

NASA
Plum Brook Station

Jan Temple
PB Sta Files
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Sandusky, Ohio
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MEMORANDUM to Charles S. Moore

Subject: Information for yearly experimental facilities operation report
for Plum Brook Station

1. The information contained herein is submitted as per your telephone request of 29 June 1962. The experimental facilities at Plum Brook Station do not lend themselves to the "running time" type of reporting usually associated with Wind Tunnels and similar rigs. This makes it necessary to present the information in a different format.

2. The Plum Brook Reactor went critical on a minimum size core June 14, 1961 and was first operated with the full size core on June 27, 1961. Since that time the Reactor has operated 318 hours at low power for calibration and training. Of this number 195 were spent approaching critical and 123 were spent at critical. A total integrated power for these very low power operations was 894 kilowatt hours. In addition to the Reactor operation at PBRF approximately 200 hours were spent in completing the hydraulic testing of the core. These are actually operating hours with the primary system pumps, etc being used. Test set up time of course has not been included.

3. Operations have continued in the Rocket Systems area for certain of the facilities and certain of the new facilities have gone operational during the past fiscal year. Many of the new facilities have been going through the shake-down runs and calibration tests associated with the initial operation. Some of the facilities have required rather extensive changes between scheduled test programs. Each of the facilities have been listed below with notes describing operations for the past year:

a. "A" Site - Pump Research Laboratory:

Between September of 1961 and May of 1962 ten Liquid Nitrogen and one Liquid Hydrogen run were made on the Liquid Hydrogen Pump Installation. No operation of the LOX pump portion of the facility took place during the year.

b. "B" Site - NERVA Test Stand:

This facility is still in the construction phase, no operation was scheduled during the past year.

c. "C" Site - Turbo Pump Facility:

The Boiling Fluids rig was in operation throughout the year using Liquid Hydrogen. Several preliminary runs were made in order to check out the newly installed equipment and the data handling capabilities of the equipment associated with the experiment operations of the Hydrogen Pump rig have been limited to five or six check-out runs on the thrust balance system of the pump and to cold shock tests

of the pump suction and discharge lines.

d. "D" Site - Turbine Test Facility:

Operations have been limited to cold flow tests to investigate control problems and to a hot check of the gas generator. Results of these tests indicated that certain of the control valves and systems had to be modified and these changes are now being made.

e. "E" Site - Dynamics Laboratory:

Twenty-Nine research runs were completed between February and July of 1962 to support the MECA program, the SCOUT program and the Ranger payload systems as well as others.

f. "F" Site - Hydrogen Flow Facility:

This site was not operational during the Fiscal Year except for shake out testing that required several modifications to the existing equipment.

g. "G" Site - Pilot Plant:

Test operation of the Liquid Hydrogen Pump continued until the end of September 1961. After that time a new pump was installed and one run was made in June 1962. The turbine test facility at the same site had twelve runs between November 1961 and January 1962 using the NERVA three stage turbine. In addition one run was made in June of the Hy-Nut Turbine using Nitrogen gas.

h. Central Control:

This facility operates as a central control and data acquisition facility for most of the test stands. It has been in operation throughout the year as required to meet the various runs scheduled. In addition a considerable amount of time has been spent in de-bugging the data acquisition and read-out gear in order to eliminate deficiencies that showed up as part of various test operations as well as to improve the capabilities of the installed systems.

i. "I" Site - Liquid Fluorine Pump Laboratory:

During the past year this newly completed facility has been going through various check runs using gas helium and liquid nitrogen in order to "prove" the systems for use with liquid fluorine. Two liquid fluorine tests were conducted in March of 1962, one of which was considered successful. The second test resulted in partially destroying the test facility when a fluorine leak occurred in the equipment under test. The remainder of the fiscal year has been spent in rebuilding the facility for future fluorine tests.

j. "J" Site - Rocket Test Area:

The operation of the various test stands making up the "J" site are listed below:

"J-1", The gaseous hydrogen - liquid oxygen rocket test engine has been in operation throughout the year. Work has now progressed to include the second phase of the test program.

"J-2", The rocket systems test stand ran from July 1, 1961 to December 31, 1961 with an H₂-F₂ rocket system test program and from December 31, 1961 to May 7, 1962 the cell was inactive. The remainder of the year has been spent in preparing for the new H₂-O₂ rocket system.

"J-3" has not been in operation during the past twelve months but construction has taken place to prepare for tests for the Space Tank Facility.

"J-4" has been in operation from March 2, 1962 to July 1, 1962 doing tests of liquid hydrogen tank insulation materials. This program will continue with another series of tests to be done in the coming year.

"J-5", The fluorine material compatibility facility, was in operation from the beginning of the Fiscal Year until March 2, 1962. It has been inactive during the remainder of the Fiscal Year, as new test programs are prepared.

4. It is hoped that the above material will satisfy your requirements for information on the Plum Brook operations during Fiscal Year 1962. Should additional information be required please contact the writer.

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Director, Plum Brook Station

ADJ:ejf

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B-1 STATUS REPORT

Approximately one year ago, the decision was made to convert the B-1 facility into a simulated nuclear rocket engine test stand in support of the "Nerva" Program. The essential items of equipment needed to conduct tests are a liquid hydrogen tank, turbo pump assembly, nozzle and inactive reactor package. The tests objectives are to study the start-up transients of a pump fed nuclear rocket engine to include cool-down and turbo pump "bootstrapping". It is also planned to conduct limited pump mapping.

Since the initial decision to convert the facility, extensive work has been done in determining modifications required to accommodate the new program. The bulk of the design work was completed approximately one month ago which included process piping, electrical, structural modification, and exhaust system modification. Almost all major contracts have been let to date. Present scheduling calls for facility checkout in mid January 1963. It appears that some of the major tasks which could delay this date are:

- a. Procurement and Fabrication of nozzle components
- b. Fabrication and ⁶⁰instruction of reactor package instrumentation, and:
- c. Availability of the Mark 9 turbo pump assembly. According to present best estimates, this could result in a delay of as much as 5 months.

PUMP RESEARCH LABORATORY A-1 (LH₂ PUMP)

Approximately 10 liquid nitrogen runs were completed between September 1961 and May of 1962. One liquid hydrogen run was completed. The objective of the program is to determine data for a shrouded impeller. The pump design criteria includes a Q of 50#/sec at 30,000 RPM. During the LN₂ runs the control systems of the support facility were modified for efficient operations.

PUMP RESEARCH LABORATORY A-2 (LOX PUMP)

The LOX pump side of "A" Site has been in a maintenance status the past Fiscal year.

OPERATION OF "C" SITE - JULY 1, 1961 TO JULY 1, 1962

The following two rigs were operated during the above fiscal year:

- A. C' - Boiling Fluids Rig
- B. C - Hydrogen Pump Rig

A. BOILING FLUIDS RIG

Two inducer blades were operated in liquid hydrogen to obtain data and characteristics so that a correlation could be made between this data and that obtained when operated in water. A straight leading edge inducer and a tapered leading edge inducer were involved. These were operated at speeds of 5400, 6000, 6400, and 9300 RPM.

Eight vapor bulbs of various shapes, sizes, and materials of construction were installed and checked for time response and efficiency of operation.

Initially, start up tests were carried out in which everything was recorded from the beginning of each run in order that the digital and actuators could be de-bugged. Scanni valves were installed and checked for proper operation. After running a few times heaters were put on the scanni valve lines to prevent percolation within the small diameter lines.

Actuators were submerged in the liquid hydrogen and data obtained on this low temperature operation. These were first submerged in liquid nitrogen and tested.

Pump out runs were made in which the liquid hydrogen was pumped from the tank to the dewar under various conditions of pressure and temperature so that inter-related data could be obtained that pertained to proper inducer operation and calculated performance could be determined.

Supplemental data was obtained by the use of stroboscope and movie cameras so that cavitation of the inducers could be observed and recorded.

A movie of the complete operation of the boiling fluids rig was made and is being developed.

A nuclear heater was installed at the suction end of the pump in order that vigorous boiling could be made to occur near the inducer. Two runs were made with the heater in place but not connected.

To accomplish the research objectives, instrumentation and rig changes were made throughout the year. This involved the addition of valves, lines, and various electrical equipment.

At present, a new inducer of smaller diameter than the other two is being installed. This inducer will be operated at 15,000 RPM. In addition to this, the above mentioned nuclear heater will be connected and operated prior to the next run.

B. HYDROGEN PUMP RIG

The liquid hydrogen pump used in this rig was designed for speeds up to 60,000 RPM with an outlet pressure of 1000 psi. Pump, impeller, and bearing design were the research variables. A hydrogen supply dewar and a hydrogen receiver dewar along with venturi and control valve make up the important parts of this system. By varying speeds using gaseous hydrogen in the turbine and by creating various pump discharge conditions by partially closing the control valve it was hoped that research data could be obtained.

The pump loop consisted of an eight inch diameter discharge line. *Suction line 6" diameter.* In order to operate this pump as desired the following work was carried out during the past year.

1. Installed NPSH system
2. Assembled research pump
3. Installed oil mist system
4. Installed turbine oil system
5. Installed nitrogen purge and pressurization system
6. Installed dry air to NPSH system

Upon completion of this work, the pump and line were cold shocked. This resulted in a broken pump discharge line due to line size being too large for the pump to be researched. A suction and discharge bellows was installed to prevent a reoccurrence of this nature. A new loop of smaller line diameter was initiated in design so that pump and loop might be more compatible. However, the loop of larger diameter with bellows is now being used until new design is completed and installed.

Five or six check out runs have been made on the thrust balance system of the pump and at present this problem is being worked on.

OPERATION OF "D" SITE FROM JULY 1, 1961 to JULY 1, 1962

"D" SITE IS A TURBINE TEST FACILITY CAPABLE OF TESTING MULTI-STAGE TURBINES

TWO TURBINES CAN BE INSTALLED AT THE SAME TIME AND EACH HAS ITS OWN GAS GENERATOR TO SUPPLY HOT GAS AND ITS OWN HIGH SPEED GEAR BOX AND EDDY-CURRENT DYNAMOMETERS TO ABSORB AND MEASURE THE POWER OUTPUT.

At the beginning of Fiscal year 1961, the construction of the site was complete, and some cold flows to check the system had been made.

Several more cold flows and necessary changes had to be made before the hot check out of the gas generator was made in February 1962. It resulted in a burn out caused by a control problem.

Additional cold flows were made to investigate the control problem which was fully defined by June 1962. It was found that the control valves were too slow. Therefore, a decision was made to change the control valves from pneumatic to hydraulic operation. At the same time it was also decided to change from liquid H₂ to gaseous H₂ to increase the running time and permit cold running. These changes are now being made.

DYNAMICS LABORATORY (E SITE)

Vibration analysis data was obtained during the past Fiscal year (July 1, 1961 to July 1, 1962) in support of the following research programs:

- a. Mercury Evaporation & Condensing Analysis (MECA)
- b. Scout Rocket Pickup Calibration
- c. Ozone Release
- d. Micrometeor Patch
- e. Ranger Payload (Bell Aero)

Twenty-nine research runs were completed between February and July of 1962. Prior to February the Dynamics Laboratory was in a maintenance status. During that time period a major modification was completed. This modification included changing the cooling oil from water glyco base to Sheel TULUS # 23.

STATUS OF "F" SITE FROM JULY 1, 1961 TO JULY 1, 1962

The liquid hydrogen flow facility has been in various stages of construction and modification during this one year period of time. Problems have been encountered that have caused delays in making the system operational. Such items as flanges in high pressure systems with ^hphonographic serrations or no serrations at all have been found. The hydraulic system had to be cleaned out and refilled with a new oil. All hydraulic components have been removed and are now being rebuilt.

As of July 1, 1962 all piping changes have been completed. The gas systems are being pressure checked and blown down to remove foreign matter from the lines.

The major block remaining in this facility is the amount of electrical changes that have to be made. The cell is grossly under powered electrically and major changes are necessary.

Checkouts with liquid nitrogen are intended to start by the end of September 1962.

OPERATIONS OF THE PILOT PLANT PUMP FACILITY ("G" SITE)
July 1, 1961 to July 1, 1962

1. Between July 1, 1961 and September 26, 1961, five (5) test operations were conducted with LH_2 . The pump under test had a 0.6 hub tip ratio and ran at a speed of 15,000 RPM. Objectives were the loading limits of axial flow pumps and the reliability of similar pumps in dissimilar liquids. Sufficient data was taken to plot the characteristics of the 0.6 hub tip ratio pump.

2. The test facility was in a maintenance status between October 1961 and April 1962.

3. At the present time a 0.7 hub tip ratio pump is being tested. One run of this pump with LN_2 occurred before the end of the Fiscal year.

4. Operations of the Turbine Facility ("G" Site)

In the period between November 1961 and January 1962, 12 runs were made on the NERVA, 3 stage turbine. One run was made in June on the HYNUT, 6 stage turbine using N_2 gas.

OPERATION OF "I" SITE FROM JULY 1, 1961 to JULY 1, 1962

"I" site is a liquid fluorine pump laboratory. In this test cell, data in the form of parameters is gathered to facilitate in the design of liquid fluorine pumps.

Within the past year, 50% of the time was spent checking the system with gas helium and liquid nitrogen. 17% of the time was spent calibrating the system with liquid nitrogen. This work was performed to prove the system safe for a liquid fluorine test.

Two liquid fluorine tests were conducted in early March 1962. The first test lasted forty-nine minutes and was considered successful. During the early moments of the second test, a fluorine leak occurred partially destroying the laboratory.

Since March, the remaining 33% of the time was used in rebuilding the laboratory for future fluorine tests.

STATUS REPORT OF "J" SITE FROM JULY 1, 1961 = JULY 1, 1962

J-1

The gaseous hydrogen-liquid oxygen rocket test engine has been in operation for the entire 1 year period. At the same time construction has been proceeding to support the second phase of work to be done in the J-1 test rig.

J-2

For the period July 1, 1961 to December 31, 1961, the cell was operational. The H_2-F_2 rocket system test program was completed on December 31, 1961. From December 31, 1961 to May 7, 1962 the cell was inactive. Construction began on May 8, 1962 on a new H_2-O_2 rocket system. Construction is continuing and should be complete by August 1, 1962.

J-3

This facility has been under construction for the past 12 months. The space tank facility will be in partial operation by July 16, 1962.

J-4

The facility was inactive for the first six months of the period. The next three months were spent in construction and reactivation for a series of tests of liquid hydrogen tank insulations. From March 2, 1962 to July 1, 1962 the tests were run and the program completed. The liquid hydrogen tank is now being reinsulated by Goodyear Aircraft at their plant. When the insulation installation is complete another series of tests will be run in the facility.

J-5

The fluorine material compatibility facility was operated from July 1, 1961 to March 2, 1962. Since this period of time the cell has been inactive. New tests are now being discussed between Lewis and Plum Brook engineers.