DOCTOR OF ENGINEERING INTERNSHIP REPORT

By

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DOCTOR OF ENGINEERING

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Major Subject: Ocean Engineering

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May 1976

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INTRODUCTION

The purpose of this report is to establish that the author has previously met the essential objectives of the Doctor of Engineering Internship.

These objectives are: (a) to demonstrate the student's ability to apply his knowledge and technical training to real problems by making an identifiable contribution in an area of practical concern to the organization or industry in which the internship was served, and (b) to enable the student to function in a non-academic environment in a position where he will become aware of the organizational approach to problems, in addition to traditional engineering design or analysis.

Since the author is a licensed professional engineer in two states, with over twenty years of engineering experience, it is reasonable to assume that he has previously fulfilled these objectives. It is then necessary to choose from his experience that job assignment which best illustrates a combination of technical abilities and understanding of organizational interaction. Unfortunately, the two objectives tend to be somewhat contradictory, since high technical skill assignments are more often theoretical and quite specialized, frequently not requiring a great deal of organizational interrelationships. On the other hand, the jobs requiring organizational understanding tend to be "hardware" oriented, requiring perhaps a theoretical understanding of operation and design but not highly specialized technical skills.

The author will give a short summary of his engineering work experience and select one position, for a more detailed description, which he feels best demonstrates fulfillment of the above listed objectives of the internship.

That position was one involved in the setting up of a test program and providing test equipment for an early earth orbiting spacecraft for the U. S. Air Force. The author has in his files, documents, a number of which are reproduced and included with this report, to illustrate some of the problems which were encountered with subsequent solutions. These solutions were obtained through the author's own efforts and with the assistance of the organizational structure of the employer; the General Electric Company. In addition, precedence and standards were established which are still being used within the space industry; for example, the recent Manned Orbital Laboratory (MOL) hydrostatic tests at the Douglas Space Laboratory in Huntington Beach, California.

SUMMARY OF ENGINEERING WORK EXPERIENCE

The discussion contained within this report will be confined to engineering positions held since the author's graduation from Purdue University in February 1953. The author did, however, perform surveying work for the Miller Construction Company, in Illinois, during the summer of 1950, and worked in the Fluid Mechanics Laboratory for Dr. R. C. Binder, Professor of Mechanical Engineering at Purdue University while pursuing his undergraduate degree.

Immediately following graduation he commenced working for the McDonnell Aircraft Corporation (MAC) at Lambert Field in St. Louis, Missouri. In conformance with that company's policy, two weeks were spent in a training group being introduced to the company's organization, policies and drawing system. The training group leader gave lectures, conducted tours of all the McDonnell Aircraft Corporation facilities, and had each trainee write drawing change notices, engineering orders and work on actual drawings to gain experience in using the MAC system. This training was intended to encompass the entire aircraft and did, in fact, include structural, electrical and hydraulic system drawings. The author was then assigned to the Rotor Blade and Hub Group of the Helicopter Division, for which he had been hired. The Division had a Navy contract to develop a large transport convertaplane (XHRH-1 MAC Model 78) for the U. S. Marine Corps, with the same hub and rotor blade system being used for a heavy lift helicopter(XHCH-1 MAC Model 86) for the Navy. This rotor system is of some interest principally because it was driven by a tip pressure jet, with the air supply being pumped out through the leading edge of each rotor blade. The author was assigned the task of designing various hub parts, including the "spears" attaching the blades to the hub and the fuel line from hub to tip jets. The author was responsible for making layout and detail drawings of the various parts and made stress calculations based on centrifugal and bending loads on the blades. The author considered himself fortunate to be employed at McDonnell at this particular time as it was possible for him to witness the first flight of the converted F-88 with a turboprop in its nose, to see the mockup of the F-101, and to have many discussions with a friend working on the F4H preliminary design for the U. S. Navy, concerning the design philosophy being used.

In April 1953 the author left the McDonnell Company and joined the U. S. Navy.

In May 1953 the Navy sent the writer to Officer Candidate School in Newport, Rhode Island, where he successfully completed the courses listed on Page 23. He graduated in September 1953 and was commissioned an Ensign, USNR, with a 1515 Aeronautical Engineering Designator (AEDO). He next attended Aviation Ground Officers School at the Naval Air Technical Training Center, Jacksonville, Florida, until November 1953, and then to Catapult and Arresting Gear School in Philadelphia, Pennsylvania. Upon completion of these courses, his orders were changed to allow him to attend the first Steam Catapult School. While there, all members of his class were present at the first launch of a Douglas AD off the C-11 land based steam catapult at Mustin Field, adjacent to the school.

Duty aboard the USS INTREPID, CVA-11, was the next assignment. The USS INTREPID was the first aircraft carrier to have American built steam catapults and Mark 7 arresting gear. While a part of the pre-commissioning detail at Newport News Shipbuilding and Drydocking Company, in Newport News, Virginia, he observed and participated in many tests of the catapults, including structural, alignment and dead-loaded performance tests. After commissioning, the USS INTREPID was the subject of Project Steam II, which consisted of an extensive series of tests of the catapult and arresting gear using aircraft from the Naval Air Test Center (NATC) Patuxent River, Maryland. For these tests engineers and technicians were assigned from the Naval Aircraft Factory (NAF) in Philadelphia to instrument the catapults and arresting gear. The author, at this time the only Aeronautical Engineering Duty Officer stationed aboard the USS INTREPID, provided extensive support and advice for this group, being familiar with all the ship's systems and equipment installations. At the completion of Project Steam II, the author was able to convince the Project Officer to leave some of the instrumentation aboard for later use during operations. Neither the catapults nor arresting gear were giving consistent performance and the author felt this instrumentation was necessary to keep tabs on operational performance. In order to make use of this instrumentation, it was necessary for the author to train his sailors in the calibration, use, and maintenance of this equipment. In addition, he set up a maintenance system and gathered statistical data on parts usage and landing patterns aboard the aircraft carrier, which were transmitted to other Navy activities, particularly the Naval Aircraft Factory, for application to newer aircraft carriers.

In August 1955, the author was transferred to the Naval Aircraft Factory in Philadelphia, where he served as a Test Officer and Site

Officer on several catapult sites, being responsible for all testing, operations, maintenance, scheduling, etc. on these sites. He wrote reports concerning the above activities and was involved in the initial testing at the XC10-3 and XC1-1 sites, which were more advanced steam catapult designs. He also wrote Engineering Orders to the Design Division for investigation of several of his concepts on catapults and arresting gear.

Upon release from active duty in the U. S. Navy, he joined the E. W. Bliss Company in October 1957 rather than return to McDonnell Aircraft Corporation. This decision was based on the realization that he found catapult and arresting gear work more interesting than the design of helicopter parts, and the fact that the Bliss Company offered a position with their Catapult and Arresting Gear Fleet Service Unit (CAFSU), located at the Naval Aircraft Factory, Philadelphia. He had met and worked with many of the personnel of the Unit while on active duty, so was familiar with the group. While working for the E. W. Bliss Company he conducted tests in shipyards, aboard ships undergoing conversions, and acted as troubleshooter at sea when problems were encountered. While aboard the USS KEARSARGE CVA 33, the starboard catapult blew up off the south coast of Japan killing three crew members. The author's diagnosis of a fatigue failure as the cause initiated a fatigue life study for all U. S. Navy catapults in use throughout the fleet, and x-ray inspection of same.

In July 1958, the author accepted employment with the Radio Corporation of America (RCA) in the Airborne Systems Division located at Camden, New Jersey. There he was a member of an Engineering group charged with designing a facility for assembling, installing and testing the electronics and fire control system for the AVRO CF-105, Arrow Aircraft. He was one of a team of six engineers laying out the entire system test sequence. He was also responsible for coordinating the design of the Antenna Pattern Range Facility for this same location, Malton Airfield, near Toronto, Canada.

Upon cancellation of the CF-105 by the Canadian Government, the author was transferred to RCA's Moorestown, New Jersey plant and was involved in the design of the umbilical junction boxes for the Atlas Missile Initial Operational Complex (IOC). This design included an external coating to withstand temperatures in excess of 2000^{o}F, and an internal pressurization system. He demonstrated how pressure and leak test instrumentation could be built for less than $5.00 worth of materials (Manometer Board), which was used for Acceptance Testing of the umbilical junction boxes by the U. S. Air Force Inspectors.

In April 1959, RCA transferred him to Alexandria, Virginia to manage the Hawk Liaison Office at the RCA Service Company's facility. A high level decision within the company had been reached to transfer all Hawk Test Equipment design and manufacturing effort to Camden, New Jersey. The author was to insure that all research and development, design, production and documentation knowledge, effort and information were smoothly transferred. Ten RCA Service Company engineers were available to assist him as necessary, and as many RCA Camden engineers as required from time to time. The move was successfully accomplished with the previously contracted equipment delivery date being met. A substantial amount of patience and tact in handling people was essential in this particular job. The author and one other mechanical engineer handled the sign off and approval for all Hawk mechanical drawings at this time.

The final assignment at RCA was on the TRADEX (BEMEWS type) tracking antenna pedestal, again at the Moorestown plant in New Jersey. TRADEX was a large radar tracking antenna for Kwajalein Atoll in the Pacific, designed to track missiles during tests. The author worked on the design of a hydraulic system, a cable windup assembly, a large slip-ring assembly, and finally the lightning protection for the antenna. This effort required conceptual design, stress analysis, material selection and drawing approval for assemblies and parts.

In May 1960, the author left RCA and joined the M&T Company to manage and organize a catapult test site under U. S. Navy contract. The physical location was the Naval Air Station in Lakehurst, New Jersey. The position involved planning and scheduling tests, training of engineers and operating personnel in testing and operating procedures, evaluating tests, procedures, safety, etc. The testing included both deadloads and manned aircraft and drew heavily on the experience and background the author had acquired during the years spent in the Navy and with the E. W. Bliss Company.

After joining the General Electric Company in June 1962 he was assigned to the Advance Space Projects Department in King of Prussia, Pennsylvania. He was a member of a group pioneering a new concept of a project engineering type group charged with the responsibility of insuring complete vehicle testing without duplication. This particular job involved interaction with every group in the department, and has been selected for more detailed reporting in the next section. This effort resulted in the publication of a General Electric Technical Information Series (TIS) Report and a patent disclosure.

In August 1963, the author was transferred to Daytona Beach, Florida as part of the newly formed Apollo Support Department, of General Electric's Command Systems Division. This Department was formed specifically to support the National Aeronautics and Space Administration (NASA) Headquarters in their checkout, integration and reliability effort on the Apollo Program to place a man on the moon before the year 1970. The first assignment was in the Advance Systems Engineering group looking into new methods and devices applicable to the test and checkout of the entire space vehicle. The author specifically had studies underway in the use of acoustic monitoring for prediction of engine performance. This involved various pattern recognition techniques under development at General Electric's Research Laboratory in Schenectady, New York, and Electronic Laboratory in Syracuse, New York. The author also initiated a computerized fuel monitoring system study to develop a means of measuring on-board fuel level for use in all cryogenic fuel systems of the launch vehicle. A reorganization within NASA phased out this effort.

The next assignment, as a member of a Design Reliability Group, was entitled the Saturn S-1C, SII and later SIVB stage cognizant engineer. Responsibilities included:

1) Interfacing with NASA HQ personnel in Washington, D. C. and NASA and contractor people at various other centers and facilities.

2) Evaluating and providing status information for the Director of the Apollo Program, General Samuel Phillips.

3) Conducting studies and investigations as requested by NASA Headquarters.

Examples of such studies include an Allied Program Study and a maintenance survey at Kennedy Space Center. The Allied Program Study included an investigation of reliability methods used and results achieved in various missile, space, and weapon-system programs for applicability to the Apollo program.

On his own time the author instigated a proposal for a deep submergence test facility which was presented to the Division Vice-President and eventually turned over to another department for exploitation as a new business. This facility was suggested by the loss of the USS THRESHER.

In October 1967, the author became a member of the Apollo Test Program Evaluation Team. In this assignment the author was responsible for the Lunar Module (LM) Test evaluation report integration. Five to seven other engineers provided subsystem inputs which he coordinated and edited into an Evaluation Report. Individual reports covered LM-2, 3, and 4 flights. He also performed individual system test evaluations for some of the LM systems, and for Command Service Module (CSM) systems for a similar CSM report. These individual systems included at one time or another: structures, electrical power, docking, propulsion and ordinance. He also initiated an unsolicited proposal to another General Electric Department, for an ocean wave and wave force study based on courses he had taken at the University of

Florida.

In May 1969, he transferred to General Electric's Reentry and Environmental System Division (RESD) in Philadelphia, Pa. This was for eventual assignment as a member of a consulting team to the U. S. Air Force at the San Antonio Air Material Area (SAAMA), Kelly Air Force Base, San Antonio, Texas. This effort was to produce an aging and surveilance (A&S) test program for the Minuteman III, Mark 12 Reentry Vehicle; the end product of the program to consist of a set of test equipment, test plans, test procedures and test articles, all installed and working in SAAMA, with testing to eventually be conducted by Air Force technicians. While in Philadelphia, he was involved in a system philosophy review, attempted to set up a test equipment design review, worked on a standardization effort, interfaced with the Program Office, and conducted initial training of Air Force civilian technicians.

Upon transfer to San Antonio he was responsible for setting up vibration, shock and acceleration testing for a number of components and for all effort on the structural test program.

All General Electric furnished equipment, consisting of a number of electronic test racks and various fixtures and components, had to be integrated into the Air Force facilities and made compatible with Air Force equipment, such as centrifuges and shakers. This involved working with the Air Force (AF) Program Manager, Air Force Engineers, the Air Force technicians who were to conduct the testing, the Kelly Air Force Base machine shop personnel, structural test lab personnel and ultrasonic test people. All of these people had to be imbued with the A & S philosophy, educated to the goals of the A & S program and motivated to accept a new program the philosophy of which was outside of their previous experience. This work required a broad knowledge of mechanical and electrical characteristics of components and materials as well as a detailed knowledge of vibration, shock, acceleration and tensile testing. The author also initiated a proposal for using acoustic signatures for additional information in aging analysis and failure prediction.

In September 1971, the author became a Technology Mobilization and Retraining Program (TMRP) Consultant to the Texas Employment Commission (TEC) in San Antonio. This was part of a nationwide effort to locate jobs and/or retrain some of the 100,000 or so unemployed engineers throughout the United States. The author gave talks before several engineering societies in San Antonio, appeared on television in San Antonio, wrote articles for newspapers and magazines and particpated in NSPE and AIAA meetings on the problem. He interviewed numerous unemployed engineers in San Antonio, advised them, and visited employers in the area, attempting to locate jobs where the talents of these unemployed engineers could be properly utilized.

In December, having been offered a research assistantship at Texas A&M University (TAMU), he recommended another consultant to TEC. His recommendation was accepted in January and he terminated his contract with TEC and entered Texas A&M University.

While at TAMU, the author worked as a Research Assistant setting up and running dynamic tests on models of moored systems for the U.S. Naval Facilities Engineering Command under Dr. R. F. Dominguez. He then performed abstracting for the U.S. Maritime Administration under Dr. E. L. Kistler and finally taught two fluid mechanics laboratory classes under Dr. Y. K. Lou. In addition, he was elected to the Student Senate and to the Graduate Student Council representing Engineering.

In January 1975, he completed the requirements for a Master of Science in Civil Engineering. He has completed the course program for the Doctor of Engineering and in February 1975 commenced working for the Shell Oil Company in Houston, Texas.

With Shell he is a member of the Head Office Civil Engineering Staff in the Exploration and Production Department. He is developing the capability, within Shell Oil, to design and install single point mooring and loading systems for tankers, anywhere in the world. He has worked on a study of the use of single buoy storage systems for offshore southern California, and the use of various single point mooring (SPM) systems in the Gulf of Alaska. He has made a presentation on SPM's before a group of Shell, Arco and Mobile (SAM Group) people, has represented Shell at a Buoy Mooring Forum Meeting in Philadelphia and attended a Shell Group Single Buoy Mooring Seminar in London. He is presently working on a study of the use of SPM's in Bristol Bay in the Bering Sea.

INTERNSHIP EQUIVALENCY

The position to be examined in detail for its applicability in meeting the requirements for the Doctor of Engineering Internship is that of System Test Engineer with the General Electric Company's Advanced Space Projects Department, in King of Prussia, Pennsylvania. This assignment covered the period from June 1962 to August 1963. The author was a member of a group entitled System Quality Control Engineering, composed of approximately twelve engineers and specialists. The manager of the unit, K. Igler, reported to the Reliability and Quality Assurance Manager, L. Pearson, who in turn reported to the Department General Manager, L. Cowles (see Figure 1). The function of the group was:

a) To determine what system level acceptance testing was to be accomplished on the space craft.

b) To write appropriate test plans and test requirements (TR's), delineating test equipment and facilities, (Appendix A).

c) To monitor and review the design and acquisition of the facilities and test equipment.

d) To check the facilities and test equipment.

e) To prepare test Standing Instructions (SI's).

f) To supervise the actual testing by the test technicians.

g) To evaluate the results.

The author was specifically hired to handle all the hydraulic and pneumatic systems, of which there were five in the beginning of

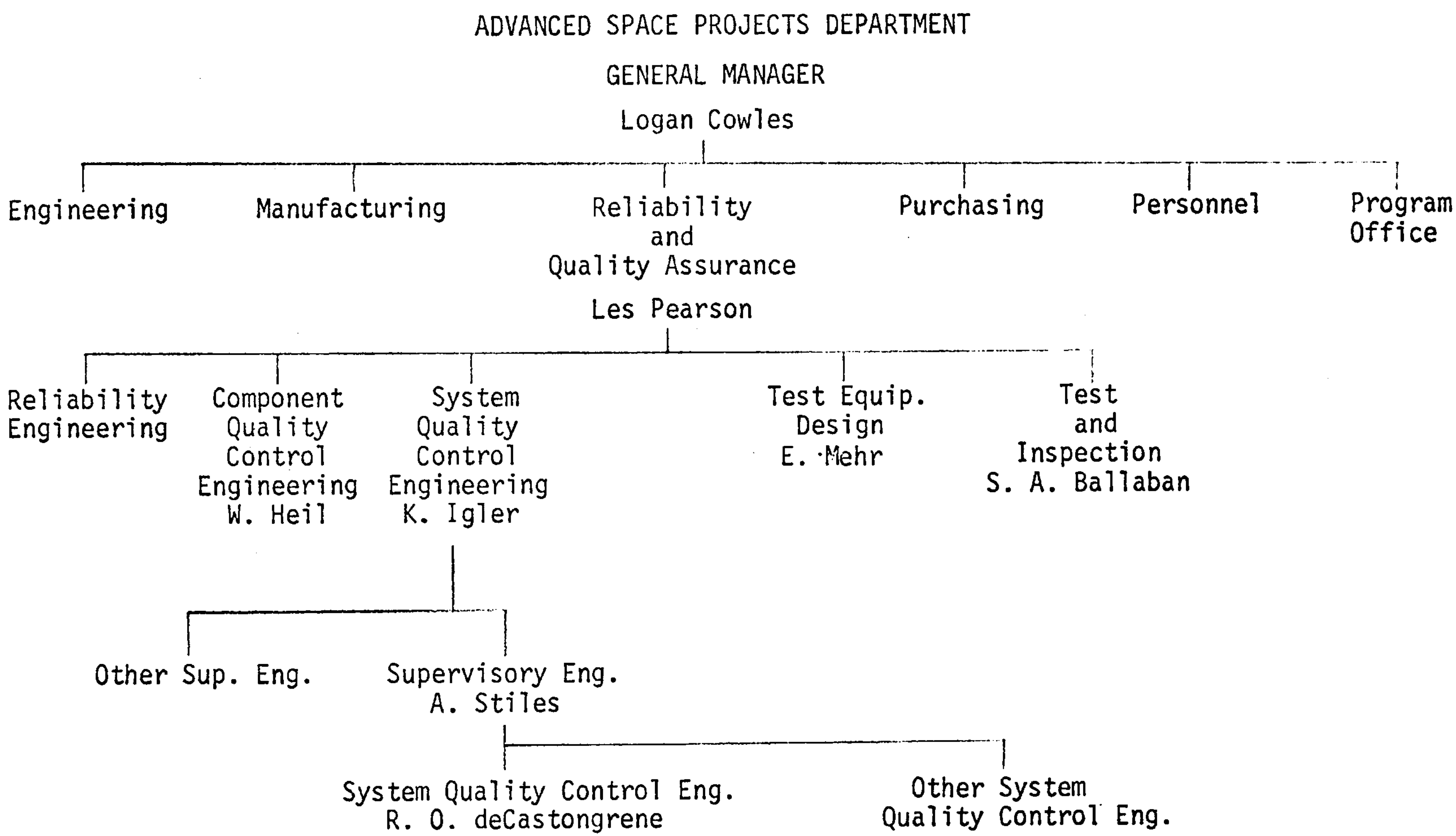


Figure 1 Advanced Space Projects Department Organization Chart

the program, declining to three at the time of completion.

The first task, to devise a test philosophy, was reasonably straightforward since few people paid any attention to it, the Reliability and Quality Assurance Manager, Les Pearson, being one of the exceptions. This test philosophy was defined in PIR 1343-PIR-020 (Appendix B) by the author and was partly based on his previous experience in testing hydraulic systems with the U. S. Navy, the E. W. Bliss Company and RCA. It was designed to insure both operability and safety of the system and was not specifically concerned with performance.

A review of the design of some of the systems under the author's cognizance revealed that testing was not possible, primarily due to the lack of test points at appropriate locations throughout the piping.

The suggestion for design changes, (PIR 1343-PIR-024, Appendix C), to enable testing in accordance with the test philosophy, evoked some heated discussion, (PIR 1173-698-117, Appendix D, PIR 1343-PIR-036 and others, Appendix E), and required extensive time and negotations to resolve. Eventually the system was modified to incorporate the recommended changes. At least part of this resolution was due to the previous semi-passive acceptance of the test philosophy by several of the second level managers, particularly, Les Pearson, Manager, Reliability and Quality Assurance and the Propulsion Program Manager, C. L. Robinson. PIR 1173-184, (Appendix E) mentions this inclusion of new test ports and discusses the agreement reached on testing at a meeting attended by representatives of all the G. E. groups involved.

Even with the redesign, a major problem existed in the extreme cleanliness requirement for these systems which increased the difficulty of testing. This requirement was determined by the nature of the fuels to be used, hydrazine and nitrogen tetroxide, and the long orbital life with resulting high reliability required of the spacecraft. This necessitated:

1) Using a clean gas for proof testing.
2) Using a common fluid and then in some manner cleaning the entire system after the test.
3) Using an extremely clean fluid and completely removing it after the proof tests.

Gases, particularly nitrogen, were readily available to the high degree of cleanliness required. However, due to the hazards associated with high pressure testing, 7500 psi in one system, the author considered it desirable to use a liquid to proof test. Heretofore, General Electric Missile and Space Systems products had been proof-tested with gas. Most liquids, due to their low compressibility, require much less energy to be compressed to a given pressure than do gasses. Therefore, a failure is less hazardous to personnel, equipment and facilities when liquids are used.

Cleaning an assembled system, particularly with bladders installed in the fuel tanks, did not appear feasible. It was thus decided to attempt to devise a method of using a clean fluid and somehow removing it all afterward. Consideration of various fluids revealed that freon could be obtained in such an extremely clean condition from the DuPont Company. In addition, Freon 114 had a low boiling point, which meant it would be a gas at normal temperature and pressure. Therefore, it could be easily purged from the system, following testing, by letting it boil out. The test equipment design group concurred and the equipment was designed as described in TIS 63SD282, (Appendix F). In addition, a patent disclosure was filed as this procedure had not been attempted before, although it has been used since in several similar hypergolic propulsion systems and in some liquid oxygen system testing programs. Figure 2 is a photograph, taken inside the test control room of some of the test panels. The panel to the right is the pressure control panel while the console to the left contains an electrical control panel, the instrumentation and recording oscillograph.

Although the Proof Test, as mentioned, was somewhat unusual, the leak testing proved to be the greatest problem, since the orbital life of the spacecraft necessitated extremely low gaseous leak rates, and the hypergolic nature of the fluids, required essentially zero leakage.

The first thought, in cooperation with the component Quality Control people, was to use a very sensitive flow meter manufactured by the Hasting Raydist Company in Hampton, Virginia. Although the flow meter worked quite well when observed in the Hastings Raydist plant, the attempts to use it at the General Electric facility were unsuccessful due to its extreme sensitivity. Temperature changes during test produced large flow fluctuations which completely masked the leak rates.

It was decided to try a method of leak testing using a helium mass spectrometer in which the system is pressurized with a mixture of air and helium. The system to be tested was placed inside a plastic tent, the concentration of helium in the tent monitored over a period

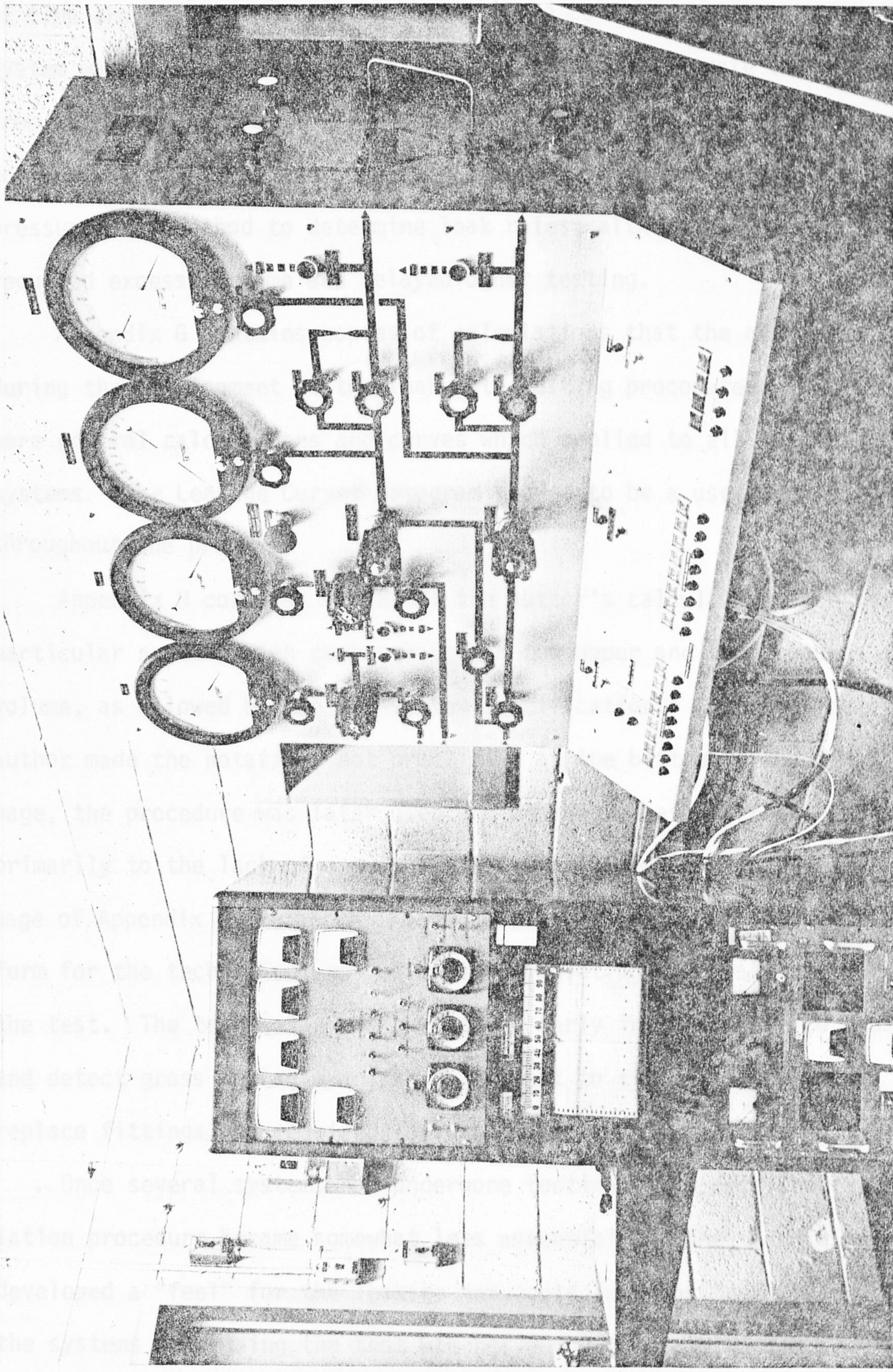


Figure 2 Picture of Control Room

of time and the leak rate calculated. As a backup, the pressure in the system was monitored throughout the test and the leak rate calculated from the pressure drop. (See Appendix G.) The mass spectrometer was not always operative, and it became necessary at times to use the pressure drop method to determine leak rates, although that procedure required excessive time and delayed other testing.

Appendix G contains copies of calculations that the author made during the development of the leak rate testing procedures. These were general calculations and curves which applied to all of the systems. The Leakage Curves Nomogram proved to be a useful expedient throughout the program.

Appendix H contains copies of the author's calculations for one particular system, with curves based on the upper and lower bounds of volume, as allowed by the sub-system specification. Although the author made the notation "not practical" at the bottom of the first page, the procedure was later used and designated as "bearable", due primarily to the lack of a suitable alternate procedure. The final page of Appendix H, which is labled Calculation Page, provides a sample form for the technicians to follow in calculating the leak rate during the test. The technician was thus able, early in the tests, to monitor and detect gross leakages and stop the test to tighten, repair or replace fittings, as required, before too much time had expired.

Once several systems had undergone testing, this detailed calculation procedure became somewhat less essential, as the technicians developed a "feel" for the leakage and could judge by "eye" which of the systems undergoing the test was not going to pass. Again, cleanliness was a major consideration during leak testing, the same as it had been during proof testing. In this case, it was necessary to be positive that particles generated from operation of solenoids and valves in the test equipment were not carried into the vehicle piping by the gasses during leak test pressurization. PIR 1343-PIR-137 (Appendix I) discusses the method decided upon to prevent contamination during leak test. This involved using a special Millipore filter installed on each test port to both filter the gasses entering the system under test, and to be examined after testing, with a microscope, to see if any particulate contamination was present. Special filter holders were obtained from the Millipore Company that enabled filtering in both directions, vice the normal one for flow in only one direction. This greatly simplified the installation and reduced the cost and time required for preparation for testing. These filters were installed during manufacturing, and remained in place until the space vehicle was shipped out to the launch site.

Other systems under the cognizance of the author included the orbit adjust system, which was the electronics portion of the above discussed propulsion system. Testing involved using earth gravity to simulate the thrust of the rocket motors, similar to methods used in previous catapult instrumentation calibration. In this case a special gravity survey was required at the test site due to the extreme accuracy of the accelerometer used.

The accelerometer was placed at several known angles to the local earth gravity field and tests conducted to be sure it would accurately operate under the accelerations to be expected in orbit.

Previous thinking had required the use of centrifuges to conduct such tests. This use of earth gravity saved considerable test time and the cost of the centrifuge.

In summary, the author was successfully able to apply his knowledge in the design of a test program for several systems of an early earth orbiting spacecraft. This application was accomplished within the existing organizational structure of a major corporation and involved the cooperation of a large number of people with diverse backgrounds. It was necessary to obtain agreement on new procedures and design changes from such separate groups as Propulsion Subsystem Engineering, Aerospace Ground Support Equipment Engineering, Field Operations, Value Engineering, Logistics, Reliability Engineering, Test Equipment Design, Company Program Manager, Customer (Air Force) Program Manager and Subcontractor design group.

One valuable lesson learned from this experience by the writer is to obtain top management approval or concurrence in a course of action, at least a tacit approval, in the very beginning of a project, so when problems arise, management has already been comitted to support the program and their people.

EDUCATIONAL DATA

Purdue University - Bachelor of Science in Aeronautical Engineering
Graduated February 1953

Texas A&M University - Master of Science in Civil Engineering
Graduated May 1975

University of Florida - 27 credit hours toward a Master of Science in Engineering

U. S. Navy Schools

Officer Candidate School, Newport, R. I.
Graduated September 1953
Subjects: Gunnery, Navigation, Seamanship, Communications, Naval Operations, Naval and International Law, Naval Organization, Naval Engineering and Damage Control

Aviation Ground Officers School, Jacksonville, Florida
Graduated November 1953
Subjects: Naval Aeronautic Organization, Leadership, Naval Air Equipment, Aircraft Operation and Maintenance, and Airborne Electronics

Naval Air Technical Training Unit, Philadelphia, Pa.
Graduated February 1954
Subjects: Hydraulic and Steam Catapults and Hydraulic Arresting Gear

Fire Fighting School, Norfolk, Va.
Graduated March 1954
Subjects: Firefighting and fire prevention at sea and on shore

Guided Missile Seminar, Bureau of Naval Weapons, Washington, D. C., attended February 1962

Weapons Research and Development Seminar, Naval Ordnance Lab., White Oak, Md., attended June 1964

Undersea Warfare Seminar, Naval Underwater Weapons Research and Engineering Station, Newport, R. I., attended September 1966

Conventional Weapons School, RCVW-4, Cecil Field, Jacksonville, Florida, attended March 1967

Military Hydrography and Oceanography, NAVOCEANO, Suitland, Md., attended July 1968

Industrial College of the Armed Forces - National Security Management - Completed 1971

Other U. S. Government Courses

Office of Civil Defense, DOD, Sponsored Courses

Fallout Shelter Analysis, Rockledge, Flordia, attended September to December 1966 (Night Course)

Environmental Engineering, San Antonio, Texas, attended September to December 1970

Fallout Shelter Analyst Updater, San Antonio, Texas attended May to June 1971

Kennedy Space Center (NASA) Sponsored Courses

Launch Vehicle Familiarization
Range Safety
Ordnance Systems
Hydraulic Systems
Electrical System (I.U.)
Propulsion System
Checkout and Launch Procedures

Manned Spacecraft Center Sponsored Courses

CSM - Structures
CSM - LM Docking

NASA Headquarters Sponsored Course

Course for Quality Surveyors 1963

Miscellaneous Schools

McDonnell Aircraft Corp. - Stress Analysis attended February to April 1953 (night school)

Radio Corporation of America - Design Philosophy of ASTRA, attended July to September 1958

General Electric Courses

Reliability Engineering 1963
Apollo Reliability Modeling 1964
Creative Approach Seminar 1965
Explosives Handling and Safety 1970

Dunegan/Endevco Seminar

Acoustic Emission April 1974

PROFESSIONAL SOCIETY AFFILIATIONS

American Aviation Historical Society

American Institute of Aeronautics and Astronautics

American Society of Civil Engineers

American Society of Naval Engineers

National Society of Professional Engineers

Naval Institute

Naval Reserve Association

Society of Automotive Engineers

Texas Society of Professional Engineers

APPENDIX A

TEST REQUIREMENTS FORM 1-3431 REV. (6-60)	S.I. NO.	PERM.	TEMP.	ORIG. T.R. NO. 2343-21	DATE	PAGE OF	Q.I.E.E. SCHD.
TO: E. Mahr J. Sebastian		FROM: R.O. deCastongrene			W.C.S. NO.	PROGRAM 698-AL	
DRAWING NO.		COMPONENT NAME: Pneumatic Subsystems			SERIAL NO.		

ITEM NO.

PNEUMATIC & PROPULSION SUB-SYSTEMS

1.0 The following types of testing will be performed on all pneumatic and propulsion sub-systems.

A. Proof Test
B. Leak Test
C. Functional Tests

These will be modified and taylored to the individual systems but will in general use the same test equipment.

2.0 Test Equipment Required

2.1 Mechanical Equipment

2.1.1 Jig to check nozzle allign. 4 sys.

2.1.2 A6 Dolly

2.1.3 Fwd sec. Dolly

2.1.4 OCV Dolly

2.1.5 Slings 2-3

2.1.6 Torque wrenches

2.2 Leak Detection Eq.

2.2.1 Flow meter test

2.2.1.1 Pneumatic Test Stand Flow Meter & Diff. Pres. across bladders and discs.

2.2.1.2 Gas Supply Nitrogen Freon & Helium (5000 psi)

2.2.2 Mass Spec. Test

2.2.2.1 Mass Spec.

DISTRIBUTION	APPROVED BY	REQUIREMENTS	ITEM NO.	NEED DATE	PROM. DATE
	APPROVED BY	STANDING INSTRUCTION			
	ACCEPTED BY	TEST EQUIPMENT			
	ACCEPTED BY	TEST FIXTURES			
		FACILITIES			

2.2.2.2 Calibrated leak

2.2.2.3 Box for OCV

2.2.2.4 Box for A1-4

2.2.2.5 Gas Supply Helium

2.3 Proof Test Eq.

2.3.1 Liquid Freon Supply

2.3.2 Pump & Gage Set

2.3.3 Connecting lines & fittings

2.3.4 Cap for burst disc and relief valve lines. (3)

2.4 Functional Test Eq.

2.4.1 Test Cables

2.4.1.1 Press Trans. 3 sets

2.4.1.2 Temp. Trans. 3 sets

2.4.1.3 Solenoids 3 sets

2.4.2 P.S. for Transducers 28 VDC

2.4.3 Oscilligraph for pres. temp and voltage readouts

2.4.4 P.S. & control for tank heaters

2.4.5 Flow bench for regulator tests

2.5 General

2.5.1 Nozzle plugs for Proof & leak Tests and functional 4 sets with vents.

2.5.2 Solenoid Operating Panel & Harness.

3.0 Facilities

A Pneumatics Test cell is required for conducting the tests. It must have sources of nitrogen, helulm and freon. Also it must be vented and walls reinforced to minimize effects of explosion. Also it should have continual air change to clean out leaking nitrogen heluim etc. To prevent suffication of operating personell.

Clean facilities should be available so that part changes etc. can be made in event of failure.

4.0 References

SVS 3955	PIR 1343-020
SVS 3994	PIR 1343-021
SVS 3995	PIR 1340-011

5.0 Test Description

5.1 Prop. Sys.

Each Prop. Sys. will be tested individually.

5.1.1 Proof Test

A proof test will be run on the complete Prop. System. Recording temp. and pres. on oscillagraph.

5.1.1.1 The N_2 Pressurization system will be proof tested to 7500 psi.

5.1.1.2 The low pressure portion of the system will be pressurized to 374 psi. After installing nozzle plugs and hooking up solenoid actuating panel.

5.1.2 Leak Test

A leak Test will be run on the complete Prop. System.

5.1.2.1 High Pres Tank & Pip. Max. leakage ------ including across squib.

5.1.2.2 Lo Pres System Max. leak rate-------

5.1.2.3 Leakage across burst Diap.

5.1.2.4 Leakage across bladders.

5.1.2.5 Leakage across solenoids

5.1.2.6 Leakage through fill valves

5.1.2.7 Leakage through relief valves

5.1.3 Functional Tests

Operability of all electrical and mechanical eq. except squibs will be checked.

5.1.3.1 Check flow and lockup press. of regulator & freq. response.

5.1.3.2 Check freq. resp. of solenoid valves

5.1.4 Nozzle allignment

A nozzle allignment check will be made and torque checked on mounting bolts.

5.2 Pneu. Sys. Each pneu. sys. will be checked individually.

5.2.1 Proof Test. A proof test will be conducted on the complete system using N_2 and recording temp. and pres. on oscilligraph.

5.2.1.1 The high pressure bottle will be proofed to 5250 psi.

5.2.1.2 The downstream system will be proofed to 5250 psi.

5.2.1.3 The lo pres. noz. sys. will be proofed to 100 psi.

5.2.1.4 The hi pres noz. sys. will be proofed to 600 psi.

5.2.2 Leak Test

A leak Test will be run on each Pneu. Sys.

5.2.2.1 High Pres. tank and piping. Max. leakage __________ including across squips.

5.2.2.2. Low Pres. Piping ______________________

5.2.2.3 Leakage across solenoids. Each solonoid should have a max. leakage of ________ with a max of ________ total.

5.2.2.4 Leakage thru fill valves. ____________________

5.2.3 Functional Test

Functional will be run on stabilization components.

5.2.3.1 Flow thru Pres. Regulators with all combinations of nozzles.

5.2.3.2 Freq. response & operations of solenoids.

5.2.3.3 Check operation of tank heaters and thermostats.

5.2.4 Allignment

An allignment check will be made of all nozzles, and check of projection clearance made for plume.

6.0 Problem Areas

1. Firm leak rates

2. Cleaniless Requirements for Sys.

3. Need for Design change in Prop Sys.
   to enable proofing.

7.0 Requirement

1. Test Eq. needed about week 40.

PERM.	TEMP.	ORIG T.R. NO.	DATE		SCHED.
		1343-11-1	10/30/62		
FROM R. deCastongrano			N.C.S. NO.	PROGRAM	
COMPONENT NAME Pneumatic Subsystems			SERIAL NO.		

NO.

Since T. R. 1343-11 was issued the following changes and additions to the requirements have occurred or become available.

2.1.1 Jig. Delete Req.

2.1.2 A4 Dolly Delete.

2.1.6 Torque wrenches. Add specifications:

0-50 in# with Graduations in steps of 2 in lbs.
0-200 in # with Graduations in steps of 10 in #.
Include adaptors for use on all Vehicle Tube Fittings and if practical have direct reading scale for adaptors on Torque Wrenches.

2.1.7 Filters for all Fill lines, Pressure tops and burst disc line.

2.2.1.2 Gas Supply Add: Spec. Dew Pt. - 100°F
Oil < 10 ppm
98% of particles having a Dia < 5 microns and all < 12 microns.

2.3.1 Liquid Freon Add: Spec. Moisture < 10 ppm
Oil < 10 ppm
Particules count range close to Freon TF

2.4.2 Power Supply for Transducer 28 VDC
Add: and 5 V ± 1% DC

2.4.4 Power Supply and Control for Tank Heaters
Add: 115 VAC & Reostat.

2.5.1 Add: Nozzle plugs for stabilization Proof and leak. Plugs not required for Prop. Nozzles.

5.1.1.2 Change 374 to 300 psi. Delete installing Nozzle plugs.

5.1.4 Delete.

5.2.4 Delete.

DISTRIBUTION		APPROVED BY	REQUIREMENTS	ITEM NO.	NEED DATE	PROM. DATE
B. Kehr	J. Testa	10/31/62				
G. Christopher	W. Mitchell	APPROVED BY	STANDING INSTRUCTION			
F. Harrigan	A. Bartoletto	11/1/62				
W. Bell	W. McConnaughy	ACCEPTED BY	TEST EQUIPMENT			
J. Swanson	J. Atamian	E. P. Mish 11-5-62				
J. Swab	R. Woodyard	ACCEPTED BY	TEST FIXTURES			
H. Wenzel	C. Beauchamp					
K. Igler	J. Sebastion					
L. Silverstrand	F. B. Klaser		FACILITIES			

T. R. 1343-11-2
Page 2

6.0 1. Leak rates are presently as follows:

Stabilization - PIR 1181-083

Propulsion

Pressurant Bottle 210 scc/hr @ 5000 psi

Start valve to reg. 1.3 scc/hr @ 300 psi

Regulator to Burst disc 75 scc/hr @ 300 psi

Burst to Bladder 100 scc/hr @ 300 psi

Bladder to Burst (Liq.) 150 scc/hr @ 300 psi

Burst to Solenoid 100 scc/hr @ 300 psi

3. Design Change accomplished.

(Delete.)

NOTE: Testing in Pneumatics Test Cell will be performed with the section on the Manufacturing dollies.

TEST REQUIREMENTS FORM 1-0431 REV. (6-60)	S. I. NO.	PERM.	TEMP.	ORIG. T.R. NO.	DATE	PAGE	Q.I.E.E. SCHED.
				1343-11-2	12/20/62	1 OF 2	

TO	FROM	N.C.S. NO.	PROGRAM
E. Mehr	R. O. daCastongrena		

DRAWING NO.	COMPONENT NAME	SERIAL NO.
	Pneumatic Subsystem	

ITEM NO.

T. R. Addendum

1. In light of the problems which AGE has encountered in using Flowmeters for leak rate testing, it is essential that we have a backup leak rate testing method. Therefore we should implement Para. 2.2.2 which calls for Mass Spectrometer Leak Testing. This will require either the box, as delineated in 2.2.2, 2.2.3, and 2.2.4 or an equivalent container to hold the vehicle.

   Additionally we need the following additions to T.R. 1343-11:

   Add: 2.2.2.6 External Cold Trap for CEC 24-120A Mass Spectrometer. (M.S.)

   2.2.2.7 Remote Meter for above M.S.

   NOTE: The M.S. of Paragraph 2.2.2.1 is part of AGE Item 41 and is furnished with the calibrated leak (Para. 2.2.2.2)

2. Some question has been raised about the ability of our procedures to Pressurize the Propulsion Tanks without collapsing the Bladders. To demonstrate this capability we need the following:

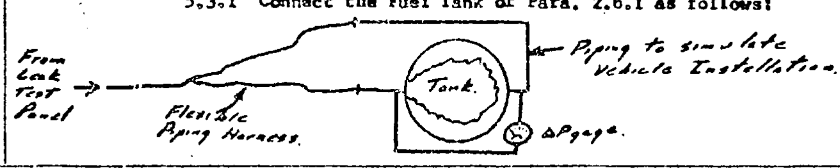
   Add: 2.6 Procedure Test Material

   2.6.1 Fuel Tank with Bladder. The old A4 Section Tanks are still available and can be obtained thru S. G. Mangano, Room 5707.

   2.6.2 A Differential Gage able to withstand 400 psi and reading 0 - 20 psi in maximum of 0.5 psi increments. Such a gage should be available from the Advent Program.

   Add: 5.3 Procedures Test

   5.3.1 Connect the Fuel Tank of Para. 2.6.1 as follows:



DISTRIBUTION	APPROVED BY	REQUIREMENTS	ITEM NO.	NEED DATE	PROM. DATE
	APPROVED BY	STANDING INSTRUCTION			
	ACCEPTED BY	TEST EQUIPMENT			
	ACCEPTED BY	TEST FIXTURES			
		FACILITIES			

5.3.2 Pressurize to 400 psi in 5 psi increments recording the pressure indicated on Differential Pressure Gage.

3. The following additions and changes to the T.R. are required:

2.2.1.2 Gas Supply

Was: Oil Contamination 10ppm

Change To: Oil Cont. 5ppm

2.3.1 Liquid Freon

Was: Particule Count range close to Freon TF

Change To: Particule Count as follows:

98% of particles having a diameter less than 5 microns and all less than 12 microns.

2.4.1.4 Umbilical Connection for monitoring Pressure and Temperature during Pre and Post Vibration Leak Test.

2.4.6 Need Pressure Transducer for recording lock up Pressure at outlet from Pressure regulator. See Para. 3.3 SI # 238148.

2.5.3 Diving Board - Provide a means to reach the Prop. Fittings within sec. 6 and lighting during this time.

TEST REQUIREMENTS FORM 1-0431 REV. (6-60)	S.I. NO.	F.		ORIG. T.R. NO.	DATE	PAGE	Q.C.E.E. SCHED.
	.			1343-11-3	3/11/63	1 OF 1	
TO: E. Mohr		FROM: R. O. LeCastongrena			N.C.S. NO.	PROGRAM	
DRAWING NO.		COMPONENT NAME: Pneumatics			SERIAL NO.		

ITEM NO.

This T.R. addendum adds equipment needed for testing the Fwd. Pneu. Sys. and for the change to Leak Test Procedure.

The following New Equipment is required:

1. Calibrated leaks: 10, 20, 30, 100, 150, and 200 scc/hr.
   50, 100 & 200 avail.
   These should all be calibrated with both Pure He and a 10-90 mixture of Helium and Nitrogen.

2. 0-4000 psi Heise Gage 0-5000 Avail

3. Thermocouples and readout equipment (As presently in use) Avail

4. Templistiks for following Temp. Ratings: Contamination??
   150°F, 163°F, 175°F, 188°F, and 194°F

5. Another set of Millipore Filters (two way) (15 Min.) 20 presently on hand

6. Heat Lamps. (As presently in use) available

7. Torque wrench 0-300 in. lb. with graduations in steps of 10 in. lbs. Bldg 4 Toolcrib

8. 4 Nozzle plugs for P/N 11329577 able to withstand 500 psi. On order

9. Voishan Seals per G.E. Dwg. 163A4166 for all connections on Propulsion System. obtain from Mfg or shop supplies

10. Means of reducing voltage from 28 VDC to 12.5 ± 2 VDC for holding abort (fill) solenoids open during leak test filling and venting. (Should be part of test cell equipment).

Further defination of the leak test box indicates dimensions should approximate 10' x 10' x 10' to hold both bulkhead and Sec. 6. Tent 6' x 8' x 10' installed.

Propulsion Fuel Tank and Test called out in T.R. 1343-11-2 is still required.

Testing of Prop. Sys. may be held up if this is not soon run. TED does not run Tests.

Notes: Provide the Tank & we will perform the Test.

DISTRIBUTION	APPROVED BY / ACCEPTED BY		ITEM NO.	NEED DATE	PROM. DATE
E. Mehr, G. Gifford	APPROVED BY: 3/12/63	REQUIREMENTS			
W. Wunch, SQCE	APPROVED BY: 3/12/63	STANDING INSTRUCTION			
G. Blume	ACCEPTED BY: W. Wunch 4/11/63	TEST EQUIPMENT			18
F. Swan, J. McGuire, V. Ries	ACCEPTED BY	TEST FIXTURES			17
P. McCullagh		FACILITIES			

TEST REQUIREMENTS FORM E-0481 REV. (6-63)	S.I. NO.			ORIG. T.R. NO.	DATE	PAGE	Q.I.E.E. SCHED.
				2143-11-4	4/5/63	1 OF 1	
TO E. Mehr		FROM R. O. deCastongrene			N.C.B. NO.	PROGRAM	
DRAWING NO.		COMPONENT NAME Pneumatics			SERIAL NO.		

ITEM NO.

T. R. Addendum

Delete Requirement for Freon 14 Supply.

DISTRIBUTION	APPROVED BY	REQUIREMENTS	ITEM NO.	NEED DATE	PROM. DATE
E.J. Mehr	A. M. Stiles Jr. 4/11/63				
W. Wunch	APPROVED BY ... 4/11/63	STANDING INSTRUCTION			
G. Blume	ACCEPTED BY ... 4-15-63	TEST EQUIPMENT			
G. Gifford	ACCEPTED BY	TEST FIXTURES			
G. Wenning		FACILITIES			
K. Igler					
A. Stiles					

TEST REQUIREMENTS	S.I. NO.	PERM.	TEMP.	ORIG. T.R. NO.	DATE	PAGE	Q.I.E.E. SCHED.
				[illegible]	6/17/63	1 OF 1	
TO: E. Mohr		FROM: R. O. deCastongrene			N.C.S. NO.	PROGRAM	
DRAWING NO.		COMPONENT NAME: Pneumatics			SERIAL NO.		

ITEM NO

Leak Test

Box of Para. 2.2.2.4 should be about 3' x 3' x 3'.

Afixed Volume Tent of these dimensions should be satisfactory.

5' dia x 4' high Tent & Frame has been provided

wfd

DISTRIBUTION					
E.J. MEHR K. IGLER	APPROVED BY R.M. Stiles, Jr. 4/17/63	REQUIREMENTS	ITEM NO.	NEED DATE	PROM. DATE
W. WUNCH	APPROVED BY [illegible] 4/18/63	STANDING INSTRUCTION			
G. BLUME	ACCEPTED BY [illegible] 4/25/63	TEST EQUIPMENT		16	
C.M. SMITH	ACCEPTED BY	TEST FIXTURES		16	
G. GIFFORD		FACILITIES			
R. deCASTONGRENE ✓					
G. WENNING					
A. STILES					

TEST REQUIREMENTS FORM 1-6431 REV. 1-60	S. NO.	PERM.	TEMP.	ORIG. T.R. NO.	DATE	PAGE	Q.I.E.E. SCHED.
				1343-11-6	5/29/63	1 OF 1	
TO E. Metz		FROM R. deCastongrene			N.C.S. NO.	PROGRAM	
DRAWING NO.		COMPONENT NAME Syst. Pneumatics			SERIAL NO.		

ITEM NO.

Test Cell Instrumentation

Revise wiring of Test Equipment to improve linearity and to use more sensitive galvos (312).

Construct Resistance calibration box to simulate transducer for calibration of Oscillograph. Include 0 switch on Panel to give full transducer Resistance Drop to Galvo Signal.

On the three pressure trans circuits the Panel Meters will be disconnected but may be retained in the panel if desired.

DISTRIBUTION					
E.J. Metz, R. deCastongrene, W. Wunch, G. Wenning, J. Swanson, R. Stiles, G. Blume, File, G. Gifford, K. Igler, C.M. Smith					

		ITEM NO.	NEED DATE	PROM. DATE
APPROVED BY A. Stiles, Jr 5/29/63	REQUIREMENTS			
APPROVED BY [illegible] 5/31/63	STANDING INSTRUCTION			
ACCEPTED BY W. Wunch 6/3/63	TEST EQUIPMENT			22
ACCEPTED BY	TEST FIXTURES			22
	FACILITIES			22

GENERAL ELECTRIC
MISSILE AND SPACE VEHICLE DEPARTMENT
PHILADELPHIA

PROGRAM INFORMATION REQUEST/RELEASE

NO.	1343-PIR 176
FROM	R. O. deCastongrene SQCE Rm. 3226 CC&F #3
TO	E. J. Mahr/Mgr. Test Equipment Design Rm. 2246 CC&F #2
DATE SENT	3/5/63
DATE INFO. REQUIRED	
PROJECT AND REQ. NO.	
REFERENCE DIR. NO.	

SUBJECT

LEAK BOX FOR PNEUMATICS LEAK TEST

INFORMATION REQUESTED/RELEASED

The purpose of this PIR is to re-emphasize the need for the Leak Box called out in TR 1343-11 dated 8/3/62 and 1343-11-2 dated 12/20/62. The Fixed Volume Tent outlined in D. Temples suggestion A133 would be satisfactory. This box must be large enough to hold the complete sec. 6 including bulkhead. Based on our present test configurations a separate container would be desireable for the bulkhead alone.

The present leak test method is unsatisfactory since it is relatively impossible to repeat a volumn configuration. We require a relatively fixed volumn for repetitive leakage measurements and a minimum of calibration runs especially for pre-and post-OA leak test comparisons. A means should also be provided to permit easy evacuation of the helium concentrations.

Concurred A. M. Stiles Jr.
A. Stiles/Supv. Engr.
SQCE

DISTRIBUTION

K. Igler	E. J. Mahr	W. Wunch	G. Gifford
W. W. Hall	J. L. Swanson	R. deCastongrene	A. Stiles
G. Blume	L. C. Pierson	G. Wenning	L. Gallagher

PAGE NO. 1 OF 1

CONT. ON Final

FORM 1020 Rev. (9-58)

APPENDIX B

GENERAL ELECTRIC
MISSILE AND SPACE VEHICLE DEPARTMENT
PHILADELPHIA

PROGRAM INFORMATION REQUEST/RELEASE

NO.	1343-PIR-020
FROM	R. O. deCastongrene Systems Q. C. Engineering CC&F #3 Rm. 3212 Ext. 6215
TO	Distribution List
DATE SENT	
DATE INFO. REQUIRED	
PROJECT AND REQ. NO.	
REFERENCE DIR. NO.	
SUBJECT	PROP SYSTEM SE 5 1 & 2

INFORMATION REQUESTED/RELEASED

The 698 Philosophy of Pneumatic System Testing includes the following types of test:

A. Proof test to ensure structural integrity
B. Leak testing to ensure performance
C. Functional test to ensure system operability

This PIR deals with the System Proof Test. Although the components are proof tested individually it is necessary to proof as a system to reveal any damage in assembly, poor joints, structural weakness etc.

In order to demonstrate the integrity & safety of the system, proof testing is conducted at 1½ times operating pressure. With the present Design of the Propulsion System (check valve back to back with Burst Diaphram) Proof Testing is not possible other than for the Nitrogen pressurization. In addition we are unable to even go to ½ operating pressure, therefore it is essential that a modification be instituted to enable proof testing of the complete high & low pres. sys.

DISTRIBUTION	PAGE NO. OF
	CONT. ON

FORM 1020 Rev. (9-58)

GENERAL ELECTRIC

MISSILE AND SPACE VEHICLE DEPARTMENT
PHILADELPHIA

PROGRAM INFORMATION REQUEST/RELEASE

NO.			1343-PIR-021
FROM: R. O. deCastongrene Systems O. C. Engineering CC&F 3 Rm. 3212 Ext.6215		TO: Distribution List	
DATE SENT	DATE INFO. REQUIRED	PROJECT AND REQ. NO.	REFERENCE DIR. NO. PIR 1343-020

SUBJECT

PROOF TESTING

INFORMATION REQUESTED/RELEASED

Safety

The method of Proof Testing using high pressure gas has inherent safety limitations due to the high amount of energy stored. In the event of failure a blast effect is encountered in which pieces are scattered similar to shrapnel, causing extensive vehicle damage. This effect dictates use of a very strong test cell capable of absorbing the blast.

A method exists of reducing this effect to more readily controlled levels. This is the hydrostatic test, in which an incompressable fluid is used to conduct the proof test rather than a gas. In the hydrostatic test the yielding of the metal tends to reduce the pressure of the medium to such an extent that little or no explosion results.

The first thought along these lines was to use water as the pressurizing medium. However many objections were voiced against water due to possible difficulties in removal from system & possible ill effects on the regulator.

To eliminate these posibilities thought has been given to the use of freon 114 as the pressurizing medium. It appears to have little or no effecton the existing system materials, has a low compressibility and will boil at about 38°F at Atmospheric pressure. This means that upon completion of the test you merely open the valve and the freon boils, purging itself from the system. If necessary the heaters can be energised to speed up the process.

We are presently planning to use this method and welcome any suggestions and/or comments, by August 1, 1962.

DISTRIBUTION	PAGE NO. OF
	CONT. ON

FORM 1080 REV. 4-60

APPENDIX C

GENERAL ELECTRIC
MISSILE AND SPACE VEHICLE DEPARTMENT
PHILADELPHIA

PROGRAM INFORMATION REQUEST/~~RELEASE~~

NO.
1343-PIR-1343-024

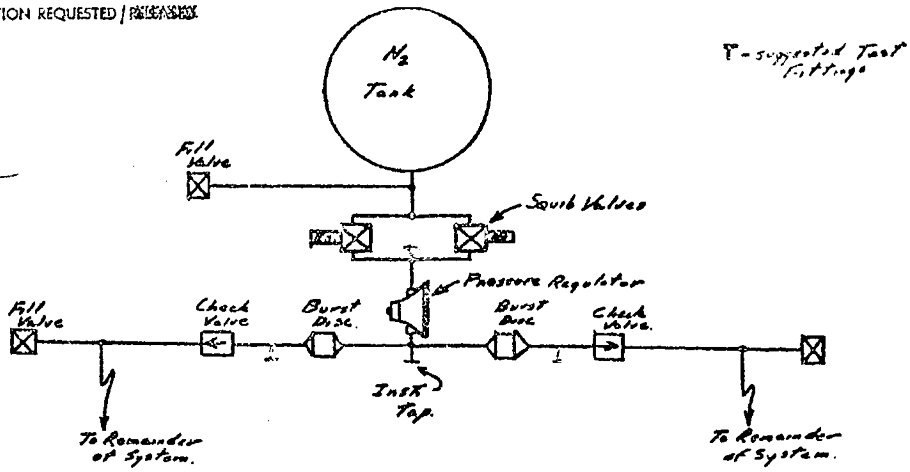
FROM	TO
R. deCastongrene, SQCE Rm. 3226, CC&F #3, Ext. 6215	C. L. Robinson, Program Engineer Rm. 5823, CC&F #5, Ext. 3897/8

DATE SENT	DATE INFO. REQUIRED	PROJECT AND REQ. NO.	REFERENCE DIR. NO.
8/8/62	-	698-AL	1343-PIR-020

SUBJECT

PROPULSION SYSTEM CHANGE REQUEST

INFORMATION REQUESTED/~~RELEASED~~



In the Propulsion Systems as presently designed and built we have the situation depicted above. The N_2 Tank and Piping to the squibs can be pressurized and tested as desired. However the piping between the squibs and the regulator is completely inaccessable. In addition, the system downstream of the regulator can be pressurized by filling thru all fill lines and instrumentation taps at once, so that no Δp is seen across the burst disc. However, when this pressure is vented at the end of the test, the section between the burst disc and the check valve remains pressurized due to entrapment of the gas. Thus when the pressure in the other lines goes low enough the burst discs will break. This situation limits us to testing at about 25% of operating pressure. Which means this system will never see operating pressure until it is actuated in orbit.

Thus, it is obvious the system must be modified. This is easily done by adding taps upstream of the regulator and between the check valves and burst discs. This will enable us to completely check the system and will provide a dividend in the form of enabling a performance check on the regulator in the system.

In addition, inspection of the first delivered SES-1 system and the mockup, reveals

DISTRIBUTION	PAGE NO.
See attached list.	1 OF 2 CONT. ON 2

FORM 1020 Rev. (9-58)

that the instrumentation tap immediately upstream of the engine is inaccessable. If any problems are encountered with the nozzle plugs, no testing of that portion of the system will be possible, especially at the MAB. Therefore this should be relocated to improve accessability.

APPENDIX D

GENERAL ELECTRIC
MISSILE AND SPACE VEHICLE DEPARTMENT
PHILADELPHIA
ꓘOGRAM INFORMATION REQUEST / RELEASE

NO. 1173-698-117

FROM		TO	
C. C. Rich, SE Prop. & Pwr. S/S Eng'g. Room 6624, CC&F #6, Ext. 6589/90		R. DeCastongrene, SQCE Room 3226, CC&F #3, Ext. 6215	

DATE SENT	DATE INFO. REQUIRED	PROJECT AND REQ. NO.	REFERENCE DIR. NO.
8-14-62	--	698 AL	PIR 1343 - PIR 1343-024

SUBJECT

PROPULSION SYSTEM CHANGE REQUEST

INFORMATION ~~REQUESTED~~ RELEASED

In reference to the referenced document, the following points should be considered:

1 - The sketch supplied is incorrect in the relative placement of the burst diaphragms and check valves.

2 - The regulator is thoroughly acceptance and OA tested, including flow tests at rated operating pressure.

3 - Checking of the system at operating pressure is not recommended for two reasons. First, a 25% pressure check is felt to be adequate. Second, the pressure rating of the tanks (1.6 burst to working) makes ground pressurization of the system a hazard to test personnel. The propulsion systems are designed for airborne pressurization in accordance with MIL-T-5203A. It is not believed that leak paths unseen at 60 PSI will be discovered at 280 PSI. However, there will be, of course, variations in the rate of leakage.

Russ,
What's our answer to this? K.l.l.

aR

DISTRIBUTION

(See Attached Listing)

PIR (1343-PIR-1343-024 DISTRIBUTION)

PAGE NO. 1 OF 1

CONT. ON

FORM 1020 Rev. (9-59)

APPENDIX E

Ron

GENERAL ELECTRIC
MISSILE AND SPACE VEHICLE DEPARTMENT
PHILADELPHIA

PROGRAM INFORMATION REQUEST / RELEASE

NO. 1343-PIR-036

FROM			TO
R. O. deSautongreno, SQCE Room 3226, CC&F #3 Ext. 6215			C. C. Rich Propulsion & Pwr. S/S Eng'g Room 6624 CC&F #6
DATE SENT	DATE INFO. REQUIRED	PROJECT AND REQ. NO.	REFERENCE DIR. NO.
8/20/62		AF-76	1173-698-117 1343-PIR-024

SUBJECT

PROPULSION SYSTEM CHANGE

INFORMATION ~~REQUESTED~~ / RELEASED

In Reference to your PIR:

1. My sketch was incorrect. Check valves and Burst discs, should be interchanged. However, this does not bear on the discussion, as all comments in my PIR applied to existing system.

2. Component Testing does not necessarily eliminate the need for in system testing.

3. Since, as you pointed out, the design of the tanks is so marginal, it is even more important to test them and establish a level of confidence that they will function as designed. We have pneumatic cells where testing can be safely done, whereas at the MAB they will be presurizing for leak tests under more hazardous conditions.

   Aside from personel safety, our purpose in testing at/or above operating pressure is to ensure mission success by proving that the system can contain operating pressure. This cannot presently be done.

   Experience with Hydralic System Testing and reference to GEL reports gives little hope that leak paths not seen at 60 psi will not open at higher pressure and cause trouble. At any rate it is extremely difficult if not impossible to correlate leakage at different pressures.

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See attached list.	1 OF 1
	CONT. ON

GENERAL ELECTRIC
MISSILE AND SPACE VEHICLE DEPARTMENT
PHILADELPHIA
PROGRAM INFORMATION REQUEST / RELEASE

NO. 1131-266

FROM	TO
R. G. Yaeger, System Engineering RGY Room 6240 Ext. 2807/8 CCF #6	F. Jackson, Acting System Engineer Room 6240 CCF #6

DATE SENT	DATE INFO. REQUIRED	PROJECT AND REQ. NO.	REFERENCE DIR. NO.
n 9/10/62		AF-76	

SUBJECT
Minutes of Meeting on 1750 Propulsion Subsystem on 9/7/62

INFORMATION REQUESTED / RELEASED

ATTENDEES: A. K. Tower
N. E. Sussman
C. C. Rich
C. F. Pontier
J. J. Tague
P. N. Herr
R. O. DeCastongrene
R. R. Boericke
B. D. Downing

INTRODUCTION

The subject meeting was called to air various aspects of two problem areas in the acceptance tests of the subject hardware. These problem areas are:

1. Present plans call for system level vibration tests with empty tanks for the subject subsystem. It is important to examine this situation to determine whether this will permit reasonable and adequate tests.

2. Present subsystem design and durability considerations have prevented OA pressure tests in excess of 25% of operating pressure. It must be determined whether such tests are at all reasonable.

This PIR summarizes the results of the subject meeting.

1. TANK VIBRATION PROBLEM

The initial presentation by Quality Control expressed concern over the addquancy of a systems level vibration test, for this propellant system, with the four tanks empty. Discussion disclosed the following factors:

(a) Depending upon relative frequencies the empty tanks could represent either a more severe or a less severe test. Mass change is by a factor of 10 and tank support frequencies will increase by a factor of 3 or better. Mr. Sussman will obtain data on this factor.

(b) It is undesireable to load any liquids other than the propellants into the system for reasons of cleanliness and operational performance

DISTRIBUTION

See attached sheet

PAGE NO. 1 OF 2

CONT. ON Page 2

(c) Excessive friction in vibrating the uninflated tank bladder can result in failure of this item.

(d) Propellant mass simulation without the use of some liquid will most likely represent a compromise in the area of dynamic restraint.

(e) Safety considerations preclude the idea of running the vibration test with the proper propellants in the tanks.

It was accepted that Systems Engineering will make the decision on this question as soon as additional dynamic data be supplied by Mr. Sussman. (AN to OA Test Spec.)

2. PRESSURIZATION

The present system design does not permit proof pressure tests at any value in excess of 25% of operating pressure. This is the result of a combination of a diaphragm and a check valve in one area. Present OA test specifications reflect this condition, but it is desired to test at higher pressure values to establish greater confidence in the assembled system. Discussion disclosed the following information:

(a) Present plans for the use of helium gas as a testing fluid were made on the assumption that the greater leak potential in this gas would compensate in some way for the reduced pressure.

(b) The ratio of burst to working pressure for these tanks is low and an element of risk is present in an operating level pressure test.

(c) Excessive cycling of the bladders can be expected in cleaning the tanks (liquid to be used at the higher pressure value).

Mr. C. C. Rich will undertake a study to determine the extent of changes required to permit adequate pressure tests. Data to be provided will include costs, delivery, etc. and any other data pertinent to consideration of a change of this nature. The Systems Engineers office will issue an AN on this subject if a change is appropriate.

GENERAL ELECTRIC
MISSILE AND SPACE VEHICLE DEPARTMENT
PHILADELPHIA
PROGRAM INFORMATION REQUEST/RELEASE

NO. 1173-184

FROM R. Boericke
Propulsion & Pwr. S/S Eng'g.
ASPD #6, Room 6624, Ext. 6589

TO DISTRIBUTION

DATE SENT	DATE INFO. REQUIRED	PROJECT AND REQ. NO.	REFERENCE DIR. NO.
10-15-62	---	AF 76	---

SUBJECT

MINUTES OF MEETING ON PROPULSION SYSTEM TESTING

INFORMATION ~~REQUESTED~~/RELEASED

ATTENDEES:

R. Boericke	Propulsion S/S
C. Rich	Propulsion S/S
H. Krenak	AGE
L. Shanin	AGE
R. Martin	AGE
A. Wyman	Field Operations
J. Freeman	Field Operations
W. Kain	Field Operations
C. Kopanski	Field Operations
B. Day	VE
~~R.~~ deCastogrene 3226/#3	Systems Q.C.
P. Kajmo	Logistics
W. Wunch	Test. Equip. Des.
D. Temple	Test. Equip. Des.
U. Alvarado	OSE

A meeting was held to discuss the use of three new pressure taps recently added to the propulsion pressurizing system, and to review the leak and functional tests to be performed on the propulsion system. The following agreements were reached:

1. The new pressure taps will be used by Q.C. at G.E. to test the regulator and relief valves, and to pressure check the system to full operating pressure.

2. Field testing of the propulsion system will be limited to leak tests at 60 psi for the low pressure system, and will not utilize the new pressure taps.

3. Lack of access to the pneumatic panel after vehicle assembly will prohibit leak testing of seven "B" nut joints in the VSB prior to launch. All of the "B" nuts are on the pneumatic panel (providing maximum resistance to vibration) and will have been leak tested in the MAB.

4. A leak test of the liquid burst diaphragms will be incorporated into VSB test procedures to insure the diaphragms were not ruptured during previous leak testing or system flushing. The pneumatic burst diaphragms are not as critical as the ones in the propellant lines because they are backed up by check valves.

DISTRIBUTION ATTENDEES
E. Gantz
F. Walker
F. Harrigan
D. Downing
D. Deary
P. Herr
D. Kreines

PAGE NO. 1 OF 1

CONT. ON ---

FORM 1820 Rev. (9-59)

APPENDIX F

GENERAL ELECTRIC

TECHNICAL INFORMATION SERIES

Title Page

AUTHOR	SUBJECT CLASSIFICATION	NO. / DATE
R. deCastongrene	Pneumatic Testing	63 SD 282 / 6/12/63

TITLE

A NEW METHOD OF PROOF PRESSURE TESTING OF PNEUMATIC SYSTEMS

ABSTRACT

A method has been found to proof test a Pneumatic System using a relatively incompressible liquid with no danger of contamination. This involves using liquid Freon 114, maintained under pressure and pumped up to the required proof pressure. The pressure can then be relieved and the Freon drained. The remaining droplets and residual effluence will then boil off at

G.E. CLASS	REPRODUCIBLE COPY FILED AT	NO. PAGES
II	Documentation, Room 5819	10
GOV. CLASS. None	Advanced Space Projects Dept. P. O. Box 5661, Phila. 1, Pa.	

ambient temperature in a short time, whereupon the vapors can be cleared with a quick N_2 purge.

CONCLUSIONS

This use of Freon 114 has proven to be a safe, convenient and useful technique for proof pressure testing while maintaining the highest of cleanliness requirements.

It may prove to have other applications not presently anticipated.

By cutting out this rectangle and folding on the center line, the above information can be fitted into a standard card file.

For list of contents—drawings, photos, etc. and for distribution see next page (FN-610-2).

INFORMATION PREPARED FOR General Distribution

TESTS MADE BY Advance Space Projects Dept.

Author R. O. deCastongrene R O deCastongrene

COUNTERSIGNED A. M. Stiles A M Stiles, Jr.

Supv Engr.

DIVISION Missile & Space LOCATION King of Prussia, Pa.

FN-610-1 (1-40)

GENERAL ELECTRIC COMPANY
TECHNICAL INFORMATION SERIES
CONTENTS PAGE

CONTENTS OF REPORT

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R. O. de Castongrene (10) — Bldg. #1, Room 308, P. O. Box 2500, Daytona Beach, Fla.

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L. Pierson
A. Stiles (2)
G. Wenning
W. Wunch
E. Gantz
W. Berkey
F. DiSanto
G. Polansky

RSD

R. Brame

Spacecraft Dept.

R. Porter

G.S. Emmons

WHY PROOF PRESSURE TESTS ARE NECESSARY

A proof pressure test is generally necessary for the following reasons:

a. For safety - to demonstrate system safety for later testing
b. To ensure success at operating pressure by:

    1. Checking installed piping structure
    2. Testing proper torquing of fittings
    3. Testing pipe and component hangers, straps and mounts
    4. Testing manufacturing & assembly (workmanship) of all of the above items

c. To enlarge and reveal leaks
d. To "set" 0-rings, cables, etc which are subject to this phenomenon

PROBLEMS IN PROOF PRESSURE TESTING

Proof pressure testing (proofing) in aerospace applications presents several problems. If, as usual, a gas is used in proofing, a large amount of energy is stored which, in event of failure, is dangerous to personnel and can severly damage and possibly destroy a vehicle. In addition, when pressurizing and depressurizing with a gas medium, large temperature variations are encountered which require excessive time to monitor and control.

If, on the other hand, liquid mediums are used, the above problems are materially lessened but the possibilies of contamination are high. Because the system cleanliness requirements are extreme in most missile applications, liquids are generally intolerable.

SOLUTION

Our solution to these proof-test problems is hydrostatic testing using liquid Freon 114* ($CClF_2$ - $CClF_2$) as the pressurizing medium. The physical properties of Freon 114 are described below.

Table 1. Freon 114 Physical Properties

Molecular Weight	170.93
Boiling Point at Atmospheric Pressure	38.39°F
Freezing Point	-137°F
Density Liquid at 86°F	89.91 lb/cu ft
Viscosity at 86°F liquid	.356 centipose

Freon 114 is readily available from DuPont in the following levels of contamination:

Moisture contamination	10 ppm max
Oil contamination	10 ppm max

Prior to testing, solid particles were easily filtered to the following level: 98% of particles were < 5 micron dia, and 100% of particles were '2 micron diameter.

Freon can be obtained with lower moisture and oil levels at an increased price. This however should not be required, since the moisture and oil are in solution, and will not normally separate from the Freon and remain in the system.

* "Freon" is DuPont's registered Trade Mark for its fluorinated hydrocarbons.

In this test the system is first filled completely with Freon. The pressure is then increased to the test pressure, held as required for test, and relieved; the Freon is then drained and the system vented to atmosphere. It can be seen from the low boiling point (table 1 & figure 1) that after the Freon has been drained and the system vented to atmosphere, the small amount remaining will boil off. Thus a clean, uncontaminated system is assured.

TEST EQUIPMENT REQUIRED

The test set used was built on a portable cart to be readily movable as testing required. The schematic is depicted in figure 2A. The following components are required for such a test set:

a. Tank. Must hold liquid under at least 30 psi pressure, and have a volume at least twice the volume to be tested. (The tank actually used was rated at 100 psi pressure, which assisted in filling the system without the use of an auxiliary fill pump).

b. Vacuum pump. Must be capable of pulling a vacuum to a pressure of 1 mm Hg. This was required in the tests reported because the system to be tested had no vents. The pump capacity depends upon the size of the system and the time available for testing.

   Initially, a Veeco Cat. No. 1406H pump was used; this pump has a free air capacity of 33.4 liters/min and is capable of reaching a pressure of 5 microns, or .005 mm Hg. However, because excessive time was required to evacuate the system, a Veeco 1405H pump was added external to the test set, thereby accelerating the procedure considerably (see "Procedure"). This second pump has the same free air capacity as the first pump, but can reach a pressure of .05 microns or .00005 mm Hg.

c. Proof pressure pump. A diaphram-type, air driven hydrostatic pump was chosen to avoid contamination. The minimum pressure capacity should be 1.5 times the required pressure. The pump used was an Aminco 46-4025 diaphragm-type compressor (pump) rated at 10,000 to 15,000 psi. Displacement is .13 cu in./stroke with a normal speed of 120 strokes/min.

d. Heat lamp. Two 200 watt lamps were used to build up vapor pressure in the system. This higher pressure speeded up draining of system.

e. Filter. A five-micron filter was used to ensure cleanliness of the system. Special filters (Millipore No. XX45047-50) were obtained to permit flow in either direction.

f. Transfer Pump. Although this item was not used, a large capacity pump could have been used effectively to expedite fluid transfer into vehicle. A 10 to 50 cu in./min capacity would be suitable. However, this transfer pump would not have helped much in draining tanks because the small fill line would probably have caused pump cavitation.

AN IMPROVED TEST SET

Our experience to date has shown that the set depicted in figure 2B would improve and expidite testing. The major changes would be incorporating a transfer pump described above, using a larger vacuum pump to eliminate the auxiliary external pump that was used, and a tank-to-vehicle straight line of pipe with a minimum of bends and fittings to reduce pressure drop and facilitate draining.

PROCEDURE

The test procedure below was performed on a system with no vents. Where vents exist in a system, both the test equipment and procedure are simpler.

a. Pull vacuum to eliminate all air and/or gases from the system. This will also indicate any bad leaks. A pressure of 2 mm Hg (absolute) was reached on a four cubic foot volume in less than three hours using both vacuum pumps. Longer times or inability to reach vacuum indicate leaks in the system. (Originally, with only one vacuum pump, as installed on the cart, eight hours were required to reach 3 mm Hg).

b. Shut vacuum valves and open valve to Freon tank, allowing fluid to fill system. The system is full when the level in the tank no longer moves and the volume change in the tank equals the volume of the system. (Filling has required up to 13 hours for our set-up; this excessive time is generally due to extremely small fill lines, for example, 0.25-inch high pressure tubing.

c. Start pump and bring the system up to proof pressure. Leaks are detectable since the vapors can be seen. Our set-up requires approximately two hours to reach 5000 psi. If the pressure does not start up within 10 minutes after starting the pump, the system is not yet full.

d. Hold for the required test, detecting leakage and checking structure.

e. Vent back to the tank by opening the vent on top of the tank and opening the valve to tank.

f. Heat the system with heat lamps to build up vapor pressure and speed up fluid transfer. One hour is required to vent. Without the heat lamps, the only pressure transferring fluid is the Freon vapor pressure which is about 25 psi at normal temperature (ref: figure 1). Thus an extremely long time is required.

g. When almost all of the fluid is back in tank (see level) open the valve to atmosphere and allow venting.

h. Finally, pull vacuum to check that all Freon is out of the system. If vacuum cannot be established, Freon is still in the system. It is then necessary to continue heating with lamps; approximately three hours are required.

RESULTS

Generally excellent results have been obtained using the procedures described above. One minor problem was experienced when a filter element support screen was installed facing the system under test; this resulted in the filter element falling into the system. Leaks can be detected by the vapors which are visible, and/or by inability to reach a vacuum.

It is probable that Freon 12 can also be used as a proof pressurizing medium, with same test procedure, depending on the system.

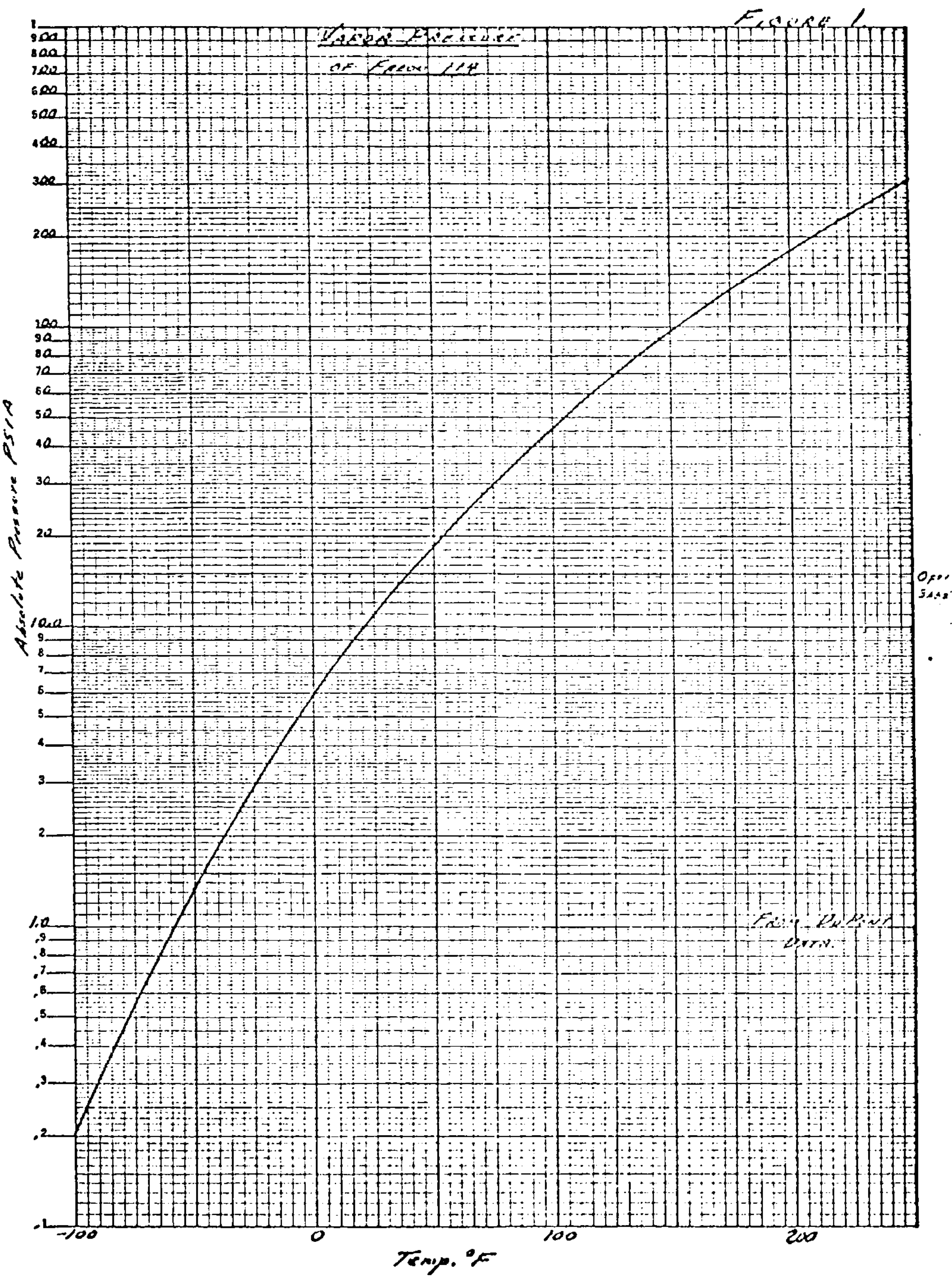
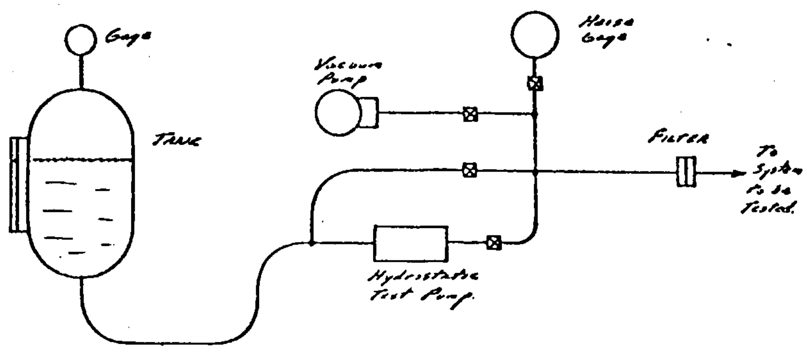


Figure 1.
Vapor Pressure
of Freon 114
Absolute Pressure PSIA
Temp. °F
-100
0
100
200
From DuPont
Data.

■ VALVES

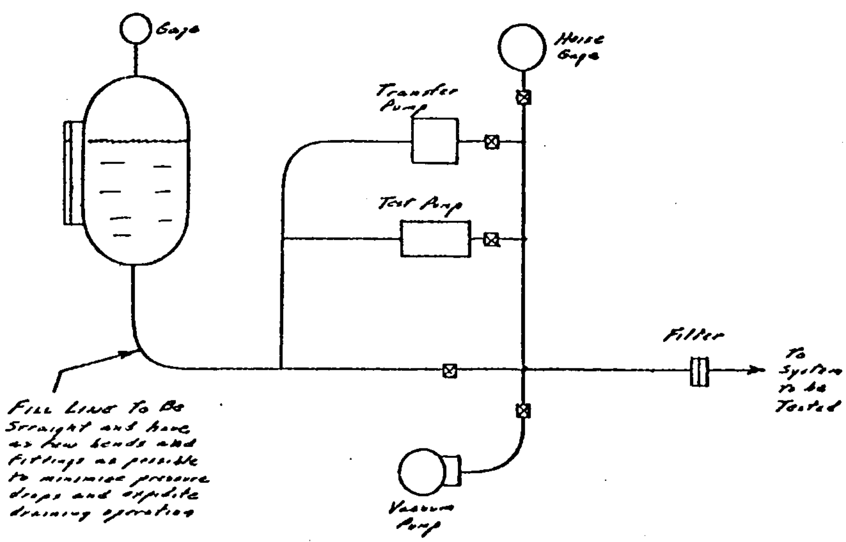
TEST SET USED

FIGURE 2A



IMPROVED VERSION

FIGURE 2B



GENERAL ELECTRIC
MISSILE AND SPACE DIVISION
VALLEY FORGE SPACE TECHNOLOGY CENTER
P.O. BOX 8555
PHILADELPHIA 1, PA.

ACCENT ON VALUE

COPIES: Mehr, E. J.
Horn, H.
Allard, Joan

SUBJECT PATENT DOCKET

August 26, 1963

Messrs. Wunch, W. J. (Pay No. 98728)
DeCastogrene, R. O. (Pay No. 21919)
Rooms 2246 and 3226,
Cabot, Cabot and Forbes

Gentlemen:

A patent docket has been prepared to cover the invention described in your Patent Disclosure Letter dated 8/21/63, entitled Portable Proof Pressure System.

The number assigned to this docket is 39-2D-165, and it is requested that you refer to this docket number in all future correspondence relating to this invention.

To insure our obtaining the most comprehensive patent coverage on this invention and on any subsequent improvements, please notify us immediately of any further developments (construction of samples, test results, etc.) including disclosures of any additional modifications or improvements.

It is particularly important that you keep me informed in advance of: (1) any sales or contemplated sales of equipment using this invention, (2) any demonstration of equipment to others, and (3) any publication of a technical paper, brochure or the like.

After consideration of the invention by the Missile and Space Division Patent Review Panel, you will be advised of their decision relative to the filing of a Patent Application.

If you have any questions regarding this invention or any other patent matter, please feel free to call or write me.

Very truly yours,
Edward W. Hughes
Edward W. Hughes,
Patent Counsel
Room 3210M, Ext. 2431
Valley Forge

nm

APPENDIX G

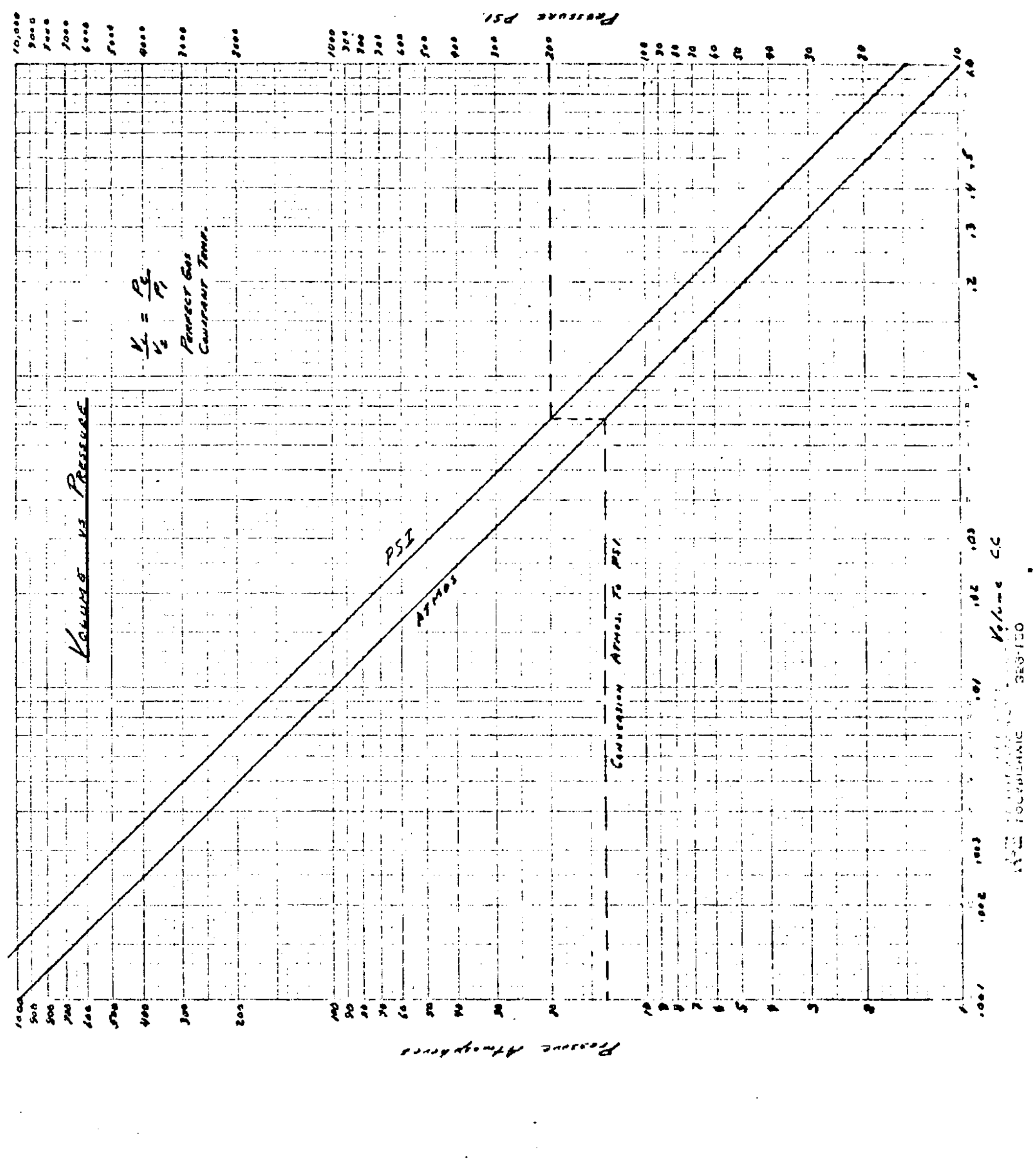
1 STANDARD CC Volume at increased Pressures.

Data

Assuming Perfect Gas.
Constant Temp.

Atmos.	PSI	Vol. CC.
1	14.7	1
	20	
	25	
2		.5
	30	
3		.33
	50	
4	58.8	.25
5		.20
6.8	100	.147
10		.10
13.6	200	.0735
20		.05
	300	
30		
	500	
50		.02
68	1000	.0147
100		.01
	2000	
200		.005
	3000	
	4000	
300		.003
	5000	
400		.0025
	6000	

Atmos	PSI	Vol. CC
400		.0025
	6000	
	7000	
500		.002
	8000	
600		
680	10000	.00147
700		


Volume vs Pressure
Perfect Gas
Constant Temp.
PSI
ATMOS
Conversion Atmos. to PSI
Pressure PSI
Pressure Atmospheres
Volume CC

Leakage, Pressure Drop, Formula

$$\frac{P_1}{P_2} = \frac{V_2}{V_1}$$

Assuming Leak rate [illegible] Pressure

P_1 = Starting Pressure

P_2 = Final Lower Pressure.

x = Leakage Volume for given period time. $= \Delta V$

V_2 = Final Volume

$= V_1 + x$

V_1 = Starting Volume.

$$P_2 = \frac{P_1 V_1}{V_2}$$

$$= \frac{P_1 V_1}{V_1 + x}$$

$P_1 - P_2$ = Pressure Drop $= \Delta p$

$$= P_1 - \frac{P_1 V_1}{V_1 + x}$$

$$= \frac{P_1 V_1 + P_1 x - P_1 V_1}{V_1 + x}$$

$$= \frac{P_1 x}{V_1 + x}$$

$$\Delta p = \frac{P_1 \Delta V}{V_1 + \Delta V}$$

or

$$V_1 \Delta p + \Delta p \Delta V - p_1 \Delta V = 0$$

Then $\Delta V = \dfrac{V_1 \Delta p}{p_1 - \Delta p}$

<u>Weight of 1 scc N_2</u>

$PV = wRT$

$P =$ PSF

$= psi\,(144)$

$V =$ cu ft

$= \frac{\text{cu in}}{1728}$

$= \frac{cc}{28317}$

$w =$ lbs.

$R = \frac{1544}{28}$

$= 55.1$ for N_2

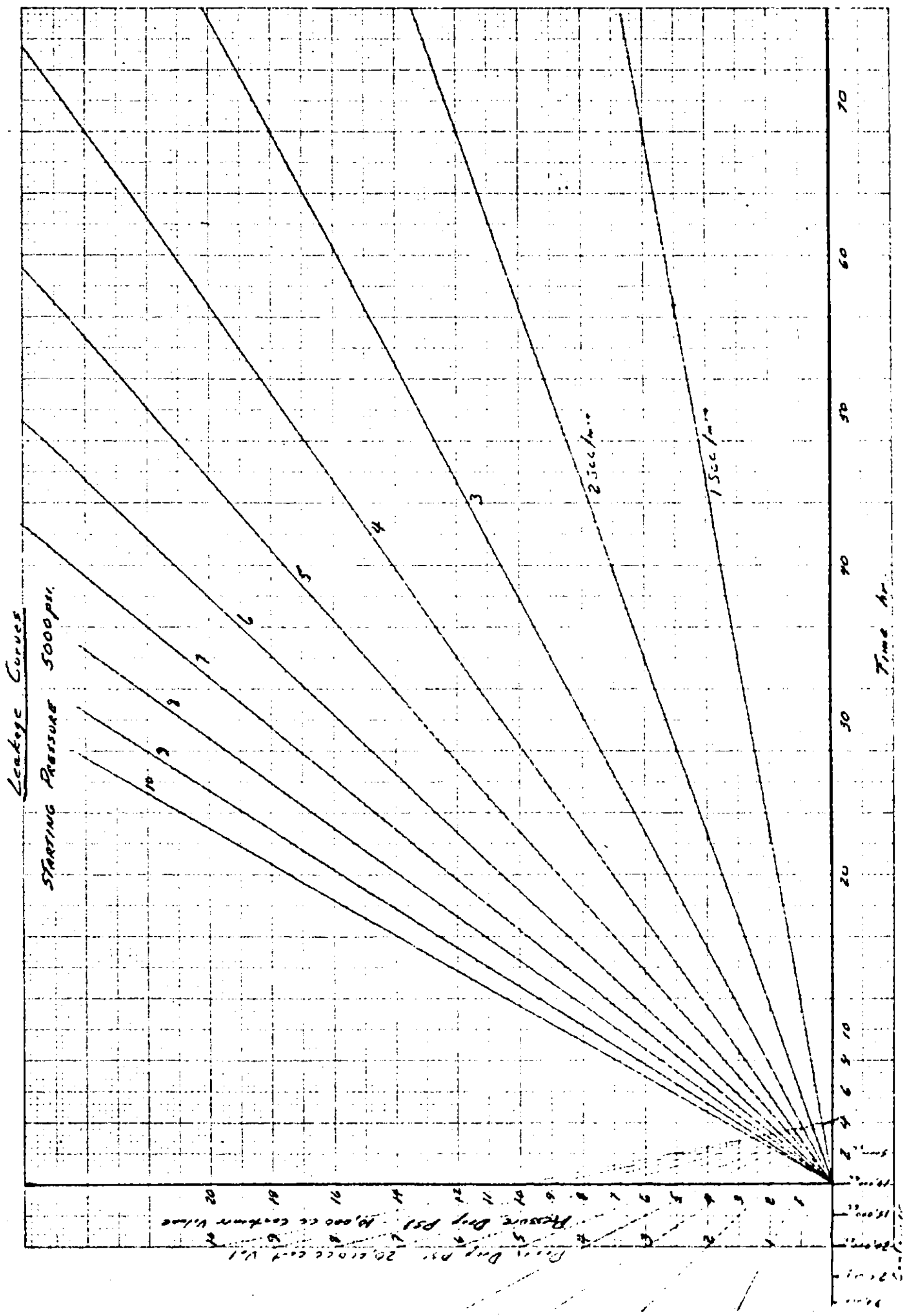
$T = {}^\circ R$

$= 492\,{}^\circ R$

$w = \frac{pV}{RT}$

$= \frac{14.7\,(144)}{28317\,(55.1)\,492}$

$= .0000027575$


Leakage Curves
Starting Pressure 5000 psi.
Time hr.
2 scc/min
1 scc/min

APPENDIX H

A83 Bottles

Volume 75 ± 3 cu in

= 1230 cc ± 50 cc

.004 = volume of 1 scc @ 3750 psi

15 scc/hr = .004 (15) cc/hr @ 3750

= .06 cc/hr

With 1180 cc Volume @ 3750

1 psi Drop = .314 cc leakage

10 psi Drop = 3.14 cc leakage

Time for 10 psi Drop = $\frac{3.14}{.06}$ hr

= 52.4 hr

With 1280 cc Volume @ 3750

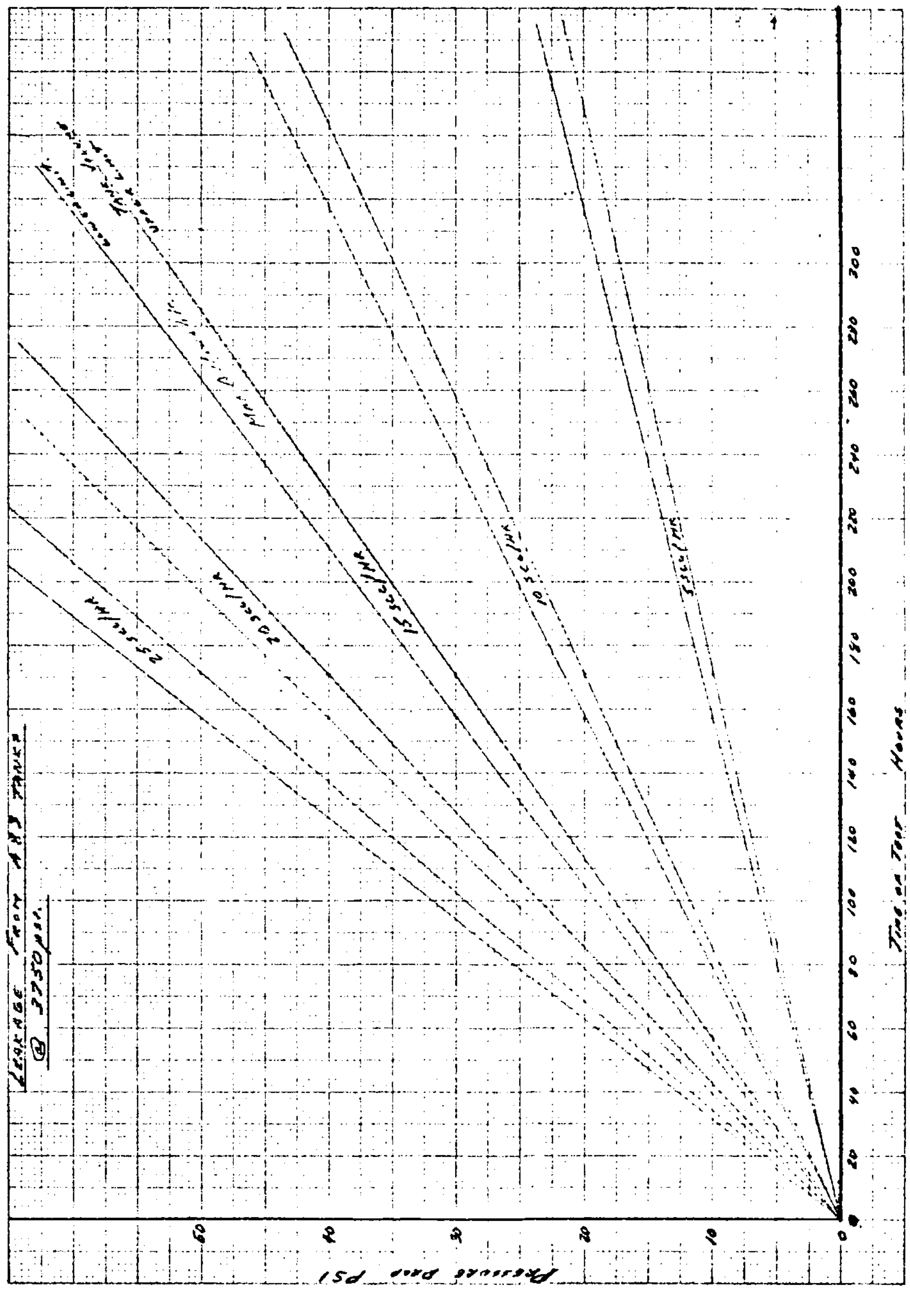
1 psi Drop = .342 cc leakage

10 psi Drop = 3.42 cc leak

Time for 10 psi Drop = $\frac{3.42}{.06}$ hr

= 56.9 hr.

Not Practical


Pressure Drop PSI
0
10
20
30
40
60
Time on Test Hours
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
25 scc/HR
20 scc/HR
15 scc/HR
10 scc/HR
5 scc/HR

Calculation Page

Pressure Drop = $P_{FC} - P_I$ for 180 hour Test

$$P_{FC} = \frac{P_F T_I}{T_F}$$

Where
P_I = Pressure Reading Initial (at beginning of Test)
P_F = Pressure Reading Final (at end of Test)
T_I = Temp. Reading Initial + 460
T_F = Temp. " Final + 460
P_{FC} = Pressure Final Corrected

T_I = ________ + 460 = ________
T_F = ________ + 460 = ________

P_F = ________

P_{FC} = $\frac{\underset{(P_F)}{\_\_\_\_} \times \underset{(T_I)}{\_\_\_\_}}{\underset{(T_F)}{\_\_\_\_}}$ =

Pressure Drop = ________ (P_{FC}) − ________ (P_I)

APPENDIX I

GENERAL ELECTRIC
MISSILE AND SPACE VEHICLE DEPARTMENT
PHILADELPHIA
PROGRAM INFORMATION REQUEST/RELEASE

NO. 1343-PIR-137

FROM	TO
A. M. Stiles, Jr./Supv. Engr. SQCE Rm. 3226 CC&F #3	N. White J. Kofchur C. Bryant U. Alvarado

DATE SENT	DATE INFO. REQUIRED	PROJECT AND REQ. NO.	REFERENCE DIR. NO.
			PIR1343-130 PIR1173-272

SUBJECT

PROPULSION SYSTEM CLEANLINESS CHECK DURING TEST CYCLES

INFORMATION REQUESTED/RELEASED

At a meeting on Friday, December 21, 1962, the major topic covered was how can we devise a method to periodically check the Propulsion Plumbing to determine the relative cleanliness of the system after each charging and test phase and when on the Pad for final loading. At this meeting an Action Item was placed jointly on Quality Control and Test (A. M. Stiles) and Propulsion Subsystem Design Engineering (Dr. E. S. Gantz). The action item requested that a test plan and proposed setup be prepared by January 9, 1963.

Using the planned test layout for checkout of the Propulsion System and the idea proposed by C. C. Rich (in PIR 1173-272), R. deCastongrens (SQCE) and W. Wunch (QC-TED) came up with the plan as outlined in the attachments. As indicated Millipore can provide dual direction filters at a nominal increase in price. The normal millipore filter is unidirectional which if used in this system would require a multiple number of bypasses and shutoffs. Some limitations are indicated below.

Due to the location of the Propulsion System (with Bulkhead attached) and the necessity of equal pressurizing of many inlet ports at the same time, the pneumatic harness of necessity must be of flexible tubing for ease of connecting. Since flaking is always possible the millipore filters must be placed at the port or fitting. The space limitations would make it relatively impossible to install thirty (30) uni-directional filters and by pass connections and shutoffs.

With the dual-directional millipore filter installed it is known that during gas discharge or return to ambient the particles trapped during the charging cycle may be dislodged. However the prime concern is for the status of the filter on the side toward the vehicle.

After each test the Quality Control-Materials and Processes Organization must perform contamination checks on each filter. The capping off procedures and at what location the filters are to be removed shall be settled upon acceptance of this plan.

As indicated the cost of hardware for this test cycle may be in the neighborhood of $2000 plus labor and test coverage.

DISTRIBUTION	PAGE NO.
See attached list	1 OF 4
	CONT. ON Page 2

1343-PIR-137
Page 2

The exact same method cannot be used at the field locations since their test equipment is entirely different. However a similar setup should be possible using the AGE equipment.

Concurred [illegible] 1/8/63
Dr. E. S. Gantz/Manager
Propulsion & Power Subsystems

scheme in the attachment
should be very
satisfactory. ESG

Concurred ____________________
T. F. Smyth/Project Engr.
Materials & Processes

ATTACHMENT

SUBJECT Monitoring Propulsion System Cleanliness

1. The meeting of 21 Dec. 1962 proposed building a propulsion tubing mockup to process and test along with the Prime Vehicle so that at the launch area it could be disassembled and inspected for degree of cleaniless.

2. Obviously to be done properly this mockup should go through the initial processing at Rocketdyne in order to be truely representative. This is not feasable due to lack of time and money.

3. C. Rich in PIR 1173-272 proposed using two millipore filters to monitor the gasses going in and out of the vehicle. This appears to be a good practical method of monitoring cleaniless control after the manufacturing cycle. Since the assembly is done in a clean room environment the above method should be sufficient.

4. Systems Q.C. Engineering previously had required a filter to be placed on each Fill line or part while the vehicle was in the clean area. (See S.I. 238148). Test Equipment Design checking with Millipore revealed that they can make a filter which will work in both directions. We can therefore replace each inlet filter with one of these Millipore filters and accomplish our filtering and additionally provide monitoring as suggested by C. Rich.

5. These filters will cost approximately $110 each with $18.50/100 elements. We will require about 15 of these for the propulsion and stabilization systems.

R. deCastongrene/SQCE

W. Wunch/QC-TED

GENERAL ELECTRIC
MISSILE AND SPACE VEHICLE DEPARTMENT
PHILADELPHIA

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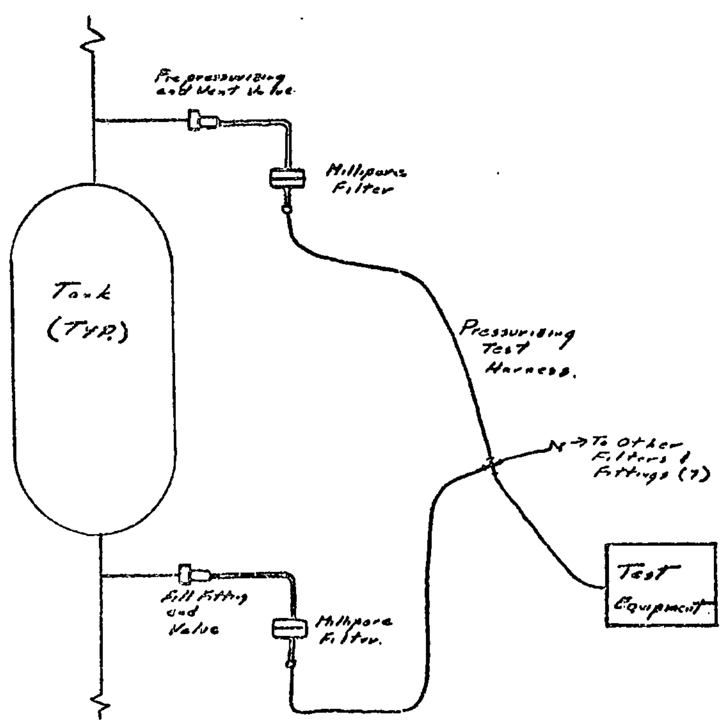

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C. Rich	6626-6	W. Wunch	2240-2
L. Shanin	7313-7	L. Gordon	5541-5
A. Stiles	3226-3	F. Schrietar	5541-5
A. Vitali	6310-6	J. Hoban	5541-5
N. White	5520-5	A. Maino	5541-5
R. Donovan	4224-4	J. J. O'Neill	4224-4

PERSONAL DATA

NAME	:	Russell O. deCastongrene, Jr.
DATE OF BIRTH	:	June 16, 1931
PLACE OF BIRTH	:	Indianapolis, Indiana
ADDRESS	:	27126 Kane Lane Conroe, Texas 77301
PHONE NUMBER	:	(713) 292-3248
HEIGHT	:	5'9"
WEIGHT	:	145 lbs
MARRIED	:	Former Patricia Murphy
CHILDREN	:	Russell, Michelle, Martin, Richard, Peter