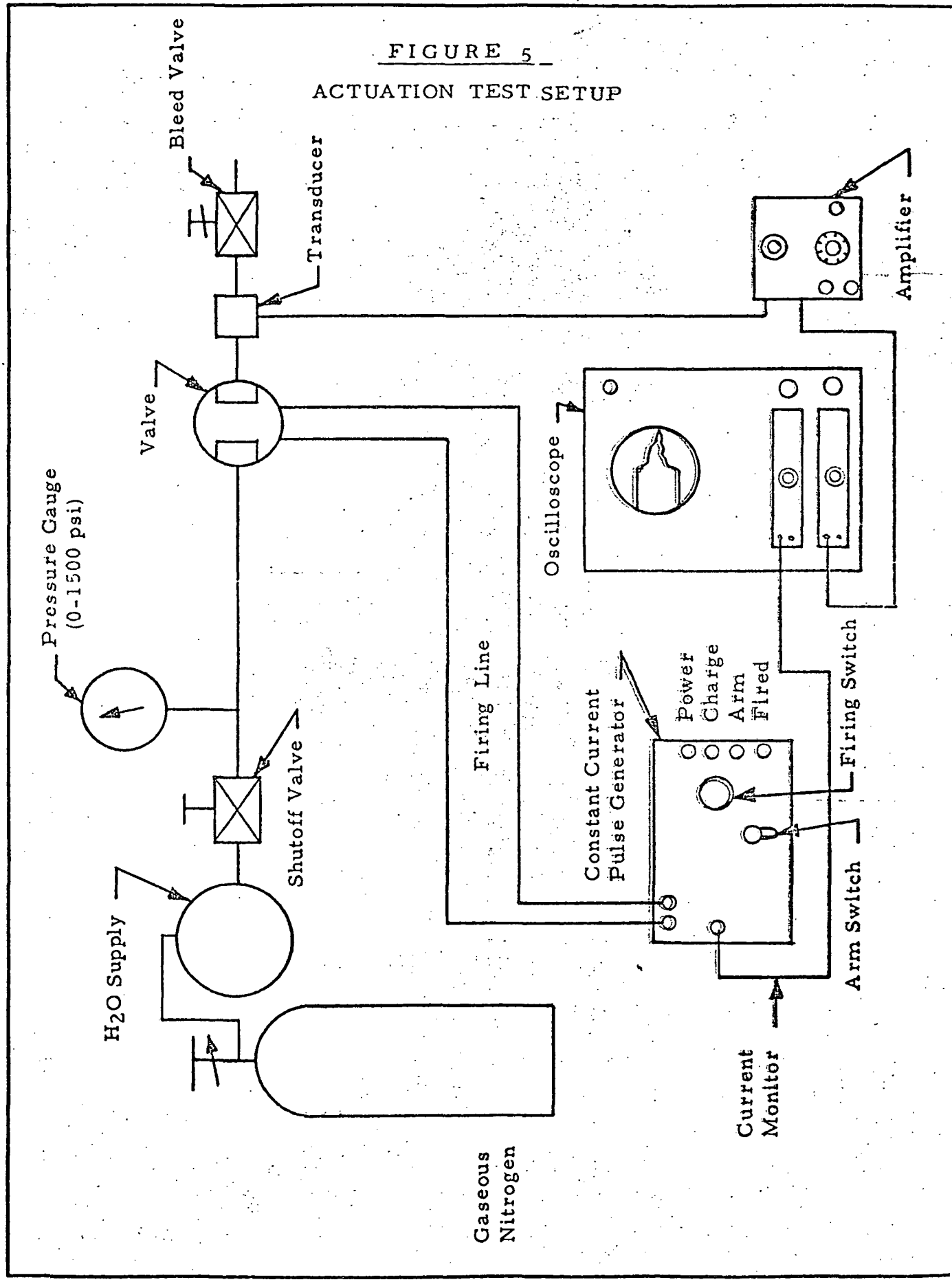


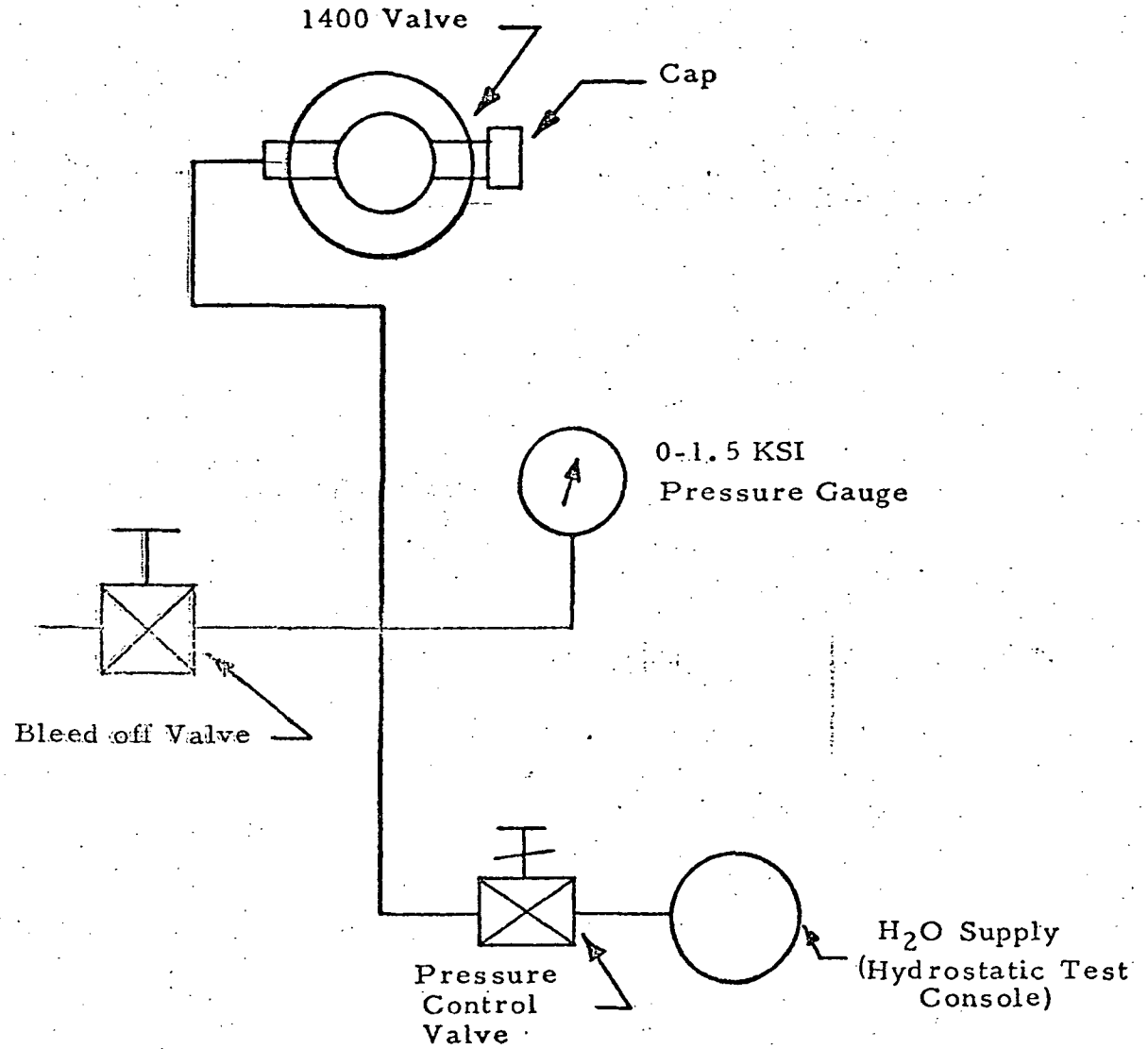
LEAK TEST (HOT WATER) SETUP

FIGURE 4

FIGURE 5

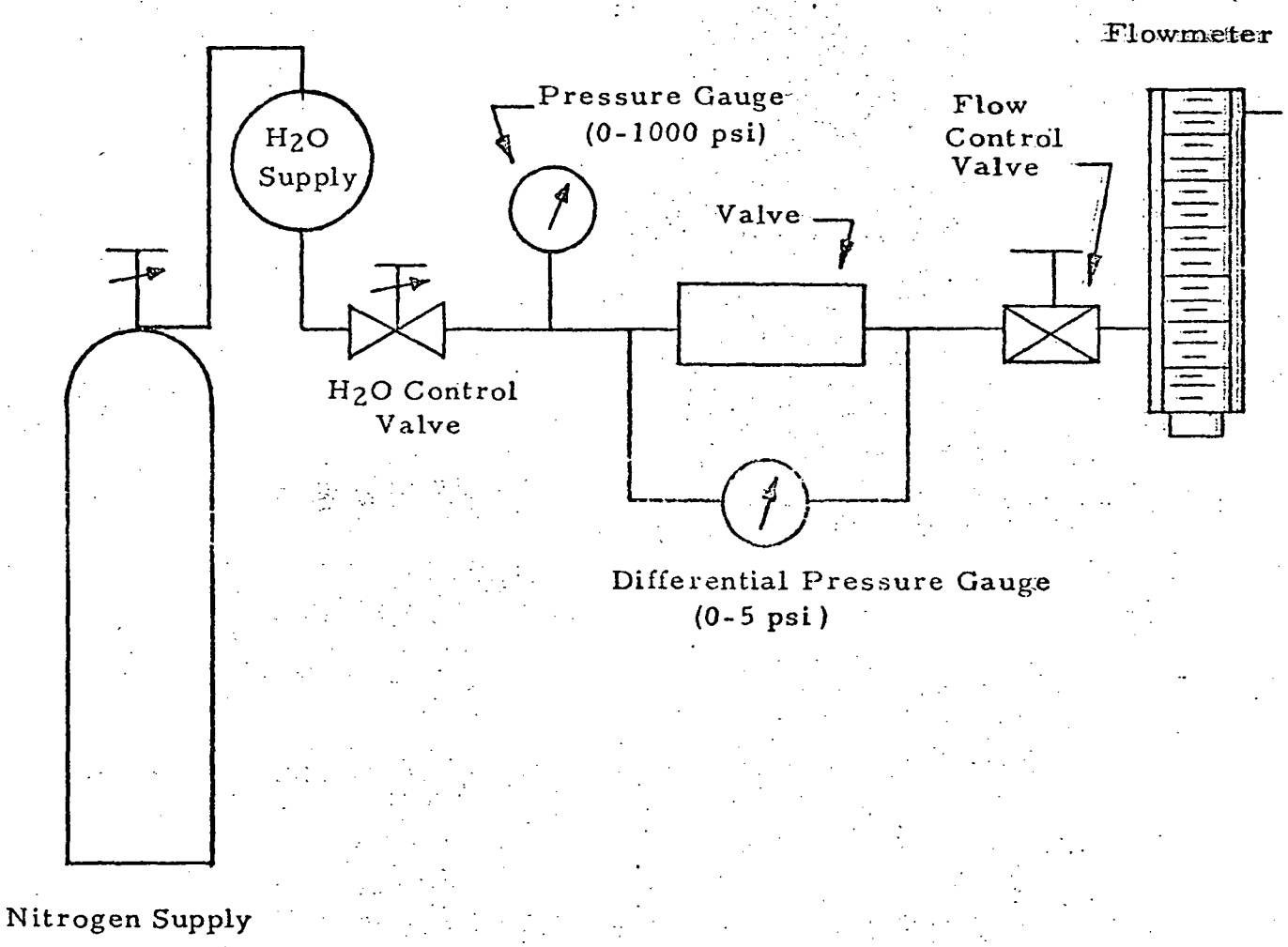
ACTUATION TEST SETUP





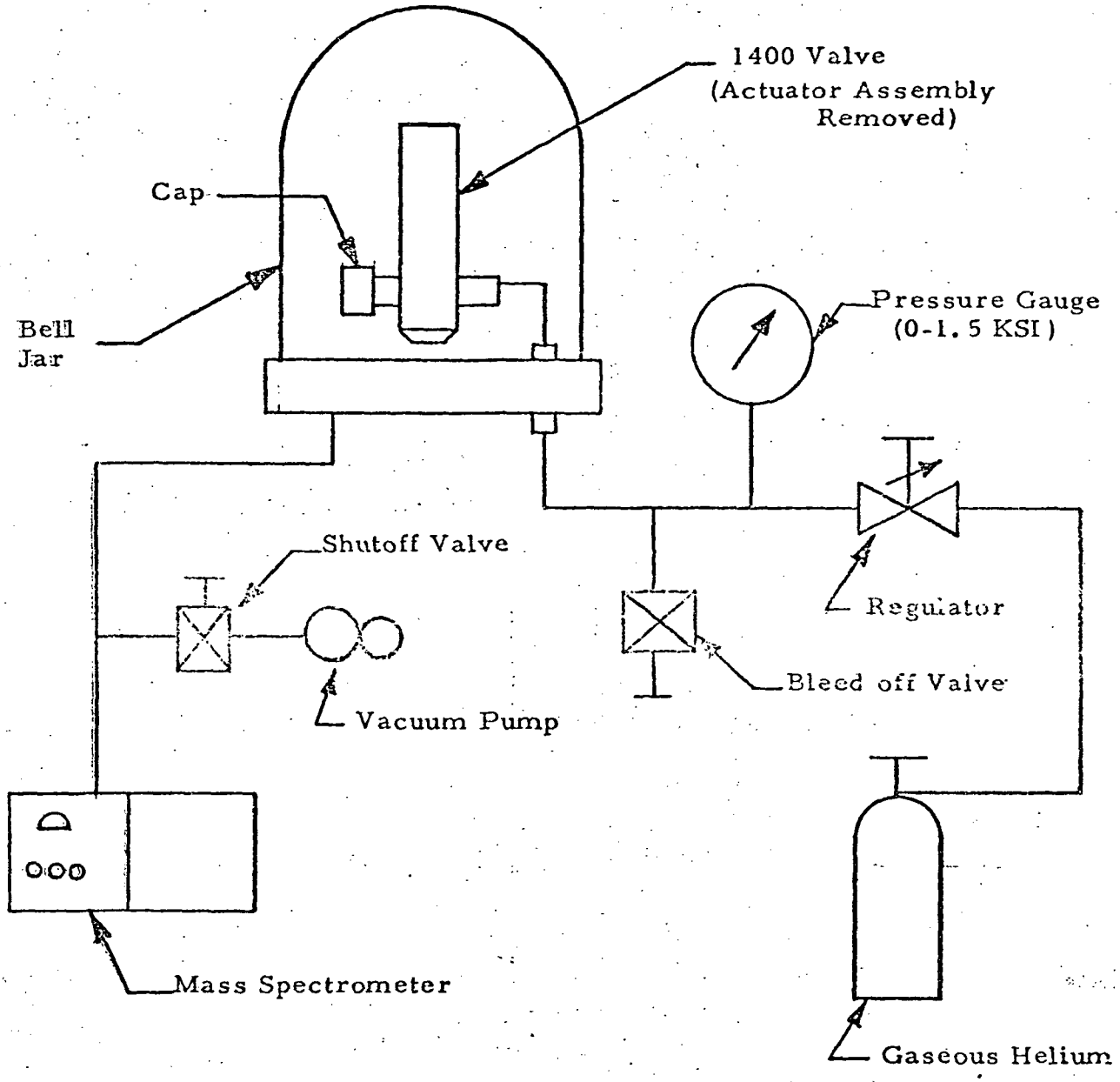
POST ACTUATION PROOF PRESSURE TEST SETUP

FIGURE 6



FLOW VS PRESSURE DROP SETUP

FIGURE 7



POST ACTUATION LEAKAGE TEST SETUP
(LESS ACTUATOR ASSEMBLY)

FIGURE 8

APPENDIX 1

Pyronetics®
Pyronetics inc 10025 SHOEMAKER AVE.
SANTA FE SPRINGS, CALIF.

LUG S/N [illegible]

LABORATORY TEST REPORT

JOB NO. 1068 MODEL 1400 Tests Conducted By R.D.

Instruments and Procedure Per: TS 1400 DATE 6-25-71 / 6-29-71

Witnessed By _____ Source Insp. _____

Traveler S/N 4183

PARAGRAPH NO. 4.1 Proof Pressure & Internal Leakage 4.2 Proof Pressure and External Leakage

Serial No.	Helium Pressure Tubes PSIG	Time MIN.	Leak Rate SCCS		Helium Pressure Cart. Port PSIG	Time MIN.	Leak Rate SCCS				
1	1000	32	3.0×10^{-8}	P11	1000	35	9.0×10^{-9}	P11			
2	1000	35	2.5×10^{-8}	P11	1000	33	2.0×10^{-8}	P11			
3	1000	33	2.1×10^{-8}	P11	1000	37	1.3×10^{-8}	P11			

APPENDIX 2

Pyronetics inc
10025 SHOEMAKER AVE.
SANTA FE SPRINGS, CALIF.

LABORATORY TEST REPORT

JOB NO. 1068 MODEL 1400 Tests Conducted By K.D.

Instruments and Procedure Per: TS 1400 DATE 7-1-71

Witnessed By _____ Source Insp. _____

Traveler S/N 4196

PARAGRAPH NO. 4.3 Proof Pressure and Leakage Test (Actuator Assembly)

Serial No. 1068-	Helium Pressure psig	Time minutes	Leak Rate sccs								
004	500	37	9.5×10^{-9}								
005	500	31	1.5×10^{-8}								
006	500	33	1.4×10^{-8}								

APPENDIX 3

Pyronetics® inc
10025 SHOEMAKER AVE.
SANTA FE SPRINGS, CALIF.

'/N 140004

LABORATORY TEST REPORT

LOG S/N 1185

JOB NO. 1068 MODEL 1400 Tests Conducted By R.D. (P11)

Instruments and Procedure Per: TS 1400 DATE 7-1-71

Witnessed By _____ Source Insp. _____

Traveler S/N 4196

PARAGRAPH NO. 4.4 Gross Leak Test (Actuator Assembly)

Serial No. 1068-	Deionized H_2O Temp. °F	Leakage w/bellows Submerged	
004	+180	ZERO	(P11)
005	+180	ZERO	(P11)
006	+180	ZERO	(P11)

Dynamics Inc
SUBSIDIARY OF COSMODYNE
10025 SHOEMAKER AVE.,
SANTA FE SPRINGS, CA 90670

APPENDIX 4

10035 SHOEMAKER AVE.
SANTA FE SPRINGS, CALIF.

CONFIGURATION IDENTIFICATION INDEX

CUSTOMER INFORMATION

Date 15 July 1971

CUSTOMER Jet Propulsion Lab. P.O. NO. ES-536829 CONTRACT NO. NAS 7-100

PART NO. 1400 MODEL NO. 1400 SERIAL NO. [S] 1068-

CHG. LET.	PART NO.	QTY	PART DESCRIPTION	S/N or Lot No.	DCN No.
B	1400	1	Valve, Normaly Closed	1068-	5101
A	140000	1	Valve, Assembly	1068-	5102
C	140020	1	Body Subassembly	1068-	5255
D	140021	1	Body	1068-	5076
C	140022	2	Nipple	Lot 1068	5104
A	140024	1	Actuator Assembly	Lot 1068	5053
A	140025	1	Piston	Lot1068	5118
C	140026	1	Body Actuator	Lot 1068	5066
A	140027	1	Bellows	Lot 1068	5048
	2-010 E515-8	1	O-Ring	Lot 1068	
	MS 28774-010	1	Retainer	Lot 1068	
	AN 814-10J	1	Plug	Lot 1068	
	3-910 E515-8	1	O-Ring	Lot 1068	
	Krytox 240 AC	A/R	Lubricant	Lot 1068	
B	140023	1	Ram	Lot 1068	5248
	3-909 E515-8	1	O-Ring	Lot 1068	
	MS 02995C32	A/R	Lockwire		
	G-283		Cleaning of Details and Assembly		
	G-270		Standard Machining Practices		
A	G-252		Electro-Chemical Etch		4554
	MIL-W-8604		Heliarc Welding		
	TS 1400		Acceptance Test		

S/N 1068-001, 002, 003

JUL 12 1971

DATE 6-16-71 INSP. BY [illegible]
AMT. INSP. 3
AMT. ACC. 3
DMR. NO. 2 JOB NO. [illegible]

B

140000 A

QTY REQD	PART NUMBER	DESCRIPTION
AR	MS20995C32	LOCKWIRE
1	3-909, E515-8	O-RING
1	140024	ACTUATOR ASSY
1	140023	RAM
1	140020	BODY SUBASSEMBLY

CONTRACT NO.

Pyronetics, inc.
SUBSIDIARY OF COSMODYNE

10025 SHOEMAKER AVENUE
SANTA FE SPRINGS, CALIF. 90670

DRN	BRL	4-14-71
CHKD	Magargal	4-12-71
APPD	COW	
	Hackett	3-29-71

VALVE ASSEMBLY

A

SIZE	CODE IDENT. NO.	DWG NO.	REV LTR
D	19689	140000	A

SCALE 2/1 | UNIT WT. | SHEET

GARWOOD LABORATORIES, INC.
708 SO. VAIL AVENUE
MONTEBELLO, CALIF.
90640
(213) 723-0011

PYRONETICS

Number C3824-5

Date 7-13-71

Your Order 12170
1230-1068

Delivered To

Date Pickup Via

Eng'r. VLW

Pyronetics Inc.
10025 Shoemaker Ave.
Santa Fe Springs, Calif. 90670

Attention:

CERTIFICATION

QUAN	Description
3	Pyronetics P/N 1400-B, Valve Normally Closed S/N 1063-001 thru 1068-003
3	Pyronetics P/N 1399-B, Valve Normally Open S/N 1068-001 thru 1068-003 JPL P.O. ES-536829 Cont. NAS 7-100

This will certify that the above items were processed according to the following methods and that the specification requirements were complied with:

~~Tested Per~~ Assy by Pyronetics per Applicable Dwg.

Cleaned Per JPL Spec. FS504574, Level D2

Packaged Per JPL Spec. FS 504574

Quality Assurance Supervisor

G-73 20M 6-69

APPENDIX 6

Pyronetics Inc.
SUBSIDIARY OF COSMODYNE
10025 SHOEMAKER AVE.
SANTA FE SPRINGS, CALIF.

TEST DATA SHEET

Part Name: VALVE NORMALLY CLOSED
Pyronetics P/N: 1400
Pyronetics Spec: TS 1400
Test Para. No.: 4.7
Test Sequence No.: 7
Date Started: 15 JULY 1971
Date Completed: 30 JULY 1971

Test Title: LOT ACCEPTANCE TESTS
Customer: JPL
Customer P/N:
Cust. Spec. No.:
Cust. Spec. Para. No.:
Customer P.O.: ES -536829
Prime Contr. No.:

TEST DESCRIPTION: ACTUATION TEST

Serial No. 1068	Bridge Wire Resistance AB	Bridge Wire Resistance CD	Pressure 500 +10 -0 (PSIG)	Current 5.0 (Amp)	Bridge wire Burnout (ms)	Response Time 10ms max (MS)	Flow Passage DIA (0.172 Nom.)	Pass / Fail
-001	1.09	1.01	509	5.0	1.0	1.10	0.172	Pass
-002	1.09	1.02	500	5.0	0.95	1.00	≈25% obstruction	
⊗ -003	1.08	1.05	510	5.0	1.0	1.05	0.172	PASS

REMARKS: ⊗ Cartridge P/N 1003514-1 75% Load
S/N 7676S

APPROVALS:

G.A. Bhl	E-A	R. Hagler		
Tested by	Test Engineer	Customer Witness	Customer Witness	DCAS

APPENDIX 7

Pyronetics Inc.
SUBSIDIARY OF COSMODYNE
10025 SHOEMAKER AVE.
SANTA FE SPRINGS, CALIF.

TEST DATA SHEET

Part Name: Valve Normally Closed
Pyronetics P/N: 1400
Pyronetics Spec: TS 1400
Test Para. No.: 4-8
Test Sequence No.: 8
Date Started: 15 July 1971
Date Completed: 15 July 1971
8-3-71

Test Title: Lot Acceptance Test
Customer: JPL
Customer P/N:
Cust. Spec. No.:
Cust. Spec. Para. No.:
Customer P.O.: ES-536829
Prime Contr. No.:

TEST DESCRIPTION: Proof Pressure Test (after Actuation of Valve)

Serial No. 1068-		Pressure 1000 +30 -0 psig		Time 2 minutes min				Pass / Fail
001		1000	(1)	2.0	No evidence of	Deformation		PASS (2)
002		1000	(1)	2.0	No evidence of	Deformation		PASS (2)
003		1000	(1)	2.0	No EVIDENCE OF	DEFORMATION		PASS (2)

REMARKS:

APPROVALS:

Tested by	Test Engineer	Customer Witness	Customer Witness	DCAS

APPENDIX 8

Pyronetics Inc.
SUBSIDIARY OF COMMODYNE
10025 SHOEMAKER AVE.
SANTA FE SPRINGS, CALIF.

TEST DATA SHEET

Part Name: VALVE NORMALLY CLOSED
Pyronetics P/N: 1400
Pyronetics Spec: TS 1400
Test Para. No.: 4.9
Test Sequence No.: 9
Date Started: 15 JULY '71
Date Completed: 30 JULY '71

Test Title: LOT ACCEPTANCE TEST
Customer: JPL
Customer P/N:
Cust. Spec. No.:
Cust. Spec. Para. No.:
Customer P.O.: ES-536829
Prime Contr. No.:

TEST DESCRIPTION: FLOW VS PRESSURE DROP TEST

Serial No. 1618-	@ 500 PSIG INLET PORT H2O FLOW RATE LBS/SEC.	GROSS ΔP	TARE ΔP	NET ΔP				Pass / Fail
001	0.15	4.45	3.65	0.80				PASS
003	0.15	4.42	3.65	0.77				PASS

REMARKS:

APPROVALS:

E.A. & B.T.L.	E.A.	R. HAGLER		
Tested by	Test Engineer	Customer Witness	Customer Witness	DCAS

APPENDIX 9

Pyronetics Inc.
SUBSIDIARY OF COSMODYNE
10025 SHOEMAKER AVE.
SANTA FE SPRINGS, CALIF.

TEST DATA SHEET

Part Name: VALVE N.C.
Pyronetics P/N: 1400
Pyronetics Spec: T.S 1400
Test Para. No.: 4.10
Test Sequence No.: 10
Date Started: 7-19-71
Date Completed: 7-19-71
8-3-71

Test Title: LOT ACCEPTANCE
Customer: JPL
Customer P/N:
Cust. Spec. No.:
Cust. Spec. Para. No.:
Customer P.O.: ES-536829
Prime Contr. No.:

TEST DESCRIPTION: DISASSEMBLY INSPECTION

Serial No. 1068-								Pass / Fail
001	NO VISIBLE DEFECTS							PASS
002	NO VISIBLE DEFECTS							PASS
003	NO VISIBLE DEFECTS							PASS

REMARKS:

APPROVALS:

R. DeFrisco — Tested by
E. Avalos — Test Engineer
Customer Witness
Customer Witness
DCAS

APPENDIX 10

Pyronetics Inc.
SUBSIDIARY OF COSMODYNE
10025 SHOEMAKER AVE.
SANTA FE SPRINGS, CALIF.

TEST DATA SHEET

Part Name: VALVE N.C.
Pyronetics P/N: 1400
Pyronetics Spec: TS 1400
Test Para. No.: 4.11
Test Sequence No.: 11
Date Started: 7-19-71
Date Completed: 7-19-71
8-3-71

Test Title: LOT ACCEPTANCE
Customer: JPL
Customer P/N:
Cust. Spec. No.:
Cust. Spec. Para. No.:
Customer P.O.: ES-536829
Prime Contr. No.:

TEST DESCRIPTION: POST ACTUATION LEAKAGE (ACTUATOR ASSY.)

Serial No. 1068-	HELIUM PRESSURE PSIG	TIME MIN.	LEAK RATE SCCS					Pass / Fail
001	500	45	4.3×10^{-8}					PASS
002	500	49	1.4×10^{-8}					PASS
003	500	40	2.6×10^{-8}					PASS

REMARKS:

APPROVALS:

Tested by	Test Engineer	Customer Witness	Customer Witness	DCAS
R. DeFrisco	E. Avalos			

APPENDIX 11

Pyronetics Inc.
SUBSIDIARY OF COSMODYNE
10025 SHOEMAKER AVE.
SANTA FE SPRINGS, CALIF.

TEST DATA SHEET

Part Name: VALVE N.C.
Pyronetics P/N: 1400
Pyronetics Spec: TS 1400
Test Para. No.: 4.12
Test Sequence No.: 12
Date Started: 7-19-71
Date Completed: 7-19-71
8-3-71

Test Title: LOT ACCEPTANCE
Customer: JPL
Customer P/N:
Cust. Spec. No.:
Cust. Spec. Para. No.: ES-536829
Customer P.O.:
Prime Contr. No.:

TEST DESCRIPTION: POST ACTUATION LEAKAGE - GROSS (ACTUATOR ASSY.)

Serial No. 1068-	DEIONIZED H_2O TEMP. °F	LEAKAGE W/BELLOWS SUBMERGED @ 1 MIN.						Pass / Fail
001	+180	ZERO						PASS
002	+180	ZERO						PASS
003	+180	ZERO						PASS

REMARKS:

APPROVALS:

R. DeFrisco	E. Avalos			
Tested by (15/11)	Test Engineer	Customer Witness	Customer Witness	DCAS

APPENDIX 12

Pyronetics Inc.
SUBSIDIARY OF COSMODYNE
10025 SHOEMAKER AVE.
SANTA FE SPRINGS, CALIF.

TEST DATA SHEET

Part Name: VALVE N.C.
Pyronetics P/N: 1400
Pyronetics Spec: TS 1400
Test Para. No.: 4.13
Test Sequence No.: 13
Date Started: 7-20-71
Date Completed: 7-20-71
8-3-71

Test Title: LOT ACCEPTANCE
Customer: JPL
Customer P/N:
Cust. Spec. No.:
Cust. Spec. Para. No.:
Customer P.O.: EJ-536829
Prime Contr. No.:

TEST DESCRIPTION: EXTERNAL LEAKAGE AFTER ACTUATION (VALVE ASSEMBLY LESS ACTUATOR ASSY.)

Serial No. 1068-	HELIUM PRESSURE BOTH PORTS PSIG	TIME MIN.	LEAK RATE SCCS					Pass / Fail
001	1000	38	7.6×10^{-8}					PASS
002	1000	35	9.0×10^{-8}					PASS
003	1000	37	8.6×10^{-8}					PASS

REMARKS:

APPROVALS:

Tested by	Test Engineer	Customer Witness	Customer Witness	DCAS
R. DEFRISCO	E. AVALOS			

APPENDIX 13

Pyronetics Inc.
SUBSIDIARY OF COSMODYNE
10025 SHOEMAKER AVE.
SANTA FE SPRINGS, CALIF.

TEST DATA SHEET

Part Name: VALVE N.C.
Pyronetics P/N: 1400
Pyronetics Spec: TS 1400
Test Para. No.: 4.14
Test Sequence No.: 14
Date Started: 7-20-71
Date Completed: 7-20-71
8-3-71

Test Title: LOT ACCEPTANCE
Customer: JPL
Customer P/N:
Cust. Spec. No.:
Cust. Spec. Para. No.:
Customer P.O.: ES-536829
Prime Contr. No.:

TEST DESCRIPTION: BURST PRESSURE TEST

Serial No. 1068-	HYDRO. PRESSURE TUBE PORT PSIG	RESULTS						Pass / Fail
001	10,000	O.K.	NO BURST					PASS
002	10,000	O.K.	NO BURST					PASS
003	10,000	O.K.	NO BURST					PASS
001	12,900	RAM BACKED OUT						
002	13,500	RAM BACKED OUT						
003	12,600	RAM BACKED OUT						

REMARKS:

APPROVALS:

Tested by (P 11)	Test Engineer	Customer Witness	Customer Witness	DCAS
R. DeFrisco	E. Avalos			

APPENDIX 14

Pyronetics

1068 PROJECT NAME

TROUBLE & FAILURE REPORT

S/N 0069

THIS REPORT COVERS A ☐ REWORK ACTION ☐ TROUBLE ☒ FAILURE

ORIGINATOR

SYSTEM/SUBSYSTEM NAME	P/N	S/N	DATE (MO. / DAY / YR.)
VALVE, N.C. EXPLOSIVE ACT'D	1400	002	7 / 15 / 71

REPORTING FACILITY	REPORTED BY	TFR CONTINUATION USED
PYRONETICS	E. AVALOS	☐

TROUBLE/FAILURE OBSERVED WAS: (TEST CONDITIONS, SYMPTOMS, SEVERITY, ETC., INCLUDING "IS" AND "SHOULD BE" DATA)

VALVE UNDERACTUATED ON FIRING CAUSING APPROX 25% OBSTRUCTION OF THE FLOW PASSAGE.

TROUBLE/FAILURE OCCURRED DURING: EVALUATION TESTING (LAT)

ACTION TAKEN TO CORRECT TROUBLE/FAILURE: (A) ☐ REPLACED ITEM (B) ☐ REPAIRED ITEM

ITEM REPLACED NAME	P/N	S/N	ITEM INSTALLED NAME	P/N	S/N	DISPOSITION OF REPLACED ITEM

VERIFICATION

WERE OTHER TROUBLES/FAILURES, NOT RELATED TO ORIGINAL NOTED? (A) ☒ NO (B) ☐ YES — LIST ON NEW TFR – TFR NO. _____

WAS REPORTED TROUBLE/FAILURE VERIFIED? (A) ☒ YES (B) ☐ NO

FAILED ITEM NAME	P/N	S/N	MANUFACTURER
VALVE, N.C.	1400	002	PYRONETICS

NEXT HIGHER ASSY: NAME	P/N	S/N	MANUFACTURER
N/A			

(A) ☐ REWORK REQUIRED IS (B) ☒ REWORK IS NOT REQUIRED BECAUSE

SINGLE SHOT ITEM

VENDOR REWORK/ANALYSIS IS REQUIRED ☒

DISPOSITION OF ITEM IF NOT REWORKED: USE FOR ANALYSIS — AUTHORIZATION BY: C. Nagengast — DATE

REWORK & RETEST

LIST BELOW ALL PARTS REPLACED, REPAIRED OR ADJUSTED

PART NUMBER	S/N	MANUFACTURER	DEFECT	REWORK ACTION TAKEN	RECEIVING LOT NO.

OTHER REWORK ACTION: REMAINING LAT UNIT (S/N 003) RAM (P/N 140023) REWORKED TO REV 'B' FOR REMAINING LAT TEST

REWORKED BY	RETESTED BY	RETEST RESULTS APPROVAL	DATE / Q.C.
		C. Nagengast	8-3-71

RETEST RESULTS: REPAIRED ITEM IS ACCEPTABLE FOR ☐ UNRESTRICTED USE ☐ RESTRICTED USE ☐ NOT ACCEPTABLE: N/A

DISPOSITION OF ITEM AFTER RETEST: N/A

ENGINEERING

CAUSE OF FAILURE – COMMENTS (IF ANALYSIS NOT PERFORMED, EXPLAIN): RAM/BODY BORE CLEARANCE APPROX .0010/.0015 TIGHTER THAN OTHER UNITS FIRED SUCCESSFULLY. LEADING EDGE OF RAM TAPER HAD MINIMUM ALLOWABLE RADIUS AND WAS NOT SMOOTHLY BLENDED AS ON SUCCESSFUL UNIT FIRINGS. RAM LEADING EDGE SHOWED EVIDENCE OF DIGGING INTO MATING BODY TAPER.

BASIC CAUSE OF TROUBLE/FAILURE (SELECT FROM BLOCK 1 SHEET 2): DESIGN WORKMANSHIP — SIGNATURE: C. Nagengast — DATE: 12-26-71

CORRECTIVE ENGINEERING ACTION TAKEN (IF NONE, JUSTIFY) – CONCLUSIONS: RAM/BODY BORE CLEARANCE INCREASED. RADIUS INCREASED ON LEADING EDGE OF RAM TAPER AND REQUIREMENT FOR BLENDING OF RADIUS INTO TAPER ADDED. RAM SLOT ELONGATED .020 FOR ADDED INSURANCE

SIGNATURE: C. Nagengast — DATE: 8-3-71

FORM 65-2

Pyronetics

1068 PROJECT NAME **TROUBLE & FAILURE REPORT**

S/N 00

GENERAL INSTRUCTIONS

1. THE TFR IS USED TO DOCUMENT THE TROUBLE FAILURE OF ONLY ONE (1) ITEM PER REPORT. IF MORE THAN ONE ITEM IS INVOLVED IN A SINGLE FAILURE EVENT, OR IF TWO OR MORE FAILURES ARE DISCOVERED IN A SINGLE ITEM, A SEPARATE REPORT SHALL BE COMPLETED FOR EACH ITEM OR FAILURE AND IDENTIFIED BY CROSS-REFERENCING
2. UNLESS INSTRUCTED OTHERWISE, ALL REQUIRED BLOCKS MUST BE COMPLETED.
3. USE A TFR CONTINUATION SHEET WHENEVER ADDITIONAL SPACE FOR ENTRIES IS REQUIRED.

DETAIL INSTRUCTIONS

ENTRIES ON THE TFR ARE SELF-EXPLANATORY AND DO NOT REQUIRE DETAIL INSTRUCTIONS. SPECIAL INSTRUCTIONS FOR ENTRIES ARE COVERED IN IMPLEMENTING INSTRUCTIONS ISSUED BY THE USING ORGANIZATION.

RELIABILITY ANALYSIS AND FOLLOW-UP

1. CAUSE OF DIFFICULTY

- [X] DESIGN
- [ ] MFG. PROCESS
- [ ] TEST EQUIPMENT
- [ ] TEST PROCEDURE
- [ ] HUMAN ERROR
- [X] WORKMANSHIP
- [ ] ROUGH HANDLING
- [ ] ENVIRONMENTAL EFFECT(S)
- [ ] OTHER ITEM FAILURE _____ SPECIFY
- [ ] DEFECTIVE PARTS
- [ ] UNKNOWN
- [ ] OTHER _____ SPECIFY

2. EFFECT ON

VALVE, N.C. (ITEM NAME)

- [ ] INOPERATIVE
- [ ] BADLY DEGRADED
- [X] SLIGHTLY DEGRADED
- [ ] NUISANCE

3. CORRECTIVE ACTION STATUS DATE

- [X] IN EFFECT 8-3-7
- [ ] UNDER INVESTIGATION
- [ ] SCHEDULED
- [ ] INTERIM FIX
- [ ] NOT REQUIRED
- [ ] ACTION PREVIOUSLY TAKEN

ANALYSIS

THIRD L.A.T. UNIT, S/N 003, HAD MODIFICATION OF RWO 72 REV. B PERFORMED AND WAS THEN TESTED PER TS 1400. A 75% (UNDERLOAD) SQUIB WAS UTILIZED AT JPL REQUEST. RESULTS WERE SATISFACTORY.

RELIABILITY ANALYSIS BY C NAGENGAST DATE 8-3-7

APPROVALS:

VENDOR CUSTOMER (IF APPLICABLE) C Nagengast ENGINEERING (IF APPLICABLE) RELIABILITY

8 MO 3 DAY TFR CLOSED