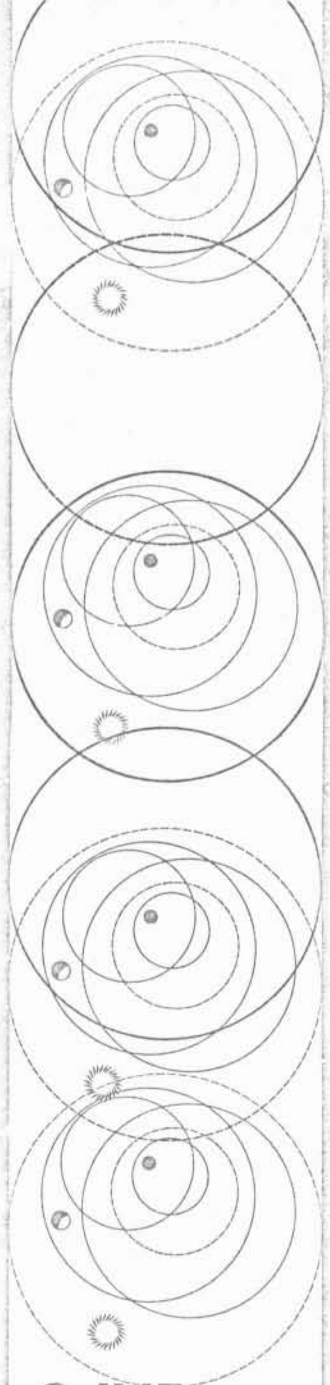

SATURN QUARTERLY TECHNICAL PROGRESS REPORT

S-IVB

DAC-56445
SEPTEMBER 1966

MISSILE & SPACE SYSTEMS DIVISION
DOUGLAS AIRCRAFT COMPANY, INC.
HUNTINGTON BEACH/CALIFORNIA

DOUGLAS

SATURN S-IVB QUARTERLY TECHNICAL PROGRESS REPORT

DOUGLAS REPORT DAC-56445
SEPTEMBER 1966

PREPARED BY: B. J. RAINWATER
SATURN PROJECT OFFICE

PREPARED FOR:
NATIONAL AERONAUTICS AND
SPACE ADMINISTRATION
UNDER NASA CONTRACT NAS7-101

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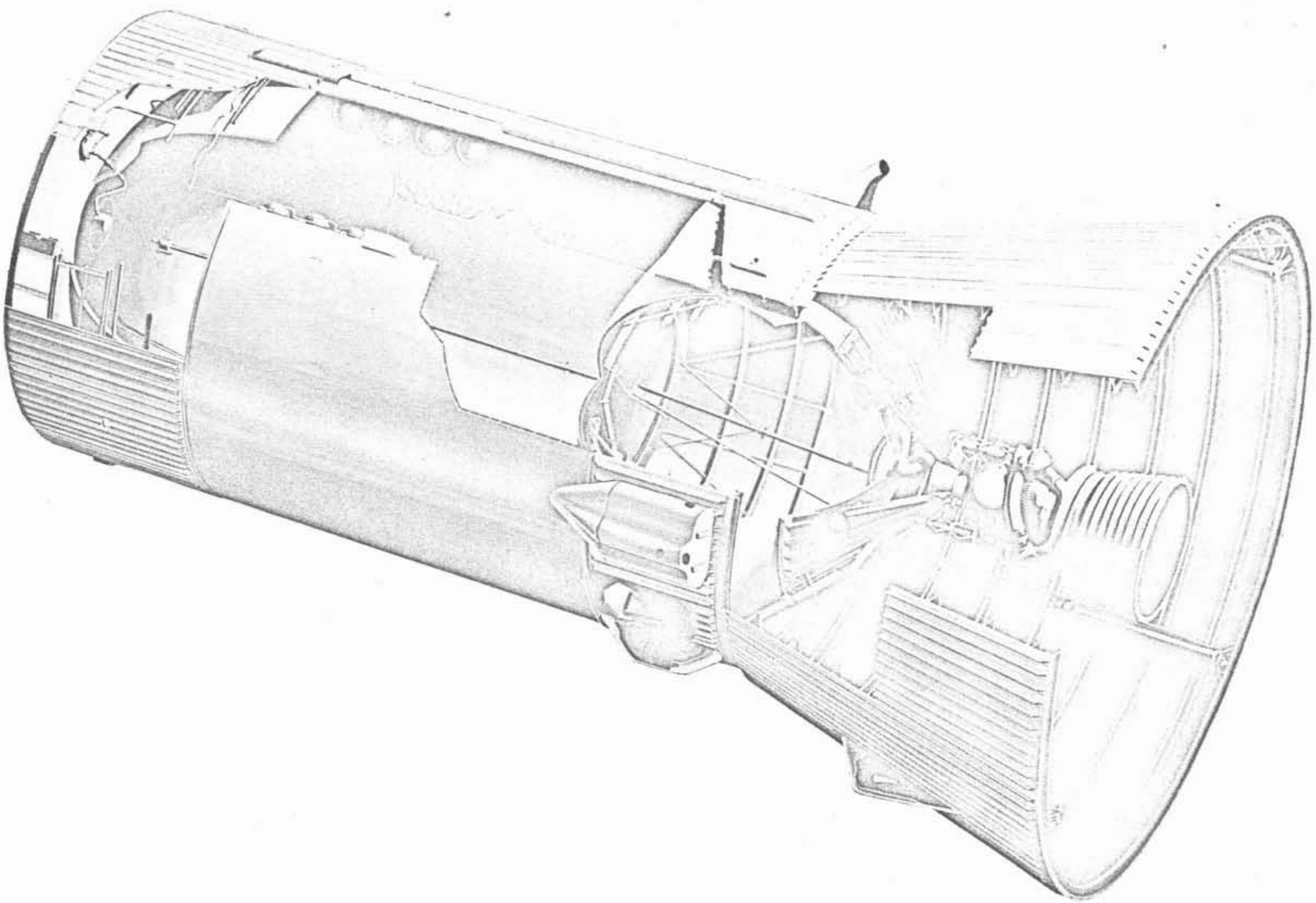
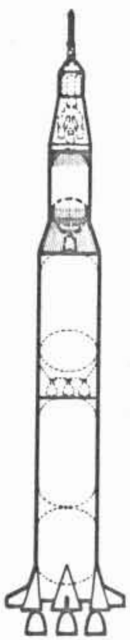
DOUGLAS MISSILE & SPACE SYSTEMS DIVISION
SPACE SYSTEMS CENTER – HUNTINGTON BEACH, CALIFORNIA

SATURN V/S-IVB





ABSTRACT

Douglas Aircraft Company Report DAC-56445, Saturn S-IVB Quarterly Technical Progress Report, covers design and development progress on the Saturn IB and Saturn V configurations of the S-IVB stage during August and September 1966. This report is prepared for the National Aeronautics and Space Administration under Contract NAS7-101.

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1. Saturn Vehicle AS-202 Launch at Kennedy Space Center on 25 August 1966. 28

SECTION I

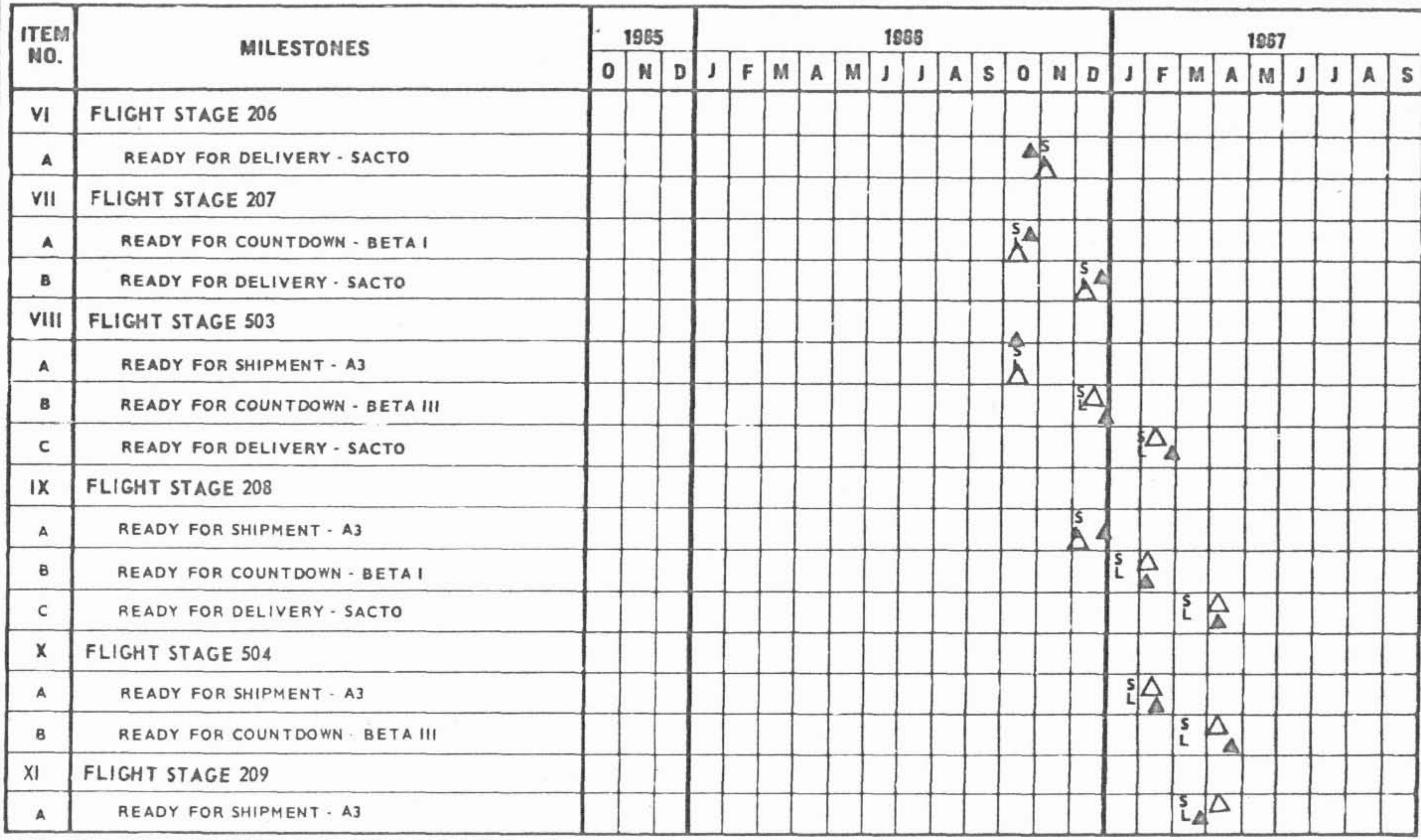
PROGRAM STATUS

S-IVB PERT PROGRAM FORECAST

ITEM NO.	MILESTONES	1965 (O N D) / 1966 (J F M A M J J A S O N D) / 1967 (J F M A M J J A S)
I	**QUALIFICATION TESTING**	
A	COMPL DE/Q & FORMAL QUAL TESTS — 204 LAUNCH	S L
B	COMPL RELIABILITY VERIF TESTING	S L
C	COMPL O_2H_2 BURNER QUAL TEST (503)	TBD
II	**NASA SUPPORT EQUIPMENT**	
A	AVAIL AT KSC/MSFC	VARIOUS
III	**DUAL REPRESS SYSTEM**	
A	START 503 DUAL REPRESS SYS MOD — SACTO	REPORTED UNDER "503 STAGE – READY FOR COUNTDOWN
IV	**HYDROSTATIC TEST STAGE — S005**	
A	COMPL PHASE II TEST	S L COMPL
V	**FLORIDA TEST CENTER**	
A	FCV COMPL WET TEST (LC 39)	S L
B	204 COMPL. APS LOAD (LC 34)	S L
C	501 COMPL APS LOAD (LC 39)	S L

LEGEND
HF = HELD FOR
T/N = TIME NOW
S = SCHEDULE DATE
L = LATEST ALLOWABLE OR NEED DATE
▲ = PERT PREDICTED COMPLETION DATE THIS T/N
△ = PERT PREDICTED COMPLETION DATE LAST T/N
▼ = PERT PREDICTED COMPLETION DATE FOR ALTERNATE PATH THIS T/N

S-IVB PERT PROGRAM FORECAST



PROGRAM SUMMARY

Design and development progress on the Saturn IB and Saturn V configurations of the S-IVB stage continued during August and September. The majority of layout drawings reflecting late changes have been completed and forwarded to NASA. The majority of late changes to production drawings have been completed. Individual system and module design and hardware and component design development, qualification, and formal qualification testing are now being emphasized.

Battleship testing has been completed establishing the validity of Saturn S-IVB design concepts and functional operation of flight-type hardware. S-IVB/Saturn IB and Saturn V auxiliary propulsion system module testing has been completed.

Six S-IVB/Saturn IB flight stages (S-IVB-201 through S-IVB-206) and two S-IVB/Saturn V flight stages (S-IVB-501 and S-IVB-502) have been successfully acceptance fired. Eight S-IVB stages (Dynamics, Facility Checkout Stage, S-IVB-500-ST MSFC stage simulator, S-IVB-201 through S-IVB-204, and S-IVB-501) have been delivered to NASA. S-IVB stage flight performance has been successfully demonstrated during the first three Saturn IB missions, AS-201, AS-202, and AS-203.

Testing

Flight Testing (Kennedy Space Center)

The third successful flight of the S-IVB stage was accomplished with the launch of the AS-202 uprated Saturn I vehicle on 25 August.

Stages S-IVB-204 and S-IVB-501 were undergoing prelaunch checkout and modifications at the end of September.

Acceptance Testing (Sacramento Test Center)

The S-IVB-204 stage was shipped to the Kennedy Space Center on 5 August. Post-turnover modifications continued on the S-IVB-205 stage during the quarter.

S-IVB-206 stage acceptance firing, with a mainstage duration of 433.7 seconds, was successfully accomplished on 19 August. An engine performance verification firing was accomplished on 14 September to verify proper operation of a newly-installed liquid oxygen turbopump assembly and its compatibility with the engine.

The S-IVB-207 stage was installed in the Beta 1 Test Stand on 1 September. Stage subsystems checkout were nearing completion at the end of September in preparation for acceptance testing.

The initial Saturn V flight stage, S-IVB-501, was shipped to the Kennedy Space Center on 12 August, marking a significant milestone in the Apollo Program.

S-IVB-502 stage post-firing checkout was successfully completed with an All-Systems test on 12 August. The stage will remain in storage until November, during which time post-turnover modifications will be accomplished.

Auxiliary Propulsion System Testing

Phase IV Preflight Rating Tests on the S-IVB/Saturn V auxiliary propulsion system module were completed on 12 August.

S-IVB/Instrument Unit (500-FS) Environmental Testing

Two tests conducted during August concluded the S-IVB/Instrument Unit environmental test program at the Space Systems Center Space Simulation Laboratory.

Hydrostatic Test No. 2 Test

The Hydrostatic test stage No. 2 successfully completed the planned failure test at the Space Systems Center Veritical Checkout Laboratory on 26 September.

High-Force Dynamic Test Program

The S-IVB/Saturn V high-force dynamic test program was completed on 15 August at the Wasatch Division of the Thiokol Chemical Corporation at Brigham City, Utah. The tests provided further confidence that S-IVB structures and mounting equipment will withstand any acoustic and dyanmic stresses imposed during flight.

Oxygen-Hydrogen Burner Installation Testing

Oxygen-hydrogen burner development testing progressed satisfactorily during August and September at the Sacramento Test Center.

Component Testing

Design development testing is nearing completion, with 284 tests completed of 321 tests scheduled. Qualification testing is progressing, with 506 tests completed of 746 tests scheduled. Formal qualification testing is also progressing, with 6 tests completed of 36 tests scheduled. Preparations are in progress for the start of Reliability Verification testing in October.

Manufacturing

S-IVB-207 final preparations were completed and the stage was shipped to the Sacramento Test Center on 30 August.

S-IVB-208 stage joining operations were completed in August. Stage checkout, initiated on 22 August, was continuing at the end of September.

S-IVB-209 stage liquid hydrogen tank internal installation and internal installations were accomplished during the quarter.

S-IVB-210 tank assembly was completed in August and proof testing was accomplished in September. During hydrostatic testing, water was inadvertently admitted to the common bulkhead cavity. Pumping activities to remove the water were in process at the end of September.

Fabrication of S-IVB-211 subassemblies was in process at Santa Monica during the quarter.

S-IVB-503 stage checkout, initiated on 21 July, was concluded on 14 September. Stage shipment is planned for 11 October.

Fabrication assembly at the Space Systems Center and at Santa Monica continued during August and September on stages S-IVB-504, S-IVB-505, and S-IVB-506.

SECTION II

ENGINEERING

2. ENGINEERING

2.1 Propulsion

2.1.1 Propellant Systems

The liquid hydrogen continuous propulsive vent module assembly has been redesigned to incorporate a new design of the pneumatic actuation valve.

Repeated failure of the valve portion of the continuous vent module during qualification tests necessitated this redesign, which will be effective on stages S-IVB-501 through S-IVB-515.

2.1.2 Pneumatic System

The repressurization system installation drawing (1B51444) is being revised to add the redesigned repressurization control module (1B56653). This redesign will prevent relief valve contamination.

The switch installation (aft section) installation drawing (1B58001) (Saturn V) has been revised to delete the liquid oxygen translunar switch and add Calips switches. The drawing was also revised to add pressure switches and piping for the inline oxygen-hydrogen burner installation stages S-IVB-507 through S-IVB-515 at the Huntington Beach Space Systems Center.

Work on the pneumatic system kits drawing to support spent stage experiments on stage S-IVB-209 is being delayed pending a NASA decision on the hand operated valve. NASA will give direction to use either a 3/4-inch valve, two 3/4-inch valves, or a 1 1/2-inch valve. Analysis has been performed on the utilization of helium required by the pneumatic systems to meet flight requirements. Analysis results are being used as a guideline to determine whether individual component leak rate specifications can be increased or decreased as required.

This study is continuing on the pneumatic power control system and liquid oxygen and liquid hydrogen pressurization systems for stages S-IVB-207 through S-IVB-212, S-IVB-501, S-IVB-503 and S-IVB-504 and propellant repressurization systems for stages S-IVB-501 and S-IVB-504.

2.1.3 Oxygen-Hydrogen Burner System

Work is progressing on development on an injector design to preclude icing on the injectory face which was encountered during burner development tests at the Sacramento Test Center.

Drawings are being revised to convert stages S-IVB-503 through S-IVB-506 to the dual repressurization system. This conversion includes an ambient helium repressurization system to supplement the oxygen-hydrogen burner.

A shutdown valve has been incorporated in the oxygen supply line to eliminate a high temperature spike which occurred at burner shutdown.

2.1.4 Auxiliary Propulsion System

Pressurization System

The quadruple valve support bracket has been redesigned for increased passive thermal protection. Redesign was necessitated by the out-of-specification temperature (0°F) encountered during environmental testing. The minimum temperature requirement is 20°F.

Development of a new tube assembly of the auxiliary propulsion system Development Fixture has been completed.

Monitoring disconnects have been deleted from the helium low pressure modules (1A49998) and replaced by MC unions and caps. Disconnect configurations -1 and -501 have been replaced on the aft auxiliary propulsion system bulkhead with the newly configurated -523 and -525 disconnects. Drawings have been revised to remove the regulator assembly (1B54601-503) and replace the component with a -505 configuration. The -503 configuration experienced bellows problems during qualification testing.

S-IVB/Saturn V Propellant Testing

Redesign of the covers on the propellant tanks to provide an electrostatic ground has been completed. Deletion of the monitoring disconnect from the propellant control modules (1A49422) and substitution of MC unions and caps has been completed.

S-IVB/Saturn Propellant Tank Assembly (1B39468)

Bell Development Program

The oxidizer tank test has been successfully completed. The fuel tank test was interrupted after completion of propellant storage. The fuel tank will be placed in dry storage until the vibration test fixture is available.

Bell Qualification Program

Bell will start qualification tests under NASA/Bell Contract NASW-1317 upon completion of vibration testing of the R&D or "third tank" in the three-tank program. This will permit NASA to perform the desired full-scale vibration tests with live propellants without impeding the Saturn qualification test program and also to provide maximum utilization of the vibration fixture for both the development and qualification test programs. The balance of the program will be conducted under the Douglas/Bell contract upon completion of dynamic testing.

2.1.5 Solid Propellant System

S-IVB/Saturn IB and V Ullage Rockets

Review of AS-203 flight data indicates that all three ullage rocket motors operated satisfactorily and simultaneously.

Review of chamber pressure data from AS-202 indicates that all three ullage rocket motors operated simultaneously and satisfactorily. Photography indicated that one motor was operating differently from the other two. This discrepancy has been attributed to the lighting conditions.

Saturn IB/S-IB Retrorockets

The use of notched nozzles on the next four 1A59670-501 flight motors has been authorized.

Propulsion drawings have been corrected to delete the callout for chamber pressure instrumentation beyond stage S-IVB-204 and to delete leak checks on retrorocket motors on all Saturn IB vehicles.

A requirement to tighten the plug in the chamber pressure port to 144 plus or minus 12 inch-pounds and to add a torque stripe will be added to all Sacramento Test Center Handling and Checkout drawings.

Review of AS-203 flight data indicates all four retrorockets performed satisfactorily and simultaneously.

Review of chamber pressure data from AS-202 indicates that one retrorocket shut down abruptly 10 per cent short of the normal duration. As a result of this malfunction, Douglas took a second look at "hot spots" reported in qualification test reports. The qualification test report was previously disapproved because more substantiation was required for Thiokol's claim that "hot spots" were unimportant. Thiokol has not yet satisfactorily substantiated this claim.

One "quality acceptance" test firing has been performed by Thiokol (Motor Serial Number PV16-616-5) and acceptance test data have been received by Douglas.

At NASA request, the General Test Plan has been changed, adding Line T-15 to vibration test two retrorocket motors used in the S-IVB Saturn IB aft interstage structure and to follow this by static test firing both motors. All testing will be conducted at ambient temperature. The vibration testing of Line Item T-15 is in lieu of vibration testing of an inert motor in the same structure as specified in Line Item A-27.

Saturn V/S-II Retrorockets

The redesigned forward segment of the retrorocket insulation has been fabricated and a fit check on the S-IVB-502 interstage has been performed.

Propulsion drawings have been corrected to delete the callout for chamber pressure instrumentation beyond S-IVB-503 and to delete leak checks on retrorocket motors on all Saturn V vehicles.

A requirement to tighten the plug in the chamber pressure port to 144 plus or minus 12 inch-pounds and to add a torque stripe will be included in Sacramento Test Center Handling and Checkout procedures.

2.2 Structural/Mechanical

2.2.1 Structures

Internal Insulation

Liquid hydrogen tank internal insulation tile dimensions were revised during August to eliminate prefit and trimming during installation. Balsa pads around tank fittings were replaced by foam tiles to lower conductivity.

Stage Tunnels

The main and auxiliary tunnel covers were revised to attach metal electrical ground strips between the tunnel covers and the liquid hydrogen tank thereby providing a path for conducting electrical engergy generated by a lightning stroke.

Insulation

Aluminized Mylar on the forward and aft domes of stages S-IVB-505 through S-IVB-515 was changed from Schjeldahl's type X-912 to type X-850 to minimize static electricity buildup.

Tankage

In an effort to improve the quality of welds on the S-IVB stage, Douglas inhouse and specification control drawings were revised to eliminate alodine or anodize coatings from the weld areas of vendor-furnished components.

Thrust Structure

A kit has been provided for dual launch capabilities (effective on stages S-IVB-204 through S-IVB-208) which replaces the S-IB small control bottle with the large (4.5 cubic feet) Saturn V control bottle. Converting of S-IVB-204 to the new control bottle configuration will be accomplished at Kennedy Space Center.

IB/S-IVB Interstage

The aft interstage access door was redesigned to make the door removable. This change was necessary because of interference with the door by personnel, especially when equipment was passed through the door.

Impingement Curtains

Two curtains for stages S-IVB-501 and S-IVB-502 were revised to provide a boot around the environmental duct leading to the control bottle on the thrust structure.

On stages S-IVB-503 through S-IVB-515, one curtain in the same area as mentioned above will be revised to enlarge existing duct boots for the insulation on the helium heater supply lines.

2.2.2 Environmental Control

Saturn IB/S-IVB Aft Interstage Gas Concentration During Boost Phase

The gas composition of the S-IVB interstage was analyzed for the boost phase during August. Maximum allowable leakage of hydrogen and oxygen was applied to the interstage gas as it reduced in pressure during boost. The concentration of hydrogen gas ended at 7.3 percent by volume and the oxygen ended at 7.10 percent by volume, at the time of separation.

S-IVB/Saturn V Storage

A storage study of S-IVB stages (S-IVB-507 through S-IVB-515) was released under Douglas report DAC-56441. This study, made to determine the feasibility of storing the S-IVB/Saturn V stages for an extended period of time, indicates that stages may be stored for periods up to 24 months without significantly affecting reliability and performance if adequate storage procedures and techniques are followed. The study also concludes that existing facilities and support equipment can be utilized for stage storage, with a minimum addition of new or existing support equipment items required.

2.3 Electronics

2.3.1 Networks

A study conducted to determine power capacities of the engine ignition and control buses concluded that limited additional power required by the J-2 engine control and ignition buses is available on the existing S-IVB power supply.

A study was conducted to determine the effects of a reduction in voltage of the forward 5-volt excitation module on measurements powered by the module for S-IVB-202.

S-IVB system power requirements for S-IVB-501 and S-IVB-207 have been documented.

Analysis is being conducted to determine in detail changes required to convert the 500-ST MSFC stage simulator from a S-IVB-501 to a S-IVB-502 configuration.

During the quarter, the S-IVB-502 spark exciter failure was duplicated and resolved at Rocketdyne.

Control circuit analysis and design for the oxygen-hydrogen burner kit have been completed and drawings released.

Design analysis and layout sketches of the dual repressurization system have been completed. An investigation was also completed to determine oxygen-hydrogen burner emergency detection system requirements.

2.3.2 Special Components

Failure analysis of the 50-ampere motor-driven switch (1A88061-1) (Serial Number 224) revealed an open circuit across the motor contacts. To correct the problem, the specification control drawing was revised to (1) specify a make-before-break condition in the motor circuit, (2) add to the final assembly drawing the exact positioning of the motor contacts and auxiliary circuit, and (3) use a spring with more tension to improve motor braking action.

Douglas and the Mason Electric Company completed analyses on potting compounds and primers for effecting leak repairs on the hydraulic power unit switch (1B32647-505).

Failure analysis of the pressure switch (1B52624-507) (Serial Number 006) indicated contamination on the contacts. A chemical analysis will be performed to determine its identity.

An investigation has been made with the Hydra-Electric Company on the availability of a pressure switch for use in the helium heater liquid hydrogen tank repressurization system. A thermal switch is also under consideration for the requirement.

Additional requirements for electromagnetic interference testing on the helium heater system (1B59986-1) have been incorporated in the Douglas specification control drawing.

2.3.3 Subsystem Design

The propellant utilization electronics assembly acceptance test procedure has been changed to incorporate the -521, -523, -525, and -527 configurations. These configurations were created by the addition of the new system shaping module.

The first units of the redesigned liquid oxygen and liquid hydrogen mass probes have been shipped from the vendor on schedule.

No significant battery problems were encountered during the pretest and firing of AS-202 at Kennedy Space Center. Battery voltages were within expected parameters throughout the entire flight. Battery temperatures were controlled by the heaters at the normal operating range before liftoff. Temperatures were within the desired range during flight.

The recent failure of NASA batteries in the 500-FS test has caused concern due to the similarity to Douglas batteries. The vendor has assured Douglas that although the cells are similar in the two batteries, the physical orientation of the cells within the casting are sufficiently different to preclude occurrence of the potting problem that was observed in the NASA batteries.

An investigation is underway to determine why the potting deficiency in the NASA batteries occurred and what corrective action is being taken by the vendor to improve quality control.

2.4 Weight Status

Current stage dry weight predicted on all contracted S-IVB flight stages is indicated below.

STAGE NO.	CURRENT DRY SPECIFICATION WEIGHT	CURRENT PREDICTED STAGE DRY WEIGHT	SPECIFICATION WEIGHT MINUS CURRENT PREDICTED WEIGHT
S-IVB-201	24,555	23,286 (3)	1,269
S-IVB-202	24,576	23,306 (3)	1,270
S-IVB-203	26,077	25,198 (3)	879
S-IVB-204	23,862	23,727 (1)	99
S-IVB-205	22,156	21,863 (2)	293
S-IVB-206	22,029	21,696 (2)	333
S-IVB-207	22,023	21,849	174
S-IVB-208	22,138	21,999	139
S-IVB-209	22,101	21,961	140
S-IVB-210	22,207	22,067	140
S-IVB-211	22,089	21,968	121
S-IVB-212	22,207	22,086	121
S-IVB-501	26,707	26,446 (1)	261
S-IVB-502	26,741	26,501 (2)	240
S-IVB-503	25,970	25,661	309
S-IVB-504	24,094	23,906	188
S-IVB-505	24,091	23,906	185
S-IVB-506	24,161	23,955	206

(1) Based upon final actual weighing (2) Based upon Huntington Beach Space Systems Center actual weighing (3) Final flight weight

More detailed weight information is presented in Douglas report DAC-56456, Saturn S-IVB Weight and Balance Status Report Model DSV-4B, dated 15 September 1966.

2.5 Reliability

2.5.1 Reliability Analysis

2.5.1.1 Reliability Engineering Models and Supplements

The preliminary and final versions of the S-IVB-207 Reliability Engineering Model were submitted in September. The preliminary and final versions of the S-IVB-208 model were submitted in August. The preliminary and final versions of the S-IVB-503 model were submitted in August and September, respectively.

Modification of the S-IVB-208 stage (instead of S-IVB-207) for the 207-208 Dual Launch Program resulted in corresponding changes in the two Reliability Engineering Models.

Flight Critical Items

The Saturn S-IVB Stage Flight Critical Items Drawing Numbers List drawing (1B53279 (E) was revised during August.

The first version of the S-IVB-204 Stage Flight Critical Items-Hardware List was completed and distributed.

Flight Critical Items Second Tier Analysis

The Second Tier Analysis on the valve power amplifier (propellant utilization electronics assembly 1A59358-517) was completed.

Time/Cycle Significant Items

Total operations on time and cycle significant items on S-IVB-202 up to liftoff were compiled.

Time/cycle significant items for operations prior to liftoff for S-IVB-203 have been summarized.

Accumulated time/cycles of the Reliability and GFP/TSI on S-IVB-202 have been summarized.

Multifailure Analyses

Multifailure analysis of the auxiliary propulsion system quadruple redundant propellant valve assembly was initiated and was 70 percent complete at the end of the quarter.

2.5.1.2 Test Report and Test Drawing Review

Reliability Analysis reviewed the following reports, drawings, and procedures:

	Total Reviewed	Total Approved	Returned to Design Sections for Corrections
Qualification Test Reports	28	15	13
Qualification Test Control Drawings (New)	7	7	0
Qualification Test Control Drawing Engineering Orders	52	49	3
Formal Qualification Test Procedure Engineering Orders	3	3	0
Formal Qualification Test Control Drawing Engineering Orders	10	10	0

2.5.1.3 Reliability Verification Tests

Reliability Analysis continues to review Test Control Drawings and Test Plans for the Reliability Verification Test Program (Change Order 890).

Reliability Verification testing on four specimens of the liquid hydrogen chilldown pump (Test Plan Item RVF-7) continued during the quarter (Change Order 202).

2.5.1.4 Reliability Assessment

Effort on the updated S-IVB-204 stage Reliability Assessment continued during the quarter.

2.5.1.5 Formal Qualification Test Program

Documentation was issued signifying successful completion of Formal Qualification Tests on the propellant tank helium storage sphere (1A49990) (Test Plan Item FQB-2).

2.5.1.6 Engineering Drawing Reviews

Documentation reviewed and approved during the quarter included 24 drawings, 58 Engineering Drawing Engineering Orders, 5 Waiver Requests, 2 Design Deviation Requests, and 5 Production Acceptance Test Procedures.

2.5.1.7 Failure Effect Analysis, GSE

The preliminary Failure Effect Analysis for GSE is 90 percent complete.

2.5.1.8 Malfunction Detection System Design Analysis

Malfunction Detection System design analysis status is indicated below:

Stage	Estimated Submittal
S-IVB-501 (Revised)	Delivered 3 August
S-IVB-502 (Preliminary)	Delivered 3 August
S-IVB-502 (Revised)	14 October
S-IVB-503 (Preliminary)	18 October

2.5.1.9 Formal Design Reviews

The following items are scheduled for Formal Design Review Meetings:

Part Number	Nomenclature
1B57781	Cold Helium Fill Module
1A48312	Oxidizer Tank Vent and Relief Valve
1B40689	Gas Heat Exchanger (DSV-4B-438)
1B59993	Gas Heat Exchanger (DSV-4B-438A)

2.5.2 Human Engineering

Results of Human Engineering Recommendations during the quarter included:

a. Design and installation of slip-fit load cell pivot bosses to preclude installation damage to load cells used in stage weighing.

b. Liquid oxygen and liquid hydrogen tank ullage pressure gage overlays with enlarged digits to enable dependable television monitoring during stage acceptance firing.

Human Engineering Recommendations submitted during the quarter included:

a. Addition of a countdown clock in the Sacramento Test Center Control Center to enable viewing by recording personnel.

b. Remounting of a countdown clock in the Sacramento Test Center Control Center for better viewing by strip chart personnel.

c. Better illumination in the stage aft skirt area for post-test checkout in the Sacramento Test Center Vertical Checkout Laboratory.

d. Valve safety covers on the Phase 2 hydrostatic testing facility for S-IVB-9005.

2.5.3 Reliability Data Acquisition

2.5.3.1 Subcontractor and Supplier Control

Reliability Data Acquisition supervision of Vendor Information Request activity continued during the quarter.

2.5.3.2 RECAP Reliability Case Analysis Presentation

The monthly RECAP report for the period ending 5 August, containing 952 items, was submitted to NASA on 15 August. The monthly report for the period ending 9 September, containing 1,443 items, was submitted on 13 September.

2.5.3.3 Traceability

Approximately 1,400 drawings and drawing changes were reviewed for identification/traceability requirements; 25 drawings were processed for additional requirements, effectivities, and incorporation in the Identification/Traceability Parts List.

SECTION III

MANUFACTURING

3. MANUFACTURING

Manufacturing and fabrication of S-IVB stage components and subassemblies continued during the quarter at the Santa Monica, California, facility with stage assembly and checkout at the Huntington Beach, California, Space Systems Center. Fabrication progress on individual stages is described below. Stage activity following checkout is reported in Section 4.

3.1 S-IVB/Saturn IB Stages

S-IVB-207

S-IVB-207 stage painting, weigh and balance operations, and final preparations for shipment were completed at the Space Systems Center and the stage was shipped to the Sacramento Test Center via Super Guppy aircraft on 30 August.

S-IVB-208

S-IVB-208 stage joining operations, final installations, and Megger checks were completed in mid-August at the Space Systems Center Tower 2. J-2 engine and hydraulic system installations were then completed in the Production Test Facility by the end of August. S-IVB-208 stage checkout, initiated in Tower 5 on 22 August, was continuing at the end of September. Stage shipment is planned for December.

S-IVB-209

S-IVB-209 stage liquid hydrogen tank internal insulation installation continued throughout August in the Space Systems Center Insulation Chamber. Liquid hydrogen tank insulation and bonding of exterior mounting clips were completed in early September. The stage was positioned in Building 45 for interior installations at the end of September. Astronaut Lt. Commander Allan L. Bean visited the Space Systems Center during the quarter to inspect attach fittings in the S-IVB-209 liquid hydrogen tank interior provided for the manned orbital experiment.

S-IVB-210

The basic tank assembly of the S-IVB-210 stage was completed and the tank assembly was ready for proof test at the end of August. Proof testing was accomplished on 3 September. At the conclusion of testing it was discovered that a cover plug had failed to seal a fitting connected to the common bulkhead cavity. Consequently, water from the tank had been admitted to the common bulkhead cavity during testing. After allowing the water to drain, vacuum pumping operations were initiated to remove the remaining water which had accumulated in the fiberglass honeycomb. Pumping operations were continuing at the end of September with the stage in the Insulation Chamber under elevated temperatures to assist the vacuum pumping rate. NASA and Douglas were determining schedule impact at the end of September.

S-IVB-211

Fabrication of the S-IVB-211 common bulkhead was completed in August at Santa Monica. Fabrication of the aft dome was in process. Forming of material for the stage tank cylinder and work on the forward dome were started during August at Santa Monica. The liquid oxygen tank assembly (common bulkhead and aft dome) was nearing completion at the end of September.

3.2 S-IVB/Saturn V Stages

S-IVB-503

S-IVB-503 stage checkout, initiated at the Space Systems Center Tower 6 on 21 July, was concluded on 14 September. No test discrepancies existed at the conclusion of testing. The stage was then moved to Tower 8 for leak checks, post-checkout installations, and the completion of final inspection. Stage shipment to the Sacramento Test Center is planned for 11 October. Installation of the oxygen-hydrogen burner installation and dual repressurization systems will be accomplished at the Sacramento Test Center prior to acceptance firing.

S-IVB-504

S-IVB-504 liquid hydrogen tank installations were completed in early August and the tank was cleaned and closed. Liquid oxygen tank installations and cleaning were then completed and the tank was closed on 24 August. Stage joining operations were started in Tower 2 in late August. The stage was erected in Tower 6 on 22 September for Megger checks and final installations prior to J-2 engine installation. Engine installation was then accomplished on 30 September. Stage checkout will be initiated in early October.

S-IVB-505

The S-IVB-505 common bulkhead was completed in early August at Santa Monica. Liquid oxygen tank and forward dome assembly was in process at the end of August. Tank cylinder assembly continued during August at the Space Systems Center. Tank assembly and proof testing were completed in September. Subassembly of the aft skirt was initiated during September at the Space Systems Center.

S-IVB-506

S-IVB-506 aft common bulkhead and forward common bulkhead assembly was in process at Santa Monica during August. Aft dome fabrication was initiated in late August. Work was initiated on waffle milling of tank cylinder segments at Santa Monica during September.

SECTION IV

TESTING

4. TESTING

4.1 System Testing

Testing of S-IVB stage systems continued during the quarter at the Huntington Beach Space Systems Center, Sacramento Test Center, and at other Douglas and vendor facilities.

4.1.1 Flight Testing

S-IVB-202

The third successful flight of the S-IVB stage was accomplished with the launch of the AS-202 uprated Saturn I vehicle at the Kennedy Space Center on 25 August. The S-IVB stage helped boost an unmanned Apollo spacecraft on a flight designed to test the Apollo heat shield in a long-duration re-entry from space.

The S-IVB stage ignited at an altitude of about 35 miles, following burnout of the S-IB booster stage. The S-IVB Rocketdyne J-2 engine consumed approximately 80,000 gallons of propellants during the 7 1/2-minute burn time. Payload weight exceeded 28,000 pounds.

After J-2 engine shutdown, S-IVB altitude-control rockets were fired intermittently to stabilize the vehicle during Apollo separation from the launch vehicle.

After completion of the primary mission, an experiment was conducted to test the strength of the common bulkhead separating the S-IVB stage propellant tanks. All left-over oxygen was vented overboard and the oxygen tank depressurized. Hydrogen tank vents were closed, permitting pressure to build up as the residual liquid hydrogen boiled off. Temperature and pressure data were then recorded until the bulkhead collapsed or ruptured, resulting in stage destruction.

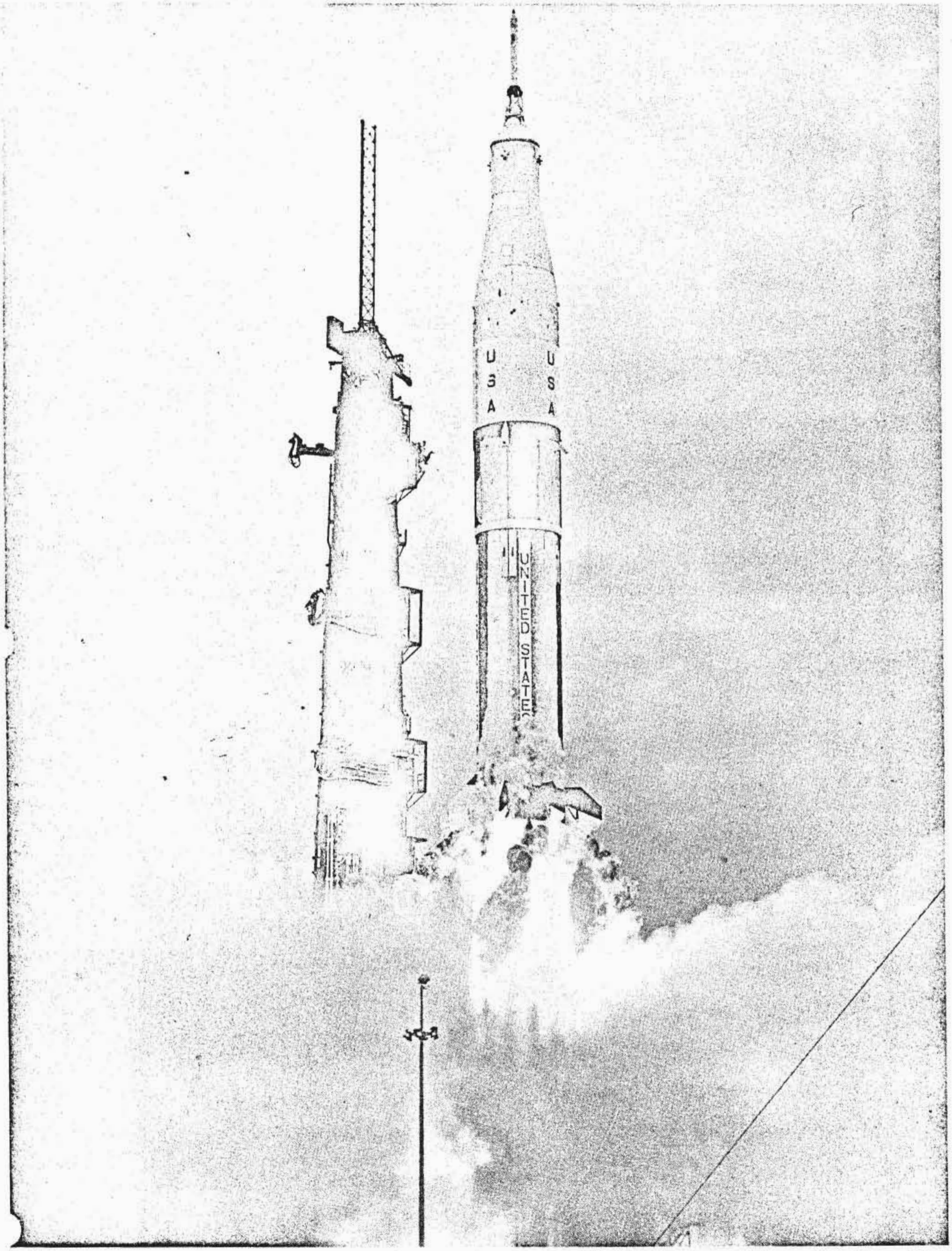


Figure 1. Saturn Vehicle AS–202 Launch at Kennedy Space Center on 25 August 1966.

S-IVB-204

The S-IVB-204 stage arrived at the Kennedy Space Center via Super Guppy aircraft on 7 August and was moved to the VAB low bay for ultrasonic and Growler inspections. After completion of checkout and modifications, the stage was transported to Launch Complex 34 on 30 August and erected on 31 August. AS-204 space vehicle checkout was in process at the end of the quarter.

S-IVB-501

The S-IVB-501 stage arrived at the Kennedy Space Center via Super Guppy aircraft on 14 August and was transported to the VAB low bay on 15 August. Modifications and installations were continuing in the low bay at the end of the quarter.

4.1.2 Acceptance Testing

S-IVB-204

After completion of stage modifications, the fourth S-IVB flight stage, S-IVB-204, was shipped from the Sacramento Test Center to Kennedy Space Center on 5 August.

S-IVB-205

The S-IVB-205 stage remained in the Sacremento Test Center Tower No. 2 vertical stand during August. The stage was placed on the roll fixture in early September and post-turnover modifications were initiated. Stage shipment to Kennedy Space Center is scheduled for 15 November.

S-IVB-206

S-IVB-206 stage acceptance firing was successfully accomplished on 19 August in the Sacramento Test Center Beta 3 Test Stand. Mainstage duration was 433.7 seconds. Subsequent replacement of the liquid oxygen turbopump necessitated a J-2 engine balance verification firing.

The engine performance verification firing was accomplished on 14 September. The 66.6-second mainstage operation of the J-2 engine verified proper operation of the newly-installed liquid oxygen turbopump assembly and its compatibility with the engine. Stage post-firing activities on the Beta 3 Test Stand were completed by the end of September. The stage will be transferred to the Vertical Checkout Laboratory in early October for All-Systems testing.

S-IVB-207

The S-IVB-207 stage arrived at the Sacramento Test Center on 31 August. Following removal of flight instrumentation and covers, the stage was installed in the Beta 1 Test Stand on 1 September. Prefiring activities were initiated and on 7 September stage power was turned on. Stage subsystems checkout will be complete on 5 October.

S-IVB-501

The initial Saturn V flight stage, S-IVB-501, was shipped to the Kennedy Space Center via Super Guppy aircraft on 12 August, marking a significant milestone in the Apollo Program. The Governor of California delivered the stage to NASA on behalf of Douglas at a ceremony at Mather Air Force Base on 12 August.

S-IVB-502

S-IVB-502 stage post-firing activities continued at the Sacramento Test Center during August. The stage was transferred to the Vertical Checkout Laboratory on 10 August. Post-firing checkout was successfully completed with an All-Systems test on 12 September. The "stage ready for delivery" milestone was reached on 21 September. The stage will remain in storage until late November, during which time post-turnover modifications will be accomplished.

4.1.3 Auxiliary Propulsion System Testing

S-IVB/Saturn V Auxiliary Propulsion System Module Phase IV Testing

Phase IV Preflight Rating Tests on the Saturn V auxiliary propulsion system module were completed on 12 August at the Sacramento Test Center Gamma Complex.

A test conducted on 4 August consisted of helium regulator and injector valve malfunction effects firings which simulated various modes of failures of these components during a firing program. All test objectives were satisfied.

Testing was concluded with a mission profile firing initiated on 9 August and completed on 12 August. Following propellant loading, a 3-day hold was initiated to monitor tank bladder conditions. The 6.5-hour mission profile firing was accomplished on 12 August and satisfied all test objectives. Following a special series of cleaning agent evaluation tests, the modules are being held in storage pending NASA direction. After the conclusion of testing, the test site was deactivated in September.

4.1.4 S-IVB/Instrument Unit (500-FS) Environmental Test

The sixth test of the S-IVB/Instrument Unit environmental test program was successfully conducted on 2 August in the Space Systems Center Space Simulation Laboratory. This test simulated the maximum temperature condition experienced during launch, earth orbit, and translunar injection. The final test, simulating a combination of worst conditions, selected failures, and changed test parameters, was successfully completed on 9 August. In addition, an unscheduled corona investigation test was accomplished as requested by MSFC to determine if significant electrical discharge occurs in the Instrument Unit or S-IVB stage electronics during the critical pressure range of 10^{-2} to 10^{-4} Torr.

4.1.5 Hydrostatic Test No. 2 Test

The hydrostatic test stage No. 2 successfully completed the planned failure test at the Space Systems Center Vertical Checkout Laboratory Tower 3 on 26 September. Tank rupture occurred during burst testing at values above ultimate pressure. This completed Phase II testing.

4.2 Subsystems Testing

4.2.1 Design Development Testing

Design development testing is continuing to provide information which can be applied to the Saturn S-IVB effort. Design development testing is nearing completion with 284 tests completed of 321 tests scheduled. Significant design development testing accomplished during August and September is described below.

4.2.1.1 Airframe/Structures

Mechanical Properties of Welded Joints (Shear Tests) (A-16D)

Tests to determine the shear strength of the liquid oxygen dome Meridional weld at room temperature and at -320°F were completed successfully during August.

Boattail Assembly (A-55)

The Saturn V/S-IVB high-force dynamic test program was completed ahead of the NASA contractual milestone requirement with a series of tests on 15 August at the Wasatch Division of the Thiokol Chemical Corporation's test facility at Brigham City, Utah. The tests provided further confidence that S-IVB structures and mounting equipment will withstand any acoustic and dynamic stresses imposed during flight.

The complete forward skirt structure, including an operational thermo-conditioning system, was subjected to low-frequency vibration in the longitudinal and lateral axes. Since performance of the Douglas-designed test fixtures exceeded expectations, the number of tests was reduced from five to three. The S-IVB boattail section, consisting of the liquid oxygen tank aft dome, thrust structure, and aft skirt, was subjected to low-frequency vibration in six different force modes.

Liquid Hydrogen Dome Enlarged Manhole (A-61)

Testing of the liquid hydrogen dome specimen No. 1 (1T09416-1), which has an enlarged (43-inch-diameter) manhole, was completed successfully during August. Failure occurred at 116 percent of design ultimate, indicating adequate strength capability.

Forward Skirt Anti-Flutter Panel Development Test (A-64)

A compression load test was completed successfully during August on the forward skirt anti-flutter test panel (1T09811) to evaluate the effect of structural loading on the adhesive bond of the aerodynamic flutter-prevention stiffeners proposed for the S-IVB/Saturn V forward and aft skirts.

Fire Resistant Coating for Liquid Hydrogen Tank (A-65)

A development test program is continuing at the Sacramento Test Center to find a material which when bonded or coated over the existing liquid hydrogen tank interior insulation will provide a fire resistant coating or layer. The purpose of the tests is to prove the structural adequacy of a fire-resistant coating or layer over the internal insulation when subjected to environments the liquid hydrogen tank will experience during its life cycle.

4.2.1.2 Propellant Dispersion System Components

Safety and Arming Device Vent Port (AC-28)

A series of 10 development tests was conducted using both Saturn IB and Saturn V safety and arming devices modified to a vented configuration. As a result of the successful completion of Item AC-28 using production parts, the vented configuration was qualified and a series of five qualification tests (AC-29) was deleted.

4.2.1.3 Cryogenic Repressurization System

Oxygen-Hydrogen Burner Installation (AH-11A)

Oxygen-hydrogen burner development testing progressed satisfactorily during August and September at the Sacramento Test Center Alpha Test Stand 2B. Injector icing problems have been resolved and the final injector configuration has been determined. Performance of the selected injector design will be demonstrated during a series of 16 tests which started on 1 September. Testing being conducted for investigation of igniter-injector compatibility and other problems experienced with burner start, steady state, and shutdown operations continued during September.

1-Inch Shutoff Valve (AH-14)

Development testing on the 1-inch shutoff valve (1B59010) is progressing satisfactorily. An ECP has been approved to authorize redesign and reconfiguration of the -1 valve to -501 for use on S-IVB-503 through S-IVB-515. The redesign consists of the addition of orifices required to meet new response time requirements.

4.2.2 Qualification Testing

Qualification testing of parts, components, subassemblies, and higher levels of assembly to ensure that the design is capable of meeting established requirements is continuing. Qualification testing is progressing, with 506 tests completed of 746 tests scheduled. Significant qualification testing accomplished during August and September is described below.

4.2.2.1 Airframe/Structures

S-IVB/S-II Interface Test (A-47)

The seventh and eighth tests (of 12 scheduled) to qualify the S-IVB/Saturn V aft interstage and the S-IVB/S-II interface joint were completed successfully in August.

The ninth (temperature parameter test) and tenth (S-IC engine cutoff design ultimate test) tests were completed during September.

The first (bending moment parameter test) and second (maximum αq design ultimate test) of five tests to qualify the aft skirt were completed successfully during September.

4.2.2.2 Propulsion System Components/Fuel Tank Fill System

Fill and Drain Valve (F-3)

Both ambient and cryogenic qualification vibration tests were performed on the fill and drain valve (1A48240-501) to qualify redesigned valve springs and microswitches. No structural failures occurred and only slight microswitch chatter was observed during testing in the last (radial) axis.

4.2.2.3 Propulsion System Components/Ambient Helium System

Actuation Control Module (J-3B)

A -503 configuration has been created for the actuation control module (1B65292) to incorporate polyimide seals which performed satisfactorily during development testing. Two -501 modules, which had been reworked to the new -503 configuration, failed low temperature leakage during qualification testing. The test specimens were returned to the vendor for readjustment. Resumption of testing is scheduled for 20 October.

Positive Pressure System Hand Valve (J-16)

Ambient vibration qualification tests were successfully run on a redesigned positive pressure system hand valve (1B53817-505). No structural failures, malfunctions, or leakage occurred during or after vibration testing of the redesigned valve.

4.2.2.4 Auxiliary Propulsion System

Auxiliary Propulsion System High Pressure Helium Tank (L-63)

Qualification testing of two units of the auxiliary propulsion system high pressure helium tank (1B39317) has been successfully completed.

Auxiliary Propulsion System Filter (L-67)

Particles up to 100 microns passed through the filters dur ng qualification testing of two units of the auxiliary propulsion system filter (1B55934). The maximum requirement is 25 microns. The vendor is preparing a filtration test procedure for approval by Douglas and will perform these tests on two additional production units for qualification.

4.2.2.5 Environmental Control System Components

Thermo-Conditioning System Flexible Hose (N-13)

Testing of the 1B38429-1 flexible hose was completed successfully during September.

Thermo-Conditioning System Coupling Assembly (N-20)

Testing of the 1B38430-1 coupling was completed successfully during September.

4.2.2.6 Auxiliary Power Supply System - Electronic Components

Hydraulic Power Unit Motor-Driven Starter Switch (P-47)

Qualification testing of the hydraulic power unit motor-driven starter switch (1B32647-503) was completed during the quarter.

4.2.2.7 Subsystem Panel

Cold Panel No. 10, Telemetry Equipment (Forward) (R-18C)

Vibration qualification tests were successfully run on cold panel No. 10 (1B55689-1). The panel was mounted on a section of the forward skirt using the Barry Controls vibration isolators. No structural failures or electrical malfunctions occurred.

Telemetry Equipment Aft Panel Numbers 4 and 5 (R-45)

Qualification testing of telemetry equipment aft panel Numbers 4 and 5 (1B58925-1) had been completed by the end of September.

Aft Equipment Panel No. 3, Telemetry Equipment (R-46)

Vibration qualification tests were successfully performed on the panel (1B58924-1) during the quarter. The panel was then placed in the acoustic test chamber and subjected to an operational acoustic test. There were no structural failures or malfunctions during the acoustic test.

4.2.2.8 Electrical System Components

Hydraulic System Temperature Thermal Switch (U-37A)

High Performance Pressure Switch (U-58C)

Qualification testing of the hydraulic system temperature thermal switch (1A74765-501 and -507) and the high performance pressure switch (1B52624-507) was completed during the quarter.

4.2.2.9 Data Acquisition System

Qualification testing of the following data acquisition system components was completed during the quarter:

a. Absolute Pressure Transducer (1B39293-1) (W-30B)
b. High Temperature Pressure Strain Gage Transducer (1B32291-1) (W-92E)
c. Low Absolute Pressure Transducer (1A97442-1) (W-92M)
d. Liquid Hydrogen Pressure Transducer (1B53574-501) (W-92Z).

4.2.2.10 Ullage Rocket System

Detonator Block and End Fitting (AE-8)

A failure of some of the cords to propagate following vibration test is being investigated and a survey will be conducted on the fixture used to vibrate the specimens. X-ray photos showed that the confined detonating fuse explosive core of several specimens was cracked and had parted during vibration. The fixture survey will aid in determining if the failures were due to a faulty test setup, or if a design change is required. The vibration portion of the test will be rerun.

Confined Detonating Fuse Separation Device (AE-15)

The first 8 of 30 test specimens subjected to vibration test at 165°F have completed the test successfully.

4.2.3 Formal Qualification Testing

Formal qualification testing, to demonstrate, through controlled component tests, that Saturn S-IVB stage hardware meets established requirements under various applicable combinations of service environments, is continuing. Six tests have been completed of 36 tests scheduled in the formal qualification test program. Significant formal qualification testing accomplished during August and September is described below.

4.2.3.1 Propulsion System Components/Fuel Tank Fill System

Fill and Drain Valve (FQ-F-3)

Vibration testing of fill and drain valve (1A48240-505) Serial Number 0048 was successfully completed.

Prevalve (FQ-F-12)

Vibration testing of the prevalve (1A49968-507) Serial Numbers 114 and 115 was successfully completed.

4.2.3.2 Propulsion System Components/Oxidizer Tank Fill System

Oxidizer Low Pressure Duct Assembly (FQ-G-4)

Vibration testing of oxidizer low pressure duct assembly (1A49969-501) Serial Number 0033 was successfully completed.

Liquid Oxygen Auxiliary Motor-Driven Chilldown Pump (FQ-G-7)

Vibration testing of liquid oxygen auxiliary motor-driven chilldown pump (1A49423-501) Serial Number 1758 was successfully completed.

4.2.3.3 Propulsion System Components/Fuel Tank Pressurization System

Fuel Tank Pressure Control Module (FQ-H-2)

Vibration testing of fuel tank pressure control module (1B64443-503) Serial Numbers 1022 and 1025 was successfully completed.

Fuel Tank Vent and Relief Valve (FQ-H-5)

Vibration testing of fuel tank vent and relief valve (1A48257-501) Serial Number 0026 was successfully completed.

Fuel Tank Relief Valve (FQ-H-12A)

Vibration testing of fuel tank relief valve (1A49591-527) Serial Number 0115 was successfully completed.

4.2.3.4 Propulsion System Components/Oxidizer Tank Pressurization System

Cold Helium Fill Module (FQ-I-2)

Vibration testing of cold helium fill module (1B57781-1) Serial Numbers 0013 and 0023 was successfully completed.

Liquid Oxygen Tank Pressure Control Module (FQ-I-3)

Formal qualification testing of the liquid oxygen tank pressure control module (1B42290) is in process at the Douglas, Santa Monica, California, facility.

4.2.3.5 Propulsion System Components/Ambient Helium System

Pneumatic Power Control Module (FQ-J-6)

Two new configurations (-513 and -515) have been created of the pneumatic power control module (1A58345), which are identical to the -509 and -511 configurations, respectively, except that width of the regulator poppet seals is controlled on the new configurations. Formal qualification testing, using two -509 specimens reworked to the -513 configuration, was resumed on 27 September.

Engine Pump Purge Control Module (FQ-J-7)

Formal qualification testing of the engine pump purge control module (1A58347) is in process at Beech Aircraft, Boulder, Colorado. ECP 7599, to reconfigurate the modules (-505 to -509 and -507 to -511) was submitted on 7 September. The new configuration would use a redesigned static seal to reduce low temperature leakage.

4.2.3.6 Auxiliary Propulsion System

Propellant Control Module (Oxidizer) (FQ-L-5)

Vibration testing of oxidizer propellant control module (1A49422-507) Serial Number 0000051 was successfully completed.

Propellant Control Module (Fuel) (FQ-L-5A)

Vibration testing of fuel propellant control module (1A49422-508) Serial Number 0000232 was successfully completed.

Auxiliary Propulsion System Propellant Tank (FQ-L-21)

Formal qualification testing of the auxiliary propulsion system propellant tank (1A93231) is in process. One unit has completed proof, functional, and leakage tests; has partially completed pressure cycle and life cycle tests; and is currently undergoing propellant exposure testing. Failure of the first specimen was inadvertently caused by over-pressurizing to 200 psid inside the bellows.

Auxiliary Propulsion System Helium Pressure Regulator (FQ-L-66)

Redesign has been completed and formal qualification testing of a redesigned auxiliary propulsion system helium pressure regulator (1B54601) is being expedited at Beech Aircraft for completion prior to AS-204 launch.

4.2.3.7 Flight Control System Components

Engine-Driven Hydraulic Pump and Isolator Assembly (FQ-M-3)

During the vibration test portion of the formal qualification test program, one of the test specimens developed fluid leakage in the face seal between the pressure compensator and the pump body. NASA reported that two test specimens had experienced similar leakage problems while undergoing tests at MSFC. Examination of the O-rings in the face seal revealed them to be nibbled and partially extruded. Pressure compensators were removed from all test pumps and O-ring grooves were measured for adequate depth; mating surfaces were measured for flatness and damaged O-rings were replaced. The compensators were reinstalled with the torque increased on the two holding screws from 35-40 inch/pounds to 70-75 inch/pounds. This change was also performed on S-IVB-204 at Kennedy Space Center.

The proof pressure test also experienced a failure when the low-pressure O-ring in a "C" change pressure compensator face seal was "washed" downstream into the pump case. A fix, consisting of a floating-type spacer to retain the low-pressure O-ring, will be effective for all "C" change pump units.

Accumulator-Reservoir (FQ-M-8)

During the low-temperature (-35°F) portion of the formal qualification test program, fluid leakage occurred at the accumulator-to-reservoir static seal and through the R-10 reservoir vent relief valve. Examination revealed that the finish on the anodized surface of the reservoir bore was 50 to 60 microns instead of the required 8 microns.

The inside reservoir surface was hand-polished by the vendor to a 16 to 20 finish. The static interface packing was examined and appeared satisfactory. The test specimen was reassembled using a new static seal O-ring and testing was resumed. This specimen has now satisfactorily completed all tests except for the vibration and burst tests.

Electrical Auxiliary Hydraulic Pump (FQ-M-29)

As a result of a compensator spring guide failure during laboratory qualification testing of the system, the spring guide was redesigned with a larger wall thickness and stronger material. Retesting of the system using the redesigned spring guide is in progress.

During recent hardware parts inspections at the Vickers Company, some pistons exhibited hairline fissures in the piston skirts after hot forming to the piston rod. The manufacturer conducted pull and hardness tests on various fissured and non-fissured pistons and determined that, although the piston strength was considerably reduced with fissures, a safety margin of 16 to 1 is still retained. Vickers will control the hot forming operation more closely, give special attention to inspecting for fissures after the hot forming operation is complete. All units will be returned to Vickers from the field for inspection; pistons which exhibit the fissures will be replaced.

Vibration testing of Serial Number 454662 was successfully completed during the quarter.

4.2.4 Reliability Verification Testing

Preparations were active during the quarter for start of Reliability Verification testing, designed to increase the engineering confidence in the probability of flight. This increased confidence will be accomplished by environmental and overstress environmental testing of 26 Flight Critical Items. Component testing will be initiated in October.

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