PROPULSION AND VEHICLE
ENGINEERING LABORATORY

MONTHLY PROGRESS REPORT

For Period

August 1, 1967 Through August 31, 1967

FOR INTERNAL USE ONLY

GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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PROPULSION AND VEHICLE ENGINEERING LABORATORY

MPR-P&VE-67-8

MONTHLY PROGRESS REPORT

(August 1, 1967 Through August 31, 1967)

By

Structures Division
Advanced Studies Office
Materials Division
Propulsion Division
Vehicle Systems Division

GEORGE C. MARSHALL SPACE FLIGHT CENTER

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MONTHLY PROGRESS REPORT

STRUCTURES DIVISION

(August 1, 1967 - August 31, 1967)

SATURN IB

I. Saturn IB System

A. AS-204

Lateral dynamic loads analyses are being updated for the AS-204 vehicle using the new booster stiffness data obtained from the shake tests and pull tests.

An analysis was performed on the data acquired from the pull test conducted on Saturn IB, AS-204/LM-1. The results are as follows:

1. Higher stiffness (EI) of S-IB stage confirmed for cantilever mode.

2. Fuel tank pins do slide indicating no bending moment transferred through these tanks.

3. The equipment and instrumentation used for this test were adequate for obtaining data applicable to ground wind analysis.

B. AS-206

A lateral vibration analysis of the Saturn IB, AS-206 restart vehicle during first stage flight was completed.

A lateral vibration analysis of the Saturn IB, AS-206 restart vehicle during S-IVB stage burning was completed.

I. S-IC Stage

A. Slow-Release Mechanisms

Stiffness testing of the slow-release mechanisms on AS-502 vehicle was performed at KSC August 22-24, 1967. The testing indicated that the slow-release system was approximately four times softer than previously determined by bench testing. However, this new spring constant is still not soft enough to allow preloading prior to loading lox in all three stages and RP-1 in the S-IC stage. Preliminary evaluation of the data indicates that RP-1 must be loaded prior to preloading the mechanisms. This will allow the mechanisms to maintain approximately 40 kips of preload at lift-off, since the preload relief due to lox loading will not exceed the preload regained by ignition and buildup of the engines just prior to holddown arm release.

The testing conclusively showed that the required 40 kip preload cannot be accomplished by merely torquing each mechanism to some designated torque value. There was too much scatter in the torque loadings throughout the testing and when one mechanism was torqued it sometimes changed the preload in the adjacent mechanism by 50%. The 40 kips could only be guaranteed in all mechanisms by continuously monitoring strain gages on each rod and iterating back and forth from one mechanism to another until they all leveled out at approximately 40 kips. Strain gages must be installed on AS-501 and subsequent vehicle slow-release mechanisms to insure the 40 kip preload. At the present time, KSC is not convinced of this strain gage requirement.

The testing also showed that present torquing procedures are inadequate for AS-501 vehicle because of interference of the 5 to 6 foot torque wrench with the airscoop, shroud, engine, and service arms. The scoops and shrouds were not installed on AS-502 during the test. It is reemphasized that KSC must be convinced of the requirement for strain gages on the rods and of the need for a special torquing tool to accomplish the installation.

B. Engine Fairings

The aluminum and titanium engine fairings have been evaluated and found to be structurally adequate for the recent increase in temperatures resulting from the latest up-to-date maximum heating trajectory for AS-501.

C. Helium Bottle Lock Nuts

The torque on the helium bottle lock nuts which were installed on the S-IC-T with the revised lock washers was checked after the recent S-IC-T

static firing. The torque on the nuts had not diminished, and it appears that the revised washers will prevent any further problem with loss of torque. The controlled release mechanism was revised to provide for misalignment of the vehicle die and the holddown bracket. Installation of the controlled release device on vehicle number AS-501 revealed that misalignment could occur and may adversely affect the function of the controlled release mechanism.

II. S-II Stage

A. 403 Structure Test (V7-23, C Structure)

The following items were completed during this report period:

1. Thrust structure was mated to the cryogenic load ring, using epocast to negate irregularities at the interface.

2. Interstage was mated to S-II aft skirt. This interface was shimmed during the bolting procedure to provide a flight type interface.

3. The entire "stack-up" was centered and plumbed under the crosshead and epocast was poured between the interstage and test floor to provide a uniform load distribution at that interface.

4. The Electronic Deflection Indicator Support Towers were moved into position and bolted to the test floor.

The above completed the test setup to the extent that The Boeing Company could begin full scale instrumentation of the specimen with a very minimum of interference as other mechanical test setup work progresses.

B. High Force Thrust Structure Test (404)

1. The repair on the damaged center engine crossbeam web was completed August 17, 1967. Quality inspection indicates first-rate repair.

2. Request for Tulsa personnel to replace thrust block bolts has been officially signed.

3. The preliminary test plan was received August 18, 1967. It is now being reviewed.

4. The fabrication and erection of Phase I test fixtures continued. Adapters that connect load cells to hydraulic cylinders are becoming a critical item and were delayed because of material availability. The test plan draft was corrected and revised.

The test setup was continued and is approximately 90 percent complete. Bolts in the thrust blocks must be replaced with the proper bolts before the remaining thrust load fixtures can be installed. Also, due to an approximate 60% increase in the magnitude of the shear loads at the thrust blocks, some of the test fixtures must be "beefed up."

III. S-IVB Stage

Forward Skirt Flutter Kit Heating

After extensive coordination with The Boeing Company, McDonnell Douglas Company, R-P&VE-P, and R-AERO, it was established that no structural problem existed on the S-IVB, AS-501 forward skirt due to aerodynamic heating. Therefore, no additional insulation is required around the flutter kit hat section and holes.

IV. Instrument Unit

S-IVB/IU Tension Tests

The five S-IVB forward skirt tension test panels arrived at MSFC from McDonnel Douglas Company with interface flange thicknesses out of tolerance. Nominal drawing thickness for the flange is .1875 inches with a tolerance of +1/32 in. All five panel flanges had thicknesses of approximately .32 inches. The panels were inspected and sent to BECO for machining to bring them into drawing tolerances. After machining and inspection it was found that the flanges were warped. With the newly machined upper surfaces, four of the five panels were still out of tolerance. Two of the four were only slightly too thick (up to .236 inches). These two were considered acceptable for test by the MDC, but the Structures Division did not concur in this opinion. All hardware should be within tolerance for these tests. Testing of the one panel that is within tolerance has been completed. In an attempt to bring the four remaining panels within tolerance, Structures Division agreed to allow BECO to remove the flanges and machine from the under side. This effort resulted in bringing two more panels within tolerance. Three S-IVB/IU panels have successfully withstood the engine-out loads expected for this interface (Station 3222). Specifically, the panels failed at 141%, 147%, and 158% of limit loads. It is the consensus of both Structures Division and IBM that sufficient data have been generated from the above three tests and that the two remaining panels can possibly be utilized in some other type testing. Alternative test programs are now being formulated.

V. Saturn V System

A. Damper System

A redesign of the cable system for the centering cylinders has been completed and tested, and was shipped to Kennedy Space Center on August 14, 1967.

These cables are to be installed before rollout of AS-501. Another permanent cable system has been designed and is presently being tested.

B. Flex Cycle Testing of Saturn V Service Arms Lox Line

The second flex line, NAS p/n 75M14015-5 was subjected to 500 cycles as per requirements. The vacuum loss was negligible; therefore, the line was considered to have successfully completed the tests. The test fixture was removed from the building, but is being held in storage because of the possibility that KSC may require additional tests.

C. Swing Arm Test at Kennedy Space Center

On August 9-10, representatives of MSFC and IBM visited KSC for purpose of defining the need for having the IU access door installed when subjecting the umbilical area to disconnect loads arising during swing arm testing of AS-501. The problem apparently arose when KSC wanted to leave the IU access door out to allow passage of power cables and personnel to the IU/S-IVB compartment during the tests. It was revealed that a possible rerouting of the cable through two SLA ports was possible and proved successful so the IU door was installed. This method of cable routing had been successfully utilized on the three uprated Saturn I vehicles. The cables were rerouted with no problem. The swing arm tests were then completed with no apparent damage to the IU structure. It is understood that the IU cables can be routed through the SLA ports on AS-502, but cannot be on AS-503 and subsequent vehicles since spacecraft power cables will be installed in these areas. It is further understood that IBM has been directed to develop a facilities door during the next two-three months that will offer both structural integrity and access.

D. AS-501

A ground winds study was completed to provide AS-501 structural capability for various propellant loading conditions. The results were forwarded to the Technical Systems Office.

Resultant deflections of the AS-501 vehicle for varied wind probabilities were provided to Mr. R. P. Dodd, Civil Engineering and Facilities Manager, at KSC. Base rotation was included in the analysis since the mobile service structure annulus system was the item for which this information was generated.

A longitudinal lift-off loads analysis was performed incorporating engine ignition associated with a count-down sequence failure. This type of failure can result in adjacent out-board engine ignition followed by the other two adjacent out-board engines. Another possible engine sequence is a 1-4 buildup. These two conditions were analyzed and the resulting loads have been given to Strength Analysis Branch for their appraisal.

Longitudinal loads are being calculated for AS-501 lift-off using data from the recently conducted arm release test at Cape Kennedy. The results of these analyses will be used in determining the required minimum preload for the slow release rods.

A request has been made to the Vibration and Acoustics Branch to take action to have the already installed strain gauges on the holddown arm to be connected and recorded during arm release at lift-off. (These gauges were used for holddown arm drop tests.)

APOLLO APPLICATIONS PROGRAM

I. Apollo Telescope Mount

A. Rack/ATM

A full scale mockup of the aft LM Ascent Stage support fitting and surrounding area of the Rack was received from Manufacturing Engineering Laboratory. Also, a LM separation bolt, nut and electrical connector were obtained on loan from Grumman.

Manufacturing Engineering Laboratory has indicated unexpected difficulties in the tube swaging operation required in the released Rack structural members. A design investigation was made and several redesign alternatives were found to be acceptable. Further action is pending a request from Manufacturing Engineering Laboratory for redesign.

Vehicle Systems Division requested that Structures Division provide a design of a thermal shield that is to be suspended below the Rack structure (sun end of ATM). Initiation of the shield design has been hampered by lack of definition of: a door in the shield for passage of an astronaut, thermal requirements of the shroud, solar panel module mounting requirements and handling requirements.

B. Experiment Package/ATM

Propulsion Division has concluded that the aluminized mylar originally planned for the canister exterior insulation is not satisfactory. New concepts being considered are multilayer teflon, foam and honeycomb filled with a fusible material. A change in the insulation could cause severe impacts on the weight and complexity of the canister structure and the gimbal system, particularly the launch locking system. The new concepts appear to be considerably heavier than the aluminized mylar with estimates of 350 to 1000 pounds additional weight. Clearance problems are also present since it appears that all the concepts are thicker than the 1/2 inch allowed for the aluminized mylar.

A single spar wing is being produced in order to obtain numbers for use in alignment considerations. This "wing" will be put through manufacturing processes exactly as planned for the flight spar. It will then be dimensionally checked, particularly for flatness.

The high altitude observatory experiment is 3 to 10 inches longer than the allotted 120 inches. Since the experiment package is not designed, it appears the canister structure can be arranged such as to accommodate a 3-inch extra length. High Altitude Observatory (HAO) claims the instrument cannot be shortened further without degrading the optics.

C. ATM Experiments Design Review Team

This Division has been requested to supply extensive support over the next three-month period to reviewing the structural and mechanical design of certain ATM experiments. This reflects a considerable increase in requested participation and results from expansion of the review team's scope as requested by NASA Headquarters. Additional Propulsion and Vehicle Engineering Laboratory support from the Vibration and Acoustics Branch of Structures Division and from Materials Division is also expected for this period.

D. ATM Transportation Container

The vibration environment associated with transportation of the ATM has been reviewed and found to be in excess of the payloads design criteria. An evaluation of the above condition has resulted in the selection of a shock mount to be used in the ATM transportation container. A memorandum documenting the transportation criteria is being prepared to send to Astrionics Laboratory defining the ATM rack response to aircraft and barge transportation environments using the recommended four point shock mount container configuration.

II. Multiple Docking Adapter (MDA)

The expected release date for the forward bulkhead drawings has been slipped two weeks, until September 21. This has resulted from design changes to accommodate mobility aids, as requested by Vehicle Systems Division, and from a request by Manufacturing Engineering Laboratory to integrally machine the bulkhead longerons rather than to weld them to the bulkhead.

A design study was initiated to assess the feasibility of a revision to the experiment support structure proposed by Vehicle Systems Division. Also expected is a request to incorporate an astronaut floor and additional mobility aids into the current MDA shell. Initial estimates indicate a severe structural dynamic environment with the new arrangement.

The design of a thermal test fixture was initiated at the request of Propulsion Division. The fixture incorporates two docking ports into an insulated lenticular vessel for determination of docking port heat leak. Drawings of the fixture will be completed by September 7.

III. Rack/PM

Final release of all structural detail and assembly drawings for the Rack/PM has been accomplished. Close coordination with Manufacturing Engineering Laboratory has been required in some areas where the planned manufacturing techniques have not proved satisfactory and alternate methods are being pursued with some minor design changes resulting.

IV. Nuclear Ground Test Module

The drawings for modification of the nine-foot Rift tank to be used for insulation testing are 75% complete. Information copies have been sent to Manufacturing Engineering Laboratory. Preliminary discussions have been conducted on the requirements and modifications to the S-IB 105" tank, also to be used for insulation testing.

V. Experiments

A. MSFC Flight Experiment #8

The preliminary design of the tensile testing machine for pulling thin film specimens in space has been completed and an engineering report prepared. Difficulties have been encountered in mounting the tester on the MDA because of interference with the SLA (shroud) and solutions are being investigated.

B. Electron Beam Welding Experiment

The material evaluation test panels for the acoustical cover are being tested. Preliminary test results indicated a preference for the Beta Cloth and Beta Batt material combination. Materials Division has initiated a procurement request for a sufficient quantity of these materials to fabricate test and flight covers for the Electron Beam Welder.

VI. BP-30 Service Module

The forward and aft manifold valve system to be installed in the BP-30 service module has successfully completed vibration testing. A number of design changes had been incorporated in the manifold as a result of previous vibration tests.

Chief, Structures Division

GEORGE C. MARSHALL SPACE FLIGHT CENTER

PR-P&VE-A-67-8

MONTHLY PROGRESS REPORT
ADVANCED STUDIES OFFICE
(August 1, 1967, Through August 31, 1967)

SATURN V

Voyager Program

A. Baseline Spacecraft Design

1. P&VE Spacecraft Design Status --- The results of the P&VE spacecraft design effort are presently being documented in MSFC Internal Note IN-P&VE-A-67-8 and will be published early in September. This document will contain a description of the Voyager spacecraft concept identified as the "baseline concept." Continued design efforts will involve changes as necessary. Publication of this document will culminate a six-month preliminary design effort by the P&VE Laboratory.

2. Voyager Review to MSFC Management --- A Center-wide technical review on the status of the in-house Voyager effort was conducted for MSFC management on August 10 and 11, 1967. This Office presented the results of the P&VE design effort on the baseline spacecraft system and the MSFC effort on the recommended shroud design. In addition to the baseline spacecraft design (140-inch-diameter concept), a 260-inch-diameter spacecraft concept was introduced. Decisions were made that the baseline concept be included in the Phase C RFP package and that the 260-inch-diameter concept be more thoroughly defined by in-house studies.

B. Voyager Spacecraft Science

A brief study was performed to assess packaging and accommodation of increased science, power, and communications for an

"orbiter only" Voyager Planetary Vehicle. A significant problem exists in satisfying the pointing requirements of the data transmission system for the added science. The study was requested by R-TO to develop alternate approaches to the 1973 Voyager Mars mission as a result of Voyager program budget cuts.

C. Alternate Spacecraft Design Studies

As a result of the favorable interest expressed by MSFC management during recent Voyager technical reviews, an exercise to examine a 260-inch-diameter spacecraft concept, utilizing the LEM engine, has been initiated within P&VE Laboratory. The study is to be a two-phase effort terminating in the latter part of October. The initial conceptual study will be conducted within this Office until September 1. At that time, the P&VE Laboratory Divisions, as well as the other affected Laboratories, will participate more actively to complete the conceptual design. In addition to defining the 260-inch-diameter spacecraft, the impact of this design on the baseline shroud and its supporting subsystems will be examined.

The 260-inch-diameter spacecraft concept, as compared with the 140-inch-diameter baseline design, offers a less complex shroud/planetary vehicle separation, greater growth potential in propellant tankage and equipment and packaging, and a shorter payload envelope above the Saturn Instrument Unit.

In addition to the basic LEM propulsion system, an alternate propulsion system design employing the Agena engine is being prepared for the 260-inch-diameter spacecraft. Engine functions and capabilities will be identical to the Agena system used in the 140-inch-diameter spacecraft design.

D. Voyager Missions to Jupiter and Venus

A study of the application of the Voyager spacecraft to Venus and Jupiter missions has been initiated. The purpose of the study is to define changes which might be incorporated into the Mars Voyager spacecraft to make it suitable for Venus and Jupiter orbital missions. A study group has been formed, with a representative from each co-located in Advanced Studies Office and the Advanced Systems Office. Mr. B. Ellison, R-AERO-X, is the study manager. Mr. D. R. Mercier has been appointed as the P&VE Laboratory representative for this in-house study.

E. S-IVB Staging Study

In addition to the effort reported last month on utilization of the spacecraft for providing the final transmartian injection velocity increment, the effect of coast time on the payload delivered to Mars orbit after staging of the S-IVB stage has been investigated. It was estimated that a minimum coast time of 10 minutes may be necessary to effect the separation and stabilization of the spacecraft before it could be burned. The 10-minute coast time resulted in a payload loss of about five per cent when compared to zero coast time. The results of this study and the previously mentioned S-IVB staging study are being documented and will be reported in memorandum R-P&VE-AV-67-242

APOLLO APPLICATIONS PROGRAM

I. Advanced S-IVB Workshop

The in-house effort has concentrated primarily on the definition of the zero-gravity concept, with emphasis on accommodation of the experiment package developed in the MDC study. A zero-gravity baseline configuration is being modified to accommodate alternate experiment programs which emphasize astronomy, earth resources, biology or orbital research and development.

Briefing material has been prepared and a dry run presentation made in preparation for presentations to P&VE management and MSFC management on the current status of the advanced S-IVB Workshop. The presentation for the P&VE Technical Seminar has been postponed and is pending. The presentation to MSFC management was given on August 31, 1967.

A preliminary thermal analysis of the ground-fitted S-IVB EOSS has been completed to compare candidate compartment insulations. Results of the study indicate that an insulation such as the Goodyear-type MDA insulation, with lower performance characteristics than the super insulation, would maintain acceptable internal wall temperatures. Low performance insulations such as polyurethane foam did not maintain acceptable wall temperatures.

II. EOSS Experiments

The general experiment package developed in the MDC study is being programmed into the Experiment Scheduling and Compatibility Program (ESCAPE) to determine the compatibility of these experiments with the EOSS. This program run will assist in determining the experiments that are compatible with the EOSS for a 1971-1972 EOSS launch. This general experiment package is also being programmed into a computer program developed by LaRC for MORL. Inputs for this program were provided to LaRC.

III. Lunar Systems

A. Mobility Test Program

The calibration and moment of inertia determination of the Bendix MTA is complete; the GM/MTA will be completed in early September 1967. Calibration of the BECO LSSM mock-up is also complete; however, checkout of the MTA telemetry systems and test course preparation will take about six weeks.

B. LSSM Program

At the request of I-S/AA, this Office is preparing a preliminary design of a small unmanned (or emergency manned) LSSM for use with an extended LM on a single-launch mission. Overall drawings and performance predictions are being prepared.

As a result of the Santa Cruz conference and the decisions of the Lunar ad hoc Committee, two LSSM configurations are being considered: a small unmanned version for a single launch mission and a two-man larger vehicle for the dual launch mission. The second configuration may include a pressurized cabin.

C. AAP Lunar Integration Program

Personnel from this Office, R-AS, and I-S/AA attended a briefing by The Martin Company on the AAP Lunar Integration Program. There was a discussion of the lunar ad hoc study and the Santa Cruz meeting, the Lockheed studies, Martin's work statements, and current hardware status.

NUCLEAR STUDY PROGRAM

Nuclear Vehicle Design Sensitivity Study

Results achieved to date in the study of the LMSC Phase I concept and growth versions are being documented as a part of a report entitled "Preliminary Identification of an Advanced Saturn/Nuclear Launch Vehicle for Manned Planetary Missions." This document is in final review status and is expected to be available shortly. The material covered includes that presented to R-P&VE and R-AS management in June, plus additional material.

Identification of a preliminary Phase II reference module and a parametric performance survey of this module as applied to the 1982 Mars landing mission are substantially complete. Documentation of these tasks is expected to be in hand within the first week of September.

ADVANCED PROGRAMS

I. Launch Vehicles

A. Kick Stage Study

The kick stage design handbook is being updated to reflect more recent thermodynamic insulation designs for cryogenic kick stages. Also, the boiloff rates for cryogenic kick stages will be updated accordingly. The kick stage study will be documented in the form of an MSFC Internal Note.

B. Liquid Strap-on Pods, 660 K Launch Vehicle

A short study is being performed to determine if hydrogen peroxide can be used to regeneratively cool the pod engines. Nozzle ablative cooling and pod pressurization methods are also being investigated. Propellants under consideration are hydrogen peroxide/alumizine and nitrogen tetroxide/alumizine. The performance, control, aerodynamic, and separation parameters are presently being determined with the help of R-AERO-X.

C. Launch Vehicle Handbook

Computer programs are still being modified and checked out for the control study portion of the handbook. A copy of the U. S. Air Force Space Planner's Guide was recently acquired and is being evaluated to determine if the methods used can be applied to the launch vehicle handbook.

D. Stage Design for Personnel Transfer

The conceptual design of a 260-inch-diameter storable propellant stage for the Personnel Transfer study has been completed. The injection into synchronous orbit of payloads of a Gemini capsule, a standard, or an advanced Apollo capsule and stage is well within the capability of the Saturn V. Since these payloads can readily be delivered by the Saturn V launch vehicle, the storable stage was evaluated to be used only for performing the docking and de-orbit maneuvers.

Further effort will be made to investigate a 260-inch-diameter cryogenic stage and a 140-inch-diameter stage which would use cryogenic or storable propellants for these applications.

E. Three-burn S-IVB Stage

An MSFC Internal Note concerning the utilization of a three-burn S-IVB stage for advanced earth and lunar orbital missions is in preparation and will be published soon. Advanced Saturn V missions, such as the synchronous orbit mission, the S-IVB in lunar orbit, and others, will be discussed. S-IVB stage and IU capabilities and changes required for each mission are also covered.

F. Saturn V SA-520 Document

A study has been initiated to update the Saturn V SA-516 Saturn Uprating document. The vehicle described in this document will be renamed the Saturn V SA-520. The J-2S engine will be utilized in the S-II and S-IVB stages.

This document proyides a consistent set of launch vehicle criteria for use as a baseline in advanced studies. The document should be published during the first week of October.

G. Saturn V Improvement

This Office participated in a presentation given to Center Management, July 26, 1967, on the possible methods of improving the Saturn V launch vehicle. The modifications required to the various manufacturing, test, transportation, and launch facilities for the improvement schemes considered were discussed by a representative of this Office.

H. Low-cost Launch Vehicle Study

This in-house study was initiated on August 24, 1967, and is comprised of two directly-related efforts. The Conceptual Design and Analysis portion of the low-cost launch vehicle system study, under the study management of Mr. Jay H. Laue, R-P&VE-AP, will produce a conceptual definition of a launch vehicle system, or systems, which primarily emphasize low-cost as a design goal. This effort will contribute toward and capitalize on the test findings resulting from the TVC Technology Development Program, a complementary hardware fabrication and test activity under the management of Mr. Billy A. Neighbors, R-AS-SP, who is also responsible for coordination of the overall Low-cost Launch Vehicle study. The Conceptual Design and Analysis study will attempt to identify itself with a design study philosophy characterized by the following:

(1) Major emphasis on simplicity and low cost.

(2) Open-minded attitude toward "non-traditional" design concepts

(3) Conceptual verification through precursory hardware testing.

(4) Potential for systems scaling and/or subsystems repeatability

(5) Early study identification and emphasis on design areas which most significantly impact overall program cost.

(6) Potential for minimizing management interfaces through all phases of development.

The following individuals have been identified as primary contacts for the Conceptual Design and Analysis study effort on behalf of their respective organizations:

Mr. J. Laue, R-P&VE-AP (Study Manager)
Mr. A. Orillion, R-P&VE-AV

Mr. B. Neighbors, R-AS-SP
Mr. W. Wood, R-AS-SR
Mr. S. Saucier, R-AS-VG
Mr. R. Jump, R-AERO-XS

II. Earth Orbital

Common Mission Module (CMM)

1. Requirements --- A matrix of planetary characteristics has been developed in an effort to establish typical mission requirements for a common mission module definition study. All pertinent missions, both fly-by and capture, during the 1975-1982 time frame were considered in developing this matrix. Only characteristics considered to influence or impact the design of the CMM were retained for matrix evaluation.

2. Configuration --- A configuration matrix has been established for the CMM which identifies the multiple variables that should be considered. Efforts are continuing to trade off and evaluate these variables in order to arrive at a desirable configuration. Preliminary layouts and designs are being performed to investigate methods of packaging, arranging, and assembling CMM equipment and interiors. Parametric analyses are continuing to compare structural design approaches. Thermal analyses are also being performed to define the thermal environment and provide preliminary definition of a thermal control system.

III. Planetary Systems

A. Manned Planetary Fly-by

A working group meeting was held at MSFC on July 27, 1967, and at NASA Headquarters with Dr. Frank Dixon on July 28, 1967, concerning the results of the MDC study on the design of a new chemical stage capable of performing the Manned Planetary Fly-by and Capture Missions. The results of this study indicated that the only additional mission that can be accomplished with the new stage (as compared with the S-IVC) is the Venus capture mission. The Mars capture mission requires an excessive number of launches (9 to 11). The final review of this study is scheduled for September 6, 1967.

B. Planetary Systems (Mars Orbital Probe)

The study to conceptually define a Mars probe which will be launched from a fly-by spacecraft, orbit the planet, and collect and transmit data pertaining to the surface, atmosphere, and environment of the planet Mars has been completed. The results of this study are currently being documented.

IV. General

A. Engineering Support to Integrated Long-range Plan

Engineering support to the integrated long-range planning efforts of R-AS has been established as an in-house study effort within R-P&VE-A in cooperation with R-AS and the other co-located Advanced Studies Offices. The objective of this engineering support effort is to establish the physical and performance characteristics of various hardware items and the descriptions of various missions which are options under consideration by the ILRP group. The data will be defined to a level such that rough cost estimates of each item can be made and so that trade-offs may be made between the many options. Mr. John Massey has been appointed as the R-P&VE-A study coordinator for this study effort.

B. Development of SRT Requirements

Representatives of MSFC, MSC and KSC met with OMSF personn at NASA Headquarters on August 8, 1967, to determine the advanced develo ment requirements for OMSF to prepare for probable new manned space flight projects. The following action items, proposals, and decisions resulted from this meeting:

(1) A matrix format was established and it was agreed that the SRT requirements would be reported in the following mission-oriented sub-divisions: AAP, Earth Orbit, Lunar, Planetary, and Launch Vehicles.

(2) The time period to be considered is 1970-1980.

(3) The use of a new 24-category Coding System was proposed.

(4) It was proposed that each Center prepare by December 1, 1967, a "Results" book containing all SRT requirements.

This Office is now in the process of filling in the columns of the matrix format, covering the systems and subsystems requirements as currently foreseen.

Erich E. Goerner
Chief, Advanced Studies Office

GEORGE C. MARSHALL SPACE FLIGHT CENTER

R-P&VE-M-67-8

MONTHLY PROGRESS REPORT

AUGUST 1, 1967 THROUGH AUGUST 31, 1967

SATURN IB

I. S-IB Stage

Investigation of the Corrosive Effects of MIL-H-5606 Hydraulic Oil

Tests comparing the corrosive effects of MIL-H-5606A revision hydraulic fluid to the B revision fluid have continued. These tests have been in progress for 227 days. Since some corrosive effects have been reported with the B revision fluid on a mild steel (in the form of small particle increase) particulate counts have been taken after a seven-month exposure. Results of these measurements will be reviewed again after additional exposure. In addition to the above tests, similar test materials have been exposed to a Brayco 757B fluid manufactured by the Bray Oil Company. This fluid is reported to meet the B revision specification requirements with an additional corrosion inhibitor added. This fluid is proposed for use in the hydraulic system of the S-IB vehicles during extended storage periods.

II. H-1 Engine

Examination of H-1 Engine H-2038

H-1 engine H-2038 was stored approximately four years, removed from storage and static fired, and then shipped to this Center for a complete tear-down. All components have been examined and no corrosion was evident on any of the parts.

I. S-IC Stage

A. Evaluation of Commercial Adhesives

Studies have continued as outlined below in the development, modification or evaluation of high performance adhesive systems for use on the Saturn V system.

1. Polyurethane Adhesives

The long-term aging study on Narmco 7343 adhesive is continuing and the data continue to support earlier conclusions, i.e., degradation of primed specimens is noticeably less than that of the unprimed adherends and strength of unprimed specimens at room temperature shows an almost 50 percent decline during 18 months, while the decline at 180°F (82°C) and -200°F (-129°C) remained minor. Also, only minor strength loss was noted for specimens primed with XC-3901 or G-207.

Work reported previously has demonstrated that spectacular improvements in the high temperature (approximately 200°C) strength of Narmco 7343 adhesive are obtainable by the addition of small proportions of silane derivatives normally applied to commercial fiberglass as coupling agents. This earlier work was based upon aluminum adherends. During this report period, similar compositions were evaluated as adhesives for Mylar sheet and honeycomb, aluminized Mylar film and Mylar-aluminum-aluminum-Mylar laminate (MAAM). It appears that the additives which promote higher strength on aluminum adherends are ineffective on these substrates.

2. Evaluation of Urethane-Epoxy Adhesive Blends

Narmco 7343 urethane and Shell's Epon 828 epoxy are being investigated as a model system representative of a urethane-epoxy blend. Another epoxy, Resinbond 907, was also evaluated. Although further study is indicated, these preliminary compositions did not have promising peel strengths.

3. Study of Catalyst Concentrations for Lefkoweld 109 Adhesive

Conflicting data on the Lefkoweld 109 adhesive system indicated the need for an evaluation of the characteristics of the adhesive after curing with various amounts of LM-52, the recommended catalyst.

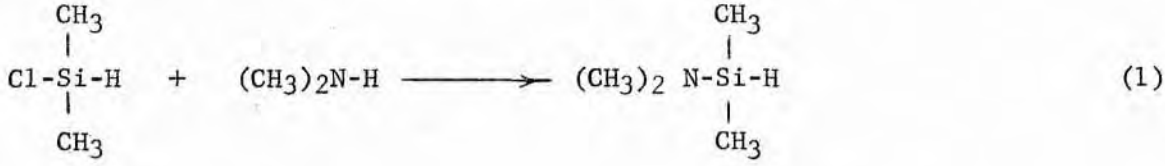
The compositions were chosen to bracket the recommended catalyst concentration of 74 phr (parts catalyst per hundred parts of Lefkoweld 109 resin). Data from peel and laphsear tests confirmed that the recommended catalyst ratio is the optimum.

B. Development and Evaluation of Potting Compounds and Conformal Coatings

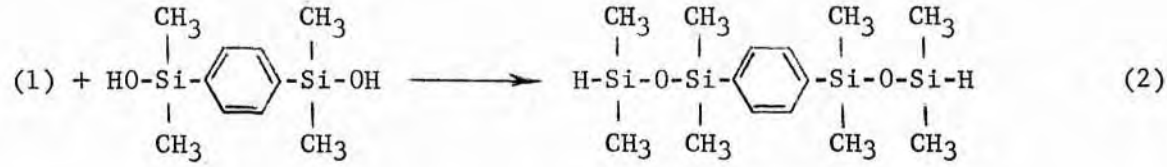
Continued effort has been devoted to the development of specialized polymeric materials for the encapsulation of electronic hardware. Two siloxane polymer intermediates were prepared for conversion into embedment compounds and several polymer systems have been investigated as potential conformal coatings.

1. Development of Epoxy Siloxane Embedment Materials

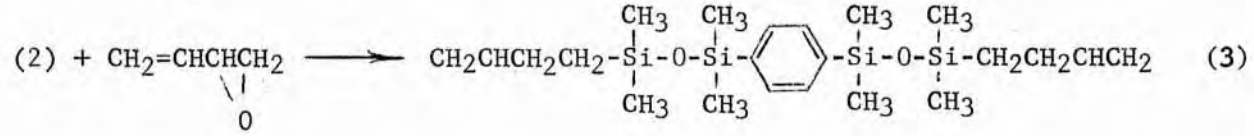
The preparation of three epoxides, 1,7-bis(p(2,3-epoxypropyl)-phenyl)octamethyltetrasiloxane, 1,9-bis(p(2,3-epoxypropyl)phenyl)decamethyl-pentasiloxane, and 1,4-bis(3,4-epoxybutyldimethylsilyl)benzene, has been partially complated. The first two compounds represent epoxidation products of allyl-siloxane intermediates described in the last report. The latter compound was prepared through a multistep synthesis:



(1)



(2)



(3)

Compound (1) was isolated in 90 percent yield as a colorless liquid, boiling at 62-63°C/760 torr. This material was condensed with 1,4-bis(hydroxydimethyl silyl)benzene to form compound (2), which was recovered as a colorless oil, boiling at 93-95°C/5 torr. Compound (2) was treated with freshly distilled 3,4-epoxy-1-butene in the presence of chloroplatinic acid to yield compound (3), 1,4-bis-(3,4-epoxybutyldimethylsilyl)benzene. Compound (3) was distilled as a colorless oil at 137-140°C/5 x 10^{-3} torr. Infrared and silicon analyses supported the assumed structures of compounds (1), (2), and (3). A series of seven diepoxides have now been prepared for a study of the effect of polymer structural modifications on dielectric and mechanical properties of the cured embedment materials.

Formulation studies involving fillers were carried out on two intermediates, 1,4-bis(2,3-epoxypropoxypropyldimethylsilyl)benzene and 1,3-bis(p-2,3-epoxypropyl)phenyl) tetramethyldisiloxane. The preparation and properties of these materials have been discussed in previous reports. One advantage of using these lower molecular weight polymer precursors in embedment applications as opposed to a more viscous, higher molecular weight prepolymer lies in the ease of processing of the more fluid materials. Comparative studies were carried out on two of these local materials and Epon 828, a medium viscosity epoxy prepolymer produced by Shell Chemical Company. The local formulations were easily degassed and pourable at microballoon filler loadings up to 25 percent by weight; at this filler level the Epon 828 was prohibitively viscous.

2. Development of Conformal Coating Materials

Additional evaluation studies have been carried out on the butadiene-containing polymer prepared from hydroxyl-terminated polybutadiene (m.w. 2,500) and toluene-2,4-diisocyanate. The polymer was characterized by a dielectric constant and dissipation factor of 3.11 and 0.018, respectively. These were average values of 4 specimens, measured at 1 kilocycle. A 1/16-inch thick coating of this polymer retained 75 percent of its room temperature flexibility at -60°C. Attempts will be made to obtain modulus data for this polymer at -60°C to aid in assessment of the possible stress which coatings of this type might impose on printed circuit board components.

C. Investigation of Corrosive Nature of Atmosphere at Michoud

Exposure of various alloy panels with several protective coatings is being continued. During a short visit to the Michoud facility on July 25, 1967, a very brief examination was made of those panels exposed both indoors and outdoors at Michoud. A considerable contrast was noted between the indoor and outdoor panels; however, time did not permit a detailed evaluation. Since it has been slightly over five years that the panels have been exposed to this environment, it was recommended that a close evaluation be made and a record made for future reference.

D. Evaluation of O-rings for S-IC GOX Flow Control Valve

The results of a cooperative testing program using Viton O-rings indicate that LOX impact test results generated at The Boeing Company are comparable to test results obtained by personnel of this Center. The Boeing Company has been re-certified for batch testing per MSFC-SPEC-106B.

II. Contract Research

During this report period, Saturn-related supporting research activities have continued in the fields of technology with the contractors and under contract numbers listed below.

A. Polymer Research, Development, and Testing

1. Thiokol Chemical Corporation, NAS8-21197, NAS8-21149
2. University of Florida, NAS8-20247
3. Peninsular ChemResearch, Incorporated, NAS8-5352

B. Development of Cryogenic and High Temperature Insulation Material

Goodyear Aerospace Corporation, NAS8-11747

C. Analytical Methods Development

Beckman Instruments, Incorporated, NAS8-11510

D. Assessment and Evaluation of Blast Hazards

Edwards Air Force Base, Government Order H-61465

E. Nondestructive Testing Techniques

1. North American Aviation, NAS8-20764
2. R. W. Benson and Associates, NAS8-20208

III. S-II Stage

A. Investigation of Fracture Toughness of 2014-T6 Weldments

Studies have continued into the fracture toughness of S-II stage weldments at temperatures down to -423°F (-253°C). Tests are being made on specimens taken from actual S-II weldments (S-II-T) and also on test weldments simulating S-II conditions. This includes weld repairs and MIG-pulsed arc weldments. Results of these tests to date indicate the following:

1. A definite increasing trend of K_{IC} with decreasing temperature exists for the 1.00 inch 2319-TIG welds and 0.460 inch 2014-T6 parent metal.

2. A compact K_{IC} range exist for all the different weld types even when considering valid and invalid test results.

3. The weld metal has the lowest fracture toughness except when the crack is partially located in the heat affected zone (HAZ) and weld metal at the same time.

4. A K_{IC} of 17.7 ksi $(inch)^{1/2}$ is the minimum value experienced to date. The critical crack size for the 27,350 psi operating stress at -423°F (-253°C) temperature is 0.100 inch.

Evaluation of Spray Foams for Applicability as S-II Liquid Hydrogen Tank Insulation

Representatives of this division were in continuous residence at the Douglas Sacramento test facility during recent tests on the Th tank insulated with spray foam. This tank failed structurally on Aug during an attempt to pressurize it to 79 psig. Failure occurred at 7 Attempts are now being made to devise other means of studying the prob which came to light during earlier fill tests with this tank.

Problems were encountered during every test due to the tendenc the foam to blister during warmup, following the detanking operation. occurrence of this effect only during warmup indicates that cracking an subsequent cryopumping of the foam caused the failures and there is ten evidence that the failures occurred mostly near foam overlaps or closeo

Therefore, it appears that a coating of some type will be necess to hinder cryopumping, and that this same coating must withstand and pre offer some protection against the ascent heating environment. The "Chem coating previously favored by S&ID for this purpose does not appear acce because it melted like an ordinary thermoplastic during tests conducted h on samples provided by S&ID. Better results have been obtained locally w a General Electric Silicone, GE SR-529. A Narmco 7343 foam seal coating been tested also with tentatively promising results. Evaluation of a new material developed for X-15 aircraft application also is in progress.

C. Evaluation of Nondestructive Techniques for Examining Composite Materials

Several very effective methods of evaluating complex honeycomb composite materials (such as are used in the common bulkhead of the S-II stage) have been developed. However, further work is required to develop better coupling techniques (e.g. air coupling) and to establish better and more meaningful standards.

Recent work in this area has been directed toward the nondestructive evaluation of aluminum-foam composite materials which are to be used for the S-II stage and for the Nuclear Ground Test Module.

Conventional ultrasonic techniques have proven unsatisfactory for the nondestructive evaluation of low density foam-aluminum composites. Methods of introducing sound directly into the foam side of the composite are being evaluated. A "Resonant Foam Coupler" has been developed which is satisfactory for laboratory testing. Details of this development have been filed with the local Patent Council's Office for possible patent application.

Recent attempts to use this device for field type inspections revealed the need for certain modifications in the transducer design. These modifications are now being made.

D. S-II Stage, Project Management, Materials

Efforts have continued in the coordination and resolution of problem areas of a materials nature related to the S-II stage. During this report period these efforts have included the following:

1. During a proof pressure test of the S-II-4 stage sidewall insulation, a facing sheet debond occurred over one-quarter panel, apparently initiating at a small repair. The repair was not verified using the vacuum bell test as required by specification; thus, it is believed that the repair was partially debonded providing a starter for failure. To prevent further such occurrences, NAA/SD has been directed to reinspect all subsequent repairs for any debond greater than one cell.

2. As a result of unsatisfactory results from the insulation blow-down test conducted on S-II-4, the S-II-1 stage was checked and also found to be unsatisfactory. Additional manifolds for the purge gas have been provided to satisfy engineering requirements. All subsequent stages having this type of insulation will be similarly checked.

3. The spray foam insulation test tank failed at the MDC test facility as a result of overpressurization. Prior to delivery to NAA/SD for the application of spray foam, MDC, Huntington Beach, had certified the tank as being capable of enduring 79 psi at the bottom of the tank in an LH_2 environment. At the top of the tank, however, the pressure limit would be approximately 68 psi at LH_2 temperature, thus a failure at 77 psi is above expectations. The failure entailed a blow-out and shattering of the forward bulkhead. The tank sidewall has one crack (approximately 4 inches long) in a longitudinal weld above the point where the bulkhead was joined to the sidewall. Damage to the test stand was negligible.

The insulation remained intact during the proof test and after failure. There were several (26) blisters resulting from cryopumping and several cracks. The cracks were not observed until the hypalon coating was removed, and it is not known if they occurred as a result of strain level or the impact of tank failure. PQV plugs are now being obtained in areas of previous discrepancies as well as areas which have not endured any discrepancies. The PQV results are equivalent to those obtained during the manufacturing inspection operation, indicating no degradation as a result of the cryogenic pressure cycles.

Both NAA and MSFC agree to the need for another tank to continue the test program. Personnel of MDC are presently surveying various facilities for another tank similar to this Thor tank. Further, both NAA/SD and MSFC are exploring possible in-house programs which could provide information relative to the problems of cryopumping and cracking of the insulation.

IV. S-IVB Stage

A. Study of Materials Problems Attendant to the S-IVB Workshop Program

1. Study of Flammability of Materials

Testing has continued with support from Test Laboratory on the study of the flammability hazard of aluminum foil-covered S-IVB insulation and to compare the effective flame retarding capability of 2-, 3-, and 5-mil aluminum foil. Standard 3-foot diameter samples are used in all tests. The samples are flanged to a 3-foot diameter by 5-foot test tank. The tank is placed in a vacuum chamber, evacuated, and back-filled with gaseous oxygen to 5 to 5.7 psia flowing oxygen. A nichrome wire is used to ignite the samples. The igniter is placed over the damaged area 1/8 to 1/16-inch away from the foam. The power used for the igniter is 21 volts at 9 amps. Additional tests have been conducted using the 5-and 3-mil aluminum foil. The results of 8 tests with the 5-mil aluminum indicate that the maximum burn diameter with the 5-mil aluminum foil is approximately 5 inches under the conditions of this test procedure. The preliminary results of three tests using the 3-mil aluminum foil indicate that the maximum burn diameter is approximately the same as the 5-mil aluminum foil. Additional tests are scheduled to further evaluate the effect of liner thickness on the flammability of S-IVB insulation.

During this period, 30 materials were evaluated for flammability in accordance with the new provisions of MSC-A-D-66-3, Revision A, "Procedures and Requirements for the Evaluation of Spacecraft Non-Metallic Materials."

2. Study of the Combustion Products of S-IVB Stage Materials

A new combustion chamber has been designed and fabricated to provide for further more meaningful tests to determine the products of combustion which might be expected on the S-IVB Workshop should selected materials be ignited. In previous tests the starting pressure was approximately 5 psi, and due to the small sample size, the pressure never rose to atmospheric pressure. In the new chamber, test conditions will more nearly simulate the situation aboard the spent stage in regard to the weight of insulation to the volume of oxygen present. Previously, all tests were made with sufficient oxygen to obtain complete combustion. In simulating combustion that would occur aboard the spent stage, the tests will be made with approximately one-tenth of the amount of oxygen that is actually needed for complete combustion. The combustion products will be considerably different in these tests than compared to the previous tests.

3. Study of the Outgassing Characteristics of Orbital Workshop Materials

A test program has been initiated to determine the outgassing rate of helium from within the S-IVB fuel tank insulation. The specimen for this test is a one-inch thick by 15-inch diameter disc of 3-D insulation sealed to an aluminum plate which serves as a vacuum flange. The disc is sealed with resin and over-coated with 3-mil perforated aluminum foil. The layup of the specimen compares favorably to actual tank fabrication

techniques. The flange with attached specimen will be fitted to a high vacuum system, evacuated, purged with helium, then stored under helium atmosphere for 24 hours. The system will be evacuated, flushed with nitrogen, and re-evacuated to a pressure less than 1×10^{-5} torr. The concentration of helium in the chamber resulting from diffusion of helium from the insulation will be monitored with a quadrapole type residual gas analyzer as a function of time. This test program has been given highest priority.

B. S-IVB Stage, Project Management, Materials

Efforts have continued on the coordination and resolution of problem areas of a materials nature related to the S-II stage. During this report period these efforts have included the following:

1. Radiographic Inspection of Welds

Review of the contractor's quick response proposal has been completed on implementation of our radiographic inspection requirements into the stage contract, and technical differences have been resolved. A memorandum has been issued recommending certain changes to the contractor's process control drawing. The recommended changes are believed to be acceptable to both the contractor and this Center.

2. Majority Voting Actuators

In order to eliminate stress corrosion susceptible materials from the Majority Voting Actuators, the stage contractor (MDC) proposed the use of 7075-T73 aluminum, either forged or machined, for the actuator body and end cap. All other aluminum alloy components will be of 6061-T6 or -T8 temper. Some question still remains about the use of 17-7 PH stainless steel for springs; however, MDC will clarify this in the near future.

3. Stress Corrosion

Bellville springs of 17-7 PH stainless steel are used in the cold helium dump module, 1B57781, and in the LOX tank pressurization module, 1B42290, of the S-IVB stage. This material is susceptible to stress corrosion failure. The stage contractor contends there is no problem because the stresses are low. We do not agree that the problem has been eliminated entirely; thus the stage contractor has been requested to investigate changing from 17-7 PH to some other alloy which is not susceptible to stress corrosion failure.

4. Shot Peening of SAT V/S-IVB APS Tanks of Titanium

Review of the stage contractor's shot peening procedures have been completed with only minor changes recommended. The proof operation of shot peening tanks at the stage contractor's site was completed successfull Thus, the stage contractor will conduct shot peening of APS tanks for SAT V, effective with S-IVB-504 and subsequent stages.

5. LOX Vent and Relief Valves

This division recommended coating the 60-40 tin-lead solder in the LOX and vent valves, I-7 and I-9A, with electroless nickel. The stage contractor suggested coating with gold which is acceptable to this division. An ECP (engineering change proposal) is forthcoming from the stage contractor on coating the affected parts with gold to inert the tin-lead solder from LOX and/or GOX, and on complete redesign of the affected parts to eliminate the tin-lead solder altogether.

6. Thermal Insulation of S-IVB-501 and -503 Flutter Kit

Thermal insulation of the flutter kit on S-IVB-501 and -503 was required; however, this requirement has been cancelled for S-IVB-501. The contractor's proposal for S-IVB-503 includes small clips riveted in place and sealed with an RTV adhesive to preclude air flow across the faying surfaces of the clips. This proposal is being reviewed for technical adequacy.

7. Orbital Workshop

a. Emissivity of Workshop Interior

Work continues with testing coatings to control emissivity inside the Workshop. The most promising candidate for coating the aluminum foil liner is K_2SiO_3/ZnO on an alodine 1200 base. Samples of the candidate coating are being prepared, relative to refinement of application techniques. This work is scheduled for completion during the forthcoming report period, at which time it is expected that a coating will be selected for use in S-IVB-211 and -212.

b. Fire Retardant Liner of Aluminum Foil

Continuing evaluation of a fire retardant liner of aluminum foil for the LH_2 tank insulation of S-IVB-212 revealed that fire retardation may be improved by increasing the thickness of the aluminum foil from 2 mils (0.002 inch) to 3 mils (0.003 inch). Thus, a memorandum has been issued requesting that the stage contractor be directed to use 3-mil aluminum foil as a fire retardant liner in the LH_2 tank of S-IVB-212.

c. S-IVB-500F

A contractor engineering change proposal is being reviewed for conversion of the S-IVB-500F stage to conduct Orbital Workshop thermal vacuum tests. Completion of this review is expected within the forthcoming report period.

8. The following documents have been reviewed:

a. S-IVB stage paint requirements

b. MDC ECP 2130-R1, "Eddy Current Tests of Helium Pressure Vessels"

c. MDC 1P20121B, "Wire, Welding, Spooled Type, Aluminum Alloy 4043"

d. MDC STM0307, "Film, Aluminized Polyethylene Terephthalate, Laminated, Fiber Reinforced"

e. MDC PDR 1P00125, "Radiographic Inspection: Soundness Requirements for Fusion Welds in Aluminum and Magnesium Alloys"

f. Process and inspection requirements for adhesive bonding of the S-IVB stage

g. Orbital Workshop technical work statement

h. MDC MRD 1P20015, "Gas, Shielding, Helium, for Welding"

i. Two level crew quarters for Orbital Workshop

j. Liquid Hydrogen Tank Internal Insulation Outgassing Testing for S-IVB Orbital Workshop

k. MDC MRD 1P00128, "Mechanized Fusion Welding of Titanium Alloys"

l. MSC response to Orbital Workshop PDR RID actions

m. S-IVB Orbital Workshop, General Test Plan

n. MDC STP0212, "Peening, Glass Bead, Titanium Tanks"

o. MDC DPS-10160, "Glass Bead Peening"

p. MDC STM0221, "Seal Coat, Silicone Rubber Dispersion"

q. MDC STP0206, "Ablative Coating System, Application of"

r. Requirements for type of thermal protection material required to protect S-IVB-501 and -503 forward skirt structure with anti-flutter kit installed.

s. MDC PRD 1P00055B, "Bonding, Panel, Paper Honeycomb Core, Metal Faced"

t. MDC STM0298, "Primer, Silicone, Air Dry, Chemical Conversion Type"

u. MDC STM0124A, "Adhesive, Silicone, Elevated Temperature"

V. F-1 Engine

Investigation of Insulations for Use on F-1 Engine Injector Face Baffles

Evaluation of the seven candidate ceramic oxide coatings for insulating the F-1 engine fuel injector face baffles has been completed. Final analysis of the test results indicates that zirconium oxide (ZrO_2) applied by the "Metco" flamespray process is the best coating for this application. When applied to a copper specimen which simulated the F-1 engine fuel injector face baffle and tested under a thermal environment which simulated the F-1 engine service conditions, the insulating efficiency of the "Metco" ZrO_2 coating was better than five of the other candidate coatings and at least equal to the "Rokide" ZrO_2 flamesprayed coating. However, the adherence of the "Metco" ZrO_2 coating to the copper specimens was superior to the adherence of the "Rokide" ZrO_2 coating. Based upon the above results, it is being recommended that a full-sized F-1 engine fuel injector baffle plate be coated with "Metco" ZrO_2 and tested under actual F-1 engine service conditions.

VI. Instrument Unit

A. Study of Possible Gas Evolution in the Environmental Control System

An investigation was initiated to determine if the reaction of the coolant with metal components is the cause of the pressure buildup in the environmental control system (ECS). A previous test using dissimilar metal couples exposed to inhibited methanol/water solution has produced hydrogen gas after 72 days of exposure. This test is being repeated to verify the results, and the test has been in progress 30 days with the following results:

Metallic Couple	Milliliters of gas evolved
Stainless steel 316 - anodized 6061 aluminum	5
LA 141 magnesium - anodized 2024 aluminum	32
LA 141 magnesium - anodized 6061 aluminum	
316 stainless steel	48
356 aluminum - 316 stainless	6

These results are similar to those obtained in the previous test. Additional tests are being conducted using dissimilar metal couples in methanol/water inhibited with sodium dichromate and sodium benzoate separately and in combination; dissimilar metal couples are also being run in distilled water inhibited with sodium dichromate. These inhibited solutions are being evaluated as a possible substitute for the existing methanol/water in the ECS. The effect of pH on the corrosion of LA 141 and 6061 aluminum in inhibited (sodium benzoate) methanol/water (using distilled and deionized), and also distilled and deionized water inhibited with sodium dichromate is being evaluated by exposing panels of LA 141 and 6061 (coupled and uncoupled) in these solutions. The pH in one test is being controlled by periodic solution changes for comparison with a second test without changing the solution or controlling the pH.

B. Evaluation of Diffusion-Bonded Tube Joints for Use in the Environmental Control System of the Instrument Unit

Tubular joints made by silver diffusing aluminum (6061) to stainless steel (300 series) are being evaluated for resistance to corrosion in inhibited and unhibited methanol/water solution. Joints are being tested with no surface protection and with an alodine 1200 treatment. This type of joint is being considered for use in the Environmental Control System. Due to the time dependent nature of these tests there are no significant data to report at this time.

VII. Apollo Telescope Mount (ATM)

A. Investigation of Contamination and Contamination Sources

Investigations have continued in the determination of possible contamination of the optical environment of the ATM experiment, both by direct deposition of contaminant materials on optical surfaces and by degradation of the view area of the equipment.

Evaluation of potential materials for use on the ATM is continuing. All materials are tested in accordance with the Materials Management Plan for ATM contamination. To be acceptable a material must have a maximum rate of weight loss during temperature cycling from 25 to 100°C which does not exceed 0.2 percent/cm^2/hr.

Sixteen materials were tested in vacuum (10^{-7} torr) to 100°C with periodic mass spectrographic determinations being made. Materials of particular interest with test results are as follows: Dyna Damp P.C. board, glass filled diallylphthalate connector, microdot connector (rubber insulation), Stycast 2850GT and laminated plastic sheet, type EG all showed excellent stability to 100°C with no weight loss indicated. RTV-118 is stable to 100°C with maximum rate of weight loss occurring in the interval from 80° to 100°C. The saddle adhesive is unacceptable because its rate of weight loss exceeds the maximum allowable. Silastic 140 is very stable to 100°C with the rate of weight loss being constant from ambient to 100°C. Stycast 1090 is an acceptable material with a varying rate of weight loss occurring from ambient to 100°C. EX 1663 is also a stable material with weight loss indicated only at ambient and 100°C.

Testing has been initiated in the determination of the redeposition characteristics of materials which have evolved or vaporized under the influence of reduced pressure and elevated temperature. These redeposition tests are performed in an oil-free vacuum system. The system is evacuated by sorption, ion, and titanium sublimation pumping. The sample is mounted on a heater 3 inches below the quartz crystal microbalance (QCM). A glass slide is located adjacent to the QCM and at the same distance as the QCM from the sample. The slide will be used for making resistance and total thickness measurements.

Three redeposition tests were made during this report period. A sample of Epon 828 was heated to 221°C at 10^{-7} torr over a 50-hour interval. Microscopic inspection of the slide showed that there was no deposit. PR-1538 was heated to 148°C at 10^{-6} torr in 26 hours. A film thickness of 400Å was measured with an angstrometer. The slide had a resistance of 5.9×10^{10} ohms in vacuum at ambient temperature. During the heating cycle the resistance exceeded the range of the measuring bridge. At the end of the test the resistance was 5.8×10^{11} ohms in air. This indicates that some of the film revaporized and/or water vapor on the film lowered its resistance within the range of the bridge. Sylgard 182 was heated from ambient to 195°C on 27 hours. Inspection of the slide indicated that a very thin film was deposited but a step could not be located with an angstrometer. The film was estimated to be less than 50Å in thickness. The slide resistance in vacuum was 3.6×10^{10} ohms and 6.3×10^{10} ohms at 190°C.

Redeposition tests will be continued on prospective ATM materials.

B. Investigation of the Cleanliness of the Space Environment Simulation Chamber

One of the requirements of the ATM program is that the completed ATM undergo systems checkout in a simulated space environment prior to flight. In order to assure that the test environment does not adversely effect the ATM, tests must be made to assure the cleanliness of the test chamber.

Samples for determining the cleanliness of chamber A at the Space Environment Simulation Laboratory at Manned Spacecraft Center (MSC) are being fabricated. Personnel at this Center, at MSC, and at the Naval Research Laboratory have requested a total of 169 test specimens to go in chamber A. Additional test specimens will be supplied by the principal investigators.

A thermally controlled sample test fixture has been designed and two of these units are being fabricated. The experiment requires that the optical samples be covered during the portion of the experiment that the solar array is off. A shutter mechanism is being designed for covering and exposing the optical samples as required during the solar cycle.

Four instruments will be employed to monitor chamber A during the cleanliness test: (1) a crystal oscillator for film thickness deposit determinations, (2) a discharge gauge for pressure measurements, (3) a hot cathode ion gauge for pressure measurement, and (4) a nude source residual gas analyzer (RGA). These instruments are normally equipped with ten-foot cables between the sensor and control unit.

For these instruments to be used in chamber A a cable length of 50 to 75 feet will be required. The film thickness monitor and discharge gauge have been modified (in-house) for use with the required cable length. Inquiries directed to the manufacturer concerning this problem with the RGA indicates that in-house modification can extend the cable length to 40 feet without adversely affecting performance. Modifications to the nude ion gauge installation are presently being made.

C. Study of Thermal Control Surfaces and Materials for ATM

Evaluation of thermal control coatings for application on the Apollo telescope mount has continued. As reported previously, S-13G and Z-93, zinc oxide pigmented paints, developed by the IIT Research Institute have the requisite outgassing and optical property characteristics for applications where low solar absorptance (α) and high emittance (ϵ) coatings are required. For applications where a paint with high α and ϵ values are required, CAT-A-LAC flat black paint No. 463-3-8, manufactured by Finch Paint and Chemical Company, is recommended. Although the outgassing characteristics of the above coatings are acceptable when cured by the recommended procedures, from an application standpoint, it would be desirable to change the curing cycles for some applications. Studies are presently underway to determine if the requisite outgassing characteristics of the paints can be maintained when cured by other and more desirable procedures.

D. Investigation of ATM Bearing Lubrication

To protect moving parts of the Apollo Telescope Mount lubricants will be required which will not break down or outgas in the environment of outer space. During this period tests were made on size 203 ball bearings oscillating $\pm 5°$ under a 30-pound thrust load at a pressure of 10^{-8} torr. All test bearings were provided with reinforced Teflon retainers and with MLF-5 and Vitro Lube dry film lubricants applied to the bearing races. All bearings completed approximately 250,000 oscillations and the results are being evaluated. These tests should complete the series.

Work being done on the inertial system control gimbals at Midwest Research Institute under contract NAS8-21165 indicates that the bearings and gears for this system can be successfully lubricated with dry film lubricants. A torque drive test fixture for this system was delivered to this laboratory for vacuum testing; however, checkout tests indicated that the bearings in the fixture were misaligned and the system was returned to the Bendix Company for repair. As of this reporting period the test fixture has not been returned.

VIII. Nuclear Ground Test Module

In-house and contractual studies are being pursued to develop the materials technology required to support the Nuclear Ground Test Module Program. Specifically, the areas of cryogenic insulation, valve seals, transducer materials, gimbal and bearing lubricants, and induced neutron activation are being investigated.

The new liquid hydrogen (LH_2) cryogenic insulation test ... fabricated by General Dynamics/Fort Worth (GD/FW) was shipped to this Center for application of the spray foam insulation where it was insulated with CPR 385-2 spray foam and shipped back to GD/FW for environmental testing during the week of August 20. The test environment to which the CITD, will be subjected will consist of nuclear radiation (2×10^{10} ergs-gm^{-1} (C)) acoustic excitation (140 db), and cryogenic temperature (-423°F).

The drawings for the shrouds and other modifications required to prepare the RIFT tank for the radiation tests to be made under contract NAS8-18024 have been completed by Structures Division and the fabrication of hardware will be initiated the last week in August. The instrumentation to be evaluated using this tank has been determined in cooperation with the Astrionics Laboratory and the Propulsion Division. Both discrete and continuous type LH_2 level sensors and several types of pressure transducers have been selected for evaluation. A fill and drain valve (NAN S-II 10-inch valve) has been procured by Propulsion Division for testing on the RIFT tank. The other valve to be evaluated is the Whittaker 17-inch LOX prevalve. Currently, the Narmco Division of Whittaker is modifying this valve for use in a nuclear radiation - LH_2 environment. In-house irradiations of candidate valve seal materials supplied by Narmco now are in progress. The dry film lubrication of critical parts of this valve will be done by Midwest Research Institute under contract NAS8-21165 with this division.

Activities have continued under contract NAS8-21031 with IIT Research Institute (IITRI) in the computation of neutron induced activation of mater on or adjacent to the NGTM. These computations are being made by means of a computer program developed earlier for this division by IITRI.

The results of the spectrographic analysis of specimens of aluminum al 2219 -the alloy proposed for fabrication of the NGTM propellant tank - wer fed into the computer code. The pre-irradiation isotopic composition of 2219 aluminum was obtained by assuming the naturally occurring isotopic abundances for the elemental composition, and estimating an alloy density of 2.85 g/cc (171.5 lb/cu.ft.). The radioisotopic atom densities, gamma source strengths, dose rates, and dose are all directly proportional to estimated density. Therefore, the effect on these quantities of a chang in the alloy density may be evaluated accurately and quickly by a simple multiplication.

The neutron spectrum and flux of the GD/FW ASTR reactor were fed ir the code as the activation source. Neutron energy group limits used w 8.1, 2.9, 1.5 and 0.85 MeV, 10 keV, 0.414, and 0.001 eV. By assuming a 1/E energy dependence, the neutron flux integrated over energy from 0.48 eV to ten keV is estimated as 7.56×10^5 neutrons/cm^2-sec-watt. result is an overestimate of the actual integrated flux spectrum for energy range. This was partially compensated for by increasing the e range without increasing the integrated spectrum, i.e., the integral between 0.414 eV and ten keV was assumed to be 7.56×10^5 neutrons/cr sec-watt. All the input energy limits and integral flux values were automatically adjusted by the computer program to be consistent with neutron energy group structure in the NAP Cross Section Library.

The computer output is appropriate to one cubic centimeter of 2219 aluminum alloy placed at position D4 on rack No. 1 in the irradiation test cell of the ASTR. The reactor power level was assumed to be ten MW for four hours. No neutron flux spatial dependence was accounted for, i.e., it was assumed that all portions of the alloy were exposed to the same number of neutrons.

The gamma ray dose rate and dose given in the computer output is that dose rate (and dose) which would be measured by a detector situated ten centimeters from the center of the alloy sample, assuming no gamma ray self-absorption in the sample and that the sample may be regarded as a point source.

Neutron flux depression in the interior of the alloy sample is not expected to alter materially the results obtained thus far. This is because epithermal (rather than thermal) neutrons are responsible for most of the induced activity. This effect, along with consideration of neutron thermalization within the sample, should be considered when a more definitive description of the alloy sample is available. Gamma ray self-absorption within the sample can be expected to decrease the calculated dose rate and dose no more than 10-20 percent.

A number of preliminary computer runs were performed to determine which isotopes initially present in the alloy do not lead to production of gamma-emitting radioisotopes, and the number and duration of time intervals required to depict accurately the change in gamma ray source strengths as a function of time after irradiation.

Seven gamma ray energy groups were used in computing gamma ray strength. Radiation in energy group 1 (4.0 to 3.0 MeV) is due entirely to Mn-56 activity; group 2 (3.0 to 2.0 MeV) to both Na-24 and Mn-56; group 3 (2.0 to 1.7 MeV) to Al-28 and Mn-56; group 5 (1.5 to 1.0) to Na-24, Mg-27, V-52, Fe-59, Cu-64, and Zn-65; group 6 (1.0 to .8 MeV) to Mg-27, Mn-54, and Mn-56; and group 7 (0.8 to 0.1 MeV) to Mg-27 and Fe-59. No photons are found emitted in group 4 (1.5 to 1.7 MeV).

The dose rate has been calculated assuming a source-detector separation of ten cm, no gamma ray attenuation, and a cubic centimeter of aluminum acting as a point source. The most significant contributors to the activity (and their predominant gamma ray energies) are:

Radioisotope	Halflife (min)	Gamma Energy (MeV)
Al-28	2.31	1.78
Mn-56	154	2.12, 1.81, 0.845
Cu-64	780	1.34
Zn-65	3.5×10^5	1.11

The total dose attained in thirty days after irradiation is 19.3 rads, of which more than 80 percent is achieved in the first two days.

I. Contract Research

Supporting research activities have continued in the areas of technology and with the contractors as specified as follows:

A. Polymer Development and Characterization

1. Southern Research Institute, NAS8-20190
2. National Bureau of Standards, Government Order H-92120

B. Adhesive Development

1. Narmco Research and Development, NAS8-11068
2. Monsanto Research Corporation, NAS8-11371, NAS8-20402, NAS8-20406

C. Developmental Welding

The Boeing Company, NAS8-20156

D. Thermal Control Coatings

The Boeing Company, NAS8-21195

E. Physical and Mechanical Metallurgy

Battelle Memorial Institute, NAS8-20029

F. Composite Material Development and Testing

1. Solar, Division of International Harvester, Inc., NAS8-21215
2. Mitron, Research and Development Corporation, NAS8-20609
3. McDonnell Douglas Corporation, NAS8-21083
4. Babcock and Wilcox Company, NAS8-21186

G. Lubricants and Lubricity

1. Midwest Research Institute, NAS8-21165
2. The Boeing Company, NAS8-21121

H. Corrosion in Aluminum and Steel

1. Aluminum Company of America, NAS8-20396
2. National Bureau of Standards, GO-H2151A
3. Northrop Corporation, NAS8-20333
4. Tyco Laboratories, Inc., NAS8-20297
5. Kaiser Aluminum and Chemical Company, NAS8-20285
6. North American Aviation, Inc., NAS8-20471
7. Hercules, Inc., NAS8-21207

I. Explosion Hazards and Sensitivity of Fuels

Standard Research Institute, NAS8-20220

J. Synergistic Effects of Nuclear Radiation, Vacuum, and Temperature On Materials

1. General Dynamics Corporation, NAS8-18024
2. Hughes Aircraft Company, NAS8-21087
3. IIT Research Institute, NAS8-21031

K. Instrument Development

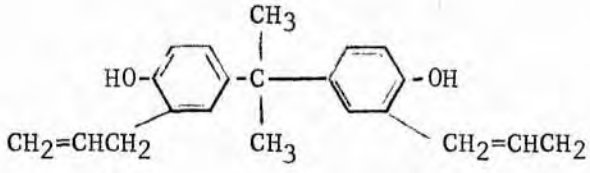
1. Battelle Memorial Institute, NAS8-11891
2. Canadian Commercial Corporation, NAS8-20529

II. General - In-House

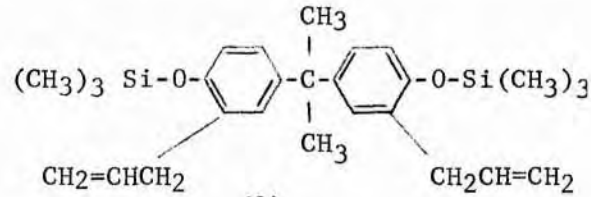
A. Development of High Temperature Resistant Polymers

Activities have continued in the development and evaluation of high temperature resistant polymers. Specific emphasis has been directed toward development of improved crosslinking systems for the polyaryloxysilane and polymers of related structure. The preparation of a low molecular weight, amine-terminated aryloxysilane polymer has been attempted in order to provide a highly crosslinkable system. The polymer has a calculated degree of polymerization of 2-3 and the molar proportion of amine groups present is approximately 10 times greater than in the previously prepared polymer of this type. Further evaluation of this material will be carried out after molecular weight analyses are completed. The optimum form of this type of polymer appears to be that of sufficiently high degree of polymerization to retain toughness in the cured polymer, together with sufficient amine group concentration to result in a relatively high crosslink density.

The model compound study relating to unsaturated polyaryloxysilanes has continued with preparation of two additional compounds:



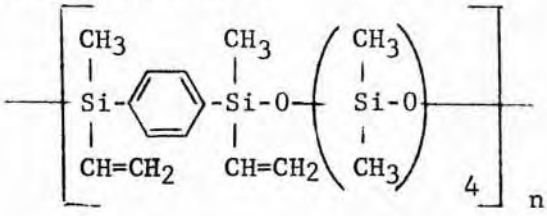
(1)



(2)

Compounds (1) and (2) complete the series of structures originally proposed for study of the silicon hydride crosslinking reaction. In the event that crosslinking studies involving compound (2) prove favorable, compound (1) can be incorporated directly into the aryloxysilane polymer chain to provide convenient crosslinking sites.

Crosslinking studies of the silphenylene-siloxane polymer have continued for ultimate application of the material represented in the following structure:



as a conformal coating. The preparation of this polymer was initially described in previous reports.

An evaluation of the silicon-hydride crosslinking reaction is being carried out utilizing model compounds, which are more readily obtainable than the polymer itself. A study of the reaction between phenyldimethylhydrogensilane and phenyldimethylvinylsilane should provide an indication of the crosslinking conditions necessary to cure the vinyl-containing polymer.

B. Development and Characterization of Phosphonitrilic Polymers

Studies have been directed toward the characterization of the product obtained when 2,4,6,8-tetrachloro-2,4,6,8-tetramethylcyclohexylaminophosphazine is treated with phenyl magnesium bromide in refluxing butyl ether (Bu_2O):

$$P_4N_4Cl_4(CH_3NC_6H_{11})_4 + 4\ \text{Ø}MgBr \longrightarrow P_4N_4\text{Ø}_4(CH_3NC_6H_{11})_4 + 4\ MgBrCl.$$

The slightly yellowish oil obtained from a typical preparation was purified by chromotography on alumina (benzene) and subjected to elemental analyses. The resulting C, H, and N values were inconclusive because of the difficulty encountered in the analyses with complete oxidation of the sample in the combustion train. However, the P value (Na_2O_2 fusion method) obtained was 12.52 percent as compared with a theoretical value of 13.22 percent. Furthermore, the log ratio of the tetrameric PN ring absorption band at 1280 cm^{-1} to the phenyl absorption band at 695 cm^{-1} was 1.63 for the oil and 1.67 for a known sample of β-trans $P_4N_4\text{Ø}(CH_3NC_6H_{11})_4$. At this time evidence tends to indicate that ring phenylation occurred in the Grignard reaction and that the resultant product is an isomeric mixture of the desired compound.

Proceeding on the assumption that the isolated oil is the tetraphenyl derivative, reactions were investigated which effect replacement of the N-methylcyclohexylamido groups with Cl atoms (viz.):

$$P_4N_4\text{Ø}_4(CH_3NC_6H_{11})_4 + 8\ HCl \longrightarrow (\text{Ø}PNCl)_4 + 4\ \text{amine}\cdot HCl.$$

The most promising procedure evolved during a number of experiments calls for the use of a pressure reaction vessel and glacial acetic acid solvent. In a typical experiment a portion of the oil was dissolved in acetic acid and the resultant solution saturated with anhydrous HCl. The acidified solution was transferred to a pressure bottle equipped with a Teflon gasket and the enclosed system heated in a boiling water bath for two hours during which time separation of solid occurred. The cooled solution was concentrated in vacuo and the residue triturated with acetonitri Solid was separated by filtration and the filtrate evaporated to dryness leaving a dark colored oil whose infrared spectrum showed no PN ring absorption. The solid obtained from the reaction is being characterized. However, solubility tests indicate that replacement of the amido groups probably did not occur, but rather salt formation took place:

$$P_4N_4\emptyset_4(CH_3NC_6H_{11})_4 + n\ HCl \longrightarrow P_4N_4\emptyset_4(CH_3NC_6H_{11})_4 \cdot n\ HCl$$

In another approach to the preparation of non-geminally substituted phosphonitrilic chloride derivatives, tetramer was treated with four equivalents of α-naphthyl-magnesium bromide in Bu_2O:

$$(PNCl_2)_4 + 4\ C_{10}H_7\ MgBr \longrightarrow P_4N_4Cl_4R_4 + 4\ MgBrCl.$$

The product isolated from the reaction was an oil which failed to crystallize. Dissolution of the oil in tetrahydrafuran followed by exhaustive monomethylamination gave rise to the separation of methylamine hydrochloride which was collected and weighed. The weight of the separated salt indicated that only three Cl atoms had been initially replaced in the Grignard reaction. This reaction was not investigated further.

C. Investigation of Metallic Composites

Activities have continued in the development and evaluation of wire reinforced metallic composites. During this reporting period emphasis was directed toward a composite consisting of beryllium wire (0.005 inch diameter) in a matrix of magnesium (AZ91C alloy). The composite specimens were formed by vacuum infiltration of molten magnesium into a bundle of the beryllium wires as described in previous reports. Three specimens were prepared and evaluated as indicated below.

Test No.	Infiltration Temperature	Volume Wire, %	Strength to Density Ratio	Failure Mode
1A	1500°F	21.2	0.45×10^6	Normal
1B	1250°F	21.2	-	Failed in Jaws
2A	1400°F	To be determined	0.48×10^6	Wire pullout

It is interesting to note that the strength to density ratio for the beryllium wire-magnesium composite exceeds that recorded for similarly prepared steel wire-magnesium composite, i.e., Be wire-Mg = 0.45×10^6 versus steel wire - Mg = 0.375×10^6 (for approximately the same volume of wire).

D. Investigation of Stress Corrosion Characteristics of Various Alloys

Tests are continuing on aluminum 7001-T75 to determine the threshold stress level in the short transverse and longitudinal grain directions. Round threaded-end tensile specimens stressed in the longitudinal grain direction to 70 percent (60 ksi) of yield strength and stressed short transverse specimens to 44 (30 ksi) and 37 (25 ksi) percent are being tested in the alternate immersion tester using 3.5 percent sodium chloride solution and synthetic sea water. There have been no failures after 14 days of exposure in either solution.

Studies have continued in the evaluation of the stress corrosion susceptibility of aluminum vehicle components under semi-controlled conditions. Bare and chromic acid anodized round tensile specimens of 2014-T6, 2024-T4, 7075-T6, and 7079-T651 were stressed in the short transverse grain direction to 75 percent of their yield strength and exposed to inside and outside atmospheres. Failures to date have been confined to the outside atmosphere and there has been no change in the test since the last report. The test has been in progress for 128 days.

Specimens of aluminum alloys X2021 and X7007 were stressed in all three grain directions and exposed in the alternate immersion tester and to the local atmosphere. Both alloys were found to be susceptible in the alternate immersion tester. Tests in the atmosphere have been in progress for 18 months and the only failures encountered were with X7007-TE136 specimens stressed in the short transverse direction at loads as low as 10 ksi.

Studies have continued into the stress corrosion susceptibility of Ti-6Al-4V alloy in various fluids. No failures have occurred in any of the fluids except methyl alcohol. Specimens that had not failed in methanol containing 0.50 and 1.0 percent water for 176 days failed within two days after the addition of 16.5 ppm sodium chloride (10 ppm cl). Specimens exposed to methanol containing 3.0 percent water for 176 days have not failed in 79 days after the addition of 66 ppm sodium chloride.

Additional tests to evaluate the stress corrosion resistance of NAA, General Electric, and Aero Quip type stainless steel fittings welded and brazed to 321 stainless steel tubing have been exposed in the alternate immersion tester for 143 days without any failure. These tests will be terminated after 180 days.

Arde low silicon 301 stainless steel cryogenically stretched to a nominal 240 ksi, is being studied for stress corrosion susceptibility in the aged (20 hours at 790°F (421°C) in air) and unaged condition. The specimens were passivated according to an Arde specification (AZ8454 Solution A). Longitudinal specimens stressed to 75 percent of the yield strength (unaged 184 ksi and aged 196 ksi) have not failed after 165 days in the alternate immersion tester. Additional welded and aged (20 hours at 790°F (421°C)) Arde low silicon 301 stainless steel cryogenically stretched to a nominal 252.6 ksi is being tested for stress corrosion susceptibility. The weld was made with full penetration, TIG per Arde AES 501 using Argon gas backup. After machining, each specimen

was liquid cleaned per AES 253, annealed per AES 351, pickled per AES 251 and passivated per AES 254, Solution A. Longitudinal specimens stressed to 75 percent (189.8 ksi) and 90 percent (227.7 ksi) of the yield strength have been exposed in the alternate immersion tester for 19 days without failures.

E. Investigation of Organic Semi-Conductor Materials

Experimental studies have continued in the establishment of the characteristics of the semi-conductor, chrysene.

The results of the analysis of electrical conductivity data on single crystals of chrysene, $C_{12}H_{18}$, show a change in conduction mechanism at approximately 31°C. The activation energy is approximately 3.4 ev in the region from 10° to 31°C whereas above 31°C to approximately 50°C the activation energy is approximately 2.0 ev.

Bulk photoconductivity measurements are in progress. Plans call for an investigation of intensity, voltage, spectral response and temperature dependence of the photocurrent. Spectral response of the photocurrent will be determined over the absorption spectrum range from 2000Å to 4500Å provided the intensity of the continuous source (tungsten lamp) is great enough. Calibration of intensity has been made for the tungsten lamp by comparing it to a standard lamp through the use of a photomultiplier microphotometer having an S-5 response.

F. Development and Evaluation of Light Weight Ceramic Foams

Efforts have continued to improve the pore structure and strength of the silicate-based foams by restricting and controlling growth during foaming. Strong molds were designed and fabricated to accommodate a predetermined amount of the foam mix required to produce a foamed specimen of the desired density. The foam mix was poured into the mold and the cover of the mold secured firmly. The mold was then placed in the oven at 188°C (370°F) for 5 hours to accomplish foaming. Foams produced in this manner contained some soft spots. These soft spots appeared to be due to variation in the foaming rate during the early stages of foaming. In efforts to overcome the uneven foaming, the foam mix was dried in the open mold at 74°C (165°F) for 16, 24, 48, and 72 hours prior to foaming at 188°C (370°F). This technique appeared to be effective in controlling foam structure. Good foams were produced when the foam mix was dried for 24 hours or longer. Water content of the foam mix changed very little beyond the 24-hour drying period. Some difficulty was encountered in removing the foams from the molds. Efforts will be undertaken to devise a method of mold release and to scale-up the size of the foam specimens produced.

A series of phosphate-bonded foams was investigated using silica microballoons as an inert, lightweight filler, monoaluminum phosphate as the binder, and aluminum powder as the foaming agent. Although these foams were characterized by good strength, they were relatively dense (20-25 lbs/f Attempts to reduce the density of the foams by varying the ingredients were unsuccessful.

G. Investigation of Electroplating Processes

1. Electroplating on Anodized Aluminum

Several test panels were nickel plated by the conventional zincate method and by an "anodizing" method (in a mixture of sulfuric and phosphoric acids). Although good adhesion, appearance, etc. was achieved by the anodizing method, subsequent corrosion tests in a 5-percent salt spray indicated that the corrosion protection afforded was not as good as that afforded by the zincate method. These results are contrary to literature reports. This work will be discontinued for the present time.

2. Electroplating on Magnesium - Lithium Alloys

In the last progress report, it was reported that a 6-percent (by volume) nitric acid pickle appeared to be the most promising surface preparation prior to plating this alloy (LA141). Work has continued using this pretreatment. Although the results are still somewhat erratic, panels have been successfully plated which had plating adhesion bond strength in excess of 4300 psi. This is greater than bond strengths of platings reported by other researchers. The bonding strengths were determined by using organic adhesive bonding techniques followed by a conventional pull test.

3. Evaluation of the "Alstan 70" Process

Work has continued on the evaluation of the "Alstan 70" process which has been reported to be favored over the conventional zincate method for plating on aluminum. Previous work has not been satisfactory from either a plating or a corrosion protective standpoint. New "Alstan 70" materials were obtained and subsequent work has revealed surprisingly good results with respect to plate adhesion, appearance, etc. Additional panels are being prepared for corrosion tests. The indications are that the "Alstan 70" bath materials originally received were not correctly formulated or had deteriorated prior to use.

H. Investigation of Thin Film Dielectrics

Thin film capacitors using silicon monoxide (SiO) dielectrics were prepared and studied electrically over the temperature range 25°C to -195°C (LN_2). With reference to capacitor and dissipation values at 25°C, the average capacitor coefficient varies from 0.016 percent/°C to 0.034 percent/°C and the average dissipation coefficient has been found to be approximately 0.4 percent per °C. In agreement with recently published data, the breakdown voltage increases slightly as temperature decreases from +25°C to -195°C.

Aluminum-cerium oxide-aluminum (Al-CeO_2-Al) capacitors have been prepared by vacuum evaporation using a tungsten boat for the CeO_2 deposition. Cerium oxide was deposited at 3-5 Å/sec. (at a 12-inch source-to-substrate

distance) onto unheated microscope slides. X-ray diffraction shows the resulting films are polycrystalline CeO_2 (face-centered cubic). No free cerium or other cerium compounds were detected. These capacitors are similar to Al-SiO-Al but have a much higher dissipation factor, much higher dielectric constant and somewhat lower breakdown voltage. Measurement of dissipation factor versus temperature shows a peak occurring at about -90°C. Capacitance decreases almost linearly to a temperature just below that for the dissipation factor peak and then changes very little from there down to -195°C. In the region of rapid change in capacitance the capacitor coefficient is 0.48 percent/°C to 0.95 percent/°C relative to the capacitance at +25°C. These values are over an order of magnitude greater than those for Al-SiO-Al capacitors. The capacitance generally decreases slightly when the capacitors are subjected to vacuum. Leakage current at +25°C in a capacitor with a 4700Å thick dielectric varied from 5 μa at one volt to 620 μa at ten volts.

Copper-silicon monoxide-aluminum (Cu-SiO-Al) capacitors have been fabricated with a very thick bottom electrode (copper-3-5 microns). The copper electrode should serve as a shield so that a microprobe analysis of breakdowns may be made. Determination of the location of crystalline silicon produced by breakdown should indicate its role in the onset of breakdown.

Aluminum-cerium oxide-aluminum (Al-CeO_2-Al) capacitors are to be microprobe scanned in a similar fashion as Cu-SiO-Al in search of breakdown center defects.

Efforts to sputter aluminum oxide (Al_2O_3) and titanium oxide (TiO_2) from anodized metal plates have been unsuccessful. The regions near the edge of the source seems to sputter more rapidly. Successful evaporation of these by sputtering will probably require a thicker source material.

A 1/8-inch thick Teflon source was sputtered and yielded a 7500Å film in 45 minutes. With a capacitance of 7.80 nf and dissipation factor of 0.0054 at 25°C the dielectric constant was 1.10. Capacitance and dissipation factor show very little change from +25°C to -195°C. Breakdown voltage was about 75 volts corresponding to an average field of 1×10^6 v/c

I. Development and Evaluation of Materials for Electrical Contacts in Vacuum

Electrical contacts in vacuum concerns any device for transferring electrical energy through moving contact surfaces, such as brushes, slip rings, and make-break switches. Standard brush-commutator type machines suffer a severe degradation of performance at high altitudes, principally due to rapid wear of the graphitic carbon brushes. This results from failure of the normal process of lubrication of the contact surfaces. Therefore, this program was initiated to develop electrical brushes for use in a space environment.

One of the characteristics required in a good brush is the ability of the brush to furnish a lubricating film so as to minimize wear of the commutator and at the same time remove any substantial film buildup. In previous work with the MoS_2-Ag system, an erratic failure mechanism prevented the material from attaining the requisite reliability for space applications. The failure mechanism was apparently triggered by the build-up of a heavy film of MoS_2 on the commutator surface. It is believed that control of the commutator film thickness by a third component will provide reliable operation of the material.

A three-component system of MoS_2-Ag-silicon carbide (SiC) is being studied. For the initial work, the basic composition 85 MoS_2-15 Ag (volume percent basis) with additions of 8 and 15 percent SiC has been hot pressed. Hot pressing presents no problems; the SiC acts as an inert filler. Brush specimens are being prepared from these materials. If the SiC proves to be too abrasive for the commutator, a material of lower hardness, such as molybdenum disilicide, will be substituted for the SiC.

J. Documentation Review

The following specifications, documents, or reports were reviewed, and comments were forwarded, where appropriate, to responsible individuals or organizations:

1. 1P20115, "Gas Shielding, Helium, for Welding," dated January 18, 1967.

2. 60B32032, "Radiographic Inspection: Soundness Requirements for Fusion Welds in Aluminum and Magnesium Missile Components," dated April 6, 1964.

3. MA0107-016F, "Machine Fusion Welding of Aluminum Alloys for Saturn S-II Vehicle," dated February 21, 1967.

4. 1P00125, "Radiographic Inspection: Soundness Requirements for Fusion Welds in Aluminum and Magnesium Alloys," dated May 2, 1966.

5. 1P00128, "Mechanized Fusion Welding of Titanium Alloys," dated June 7, 1967.

6. 1P20121A, "Wire, Welding, Spool Type, Aluminum Alloy 4043."

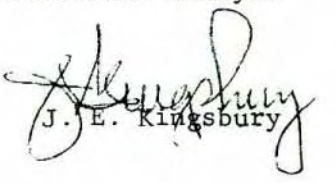
7. MSFC-PROC-281, "Weld, Low Alloy, High Strength, Structural Steel," dated August 1, 1967.

8. MSFC-SPEC-259A, "Radiographic Inspection: Soundness Requirements for Fusion Welds in Aluminum and Magnesium Alloy Sheet and Plate Material," dated April 9, 1965.

K. Literature Survey

Surveys of the pertinent literature have been initiated as are continuing on the following subjects:

1. Radiation effects on engineering materials
2. Vacuum effects on engineering materials
3. Lubricants and lubricity
4. High and low temperature resistant polymers
5. Stress corrosion on structural alloys.



J. E. Kingsbury

MONTHLY PRODUCTION REPORT

MATERIALS DIVISION

AUGUST 1, 1967 THROUGH AUGUST 31, 1967

I. Radiography

Seventy-six miscellaneous parts, components, and test specimens were inspected by radiographic techniques during this report period.

II. Photography

	Negatives	Prints
Engineering photography	40	172
Metallography and fractography	40	221
Miscellaneous photography, processing copywork, etc.	45	125

III. Metallurgical and Metallographic Testing and Evaluation

A. Two additional snap diaphragm test assemblies were electron beam welded for the Propulsion Division. The first design, utilizing an AISI type 301 stainless steel diaphragm, did not maintain the desired concavity during electron beam welding. The second design, utilizing an Inconel X diaphragm with a preformed 0.015-inch concavity, showed only a slight deformation as a result of the welding heat input.

B. The addition of electroplated copper at the abutting edges, reportedly, is a feasible technique for radiographically detecting lack of fusion in aluminum alloy plate weldments. A study is being made to evaluate this technique and the effect of the additional copper on the weldment mechanical and metallurgical characteristics. Panels were prepared from aluminum alloy 2014-T6 (5/8 inch thick plate) using a square butt joint, 4043 filler metal, two passes (one each side), and the TIG process. Radiographs have been made of these panels with intact bead. The panels have been submitted to the machine shop for removal of weld bead to a height of 0.010 inch. After bead removal, the remaining evaluations on these weldments will be made.

IV. Spectrographic Analyses

Ninety-eight determinations were made on eight samples and one hundred and sixty standard determinations were made.

V. Infrared Analyses

Thirty qualitative analyses were made by infrared techniques on a variety of materials including experimental and commercial polymers, paints, and oils.

VI. Chemical Analyses

	Determinations
Chromic acid anodize solution for	
aluminum	2
sulfates	2
chlorides	2
honeycomb cleaning solution for	
iron	2
aluminum	2
copper	2
chromium (trivalent)	2
igneous rock samples for	
iron	10
magnesium	10
sodium	10
silicon	10
polymeric samples and intermediates for	
nitrogen	10
silicon	10
chlorine	2
ash	2
magnesium	1
phosphorus	6
steel for carbon	3
titanium for	
hydrogen	8
oxygen	8
gas samples for	
methane	28
ethane	28
propane	24
butane	24
carbon dioxide	65
hydrogen	79
nitrogen	30
oxygen	30
argon	30
freon	30
carbon monoxide	1

VII. Physico Chemical Analyses

density of RP-1	10
molecular weight of experimental polymers	4

VIII. Rubber and Plastics

	Items
molded and extruded	56
coated	130
cemented	50
fabricated	2

IX. Electroplating and Surface Treatment

	Items
acid cleaned	113
cleaned for LOX tests	1600
anodized with Dow 17	8
anodized	12
stripped tin plate from wire braid	6 feet

X. Development Shop Production

A. A total of 9,786 man-hours, direct labor, was utilized during this period for machining, fabricating, and welding.

B. Three thousand five hundred and sixty-five man-hours, approximately 36.4 percent of the total man-hours, were expended on work of a non-routine nature and applied to the work orders listed below.

1. Six-Inch UV Camera Assembly

Assembly of the second 6-inch UV camera assembly is held up pending design.

2. X-ray Astronomy Assembly

This X-ray astronomy assembly is complete and delivered.

3. Coupling Assembly

The coupling assembly is approximately 30 percent complete.

4. Saturn V Sled Test Module

The Saturn V sled test module is approximately 35 percent complete.

5. Spherical and Roller Bearing Assemblies

The spherical bearings have been delivered and the roller bearings are 50 percent complete.

6. Models of ATM Experiment Package

This work is held up because of funding problems.

7. Simulator Mass Neutral Buoyancy - Saturn V

Work on this job has been started.

8. PM/Rack and 1/10 Scale Model

Work on this order is 30 percent complete.

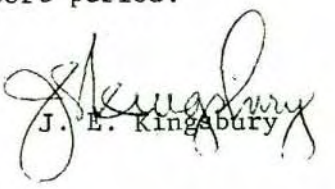
9. Meteoroid Test Specimens

This work is complete and delivered.

XI. Miscellaneous

A. Twenty materials were evaluated in accordance with the provisions of MSFC-SPEC-106B. Data generated from these evaluations were forwarded to requesting groups and will appear later in applicable reports.

B. Thirty-four items of stainless steel and five items of tool steel were heat treated during this report period.



J. E. Kingsbury

GEORGE C. MARSHALL SPACE FLIGHT CENTER

PR-P&VE-P-67-8

MONTHLY PROGRESS REPORT

PROPULSION DIVISION

August 1, 1967 through August 31, 1967

SATURN IB

I. S-IB Stage

A. H-1 Engine Stability Testing

Testing at MSFC was started to investigate the combustion stability problems encountered at Neosho during the production sampling program. Additional out-of-specification instabilities have occurred during testing at Neosho. The specification states that the bomb-induced instability should be self-damped within 100 milliseconds. Three bomb tests were conducted at a thrust level of 207K at MSFC, all of which have self-damped in 35 milliseconds or less. Additional testing will be conducted at the 210K thrust level.

B. S-IB-4 Gimbal System Sampling

Fluid samples were taken from the gimbal systems on engine positions 2 and 3 of the S-IB-4. Analysis of these samples revealed the same type of small particle contamination as was found in the S-IB-10 systems. The systems were purged with the ground hydraulic servicers and refilled. However, there is a question about the effectiveness of the purging operation. Although the systems on the S-IB-10 were flushed prior to static firing, post static samples still showed contamination in the size range below 10 microns. It was requested that closed loop samples again be taken from the S-IB-4 systems to determine the effectiveness of the cleaning operation at the Cape.

C. Minuteman Strap-on

The Minuteman Wing VI solid propellant rocket motor is being evaluated as a strap-on booster for the S-IB vehicle. These studies established a tentative qualification program for the strap-on application. Based on the informati available, the Minuteman can be man-rated within the time available for the program. Further analysis will be required to define the qualification temperature and vibration limits and to establish a test program.

II. S-IVB Stage

A. S-IVB-205 Final Flight Prediction Received

This prediction is being verified for adequacy.

B. Orbital Workshop

The study on the OWS compressor for experiment support showed that a compressor system is not feasible because of schedules and power requirements.

Fluid requirements for AAP-2 were established to define the necessary support system.

Analyses to parametrically establish the Orbital Workshop atmosphere thermal and humidity environment as a function of attitude (solar fixed and gravity gradient), attitude dead bands, heater power and orbital inclination were completed.

SATURN V

I. AS-501 Vehicle

A. Saturn V-501 Flight Critical Components Review

The review of data and documentation on the Saturn V stages to determine the flight worthiness of the propulsion systems flight components is complete. All "Certification of Component Qualification" (COCQ) sheets are signed; except for those items which require action before Saturn V-501 roll-out.

B. Saturn V Interlock Bar Charts Completed

These charts will be used by Launch Information Exchange Facility (LIEF) personnel during the AS-501 countdown.

II. S-IC Stage

A. F-1 ENGINE

1. R&D Engine Tests at EFL

Twenty-six tests were conducted, and a total duration of 3257.4 seconds was accumulated. Eighteen of these tests were full-duration runs (150 seconds or more). One test was terminated prematurely due to gas generator combustion roughness during dual thrust testing.

2. Production Engine Testing at EFL

Ten tests were conducted and a total duration of 774 seconds was accumulated. Three of these tests were full-duration runs. One test was terminated prematurely due to the LOX inlet pressure going below the redline value.

3. Qualification of Redundant Shutdown System

Component Qualification of the Three-Way Solenoid Valve and the two lines of the F-1 redundant shutdown system was completed. Fatigue-type failures previously occurred during the pressure cycle testing of other specimens of the lines. The cause of these failures is being investigated.

B. LOX Turbopump Purge

The LOX turbopump purge capability during "power off" periods is effective with S-IC-1 and S-IC-2. A checkvalve will be installed parallel with the existing normally closed solenoid valve in these stages. Some GSE changes are also required. The need to incorporate this change for S-IC-3 and subsequent stages will be determined later.

C. LOX Tank Model Drainage Study

The model tank was modified to prevent a decrease in the flow-rate of the outboard suction lines after air entered the center suction line. Additional tests were performed to determine the flow characteristics around the center line stand pipe. The film data for these tests are being evaluated.

III. S-II Stage

A. J-2 ENGINE

1. R&D Testing at SSFL

Twenty tests were conducted, and a total of 5510 seconds was accumulated. Four of these tests were full-duration runs. Two tests were terminated prematurely due to a fuel turbine overspeed trip and failure of a fuel inlet duct bellows.

2. Production Engine Test at SSFL

Nine tests were conducted, and a total of 1590 seconds was accumulated. None of the tests were full-duration runs.

3. Helium Regulator

Testing of the J-2 helium regulator diaphragm to determine the cause of the five R&D engine failures was completed. No failures were achieved in nearly 4 1/2 times the number of cycles an engine would experience before flight. It was determined that low inlet pressures reduced the life of the diaphragm but not below a safe margin.

4. J-2S Testing

Engine J108 completed the acceptance testing. The engine is to be delivered to MSFC for testing in the S-IVB Battleship test stand.

5. J-2X Experimental Engineering Program

Fourteen tests were completed on the J-2X 015 engine for a total of 70 sec. operation. This engine, which incorporates a 40:1 expansion ratio thrust chamber, series drive turbopumps, and a turbine exhaust aspirator, is the closest to a J-2S configuration engine yet fired. Test objectives are to examine the characteristics of the higher chamber pressure 40:1 thrust chamber under tank head start conditions and limited throttle control. Firings thus far were limited to adjusting the engine start sequence and setting up the turbine exhaust aspirator.

6. J-2 Engine Timers

As a result of five timer failures (instantaneous time out) since the first of the year, failure data, timing history of timers from 13 engines, and results of test programs were examined in making assessment for AS-501. It was decided by R&DO to fly with present timers; however, replacement with timers of an interim design is considered. Forty of the interim timers have been manufactured, acceptance tested and delivered. Eight of these timers are undergoing test and should be qualified by September.

7. J-2 Engine Turbopump Propellant Leakage Excessive

Results of recent tests on numerous J-2 engine LOX turbopumps indicate that previous predicted values of interstage propellant leakage are in error. Overboard draining will be employed to prevent accumulation of oxygen.

B. Verification Tests of Three Main Pumps

Low temperature testing of the third S-II main pump was completed, and the pump is undergoing endurance testing. To date, the pump has undergone 50 hours of successful endurance testing.

C. Propellant Pre-Valve

The modified valve was subjected to acceptance, low temperature, and vibration (sine and random in the z and x axes) tests. The fail-safe did not work properly during any of the tests. Excessive leakage from the shaft seal was detected after vibration testing in the x-axis. New seals and refinements to the actuator assembly are being made. Testing will continue.

D. S-II-1 and Subs Anticipated LH_2 Flight Ullage Pressure History

The S-II LH_2 tank ullage pressure history for AS-501 and subsequent was predicted. These values will be used to determine the adequacy of the ambient temperature structural proof test and requirement for cryogenic proof tests.

IV. S-IVB Stage

A. S-IVB-504N Stage Acceptance Firing

The S-IVB-504N stage was successfully static fired for a duration of 437.6 seconds at Sacramento Test Facility. Automatic cutoff command was given at 1.0% LOX level. The following anomalies were observed post-test:

1. The LOX prevalve was slow in closing and required 1 to 2 seconds on successive attempts to close it manually.

2. An LH_2 leak was detected in the area of the LH_2 pressurization control module. Conoseals had been replaced in the module before this test.

B. Propellant Management Systems

All reported electrical failures on the S-IVB General Test Plan were reviewed. It was concluded that the chronic problems with position switches and electrical connectors were a result of inadequate quality control provisions and minor design discrepancies.

The cause of the problems encountered with the depletion sensors on S-IVB-504 was traced to a reversal of the depletion sensor and instrumentation sensor electrical connectors. The reversed connections were corrected and depletion sensor operated satisfactorily. The system will be verified during acceptance firing of S-IVB-504.

V. Instrument Unit

A. Sublimator Acceptance Test

The test setup is completed and Sublimator S/N 026 is scheduled to be tested in the Sunspot I vacuum chamber. Sublimator S/N 020 failed to meet the acceptance test requirements. The water inlet pressure was reduced by 0.4 psi and the sublimator is considered conditionally acceptable.

B. Gas Bearing Regulator

The burst testing of two gas bearing regulators, S/N 5 and S/N 13 was completed, and all tests were successful. An additional life testing on the gas bearing regulator, S/N 3 will be performed.

SPECIAL STUDIES

I. VOYAGER

A. Voyager Spacecraft Design

The propulsion system for the 140-inch diameter configuration was changed to reflect the updated mass and inertia models. The TVC system gimbal capability was expanded to $\pm$ 10° for the LEMDE and $\pm$ 20° for the auxiliary propulsion engines The attitude control modules were relocated from the outriggers to the auxiliary propulsion system structural arms (at the aft end of the spacecraft).

B. LEMD Engine Demonstration

The LEMDE Head End Assembly, which was to be used in the Dec tamination and Space Storage Tests, was acceptance tested. During acc tance tests a shift in hydraulic conductance was noted. After inspecti of the injector it was determined that two gaps had developed between t injector sleeve and the seal ring. This allowed oxidizer to flow axial in the chamber. Conditions existed that could have been detrimental to the injector: the sleeve had been reworked during Head End Assembly re bishing, this reworking may have weakened the sleeve in the area of the gap, and the LEMDE experienced a rough combustion shutdown during the acceptance tests. The cutoff signal had been received, and the thrust had dropped to between 50-20% thrust level. Pressure oscillations were noted between 20-100 psia. The probable cause of the rough combustion shutdown was a loose guide bar in the injector.

C. Propellant Settling Feasibility Study

A study was performed to estimate the propellant consumption and settling thrust durations required to properly settle propellants prior to engine starts. The settling duration is extended and propellant consumption is minimized by minimum thrust levels. The capillary devices planned for Voyager are designed for an adverse acceleration of 10^{-3} a/g_0. Therefore, a settling acceleration greater than 10^{-3} a/g_0 (50 pounds thrust) would be required to force any trapped ullage through the capillary devices.

D. Thermal Control

A mathematical model capable of calculating the effective emissivity and heat dissipation rates of a louver assembly was completed. The effects of appendages, such as solar array, capsule or antenna, can be evaluated. The model is used to assist in optimizing the solar array configuration and operating temperature and location of the electronic equipment bays.

E. Pressurization System Evaluation

Several candidate pressurization systems are being evaluated. A cold helium gas system has the advantage of being simple. The addition of a heat exchanger may reduce the system weight by 25-50 pounds but increases the complexity of the control system. Preliminary results indicate that an active pressurization system would not be required for the mid-course or orbit trim maneuver if a tank pressure variation from 230 down to 190 psia can be tolerated.

II. Apollo Telescope Mount (ATM)

A. Spar Thermal Deflection Tests

Testing was completed.

B. Cannister Insulation Acceleration and Vibration Test

The cannister is awaiting a mechanical shaker in lieu of the planned acoustic horn. Insulation requirements for the ½ scale mock-up are also awaiting further definition.

C. Quadrant IV Thermal Control Systems Test

New testing and hardware configuration requirements were determined in light of changing thermal control system concepts. Foam insulation and heaters for the cannister were designed and ordered. Insulation of the experiment packages was completed. The environmental lamp support structure was designed and fabrication should be completed soon.

D. Quarter Rack Test

A preliminary test plan was completed. Design drawings of the rack were obtained and fabrication of a quarter rack section was started. Design of a solar panel simulator and a solar shield were also completed and fabrication was started.

III. Investigation of Insulation for the Multiple Docking Adapter

An unperforated insulation panel 20" X 20" was tested under vacuum to determine the evacuation rate inside the panel. Test results indicate that the evacuation rate is not as rapid as required. Additional tests are being prepared for a perforated insulation panel.

IV. Nuclear Ground Test Module (NGTM)

A volumetric analysis of the NGTM container and the study to determine the number and location of the probes required for the NGTM propellant management and liqui level system was completed. A closed loop frequency analysis of the pressurization system was made. The regulator system presently planned is more than adequate to maintain an ullage pressure within a tolerance of ± 1.5 psia. The temperature increase of the aluminum shield to be placed between the propellant tank and the reactor, was calculated to be approximately 200°F for one-half hour of operation.

V. LEM Ascent Engine

An in-house redesign of the LEM Ascent engine injector was completed and forwarded to Bell Aerosystems. A recommendation was made to test the design in at lea one experimental injector. The injector modification minimizes welding and face warping.

VI. Investigation of Freon E-3 as a Low Temperature Hydraulic Fluid

Calibration tests were attempted on a Vickers Pump at -130°F; however, the pum compensator failed to regulate the outlet pressure at this temperature. The pressu reached 4500 psi during the test before system shutdown. The test was repeated at ambient temperatures, but the compensator still would not regulate the outlet pressure. The pump was removed and sent to the manufacturer for disassembly and inspection. A Kellog Hydraulic Pump was installed. Low temperature testing will begin upon completion of installation and checkout of the pump.

VII. Investigation of Brazed & Welded Connectors

Impulse tests were conducted on ten 3/4-inch thickwall specimens. Five 1 1/4-inch and eighteen 1 1/2-inch specimens have been proof tested. Vibration tests at 500°F were completed on two 1/4-inch specimens.

VIII. Thermal and Hydrodynamic Research

Proof and leakage tests were completed successfully on the six welded connectors.

IX. C-1 Engine

The analytical investigation of acoustic liner designs for damping the combustion instability of the C-1 engine was completed. Two basic configurations that should give good absorption over the design conditions were established.

X. Molten Seat Valve Testing

Preliminary testing of the molten seat valve was successfully completed for 50, 100, and 150 psi pressures. Leakage of better than 10^{-4} sccs was observed. Mass spectrometer testing to determine exact leakage will be used at a later date. The valve is currently being tested at 200 psi.

XI. Solar Heat Flux Simulation System

Two hundred infra-red lamps and reflectors were received for use in the Sunspot I high vacuum facility to simulate solar heat radiation. These lamps, which have a power rating of 500 watts each, can produce a solar heat intensity of near earth space on a surface area of approximately 400 square feet. A system for automatically programming power to the above lamps will be used with this system; desired profiles of heat flux, temperature, etc. may be programmed to simulate orbiting or rolling of a space vehicle. Power for up to nine banks or zones of lamps may be independently controlled.

XII. High Speed Data Acquisition Systems

The system was checked out and the training course was completed. The updated programs for system operation and the cross-connection panels and cable connection tools for input cables have not been received. The system can be used for up to nineteen inputs.

XIII. Laser Velocimeter Applications

Data for the transition region in pipe flow was taken. Numerical correlation of the skewness was completed.

ADVANCED PROPULSION TECHNOLOGY

I. Advanced Engine Aerospike Experimental Investigation

Post-test inspection of the stainless steel thrust chamber revealed general tube overheating of a number of tubes near the injector. Coolant flow was partially blocked in two tubes. Blockage was found to be caused by a piece of braze material in one case and the tip of a file used to clean the tubes in the other case. The general overheating is believed to have been caused by the injector impingement configuration. Modifications are being made to bias the injector to produce excess hydrogen coolant along the walls.

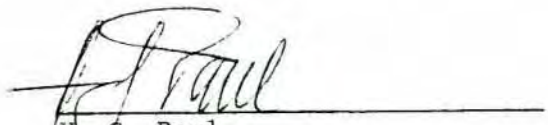
Performance data indicate the presence of chug mode pressure oscillations with a possible link with a rotating combustion pressure wave. Run conditions for these tests resulted in low propellant flow delta pressures that may have caused flow instabilities contributing to the chug oscillations.

II. Evaluation of Advanced High-Thrust Booster Propulsion Systems

The last phase of several systems analyses of toroidal aerospike and plug multichamber propulsion systems was completed. The systems studied were 18 to 30 million pounds thrust, and employed oxygen and hydrogen as propellants. The final phase compared the relative merits of these propulsion systems. It was concluded that the toroidal aerospike system is superior to the plug multichamber in performance, weight, and cost. The differences, however, are generally on the order of 10-15 percent.

III. Subscale 120" and 156" Diameter Solid Motors for Model Testing

A reduction in the number of motors to be purchased is currently being negotiated with the contractor. All the inert hardware for the subscale 120" diameter motors, along with 51 propellant cartridges and 100 propellant ignitors, have been delivered to MSFC. Additional deliveries of 24 propellant cartridges and 100 EBW high voltage initiators which are expected soon, will complete the 120" program. Design work was completed on the subscale 156" diameter motor. Design and performance verification tests for the subscale 156" diameter motor are scheduled for mid September and deliveries to MSFC will begin shortly thereafter.



H. G. Paul
Chief, Propulsion Division

GEORGE C. MARSHALL SPACE FLIGHT CENTER

PR-R-P&VE-V-67-8

MONTHLY PROGRESS REPORT

VEHICLE SYSTEMS DIVISION

(August 1, 1967, through August 31, 1967)

SATURN IB

I. S-IB Stage

A. Cable Supports

Requirements for additional support/protection brackets on the no-step plates and propulsion distributor of the S-IB stage were submitte This request was the result of an inspection conducted on the S-IB-II stage at the Michoud facility on August 2, 1967.

B. Flight Measurement Manual

The S-IB-12 supplement to the flight measurement manual was reviewed. It will be distributed after corrections are incorporated.

C. Critical Hardware Reusability

A reusability hardware list for the S-IB and S-IVB stages was p pared and submitted to Materials Division and Structures Division of this laboratory for analysis.

II. S-IVB Stage

S-IVB/AS-206 Restart Mission

A review was completed on the McDonnel Douglas Corporation (MDC configuration for the AS-206 restart mission. This review revealed a need to change the support concept on the restart sphere manifolds and for testing of a common sphere/bracket installation. A memorandum is being prepared for submittal to the S-IVB manager for action by MDC.

III. General

A. LEM/AS Hypergol Leakage

Presentation material was prepared on the potential hyper-golic fuel leakage from the lunar module (LM) on the AS-204 vehicle. A proposed configuration for a Scupper on the propellant fill lines and sketches showing the probable flow path of hydrazine fuel which might drip on the S-IVB forward bulkhead were included.

B. SA-204 Composite Schematics

Revision C of the SA-204 composite mechanical schematic (60C90216), prepared by Chrysler Corporation Space Division (CCSD) under the technical cognizance of this division, was released. This schematic consists of an integration of schematics of all stages of the vehicle with the mechanical ground support equipment (MGSE) and facilities equipment.

C. Operations Analysis

The Saturn IB Launch Vehicle Design Reference Ground Sequence (DRGS), MSFC drawing 10M30576, Revision "A", was released. The document which presents a launch vehicle DRGS covering the time period from stages arrival at Kennedy Space Center (KSC) until the vehicle is launched, is intended to be for analysis and planning purposes. Major launch site operations to be performed on the vehicle as currently identified are presented for the prelaunch period.

D. Weight Status Reports

The monthly weight status report for launch vehicles SA-201 through SA-212 and for AAP-1A through AAP-5 and the detail monthly weight status report for the SA-212 launch vehicle were completed and distributed.

E. Mass Characteristics

The final predicted mass characteristics, guidance cutoff, for AS-204 and the weight and inertia distributions and depletion cutoff mass characteristics for the AS-206 were distributed.

F. Nose Cone Mass Characteristics

Mass characteristics on a feasibility study of a jettisonable nose cone apparatus for the Saturn IB launch vehicle were completed. This study consisted of calculating centers of gravity and moments of inertia on the nose cone, jettison motor, and adapter.

G. Program Specifications

1. Revision A to the Saturn IB Program Specification Baseline SA-204 through SA-212 was submitted to the level II board Configuration Control Board (CCB) for action.

2. Revision A to the Saturn IB Program Specification Baseline for vehicles SA-213 through SA-228 was submitted to the level II board for action.

H. Multiple Docking Adapter (MDA)

The MDA Functional Systems Checklist was completed.

I. S-IC Stage

A. Hazardous Gas Detection System (HGDS)

Documentation was prepared requesting that the HGDS in the S-IC thrust structure be modified to provide a sampling orifice in each quadrant. At present, the third quadrant does not contain an HCDS orifice.

B. S-IC Flush and Purge Servicer (F&PS)

1. General refurbishment of the S-IC F&PS unit (S/N 002) was completed; the unit was received at KSC on August 16, 1967.

2. Environmental testing of the 35-gallon turbopump bearing preservative unit (TBPU) is being performed. It is anticipated that all testing will be completed and the unit prepared for shipment during the early part of September 1967.

C. Integration Test Requirement/Specification

Revision B of the integration test requirements/specifications for local control for the S-IC ground hydraulics subsystem checkout and the S-IC ground hydraulics system checkout launch control center (LCC) to be used on mobile launcher (ML)-1, were reviewed for technical adequacy. A recommendation was made that certain portions of both documents be re-written. Revision C of the integration test requirements/specifications for S-IC pneumatic console (phase I) and the S-IC pneumatics local control subsystem checkout to be used on ML-1, were accepted.

II. S-II Stage

A. Fluid Distribution Lines for ML-1

The engineering effort required to provide full flow relief capability for the 22-stage oriented fluid distribution lines in ML-1 was completed. A total of 17 circuits, originating in the S7-41 pneumatic console set, are now protected. Five circuits in the S7-45 purge console are also protected.

B. Fluid Requirements

1. KSC presented a request for MSFC to revise fluid requirements for LH_2 tank precool procedures for the S-II stage. The procedure change was requested to help alleviate the insulation separation problem encountered on the stage. This requested procedure was acceptable to MSFC and an Internal Revision Notice (IRN) was prepared and released against the S-II LH_2 fluid requirements Interface Control Document (ICD) 13M50097.

2. A detailed investigation by KSC of the proposed change in the S-II lox fast fill rate from 5000 g.p.m. to 3700 g.p.m. reveals that the minimum capability of the existing launch complex (LC) 39 system is 4100 g.p.m. To provide 3700 g.p.m. would require a hardware change and possible schedule slip. The reduction in flow was requested due to failure of the S-II lox fill and drain duct. Propulsion Division has been informed of the problem and is reassessing the situation to determine if 4100 g.p.m. is acceptable or if the redesigned duct will be available for SA-501.

C. Umbilicals

The following changes to the S-II umbilicals were implemented at KSC:

Instrumentation was added at the 1-inch lox drain disconnect on the intermediate umbilical carrier plate to verify that the stage lox fill and drain line is purged within the time allowed during countdown.

Bungee cords were attached to the intermediate umbilical carrier plate legs which prevents the carrier plate from striking the stage at umbilical disconnect.

Strain gauge instrumentation was added to the LH_2 and lox fill and drain disconnect strut assemblies to measure KSC loads transmitted through the umbilicals to the S-II stage during CDDT.

III. S-IVB Stage

A. J-2 Engine LO_2 Pump Seal Bleed Line

Studies and layouts were completed on a proposed configuration for dumping LO_2 leakage from the J-2 engine lox pump seal overboard. This change is required on the S-IVB-1. An Engineering Change Request (ECR), BBON-191, was completed and submitted to the S-IVB stage manager on August 17, 1967. The solution was followed up by visiting the contractor's plant to observe the installations.

B. Auxiliary Propulsion System (APS)

Engineering Change Proposal (ECP) 2054-1 and ECP 2054-2, Redesign of APS Propellant Tank Recirculation System, was reviewed and recommended for approval. This ECP provided the necessary engineering and equipment for removal of gas bubbles through the fuel and oxidizer tank bladders during holds at ambient temperatures. Technical meetings were held and testing accomplished; the equipment became a part of the fuel and oxidizer DSV-4B-472 and DSV-4B-473.

C. Umbilicals

MDC initiated qualification testing of the new LH_2 fill and drain disconnect vehicle seal on August 11, 1967. Qualification test on the first specimen was successfully completed August 24, 1967. Expected completion date of testing on the second specimen and qualification of the new seal configuration is September 23, 1967.

D. Integration Test Requirements/Specifications

Revision B of the integration test requirements/specifications for the S-IVB pneumatic console (model DSV-4B-433A) for ML-1 was accepted.

IV. Instrument Unit (IU)

A. Fluid Requirements

An IRN was prepared and released for the IU for the purpose of defining the water/methanol external cooling loop supply temperature tolerances. This IRN (R-15) brings the ICD up to date.

B. Access Door

Since the IU access door provides access to the forward end of the S-IVB, to the IU and to the Lunar Excursion Module (LEM) above, KSC has designated International Business Machines (IBM) to assure compatibility among all operations and to assure that traffic demands upon the access opening are not excessive. IBM has requested a meeting among contractor personnel to coordinate those operations. At present, this meeting is scheduled for Monday, September 11, 1967, at KSC.

V. General

A. Vehicle Assembly Drawing (VAD)

1. The following documentation was completed:

Revision A of SA-503 VAD (10M15003).

Revision A of SA-501 Torquing Procedure Drawing (10M14503).

The Torquing Procedure Drawings for SA-503 (10M15013).

2. The Saturn V Vehicle Assembly Documentation Release Schedule was revised. The revised schedule requires the VAD's to be released approximately 5 months prior to the scheduled arrival of the S-IC stages at KSC. This lead time is considered ample for The Boeing Company (TBC) to procure the stage-to-stage mating hardware and ship this hardware to KSC.

3. The TBC "Proposal for Providing Additional Vehicle Assembly Hardware" was reviewed to determine its technical accuracy. Verbal approval of the proposal was given to the Saturn V Program Office.

B. Hazardous Gas Analyzer (HGA)

The HGS system on ML-1 has been undergoing additional tests during the past two weeks to check performance. During these tests, the output peaks almost disappeared on some gas samples. This problem was found to be caused by temperature sensitive zener diodes in the ion accelerator control (IAC) pane and has temporarily been corrected by using an outside power source for supplying regulated positive 410 volts and negative 35 volts to the IAC panel. Following this fix, the system performed adequately. The temporary fix will remain until an FCP is submitted for a permanent fix which will probably be after SA-501 launch.

C. Damping, Retract, and Reconnect System (DRRS)

1. The ML-1 DRRS redundant hoist system was installed at KSC. Final checkout of the entire ML-1 DRRS was successfully completed on August 20, 1967. Installation of instrumentation is complete and the system is ready to support AS-501 rollout.

2. The ML-2 DRRS redundant hoist system refurbishment was completed and the system was shipped to KSC via air on August 14, 1967.

3. The ML-3 DRRS redundant hoist system is being manufactured and is scheduled for shipment to MSFC swing arm test area on September 1, 1967.

4. The Mobile Service Structure (MSS) Damping System is undergoing systems tests.

D. Operations Analysis

1. The Saturn V Launch Vehicle Design Reference Ground Sequence Document is being prepared. The document presents a launch vehicle (DRGS) covering the time period from stages arrival at KSC until the vehicle is launched. It is intended to be used for analysis and planning purposes. Major launch site operations to be performed as the vehicle, as currently identified, are presented for the pre-launch period.

2. Recent information contained in draft VIII of the SA-501 Vehicle KSC countdown manual, dated June 30, 1967, plans spacecraft closeout prior to cryogenic loading. Some of the major events changes are:

	Previous Time	Current Time
Connect S&A Device	T-10:30	T-7:20
Move Mobile Service Structure	T-1:10	T-6:00
Start Cryogenic Loading	T-8:20	T-4:55
Spacecraft Closeout	T-3:40	T-8:00

These changes will require P&VE efforts in the following areas:

Redlines for propellant loading

Revision of vehicle and GSE criticality

Damper system design analysis change

Revision of fluid requirements

E. Reduction of Criticality Categorization

Performance of the failure effect analysis on the damper arm assembly revealed several areas where incorporation of design recommendations would reduce component criticality and change the criticality category. One of the designs which was modified was an accumulator in the redundant arm retract subsystem. Leakage at the accumulator could cause a failure in the primary retract system by loss of fluids. The fixes to the system have eliminated the failure mode and changed the criticality category from "A" to "C".

F. Saturn V/SA-502 Flight Sequence

The division completed and released the laboratory requirements for the SA-502 flight sequency program to Astrionics Laboratory.

G. SA-501 Composite Schematic

Revision E of the SA-501 composite mechanical schematics prepared by TBC (10M30531) was released. This schematic integrates schematics of the S-IC, S-II, S-IVB, and S-IU stages with those of their respective MGSE and facilities equipment.

H. Functional Interlock Requirements

An IRN was submitted against ICD 40M05486 to properly document all interlocks for the Saturn V vehicles that cross the KSC/MSFC interface. The existing ICD controls only the functions which come across the interface. Incorporation of this IRN will require certain functions which come across the interface to be interlocked.

I. Hazardous Gas Detection System (HGDS)

This division replied to a request from Technical Systems Office through the laboratory Projects Office for an investigation into the possibility of providing a faster response HGDS for improved pad safety. The conclusion reached in the investigation was that a dual-system could be utilized which would cut the response time in half. This would also provide a redundant system that is not available in the existing HGDS if a decision is made that redundancy is necessary.

J. Weight Status Reports

1. The monthly weight status report for launch vehicles SA-501 through SA-506 was completed and distributed.

2. The detail monthly weight status report for the SA-506 launch vehicle was completed and distributed.

K. Hypergolic Fuel Leakage

Concern over potential spacecraft hypergolic fuel leakage before and after filling has precipitated a human factors investigation to determine what, if any, personnel protective measures are required during this time. IBM personnel have defined concentration limits in parts per million (PPM) which are acceptable for varying lengths of exposure. Currently, IBM and TBC systems personnel are defining the maximum expected concentration in the area and the expected numbers of personnel in the area and their expected lengths of exposure. Based upon these data, specific personnel protective measures will be recommended.

I. Systems Design

A. Multiple Docking Adapter (MDA)

1. The following designs and layouts were completed:

A typical removable-type experiment installation.

Preliminary design of the MDA window cover development mechanism.

A layout defining a double angle nosecone configuration for the mission module. This proposed configuration allowed acceptable nose clearance between the MDA docking probes and the nosecone.

2. The MDA requirements for the environmental conditioning system for the command service module and LM ascent stage LM/AS were added to SK10-9317.

3. A reevaluation of quick-release fasteners for the removable experiment packages is being made. After fabrication, the several type fasteners under consideration will be evaluated by a special working group and the mission astronauts.

4. The relocation of experiments S-69, S009, and the scientific airlock resulted in the complete rearrangement of the internal and external experiment space allocations. Experiments requiring a vent to vacuum outlet were included in this arrangement and concurrence from all affected organizations will be obtained.

5. The winch on the upper MDA hoist is being redesigned because of the increase in package weight from 130 pounds to 185 pounds. Detail drawings of the hoist support, hoist track, and hoist trolley were completed. The problem of preventing unlocking of the "free wheel" mechanism under a minimum 50 pound load on the drum has not been solved. No other apparent design problems exist.

6. Redesign of the 525 level hoist is almost complete. Design of an additional trolley beam support in the Gemini hatch opening and redesign of some detail parts have not been accomplished.

B. Multiple Docking Adapter (MDA) Mockups

1. DAC has been directed by MSFC to furnish mockups of crew quarters hardware for neutral buoyancy evaluation along with any bracketry required to interface with the MSFC neutral buoyancy mockup (NBM) of the S-IVB tank.

2. Mockup of the MDA for the Preliminary Design Review (PDR) will be given top priority. The schedule is for the MDA mockup assembly to be completed by October 26, 1967. Release of mockup drawings should begin no later than September 14 and all drawings for PDR mockup should be released by October 12.

3. Documentation of the Environmental Control System (ECS) ducts and internal installation of the hard mounted experiment package mockup has been completed with the exception of the Scientific Airlock. The installation concept on the airlock is changing. It is not clear what each experimenter is to furnish for PDR mockup.

4. The installation of one flight docking probe with two flight pressure latches was completed on the MDA Engineering Mockup drawing. Quick removal blank covers are being installed on the remaining three docking tunnels.

5. Two functional configuration mockups of the MDA window assembly are being documented for fabrication. Dummy mockups are being placed in the other window locations.

6. Work has started on configuration mockups of the four vents to vacuum for experiment packages.

7. A mockup of the temperature sensors and installation of flight item docking aids were started.

C. Apollo Telescope Mount (ATM)

1. Documentation is being prepared on dummy components for vibration testing on ATM components including telescopes. These dummy units will simulate the weights, c.g. locations, and approximate stiffness of the components.

2. SK10-7328, "ATM Experiment Package Subassembly," has been revised to define additional detail on the structural and the insulation envelopes.

3. Drawing SK10-7447, "Alternate ATM Rack to LM/AS Clearance Envelope," is being reviewed. This drawing defines the location of electronic components on the upper ring of the rack in an arrangement recently requested by Propulsion Division. This would require the redesign of equipment mounted on the LM/AS. This configuration change will be discussed at the ATM Mechanical Panel Meeting.

4. Drawing SK10-7444, "Cabling Proposal, ATM Rack to Experiment Package," was completed. This drawing defines a means of routing cables from the rack to the experiment package along with all critical clearances involved.

D. Orbital Workshop (OWS)

1. A study was completed defining the astronaut limitation in the lower OWS area while being attached to the 60-foot umbilicals. The lowest portion of the OWS (where the common bulkhead joins the aft lox bulkhead) is accessible. This study was based on the two-level crew quarters concept.

2. The mission module alignment drawing for AAP-2 has been prepared. The drawing is now being checked.

E. Nuclear Ground Test Module (NGTM)

1. Work continued on the mission configuration layout, SK10-9262, for the NGTM. The major effort on this layout is to define the line routings in the thrust structure and aft skirt area, to locate major instrumentation requirements, and to define major system configuration. Four unnumbered sketches were made for presentation purposes at an MSFC/Aerojet General Corporation (AGC) meeting. These were proposals showing MSFC's and AGC's propellant feed valve and gimbal systems. The basic differences between the proposals were that MSFC prefers the engine gimbal system to be located on the thrust structure while AGC prefers it on the engine: that the propellant feed valve to be contained completely within the thrust structure while AGC prefers it to protrude into the tank.

2. Two viewgraphs were produced for an MSFC proposal of the engine gimbal system. The proposal was scheduled for presentation in Washington, August 29, 1967.

3. Motion studies are in progress on the 8-inch fill and drain lines, the 2-inch auxiliary drain line, and the 10-inch vent lines.

4. Radiation detector locations have been defined in accordance with the instrumentation request. Concept studies were begun for supporting the detectors in the tank. A number of the detectors are in inaccessible locations or are located where there is physical interference between the mounting flanges of adjacent couplings.

5. Work was initiated on the model tank integration drawing.

F. Voyager

The access, maintenance-on-pad, and fueling study on the Voyager program was begun.

II. Systems Operations

Pneumatic Complexes

1. Drawings 13M51104 and 13M51105, physical ICD's for the upper and lower tank pneumatic complexes were updated to reflect the addition circuits required for GH_2 vent coupling retract pressure, retract supply, and residual drain valve actuation, in accordance with the August 5, 1967, revision of 13M51114, fluid requirements document. Other schematics and drawings are being updated to incorporate these additional circuits.

2. The upper service arm and access arm retract circuits in the upper tank pneumatic complex have been simplified in order to reduce the number of components and thereby improve reliability.

3. A Failure Effect Analysis (FEA) of the NCTM pneumatic consoles for the cold flow configurations, dated July 31, 1967, was reviewed and coordinated with the originating office. Certain desirable design changes which will increase reliability and safety were incorporated.

4. A study of the nuclear radiation environment for the pneumatic complexes at Nuclear Rocket Development Station (NRDS) was completed. It was determined that 100 hours of firing of a shielded 5 MW nuclear engine would not degrade our materials or cause a high enough level of activation to cause any maintenance difficulties.

III. Systems Engineering

A. Cluster

1. The Apollo Applications Program (AAP) monthly payload weight status report was completed and distributed.

2. A systems comparison study was performed on three concepts for the Data Return Capsule (DRC) for the Cluster Mission. These concepts were presented to the AAP program director at NASA Headquaters on August 23, 1967.

3. The status of planned neutral buoyancy testing for the OWS, MDA, and ATM programs was presented to Industrial Operations (IO) with personnel from this division participating. Overlap of simulation activities which affect facility and equipment requirements for the programs was a major topic of discussion; however, no resolution was determined.

B. Orbital Workshop (OWS) Review Item

1. Evaluation of the workshop floor grid was started in the Manufacturing Engineering Laboratory Neutral Buoyancy facility. Initial runs of translation over the floor in a shirt sleeve condition were completed on August 15, 1967. This action resulted from Review Item Discrepancy (RID) B-5.

2. A method for repairing micrometeroid penetrations and OWS leaks was forwarded to the project office on August 8, 1967, as a reply to RID action item B-77b.

C. Multiple Docking Adaptor (MDA) Configuration

1. The current MSFC internal MDA configuration concept was presented to MSC at Houston on August 2, 1967.

2. A proposed foot restraint ring concept was shown to astronauts and other MSC personnel. This ring is essentially a continuous "Dutch Shoe" which is intended to enable the astronaut to anchor his feet at any point facing the MDA circumference. Since evaluation of the concept was generally favorable, plans now are to refine the design of the ring and conduct more definitive simulations. It is anticipated that this concept will be presented at the MDA PDR scheduled for September 27, 1967.

3. The division recommendations for the MDA floor, floor hatch, mobility poles and foot restraint ring, all located in the MDA forward section, were defined and distributed by memorandum on August 18, 1967. The memorandum also contained the request that this information be reflected in all future design and layout documentation.

4. The sequence draft prepared by MDC for Mission A activities and deactivation was reviewed by division personnel and a representative of MDC on August 21, 1967. This document was compared with the Design Mission Reference Sequence and the Astronaut Review Outline. The conclusions were that both the MDC and MSFC documentation required minor modification and that coordination should be accomplished with the Manned Spacecraft Center (MSC).

5. A layout drawing (SK10-7449) Visual Coverage MDA Window Saturn IB Cluster, was prepared to determine the field of view from the windows in the conical structure of the MDA. This drawing will assist in analyzing the adequacy of the windows in relation to navigation, attitude orientation, docking operations, photography requirements, viewing of experiments, and Extravehicular Activities (EVA). The drawing will also be used to identify tethering and stability aids necessary to permit the astronauts efficient use of the windows in performance of the AAP-2 Mission.

6. Man-system engineering simulation requirements for MDA were formulated along with priorities and required due dates. Simulation plans will be developed specifying simulation mode numbers of test sheets, facilities and mockup requirements.

D. Lunar Module (LM)/Apollo Telescope Mount (ATM)

1. Computation Laboratory is presently interfacing the ATM point and control simulation (PCS) program with the pointing and control display and control panel. At the completion of this work the panel will be installed in the LM mockup located in Computation Laboratory. The Control Moment Gyro (CMG) moment dump panel for the pointing and control simulation has been fabricated and is being installed in the mockup also.

2. An astronaut review of the LM End Film Retrieval Workstation Concept was held in the Task Analysis Facility, building 4335, on August 15, 1967. Three astronauts (Major Engle, Dr. Garriott, Commander Bean) in block II pressure suits participated in the review utilizing both 1-g and 6 DF simulated conditions. Concurrence and comments on designs of the astronaut interface were obtained in a debriefing session following the review. It was pointed out by Commander Bean that a high fidelity mockup including all equipment mounted in the workstation area was required for a comprehensive astronaut review.

3. A baseline MSC/MSFC working agreement for LM/ATM flight crew training was established at a meeting on August 28, 1967, at MSC. Division personnel will establish training requirements and provide necessary detailed course descriptions. MSC will merge these requirements with mainline Apollo requirements and will be responsible for the training.

4. A design review of the ATM neutral buoyancy mockup being fabricated by LMSC for delivery to MSFC on September 8, 1967, was held at MSFC on August 2, 1967.

E. Experiments

1. The Experiment Interface Requirement Document (EIRD), Revision A, for experiments M-052, T-020, M-469, M-492, M-493, M-509, M-479, M-508, D-022, and S-070 was completed. The EIRD specifies experiment data requirements that will be used as an MSFC baseline for systems design, integration, and compatibility, until the experiment ICD's are implemented through the mechanical, electrical, and instrumentation and control panels. Top level, system level, and subsystem Functional Block Diagrams (FBD) for experiments M-050, M-018, D-019, D-020, D-018, and M-051 were completed.

2. Two additional experiments have been added to the AAP-2 flight list according to the August 14, 1967, Apollo Flight Mission Assignment (T003 Inflight Nephelometer and T018 Precision Optical Tracking). Currently, there are 31 corollary experiments assigned to AAP-2.

3. An investigation of the field of view for experiment S069, X-Ray Astronomy, which is located on MDA, position II, has revealed that the LM/ATM creates a significant restriction in the X-ray sensor field of view during mission B and that physical contact between the extended X-ray sensor and LM/ATM during MDA docking is possible. To alleviate these problems, this division requested that experiment S069 be relocated from Position II to Position III to provide an unrestricted field of view during missions A and B and to preclude the possibility of physical contact during MDA docking; that experiment S009, Nuclear Emulsion, be relocated from Position III to Position II to accommodate the relocation of experiment S069 and the scientific airlock.

4. Physical compatibility of Experiment T-023, Surface Absorbed Materials, poses few problems, since packaging of the "sensors" or collecting plates may be accomplished with items from the Gemini program, and attachment of the assembly to the S-IVB forward skirt

will require very minor structural modifications. However, com patibility of the experiment to the astronaut will require exter review since many ragged surfaces might hazard the astronaut dur EVA reclamation of the collecting plates from the collecting pla assembly. Materials Division will submit requirements and actio items for integration and compatibility evaluation of the experin to this division.

5. Experiment 84A, "Force Emission Capability in Zero-gravity," is approximately 40% complete with 115 sessions of 288 sessions conducted in the Manufacturing Laboratory neutral buoyanc 15-foot diameter tank. Data reduction is being performed by the Computation Laboratory. It is expected that preliminary data will be available for analysis within three weeks on 144 sessions. If significant results are obtained from 144 sessions based in the dat analysis, the remaining 144 sessions may not be required.

F. Voyager Weight Data

1. The revised baseline launch vehicle performance weight data requested by Technical Systems Office was prepared and distribu This information along with revised propulsion parameters will be used to arrive at a new Voyager commitment. Also, the current weight status for the voyager payload was compiled and distributed.

IV. Systems Requirements

A. Nuclear Ground Test Module (NGTM) Specifications

The final draft of the NGTM Program Specification was completed and delivered to NASA Headquarters with the original approval sheet.

B. Research and Development Plan for MDA

1. An updated rework of the MDA R&D Plan has been prepared for review and comment.

2. Research into test requirements for MDA onboard experiments was undertaken. Preliminary results indicate that the scope of the testing which can be accomplished on the experiments will be minor.

3. An integrated airlock module (AM)/MDA test criteria document was generated and delivered to the laboratory Projects Office. The document covered the intercenter agreements between MSFC and MSC, the integrated test program, and the program shedules for the combined AM/MDA tests.

C. Apollo Telescope Mount (ATM) Schedules

The laboratory implementation plan schedules for ATM were reworked, updated, and coordinated with the other divisions of the laboratory prior to final approval.

D. Voyager Research and Development (R&D) Plan

The Voyager Shroud R&D Plan has been completed and delivered to the laboratory Project Office.

E. Apollo Applications Program (AAP) Documentation

1. Functional Interface Control Documents (ICD's) for AAP-1A (13M06636) and AAP-2 (13M06592) were prepared.

2. A documentation tree delineating the AAP-2 test program requirements was initiated.

F. S-IVB Orbital Workshop (OWS) Test Plan

1. Work continued on the MSFC portion of the OWS General Test Plan. This document will contain only those tests which will be conducted by MSFC personnel and will be used in conjunction with the Douglas Aircraft Company (DAC) Spent Stage Test Plan.

2. Comments were received from each branch within the division concerning the Spent Stage General Test Plan (DAC-56577) and the Spent Stage component test requirements (DAC-56580). These comments will be given to the S-IVB/AAP project engineer for further action.

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