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TEST LABORATORY

MONTHLY

PROGRESS REPORT

April 1, 1967 through April 31, 1967

GEORGE C. MARSHALL SPACE FLIGHT CENTER

HUNTSVILLE, ALABAMA

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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TEST LABORATORY MONTHLY PROGRESS REPORT

April 1, 1967 through April 31, 1967

SYSTEMS TEST DIVISION

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ADVANCED FACILITIES PLANNING OFFICE

GEORGE C. MARSHALL SPACE FLIGHT CENTER
TEST LABORATORY
MONTHLY PROGRESS REPORT
SYSTEMS TEST DIVISION
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I. SATURN IB

A. S-IB Stage

Stage S-IB-10 arrived at Redstone Arsenal docks and was installed in the Static Test Tower East on April 10, 1967. A propellant load test was performed on April 28, 1967.

B. H-1 Engine

Test P1-495, using engine H-7057, was successfully performed on April 3, 1967, for a duration of 139 seconds. The engine was started with no hydraulic accumulator precharge and no hydraulic system pressure. All test objectives were met. This test, as well as test P1-494, utilized the new type spinners (P/N 650149A). Review of data showed that the spinners performed satisfactorily. The new type spinners will be used on stage S-IB-10 during acceptance testing.

C. S-IVB Stage

1. S-IVB-209 is presently in the Sacramento Vertical Checkout Laboratory waiting to be installed in the Beta I Test Stand after the acceptance firing of S-IVB-503 (new). The installation in the stand will now be on or about May 12, 1967.

2. The Beta III Test Stand rebuild 90% design review was held at the Sacramento Test Center on April 27, 1967. Douglas Aircraft Company was informed that Marshall Space Flight Center wanted all critical equipment on the test stand moved behind concrete for protection. Douglas Aircraft Company has scheduled a meeting with Marshall Space Flight Center, Test Laboratory personnel on May 10, 1967, to discuss the problems involved in such an operation.

II. SATURN V

A. S-IC Stage

1. The tests performed at Marshall Space Flight Center on the S-IC-S fuel tank were completed on April 28, 1967. The suction duct structural test was completed on April 27, 1967, and the tank hydrostatic test at ultimate pressure (44.1 p.s.i.g. at top of upper bulkhead) was conducted the following day. A small weld crack occurred in the apex of the aft bulkhead at the above stated pressure.

2. The S-IC-4 stage was installed in the Mississippi Test Facility Test Stand B-2 on April 5, 1967. The propellant load test is scheduled for May 3 and 4, 1967, and the acceptance firing for May 11, 1967.

B. F-1 Engine

Test FW-061 was conducted at the West Area F-1 Test Stand with F-1 engine S/N F-6049 for a mainstage duration of 31 seconds on April 20, 1967. Primary purpose of the test was to verify acceptable engine performance after re-orificing. The engine was removed from the test stand and returned to Quality and Reliability Assurance Laboratory.

C. S-II Stage

1. The first static firing of S-II-2 was made at Mississippi Test Facility on April 6, 1967. The test was terminated by the LH_2 console operator at 2% LH_2 level plus four seconds with a duration of 362 seconds. Some engines start measurements were not properly obtained at the Data Acquisition Facility due to the S-II-2 test conductor calling for a hold at T+2:21 and a subsequent slowdown of recorders for the anticipated hold period. The count was resumed at T+2:27 which did not allow the recorders to regain speed before ignition. The LOX fill and drain line bellows was found to be burst after the static firing. This is thought to have been the problem in draining the fill line before simulated lift-off that caused the hold at T+2:21. The line was replaced prior to the second static firing. The No. 4 engine (J-2040) indicated an oscillation in performance during the first static firing. It was finally decided not to change the engine for the second static firing.

2. During leak check testing in preparation for the second firing, the LH_2 re-circulation pumps No. 1, 2, 3, and 4 were inadvertently spun for approximately one minute each at 1.5 to 1.75 p.s.i.g. pressure. This incident necessitated the replacement of these pumps prior to the second static firing. The second static test of S-II-2 was made on April 15, 1967, for a duration of 368 seconds. Cutoff was by LOX depletion sensors. Post-test performance analysis of engines No. 3 and 4 indicated that some LOX pump cavitation occurred prior to cutoff of both tests. The oscillation in performance noted on engine No. 4 did not occur during the second test. Engine performance data on all engines were hard to compare with previous data, due to a shift in flow data. This may be due to having inadvertently spun the flow meters during sequence tests prior to the second test. The go-ahead for post-static checkout was given on April 18, 1967. The start of automatic checkout was delayed due to problems associated with the C7-400 station. AC power failure in the S-II complex on April 22 and 24, 1967, brought checkouts to a complete halt. The power was completely restored on April 27, 1967. The power failure caused about a week delay in S-II-2 checkouts.

3. Several meetings were held to coordinate the S-II-4 Structures Test program requirements. The scheduled completion date for the test assembly, including checkouts, is November 1, 1967.

D. S-IVB Stage

1. Preparations for the static firing of S-IVB-503 (new) progressed on schedule for the firing on April 26, 1967. Douglas Aircraft Company

began the countdown on April 25, 1967, for the planned firing, but on April 26, 1967, the test was canceled during LH_2 loading due to erratic indications on the LH_2 P.U. probe. Douglas Aircraft Company personnel entered the LH_2 tank on April 27, 1967, and discovered an electrical short in the probe; consequently, the probe was replaced. The next attempt to fire will be May 3, 1967.

2. Test No. S-IVB-042 with J-2 engine S/N J-2048 was successfully conducted at the Marshall Space Flight Center S-IVB Test Stand on April 21, 1967, for a duration of approximately 300 seconds. The main objective of this test was the simulation of S-IVB-503 (new) acceptance test configuration. Review of data showed all parameters to be normal.

3. During this report period, the following tests were conducted on the O_2/H_2 burner system at the S-IVB Test Stand:

a. Test S-IVB-H02 was conducted for a duration of 255.4 seconds on April 4, 1967. The LOX and LH_2 re-pressurization systems were utilized in an attempt to re-pressurize the Battleship tanks. The LH_2 tank pressurized normally; however, the LOX tank did not fully pressurize.

b. Test S-IVB-H03 was conducted for a duration of 300 seconds on April 14, 1967. The LOX tank ullage pressure was maintained at burner start requirements for approximately 9 minutes prior to burner start to allow ullage conditions to stabilize. Both propellant tanks pressurized normally.

c. Test S-IVB-042 (H04) was conducted in conjunction with J-2 engine test S-IVB-042 for a duration of 235.8 seconds on April 21, 1967. The tests were conducted to simulate the S-IVB-503 (new) acceptance test configuration and restart procedures. The LOX and LH_2 tanks were re-pressurized utilizing the burner re-pressurization systems. Prior to test S-IVB-042 (H04) modifications were made to the burner propellant lines to provide sufficient vibration support when subjected to J-2 engine firing.

A report is being prepared on the O_2/H_2 burner tests conducted thus far. Future tests are planned utilizing the newly modified flight type burner. Hardware is scheduled to be delivered by the first of June 1967.

III. APOLLO APPLICATIONS

A. Lunar Drill Program

1. R-TEST-SP continued to support R-RP Laboratory in their exploratory drilling at the Howell Crater at Howell, Tennessee. This drilling is being accomplished with the Longyear Equipment Company wireline drill system. This system is similar to the Westinghouse Drill Concept and has been very effective for training of personnel as well as illustrating the problems that can be encountered in core drilling.

2. Request for Quotation for the second phase effort of the Moderate Depth Lunar Drill has been delivered to the various contractors for review and proposal.

B. LSSM Project

1. The three Mobility Test Articles arrived at Test Laboratory on April 21, 1967. They are presently undergoing reassembly and checkout for a test program tentatively scheduled for June 1967, through October 1967. Propulsion and Vehicle Engineering Laboratory has submitted a preliminary test plan for the three Mobility Test Articles calling for 54 test runs, to investigate vehicle power requirements, and additional tests to obtain human factors information. A meeting was held on April 19, 1967, to coordinate the efforts of Test Laboratory, Propulsion and Vehicle Engineering Laboratory, Computation Laboratory, and Advanced Systems Office.

2. The final presentation for the lunar wheel and drive program performed by General Motors will be held on May 4, 1967.

3. During this period three meetings were held to refine the RFP for the LSSM contract and to compile its content in final draft.

4. An interim presentation on the MOLAB driving simulator tests conducted at Computation Laboratory was held on April 6, 1967. A final report will be forthcoming.

5. Additional effort was expended in the finalization of two study contracts, one to Bendix and one to Boeing, for further evaluation of special test and integration requirements. These contracts are currently scheduled for negotiation the early part of May 1967.

IV. SUPPORTING RESEARCH AND TECHNOLOGY

Preliminary sketches and schematics were prepared for the Hydrogen Embrittlement Test System at the Marshall Space Flight Center S-IVB and Power Plant Test Stands. The high pressure compressor (Aminco) that will be used to compress the GH_2 is being serviced by Vitro, R-TEST-BP.

V. VEHICLE STORAGE PROGRAM

Test Laboratory was assigned the lead laboratory responsibility for long term storage of Saturn stages and related hardware, effective April 14, 1967. A development plan is in preparation at this time. Immediate effort was directed to determine the status of current work in process by the stage contractors and the engine contractor. All contractors have studies or plans presently being developed under 1.0.cognizance. Continuing laboratory effort is directed at review of the various contractor efforts and existing facilities

and transport problems. Standardization of storage requirements will be a major near term objective in order to provide guidance to existing Stage or Engine Storage Study contracts.

Daniel H. Driscoll, Jr.

GEORGE C. MARSHALL SPACE FLIGHT CENTER
TEST LABORATORY
MONTHLY PROGRESS REPORT
COMPONENTS & SUBSYSTEMS DIVISION
April 1, 1967, through April 30, 1967

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.

Tests C-039-5 and -6 of the Fuel Additive Test Series were conducted during this reporting period. The first test was a "base line" run (no FR-3 mixed in the RP-1) to determine if the new turbine which was recently installed altered the operation characteristics of the turbopump. The second test was an additive run with an FR-3/RP-1 mixture ratio of 1/1000 by volume. The FR-3 friction reduction additive did not improve feed system performance. Fuel samples indicate that a homogeneous mixture was obtained utilizing the intermediate mixing system. An increased mixture ratio is presently being considered for the next test which is planned for the early part of May.

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.

An R&D 6 x 6 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 6 x 6 fuel and LOX impellers in comparison with the standard 6-blade impellers. Preparations for

testing this pump are now underway. Current modifications will bring the F-1 Turbopump Facility up to the F-1 Block VI configuration.

A 17-inch turbine-type S-IC LOX flowmeter of new Teflon bearing design and a Flexonics S-IC LOX outboard PVC have been installed in the LOX flow line at the F-1 Turbopump Facility. Testing of these items is scheduled to begin during the second week of May, 1967.

2. F-1 Heat Exchanger Development Tests

Requestor: R-P&VE-PT

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

One test was conducted during this report period. Cold helium was used in the heat exchanger and the lox flows were held to 4 lb./sec. The data from this test sufficiently verified previous testing done in Phase II of this test program. Therefore, as requested by R-P&VE-PT, this program will be terminated at this point and the test stand will be placed in a standby condition. A report to close out and document this program is in preparation. This project will not be reported any longer.

3. F-1 Gas Generator Development Tests

Requestor: R-P&VE-PAC

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.

Two tests of 30 seconds each were conducted during this report period. These tests on the P&VE-designed double-swirl cup injector, were conducted at LOX/Fuel ratios of .327 and .446 and fuel flows of 100 and 90 lbs/sec, respectively. Both tests were successful and the data was transmitted to the requestor for evaluation and analysis.

After a test program review with R-P&VE-PAC, it was decided that one more test at an O/F of .35 with a fuel flow of 100 lb/sec would be sufficient to complete the data requirements and to terminate the test program after successful completion of that test. At that time the test stand

will be put in a standby condition. The remaining test will be completed in May 1967.

4. F-1 Turbopump Seal Test

Requestor: R-P&VE-PA

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

Due to the unsatisfactory performance of the test fixture, P&VE has evaluated the program justification and terminated the program. The test fixture shaft seal (secondary seal) has historically experienced excessive random leakage. Thus far no satisfactory solution to this problem has been developed. With this excessive leakage it is impossible to maintain a reasonably stable seal chamber pressure, and therefore, impossible to obtain meaningful data on the test seal and mating ring assembly leakage. The work done will be documented in a report in preparation now. This is the last monthly progress report including this project.

5. LOX Stratification

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

Testing was completed the week of April 7, 1967, as scheduled. Test data evaluation indicated data correlation was successful. The report is now in progress.

6. LOX Depletion Testing

The purpose of this test program is to support R-TEST-SP in a study of the LOX depletion characteristics of the F-1 Engine shutdown sequence. The ultimate goal of the test program is to predict LOX depletion characteristics of the S-IC stage engine system.

The facility buildup is in progress. The test start date has slipped to June 19, 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.

The Dual Seal 70" tank report was completed April 6, 1967, and the LH_2 Thermodynamic Ullage Memorandum Report is being prepared.

B-Cell Position 1 - Foam Insulation (70" Tank):

This test program was requested by P&VE Laboratory to evaluate the structural integrity and thermal performance of an S&ID, CPR-369-3 foam insulation system.

One fill and drain test (C-018-70F-1) was performed on April 6, 1967. Preliminary analysis indicated that the results were satisfactory. Five tests remain to be conducted and will resume the first week in May.

C. S-IVB Stage

1. J-2X Turbopump Test

Requestor: R-P&VE-PAC

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

The shop has completed 95 per cent of the structural work including new structure and modifications to the existing structure. Piping crews are working on the gas generator exhaust piping, LOX and LH_2 stage tank pressurizing piping, vent piping and fire-x system. The above piping is approximately

60 per cent complete. The GH_2 recharger has been activated and up to 3500 psi hydrogen gas has been put in the storage bottles. The 100,000 gallon LH_2 storage tank was inspected and found to be very dirty. Plans are being made to have it cleaned during the month of May and to start assembly and checkout of the complete LH_2 storage tank system. Present schedules call for completion of the remaining shop work on T.S. #501 by July 1, 1967. Systems cleaning and checkout tests will follow without delay.

2. J-2X Thrust Chamber Throttling Tests

Requestor: R-P&VE-PA

This program was established to evaluate the throttling characteristics of J-2 thrust chambers. Engine thrust excursions of 5K to 200K (Sea Level) are contemplated. This will be accomplished in a 2-phase program.

Phase I 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 will utilize a J-2 thrust chamber with tapoff capability. The thrust chamber will be evaluated at steady state conditions, four to six mixture ratios, and between 5K and 200K SL thrust levels (no dynamic throttling).

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.

Buildup is complete, the facility checkout is complete, four dry runs have been conducted (two using LN2 in both LOX and LH_2 systems) and one ignition test has been conducted. The ignition test duration was five seconds at a chamber pressure of 40 psi. All test objectives have been met. After one more ignition test, planned for May 2, 1967, mainstage tests as planned under Phase I, initial J-2X testing, will begin.

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.

Three tests were conducted during April on the S-IVB fuel prevalve. These tests were performed to determine the effects of flow and closing time upon the valve. The valve potentiometer malfunctioned on the second test and no usable data was obtained. The last test was successful, providing data at 55%, 75%, 108%, and 112% of rated engine flow. One additional test will be required and will be conducted the first week of May.

4. 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.

Three S-IVB configuration engines (S/Nos. 812, 813, and 814) were installed in the Phase IV Saturn V/S-IVB APS module, and a series of tests were conducted to evaluate module system dynamics and performance utilizing these engines. In Test C-008-C1-512 engines 1 and 2 were fired simultaneously through 100 pulses of 63 ms on - 137 ms off, and the pulse train was repeated with engine 2 lagging engine 1 by 20, 40, and 60 ms. The same four cycles were then repeated using engines 3 and 2, with 2 lagging 3 in the above manner. Test C-008-C1-513 consisted of a series of pulsing cycles (100 pulses total) on engines 2 and 3 with engine 4 (70 lb. thrust ullage engine) firing steady state during the pulsing cycles. A simulated pressure altitude of 140,000 feet was maintained during the subject tests. A preliminary review of test data indicated normal APS system operation. Engine performance data is being reduced by Computation Laboratory

D. Ground Support Equipment

1. LC-39 Service Arms

a. 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.

The normal test program was restarted after the conclusion of the special series of tests on the deceleration valve and cam C. System tests dry were successfully completed during this reporting period.

A special series of tests are being run for P&VE using a chilled (-68°F) skin panel and cryogenic flow to determine if the carrier would reconnect under rain conditions. Reconnect could not be accomplished due to icing of the skin panel. Also special tests, under aiding and retarding wind conditions, are now being conducted for KSC to determine the effect of removing the GN_2 accumulators from the secondary retraction system. Testing will continue during next report period.

b. 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.

During this reporting period thirty-three (33) instrumented tests were conducted. These tests included three (3) arm retraction timing tests with the modified deceleration valve and modified cam (Cam C); six (6) arm retractions with assisting and retarding winds; six (6) system tests with random motion; three (3) lanyard withdrawals; and fifteen (15) umbilical kickoffs and withdrawals. Preparation for systems test has begun. (50 reliability runs).

c. S-II Intermediate (Set II) - This inflight service arm provides air conditioning, electrical, pneumatic, LH_2, and lox services to the S-II stage. The lox and LH_2 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 AA-04-02 arm was modified at MSFC by installing a lanyard withdrawal system for the main umbilical to replace the dual cylinder withdrawal system used on AA-04-01 and AA-04-03. R&D tests on the lanyard withdrawal system are now underway. At the conclusion of the R&D testing on the lanyard system, it is planned to retrofit the lanyard system on AA-04-01 and AA-04-03.

Initial umbilical withdrawal tests have resulted in damage to the withdrawal cables. Modifications are being performed to eliminate cable interferences; however, if these modifications are not satisfactory, a redesign of the withdrawal mechanism may be required. R&D testing on the lanyard withdrawal system will continue during next report period.

Arm retraction tests have been conducted using the modified deceleration valve and the revised cam (cam C). These tests were successfully conducted on the secondary, primary, and cable retract systems. Each of these systems were tested with aiding, retarding, and no wind conditions.

d. S-II Forward (Set I) - 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 reworked withdrawal mount (75M06095) and boom weldment (J75M19872-5) were reinstalled on the arm after incorporating E03 of SK75M24521 to correct a discrepancy in pivot point location on the hydraulic cylinder (ref. last month report).

The hinge cylinders, 75M08260-1 and 75M08261-2 were removed, reworked, and reinstalled to the requirements of E03.

A check of the "A" dimension required to adjust the static lanyard showed:

(1) The Static lanyard was designed and built too long.

(2) The static lanyard when installed hangs over the 45° flange on the LH vent disconnect. UCR 60675 documents this problem.

The deceleration valve cam was adjusted and rotation tests were successfully completed.

Twelve umbilical disconnect and withdrawal tests using the primary lanyard system have been performed. R&D testing on the lanyard withdrawal system will continue during the next report period.

e. S-IVB Aft (AA-06-01) - This inflight service arm provides LO_2 and LH_2 fill and drain services to the S-IVB stage. AA-06-01 was returned to MSFC after being used at KSC 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 tested on AA-06--2 and AA-06-03.

Testing was stopped from April 1 until April 11, 1967, in order to relocate the hydraulic cylinder trunnion mount.

During the downtime, the withdrawal boom was removed and instrumented with strain gauges on the boom and on the trunnion mount. The purpose of this instrumentation was to provide data to check the actual stresses and loads during umbilical withdrawal against those used in design of the system.

Continued testing of the lanyard system showed that, from some vehicle positions, (particularly those farthest away from the arm) the loads in the primary lanyard during withdrawal exceeded the recommended load. Numerous attempts to correct this problem have been made, and based on the results of testing to date, a satisfactory solution has been found, and is being incorporated. Briefly, the solution is as follows:

In order to reduce the bending of the LO_2 and LH_2 propellant lines in the fully withdrawn position, an additional 6 inches of slack was pulled in the primary lanyard. This lowered the final position of the umbilical carrier, allowed the propellant lines to remain straighter, and thus reduced the load in the primary lanyard. However, it created another problem; the additional slack allowed the top of the umbilical carrier to bounce into the lanyard when the lines tray reached the fully withdrawn position. To correct this situation, the lines tray and trolley shock absorbers were relocated so that the lines tray movement was reduced by approximately 8 inches. The propellant lines therefore held the carrier away from the lanyard at full withdrawal. This succeeded in reducing the lanyard loads significantly, and consistent results within prescribed limits have been obtained. A modification to permanently incorporate the solution into the system is forthcoming.

To date, approximately 100 disconnect and withdrawal tests have been made on the system, including 80 full-systems tests, using a prototype cam and the secondary system for arm retraction. A new cam has been received, and the arm rotation series of tests is scheduled to begin on May 1, 1967.

f. 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.

192 tests have been conducted on this service arm. Umbilical disconnect and withdrawal tests and "T" head tracking tests were completed during this report period. Arm rotation tests (Primary system) were successfully completed. System tests will continue during next report period.

g. 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 normal test program was resumed on March 30, 1967, after a special series of tests were conducted for KSC on the modified deceleration valve and cam C. System tests are underway and the 50 reliability test runs will begin during May. Testing should be completed by June 5, 1967.

h. 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.

Arm rotation tests to verify the operation of the new deceleration valves were completed on April 26, 1967. The valves were found to be satisfactory after adjustments were made.

Extensive redesign of the entire command module access arm system is in work at KSC. It is anticipated that the arm now in the test area will be reworked to the new configuration and tested. The period of testing is not known at the present time.

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 program is being conducted for P&VE Lab to qualify the system prior to its use on LC-39.

The static cable support brackets were received from ME Lab on April 2 and the ML-2 damper arm structure was installed in the test stand on April 3. Alignments and adjustments were completed on April 4, 1967, and the static load test was performed on April 5, 1967.

The control console was returned from ME Lab on April 7, and the winch control console and kickoff panel were delivered to Test Lab on April 13. Subsequent to all hardware delivery, checkout and calibration and the systems test was conducted. All tests were completed by April 17.

A redundant hoist system, consisting of two vertically mounted hydraulic cylinders and associated mounting structure, plumbing, and controls, has been designed and is presently in work at ME Lab. The hardware was due to be delivered to Test Lab on April 19 but has not been received as yet. The latest anticipated delivery date is May 1.

After receipt of the redundant hoist system, the hardware will be installed on the test stand and the entire DRRS will again be tested. The anticipated completion date for test is June 5 based on hardware delivery from ME Lab of May 1.

3. Auxiliary Damping, Retract, and Reconnect System (ADDR

The ADRRS 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.

All testing was successfully completed during the last report period and the hardware was returned to ME Lab. This item will no longer appear in the progress report.

4. LC-39 Tail Service Masts (Set I)

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.

Testing was interrupted from March 24, 1967, to April 24, 1967, to fabricate and install modifications to relieve interferences encountered during the right and left lateral vehicle offset retraction tests. Testing was resumed on April 25, 1967.

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. Twelve holddown arms have been tested and shipped to KSC. Structural testing of the final set of arms (fourth set) 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 systems and blast shield.

Concept evaluation of a secondary (explosive) release system (to be used as a back-up release to the normal, pneumatic release system) was successfully conducted between April 3 and April 14, 1967. A test report is being prepared.

During testing of the secondary release system, cracks were discovered in the base castings (in the general area of upper arm pivot point) of arms 002, 004, and 006. Currently, the magnitude of the cracks is being investigated using dye-penetrant and ultra-sonics techniques. A firm disposition of the base-casting crack problem is not defined at this time; however, KSC Design has been made aware of the problem and a plan of action is expected from them in the near future.

Present plans for further testing of the holddown arms include installation (on arm 003) and testing of a hood for vehicle engine exhaust blast protection. According to KSC, all parts required for the hood installation should be available by May 8, 1967.

6. Saturn V Lift-Off Switches

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

No tests were conducted during this report period due to higher priority projects.

7. Q-Ball Cover Removal System

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

No tests were conducted during this report period. It is planned to conduct further tests in conjunction with the Primary Damper System during the next report period to verify that a KSC modification will eliminate an interference problem between the damper arm and the Q-ball cover pneumatic line.

8. High Pressure Test Facility

Anderson Greenwood and Company Relief Valves - The purpose of this testing is to evaluate the operating characteristics of two pneumatic pressure relief valves for the Mississippi Test Facility (I-MT-EF)

(1) P/N 3518G23-S - Testing was completed April 7, 1967, on this valve which had pulsating flow characteristics. MTF will send MSFC an identical valve, except for enlarged ports, for evaluation. Testing will be conducted on this valve and a report will be written to cover the original and modified valves.

(2) P/N 81C68-4 - Testing is 95% complete on this valve. No problems have been encountered to date. Tests should be complete by May 8, 1967.

9. S-IVB Aft Withdrawal Cylinder Life Cycle Test

The purpose of this test program, for KSC, is to determine the ability of one withdrawal mechanism to "track" vehicle motion for 1,100,000 cycles. Testing began November 22, 1966, and should be completed by May 29, 1967. The completion date has changed because nine (9) additional cylinders were functionally tested.

Cycling of the pneumatic withdrawal cylinder continued during this report period. The cylinder, to the latest design configuration, has successfully completed 608,000 cycles. Testing will continue during the next report period.

10. Flush and Purge Truck

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

Testing was initiated December 16, 1966, and the tests have been completed according to the original test procedure. P&VE has requested additional testing. R-TEST-CF is presently reveiwing these additional test requirements.

III. SUPPORTING RESEARCH AND TECHNOLOGY

A. 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.

Seventeen tests were conducted during this reporting period. Five tests were conducted to evaluate the performance of the Bendix and Acoustic Liquid vapor sensors at 5×10^{-4} g. The remaining tests were performed to provide additional information on slosh wave amplification due to residual sloshing at orbit injection.

B. S-IC Model Drop

This test program was requested by R-AS to evaluate the S-IC booster on scale models impacting on water.

Tests C-035-3 through 23 were successfully conducted during this report period. Data on tests C-035-3 through C-035-9 were distributed to R-AS on April 25, 1967. Testing will continue into the next report period.

C. Liquid Hydrogen Super Insulation

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.

Test tank No. 3 has completed 2 tests at CTL simulating ground hold thermal performance as well as evaluating tank and insulation quality. It was concluded that the tank was leak free, however, the insulation bag has numerous leaks necessitating the return of the tank to M.E. for insulation repair.

30-Inch Calorimeter: This program is being delayed due to higher priority work (Orbital Workshop).

D. Storable Propellant Space Engine Testing

This program was requested by R-P&VE-P to provide support for testing (1) engines to be used on Project Thermo, and (2) advanced technology engines.

The 20-pound thrust beryllium engine was fired steady state for 1.64 hours at a simulated pressure altitude of 120,000 feet on April 18, 1967, with no degradation in performance. This engine is being tested to destruction to determine its life cycle.

Two Kidde 40-pound thrust monopropellant engines are scheduled for delivery in mid-May.

E. Jet Impingement on Water (½K Cluster Phase)

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.

Tests C-002-18C and 19C were successfully conducted during this report period. The ½K cluster tests are proceeding on schedule. The estimated test completion date is October 1, 1967.

The single engine report is in progress.

F. Combustion Dynamics

Requestor: R-P&VE-PA

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.

No tests of the 30K LOX/RP-1 engine were conducted during this reporting period. Fabrication of the new injector was completed and this injector has been flow-calibrated. Approximately 12 tests will be required to map the injector's performance. Testing will be continued in early May.

P&VE has requested that testing of high chamber pressure levels with the 15K engine be temporarily suspended in order that a few research tests with liquid hydrogen at low chamber pressure levels can be conducted. Modification to the test position to support the tests has been completed and the first test is to be scheduled the first week of May. All of the fuel (LH_2) will be injected through the transpiration-cooled wafers and the LOX will be injected through a slightly modified injector. The purpose of the tests is to measure the temperature at the combustion chamber wall, near the injector, so that the phase of the combustion products might be determined.

G. Pump Inducer Development Project

Requestor: R-P&VE-PAC

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

Difficulties have been experienced in previous tests because the pump inducer (LH_2 high speed) is not compatible with the volute and the design flowrate cannot be reached. P&VE-PAC has reviewed their requirements and requested that a cavitation test be run.

The cavitation test was conducted on April 26, 1967, with the LH_2 High Speed Inducer. The test was conducted at 6500 rpm and synchronized movies with strobe light were taken. The results of this test and the film are to be reviewed before further testing.

H. LH_2 Seal Evaluation Tests

Requestor: R-P&VE-PM

The purpose of this test is to evaluate the sealing capability of the Conoseal and Naflex seal installed in an 18-inch diameter manhole cover of a liquid hydrogen tank. The tests will be performed with LH_2 at pressure levels of 5 to 50 psig. Leakage from each seal will be measured and recorded at each pressure level.

Test results have proven the Conoseal to perform satisfactorily. The Naflex seal, however, did not meet the requirements; it exceeded the desired leakage rates. The Naflex seal's secondary seal is very poor and elimination of the leakage there is mandatory if the leakage rates of the primary seal are to be accurately determined. It was therefore decided to obtain new Naflex seals with improved Teflon coating and also modify the test fixture to provide the possibility of measuring primary and secondary seal leakage rates. This will be accomplished in a followup program.

The test tank has been shipped to the Manufacturing Engineering Laboratory to accomplish the modifications required for the evaluation of the 18-inch Naflex seal. Due to higher priority work a delivery schedule of the modified tank is not available yet. Testing will follow delivery and buildup.

I. Acoustic Studies

Requestor: R-P&VE-SVR and R-AERO-AU

Acoustic Studies currently being performed at AMTF are to investigate, analyze, and evaluate the noise generating mechanisms and the resultant acoustic fields of aerodynamic

flows, i.e., rocket exhaust flows. These flow fields are generated by launch vehicle propulsion systems which are large in size and power; consequently, very severe acoustic environments are created. Techniques for estimateing these adverse environments in many instances are very crude or non-existent. Therefore, it is necessary that prediction techniques be developed and verified that will adequately define the associated acoustic environment.

These test programs cannot be conducted using full-scale flow fields, but by careful consideration of dynamic similarity principles and valid scaling procedures, scale model test programs of these flow fields can be successfully performed, to accomplish the above stated objectives.

Specific programs now planned at the AMTF are:

(1) Comparison of acoustic environmental characteristics of a cone and bell-shaped engine nozzle with duplicate exit diameters.

(2) Acoustic environmental variations due to nozzle exit pressure variations for a single engine.

(3) Ground plane acoustic environment (amplitude) for static and flight operation of a 1/20th scale Saturn V vehicle configuration.

(4) Vehicle acoustic environment (phase and amplitude) for the launch condition of a 1/20th scale Saturn V Vehicle configuration.

(5) Acoustic source location study of a single, undeflected, rocket exhaust flow.

(6) Saturn V, MLV acoustic environmental definition for strap-on configurations.

(7) Supplementary study of cluster effects as a function of engine separation distance and cluster diameter.

(8) Study of the three dimensional acoustic field developed by a rocket exhaust flow impingement on a deflector (uni- and bi-directional flow).

Testing to compare the acoustic environmental characteristics of a cone-and bell-shaped engine nozzle was completed during this reporting period. All the acoustic data that has been reduced to date has been given to the program requestor. The report of these tests is approximately 75 per cent complete.

Testing to determine the effects of varied engine exit pressures began during early April; however, due to unacceptable meteorological conditions, no tests for acoustic data have been conducted. One test to verify engine performance and exit pressure calculations was conducted.

Testing will continue when weather conditions permit.

J. Flame Study

Requestor: R-TEST-C

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. This test series is to generate additional data to supplement data obtained from earlier tests to completely plot engine plume environments.

The requested additional total pressure and temperature measurements of the engine plume are being made. Three tests were conducted at a plane 60 engine exit diameters from the engine, and one test conducted at 50 engine exit diameters. Testing is continuing and a data processing program is being written.

Progress on the Internal Note continues and the planned completion date is May 19, 1967.

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

Requestor: KSC

This program 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:

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

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

c. 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.

Seven tests of Phase I testing on the lower portion of the tower (120 feet) were conducted during this report period. Data were recorded for the basic Saturn V during vertical liftoff (two tests), Case #4 No Yaw (one test), Case #5 Center Engine Cant (three tests), and Case #5 Yaw (one test).

Presently, one more test, maximum vehicle drift short of tower interference, is being scheduled before relocating the engine cluster and start baseline testing on the upper part of the umbilical tower.

Initial delivery of 12 scale model 120-inch solid strap-on motors is scheduled for late June 1967. Testing with 120-inch scale model strap-on motors will begin immediately after delivery.

IV. APOLLO APPLICATION

A. S-IVB Workshop

1. Quick Release Manhole Cover, S-IVB Orbital Workshop

Requestor: R-P&VE-VSA

The purpose of this test is to evaluate and qualify a Quick-Release Manhole Cover for the Forward Fuel Bulkhead on the AS-209 S-IVB Stage for the SAA-209 Orbital Workshop Mission. The manhole cover is mounted to the Forward Fuel Bulkhead. The manhole cover is attached to the adapter ring by 24 sliding wedges. The wedges are drawn into place by means of 12 turnbuckles. After final adjustment the turnbuckle is secured by a locknut tightened against the turnbuckle. The cover is removed by the astronaut while in orbit.

The test will functionally evaluate the wedge-cam retaining device; establish installation procedure and torqu requirements for the manhole cover; evaluate the structural integrity of the manhole cover, while being subjected to the required environments; qualify the manhole cover seal with respect to minimum leakage rates; and qualify the seal used to prevent hydrogen leakage through the adapter ring bolt ho

The test fixture was cold-shocked and leak-checked before installation of foam insulation by the Manufacturing Engineering Laboratory. The manhole cover has been installed and the test fixture will be delivered to R-TEST-CV in early May. Testing will then begin during the May 15 week.

2. Environmental Control System

This program, requested by R-P&VE-P, is required to support the thermal design of the S-IVB Orbital Workshop environmental control system. Tests are scheduled for a condensation model and a 1/8 segment of the workshop compartment liner. The condensation model tests will be used to confirm the analytical model being used to investigate condensation effects. Results from the 1/8 segment will provide data on heat transfer coefficients, fan performance, wall temperature, condensation rates, and curtain temperatures.

Buildup of the condensation model is basically complete and checkout tests have commenced.

W. L. Grafton

GEORGE C. MARSHALL SPACE FLIGHT CENTER
TEST LABORATORY
MONTHLY PROGRESS REPORT
TECHNICAL SUPPORT DIVISION
April 1, 1967 through April 30, 1967

I. SATURN IB

A. Transportation of Stages

Fabrication of the second Saturn IB Nose Cone Transporter has progressed almost to completion. Completion is expected by May 5, 1967.

II. SATURN V

A. S-IVB Testing

1. Performed an evaluation for Industrial operations of the Douglas Company's proposed blast protection and relocation of GSE on the S-IVB-Beta III Test Stand in Sacramento.

2. Provided technical follow-up on the installation of blast protection as proposed by Test Laboratory on the S-IVB-Beta I Test Stand in Sacramento.

B. Component Testing - S-II Structural

Design continued on the build-up for the S-II Structural Test Specimen. Design reached about 30 percent completion, with completion date tentatively set as July 1, 1967.

C. GSE Testing

1. Participated in the technical consultations covering the cracks discovered in the S-IC Launch Hold Down Arms.

2. Continued participation in the technical consultations concerning testing of the Launch Escape System on the Random Motion Simulator of the Command Module.

D. Acoustics Study

Design was completed on model engine cluster mounting plates for various configurations to be used on Acoustic Test Facility Position 116.

E. Transportation of Stages

1. The S-IC-D Steel Forward Handling Ring was completed, tested, and used to remove the S-IC-D from the Saturn V Dynamic Test Stand. It remained attached to the stage which was shipped to Michoud for storage.

2. The S-IC-F Steel Forward Handling Ring was procured from the Blue Springs Machine Company by contract termination due to faulty workmanship. The ring was removed to MSFC where reclamation will be attempted as current work schedule permits. Total contract price for the S-IC-D and S-IC-F Handling Rings was $62,000; settlement price for both rings was $37,000.

3. Procurement action was taken to acquire, by June 1, 1967, a Steel Forward Handling Ring for the S-IC-T stage and at a later date an additional two S-IC Flight Stage Steel Handling Rings. Contract prices were $41,000 for the S-IC-T Ring and $38,000 each on subsequent rings from Progressive Welders, Inc.

4. The S-IB Transporter and the S-IC Thrust Structure Cradle have been shipped to NAA for their use in handling the S-II Structural Test Specimens.

5. Work is continuing on purchase approvals and resolution of field problems for the Barge "Orion" modification in Savannah, Georgia by the Diamond Manufacturing Company. All dry dock work and bottom repairs are complete. The design for the Nitrogen Pressurization System for the Barge "Orion" was completed and will be released for fabrication the first week of May.

6. Work is continuing on the revisions to the S-IC Transporter drawings and manual.

7. Design and documentation have been completed on the modifications to the A-Frame Handling Boom for the Barge "Poseidon".

8. The third set of S-IC Storage Stands was shipped to Michoud for use by the Boeing Company.

9. The Cargo Lift Trailers were completed.

10. Tie down arrangement drawings were completed for transporting the S-II, a pressure vessel, and several Titan Missiles on the Barge "Point Barrow".

11. Design and documentation continue on such projects as: (a) "As built" drawings of the MTF Shuttle Barges (b) S-IC Fin, Fairing, and Engine Extension Trailers (c) Marine tie down for empty S-IC Transporters (d) Modifications to Instrumentation Unit protective covers.

F. MTF Support

1. Study and evaluation of the removal of the Engine Fragmentation Shields for the A-1 and A-2 S-II Test Positions were completed.

2. Evaluation and recommendations for the redesign of high pressure and cryogenic systems at MTF continues.

III. SUPPORTING RESEARCH AND TECHNOLOGY

A. Design was completed on the Safety Support Hardware for the 1/10 scale model S-IC Booster used in drop tests.

B. Design was started on the 1/10 model S-IC Stage and Facility for rotational drop tests of the S-IC Stage Recovery Program.

C. Design was completed on the existing Monorail System at Building 4732.

D. Design was completed on the lubrication system and the chain drive idler adjustment modification for the 5,000,000 pound load cell tester at the Instrumentation Laboratory.

E. Design was completed on a camera viewing port modification for the 40 percent scale model S-IC LOX Slosh Tank.

F. Finished preliminary design on the LH_2 Mass Flow Calibration System.

G. Design continued on mounting the 6' X 9' vacuum chamber in the S-IB Dynamic Test Stand.

H. Design criteria preparation for the 38' diameter X 65' long vacuum chamber to be located near the S-IB Dynamic Test Position continued.

I. Continued investigation and evaluation and overseeing of Test Laboratory effort in the studying of Hydrogen Embrittlement of metals.

J. Proposed a protective blast shield study program in conjunction with current Pyro project being conducted at Edwards Air Force Base.

IV. OTHER PROGRAMS

A. S-IVB Orbital Workshop

Design of a condensation model to be used to support the design of the S-IVB Orbital Workshop Environmental Control System progressed to 90 percent completion.

B. Apollo Telescope Mount

A work order for a design estimate on the Apollo Telescope Mount Rack and Transporter has been issued along with preliminary requirements to the Support Contractor (BECO).

C. Lunar Drill

Work continued in the redesign improvement of components found inadequate on the prime contractor's prototype drills. This is a continuing project for as long as drill evaluation is carried out.

D. Voyager

Studies began on the transporter requirements of the Voyager Modules.

E. Nuclear Ground Test Module

Budget request for route surveys to determine best transporter route for the Nuclear Ground Test Module.

F. Other Programs

1. J-2X-J-2T Program

Redesign of components Test Position 502 high pressure gas and cryogenic systems to accommodate the J-2X-J-2T program continued to about 20 percent completion. Design started on an emergency escape system from this position.

2. Project Pyro - Edwards Air Force Base

Design was completed on a deceleration device for thin walled propellant tanks in support of the joint NASA Air Force propellant catastrophic studies.

3. 38' X 65' Vacuum Chamber

Design criteria preparation continued on the 38' X 65' vacuum chamber to be located near the Saturn IB Dynamic Test Position. Design criteria progressed to about 15 percent completion.

William E Marsalis

William E. Marsalis

GEORGE C. MARSHALL SPACE FLIGHT CENTER
TEST LABORATORY
MONTHLY PROGRESS REPORT
ADVANCED FACILITIES PLANNING OFFICE
APRIL 1, 1967 through APRIL 30,1967

I. FACILITIES

A. R&A Projects

1. A project request is being prepared for modifications to building 4684.

2. Completion of design criteria has been accomplished and the following projects are awaiting start of design:

   a. Helium Line Extension to Building 4650

   b. High Pressure Air Pipeline

   c. Project 8008 - Installation of Steam Ejector System (Bldg. 4557)

3. Design is underway on Project No. 7072 - Additions to Cryogenic Stora

4. Completion of design has been accomplished on Project No. 6742 GN_2 Connector Line.

5. Projects Advertised for Bids Include:

   a. Project No. 7056 - LOX Trailer Parking Area

   b. Project No. 6255 - Pavement Addition, Building 4653

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

   d. Fire Detection System

   e. Improvements in the Vicinity of Building 4650

   f. Project No. 7021 - GH_2 Transmission System, Phase II

   g. Project No. 7023 - GH_2 Pipeline System, CTL Area

   h. Project No. 7031 - Modifications to Provide LH_2 Servic at Test Stand 300 - Phase II.

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