TEST LABORATORY

MONTHLY

PROGRESS REPORT

February 1, 1967 through February 28, 1967

GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MSFC - Form 1262 (September 1961)

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SYSTEMS TEST DIVISION

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ADVANCED FACILITIES PLANNING OFFICE

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I. SATURN IB

A. S-IB-9 Stage

1. Stage S-IB-9 was received and installed in the Static Test Stand East on January 27, 1967. During the course of routine preparations for static test, three thrust OK pressure switches and two associated electrical cables, four auxiliary hydraulic pump motors, and one ignition monitor valve were replaced because of malfunction or evidence of damage. One gas generator control system leaked in excess of specified allowable and was therefore removed for inspection and servicing. Inasmuch as an unidentified foreign particle contamination was found, the remaining seven gas generators were also removed for inspection. A small metal chip was found in the vicinity of the LOX control valve seating surface in one gas generator.

2. A propellant loading test was performed on February 15, 1967. The test was successful.

3. The short duration test SA-42, was scheduled for 35 seconds on February 24, 1967. The test was terminated prematurely at 10 seconds after simulated lift-off because of a power failure in the Beckman digital data acquisition system. This condition caused the indication of a low lube oil pressure, below the redlined minimum, and a cut-off command was automatically given. The actual lube oil pressure, and other engine parameters, were satisfactory, however.

4. The re-scheduled short duration test, SA-43, was terminated at approximately 35 seconds on February 27, 1967. The test was successful and all test objectives were obtained.

B. H-1 Engine

One firing, test P1-493, was conducted at the Power Plant Test Stand on February 15, 1967. The test was 40 seconds in duration and utilized engine H-7057. A successful gimbal program was accomplished with zero accumulator pre-charge pressure on the hydraulic system. Engine parameters appeared normal.

II. SATURN V

A. S-IC Stage

1. The S-IC-S fuel tank is scheduled to be installed in the S-IC Test Stand on March 6, 1967. It is anticipated that approximately two and

one-half weeks will be required for the preparation and hydrostatic pressure test. This test will be conducted to obtain empirical test data for tank design evaluation by Boeing.

2. Two successful propellant load tests were accomplished on the S-IC-T stage at MTF by Boeing February 14-15 and 24-25, 1967. Present plans stipulate two static firings on the S-IC-T stage. These tests are scheduled to be performed on March 3 and 15, 1967, for 15 seconds and 40 seconds, respectively.

B. F-1 Engine

Test FW-059 was conducted on the West Area F-1 Test Stand on February 10, 1967, with F-1 Engine S/N F-4024 for a mainstage duration of 51 seconds. Cutoff was initiated by the facility panel operator as planned. Primary purpose of the test was to calibrate the engine allocated as spare for S-IC-503.

C. S-II Stage

1. S-II-2 arrived at MTF on February 10, 1967, with approximately 10,000 hours of manufacturing work scheduled to be performed prior to static firing on March 25, 1967. S-II-2 was installed in the MTF A-2 Test Stand on February 18, 1967, two days ahead of schedule. The LO_2 and LH_2 tanks were entered and inspected between February 11 and 23, 1967, for structural damage during transportation from Seal Beach. No major structural damage was located. The V2-300 modifications (period prior to initiation of checkout operations at MTF) are scheduled to be completed on March 3, 1967.

2. The End Item Test Plan (SID 66-977) and Static Firing Acceptance Specification (MA0201-4023) have been reviewed, modified, and tentatively approved for S-II-2 by R-TEST-ST pending agreement with S&ID. Volume II of the Part II CEI for S-II-3 and subs has been reviewed and a R&DO position has been established.

D. S-IVB Stage

1. All titanium spheres that are installed on the S-IVB Battleship stage in the S-IVB Test Stand at MSFC and stored as MSFC spares were eddy-current checked during this report period to determine if the type of welding rod used in fabrication allowed their usage. All spheres were found to be acceptable.

2. Installation of the O_2/H_2 burner system on the S-IVB Battleship stage has been completed and checkouts are underway. The first hot test is scheduled to be conducted during the week of March 6, 1967.

3. The NASA investigation of the S-IVB-503 explosion has been completed. According to the findings of the board, a weld deficiency on one of the titanium spheres in the helium re-pressurization system caused the destruction of the stage. This weld deficiency was the result of the vendor's use of an out-of-specification filler weld material.

4. Pre-static checkout of S-IVB-504 on the Beta I Test Stand at the Sacramento Test Center of Douglas is progressing. The acceptance firing is scheduled for April 21, 1967. Most of the test stand modifications have been completed to allow firing of the O_2/H_2 burner as part of the stage static test.

III. APOLLO APPLICATIONS

A. Lunar Drill Program

1. The main objective of the Moderate Depth Lunar Drill program is to develop a system which will drill and take core samples to a depth of 100 feet in the lunar sub-surface. The two different drill concepts in preliminary development are the modified rotary and the rotary percussive. Hardware for both concepts has been delivered to MSFC and testing has begun with the objective to select one concept for production.

2. Components of the percussive drill system sent to Midwest Research for solid lubricant coating have been received and are being assembled for testing.

3. The final shipment of hardware for the Westinghouse Engineering Model was received by Test Laboratory.

B. LSSM Project

1. Field tests of the Mobility Test Articles (MTA's) being conducted at Yuma Proving Grounds (YPG) were completed February 8, 1967. The vehicles are being temporarily stored at YPG pending completion of data reduction at MSFC. YPG is preparing the test report and is continuing effort in data evaluation and in preparation of terrain evaluation information. This effort should be completed in March 1967. There are no current problems, funding or operational, in this area. It remains only to verify final report presentation, currently scheduled for early or mid March.

2. Test Plans and Requirements are being generated by R&DO for additional test effort on MTA's at MSFC. The initial planning meeting was held at R-TEST on February 21, 1967, resulting in assignment of specific action items to the various laboratories. Problem areas currently envisioned include correlation of data to existing or planned Computation Laboratory simulators, including electrical similitude, power for LSSM, and test course location.

3. Participation in preparation of the evaluation technique for the selection of a contractor for the LSSM continued in February. An evaluation of the scope of work for the follow-on effort of Boeing and Bendix (through July 1, 1967) for some $300,000 was completed and input

provided to the project manager on February 27, 1967. Presentation material for a briefing of the SEB chairman was completed and delivered to the project manager on March 1, 1967. This effort is expected to continue and expand until the award of contract about July 1, 1967.

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I. SATURN IB

A. S-IB Stage

1. 200K H-1 Turbopump Testing

The H-1 Turbopump Facility supports R-P&VE in S-IB propellant feed system studies. The facility provides S-IB vehicle system simulation including prevalves, suction ducts, turbopump, high pressure ducts, and main engine valves.

Test C-039-4 of the Fuel Additive Test Series was conducted during this reporting period. This test was the first run of the series with FR-3 friction reduction additive mixed in the fuel. The FR-3/RP-1 mixture ratio was 1/1000 by volume. The primary objective of the test was to determine the effects of FR-3 on the fuel feed system operation. The data is being evaluated, although results of the fluid samples analysis indicate that the FR-3 did not mix homogeneously with the RP-1. A system is being installed to obtain proper mixing and testing will continue during the next reporting period.

B. Ground Support Equipment

1. Saturn IB Service Module Swing Arm - Launch Complex 34

The swing arm will be used on the LC 34 umbilical tower to support electrical, water glycol, GH_2 venting, and air conditioning service lines to the Apollo Service Module umbilical connection. The test program was requested by KSC to qualify the swing arm in conjunction with the redesigned umbilical housing assembly furnished by NAA-S&ID through Manned Spacecraft Center (MSC).

The test program on the Service Module swing arm and the umbilical housing (Models A34-243) is complete. All umbilical disconnect tests performed after the gaseous hydrogen (GH_2) vent couplings were modified were successful. The tests were also completed after relocating the water glycol quick disconnect coupling to the same side (right hand) of the umbilical.

The A34-243 umbilical disconnect set is now considered acceptable for use with the service module swing arms.

Data is being evaluated and the report is being prepared.

II. SATURN V

A. S-IC Stage

1. F-1 Turbopump Testing

The F-1 Turbopump Facility provides the capability to perform checkout, calibration, qualification, and development tests on S-IC/F-1 Turbopump propellant feed systems. This facility contains a gas generator driven F-1 Turbopump which is mounted on a thrust chamber and simulates the S-IC flow system from the suction duct inlets to the main shutoff valves of the engine.

Test C-006-66 was conducted at the F-1 Turbopump facility. This test was the third in a series of F-1 fuel pump inlet fairing bolt evaluations. The objective of the test program is to evaluate the stresses and strains seen by the inlet fairing and its retaining bolts during nominal F-1 Turbopump operation. One more test using this specially instrumented pump is scheduled to be conducted during the month of March.

An R&D 6x6 impeller Turbopump is currently being assembled by Rocketdyne for testing at the F-1 Turbopump Facility. The purpose of this test program is to determine the operating characteristics of the 6x6 fuel and LOX impellers in comparison to the standard 6 blade impellers. Testing of this impeller configuration should commence in the summer.

Additional tests of a new, Teflon bearing design for a 17" turbine-type S-IC LOX flowmeter have been requested. These tests will be performed in conjunction with a LOX outboard PVC. Tests are scheduled to begin during the month of March.

2. F-1 Heat Exchanger Development Tests

The purpose of this program is to establish reliability and to verify the design of the F-1 heat exchanger.

No tests were conducted during this report period. The planned tests to verify test results from Phase II testing are now scheduled for the week of March 13-17. After completion of these tests, the test program will terminate; however, the set-up will be placed in a standby condition.

3. F-1 Gas Generator Development Tests

A project was established to conduct tests on an F-1 Gas Generator with different injector configurations. The objectives of the program are to alleviate detrimental pressure oscillations, reduce continued combustion in the turbine manifold, and to increase gas generator performance.

The test stand system is being re-assembled after servicing the gas generator and other components. The P&VE-designed double-swirl cup injector testing is scheduled to resume March 7, 1967.

4. F-1 Turbopump Seal Test

This program is being conducted to develop and improve LOX turbopump seals. This will be accomplished by comparing wear characteristics of various materials and configurations in the seal test fixture at simulated turbopump operating conditions.

The initial checkouts of the modified shaft seals (two different types) were conducted in January. The Kel-F lip seal configuration allowed excessive leakage and was rejected. Presently, minor modification to the new labyrinth seal design is being accomplished by the support shop. Checkout will continue upon return of the seal. Estimated delivery is March 6, 1967.

5. LOX Stratification

This program was requested by P&VE to verify analytics used to predict LOX Stratification in spherical containers using LN_2 for simulation. An attempt will be made to correlate LOX Stratification data with previously obtained LN_2 stratification data.

Tests C-025-12, 13, and 14 were successfully conducted during this report period. The estimated completion date for testing is 1 April 1967.

6. LOX Depletion Test

The purpose of this program is to support R-TEST-SP in a study of the LOX depletion characteristics during ground static tests with the ultimate goal of the combined effort to predict the LOX depletion characteristic.

Facility buildup is in progress. Test start date slipped to May 22, 1967, due to testing on the adjacent LH_2 Slosh Facility.

B. S-II Stage

1. S-II Insulation

B-Cell Position 1 - 70" Tank Insulation and Thermal Ullage Study:

The combined test programs were requested by P&VE Laboratory to (1) determine if the Dual Seal Insulation field repair techniques are structurally adequate under thermal cycling, (2) determine what effect tank geometry and insulation closeouts have on the thermal performance and structural integrity of the insulation under simulated aerodynamic heating, and (3) conduct a LH_2 ullage thermodynamic study.

Separate Memorandum Reports are being written on the 3 Dual Seal Insulation tests and the LH_2 thermodynamic Ullage Test.

C. S-IVB Stage

1. J-2X Turbopump Testing

This project was requested by P&VE to further the development and verify the performance of advanced J-2 turbopumps and subsystems. Test Position 501 is being prepared for this project.

All drawings pertinent to the present buildup have been released for fabrication. A memorandum (R-TEST-CV-#124-66, dated December 14, 1966) has been released which shows the revised buildup sequence for completion of all systems at Test Stand 500. Fabrication work did not progress on the 501 buildup due to higher priority work.

2. J-2X Thrust Chamber Throttling Tests

This program was established to evaluate the throttling characteristics of J-2 thrust chambers. Engine

thrust excursions of 5K to 200K SL (Sea Level) are contemplated. This will be accomplished in a 2-phase program.

Phase 1 consists of facility design, facility activation, and initial J-2X testing. The facility utilizes pressurized propellant tanks and throttle valves to control the engine thrust level. The activation test firings will include ignition, partial transition, full transition, and mainstage of a tubular wall J-2 thrust chamber with a ceramic coating to increase combustion zone durability.

The initial J-2X testing utilizes a J-2 thrust chamber and will evaluate at steady state conditions, four to six mixture ratios at thrust levels between 5K and 200K SL.

Phase II will consist of dynamic throttling of J-2 thrust chamber with and without hot gas tapoff capabilities, at four to six mixture ratios, and between 5K and 200K SL thrust. These tests will define engine and facility operating capabilities and will permit thrust chamber and tapoff optimization.

At present, the propellant systems are complete, the pressurizing systems are complete, the test stand structur is about 98 per cent installed, and the ignition, bleed and purge systems are about 90 per cent complete; instrumentation is about 65 per cent complete, and control systems are about 50 per cent complete.

The cryogenic cleaning has been completed and cold flow (LN_2) tests of the LOX system will be accomplished the first week of March. LH_2 system cold flow tests will follow.

It is estimated that testing will begin in late March.

3. LH_2 Slosh Testing

This program supports P&VE in the areas of LH_2 and LOX propellant feed systems studies in an ellipsoidal tank.

No tests were conducted during this report period. The stand is being modified for a series of S-IVB fuel prevalve tests. The purpose of these tests is to determine dry "Flow" closing time characteristics and pressure loads. These tests are scheduled to begin the first part of March.

4. S-IVB LOX and Fuel Tank Relief Valves

The test objectives for the S-IVB relief valves were to determine the valve operating characteristics with simulated flight vehicle environment. Emphasis was placed on determining possible valve chatter during relief modes. Tests on both valves were reported complete in the January Progress Report with no indication of chatter.

Test report on the S-IVB Fuel Tank Relief Valve has been completed and submitted. The test report on the S-IVB LOX Tank Relief Valve is in process and will be completed by March 10, 1967.

5. S-IVB Auxiliary Propulsion System Testing

The S-IVB Auxiliary Propulsion System Test Program was requested by P&VE Laboratory for conducting tests on upper stage ullage and attitude control engines at simulated vacuum environments.

Six tests (C-008-C1-8 through 13) were conducted at 140,000 feet simulated altitude on a C-1 engine during the reporting period, with each test consisting of a 50 second steady state firing, 10 pulses of 63 ms on - 437 ms off, and 50 pulses of 73 ms on - 137 ms off. Four of the tests were conducted at the 80 pound thrust level using helium saturated propellants at both ambient and 100°F temperature, and at 180 psia and 195 psia valve inlet pressures. The two remaining tests were conducted at 84 pound thrust level using unsaturated propellants, ambient and 100°F, at the standard valve inlet pressures of 195 psia. Low frequency instability of approximately 300 cps was noted in all tests, with the most severe case occurring when saturated propellants at ambient temperature were utilized in conjunction with 180 psia inlet pressures. The magnitude of the Pc oscillations in this case were ± 18 psi. The oscillations damped to ± 2 psi by approximately mid-test in all the 50 second firings.

Further testing on the subject C-1 engine is scheduled for the month of March to determine the thrust/Pc level at which the engine becomes stable. Reaction Motors Division reports this value to be between 85 and 90 lbs/psia.

D. Ground Support Equipment

1. LC-39 Service Arms

(1) S-IC Intertank (Set III) - This preflight arm

supplies the vehicle S-IC stage with lox fill and drain service, as well as personnel access to the vehicle. The arm has automatic capabilities to allow reconnection in case of a mission hold or abort.

Conducted tests on the newly installed redundant hydraulic retraction system. An average retraction time of 5.13 seconds for both systems was obtained.

Normal testing was suspended to run a series of tests for KSC on the deceleration valve. One series of tests was conducted to determine an optimum spacer to place in the flow compensator section to prevent the compensator spool from going full close. A 0.487-inch spacer resulted in an arm retraction time of 4.70 seconds with the compensator normal and 5.27 seconds with it blocked closed.

A new cam was installed to determine the effect of using a different cam. A retraction time of approximately 4.3 seconds was obtained. Using either the original cam or the new cam, the arm impacted the tower mounted shocks hard.

Tests are now being conducted to determine the effect of removing the flow compensator from the deceleration valve.

(2) S-IC Forward (Set III) - This preflight arm supplies the forward end of the S-IC stage with electrical, pneumatic, air conditioning services and personnel access.

Tests were conducted on the newly installed redundant hydraulic retraction system. An average time of 4.5 seconds was obtained for both systems.

Normal testing was suspended to run a series of tests for KSC on the deceleration valve. One series of tests was conducted to determine an optimum spacer depth to place in the flow compensator section to prevent the compensator spool from going full close. A 0.487-inch spacer resulted in an arm retraction time of 4.6 seconds with the compensator normal and 4.8 seconds with it blocked closed.

A new cam was installed to determine the effect of using a different cam. A retraction time of approximately 4.1 seconds was obtained. Using either the original cam or the new cam the arm impacted the tower mounted shocks hard.

Tests are now being conducted to check the operation of the deceleration valve without the flow compensator.

(3) S-II Aft (Set III) - Test report has been written, approved, and went to Reproduction March 1, 1967.

(4) S-II Intermediate (Set II and III) - This inflight service arm provides air conditioning, electrical, pneumatic, LH_2, and lox services to the S-II stage. The LH_2 and lox fill lines have independent connections to the stage while the remainder of the service lines in the arm are connected to the stage through one common carrier.

The Set III Arm was shipped to KSC via the Super Guppy on February 23, 1967.

The Set II Arm is being modified to incorporate a lanyard withdrawal system to replace the present dual cylinder withdrawal system. This modification is scheduled for completion on March 24, 1967.

(5) S-II Forward (Set I and III) - This inflight service arm provides air conditioning, electrical, and pneumatic services, plus a GH_2 vent for the S-II stage. All connections to the stage are through a common carrier.

The S-II Forward Service Arm, AA-05-03, was shipped to KSC on February 1, 1967.

The S-II Forward Service Arm, AA-05-01, is undergoing modification and refurbishment at MSFC. This arm will be installed in the test stand on March 13, 1967. Testing of the lanyard withdrawal modifications is scheduled to start on March 15, 1967.

(6) S-IVB Aft (Set I and III) - This inflight service arm provides LO_2 and LH_2 fill and drain services to the S-IVB stage.

(a) AA-06-03 - The set III S-IVB Aft service arm testing was completed on January 3, 1967, having successfully performed the requirements of the Revised Minimum Test Plan. The testing also included modification of the umbilical carrier to add a third ball lock assembly, which greatly improved the vehicle tracking capability of the system.

The set III arm was removed from the tower simulator on January 3, 1967. Refurbishment was accomplished in Building 4656, and the arm was shipped to KSC on February 15, 1967.

(b) AA-06-01 - The set I arm, which will be used to support the Saturn V launch, was returned to MSFC after being used in the Saturn V 500F wet test. The service arm was modified at MSFC to a lanyard withdrawal system which replaced the dual cylinder withdrawal system used on previous arms. The conversion to the lanyard withdrawal system was completed on March 4, 1967, and following the cleaning of the system operating lines, will be installed on the tower simulator on March 8, 1967. Checkout operations are scheduled to begin as soon as installation is complete.

(7) S-IVB Forward (Set I) - This inflight service arm provides air conditioning, electrical, pneumatic, water glycol, and LH_2 venting services to the S-IVB forward and the instrument Unit (IU) carriers, as well as through the Lunar Excursion Module (LEM) carrier.

During this report period a total of 47 R&D instrumented tests were conducted on the deceleration valve

The LEM fluid service line installation is approximately 95% complete. The S-IVB/IU vehicle electrical cables have been installed on the arm and the hydraulic W/D cylinder has been installed.

(8) Service Module - The service module arm is an inflight arm and provides air conditioning, electrical, GH_2 venting, and water glycol cooling services to the Apollo service module umbilical connection.

The set III arm was shipped to Cape Kennedy on November 17, 1966. An internal note test report was distributed February 10, 1967.

The set II arm was modified to the latest drawing configuration and was installed on the test tower simulator on December 12, 1966. However, during the installation, the arm truss was damaged and the arm had to be removed for repairs. The truss diagonals were repaired and the arm was re-installed in the test stand on January 12, 1967. Testing is now in progress. The normal test program has been interrupted due to a special series of deceleration valve tests for KSC. Systems and subsystems testing of the arm will resume after completion of these tests.

(9) LC-39 Command Module Access Arm - The LC-39 command module access arm is a preflight arm which supports an environmentally conditioned chamber through which the astronauts and service personnel can enter the Apollo spacecraft. The arm also provides a support structure for air conditioning and space suit checkout lines.

The water spray test and the ECS pressurization tests were completed on February 23, 1967. Chamber performance during both tests was unsatisfactory. The EC bellows allow water to get inside because of small pinholes that develop during normal use. Also, the EC will not hold a positive pressure during oscillation of the vehicle.

The upper and lower deceleration valves that were used during the test program were replaced with those from the Set II arm at KSC. However, testing has not yet begun on this set of valves.

2. Saturn V Damping, Retract, and Reconnect System (DRRS)

The DRRS is a system for the primary purpose of damping the Saturn V vehicle oscillation due to vortex shedding. The system has the capability of automatic extension, connection, disconnect, and retraction as well as damping oscillations. The test will be conducted for P&VE Lab to qualify the system prior to its use on LC-39.

The redesigned and modified hooking mechanism was received from ME Lab on February 13, 1967. The new design incorporates a roller arrangement on the hooks in lieu of the guide rod system previously used.

The test program (consisting primarily of connecting, damping, and uncoupling from vehicle simulator) was satisfactorily completed on the system on February 20, 1967.

Interference with the Command Module Access Arm and the Q-ball cover removal system are now the most serious problems. KSC design personnel are working on a change to the Q-ball system to alleviate the interference problem in that area. However, the Damper Arm/Access Arm interference problem (which exists only in certain extreme conditions) will necessitate placing an operational restriction on the two systems in order to assure that the access arm will not hit the damper arm during mating operations to the space craft.

The ML-1 damper arm was removed from the test tower on February 21, 1967, and delivered to ME Lab for refurbishment and shipment to the Cape. The arm was shipped to KSC on February 25, 1967.

3. Auxiliary Damping, Retract, Reconnect System (ADRRS)

The ADDRS is mounted on the Mobile Service Structure (MSS) at the 326-foot level, and is used to dampen vehicle oscillations caused by vortex shedding. This damping system will be used when the vehicle is enclosed by the MSS, whereas the primary damping system will be used during vehicle transit to the launch site and at the launch site when the MSS is not at the pad.

The left-hand latch assembly was received from the ME Lab on February 15, 1967. Stiffeners were added to prevent bending (bending of this assembly was discussed in the last report). During leg connection tests on February 18, 1967, the hook portion of the latch assembly broke. This occurred when the hook, which is spring loaded open, rotated around as the LES leg impacted the latch assembly. The LES leg hit the back of the hook and broke it. The latch assembly was returned to the ME Lab for repair. It was also determined during these connection tests that high loads (approximately 6,000 lbs) are being imposed on the LES leg. Connection load tests will be conducted to determine the maximum amplitude at which a connection can be made at a frequency of 0.67 C.P.S. with allowable loads.

As a result of the hook failure, LES leg connection tests were discontinued, and damper tests were conducted on the right-hand damper panel using the right-hand latch assembly. These tests were completed March 2, 1967.

4. LC-39 Tail Service Masts

The three service masts (lox, fuel, and environmental) are located on the deck of the Mobile Launcher and are used to service the S-IC stage tail section. Mast retraction is initiated by vehicle lift-off.

Set II tail service masts (S/N 1004, 1005, and 1006) were shipped to LC-39 on October 10, 1966. An internal note was distributed February 24, 1967, to cover the testing program run on these masts.

Set III tail service masts (S/N 1007, 1008, and 1009) testing was completed on October 24, 1966. Refurbishment by R-TEST-RT was completed and the masts were shipped to Cape Kennedy November 30, 1966. An internal note is being prepared (approximately 70% complete) to cover the testing program run on this set of tail service masts.

Set I tail service masts (S/N 1001, 1002, and 1003) were received on December 20, 1966. TSM 1-2 (fuel mast) was delivered to the test area on December 29, 1966, and was installed on the mounting base. TSMs 3-2 (environmental mast) and 3-4 (lox mast) were subsequently installed. A special test for R-P&VE-VO was completed in which the interface distance between the umbilical carrier mounting surface and the vehicle umbilical plate was two inches less than shown on the ICD installation drawings. The test runs on masts 3-4 and 1-2 gave no indication why the lesser dimensions could not be used successfully in the launch of SA-501. A flash report was distributed for these special tests and results.

5. LC-39 Mobile Launcher Holddown Arms

The purpose of this test program for KSC is to verify the physical and functional integrity of the Saturn V holddown arms prior to installation on the mobile launcher. All four holddown arms of the second and third set with forged links have been tested and shipped to KSC. Structural testing of the fourth set of arms began August 11, 1966, and was successfully completed November 2, 1966.

This fourth set of arms is a spare set and is being retained at MSFC to serve as test bed for development of the holddown arm secondary release system. Synchronization tests using control panel 75M18516, and pneumatic plumbing simulating launcher installation 75M05972 and 75M05973, were successfully conducted between January 9 and February 21, 1967. Preparations are underway for testing a secondary release system, employing an explosive nut installed in the torquing linkage of one arm. Start of testing is dependent on supply of special hardware by KSC, but should begin by March 14, 1967.

6. Saturn V Lift-Off Switches

This program is being conducted for KSC to ensure that the lift-off switch actuator arms can signal initiation of the umbilical disconnect and service arm rotation at the required vertical distance of vehicle lift-off.

Three switches (S/N 5, 8, and 9) have been adjusted and sent to KSC. A report was released September 21, 1966. Three more switches (S/N 6, 7, and 10) have been adjusted during the acceptance testing of the switch adjustment jig (SK-17886) and were shipped to KSC on January 26, 1967. A test report was released February 20, 1967. Another switch (S/N 11) with a modified primary actuator will be tested to determine the acceptability of the modification for use at KSC. The test procedure for this test has been submitted for approval. Testing of the modified actuator has been delayed because of projects with higher priority.

7. Q-Ball Cover Removal System

The prupose of the test was to demonstrate operational reliability of the system for removing the cone cover from the vehicle nose.

Testing of the first of three removal units was completed November 28, 1966. Modifications to the system were made as a result of testing. A final functional test of the modified system was conducted December 5, 1966. Testing on Unit number 2, was completed December 30, 1966. Testing on Unit Number 3 was completed January 18, 1967. Unit 2 was shipped March 3, 1967. Unit 3 will be shipped March 10, 1967. An internal note is in progress.

8. High Pressure Test Facility

a. The following test programs are being conducted in the High Pressure Test Facility, Building 4648.

(1) Pacific Back Pressure Regulator (KSC) - The purpose of this test program is to evaluate operating characteristics of the regulator. An approved test procedure has been written. Testing has been temporarily delayed because of priority of MTO valves.

(2) Connector Burst Test (Test Lab) - The purpose of this test program is to establish a factor of safety based on burst failure for commonly used tube and pipe connections and to observe factors that affect burst or excessive leakage. Three sizes (½", 3/4", 1") were tested in each of the following type fittings:

(a) Male AN to flared tube

(b) Male AN with cap

(c) AN O-ring to boss

(d) Pipe to pipe union

Testing began on October 17, 1966, and was completed on November 25, 1966. The results have been evaluated and the report has been prepared.

b. The following test programs are being conducted in the High Pressure Test Facility, Building 4648, for the Mississippi Test Facility (I-MT-EF).

(1) CPV and MVP Relief Valves - The purpose of the testing for these two valves, manufactured by the Combination Pump and Valve Company and the Mission Valve and Pump Company, is to evaluate their operating characteristics. Testing was started on September 19, 1966, and was completed on October 21, 1966. The MVP was found unsatisfactory for its requirements, however, the CPV was found satisfactory for reduced flowrate application. The test report for the CPV valve has been written. The MVP report is in progress.

(2) Anderson Greenwood and Company Relief Valve (MTO) - The purpose of this testing is to evaluate the operating characteristics of two Anderson Greenwood and Company pneumatic pressure relief valves. The test procedure has been written and approved. Testing was interrupted because of the MTF Grove ball valves and KSC testing requiring High Pressure Test Cell instrumentation. Testing should be completed by approximately March 31, 1967.

(3) Grove Ball Valves, Models M-16821-J and M-16821-G (MTO) - The purpose for testing these valves, manufactured by Grove Valve Company, is to evaluate flow, leakage and closing characteristics. These valves are possible replacements for the ITT Hammel-Dahl V950 series in the high pressure systems at MTF. Testing started January 17, 1967, and completed February 14, 1967. The units were unsatisfactory as a replacement and a report is being compiled.

9. S-IVB Aft Withdrawal Cylinder Life Cycle Test

The purpose of this test program, for KSC, is to determine the ability of the withdrawal mechanism to "track" vehicle motion for 1,100,000 cycles. Testing began November 22, 1966, and should be completed by April 28, 1967. The completion date has changed because eight (8) additional cylinders are to be tested.

On November 25, 1966, a teflon guide ring failed and a new teflon guide ring was installed. Testing at that time was not continued because of the differences in guide ring tolerances. A third teflon guide ring was installed and failed (excessive wear) after 8,820 cycles. After installing the fourth guide ring, made from Delrin material, testing was resumed. Ten-hour runs of continuous cycling caused temperature buildup resulting in cylinder overload. At 200,000 cycles, a GN_2 purge was initiated through the cylinder to dissipate heat. The purge, although successful, was removed after 30,000 cycles. Removing the GN_2 purge let the temperatures in the cylinder rise to 264°F which caused the Delrin bearing head ring and the guide head guide ring to melt. Both guide rings were damaged too much for further use. New serrated Delrin guide rings were fabricated, installed, and a twelve-hour run of continuous cycling was successfully accomplished. Cycling is still in progress at 990,000 cycles and no further problems have been encountered with the modified Delrin guide rings. Modified pneumatic cylinders for Arms 4, 5, and 6 have been cycled a minimum of 31,000 continuous cycles (12 hours) each and shipped to Cape Kennedy for installation at LC-39 to support 501 vehicle.

10. Flush and Purge Truck

This test program is being conducted (for P&VE Lab) to ensure that the truck will service the F-1 engine as required.

Testing was initiated December 16, 1966, and the following tests have been successfully completed: relief valves, GN_2 system, trich tank fill, filtration and circulation, fuel jacket flush, fuel jacket purge, lox dome, hypergol cartridge, no flow portable pump, ullage pressure, solenoid valves, and emergency stop. The transformer burned out during the turbopump preservative test. A revision to the unit will require a rerun of the lox dome test. Testing is 90% complete.

III. RESEARCH AND DEVELOPMENT TECHNOLOGY PROGRAMS

A. The Zero Gravity Test Facility

The Zero Gravity Drop Tower is utilized to assist P&VE in the study of low gravity fluid mechanics and thermodynamics phenomena. The facility is located in the Saturn V Dynamic Stand.

Fifteen tests were conducted in February. Eight tests were to study draining of the S-IVB fuel tank. Seven tests were performed to study LOX interface characteristics using a vacuum formed LOX tank dome that reduces distortion.

B. S-IC Model Drop

This test program was requested by R-AS to evaluate the S-IC booster recovery concept as proposed by the Boeing Company. Testing is to be accomplished on scale models impacting on water.

The 1/10 scale model has been fabricated. On Stand buildup is approximately 90% complete. Test start date is estimated 13 March 1967.

C. Liquid Hydrogen Super Insulation Program

This program, requested by P&VE, consists of studying the effectiveness of "super insulated" LH_2 tanks in a simulated space environment of 10^{-6} torr pressure.

It is planned to test tank #3 with Linde S-I insulation at ground hold conditions during March 1967. The test tank will then be tested in the vacuum chamber during June 1967.

30 Inch Calorimeter: The uninsulated calorimeter was tested in the vacuum chamber with LH_2 during this period. It was concluded that there were no leaks and the calorimeter is at M.E. Laboratory for insulating. Testing of the NRC-2 insulation should begin again around the middle of March.

D. B-Cell Position 2 - 20" Tank

This program was requested by P&VE Laboratory to evaluate a laminated cork insulation as a possible insulation for the liquid hydrogen container on the Ground Test Module - Nuclear Engine.

A memorandum Report has been written covering the test effort, which indicated that the cork insulation is a good candidate for the Ground Test Module. This program is now complete and will no longer appear in this report.

E. Storable Propellant Space Engines Testing

A 20 pound vacuum thrust beryllium engine, manuafactured by Rocketdyne, was tested at sea level conditions at the storable

propellant test facility on February 21, 1967. The purpose of this initial test was to check out the facility and engine systems.

F. 40,000 GPM Flowbench

This facility supports the Instrument Development Branch of Test Laboratory by providing a high flow water calibration capability.

Weighing system modifications are re-scheduled for April. A volumetric test was conducted on January 31, 1967. Further volumetric tests are to be scheduled in conjunction with the F-1 turbopumps testing.

G. Jet Impingement on Water

This program was requested by KSC to study the feasibility of launching large flight vehicles of the Saturn V and NOVA classes from offshore sites.

No tests were conducted during the month of February. Testing is scheduled to resume on March 10, 1967, with Tests 15C and 16C. Acoustic data will be obtained during these tests.

Analytical development (first draft) on the single engine report has been completed.

H. Combustion Dynamics

This project investigates, at an intermediate thrust level, the combustion stability theories which have been developed analytically or at a very small thrust level. The main areas of interest are combustion stability of LOX/RP-1 and LOX/H_2 systems at the 30K and 15K thrust levels respectively.

One test using the 30K thrust level engine was conducted during this reporting period. During this test the injector (nickle face) was damaged beyond repair. After approximately 1.7 second of operation an "O"-ring failure in the igniter inlet port allowed back flow of combustion gases, which burned through the injector body and the oxidizer inlet lines. Damage to the facility was minor.

P&VE Laboratory is presently fabricating another injector of similar design. Testing with this injector will begin around March 15, 1967

One test was conducted with the 15K LOX/GH_2 transpiration-cooled engine. The chamber pressure was 2000 psig, the O/F ratio 5:1 and the duration 1 second. Testing will continue at a chamber pressure level of 2200 psi with the ultimate goal being 3000 psi.

I. Pump Inducer Development Project

This project has been requested by P&VE in an effort to develop the hubless inducer for use on future turbopumps.

The high speed LH_2 inducer is being tested at T.P. 100. Test 186-36 was conducted during this reporting period. The data is being reduced and synchronized camera strobe light movies are being developed. The desired flowrate for the pump was not obtained due to high pump volute losses. Testing will continue.

J. Carbon Deposition Studies

This program is to determine what effect variables such as accumulated test time, heat exchanger surface temperature and water injection rates have upon the prediction of carbon film resistance on heat exchangers. A test apparatus is being used which provides the capability to measure the thickness of carbon deposited on a tubular heat transfer section in cross flow.

R-P&VE-PT requested that this program be put in a stand-by status until further notice.

K. LH_2 Seal Evaluation Tests

This program was initiated to test various static seals for special manhole covers on a liquid hydrogen test tank.

A memorandum report is being prepared to transmit the results of this program and to officially close it out. A meeting was held with representatives from P&VE to discuss a follow-up program, which will use the same test fixture used in this program. The proposed program will be considered a new project. The test tank is to be modified and scheduled to arrive in early April 1967. Testing will begin about one week later.

L. Acoustic Studies

Testing to study the effects of varied nozzle geometry

began on February 15, 1967. Four checkout tests were conducted with good results and four tests to take acoustic data were conducted -- two tests with the bell nozzle engine and two tests with the conical nozzle engine.

Testing will continue during exceptable weather periods with wind speeds less than three miles per hour.

No tests were conducted on the convectively-cooled deflector. One test was attempted but due to a regulator failure in the facility pressurizing system, the test was cancelled. The pressurizing system has been repaired and testing is planned for the week of March 6, 1967.

M. Solid Motor Particle Study

This test program is being conducted to obtain information concerning solid particle distribution, heat transfer distribution, and heat transfer characteristics of plumes from solid propellant rocket motors.

The test report is being retyped after the final revision and will be completed in early March 1967.

N. Flame Study

This project is to obtain free stream and disturbed stream calorimetric, temperature, and pressure data, from existing Test Laboratory model rocket engines, which will be useful in predicting full-scale rocket engine plume environments.

One test was conducted at T.P. 107 in an attempt to make total pressure measurements in the plume of the 4K LOX/RP-1 engine at five exit diameters with no expansion skirt on the engine. The pressure rake was damaged and no data was obtained.

Work is continuing on the preparation of the Internal Note for this program. Completion is anticipated April 1, 1967.

O. Improved Saturn V Launch Facilities (VLF-39) Model Study

This program, requested by KSC, is a specific study of existing facility capabilities (VLF-39) necessitated by the proposed use of improved Saturn V Boosters which will use five uprated F-1 engines and 4-each "strap-ons" 120-inch or 156-inch solid rocket motors. This study will be used to establish the extent of launch facility (VLF-39) capability and/or modifications required when using the improved Saturn V Booster Configuration.

The test program, utilizing 1/58 scale model facilities, has the following objectives:

1. Determine the environment of vehicle base and facility elements during holddown and initial liftoff.

2. Determine the environment of the mobile launcher and umbilical tower for maximum vehicle drift.

3. Determine the extent of facility modification necessary for compatibility with improved Saturn V vehicles.

The test program will be conducted in four phases. A 1:58 scale model of the Saturn V Booster will be utilized for all four phases of the test program.

The first phase will be conducted using the Basic Saturn V Booster scale model and will serve to establish baseline data. Phase II tests will use the same scale model booster but with the uprated F-1 engines. Phase III will utilize uprated Saturn V scale model with 120-inch simulated Solid Motor Strap-Ons. Phase IV will use the uprated Saturn V scale model with 156-inch simulated Solid Motor Strap-Ons.

Systems checkout tests of the 1:58 scale model cluster were successfully completed February 15 and presently the 1:58 scale model launch facility (VLF-39) is being installed and readied for a checkout test scheduled March 3. After facility checkout testing has been completed, Phase I testing, which will establish baseline data, will begin.

W. L. Grafton

GEORGE C. MARSHALL SPACE FLIGHT CENTER
TEST LABORATORY
MONTHLY PROGRESS REPORT
ADVANCED FACILITIES PLANNING OFFICE
February 1, 1967 through February 28, 1967

I. FACILITIES

A. R&A Projects

1. Design Criteria is underway on High Pressure Air Piping.

2. Design Criteria completed and awaiting start of design on GN_2 Connector Line.

3. Design is underway on the following Projects:

a. Project No. 7021 - GH_2 Transmission System - Phase II.

b. Project No. 7031 - Modifications to Provide Hydrogen Service at Test Stand 300 - Phase II.

c. Project No. 7058 - Steam Line Extension to LH_2 Test Facility.

d. Project No. 7056 - LOX Trailer Parking Area

e. Project No. 7023 - GN_2 Pipeline System

4. The following projects were advertised for bids:

a. Project No. 7068 - Cable Trays and Cable Installation, East Test Area.

b. Project No. 7013 - Elevator for Test Stand 500.

c. Project No. 7008 - Additional LOX Storage for All Test Positions, Building 4583.

d. Project No. 7009 - Firex System Addition - Test Stand 115.

5. Construction is underway on the following projects:

a. Project No. 66-35 - Elevator at Liquid Hydrogen Test Stand (S-IV B).

b. Project No. 7005 - Installation of Heaters, S-IC Test Stand.

c. Project No. 7018 - Transformer Substation - Test Stand 500.

d. Project No. 7021 - GH_2 Transmission System - Phase I

e. Project No. 7031 - Modifications to Provide Hydrogen Service at Test Stand 300 - Phase I.

B. NUCLEAR GROUND TEST MODULE

Preparations of criteria for the project is on schedule. Several drawings have been submitted for review. The criteria is about 80% complete.

J. B. Carrington