# REVIEW

# OF THE

# CRYOGENIC PROPELLANT TEST FACILITY

(Plum Brook "K" Site)

December 18, 1964

## BOARD OF REVIEW MEMBERS

Robert R. Godman - Chairman

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# GUIDE LINES
# FOR
# REVIEW OF FACILITY DESIGN
# AND
# OPERATION PROCEDURES

1. A study of the research and development program shall be made in order to provide initial facility and experimental test requirements.
2. A critical review shall be made of drawings, specifications, and planned operating procedures for all equipment and systems.
3. Assurance shall be made that necessary design studies and calculations have been or will be completed. The results and methods should be reviewed in detail.
4. All failure modes and interactions shall be determined and reviewed in detail.
5. All testing that has been conducted to support the design, selection of components and material shall be reviewed.
6. All critical problems, hazard and safety considerations, failures in testing or in construction shall be reviewed.
7. The review shall summarize detailed engineering recommendations which are in the best interests of the Center for effective and safe utilization of the test facility.

## GENERAL

A detailed design review of the Cryogenic Propellant Test Facility has been conducted to provide assurance that sound standards of design have been used; that best operational capability exists; and that hazards to personnel, facility, and site are minimum.

The research project which generated the need for this facility has had a lengthy history and as a result the facility has suffered certain problems of inefficient contractor work coordination. Such a history emphasizes the need for strong project management, complete records, and adequate procurement specification. Additionally, equipment bought early in the program and placed in storage requires recertification and possible modification or replacement.

The adaptation of this former power house to its present use represents effective utilization of existing structures at Plum Brook with subsequent cost savings to the government.

## III. SUMMARY OF RECOMMENDATIONS

In the following Summary of Recommendations the identification of paragraphs is cross referenced to corresponding portions of the detailed discussion within the text of the report.

## IV. EQUIPMENT AND SYSTEMS

### A. Emergency Electrical Power

2. The emergency power system need not be installed as there appears to be no need for it in the present experimental program operating test procedure.

(In the following recommendations reference to valve numbers refers to schematic flow diagram PF29449.)

### B. Hydraulic Shaker System

1. The shaker system hydraulic cylinder should be evaluated for adequacy of end cushions for stopping under high inertia loads. If the design appears marginal, the addition of an overtravel sensor and protection system is recommended.

2. Vacuum System

2.1 One diffusion pump and one mechanical pump and associated equipment may be used for continuous operation during testing. This will require use of approved electrical components and purging of the mechanical pump discharge line.

2.5 A section of pipe between valve #264 and the vacuum system should be removed during test operation and valve #264 capped.

2.6 It is recommended that the vacuum piping supports, anchors and guides be re-examined for adequacy. Metal bellows should be used to replace the rubber expansion joints.

2.7 The basement in which the vacuum system is located should be more adequately ventilated.

2.0 Permanent taps should be provided in the vacuum pumping system to allow mass spectrometer usage in checking manifolds in the event of flange, valve, or weld leaks.

2.0.0 Remote water pressure indication and an automatic cutoff of the diffusion pumps should be provided.

3. Gaseous $H_2$, $N_2$, He and Liquid $H_2$ and $N_2$ Systems

3.1 Parts and equipment list for system drawings should show true working pressure of component rather than pressure of system in which it is installed. Also cooling fins and extended stems for valve designations should be identified.

3.2 Nitrogen operated valves should be supplied from the permanent gas supply rather than from a trailer supply. This will insure their operation during a possible power failure and during periods where trailers are unavailable.

3.3 The piping systems should be re-examined for the possibility of reduction in the number of valves in the system.

3.4 No pressure relief is provided between valves in certain areas of the liquid nitrogen and liquid hydrogen systems. These valves should be removed, pressure relief provided between valves, or open the extra valve and remove handle and tag them.

3.5 All solenoid valves in the system should be re-examined to be certain they will not allow reverse flow when the downstream pressure exceeds the upstream pressure, and those valves requiring a differential pressure for operation are properly used in the system.

3.6 Valve 236 should fail in its "last" testing position during the occurrence of a power failure and valves 239, 240, and 245 should fail open. Valve 321 should be physically close to valve 236.

3.7 All pressure regulators should have relief valves immediately downstream in order to protect components.

3.8 Valve #222 should be capped when not in use.

3.9 Practically all valves in the system have individual controls. It is recommended that an attempt be made to automate these systems for improved operational safety and ease.

3.10 System fault analysis should be carried out with possible failure modes simulated including total power failure during initial checkout of the facility.

3.11 Liquid $H_2$ storage is very close to the building. Suitable blast protection provided for the $LH_2$ dewar.

3.12 A keyed master control power switch should be installed in the control room.

3.0 Liquid nitrogen feed lines to the roughing pump cold traps should be re-examined for line size adequacy and possible need for a liquid by-pass plus good insulation.

3.0.0 Flexible sections should be built into the liquid nitrogen system feeding cold traps and heat exchangers.

4.. Vent Systems

4.1 The entire 4" hydrogen vent system should be re-examined with regard to routing, purge procedure, installation of flame arrestor, supports, and use of natural gas torch rather than hydrogen.

4.4 The vacuum chamber vent system should be redesigned to provide greater lateral movement and to provide materials more compatible with cryogenic temperatures. The check valve at the exit should be checked for proper operation prior to each run. The ventilator openings at the top of the vent stack should be screened to prevent foreign objects from entering.

5. Heat Exchanger

5.2 The black iron pipe between valve #504 and steam trap #503 should be changed to stainless to allow for possible cryogenic temperature.

5.3 The rupture disc on the heat exchanger should be piped out of the building to prevent injury to personnel.

C. Structures and Vessels

3.3 A dynamic analysis of the interent stability of this vacuum chamber and its supporting system should be made by study contract with the original contractor or qualified independent contractor.

3.1 The lower half of the vacuum chamber should be provided with some means such as a liner or insulation to prevent wetting the vessel directly with $LH_2$ in the event of a spill.

F. Piping Modifications for 13 Foot Diameter Test Tank

1. The piping modifications required for the 13 foot diameter tank should be reviewed in accordance with the recommendations made on the previous piping systems.

2. Detailed specification recommendations should be referred to under Section F.

GENERAL RECOMMENDATIONS

1. Adequate simulation by test cycling should be

conducted on the test tank flexible hoses to assure reasonable safety in the number of cycles to failure for this application.

2. The Plum Brook operations personnel should have a thorough briefing on the over-all test program so that they may better establish good efficient operational procedures.

3. All combustible material as used in stairs and window casings should be removed from the building.

4. An early test of the building pressurization system should be made to determine its adequacy. The building and room construction will make pressurization very difficult and modifications will probably be required.

5. Purging should be provided for all electrical devices not Class 1, Group B, required during test operation as well as elements of the Ruckers hydraulic unit.

6. Freeze protection for critical items in the shop area should be provided.

7. The access ladders and catwalks around the environmental chamber should be brought up to adequate standards for personnel convenience and safety.

8. Some form of monorail hoist or swinging boom hoist should be installed in the building for efficient safe handling of test hardware.

## IV. EQUIPMENT AND SYSTEMS DISCUSSION

### A. Electrical Power System

1. The electrical system appears to be adequate for initial tests. 34KVA power is available and leads from the transformer to the building are capable of carrying 100 KVA if future needs increase.

2. The facility, its systems and the experiments planned were reviewed and it was determined there is no need for the emergency power system unless it is required for future future experiments. In the event of power failure, the liquid hydrogen would just gradually boil away if all systems are designed to fail safe. The emergency power wiring complication necessary to allow run continuation is not considered necessary for the particular experimental program presently planned.

### B. Process Systems, Components and Controls

#### 1. Hydraulic Shaker System

The shaker system was reviewed and, in general, it was designed well; however, inertia loads on the vacuum tank could be severe if the hydraulic cylinder reached the end of its stroke while traveling at high speeds because of servo valve malfunction, electronic failure or operator error. The cylinder has end cushions, but they may not be very effective against large inertia loads. It is recommended that they be tested during the initial shake down runs. If it is deter-

mined that the end cushions are adequate, an overtravel sensor and protection system should be installed, which would gradually stop the hydraulic cylinder.

2. Vacuum System

2.1 Many electrical components used in the vacuum system are not suitable for use in hydrogen areas. The liquid hydrogen tank will effectively cryopump air from small leaks in the vacuum chamber, however, it may be necessary to use the vacuum system during tests for the following reasons:

a. To overcome small hydrogen leaks into the vacuum tank from the test tank,

b. Provide buffer vacuum for the actuator and door seals.

c. To maintain vacuum in the chamber between test runs if the liquid hydrogen tank warms up releasing the cryopumped gas that has accumulated on the tank. It is recommended that any questionable electrical equipment be converted so that the vacuum pumps can be operated as required while a test is in progress. In addition, the mechanical pump discharge line should be purged to eliminate any hydrogen accumulation.

2.2 All of the 36" vacuum valves should have been made of materials suitable for cryogenic service in the case of tank rupture. Two of them were not.

2.3 Vacuum chambers are normally roughed down by pumping directly through the diffusion pumps, therefore, the diffusion pump bypass line with valves #9 and 18 could have been eliminated.

2.4 The 6" valves in the diffusion pump forelines could have been eliminated; they add very little to the vacuum system operation.

REVIEW

2.5 To eliminate the possibility of getting high pressure hydrogen into the vacuum system from the vent line, if valve #264 should leak excessively or is inadvertently opened during the test, it is recommended that a section of the pipe between valve #264 and the vacuum system be removed during operation (possibly a quick disconnect hose) and valve #264 capped. An alternate (less desirable) method would be to interlock valve #264 so that it cannot be operated when pressure is in the vent line.

2.6 The vacuum piping which connects the mechanical pumps to the environment chamber has minimum anchorages guides and/or tie systems to provide for possible line contraction, vibration and vacuum loads across rubber expansion joints existing in the line. It is recommended that this be re-examined and that metal bellows be used to replace the rubber expansion joints.

2.7 It is recommended that the basement in which the vacuum system is located be more adequately ventilated.

SOLUTION: He TEST ONE EXISTING PANEL & TAKE SAMPLE READINGS UNDER PANEL FOR He LOSS RATE (5 MIN. INTERVALS FOR 1/2 HR.) " SAFETY COM. REQUIRES 6 AIR CHANGES PER HR. (MIN.).

3. Gaseous Nitrogen, Helium, Hydrogen, and Liquid Hydrogen and Nitrogen Systems

3.1 The working pressure listed for the systems components in the "Parts and Equipment List" is sometimes listed as the line pressure in which they are installed. This is not the true working pressure of these components and has made it very difficult to properly check the piping systems from the schematic and it is recommended that the "Parts and Equipment List" be corrected so that the components working pressure listed be the true working pressure of the components. In addition, the "Parts and Equipment List" does not show cooling fins or extended stems for valves 427, 278, 222, 245, 246, 252, 424, etc. The valves should be examined and cooling fins or extended stems added, if necessary. The lists should then be corrected.

3.2 Most of the valves in the system are nitrogen operated. To insure their operation during power failure, they must be operated from the permanent gaseous nitrogen storage system since the trailer supply is cut off upon power failure. It is recommended that operation procedures be set up to guarantee this type of operation as well as necessary operation during the absence of nitrogen trailers at the site.

3.3 The piping system, in general, has more valves than are actually required. This tends to make the system cumbersome and confusing to the operators and at times dangerous. For example:

a. The system would be safer, operate just as well, and be more easily maintained if valves #459, 461 and 470 were eliminated.

b. Pressure regulator #310 has valve 308 upstream and 309 downstream. This regulator would perform just as well and be as easy to maintain if valve 308 and valve 309 were eliminated.

c. See Items #3 and 4 under "Vacuum Systems"

d. See Item #4

e. Etc.

3.4 There are many valves installed in the liquid nitrogen and hydrogen systems between which there are no pressure relief provisions. It is recommended that these valves be removed or else pressure relief valves installed. Alternate (less desirable) solutions would be to open the extra valves, remove the handles and tag them, or have the operating personnel use extreme care in operating the system, however, one mistake could cause an accident. For example:

a. Valve #427 and 470 in the liquid nitrogen system.

b. Valve #262 and 275 or 286 in the liquid hydrogen system. These valves are remotely operated, therefore, there must be pressure relief between the valves.

3.5 There are many solenoid valves in the interconnecting lines of these systems (valves 255, 276, 285, 290, 291, 307, 317, 338, 412, 413, 443). These valves can allow reverse flow when the downstream pressure exceeds the upstream pressure, for instance:

a. Valve #332, which is in a 100 psi nitrogen line, has a working pressure of 100 psi (as listed in the "Parts and Equipment List"), but is connected to a hydrogen or helium line which operates at pressures up to 150 psi. It is recommended that valve #332 be replaced with a more positive operating valve suitable for cryogenic service and a check valve installed to minimize the possibility of getting reverse flow in the system.

b. Valve #413 in a 20 psi nitrogen line is connected through a check valve to the 100 psi steam line. If the check valve leaks, steam will leak past valve #413 and out of the relief valve 460. An alternate valve such as an Annin would have been a better choice for valve 413.

c. Valves #255, 276, 285, 290, and 291 are pilot operated solenoid valves in the flow measuring test

section. This type of valve usually requires a minimum pressure differential to operate, therefore, they may not function properly in this location due to the low pressure differentials available. It is recommended that these valves be reexamined to be certain they will operate properly and safely in their locations.

3.6 If electric power failure occurs during hydrogen testing valve 236 switches to helium and valves 246, 252, 239, 240 and 245 all go closed. This results in trapped pressure between these valves. Pressure between valve 246 and 236 will be such that hydrogen can contaminate the helium system up to check valve #321. A preferred operating procedure would call for valve 236 to fail in its "last" test position and for valve 321 to be located physically close to 236 to minimize contamination of any significant line volume. In addition, valves 246 and 251 should fail closed (as presently designed) but valves 239, 240 and 245 should fail open.

3 WAY IN LAST POSITION

3.7 Valve #317 has a working pressure of 500 psi (as noted in the "Parts and Equipment List"). It is immediately downstream of pressure regulator #316 which is set at 100 psi. If #316 fails, valve #317 would be subjected to full bottle pressure. Similarly, components downstream of pressure reducing valve #246 could be subjected to overpressure unless pressure relief is provided. In general, all pressure regulators of this type should have a pressure relief valve located

immediately downstream of them to protect all components of the system and prevent pressure surges when valves are opened. There are many places in the system where this is not done.

3.8 It is recommended that valve #222, which is in the liquid hydrogen system, by capped when not in use to prevent leaks in the building.

3.9 Practically all valves in the system have there own individual controls. The system would have been safer and easier to operate with less chance for error if some of the valves had been grouped together in small automatically operated subsystems. It is recommended that an attempt be made to automate these systems and clear concise procedures written for the setup and operation of the systems. All operators must know the systems thoroughly.

3.10 It is recommended that a fault analysis be run on the system by the operations personnel and where possible these faults be inserted during an actual run using liquid nitrogen before the first test.

3.11 The location provided for the $LH_2$ dewar at the site is quite close to the building. It is recommended that this area be provided with an appropriate blast protection structure. An alternate solution for improving the safety of the $LH_2$ dewar would be to relocate it a safe distance from the building. In the event the latter recommendation

SAFETY COM. SAID "FORGET-IT"

is followed, a separate dewar vent should be provided rather than tying it to the common vent system as presently done.

Check ON

3.12 Electric power goes directly from the circuit breakers to the system controls; this power probably will be on at all times. To prevent accidents from "irresponsible button pushers", it is recommended that some form of keyed master control power switch be used for the systems.

4. Vent Systems

4.1 The 4" vent pipe requires additional supports and provisions for thermal expansion within the building and provisions for thermal expansion outside the building (perhaps pipe support rollers). It is recommended that it be re-examined.

4.2 The 4" vent line runs approximately 60' horizontally, 30' down, and 200' out horizontally to the flare. This long vent line will be difficult to purge for the following reasons:

a. Six different vents are vented by this one line; to inert the line, it must be purged in a definite sequence.

b. It is a long line and part of it is in a downward vertical direction.

It is recommended that a definite purge sequence be set up, an appropriate flame arrestor installed, and a check valve

Check Conduit Rigidity

Calc B. Godman

installed in the vent line just upstream of where the liquid hydrogen vent comes in to minimize the possibility of contaminating the line by using an improper purge sequence. Also see recommendation d. under Item #4.

4.3 The 4" vent flare system has the following **disadvantages:**

a. The gaseous hydrogen trailer must be on site at all times a liquid hydrogen dewar is present.

b. The flare will go out whenever there is a power failure and possibly large accumulations of hydrogen gas could be ignited when it is restarted. It is recommended that natural gas be used for the flare with a control system that allows it to burn even if there is a power failure.

CHECK & CHANGE

4.4 The vacuum chamber emergency vent system should have been designed to handle cryogenic gases. A few problem areas are:

a. The 24" vent valve was assembled using standard components as far as practical but the total valve assembly was not tested separately.

b. The expansion joint just above the tank is made of rubber, it would become brittle and probably fail under conditions of cryogenic temperatures and vacuum chamber vibration dumping vent gases into the building.

c. The main relief valve diaphragm is made of

rubber. It will become brittle and break at cryogenic temperatures; it will still relieve the internal pressure, but the diaphragm would have to be replaced after the incident.

d. Parts of the internal pilot valve are not suitable for use at cryogenic temperatures, (diaphragm seals, etc.). The valve would function properly except the diaphragm and other parts would have to be replaced after the incident.

e. The vent stack is made of black iron and is not suitable for use at cryogenic temperatures.

f. The check valve which is at the exit of the vent stack has guide bearings which may rust and seize in time making the valve inoperative and requiring frequent surveillance.

g. The ventilator on top of the stack has large openings which would allow foreign objects to enter (perhaps a good spot for a birds nest).

h. Large quantities of hydrogen gas may be vented out of this stack, presenting a hazard.

4.5 The recommendations are:

a. The expansion joint should be redesigned to allow for reasonable lateral movement resulting from any vacuum chamber vibration. In addition, the joint material should be suitable for exposure to gas at cryogenic temperature.

b. The checkvalve at the exit should be checked before each run for proper operation with the existing chain operator or the valve replaced with a Mylar burst diaphragm.

c. The ventilator openings should have screens added to prevent foreign objects from entering.

5. Heat Exchanger

5.1 The heat exchanger is used with liquid nitrogen and steam and will present many operating problems if not properly purged.

5.2 The pipe between valve #504 and steam trap #503 appears to be a short piece of black pipe which is not suitable for use at cryogenic temperatures, it is recommended that it be changed to stainless and made longer to keep the steam trap at ambient temperatures.

5.3 The rupture disc on the heat exchanger should be piped out of the building to prevent injury to personnel.

CHECK THRUST SUPPORT ON BUP PIPE

C. Structures and Vessels

1. Test Cell

The major structural aspects of the brick and mortar portion of the facility have been determined to be satisfactory. The nature of the modifications and new construction is conventional and adequate.

2. 13 Foot Diameter Tank

The 13 foot diameter propellant test tank details were examined and determined to have a sound basis for design and properly detailed specifications for procurement. The contractor is recognized as having the desired fabrication experience and test capability.

3. Environmental Vacuum Chamber

The contract drawings and specifications for the 25 foot diameter spherical environmental vessel were reviewed. This review indicates certain deficiencies in the contract specifications.

3.1 The vessel and its appendages were not designed for possible cryogenic temperatures but rather for -10°F. The A-36 stiffener material on the sphere is brittle at cryogenic temperatures and would not normally be used on a cryogenic vessel. Such material has been used on stainless vessels with cryogenic shrouds. If the shell becomes wetted by $LH_2$, a thorough inspection will be required before returning it to service.

3.2 The contractor was not required to fabricate by any particular structural code nor was he required to furnish his design analysis for approval by the government. He was only required to demonstrate chamber capability by

performance testing per contract specifications. The performance tests were conducted satisfactorily.

3.3 The contract specifications do not describe very well the nature of the research to be conducted within. Quoting from Spec. C-65089-PB, paragraph 101(2) in part, "The chamber is to be used for research and testing of space hardware under environmental conditions" and a notation on contract drawing CF620011 "30,000 lb. max. horizontal thrust (⟷) at 2 cycles per sec." is the extent of the description of the research to be conducted in the chamber. From the dynamics viewpoint, this description was very meager. The contractor did consider the above mentioned reaction load when dealing with the local problem of reinforcement about the shaker mount, <u>but the over-all dynamics and stability of the chamber and its supports was not considered for the conditions existing during a test</u>.

3.4 The contractor in 1959 conducted full scale tests on reinforced spheres under external pressure to validate the reinforcing technique as used on this vacuum chamber. He considers the design approach to be an extrapolation of the ASME code and as such proprietary to the company.

3.5 Some spot X-ray of shell welds was conducted during fabrication in the field.

3.6 The following recommendations for validating the integrity of this vacuum chamber are suggested:

a. A dynamic analysis of the inherent stability of the vessel and its supports under experimental test conditions should be made by appropriate design study contract with the original contractor or an independent qualified contractor.

b. An inner liner or other suitable means should be provided in the lower half of the vessel to prevent wall temperatures approaching the cryogenic level in the event of an $LH_2$ spill.

D. Detection Systems

The safety detection system consists of the following components:

a. Six Mine Safety $GH_2$ detectors

b. Five General Monitor $GH_2$ detectors

c. Five Minneapolis-Honeywell fire detectors

d. Four smoke detectors.

The number of detectors used is adequate for the job. The whole $GH_2$ detection system was built to sense leaks quickly, so remedial action could be taken. Hoods were built over piping runs to collect the $H_2$ - air mixtures with the detectors located at the high point in the hood. The units were spotted directly over and close to $H_2$ piping. It is not necessary for $H_2$ gas to travel more than 5 or 10 feet before it is sensed. Some thought is being given to the use of partial pressure analyzer for sensing $H_2$ under vacuum conditions in the 25' vacuum tank. (Aside from safety, it would also provide a device for isolating leaks into the chamber by analyzing the composition of the leaking gas) ($H_2$, He, $N_2$, Air, etc.). None of the detectors purchased will detect $H_2$ in an inert gas background and this problem is being explored.

E. Instrumentation

The number of spare wires and signal conditioning equipment is adequate to allow for 25 to 35% expansion over present anticipated needs. Standard techniques are used for data acquisition. The main problems associated with instrumentation are as follows:

1. The equipment was purchased in the past three years and some is now obsolete relative to present "state of the art". This is particularly true of vacuum sensing equipment.

2. Strip charts, transducers, and readout gages are not Plum Brook standards and will require separate spare parts inventory.

3. Equipment has been stored in a number of different locations, used by others, and in the process, manuals have become lost. Instrument people must now procure manuals and re-check all equipment.

4. The AMP board to be installed is not of the type found best at Plum Brook. A change of this board is being made.

5. Consolidation of the 100 channels of 30KC data system in the "H" building should provide for continuous quality in the data acquisition process as well as more effective Plum Brook utilization. Initial planning had considered this site operation as independent with the attendant additional manpower and intermittent surveillance problems.

F. Piping Modifications for 13 Foot Diameter Test Tank

1. Piping Schematic (Dwg. No. PF29460)

The piping modification design was reviewed and, in general, it is similar to the original piping only larger. It should be re-examined with respect to the comments and recommendations on the original system. If the original system is changed as a result of the comments submitted, these changes should be incorporated in this system, otherwise, no

changes need be made.

2. Specifications

The specifications in general, were well written; however, there are a few comments as follows:

a. Paragraph 1-02-b-1 should read: "fabricating and erecting piping systems for required services including, but not limited to $GN_2$, $LN_2$, etc."

b. Paragraph 1-02-d, Drawing No. CB-750965 should be included in this list so bidder is familiar with the work required to put NASA serrations on stub ends.

c. Paragraph 1-05-b. The words "proper mechanical operation" should be clarified.

d. Paragraph 40-01-b. The words "exercise care at all times to protect equipment and buildings from damage" are vague terms and should be expanded and clarified.

e. Paragraph 40-02-23. There should be a statement added pointing out that the method of support should also allow for thermal expansion.

f. Paragraph 40-02-23. A better spec for "weather-proof white paint" should be added.

g. Paragraph 40-02-30. Some reference should be added so that contractor knows that this is for the $GN_2$ system.

h. Paragraph 40-02-31-a. The statement, "shall be accepted as clean after the hydrostatic test", could be misleading.

i. Paragraph 40-02-31 and 32. The cleaning and hydrostatic testing procedure would be simpler and safer if trichlorethylene (NASA 500 solvent) were used and furnished by the government and if the hydrostatic test were performed with the same solvent. Also, the specification says "the system should be cleaned and then pressure checked." It seems that reversing these two procedures would be more logical.

j. Paragraph 40-02-48. The statement, "the working pressure shall be 150 psig maximum", should read "the working pressure shall be 150 psig or higher".

k. Paragraph 40-02-49. The vacuum jacket should also have some relief provision in case the inner pipe leaks.

## V. RESEARCH INSTALLATION

1. The experimental tanks to be used for the research program planned for this facility will require on-sight improvised hoisting procedures to set in place in the vacuum chamber. It is unlikely that a tank can be directly transferred from a motor crane outside the building to the environmental chamber. It is more likely that the crane will transfer the tank from the transport vehicle to the working floor of the facility. From there, it will be necessary to provide a second lift and subsequent transfer to the vacuum chamber. Considering the dynamic manner in which the test tankage will be used this much handling seems undesirable and not without risk, however with due precaution can serve the purpose. Any accelerated program would warrant the installation of at least a motorized monorail hoist or a swinging boom hoist for efficient handling of test hardware.

2. Operation within a vacuum chamber presents certain problems of instrumentation which must certainly be recognized in their specifications for procurement and subsequent use.

3. The integrity of the main hatch seals calls for good maintenance procedure with regard to cleanliness and inspection.

4. Presently, the entire hatch locking mechanism has been painted. In time, this may introduce operational difficulties requiring the removing of paint from the affected parts.

## ATTACHMENT A

### Board Assignments

In order to effectively investigate the detailed design of all facets of the facility, the members of the review board were assigned to the following areas:

| | | |
|---|---|---|
| Holmes Neal | - | Structures, vessels |
| Duane Rohde ) | - | Process systems and components |
| Harold Arndt) | - | Control systems, electrical |
| John Gibb | - | Safety detection systems<br>Site considerations<br>Plum Brook operation plan<br>Data Systems |
| John Esterly | - | Research installation |
| Robert Godman | - | Summary evaluation and recommendations |

ATTACHMENT B

Board Meetings and Activities

October 5, 1964

Memorandum from Associate Director, Bruce T. Lundin, to Robert R. Godman requesting design review of Cryogenic Propellant Test Facility.

October 12, 1964

Memorandum from Robert R. Godman to Bruce T. Lundin for designation and approval of facility review task group.

October 16, 1964

Bruce T. Lundin outlined the purpose and objectives to be achieved by the Design Review Board.

October 20, 1964

| | |
|---|---|
| Richard DeWitt | - Research program objective |
| Bernard I. Sather | - History of facility development and research hardware |

October 22, 1964

| | |
|---|---|
| John Czernicki | - Vacuum chamber design<br>Actuator<br>5' Diameter Nomad tank<br>Tank Support Systems |
| John Gyekenyesi | - Process piping |
| Melvin Werner | - Building and control structures |
| Anthony Schoeffler | - Electrical Systems |

October 28, 1964

Following a complete inspection and tour of the facility with cognizant Plum Brook personnel, a detailed discussion of critical design, construction, safety, and operational problems was held. Those present were as follows:

**Review Board - All present**
Glen Hennings
Robert Siewert
Joe Gillette
James Cairelli
Norman Hammersmith
Delbert Cole
Albert Schultz
James Shepherd
Gordon Kennedy

November 3, 1964

Review Board meeting to review detailed assignments.

November 16, 1964

Review Board meeting to complete initial studies.

December 15, 1964

Board Members reviewed rough draft report and made necessary revisions.

December 17, 1964

Review Board presented results to cognizant research and operations engineers.