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VACUUM JACKETED UMBILICAL LINES TECHNOLOGY ADVANCEMENT STUDY

VACUUM SEAL VALVES

AMETEK/Straza
790 Greenfield Drive
El Cajon, California 92021

December 12, 1969

Final Technical Report, Task II
Contract Number NAS 10-6098

Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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15. Supplementary Notes

This report is one of seven similar tasks related to vacuum jacketed components used on the service arms of the launch umbilical tower at Launch Complex 39, Kennedy Space Center, Florida.

16. Abstract

This report presents results of a detailed study of the seal-off vacuum valves used in the propellant lines and vent lines on the launch tower service arms at Kennedy Space Center. Phase I of the study sought to develop improved valve designs to overcome residual leaks and poor resealability, thereby eliminating excessive field maintenance. Hardware was evaluated, valve failure histories were searched, a state-of-the-art product review was made, and designs were studied. Improvements in materials, configurations, and seal port designs were sought. Phase II was a testing program for valves manufactured under new specifications incorporating the improvements resulting from Phase I studies. Environmental factors and possible operational problems were simulated to determine that the newly developed valve materials and designs would meet all requirements for a satisfactory 5-year minimum life in a seacoast environment. Conclusions based on this study led to recommendations of further study and improvement of vacuum seal valve materials and designs, possible replacement of existing valves with improved ones, and inspection and necessary replacement of poppet springs in the SV3-812 valves to reduce abrasion and contamination.

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Final Technical Report
for
Vacuum Jacketed Umbilical Lines
Technology Advancement Program

Vacuum Seal Valves

Contract Number NAS 10-6098
Date - December 12, 1969

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ABSTRACT

The seal-off valve study under NASA Contract Number NAS 10-6098 for Vacuum Jacketed Umbilical Lines Technology Advancement Program was accomplished in two phases: Phase I and Phase II. The Phase I study objectives were to develop an improved vacuum seal valve design to overcome the problem of residual leaks and poor resealability which has necessitated excessive field maintenance operations. The study also included improvements in seal materials, seal configurations, and seal port design. The Phase I portion of the study consisted of: (1) Hardware evaluation, (2) product review, (3) design phase, and (4) Phase II proposal. The Phase II testing program consisted of: (1) Procurement of test specimens, (2) preparation of test procedures, (3) testing and preparation of the test report, and (4) final report. This logical sequence of performance has produced the technology and information necessary to complete the program and reach the final conclusions.

Phase I

The hardware evaluation phase of the program has established hardware failure history, conditions under which the component is operating, the environment and other elements that have contributed to failures. This information has made possible the failure mode analysis, hardware reliability numbers and goals, and the design objectives and criteria.

An on-site inspection of the service arm hardware was conducted at Kennedy Space Center to evaluate the system conditions and environment. An extensive search of the Inspection Report (IR) file at AMETEK/Straza was made to identify failures for the seal valves that would substantiate the failure mode analysis and program reliability numbers and goals.

A state-of-the-art evaluation was made by a product review, literature search and contact of manufacturers for the available hardware in the industry which could meet the program study objectives.

The design information received from the vendors resulted in the selection of 12 vendors whose hardware could be modified to meet the requirements of the contract. This preferred vendor list was ultimately reduced to six based on an expressed desire to assist AMETEK/Straza in development of new designs and a desire to implement revision to their present product line to meet study objectives.

The design phase was conducted concurrently with the hardware evaluation and product review. This consisted of

establishing the preliminary design and program objectives which would increase hardware reliability. An analysis was made to determine optimum valve sizing incorporating a filter to eliminate the possibility of internal contamination during pumpdown operations. All vendor designs were evaluated through a "comparative analysis," taking into consideration such items as: sealing, flow passage, material compatibility, simplicity in design, profile, structural integrity, and other related design characteristics.

The basic design improvements that were considered as the main objectives for seal-off valves that have been incorporated into test hardware are: (1) a reduction in valve profile to reduce the possibility of damage during vacuum jacketed line and launch tower maintenance operations, (2) elimination of the seal-off valve operator, incorporating an integral operator to help eliminate contamination, (3) an improvement in seal material, and (4) the incorporation of a relief mechanism with the integral operator to combine the vacuum pumpdown and relief capabilities in one unit.

The reliability and trade-off analysis of all hardware received from the vendors has shown that the integrally operated vacuum seal valve will meet study objectives. (See Figures 1 through 3.)

Phase II

Procurement specifications were written for two vacuum seal valves. (AMETEK/Straza Specification Numbers 8-410018 "Vacuum Seal-Off Valve", and 8-410019 "Vacuum Seal-Off/ Relief Valve".) These specifications incorporated all of the design improvements resulting from the Phase I study.

The Cryolab Company, Los Osos, California, was selected for procurement of test specimens. Eighteen (18) total valves were purchased which included six (6) SV3-812 seal-off/relief valves of the type that are presently installed on Complex 39; six (6) seal-off valves incorporating the basic design improvements established during Phase I; and six (6) seal-off/relief valves. The seal-off/relief valve is identical to the seal-off valve incorporating design improvements with the addition of the spring operated relief.

Testing was conducted on all valves. The valves functioned per specification after exposure to environmental and operational testing, including salt fog, sand and dust, thermal tests, and contamination, shock and vibration.

Test reports, installation and maintenance procedures and final reports were written following the testing program.

Conclusions

The vacuum seal valves developed during this program have been tested and will meet all operational and environmental requirements in a seacoast environment for a five-year minimum life. The integral valve operator has reduced the potential for externally introduced contamination. The "Wilson" shaft seal provided leakage-free pumpdown operations for all test conditions, even after 500 open-close cycles.

The conical seat on these valves is self-aligning and seals consistently. An inlet screen provided adequate filtering from annulus contamination. Testing results indicate that Viton O-ring seals are marginal at +200°F. Ethylene propylene O-ring seals leak excessively above +180°F. Butyl is a superior O-ring seal in the range of from -65°F to +200°F. All of the above O-ring seals are leak-free at -65°F.

Dow Corning "Silastic" silicone resisted a direct flame of 1400°F for ten (10) seconds and was selected as the protective material for relief cap. The electroless nickel-plated valve handles showed no signs of corrosion throughout the test program. (For details of these conclusions, see Paragraph 2.3)

Recommendations

Based on the study and testing that was conducted on the vacuum seal valves, several recommendations can be made. These are summarized as follows:

1. Perform a retrofit study program to fully evaluate the desirability of replacing the present valves in the field with the more reliable vacuum seal valves.

2. A seal development program is recommended which will expand the present capabilities of the state-of-the-art elastomers, plastics and metal seals relative to temperature and re-usability.

3. The poppet spring in the SV3-812 valves now installed can rotate and abraid metal chips. These chips can become imbedded in the O-ring and cause leakage. It is recommended that each valve spring be inspected and replaced with an improved spring with a crimped end to eliminate future abraiding. (For details on these recommendations, see Paragraph 2.4.)

2.0 FINAL REPORT

2.1 Phase I Technical Report

2.1.1 Hardware Evaluation

2.1.1.1 Functional Review

The purpose of the development item "Functional Review" was to evaluate the seal valve within the total system requirement as installed on propellant lines and vent lines.

Initially, the original Hayes International Corporation Purchase Order No. 72473 for the propellant lin es was reviewed to establish the number of units that were manufactured under the original contract. All this information was then coordinated and checked against Quality Control and Shipping Department records.

Records indicate a total number of 170 propellant lines and 65 vent lines were built and delivered. Each of these propellant lines had a seal-off valve installed. (NASA Part Number 75M08348) Vent lines also have a seal-off valve installed. (Cryolab Part Number SV3-812-5W5)

Following the determination of the hardware and components that were in the field, a review of all of the design data was accomplished. This included review of NASA Specifications for the Propellant Lines 75M08565 and 75M06519, and 75M09783 for vent lines. The drawings for these lines were drawn from the Straza files and reviewed along with the Seal-Off Valve Specification Control Drawing 75M08348.

Each drawing for the different line assemblies that incorporated every type of construction that Straza had built for installation on the Launch Tower Service Arms was reviewed for the purpose of familiarization with service arm systems.

The requirements of the drawings, components and details were compared with the specifications to ensure that each was compatible.

The information on system requirements gained on several trips that were made by program personnel was coordinated and documented. This included determination of hardware configuration, blast damage, refurbishing required, etc.

The propellant line hardware requirements which consisted of the following parameters were compatible with site system requirements.

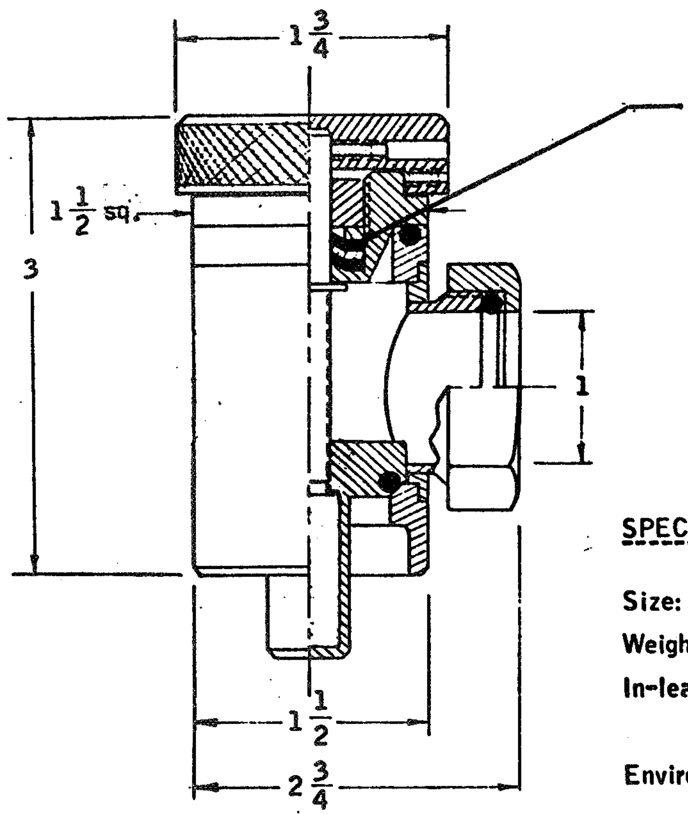
SYM	REVISION	DATE	APPD

...NAL INFORMATION

Item: "SEAL-OFF" Vacuum Valve

Service: Low Pressure & High Vacuum

Part Number: 7079-1



SPECIFICATIONS

Size: Nominal 1" port diameter

Weight: Approx. 20 ounces

In-leakage: Less than 10^{-10} std. cc./sec.

Environment:

Vacuum: Compatible with 10^{-9} torr

Pressure, operating: 0 psia to 65 psig.

Pressure, proof: 150 psig.

Temp., operating: -65°F to +180°F.

Service life: Over 2500 cycles.

UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES AND TOLERANCES ARE:

FRACTIONS		DECIMALS		ANGLES
UNDER 1"	± 1/64	.X	±0.030	
1" TO 2"	± 1/32	.XX	±0.015	± 1°
OVER 2"	± 1/16	.XXX	±0.007	

BREAK SHARP EDGES 0.007 MAX; ALL MACHINED SURFACES 63

DATE OF ORIGINAL DRAWING: 3 May '69

DWN: [illegible]

CHK

ENGR

SEAL-OFF VACUUM VALVE

NEXT ASS'Y:

CRYOLAB
DIVISION OF STATION-DYNAMICS INC

SCALE Full | SHEET 1 OF 1 | A | DRAWING No. 7079 Figure 1

CRYOLAB
DIVISION OF STATION-DYNAMICS INC

SCALE Full | SHEET 1 OF 1 | A | DRAWING No. 7079 Figure 1

Figure 1. Vacuum Seal-Off Valve

Figure 1. Vacuum Seal-Off Valve

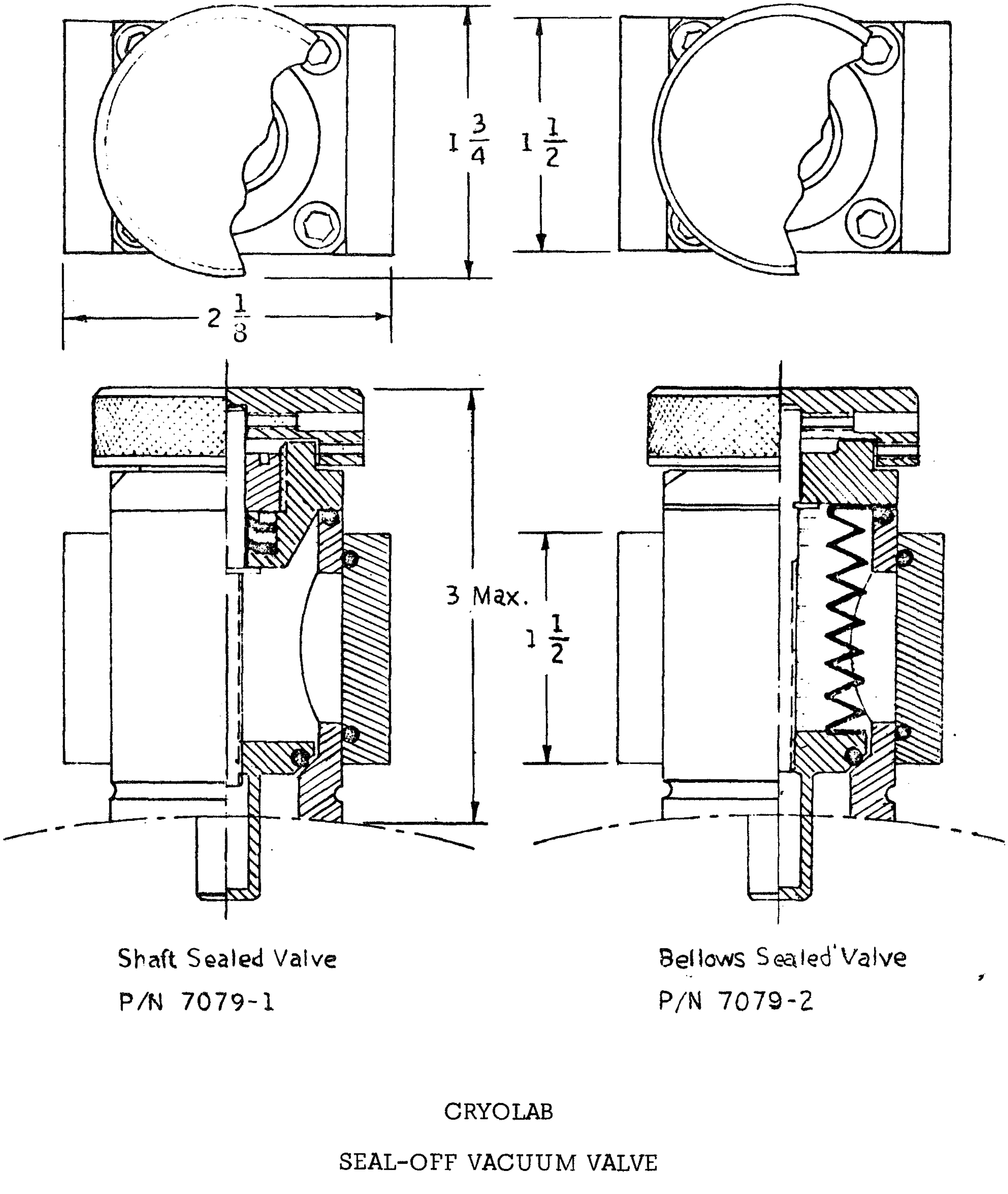


Figure 2. Seal-Off Vacuum Valve

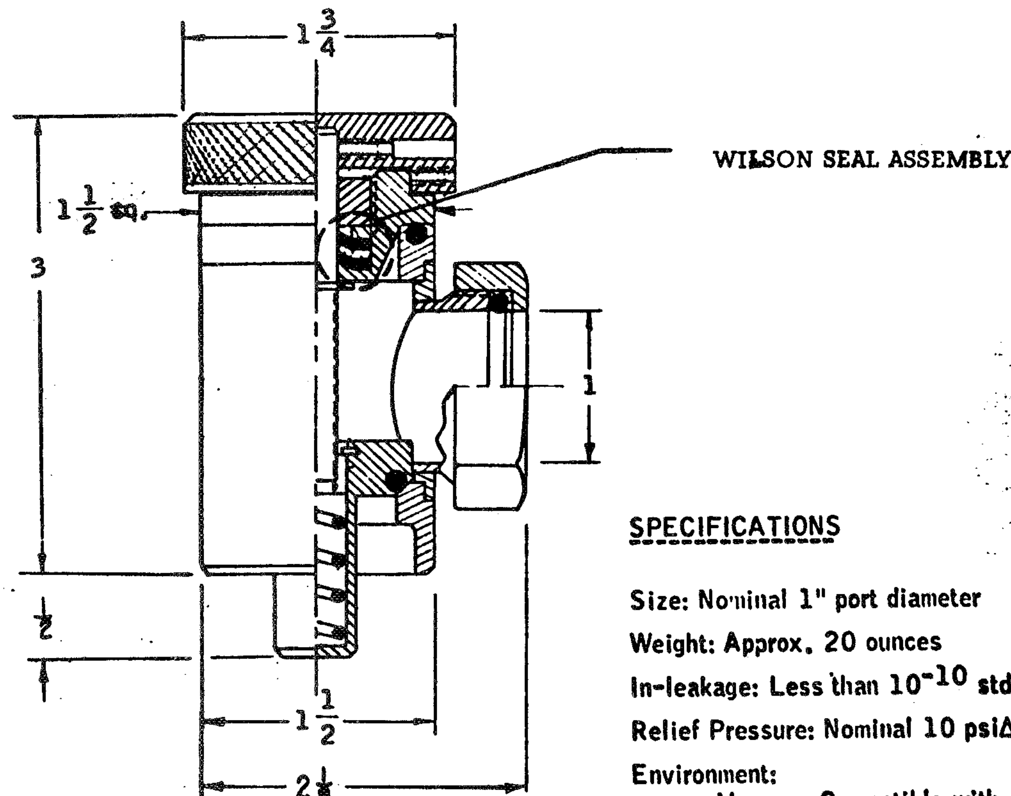
SYM	REVISION	DATE	APPD

GENERAL INFORMATION

Item: Relief Action Vacuum Valve

Service: Low Pressure & High Vacuum

Part Number: 7089-1



SPECIFICATIONS

Size: Nominal 1" port diameter

Weight: Approx. 20 ounces

In-leakage: Less than 10^{-10} std. cc./sec.

Relief Pressure: Nominal 10 psiΔ

Environment:

Vacuum: Compatible with 10^{-9} torr
Pressure, operating: 0 psia to 65 psig.
Pressure, proof: 150 psig.
Temp., operating: -65°F to +180°F.

Service life: Over 2500 cycles.

UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES AND TOLERANCES ARE: FRACTIONS: UNDER 1" ± 1/64; 1" TO 2" ± 1/32; OVER 2" ± 1/16. DECIMALS: .X ±0.050; .XX ±0.015; .XXX ±0.007. ANGLES: ± 1°. BREAK SHARP EDGES 0.007 MAX; ALL MACHINED SURFACES	RELIEF ACTION VACUUM VALVE	NEXT ASS'Y:
DATE OF ORIGINAL DRAWING: 3 May '69 — DWN Zu. — CHK — ENGR		CRYOLAB DIVISION OF STATICS DYNAMICS INC
	SCALE Full — SHEET 1 OF 1	A — DRAWING Nº 7089 Figure 3

Figure 3. Relief Action Seal-Off Valve

A.	Vent Requirements	500 SCFH at 2 psi across seat
B.	Relief Pressure	30 ± 3 psig
C.	Vacuum	10 microns. One (1) micron rise in 48 hours with 40 microns after 60 days.
D.	Seal-Off Valve	One (1) inch seal-off/relief combination, NASA Part No. 75M08348

The vent line hardware which consisted of the following were also compatible with site system requirements.

A. Hard Lines

(1) Vent Requirement	120 SCFM
(2) Relief Pressure	30 ± 3 psig
(3) Vacuum	No requirements
(4) Seal-Off Valve	One (1) inch seal-off/relief combination, NASA Part No. 75M08348

B. Flex Hose

(1) Vent Requirements	700 SCFM
(2) Relief Pressure	40 ± 3 psig
(3) Vacuum	No requirements
(4) Seal-Off Valve	Two (2) - 1 1/2 inch seal-off/ relief combination valves manufactured by the Cryolab Company, Part Number SV3-812-5W5

Since several problems and hardware failures could be related to insufficient testing qualification, the acceptance and qualification test requirements were reviewed against the environmental and operational conditions in the service installation.

It was determined from this functional review that in order to ensure the components' capability with the conditions in the field, a design evaluation testing program will be required to simulate actual field conditions.

The hardware presently installed is functional within system and specification requirements. However, the present hardware has the potential for residual leakage which could cause excessive maintenance to be performed on the vacuum jacketed lines to return the vacuum level to specification requirement.

2.1.1.2 Component Operating Conditions (Existing Hardware)

The present Seal-off Valve (NASA Part Number 75M08348) requires the use of an externally introduced operator for opening and closing the valve during vacuum pumpdown operations. This is in lieu of an integral actuator that remains part of the valve assembly at all times.

Discussions with the personnel at the site were held for an evaluation of seal-off valve problems. Several commented that the seal-off valve operator that is used to open and close the valve and connects to the vacuum pump for drawdown creates problems in its operation. Maintenance Procedure V36096, "S-II Intermediate Service Arm Propellant Line Monitoring and Maintenance", was reviewed for clarity, simplicity and content. It was found that this maintenance procedure was not clear and required expansion, clarification, and inclusion of several steps to eliminate confusion in the use of the valve operator. Maintenance of cleanliness levels prior to and after pumpdown operations were also lacking.

The seal-off valves were examined to determine the causes of residual leakage and poor resealability that had been experienced. This inspection revealed several design deficiencies in the seal-off valve. The examination revealed that an electro-coating of the valve plug is used to prevent galling during opening and closing of the valve. It was determined that particles from this electro-plating were abraided and being deposited on the internal surfaces of the valve.

The guide is also causing wear on the side of the valve and metal particles and residue can be deposited on the sealing surfaces. It was also determined that some of the contaminants found in the valves were dexter paper, mylar particles from the inner line insulation, and metal particles.

It is concluded that an improved maintenance procedure and several design changes in the present hardware would result in an improvement in hardware performance. Initially, it would appear that a valve with an integral operator rather than an independent operator will decrease problems with contamination resulting from externally introduced foreign particles. An inlet filter would help to eliminate internally introduced foreign particles.

The maintenance procedure should be expanded to include more detail in the actuation, opening, and closing of the valve. This will also include more instructions relative to cleanliness in the use of the externally introduced operator.

Personnel should be cautioned as to the complexity of vacuum jacketed components and systems. Personnel training could be integrated in this area so that only certified technicians operate and maintain these components.

A review of the pump-down procedures now in use indicate a need for expansion of instructions to include:

A. <u>Verification</u>

(1) Verification should be explicit that valve operators on drawdown equipment are in the operating condition for a noncontamination operation.

(2) Verification of the calibration of the meters used during maintenance operations.

B. Vacuum Monitoring Operations

Removal of protective covers and the connection of equipment should be carefully outlined and specified that it be made with care to avoid contamination.

C. Pumpdown Operations

(1) Include more information sketches, etc., on the workings of the valve operator as it is introduced into the valve.

(2) Closing of the seal-off valve, removal of the operator, cover replacement should include procedures that would eliminate the possibility of damage and contamination.

2.1.1.3 Evaluation of Equipment - Total Program Effort

Several trips were made to Cape Kennedy and Huntsville to determine if problems that are being experienced with the vacuum seal-off valve are associated with the installation, removal of the component from the system, or during line and launch tower maintenance operations.

As a result of these trips, the following conclusions were reached relative to site evaluation conducted by the AMETEK/Straza survey team.

A. The seal-off valves are being subjected to severe corrosion environment due to salt fog atmosphere. Where lubricant has been required during field maintenance operations to reduce the corrosion problem, it has been left off the hardware. Procedures have not been explicit or well defined in this area.

B. It was made known to Straza by maintenance personnel at the site that installation and removal of components have not been the cause of problems to date. The evaluation determined that leakage is due to contamination.

C. The location of the component on the vacuum jacketed line makes service operations difficult due to hard-to-reach locations and contribute to the problems presently being experienced during maintenance operations such as contamination and internal damage.

2.1.1.4 Review of Conditions and Failure

A review was conducted of all of the accumulated data received from Kennedy Space Center through the data bank, tab runs and Straza Inspection Report (IR) file. This review evaluated all written data that described conditions to which the system and components are subjected. Site personnel were also interviewed to determine the failures that had occurred for which no documentation existed.

Tab runs were not available for propellant lines or their components. Consequently, no failure data is available through these "Unsatisfactory Condition Reports."

Straza IR files for lines received for rework due to failure or discrepancy were inspected for failure data that would be applicable to this study. Approximately 1200 IR's were reviewed with the following results:

Only two (2) IR's were applicable to the present hardware. (IR Numbers 8972 and 8988 on Straza Drawing 8-030159-1, Serial Numbers 6 and 7.)

These Inspection Reports indicated that rust was discovered on the inside of the cap. (There was no indication that the valve had leaked as a result of this discrepancy.)

Summary

Although only two (2) failures were uncovered for seal-off valves on the propellant lines, coordination with site personnel over the length of the hardware evaluation phase of the study revealed that failures were occurring that resulted in excessive maintenance operations. The fact that written documentation of these failures was limited did not limit the design evaluation. A failure mode analysis was made and a number of failures added to a specific failure mode to establish a hardware reliability goal that is realistic. (For hardware reliability numbers, see Section 2.1.3.3.)

2.1.1.5 Review of Test Data

An industry-wide search was made for test reports on tests that had been conducted on vacuum seal-off valves that could be applicable for reference in this program. The basic philosophy of the program, as preliminary plans were laid for the Phase II testing, was to avoid repetition of tests that had been conducted on hardware of a similar type.

Several of the large aerospace prime contractors were solicited for test reports for vacuum and relief valves including North American Rockwell and Douglas, primarily because it had come to our attention that some work had been done in the testing of vacuum seal-off/relief valves.

The test reports received for evaluation were:

A. Solar Research Memo Number R68H-1501 dated 8 March 1968

B. Douglas Test Report TM-DSU-4B-ME-R5168-1 dated 1 March 1965

C. Douglas Test Report TM-DSV-4B-MS-R3850B

The Solar Research Memo Number R68H-1501 tested a Cryolab vacuum valve one-half inch diameter used on the Saturn S-II LH_2 and LO_2 Feed and Vent Lines. The test program was intended to demonstrate that the conditions of leakage, temperature, and vibration loading meets the North American specification requirements.

Douglas Test (#TM-DSV4B-ME-R5167-1) was performed on a Cryolab one inch diameter vacuum seal-off valve. The purpose of the test was to determine the ability of the test specimen to withstand the vibration environment to be encountered during ground support of the Saturn S-IV B Stage. Vibration input levels were as follows:

Sine

Frequency	Level
10 - 120	.024 inch D.A.
120 - 2000	18 g (0 - peak)

Random

Frequency	Level
10 - 120	+3 db/octave
120 - 1000	.13 g's/cps
1000 - 2000	-6 db/octave

Vibration tests were successful and the specimen exhibited no physical damage during or after the vibration tests.

Douglas Test Report TM-DSV4B-MS-R3850B was conducted on a Cryolab one inch I.D. seal-off/relief valve combination.

The test was intended to show that the valve could perform 1500 cycles full open and closed with a leak check performed after completion of test. The Cryolab valve seized at 1375 cycles due to light coating of brass deposited on the valve stem handle. Valve functioned perfectly after this coating was removed.

The research that was made into test data for spring-actuated seal-off/relief valves has aided in establishing the vibration criteria for the new hardware. Test reports indicate that no problems should be expected in the operating temperature range of $-65^{\circ}F$ to $+200^{\circ}F$ during vibration testing.

The research has shown that hardware of the type being proposed by AMETEK/Straza to meet NASA objectives has been life cycle tested to the same requirements proposed by Straza, which indicates that 1500 open-close cycles is realistic.

2.1.1.6 Summary and Conclusions

The Hardware Evaluation phase has established the following conclusions:

A. The failure data that was available was limited but indicated a primary failure mode resulting from contamination. This failure mode can be reduced by a more comprehensive maintenance procedure, elimination of the externally introduced valve operator, and the addition of an inlet screen.

B. External damage inflicted during line and launch tower maintenance operations can be significantly reduced by lowering the profile of the valve and positioning the valve in relation to the line installation so that pumpdown operations are not difficult to perform.

C. A comprehensive design evaluation test program is required that will ensure the components' compatibility with environments and operational conditions.

D. The existing seal-off valves installed on the propellant lines are operating within system requirements.

2.1.2 Product Review

2.1.2.1 State-of-the-Art Investigation and Vendor Coordination

The Product Review for Seal-Off Valves was conducted concurrently with the Hardware Evaluation Phase of the program. This review was made in order to gather vendor information for all valves related to vacuum seal-off service and to establish the present state-of-the-art for this hardware.

The Phase I design objectives established from the correlation of all the data gathered were related to all vendors contacted.

The vendor product review has produced a good representation of the vacuum component manufacturers valves that are available on the market. The objective of this product search was to ultimately determine: (1) The present state-of-the-art for vacuum valves, (2) off-the-shelf hardware availability to meet study objectives, and (3) the vendors' interest in cooperating by implementing design modifications to their hardware to meet design objectives.

The VSMF was used to establish a preliminary list of vacuum valve manufacturers. This preliminary list was expanded through research of current Cryogenic and Vacuum Technology publications. The philosophy of the vendor search was to solicit information from all sources in the field of vacuum technology who might express an interest in the program and a desire to contribute test, design and reliability information.

Vendors

The vacuum valve manufacturers and suppliers were contacted and solicited for brochures, design and hardware information relative to their particular hardware. Several of these that were contacted expressed not only an interest in the NASA study relative to new development, but possessed a basic knowledge of vacuum problems and a sophistication in their design approach to hardware modifications. These vendors included:

A. Aero Temescal, Berkeley, California
B. Cryenco, Denver, Colorado
C. Cryolab Company, Los Osos, California
D. C.V.I., Columbus, Ohio
E. Granville Phillips, Boulder, Colorado
F. Ion Technology Incorporated
G. Sunbeam Vacuum Corporation, North Bellerica, Massachusetts
H. Vacuum Research Corporation, San Ramon, California
I. Thermionics Laboratories Incorporated, Hayward, California
J. Varian Associates, Palo Alto, California
K. Veeco Instruments Incorporated, Plainview, New York
L. Whittaker Corporation, North Hollywood, California

The catalogs and data received from these vendors was extensively reviewed and compared.

Continued coordination with these vendors, visits to their plants, a continued interest on their part to develop a new design or incorporate modifications or improvements in their existing hardware resulted in the selection of the following six (6) manufacturers as those whose designs could meet program objectives as described in Section 2.1.3 of this report.

A. Cryolab Company, Los Osos, California
B. Consolidated Precision Corporation, Lake Park, Florida
C. Thermionics Laboratories Incorporated, Hayward, California
D. Vacuum Research Corporation, San Ramon, California
E. Varian Associates, Palo Alto, California
F. Whittaker Corporation, North Hollywood, California

Vendor Evaluation

The selected vendor's capability in fabricating quality hardware was established. Since the hardware design paralleled the reliability effort, it was important that an evaluation survey in conjunction with Quality Assurance and Reliability be conducted of those vendors' facilities.

This Quality survey consisted of: (1) determining the quality of the vendor's product and whether this type of hardware (vacuum valves) had been previously manufactured by the vendor; (2) a survey of the marketing and engineering function to establish whether the vendor was oriented toward commercial rather than government contracts. A review of the engineering staff indicated the design capability to handle problems peculiar to vacuum engineering; (3) the Manufacturing, Testing and Quality Control organizations established the vendor's capability for the manufacture of cryogenics, welding controls and equipment, radiographic inspection, and whether clean room facilities exist; (4) testing equipment available, type of fluids used and calibration of support hardware indicated that the vendor had the prior experience in meeting the stringent acceptance testing requirements of aerospace equipment which includes conformance to a governmental standard Quality Control system.

2.1.2.2 Hardware Investigation

Most of the standard commercial valves which incorporated valve stem packings and diaphragms were not applicable for the study because they did not provide the basic design objectives which included: freedom from leakage, maximum conductance and minimum outgassing.

Commercial valves usage of packing around the valve stem produces leakage when the stem moves during valve open and valve close cycles and the materials outgas heavily.

Valves utilizing the diaphragm have a better design than the O-ring seal type valve relative to valve stem leakage. However, the high outgassing rate of the diaphragm prohibits its use for high vacuum application.

Most of the vacuum valves received for evaluation incorporated either a bellows, an "O" Ring type gasket, or a combination of both.

Of the standard off-the-shelf valves evaluated, the bellows stem seal provided the only positive seal since it does not depend on the sealing action of a plastic material. It has been determined that "O" Rings have low leak rates provided that only rotational motion of the stem occurs. Translation of the stem, either in or out, produces excessive leakage. For this reason, a non-rising stem has been specified for the study hardware.

The bonnet seal that is recommended for valve design is an "O" Ring and presents little problem provided an elastomer is used that possesses good compression set characteristics. Harder materials such as teflon, Kel-F, and polyimides require large forces for adequate compression. Mating surfaces in the standard valve need to be machined smooth ($\overset{16}{\surd}$), and free of scratches, and defects and foreign materials to be kept to a minimum.

2.1.2.2.1 Angle Valves

Most of the response received from the product search were for the standard angle vacuum valve manufactured by many of the leaders in the field of vacuum components. Three vendors were selected to incorporate modifications to the hardware that would meet study objectives. These three vendors include Whittaker Corporation, Varian Associates, and Thermionics Laboratories, Incorporated.

These valves all exhibit basically the same characteristics. Their compact size and interchangeable operating assemblies make these valves especially useful as a vacuum seal-off valve. These valves are manufactured in both in-line and right angle bodies, in sizes ranging from 3/8-inch O.D. to 1 5/8-inch O.D. These valves are guaranteed leak tight and will seal against high vacuum on either port with atmospheric pressure on the opposite port. Each vendor mass spectrometer leak tests their valves and certifies a maximum leakage allowable of 1 x 10^{-7} scc/sec He. The long life bellows stem seals are fabricated from bronze and stainless steel with valve discs machined from solid bar stock with replaceable "O" Ring gasket in a retaining groove. In summary, all manufacturers of the standard angle valves feature: Easily removed bellows, body completely free of porosity, large flow cross-section and interchangeable trim assemblies.

2.1.2.2.2 Seal-Off Valve (Removable Operator)

A standard vacuum seal-off valve is presently being supplied in the industry for use as an evacuation and seal-off for vacuum insulated cryogenic liquid transfer and storage vessels.

These seal-off valves are available in a variety of types and sizes ranging from one-half inch diameter to two inches diameter. The vacuum seal is effected by an elastomer seal of various compounds, depending on the environmental and operating requirements, with the most common elastomers used being Viton-A and Buna-N. Body materials are all in the 300 series austenitic stainless steels.

These valves are all certified to a leakage allowable of 1×10^{-10} std/cc/sec of helium within an operating temperature range of from $-65^{\circ}F$ to $+200^{\circ}F$.

The standard seal-off valve possesses a low profile in the installed position. This is due primarily to the fact that an independent and externally introduced operator is used for opening and closing the valve during vacuum pumpdown operations. A protective cap which can be easily removed and replaced keeps foreign material from entering the valve during operational service.

These valves are also supplied as a seal-off/relief valve combination. The spring-loaded relief action provides venting capability in the event of an over-pressurization of the vacuum space.

2.1.2.2.3 Metal Seal Valve

Several standard all-metal valve designs are being used in the industry today. These valves are generally of an all stainless steel construction. The seal material is of a soft alloy, usually copper. The advantages of the all metal valve are that they can withstand bake-out temperatures up to $450^{\circ}C$ and will function at temperatures as low as $-195^{\circ}C$. The high reliability of the all metal valve is achieved by a sealing technique that overcomes nicks, scratches and contaminants on the sealing surface by forcing the soft seal material in and around irregularities. Generally, the closure of a metal-sealed valve requires the use of controlled closing torque applied with a torque wrench. Most metal valves require approximately 150 in/lbs for closure. The metal valves utilizes mating flanges for the installation which incorporates a reliable metal gasket seal design which captures the gasket material, thereby preventing movement away from the seal area when changes in temperature occur.

2.1.2.2.4 Valve Seals

The standard vacuum valves utilize a multitude of artificial rubber (elastomers) for "O" ring sealing. Preference is given to Vitons, and the Bunas which contain less volatiles than natural rubber. Teflon is not recommended due to its cold flow properties. Viton is recommended over the Bunas because of its superior shelf life and low permeability.

The elastomers encompass a wide spectrum of physical and chemical characteristics and their usage varies with the requirements. The advantage of elastomers is that they require low compressive forces to effect the seal.

Metal seals are superior from the standpoint of outgassing, but are not used in the standard valve due to the extreme difficulty in obtaining leak-free joints. Special valves such as the Varian Associates and Whittaker Corporation designs use metal seals but they are not recommended for the NASA Vacuum Jacketed hardware.

The metal seal permits the attainment of the lowest pressures because of the high temperature bake-out capability and low outgassing rate, but the reseal life is very low.

Polyimide seals are also used in vacuum valves. Because of the relative rigidity of the polyimide material, a firm hand closure is required to attain a vacuum-tight seal. After bake-out to 300^{o}C, the required closure torque can be expected to increase (in the case of the Varian valve, approximately 3 to 4 ft/lbs which can still be applied by hand). Experience indicates that extra force beyond 4 ft/lbs will not usually result in a better seal. (See Bibliography, "The Application of Polyimide to Ultrahigh Vacuum Seals.")

2.1.2.3 Vendor Evaluation Valve Designs

2.1.2.3.1 Whittaker Corporation

The Whittaker Corporation submitted two (2) designs which incorporated improvements from their standard vacuum valve, (Figure 4). One valve has a Viton "O" ring seal which is good in the temperature range 65^{o}F to +200^{o}F. This valve requires very little hand torque (approximately 50 in/lbs) to operate, and is of a non-rising valve stem design. The valve is entirely constructed of 300 series stainless steel with the exception of the Viton gate seal and the aluminum foil bonnet seal. The handle is aluminum with a bellows stem seal.

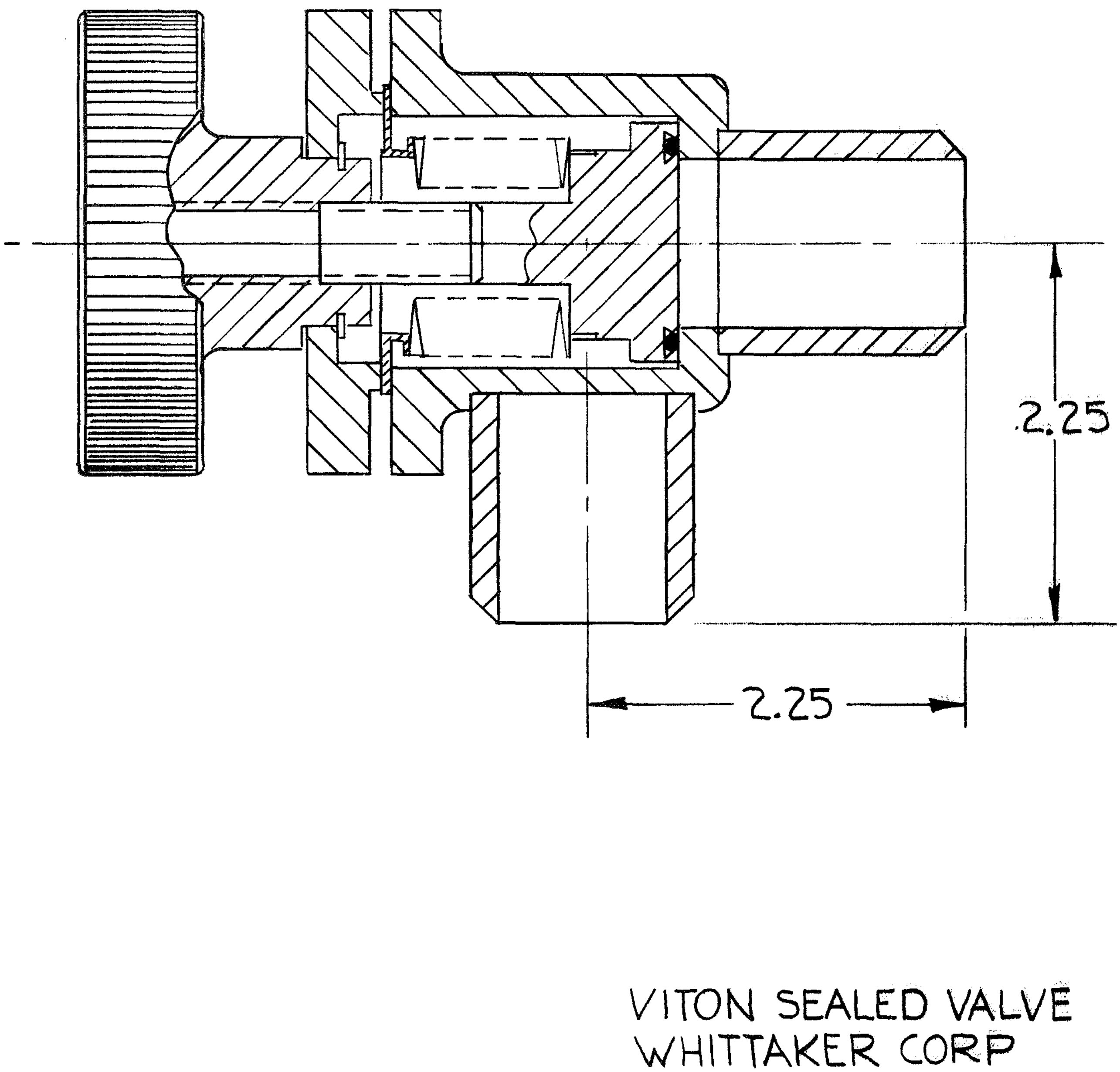


Figure 4. Whittaker Viton Sealed Valve

Figure 5 shows an all metal sealing valve which has a temperature range of from 2°K to 800°F. It features a copper sealing disc and requires substantial hand torque to seal (approximately 150 in/lbs). A torque wrench is recommended. The bonnet seal bolt torque requires approximately 50 in/lbs. It is also fabricated of 300 series stainless steel with the exception of the copper gate seal and the aluminum foil bonnet seal. The handle is aluminum.

The flange seal for both of these valves incorporates a unique and reliable metal gasket seal design. These seals permit prolonged temperature excursions from liquid nitrogen temperature to 450°C. Mating flanges are identical with seal surfaces machined at slight spherical angles. As the valve bonnet bolts are tightened, the flanges rotate until opposing seal faces are nearly parallel. The gasket material is loaded at 2000 to 3000 pounds per linear inch of gasket and strain energy is stored in the rotated flanges. This stored energy design has the added advantage of using standard steel bolts rather than special high strength stainless steel bolts. While 0.0015-inch thick stainless steel foil is the standard sealing material, household 0.008-inch aluminum foil has been used for special applications.

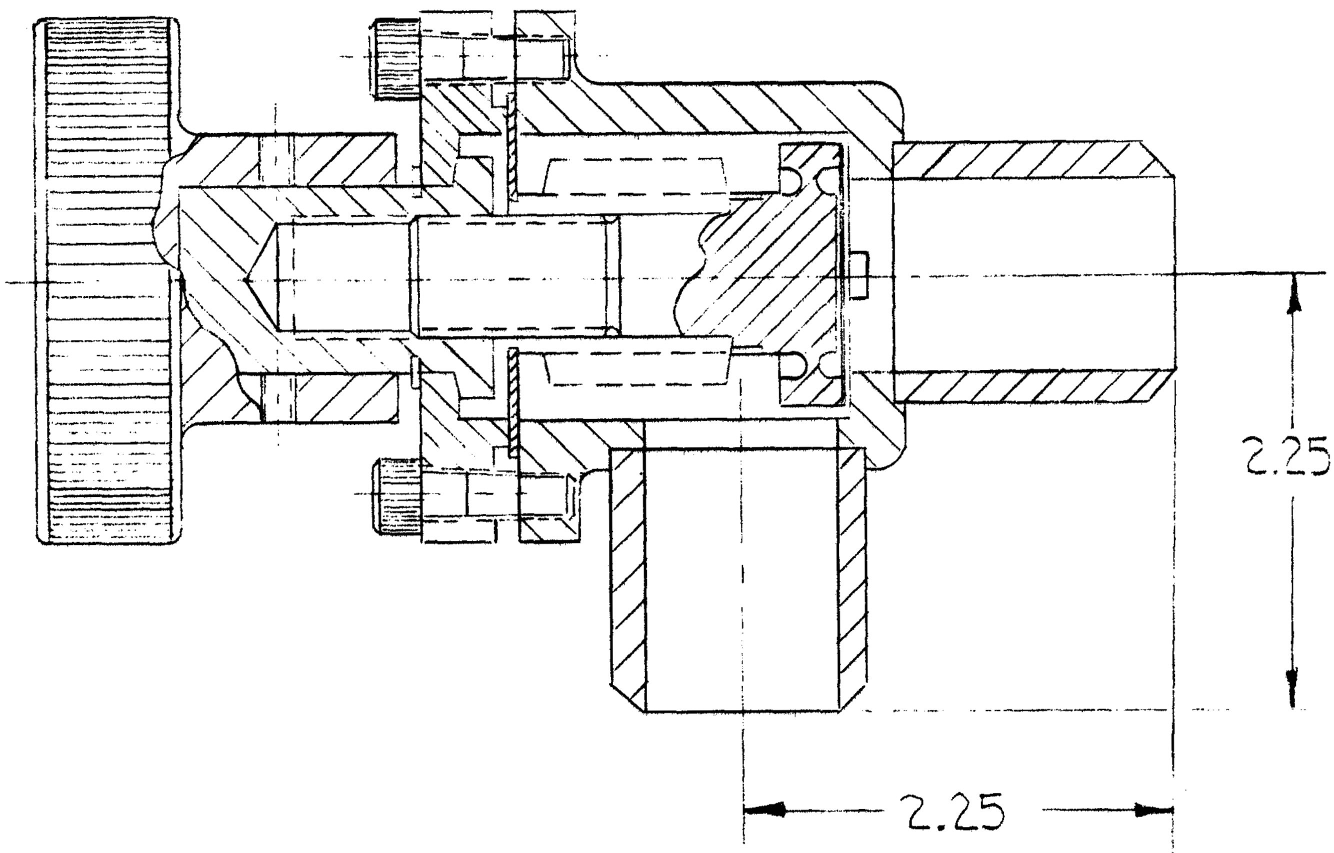
2.1.2.3.2 Varian Associates

The Varian Vacuum Valve is all stainless steel construction (see Figure 6). The seal material is a special copper alloy. Temperature can range from 450°C down to -195°C. In routine usage, these valves can achieve low leakage allowable of 1×10^{-10} scc/sec He. High reliability for stringent vacuum requirements is achieved with a sealing technique that overcomes nicks, scratches and contaminants on the sealing surface by forcing the soft metal in and around irregularities. The valve opening and closure is affected by a removable crank with a controlled closing torque applied with a torque wrench.

Elastomer Seal Valves

The Varian Associates elastomer seal valve is designed for interchangeability of Viton and Polyimide (plastic) seal (see Figure 6). This valve is also all stainless steel construction.

The valve design achieves sealing by developing uniform high sealing pressures. Standard valves of this type seal without lubricant, an extra safety factor to overcome contamination, can be achieved with measured high torque. A welded bellows seals off the actuator with the bellows and bonnet easily removable for service.



ALL METAL RIGHT ANGLE VALVE
WHITTAKER CORP

Figure 5. Whittaker All Metal Valve

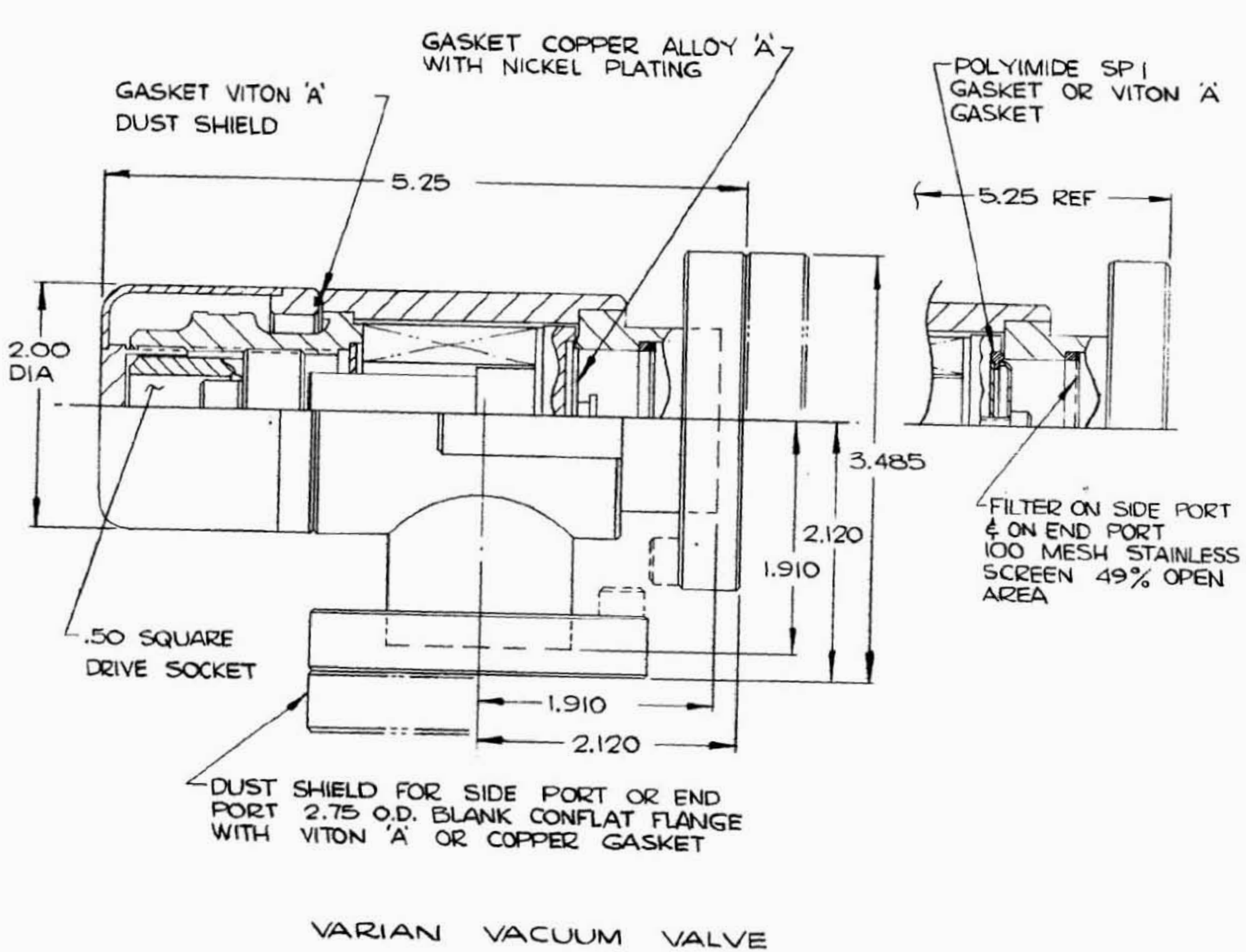


Figure 6. Varian Vacuum Valve

2.1.2.3.3 Vacuum Research Corporation

Vacuum Research Corporation submitted a ball valve design for seal-off valve application. Vacuum Research Corporation conducted a research program to ensure the Viton seat for the ball portion of the valve could meet the leakage requirements. The sealing principle for the ball valve is a seat compressed between the ball and the adapter ends during assembly.

After the valve is assembled, flexing resiliency of the seat material is not required to provide leaktight closure. This design greatly extends valve life and ensures tight shut-off under normal operation conditions.

2.1.2.3.4 C.V.I. Corporation

The C.V.I. Corporation produces a vacuum seal-off valve. The valve is available in three sizes: one-half inch, one inch and two inches. These seal-off valves function as pump-out and isolation valves as well as safety relief devices. C.V.I. does not design and manufacture a seal-off valve without the relief valve capability. The seal-off valves is opened and closed with the use of an independent operator. Valve profile is extremely low and compact due to the fact that the valve requires this externally introduced operator for opening and closing the valve.

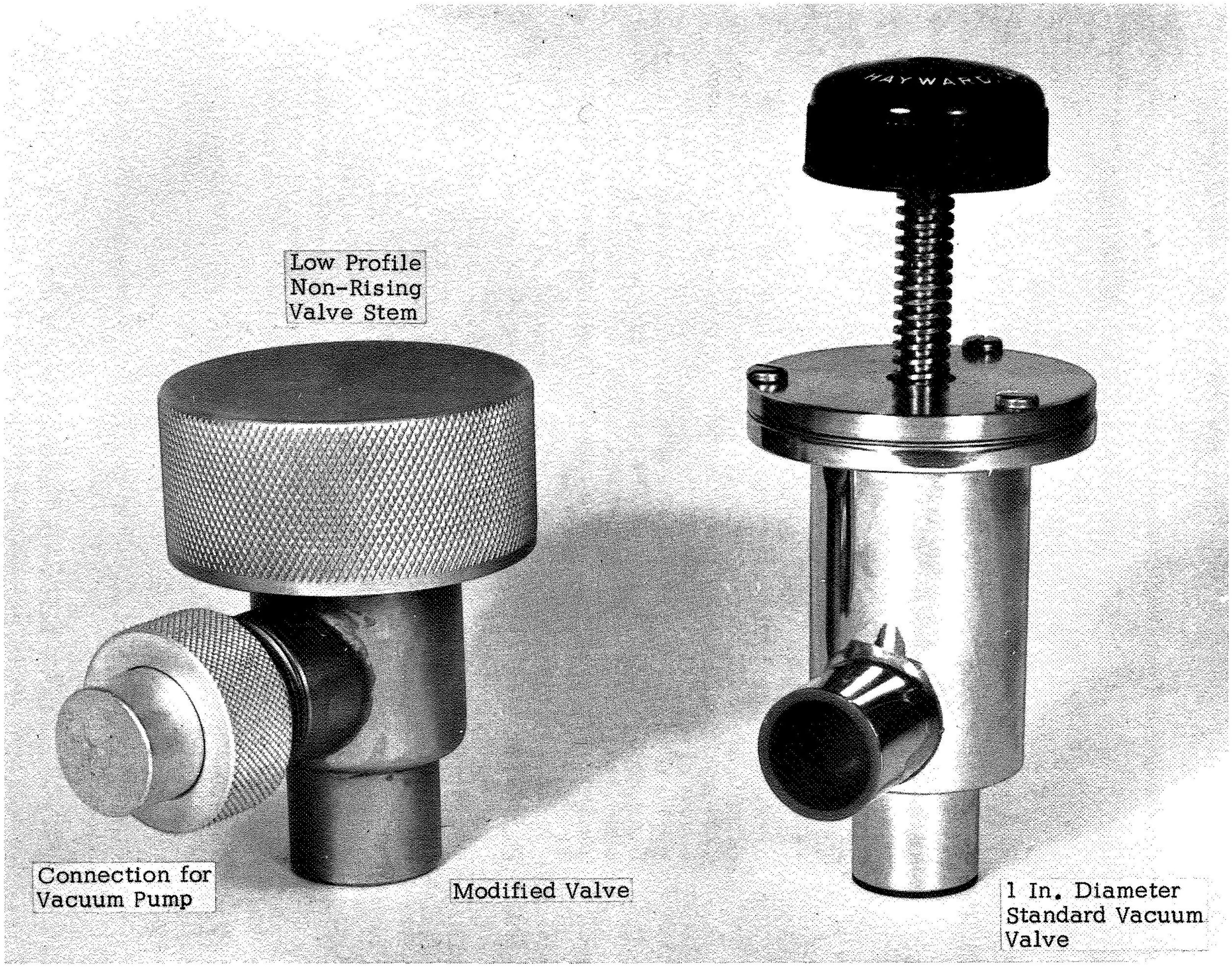
2.1.2.3.5 Thermionics Laboratories, Incorporated

The Thermionics Laboratories submitted two designs for the NASA study. One was a modification to their standard angle valve, and the second was an entirely new seal-off valve design with external operator. The modification to the standard vacuum angle valve had lowered the profile considerably by the addition of a "welded" bellows, eliminating the hydraulically formed bellows stem seal. Included in the Thermionics effort was a simplified seal-off valve and operator which offered several design advantages: (1) the operator was simple to operate as it engaged two holes in the seal poppet (see Figures 7 and 8); and (2) the valve profile is relatively low and rugged.

2.1.2.3.6 Ion Technology, Incorporated

This valve manufacturer produces both an elastomer and a metal seal angle valve.

The mechanism of their valve is completely isolated from vacuum by a welded bellows. The bellows have a high extension ratio and life is extended to over 100,000 cycles by making



THERMIONICS LABORATORIES, INC. MODIFICATION
TO STANDARD VACUUM VALVE

Figure 7. Thermionics Laboratories Modification to Vacuum Valve

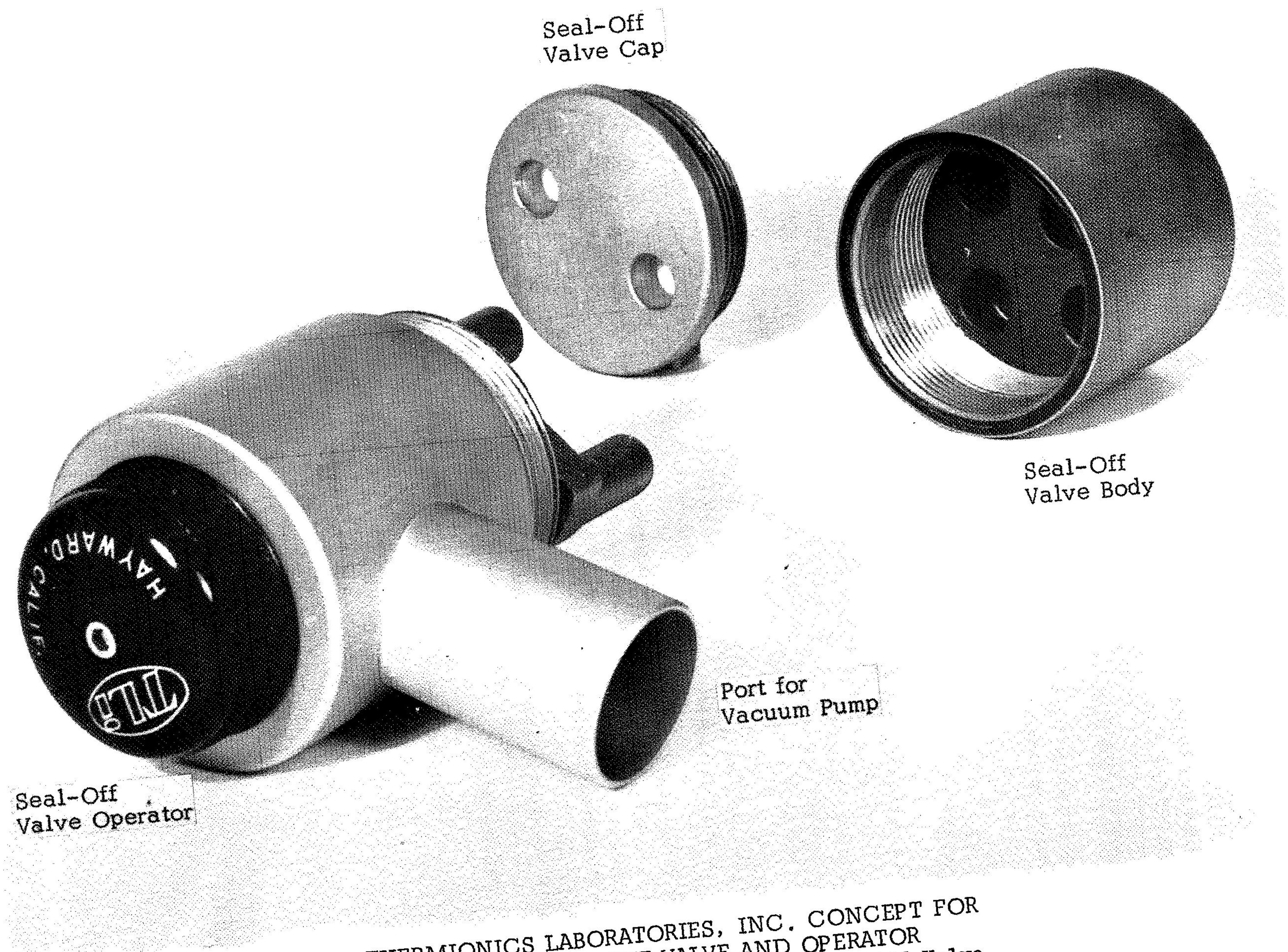


Figure 8. Thermionics Laboratories Seal-Off Valve

the disc travel considerably less than the design rating of the bellows. By using a "welded" bellows, the valve profile is kept low.

2.1.2.3.7 Cryolab Company

The Cryolab Company has been supplying valves for cryogenic vacuum jacketed transfer lines prior to this study and have excellent knowledge of the design objectives. The present hardware installed on Service Arm Lines are Cryolab seal-off valves. The Cryolab hardware submitted for evaluation includes:

A. A "dual seal" vacuum seal-off valve that enables the installation of the thermocouple gauge tube. This valve provides capability for isolating the thermocouple from the system except for periods of time during checkout of the vacuum level in the lines. (See Figures 9 and 10) The use of the Cryolab operator provides high conductance due to the complete removal of the valve plug and disc assembly.from the evacuation flow line.

B. A seal-off/relief valve combination that serves as a seal-off valve for pumpdown operations, and in the event of an over-pressurization of the vacuum annular space, will operate as a relief valve. (See Figures 11, 12 and 13)

C. A vacuum valve design was submitted for evaluation by Cryolab which incorporates many of the study objectives including:

(1) Elimination of the standard valve operator and the addition of the integrated operator with the valve, eliminating the need for technician-oriented procedures and unnecessary potential for contamination during vacuum pumpdown procedures. Elimination of the valve operator has been a prime target for the design improvements of the seal-off valve. (See Figures 1, 2 and 3)

(2) Incorporation of a non-rising valve stem for maintenance of low profile during all stages of operation. The non-rising stem incorporates a Viton-A "Wilson" seal to eliminate valve stem leakage. The valve handle is recessed and is provided with a locking screw for protection from the valve's inadvertent operation.

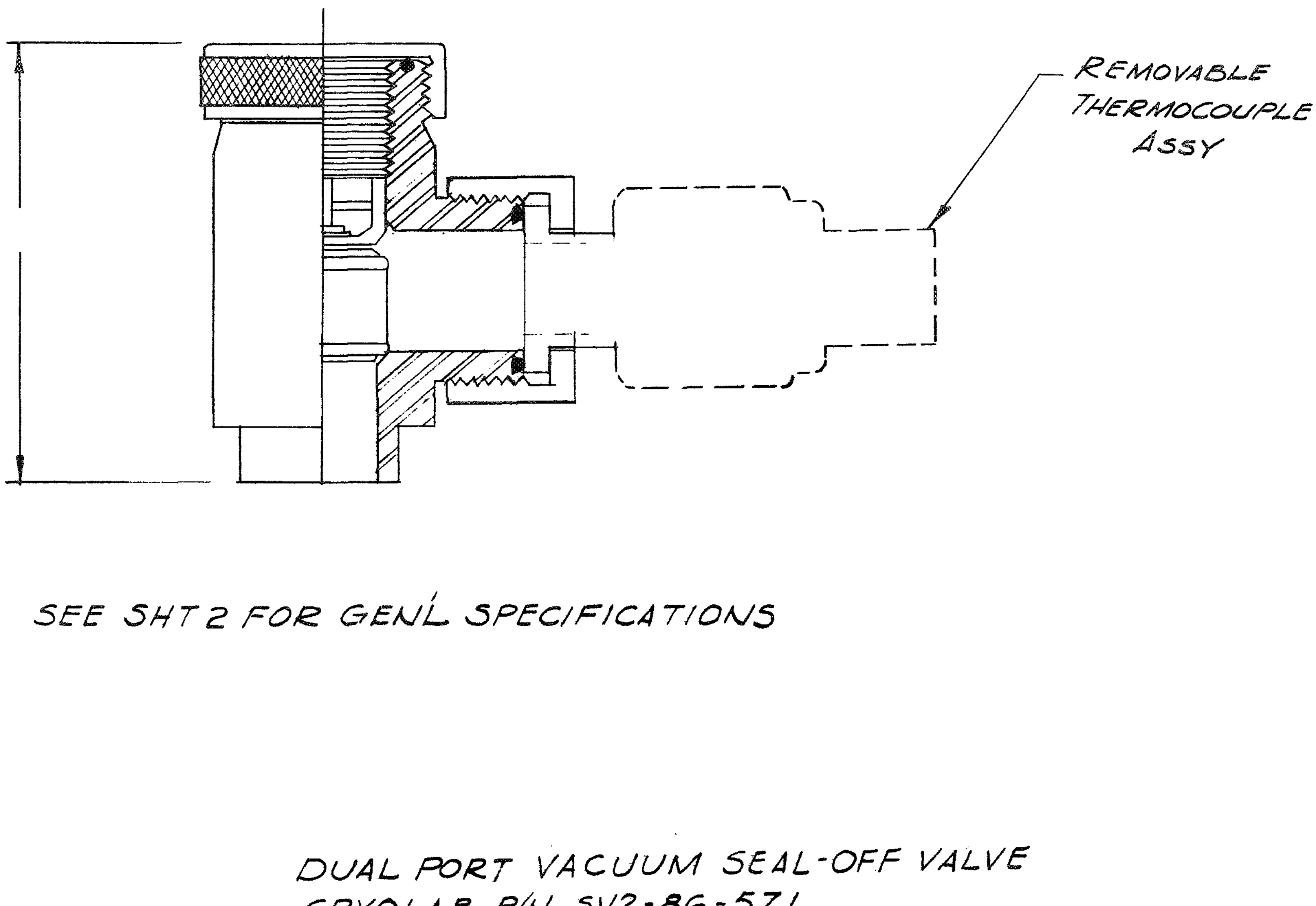


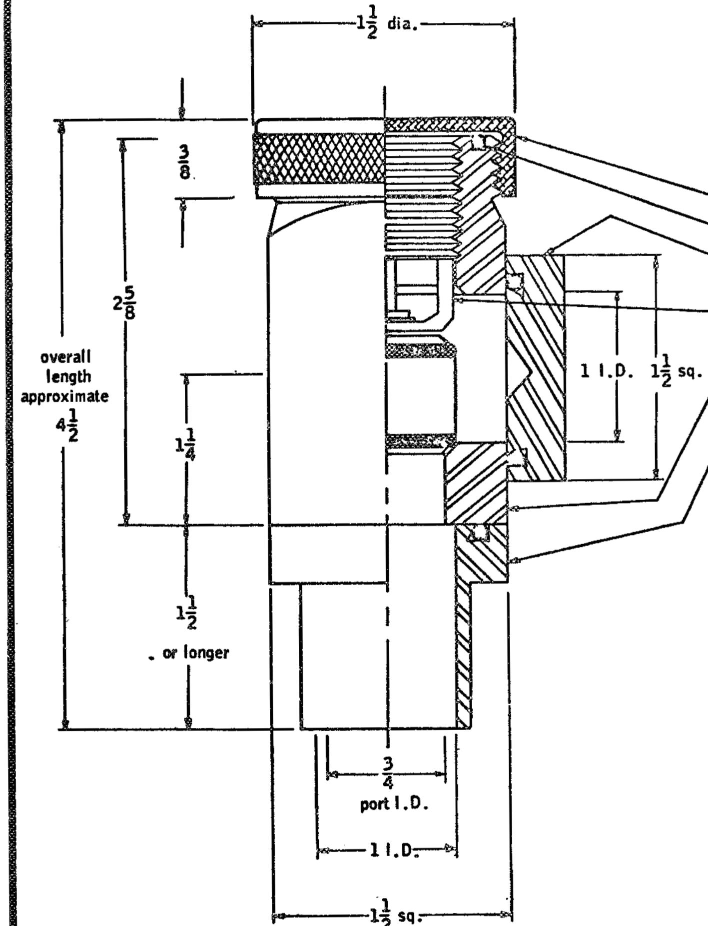
Figure 9. Cryolab Dual-Port Vacuum Seal-Off Valve Installation

GENERAL INFORMATION:

Item: valve, seal-off, dual port

Series: SV® series

P/N: SV2-86-5Z1



APPLICATION:

The CRYOLAB dual port seal-off valve is a seal-off valve having two ports plus the pump out connection. The valve with operator is the equivalent of a two valve manifold.

The dual port seal-off valve is for use where two valves are required, but are only periodially used. Typical applications include seal-off of and guage connection to space chambers (and other chambers where guage replacement should not require shut-down), and vacuum line shut-down.

COMPONENTS:

- Cap, p/n 1V1-86-5N2, 300 series cres.
- Body o-ring, p/n 2V1-86-8A120, Viton-A
- Flange assembly, p/n OF8-88-5N1, 304 cres. flange. Viton-A o-ring
- Plug & disk assembly, p/n 47V2-86-5N1, 304 cres.
- Body, p/n 3V2-86-5Z1, 304 cres.
- Flange assembly, p/n OF8-88-5L1, 304 cres. flange Viton-A o-ring

Note: and OF8-88 model flange may be attached to the side port and/or to the system port.

SPECIFICATIONS:

Service: High vacuum (compatible with 10^{-8} torr) and low pressure

Size: Three-quarter inch nominal port I.D., one inch I.D. flange connections

Leakage: Less than 10^{-12} std cc/sec. GHe, assured by MSLD test

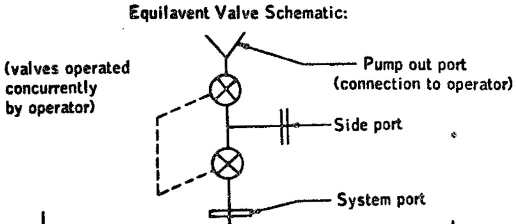
Materials: 300 series cres & viton-A as noted

Environment: Temperature: $-65^{\circ}F$ to $+200^{\circ}F$
Operating pressure: 0 psia to 150 psig
Burst pressure: over 250 psig

Service life: Over 2500 cycles

Operation: Attach CRYOLAB V01-86 operator or V02-86 operator to operate valve. Turn operator handle CW to open system port to side port, and to seal-off pump-out port; turn operator handle CCW to open pump-out port to side port, and to seal-off system port.

Equilavent Valve Schematic:



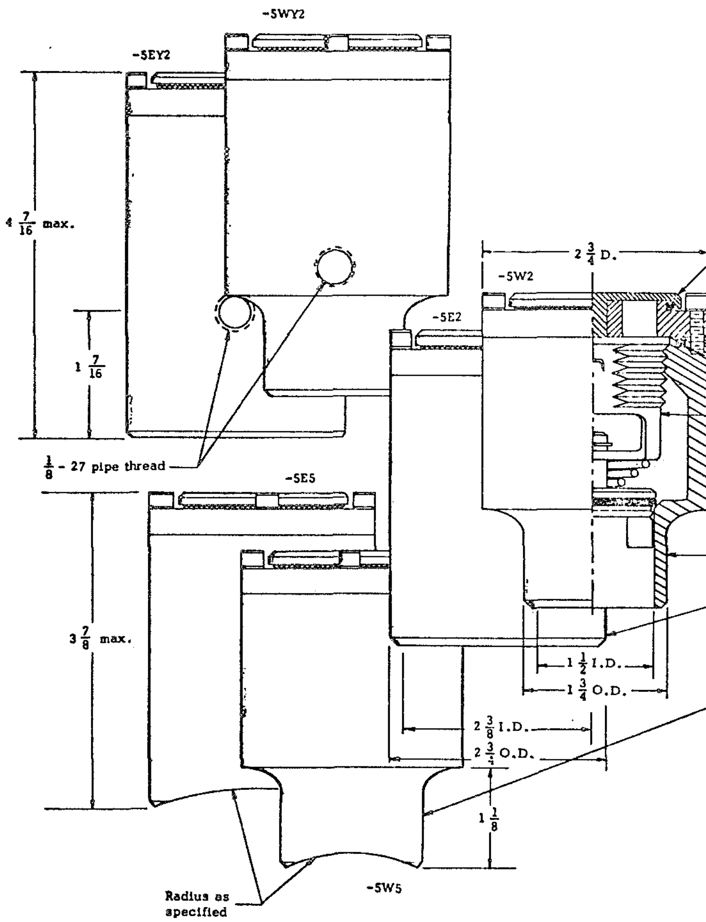
Chg.	Revision	Date	By

CRYOLAB - DIVISION OF STATICS-DYNAMICS INC.

Figure 10. Cryolab Dual-Port Vacuum Seal-Off Valve

GENERAL INFORMATION:

Item: Valve, seal-off, high vacuum positive relief
Series: CRYOLAB SV® series
P/N: SV3-812-plus applicable dash no.



APPLICATION:

The CRYOLAB SV® series high vacuum positive relief seal-off valve is for use as a connection to volumes requiring evacuation or other processing, and subsequent seal-off. The relief action is a safety feature to provide an exhaust for over-pressurization.

The SV® series positive relief seal-off valve is designed for application in the evacuation of cryogenic insulating volumes. It is also an ideal relief valve for low pressure volumes and, in non-critical processes, may be used as a regulator.

COMPONENTS:

Relief cap assembly, p/n 1V3-812-SN3
  Consisting of:
  Cap cover, p/n 11V3-812-SN3, Cres
  O-ring, p/n 2V1-812-8A130, Viton A
  Cap body, p/n 13V3-812-SN4, Cres
  Retainer, p/n SV3-88-SN4, Cres
  Spring, p/n 8V3-88-SN1, Cres
Bolt, p/n 8F4-40-SN5, Cres steel (4 required)
Body O-ring, p/n 2V1-812-8A225, Viton A
Plug and disk assembly, p/n 47V3-812-SN4
  Consisting of:
  Plug, p/n 4V3-812-SN2, 304 Cres with 2306 electrofilm
  Retainer, p/n SV3-816-SN1, Cres
  Relief spring, p/n 8V3-812-SN3, Cres
  Disk, p/n 7V3-812-SN1 or p/n 7V31812-SN2, 304 Cres
Body, p/n 3V3-812-SW2, 304 (or 304 L) Cres
Body, p/n 3V3-812-SE2, 304 (or 304 L) Cres
Body, p/n 3V3-812-SWY2, 304 (or 304 L) Cres
Body, p/n 3V3-812-SEY2, 304 (or 304 L) Cres
Body, p/n 3V3-812-SW5, 304 (or 304 L) Cres
Body, p/n 3V3-812-SE5, 304 (or 304 L) Cres

*ALTERNATE DASH NOS.	CONNECTION
-SW2	Weld
-SE2	Extra large weld
-SWY2	Weld with side port
-SEY2	Extra large weld with side port
-SE5	Extra large radius-weld
-SW5	Radius-weld

SPECIFICATIONS:

Size: nominal $1\frac{1}{2}$" port I.D.
Weight: approx. $3\frac{1}{2}$ pounds
Service: high vacuum (compatible with 10^{-9} torr) and low pressure
Leakage: less than 10^{-10} std cc/sec.
Materials: predominately 304 (or 304 L) stainless steel
Environment:
  Temperature: -65° F thru $+200^\circ$ F
  Operating pressure: 0 psia thru 65 psig
  Proof pressure: 150 psig
Service life: over 2500 cycles
Operation: use CRYOLAB Series "V0" operators; size "812" to evacuate, process, and/or vent. For relief action only, valve will operate without external connections.

Chg.	Revision	Date	By

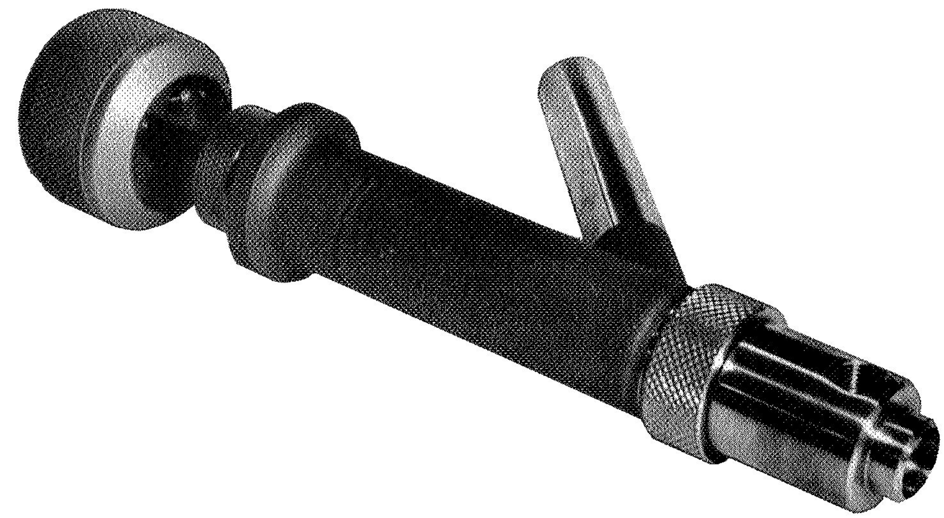
CRYOLAB
DIVISION OF STATICS-DYNAMICS, INC.
1155 SUNSET DRIVE, LOS OSOS, CALIFORNIA 93401
TELEPHONE (805) 528-1598

HIGH VACUUM POSITIVE RELIEF
Seal-Off Valve
SV® Series, p/n SV3-812-*

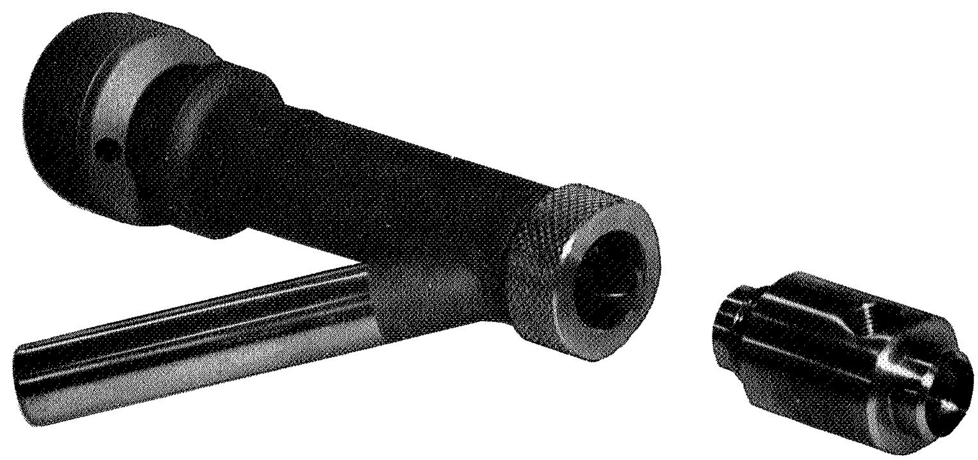
16 July 1965

Figure 11
DWG NO. SV3-812

Figure 11. Cryolab Standard Seal-Off/Relief Valve



Operator
6 In. in Length

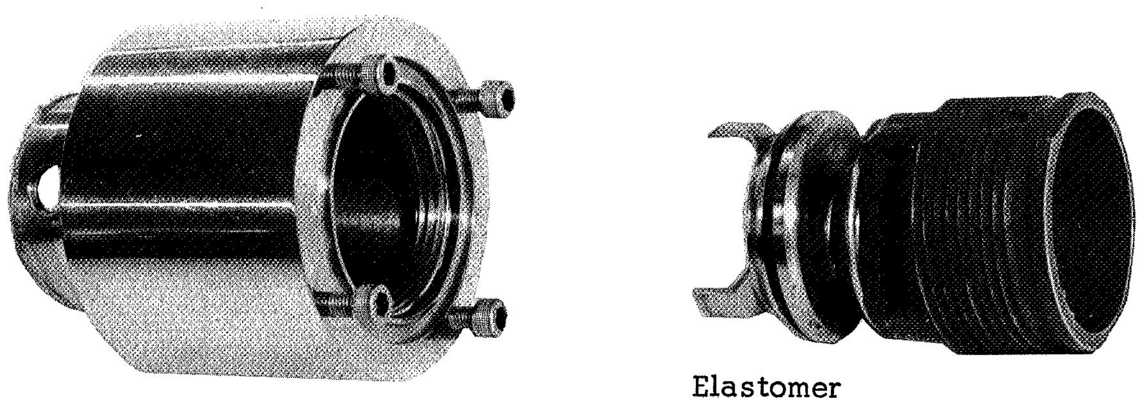


Vacuum Pump — Down
Connection (3-1/2 In.
in Length)

1/2 In. Dia. Valve
2 In. in Length

Cryolab Seal-Off Valve
(And Independent Operator)

Figure 12. Cryolab Vacuum Seal-Off Valve Operator



Cryolab Company

Seal-Off/Relief Valve Combination

Figure 13. Cryolab Vacuum Seal-Off/Relief Valve

2.1.2.4 Comparative Analysis - Seal-Off Valves

The following tabulation of the salient features of the vendor products represents the industry standard for usage of materials and their design application for vacuum seal-off valves used in a vacuum annulus. All of the basic components of each design have been evaluated and compared. As a result of this and other evaluations including reliability, analysis and design, has evolved the hardware that is recommended as meeting Phase I study objectives.

2.1.3 Design Phase

The objective of the Design Phase of the study program was to perform the following tasks:

A. Design, fabricate, test and evaluate improved vacuum seal valves.

B. Provide a seal-off valve with high quality sealing, long life, and maintenance-free service.

C. Evaluate present maintenance procedures for adequacy. Concurrent with this evaluation, perform a study of seal materials, seal configuration and seal port design of the existing seal-off valves.

The design criteria for seal-off valves was formulated to include:

A. Setting the size of the seal-off valve at one (1) inch nominal, I.D., based on vacuum pumpdown requirements.

B. Incorporate the improvements needed in the seal-off and retain the relief valve function at 30 ± 5 psig.

C. Minimum valve operating pressure 50 psig - proof pressure 150 psig.

The seal-off valve program design improvement objectives were established to assure that no area in seal-off valve design would be overlooked that would ultimately affect part reliability. Proposed hardware incorporated these design improvements including:

A. Improve seals or seal seating design.

B. Reduce or eliminate the potential for contamination during installation and/or maintenance operations.

C. Reduce corrosion from salt fog environment.

CHART I

COMPARATIVE ANALYSIS — SEAL-OFF VALVE

Vendor	Type	Diameter (Inches)	Sealing Method				Actuator	Flow	Corrosion Protection		Simplicity in Design			Configuration	Minimum Leakage scc/sec He	Interface Connection	Maintenance	
			Main Seal	Cap Seal	Other	Seal Redundancy			Material Compatibility	Moisture Trap	Design	Operation	Maintenance				Minimum Technician Procedures	Ease Of Maintenance
Aerco-Temescal	Vacuum	1	"O" Ring Viton A	"O" Ring Viton A	Bellows Stem Seal	None	Manual Integral W/Valve	Angle	Yes	None	Average	Average	Complex	Flat Seat	1×10^{-10}	Weld	Yes	Yes
Cryenco	Seal-Off	1-1/8	"O" Ring Buna-N	Aluminum Cover	---	None	Independent Operator	Straight W/Relief	No	None	Simple	Simple	Simple	Side Compression	1×10^{-8}	Weld	No	Yes
Cryolab	Seal-Off	1	"O" Ring Viton A	"O" Ring Viton A	---	Interchangeable Seals	Independent Operator	Straight W/Relief	Yes	None	Average	Simple	Average	Conical Seat	1×10^{-10}	Weld	No	No
C.V.I.	Seal-Off	1	"O" Ring Viton A	"O" Ring Buna N	---	Yes	Independent Operator	Straight W/Relief	No	None	Average	Simple	Average	Flat Seat	1×10^{-9}	Weld	No	No
Ion Technology, Inc.	Vacuum	1	"O" Ring Viton A	"O" Ring Viton A	Bellows Stem Seal	None	Manual Integral W/Valve	Angle	Yes	None	Average	Average	Complex	Flat Seat	1×10^{-10}	Flange	Yes	Yes
Thermionics	Vacuum	1	"O" Ring Viton A	---	Bellows Stem Seal	None	Manual Integral W/Valve	Angle	No	None	Average	Simple	Complex	Flat Seat	1×10^{-10}	Weld	Yes	Yes
Thermionics	Seal-Off	1	"O" Ring Viton A	"O" Ring Viton A	---	---	Independent Operator	Straight	No	None	Simple	Simple	Simple	Flat Seat	1×10^{-10}	Weld	Yes	Yes
Varian Associates	Vacuum	1	Stainless Steel to Copper	"O" Ring Viton A	Bellows Stem Seal	---	Manual Integral W/Valve	Angle	Yes	None	Average	Simple	Average	Flat Seat	1×10^{-10}	Flange	Yes	No
Varian Associates	Vacuum	1	Polyimide Viton A	"O" Ring Viton A	Bellows Stem Seal	Interchangeable Seals	Manual Integral W/Valve	Angle	Yes	None	Average	Simple	Average	Flat Seat	1×10^{-10}	Flange	Yes	No
Vacuum Research Corp.	Seal-Off	1	"O" Ring Viton A	Anodized Aluminum Cover	---	---	Manual Removable Handle	Angle	Yes	None	Simple	Simple	Simple	Flat Seat	1×10^{-10}	Weld	Yes	No
Veeco	Vacuum	1	"O" Ring Viton A	"O" Ring Viton A	Bellows Stem Seal	---	Manual Integral W/Valve	Angle	Yes	Yes Valve Stem	Average	Simple	Average	Flat Seat	1×10^{-10}	Weld	Yes	Yes
Whittaker	Vacuum	1	"O" Ring Viton A	Stainless Steel Gasket	Bellows Stem Seal	---	Manual Integral W/Valve	Angle	Yes	None	Average	Simple	Average	Flat Seat	1×10^{-10}	Weld	Yes	No
Whittaker	Vacuum	1-3/4	Stainless Steel to Copper	Stainless Steel Gasket	Bellows Stem Seal	---	Manual Integral W/Valve	Angle	Yes	None	Average	Simple	Average	Flat Seat	1×10^{-10}	Weld	Yes	No

D. Low profile stainless steel body will reduce impact damage.

E. The unit is of such a design that technicians unfamiliar with vacuum equipment can perform maintenance.

F. The incorporation of an inlet filter will eliminate the potential from internal contamination.

G. Advancement in seal compounds will improve seal leakage.

2.1.3.1 Analysis

The following analysis establishes the requirements for the seal-off valve design.

A. An analysis was performed to determine the minimum valve size which will meet relief and pumpdown flow requirements. A one-inch valve was found to be adequate.

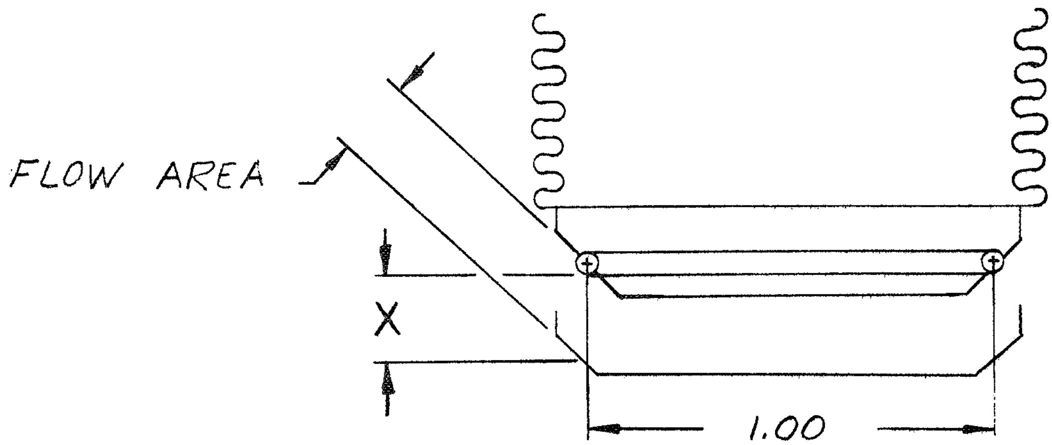
B. An analysis was performed to determine the resistance to flow created by the addition of a protective filter to the inlet port of a one (1) inch diameter seal-off valve.

C. The minimum poppet stroke that would be required in a "welded type" bellows to provide full flow was determined.

The following analysis has been performed to determine the resistance to flow created by the addition of a protective filter to the inlet port of a one-inch diameter vacuum seal valve. In addition, the minimum poppet stroke for full flow is determined. The value of 63.3% flow reduction applies only to a flat plate filter made of mesh. This flow restriction will be nullified if a mesh dish filter is installed one-half inch into the vacuum annulus which will approximately triple the working area.

The one-inch vacuum seal valve was selected as a minimum size commensurate with the gas flow required to vent the vacuum annulus in the event of overpressurization.

1" Tube to 1" Valve



Tube Area $= A_t$

$\overline{1.00}^2 \quad \pi/4 = A_t$

$.7854 \text{ in}^2 = A_t$

$X = \frac{A_t}{A_v}$

$A_v = \pi d$

$= 3.1416 \times 1.00$

$= 3.1416$

$X = \frac{\pi/4}{\pi}$

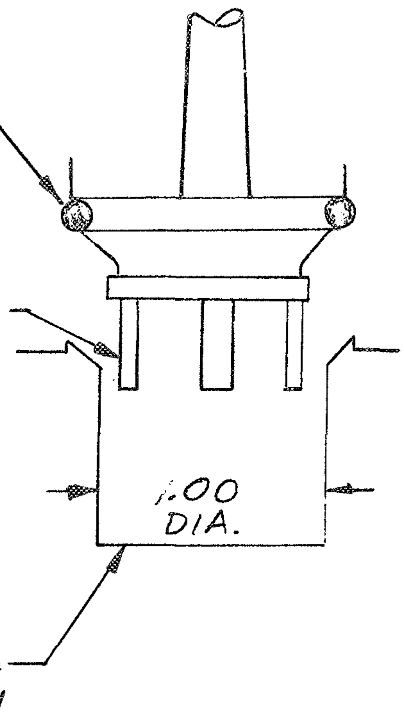
$= .25$ in

Assume Valve $C_v = .80$

$X^1 = X/.80$

$= .25/.80$

$= .312$ inch rise required to get equivalent 1.0 in^2 area



Assume a 200μ filter made of 100 mesh .003" ∅ wire, width opening .007 inches, open area of 49% (Cambridge Wire Cloth Company, Catalog Page No. 41)

Impedance of 1" ∅ x 2" long passage = W_1

$$W_1 = \frac{1}{C}$$

$$= \frac{1}{13.8 \frac{(1.0)^3}{2.0/12}} = \frac{1}{82.8} = .01207 \text{ sec/ft}^3$$

Impedance of filter with $\overline{100}^2$ openings x .007 inches square each = W_2 (Ref: Veeco "High Vacuum Equipment" Catalog)

$$W_2 = \frac{1}{Cap} = \frac{1}{125D^2}$$

$$W_2 = \frac{1}{125\,(.007)^2\ \overline{100}^2\ \pi/4} = \frac{1}{48.1}$$

$$= .02078 \text{ sec/ft}^3$$

$$\Sigma W = .01207 + .02078$$

$$= .03285 \text{ sec/ft}^3$$

$$C_{Total} = \frac{1}{.03285} = 30.4 \text{ ft}^3/\text{sec}$$

$$\% \text{ of flow reduction} = \frac{82.8 - 30.4}{82.8} \quad 100$$

$$= 63.3\%$$

Resizing of vacuum jacket port to compensate for addition of 200 screen filter.

Assume a vacuum jacket port diameter of 1.56"

$$W_1 = \frac{1}{C} = \frac{1}{13.8 \frac{(1.56)^3}{2.0/12}} = \frac{1}{314.3}$$

$$= .00318 \text{ sec/ft}^3$$

$$W_2 = \frac{1}{125\ (.007)^2 \frac{2}{100^2}\ \pi/4\ (1.56)^2}$$

$$= \frac{1}{117.1}$$

$$= .00853 \text{ sec/ft}^3$$

$$\Sigma W = W_1 + W_2 = .00318 + .00853$$

$$= .01171 \text{ sec/ft}^3$$

$$C_{Total} = \frac{1}{\Sigma W} = \frac{1}{.01171} = 85.4 \text{ ft}^3/\text{sec}$$

Seal-off valves are mounted on the vacuum jacket and will be sized in combination with the annulus having the lowest conductance. This will be Line No. 8-030189-1 installed on Launch Tower Service Arm 6.

$$\frac{1}{C} = \frac{1}{C_{Valve}} + \frac{1}{C_{Annulus}}$$

$$C = \frac{(C_{Annulus})\ (C_{Valve})}{C_{Annulus} + C_{Valve}}$$

Conductance in Liters/Sec at .050 Torr.

$$C_{Annulus} = \frac{10^3\ \alpha (D_2 - D_1)^2\ (D_2 + D_1)}{\ell\ 48\ \pi^2\ \sqrt{M}}$$

Ref: Vacuum Technology Notes - UCLA

D_2 = 21.34 CM inside radius of V.J.

D_1 = 15.70 CM outer radius of line

α = 1.29

ℓ = 752 CM - length of line

M = 29.2 GM. Mole - weight of air

$$C_{Annulus} = \frac{1.29 \times 10^3 \; (21.34 - 15.70)^2 \; (21.34 + 15.70)}{48 \times 752 \quad \pi \sqrt{29.2}}$$

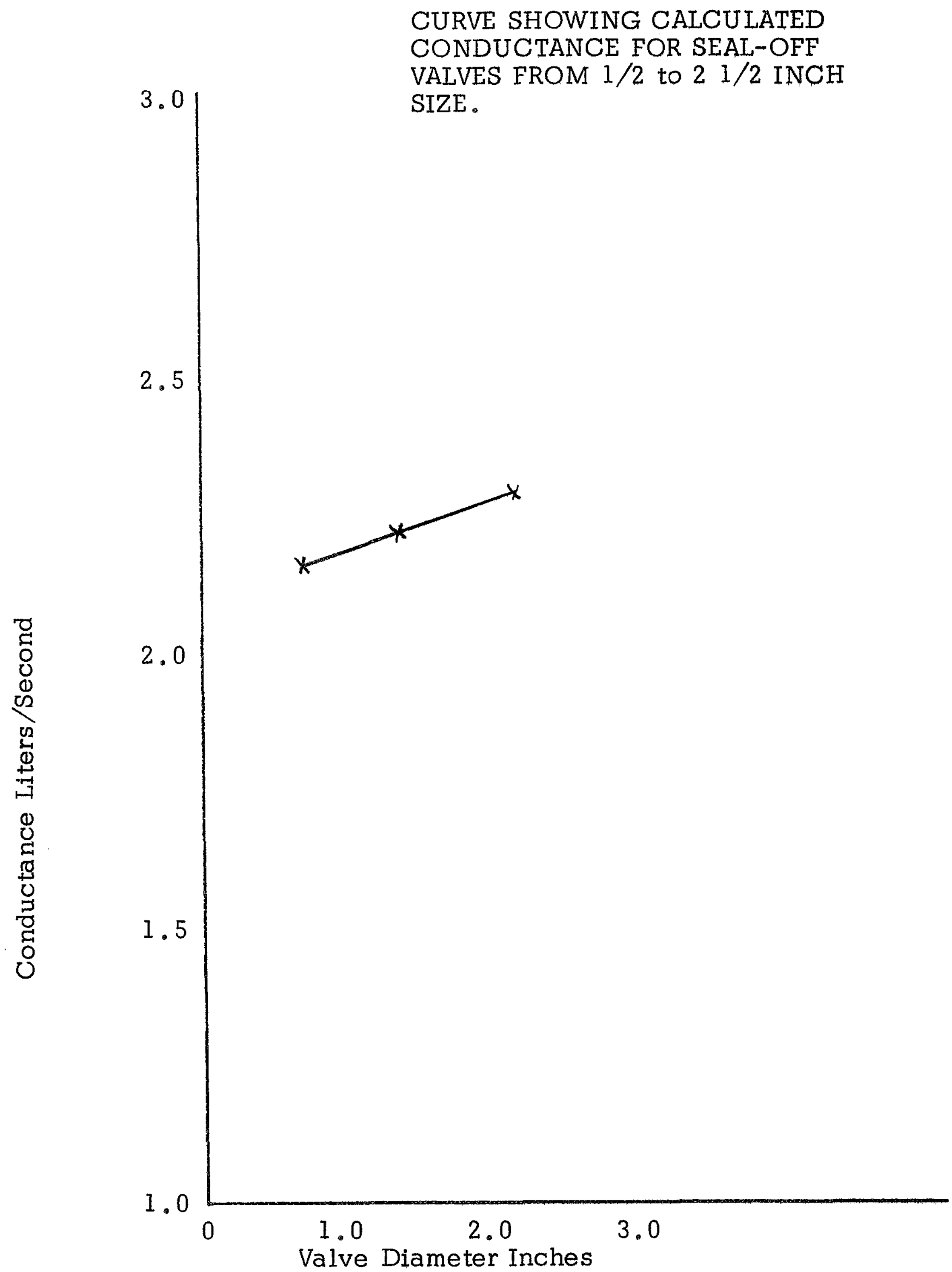
$$= 2.47 \text{ liters/sec}$$

C_{Valve} taken from "Handbook of High Vacuum Engineering" by Steinherz, Page 22.

Conductances are based on .050 Torr.

Valve Size		Conductance Liters/Sec		
Inches	MM	Valve	Annulus	C
1.26	32	63	2.47	2.376
1.97	50	108	2.47	2.415
2.56	67	505	2.47	2.458

Note: The extrapolated curve on the following page indicates a negligible drop in conductance in going from a 1.26 inch diameter to a .50 inch diameter valve. A valve size in excess of .50 inch diameter is not economical.


CURVE SHOWING CALCULATED CONDUCTANCE FOR SEAL-OFF VALVES FROM 1/2 to 2 1/2 INCH SIZE.
3.0
2.5
2.0
1.5
1.0
Conductance Liters/Second
0
1.0
2.0
3.0
Valve Diameter Inches

2.1.3.2 Seal Design

2.1.3.2.1 Static Seals

The review of seal materials has been a continuing effort during the design evaluation phase to establish an improvement in valve sealing quality. It has been established that elastomers are the most desirable static seal in the temperature range established as a design objective of -65°F to +200°F.

Metal seals and the hard plastics were evaluated but are not recommended for use in this range. Polyimide, which is a plastic, has been grouped with the metal seals because of its physical toughness and resistance to abrasion and chemicals. It possesses a shore hardness of D85-95 and a compressive strength of 24,400 psi.

Several new improved compounds are recommended for the seal-off valve and will be tested during the Phase II portion of the program. The following new compounds represent the latest in seal materials that will be tested for conformance to study objectives.

A. Viton Compound, 75 Durometer (Parker V655-75) indicates a significant improvement in compression set resistance over existing fluorocarbon materials.

Original Physical Properties	Conventional Viton	V655-75
Hardness, °Shore A	75	75
Tensile Strength, psi	1800	1900
Elongation, %	200	200
ASTM Fuel B Immersion 70 Hrs @ Room Temp.		
Volume Change, %	+1	+1
Di-Ester Lubricant Immersion 70 Hrs @ 392°F (200°C)		
Volume Change, %	+12	+8
Air Age, 70 Hrs @ 482°F (250°C)		
Hardness Change, °	0	+2
Tensile Change %	-8	-7
Elongation Change %	-12	0

Original Physical Properties	Conventional Viton	V655-75
Compression Set, 70 Hrs @ 392°F (200°C). Expressed as % of Original Deflection		
.139 Cross-section "O" Ring	55	30
.210 Cross-section "O" Ring	37	20

B. Butyl (Parker Compound B612-7) is an excellent material for vacuum sealing at moderate temperatures.

(1)

Original Physical Properties	6 x 6 x .075 B612-7
Hardness Shore A, pts.	67
Tensile Strength, psi, min.	1762
Elongation %, min.	222
Specific Gravity	1.14

(2)

Vacuum Stability, % Weight Loss, Max	6 x 6 x .075 B612-7
(a) After 24 hr. minimum exposure @ room Temperature 10^{-6} torr.	0.04
(b) After 14 days minimum exposure @ room temperature, 10^{-6} torr.	0.09

(3) Compression Set, 72 Hrs. @ 160°F. 30% deflection used

% of original deflection, max 13.7

(4) Heat Stability, % Weight Loss, Maximum 2 Hrs. @ 300°F 0.19

C. Ethylene Propylene (Parker Compound E603-7) has excellent stability and compression set characteristics for the temperature of 65°F to +300°F.

(1)

Original Physical Properties	E603-7 Slabs
Hardness, Shore A, points	73
Tensile Strength, psi	2169
Elongation, %	207
Modulus @ 100% elongation, psi	858
Specific gravity	1.197
Tear, Die B, lbs/in	208
Tear, Die C, lbs/in	135

(2) Compression Set, Method B, 25% Deflection Used, %

Compression Set, Method B, 25% Deflection Used, %	Plied Slabs	2-214 "O" Rings
70 Hrs @ 158°F	9.9	16.2
70 Hrs @ 212°F	11.1	17.6
70 Hrs @ 250°F	18.0	27.1
70 Hrs @ 300°F	24.8	50.1

(3) Low Temperature Tests

Low Temperature Tests	
ASTM D746, Procedure B, -67°F (-55°C), TR10 (2-218 "O" ring)	Passed 59°F

Elastomers offer good resiliency, excellent conforming properties, and low cost and they are reusable. The plastic seals (Teflon, for example) are subject to creep and cold flow under load. Plastic seals should be used only where elastomers are not compatible with the sealed media.

Temperature limits of various basic elastomer compound vary as a function of duration of time exposure to heat: For temperature time exposure over 50 hours, the nitriles are recommended at temperatures of 200°F to 300°F. Neoprenes, fluoroelastomers, and silicones are recommended for temperatures of 340°F, 400°F and 450°F, respectively.

2.1.3.2.2 Vacuum Considerations - Seals

Vacuum affects the seal in two general ways. First, the materials contain absorbed and adsorbed gasses which may be removed by outgassing. Secondly, vaporization or sublimation of the material or of a volatile component of the material may occur. The rates of the reactions can be radically affected by temperature. All of these things can cause seal shrinkage and deterioration of the seal material. It is generally accepted that all elastomers have vapor pressures between 10^{-4} and 10^{-9} torr. and would, therefore, all sublime or vaporize selectively as these pressures were reached in hard vacuum. Parker Seal has conducted tests which show that this is not necessarily true. Sublimation, where it did occur, was found to be a surface effect. Though the sample was eroded on the surface, it did not completely sublime. Other specially compounded elastomers were developed that were not affected at vacuums of 10^{-9} torr. It was also found that temperatures can have a significant effect on sublimation rates as shown.

Weight Loss Under Vacuum as a Function of Temperature

Compound (Base Elastomer)	Temp. Of	Weight Loss %	Pressure Torr.
B 318-7(1) (Butyl)	77	3.3	6×8^{-8}
	120	5.1	2×8^{-8}
	165	6.8	3×10^{-8}
77-545(2) (Viton)	77	2.1	$.18 \times 10^{-8}$
(1) (Viton)	77	0	1.2×10^{-8}
	120	0.7	4×10^{-8}
	165	1.3	5×10^{-8}
ES15-8(3) (EP)	75	0.4	4×10^{-8}

NOTE: (1) Test - 8 days; (2) Test - 84 hours; (3) Test - 24 days.

2.1.3.2.3 Seal Characteristics

The following seal ("O" ring) characteristics have been taken into consideration in the selection of seal materials.

A. The shape of the static seal groove is unimportant as long as it results in proper compression of the seal between the bottom of the groove and cylinder wall and provides room for the compressed material to flow so that the seal is not solidly confined between metal surfaces.

B. The effects of temperature changes from $-65^{\circ}F$ to $+250^{\circ}F$ on the performance of "O" ring seal depends on the seal material used. Synthetic rubber can be made for continual use at high or low temperature or for occasional short exposure to wide variations in temperature. At extremely low temperature, the seals may become brittle but will still seal and will resume their normal flexibility without harm when warmed. Prolonged exposure to excessive heat causes permanent hardening and usually destroys the usefulness of the seal. The coefficient of thermal expansion of synthetic rubber is usually low enough so that temperature changes present no design difficulties.

C. "O" ring seals are extremely dependable because of their simplicity and ruggedness. Static seals will seal at high pressures in spite of slightly irregular sealing surfaces and slight cuts or chips in the seals.

D. The cost of "O" ring seals and the machining expense necessary to incorporate them into a design are as low as for any other reliable seal. "O" rings may be stretched over large diameters or folded through small diameters for installation and no special assembly tools are necessary.

2.1.3.2.4 Seal Lubrication

The lubrication of "O" rings is extremely important in vacuum application. This is due to the fact that lubricity from the fluid does not exist. The proper lubricant for any application depends on the operating conditions - temperature, fluid, pressure, type of seal and should be compatible with the system fluid and "O" ring compound. Two types of "O" ring lubrication are as follows:

Name:	Celvacene	DC55 MIL G 4343
Manufacturer:	Consolidated Vacuum Co., Rochester, N. Y.	Dow Corning Corp., Midland, Mich.
Type:	Cellulose ester and Caster Oil	Silicone Grease
Temp. Range of:	-40 to +266^{o}F	-65 to +400^{o}F
Seal Use:	Vacuum Static 1×10^{-2} torr.	Vacuum Extreme Temperature Lub.
Best Service with (Base Rubber):	Silicone, Nitrite, Neoprene, Viton/ Butyl, Ethylene, Propylene	Nitrite, Butyl, Ethylene Propylene Viton, Neoprene

Before selection of a lubricant is made for use with "O" rings, the following determination should be made:

A. It, or the additives which it contains, should not cause shrinkage or excessive swelling of the "O" ring being used.

B. It should not excessively soften or solidify over the anticipated temperature range.

C. It should not break down and leave gummy or gritty deposits after cycling.

D. It should be capable of forming thin, strong films over the metal being lubricated which the "O" ring cannot wipe away.

2.1.3.2.5 Cleanliness and Assembly

Cleanliness is important for proper seal action and long seal life. Every precaution should be taken to ensure that all parts are clean at and during assembly. Any foreign particle in the gland can cause leakage and possibly damage the "O" ring. Equally as important is the maintenance of clean surfaces during operation.

Assembly must be made with care so that the "O" ring is properly placed in the groove and without being damaged as the gland is closed. Some of the more important design features to ensure this are:

A. I.D. stretch as installed in groove is not more than 5% because more stretch will shorten the life of most "O" ring materials.

B. I.D. expansion to reach groove during assembly should not exceed 100%. For very small diameter "O" rings, it may be necessary to exceed this. If so, one should allow sufficient time for the "O" ring to return to its normal diameter before closing.

C. The "O" ring should not be twisted. Twist during installation will readily occur with "O" rings having a large diameter I.D. to cross-section diameter.

D. "O" rings should not be forced over sharp corners, key ways, threads, slots, splines, ports or other sharp edges. If impossible to avoid by part design, then thimbles, supports or other arrangements must be used.

E. Closure of the gland should not pinch the "O" ring at the groove corners.

2.1.3.2.6 Hardness

This "O" ring characteristic was carefully considered because its variation produces many results in different applications. While the majority of applications are best served by 70^{o} shore A durometers, there are cases in which other durometers prove more suitable.

A. Break-out friction is reduced with low durometer; increased with high durometer in a given gland.

B. Low pressures are easier to seal with low durometer.

C. Sealing at low temperatures is usually more readily obtainable with low durometers. If the same seal must also operate at high temperatures (i.e., wide temperature range), the resistance to high temperatures must be investigated.

D. Wear and abrasion resistance is greatest with a 70° to 80° durometer. Softer or harder seals wear proportionately more rapidly.

E. Running friction is somewhat less with high durometers providing the squeeze has been reduced to give the same unit loading of the seal against the rubbing surface.

F. Resistance to extrusion is improved with high durometers.

2.1.3.2.7 Seal Seat

A design evaluation was made of the flat seat and the conical seat to determine which would be more reliable in this application. The conical seat provides a mechanical load advantage effect which allows a working contact stress to be developed with reduced loads.

A force component which resists lateral motion (i.e., the motion induced by vibration), is a serious disadvantage in flat seating if high frequency vibration causes the seat to scrub laterally.

The basic disadvantage of the conical poppet is that slippage during seating takes place and has the potential error of axis tilt and are not self-aligning. From a performance standpoint, the flat seat would be the natural choice for lowest leakage combined with maximum life. However, conical seating has been selected because of its stability in vibration over the flat seat and experience has proven that the conical seat offers reliable performance.

2.1.3.3 Seal-Off Valve Reliability Program

A complete functional on-site review of Launch Complex 39 and other Kennedy Space Center installations was accomplished early in the program to gather the maximum amount of available reliability information on present seal-off valves.

The KSC Data Bank and failure reporting systems were fully interrogated for all available data. Tab runs were made from the data bank and examined in detail. KSC and Boeing Reliability personnel were extensively interviewed.

Straza internal failure data for seal-off valves was tabulated and reviewed. A substantial effort was exerted to identify and calculate the degree of severity of each of the predominant failure modes for each of the items.

Subsequent to a comprehensive review of the preceding information, a basic decision was made concerning the reliability calculations to be accomplished for seal-off valves.

The exponential distribution normally used as characteristic of systems with many parts whose failures will average out to essentially a random failure occurrence is not the reliability frequency distribution which best describes the characteristics of the items under study. The normal probability distribution is a better description of the reliability characteristics of the individual items. Units following a normal distribution have a failure rate that increases with time; essentially a "wear-out" characteristic due either to functional use, cycling effects, or effects of the environment such as corrosion.

The individual item Reliability, therefore, is equated to the probability of survival (without failure) of the item for the two-year period.

Where:

$$R = \frac{\text{Number of Units Which Did Not Fail}}{\text{Total Number of Units in Use}}$$

The probability of survival ratio utilized is the least complex of reliability calculations but was necessitated basically by the absence of substantial time-oriented data.

It was determined that heavy reliance would be placed on establishing critical failure modes and utilizing the reliability (probability of survival) numbers as a measure of the severity of each failure mode. It was recognized that the minimal data and differences of environmental and other factors mixed in the data was likely to introduce an uncertainty into the reliability numbers. But, by using the same approach for each of the subsequent calculations and evaluations, it would be possible to establish the relative degree of improvement or degradation from that established base line. The relative measure of improvement was determined to be the primary quantity required by the study, rather than a fixed true reliability number for a long operation period with a high confidence factor. That figure is not available with the data recorded.

Engineering Reliability supported the Phase I study of Seal-Off Valves using a four-step approach to the problem. The methodology utilized was intended to provide the maximum visibility of the overall system situation to the individual detailed design problems. The following four reliability milestones were used:

A. Document actual existing hardware reliability.

B. Establish preliminary reliability goal.

C. Establish present state-of-the-art reliability.

D. Establish final reliability goal.

Existing Hardware Reliability

The comprehensive review mentioned previously was performed in conjunction with the design engineer to establish what the operational requirements demand of the various components versus what is the inherent capability of the equipment to satisfy that demand.

All failure data, repair data, maintenance data, unsatisfactory condition or procedure data and all operating environment data made available by the Contracting Agency was reviewed and a detailed examination or analysis made as to the cause and effect of each incident. Each component deficiency was categorized and a determination made of the relative contribution of this type of deficiency to the total performance of the component.

By the systematic grouping of faults and the establishment of the degree of effect on performance of each category of fault, visibility was provided to direct attention to areas of greatest need and greatest potential for improvement.

The existing hardware reliability value and the calucations from which it was derived were documented and the derived value was cross-checked with available in-house data on the same type components.

Preliminary Reliability Goal

The preliminary reliability goal was established using the existing hardware reliability values. The insight developed in analysis of existing hardware failure modes was utilized to set a preliminary goal of eliminating those modes most practical to do so or improvement in those areas of greatest impact on performance.

Failure Potential

A. Possibility of damage from external causes:

(1)	Shock	One (1) unit out of 300 will leak as a result of 1, 2, and 3.
(2)	Impact	
(3)	Vibration	One (1) unit out of 300 will be damaged to the extent that it will leak. Leakage will result in four (4) additional pumpdown operations per month.
(4)	Handling	

B. Possibility of damage to mating surfaces, seal faces, etc., as a result of disassembling.

Removal of "O" ring, etc., to assemble onto line assembly will result in one (1) unit having foreign matter added out of 300 units.

This will result in "O" ring damage and require replacement of "O" ring.

C. Possibility of corrosion due to atmosphere - none.

D. Possibility of damage to internal surfaces due to foreign material being introduced into valve from annulus - none.

E. Assembly of the unit will result in leakage at a weld (one out of 300 units). This will necessitate removal of unit and repair of the weld.

F. Possibility of failure due to faulty vendor part being received at Straza prior to assembly.

2% of 300 units = 6 units

G. Possibility of "O" ring deterioration due to <u>age</u> and <u>lubrication</u> incompatibility.

(1) Failure of "O" ring due to improper aging - one out of 300.

(2) Effect on "O" ring due to omitting lubricant - two out of 300 replacements due to leakage at "O" ring.

H. Total failure potential from all causes, sum of Items A through G above. Thirteen total failures out of 3000. Total reliability considering all failure modes: R = .9956.

$$\frac{2987}{3000} = .9956$$

State-of-the-Art Reliability

A data search was instituted using customer data, vendor data, industry data, and in-house data. The reliability data services of the IDEP Program, the FARADA Program, the Defense Documentation Center (ASTIA), the NASA Information Center (PRINCE), the VSMF Design Data File, and others were utilized.

The accumulated data was used to define the current state-of-technology for each of the components. Emphasis was placed on the actual operating test data when available rather than potential achievements or analytical projections. The data

Table 1. Reliability for State-of-the Art Hardware

Failure Mode	R Goal (+ 6)	Seal Off Valve + 6	Seal Off/Relief + 6	Seal Off/Relief Ind. Oper. + 6	Double Seal +6	State-of-the art Seal-off
Contamination	-0-	2/3000	4/3000	4/3000	4/3000	
"O" Ring Failure	3/3000	3/3000	4/3000	4/3000	5/3000	
Ext. Damage Shock Vibration Impact Handling	2/3000	4/5000	4/3000	2/3000	2/3000	
Disassembly Damage	1/3000	2/3000	3/3000	2/3000	2/3000	
Corrosion	-0-	1/3000	2/3000	2/3000	1/3000	
Assembly Weld Leakage	1/3000	1/3000	2/3000	2/3000	1/3000	
Total	13/3000	19/3000	25/3000	22/3000	21/3000	R = .9927

accumulated was correlated to the same format as the data on the existing hardware so far as possible. This provided a basis of comparison and illuminated the detailed areas where improvement potential existed.

Final Reliability Goal

The final reliability goal was established based on the final component configuration defined in the final Phase I Technical Report. It is a numeric expression of the inherent improvement in performance based on the physical change to the component.

The elimination of a failure or a demonstrated decrease in probability of occurrence of an unsatisfactory condition or procedure is required to justify an increase in reliability level.

Several trade-off studies/analyses were conducted in the course of the study. Evaluation from a reliability and failure modes viewpoint was made of four basic types of seal-off valves.

The SV1-88, 7079-1, 7079-2 and SV2-86 5ZI Type Seal-Off Valves were the subject of an additional reliability study. The advantages and disadvantages, separate versus combinations of burst discs, seal-off valves and thermocouples were analyzed. (See Table 2 for Reliability Trade-Off Study between burst disc and seal valve.)

Final Reliability Goal - Seal-Off Valve

Failure Potential

A. Possibility of damage from external causes:

(1)	Shock	None
(2)	Impact	One (1) unit out of 3000 will leak in spite of incorporation of low profile.
(3)	Vibration	None
(4)	Handling	None. Possibility of damage reduced by new design features.

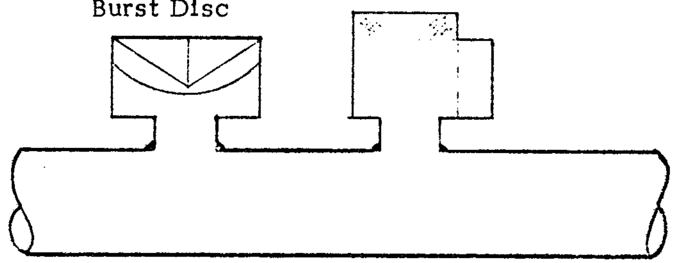
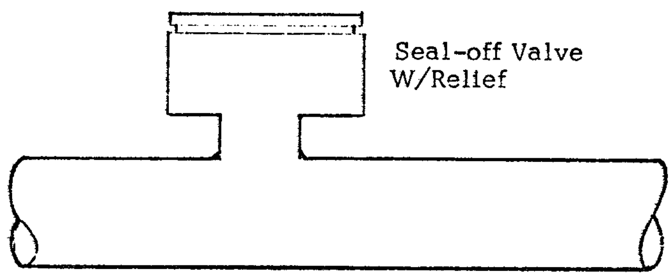
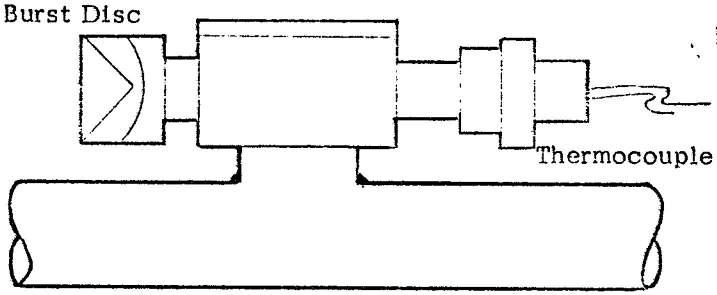
B. Disassembly Damage:

One unit out of 3000 will leak after disassembly due to contamination, seal problems, or assembly error.

C. Corrosion - None

D. Weld Leakage - One (1) unit out of 3000 will leak.

Table 2. Reliability Trade-off Analysis

	Configuration	Advantage	Disadvantage
1.		1. Independence of Function and design objective. 2. Reverse buckling/cutter relief action. 3. Simplicity 4. Variability - to use one and not the other. Reliability $8 + {}^{8}/_{3000} = {}^{16}/_{3000}$	1. Two welds and two entrances to cavity. 2. Mounting space/area.
2.		1. Compact - Low Profile 2. Single entrance to line. Reliability Indep Oper ${}^{19}/_{3000}$ or Integ Oper ${}^{16}/_{3000}$	1. Combination Function 2. Greater complexity 3. Relief action by spring action - obstructed flow 4. No reduction in no. seals actions, moving parts, or elimination of failure modes from above design.
3.		1. None	1. Multi-openings 2. Relative complexity 3. Bulky design

6 failures attributed to
Manufac.
Processing
Q.C.

Basic difference between units is contamination
No basic reliability difference between separate installations - same functions performed same way.

Table 3. Reliability Numbers for Seal-Off Valves

Failure Mode	SV1-88	7079-1	7079-2	SV2-86-5Z1
Seal Leakage Goal = 2/3000	Valve Cap "O" ring becomes Operator "O" Ring P = 2/3000	Valve Cap "O" Ring seal at pump out port P = 1/3000	Valve Cap "O" Ring seal at pump out port P = 1/3000	Valve Cap "O" Ring seal at pump out port P = 1/3000
Seal Leakage Goal = 1/3000	"O" Ring seal at throat of tube P = 1/3000	"O" Ring Seal at throat of tube P = 1/3000	"O" Ring Seal at throat of tube P = 1/3000	"O" Ring Seal at throat of tube (2) double seal P = 2/3000
Contamination Corrosion Goal = 0/3000	Contaminate after removal of cap a and in operator assembly carried around P = 4/3000	Contaminate after removal of cap at port P = 2/3000	Contaminate after removal of cap at port P = 2/3000	Contaminate after removal of top cap or second port cap P = 4/3000
Seal Leakage (Operator Shaft) Goal = 0/3000	N/A P = 0/3000	Operator Shaft Seal Plus "O" Ring Seal at top of Assembly P = 2/3000	Operator Shaft Seal replaced by bellows "O" Ring at top P = 1/3000	N/A P = 0/3000
2/3000 External Damage	P = 1/3000	P = 1/3000	P = 1/3000	P = 2/3000
1/3000 Disassembly Damage	P = 0/3000	P = 1/3000	P = 1/3000	P = 2/3000
1/3000 Weld Leakage	P = 1/3000	P = 1/3000	P = 1/3000	P = 1/3000
TOTAL Goal = 13/3000	9 + 6 P = 15/3000	9 + 6 P = 15/3000	8 + 6 P = 10/3000	12 + 6 P = 12/3000

E. "O" ring failure/seal failures: "O" ring failure, seal failure, and bellows failures. Two (2) failures out of 3000 units.

Total expected failures - 11/3000 units

$$R = \frac{T-F}{T} = \frac{3000 - 11}{3000} = \frac{2989}{3000} \quad R = .9963$$

2.1.4 Phase II Proposal

The Phase II Test and Hardware Procurement Plans reflect the technology gained through the Phase I Task for the Vacuum Jacketed Umbilical Lines Technology Advancement Program.

The testing proposed is predicated on a comprehensive design evaluation testing that will verify elimination of the failure modes that have been problems on the service arm hardware of the SATURN V Launch Tower.

The test program will be conducted using very few specimens and a sufficient number of tests to achieve a 90% confidence level in reliability. A requirement will be tempered with the experience to achieve an acceptable confidence level and still fulfill design objectives.

2.1.4.1 Test Plan

2.1.4.1.1 Scope

The purpose of this test plan is to describe the test methods, hardware procurement, test criteria and objectives for design verification testing of improved Seal-off Valve designs.

2.1.4.1.2 Test Philosophy

Testing requirements are based on the reliability Failure Mode Analysis that originally determined the possibilities for failure of a seal-off valve.

The following indicates the failure mode and the appropriate test that will provide design verification.

Failure Mode	Design Verification Test
Corrosion	Salt Fog
Contamination	Pump Out Test
	Sand and Dust
Damage from externally applied loads	Vibration
	(1) Sine
	(2) Random

Failure Mode	Design Verification Test
Shipping Damage	Shock
Structural Integrity of valve body weld quality	Proof Pressure
Assembly Damage	Valve Cycle Test
Seal Stability	Life Cycle Test High Temperature Test Low Temperature Test
Basic Design Verification	
Verification of Cycle Life	Valve Life Cycle Test
Design Verification	Shock Test
Structural Integrity	Leakage Test

2.1.4.1.3 Applicable Documents

The following documents form a part of this test plan to the extent specified herein:

SP-4-38-D	Acoustics and Vibration Environments and Tests Specification Levels Ground Support Equipment Launch Complex 39
NASA TMX-53023	Terrestrial Environment (Climatic) Criteria Guidelines for Use in Space Vehicle Development
MIL-STD-810A (USAF)	Environmental Test Methods for Aerospace and Ground Equipment
MSFC-SPEC-279	Electronic Capability
KSC-STD-164D	Environmental Test Methods for Ground Support Equipment Installation at Cape Kennedy

2.1.4.1.4 Tests

Prior to and as a condition of acceptance, the supplier shall subject each specimen to the acceptance tests of Table 4 in the sequence shown. The contractor reserves the option of reconducting any or all of the acceptance tests as receiving inspection.

Table 4. Acceptance Tests	
ACCEPTANCE TESTS	
Test	Page No.
Examination of Product	55
Functional Test	56
Proof Pressure	56

Design Evaluation tests are to be conducted by AMETEK/Straza in accordance with Table 5.

Table 5. Design Evaluation Tests	
DESIGN EVALUATION TESTS	
Test	Page No.
Life Cycle Test	58
Salt Fog	56
Sand and Dust	56
Pumpout Test	56
Contamination Test	56
Thermal Shock	57
Shock	57
Sine Vibration	57
Random Vibration	57

Testing Sequence

Tests shall be conducted in the sequence that is the most consistent with operational environments under normal installation conditions. This test sequence will verify: design, environmental stability, and ability to withstand the operational environments.

A. Receiving Inspection
B. Functional Test
C. Proof Pressure
D. Sand and Dust
E. Salt Fog
F. Life Cycle
G. Pumpout Contamination
H. Contamination - Seal Surface
I. Thermal Shock
J. Shock
K. Vibration - Sine
L. Vibration - Random

Test Data Sheet

The test data sheet shall be filled out in its entirety and signed by all personnel involved in performance of the test.

Photographic evidence shall be made of the specimen following each individual test. The photographs shall be identified with date, type of test, specimen identification and any unusual condition present.

Test Report

A test report following the test program will be prepared. This report will include all facts and conclusions which result from the tests. In addition, this report will contain a section entitled, "Recommendations." This section will contain suggestions regarding further design improvements which are a result of the test program.

2.1.4.2 Test Procedure

Examination of Product

The test specimen shall be examined dimensionally against the drawing or specification to determine conformance to general requirements.

Functional Test

The test specimen shall be evacuated by means of a helium mass spectrometer to 1 X 10^{-4} mm Hg or better. A plastic bag shall be placed over the outside of the specimen and helium admitted into the bag until all air is displaced. The leakage test shall be accomplished using a helium mass spectrometer set at a sensitivity of 1 X 10^{-8} std cc/sec of helium. Repeat leakage test after cycling valve through one cycle.

Proof Pressure Test

The proof pressure test shall be conducted on each specimen. The specimen shall be internally pressurized with helium to a pressure of 150 psig for a period of two (2) minutes. Following the proof pressure test, the specimen shall be visually inspected for deformation.

Sand and Dust Test

The test shall be conducted in accordance with Section 16 of KSC-STD-164D. The test item shall be installed in the test chamber in accordance with Paragraphs 3.4 and 4.4.1 of KSC-STD-164D with protective covers in place during the test. The test item shall be exposed to a sand and dust environment with a sand to air ratio of 0.1 to 0.25 grams per cubic foot and with an air velocity of from 100 to 500 feet per minute.

Salt Fog

The test specimen shall be exposed to a solution of salt, five parts by weight in 95 parts by weight of water, at a temperature of 95^{+2}_{-4} °F for a period of 240 ±2 hours. The specimen will be non-operating with protective covers in place.

Pumpout/Contamination Test

The test specimen shall be subjected to a pumpout rate test with and without 200 micron filter. Following this test, the filter shall be contaminated to cause one (1) atmosphere differential pressure across the filter. Following this test, the specimen filter shall be examined for deformation or collapse.

Seal Surface Roughness Test

The test specimen shall be subjected to two (2) tests for seal surface irregularity.

A. Sand blast or flame spray the seal seating surface to various degrees of irregularity until failure occurs during leakage test. Record results after each increase in seal surface irregularity.

B. Contaminate the sealing surface with hair or wire and increase diameters until failure occurs.

Thermal Test - Low Temperature and High Temperature

The specimen shall be placed in an environmental temperature chamber and allowed to stabilize at a temperature of $-65^{\circ}F$.

Following the low temperature functional test, the specimen will be placed in the test chamber and allowed to stabilize at a temperature of $+200^{\circ}F$. Following the high temperature test, the specimen shall be subjected to the functional test.

Thermal Shock

The specimen shall be exposed to an area flame at $1400^{\circ}F$ $\pm 100^{\circ}F$ for a period of ten (10) seconds.

Shock Test

The test specimen shall be subjected to a peak shock pulse level of 20 g attained in 10 ± 1 milliseconds. The total pulse duration shall be 20 ±1 milliseconds.

Sine Vibration (Table 6)

The specimen shall be subjected to sine vibration frequency cycling along each of three (3) mutually major perpendicular axes. A frequency cycle shall consist of sweeping the frequencies from 20 to 2000 to 20 cps in ten (10) minutes. The rate of frequency change shall be logarithmic;all resonant frequencies shall be recorded during the frequency cycling test.

Table 6. Sine Vibration Test

Frequency	Search	Frequency Cycling
20 - 150	± 3.59	± 7 g
150 - 292	0.003 in. da.	0.006 in. da.
292 - 2000	± 13 g	± 26.0 g

Random Vibration Test (Table 7)

The test specimen shall be subjected to random vibration for a period of ten (10) minutes in each of three (3) mutually perpendicular axes of an ambient temperature.

Table 7. Random Vibration Test	
Frequency - CPS	Vibration Level
10 - 100 100 - 1000 1000 - 2000	+ 6 db/Octave .5 g^2/CPS -6 db/Octave

Life Cycle Test

The cycle life test will be conducted on all test items using seal materials in accordance with the following plan:

Test Item: Part Number 7079 (Non-Relief)

3 Each with Viton V655-75 seal material
3 Each with Butyl B612-7 seal material

Test Item: Part Number 7089 (With Relief)

3 Each with Viton A seal material
3 Each with Ethylene Propylene E603-7 seal material

Test Item: Part Number SV3-812-5W2

3 Each with Viton V655-75 seal material
3 Each with Butyl B-612-7 seal material

Each test item will be identified showing the seal material installed. Each test item will be cycled through 500 (open-close) cycles.

At the conclusion of the cycle life test, a functional test will be performed.

2.1.4.3 Procurement Plan

Test Specimen Selection

The following units have been selected for procurement for Phase II based on the results of the Phase I evaluation.

Hardware Procurement

Cryolab 1"	7079-1 Seal-off Valve with Wilson seal (non-relief)	6 Units
Cryolab 1"	7089-1 Seal-off Valve with Wilson seal (with relief)	6 Units
Cryolab $1\frac{1}{2}$"	SV3-812-5W2 Seal-Off/Relief Valve	6 Units

2.2 PHASE II PROGRAM

The Phase II Test Program of the NASA Vacuum Jacketed Umbilical Lines Technology Advancement Program was organized so that pre-test activities, hardware procurement, and testing could be accomplished within planned limits. Procurement specifications for vacuum seal valves, with and without relief capability, incorporated all of the design objectives and improvements needed to eliminate the problems that were being experienced at the Cape Kennedy Launch Complex with the presently installed vacuum seal valve.

Purchase orders were placed for 18 vacuum seal valves. These included six vacuum seal valves (without relief), six vacuum seal/relief valves, and six SV3-812 vacuum seal/relief valves of the type that are presently being used at Cape Kennedy.

Upon receipt of test specimens, all units underwent receiving inspection and functional testing to determine conformance to vendor drawings and Procurement Specification. Following this initial acceptance, the test specimens were subjected to the Phase II Testing Program.

The test report describes the results of tests conducted on vacuum seal valves during Phase II of the NASA Vacuum Jacketed Umbilical Lines Technology Advancement Program, Contract Number NAS 10-6098.

All testing was completed and has provided the criteria for the design evaluation and basis for recommendation to NASA for future procurement of vacuum seal valves. The recommendations and conclusions for Phase I and II are included following the test report.

Tests that were conducted evaluated the basic design features and structural integrity of the specimens including: (1) Receiving Inspection; (2) functional leakage; (3) proof pressure; (4) cycling; (5) elevated and low temperature; and (6) pumpout tests. Operational tests included: (1) thermal shock; (2) shock; and (3) vibration. Figure 14 shows the seal-off valves installed in the test fixture.

Specimens

The test specimens included six CryolabCompany SV3-812 vacuum seal/relief valves of the type that are presently used at Cape Kennedy on the launch tower service arm vacuum jacketed umbilical lines. Also included are six Cryolab Company 7079-1 vacuum seal valves and six 7089-1 vacuum seal/relief valves developed and fabricated during the Phase I study.

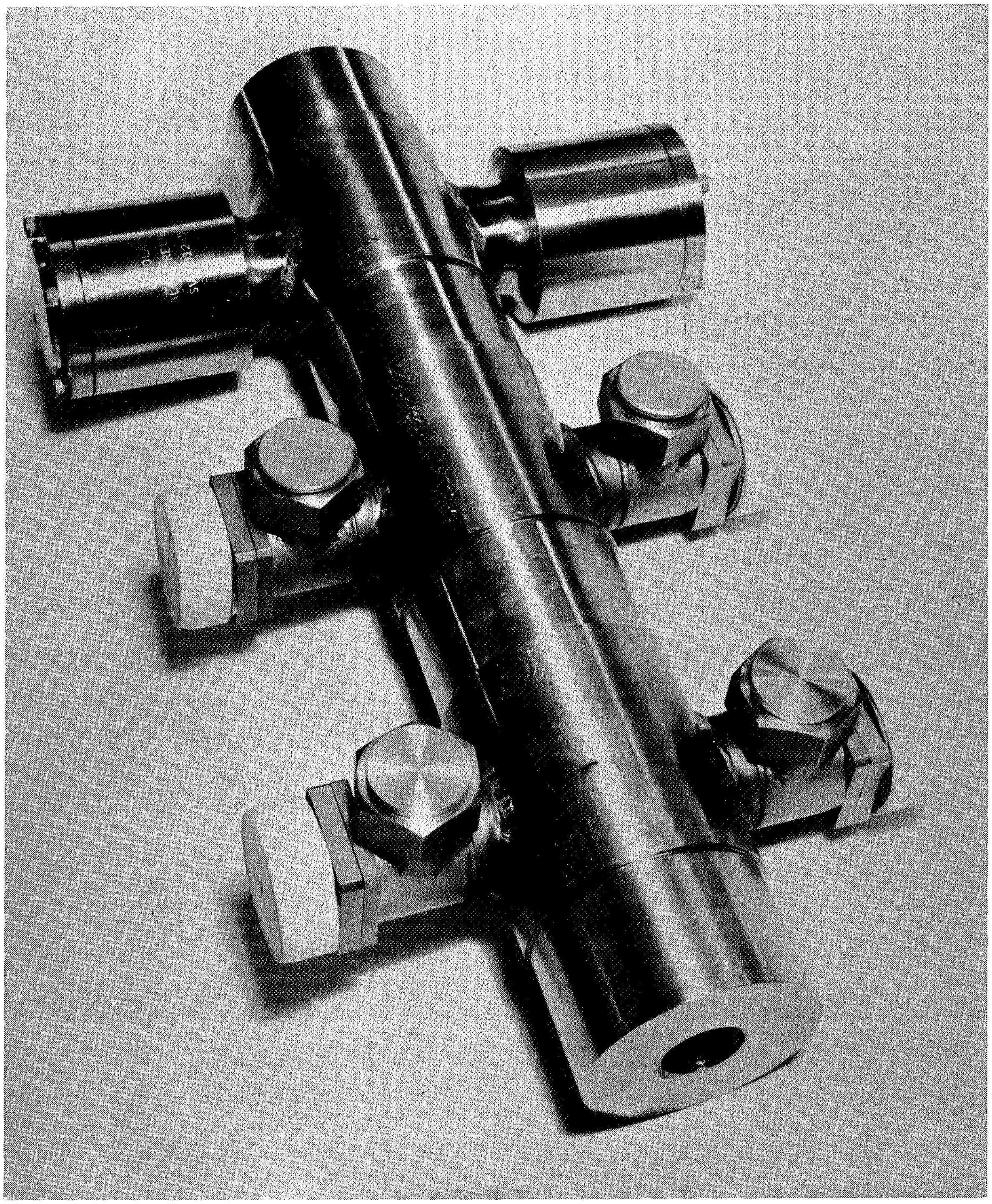


Figure 14. Seal-Off Valves on Test Fixture

Test Program Results

The Phase II Test Program accomplished and has validated the design concepts that were incorporated into test hardware. The following is a summary of the test results.

1. The non-rising stem and "Wilson" dynamic seal was demonstrated to be a reliable and leak-free component following cycling test (500 open-close cycles).

2. Pumpdown operations using the pumpdown assembly (see Figure 15) attached to the integral operator valve quick coupling port were made with less difficulty than with the standard external valve operator/pumpdown assembly.

3. Material evaluation showed that the Viton O-ring seals are marginal at +200°F. Butyl O-ring seals met all test objectives and were the most reliable tested. All seal materials tested were leak-free at -65°F. Ethylene Propylene O-ring seals leaked excessively above +180°F. Dow Corning Silicone "Silastic tt" resisted a 1400°F flame for ten seconds and is selected as the relief valve cap material.

4. The SV3-812 valve relief spring caused metal to be abraided from the valve plug during life cycling tests. This metal can become lodged in the O-ring and cause leakage.

5. All of the vacuum seal valves completed the following tests: (1) Proof Pressure; (2) Salt Fog; (3) Sand and Dust; (4) Elevated and Low Temperature Leakage; (5) Pumpout/Contamination; (6) Thermal Shock; (7) Shock; and (8) Vibration; and (9) Life Cycle.

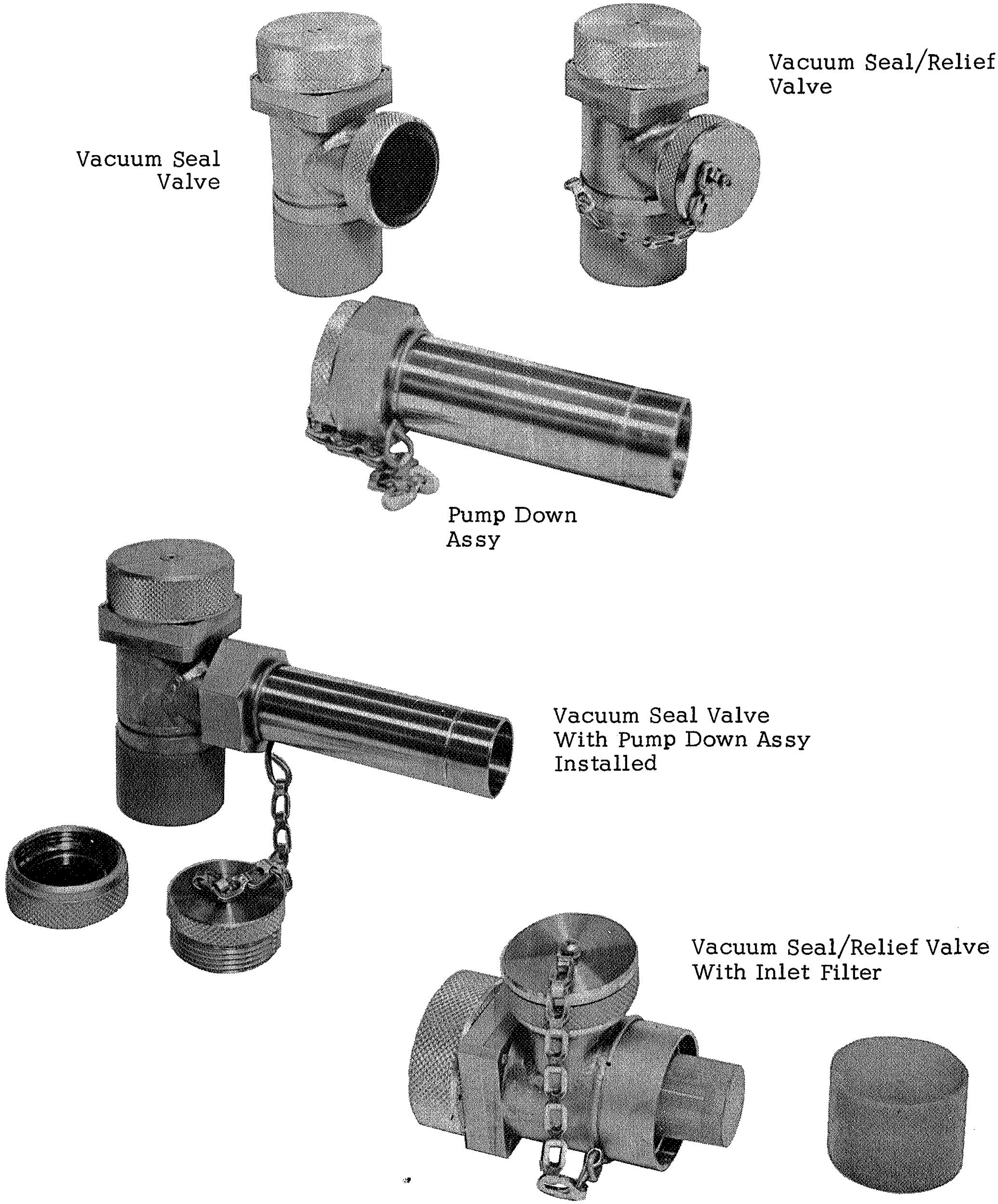
2.2.1 Test Report

2.2.1.1 Scope

The purpose of this test program was to validate the design of vacuum seal valves. Testing was conducted in accordance with NASA approved test procedures. Figure 16 shows the relief type seal-off valve tested, disassembled.

2.2.1.2 Item Description

Test Specimen Part Number	Test Specimen Serial Number	Type
Cryolab SV3-812	1, 2, 3, 4, 5, 6	1-1/2 inch Seal-off/relief
Cryolab 7079-1	1, 2, 3, 4, 5, 6	1-inch diameter seal-off
Cryolab 7089-1	1, 2, 3, 4, 5, 6	1-inch diameter seal-off/relief



Vacuum Seal Valve, Vacuum Seal/Relief Valve, and Pumpdown Assembly

Figure 15. Vacuum Seal Valves and Accessories

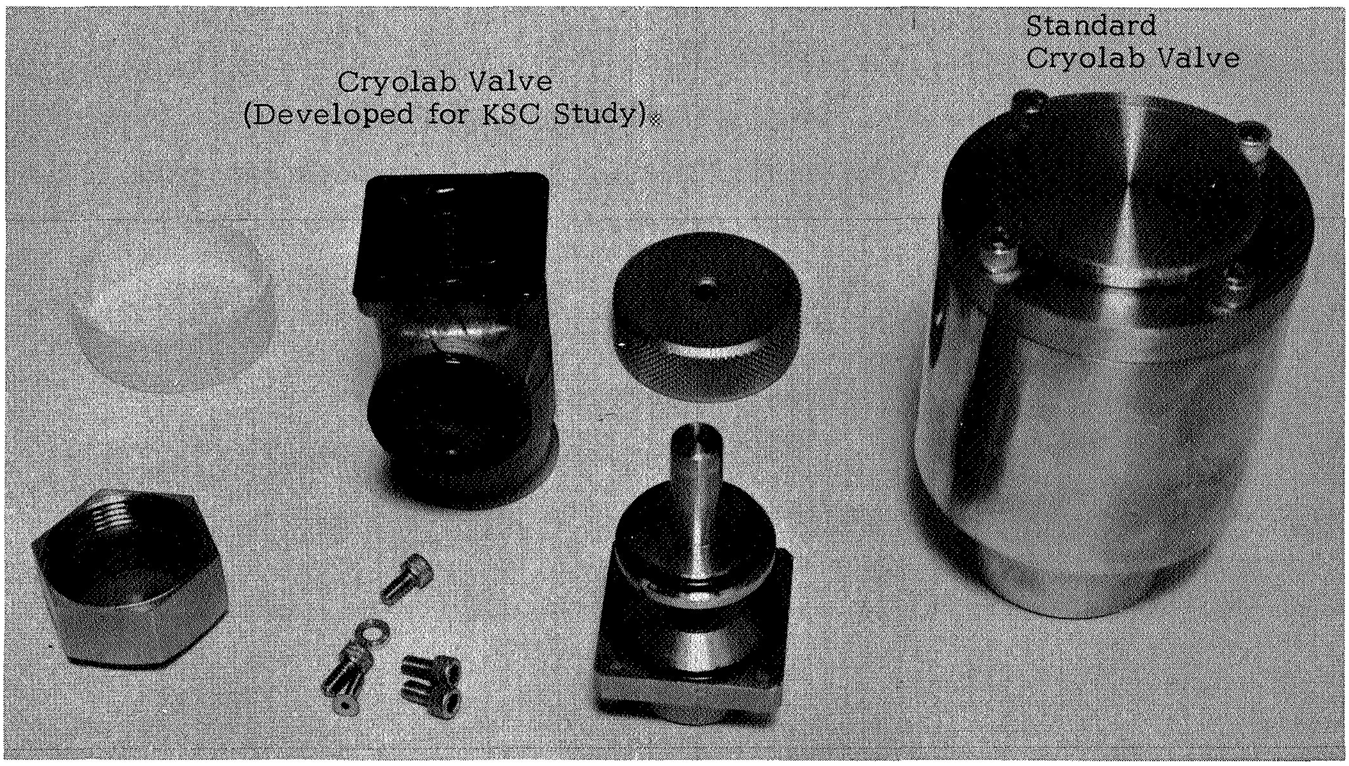


Figure 16. Vacuum Seal Valves - Cryolab

Manufacturer

Cryolab (Division of Statics-Dynamics, Inc.)
2280 Sunset Drive
Los Osos, California 93401

2.2.1.3 Applicable Documents

NASA — KSC Contract Number NAS 10-6098

AMETEK/Straza Design Verification Test Procedure Seal-Off Valve 8-480091

KSC-STD-164D Environmental Test Methods for Ground Support Equipment Installations at Cape Kennedy

Phase I Technical Report — Task II Vacuum Seal Valves

2.2.1.4 Tolerances

Ambient

Temperature	75°F ±15°F
Pressure	30 ±2 in. Hg
Relative Humidity	80% or less

Test

Pressure	±5%
Temperature	Below 100 ±10°F Above 100 ±5°F
Relative Humidity	+5% -0%
Vibration Amplitude	±5%
Vibration Frequency	±2% or 1 cps, whichever is greater

Instrument

Pressure	±0.5%
Flow	±2%
Temperature	±1%
Vibration Amplitude	±5%

2.2.1.5 Test Requirements

The general requirements of KSC-STD-164D have applied to tests described in this document. In all instances in which KSC-STD-164D has been in conflict with the test procedure, statements in the test procedure have taken precedence. At the conclusion of each environmental test, the test item was visually inspected for signs of damage and deterioration. A functional leakage test was performed following each major test.

Unless otherwise specified, the test item was installed in the test fixture in a manner that simulated service usage. All test items were subjected to all test requirements of the approved test procedures.

Testing Sequence

The test specimens were subjected to the design evaluation tests in the sequence listed:

1. Receiving Inspection
2. Functional Leak Test
3. Proof Pressure
4. Salt Fog
5. Sand and Dust
6. Life Cycle
7. Leakage Test — Elevated Temperature
8. Leakage Test — Cold Temperature
9. Pumpout — Contamination
10. Thermal Shock
11. Shock
12. Vibration
13. Seal Surface Contamination

2.2.1.6 Tests Performed

2.2.1.6.1 Receiving Inspection

Requirement

This inspection was made to determine the conformance of the hardware with applicable vendor drawing and AMETEK/Straza specifications to the extent possible without disassembly of the test item.

Procedure

All specimens were subjected to a Receiving Inspection which included:

A. Identification of test items by marking or tagging to establish manufacturer's part number and serialization.

B. Visual Inspection to establish the "as received condition" and verify that the items' configuration and external dimensions are in conformance with the applicable drawings and specifications.

C. Photograph and weigh one (1) item of each part number.

Receiving Inspection data recorded included the following:

A. Manufacturers' part number and serial number for each item.

B. Statement of condition of each item.

C. Dimensions of each item.

D. Photo and weight of one of each part number.

E. Material certification and IAT results (See Data Sheet).

Results

The Receiving Inspection verified that each part was in accordance with the requirement of the drawings and procurement specification. This included material, dimensions, quality of workmanship and weight. Each specimen was electro-etched with a serial number for identification. Material certifications were reviewed, accepted and filed.

Test Data

The following data sheets reflect the results of the Receiving Inspection.

ITEM: Vacuum Valve, Relief Action	CUSTOMER: Straza
PART NUMBER: 7089-1	REFERENCE P/N: DNA
DATE OF TEST: 27 June 1969	ORDER NO: 73324
TEST PROCEDURE: No. not assigned (leak test valve body & seat, test relief)	
TEST LOCATION: Los Osos, Cal.	CUSTOMER INSPECTOR: NA
CRYOLAB INSPECTOR:	GOVT. INSPECTOR: NA

Serial Number	VISUAL INSPECTION	PROOF OR OPERATING PRESSURES	PRESSURE LEAKAGE	OPENING PRESSURE (PSIG)	REPEAT PRESSURE (PSIG)	FLOW	VACUUM LEAKAGE STD.CC/SEC.	COMMENTS	ACCEPTANCE
Test Item 2	O.K.	--	O.K.	9 psig	8 psig	Off scale at 10psig	$< 10^{-9}$	O.K.	(25)
Test Item 3	O.K.	--	O.K.	9 psig	8 psig	Off scale at 10psig	$< 10^{-9}$	O.K.	(25)
Test Item 4	O.K.	--	O.K.	8 psig	7 psig	Off scale at 10psig	$< 10^{-9}$	O.K.	(25)
Test Item 5	O.K.	--	O.K.	7 psig	7 psig	"	$< 10^{-9}$	O.K.	(25)
Test Item 6	O.K.	--	O.K.	8 psig	6 psig	"	$< 10^{-9}$	O.K.	(25)
Test Item 7	O.K.	--	O.K.	7 psig	7 psig	"	$< 10^{-9}$	O.K.	(25)

CRYOLAB
Division of Statics-Dynamics, Inc.
115 Sunset Dr. Los Osos, Calif.
93401

TEST DATA FORM IAT-12

TEST NO.

DESIGN VERIFICATION TEST

RECEIVING INSPECTION DATA SHEET

VACUUM SEAL VALVES

Each specimen shall be examined to determine conformance to Specification 8-410018 relative to:

Material 316L S. Stl

Dimensions within envelope Reqt ✓ Yes ___ No

Construction All Welded

Identification Elec. Etch.

Quality of Workmanship Good

Weight: Actual 19 oz Max. Allow. 20 oz

Six (6) Specimens Cryolab Part Number 7089-1

	Accepted	Rejected
Serial Number 1	☑	☐
Serial Number 2	☑	☐
Serial Number 3	☑	☐
Serial Number 4	☑	☐
Serial Number 5	☑	☐
Serial Number 6	☑	☐

Test Engineer J. Martins Inspector M. Hess

Date of Test 6-29-69

DESIGN VERIFICATION TEST

RECEIVING INSPECTION DATA SHEET

VACUUM SEAL VALVES

Each specimen shall be examined to determine conformance to Specification 8-410018 relative to:

Material 304 St.Stl.

Dimensions within envelope Reqt ✓ Yes ___ No

Construction Single Piece

Identification Elec. Etch.

Quality of Workmanship Good

Weight: Actual 3.5 lbs. Max. Allow. N/A

Six (6) Specimens Cryolab Part Number SV3-812

	Accepted	Rejected
Serial Number 1	☑	☐
Serial Number 2	☑	☐
Serial Number 3	☑	☐
Serial Number 4	☑	☐
Serial Number 5	☑	☐
Serial Number 6	☑	☐

Test Engineer J. Martins Inspector M. Hess

Date of Test 6-29-69

DESIGN VERIFICATION TEST

RECEIVING INSPECTION DATA SHEET

VACUUM SEAL VALVES

Each specimen shall be examined to determine conformance to Specification 8-410018 relative to:

Material 316L St. Stl.

Dimensions within envelope Reqt ✓ Yes ___ No

Construction Welded

Identification Elec. Etch.

Quality of Workmanship Good

Weight: Actual 19 oz Max. Allow. 20 oz

Six (6) Specimens Cryolab Part Number 7079-1

	Accepted	Rejected
Serial Number 1	☑	☐
Serial Number 2	☑	☐
Serial Number 3	☑	☐
Serial Number 4	☑	☐
Serial Number 5	☑	☐
Serial Number 6	☑	☐

Test Engineer J. Martins Inspector M. Hess

Date of Test 6-29-69

2.2.1.6.2 Functional Test

Requirement

This test was required to evaluate the test item leakage within the parameters of the specification.

Procedure

The test item was installed by its normal means in a test setup as shown in Figure 17 and subjected to the following tests:

A. Leakage

The leakage rate was to be determined by means of a helium mass spectrometer and was not to exceed 1×10^{-7} std cc/sec of He.

B. Cycle Test

The valve was to be cycled through one (one open, one closed) cycle and leak tested as described above.

The test item was photographed at the conclusion of the first functional test only while still in the test position. The leak rate before and after cycle test was to be recorded.

Test Results

Each valve completed functional testing before and after one cycle. Recorded leakage rate: 1×10^{-10} scc/sec of helium (see Figure 18).

Test Data

The following data sheets reflect the results of the functional leak test.

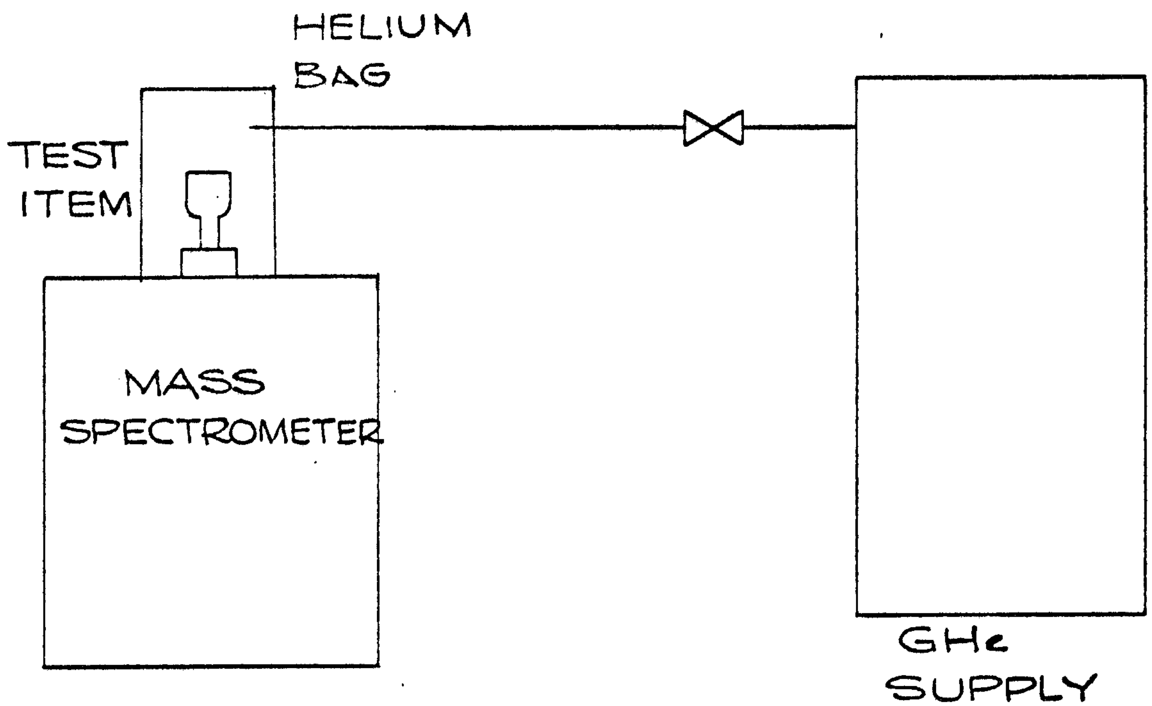


Figure 17. Functional Test Set-up

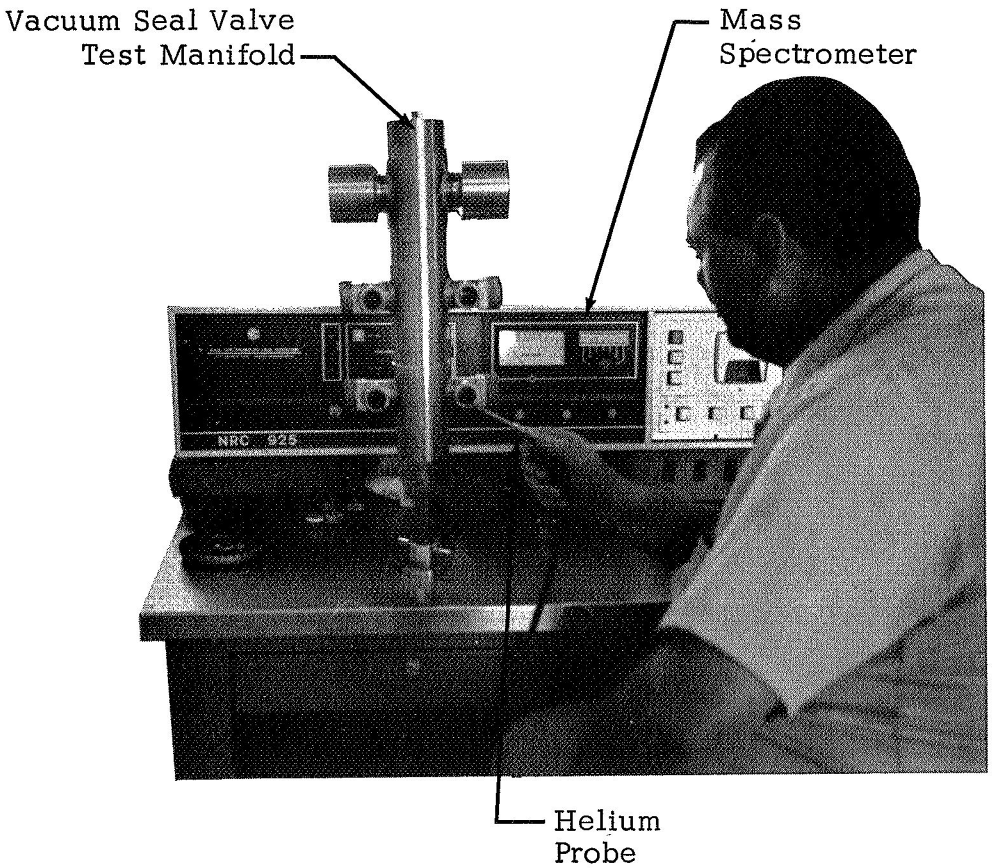


Figure 18. Functional Test Set-up Photograph

DESIGN VERIFICATION

TEST DATA SHEET

Type of Test Functional Date of Test 8-1-69

Part Name Seal-Off Valve Part Number 7079-1

Test Procedure 8-440091 Para 5.2 Part Serial Number 1 thru 6

A. Leakage

Leak Rate Before Cycling $< 1 \times 10^{-10}$ scc/sec

Leak Rate After Cycling $< 1 \times 10^{-10}$ scc/sec

Remarks

1. This test was performed prior to the Proof Pressure Test (Para 5.3)

B. Cycle

(One Open, One Closed)

Test Technician S. H. Moore

Test Engineer J. Martin

DESIGN VERIFICATION

TEST DATA SHEET

Type of Test: Functional | Date of Test: 8-1-69

Part Name: Seal-Off Valve | Part Number: 7089-1

Test Procedure: 8-440091 Para 5.2 | Part Serial Number: 1 thru 6

A. Leakage

Leak Rate Before Cycling $<1x10^{-10}$ scc/sec

Leak Rate After Cycling $<1x10^{-10}$ scc/sec

Remarks

1. This test was performed prior to the Proof Pressure Test (Para. 5.3)

B. Cycle

(One Open, One Closed)

Test Technician: S. H. Moore

Test Engineer: J. Martins

DESIGN VERIFICATION
TEST DATA SHEET

Type of Test Functional Date of Test 8-1-69

Part Name Seal-Off Valve Part Number SV3-812

Test Procedure 8-440091 Para 5.2 Part Serial Number 1 thru 6

A. Leakage

Leak Rate Before Cycling $<1 \times 10^{-10}$ scc/sec

Leak Rate After Cycling $<1 \times 10^{-10}$ scc/sec

Remarks

1. This test was performed prior to the Proof Pressure Test (Para. 5.3)

B. Cycle

(One Open, One Closed)

Test Technician S. H. Moore

Test Engineer T. Martins

2.2.1.6.3 Proof Pressure Test

Requirement

The Proof Pressure Test was performed to establish the structural integrity of the test item.

Procedure

The test item was installed in a test setup as shown in Figure 19 and in accordance with Paragraph 4.4.1 of KSC-STD-164D. Specific test parameters and levels are as follows:

A.	Proof Pressure	150 ±3 psig
B.	Test Media	Nitrogen Gas
C.	Duration of Test	Three minutes

The amount and location of any distortion or other defects as a result of the test was to be recorded. All visible defects were to be photographed (see Figure 20). Proof pressure, test media and duration of test was recorded. A functional test was conducted immediately following the proof pressure test and the test data recorded.

Test Results

The proof pressure test was completed for all specimens. No damage or deformation was noted in any of the valves after test. The functional leakage test that followed showed no detectable leakage (leakage rate — 1×10^{-10} scc/sec He).

Test Data

The following data sheets reflect the results of the proof pressure test and the functional leak tests which followed.

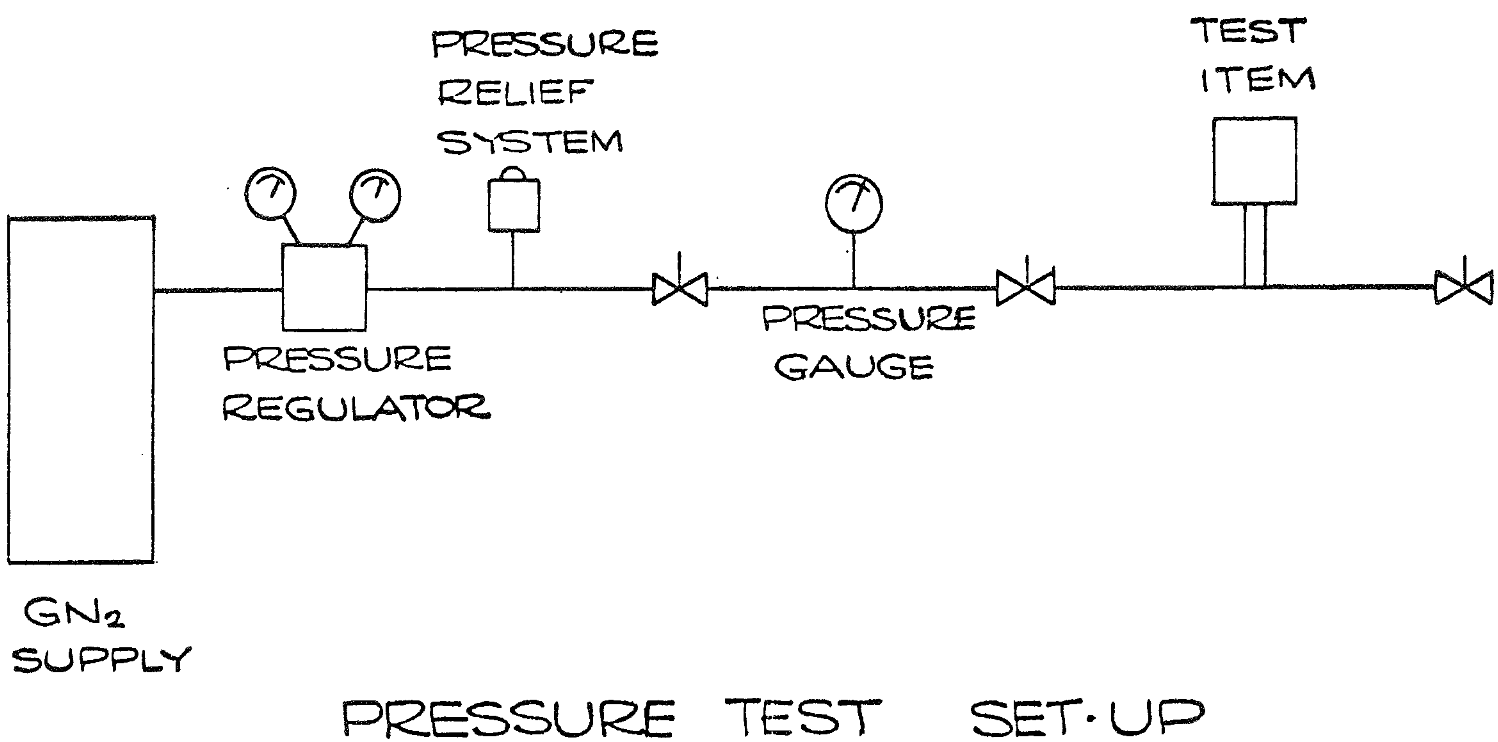
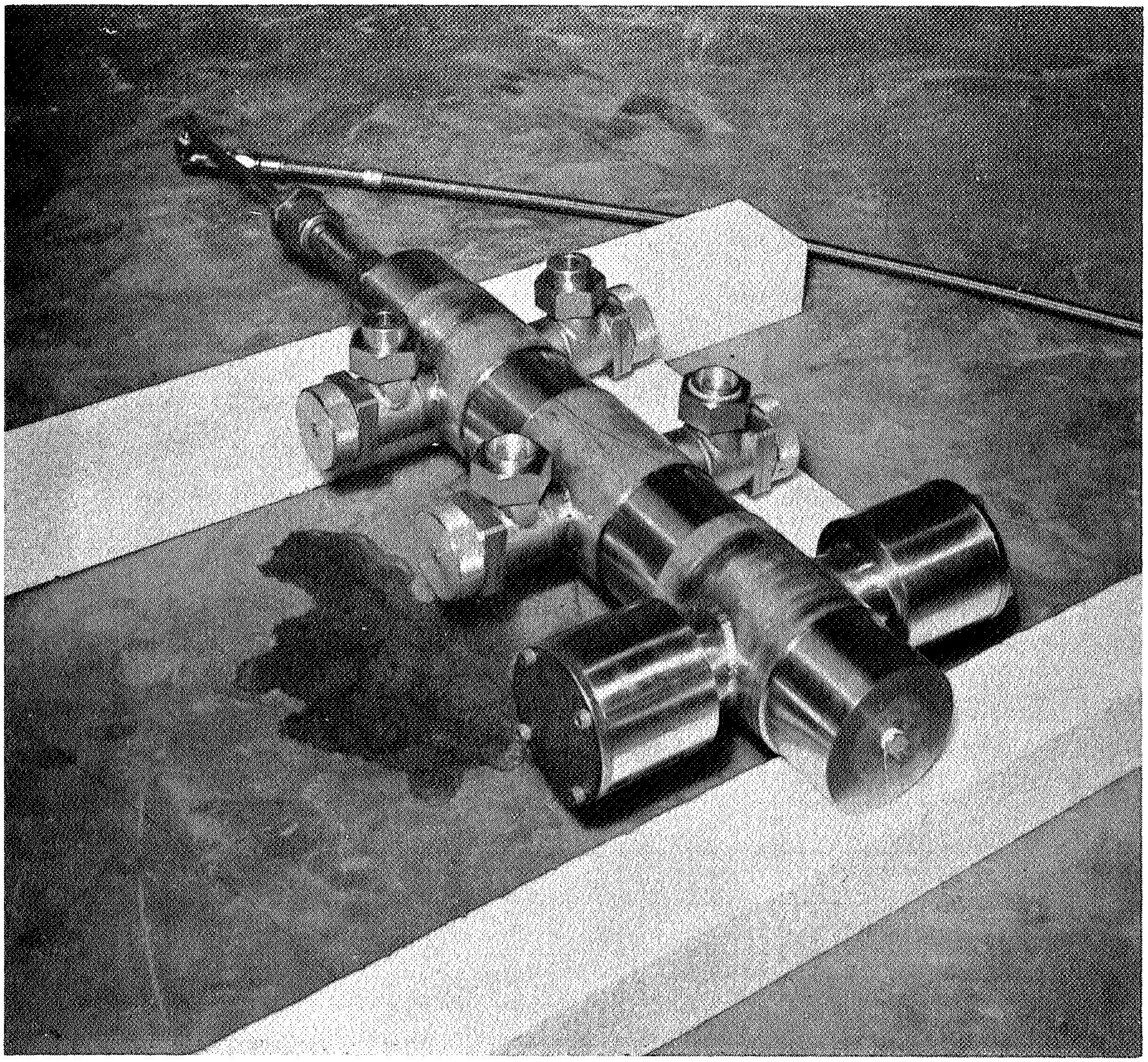


Figure 19. Proof Pressure Test Set-up



Proof-Pressure Test of Vacuum Seal Valves

Figure 20. Proof Pressure Test Photograph

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test: Proof Pressure — Date of Test: 8-5-69

Part Name: Vacuum Seal Valves — Part Number: As Shown

Test Procedure: 8-480091 — Part Serial Number: As Shown

Test Pressure: 150 psig — Test Media: ______ — Duration of Test: 2 min.

	Manufacturer	Serial Number	Remarks		
1.	CRYOLAB 7089-1	1	No visible deformation - no detrimental effect		
2.	"	2	"	"	"
3.	"	3	"	"	"
4.	"	4	"	"	"
5.	"	5	"	"	"
6.	CRYOLAB 7089-1	6	"	"	"
7.	CRYOLAB 7079-1	1	"	"	"
8.	"	2	"	"	"
9.	"	3	"	"	"
10.	"	4	"	"	"
11.	"	5	"	"	"
12.	"	6	"	"	"
13.	CRYOLAB SV3-812	1	"	"	"
14.	"	2	"	"	"
15.	"	3	"	"	"
16.	"	4	"	"	"
17.	"	5	"	"	"
18.	"	6	"	"	"
19.					
20.					
21.					
22.					
23.					
24.					

Test Technician: L. Mc Knight — Test Engineer: T. Martinez

DESIGN VERIFICATION

TEST DATA SHEET

Type of Test Functional Date of Test 8-5-69

Part Name Seal-Off Valve Part Number 7089-1

Test Procedure 8-440091 Para 5.2 Part Serial Number 1 thru 6

A. Leakage

Leak Rate Before Cycling $<1x10^{-10}$ scc/sec

Leak Rate After Cycling $<1x10^{-10}$ scc/sec

Remarks

1. This test performed following Proof Pressure Test (Para. 5.3). No detectable leakage.

B. Cycle

(One Open, One Closed)

Test Technician L. McKnight

Test Engineer J. Martinez

DESIGN VERIFICATION

TEST DATA SHEET

Type of Test: Functional — Date of Test: 8-5-69

Part Name: Seal-Off Valve — Part Number: 7079-1

Test Procedure: 8-440091 Para 5.2 — Part Serial Number: 1 thru 6

A. Leakage

Leak Rate Before Cycling $<1x10^{-10}$ scc/sec

Leak Rate After Cycling $<1x10^{-10}$ scc/sec

Remarks

1. This test performed following Proof Pressure Test (Para. 5.3). No detectable leakage.

B. Cycle

(One Open, One Closed)

Test Technician L. McKnight

Test Engineer J. Martin

DESIGN VERIFICATION

TEST DATA SHEET

Type of Test Functional Date of Test 8-5-69

Part Name Seal-Off Valve Part Number SV3-812

Test Procedure 8-440091 Para 5.2 Part Serial Number 1 thru 6

A. Leakage

Leak Rate Before Cycling $< 1 \times 10^{-10}$ scc/sec

Leak Rate After Cycling $< 1 \times 10^{-10}$ scc/sec

Remarks

1. This test performed following Proof Pressure Test (Para. 5.3) No detectable leakage.

B. Cycle

(One Open, One Closed)

Test Technician L. McKnight

Test Engineer J. Martins

2.2.1.6.4 Salt Fog Test

Requirement

The Salt Fog Test was performed to determine the resistance of the test item to a salt fog atmosphere.

Procedure

The test was conducted in accordance with Section 17 of KSC-STD-164D. Prior to installation in the test chamber, the test item was visually inspected for corrosion, dirt, and oily film. The location and extent of corrosion was recorded and contaminants removed. Figure 21 shows the schematic of the Salt Fog Test setup.

The test item was installed in the test chamber in accordance with Paragraph 4.4.1 of KSC-STD-164D. The test item was in the closed position with the protective covers in place.

After 240 ±2 hours of exposure in a salt fog of 5% salt and 95% water at 95 +2/-4°F, the test item was allowed to stand until thoroughly dry.

The test item was photographed at the conclusion of the test while in the test position. The item was visually inspected for corrosion and the location and extent of corrosion recorded.

Test Results

Inspection of the specimens showed superficial corrosion on interface welds and vent port caps (see Figure 24). This appeared to be the result of tramp iron deposits caused during fabrication and assembly. The unplated brass handles showed excessive oxidation. Normally, these handles would be plated. (A plated handle was tested and it showed no oxidation at all.)

The handle-locking screw was left loose on two valves and moisture was able to accumulate in the well above the Wilson Stem Seal. This was not detrimental since corrosion did not occur and all valves passed functional leak testing. Leak rate was 1×10^{-10} scc/sec of helium (Figures 22, 23, 24, and 25 show the specimen before and after the salt fog test).

Test Data

The following data sheets reflect the results of the Salt Fog Test and the functional leak tests which followed.

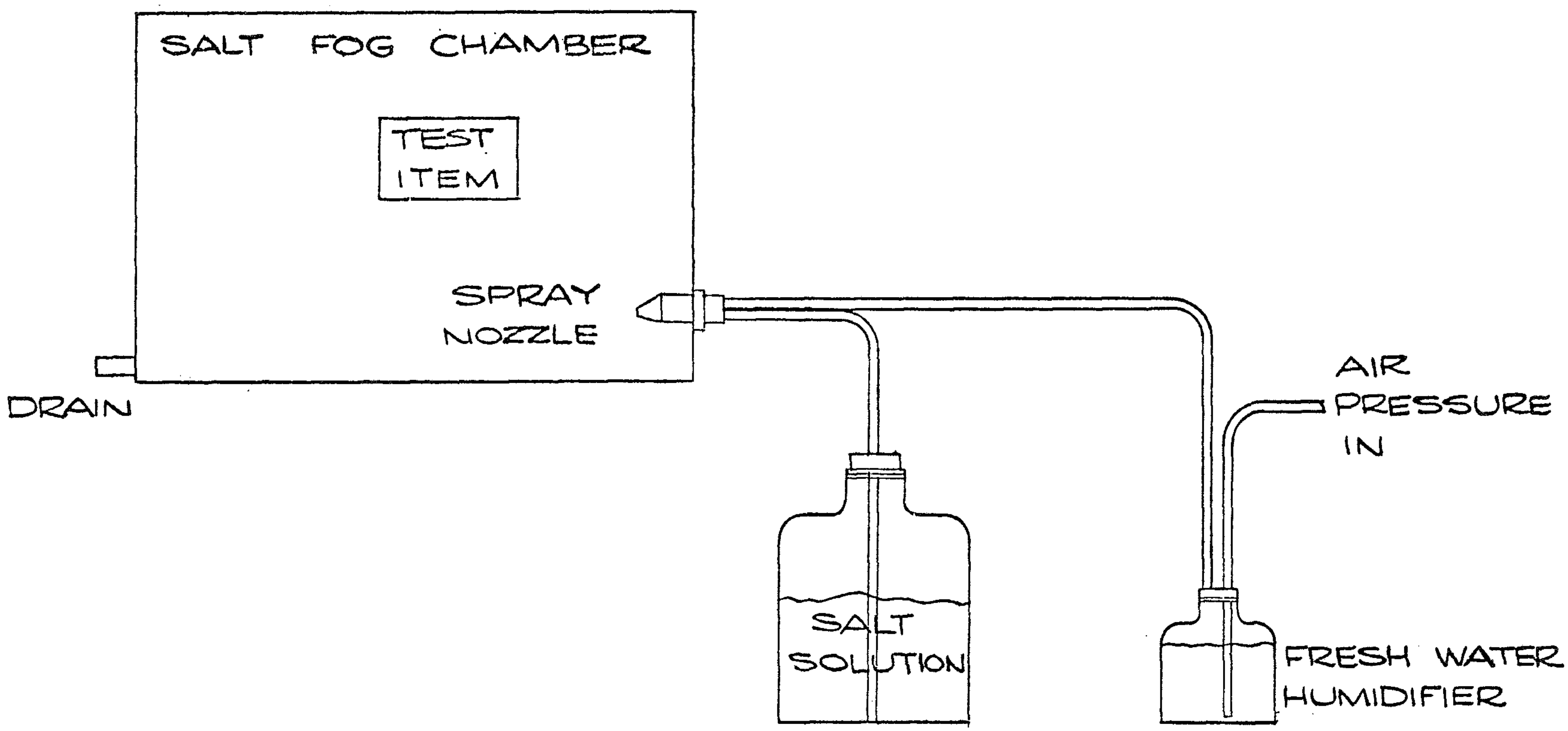


Figure 21. Salt Fog Test Set-up

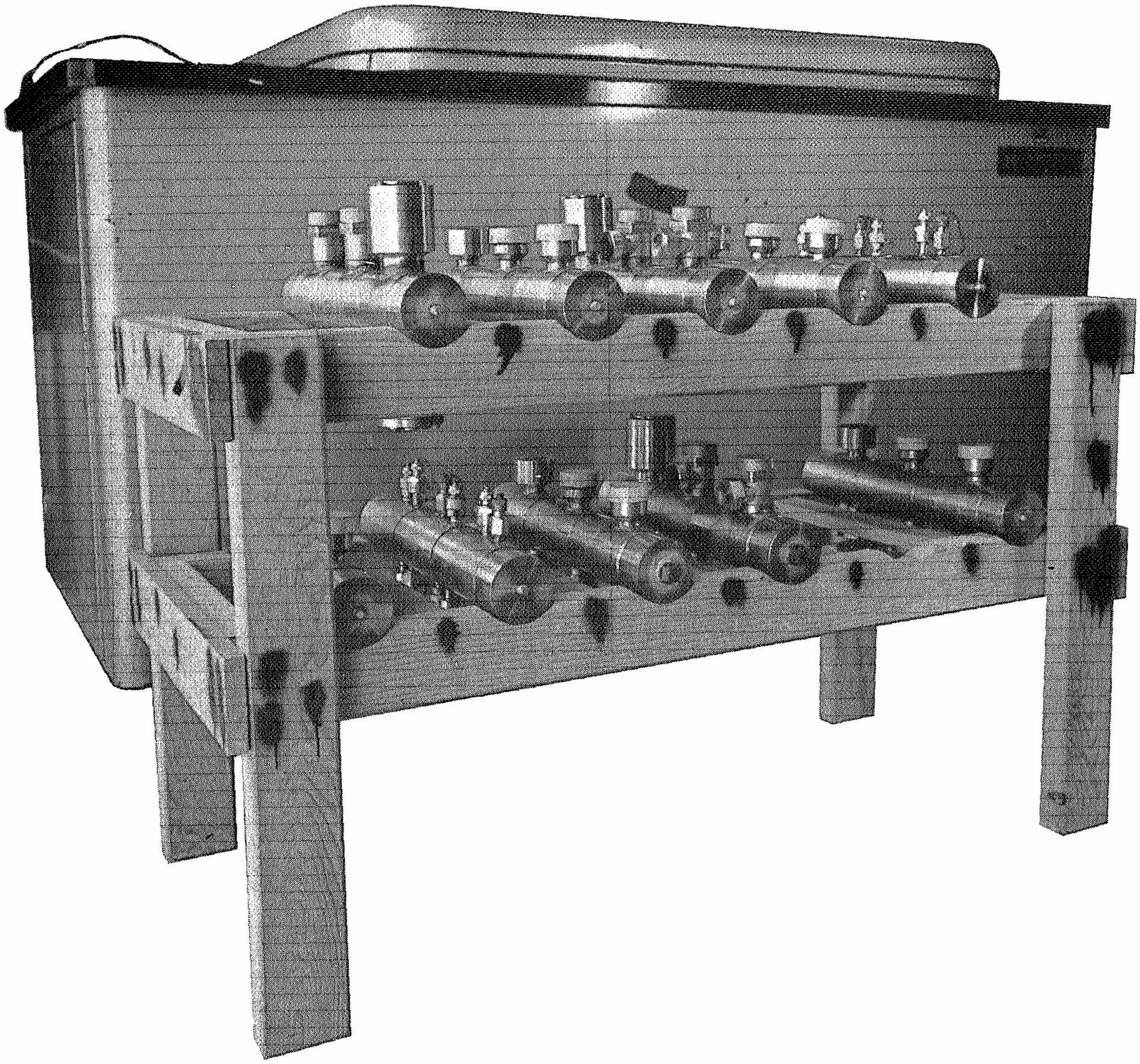
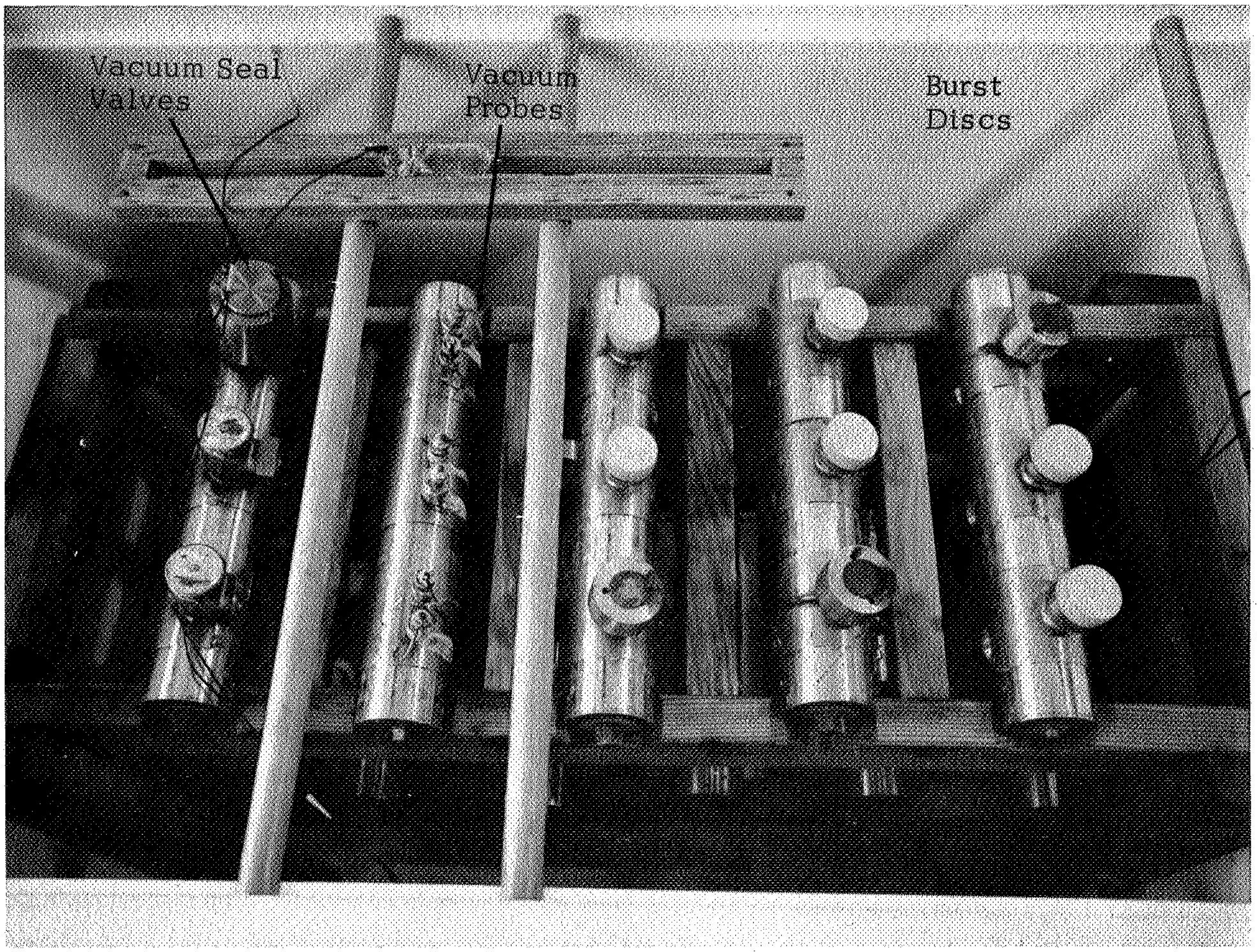


Figure 22. Salt Fog Test Chamber and Test Manifold Support Rack

Specimens Shown Inside of Salt Fog Chamber

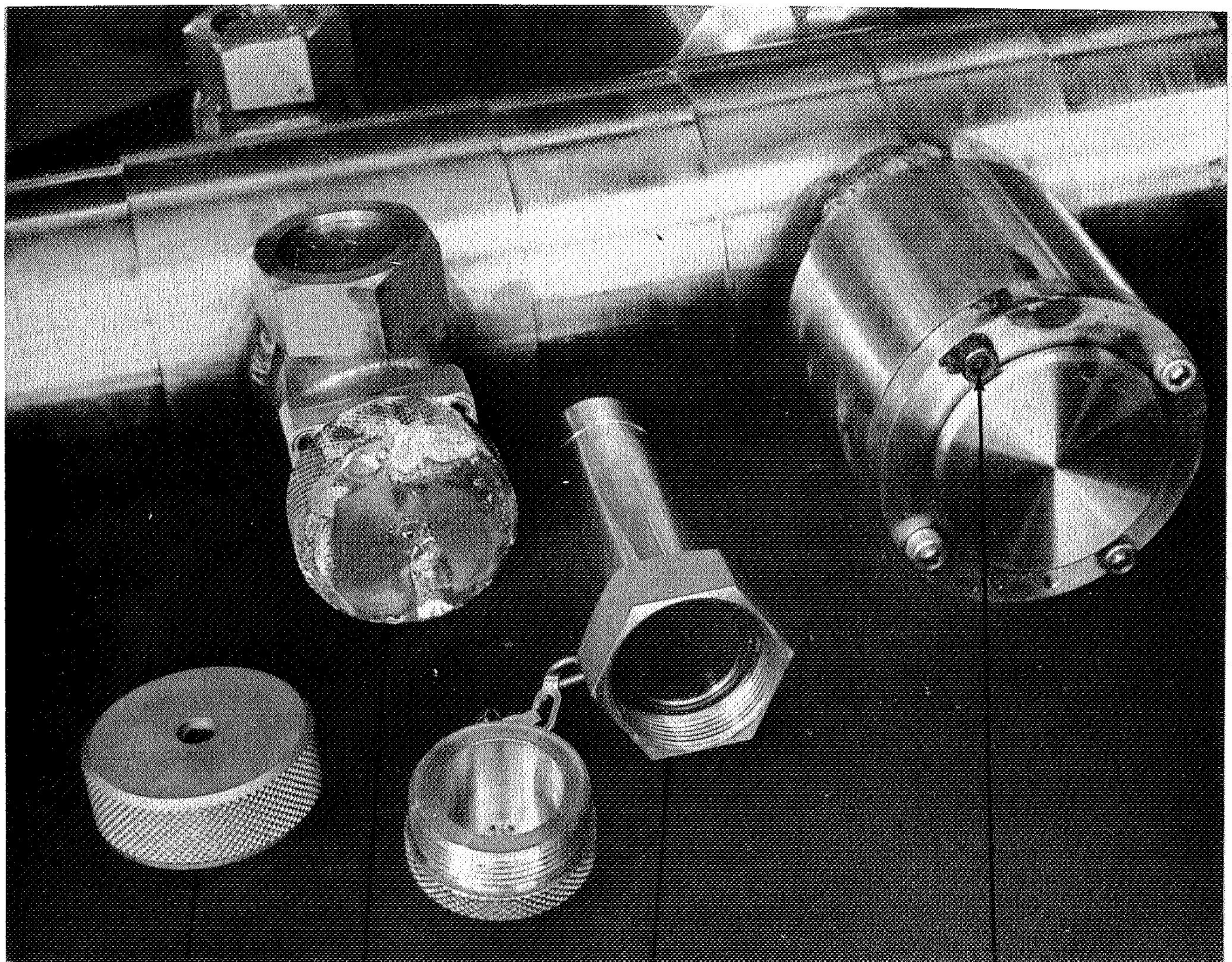


Note Drainage on Vacuum Probe's Manifold From Caps

Note Drainage On Burst Discs From Interface Weld and Spanner Wrench Holes

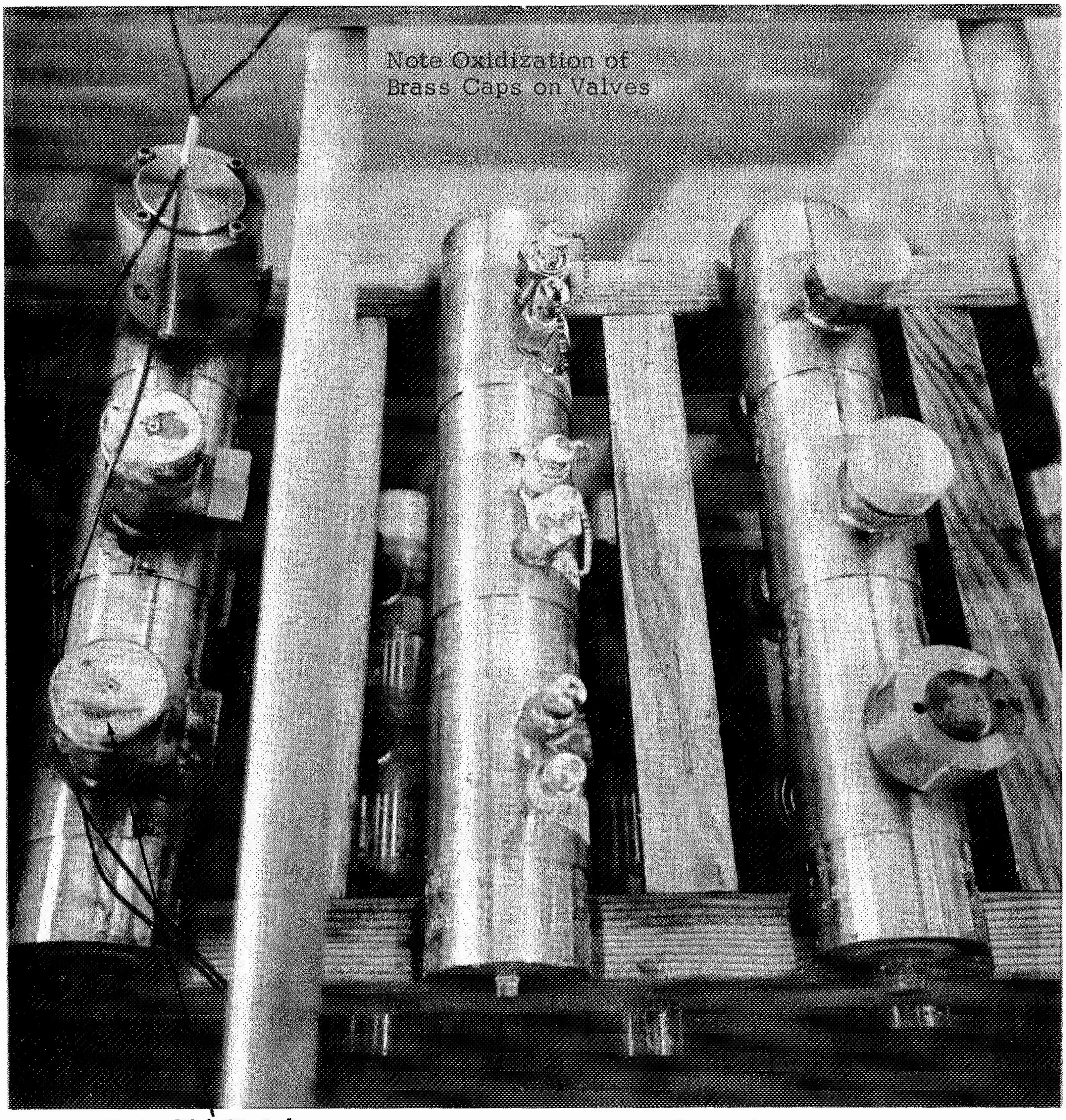
Test Manifolds Following Salt Fog Test
(Vacuum Probes, Vacuum Seal Valves, and Burst Discs)

Figure 23. Test Manifold on Support Rack - Salt Fog Test



Vacuum Seal Valves And Accessories
Following Salt Fog Test

Figure 24. Vacuum Seal Valves and Accessories - Salt Fog Test



Note 304 Stainless
Steel Port Cap
Corrosion

Note Drainage From
Vacuum Probe Caps

Vacuum Seal Valves, Vacuum Probes, and
Burst Discs Following Salt Fog Test

Figure 25. Vacuum Seal Valves - Probes and Burst Discs - Salt Fog Test

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test: Salt Fog — Date of Test: 8-12-69 - 8-22-69

Part Name: Vacuum Seal Valves — Part Number: As Shown

Test Procedure: 8-480091 — Part Serial Number: As Shown

Test Pressure: Amb. — Test Media: 5% Salt Sol — Duration of Test: 240 hrs.

	Manufacturer	Serial Number	Remarks
1.	CRYOLAB SV3-812	1	No Corrosion - No Detrimental Effect.
2.	"	2	No Corrosion - No Detrimental Effect
3.	"	3	" " "
4.	"	4	" " "
5.	"	5	" " "
6.	"	6	" " "
7.	CRYOLAB 7079-1	1	" " "
8.	"	2	
9.	"	3	" " "
10.	"	4	" " "
11.	"	5	" " "
12.	"	6	" " "
13.	CRYOLAB 7089-1	1	" " "
14.	"	2	" " "
15.	"	3	" " "
16.	"	4	" " "
17.	"	5	" " "
18.	"	6	" " "
19.			
20.			
21.			
22.			
23.			
24.			

Test Technician: C. McKNIGHT — Test Engineer: T.A. Martins

DESIGN VERIFICATION

TEST DATA SHEET

Type of Test: Functional — Date of Test: 8-25-69

Part Name: Seal-Off Valve — Part Number: Cryolab 7089-1

Test Procedure: 8-440091 Para 5.2 — Part Serial Number: 1 thru 6

A. Leakage

Leak Rate Before Cycling $<1\times10^{-10}$ scc/sec

Leak Rate After Cycling $<1\times10^{-10}$ scc/sec

Remarks

This test performed following Salt Fog Test (Paragraph 5.7)

B. Cycle

(One Open, One Closed)

Test Technician: L. McKnight

Test Engineer: J. Martins

DESIGN VERIFICATION

TEST DATA SHEET

Type of Test Functional   Date of Test 8-25-69

Part Name Seal-Off Valve   Part Number Cryolab 7079-1

Test Procedure 8-440091 Para 5.2   Part Serial Number 1 thru 6

A. Leakage   Remarks

Leak Rate Before Cycling $<1x10^{-10}$ scc/sec   This test was performed

Leak Rate After Cycling $<1x10^{-10}$ scc/sec   following Salt Fog Test

(Paragraph 5.7)

B. Cycle

(One Open, One Closed)

Test Technician L. McKnight

Test Engineer J. Martin

DESIGN VERIFICATION
TEST DATA SHEET

Type of Test: Functional — Date of Test: 8-25-69

Part Name: Seal-Off Valve — Part Number: Cryolab SV3-812

Test Procedure: 8-440091 Para 5.2 — Part Serial Number: 1 thru 6

A. Leakage

		Remarks
Leak Rate Before Cycling	$<1x10^{-10}$ scc/sec	This test was performed
Leak Rate After Cycling	$<1x10^{-10}$ scc/sec	following Salt Fog Test
		(Paragraph 5.7)

B. Cycle

(One Open, One Closed)

Test Technician: L. McKnight

Test Engineer: J. Martins

2.2.1.6.5 Sand and Dust Test

Requirement

The Sand and Dust Test was performed to determine the resistance of the test item to blowing fine sand and dust particles.

Procedure

The test was conducted in accordance with Section 16 of KSC-STD-164D. The test item was installed in the test chamber as shown in Figure 26 and in accordance with Paragraphs 3.4 and 4.4.1 of KSC-STD-164D with protective covers in place during the test. The test item was exposed to a sand and dust environment with a sand to air ratio of 0.1 to 0.25 grams per cubic foot and with an air velocity of from 100 to 500 feet per minute.

The test item was exposed to this environment for two hours at 77 ±2°F. The temperature was then raised to 160 ±2°F and the item tested under the same conditions for an additional two hours.

Three different times during the test, three test items of each configuration were cycled through one open-close cycle. The test items were wiped clean, and the protective covers were removed; the item was cycled and the protective covers replaced. This was accomplished by three different technicians. At the conclusion of the test the test item was returned to room ambient conditions and the functional leak test conducted.

The test chamber ambient temperature was continuously recorded. The sand to air ratio was measured at the beginning and at the conclusion of the test and every two hours during the test.

The identity of the test items cycled was recorded. The test items were photographed at the conclusion of the test.

Test Results

The sand and dust test was completed for all valves. Three valves of each type (7079 Serial No. 2, 3, and 4; 7089 Serial No. 2, 4, and 5; SV3-812 Serial No. 2, 3, and 5) were cycled once after the first and second hour and the fourth hour without any detectable contamination or leakage. Damage to the photo negative destroyed the photograph of this test.

At the end of the four-hour test all specimens were functionally leak tested with no detectable leakage. Leakage rate was $<1 \times 10^{-10}$ scc/sec of helium.

Test Data

The following data sheets reflect the results of the test conducted at Ogden Technology Laboratories, Monterey Park, California.

All testing performed following the Sand and Dust Test indicated no detectable leakage.

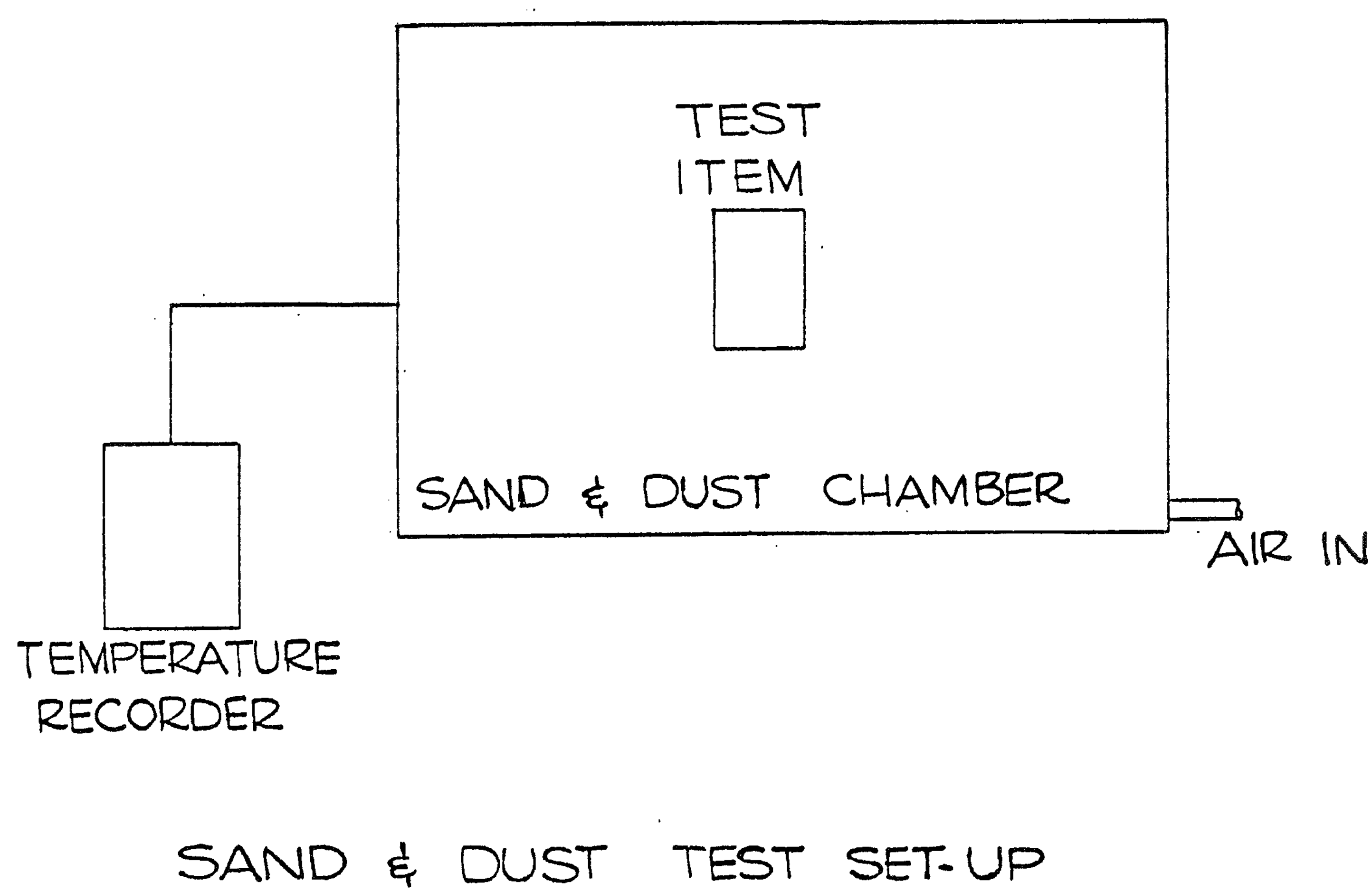


Figure 26. Sand and Dust Test Set-up

OGDEN TECHNOLOGY LABORATORIES, INC.
Subsidiary of Ogden Corporation

573 MONTEREY PASS ROAD, MONTEREY PARK, CALIFORNIA 91754
TELEPHONE: 213 - 299-4425 TWX: 213 - 233-3123

September 3, 1969

MONTEREY PARK DIVISION REPORT NUMBER M-69477
Ametek/Straza Purchase Order Number 73947

A. TEST: Sand & Dust Test

B. SAMPLE: (2) Vacuum Probes, (3) Vacuum Seal Valves, (5) Burst Discs

C. SPECIFICATION: Ametek/Straza Test Document No. 8-480090, 8-48009, 8-480087

D. RESULTS: This is to certify that the samples were subjected to the Sand & Dust Test according to the above Specifications and the following results recorded:

The samples met the requirements of the Sand & Dust Test. See Data Sheet for Performance Tests during the Sand & Dust Test.

OGDEN TECHNOLOGY LABORATORIES, INC.
Monterey Park Division

R. Short
Operations Manager

Subscribed and sworn to before me this 3rd day of September 1969.

OFFICIAL SEAL
JUDITH L. PITTS
NOTARY PUBLIC-CALIFORNIA
LOS ANGELES COUNTY
My Commission Expires Feb. 24, 1973

Judith L. Pitts, Notary Public in and for the County of Los Angeles. State of California.

OGDEN 0413

A. Darco
Quality Assurance Manager

Helmut A. Stegmeier
Project Engineer

rv

EQUIPMENT LIST

Apparatus	Calibration Date
OTL Sand & Dust Chamber .1 to .25 9/ft3 Control No. 2056	One Shot
General Radio Strobotac Model 631-BL 600 - 3600 rpm Control No. 5299	6 months Due 9-5-69
Leeds & Northrup Potentiometer Model 8360 .2% Accuracy, -100°F +500°F. Control No. 1016	12 months Due 4-4-70
Hygrodynamics Hygrometer Model 15-3001 0-100%, 0-140°F. Control No. 2194	12 months Due 7-8-70
Ashcroft Test Gauge Model 1279, Accuracy ± .25%, 0-30psig, Control No. 991	3 months Due 10-7-69
Minerva Stopwatch Accuracy 1%, 0-30psig, Control No. 415	6 months Due 2-18-70
CEC Leak Detector Model 24-120 Accuracy ± .25%, 1 x 10^{-10} cc/sec. 0-100,000 units Control No. 1465	Before Use

OGDEN TECHNOLOGY LABORATORIES, INC.

SAND AND DUST DATA SHEET

Date 8-29-69 Job Number M69477

Customer AMETEK/STRAZA Page Number

Specimen Vac. Seal Valves Part No. Serial No. As Noted on Funct. Data Sheets

Specification No. 8-480091 Para. No.

Preparation of Specimen(s) Three (3) Tube Assemblies

Protective Covering on Non-Tested Parts

Vents, Ports, Connectors, etc., Capped: Yes X No Remarks

Support Method One (1) Unit suspended vertically - two (2) horizontally

Orientation of Specimen(s)

Chamber Controls: Sand and Dust Density 0.1 to .25 grams/cubic foot

Wind Velocity 100 to 500 feet/minute

Relative Humidity < 30 % percent

Temperature 77°F °F

Elapsed Time (hours)	Sand and Dust Density (grams/cu.ft.)	Air Velocity (ft/minute)	Temperature (°F)	Relative Humidity (%)
1020	.25	375	76°F	< 30%
1120 *	.25	375	78	
1630	.25	375	78	< 30%
1730 *	.25	375	78	
12:10 9-2-69	.25	375	158	< 30%
14:10	.25	375	159	

REMARKS:

None

Interruptions during test (Explain): * Values cycled once

Results: Damage or Deformation: Yes No XX (Explain above)

Photograph taken: Yes XX No

Test Technician Phil Paredes Test Engineer H. A. Stegmeier

Inspector (Customer or U.S. Gov't) Joseph Martins

A. Darco

Q.A. Mgr. Signature

Date Started: 8-29-69	TEST DATA	Performed By: Martinez / Kunst
Date Completed: 8-29-69	Specimen Description: VAC. SEAL VALVES	OTL Q.A. H.A. Steegmeiher
Temp: AMB Humidity: AMB	Test: SAND AND DUST	Cust. Insp. T. Martinez
P/N: 7079-1 7089 SV3-812	Customer: STRAZA	Gov't. Insp. N/A
Spec: 8-480091	Para.: 5.8.2 S/N:	J/N: M 69477

Manifold S/N	Cycle open & close vacuum valve after 1st hour of sand and dust test.	
1	SV3 - 812	S/N 2
	7089-1	S/N 2
	7079-1	S/N 4
3	SV3 - 812	S/N 3 & 5
	7089-1	S/N 4 & 5
	7079-1	S/N 2 & 3
2	UNDISTURBED DURING LENGTH OF TEST	

Date Started: 9-2-69	TEST DATA	Performed By: Martinez/Kuntz
Date Completed: 9-2-69	Specimen Description: VAC. SEAL VALVES	OTL Q.A. H.A. Steckmeier
Temp: Amb. Humidity: Amb.	Test: SAND AND DUST	Cust. Insp. J. Martinez
P/N: 7079-1 7089-1	Customer: AMETEK/STRAZA	Gov't. Insp. n/a
Spec: SV3-812 8-480091	Para.: 5.8.2 S/N:	J/N: M 69477

Manifold S/N	Cycle open and close vacuum valve after 2nd hour of sand and dust test	
1	SV3-812	S/N 2
	7089-1	S/N 2
	7079-1	S/N 4
3	SV3-812	S/N 3 & 5
	7089-1	S/N 4 & 5
	7079-1	S/N 2 & 3
2	UNDISTURBED DURING LENGTH OF TEST	

DESIGN VERIFICATION
TEST DATA SHEET

Type of Test: Functional — Date of Test: 9-3-69

Part Name: Seal-Off Valve — Part Number: SV3-812

Test Procedure: 8-440091 Para 5.2 — Part Serial Number: 1 thru 6

A. Leakage — Remarks

Leak Rate Before Cycling $<1\times10^{-10}$ scc/sec — Performed following

Leak Rate After Cycling $<1\times10^{-10}$ scc/sec — "Sand and Dust Test"

B. Cycle

(One Open, One Closed)

Test Technician L. McKnight

Test Engineer T. Martinez

DESIGN VERIFICATION

TEST DATA SHEET

Type of Test: Functional | Date of Test: 9-3-69

Part Name: Seal-Off Valve | Part Number: 7089-1

Test Procedure: 8-440091 Para 5.2 | Part Serial Number: 1 thru 6

A. Leakage | Remarks

Leak Rate Before Cycling $< 1x10^{-10}$ scc/sec | Performed following

Leak Rate After Cycling $< 1x10^{-10}$ scc/sec | "Sand and Dust Test"

B. Cycle

(One Open, One Closed)

Test Technician L. McKnight

Test Engineer T. Martinez

DESIGN VERIFICATION

TEST DATA SHEET

Type of Test Functional Date of Test 9-3-69

Part Name Seal-Off Valve Part Number 7079-1

Test Procedure 8-440091 Para 5.2 Part Serial Number 1 thru 6

A. Leakage

Remarks

Leak Rate Before Cycling $<1 \times 10^{-10}$ scc/sec Performed following

Leak Rate After Cycling $<1 \times 10^{-10}$ scc/sec "Sand and Dust Test"

B. Cycle

(One Open, One Closed)

Test Technician L. McKnight

Test Engineer T. Martins

2.2.1.6.6 Life Cycle Test

Requirement

The life cycle test, which consisted of 500 open-close cycles, was performed to determine the reliability of the sealing materials to be tested and the leakage-free pumpdown capability of the valve stem seal.

Procedure

The cycle life test was conducted on all test items using seal materials in accordance with the following plan:

Test Item: Part No. 7079 (No Relief)

3 each with Viton V655-75 seal material
3 each with Butyl B612-7 seal material

Test Item: Part No. 7089 (With Relief)

3 each with Viton A seal material
3 each with Ethylene Propylene E603-7 seal material

Test Item: Part No. SV3-812-5W2

3 each with Viton V655-75 seal material
3 each with Butyl B-612-7 seal material

Each test item was identified showing the seal material installed. Each test item was cycled through 500 open-close cycles.

At the conclusion of the life cycle test a functional test was performed and the test data recorded.

Test Results

Each valve was manually cycled open and closed for a total of 500 cycles each. TheCryolab 7079 and 7089 valves with integral operators were cycled without any problem.

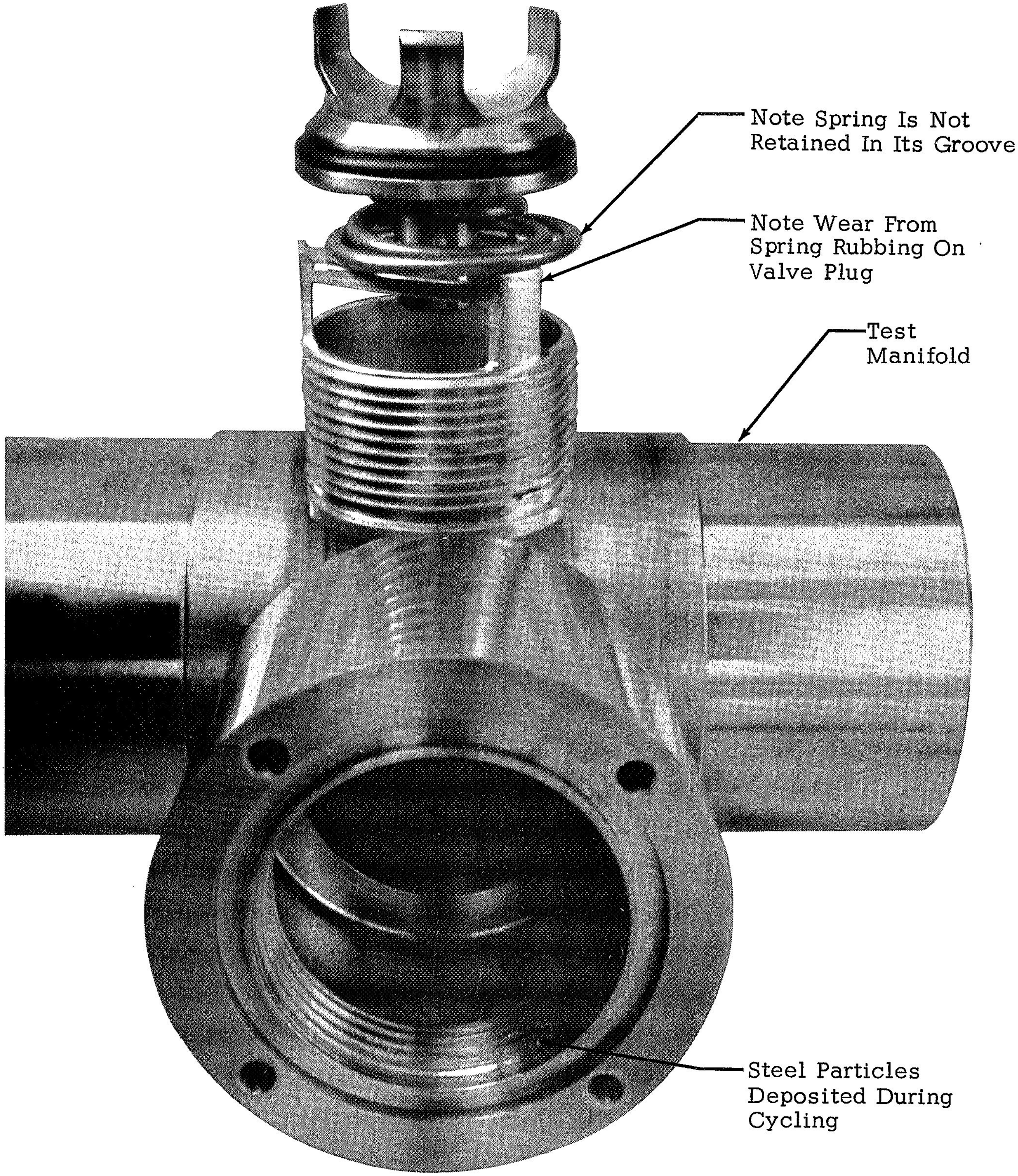
All Cryolab SV3-812 valves deposited metal chips on the inner surface of the valve (see Figure 27). (Cryolab SV3-812 valves require an externally introduced operator for opening and closing.) These metal chips were caused by a rotation of the relief spring. The relief spring is assembled on the valve plug and retained in a groove just above the valve disc main O-ring seal. When the main seal seats during closure, a maximum of four turns are still required to close the valve and enable the valve relief cap to be bolted on after closure. With the disc fully seated, the additional turns of the valve plug cause the spring to rotate in its retainer groove abraiding the metal from the valve plug. After as few as two cycles, metal chips are generated at the spring and body interface. From the point of generation, they migrate to the adjacent valve seal and inbed themselves in the sealing surface at the next valve cycle.

The functional test following the cycling test indicated a leak rate of $<1 \times 10^{-10}$ scc/sec He for all valves tested except one. Cryolab 7089-1 Serial No. 2 leaked as the result of a defective Viton A O-ring.

During the functional leak test, a valve stem leak rate test was made to ensure valve pumpdown capability following the cycling test. Two valves leaked during this test due to loose stem packing retainer nuts (Cryolab 7079 Serial Nos. 3 and 4). The packing nut was tightened on these valves and the leakage rate was $<1 \times 10^{-10}$ scc/sec He.

Test Data

The following test data sheets reflect the results of cycling tests and functional leak test which followed.



Cryolab SU3-812 Vacuum Seal Valve Following Cycling Test

Figure 27. Vacuum Seal Valve Following Cycling Test

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test Cycle Life Date of Test

Part Name Seal - Off Valve Part Number

Test Procedure 8-440091, Paragraph 5.4 Serial Number

Test Manifold No. 1

Valve Type	Serial Number	Seal Type
7079-1	4	Viton V655-75
7079-1	5	Viton V655-75
7089-1	2	Viton A
7089-1	6	Viton A
SV3-812	2	Viton V655-75
SV3-812	6	Viton V655-75

Test Manifold No. 2

7079-1	1	Butyl B612-7
7079-1	6	Viton V655-75
7089-1	1	Viton A
7089-1	3	E603-7
SV3-812	1	Butyl B612-7
SV3-812	4	Viton V655-75

Test Manifold No. 3

7079-1	2	Butyl B612-7
7079-1	3	Butyl B612-7
7089-1	4	E603-7
7089-1	5	E603-7
SV3-812	3	Butyl 612-7
SV3-812	5	Butyl 612-7

Test Technician S. Amore Test Engineer J. Martin

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test: Cycle Life

Date of Test: 9-28-69

Part Name: Seal-off Valve

Part Number: As Shown

Test Procedure: 8-440091, Para 5.4

Part Serial Number: As Shown

Type of Seal: E603-7

Material Installed: Ethylene Propyl.

Number of Cycles: 500 ea.

Remarks

Cryolab 7089-1 S/N 3

4

5

No detrimental effect due to cycling.

Test Technician: J. Martinez

Test Engineer: J. Martinez

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test: Cycle Life — Date of Test: 9-28-69

Part Name: Seal-off Valve — Part Number: As shown

Test Procedure: 8-440091, Para 5.4 — Part Serial Number: As shown

	Remarks
Type of Seal: B612-7	Cryolab 7079-1 S/N 1
Material Installed: Butyl	2
Number of Cycles: 500 ea.	3
	Cryolab SV3-812 1
	3
	5
	No detrimental effect due to cycling.

Test Technician: J. Martinez

Test Engineer: J. Martinez

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test: Cycle Life — Date of Test: 9-28-69

Part Name: Seal-off Valve — Part Number: As shown

Test Procedure: 8-440091, Para 5.4 — Part Serial Number: As shown

Type of Seal: V655-75

Material Installed: Viton

Number of Cycles: 500 ea.

Remarks

Cryolab SV3-812	S/N 2
	4
	6
Cryolab 7079-1	2
	4
	6

No detrimental effect due to cycling.

Test Technician: J. Martinez

Test Engineer: J. Martinez

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test: Cycle Life — Date of Test: 9-28-69

Part Name: Seal-off Valve — Part Number: As shown

Test Procedure: 8-440091, Para 5.4 — Part Serial Number: As shown

	Remarks
Type of Seal: V77-545	Cryolab 7089-1 S/N 1
Material Installed: Viton A	4
Number of Cycles: 500 ea.	5
	No detrimental effect due to cycling.

Test Technician: J. Martinez

Test Engineer: J. Martinez

DESIGN VERIFICATION

TEST DATA SHEET

Type of Test: Functional — Date of Test: 9-23-69

Part Name: Seal-Off Valve — Part Number: Cryolab 7089-1

Test Procedure: 8-440091 Para 5.2 — Part Serial Number: 1,3,4,5, & 6

A. Leakage

Leak Rate Before Cycling $<1x10^{-10}$ scc/sec

Leak Rate After Cycling $<1x10^{-10}$ scc/sec

B. Cycle

(One Open, One Closed)

C. Valve Stem

Leak Rate After Cycling

$<1 \times 10^{-10}$ scc/sec He.

Remarks

1. This test performed following cycling test (500 cycles).

2. Valve Stem was leak tested during this functional test to insure valve pumpdown capability following cycling test.

Test Technician: L. McKnight

Test Engineer: J. Martins

DESIGN VERIFICATION

TEST DATA SHEET

Type of Test: Functional — Date of Test: 9-23-69

Part Name: Seal-Off Valve — Part Number: Cryolab SV3-812

Test Procedure: 8-440091 Para 5.2 — Part Serial Number: 1,2,3,4,5, & 6

A. Leakage — Remarks

Leak Rate Before Cycling $<1\times10^{-10}$ scc/sec — 1. This test performed following cycling test (500 cycles).

Leak Rate After Cycling $<1\times10^{-10}$ scc/sec

B. Cycle

(One Open, One Closed)

Test Technician: L. McKnight

Test Engineer: J. Martin

DESIGN VERIFICATION

TEST DATA SHEET

Type of Test Functional Date of Test 9-23-69

Part Name Seal-Off Valve Part Number Cryolab 7089-1

Test Procedure 8-440091 Para 5.2 Part Serial Number 2

A. Leakage

Leak Rate Before Cycling $>1\times10^{-7}$ scc/sec

Leak Rate After Cycling ______

B. Cycle

(One Open, One Closed)

______

C. Valve Stem

Leak Rate after cycling test

$< 1 \times 10^{-10}$ scc/sec He.

Remarks

1. This test performed following cycling test. (500 cycles).
2. Leakage due to damaged Viton "A" Seal. Examination revealed four (4) circumferential cracks.
3. Seal Replaced. Leakage $< 1 \times 10^{-10}$ scc/sec He.

NOTE: Valve stem leak tested following cycling test to validate stem seal.

Test Technician L. McKnight

Test Engineer J. Martin

DESIGN VERIFICATION

TEST DATA SHEET

Type of Test Functional · Date of Test 9-23-69

Part Name Seal-Off Valve Part Number Cryolab 7079-1

Test Procedure 8-440091 Para 5.2 Part Serial Number 1,2,5,6

A. Leakage

Leak Rate Before Cycling $<1\times10^{-10}$ scc/sec

Leak Rate After Cycling $<1\times10^{-10}$ scc/sec

B. Cycle

(One Open, One Closed)

C. Valve Stem

Leak rate after cycling

$<1 \times 10^{-10}$ scc/sec He

Remarks

1. This test performed following cycling test. (500 cycles).

2. Valve stem was leak tested during this functional test to insure valve pumpdown capability following cycling test.

Test Technician L. McKNIGHT

Test Engineer J. Martinez

DESIGN VERIFICATION

TEST DATA SHEET

Type of Test Functional Date of Test 9-23-69

Part Name Seal-Off Valve Part Number Cryolab 7079-1

Test Procedure 8-440091 Para 5.2 Part Serial Number 3 & 4

A. Leakage

Leak Rate Before Cycling $<1 \times 10^{-10}$ scc/sec

Leak Rate After Cycling $<1 \times 10^{-10}$ scc/sec

Remarks

1. This test performed following cycling test. (500 cycles)

*Stem Packing retainer nut required tightening following cycling (500 cycles)

B. Cycle

(One Open, One Closed)

C. Valve Stem

Leak Rate after cycling test

$< 1 \times 10^{-10}$ scc/sec *

Test Technician L. McKnight

Test Engineer J. Martinez

2.2.1.6.7 Leakage Test — Elevated Temperature

Requirement

This test was performed to verify that the test item would function during a high temperature environment.

Procedure

The test item was installed in the environmental chamber as shown in Figure 28 and in accordance with Paragraphs 3.4 and 4.4.1 of KSC-STD-164D.

A thermocouple was attached to the largest mass of the test item. A helium mass spectrometer was connected to the test item. The temperature in the chamber was increased until the test item temperature was stabilized at +200 +10/-0°F. The test item was then evacuated and helium gas introduced into the chamber. The leak rate was not to exceed 1 x 10^{-7} std cc/sec of He.

The stabilized temperature of the test item and the leak rate were recorded. The test item was photographed while in the test position. When the test item had returned to room ambient conditions, it was visually inspected for defects as a result of the test. A functional test was performed and the test data recorded.

Test Results

Each valve was helium leak tested while subjected to a temperature of +200°F (see Figure 29).

The Vitons (A and V655-75) leaked at a rate of 1.2 x 10^{-7} scc/sec of helium. Ethylene Propylene leaked at a rate of 1 x 10^{-6} scc/sec of helium. Butyl leaked at a rate of 1 x 10^{-7} scc/sec of helium. Leakage allowable was 1 x 10^{-7} scc/sec He.

Following the high temperature leak test, the specimens were allowed to cool to room temperature and a functional leak test was performed. Leakage rate for this test was 1 x 10^{-10} scc/sec He.

Vitons were marginal at +200°F. Ethylene Propylene Helium permeability is excessive above +180°F. Butyl met all test criteria temperatures.

Test Data

The following test data shows the results of the high temperature leakage test and functional leak test.

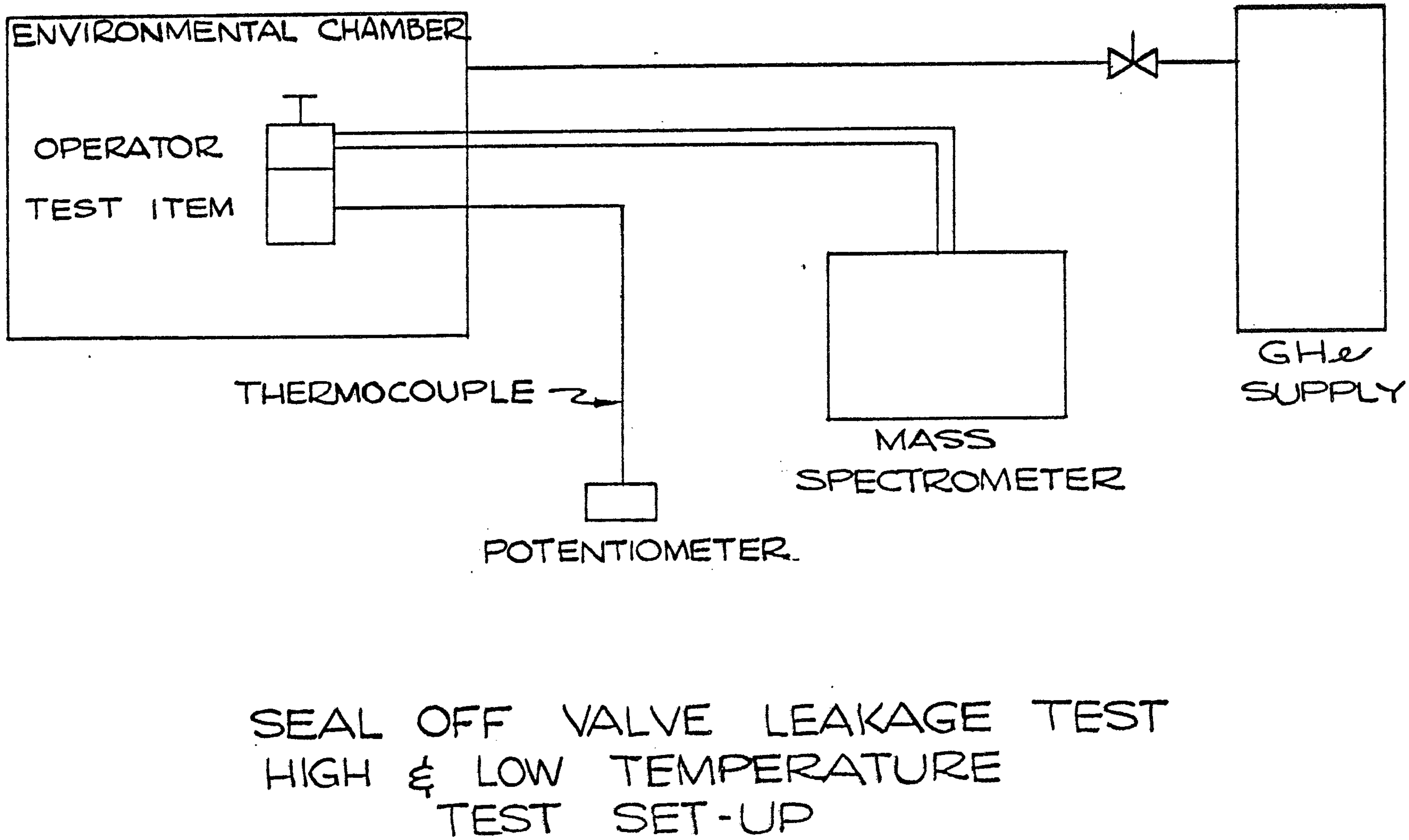
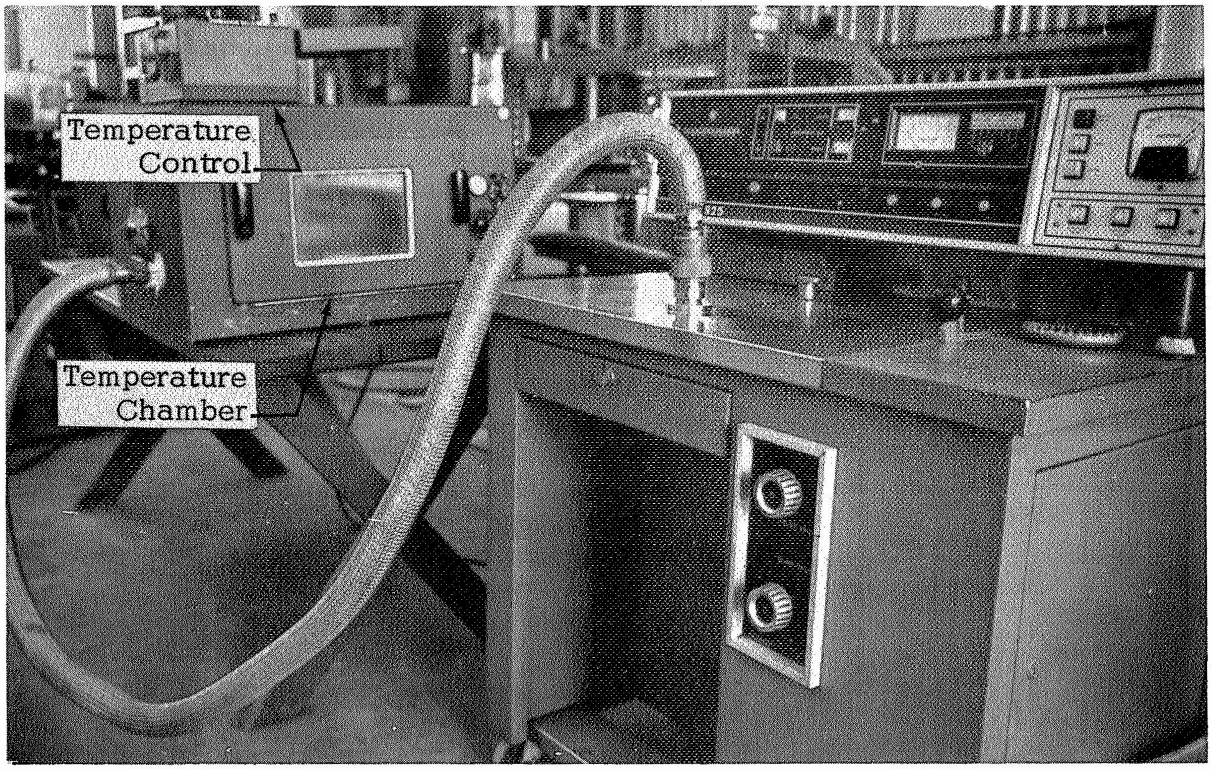
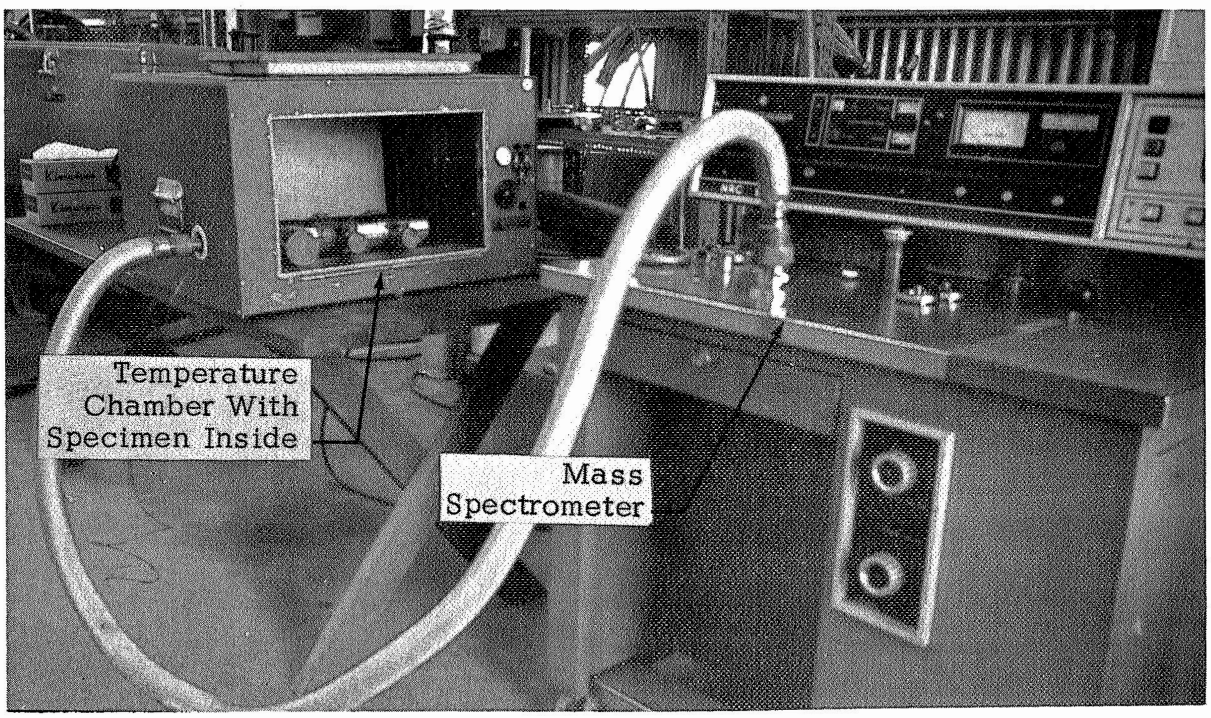


Figure 28. High and Low Temperature Test Set-up



Vacuum Seal Valve High Temperature Test Setup
(Test In Progress)



Vacuum Seal Valve High Temperature Test
(Conclusion Of Test)

Figure 29. High Temperature Test Photograph

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test: High Temperature

Date of Test: 9-24-69

Part Name: Vac Seal Valves

Part Number: Cryolab SV3-812

Test Procedure: 8-480091 Para. 5.5

Part Serial No.: 5

Test Temperature: + 200°F

Duration of Test: 5 Min.

Visually Inspect: ____

Type Seal: Butyl B612-7

Leakage Allowed: $< 1 \times 10^{-7}$ scc/sec

REMARKS

This test performed after "Cycling Test (500 Cycles)"

Leakage: 4×10^{-8} scc/sec He (1 Min)

6×10^{-8} scc/sec He (2 Min)

8×10^{-8} scc/sec He (3 Min)

8×10^{-8} scc/sec He (4 Min)

9×10^{-8} scc/sec He (5 Min)

9×10^{-8} STABILIZED

Test Technician: S. H. Moore

Test Engineer: J. Martins

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test: High Temperature

Date of Test: 9-24-69

Part Name: Vac Seal Valves

Part Number: Cryolab 7079-1

Test Procedure: 8-480091 Para. 5.5

Part Serial No.: 3

Test Temperature: + 200°F

Duration of Test: 5 Min.

Visually Inspect: ____

Type Seal: Butyl B612-7

Leakage Allowed: $< 1 \times 10^{-7}$ scc/sec

REMARKS

This test performed after "Cycling Test (500 Cycles)"

Leakage: 1×10^{-9} scc/sec He (1 Min)

2×10^{-9} scc/sec He (2 Min)

6×10^{-9} scc/sec He (3 Min)

1.6×10^{-8} scc/sec He (4 Min)

$2 \times 4 \times 10^{-8}$ scc/sec He (5 Min)

3.6×10^{-8} STABILIZED

Test Technician: S. H. Moore

Test Engineer: T. Martin

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test: High Temperature

Part Name: Vac Seal Valves

Test Procedure: 8-480091 Para. 5.5

Date of Test: 9-24-69

Part Number: Cryolab 7079

Part Serial No.: 4, 5, & 6

Test Temperature: + 200°F

Duration of Test: 5 Min.

Visually Inspect: ______

Type Seal: Viton V655-75

Leakage Allowed: $< 1 \times 10^{-7}$ scc/sec

REMARKS

This test performed after "Cycling Test (500 Cycles)"

S/N 5 Leakage: 1.3×10^{-7} scc/sec He

S/N 4 Leakage: 1.2×10^{-7} scc/sec He

S/N6 Leakage: 1×10^{-6} scc/sec He

Test Technician: S. H. Moore

Test Engineer: J. Martin

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test High Temperature

Part Name Vac Seal Valves

Test Procedure 8-480091 Para. 5.5

Date of Test 9-24-69

Part Number Cryolab SV3-812

Part Serial No. 3

Test Temperature + 200°F

Duration of Test 5 Min.

Visually Inspect

Type Seal Butyl B612-7

Leakage Allowed $< 1 \times 10^{-7}$ scc/sec

REMARKS

This test performed after "Cycling Test (500 Cycles)"

Leakage: 1×10^{-8} scc/sec He (1 Min)

3×10^{-8} scc/sec He (2 Min)

3×10^{-8} scc/sec He (3 Min)

6×10^{-8} scc/sec He (4 Min)

8×10^{-8} scc/sec He (5 Min)

8×10^{-8} STABILIZED

Test Technician S.H. Moore Test Engineer V. Martinez

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test High Temperature

Date of Test 9-24-69

Part Name Vac Seal Valves

Part Number Cryolab SV3-812

Test Procedure 8-480091 Para. 5.5

Part Serial No. 2 - 6

Test Temperature + 200°F

Duration of Test 5 Min.

Visually Inspect

Type Seal Viton V655-75

Leakage Allowed $< 1 \times 10^{-7}$ scc/sec

REMARKS

This test performed after "Cycling Test (500 Cycles)"

S/N 2 Leakage: 1.2×10^{-7} scc/sec He

S/N 6 Leakage: 1.4×10^{-7} scc/sec He

Test Technician S. H. Moore Test Engineer J. Martinez

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test: High Temperature

Date of Test: 9-25-69

Part Name: Vac Seal Valves

Part Number: Cryolab SV3-812

Test Procedure: 8-480091 Para. 5.5

Part Serial No.: 1

Test Temperature: + 200°F

Duration of Test: 5 Min.

Visually Inspect:

Type Seal: Butyl B612-7

Leakage Allowed: $< 1 \times 10^{-7}$ scc/sec

REMARKS

This test performed after "Cycling Test (500 Cycles)"

Leakage: $< 1 \times 10^{-7}$ scc/sec He

Test Technician: S. H. Moore

Test Engineer: J. Martinez

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test High Temperature

Date of Test 9-25-69

Part Name Vac Seal Valves

Part Number Cryolab SV3-812

Test Procedure 8-480091 Para. 5.5

Part Serial No. 4

Test Temperature + 200^{o}F

Duration of Test 5 Min.

Visually Inspect

Type Seal Viton V655-75

Leakage Allowed < 1 x 10^{-7} scc/sec

REMARKS

This test performed after "Cycling Test (500 Cycles)"

132^{o}F - Leakage started

148^{o}F	2 x 10^{-8}	scc/sec He		
154^{o}F	3.2 x 10^{-8}	scc/sec He		
165^{o}F	5 x 10^{-8}	"	"	"
183^{o}F	2.1 x 10^{-7}	"	"	"
190^{o}F	2.1 x 10^{-7}	"	"	"
197^{o}F	2.6 x 10^{-7}	"	"	"
200^{o}F	2.6 x 10^{-7}	"	"	"

Test Technician S.H. Moore

Test Engineer J. Masting

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test: High Temperature

Part Name: Vac Seal Valves

Test Procedure: 8-480091 Para. 5.5

Date of Test: 9-25-69

Part Number: Cryolab 7089

Part Serial No.: 3, 4, & 5

Test Temperature: + 200°F

Duration of Test: 5 Min.

Visually Inspect:

Type Seal: E.P. E603-7*

Leakage Allowed: $< 1 \times 10^{-7}$ scc/sec

REMARKS

This test performed after "Cycling Test (500 Cycles)"

Leakage: 1×10^{-6} scc/sec He

* Ethylene Propylene

Test Technician: S.H. Moore   Test Engineer: T. Martin

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test: High Temperature

Date of Test: 9-25-69

Part Name: Vac Seal Valves

Part Number: Cryolab 7089

Test Procedure: 8-480091 Para. 5.5

Part Serial No.: 1,2, & 6

Test Temperature: + 200°F

Duration of Test: 5 Min.

Visually Inspect: ______

Type Seal: Viton A

Leakage Allowed: $< 1 \times 10^{-7}$ scc/sec

REMARKS

This test performed after "Cycling Test (500 Cycles)"

S/N_1 Leakage: 1×10^{-6} scc/sec He

S/N_2 Leakage: 1.3×10^{-7} scc/sec He

S/N_6 Leakage: 1.2×10^{-7} scc/sec He

Test Technician: S. H. MOORE Test Engineer: J. Martinez

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test High Temperature

Date of Test 9-25-69

Part Name Vac Seal Valves

Part Number Cryolab 7079

Test Procedure 8-480091 Para. 5.5

Part Serial No. 1

Test Temperature + 200°F

Duration of Test 5 Min.

Visually Inspect

Type Seal Butyl B612-7

Leakage Allowed $< 1 \times 10^{-7}$ scc/sec

REMARKS

This test performed after "Cycling Test (500 Cycles)"

Leakage: $< 1 \times 10^{-7}$ scc/sec He

Test Technician S.H. Moore Test Engineer J. Martinez

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test: High Temperature

Part Name: Vac Seal Valves

Test Procedure: 8-480091 Para. 5.5

Date of Test: 9-24-69

Part Number: Cryolab 7079

Part Serial No.: 2

Test Temperature: + 200°F

Duration of Test: 5 Min.

Visually Inspect:

Type Seal: Butyl B612-7

Leakage Allowed: $< 1 \times 10^{-7}$ scc/sec

REMARKS

This test performed after "Cycling Test (500 Cycles)"

Leakage: 1.6×10^{-8} scc/sec He (1 Min)

2.6×10^{-8} scc/sec He (2 Min)

5.0×10^{-8} scc/sec He (3 Min)

6.0×10^{-8} scc/sec He (4 Min)

7.0×10^{-8} scc/sec He (5 Min)

7.0×10^{-8} stabilized

Test Technician: S. H. Moore

Test Engineer: V. Martinez

DESIGN VERIFICATION
TEST DATA SHEET

Type of Test Functional Date of Test 9-28-69

Part Name Seal-Off Valve Part Number Cryolab 7089-1

Test Procedure 8-440091 Para 5.2 Part Serial Number 1,2,3,4,5, & 6

A. Leakage — Remarks

Leak Rate Before Cycling $<1\times10^{-10}$ scc/sec — This test performed

Leak Rate After Cycling $<1\times10^{-10}$ scc/sec — following "Leakage

Test - Elevated Temp"

Para. 5.5

B. Cycle

(One Open, One Closed)

Test Technician S. H. Moore

Test Engineer J. Martins

DESIGN VERIFICATION

TEST DATA SHEET

Type of Test Functional Date of Test 9-23-69

Part Name Seal-Off Valve Part Number Cryolab 7079-1

Test Procedure 8-440091 Para 5.2 Part Serial Number 1,2,3,4,5, & 6

A. Leakage

Leak Rate Before Cycling $<1\times10^{-10}$ scc/sec

Leak Rate After Cycling $<1\times10^{-10}$ scc/sec

Remarks

This test performed following "Leakage Test - Elevated Temp" Para. 5.5

B. Cycle

(One Open, One Closed)

Test Technician S. H. Moore

Test Engineer J. Martinez

DESIGN VERIFICATION
TEST DATA SHEET

Type of Test: Functional — Date of Test: 9-23-69

Part Name: Seal-Off Valve — Part Number: Cryolab SV3-812

Test Procedure: 8-440091 Para 5.2 — Part Serial Number: 1,2,3,4,5 & 6

A. Leakage

Leak Rate Before Cycling $< 1 \times 10^{-10}$ scc/sec

Leak Rate After Cycling $< 1 \times 10^{-10}$ scc/sec

Remarks: This test performed following "Leakage Test - Elevated Temp." Para. 5.5

B. Cycle

(One Open, One Closed)

Test Technician: S. H. MOORE

Test Engineer: J. Martinez

2.2.1.6.8 Leakage Test — Cold Temperature

Requirement

This test was performed to verify that the test item would continue to function when exposed to a low temperature environment.

Procedure

The test item was installed in the environmental chamber as shown in Figure 30 and in accordance with Paragraphs 3.4 and 4.4.1 of KSC-STD-164D. A thermocouple was attached to the largest mass of the test item. A helium mass spectrometer was connected to the test item. The temperature in the chamber was reduced until the test item temperature was stabilized at -65 +0/-5°F. The test item was evacuated and helium gas introduced into the chamber. The leak rate was not to exceed 1 x 10^{-7} std cc/sec of helium.

The stabilized temperature of the test item and the leak rate was recorded. The test item was photographed while in the test position. When the test item had returned to room ambient conditions, it was visually inspected and all defects as a result of the test recorded. A functional test was performed and the test data recorded as specified.

Test Results

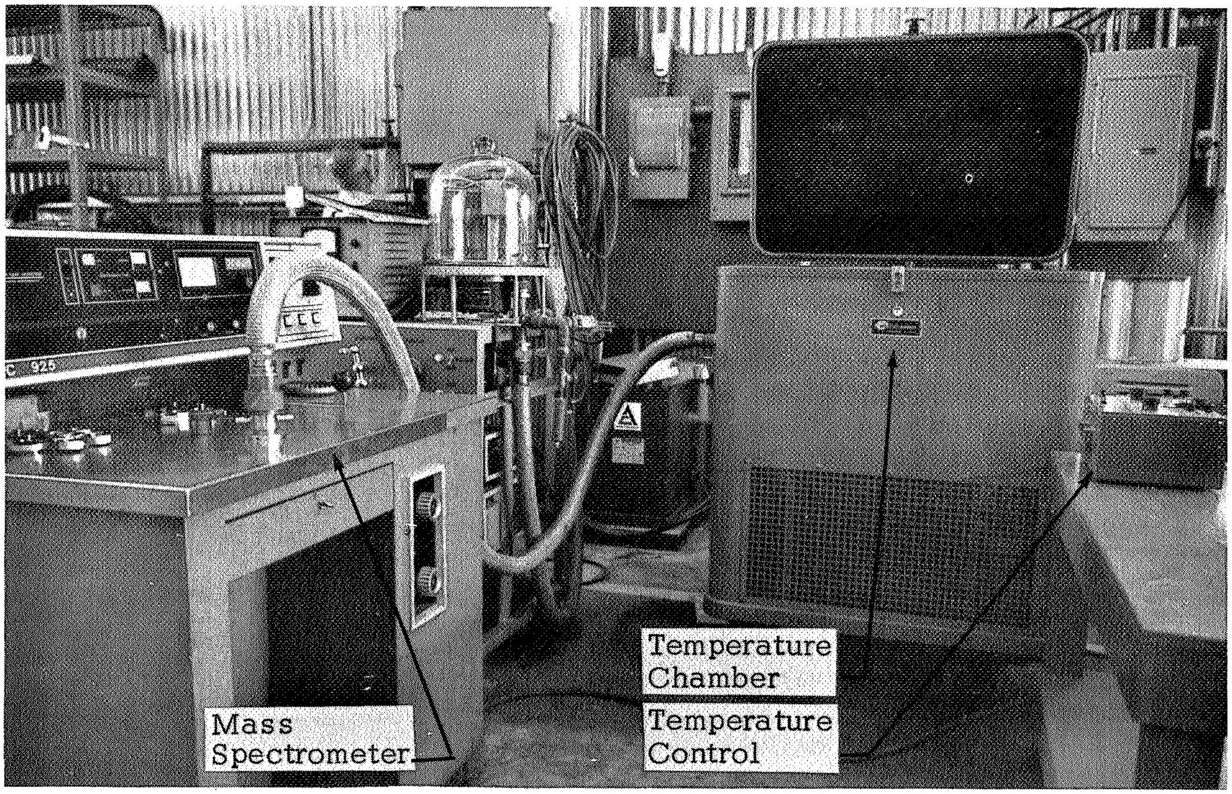
Each valve was helium leak tested while subjected to a temperature of -65°F. All valves passed this test with the following exceptions:

Cryolab 7089-1 Serial No. 6 with Viton A
Cryolab 7079-1 Serial No. 4 and 6 with Viton V655-75
Cryolab SV3-812 Serial No. 2 and 6 with Viton V655-75

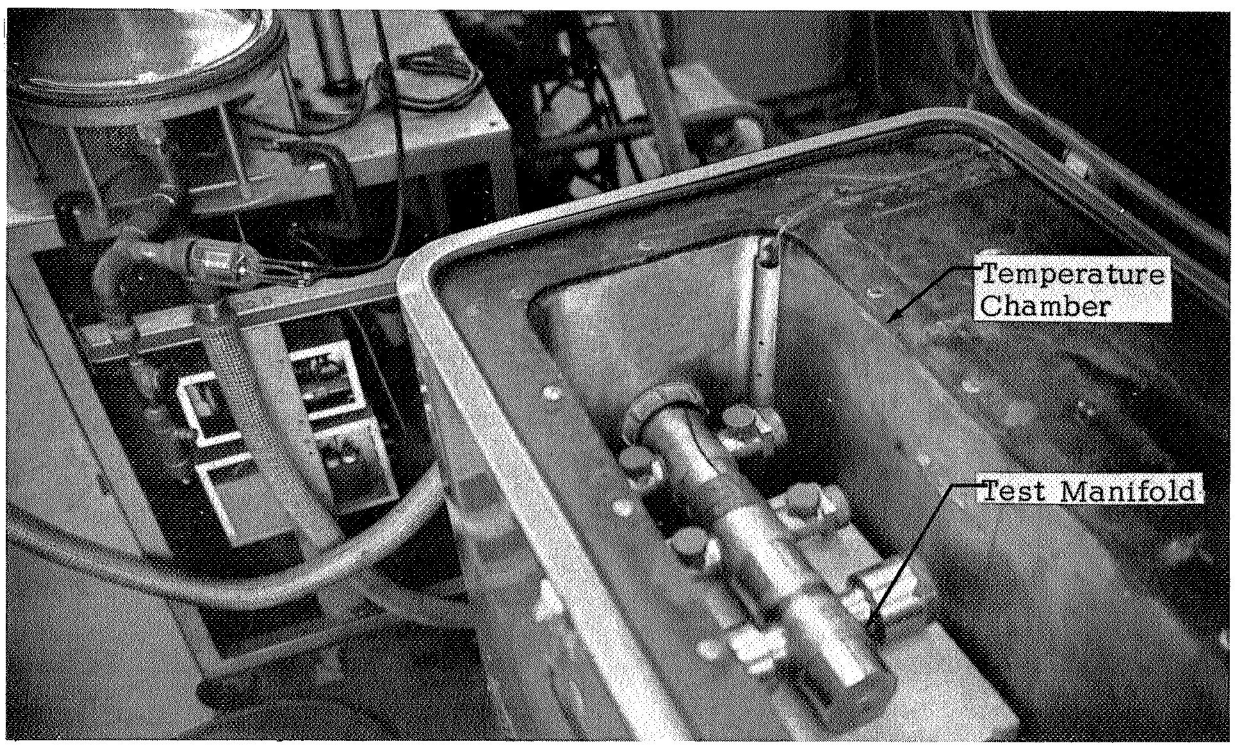
The seals in these valves leaked in excess of 5 x 10^{-6} scc/sec helium (this leak rate is the largest leak measurable using the mass spectrometer). The most stable seal material at the cold temperature was the Ethylene Propylene and Butyl. Figures 30 and 31 are photos showing the valves installed in the environmental chamber.

Test Data

The following data sheets reflect the results of the test followed by the functional leak test.

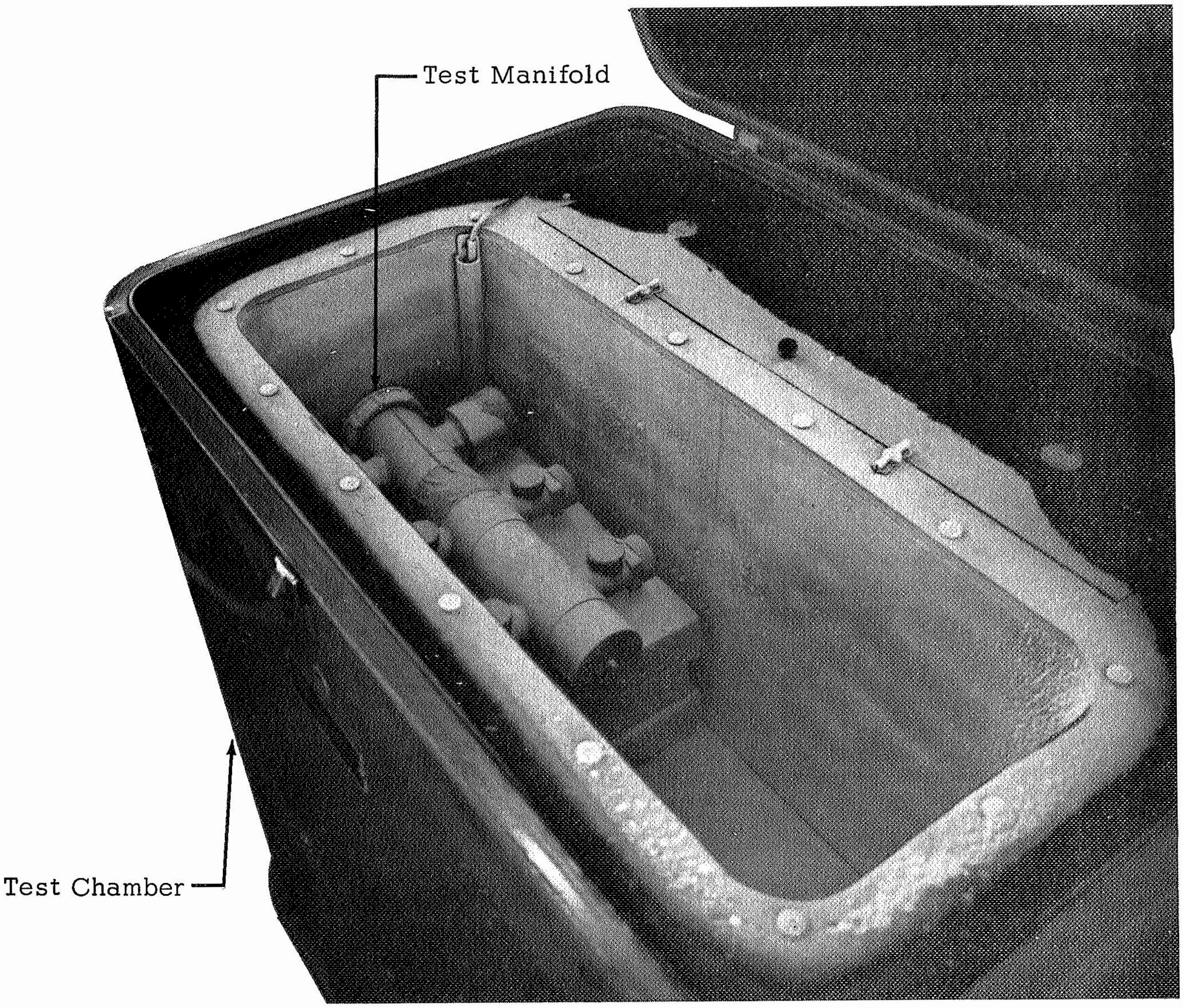


Vacuum Seal Valve Cold Temperature Test Setup



Vacuum Seal Valves Cold Temperature Test Setup
(Test Manifold In Chamber)

Figure 30. Cold Temperature Test Set-up Photograph



Vacuum Seal Valves Leakage Test — Cold Temperature
(At Conclusion Of Test)

Figure 31. Cold Temperature Test (Conclusion) Photograph

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test Low Temperature

Part Name Vac. Seal Valves

Test Procedure 8-480091 Para. 5.6

Date of Test 9-26-69

Part Number Cryolab 7089-1

Part Serial No. 6

Test Item Temperature $-65^{\circ}F$

Leakage Rate Allowed $< 1 \times 10^{-7}$ scc/sec He

REMARKS

This test performed following "High Temp. Test" Para. 5.5

Leakage at test temp. $> 1 \times 10^{-7}$ scc/sec He

Seal Type: Viton A

Test Technician S. H. Moore

Test Engineer J. Martinez

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test Low Temperature

Part Name Vac. Seal Valves

Test Procedure 8-480091 Para. 5.6

Date of Test 9-26-69

Part Number Cryolab 7079-1

Part Serial No. 4

Test Item Temperature $-65^{\circ}F$

Leakage Rate Allowed $< 1 \times 10^{-7}$ scc/sec He

REMARKS

This test performed following "High Temp. Test" Para. 5.5

Leakage at test temp. $> 1 \times 10^{-7}$ scc/sec He

Type Seal: V655-75 Viton

Test Technician S.H. Moore

Test Engineer J. Martinez

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test Low Temperature

Part Name Vac. Seal Valves

Test Procedure 8-480091 Para. 5.6

Date of Test 9-26-69

Part Number SV3-812

Part Serial No. 2 & 6

Test Item Temperature $-65^{\circ}F$

Leakage Rate Allowed $< 1 \times 10^{-7}$ scc/sec He

REMARKS

This test performed following "High Temp. Test" Para. 5.5

Leakage at test temp. $> 1 \times 10^{-7}$ scc/sec He

Seal Type: Viton V655-75

Test Technician S. H. Moore

Test Engineer J. Marting

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test Low Temperature

Part Name Vac. Seal Valves

Test Procedure 8-480091 Para. 5.6

Date of Test 9-26-69

Part Number SV3-812

Part Serial No. 1,3,4,5

Test Item Temperature $-65^{\circ}F$

Leakage Rate $< 1 \times 10^{-7}$ scc/sec He

REMARKS

No detectable leakage at test temp.

This test performed following

"High Temp. Test" Para. 5.5

Test Technician S. H. Moore

Test Engineer J. Martinez

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test: Low Temperature

Date of Test: 9-26-69

Part Name: Vac. Seal Valves

Part Number: Cryolab 7089-1

Test Procedure: 8-480091 Para. 5.6

Part Serial No.: 1,2,3,4,5

Test Item Temperature: $-65^{o}F$

Leakage Rate: $< 1 \times 10^{-7}$ scc/sec He

REMARKS

No detectable leakage at test temp. This test performed following "High Temp. Test" Para. 5.5

Test Technician: S. H. Moore

Test Engineer: J. Martin

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test: Low Temperature

Date of Test: 9-26-69

Part Name: Vac. Seal Valves

Part Number: Cryolab 7079-1

Test Procedure: 8-480091 Para. 5.6

Part Serial No.: 6

Test Item Temperature: $-65^{\circ}F$

Leakage Rate: 5.4×10^{-6} scc/sec He

REMARKS

This test performed following "High Temp. Test" Para. 5.5

Specimen leaked from $-18^{\circ}F$ to $-65^{\circ}F$

Examination of seal revealed no damage.

Seal Material: Viton V655-75

Test Technician: S. H. Moore

Test Engineer: J. Martin

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test: Low Temperature

Date of Test: 9-26-69

Part Name: Vac. Seal Valves

Part Number: Cryolab 7079-1

Test Procedure: 8-480091 Para. 5.6

Part Serial No. 1,2,3,5

Test Item Temperature: $-65^{o}F$

Leakage Rate: $<1 \times 10^{-7}$ scc/sec He

REMARKS

No detectable leakage at test temp.

This test performed following

"High Temp.Test" Para.5.5

Test Technician: S. H. Moore

Test Engineer: J. Martinez

DESIGN VERIFICATION

TEST DATA SHEET

Type of Test Functional Date of Test 9-29-69

Part Name Seal-Off Valve Part Number Cryolab SV3-812

Test Procedure 8-440091 Para 5.2 Part Serial Number 1,2,3,4,5, & 6

A. Leakage

Leak Rate Before Cycling $< 1 \times 10^{-10}$ scc/sec

Leak Rate After Cycling $< 1 \times 10^{-10}$ scc/sec

Remarks

This test performed following "Leakage Test - Cold Temp" Para. 5.6

B. Cycle

(One Open, One Closed)

Test Technician S. H. Moore

Test Engineer J. Martinez

DESIGN VERIFICATION

TEST DATA SHEET

Type of Test Functional Date of Test 9-29-69

Part Name Seal-Off Valve Part Number Cryolab 7089-1

Test Procedure 8-440091 Para 5.2 Part Serial Number 1,2,3,4,5, & 6

A. Leakage

Leak Rate Before Cycling $< 1\times10^{-10}$ scc/sec

Leak Rate After Cycling $< 1\times10^{-10}$ scc/sec

Remarks

This test performed following "Leakage Test - Cold Temp" Para. 5.6

B. Cycle

(One Open, One Closed)

Test Technician S. H. Moore

Test Engineer T. Martinez

DESIGN VERIFICATION

TEST DATA SHEET

Type of Test: Functional — Date of Test: 9-29-69

Part Name: Seal-Off Valve — Part Number: Cryolab 7079-1

Test Procedure: 8-440091 Para 5.2 — Part Serial Number: 1,2,3,4,5, & 6

A. Leakage

Leak Rate Before Cycling $<1x10^{-10}$ scc/sec

Leak Rate After Cycling $<1x10^{-10}$ scc/sec

Remarks: This test performed following "Leakage Test - Cold Temp" Para. 5.6

B. Cycle

(One Open, One Closed)

Test Technician: S. H. MOORE

Test Engineer: J. Martins

2.2.1.6.9 Pump-out/Contamination Test

Requirement

The purpose of this test was to compare the pumpout rate of one test item with no filter installed with the pumpout rate of one test item with a filter installed.

Following the test, the filter was contaminated to cause a differential pressure across the filter of 1 atmosphere to test the structural integrity of the filter.

Procedure

The test setup (Figure 32) for this test consisted of a vacuum chamber with a vacuum gauge tube installed, a vacuum meter (1 to 1000 micron range), a shut-off valve, and a vacuum pump.

The test item, without the filter, was installed between the vacuum chamber and the shut-off valve. The system was evacuated to test pressures of 1000 microns, 500 microns, 100 microns, 50 microns, and 20 microns. The time required to reach each pressure was recorded.

This test item was then removed from the system. A second item with a filter installed was then installed in the system between the vacuum chamber and the shut-off valve. The system was again evacuated to each of the test pressures and the time required to reach each pressure recorded. The filter was to be contaminated and the system evacuated to cause 1 atmosphere differential across the filter.

A functional test was performed on each test item and the test data recorded. The test item with the filter installed was disassembled and the filter inspected for deformation or collapse. All defects as a result of this test were recorded and photographed.

Test Results

Only a small difference was recorded in pumpdown time between a unit with or without the 200 micron filter. This indicates that a filter can be incorporated as a reliable component on the valve without affecting pumpdown time. The contamination test caused the filter to collapse. Figures 33 and 34 show the pumpdown apparatus and the filter after collapse, respectively.

Test Data

The following data sheets reflect the results of the tests conducted to determine the effects of a filter in pumpdown time.

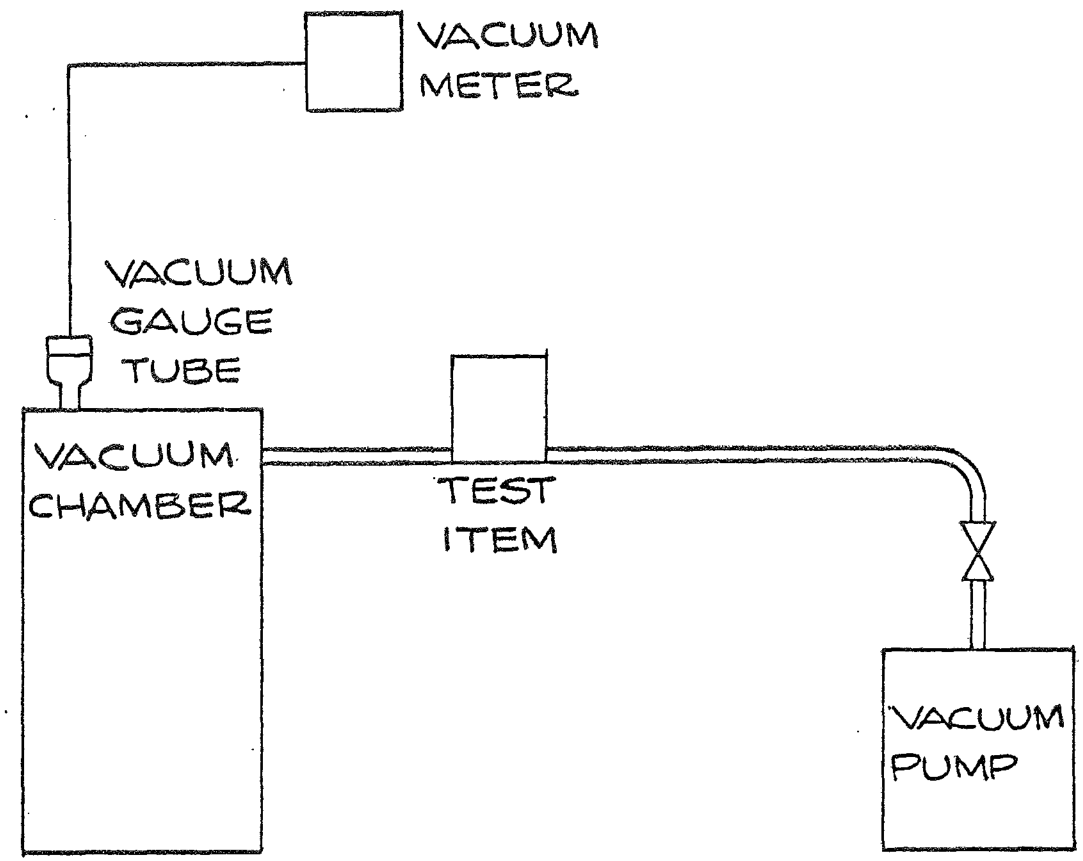
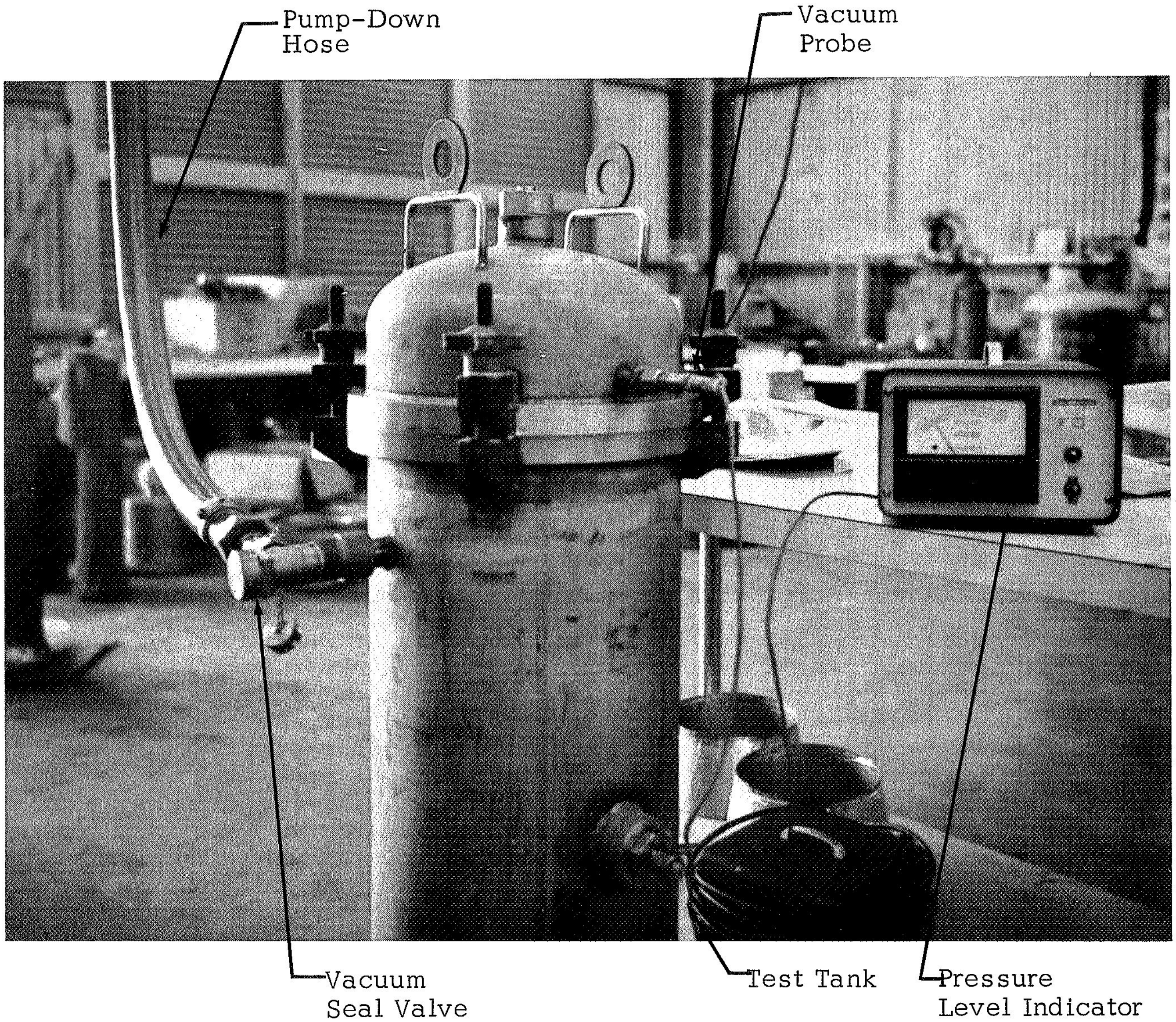
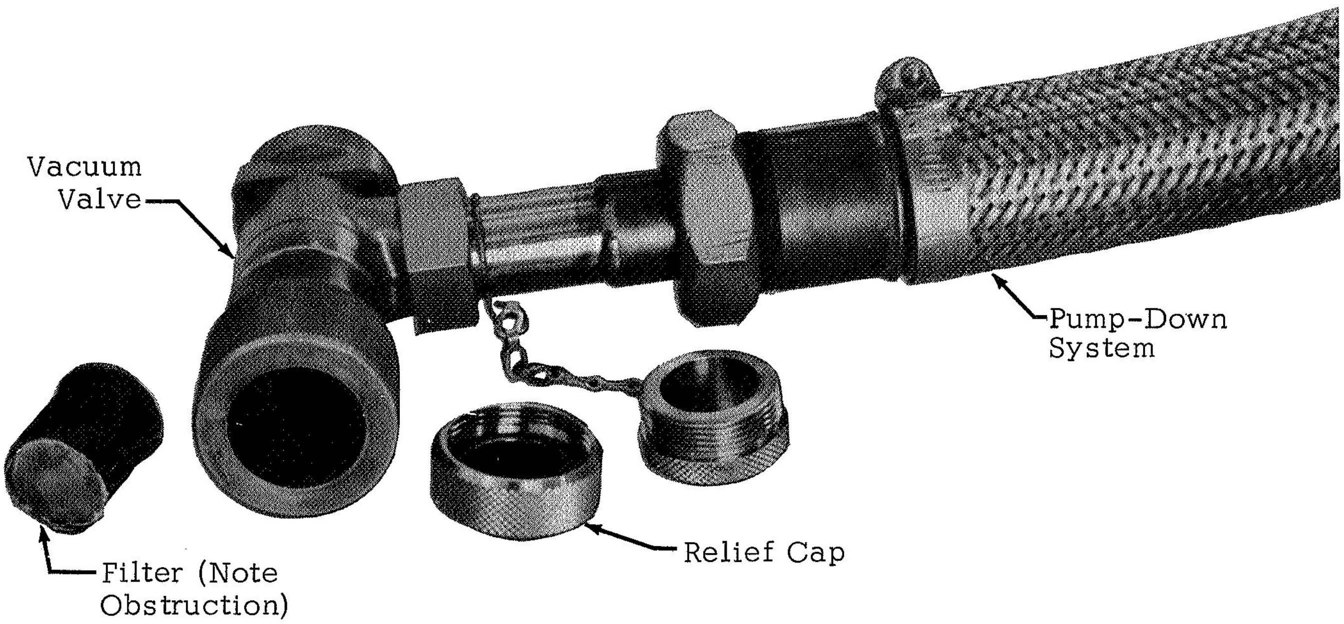


Figure 32. Pump-out/Contamination Test Set-up

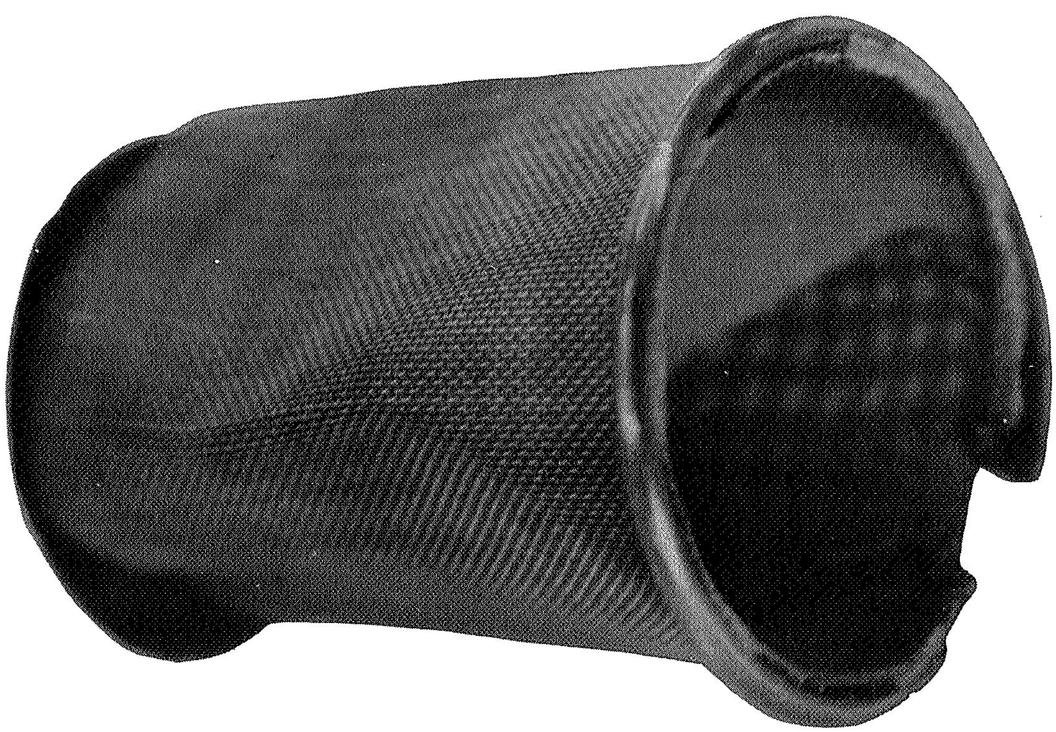


Evacuation Rates
Pump-Down Test With And Without
Filter In Vacuum Seal Valve

Figure 33. Filter Pump-down Test Photograph



Filter Contamination Test Set-Up



Filter After Collapse Pressure Test

Figure 34. Filter Test Photograph

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test: Pump Down — Date of Test: 10-7-69

Part Name: VAC. SEAL VALVES — Part Number: As Shown

Test Procedure: 8-480091 — Part Serial Number: As Shown

Test Pressure: N/A — Test Media: N/A — Duration of Test: As Shown

	Manufacturer	Serial Number	Remarks
1.	CRYOLAB	7	WITHOUT FILTER
2.	PUMP DOWN TIME		
3.	3 Min. 20 Sec.		ATMOSPHERIC TO 1000 MIC
4.	15 Sec.		1000 MIC TO 500 MIC
5.	1 Min.		500 MIC TO 100 MIC
6.	35 Sec.		100 MIC TO 50 MIC
7.	1 Min. 25 Sec.		50 MIC TO 20 MIC
8.	10 Min. 20 Sec.		20 MIC TO 5 MIC
9.			
10.	CRYOLAB 7089-1	7	WITH FILTER
11.	3 Min. 55 Sec.		ATMOSPHERIC TO 1000 MIC
12.	26 Sec.		1000 MIC TO 500 MIC
13.	1 Min. 40 Sec.		500 MIC TO 100 MIC
14.	50 Sec.		100 MIC TO 50 MIC
15.	2 Min.		50 MIC TO 20 MIC
16.	10 Min. 35 Sec.		20 MIC TO 5 MIC
17.			
18.			
19.			
20.			
21.			
22.			
23.			
24.			

Test Technician: S. H. MOORE — Test Engineer: J. Martinez

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test CONTAMINATION (FILTER) Date of Test 10-7-69

Part Name VAC. SEAL VALVES Part Number 7089-1

Test Procedure 8-480091 Part Serial Number 7

Test Pressure ____ Test Media N/A Duration of Test N/A

Manufacturer	Serial Number	Remarks
1. FILTER PLUGGED UP TO RESTRICT FLOW		
2. FILTER INSTALLED IN VALVE		
3. VALVE INLET CONNECTED TO VACUUM PUMP WITH OUTLET OPEN TO ATMOSPHERE		
4. VALVE EVACUATED TO 1 ATMOSPHERE ΔP		
5. FILTER COLLAPSED FROM PRESSURE		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		
17.		
18.		
19.		
20.		
21.		
22.		
23.		
24.		

Test Technician *S. H. Moore* Test Engineer *J. Martinez*

2.2.1.6.10 Thermal Shock Test

Requirement

The thermal shock test was conducted to evaluate the test item under the most severe simulated high temperature conditions, that of its expected proximity to the blast of a launch vehicle during lift-off.

Procedure

A flame source having the minimum capability of 1400 ±100°F was mounted in a fixed position (Figure 35). The distance from the flame at which the temperature of 1400 ±100°F is attained was determined and marked. The test item was then exposed to the flame at that point for a period of 10 seconds.

When the test item had returned to room ambient conditions, it was photographed in the test position and visually inspected. Visible defects as a result of this test were recorded. The test item was then functionally tested and the test data recorded.

Test Results

The valve bodies did not absorb enough heat to damage the valve or effect elastomer seals. The valve bodies could be handled with the bare hand following this test. The flame caused approximately a 40° rise in temperature. Inspection revealed no physical damage as a result of the test. Following an inspection of the test specimens, they were functionally leak tested. Leakge rate was 1×10^{-10} scc/sec of helium. Figure 36 shows the specimens after the thermal shock test.

Test Data

The following data sheets reflect the results of thermal shock test and the functional leak test which followed.

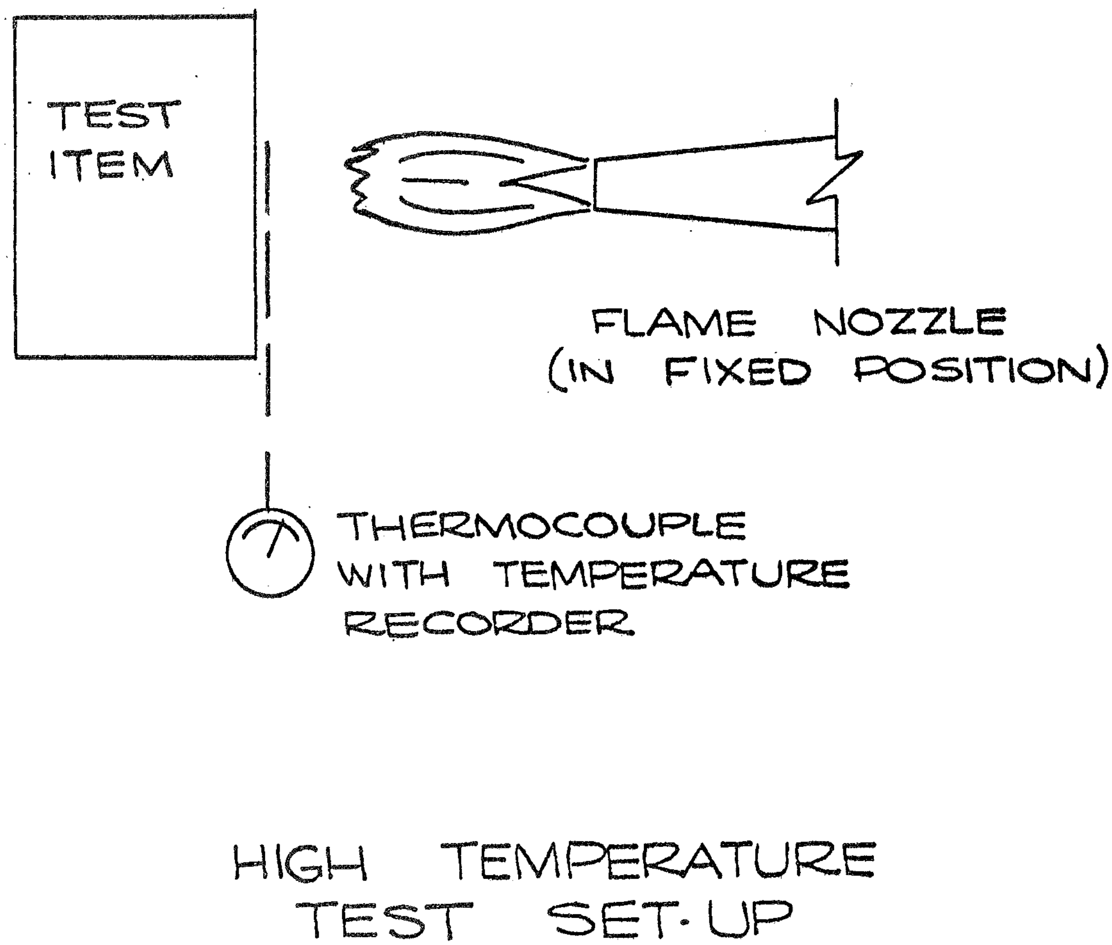
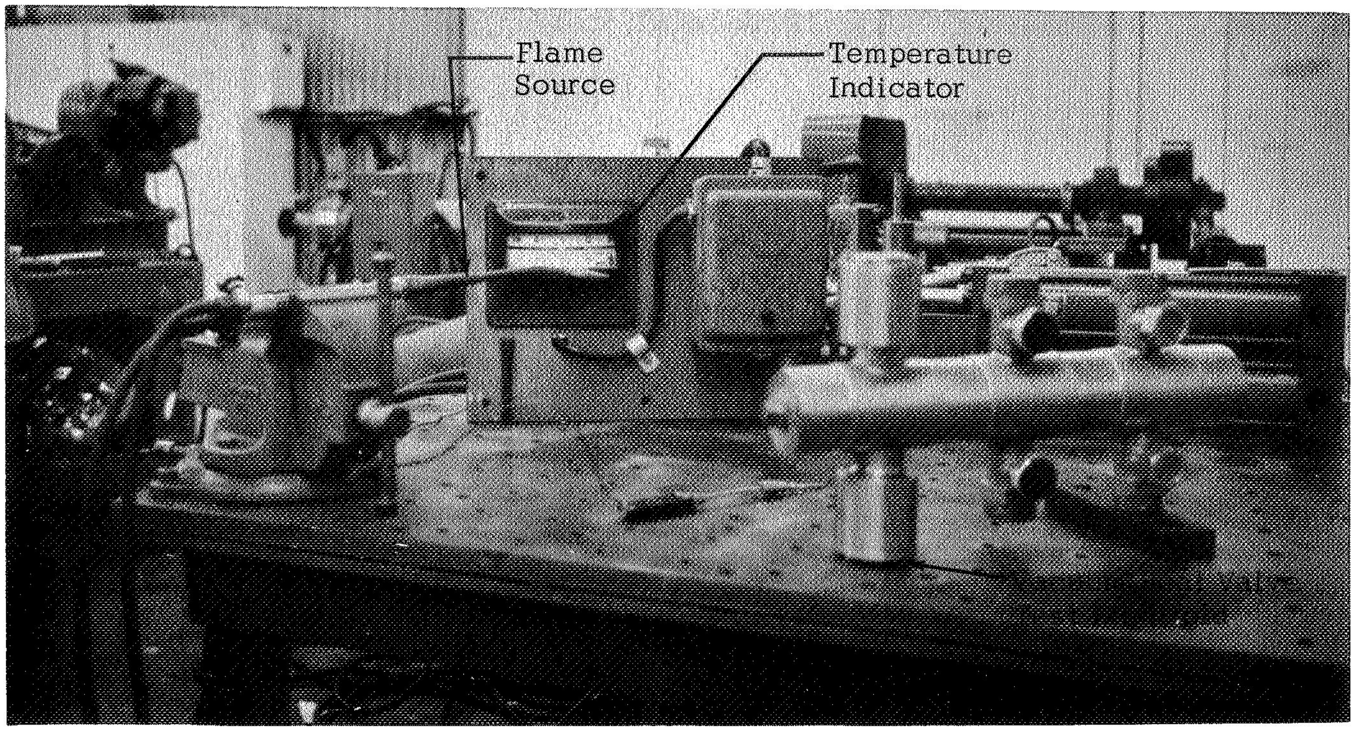
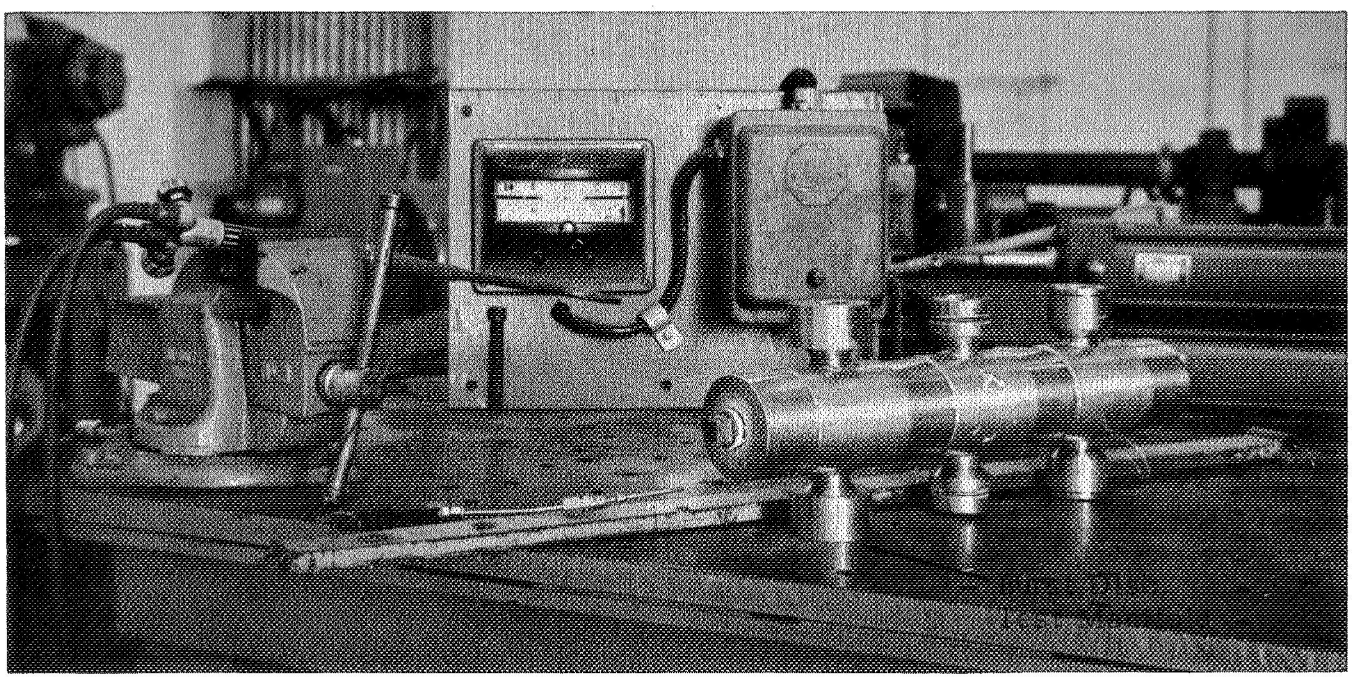


Figure 35. Thermal Shock Test Set-up



Thermal Shock Test Set-Up



Thermal Shock Test Set-Up

Figure 36. Thermal Shock Test Photograph

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test: THERMAL SHOCK   Date of Test: 10-7-69

Part Name: VAC. SEAL VALVES   Part Number: As Shown

Test Procedure: 8-480091   Part Serial Number: As Shown

Test Pressure: N/A   Test Media: Flame 1400°F   Duration of Test: 10 Sec.

	Manufacturer	Serial Number	Remarks
1.	CRYOLAB SV3-812	1	NO VISIBLE DAMAGE
2.	" "	2	" " "
3.	" "	3	" " "
4.	" "	4	" " "
5.	" "	5	" " "
6.	" "	6	" " "
7.	7079	1	" " "
8.	" "	2	" " "
9.	" "	3	" " "
10.	" "	4	" " "
11.	" "	5	" " "
12.	" "	6	" " "
13.	" 7089	1	" " "
14.	" "	2	" " "
15.	" "	3	" " "
16.	" "	4	" " "
17.	" "	5	" " "
18.	" "	6	" " "
19.			
20.			
21.			
22.			
23.			
24.			

Test Technician: J. EPPERLY   Test Engineer: J. Martinez

DESIGN VERIFICATION

TEST DATA SHEET

Type of Test Functional Date of Test 10-7-69

Part Name Seal-Off Valve Part Number CRYOLAB 7079-1

Test Procedure 8-440091 Para 5.2 Part Serial Number 1 through 6

A. Leakage

Remarks

Leak Rate Before Cycling $<1x10^{-10}$ scc/sec PERFORMED AFTER

Leak Rate After Cycling $<1x10^{-10}$ scc/sec THERMAL SHOCK TEST

B. Cycle

(One Open, One Closed)

Test Technician S. H. MOORE

Test Engineer J. Martin

DESIGN VERIFICATION

TEST DATA SHEET

Type of Test Functional Date of Test 10-7-69

Part Name Seal-Off Valve Part Number CRYOLAB 7089-1

Test Procedure 8-440091 Para 5.2 Part Serial Number 1 through 6

A. Leakage — Remarks

Leak Rate Before Cycling $< 1x10^{-10}$ scc/sec — PERFORMED AFTER

Leak Rate After Cycling $< 1x10^{-10}$ scc/sec — THERMAL SHOCK TEST

B. Cycle

(One Open, One Closed)

Test Technician S. H. Moore 5/5

Test Engineer J. Martin

DESIGN VERIFICATION
TEST DATA SHEET

Type of Test: Functional — Date of Test: 10-7-69

Part Name: Seal-Off Valve — Part Number: CRYOLAB SV3-812

Test Procedure: 8-440091 Para 5.2 — Part Serial Number: 1 through 6

A. Leakage — Remarks

Leak Rate Before Cycling $< 1 \times 10^{-10}$ scc/sec — PERFORMED AFTER

Leak Rate After Cycling $< 1 \times 10^{-10}$ scc/sec — THERMAL SHOCK TEST

B. Cycle

(One Open, One Closed)

Test Technician: S. H. Moore

Test Engineer: J. Martin

2.2.1.6.11 Shock Test

Requirement

The shock test was performed to evaluate the test item for resistance to shock during normal service installation, handling, and shipping.

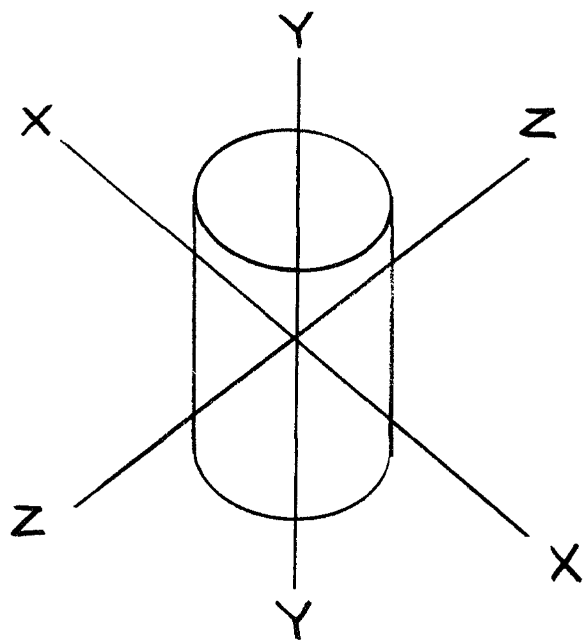
The test was conducted in accordance with Section 10 of KSC-STD-164D. The test item was installed in the test fixture as shown in Figure 37 and in accordance with Paragraph 4.4.1 of KSC-STD-164D. The test was conducted in accordance with the following parameters:

A. Pulse shape - 1/2 sine wave

B. Duration - 2 ±0.6 ms, or ±15%, whichever is greater

C. Amplitude - 30 g ±15%

D. Definition of axes and direction of shock along each axis.



Procedure

Axes are defined below. Direction of shock will be in both directions in each of the three mutually perpendicular axes.

Sequence in which axes are to be tested:

(1)	Axis X	+ to -
(2)	Axis X	- to +
(3)	Axis Y	+ to -
(4)	Axis Y	- to +
(5)	Axis Z	+ to -
(6)	Axis Z	- to +

A photograph of the sine wave of each drop was taken and identified. Drop height was recorded for each drop.

Before the test item was rotated to another axis and at the completion of the test, the item was visually inspected and functionally leak tested. All visible defects noted as a result of this test were recorded and photographed. The test data from the functional test was recorded as specified in the test procedure.

Test Results

Following each direction of each axis shock, the specimen was inspected for physical damage. A functional leakage test was then performed to determine extent of damage.

Visual inspection did not reveal any damage in any of the specimens for any direction in either of the three axes.

Functional leakage tests indicated a leakage rate of 1×10^{-10} scc/sec of helium.

Figure 38 shows the resulting force curve. Figures 39, 40, and 41 show the shock test setup for X, Y, and Z axes.

Test Data

The following data sheets reflect the results of the shock test and the functional leak test which followed.

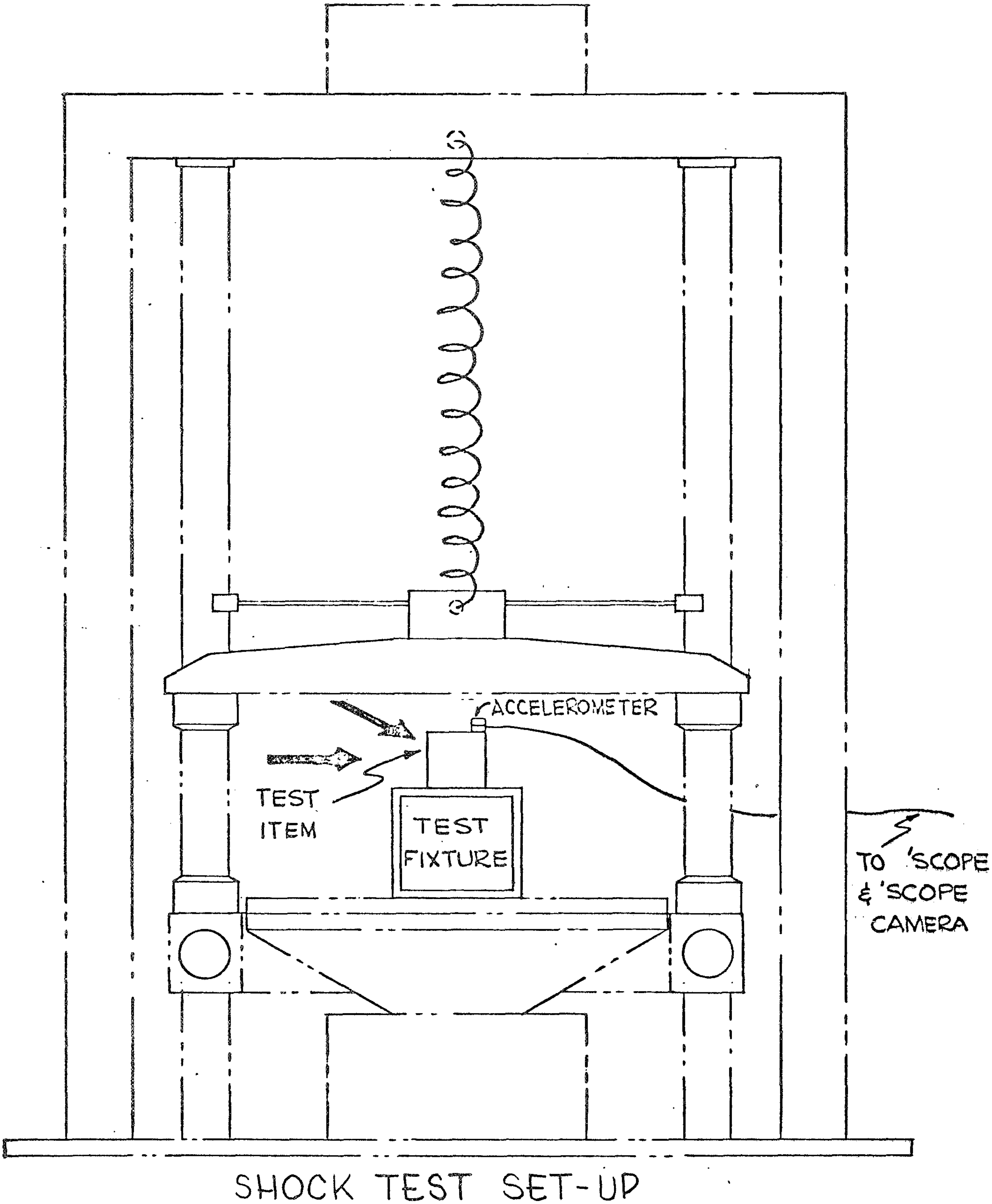
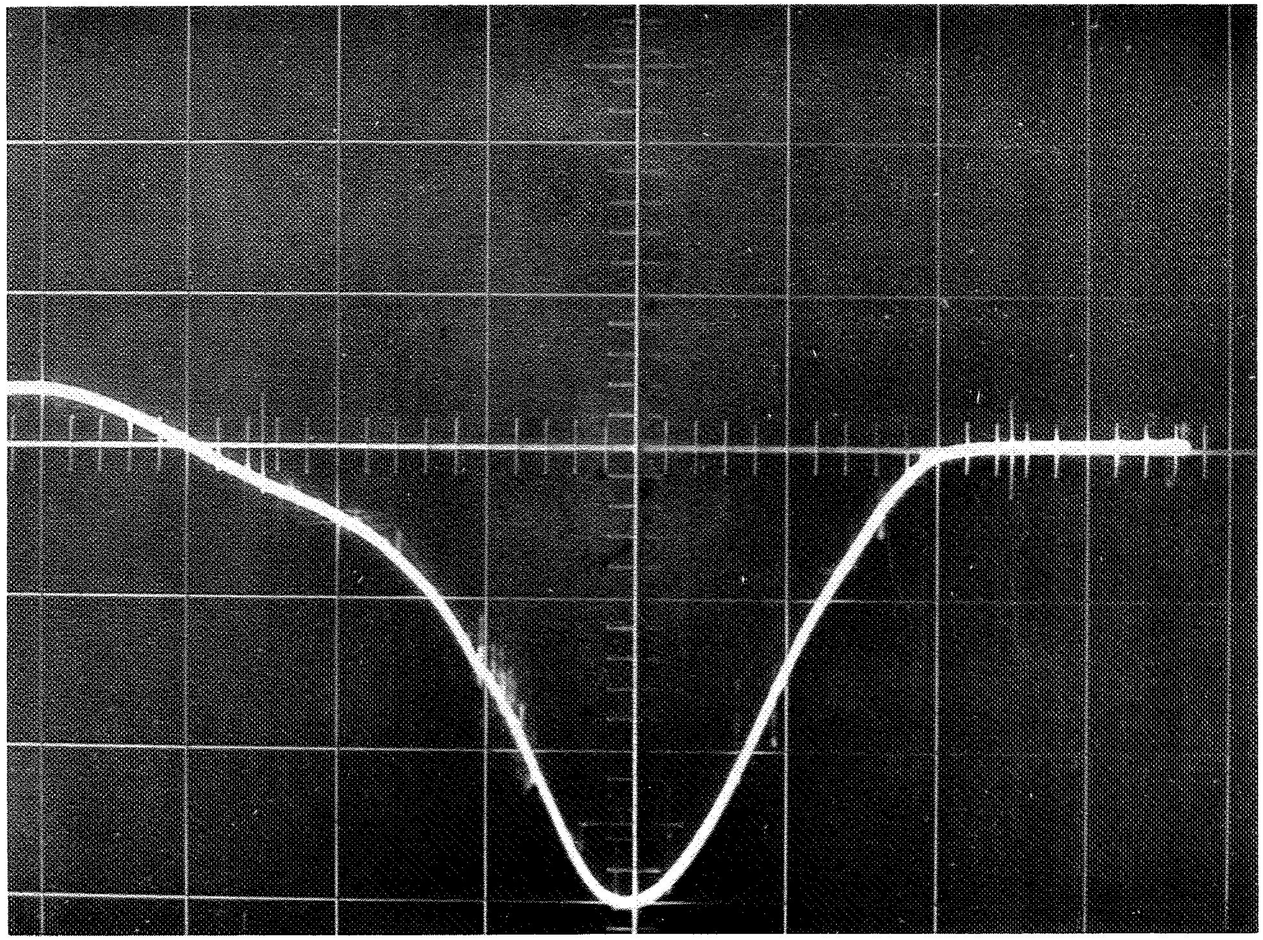
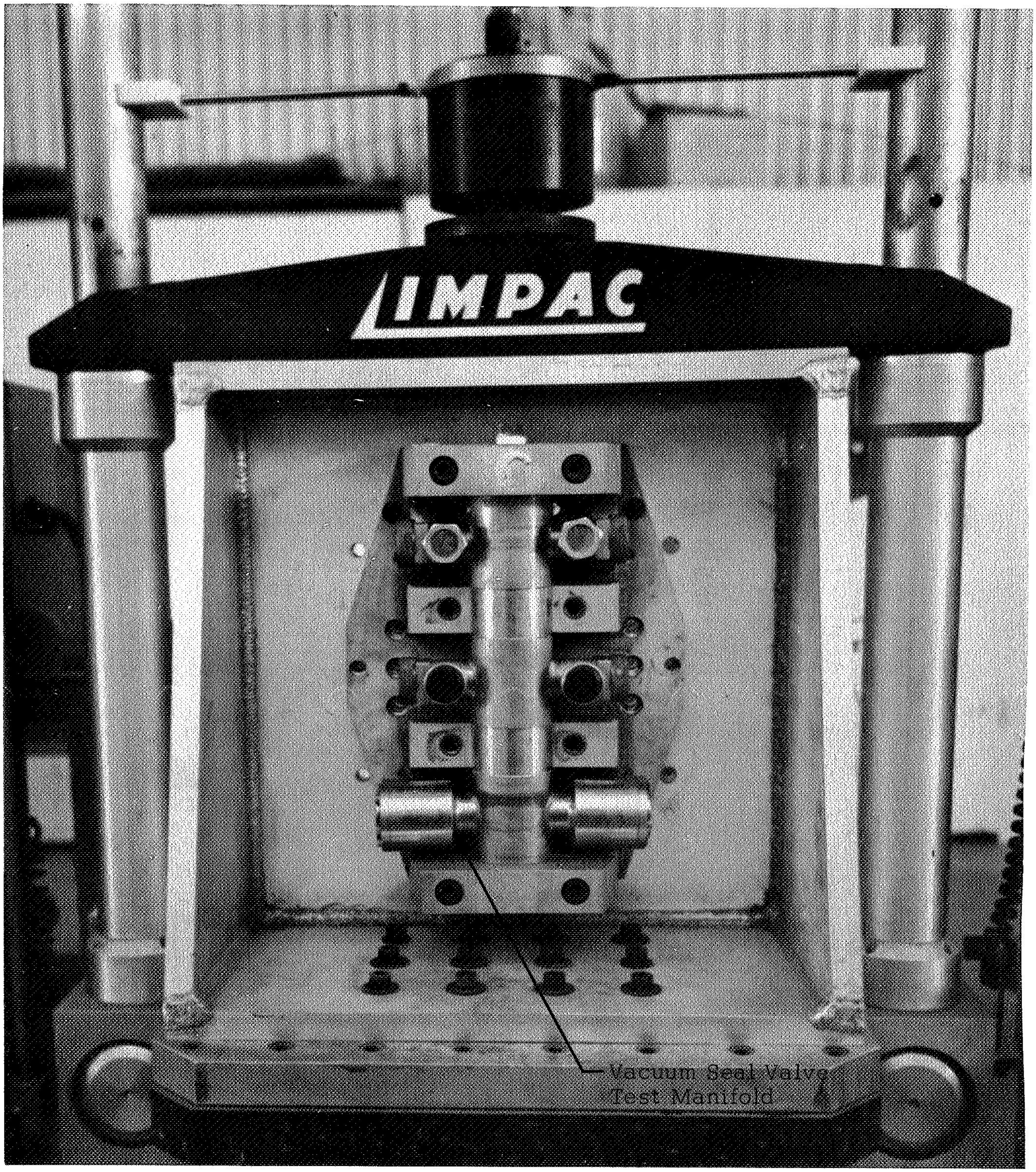


Figure 37. Shock Test Set Up



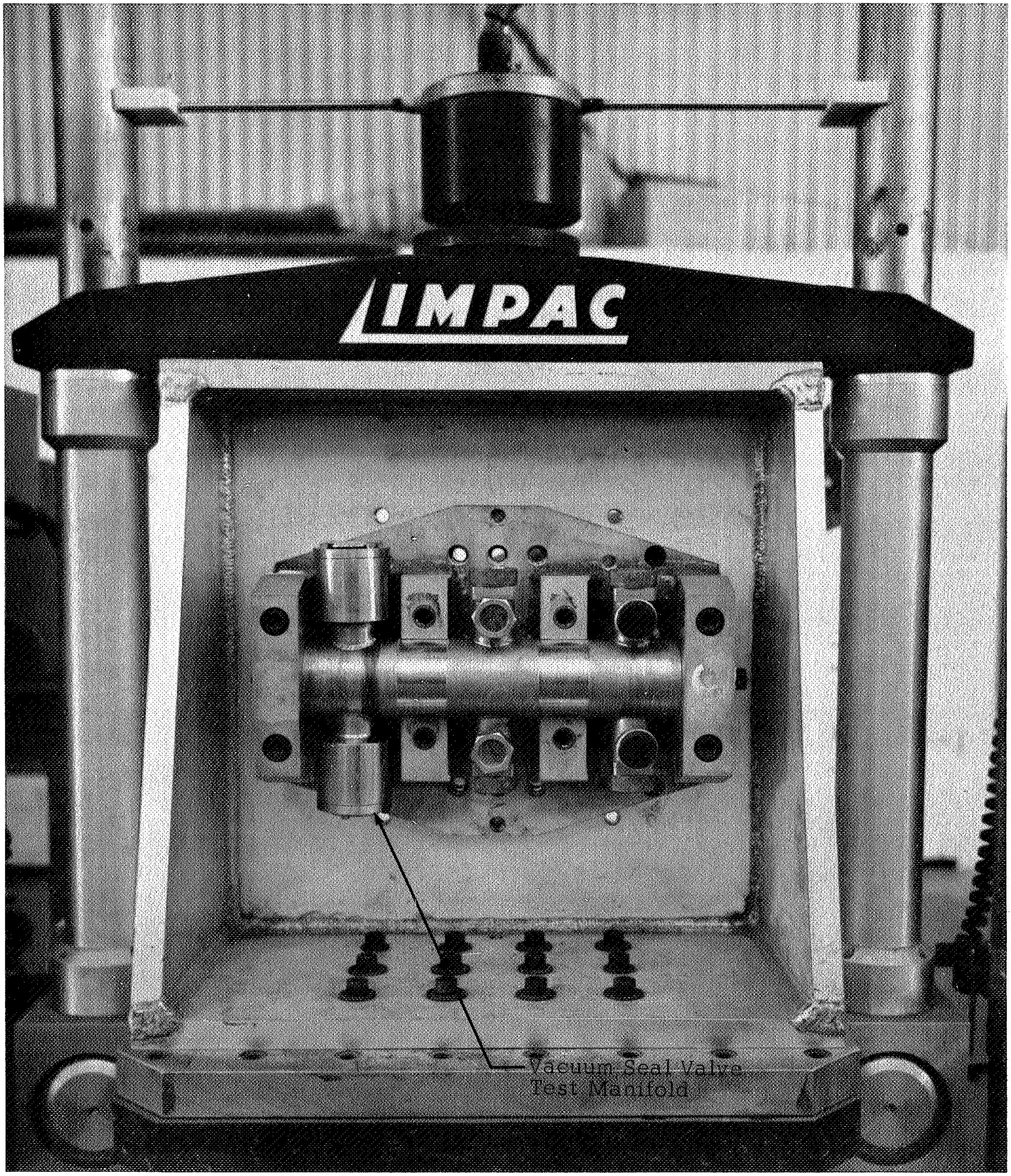
Typical Shock Pulse Waveform During Shock Test For Burst Discs, Seal-Off Valves, And Vacuum Probes

Figure 38. Shock Pulse Photograph



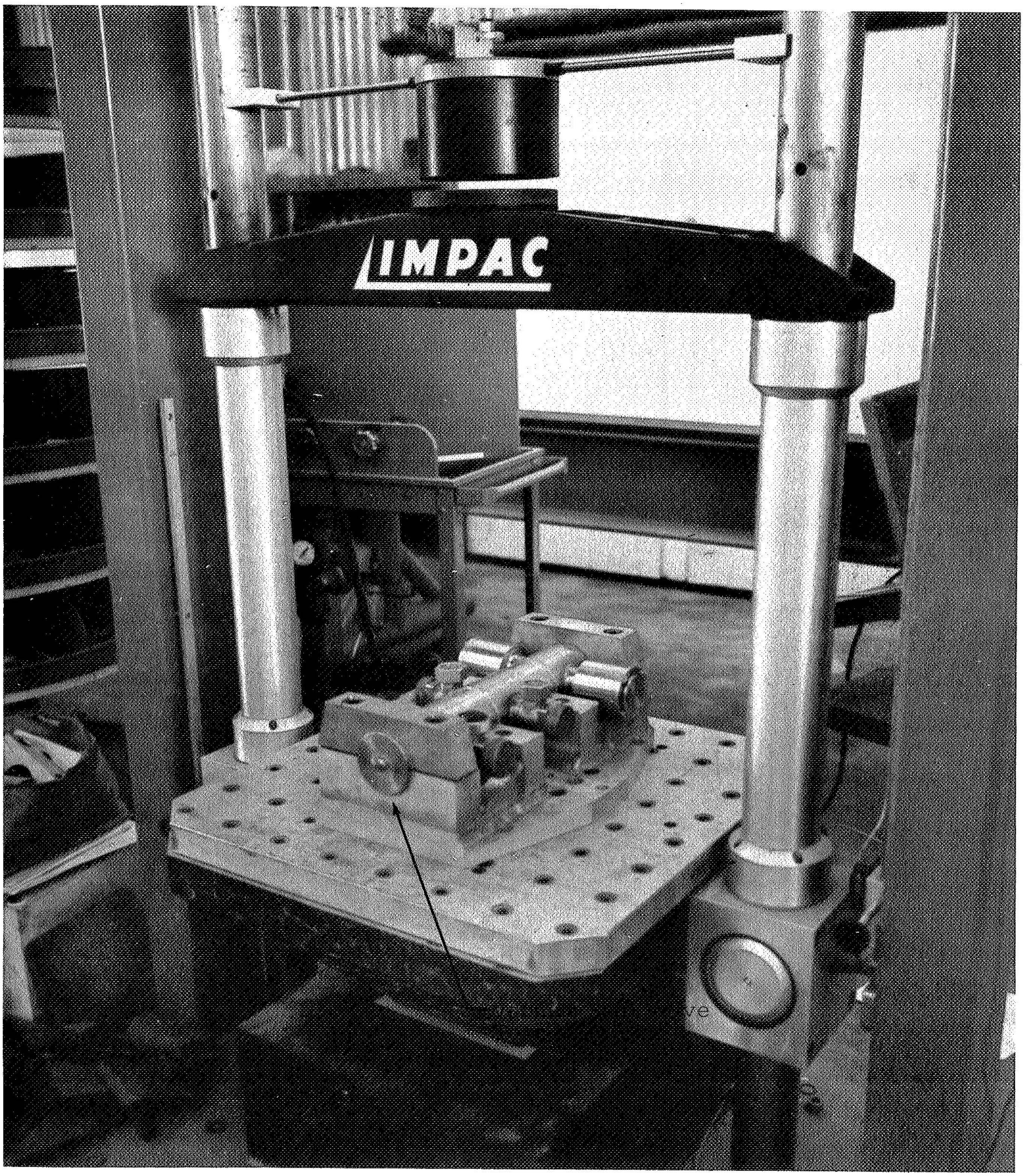
Shock Test Set-Up
Vacuum Seal Valves
X Axis

Figure 39. X Axis Shock



Shock Test Set-Up
Vacuum Seal Valves
Y Axis

Figure 40. Y Axis Shock



Shock Test Set-Up
Vacuum Seal Valves
Z Axis

Figure 41. Z Axis Shock

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test Shock Date of Test 10-7-69

Part Name Vac. Seal Valves Part Number Cryolab 7079-1

Test Procedure 8-480091 Part Serial Number 1 thru 6

Drop No.	Axis	Drop Height	Remarks
1	X + to -		NO VISIBLE DAMAGE
2	X - to +		" " "
3	Y + to -		" " "
4	Y - to +		" " "
5	Z + to -		" " "
6	Z - to +		" " "

Test Technician S. H. MOORE s/s

Test Engineer J. Martiny

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test Shock Date of Test 10-7-69

Part Name Vac. Seal Valves Part Number Cryolab SV3-812

Test Procedure 8-480091 Part Serial Number 1 thru 6

Drop No.	Axis	Drop Height	Remarks
1	X + to -		NO VISIBLE DAMAGE
2	X - to +		" " "
3	Y + to -		" " "
4	Y - to +		" " "
5	Z + to -		" " "
6	Z - to +		" " "

Test Technician J. Epperly

Test Engineer J. Martinez

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test: Shock Date of Test: 10-7-69

Part Name: VAC SEAL VALVES Part Number: CRYOLAB 7089-1

Test Procedure: 8-480091 Part Serial Number: 1 through 6

Drop No.	Axis	Drop Height	Remarks
1	X + to -		NO VISIBLE DAMAGE
2	X - to +		" " "
3	Y + to -		" " "
4	Y - to +		" " "
5	Z + to -		" " "
6	Z - to +		" " "

Test Technician: J. EPPERLY s/s

Test Engineer: J. Martin

DESIGN VERIFICATION

TEST DATA SHEET

Type of Test Functional Date of Test 8 October 1969

Part Name Seal-Off Valve Part Number CryoLab SV3-812

Test Procedure 8-440091 Para 5.2 Part Serial Number 1 through 6

A. Leakage Remarks

Leak Rate Before Cycling $< 1\times10^{-10}$ scc/sec He Test Following Y Axis Shock

Leak Rate After Cycling $< 1\times10^{-10}$ scc/sec He " " X " "

" " Z " "

NOTE: Leak rate shown is for test performed after each axis.

B. Cycle

(One Open, One Closed)

Test Technician J. EPPERLY

Test Engineer J. Martinez

DESIGN VERIFICATION

TEST DATA SHEET

Type of Test Functional Date of Test 8 October 1969

Part Name Seal-Off Valve Part Number CryoLab 7089-1

Test Procedure 8-440091 Para 5.2 Part Serial Number 1 thru 6

A. Leakage

Remarks

Leak Rate Before Cycling $< 1x10^{-10}$ scc/sec_{He} Test Following Y Axis Shock

" " X " "

Leak Rate After Cycling $< 1x10^{-10}$ scc/sec_{He} " " Z " "

NOTE: Leak rate shown is for test performed after each axis.

B. Cycle

(One Open, One Closed)

Test Technician J. Efferly

Test Engineer J. Mathis

DESIGN VERIFICATION

TEST DATA SHEET

Type of Test: Functional — Date of Test: 8 October 1969

Part Name: Seal-Off Valve — Part Number: CRYOLAB 7079-1

Test Procedure: 8-440091 Para 5.2 — Part Serial Number: 1 thru 6

A. Leakage

	Remarks
Leak Rate Before Cycling $< 1x10^{-10}$ scc/sec He	Test Following Y Axis Shock
Leak Rate After Cycling $< 1x10^{-10}$ scc/sec He	" " X " "
	" " Z " "

NOTE: Leakage rate shown is for test performed after each axis.

B. Cycle

(One Open, One Closed)

Test Technician J. Epperly s/s

Test Engineer J. Martinez

2.2.1.6.12 Vibration Test

Requirement

The vibration test was performed to determine the test item's integrity in the predicted vibration environment.

Procedure

The item was installed in a test fixture as shown in Figure 42. The test item was subjected to vibration tests in accordance with KSC-STD-164D, Paragraph 9.2, and Procedure I, Paragraphs 9.3.1 and 9.3.2, except that the test levels were as specified in this document per Figure 43.

The entire sequence of vibration tests was accomplished three times (once in each of the principle axes) and all testing was completed in one axis before changing axes. The test sequence in each axis was: (1) resonant frequency search; and (2) sinusoidal sweep.

Throughout the vibration test program, the test item was functionally monitored for possible failure detection. Prior to testing in each axis, the test item was functionally leak tested.

A. Resonant Frequency Search

The test item was installed in accordance with Paragraph 4.4.1 of KSC-STD-164D. The fixture/test item assembly was exposed to sinusoidal vibration at an acceleration level of 3 g's. The frequency range of 5 to 3000 cps was traversed logarithmically in directions of both increasing and decreasing frequency for a period not to exceed 15 minutes per axis. The test item was functionally leak teated at the conclusion of the test.

B. Sinusoidal Sweep

The fixture/test item assembly was exposed to sinusoidal sweep vibration as found in Figure 43, Curve B. The frequency range of 10 to 2000 cps was traversed logarithmically in directions of both increasing and decreasing frequency for a test period of 20 minuts (10 minutes increasing, and 10 minutes decreasing). The test item was functionally leak tested at the conclusion of the test.

Test Results

No leakage of any of the vacuum seal valves was experienced during any of the vibration axes. No structural damage was incurred during any of the vibration axes.

The 7089-1 vacuum seal/relief valve spring-loaded valve seat was able to remain seated during the three axes of vibration. The Y axis, which was shaking the valve in the most critical direction (parallel to the spring relief), was performed without failure or leakage. The SV3-812 valve also completed testing in all axes.

The last axis of vibration (Z axis) was conducted at 15 g's for each component. This was due to problems experienced with the system power amplifier which resulted in an inability to generate 30 g's force. This reduced g level in the Z axis is adequate since the X and Y axes are the two most critical axes (see Figures 44, 45, and 46).

Random vibration was not conducted. Paragraph 5.12.2.3 of Test Procedure 8-480091 random excitation was not performed for the following reasons:

1. The sine vibration for this particular hardware that was performed subjected the specimen to a more severe test than would be experienced in random vibration.

2. Fixture equalization, required to perform random vibration for each component, would require costs in excess of benefits gained.

The functional leakage test which was conducted following each vibration axis indicated a leakage rate of 1×10^{-10} scc/sec of helium.

Test Data

The following data sheets reflect the results of the vibration test and the functional leak test which followed.

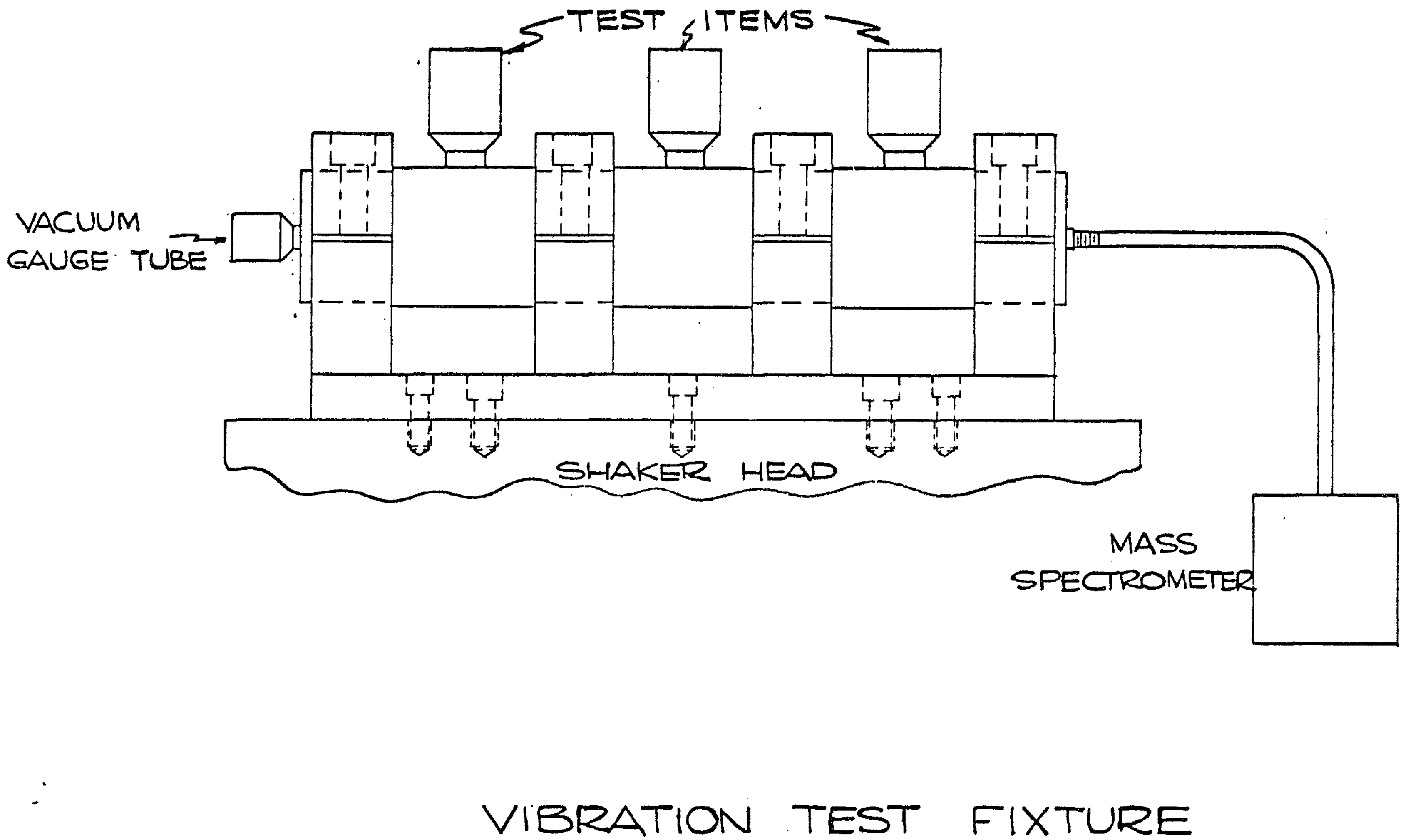


Figure 42. Vibration Test Set-up

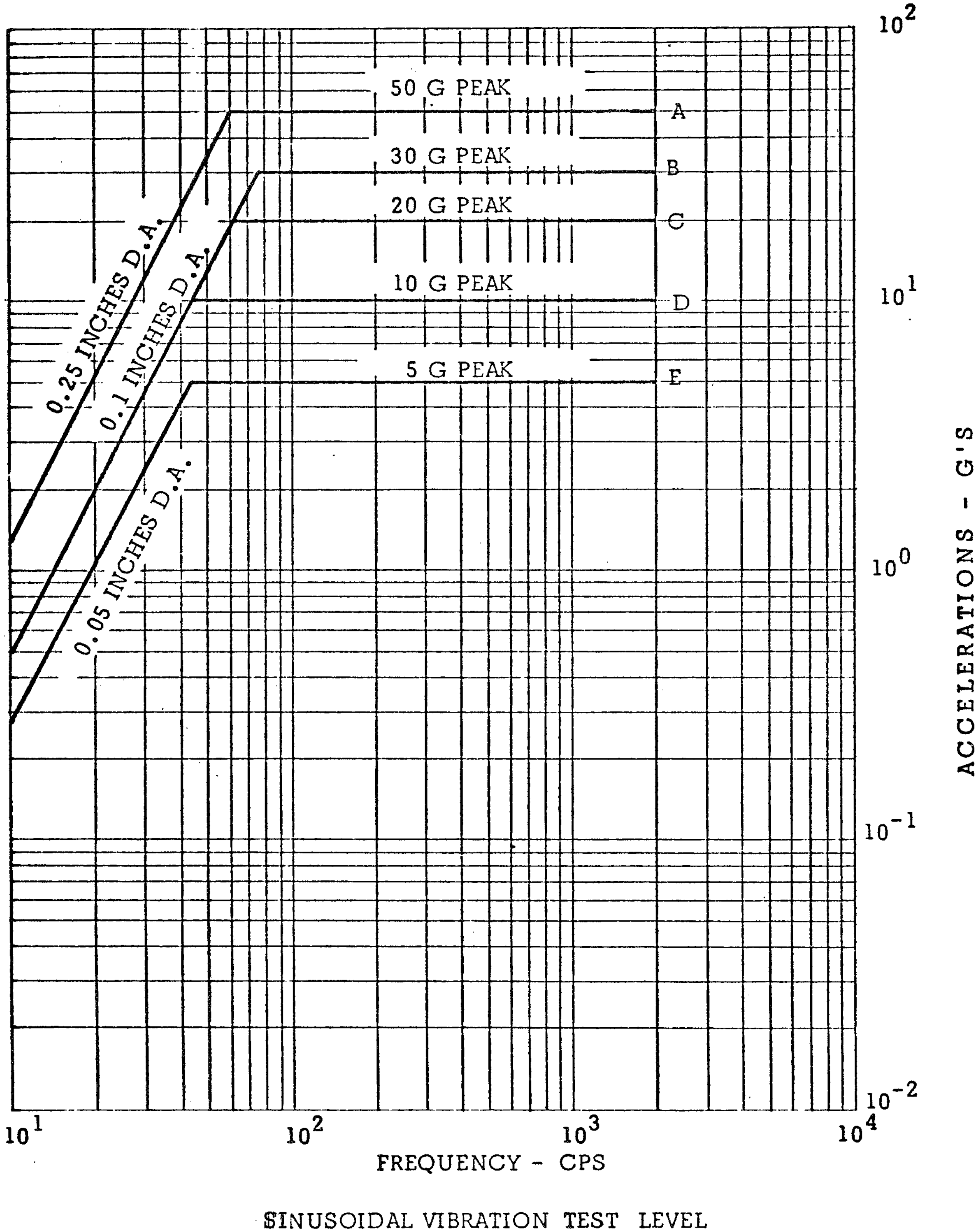
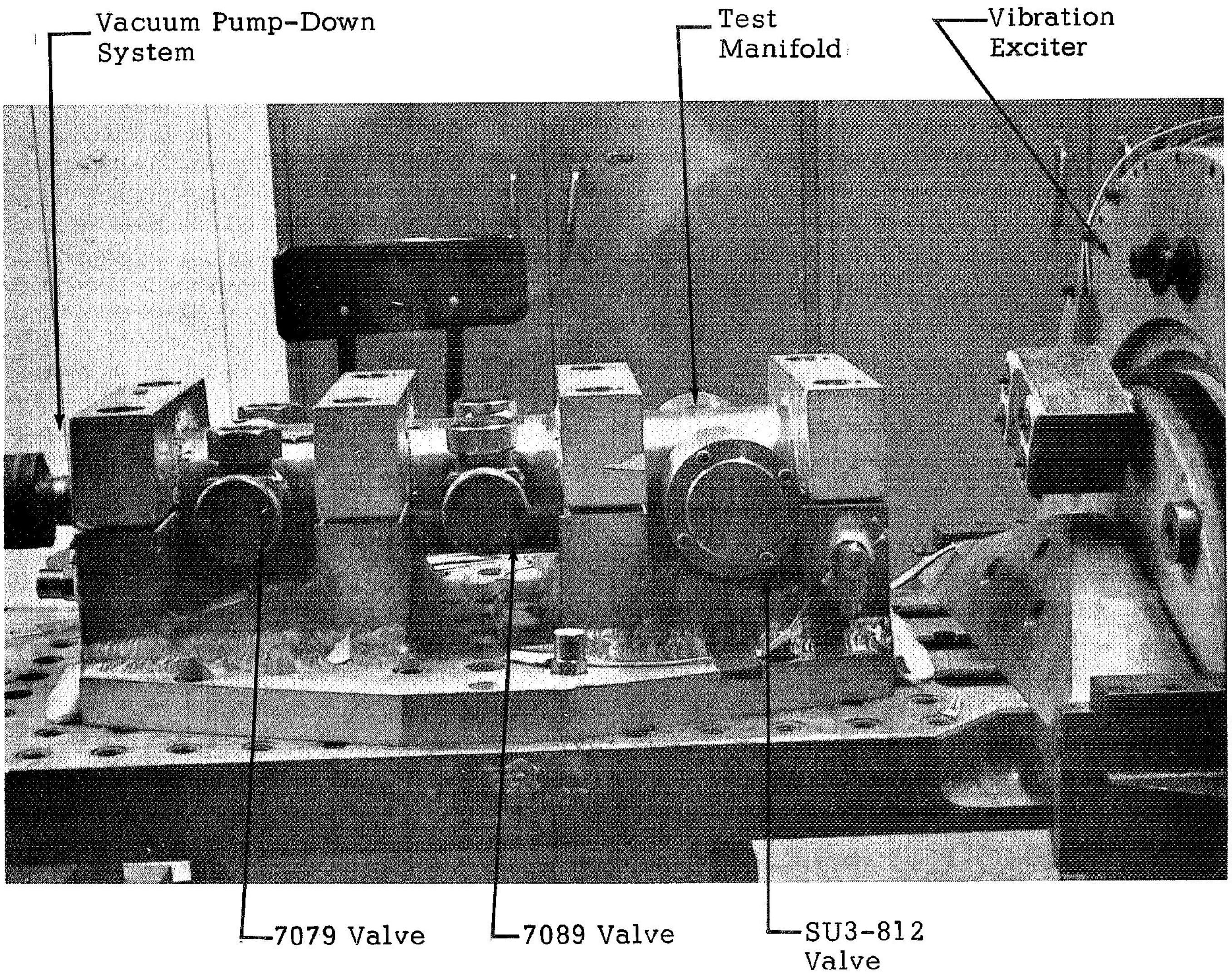
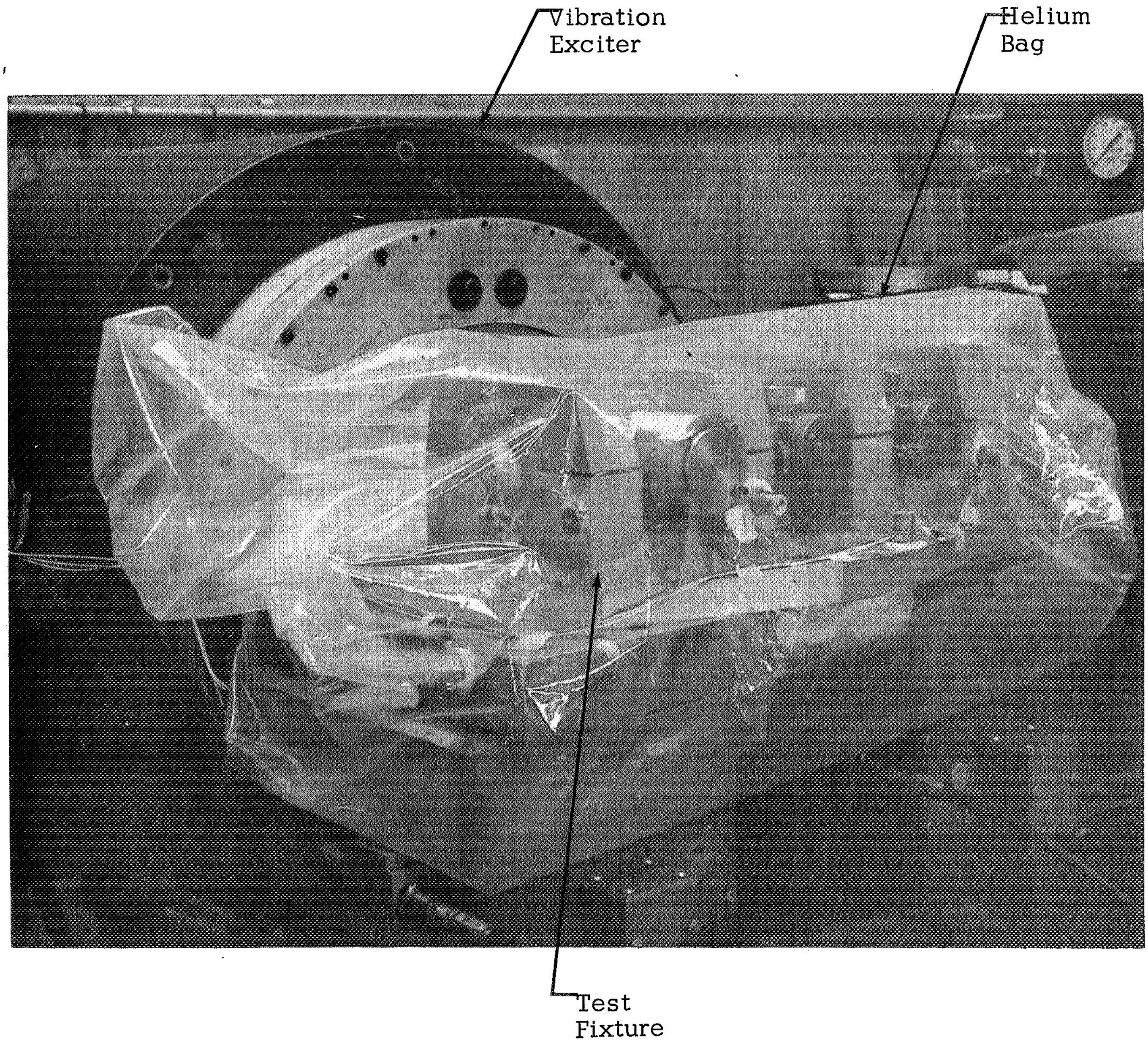


Figure 43. Sine Vibration Test Levels



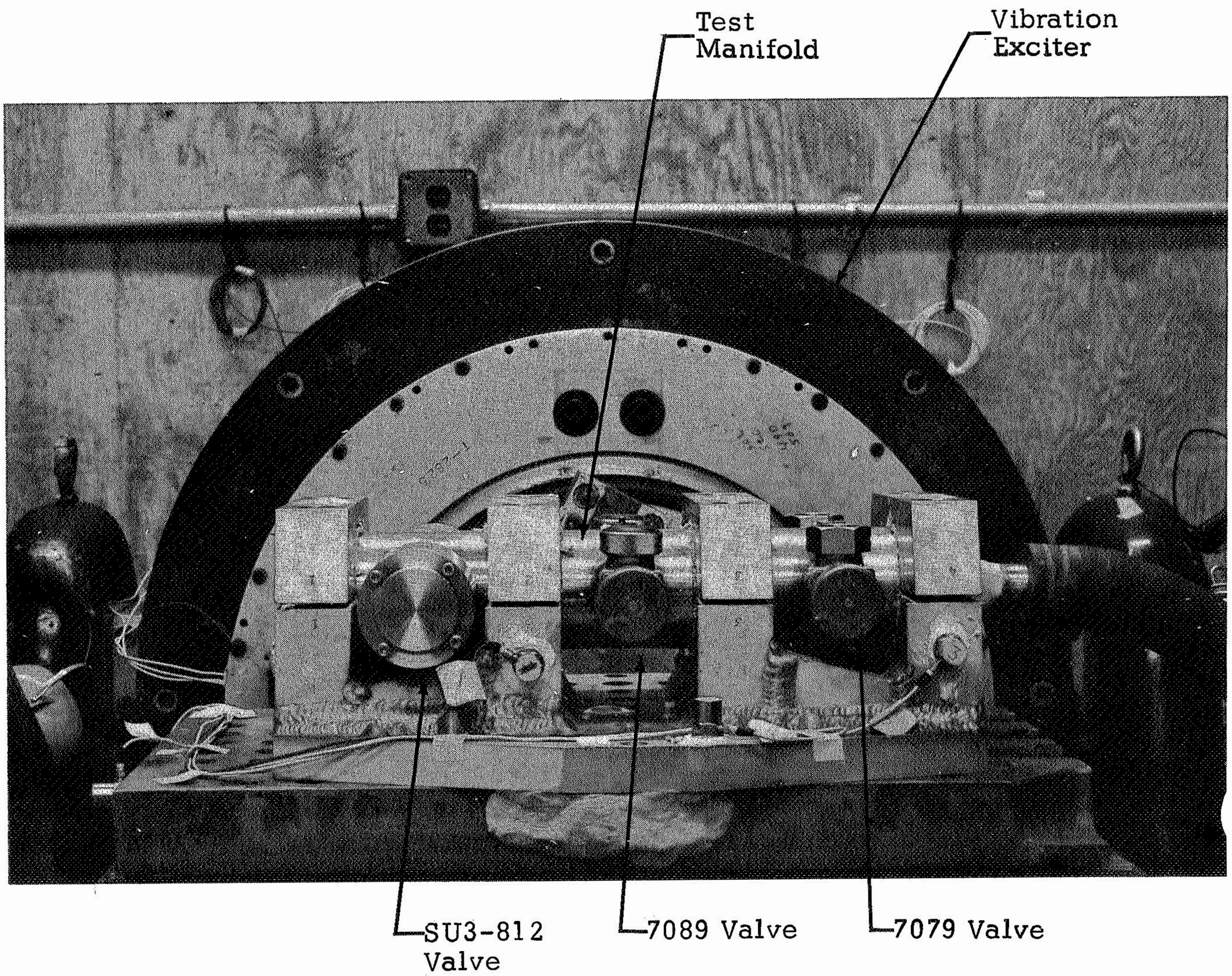
Vacuum Seal Valves Vibration Test — X Axis

Figure 44. X Axis Vibration Photograph



Vacuum Seal Valves Vibration Test — Y Axis

Figure 45. Y Axis Vibration Photograph



Vacuum Seal Valves Vibration Test — Z Axis

Figure 46. Z Axis Vibration Photograph

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test Vibration Date of Test 11-6-69

Part Name Seal-Off Valve Part Number CryoLab 7079-1

Test Procedure ____ Part Serial Number 1

Type of Recorder Sanborn 350 No. of Channels 6

Recording Calibration 0-10g's RMS 0-100 g's RMS

Bolt Torque Values ____

		Accelerometer Placement Sketch
Sine cond	Search Time 25°/Min. Sweep Time 16°/ Min.	SEE PHOTO
Search	20 to 75 cps @ 0.01 in. D.A.	
	75 to 3000 cps @ 3 G's peak	
Sweep	10 to 75 cps @ 0.10 in. D. A.	
	75 to 2000 cps @ 30 G's peak	
Z Axis Sweep	10 to 75 cps @ 0.05 in. D. A.	
	75 to 1500 cps @ 15 G's peak	
Random Cond.	Random Noise Duration ____	
	____ to ____ cps @ ____ in. 2/cps	
	____ to ____ cps @ ____ G 2/cps	
	____ to ____ cps @ ____ db octave	
	____ to ____ cps @ ____ G 2/cps	
	____ to ____ cps @ ____ db octave	

Resonant Search

Sweep Time

Resonant Frequency	AXIS X	AXIS Y	AXIS Z

Axis	Remarks	Search XXXX time or Sweep time	Operator
X	No Failure	15 Min. 20 Min.	10/4/69 O.V.T.
Y	No Failure	15 Min. 20 Min.	10/30/69 D.V.T.
Z	No Failure	15 Min. 20 Min.	10/21/69 D.V.T.

Test Technician D.C. VAN TIEGHAM Inspection ____

Test Engineer T. Martins

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test: Vibration — Date of Test: 11-5-69

Part Name: Seal-off Valve — Part Number: CryoLab 7079-1

Test Procedure: ______ — Part Serial Number: 2,3,4,5, & 6

Type of Recorder: Sanborn 350 — No. of Channels: 6

Recording Calibration: 0-10 g's RMS, 0-100 g's RMS

Bolt Torque Values: ______

Accelerometer Placement Sketch

SEE PHOTO

Sine cond	Search Time	25°/Min.
	Sweep Time	16°/ Min.
Srch.	20 to 75 cps @ 0.01 in. D.A.	
	75 to 3000 cps @ 3 G's peak	
Sweep.	10 to 75 cps @ 0.10 in. D. A.	
	75 to 2000 cps @ 30 G's peak	
Z Axis Sweep	10 to 75 cps @ 0.05 in. D. A.	
	75 to 1500 cps @ 15 G's peak	
Random Cond.	Random Noise Duration ______	
	___ to ___ cps @ ___ in. 2/cps	
	___ to ___ cps @ ___ G 2/cps	
	___ to ___ cps @ ___ db octave	
	___ to ___ cps @ ___ G 2/cps	
	___ to ___ cps @ ___ db octave	

Resonant Search

Sweep Time

Resonant Frequency	AXIS X	AXIS Y	AXIS Z

Axis	Remarks	Search XXXXXX time or Sweep time	Operator
X	No Failure	15 Min. 20 Min.	10/3/69 D.V.T.
Y	Stem Retaining Ring Became Loose - No Leakage	15 Min. 20 Min.	10/30/69 D.V.T.
Z	No Failure	15 Min. 20 Min.	10/27/69 D.V.T.

Test Technician: D.C VAN TIEGHAM — Inspection: ______

Test Engineer: T. Mastin

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test: Vibration Date of Test: 11-6-69

Part Name: Seal-Off Valve Part Number: CryoLab 7089-1

Test Procedure: ______ Part Serial Number: 1, 2, 3, 4, 5, & 6

Type of Recorder: Sanborn 350 No. of Channels: 6

Recording Calibration: 0 - 10 g's RMS / 0 - 100 g's RMS

Bolt Torque Values: ______

Accelerometer Placement Sketch

SEE PHOTO

Sine cond	Search Time	25°/ Min.
	Sweep Time	16°/ Min.
Search	20 to 75 cps @ 0.01 in. D.A.	
	75 to 3000 cps @ 3 G's peak	
Sweep	10 to 75 cps @ 0.10 in. D. A.	
	75 to 2000 cps @ 30 G's peak	
Z Axis Sweep	10 to 75 cps @ 0.05 in. D. A.	
	75 to 1500 cps @ 15 G's peak	

Random Cond.	Random Noise Duration ______
	___ to ___ cps @ ___ in. 2/cps
	___ to ___ cps @ ___ G 2/cps
	___ to ___ cps @ ___ db octave
	___ to ___ cps @ ___ G 2/cps
	___ to ___ cps @ ___ db octave

Resonant Search

Sweep Time

Resonant Frequency	AXIS X	AXIS Y	AXIS Z

Axis	Remarks	Search time or Sweep time	Operator
X	No Failure	15 Min. 20 Min.	10/4/69 D.V.T.
Y	No Failure	15 Min. 20 Min.	10/30/69 D.V.T.
Z	No Failure	15 Min. 20 Min.	10/27/69 D.V.T.

Test Technician: D.C. Van Tieghem Inspection: ______

Test Engineer: J. Martins

DESIGN VERIFICATION TEST

TEST DATA SHEET

Type of Test Vibration Date of Test 11-6-69

Part Name Seal-Off Valve Part Number CryoLab - SV3-812-5W2

Test Procedure ________ Part Serial Number 1,2,3,4,5 & 6

Type of Recorder Sanborn 350 No. of Channels 6

Recording Calibration 0 - 10 g's RMS / 0 - 100 g/s RMS

Bolt Torque Values ________

Sine cond	Search Time 25°/ Min.	
	Sweep Time 16°/ Min.	
Search	20 to 75 cps @ 0.01 in. D.A.	
	75 to 3000 cps @ 3 G's peak	
Sweep	10 to 75 cps @ 0.10 in. D. A.	
	75 to 2000 cps @ 30 G's peak	
Z Axis Sweep	10 to 75 cps @ 0.05 in. D. A.	
	75 to 1500 cps @ 15 G's peak	
Random Cond.	Random Noise Duration ____	
	___ to ___ cps @ ___ in. 2/cps	
	___ to ___ cps @ ___ G 2/cps	
	___ to ___ cps @ ___ db octave	
	___ to ___ cps @ ___ G 2/cps	
	___ to ___ cps @ ___ db octave	

Accelerometer Placement Sketch

SEE PHOTO

Resonant Search

Sweep Time

Resonant Frequency	AXIS X	AXIS Y	AXIS Z

Axis	Remarks	Dwell time or Sweep time	Operator
X	No Failure	15 Min. 20 Min.	10/14/69 D.V.T.
Y	No Failure	15 Min. 20 Min.	10/31/69 D.V.T.
Z	No Failure	15 Min. 20 Min.	10/27/69 D.V.T

Test Technician D. C. VAN TIEGHAM S/S Inspection ________

Test Engineer T. Mattin

DESIGN VERIFICATION

TEST DATA SHEET

Type of Test Functional Date of Test 11-3-69

Part Name Seal-Off Valve Part Number 7089-1

Test Procedure 8-440091 Para 5.2 Part Serial Number 1 through 6

A. Leakage

Leak Rate Before Cycling $<1x10^{-10}$ scc/sec

Leak Rate After Cycling $<1x10^{-10}$ scc/sec

Remarks

This test performed following vibration in X, Y and Z axes.

NOTE: Leak rate shown is for test in each axis.

B. Cycle

(One Open, One Closed)

Test Technician S. H. Moore

Test Engineer J. Martinez

DESIGN VERIFICATION

TEST DATA SHEET

Type of Test Functional | Date of Test 11-3-69

Part Name Seal-Off Valve | Part Number SV3-812

Test Procedure 8-440091 Para 5.2 | Part Serial Number 1 through 6

A. Leakage

Leak Rate Before Cycling $<1 \times 10^{-10}$ scc/sec

Leak Rate After Cycling $<1 \times 10^{-10}$ scc/sec

Remarks

This test performed following vibration in X, Y, and Z axes.

NOTE: Leak rate shown is the same for test in each axis.

B. Cycle

(One Open, One Closed)

Test Technician S. H. Moore 5/5

Test Engineer T. Martin

DESIGN VERIFICATION

TEST DATA SHEET

Type of Test Functional Date of Test 11-3-69

Part Name Seal-Off Valve Part Number 7079-1

Test Procedure 8-440091 Para 5.2 Part Serial Number 1 through 6

A. Leakage

Leak Rate Before Cycling $<1\times10^{-10}$ scc/sec

Leak Rate After Cycling $<1\times10^{-10}$ scc/sec

Remarks

This test performed following vibration in X,Y, and Z axes.

NOTE: Leak Rate shown is the same for each axis.

B. Cycle

(One Open, One Closed)

Test Technician S. H. Moore s/s

Test Engineer J. Martin

2.2.1.6.13 Seal Surface Contamination Test

Requirement

This test was performed to determine the extent of contamination that can exist across the seal surface of the valve O-ring before the test item fails.

Procedure

This test consisted of hairs of known diameters being placed across the seal surface of the test item starting with the smallest diameter and increasing toward the largest until failure occured. The test item was functionally tested with each diameter hair in place until failure occured.

The test data of each functional test was recorded. The hair diameter installed in the test item at each functional test was recorded.

Test Results

Several diameter hairs were placed across the seal surface of the valve with leakage resulting in excess of 1×10^{-6} scc/sec. The smallest diameter of hair was 0.0015 inch. This indicates that anything visible across the sealing surface would result in leakage greater than 1×10^{-7} scc/sec which is the maximum allowable.

2.2.1.6.14 Seal Surface Roughness Test

Paragraph 5.14 of Test Procedure 8-480091, "Seal Surface Roughness Test", was limited to seal surface contamination.

1. Leakage of the 0.0015 in. diameter hair at 1×10^{-6} scc/sec of helium, conducted as part of the seal contamination test, indicates that any surface roughness above or greater than this would result in leakage above the allowable.

2. Seal surface roughness tests were not conducted due to leakage rates experienced with the small diameter hairs. Tests have shown that 32 rms finish on the sealing surface is marginal with 16 rms finish or better adequate for this application of an O-ring seal.

2.3 CONCLUSIONS

The objectives of the Phase I and Phase II programs were met with the valves that were designed and developed for this program. The study and testing programs have produced data that enables AMETEK/Straza to make the following conclusions on the vacuum seal valves.

A. Many of the design features in the vacuum seal and vacuum seal/relief valves provide advancements in the state-of-the-art. These features eliminate the poor resealability and residual leakage that has been a problem at Cape Kennedy Launch Complex 39. As a result of their performance during Phase II testing, it is concluded that these valves will perform satisfactorily at Cape Kennedy (seacoast environment) for a minimum of five years.

B. The integral valve operator has reduced the potential for externally introduced contamination. The "Wilson" shaft seal provides a leakage free seal during pumpdown operations even after 500 open-close cycles. However, during cycling tests, the stem seal packing nut came loose and required re-tightening. A lock washer is required to retain the packing nut.

C. During assembly operations with the vacuum seal valve and vacuum seal/relief valve handle removed, it was possible to push the shaft into the valve body so that it cannot be retrieved. A retainer and washer are required on the shaft to eliminate this problem.

D. The shaft locking screw on the handle is inadequate. Lockwire shall be used to avoid inadvertent operation of the valve. This locking screw also provides inadequate handle retention and will allow water to collect just above the "Wilson" seal.

E. Design evaluation testing has indicated that Viton A and Viton V655-75 are marginal at +200°F. Ethylene Propylene leaks excessively above +180°F. Butyl is the superior seal in the range from -65°F to +200°F. All of the above seals are leak free at -65°F. Temperature range for seal usage is Viton A and V655-75 at -65°F up to +180°F. Ethylene Propylene may be used from -65°F to +150°F. Butyl B612-7 is recommended in the range from -65°F to +200°F provided age control conforms to KSC 79K 00030. The pumpdown port cap on the seal-off relief valve should be made from Dow Corning "Silastic 75" silicone which resists a flame of 1400°F for ten seconds.

F. The inlet screen provides adequate filtering for annular space contamination. A stronger screen (such as dutch twilled or plain) than the standard twilled or plain tested is required to withstand the 1 atmosphere differential. Care is required so that flow area would not be reduced. A stronger frame for support of the screen would also be an acceptable alternate. The inlet screen caused only slight increase in pumpdown time.

2.4 SPECIFICATIONS

Two specifications for future procurement of vacuum seal valves were written and submitted to NASA under Contract Number NAS 10-6098 titled "Vacuum Jacket Umbilical Lines Technology Advancement". The specification for a non-relief type seal-off valve is titled "Vacuum Seal-off Valve, Vacuum Jacketed Cryogenic Transfer and Storage Systems, NASA No. 79K00111". The specification for a relief type seal-off valve is titled "Vacuum Seal-off/Relief Valve, Vacuum Jacketed Cryogenic Transfer and Storage Systems, NASA No. 79K00110".

2.5 BIBLIOGRAPHY

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