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DOUGLAS REPORT DAC-56622

NARRATIVE END ITEM REPORT

SATURN S-IVB-507

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DOUGLAS

MISSILE & SPACE SYSTEMS DIVISION

APRIL 1968

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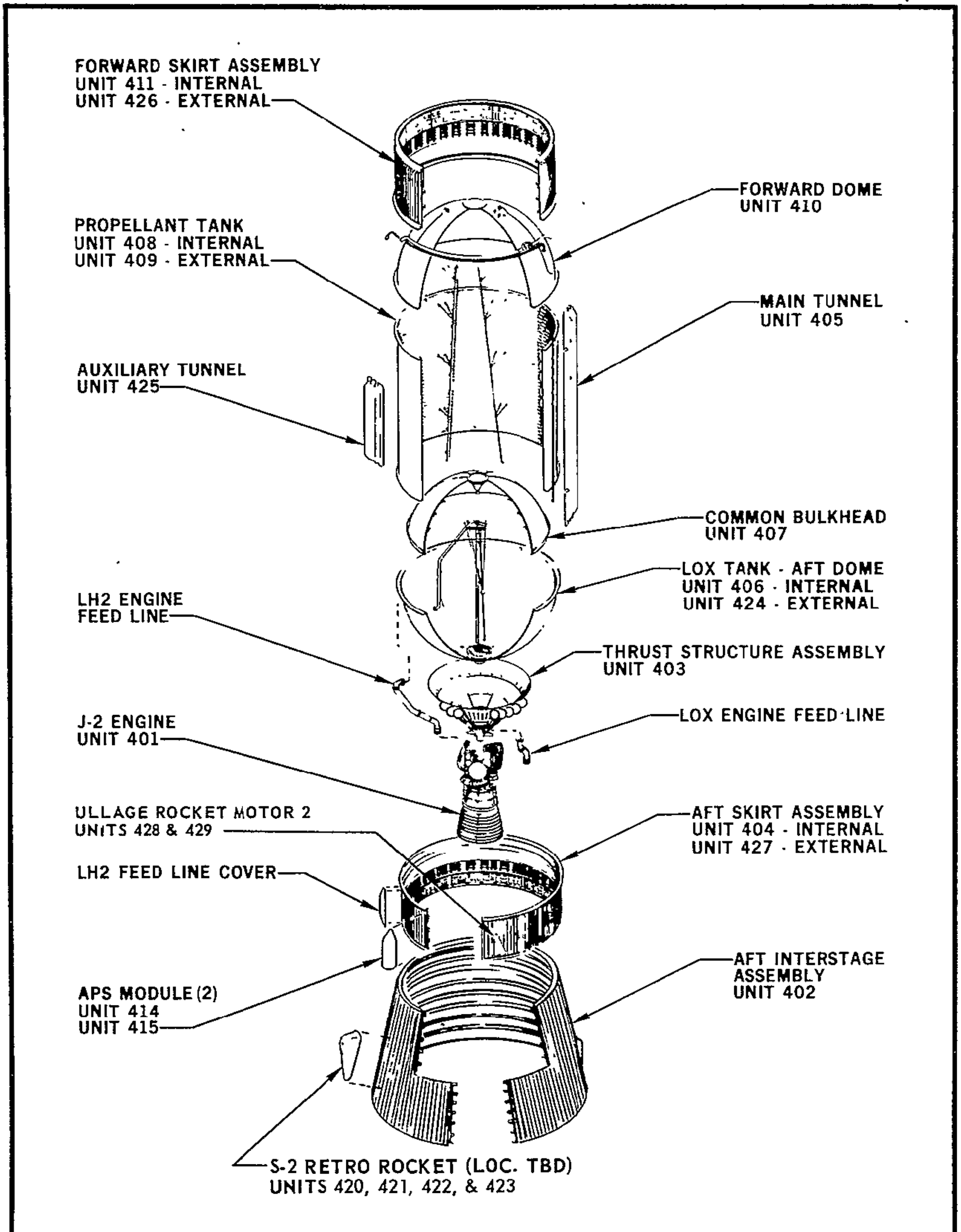

Exploded View of S-IVB Stage for Saturn V

ABSTRACT

The Narrative End Item Report contained herein is a narrative summary of the Douglas manufacturing and Space Systems Center test records relative to the Saturn S-IVB-507 Flight Stage (Douglas P/N 1A39300-521, S/N 507).

Narrations are included on conditions related to permanent nonconformances which were generated during the manufacturing cycle and existed at the time of Space Systems Center acceptance testing. The report sets forth data pertinent to total time or cycle accumulation on time or cycle significant items. Data, relative to variations in flight critical components, are also included. There is no provision to update or revise this volume of the NEIR after initial release.

Descriptors

NEIR	Significant Items
Documentation	Stage Checkout
Configuration	Manufacture and Test

PREFACE

This Narrative End Item Report is prepared by the Reliability Assurance Operations Department of McDonnell Douglas Corporation, for the National Aeronautics and Space Administration under contract NAS7-101. This report is presented in response to requirements of NPC 200-2, paragraph 14.2.4, and is issued in accordance with MSFC-DRL-021, Contract Data Requirements, which details contract data required from McDonnell Douglas Corporation. The report summarizes the period from initial stage acceptance testing at the Douglas Space Systems Center, Huntington Beach, California, through final acceptance testing at the Douglas Sacramento Test Center (STC), Sacramento, California, and turnover to NASA/MSFC for delivery to NASA/FTC.

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SECTION 1

INTRODUCTION

1.0 INTRODUCTION

1.1 Scope

The NEIR compiles quality evidence and assessments of a particular end item for use in evaluating program objectives and end item usage. This report narrates upon the Saturn S-IVB Stage and discusses the following:

a. Configuration at transfer to Sacramento Test Center.

b. Replacements made during Space Systems Center test and acceptance checkout, including the serial number of articles removed or substituted.

c. Nature of problems and malfunctions encountered.

d. Corrective action taken or pending.

e. Extent of retests or tests not completed.

f. Total operating hours or cycles for each time or cycle significant item.

1.2 Format

This document is organized into sections, with each section fulfilling a specific purpose. The title of each section and a brief outline of its purpose follow:

SECTION:

1. INTRODUCTION. This section discusses the scope of the NEIR, the Stage Design Concept, and Documentation, and Transfer Data.

2. NARRATIVE SUMMARY. A brief summary of principle test areas is presented to give management personnel a concise view of successful test achievement, and remaining areas of concern.

3. STAGE CONFIGURATION. Conformance to engineering design.

4. NARRATIVE. A presentation of checkout operations, presented in the chronological order of testing. Failure and Rejection Reports (FARR's) are referenced as applicable for each paragraph.

5. POSTRETENTION. A presentation of stage configuration, additional stage testing prior to shipment (if any), final inspection, weight and balance, preshipment purge, retest requirements, post-checkout FARR's, and flight critical items installed at shipment.

APPENDICES:

1. TESTING SEQUENCE. Graphic presentation of the order and activity dates of the VCL checkout procedures.

1.2 (Continued)

2. NONCONFORMANCE TABLES.

   a. TABLE I. A compilation of FARR's against structural assemblies.

   b. TABLE II. A compilation of FARR's recorded during systems installation and checkout.

1.3 Stage Functional Description

A detailed system analysis is beyond the scope of this report. The "S-IVB-V Stage End Item Test Plan", 1B66684, contains a description of each operational system, and includes a listing of test procedures, with the objective and prerequisite of each test. The stage is primarily a booster stage consisting of propellant tanks, feed lines, electrical and pneumatic power for operation of stage systems, and such systems as are required for checkout purposes, fuel loading and unloading control, in-flight control and pressurization, and data measurement during these operations.

1.4 Documentation

Manufacturing and test records for this stage include Fabrication Orders (FO's), Assembly Outlines (AO's), Inspection Item Sheets (IIS's), Failure and Rejection Reports (FARR's), Serial Engineering Orders (SEO's), Radiographic Inspection Records, Hydrostatic test data, Vehicle Checkout Laboratory (VCL) test data, and vendor data, FO's and AO's record in sequence all manufacturing processes, procedures, and Quality Control inspection activities. Any problem or discrepancy noted by Inspection and Test personnel is recorded on an IIS for corrective action. Any discrepancy from a drawing requirement is recorded on a FARR by Inspection and Test personnel. The FARR is also used to record the Material Review Board (MRB) disposition applicable to the discrepancy. SEO's may be written to define the rework required by a FARR; to change the effectivity of a drawing; or to change other drawing requirements. Radiographic Inspection Records and X-ray photographs of all weld seams are maintained on file by the contractor. All original data is retained in the contractor's Reliability Assurance Department Central Data Files. Vendor technical data is received on functional purchased parts and also retained in Central Data Files. The majority of documentation referenced within this report is included in the log book which accompanies the stage.

SECTION 2

NARRATIVE SUMMARY

2.0 NARRATIVE SUMMARY

The following paragraphs present a narrative summary of manufacturing and checkout of the stage. Stage manufacturing tests and stage checkouts conducted at the Space Systems Center (SCC) are summarized in paragraphs 2.1 and 2.2, respectively. Narrations on these tests and operations are presented in section 4.

Paragraph 2.3 comments on the preparations for stage retention at Huntington Beach.

2.1 Stage Manufacturing Tests

Two major manufacturing tests conducted on the stage during the manufacturing sequence verified the structural integrity of the stage propellant tank assembly. A hydrostatic proof test, successfully conducted on 13 and 14 June 1967, verified that the tank assembly could withstand the required test pressures without leakage or damage.

The propellant tanks leak check, initiated on 19 June and completed on 21 June 1967, ensured that there were no leaks in the weld areas or where the tank assembly wall was penetrated by lockbolts or other types of fasteners used to attach structural items to the tank assembly.

At the conclusion of these tests the tank assembly was accepted for continued manufacturing effort and system installation. A more detailed narration of these tests is presented in paragraph 4.1.

2.2 Stage Checkout SSC

The stage was installed in SSC VCL tower 6 on 8 November 1967. Checkout of the stage systems started on 20 November 1967, and was completed on 19 February 1968, after 52 working days of activity. A total of 34 checkout procedures involving the stage systems were accomplished during this period. An additional 10 days were used to perform troubleshooting on the Rocketdyne engine control assembly. The stage was removed from the VCL on 28 February 1968. Narrations on the checkout procedures are presented in paragraph 4.2, in the order in which the tests were started.

2.2 (Continued)

Appendix I shows the chronological sequence of the tests, giving the narration paragraph number, the H&CO drawing number and test title, and the dates each test was active.

Prior to turning on the stage power, checks were made of the stage wiring continuity and compatibility, the forward skirt thermoconditioning system, the engine alignment, the umbilical interface compatibility, telemetry and range safety antenna system checks, and the cryogenic temperature sensors. It was necessary to run a second issue of the cryogenics procedure after the LOX instrumentation probe had been removed and repaired. No major problems were encountered, although several procedure revisions were made. One FARR was written during the wiring continuity check and four FARR's were written during the T/M and RS antenna checks. This FARR, and other FARR's noted below, are summarized in the applicable narration, and in Table II of Appendix II.

Power was first applied to the stage on 1 December 1967, with the initiation of the stage power setup and turn off procedures. No major problems were encountered, although some malfunctions occurred on the first attempts. Three level sensors malfunctioned; however, after adjustment of the sensor controllers a successful run was made on 2 December 1967.

The aft skirt and interstage thermoconditioning and purge system was completed without problems, as were the signal conditioning setup, level sensor and control unit calibration, and digital data acquisition system calibration procedures. However, a second and third issue of the level sensor and control unit calibration procedure were required to adjust the fuel tank fast fill controller and test those sensors located on the LOX instrumentation probe. The probe had been removed for repair.

The digital data acquisition system automatic procedure was successfully completed on the fourth run. The transducers for measurements D1 and D4 were removed and replaced by two FARR's. The LOX instrumentation probe was removed by one FARR and repaired by another. The transducers for measurements D16 and D576 were removed and replaced by FARR's, as was the channel decoder.

The power distribution system, EBW system, APS system, range safety receiver, and range safety system automatic were all completed without encountering any

2.2 (Continued)

stage problems. However, second issue procedures were run on the range safety receiver and range safety system automatic after the range safety decoder, which malfunctioned during all systems test, was replaced.

The PU calibration manual procedure was completed without problems; however, a second issue was run after problems were encountered in the PU calibration automatic procedure. Four runs were required before the procedure was successfully completed. A malfunctioning sensor controller, which was replaced, an out-of-tolerance PU boiloff bias voltage, and a malfunction in the ratio valve hard-over tests resulted in the necessity of conducting four runs.

The hydraulic system fill, flush, and bleed procedure was successfully completed after replacement of the high pressure relief valve, the pitch actuator, an actuator hose, and a defective O-ring on the auxiliary hydraulic pump air regulator. These defects resulted in the generation of four FARR's.

Two runs were required to successfully complete the hydraulic system automatic procedure. The second run was necessary after the replacement of the actuator mentioned above.

Successful completion of the propulsion system control console stage compatibilty was accomplished after correction of the LOX repressurization helium dump open-close switch reverse talkback. It was also necessary to replace several ignitor/exciter electrodes damage during installation. This was accomplished per a FARR.

It was necessary to replace two check valves, which failed the reverse seat leakage test, before the propulsion components internal leak check could be successfully completed. One FARR was written to replace both valves.

The LH_2 tank pressurization system leak check, the repressurization system leak check, and the J-2 engine system leak check were all completed successfully after correcting minor leaks.

The pneumatic control system leak check was successfully completed after correcting the leaks found and replacing the LOX chilldown pump purge pressure switch. The LOX chilldown pump purge pressure switch, P/N 1B52624-515, and the engine pump purge pressure switch, 1B56223-515, were interchanged. A FARR was written to replace the low pressure switch, P/N 1B52624-515, which was damaged because it was installed in a high pressure system.

2.2 (Continued)

The propellant tanks system leak check was concluded successfully after correcting several problems. The LH_2 burner feed duct was removed and replaced three times before it was satisfactory. During one removal/replacement the LH_2 burner feed duct filter was damaged. It was also necessary to replace the LOX fill and drain valve. There were five FARR's written during the operation of this procedure.

The automatic propulsion systems test was conducted in three sections; the ambient helium, propellant tank pressurization, and J-2 engine. During the ambient helium test the LOX prevalve was removed and replaced by a FARR because it would not close. The propellant tank pressurization test required three runs for completion. There were several time delay problems on the first run, which were corrected. On the second run there were two pressure out-of-tolerances, which were manually checked and found to be alright. The third run was made without encountering any problems. The J-2 engine test was performed without encountering any major problems; however, it was necessary to verify timing of the gas generator valve, the main LOX valve, and the start tank discharge valve by the oscillograph recordings.

The all systems test required seven runs for successful completion. Three runs were concerned with the umbilicals-in. The first two were terminated due to many out-of-tolerance conditions; however, the third run was successful although two malfunctions occurred because of program errors.

Umbilicals-out required four runs for successful completion. The first and third runs were terminated when the forward bus 2 voltage dropped. The second run was not "sellable" because the range safety 2 decoder malfunctioned as well as several minor malfunctions due to program errors. The fourth run was siccessfully completed; however, there were some minor problems resulting from a leaking umbilical quick-disconnect. Two FARR's were written after the all systems tests from information obtained during the test data review. Additional testing activities after the sell runs were conducted to identify RFI problems and a problem with the out-of-sequence cycling of the engine control assembly.

2.3 Stage Retention

At the conclusion of the additional testing the stage was removed from the tower. The stage was placed in storage at Huntington Beach on 5 April 1968, after completion of painting. Those activities occurring during stage storage, and during the subsequent preparations for stage shipment to STC, are covered in section 5.

SECTION 3

STAGE CONFIGURATION

3.0 STAGE CONFIGURATION

Paragraph 3.1 discusses the means used to verify the stage configuration. Stage variations which represent changes in the scope of the program are presented in section five.

3.1 Design Intent Verification

This configuration of the stage is defined in the Engineering Configuration List (ECL), Space Vehicle, Model DSV-4B-1-1, Manufacturing Serial Number 507, revision A, dated 19 February 1967. This ECL document includes a listing of all parts, non-hardware drawings, and manufacturing and process specifications required for the manufacture and test of the stage, as defined by Engineering production drawings and EO releases. The ECL has been transmitted to NASA under a separate cover.

Verification of design intent was accomplished by comparing the ECL with the Planning Configuration List (PCL), and the Reliability Assurance Department As-Built Configuration List (ABCL). Any discrepancies found were resolved by the contractor, and a listing of the resultant action is filed at the contractor's facility.

SECTION 4

NARRATIVE

4.0 NARRATIVE - STAGE CHECKOUT

A narration of the stage checkout is presented in this section in the chronological order of testing. The major paragraphs comprising the detailed narrative are: 4.1 Stage Manufacturing Tests; 4.2 Stage Checkout - SSC/VCL. These major paragraphs are subdivided to the degree required to present a complete historical record of stage checkout.

Permanent nonconformances and functional failures affecting the stage have been recorded on FARR's, and are referred to by serial number throughout this section (e.g., FARR A271258). The referenced FARR's are presented in numerical order in Table I and Table II of Appendix II.

4.1 Stage Manufacturing Tests

During the manufacturing sequence of the stage, two major manufacturing tests were conducted to verify the structural integrity of the stage propellant tank assembly. These two tests, the hydrostatic proof test and the propellant tanks leak check, are presented in this paragraph. FARR's referenced in this paragraph are presented in Table I of Appendix II.

4.1.1 Hydrostatic Proof Test (1B38414 H)

The hydrostatic proof test was conducted on the tank assembly for the stage to ensure the structural integrity of the LOX and LH_2 tanks and to verify that the tank assembly could withstand the required test pressures without leakage or damage. The item subjected to this test was the tank assembly, P/N 1A39303--535, S/N 507, without the thrust structure installation, P/N 1A39316-517, the LOX sump installation, P/N 1A39154, or the LH_2 door installation, P/N 1B64441.

The hydrostatic proof test was accomplished on 13 and 14 June 1967, using acceptance test procedure (ATP) A659-1B38414-1-PATP16. The test involved varying the water head pressure inside and outside the LOX and LH_2 tanks, while varying the water in the test tank to equalize the hydrostatic head pressure across the skin of the tank assembly, as required to accomplish the following:

a. Proof the common bulkhead to a positive (internal) pressure differential of 27.5 +0.5, -0.0 psi, and the LOX tank at the common bulkhead joint to 28.7 +0.5, -0.0 psi.

4.1.1 (Continued)

b. Proof the common bulkhead to a negative (external) pressure differential of -20.6 +0.0, -0.5 psi, and the LH_2 tank at the common bulkhead joint to 22.5 +0.5, -0.0 psi.

c. Proof the aft LOX tank to a positive (internal) pressure differential of 51.0 +0.5, -0.0 psi, and the common bulkhead at the common bulkhead to aft dome joint to 19.2 +0.5, -0.0 psi.

d. Proof the LH_2 tank aft dome to 38.0 +0.5, -0.0 psi, and the common bulkhead at the common bulkhead to aft dome joint to a positive (internal) pressure differential of 5.2 +0.0, -0.5 psi.

The water head pressures were varied by adjusting the water levels in the hydrostatic test tower outer tank, LOX tank standpipe, and LH_2 tank standpipe. There was no direct correlation between the standpipe water levels used during the test and the specified pressure requirements, but the levels used were those established by Engineering to provide the required pressures.

The following water levels were achieved during the appropriate steps of the procedure. For the LOX tank pressure check the outer tank was empty, the LOX standpipe level was 81.0 feet, and the LH_2 standpipe level was 36.7 feet. For the common bulkhead positive pressure check the outer tank was full to the top of the LH_2 tank, the LOX standpipe level was 66.2 feet, and the LH_2 standpipe level was 2.8 feet. For the common bulkhead negative pressure check the outer tank was full, the LOX standpipe level was 3.9 feet, and the LH_2 standpipe level was 51.7 feet. For the LH_2 tank pressure check the outer tank was full, the LOX standpipe level was 99.6 feet, and the LH_2 standpipe level was 87.6 feet.

For each check, the levels were maintained for 5 minutes, to verify that there was no leakage or damage in the tank assembly. Following the test, the tank assembly and test tower were drained, and the tank assembly was rinsed and dried in preparation for further manufacturing operations.

No major discrepancies or problems were encountered during this test, and no FARR's were written.

4.1.2 <u>Propellant Tanks Leak Check (1B38414 H)</u>

The propellant tanks leak check verified the integrity of the stage tank assembly, and ensured that no leaks existed in the tank assembly welds, or in areas where the tank wall was penetrated by lockbolts or other fasteners attaching

4.1.2 (Continued)

structural items to the tank assembly. The item tested by this procedure was tank assembly, P/N 1A39303-535, S/N 507.

The leak check was initiated on 19 June 1967, using test procedure A659-1B38414-1-PATP30, and was completed on 21 June 1967, after 2 days of activity. There were no part shortages at the start of the test, and no parts were changed as a result of the test.

The first part of the test was a preliminary leak check of the production test equipment (PTE). The LOX tank was pressurized to 3.2 psig with gaseous nitrogen. A bubble solution was used to check the LOX tank PTE adapters and connectors for leakage. Upon completion of the LOX tank check, the LH_2 tank was pressurized to 3.01 psig with gaseous nitrogen, and the LH_2 tank PTE adapters and connections were similarly checked with bubble solution.

A tank assembly integrity test was then started by pressurizing both the LOX tank and the LH_2 tank to 12.0 psig with gaseous nitrogen. The nitrogen supply valves were then closed and the tank pressures were noted. After 10 minutes, the tank pressures were measured as 12.0 psig for the LOX tank, and 11.9 psig for the LH_2 tank, indicating that there was no major tank leakage. The tanks were then vented to atmosphere until the pressures in the LOX and LH_2 tanks reached 8.3 psig each.

The last phase of the test was a freon injection test. The freon gas was flowed into the tanks at 20 cubic feet per minute until the tank pressures reached 10.0 psig for both the LH_2 tank and the LOX tank. The freon system downstream of the evaporator, and from the evaporator to the freon bottles, was then bled to atmosphere. After allowing 1 hour for freon gas diffusion, a bubble solution and a halogen detector were used to leak check the tanks at all weld areas and at all lockbolts or other structural fasteners that penetrated the tank wall. No leakage was detected during this check. At the conclusion of the freon leak check, the tanks were exhausted to atmosphere, then purged with dry air and recapped to ensure cleanliness.

No discrepancies were noted during the operation of this procedure, and no FARR's were written. Two revisions were made to the procedure to add an "as required" note applicable to the PTE adapter listed for port 13, the SVE wire port, adapter A659-1A57431-PTE1 AD10-10088.

4.2 Stage Checkout - SSC/VCL

This paragraph details the tests performed on the stage in the Vehicle Checkout Laboratory (VCL) at the Douglas Space Systems Center, prior to transfer of the stage for shipment to the Sacramento Test Center. The stage was placed in tower 6 of the VCL on 8 November 1967. System checkouts were initiated on 20 November 1967, and continued until 19 February 1968. Checkout activity was active for 61 working days during this period. All tests required by the End Item Test Plan, 1B66684-509B, dated 14 April 1967, were activated and completed.

At the time of the all systems simulated flight test there were three interim use parts installed. These were Rocketdyne transducers, P/N NA5-27323T3, on the J-2 engine, for measurement C1, the LH_2 turbine inlet temperature; for measurement C2, the LOX turbine inlet temperature; and for measurement C215, the LOX turbine outlet temperature. The flight use transducers, P/N NA5-27323T6, will be installed prior to static firing at STC.

Paragraphs 4.2.1 through 4.2.34 contain information on the individual tests conducted, and are presented in the sequential order of testing.

4.2.1 Continuity Compatibility Check (1B59780 D)

Prior to mating the stage to the VCL electrical support equipment, an end-to-end continuity check was made of all electrical cables and wire harnesses installed on the stage, to ensure the integrity of the stage electrical systems, and to verify that the stage was prepared for the application of electrical power for VCL testing. Where possible, the end-to-end continuity of wire runs was measured through electrical component boxes. The test involved all wire harnesses and electrical wiring installed on the stage.

Initiated on 20 November 1967, the procedure was sufficiently completed by 27 November 1967, to allow stage testing to continue. The procedure was completed and accepted on 5 December 1967, after a total of 5 days of activity.

Stage wiring continuity was verified by a total of 2079 individual point-to-point resistance measurements, specified in the test procedure by reference item numbers, "from" component, cable, plug, and pin designations, and "to" component, cable, plug, and pin designations. 1961 of the measurements were within the

4.2.1 (Continued)

original resistance requirement of 1.0 ohm or less. For an additional 85 measurements, indications between 1.0 and 3.0 ohms were acceptable because of the length and type of wire involved. Another 33 measurements were accepted with indications of 50 ±5 ohms, as these measurements were made through modules containing 49.9 ohm resistors.

Engineering comments noted that no parts were short at the start of this test. There was one IIS, 366500, written during the operation of this procedure, which was recapped on FARR A271258. This FARR noted that pin A, of plug P24 on wire harness 1B67089-1, S/N 6631, was bent; and the rubber insert, of connector J4 on wire harness 1B67271-1, S/N 02, was punctured between contacts A and B. The bent pin in plug P24 was straightened per Engineering instructions. The reworked plug, P24, and the connector, J4, with the punctured insert were acceptable to Engineering for use.

Six revisions were made to the procedure for the following:

a. One revision noted the 85 measurements that were acceptable at 1.0 ohm to 3.0 ohms, because of wire types and lengths.
b. One revision noted the 33 measurements that were acceptable at 50 ±5 ohms because the measurements were made through modules containing 49.9 ohm resistors.
c. Two revisions changed three measurement end point designations that were incorrect because of procedure errors.
d. One variation revision changed the end point designation of one measurement because the aft umbilical was connected at the time of the test.
e. One revision changed the end point designations of two measurements, and added one additional measurement, because work was accomplished after the procedure was released.

4.2.2 Forward Skirt Thermoconditioning System Checkout Procedure (1B41926 D)

Before automatic checkout activities were started on the stage, the forward skirt thermoconditioning system was functionally checked by this procedure to prepare it for operation and to verify that the system was capable of supporting stage checkout operations. The items involved in this test were the forward skirt thermoconditioning system, P/N 1B38426-523, and the GSE Model DSV-4B-359 thermoconditioning servicer, P/N 1A78829-1.

4.2.2 (Continued)

The checkout of the forward skirt thermoconditioning system was started on 20 November 1967, and completed on 21 November 1967. The procedure was certified as acceptable on 23 November 1967. The procedure was run in its entirety without encountering any problems.

After the preliminary setup of the Model 359 GSE servicer and an inspection of the forward skirt thermoconditioning system for open bolt holes and properly torqued bolts, the thermoconditioning system was purged with freon gas, and then pressurized to 32 $\pm$1 psig with freon. A system leak check was conducted using a gaseous leak detector, P/N 1B37134-1, set to a sensitivity of 1 on the OZ/YEAR-R12 scale. No leakage was found at any of the system B-nuts and fittings, manifold weld areas, panel inlet and outlet boss welds, or manifold flexible bellows.

The thermoconditioning system was purged with GN_2, then water/methanol coolant was circulated through the system. Coolant samples were taken from both the fluid sample pressure valve (system inlet), and the fluid sample return valve (system outlet), and checked for cleanliness, specific gravity, and temperature. The cleanliness analysis showed that no contaminant particles were present in the coolant. The specific gravity at the pressure outlet was 0.900 and at the return outlet was 0.900, at a temperature of 60°F.

A differential pressure test was conducted by measuring the pressure difference between the thermoconditioning system inlet and outlet while a coolant flow rate of 7.8 $\pm$0.1 gpm was maintained. The coolant temperature was also measured at the system inlet and outlet. Ten measurements, taken at 2 minute intervals, showed that the differential pressure varied from 15.50 psid to 15.75 psid. The supply (inlet) temperature varied from 58°F to 62°F, and the return (outlet) temperature varied from 58°F to 61°F.

Finally, an air content test was performed by stabilizing the thermoconditioning system coolant static pressure at 20 $\pm$0.5 psig, and draining sufficient fluid from the system to reduce the static pressure by 15 $\pm$0.5 psig. The quantity of fluid drained was measured as 41 cc, acceptably less than the 48 cc maximum permissible quantity for the five cold plate configuration of the thermoconditioning system.

4.2.2 (Continued)

Engineering comments indicated that all parts were installed at the start of the test. No discrepancies or problems were noted during the test, nor were any revisions written against the procedure. The forward skirt thermoconditioning system was accepted for use.

4.2.3 <u>Forward Skirt Thermoconditioning System Operating Procedure (1B42124 B)</u>

This manual procedure controlled the setup and normal daily operation of the GSE Model DSV-4B-359 thermoconditioning servicer, P/N 1A78829-1, used to supply water/methanol coolant to the forward skirt thermoconditioning system, P/N 1B38426-515. The water/methanol coolant provided the heat source or sink, as necessary, for proper operation of the forward skirt mounted electronic components during VCL checkout.

Initiated on 22 November 1967, the procedure was used as required until 16 February 1968, and was certified and accepted on 20 February 1968. The GSE servicer was set up for operation, and the coolant supply and return hoses, P/N's 1B37641-1 and -501, were verified to be connected between the servicer and the stage thermoconditioning system. The servicer fluid level was verified to be within the proper limits. The panels of the forward skirt thermoconditioning system were inspected to verify that there were no open equipment mounting bolt holes. The servicer was purged with gaseous nitrogen, and the servicer power was applied.

For normal operation during VCL testing, the servicer was continuously purged with gaseous nitrogen to prevent any possible ignition of the methanol vapors within the servicer. When required for use, the servicer was turned on, the fluid temperature control was adjusted to stabilize the supply temperature gauge reading between 80°F and 90°F, and the servicer flowmeter indication was verified to be 7.8 $\pm$0.3 gpm. The water lines, the servicer internal piping, the pressure and return hoses to the stage, and the stage system were visually checked for leakage. At 30 minute intervals during automatic checkout operations, a check was made to verify that the supply temperature, the coolant flowrate, the coolant supply and return pressures, the gaseous nitrogen source pressure, and the servicer fluid level were within the proper limits, and that there was no leakage. At the end of each use, the servicer was shut down, and it was verified that the servicer filter differential pressure indicator buttons

4.2.3 (Continued)

were down, and that the coolant pump was stopped with a flowrate of approximately zero gpm. At the conclusion of VCL testing, the servicer and thermoconditioning system were secured by the Forward Skirt Thermoconditioning System Post-Checkout Procedure, H&CO 1B62965, (reference paragraph 4.2.34).

Engineering comments noted that there were no parts shortages affecting this test. No problems were encountered during this procedure, and no FARR's were written. No revisions were made to the procedure.

4.2.4 Cryogenic Temperature Sensor Verification (1B64678 B)

The calibration and function of each stage cryogenic temperature sensor, for which the normal operating range did not include ambient temperature, were established by the procedure. The cryogenic sensors are basically platinum resistance elements in which the resistance changes with temperature according to the Callendar-Van Dusen equation. The sensors involved in this test are listed in Test Data Table 4.2.4.1.

Two issues of this test procedure were necessary because the LOX tank instrumentation probe, measurement (369), failed during the DDA system test, 1B66564 C. The second issue covers only those sensors that required testing as a result of replacing the LOX probe. For those sensors which were tested twice, as a result of the LOX probe replacement, only the values of the second test are given in the Test Data Table, as well as those values for the sensors that were tested by the first issue procedure and did not require a second issue test.

The first issue was conducted on 27 November 1967, and was completed and accepted on 4 December 1967, with activity occurring on 3 days during this period. The second issue was conducted on 26 December 1967, without encountering any problems. The second issue was signed as acceptable on 8 January 1968.

Ambient temperature was measured and recorded, and was found to range from 65°F to 72°F during the first issue test and was recorded as 64°F for the second issue test. For each sensor, the procedure specified a resistance value at 32°F and a sensitivity value. Using these values and the measured ambient temperature, the expected ambient resistance was calculated for each sensor.

4.2.4 (Continued)

The actual ambient resistance was then measured with a General Radio Model 1652A resistance limit bridge, and was compared to the calculated expected resistance. The measured value was verified to be within 5 per cent of the calculated resistance, except for sensors, P/N's 1A67862-513, 1A67862-533, 1A67863-537, 1B51648-507, 1B34473-1, 1B37878-507, 1B51648-1, 1B51648-505, 1B67862-511, 1B67863-531, and 1B68589-505, which were verified to be within 7 per cent. The Test Data Table shows the calculated and measured resistances for each of the cryogenic temperature sensors tested. After the resistance of each sensor was measured, the sensor wiring was verified to be correct by connecting a jumper wire on the adapter cable, P/N 1B64095-1, and verifying that the sensor element was shorted out to a resistance measurement of 5 ohms or less.

Engineering comments indicated that the following parts, affecting the first issue procedure, were not installed at the start of the test:

Part	Part Number	Ref. Designation
Fuel Pump Inlet Temp Sensor	1B34473-1	403MT686
LOX Pump Inlet Temp Sensor	1B34473-501	403MT687

These parts were installed and tested on 4 December 1967. There were no parts short at the start of the second issue test.

There were six revisions written against the second issue procedure, of which five were picked up from the first issue, for the following:

a. One revision deleted the 1B40895-1 adapter cable from the "Non-End Item" list because it was not required.

b. One revision added transducers, P/N's 1B37878-507, 1B51648-1, -505, and -507, 1B67862-511, 1B67863-531, and 1B68589-505, to the list of sensors permitted to have a 7 per cent tolerance because their ice point is above 5000 ohms.

c. One revision added a statement to reconnect the temperature transducers in the stage configuration, as there were no instructions to do so.

d. One revision deleted the requirements for measurements CO 391-403 and CO 384-403, because they are not installed on the stage.

4.2.4 (Continued)

e. One revision corrected two drawing numbers listed in the procedure in error.

f. One variation revision, second issue only, deleted the requirement to test all sensors except those for measurements CO 368-406, CO 369-406, CO 059-406, CO 057-406, and CO 040-406, because they were involved in removal of the LOX tank instrumentation probe. This occurred during the DDA system test per H&CO 1B66564.

No failure and rejection reports were written.

4.2.4.1 Test Data Table, Cryogenic Temperature Sensor Verification

Meas. Number	Sensor P/N	Sensor Ref. Desig.	Resistance (ohms) Meas.	Resistance (ohms) Cal.	Ambient Temp. (°F)
C003	1B34473-1	403MT686	5139	5407	69°
C004	1B34473-501	403MT687	1514	1513.9	69°
C005	1A67863-503	405MT612	541.8	541.8	70°
C009	1A67863-535	403MT653	218.9	216.7	70°
C015	1A67863-509	410MY603	1530	1538.6	77°
C040	1A67862-505	406MT613	1480	1487.5	64°
C052	1A67862-513	408MT612	5410	5434	71.5°
C057	1A67862-501	406MT606	539	535.2	64°
C059	1A67862-517	406MT611	537	535.2	64°
C133	NA5-27215T5	401(3MTT17)	1360	1360.8	70°
C134	NA5-27215T5	401(3MTT16)	1350.8	1360.8	70°
C159	1A67863-519	424MT610	219	216.7	70°
C161	1A67863-537	404MT733	5201	5418	70°
C208	1A67863-503	405MT605	541.8	541.8	70°
C230	1A67863-509	403MT706	1550	1537	70°
C231	1A67863-529	403MT707	542	541.8	70°
C256	1B37878-501	409MT646	1544	1538.6	77°
C257	1B37878-501	409MT647	1531	1538.6	77°
C368	1A67862-505	406MT660	1490	1487.2	64°
C369	1A67862-505	406MT661	1490	1487.2	64°
C370	1B51648-507	408MT735	5190	5495	77°
C371	1B51648-507	408MT736	5190	5495	77°

4.2.5 Telemetry and Range Safety Antenna System (1B64679 C)

This test procedure was used to verify the integrity of the telemetry and range safety antenna systems by verifying that the continuities, VSWR's, insertion losses, phasing, and power levels of the system were all within the required limits. In addition, the center frequency and carrier deviation of the PCM transmitter were determined to be correct, and the operation of the PCM RF assembly and FM/FM group power functions were checked. The items involved in this test included:

Part Name	Reference Location	P/N	S/N
PCM RF assembly	411A64A200	1B65788-1-002	15502
Bi-Directional Coupler	411A64A204	1A69214-503	157
Coaxial Switch	411A64A202	1A69213-1	81
Power Divider	411A64A201	1A69215-501	51
Telemetry Antennas	411E200 & E201	1A69206-501	77 & 74
Reflected Power Detector	411MT744	1A74776-501	2-0136
Forward Power Detector	411MT728	1A74776-503	2-0131
Dummy Load	411A64A203	1A84057-1	658
Directional Power Divider	411A97A56	1B38999-1	43
Hybrid Power Divider	411A97A34	1A74778-501	31
Range Safety Antennas	411E56 & E57	1A69207-501.1	48 & 50

Initiated on 28 November 1967, the checkout was completed on 8 December 1967, after 7 days activity. The procedure was certified as acceptable on 8 January 1968.

The tests in this procedure were generally performed by disconnecting various transmission lines in the telemetry and range safety RF systems, and determining insertion losses and VSWR's for various segments of the systems. Measurements of the telemetry system components were made at 258.5 $\pm$0.1 MHz, and the range safety system components were measured at 450.0 $\pm$0.1 MHz. A test cable, P/N 1B50922-1, was calibrated for use in the procedure, with the VSWR measured at both operating frequencies. These VSWR's are shown in Test Data Table 4.2.5.1 along with other measurements made during the test.

The telemetry system insertion losses were measured from the PCM RF assembly transmitter output to each antenna, with the other antenna replaced by a 50 ohm load. The phase difference of the transmission lines from the power divider to the antennas was measured with the antennas replaced by short circuit terminations, and the VSWR's of these lines were measured with the

4.2.5 (Continued)

antennas connected. With the coaxial switch energized, the telemetry system closed loop VSWR was measured from the transmitter output to the dummy load. With the coaxial switch de-energized, the telemetry system open loop VSWR was measured from the transmitter output to the antennas.

On the range safety system transmission lines, the center conductor continuity resistances were measured from the input of each receiver to the output of each antenna, and the insulation resistances were measured between the center conductor and the shield at both receiver inputs and both antenna outputs. A series of insertion loss checks then measured the isolation between the two receiver inputs, the insertion loss between each receiver and each antenna, and between each receiver and the directional power divider closed loop checkout connector, and the insertion loss in the closed loop checkout cable between the directional power divider and the forward umbilical. VSWR measurements were then made on the transmission lines from the hybrid power divider outputs to each antenna, and on the complete range safety system from the input of each receiver to the antennas.

The stage power was turned on for the PCM transmitter tests, and, with a dummy load connected to the PCM RF assembly transmitter output, the PCM transmitter center frequency, carrier deviation, and output power were measured. With the transmitter reconnected to the system, the forward power detector output was measured and verified to be within ± 3 per cent of the detector calibration requirement for the transmitter output power. For calibration of the reflected power detector, the forward power detector output was measured, and the equivalent forward power was determined from the detector calibration. The reflected power was measured and verified to be 11 ± 1 per cent of the forward power. The output of the reflected power detector was then measured and verified to be within ± 3 per cent of the detector calibration requirement for the measured reflected power. The telemetry RF system reflected power and transmitter output power were then measured through the AO and BO telemetry multiplexers.

A final check verified that the forward bus 1 current did not increase when either the PCM RF assembly power or the FM/FM group power was turned on, and that the RF silence command would cut off the RF assembly power.

4.2.5 (Continued)

Engineering comments noted that there were no parts shortages affecting this test. Several problems encountered during the test were corrected by the following FARR's:

a. FARR A271232 rejected coaxial cable 411W206, P/N 1B58360-501, S/N 9849-3, was loose and turned in the 411W206-P2 connector. Connector P1 was removed and replaced, and connector P2 was reworked per DPS 54006-3 to an acceptable condition.

b. FARR A271233 rejected directional power divider 411A97A56, P/N 1B38999-1, S/N 37, for an out-of-tolerance db indication of 22.3 db, as noted on IIS 366478. The db indication should have been 24 $\pm$1.4 db. Another power divider, S/N 43 was installed and accepted for use.

c. FARR A271234 rejected power detector 411MT728, P/N 1A74776-503, S/N 2-0177, for an out-of-tolerance output, as noted on IIS 377620. Detector, S/N 2-0131, was installed.

d. FARR A271235 rejected power detector 411MT744, P/N 1A74776-501, S/N 286, because the output could not be properly adjusted, as noted on IIS 252407. Detector, S/N 2-0136, was installed and accepted for use.

Seven revisions were made to the procedure for the following:

a. Two revisions changed the insertion loss limits between the directional power divider and the range safety receivers to be 24.0, +1.9, -1.5, db, rather than the specified 24.0 $\pm$1.7 db, to be compatible with the production test requirements drawing.

b. One revision added a final step to perform the stage power turnoff procedure if no other stage testing was to be accomplished, to leave the stage in the proper condition.

c. Two revisions added the PCM FM/FM transmitter and FM/FM group power checks, to provide verification of the transmitter and group power capabilities.

d. One revision corrected a minor typographical error.

e. One revision added a note that measurements N18 and N55 were to be checked by the DDAS automatic procedure before the telemetry RF system reflected power and the PCM transmitter output power were measured through the multiplexers, to verify the calibration of the amplifiers supplying gain for the power detectors before the detector outputs were measured for this procedure.

f. One revision changed the quantity of the RF dummy load, Sierra 160-50D, from one to two and added a note to: "Use 50 ohm loads (Sierra 160-50D) (or equivalent) to simulate antennas when any antenna cable is left disconnected by the procedure." This revision was necessary to ensure that the ends of the transmission lines must be terminated with 50 ohms to maintain an operational system.

4.2.5.1 Test Data Table, Telemetry and Range Safety Antenna System

Function	Measurement	Limits
Test Cable Calibration		
VSWR at 258.5 MHz	16.0	-
VSWR at 450.0 MHz	12.0	-
Telemetry System Tests		
Insertion Loss to Antenna 1 (db)	4.8	6.7 max
Insertion Loss to Antenna 2 (db)	4.2	6.7 max
Antenna Line Phase Difference (deg)	17.46	30.0 max
VSWR to Antenna 1	1.51	1.7 max
VSWR to Antenna 2	1.19	1.7 max
System Closed Loop VSWR	1.35	1.5 max
System Open Loop VSWR	1.39	1.7 max
Range Safety System Tests		
Transmission Line Continuity Resistance		
Receiver 1 to Antenna 1 (ohms)	0.4	0.5 max
Receiver 1 to Antenna 2 (ohms)	0.4	0.5 max
Receiver 2 to Antenna 1 (ohms)	0.4	0.5 max
Receiver 2 to Antenna 2 (ohms)	0.4	0.5 max
Transmission Line Insulation Resistance		
Receiver 1 (megohms)	Inf	100.0 min
Receiver 2 (megohms)	Inf	100.0 min
Antenna 1 (megohms)	Inf	100.0 min
Antenna 2 (megohms)	Inf	100.0 min
Insertion Loss Checks		
Receiver 1 to Receiver 2 Isolation (db)	26.4	25.0 min
Receiver 1 to Antenna 1 Loss (db)	4.9	6.0 max
Receiver 1 to Antenna 2 Loss (db)	5.4	6.0 max
Receiver 2 to Antenna 1 Loss (db)	5.3	6.0 max
Receiver 2 to Antenna 2 Loss (db)	4.9	6.0 max
Receiver 1 to Checkout Connector Loss (db)	23.1	24.0,+1.9,-1.5
Receiver 2 to Checkout Connector Loss (db)	23.5	24.0,+1.9,-1.5
Closed Circuit Checkout Cable Loss (db)	1.0	1.5 max
VSWR Checks		
Power Divider to Antenna 1 Line VSWR	1.4	1.7 max
Power Divider to Antenna 2 Line VSWR	1.39	1.7 max
Receiver 1 System VSWR	1.34	1.7 max
Receiver 2 System VSWR	1.36	1.7 max

4.2.5.1 (Continued)

Function	Measurement	Limits
PCM Transmitter RF Tests		
Center Frequency (MHz)	258.509	258.500 ± 0.026
Carrier Deviation (kHz)	36.5	36.0 ± 3.0
Output Power (watts)	26.0	16.05 to 27.45
Forward Power Detector Output (millivolts)	120.0	-
Forward Power Detector Output (millivolts)	116.8	-
Equivalent Forward Power (watts)	25.4	-
Reflected Power (watts)	2.77	2.7 ± 0.2
Reflected Power Detector Output (millivolts)	9.1	9.1 ± 0.3
Reflected Power, AO (watts)	2.769	2.77 ± 0.21
Reflected Power, BO (watts)	2.769	2.77 ± 0.21
Transmitter Output Power, AO (watts)	25.697	25.4 ± 1.05
Transmitter Output Power, BO (watts)	25.607	25.4 ± 1.05

4.2.6 Propulsion Components Internal Leak Check (1B59455 A)

The propulsion components internal leak check was performed to determine reverse seat leakage (if any) of the pneumatic pressurization system check valves. The test was initiated and completed on 27 November 1967, with acceptance on 29 November 1967.

All components tested were removed from the stage, tested, individually, and then re-installed on the stage. A flowtester and three Heisse gauges (ranges 0-60 psig, 0-600 psig, and 0-5000 psig) were used to test the check valves. All check valves were subjected to the desired pressure for approximately 1 minute. The ambient helium fill module check valve, P/N 1A57350-505, S/N 0204 is an integral part of the module.

The LOX repressurization system check valve, P/N 1B40824-505, S/N 149, was removed and replaced by S/N 158 because of excessive leakage. However, S/N 0158 also leaked excessively and was replaced by S/N 0224. The check valves tested and the test results are given in Test Data Table 4.2.6.1. The sequence of testing follows the listing in the Test Data Table.

4.2.6.1 Test Data Table, Propulsion Components Internal Leak Check

Name	P/N	S/N	Test Pressure	Act Leakage (Scim)	Maximum Leakage Limits (Scim)
LOX V&R Vlv Purge	1B51361-1	377	1500 $\pm$100 psig	0	10
LOX F&D Vlv Purge	1B51361-1	360	1500 $\pm$100 psig	0	10
LH_2 F&D Vlv Purge	1B51361-1	385	1500 $\pm$100 psig	0	10
LH_2 Repress Line	1B51361-1	391	1500 $\pm$100 psig	0	10
Dir Cont Vlv Purge	1B51361-1	398	1500 $\pm$100 psig	0	10
Amb He Fill Mod	1B51361-1	390	1500 $\pm$100 psig	0	10
LH_2 Repress Mod	1B51361-501	408	1500 $\pm$100 psig	4	10
			28 $\pm$3 psig	0	10
LOX Repress Mod	1B51361-501	319	1500 $\pm$100 psig	0	10
			28 $\pm$3 psig	0	10
LOX Press Sys	1B40824-507	120	1500 $\pm$100 psig	0	1
LOX Press Sys	1B40824-507	124	1500 $\pm$100 psig	0	1
LOX Burner Line	1B40824-507	123	1500 $\pm$100 psig	0	1

4.2.6.1 (Continued)

Name	P/N	S/N	Test Pressure	Act Leakage (Scim)	Maximum Leakage Limits (Scim)
LH_2 Burner Line	1B40824-507	121	1500 $\pm$100 psig	0	1
LOX Repress Sys	1B40824-507	224	825 $\pm$25 psig	0	20
			28 $\pm$3 psig	0	20
LH_2 Press Sys	1B65673-1	21	300 psig	0	10
			28 $\pm$3 psig	0	10
Amb He Fill Mod Check Valve	1A57350-507	204	1500 $\pm$100 psig	0	10

4.2.7 Engine Alignment Procedure (1B39095 B)

The engine alignment procedure was conducted to verify that the exit plane of the J-2 engine thrust chamber was properly aligned with respect to the S-IVB stage structure. The items involved in this test were the J-2 engine, P/N 103826, S/N 2119; the hydraulic pitch actuator, P/N 1A66248-507, S/N 81; the hydraulic yaw actuator, P/N 1A66248-507, S/N 30; and the stage, P/N 1A39300 -521, S/N 507.

The first issue engine alignment verification was satisfactorily accomplished on 29 November 1967, and was accepted on the same date. However, a second issue was run because the hydraulic pitch actuator began leaking at the static seal on the rod end at the boot strap pressure of 65 psig. FARR A271279 removed S/N 78, and installed S/N 81.

The second issue was satisfactorily completed on 3 January and accepted on 4 January 1968 without encountering problems. See Test Data Table 4.2.8.1 for the test results of the first and second issue tests. However, two revisions, of necessity, were written against the second issue procedure. There were no revisions written against the first issue procedure. The two revisions were:

a. One revision provided instructions to set the actuator to the J-2 Engine Log Book Length per bench adjustment procedure 1B66209 B.

b. One variation revision instructed personnel to begin the engine alignment procedure at paragraph 4.4 and to continue through to the end of the procedure.

4.2.7.1 Test Data Table, Engine Alignment Procedure

Datum Plane G

Location	Inches
A	2.0
B	1.990
C	1.970
D	1.980

Clinometer Reading

Adjusted Inclination Angle (min.) (21 min. max)	8.6
Low Quadrant	Pos. I - Pos. IV

Actuator Length
($\pm$0.010 in.)

	Yaw	Pitch
Log Book	22.967	22.992
Adjusted	22.939	22.962
Final	22.940	22.961

4.2.8 Aft Skirt and Interstage Thermoconditioning and Purge System (1B40544 C)

The checkout of the aft skirt and interstage thermoconditioning and purge system was accomplished by this test procedure to verify that the airflow characteristics of the system were correct, and to show that the system could provide the inert environment required in the aft skirt and interstage area during all prelaunch and test firing operations involving the use of LH_2. The items involved in this test were the aft skirt and interstage thermoconditioning and purge system installation, P/N 1A67979-513, and the GSE Model DSV-4B-651 aft skirt ventilation system kit, P/N 1B38121-1.

This checkout procedure was initiated on 30 November 1967, completed on 1 December 1967, and certified as acceptable on 4 December 1967. Pre-operation setup steps were accomplished to prepare the Model 651 ventilation system for use, to connect it to the stage, and to cover and seal open holes in the stage system airflow areas. The stage system tests were conducted by installing various size orifices in the metering duct of the Model 651 aft skirt ventilation system, opening and closing various purge and ventilation holes on the stage, and measuring the Model 651 metering duct pressure difference and the main manifold pressure, while air was blown through the stage system.

For the main manifold leakage and fairing purge test, a 1.4 inch diameter orifice, P/N 1B38983-503, was installed, the main manifold orifices in the station 241 frame and the hydraulic system accumulator/reservoir shroud ventilation holes were sealed, and the thrust structure supply duct was clamped. From the

4.2.8 (Continued)

measured metering duct orifice pressure difference of 20.6 inches of water, and the main manifold pressure of 3.9 inches of water, it was determined that the leakage and fairing purge area was 3.50 square inches.

In the thrust structure flow test, a 2.1 inch diameter orifice, P/N 1B38983-507, was installed, the main manifold orifices in the station 241 frame and the hydraulic system accumulator/reservoir shroud ventilation holes were sealed, and the thrust structure supply duct was opened. From the metering duct pressure difference of 20.4 inches of water and the main manifold pressure of 4.3 inches of water, it was determined that the gross thrust structure purge area was 7.45 square inches. Subtracting the previously determined leakage and fairing purge area, the net thrust structure purge area was 3.95 square inches, well within the 4.1 ±1.0 square inches requirement.

The 1A67978 duct was sealed and the short tube of the 1A67978 duct was connected to the helium bottle. It was verified that the 2.1 inch diameter orifice, P/N 1B38983-507, was installed. The main manifold orifices in the station 241 frame and the thrust structure supply duct was sealed, and the hydraulic accumulator/reservoir shroud ventilation holes were open. From the metering duct pressure difference of 22.2 inches of water and the main manifold pressure of 2.6 inches of water, it was determined that the gross helium bottle shroud purge area was 9.90 square inches. Subtracting the previously determined leaking and fairing purge area it was found that the net helium bottle shroud purge area was 6.40 square inches, well within the 6.8 ±1.2 square inches requirement.

For the main manifold orifice flow test, a 5.2 inch diameter orifice, P/N 1B38983-511, was installed, all main manifold orifices were opened, the main manifold orifices in the station 241 frame and the hydraulic system accumulator/reservoir shroud ventilation holes were opened, and the thrust structure supply duct was clamped. From the metering duct pressure difference of 4.0 inches of water and the main manifold pressure of 1.5 inches of water, the gross main manifold purge area was found to be 47.50 square inches. Subtracting the leakage and fairing purge area, the net main manifold purge area was 44.00 square inches, well within the 49.0 ±6.0 square inches requirement.

4.2.8 (Continued)

Engineering comments indicated that there were no part shortages affecting the test. No discrepancies were noted during the test. The aft skirt and interstage thermoconditioning and purge system was accepted for use. However, there were eleven revisions written against the procedure for the following:

a. Two revisions corrected typing errors.

b. One revision was deleted.

c. Four revisions were written to delete instructions for clamping the helium bottle shroud supply duct, because the duct was changed to a hard line flex duct and would be damaged.

d. One revision changed the instructions for sealing the 1A67978 flanged duct. The duct must now be disconnected and sealed at both ends (DSV-4B-1-1 configuration only), because the No. 6 helium bottle is connected to the 1A67978 flanged duct.

e. One revision changed instruction to "Set the M-651 blower . . . switch to remote," from "Set the M-651 blower . . . switch to on," because the switch is labeled RUN/REMOTE.

d. One revision removed the No. 4 helium sphere to permit the O_2H_2 burner installation.

e. One revision returned the stage to the original configuration after the test.

4.2.9 <u>Umbilical Interface Compatibility Check (1B59782 F)</u>

The integrity of the stage umbilical wiring was ensured by this procedure through verification that the proper loads were present on all power buses, and that the control circuit resistances for propulsion valves and safety items were within the prescribed tolerances. The procedure involved the stage umbilical system electrical wiring and components.

This procedure was accomplished on 30 November 1967, and was accepted on 1 December 1967. A series of resistance checks were made at specified test points on the Model 463 signal distribution unit, P/N 1A59949-1, to verify that all wires and connections were intact and of the proper material and wire gauge, and that all resistance values and loads were within the design requirement limits. The test points, circuit functions, measured resistances, and resistance limits are shown in Test Data Table 4.2.9.1. Test point 463A1A5J43-FF was used as the common test point for all measurements.

4.2.9 (Continued)

Engineering comments indicated that all parts were installed at the start of this procedure. No problems or malfunctions were encountered during the procedure, and no FARR's or revisions were written.

4.2.9.1 Test Data Table, Umbilical Interface Compatibility Check

Reference Designation 463A2

Test Point	Function	Meas. Ohms	Limit Ohms
A2J29-C	Cmd, Ambient Helium Sphere Dump	33	10-60
CB-8-2	Cmd, Engine Ignition Bus Power Off	Inf	Inf
CB-9-2	Cmd, Engine Ignition Bus Power On	15	5-15
CB-10-2	Cmd, Engine Control Bus Power Off	Inf	Inf
CB-11-2	Cmd, Engine Control Bus Power On	9	5-15
A2J29-N	Cmd, Engine Helium Emergency Vent Control On	60	10-60
A2J29-P	Cmd, Fuel Tank Repress. Helium Dump Valve Open	42	10-60
A2J29-Y	Cmd, Start Tank Vent Pilot Valve Open	24	10-60
CB4-2	Cmd, LOX Tank Cold Helium Sphere Dump	35	10-60
A2J29-c	Cmd, LOX Tank Repress. Helium Sphere Dump	45	10-60
A2J29-h	Cmd, Fuel Tank Vent Pilot Valve Open	75	10-300
	(Same, reverse polarity)	Inf	Inf
A2J29-i	Cmd, Fuel Tank Vent Valve Boost Close	80	10-80
	(Same, reverse polarity)	Inf	Inf
A2J29-q	Cmd, Ambient He Supply Shutoff Valve Close	26	10-60
A2J30-H	Cmd, Cold He Supply Shutoff Valve Close	1.4K	1.5K max
	(Same, reverse polarity)	Inf	Inf
A2J30-W	Cmd, LOX Vent Valve Open	75	10-80
	(Same, reverse polarity)	Inf	Inf
A2J30-X	Cmd, LOX Vent Valve Close	75	10-80
	(Same, reverse polarity)	Inf	Inf
A2J30-Y	Cmd, LOX and Fuel Prevalve Emergency Close	80	10-80
	(Same, reverse polarity)	Inf	Inf
A2J30-Z	Cmd, LOX and Fuel Chilldown Pilot Valve Open	75	10-80
	(Same, reverse polarity)	Inf	Inf
A2J30-b	Cmd, LOX Fill & Drain Valve Boost Close	37	10-40
A2J30-c	Cmd, LOX Fill & Drain Valve Open	37	10-40
A2J30-d	Cmd, Fuel Fill & Drain Valve Boost Close	37	10-40
A2J30-e	Cmd, Fuel Fill & Drain Valve Open	38	10-40
A2J42-F	Meas, Bus +4D111 Regulation	150	100 min
A2J35-y	Meas, Bus +4D141 Regulation	300	50 min
A2J6-AA	Sup, 28v Bus +4D119 Talkback Power	100	60-120
A5J41-A	Meas, Bus +4D131 Regulation	150	20 min
A5J41-E	Meas, Bus +4D121 Regulation	2.8K	1.6K min
A5J53-AA	Sup, 28v +4D119 Forward Talkback Power	80	60-100

4.2.10 Stage Power Setup (1B66560 B)

Prior to initiating any other automatic test procedures, the stage power setup procedure verified the capability of the GSE automatic checkout system (ACS) to control power switching to and within the stage, and ensured that the stage forward and aft power distribution system was not subjected to excessive static loads during initial setup sequences. Once the procedure was successfully accomplished, it was used to establish initial conditions during subsequent automatic procedures throughout the VCL testing.

This procedure was first attempted on 1 December 1967; but did not pass because of minor adjustment problems. A second attempt on 2 December 1967, was satisfactorily accomplished and the procedure was accepted on 7 December 1967. The following narration and the measurement values shown in Test Data Table 4.2.10.1 are from this last acceptance test run.

The test started by resetting all of the matrix magnetic latching relays, and verifying that the corresponding command relays were in the proper state. Verification was made that the umbilical connectors were mated, and that plugs 404W26P1 and 404W27P1 were disconnected from the LOX and LH_2 inverters. The bus 4D119 talkback power was turned on, and the prelaunch checkout group was turned off. The forward power, bus 4D11 power, and bus 4D41 power were transferred to external power. The sequencer power, engine control bus power, engine ignition bus power, APS bus 1 and bus 2 power, and propulsion level sensor power were all verified to be OFF. The range safety system 1 and 2 receiver powers and EBW firing unit powers were all transferred to external and verified to be OFF. The switch selector checkout indication enable and the flight measurement indication enable were both turned on. The bus 4D131 28 vdc power was turned on, and the forward bus 1 initial current and voltage were measured.

The range safety safe and arm device was verified to be in the SAFE condition. The engine start pilot relay, the LOX and LH_2 chilldown pump pilot relays, the auxiliary hydraulic pump flight mode and coast mode relays, the LOX flight pressure coast period relay, and the 70 pound ullage pilot relay, were all verified to be reset. The propellant utilization system power and inverter and electronics power, the PCM system group power, the environmental control group power, the propellant utilization system boiloff bias, and the PCM RF group power, were all verified to be OFF. The EBW ullage rocket relay was verified

4.2.10 (Continued)

to be reset. The switch selector functions were turned off, and the engine cutoff was verified to be OFF. The forward bus 1 quiescent current was measured.

The cold helium shutoff valve was closed. The bus 4D111 28 vdc power was turned on, and the aft bus 1 current and voltage were measured. The LOX and LH_2 repressurization mode relay was reset, the LOX and LH_2 repressurization control valve relay was reset, and the O_2H_2 burner propulsion valve relay was reset. Measurements were then made of the O_2H_2 burner spark systems 1 and 2 voltages. The valves were then closed. The sequencer power was turned on, the PCM system group power was turned on, and the PCM system group current was measured. The bus 4D121 28 vdc power was turned on, the forward bus 2 current was verified to be less than 2 amperes, and the forward bus 2 voltage was measured. The prelaunch checkout group power was turned on, and the checkout group current was measured. The RACS run mode was turned on, and the forward and aft battery load test was turned off. The DDAS ground station source selector switch was manually set to position 1, and the ground station was verified to be in synchronization. The EBW pulse sensor power was turned off.

A series of checks verified that stage functions were in the proper state. Thirty-five functions were verified to be OFF, and fifteen functions were verified to be ON. The LOX and LH_2 tank valves were also verified to be in the proper OPEN or CLOSED positions. The range safety EBW firing unit charging voltages were measured, the aft bus 2 voltage was measured, and the voltages of the aft 5 volt excitation module and both forward 5 volt excitation modules were measured. This completed the stage power setup, and established the initial conditions for the other automatic procedures.

Engineering comments noted that no parts were short at the start of this test.

Two revisions were made to the procedure for the following:

a. One revision changed the tolerances for the O_2H_2 burner spark systems one and two from 0 ±5 vdc to 0 ±.05 vdc.

b. One revision changed the "SET" for SIM channels 12, 14, and 24 to "RESET", because the buses were not on during that portion of the procedure.

There were no failure and rejection reports written.

4.2.10.1 Test Data Table, Stage Power Setup

Function	Measured Value	Limit
Forward Bus 1 Initial Current (amp)	1.50	20. max.
Forward Bus 1 Voltage (vdc)	27.96	28. ±2
Forward Bus 1 Quiescent Current (amp)	1.60	5. max.
O_2H_2 Burner Spark Sys 1 (vdc)	0.00	0 ±5.
O_2H_2 Burner Spark Sys 2 (vdc)	0.00	0 ±5.
Aft Bus 1 Current (amp)	0.40	10. max.
Aft Bus 1 Voltage (vdc)	28.52	28. ±2
PCM System Group Current (amp)	4.70	8. max.
Sequencer Power Current (amp)	0.20	3. max.
Forward Bus 2 Current (amp)	0.10	2. max.
Forward Bus 2 Voltage (vdc)	28.40	28. ±2
Prelaunch Checkout Group Current (amp)	1.00	12. max.
Range Safety 1 EBW Firing Unit Charge Voltage (vdc)	0.00	0.0 ±1.0
Range Safety 2 EBW Firing Unit Charge Voltage (vdc)	0.00	0.0 ±1.0
Aft Bus 2 Voltage (vdc)	-0.08	0.0 ±2.0
Aft 5v Excitation Module Voltage (vdc)	5.0	5.0 ±0.030
Forward 5v Excitation Module 1 Voltage (vdc)	5.01	5.0 ±0.030
Forward 5v Excitation Module 2 Voltage (vdc)	5.00	5.0 ±0.030

4.2.11 Stage Power Turnoff (1B66561 B)

The stage power turnoff procedure shut down the stage power distribution system after completion of various system checkout procedures during VCL testing, and returned the stage to the de-energized condition. All stage relays were deactivated so that no current flowed from the battery simulators through the stage wiring, and all internal-external transfer relays were set to the external condition.

This procedure was satisfactorily accomplished on 1 December 1967, on the first test run; however, because of a DER malfunction during the test it was rerun on 2 December 1967, and was accepted on 7 December 1967. Subsequently, the

4.2.11 (Continued)

procedure was used to shut down the stage at the conclusion of automatic procedures during VCL testing.

It was verified that the umbilical connectors were mated, and that the flight measurement indication enable was turned on. Verification was made that the bus 4D119 talkback power, the buses 4D131 and 4D111 28 volt power, and the sequencer power were all on. The buses 4D31 and 4D11 voltages were verified to be 28 $\pm$2.0 vdc. The flight measurements indication enable command was verified to be set, and the LH_2 continuous vent valve relay reset was verified on. The switch selector functions were turned off, and a series of checks verified that the stage functions were in the proper state of OFF or RESET, that the O_2H_2 burner spark systems 1 and 2 voltages were 0 $\pm$0.5 vdc, that the stage bus powers were off, and that the bus voltages were 0 $\pm$1.0 vdc. The EBW pulse sensor power was turned off, and the range safety receiver 1 and 2 power and EBW firing unit 1 and 2 power were transferred to external. The range safety safe and arm device was verified to be in the SAFE condition, and the bus 4D119 talkback power was turned off. The matrix magnetic latching relays were then reset, completing the stage power turnoff.

No revisions or FARR's were written against this procedure, nore were there any part shortages that would affect this procedure.

4.2.12 Level Sensor and Control Unit Calibration (1B64680 B)

This manual procedure determined that the control units associated with the LOX and LH_2 liquid level, point level, fast fill, and overfill sensors, were adjusted for operating points well within the design calibration limits. The particular items involved in this test are noted in Test Data Table 4.2.12.1.

There were three issues of this procedure run. The first issue was initiated and completed on 1 December 1967, without encountering any problems. It was signed acceptable on 5 December 1967. The second issue procedure was run on 14 December 1967, to adjust the LH_2 fast fill control unit, which was removed and replaced. Removal of the LOX tank instrumentation probe necessitated in the issuance of the third procedure, which was satisfactorily run on

4.2.12 (Continued)

26 and 27 December 1967, to recheck liquid level sensors L14, L15, and L16, and the LOX fast fill sensor. For those sensors and control units that were tested more than one time only the last value recorded is noted in the Test Data Table.

A point level sensor manual checkout assembly, P/N 1B50928-1, and a variable precision capacitor, connected to parallel the sensor, provided capacitance changes to each control unit to simulate sensor wet conditions for calibration, and to determine the control unit operating points.

To establish the control unit operating point, the manual checkout assembly and precision capacitor supplied the appropriate calibration capacitance to simulate a sensor wet condition. These calibration capacitances were 0.7 $\pm$0.01 picofarads for all LH_2 sensors except the LH_2 overfill sensor, which required 1.1 $\pm$0.02 picofarads, and 1.5 $\pm$0.02 picofarads for all LOX sensors except the LOX overfill sensor, which required 2.1 $\pm$0.02 picofarads. With the control unit power turned on, the control unit control point adjustment, R1, was adjusted until the control unit output signal just changed from 0 $\pm$1 vdc to 28 $\pm$2 vdc, indicating activation of the control unit output relay.

The capacitance of the precision capacitor was then decreased until the control unit output signal changed to 0 $\pm$1 vdc, indicating deactivation of the control unit output relay, and then increased until the output signal changed back to 28 $\pm$2 vdc, indicating reactivation of the output relay. The deactivation and reactivation capacitance values were recorded, and appear in the Test Data Table with the appropriate minimum and maximum capacitance limits.

A series of checks then verified the operation of the output relay test function. With the associated sensor disconnected, the control unit output relay was verified to be deactivated under both normal and test conditions, while with the sensor connected, the relay was verified to be deactivated under normal conditions, and activated under test conditions.

Engineering comments noted that there were no parts shortages that affected the three issues. No problems were encountered during the tests, and no

4.2.12 (Continued)

FARR's were written. Seven revisions were made to the first issue procedure for the following:

a. Two revisions corrected the test cable connection instructions and the test setup figure to show the proper connections to the precision capacitor.

b. One revision changed a test cable part number from P/N 1B54620-1 to P/N 1B54620-503, to show the correct cable.

c. One revision corrected an error to show that function number (0550), the propellant level sensor power talkback, was to be verified as being OFF at one point, rather than function number (0551), the forward bus 1 talkback.

d. One revision corrected two errors in the procedure test table to show the proper test jacks to be used for making measurements.

e. One revision corrected errors in the procedure test table to show the proper capacitance tolerances for the LOX fast fill and overfill control units.

f. One revision added the Model DSV-4B-184A electrical checkout accessory kit A3 VCL-1, P/N 1B44042-1, and the Model DSV-4B-184B electrical checkout accessory kit A3 VCL-2, P/N 1B44044-1, to the End Item Equipment list, for use with this test in the appropriate VCL tower.

Revisions to the second issue procedure included all the revisions made to the first issue procedure, except d and e above; and added a variation revision that deleted testing requirements for all level sensors and control units, except the LH_2 fast fill control unit. The LH_2 fast fill control unit was removed and replaced during operation of H&CO 1B66567.

Revisions to the third issue included all revisions made to the first issue. A variation revisions was added that deleted the testing requirements for all level sensors and control units, except the LOX liquid level sensors and control units and the LOX fast fill sensor and control unit.

4.2.12.1 Test Data Table, Level Sensor and Control Unit Calibration

	Sensor, P/N 1A68710			Control Unit, P/N 1A68710			Deact Cap (pf)		React Cap (pf)	
Function	Ref Loc	Dash P/N	S/N	Ref Loc	Dash P/N	S/N	Meas	Min	Meas	Max
LH_2 Tank	408			411						
Liq Lev L17	MT732	-507	D91	A61A217	-509	C22	0.628	0.5	0.630	0.9
Liq Lev L18	MT733	-507	D92	A61A219	-509	C28	0.627	0.5	0.681	0.9
Liq Lev L19	MT734	-507	D93	A61A221	-509	C29	0.677	0.5	0.680	0.9
Pt Lev 1	A2C1	-507	D75	A92A25	-509	C30	0.671	0.5	0.673	0.9
Pt Lev 2	A2C2	-507	D85	A92A26	-509	C33	0.690	0.5	0.692	0.9
Pt Lev 3	A2C3	-507	D87	A92A27	-509	C35	0.670	0.5	0.672	0.9
Pt Lev 4	A2C4	-507	D88	A61A201	-509	C20	0.693	0.5	0.694	0.9
Fastfill	A2C5	-1	D123	A92A43	-509	C66	0.680	0.5	0.684	0.9
Overfill	*	*	*	A92A24	-509	C19	1.092	0.9	1.094	1.3

*Part of LH_2 Mass Probe, P/N 1A48431-509, S/N C1, Location 408A1

Function	Ref Loc	Dash P/N	S/N	Ref Loc	Dash P/N	S/N	Meas	Min	Meas	Max
LOX Tank	406			404						
Liq Lev L14	MT657	-1	D140	A63A221	-511	C19	1.475	1.3	1.477	1.7
Liq Lev L15	MT658	-1	D134	A63A206	-511	C5	1.494	1.3	1.496	1.7
Liq Lev L16	MT659	-1	D133	A63A223	-511	C21	1.466	1.3	1.468	1.7
Pt Lev 1	A2C1	-1	C1	A72A1	-511	C12	1.483	1.3	1.487	1.7
Pt Lev 2	A2C2	-1	D107	A72A2	-511	C14	1.470	1.3	1.477	1.7
Pt Lev 3	A2C3	-1	C3	A72A3	-511	C25	1.479	1.3	1.482	1.7
Pt Lev 4	A2C4	-1	D126	A63A227	-511	C134	1.490	1.3	1.493	1.7
Fastfill	A2C5	-1	D81	A72A5	-511	C53	1.485	1.3	1.487	1.7
Overfill	**	**	**	A72A4	-511	C43	2.060	1.9	2.065	2.3

**Part of LOX Mass Probe, P/N 1A48430-511, S/N C3, Location 406A1

4.2.13 Signal Conditioning Setup (1B64681 C)

This procedure calibrated the stage 5 volt and 20 volt excitation modules prior to the use of the stage instrumentation system, and calibrated any items of the stage signal conditioning equipment that were found to be out of tolerance during testing. The signal conditioning equipment consisted of those items required to convert transducer low level or ac signals to the 0 to 5 vdc form used by the telemetry system, and included dc amplifiers, temperature bridges, frequency to dc converters, and expanded scale voltage monitors. Only the particular items calibrated during this procedure are noted below and in Test Data Table 4.2.13.1. During computer holds, this procedure was also used as required to troubleshoot instrumentation problems.

4.2.13 (Continued)

The procedure was initiated on 1 December 1967, and most of the necessary calibrations were completed on the same date. The procedures was then held open for use as required during subsequent VCL activity. Additional calibrations were performed on 12 December 1967, and the procedure was closed out and accepted on 20 February 1968. The stage power setup, H&CO 1B66560, was performed prior to any calibration activity, to provide electrical power to the equipment.

Three 5 volt excitation modules were calibrated. The input voltage to each module was verified to be 28 ±0.1 vdc, and each module was adjusted to obtain a 5 vdc output of 5.000 ±0.005 vdc, a -20 vdc output of -20.000 ±0.005 vdc, and an ac output of 10 ±1 volts peak-to-peak at 2000 ±200 Hz. The final values measured, as shown in the Test Data Table, were all within the above limits. The ac output measurements were made with a test switch in four different positions, and were found to be the same for each position.

Six 20 volt excitation modules were calibrated by adjusting the coarse control and fine control on each module to obtain an output of 20.000 ±0.005 vdc. As shown in the Test Data Table, the final value measured for each module was within the above limits.

Six temperature bridges required calibration, as noted in the Test Data Table. With a low level calibration input, the temperature bridge was adjusted to obtain a bridge output of 0.00 ±0.05 mvdc. With a high level calibration input, the bridge output was verified to be 24.0 ±0.3 mvdc. As shown in the Test Data Table, the final values measured for each temperature bridge were within these limits.

One expanded scale voltage monitor module was calibrated by calibrating the associated dc amplifier. This was the static inverter-converter 5 vdc monitor, measurement M4, expanded scale voltage module 411A61A255, P/N 1A95181-1, S/N 151, and dc amplifier 411A61A254, P/N 1A82395-1, S/N 2620. With a low RACS command on, the dc amplifier zero control was adjusted to obtain a zero output of 0.002 vdc, within the 0.000 ±0.005 vdc limits. With a high RACS

4.2.13 (Continued)

command on, the amplifier gain control was adjusted to obtain a gain output of 3.999 vdc, within the 4.000 $\pm$0.005 vdc limits.

No parts shortages were recorded that affected this test. No particular problems were encountered during the test, and no FARR's were written. Thirty-three revisions were made to the procedure for the following:

a. One revision corrected the Applicable Documents list and four test setup figures to show that only channel calibration command decoder assembly, P/N 1A74053-503, was used on operational stages, not P/N 1A74053-1 through -503, as listed.

b. Three revisions corrected the Applicable Documents list to show that the 20 vdc exciation module, P/N 1A74036-1, was a 200 ma unit, rather than a 20 ma unit as listed; to show that the expanded scale voltage monitor was P/N 1A95181-1 through -501, rather than P/N 1A94181-1 through -501, as listed; and to add the central calibration command decoder assembly, P/N 1A74051-501, to the list.

c. Four revisions corrected the End Equipment list. The DSV-4B-184A electrical checkout accessory kit, P/N 1B44042-1, was identified for use at the A3 VCL 1 only. The DSV-4B-184B electrical checkout accessory kit A3 VCL 2, P/N 1B44044-1; the DSV-4B-184E electrical checkout accessory kit A45 VCL, P/N 1B44048-1; the DSV-4B-184C electrical checkout accessory kit Beta 1 A45, P/N 1B44043-1; and the DSV-4B-184D electrical checkout accessory kit Beta 3 A45, P/N 1B44047-1, were added to the list for use at the designated locations. The DSV-4B-279 instrumentation checkout unit, P/N 1B28115-1, was added for use during parts of the procedure.

d. Two revisions added paragraphs to repeat the 5 and 20 vdc excitation module calibrations on each of the modules listed in the procedure, as all excitation modules had to be adjusted before any other signal conditioning modules were adjusted.

e. Two revisions deleted specific voltage adjustment limits from the body of the low gain dc amplifier and expanded scale voltage monitor calibrations, as the proper limits for the various modules were specified in the procedure test data tables.

f. One revision deleted dc amplifier, P/N 1A82395-501, from the temperature measurement and associated dc amplifiers calibration, as the -501 was used on R&D stages only.

g. One revision added "VCL only" after an instruction to set the Model 279 RACS command to "LOW", and added "Beta only" after an instruction to set the manual checkout decoder switch S2 to "L", both during the temperature measurement and associated dc amplifier calibration. The Model DSV-4B-279 instrumentation checkout unit, P/N 1B82115-1, was used only at the VCL, and the manual checkout decoder assembly, P/N 1B50927-1, was used only at the Beta test stand.

4.2.13 (Continued)

h. One revision changed the expanded scale voltage monitor module to be P/N 1A95181-1 and -501, rather than P/N 1A95181-1 and -503, as the -503 module was for record only, and -501 units were used on the stage.

i. One revision added a 100 kilohm ±1% resistor to the Beta only Test Equipment list for the 400 Hz expanded scale frequency to dc converter calibration, as a resistor was required for the Beta test setup.

j. One revision corrected the 400 Hz expanded scale frequency to dc converter calibration to adjust a frequency generator to a period of 2.43902 ±0.00030 milliseconds, rather than to 2.4390 ±0.00030 milliseconds, to add the omitted last digit.

k. One revision added cable assembly, P/N 1B64102-1, to the VCL only Test Equipment list for the flowmeter frequency converter calibration, as it was required for the VCL test setup.

l. One revision corrected the Model DSV-4B-279 instrumentation checkout unit to be P/N 1B28115-1, rather than P/N 1B28118-1, as listed in the breakpoint amplifier calibration VCL only Test Equipment list.

m. Eight revisions corrected various callouts and designations in the procedure test data tables. Measurement C5 was redesignated Temp. - Cold Helium Sphere 3 Gas, rather than Temp. - Cold Helium Sphere. The forward rack 411A61 channel decoder connector designation was changed to be 411A61A216J1 to 411W221P1, rather than 411A61A216J1 to 411W211P1. The measurement C159 bridge was changed to P/N 1A82274-581, rather than P/N 1A82274-501. The measurement N18 decoder line channel was corrected to 01 17, rather than 10 17. The gain voltage limits were corrected for measurement M23, to 2.285 +0.005 vdc rather than 4.000 ±0.005 vdc as listed, and for measurement M68, to 4.000 ±0.005 vdc rather than 0.000 ±0.005 vdc as listed. Multiplexer matrix points were corrected to DP1-869 rather than DP1-629 for measurement M60, to DP1-870 rather than DP1-630 for measurement M61, and to CP1-647 and DP1-887 rather than CP1-188 and DP1-658 for measurement N55.

n. One revision changed the flowmeter frequency converter test setup figure to clarify the setup and to add omitted junction symbols for cable, P/N 1B54990-1.

o. One revision corrected the oven on indicator module calibration to delete the dummy oven on module, P/N 1B53627-1, from the Test Equipment list, and to add a General Radio type 1432X decade resistor or equivalent; and corrected the test setup figure to show the connection of 75 ohms from the decade resistor to connector J1 of the oven on indicator module, in place of the dummy module. This was required as the dummy oven on module, P/N 1B53627-1, was never manufactured.

4.2.13 (Continued)

p. One revision corrected the 5 vdc excitation module calibration to show that the ac frequency measurement limits were 2000 $\pm$200 Hz, rather than 2000 $\pm$20 Hz as listed, to make the stage test of the module compatible with the bench test.

q. One revision changed P/N 1B82115-1 to 1B28115-1 to correct a typing error.

r. One variation revision added instructions to make the ambient measurement at FN 2401 before pressurization occurred because the transducer could not be bled down once the system had been pressurized.

s. One variation revision deleted the Test Equipment Hookup paragraph and provided new instructions for the hookup of GSE cables and the reconnection of the stage cables. The original paragraph did not provide for verification of removal and installation of all cables required for checkout.

4.2.13.1 Test Data Table, Signal Conditioning Setup

5 Volt Excitation Module, P/N 1A77310-503.1

Reference Location	S/N	5 vdc Out. (vdc)	-20 vdc Out. (vdc)	ac Output (vpp)	ac Output (Hz)
411A99A33	144	5.001	-20.001	10.0	2048
411A98A2	191	5.002	-20.002	10.0	2052
404A52A7	174	5.000	-20.002	10.0	1996

20 Volt Excitation Module, P/N 1A74036-1.1

Reference Location	S/N	20 vdc Output (vdc)
411A61A242	293	20.002
404A62A241	296	20.000
404A63A241	294	20.000
404A64A241	370	20.001
404A65A241	262	20.000
404A63A233	265	20.000

4.2.13.1 (Continued)

Temperature Bridge Calibration

Meas. No. and Function	P/N	S/N	Reference Location	Output (mvdc) Low	High
C6 - Fuel Turbine Inlet Temperature	1A82274-559	3120	404A64A204	-0.007	23.98
C7 - Engine Control Helium Temp.	1A98088-501	86	404A64A208	-0.000	24.18
C23 - Attitude Control Hel. Press. Tank Temp.	1A82274-573	3154	404A65A228	0.005	25.015
C199 - Thrust Chamber Jacket Temp.	1A98088-1	146	404A64A209	-0.04	24.19
C200 - Fuel Injection Temperature	1A98088-1	147	404A64A210	-0.001	24.20
C215 - Oxidizer Turbine Outlet Temperature	1A82274-565	3147	404A64A217	-0.010	24.02
C368 - LOX Position A Temperature	1A82274-517	3413	404A63A239	-0.020	23.97

4.2.14 Digital Data Acquisition System Calibration, Automatic (1B66563 C)

The automatic calibration of the digital data acquisition system (DDAS) was accomplished by this procedure through the insertion of analog signals to the multiplexer inputs and discrete signals to the DDAS bilevel inputs. This test verified that the DDAS was ready to proceed with stage checkout operations. The items involved in this test were the PCM/DDAS assembly, P/N 1B65792-1, S/N 6900089; the CP1-BO time division multiplexer, P/N 1B65897-1, S/N 2; the DP1-BO time division multiplexer, P/N 1B65897-501; S/N 4; the remote digital submultiplexer (RDSM), P/N 1B66051-1, S/N 2; and the low level remote analog submultiplexer (RASM), P/N 1B66050-1.1 S/N 5.

This test was initiated and successfully completed on 2 December 1967, with acceptance occurring on 4 December 1967.

The stage power was turned on per H&CO 1B66560, then initial conditions were established for the stage and DDAS. The 72 kHz bit rate check was made of the PCM data train to ensure it was within tolerance. The 72 kHz bit rate was

4.2.14 (Continued)

measured at 72,006 bits per second, well within the 71,975 to 72,025 bits per second limits. Then the 600 kHz VCO test was accomplished by measuring the bandedge frequencies and voltages of the PCM/DDAS VCO output. The upper bandedge frequency was measured at 632.086 kHz at 2.97 vrms, within the acceptable limits of 623.2 kHz to 643.2 kHz at greater than 2.2 vrms. The lower bandedge frequency was measured at 565.780 kHz at 2.98 vrms, within the acceptable limits of 556.8 kHz to 576.8 kHz at greater than 2.2 vrms. The frequency differential was calculated at 66.306 kHz, within the acceptable limits of 70 ±10 kHz.

The next tests performed were the flight calibration and individual checks of the CP1-BO and DP1-BO multiplexers. The outputs of the multiplexer data channels were recorded for each of the calibration and input levels of 0.000, 1.250, 2.500, 3.750, and 5.000 vdc. All measured channels were within the required tolerances.

The RDSM was next verified by inserting ones (20 vdc) and zeros (0 vdc) into the RDSM inputs and checking the output at the computer for a digital word of corresponding ones or zeros. The RASM was then verified by inserting voltages from 0 to 30 millivolts, which was amplified at the output from 0 to 5 volts corresponding to the 0 to 30 millivolts input. All measured outputs for the RDSM and the RASM were within the required tolerances.

A final test measured the PCM/FM transmitter current as 4.8 amperes, within the 4.5 ±3.0 amperes limits.

Engineering comments noted that all parts were installed for the test.

Six revisions were made to the procedure for the following:

a. One revision changed the Applicable Drawings list and a procedure reference to show that the digital data acquisition ground station automatic test, S-IB-V VCL, 1B57631-1, replaced the telemetry GSE manual check - DDAS ground station, 1B53599-501, as a prerequisite to this test. The automatic procedure was required to set up the ground station following the manual procedure, and was also required for A45.

4.2.14 (Continued)

b. Two revisions changed a power supply setting tolerance from 0.0 ±1.0 vdc to be 0.0 ±0.1 vdc during the 600 kHz VCO test, for consistency, and added notes at two places to short out the power supply leads, if necessary, to obtain zero volts.

c. Three revisions added double asterisks after the 1B55536-1, 1B64103-1, and 1B64104-1 cables to denote that the -501 cable was to be used at A3-VCL only. This was required for revision 6 for stage 1010.

No FARR's were generated as a result of this test.

4.2.15 <u>Power Distribution System (1B66562 C)</u>

The automatic checkout of the stage power distribution system verified the capability of the GSE to control power switching to and within the stage, and determined that static loads within the stage were not excessive. The procedure verified that particular stage relays were energized or de-energized as required, and that bilevel talkback indications were received at the GSE. Static loading of the various stage systems or assemblies was determined by measuring the GSE supply current before and after turn-on of the system. All electrical components on the stage were involved in this test, including the point level sensors, the propellant utilization system, the auxiliary propulsion system, the J-2 engine ignition bus, the stage telemetry system, the stage power buses, the LOX and LH_2 chilldown inverters, and the external to internal power transfer system.

The procedure was accomplished by the first attempt on 2 December 1967, and was accepted on 6 December 1967. The following narration and Test Data Table 4.2.15.1 cover this attempt.

The stage power setup, H&CO 1B66560, was accomplished, and initial conditions were established for the test. To verify power supply and stage bus operation, measurements were made of the engine control bus current and voltage; the APS bus current; the engine ignition bus current and voltage with the bus on, and voltage with the bus off; and the component test power current and voltage with the power on. With the component test power turned off, the test power voltage was verified to be 0.0 ±0.2 vdc. For a check of the emergency detection

4.2.15 (Continued)

systems (EDS), it was verified that the EDS 2 engine cutoff signal turned off the engine control bus power and prevented it from being turned back on, and also turned on the instrument unit range safety 1 EBW firing unit arm and engine cutoff signal. The engine control bus voltage was measured during this check, and again after the check with the bus turned back on. Verification was then made that the EDS 1 engine cutoff signal turned on the non-programmed engine cutoff signal and the AO multiplexer engine cutoff signal indication (K13); and that with the EDS 1 signal turned off, the engine ready bypass turned off both cutoff indications.

For the point level sensor test, the propellant level sensor power current was measured, and each of the four LH_2 tank and four LOX tank point level sensors were verified to respond properly within 300 milliseconds to simulated wet condition on commands. A series of checks then verified that a dry condition indication from any two point level sensors in either tank, obtained by simulated wet condition off commands, resulted in the required engine cutoff signal. For the dry condition of LOX tank sensors 1 and 2, the engine cutoff LOX depletion timer value was measured to determine the cutoff signal delay time. Each of the point level sensors was then verified to response properly within 300 milliseconds to simulated wet condition off commands.

Verification was then made that the engine cutoff command turned on the AO multiplexer engine cutoff signal indication (K13), the engine cutoff command indication (K140), and the engine cutoff, but did not turn on the non-programmed engine cutoff indication. With the engine cutoff command turned off, it was verified that the engine cutoff command indication was off while the multiplexer engine cutoff indication and the engine cutoff remained on until turned off by the engine ready bypass.

The propellant utilization inverter and electrical power current was measured while the power was momentarily turned on. The PCM RF assembly power current was then measured, and the PCM/FM transmitter output power was measured through both the AO and BO multiplexers. With the telemetry RF silence command turned on, the RF group was verified to be off, the PCM/FM

4.2.15 (Continued)

transmitter output power was measured through the AO multiplexer, and the switch selector output monitor voltage (K128) was measured with the PCM RF assembly power and read commands 1 and 2 turned on. With the telemetry RF silence command turned off, the RF group was verified to be on, and the PCM/FM transmitter power was again measured through the AO multiplexer.

The rate gyro voltages were manually verified to be 28 ±2.0 vdc with the gyro turned on, and 0.0 ±2.0 vdc with the gyro turned off. The environmental control group current was measured while the group was momentarily turned on. The aft bus 2 current and voltage were then measured, and the aft bus 2 power supply local sense indication was verified to be off.

For the chilldown inverter tests, the chilldown pump simulator was connected to the LOX and LH_2 chilldown inverters, and, for each inverter, measurements were made of the input current, the output voltages through both hardwire and telemetry, and the operating frequency through telemetry.

A series of checks then verified the operation of the external/internal transfer system for forward bus 1 and 2, and aft bus 1 and 2. The battery simulator voltages and the electrical support equipment load bank voltages were measured first. The power bus voltages were then measured with the buses transferred to internal and the bus local sense indications were verified to be off. The bus voltages were measured again with the buses transferred back to external, and the battery simulator voltages were measured with the simulators turned off. The aft bus 2 voltage was then measured with the bus power supply turned off.

A series of checks then verified that the switch selector register was operating properly, and that the instrument unit 28 vdc power supplies were all on. The range safety receiver currents were measured with the receivers transferred to external power and momentarily turned on. The range safety system EBW firing units were verified to be on when they were transferred to external power and momentarily turned on. This completed the power distribution system test. The computer printout indicated that the range safety receivers and decoders had accumulated 9.590 seconds of running time during this test run, and that the switch selector had been used 29 times.

4.2.15 (Continued)

Engineering comments noted that there were no parts shortages affecting the test. No problems were encountered during the test, and no FARR's were written against the procedure. Four revisions were made to the procedure for the following:

a. One revision changed the chilldown inverter hardwire voltage measurement tolerances from ±3 vac to be +2, -4.5 vac, to account for the voltage drop in the GSE cables and the noise spikes that were present when the voltage monitoring circuit was not loaded by a multiplexer.

b. One revision added a setup requirement to connect input power cable connectors 404W7P10 and 404W7P9 to receptacles 404A74A1J1 and 404A74A2J1 on the LOX and LH_2 chilldown inverters, respectively, before starting the test, and to disconnect and stow the connectors after completion of the test. WRO 3611-R2 required that these power connectors be disconnected and stowed during checkout, except when the inverters were to be used, to protect the inverters.

c. One revision deleted the LOX and LH_2 chilldown inverter hardwire frequency checks, as the period counter in the Model DSV-4B-131 response signal conditioner, P/N 1A59947-1, was inoperative due to a design problem. The frequencies were measured by telemetry, as previously noted.

d. One revision added a Safety Requirements paragraph, to prevent endangering the LH_2 and LOX chilldown inverters. The test conductor was required to ensure that the inverter running times did not exceed 20 minutes, and that the inverters were off for at least three times the on time for successive operations, with a minimum of 2 minutes off time.

4.2.15.1 Test Data Table, Power Distribution System

Function	Measurement	Limits
Engine Control Bus Current (amps)	0.300	2.0 $\pm$2.0
Engine Control Bus Voltage (vdc)	28.152	28.0 $\pm$2.0
APS Bus Current (amps)	0.500	1.5 $\pm$3.0
Engine Ignition Bus Current (amps)	-0.100	0.0 $\pm$2.0
Engine Ignition Bus Voltage, Bus On (vdc)	28.184	28.0 $\pm$2.0
Engine Ignition Bus Voltage, Bus Off (vdc)	0.000	0.0 $\pm$2.0
Component Test Power Current (amps)	-0.100	0.0 $\pm$2.0
Component Test Power Voltage (vdc)	28.358	28.0 $\pm$2.0
Engine Control Bus Voltage, EDS 2 On (vdc)	0.000	0.0 $\pm$2.0
Engine Control Bus Voltage, EDS 2 Off (vdc)	28.184	28.0 $\pm$2.0
Propellant Level Sensor Power Current (amps)	0.801	1.0 $\pm$2.0
Engine Cutoff LOX Depletion Timer (seconds)	0.544	0.560 $\pm$0.025
PU Inverter and Electrical Power Current (amps)	4.100	3.0 $\pm$2.0
PCM RF Assembly Power Current (amps)	4.600	4.5 $\pm$3.0
PCM/FM Transmitter Output Power, AO (watts)	23.020	10.0 min

4.2.15.1 (Continued)

Function	Measurement	Limits
PCM/FM Transmitter Output Power, BO (watts)	22.990	10.0 min
PCM/FM Transmitter Output Power (RF Silence On) (watts)	-0.148	0.0 ±2.0
Switch Selector Output Monitor (K128) (vdc)	2.117	2.0 ±1.0
PCM/FM Transmitter Output Power (RF Silence Off) (watts)	22.604	10.0 min
Environmental Control Group Current (amps)	0.000	0.0 ±2.0
Aft Bus 2 Current (amps)	0.199	5.0 max
Aft Bus 2 Voltage (vdc)	55.358	56.0 ±4.0

Chilldown Inverter Tests

Function	LOX Inv.	LH_2 Inv.	Limits
Inverter Current (amps)	22.000	21.800	22.0 ±5.0
Phase AB Voltage, Hardwire (vac)	51.153	51.153	54.7,+2.0,-4.5
Phase AC Voltage, Hardwire (vac)	50.764	50.894	54.7,+2.0,-4.5
Phase A1B1 Voltage, Hardwire (vac)	51.414	51.283	54.7,+2.0,-4.5
Phase A1C1 Voltage, Hardwire (vac)	50.894	50.828	54.7,+2.0,-4.5
Phase AB Voltage, Telemetry (vac)	54.732	54.732	54.7 ±3.0
Phase AC Voltage, Telemetry (vac)	54.865	54.932	54.7 ±3.0
Frequency, Telemetry (Hz)	399.8	400.4	400.0 ±4.0

Function	Measurement	Limits
Forward Bus 1 Battery Simulator Voltage (vdc)	28.00	28.0 ±2.0
Forward Bus 2 Battery Simulator Voltage (vdc)	28.48	28.0 ±2.0
Aft Bus 1 Battery Simulator Voltage (vdc)	28.32	28.0 ±2.0
Aft Bus 2 Battery Simulator Voltage (vdc)	55.20	56.0 ±4.0
Bus 4D20 ESE Load Bank Voltage (vdc)	0.00	0.0 ±1.0
Bus 4D40 ESE Load Bank Voltage (vdc)	0.00	0.0 ±1.0
Bus 4D30 ESE Load Bank Voltage (vdc)	-0.04	0.0 ±1.0
Bus 4D10 ESE Load Bank Voltage (vdc)	0.00	0.0 ±1.0
Forward Bus 1 Internal Voltage (vdc)	27.92	28.0 ±2.0
Forward Bus 2 Internal Voltage (vdc)	28.36	28.0 ±2.0
Aft Bus 1 Internal Voltage (vdc)	28.52	28.0 ±2.0
Aft Bus 2 Internal Voltage (vdc)	55.20	56.0 ±4.0
Forward Bus 1 External Voltage (vdc)	27.96	28.0 ±2.0
Forward Bus 2 External Voltage (vdc)	28.52	28.0 ±2.0
Aft Bus 1 External Voltage (vdc)	28.28	28.0 ±2.0
Aft Bus 2 External Voltage (vdc)	55.20	56.0 ±4.0
Forward Bus 1 Battery Simulator Voltage (vdc)	0.00	0.0 ±1.0
Forward Bus 2 Battery Simulator Voltage (vdc)	-0.04	0.0 ±1.0
Aft Bus 1 Battery Simulator Voltage (vdc)	0.00	0.0 ±1.0
Aft Bus 2 Battery Simulator Voltage (vdc)	-0.08	0.0 ±1.0
Aft Bus 2 Voltage (vdc)	0.00	0.0 ±1.0
Range Safety Receiver 1 Current (amps)	0.000	0.0 ±2.0
Range Safety Receiver 2 Current (amps)	1.500	0.0 ±2.0

4.2.16 Propulsion System Control Console/Stage Compatibility (1B59454 C)

The Model DSV-4B-234 propulsion system control console, P/N 1A65728-1, remotely controlled and monitored the stage propulsion system during automatic and manual checkout operations in the VCL. Prior to using the console, this procedure ensured that the stage-mounted solenoid valves responded properly when the various electrical command switches on the console were operated. The checkout consisted of separate tests on valves in the forward skirt area, the aft skirt area, and the thrust structure area. A test of the O_2H_2 burner spark igniter system was also accomplished.

Initiated on 4 December 1967, the procedure was completed on 18 December 1967, after 5 days of activity, and was accepted on 28 December 1967. The proper actuation and deactuation of the solenoid valves was verified by listening for valve acutation at the appropriate modules, and it was verified that the correct indicator lights came on, on the Mainstage Propulsion Manual Control Panel of the control console.

In the forward skirt area, the valves checked were the main vent valve open/close solenoid valve 411A2L1 and boost close solenoid valve 411A2L2; and the main fuel tank bi-directional vent valve flight position solenoid valve 411A30L2 and ground position solenoid valve 411A30L1.

In the aft skirt area, the valves checked were the main fuel tank fill and drain valve open/close solenoid valve 404A44L1 and boost close solenoid valve 404A44L2; the main oxidizer tank fill and drain valve open/close solenoid valve 404A9L1 and boost close solenoid valve 404A9L2; the LH_2 and LOX chill-down shutoff valve close/open solenoid valve 404A43L1; the LH_2 and LOX prevalve close/open solenoid valve 404A43L2; the O_2H_2 burner LH_2 propellant valve open solenoid valve 404A17L1, and close solenoid valve 404A17L2; and the O_2H_2 burner LOX propellant valve open solenoid valve 403A15L1, and close solenoid valve 403A15L2. The LH_2 and LOX repressurization valves were checked by indicator light response only.

In the thrust structure area, the valves checked were the main oxidizer vent valve open/close solenoid valve 403A75A1L1 and boost close solenoid valve 403A75A1L2; the control helium shutoff valve close/open solenoid valve

4.2.16 (Continued)

403A73A1L2 and the start tank vent valve open/close solenoid valve 403A73A1L1, both in the pneumatic control module; the ambient helium sphere dump valve open/close solenoid valve 403A73A5L1 in the ambient helium fill module; the cold helium dump valve open/close solenoid valve 403A74A2L1 in the cold helium fill module; the cold helium shutoff valve open/close solenoid valves 403A74A1L1 and 403A74A1L3 in the LOX tank pressurization control module; the engine control bottle vent valve open/close solenoid valve in the engine pneumatic power package; the LH_2 tank repressurization dump valve open/close solenoid valve 403A73A4L1 in the LH_2 repressurization module; and the LOX tank repressurization dump valve open/close solenoid valve 403A74A3L1 in the LOX repressurization module. All of the valves responded properly to the signals from the propulsion system control console.

This procedure was also used for spark igniter tests of the O_2H_2 burner, in conjunction with the O_2H_2 burner igniter tip alignment and manual spark check installation procedure, drawing 1B67337. Spark tests were initiated at the propulsion system control console, and proper operation of the tests were verified by the illumination of the spark test ON lights at the console, and the presence of electric arcs at the stage spark igniter assembly.

Engineering comments noted that all parts were installed at the start of testing. One FARR, A271244, was written to remove the igniter/exciter, P/N 1B59986-503, S/N 48, because the electrode was bent approximately 10 degrees. Igniter/exciter, S/N 29 was installed and accepted for use. There were two revisions written against the procedure for the following:

a. One revision added instructions for the spark igniter manual spark setup and test, to be performed in conjunction with the O_2H_2 burner igniter tip alignment and manual spark check installation procedure, drawing 1B67337.

b. One revision added a paragraph to specify that the O_2H_2 burner igniter/exciter tips, P/N's 71980 and 71983, were cycle significant items, and to require that an operating time/cycle record be kept on these items.

4.2.17 Hydraulic System Fill, Flush, Bleed, and Fluid Samples (1B40973 E)

This manual procedure ensured that the hydraulic system was correctly filled, flushed, bled, and maintained free of contaminants during hydraulic system operation. The hydraulic pressure and temperature were checked for proper operational levels, the hydraulic system transducers were tested for proper operation, and engine clearance in the aft skirt was verified. The hydraulic system components involved in this test were the auxiliary hydraulic pump, P/N 1A66241-511, S/N X458911; the engine driven hydraulic pump, P/N 1A66240-503, S/N X123108; the accumulator/reservoir assembly, P/N 1B29319-519, S/N 33; the pitch hydraulic actuator, P/N 1A66248-507, S/N 81; and the yaw hydraulic actuator, P/N 1A66248-507, S/N 30.

This procedure was initiated on 5 December 1967, and was completed, except for the preshipment preparations, by 18 December 1967. The procedure was then held open for use during automatic testing. On 28 December 1967, the pitch hydraulic actuator, P/N 1A66248-507, S/N 78, was rejected for leakage by FARR A271279, and another actuator, S/N 81 was installed. Those parts of the test that involved the pitch actuator were repeated between 29 December 1967 and 4 January 1968, to check the new actuator. On 31 January 1968, an O-ring was replaced in the auxiliary hydraulic pump on regulator (reference FARR A271289 written during the all systems test, H&CO 1B66571), and the air tank was repressurized by this procedure to permit an air tank decay check. At the completion of stage testing, the preshipment preparations were accomplished on 16 February 1968, and the procedure was accepted on the same date. The procedure was active on 16 days during this period.

Before the test was started, the GSE and stage preliminary setups were accomplished. The GSE Model DSV-4B-358 hydraulic pumping unit (HPU), P/N 1A67443-1, was flushed and checked for hydraulic fluid cleanliness, and connected to the stage hydraulic system by pressure and return hoses.

The hydraulic system air tank was pressurized to 450 $\pm$50 psig, and a leak check of the auxiliary pump purge system verified that there was no leakage. An air tank decay check was then started, to run concurrent with other checks in the procedure. The air tank pressure was measured as 425 psia at the start of the test. After 24 $\pm$1 hours, the tank pressure was measured as 416 psia,

4.2.17 (Continued)

giving a pressure decay of 9 psi, well within the 120 psi decay limit for the 24 hour period.

After the air tank was initially pressurized, the accumulator/reservoir was pressurized to 1800 ±50 psig with nitrogen gas. The HPU was used to circulate hydraulic fluid through the stage hydraulic system at 1000 ±100 psig to flush the accumulator/reservoir. After 30 minutes of circulation, hydraulic fluid was drained from the bleed valves on the reservoir, the accumulator inlet and outlet, the engine driven pump outlet, and the auxiliary pump inlet, and the fluid air content was verified not to be excessive. The auxiliary hydraulic pump was turned on for 5 minutes to circulate hydraulic fluid while the hydraulic system components and fluid connections were checked to verify that there was no external leakage. The engine driven hydraulic pump was flushed during this period by manually rotating the pump quill shaft. Checks were then made of the accumulator/reservoir low pressure and high pressure relief valve functions, as shown in Test Data Table 4.2.17.1.

Following these checks, the hydraulic system pressure was adjusted to 3650 ±50 psig and the reservoir piston was cycled ten times by reducing and increasing the hydraulic system pressure. During the last cycle, the maximum full reservoir oil level was measured as 99.0 per cent, and the maximum empty reservoir oil level was measured as -0.6 per cent, both within the acceptable limits of 100 ±2 per cent and 0 ±2 per cent, respectively. Hydraulic fluid samples were obtained from the HPU return and pressure sample points. The cleanliness samples met the particle count requirements.

The accumulator precharge and high pressure relief valve checks were started by pressurizing the accumulator with nitrogen gas to the pressure required for the ambient air temperature. The HPU was then used to pressurize the hydraulic system to 1500 ±100 psig and then to 4400 psig maximum, while it was verified that the system had no leaks at either pressure. The system pressure was adjusted to 3650 ±50 psig and the high pressure relief valve functions were checked, as shown in the Test Data Table. The hydraulic system pressure was then reduced to 1000 ±100 psig, the air tank pressure was verified

4.2.17 (Continued)

to be 450 $\pm$50 psig, and the auxiliary hydraulic pump was turned on for 5 minutes while the reservoir nitrogen gas pressure was verified to be about 3600 psig.

The pitch and yaw actuators were detached from the stage and mounted on the GSE Model DSV-4B-474 engine actuator support kit fixture, P/N 1B56669-1. The GSE Model DSV-4B-699 gimbal control unit, P/N 1B50915-1, was then set up and connected to the actuators. The hydraulic system was pressurized to 3650 $\pm$100 psig, using the HPU, and the gimbal control unit was used to cycle the pitch and yaw actuators with $\pm$50 milliampere control signals. After 15 minutes of cycling, hydraulic fluid samples were taken from the HPU return and pressure sampling ports, and the pitch and yaw actuator bleed ports. The hydraulic fluid cleanliness samples met the particle count requirements. The gimbal control unit and the HPU were tuned off after the samples were obtained.

For the hydraulic system air content test, the system was pressurized to 3650 $\pm$50 psig, using the HPU. After 3 minutes, the HPU was turned off and the system pressure was allowed to decay to 180 psig. Sufficient hydraulic fluid was then drained from the system to reduce the system pressure to 80 psig. The amount of fluid drained was verified to be less than 30 milliliters, indicating that the hydraulic system was satisfactorily filled and bled.

The pitch and yaw actuators were removed from the engine actuator support kit fixture and re-attached to the stage, and preparations were made for a square pattern slew check. The HPU was used to pressurize the hydraulic system to 1000 $\pm$50 psig for this check, and the gimbal control unit was used to slowly slew the engine in a square pattern to the extremes of the actuator travels while the complete engine installation was checked for clearance and freedom of motion. At the conclusion of this check the actuators were centered, the hydraulic system pressure was increased to 3650 $\pm$100 psig, and the actuator centering was repeated. The gimbal control unit and the HPU were turned off, and the gimbal control unit was disconnected from the actuators.

To compensate for hydraulic fluid thermal expansion, the accumulator nitrogen gas pressure was verified to be correct for the ambient temperature, and the hydraulic system was pressurized to 3650 $\pm$100 psig for 3 minutes. The oil

4.2.17 (Continued)

temperature was measured, and the required amount of fluid for this temperature was drained from the reservoir bleed valve.

For a check of the hydraulic system transducers, the hydraulic system functions were checked, first with the hydraulic system unpressurized, and then with the hydraulic system pressurized by means of the auxiliary hydraulic pump. This completed the hydraulic system preparations, and the procedure was held open for use during automatic testing.

Following the rejection of the pitch hydraulic actuator, P/N 1A66248-507, S/N 78, parts of the procedure were repeated to check the new actuator, S/N 81. The HPU and the accumulator/reservoir were flushed as before, the system air content was reverified to be acceptable, and a fluid sample from the HPU return sample point was verified to meet the cleanliness requirements. The accumulator was pressurized with nitrogen gas to the 2350 psig required for the 70°F ambient temperature. The hydraulic system leak checks at system pressures of 1500 ±100 psig and 4400 psig maximum were repeated to verify that there was no leakage.

The pitch actuator was mounted on the engine actuator support kit fixture and cycled as before. The fluid samples were again taken and verified to meet the cleanliness requirements, and the hydraulic system air content test was repeated. The pitch actuator was then installed on the stage, and the engine alignment procedure, H&CO 1B39095, was reaccomplished. The square pattern slew check was then repeated as before. The fluid thermal expansion compensation was repeated, with the oil temperature measured as 77°F, and with 250 milliliters of fluid drained. The hydraulic system transducers were then checked as before, with the hydraulic system functions measured as shown in the Test Data Table.

After the O-ring was replaced in the auxiliary hydraulic pump air regulator, the air tank was repressurized to 450 ±50 psig, and the auxiliary pump purge system was again leak checked. For an air tank pressure decay check, the readings of measurement D209 showed that there was no pressure change over a 24 hour period.

4.2.17 (Continued)

After the completion of all other stage tests involving the hydraulic system, the system was prepared for stage shipment by depressurizing the air tank and the accumulator nitrogen gas pressure, and removing all auxiliary test equipment from the system.

Engineering comments noted that there were no parts shortages affecting this test. Several problems were encountered during the test. When the test was first started, the hydraulic fluid samples were extremely dirty. This was corrected before the test continued. Four FARR's were written to cover the other problems, as noted on IIS 377630:

a. FARR's A271237 and A271243 noted that the high pressure relief valve, P/N 1A66242-503, reseated at a differential pressure of 3396 psid. The reseat differential pressure should have been 3760 psid minimum. The valve was removed, and a new valve was installed and accepted for use.

b. FARR A271279 rejected the pitch hydraulic actuator, P/N 1A66248-507, S/N 78, for leakage at the rod end static seal at a bootstrap pressure of 65 psig. The actuator was removed, and a new actuator, S/N 81, was installed and accepted for use.

c. FARR A271280 noted that flex hose, P/N 1B63006-1, S/N 07380H100048, had gall marks on the sealing surface of the female flared end. This caused leakage during the replacement of the pitch hydraulic actuator. The sealing surface was polished to an acceptable condition.

Three revisions were made to the procedure:

a. One revision deleted the words "by inspection" from the requirement to record the dash numbers and serial numbers of the installed hydraulic system components.

b. One revision defined the parts of the procedure that were to be reaccomplished after the replacement of the pitch hydraulic actuator.

c. One revision provided for repressurizing the air tank for a repeat of the decay check after the auxiliary hydraulic pump air regulator O-ring was replaced.

4.2.17.1 Test Data Table, Hydraulic System Fill, Flush, Bleed, and Fluid Samples

Function	Measurement	Limits
Accumulator/Reservoir Relief Valve Checks		
Low Pressure Relief Valve		
Relief Pressure, Ground Return (psig)	270.0	275.0 ±25.0
Reseat Pressure, Ground Return (psig)	260.0	240.0 min
Relief Pressure, Overboard (psig)	265.0	275.0 ±25.0
Reseat Pressure, Overboard (psig)	260.0	240.0 min
High Pressure Relief Valve		
System Hydraulic Pressure (psig)	4360.0	4400.0 max
Return Pressure (psig)	270.0	*
Differential Pressure (psi)	4090.0	3900.0 min
Accumulator High Pressure Relief Valve Checks		
System Internal Leakage (gpm)	0.62	0.8 max
Relief Valve Cracking Pressure (psig)	4200.0	*
Reservoir Pressure (psig)	271.0	*
Differential Cracking Pressure (psi)	3929.0	4100.0 max
Relief Valve Reseating Pressure (psig)	4100.0	*
Reservoir Pressure (psig)	268.0	*
Differential Reseating Pressure (psi)	3832.0	3760.0 min
Hydraulic System Unpressurized (**)		
Aft 5v Excitation Module (vdc)	4.99	5.00 ±0.03
Hydraulic System Pressure (psia)	1372.0	1400.0 approx
Hydraulic Pump Inlet Oil Temperature (°F)	70.0	approx ambient
Reservoir Oil Pressure (psia)	69.4	55.0 min
Accumulator GN_2 Pressure (psia)	2215.0	2350.0 approx
Accumulator GN_2 Temperature (°F)	65.0	approx ambient
Reservoir Oil Level (%)	89.8	85.0 min
Reservoir Oil Temperature (°F)	74.5	approx ambient
Hydraulic System Pressurized (**)		
Aft 5v Excitation Module (vdc)	4.99	5.00 ±0.03
Hydraulic System Pressure (psia)	3595.0	3650.0 ±150.0
Hydraulic Pump Inlet Oil Temperature (°F)	87.4	approx ambient
Reservoir Oil Pressure (psia)	167.1	180.1 ±20.0
Accumulator GN_2 Pressure (psia)	3576.0	syst press. ±100
Accumulator GN_2 Temperature (°F)	71.4	approx ambient
Reservoir Oil Level (%)	31.7	25.0 min
Reservoir Oil Temperature (°F)	83.9	approx ambient
T/M Pitch Actuator Position (deg)	-0.002	0.0 ±0.236
T/M Yaw Actuator Position (deg)	0.005	0.0 ±0.236

*Limits Not Specified
**Measurements Made After Pitch Actuator Replacement

4.2.18 <u>Digital Data Acquisition System (1B66564 C)</u>

The digital data acquisition system (DDAS) test provided operational status verification of data channels on the stage, except certain data channels that were tested during specific system tests. The outputs of these channels were checked by the D924A computer and found to be within the specified tolerances. The proper operation of all signal conditioning units and associated amplifiers, the command calibration channel decoder assembly, and the transmitter output and the antenna system, were also checked by the computer.

Items tested by this procedure consisted of the PCM/DDAS assembly, P/N 1B65792-1, S/N 6700089; the CP1-BO time division multiplexer, P/N 1B65897-1, S/N 2; the DP1-BO time division multiplexer, P/N 1B65897-501, S/N 4; the remote digital submultiplexer (RASM), P/N 1B66051-1, S/N 02; the low level remote analog submultiplexer (RASM), P/N 1B66050-1, S/N 05; and the PCM RF assembly, P/N 1B65788-1-002, S/N 15502.

The first attempt to run the test procedure was on 6 December 1967. Four attempts were required before the test was successfully completed on 5 January 1968. The procedure was active for 6 days, which included troubleshooting of the malfunctions encountered, and additional manual checks accomplished on 16 January 1968. The procedure was accepted on 19 January 1968.

The discussion that follows covers in general the conduct of the test, the malfunctions encountered prior to a successful run, and the revisions to the procedure to obtain a successful run.

All channels having a calibration capability were compared one at a time, by the computer, to the tolerance limits. Transducer analog outputs were signal conditioned and fed to the multiplexers. The multiplexer unit input channels were electronically sampled at a given rate, then these samples were fed into the digital data acquisition assembly (DDAA). The DDAA received these output samples through a time share gate and converted them to 10 bit binary coded words. The DDAA output was fed into the ground station and the PCM RF transmitter by coaxial cable. The ground station output was fed into the computer for tolerance verification.

4.2.18 (Continued)

High mode and/or low mode calibration command signals were provided, by the remote automatic calibration systems (RACS), by binary coded ground commands to a central calibration command decoder assembly in the stage. These signals were fed into the signal conditioning modules to provide channel operation verification in the DDAS.

Channels without RACS capability and spare channels were tested by comparing the end item outputs, at ambient conditions, to tolerance limits. Ambient conditions were defined as 70 degrees Fahrenheit at 14.7 psia, and for bilevel parameters, the normal state of valves or switches during the performance of this test. All channel outputs were measured and the output printed out.

Special channel tests at 400 Hz, 100 Hz and 1500 Hz were performed, in the order given, following completion of the DP1-B0 multiplexer tests. The 400 Hz test checked the static inverter-converter frequency, the LOX and LH_2 chill-down inverter frequencies, and the LOX and LH_2 circulation pump flow rates. LOX and LH_2 flowmeter test at 100 Hz followed the 400 Hz test. The LOX and LH_2 pump speeds were checked using the 1500 Hz test input. The indications displayed during the special channel tests were as expected.

The telemetry antenna system operation was checked by verifying that the PCM RF assembly output forward power, the antenna system reflected power, and the antenna system VSWR were all acceptable.

The first attempt to run the test was completed; however, the test was not acceptable because of several channel malfunctions. Some of the malfunctions resulted from hydraulic fill and flush activity, some resulted from interim use material parts that were installed and a control unit that was not hooked up, and others were the result of negative reflected power from the PCM.

The second attempt also was unsuccessful because of malfunctions with transducer kit, P/N 1B40242-599, S/N 599-2, reference FARR A271247; the LOX tank instrumentation probe, P/N 1B37873-521, S/N D6, reference FARR A271246; and the main fuel injection transducer, P/N NA5-27412T15T, S/N 6772, reference FARR A271249.

Attempt three was run through to completion; however, it too was rejected because of several channel malfunctions due to the malfunction of the channel

4.2.18 (Continued)

decoder, P/N 1A74053-503, S/N 315, reference FARR A271283; transducer kit, P/N 1B40242-583, S/N 583-17, reference FARR A271284; and transducer, P/N NA5-27412T10T, S/N 6434A, reference FARR A271248.

Run four was satisfactorily completed; although there were several channel malfunctions. The channel malfunctions were resolved by manual checks, by deleting the measurement test for C1 and C215, as the transducers were IUM parts, and by changing the tolerance for another measurement, D209.

Engineering comments noted that six items were not installed at the start of the test. Three engine temperature transducers, P/N NA5-27323T6, for the fuel turbine inlet (C1), the oxidizer turbine inlet (C2), and the oxidizer turbine outlet (C215), had interim use transducers, P/N NA5-27323T3, installed in their place. The thrust chamber pressure transducer, P/N NA5-27412T10T; the main fuel injection pressure transducer, P/N NA5-27412T15T; the LOX prevalve, P/N 1A49968-509, S/N 146; and the cold helium sphere pressure transducer, P/N 1B40242-583, S/N 583-14, also were not installed at the start of testing.

It was also noted in the Engineering comments that an E27 error (channel 6 lockout) printout and a malfunction printout at step 4100370 (Matrix 8 not reset) occurred because the PAM ground station was not in the automatic mode.

Thirty revisions were made to the procedure, with two of these voided by two others. The remaining revisions covered the following:

a. One revision changed the Mandatory End Items list to require the use of the Model DSV-4B-188A APS simulator, rather than the listed Model DSV-4B-188, which was used on Saturn IB stages only.

b. One revision added a telemetry receiving antenna to the Non End Items list, as a mandatory item.

c. One revision added the telemetry and range safety antenna system procedure as prerequisite for the initial attempt of the procedure.

d. One revision changed a requirement to verify that the stage simulator and special cable installations were accomplished, rather than just the rate gyro package jumper installation, to clarify the instructions.

e. One revision changed a requirement to set the GSE telemetry calibrator panel to the manual operating status, rather than to the automatic status, to correct the procedure.

4.2.18 (Continued)

f. One revision changed a step to verify that the Model DSV-4B-253 auxiliary distribution unit 5 vdc and 28 vdc power supply voltages were correct, rather than just to verify that the power supplies were on.

g. One revision deleted the word "approximately" from a frequency counter measurement, as the appropriate tolerance was listed.

h. One revision deleted measurement K95, channel CP1-BO-02-00N08, from the program multiplexer table, as EO 1B67860B deleted this measurement.

i. One revision entered the engine log book high and low calibration values for eleven measurements into the RACS tabulation, in order to use the actual values obtained during predelivery checkout.

j. One revision changed the reflected RF power measurement limits, as the reflected power curve had been changed from 0 to 4 watts to be 0 to 6.15 watts, with a midrange breakpoint.

k. Four revisions corrected various printout statements to delete unrequired expected value statements or to show the correct expected value.

l. One revision added a requirement to verify that the forward power, as shown on the printout, was within tolerance. The expected value was corrected to be 21.75 $\pm$6.75 watts in the printout, rather than 20.00 $\pm$5.00 watts, but the program could not be changed to automatically check this value.

m. One revision changed the DDAS ground station frequency calibration to set the microvolt dbm control to the 100k microvolts position for the calibration, rather than to the 1k microvolts position as specified, and then to set the control to the 1k microvolts position after the frequency calibration. The 1k microvolt position did not provide enough signal strength for part of the calibration.

n. One revision modified the ambient pressure of measurement D209 from 0.0 $\pm$1.2 psig to be 16.5 $\pm$17.7 psig for automatic testing, as the pressure could not be removed after the hydraulic procedure was accomplished.

o. One revision added, by WRO 3735, a discrete response statement to MUX Tab (1226) for measurement K192 (O_2H_2 burner LOX manifold shutdown valve position talk back).

p. One revision verified the hardwire circuitry at measurements D218 and D219.

q. One revision changed the LOX and LH_2 circulation pump flowrates from 0, +1, +0 and 0, +3, +0, respectively, to 0, +1, +1 and 0, +3, +1, respectively, to use the measured value of the 400 Hz frequency rather than the nominal value.

r. One revision, to correct a procedural error, set 74312400, select DDAS No. 1, at halt point 4100052 to ensure receipt of PCM data.

4.2.18 (Continued)

s. One revision required the performance of 4.1.1.4, step c immediately following 4.1.1.3, step b to ensure sufficient signal generator output to perform 4.1.1.3, step c.

t. One variation revision deleted the ambient test for measurements C001 and C215 because IUM transducers were installed.

u. One variation revision provided for a manual check of measurements D016 and D237, because D016 was not installed at the time the automatic test was run and trapped pressure caused D237 to indicate high.

v. One variation revision changed revision 9 for measurements D001 and D004, because they were replaced.

w. One revision changed the third OSTOL statement in revision 17, because it was written in error.

x. One variation revision deleted measurements D016 and D237 from the automatic procedure, because they were performed manually per another revision.

y. One variation revision required a manual checkout of measurement K110, because the LOX prevalve was replaced after the automatic procedure was run.

4.2.19 Fuel Tank Pressurization System Leak Check (1B59456 B)

This manual procedure leak checked the LH_2 tank pressurization system prior to its use during automatic procedures. The pressurization system consisted of the ground pressurization line from the aft umbilical and the flight pressurization line from the J-2 engine, both to the pressurization control module; the pressurization line from the control module to the LH_2 tank forward dome; and the tank ullage pressure sensing lines leading to pressure switches and transducers. The repressurization line from the O_2H_2 burner to the LH_2 tank was also leak checked during this test. The flight pressurization line was checked during the J-2 engine system leak check, and not as part of this procedure. Leaks were detected by the use of a USON leak detector or leak detection bubble fluid.

The procedure was accomplished between 5 and 7 December 1967, and was accepted on 7 December 1967. The facilities pneumatic lines were connected to the stage aft umbilical plate and the LH_2 tank pressurization system was set up for the test. The LH_2 tank repressurization helium coil of the O_2H_2 burner was pressurized to 400 $\pm$10 psig with helium, and the connections were leak checked. For a helium coil pressure decay check, the pressure was measured as 400 psig

4.2.19 (Continued)

before and 399.5 psig after a 30 minute delay, meeting the requirement of no pressure decay during this period. The helium coil was vented at the end of this test.

The GSE Model 321 pneumatic console was then set up and pressurized. The LH_2 prepressurization supply valve was momentarily opened while it was audibly verified that there was no gross leakage in the stage LH_2 tank pressurization system. The supply valve was reopened and the stage system was pressurized to 400 ±50 psig with helium. Leak checks were then conducted on all connections and lines of the system. The LH_2 tank pressurization module check valve reverse seat leakage was measured as zero scim, meeting the 10 scim maximum leakage limit.

The LH_2 tank pressure switch checkout supply lines were pressurized to 35 ±1 psig with helium, and leak checked. For a pressure decay test of the pressure switches, the checkout line pressure was measured as 35.0 psig both before and after a 30 minute delay, meeting the requirement of no pressure decay during this period. At the completion of this check, the system was vented, and the test setups were removed.

Engineering comments noted that there were no parts shortages affecting this test. No problems were encountered, which required FARR's to be written. Three revisions were made to the procedure for the following:

a. One revision added the instructions for the O_2H_2 burner helium coil setup and pressure decay test, as the requirement for the decay test was established after the release of the B change of the procedure.

b. One revision added the instructions for the pressure switch diaphragm pressure decay test, to meet a requirement based on STC experience.

c. One revision changed two part number callouts. Pipe assembly, P/N 1B63355-1, was changed to be P/N 1B67025-1, to reflect a change in the installed part, and pipe assembly, P/N 1B48858-1, was changed to be P/N 1B58859-1, to correct a typing error.

There were four leaks found during the leak check as follows:

P/N	Name/Location	Remedy
1A98356-1	Pipe Assembly - Main Tunnel	Replace seal
1B62874-1	Pipe Assembly - Thrust Structure	Retorque B-nut

4.2.19 (Continued)

P/N	Name/Location	Remedy
1B64112-1	Pipe Assembly - Aft Skirt Umbilical at QD	Retorque B-nut
1B64168-1	Pipe Assembly - Main Tunnel	Replace seal

4.2.20 Exploding Bridgewire System (1B66566 C)

This automatic procedure verified the integrity of the exploding bridgewire (EBW) system, and demonstrated the capability of the EBW system to initiate ullage rocket ignition and jettison when commanded by the instrument unit during flight. The particular items involved in this test were:

Part Name	Ref Location	P/N	S/N
Ullage Rocket Ignition System			
EBW Firing Unit	404A47A1	40M39515-113	290
EBW Firing Unit	404A47A2	40M39515-113	291
Pulse Sensor*	404A47A4A1	40M02852	461
Pulse Sensor*	404A47A4A2	40M02852	456
*on Pulse Sensor Bracket Assembly	404A47A4	1B52640-1	11
Ullage Rocket Jettison System			
EBW Firing Unit	404A75A1	40M39515-113	259
EBW Firing Unit	404A75A2	40M39515-113	260
Pulse Sensor**	404A75A10A1	40M02852	479
Pulse Sensor**	404A75A10A2	40M02852	498
**on Pulse Sensor Bracket Assembly	404A75A10	1A97791-501	6

This procedure was accomplished by the second attempt on 7 December 1967, and was accepted on 8 December 1967. The first attempt was not acceptable because of problems with the GSE digital events recorder (DER). Throughout this procedure, the charged condition of each EBW firing unit was determined by verifying that the firing unit voltage indication measured 4.2 $\pm$0.3 vdc, while the uncharged or discharged condition was determined by verifying that the voltage indication measured 0.0 $\pm$0.3 vdc or, during the firing unit disable test only, 0.2 $\pm$0.3 vdc.

The stage power setup, H&CO 1B66560, was accomplished, and initial conditions were established. An EBW pulse sensor self test was conducted first, by verifying that the self test command properly turned on the four EBW pulse sensors, and that the reset command properly turned off the pulse sensors.

4.2.20 (Continued)

The ullage ignition EBW firing units were tested next. The charge ullage ignition command was verified to properly charge both ullage ignition EBW firing units while both ullage jettison EBW firing units remained uncharged. To verify that the fire ullage ignition command properly fired the ullage ignition EBW firing units, it was determined that both ignition pulse sensors were turned on while both jettison pulse sensors remained off, and that both ullage ignition EBW firing units were discharged.

The ullage jettison EBW firing units were tested in the same way, by verifying that the charge ullage jettison command charged only the ullage jettison EBW firing units, and that the fire ullage jettison command fired only the jettison firing units and turned on only the jettison pulse sensors.

A series of checks then verified that the EBW ullage rocket firing unit disable command prevented the firing units from charging when the charge ullage ignition and charge ullage jettison commands were turned on, and discharged the firing units while preventing them from firing when the fire ullage ignition and fire ullage jettison commands were turned on.

A final series of checks verified the operation of the EBW pilot relay by determining that the pilot relay reset indication was off after each of the charge ullage ignition and jettison, and fire ullage ignition and jettison commands were turned on, and that the pilot relay reset indication was on after each command was reset. The switch selector was used 22 times during this procedure, and each of the ignition and jettison firing units was discharged 3 times.

Engineering comments noted that there were no parts shortages affecting this test. No stage problems were encountered during this test, no FARR's were written, and no revisions were made to the procedure.

4.2.21 <u>Cold Helium System Leak Check (1B59458 B)</u>

This manual leak and functional check verified the integrity of the cold helium system, and demonstrated the capability of the system to supply and regulate the helium gas used to pressurize the LOX tank. The particular items involved in this test included the cold helium spheres, P/N 1A48858-1, S/N's 1168, 1173,

4.2.21 (Continued)

1180, 1185, 1187, 1191, 1194, 1216, and 1218; the plenum sphere, P/N 1A49991-1, S/N 45; the cold helium dump module, P/N 1B57781-505, S/N 38; the LOX tank pressurization control module, P/N 1B42290-503, S/N 43; the LOX chilldown pump purge pressure switch S4, P/N 1B52624-515, S/N 58; the LOX prepressurization flight control pressure switch S8, P/N 1B52624-515, S/N 55; and the associated plumbing and manifold assemblies. The procedure also checked the dual repressurization system, including the O_2H_2 burner assembly, P/N 1B62600-509-009, S/N 14.

Initiated on 6 December 1967, the procedure was completed on 8 December 1967, after 5 days of activity, and was accepted on 14 December 1967. In general the leak checks were conducted by pressurizing the system with helium gas and using a helium leak detector or LOX compatible leak detection bubble solution to locate any leakage. Gross leakage was located by listening for audible escaping gas.

The GSE and stage test setups were accomplished, and the cold helium and dual repressurization systems were isolated from other systems. The LOX tank repressurization helium coil of the O_2H_2 burner was pressurized to 400 $\pm$10 psig and the connections were leak checked. For a helium coil pressure decay check the pressure was measured as 389 psig before and at 385 psig after a 30 minute delay, showing that there was minor pressure decay over this period. The helium coil was vented to ambient at the end of this test.

The LOX tank pressure switch checkout line was pressurized to 35 $\pm$1 psig. For a pressure switch pressure decay check, the checkout line pressure was measured as 34.9 psig, and remeasured as 34.6 psig after a 30 minute delay. This slight pressure decay was acceptable, as pressure decay limits were not established. The pressure switch checkout line was leak checked and then vented to ambient.

The cold helium spheres were pressurized to 50 psig, the system was verified to have no gross leakage upstream or downstream of the control module, and the proper operation of the cold helium dump valve was verified. The LOX pressurization system downstream of the control module was then vented to ambient. The cold helium spheres were pressurized to 500 psia while a check verified that the cold helium regulator discharge pressure did not increase as

4.2.21 (Continued)

the spheres were pressurized. The cold helium spheres were then pressurized to 950, +0, -25 psia and held at this pressure for 3 minutes for an integrity test. Following the integrity test the spheres were vented to 825 $\pm$25 psia and leak checks were conducted on the cold helium and dual repressurization systems upstream of the pressurization control module, and from the cold helium dump module to the helium spheres manifold. During these checks the combined valve leakage of the cold helium shutoff valves and the LOX burner solenoid valves was measured as zero scim, meeting the 25 scim combined leakage limit. The helium spheres were then vented to 500 psig while the cold helium dump line was checked for audible leakage. The seat leakage of the cold helium dump and relief valve was measured as 0 scim, meeting the 12.5 scim maximum leakage limit.

The cold helium spheres were vented to 400 $\pm$50 psig, and the cold helium shutoff valves were verified to operate properly. Leak checks were then conducted on the cold helium and dual repressurization systems downstream of the pressurization control module, and the LH_2 and LOX repressurization valves were verified to operate properly. After the completion of these checks the cold helium and dual repressurization systems were vented to ambient and the stage was returned to the pre-test configuration.

Engineering comments noted that there were no parts shortages affecting this test. A number of leaks were located and corrected without FARR action, as follows:

a. Leaks at the downstream B-nut of pipe assemblies, P/N's 1B58838-1, 1B62879-1, 1B62874-1, and 1B64137-1, were corrected by retightening the B-nut to the proper torque value.

b. Pipe assembly 1B52441-1 required the upstream B-nut to be retorqued and on the downstream end the cross was replaced to correct the leaks.

c. It was necessary to reform pipe assembly, P/N 1B67672-1, to correct one leak.

d. Leaks at the upstream B-nut of pipe assemblies, P/N's 1B62870-1, 1B62880-1, 1B66839-1, and 1B66909 were corrected by retightening the B-nut to the proper torque value.

e. A leak at the upstream side of the adapter flange, P/N MC26339-075-12, at the cold helium module was corrected by replacing the seal.

f. A leak at the inlet seal of pipe assembly 1B52405 required the seal to be replaced to correct the leak.

4.2.21 (Continued)

Two additional leaks were corrected by the following FARR's:

a. FARR A271236 rejected the cold helium dump module, P/N 1B57781-503-003, S/N 29, for a scim leakage through the overboard vent. This exceeded the 12.5 scim leakage limit. Cold helium dump module, P/N 1B57781-505-003, S/N 38, was installed, tested, and accepted for use.

b. FARR A271239 rejected pipe assembly, P/N 1B58807-1, for a gouge and scratches on the boss, after a leak at the boss could not be corrected.

Seven revisions were made to the procedure for the following:

a. Two revisions added instructions for the O_2H_2 burner helium coil pressure decay test, as the requirement for this test was established after the release of the procedure B change.

b. One revision added instructions for the pressure switch integrity test.

c. One revision simplified the method of verifying valve operation during the control module downstream leak check.

d. One revision disconnected and capped pipe assembly 1B58859-1 instead of pipe assembly 1B66843-1, because the latter was not readily accessible for capping.

e. One revision removed pipe assembly, P/N 1B66842-1, rather than cap it, and re-installed it after the test. There was insufficient room to cap the line. The LOX repressurization module was capped instead.

f. One revision provided for identification of a new pipe assembly, P/N 1B67299-1. The former pipe assembly was, P/N 1A68668-505.

4.2.22 Auxiliary Propulsion System (1B66569 C)

The auxiliary propulsion system test procedure verified the integrity of the stage wiring associated with APS functions, and verified receipt of command signals routed from the GSE automatic checkout system, through the attitude control relay packages, to the APS electrical interfaces. The Model DSV-4B-188 APS simulators, used in place of the uninstalled flight APS modules for this test, did not simulate the APS modules functionally, but provided suitable loads at the electrical interface to determine that the stage mounted components of the APS functioned properly.

All stage mounted components of the APS were tested, in particular the attitude control relay packages, P/N 1B57731-1, S/N 360, at reference location 404A51A4, and S/N 359, at reference location 404A71A19.

4.2.22 (Continued)

The procedure was satisfactorily accomplished by the first attempt on 8 December 1967, and was accepted on the same date. The data in this narration and in Test Data Table 4.2.22.1 are from this attempt.

After initial conditions were established, the GSE IU substitute -28 vdc power supply was turned on and measured at -28.72 vdc, within the -28 ± 2 vdc limit. The APS firing enable command and the APS bus power were turned on. A series of tests were then conducted to verify the proper operation of the APS engine valve solenoids. The attitude control nozzle commands were turned on and the appropriate APS engine valve open indication voltage was measured through the AO and BO instrumentation multiplexers.

The attitude control nozzle command was then turned off and the valve open indication voltage was again measured. The 70 pound ullage engine commands 1 and 2 were then individually turned on and off, while the ullage engine relay reset was verified to operate properly. At the conclusion of these tests the stage was returned to the pretest configuration, thereby completing the test procedure. The computer typeout indicated that the switch selector was used 4 times during this test run.

Engineering comments indicated that there were no part shortages that would affect this test. No problems were encountered during the test, and no FARR's were written. No revisions were made to the procedure.

4.2.22.1 <u>Test Data Table, Auxiliary Propulsion System</u>

Attitude Control Nozzle Command		APS Engine	Valve Open Indication Voltage (vdc) AO Multi.	BO Multi.	Limits
Nozzle I IV	On	1-1 or 1-3	4.22	4.24	4.2 $\pm$0.30
	Off	1-1 or 1-3	0.00	-0.00	0.0 $\pm$0.25
Nozzle I II	On	1-1 or 1-3	4.20	4.19	4.2 $\pm$0.30
	Off	1-1 or 1-3	0.00	-0.00	0.0 $\pm$0.25
Nozzle I P	On	1-2	4.28	4.30	4.2 $\pm$0.30
	Off	1-2	0.00	-0.01	0.0 $\pm$0.25
Nozzle III II	On	2-1 or 2-3	4.14	4.15	4.0 $\pm$0.30
	Off	2-1 or 2-3	0.00	0.00	0.0 $\pm$0.25
Nozzle III IV	On	2-1 or 2-3	4.18	4.16	4.0 $\pm$0.30
	Off	2-1 or 2-3	0.01	-0.00	0.0 $\pm$0.25
Nozzle III P	On	2-2	4.16	4.17	4.0 $\pm$0.30
	Off	2-2	0.00	-0.00	0.0 $\pm$0.25

4.2.23 Propellant Utilization System Calibration (1B64367 G)

This manual calibration procedure verified the operation of the propellant utilization system, and provided the necessary calibration prior to the automatic checkout of the system. For calibration purposes, the propellant utilization test set (PUT/S), P/N 1A68014-1, was used to provide varying capacitance inputs to the propellant utilization electronics assembly (PUEA), simulating the LOX and LH_2 mass probe outputs under varying propellant load conditions. The particular items involved in this test were static inverter-converter 411A92A7, P/N 1A66212-507, S/N 23; propellant utilization electronics assembly 411A92A6, P/N 1A59358-529, S/N 32; LOX mass probe, P/N 1A48430-511, S/N C3; and LH_2 mass probe, P/N 1A48431-509, S/N C1.

Initiated on 8 December 1967, the first issue of this procedure was completed on 14 December 1967, after 4 days of activity, and was accepted on 15 December 1967. Subsequently, intermittent problems with the PUT/S voltmeter required that the propellant utilization system calibration be reverified. A second issue of the procedure accomplished this on 29 December 1967, using an equivalent external voltmeter in place of the PUT/S voltmeter. The values obtained agreed with the previous data, and the second issue was accepted on 5 January 1968. The following narration and Test Data Table 4.2.23.1 generally cover the second issue of the procedure, except that the mass probe resistance measurement values and the static inverter-converter frequency measurement are from the first issue, as these checks were not repeated.

Atmospheric conditions in the test area were measured before the calibration was started. During the first issue only, megohm resistance measurements were made on both the LH_2 and LOX mass probe elements through connector 411W11P1 at the PUEA, using a 50 vdc megohmeter. The PUT/S was connected to the PUEA and the static inverter-converter, and the stage power for these units was manually turned on. The static inverter-converter voltages and, during the first issue only, the operating frequency, were then measured.

The PUEA bridge calibrations were conducted next. Simulated empty conditions were established with the PUT/S, and the PUEA LH_2 and LOX bridge empty calibrations were accomplished by nulling the bridge tap voltages with the PUT/S

4.2.23 (Continued)

ratiometer, at settings of 0.01982 for the LH_2 bridge and 0.02001 for the LOX bridge, and then nulling the bridge outputs by adjusting the PUEA R2 potentiometer for the LH_2 bridge and the PUEA R1 potentiometer for the LOX bridge. Simulated full conditions were then established with the PUT/S using a C1 capacitor (LH_2) setting of 210 picofarads and a C2 capacitor (LOX) setting of 128 picofarads, and the ratiometer was set to 0.84108. To accomplish the PUEA LH_2 and LOX bridge full calibrations, the bridge outputs were nulled by adjusting the PUEA R4 potentiometer for the LH_2 bridge and the PUEA R3 potentiometer for the LOX bridge.

Data acquisition was verified by establishing simulated empty and full conditions with the PUT/S, and adjusting the PUT/S ratiometer to null the PUEA LH_2 and LOX bridge outputs. Bridge slew checks were conducted by establishing simulated 1/3 and 2/3 slew conditions with the PUT/S, and adjusting the PUT/S ratiometer to null the PUEA LH_2 and LOX bridge outputs for each condition.

For the reference mixture ratio (RMR) calibration, the difference between the previously determined LH_2 and LOX empty ratiometer settings, -0.00034, was multiplied by 98.4 vdc to give a reference voltage of -0.033456 vdc. Simulated empty conditions were established with the PUT/S, and the PUEA residual empty bias R6 potentiometer was adjusted to give the reference voltage output. Simulated full conditions were then established with the PUT/S, and the PUEA residual full bias R5 potentiometer was adjusted to null the RMR bias voltage. For a fuel boiloff bias calibration, simulated boiloff conditions were established with the PUT/S, using a C1 capacitor (LH_2) setting of 244 picofarads and a C2 capacitor (LOX) setting of 128 picofarads. The PUEA fuel bias R7 potentiometer was then adjusted to null the RMR bias voltage.

PUEA LH_2 and LOX bridge linearity checks were accomplished by individually setting the PUT/S C1 capacitor (LH_2) and C2 capacitor (LOX) to specific values, and adjusting the PUT/S ratiometer to null the appropriate PUEA bridge output.

For a fuel boiloff bias data acquisition check, the RMR bias voltage was measured as -0.037 vdc under simulated empty conditions, and as +10.69 vdc under bias internal test conditions. The fuel boiloff bias voltage was the

4.2.23 (Continued)

difference between these measurements, 10.74 vdc. A fuel boiloff bias limitation check was accomplished by adjusting the PUEA fuel bias R7 potentiometer fully counterclockwise, setting the PUT/S C2 capacitor (LOX) to zero picofarads, and adjusting the C1 capacitor (LH_2) to null the RMR bias voltage. The capacitor null setting was 67.3 picofarads; meeting the 48 picofarads minimum requirement. The PUT/S C1 capacitor was then set to zero picofarads and the LH_2 boiloff bias voltage was measured as 20.46 vdc. The fuel boiloff bias calibration was repeated as before to re-establish the PUEA fuel bias R7 potentiometer setting.

The hardwire loading circuits were checked by establishing simulated full conditions with the PUT/S, setting the PUT/S ratiometer to 0.00000, and measuring the hardwire loading circuit PUEA LH_2 and LOX bridge output voltages. Both voltages were 23.35 vdc, meeting the 23.52 $\pm$2.0 vdc requirements. This completed the propellant utilization system calibration.

Engineering comments noted that there were no parts shortages affecting this test. No problems were encountered during the second issue of this test and no FARR's were written. Some minor problems during the first issue, caused by design changes in the PUEA, were corrected by procedure revisions. Sixteen revisions were made to the second issue of the procedure, with eleven of these applying to the first issue also:

a. One revision added a step to measure the static inverter-converter V/P excitation voltage, with a note that this voltage was isolated from system ground and should not be connected to system ground. This corrected a procedure error.

b. One revision changed the null voltage tolerance from zero (0) $\pm$0.5 millivolts to be zero (0) $\pm$1.0 millivolts during the bridge calibrations, to correct a procedure error.

c. One revision changed the PUT/S FUNCTION SELECT switch setting from WIPER to FULL, for the data acquisition check, to correct a procedure error.

d. Two revisions changed the static inverter-converter part number reference from P/N 1A66212-505 to P/N 1A66212-507 at one place in the instructions and one place in the test record table, to correct procedure errors.

e. One revision changed the "data value or instruction" table to delete instructions that would prevent the adjustment of PUEA potentiometers R1 and R2 during the bridge empty calibrations. These adjustments were necessary to properly setup the PUEA.

4.2.23 (Continued)

f. One revision changed the order of subtraction in finding the fuel boiloff bias voltage during the fuel boiloff bias data acquisition check, as the specified order would give a negative value rather than the correct positive value.

g. One revision changed two paragraph references in the test record table, to correct a typing error.

h. Two revisions changed the fuel boiloff bias calibration and the bias limitation check, as required by changes in the PUEA boiloff bias circuitry. For the bias calibration, a PUT/S C1 capacitor setting of 244 picofarads was required to establish simulated boiloff conditions, rather than 227 picofarads as specified. For the bias limitation check, the PUEA fuel bias R7 potentiometer was adjusted fully counterclockwise rather than clockwise, and the PUT/S C1 capacitor minimum null setting was to be 48 picofarads, rather than 25.51 picofarads.

i. One revision added a note to the static inverter-converter frequency check, to verify that the frequency counter chassis was grounded to the stage ground during the check, as the measurement could not be made with the counter ungrounded.

j. Two revision, to the second issue only, added setup steps to remove the precision dc voltmeter from the PUT/S and to substitute a Fluke Model 803B differential voltmeter, or equivalent, as the test set voltmeter was inoperative; and to install a breakout box between connector P2 of test cable, P/N 1A82839-501, and connector 411A92A6J5 of the PUEA, to facilitate trouble shooting during the calibration.

k. Two revisions, to the second issue only, deleted the LH_2 and LOX mass probe resistance measurements and the static inverter-converter frequency check, as these measurements were satisfactorily accomplished by the first issue of the procedure.

l. One revision, to the second issue only, changed the acceptable limits of the static inverter-converter 21.0 vdc output voltage to be 20.00 to 23.50 vdc, rather than 20.00 to 22.50 as specified, to conform to the range change of WRO 3041-R9.

4.2.23.1 <u>Test Data Table, Propellant Utilization System Calibration</u>

<u>Pre-Test Atmospheric Conditions</u>

Temperature: 75°F

Pressure: 29.97 in. of Hg.

Relative Humidity: 46.5 per cent

4.2.23.1 (Continued)

LH_2 Mass Probe Megohm Check, Plug 411W11P1 (*)

Function	Resistance (megohms)	Limits (megohms)
LH_2 Probe Elements, Pins G to E	Inf	1000 min
Pin G to Shield	Inf	1000 min
Pin G to Stage Ground	Inf	1000 min
Pin G Shield to Stage Ground	Inf	1000 min
Pin E to Stage Ground	Inf	1000 min

LOX Mass Probe Megohm Check, Plug 411W11P1 (*)

Function	Resistance (megohms)	Limits (megohms)
LOX Probe Elements, Pins A to C	Inf	1000 min
Pin C to Shield	Inf	1000 min
Pin C to Stage Ground	Inf	1000 min
Pin C Shield to Stage Ground	Inf	1000 min
Pin A to Stage Ground	Inf	1000 min

Static Inverter Converter Measurements

Function	Measurement	Limits
5.0 vdc Output Voltage (vdc)	4.90	4.50 to 5.10
21.1 vdc Output Voltage (vdc)	21.64	20.00 to 23.50
28.0 vdc Output Voltage (vdc)	27.47	26.00 to 30.00
117 vdc Output Voltage (vdc)	120.94	115.0 to 122.5
115 vrms Monitor Voltage (vdc)	2.77	2.23 to 3.18
Test Point 2 Voltage (vdc)	21.67	20.0 to 22.5
V/P Excitation Voltage (vdc)	50.25	48.86 to 52.00
Operating Frequency (Hz) (*)	401.	394. to 406

Data Acquisition

Function	PUT/S Ratiometer	Limits
LH_2 Empty	0.00104	0.00000 to 0.00168
LOX Empty	0.00070	0.00000 to 0.00168
LH_2 Full	0.84118	0.83940 to 0.84276
LOX Full	0.84124	0.83940 to 0.84276

Bridge Slew Checks

Function	PUT/S Ratiometer	Limits
LH_2 1/3 Slew	0.27525	Not Specified
LH_2 2/3 Slew	0.56120	Not Specified
LOX 1/3 Slew	0.27001	Not Specified
LOX 2/3 Slew	0.56509	Not Specified

*First Issue Measurement

4.2.23.1 (Continued)

LH_2 Bridge Linearity Check

PUT/S C1 Value	PUT/S Ratiometer	Limits
50 pf	0.20095	0.19858 to 0.20194
100 pf	0.40071	0.39883 to 0.40219
150 pf	0.60060	0.59909 to 0.60245
200 pf	0.80104	0.79935 to 0.80271
210 pf	0.84120	0.83940 to 0.84276

LOX Bridge Linearity Check

PUT/S C2 Value	PUT/S Ratiometer	Limits
20 pf	0.13188	0.12974 to 0.13310
50 pf	0.32877	0.32687 to 0.33023
70 pf	0.45989	0.45829 to 0.46165
100 pf	0.65691	0.65541 to 0.65877
128 pf	0.84133	0.83940 to 0.84276

4.2.24 Pneumatic Control System Leak Check (1B59457 B)

This manual procedure checked the components of the pneumatic control system to verify that there was no leakage in excess of design specifications. The pneumatic control system provided gaseous helium for the stage purge system and pneumatically operated valves; and included a helium sphere, a helium fill module, a pneumatic control module, a plenum chamber, nine actuation control modules, an engine pump purge module, a LOX chilldown pump purge module, the various pneumatic valves, and the associated plumbing and electrical circuitry.

The test began on 8 December, was completed on 13 December, and signed off as acceptable on 15 December 1967, after 4 days of activity.

Test configuration was established by capping various supply and purge lines to isolate the pneumatic control system. The system was then pressurized with gaseous helium. A USON leak detector was used as the primary leak detector. Bubble fluid was used as a secondary leakage detector. Gross leakage was determined by listening for escaping gas.

Thirteen areas of leakage were found and corrected, as shown in Test Data Table 4.2.24.1.

4.2.24.1 Test Data Table, Pneumatic Control System

Leakage:

P/N	Name/Location	Remedy
1B52455	Pipe Assembly - Stringer 5 3/4	Retorque inlet B-nut.
1B52465-1	Pipe Assembly - LOX F&D Valve	Retorque inlet B-nut.
1B52624-515 (S/N 50)	Pressure Switch - 403SZ	Wrong part, replaced with P/N 1B52623-515, S/N 26.
1B64608-1	Pipe Assembly - Fwd Skirt Stringer 14	Retorque inlet B-nut.
1B64609-1	Pipe Assembly - Fwd Skirt Stringer 14	Retorque inlet B-nut.
1B65006	Monitor Port - Thrust Structure Stringer 11	Replace cap.
1B65060-1	Pipe Assembly - Fwd Skirt Stringer 14	Retorque downstream B-nut.
1B65099-1	Pipe Assembly - Thrust Structure Stringer 13A	Replace union - still leaked. Pipe assembly removed and replaced by FARR A271240.
1B66541-1	Pipe Assembly - 403A75	Replace seal at tranducer outlet.
1B66818-1	Pipe Assembly - Thrust Structure	Replace union.
1B67193-507	Continuous Vent Module Actuator to Valve Seal	Leakage acceptable for use at less than 6.1 scim.
MC177C4W	Cap - Stringer 17 1/4	Replace cap.

It was noted in the Engineering Comments that no parts were short that would affect this test. There were eighteen revisions written against this procedure for the following:

a. One revision was made to correct a typographical error.

b. Seven revisions were made to incorporate procedure omissions that were concerned with leakage rates, flow rates, and instructions for performing various portions of the leak check.

c. One revision added instructions to "cap tee and plug pipe assembly," to complete setup.

d. One revision added instructions to perform the pressure switch integrity check.

e. Two revisions added steps to verify proper installation of orifices.

4.2.24.1 (Continued)

f. One revision deleted the instructions to vent the pneumatic control sphere to 550 $\pm$50 psia to enable verification of regulator operating tolerance.

g. One revision added instructions to separate the continuous vent valve actuator leakage from the actuator control module internal leakage.

h. One revision added instructions to perform a leak check on the chilldown shutoff valve actuation control module vent port check valve.

i. One revision deleted another revision.

j. One revision deleted a step to check the O_2H_2 burner LOX shaft seal for leakage, because the vent port was inaccessible.

k. One revision deleted the instructions to remove the stage monitor panel hoses from the stage and recap the stage connections to enable the procedure to be closed out. The hoses will be removed after the all systems test.

Two FARR's were written during the operation of this procedure for the following:

a. One FARR, A271240, replaced a pipe assembly, P/N 1B65099-1, after a leak could not be fixed by replacing a union.

b. The other FARR, A271241, removed and replaced the pressure switch, P/N 1B52624-515, S/N 050, by S/N 058, which was ruined by the checkout pressure, because it was installed in the wrong location.

4.2.25 Propellant Utilization System (1B66567 C)

This automatic checkout procedure verified the ability of the propellant utilization system to determine and control the engine propellant flow mixture ratio to ensure simultaneous propellant depletion, and to provide propellant level information to control the fill and topping valves during LOX and LH_2 loading. This test involved all components of the stage propulsion utilization system, including the propellant utilization valve in the J-2 engine, and the following:

Part	Ref. Location	P/N	S/N
Propellant Utilization Electronics Assembly (PUEA)	411A92A6	1A59358-529	32
Static Inverter-Converter	411A92A7	1A66212-507	23
LOX Mass Probe	406A1	1A48430-511	C3
LH_2 Mass Probe	408A1	1A48431-509	C1

4.2.25 (Continued)

Part	Ref. Location	P/N	S/N
LOX Overfill Sensor	(Part of LOX Mass Probe)		
LOX Overfill Control Unit	404A72A4	1A68710-511	C43
LOX Fast Fill Sensor	406A2C5	1A68710-1	D81
LOX Fast Fill Control Unit	404A72A5	1A68710-511	C53
LH_2 Overfill Sensor	(Part of LH_2 Mass Probe)		
LH_2 Overfill Control Unit	411A92A24	1A68710-509	C19
LH_2 Fast Fill Sensor	408A2C5	1A68710-1	D123
LH_2 Fast Fill Control Unit	411A92A43	1A68710-509	C66

Initiated on 11 December 1967, the procedure was completed by the fifth attempt on 2 January 1968, after 6 days of activity, and was accepted on 5 January 1968. The first four attempts were not acceptable because of program, digital data, tape (DDT), and hardware problems. Procedure revisions corrected the program and DDT problems, and FARR A271242 replaced the LH_2 fast fill control unit 411A92A43, P/N 1A68710-509, to correct the hardware problem. A problem with the GSE propellant utilization test set precision voltmeter was also resolved prior to the successful fifth attempt. The operation and test results of the system per this fifth attempt are discussed in this paragraph and Test Data Table 4.2.25.1.

After initial conditions were established, ratio values were obtained from the manual Propellant Utilization System Calibration procedure, H&CO 1B64367, and loaded into the computer. From these ratio values, nominal test values were computed for LOX and LH_2 coarse mass voltages, fine mass voltages, and loading voltages. The propellant utilization (PU) system power test was conducted first. Power was applied to the PU inverter and electronics, then the forward bus 2 voltage and the static inverter-converter output voltages and operating frequency were all measured.

The servo balance and ratio valve null test was conducted next. The ratio valve position was measured, and the LOX and LH_2 coarse and fine mass voltages were measured through the AO and BO instrumentation multiplexers.

4.2.25.1 (Continued)

Bridge Balance and Ratio Valve Null Test

Function	Measured Value	AO Multi	BO Multi	Limits
Ratio Valve Position (deg)	0.419			0.0 ±1.5
LOX Coarse Mass Voltage (vdc)		-0.010	-0.010	0.005 ±0.1
LOX Fine Mass Voltage (vdc)		1.938	1.934	2.095 ±0.4
LH_2 Coarse Mass Voltage (vdc)		-0.015	-0.020	0.005 ±0.1
LH_2 Fine Mass Voltage (vdc)		1.948	1.943	2.095 ±0.4

PU Loading Test

Function	Measured Value	Limits
LH_2 Boiloff Bias Signal Volt. (vdc)	12.153	10.740 +2.0, -0.0
GSE Power Supply Voltage (vdc)	28.999	28.0 ±2.0

Loading Potentiometer Function	LOX Value	LH_2 Value	Limits
Sense Voltage, GSE Power On (vdc)	28.919	28.958	GSE Pwr ±0.4
Signal Voltage, Relay Commands Off (vdc)	0.000	-0.027	*
Signal Voltage, Relay Commands On (vdc)	7.410	7.602	*
Signal Voltage, Relay Commands Off (vdc)	0.000	0.000	*
Sense Voltage, GSE Power Off (vdc)	0.000	0.000	0.0 ±0.75

Servo Balance Bridge Gain Test

Function	Measured Value	AO Multi	BO Multi	Limits
Ratio Valve Position (deg)	0.419			0.419 ±1.5
LOX Coarse Mass Voltage (vdc)		-0.015	-0.024	0.005 ±0.1
LOX Fine Mass Voltage (vdc)		1.938	1.934	2.095 ±0.4
LH_2 Coarse Mass Voltage (vdc)		-0.005	-0.020	0.005 ±0.1
LH_2 Fine Mass Voltage (vdc)		1.948	1.943	2.095 ±0.4
1/3 Checkout Relay Commands On				
Ratio Valve Position (deg)	0.896			0.419 ±1.5
LOX Coarse Mass Voltage (vdc)		1.333	1.328	1.348 ±0.1
LOX Fine Mass Voltage (vdc)		1.494	1.484	1.587 ±0.4
LH_2 Coarse Mass Voltage (vdc)		1.357	1.357	1.377 ±0.1
LH_2 Fine Mass Voltage (vdc)		0.991	0.986	1.011 ±0.4
2/3 Checkout Relay Commands On				
Ratio Valve Position (deg)	1.306			0.419 ±1.5
LOX Coarse Mass Voltage (vdc)		2.808	2.813	2.827 ±0.1
LOX Fine Mass Voltage (vdc)		2.393	2.388	2.588 ±0.4
LH_2 Coarse Mass Voltage (vdc)		2.798	2.788	2.803 ±0.1
LH_2 Fine Mass Voltage (vdc)		2.783	2.788	3.066 ±0.4

*Limits not specified

4.2.25 (Continued)

e. One revision changed the LH_2 boiloff bias signal voltage measurement, made with the bias cutoff on, to be within +2, -0 vdc, rather than ±1 vdc, of the voltage value obtained from the PU calibration procedure. The telemetry signal voltage, measurement M10, was always about 1 volt greater than the voltage measured in the calibration procedure, because the measurements were made at different points on the PUEA boiloff bias summing network.

f. One revision deleted a previous revision that applied to the PU calibration procedure rather than to this procedure.

g. One revision changed the PU system ratio valve position tolerance to be greater than -1.5 degrees, rather than 0.0 ±1.5 degrees, at the end of the hardover test, to correct errors in the test requirements drawing and the procedure.

4.2.25.1 Test Data Table, Propellant Utilization System

Loaded Ratio Values (from H&CO 1B64367)

LOX Empty Ratio	0.001	LH_2 Empty Ratio	0.001
LOX 1/3 Bridge Slew Ratio	0.270	LH_2 1/3 Bridge Slew Ratio	0.275
LOX 2/3 Bridge Slew Ratio	0.565	LH_2 2/3 Bridge Slew Ratio	0.561
LOX Wiper Ratio	0.020	LH_2 Wiper Ratio	0.020
LH_2 Boiloff Bias Voltage (vdc)		10.740	

Computed Coarse Mass Voltages (vdc)

LOX Empty	0.005	LH_2 Empty	0.005
LOX 1/3 Mass	1.348	LH_2 1/3 Mass	1.377
LOX 2/3 Mass	2.827	LH_2 2/3 Mass	2.803

Computed Fine Mass Voltages (vdc)

LOX Empty	2.095	LH_2 Empty	2.095
LOX 1/3 Mass	1.587	LH_2 1/3 Mass	1.011
LOX 2/3 Mass	2.588	LH_2 2/3 Mass	3.066

Computed Loading Voltages (vdc)

LOX Empty	0.027	LH_2 Empty	0.027
LOX 1/3 Coarse Mass	7.547	LH_2 1/3 Coarse Mass	7.711

PU System Power Test

Function	Measured Value	Limits
Foward Bus 2 Voltage (vdc)	28.44	28. ±2
Inv-Conv 115 vrms Output (vac)	114.736	115. ±3.4
Inv-Conv 21 vdc Output (vdc)	21.823	21.25 ±1.25
Inv-Conv 5 vdc Output (vdc)	4.979	4.8 ±0.3
Inv-Conv Frequency (Hz)	400.563	400. ±6

4.2.25 (Continued)

For a final test, the PU valve hardover position command was turned on, and the PU system ratio valve position was measured as -27.9 degrees with the LOX bridge 1/3 checkout relay command and the PU activate switch both on, meeting the less than -20 degrees requirement.

At the completion of this attempt, it was noted that the inverter-converter and PU power had been on 46 minutes 56.866 seconds, that the switch selector was used 12 times, and that the LOX and LH_2 bridge potentiometers had been cycled 4 times and 3 times, respectively.

Engineering comments noted that there were no parts shortages affecting this test. No particular problems were encountered during the satisfactory fifth attempt of this procedure. As noted, one FARR was written during an earlier attempt. FARR A271242 rejected the LH_2 tank fast fill liquid level control unit 411A92A43, P/N 1A68710-509, S/N D83, for suspected malfunction. The LH_2 tank fast fill indication did not turn on when it should have, and the control unit could not be adjusted to cycle properly. A new control unit, S/N 66, was installed, tested and adjusted by the level sensor and control unit calibration procedure, and accepted for use.

Nine revisions were made to the procedure, with one of these deleted:

a. One revision added steps to verify the operation of the PU oven on indication, measurement K151, and to perform a low RACS check on this measurement to verify the RACS operation.

b. One revision changed the polarity signs in the requirements table and the data printout for the valve slew checks, as the new curve on the digital data tape had a negative slope in units of degrees, rather than a positive slope in units of volts.

c. One revision changed the system test valve position signal (error signal) from 1.00 $\pm$0.02 vdc and -1.00 $\pm$0.02 vdc to be 1.00 $\pm$0.036 vdc and -1.00 $\pm$0.036 vdc, to agree with a revised system design requirement.

d. Two revisions changed the tolerances on the LH_2 boiloff bias signal voltage measurements because of a range change of measurement M10 for this function, and then reinstated the original tolerances for this stage only, as a shortage of low gain dc amplifiers had prevented the range change from being accomplished.

4.2.25 (Continued)

The PU loading test followed. The LH_2 boiloff bias signal voltage was measured with the boiloff bias cutoff turned on, and was verified to be 0.0 ± 2.5 vdc with the cutoff turned off. The GSE loading potentiometer power was turned on, and the voltage measured. Measurements were then made of the LOX and LH_2 loading potentiometer sense voltages and signal voltages. Measurements of the LOX and LH_2 loading potentiometer signal voltages were repeated after the LOX and LH_2 bridge 1/3 checkout relay commands were turned on, and again after these commands were turned off. The GSE power was turned off, and the LOX and LH_2 loading potentiometer sense voltages were again measured.

The servo balance bridge gain test was conducted next. The ratio valve position was measured, and the LOX and LH_2 coarse and fine mass voltages were measured through the AO and BO telemetry multiplexers. The measurements were repeated with the LOX and LH_2 bridge 1/3 checkout relays on, with the bridge 2/3 checkout relays on, with the bridge 2/3 checkout relays off, and again with the bridge 1/3 checkout relays off.

The next check verified that the LOX and LH_2 tank overfill and fast fill sensors and their associated control units responded properly under ambient (dry) conditions and under simulated wet conditions of the sensors.

The valve movement test next measured the ratio valve positions during the 50 second plus valve slew and the valve positions during the 50 second minus valve slew.

The next part of this procedure was the PU activate test. All measurements for this test were made through the AO and BO multiplexers. The ratio valve position was measured, then the LOX bridge 1/3 checkout relay command was turned on and the LOX coarse mass voltage was measured. The ratio valve position was remeasured with the PU activate switch turned on, and again with it turned off. The LOX bridge 1/3 checkout relay command was turned off, then the LOX coarse mass voltage and the ratio valve position were remeasured.

These steps were then repeated using the LH_2 bridge 1/3 checkout relay, and measuring the LH_2 coarse mass voltage.

4.2.25.1 (Continued)

Function	Measured Value	AO Multi	BO Multi	Limits
2/3 Checkout Relay Commands Off				
Ratio Valve Position (deg)	0.896			0.419 ±1.5
LOX Coarse Mass Voltage (vdc)		1.338	1.328	1.348 ±0.1
LOX Fine Mass Voltage (vdc)		1.494	1.484	1.587 ±0.4
LH_2 Coarse Mass Voltage (vdc)		1.357	1.362	1.377 ±0.1
LH_2 Fine Mass Voltage (vdc)		0.996	0.996	1.011 ±0.4
1/3 Checkout Relay Commands Off				
Ratio Valve Position (deg)	0.351			0.419 ±1.5
LOX Coarse Mass Voltage (vdc)		-0.015	-0.015	0.005 ±0.1
LOX Fine Mass Voltage (vdc)		1.934	1.934	2.095 ±0.4
LH_2 Coarse Mass Voltage (vdc)		-0.010	-0.010	0.005 ±0.1
LH_2 Fine Mass Voltage (vdc)		1.948	1.943	2.095 ±0.4

PU Valve Movement Test

Function	Measured Value	Limits
Ratio Valve Position, AO (deg)	0.419	0.419 ±1.50
Ratio Valve Position, BO (deg)	0.487	0.419 ±1.50
50 Second Plus Valve Slew, AO Multiplexer		
+1 vdc System Test Valve Position Signal (vdc)	0.994	1.00 ±0.36
V1, Position at T+3 Seconds (deg)	4.091	1.92 to 6.00
V2, Position at T+5 Seconds (deg)	5.113	2.51 to 6.99
V3, Position at T+8 Seconds (deg)	5.796	2.81 to 6.99
V4, Position at T+20 Seconds (deg)	6.068	4.94 to 6.99
V5, Position at T+50 Seconds (deg)	6.000	4.94 to 6.99
50 Second Minus Valve Slew, AO Multiplexer		
Ratio Valve Position, AO (deg)	0.49	0.419 ±0.150
-1 vdc System Test Valve Error Signal (vdc)	-0.999	-1.00 ±0.036
V1, Position at T+3 Seconds (deg)	-3.817	-1.92 to -6.00
V2, Position at T+5 Seconds (deg)	-4.771	-2.51 to -6.99
V3, Position at T+8 Seconds (deg)	-5.317	-2.81 to -6.99
V4, Position at T+20 Seconds (deg)	-5.590	-4.94 to -6.99
V5, Position at T+50 Seconds (deg)	-5.658	-4.94 to -6.99

PU Activation Test

Function	AO Multi	BO Multi	Limits
Ratio Valve Position (deg)	0.351	0.419	0.419 ±1.50
LOX 1/3 Command Relay On			
LOX Coarse Mass Voltage (vdc)	1.333	1.328	1.348 ±0.1
PU System On			
Ratio Valve Position (deg)	33.008	33.076	20.0 min

4.2.25.1 (Continued)

Function	AO Multi	BO Multi	Limits
PU System Off			
Ratio Valve Position (deg)	0.761	0.761	15.0 max
LOX 1/3 Command Relay Off			
LOX Coarse Mass Voltage (vdc)	-0.005	-0.020	0.005 ±0.1
Ratio Valve Position (deg)	0.419	0.487	0.419 ±1.5
LH_2 1/3 Command Relay On			
LH_2 Coarse Mass Voltage (vdc)	1.353	1.348	1.377 ±0.1
PU System On			
Ratio Valve Position (deg)	-27.737	-27.668	-20.0 max
PU System Off			
Ratio Valve Position (deg)	0.56	0.56	-15.0 min
LH_2 1/3 Command Relay Off			
LH_2 Coarse Mass Voltage (vdc)	-0.010	-0.015	0.005 +0.1
Ratio Valve Position (deg)	0.419	0.487	0.419 ±1.5

4.2.26 Repressurization System Leak Check (1B59460 A)

This manual procedure leak checked the repressurization system prior to automatic checkout activities, and is used to repressurize the LOX and LH_2 tanks for the J-2 engine restart. The repressurization system included the LOX tank repressurization control module 403A74A3, P/N 1B56653-513, S/N 29; the LH_2 tank repressurization control module 403A73A4, P/N 1B56653-513, S/N 28; seven ambient helium storage spheres, P/N 1B66868-501, two for LOX tank repressurization, S/N's 35 and 31, and five for LH_2 tank repressurization, S/N's 33, 26, 32, 15, and 18; and the associated plumbing. The system also included an O_2H_2 burner and additional cold helium spheres for dual repressurization, but these were checked during the cold helium system leak check, H&CO 1B59458.

The procedure was initiated and completed on 13 December 1967, and was accepted on 3 January 1968. In general, the test was accomplished by pressurizing the system with helium gas and using a USON leak detector or leak detection bubble solution to locate any leakage. Gross leakage was located by listening for audible escaping gas.

After the GSE and stage test configuration was established, the repressurization ambient helium spheres were pressurized between 50 and 100 psia, and the proper operation of the LOX and LH_2 repressurization dump valves was verified. The helium spheres were then pressurized to 1750 psig for an

4.2.26 (Continued)

integrity check, with a check made at 500 psig to verify that there was no audible leakage. The integrity pressure was held for 3 minutes, then the spheres were vented to about 1500 psig.

Seat leakage measurements were then made on the valves, P/N 1B43660-509, within the LOX and LH_2 repressurization control modules. The LOX helium spheres dump valve 403A74A3L1, S/N 2200, and the LH_2 helium spheres dump valve 403A73A4L1, S/N 2187, both had zero scim seal leakages, meeting the 12 and 25 scim, allowable leakage limits respectively, for these valves. The LOX control shutoff valves 403A74A3L2 and L3, S/N's 2205 and 2204 had a zero scim combined seat leakage, while the LH_2 control shutoff valves 403A73A4L2 and L3, S/N's 2206 and 2198, had a zero scim combined seat leakage, both within the 25 scim allowable combined leakage limit.

Leak checks were then conducted on the components, fittings, and connections of the repressurization system from the helium spheres to the repressurization control modules. The helium spheres were vented to 400 $\pm$50 psig, and the proper operation of the repressurization control shutoff valves was verified. Leak checks were then conducted on the system from the repressurization control modules to the connections to the LOX and LH_2 pressurization lines. After the completion of these checks the repressurization system was vented to ambient and the stage was returned to the pre-test configuration.

Engineering comments noted that all parts were installed at the start of the test. One leak found at the B-nut junction of pipe assemblies, P/N's 1B67386-1 and 1B58853-1, was corrected by replacing the union. No FARR's were written during this test; however, eight revisions were made to the procedure for the following:

a. One revision was written to identify new pipe assemblies used in the system.
b. One revision changed the pressures used in the integrity pressure test from 300 psia, 750 psia, and 70 $\pm$50 psia to 500 psia, 1750 psia, and 1500 psia, respectively, to agree with Design Memorandum 133D requirements.
c. One revision provided for proper valve configuration and leakage rate.

4.2.26 (Continued)

d. One revision simplified the method of verifying valve operation.

e. One revision increased the repressurization sphere integrity pressure from 1000 psia to 1800 psia.

f. One revision pressurized the cold helium sphere to 400 $\pm$50 psia to ensure sufficient pressure to check the repressurization line for leakage.

g. One revision added a step to the "shutdown" paragraph to vent the cold helium bottles.

h. One revision deleted a step requiring removal of the stage monitor panel lines, because the lines would be removed as part of the all systems post test instructions.

4.2.27 J-2 Engine System Leak Check (1B59461 B)

The manual leak check of the J-2 engine system was subdivided into two separate procedures. The J-2 engine leak check began with the pressurization, leak check, and depressurization of the start sphere. This was followed by a pressurization and leak check of the control sphere, and leak checks of the pneumatic lines with the mainstage control, helium control, ignition phase control, and start tank discharge control solenoids energized and de-energized. The thrust chamber leak check involved pressurization of the chamber, and leak check of the system, under pressure, downstream of the main fuel and oxidizer valves, and the engine portion of the LH_2 tank pressurization system.

Initiated on 14 December 1967, the procedure was completed by 19 December 1967, after 4 days of activity, and was accepted on 8 January 1968. Helium gas was used for pressurization during this procedure, and leakage was detected by the use of a USON leak detector, leak detection fluid, or, for engine connections having leak detection ports, a Rocketdyne G3104 flow tester.

The thrust chamber leak check was accomplished first. After the test configuration was established, the thrust chamber was pressurized to 30 $\pm$5 psig. Leak checks were then conducted on the thrust chamber purge and chilldown line, and on those system lines and connections that were pressurized. The flapper valve, P/N 1B53920-501, on the LH_2 pressurization line, was verified to be in the proper orientation. The engine start tank and the thrust chamber were then vented to ambient to complete this part of the test.

4.2.27 (Continued)

The J-2 engine leak check was accomplished next. After the test configuration was established, the checkout line for the mainstage OK pressure switches was pressurized to 500 $\pm$10 psig and leak checked. For a pressure switch pressure decay check, the checkout line pressure was measured as 500 psig, and remeasured as 498.5 psig after a 30 minute delay period. This was within the 2 psi pressure change allowed for temperature change effects. The checkout line was then vented to ambient, and the pneumatic control sphere was pressurized to 245, +10, -20 psia.

The engine start tank was then pressurized to 100 psia, the proper operation of the start tank vent valve was verified, and the start tank vent line was leak checked. The start tank was then pressurized to 550 $\pm$25 psia for an integrity check, with checks made at 200 and 400 psia to verify that there was no gross leakage. The integrity pressure was held for 3 minutes, then the tank was vented to 485 $\pm$25 psia, the start fill line was leak checked, and the tank was vented to ambient.

The engine control sphere was pressurized to 100 psia, and the proper operation of the control sphere vent valve was verified. The control sphere was then pressurized to 1750 $\pm$50 psia for an integrity check, with checks made at each 500 psi increment to verify that there was no gross leakage. The integrity pressure was held for 3 minutes, then the sphere was vented to 1500 $\pm$50 psia and leak checks were conducted on the sphere fill and outlet lines. The control sphere was then vented to between 225 and 250 psig for the remaining system leak checks. During these leak checks the mainstage control, helium control, ignition phase control, and start tank discharge control solenoids were energized and de-energized as required to supply pressure to the various system lines, and all pressurized lines, connections, and valve check ports were leak checked. At the conclusion of these checks, the engine control sphere and the ambient helium sphere were vented to ambient, and all of the control solenoids were de-energized.

Engineering comments noted that there were no parts shortages affecting this test. No leaks were found during the operation of this procedure, nor were any FARR's generated as a result of this procedure.

4.2.27 (Continued)

Fourteen revisions were made to the procedure for the following:

a. One revision added the instructions and pressure decay limits for the pressure switch diaphragm pressure decay test, to meet requirements based on STC experience.

b. One revision changed three pipe assembly part number callouts to agree with the pipe assemblies installed on the stage. P/N 1B63355-1 was changed to P/N 1B67025-1; P/N 1B52444-1 was changed to P/N 1B43397-1; and P/N 1A97405-1 was changed to P/N 1B66824-1.

c. One revision changed the start tank integrity pressure from 650 $\pm$25 psia to 550 $\pm$25 psia, and the start tank leak check pressure from 600 $\pm$25 psia to 485 $\pm$25 psia, to comply with design memo 133D.

d. One revision changed the engine control sphere integrity and leak checks to use an integrity pressure of 1750 $\pm$50 psia rather than 1650 $\pm$50 psia, and to leak check the sphere fill and outlet lines at 1500 $\pm$50 psia, rather than at 225 to 250 psia. This was to provide the proper pressure for leak checking the high pressure lines.

e. One revision added the use of a Rocketdyne G3104 pneumatic flow tester for determing leakage at all engine flanged connections provided with leak detection ports, to conform with the requirements of Rocketdyne Technical Manual R-3825-2.

f. One revision changed the test setup to "connect a hand valve" rather than "connect a 1/4 inch hand valve," to allow the use of any available hand valve.

g. One revision added a step to vent the engine start tank after the thrust chamber leak check, to relieve the pressure resulting from pressurizing the thrust chamber.

h. Two revisions increased the GSE pressures supplied for the thrust chamber pressurization, as the dry type throat plug required a greater impact pressure for seating, and then reduced the GSE pressure for the engine low pressure supply, to maintain the required 30 $\pm$5 psig thrust chamber pressure.

i. One revision deleted an unrequired step in the post-test operations.

j. One revision added the requirement to: "Record each time the helium control solenoid is energized or de-energized and the engine control sphere pressure at each actuation. These figures will be entered into the engine log book." This was necessary to comply with provisions of Rocketdyne ECP 603.

4.2.27 (Continued)

k. One revision added a statement to; "Inspect injector face for any contamination," in two places to ensure that the engine was not contaminated during checkout.

l. One variation revision added instructions to perform a special test to determine the feasibility of a 30 psig propellant feed system leak check.

m. One variation revision added a special section to perform turbine exhaust system drying to satisfy Rocketdyne J2-567 rework.

n. One variation revision added steps to accomplish a leak test after Rocketdyne rework of the transducers for measurements D1 and D4.

4.2.28 Range Safety Receiver Checks (1B66565 B)

This combined manual and automatic procedure verified the functional capabilities of the range safety receivers prior to their use in the range safety system checkout. The receivers were checked for automatic gain control (AGC) calibration and drift, minimum acceptable deviation sensitivity, minimum acceptable RF sensitivity, and open loop operation. The items involved in this test were:

Item	Ref. Location	P/N	S/N
Range Safety Receiver 1	411A97A14	50M10697	188
Range Safety Receiver 2	411A97A18	50M10697	185
Secure Command Decoder 1	411A99A1	50M10698	046
Secure Command Decoder 2	411A99A2	50M10698	026

Initiated on 19 December 1967, the first issue procedure was completed on the same date without encountering any problems, and was signed off acceptable on 27 December 1967. The second issue procedure was initiated and completed on 26 January 1968, with sign off acceptance on 1 February 1968. The following narration and Test Data Table 4.2.28.1 cover the second issue procedure, and those portions of the first issue procedure that were not performed by the second issue.

Several manual operations were accomplished before the automatic procedure was started. The total cable insertion loss values at the 450 MHz range safety frequency were found to be 29.1 db for range safety system 1, and 29.3 db for range safety system 2. The Model DSV-4B-136 destruct system test set, P/N 1A59952-1, was set up at 450.000 $\pm$0.045 MHz with a -17 dbm output level and a

4.2.28 (Continued)

60.00 ±0.60 kHz deviation. The stage range safety antennas were disconnected from the directional power divider, and 50 ohm loads were connected to the power divider in their place for test use, until the open loop RF checks.

Initial test conditions were established, the range safety receivers were transferred to external power and turned on, and the propellant dispersion cutoff command inhibit was turned on for both receivers. The cable insertion loss values were loaded into the computer for use in the program.

The receiver AGC calibration checks were conducted next. For each input signal level used in the calibration check, the computer determined the GSE test set output level required to compensate for the cable insertion loss, and, when requested by the computer typeout, the GSE test set was manually adjusted to these output levels. The computer then determined the input signal levels and measured the low level signal strength (AGC telemetry voltage) of each receiver. These AGC measurements, in the 0 to 5 vdc range, were multiplied by a conversion factor of twenty and presented as per cent of full scale values. The AGC calibration check was conducted twice, and the difference in AGC values at each step was determined for the AGC drift check. As shown in the Test Data Table, the AGC values were all acceptable, and the drift deviations were well below the 3 per cent of full scale maximum limit.

Manual -3 db and -60 db RF bandwidth checks were individually conducted on each receiver. With a GSE test set output frequency of 450.000 ±0.005 MHz, the output level was adjusted to obtain a 2.0 ±0.1 vdc AGC voltage from the receiver under test. The corresponding receiver RF output level was determined, and +20 dbm was added to obtain the RF reference level. The GSE test set output level was increased by 3 db, and the test set frequency was increased above 450 MHz, and then decreased below 450 MHz, until the receiver AGC voltage was again 2.0 ±0.1 vdc. The frequencies at which this occurred were measured as the upper and lower -3 db bandedge frequencies. The -3 db bandwidth was found as the difference between these frequencies, and the bandwidth centering was found as the difference between the midpoint of these frequencies and 450 MHz. For the -60 db bandwidth check, this procedure was

4.2.28 (Continued)

repeated, except that the test set output level was increased by 60 db rather than 3 db. The results of these checks are shown in the Test Data Table.

For the deviation threshold check, the GSE test set was adjusted for an output of 450.000 ±0.045 MHz at a level that provided receiver input levels of -63 dbm for receiver 1, and -63.5 dbm for receiver 2. A series of checks determined the minimum input deviation frequency at which each receiver would respond to the range safety commands. For each command, the GSE test set was manually adjusted to a sequence of deviation frequencies increasing from 5 kHz, as requested by the computer typeout. At each deviation frequency, the range safety secure command decoders were checked for the presence of the command signal from the appropriate receiver. As shown in the Test Data Table, both receivers responded to all commands at minimum deviation frequencies well below the 50 kHz maximum limit.

For the radio frequency sensitivity checks, the GSE test set was adjusted for an output of 450.000 ±0.045 MHz with a fixed deviation of 60.0 ±0.5 kHz. A series of checks determined the minimum input signal level at which each of the receivers would respond to the range safety commands. For each command, the GSE test set output was manually adjusted to a sequence of levels increasing from -85.9 dbm, as requested by the computer typeout. This gave input levels increasing from -115.0 dbm for receiver 1, and increasing from -115.2 dbm for receiver 2. At each input level, the range safety secure command decoders were checked for the presence of the command signal from the appropriate receiver. Both receivers responded to minimum input levels below the -93 dbm maximum limit, as shown in the Test Data Table.

The 50 ohm loads were disconnected from the stage power divider, and the range safety antennas were reconnected for the open loop RF checks. For a manual open loop check, the GSE test set was adjusted for open loop operation, and the test set antenna coaxial switch was set to the first test position. The test set output level was set at -100 dbm and increased in 1 dbm increments until the AGC voltage of the least sensitive receivers no longer increased. This occurred at an output level of -85.5 dbm. The AGC voltage of the other

4.2.28 (Continued)

receiver was verified to be at least 3 vdc at this level. The check was repeated with the test set antenna coaxial switch set to the second test position, with the output level measured as -86.5 dbm. The test set antenna coaxial switch was returned to the first test position, and the test set output level was set at -86.5 dbm for the automatic open loop RF checks.

Under open loop conditions, the low level signal strength (AGC telemetry voltage) of receiver 1 was 3.62 vdc, while that of receiver 2 was 3.43 vdc. The range safety commands were transmitted from the GSE test set, and checks of the secure command decoders showed that both receivers responded properly to the open loop transmission. The PCM RF assembly power was turned on, the open loop PCM signal was verified to be received at the DDAS ground station, and the range safety commands were again transmitted. Checks of the decoders showed that both receivers responded properly and were not adversely affected by the PCM RF transmission. The PCM RF assembly power was turned off, the range safety EBW firing units were transferred to external power, the propellant dispersion cutoff command inhibits were turned off for both receivers, and the range safety receivers were both turned off, completing the range safety receiver checks. The computer printout indicated that both range safety receivers and both decoders had accumulated 4 hours 34 minutes 42.837 seconds accumulated running time for the first and second issue procedures.

Engineering comments noted that there were no part shortages affecting either test. No stage problems were encountered during either test, nor were any FARR's written. Failure of the RS decoder, P/N 50M10698, S/N 176, during the all systems test necessitated in the issuance of a second test procedure. Per instructions of FARR A271290 the defective decoder, S/N 176, was removed and replaced by decoder, S/N 026, which checked out satisfactorily.

Ten revisions were made to the second issue procedure, of which eight were identical to those for the first issue procedure. The revisions were for the following:

a. Three revisions changed the cable insertion loss attenuation measurement procedure. To make the test setup the same for both measurements, only the receiver input cable for the system being measured was to be

4.2.28 (Continued)

disconnected, rather than disconnecting the receiver input cables for both systems before measuring system 1. To clarify the procedure, the TAC-50 attenuator was to be set to zero attenuation, rather than to minimum output. To avoid unnecessary repetitions of the attenuation measurements, a note was added to permit the use of previously measured attenuation values if the measurements were not affected by parts changes, damage, or other condition changes.

b. One revision corrected a coaxial adapter designation to be General Radio 874-QNP, rather than General Radio 874-ONP as listed.

c. Two revisions added steps to set up the Model DSV-4B-125 PAM/FM/FM telemetry ground station, P/N 1A59942-1, for use during the open loop RF checks.

d. Two revisions added steps to set the DDAS ground station for receipt of the PCM open loop RF transmission; to ensure receipt of this transmission; and to reset the ground station for receipt of the 600 kHz hardwire signal after the conclusion of the open loop RF checks.

e. One variation revision deleted the requirement for paragraph 4.2.5 in the second issue procedure, because nothing was done to invalidate the first issue results.

f. One variation revision deleted the DER from paragraph 3.1.1 and added it to paragraph 3.1.2 because the DER was inoperative during that portion of the test.

4.2.28.1 Test Data Table, Range Safety Receiver Checks

AGC Calibration and Drift Checks (% = per cent of full scale)

Test Set Output	Receiver 1 Input	AGC 1 (%)			Receiver 2 Input	AGC 2 (%)		
(dbm)	(dbm)	Run 1	Run 2	Drift	(dbm)	Run 1	Run 2	Drift
-97.9	-127.0	42.66	42.15	0.51	-127.2	20.61	20.10	0.51
-90.9	-120.0	43.16	42.75	0.41	-120.2	20.70	20.39	0.31
-85.9	-115.0	45.12	44.39	0.72	-115.2	21.84	21.62	0.21
-80.9	-110.0	50.04	49.43	0.61	-110.2	24.51	24.71	0.20
-75.9	-105.0	60.51	59.79	0.72	-105.2	32.60	32.09	0.51
-70.9	-100.0	70.14	70.25	0.12	-100.2	49.94	49.53	0.41
-65.9	-95.0	73.22	73.13	0.10	-95.2	69.43	69.02	0.41
-60.9	-90.0	73.95	73.73	0.21	-90.2	74.36	74.24	0.12
-55.9	-85.0	74.14	74.14	0.00	-85.2	75.59	75.47	0.12
-50.9	-80.0	74.24	74.24	0.00	-80.2	76.19	76.09	0.10
-45.9	-75.0	73.95	74.04	0.10	-75.2	76.50	76.50	0.00
-40.9	-70.0	73.54	73.42	0.12	-70.2	76.41	76.29	0.12

4.2.28.1 (Continued)

-3 db RF Bandwidth Check

Function	Receiver 1	Receiver 2	Limits
Reference Voltage (AGC) (vdc)	1.983	2.00	2.0 ±0.1
Reference RF Power Level (dbm)	-86.3	-72.5	--
Upper Bandedge Frequency (Mhz)	450.169	450.176	--
Lower Bandedge Frequency (MHz)	449.842	449.834	--
-3 db Bandwidth (kHz)	327.0	342.0	340.0±30.0
Bandwidth Centering (kHz)	6.0	5.0	33.8 max

-60 db RF Bandwidth Check

Function	Receiver 1	Receiver 2	Limits
Reference Voltage (AGC) (vdc)	1.983	2.00	2.0 ±0.1
Reference RF Power Level (dbm)	-86.3	-72.5	--
Upper Bandedge Frequency (MHz)	450.504	450.537	--
Lower Bandedge Frequency (MHz)	449.560	449.543	--
-60 db Bandwidth (MHz)	0.938	0.994	1.2 max

Deviation Sensitivity Check

	Minimum Deviation (kHz)	
Range Safety Command	Receiver 1	Receiver 2
Arm and Engine Cutoff	12.5	12.5
Propellant Dispersion	15.0	12.5
Range Safety System Off	12.5	12.5

RF Sensitivity Check

	Minimum Input Level (dbm)	
Range Safety Command	Receiver 1	Receiver 2
Arm and Engine Cutoff	-105.0	-105.2
Propellant Dispersion	-105.0	-105.2
Range Safety System Off	-105.0	-105.2

4.2.29 Propellant Tanks System Leak Check (1B59459 C)

The purpose of the propellant tanks system leak check test was to verify the integrity of the S-IVB stage propellant tanks, the common bulkhead, and associated plumbing.

This test procedure was active for 10 days between 19 and 25 January 1968, and was accepted on 26 January 1968. The first test performed was the vacuum check of the jacketed ducts. The ducts were checked to a vacuum indication of 250 microns of mercury absolute. See the Test Data Table. The second test performed was the common bulkhead leak check. The common bulkhead was

4.2.29 (Continued)

pressurized to 2.5 $\pm$0.5 psig, then the common bulkhead disconnect assembly was checked for leakage. After checking for leakage, the common bulkhead was returned to an ambient pressure condition.

The LOX tank was pressurized to 12.0 +0, -0.5 psig and LH_2 tank was pressurized to 11.5 +0, -0.5 for a 3 minute integrity check. The LOX and LH_2 tanks were vented to 10.5 +0, -0.5 psig and 9.5 +0, -0.5 psig, respectively.

The LOX tank was then pressurized to 10.0 +0, -0.5 psig and the LH_2 tank was pressurized to 9.5 +0, -0.5 psig for the leak checks, and gas samples were taken to verify that the helium gas concentration in the tanks was 75 per cent or greater. During the leak checks, the LOX and LH_2 tank pressure gauges were monitored to verify that there was no pressure decrease greater than 0.5 psig. Leak checks were conducted on the LOX and LH_2 tank systems, including all valves, lines, and feedthroughs, with a USON detector sensitivity of 0.001 cubic centimeters per second. Seal leakage measurements were also made using a flowmeter. The test results are shown in Test Data Table 4.2.29.1.

The leak checks showed two areas that leaked in excess of 0.001 cubic centimeters per second limit. These were the upstream conoseal on the duct assembly connection at the LH_2 vent valve, P/N 1A49986-1; and the downstream conoseal at the LH_2 propellant valve connection on duct assembly, P/N 1B65206, S/N 15 (reference FARR A271288). The leaks were satisfactorily corrected, retested, and found acceptable.

Following the satisfactory completion of the leak checks, the tanks were vented to ambient pressure. All test connections and adapters were removed and the stage was returned to the pre-test configuration.

Five FARR's were written against this procedure for the following:

a. FARR A271282 rejected the LH_2 burner vacuum jacketed feed duct, P/N 1B65206-503, S/N 8, after IIS 377628 noted that the required 250 microns of mercury vacuum could not be attained. Duct, S/N 15, was installed, but subsequently removed (ref. e below).

4.2.29 (Continued)

b. FARR A271285 rejected the LH_2 fill and drain valve, P/N 1B48240-505, S/N 41, after IIS 378234 noted blade shaft seal leakage of 23 scim, exceeding the 6.1 scim limit. Valve, S/N 122, was installed and satisfactorily tested.

c. FARR A271276 rejected the LH_2 burner vacuum jacketed feed duct, P/N 1B65206-503, S/N 10, after IIS 377628 noted that the required 250 microns of mercury could not be attained. Another duct, S/N 8, was installed, but was subsequently removed when it did not pass the vacuum test.

d. FARR A271277 rejected the filter, P/N 1B59008-501, S/N 1036904, after IIS 377628 noted that the threads were galled during removal from the feed duct, P/N 1B65206-503, S/N 10. The galled threads were chased. The filter was cleaned and packaged per DPS's and returned to stock.

e. FARR A271288 rejected the LH2 burner vacuum jacketed feed duct, P/N 1B65206-503, S/N 15, after IIS 378235 noted that the duct leaked at the LH_2 propellant valve connection. The leak could not be fixed, although a conoseal was replaced in an attempt to stop the leakage. Another duct, S/N 18, was installed in place of S/N 15 and satisfactorily tested.

Ten revisions were made to the procedure for the following:

a. One revision added special instructions for the set up and leak check of the O_2H_2 burner system, as the requirement for a 5 psig leak check of this system was established after the release of the procedure C revision.

b. Four other revisions made corrections and changes to the added O_2H_2 burner system leak check, for proper operation.

c. One revision deleted eleven steps from the LOX and LH_2 tank checks, as they were duplicated by the added O_2H_2 burner system check.

d. One revision corrected seven part number callouts to reflect the latest changes in installed components.

e. One variation revision defined the method of repair and retest of leaks found.

f. One variation revision deleted and changed some steps of revision 3 because it was not possible to pressurize non-propulsive vent ducts using the test gauge setup.

g. One revision added instructions to install, then subsequently remove, hand valves to complete the test setup, and then return the stage to the automatic test configuration. These steps were omitted from the procedure.

4.2.29.1 Test Data Table, Propellant Tanks System Leak Check

Vacuum Checks

Part	P/N	S/N	Vacuum (Microns of Hg)
Engine LH_2 Feed Duct	1A49320-511-006	11R	18
Engine LH_2 Feed Duct	1A49320-513	9	13
LH_2 Chilldown Supply Duct	1A49966-503-003	26	24
Burner LH_2 Feed Duct	1B56206-503	18	10
Burner LH_2 Feed Duct	1B59005-501	14	7
Burner LOX Feed Duct	1B59009-501	21	2

Valve Leak Checks

Part	P/N	S/N	Leakage Measurement
LOX Fill and Drain Valve	1A48240-505	113	Main Seal 0.35 scim Blade Shaft Seal 0 scim
LOX Prevalve	1A49968-509	102	Shaft Seal 0 scim
LOX Chilldown Pump	1A49423-507	1868	Cavity Seal 0 scim
LH_2 Fill and Drain Valve	1A48240-505	122	Main Seal 0 scim Blade Shaft Seal 4.2 scim
LH_2 Vent Valve and LH_2 Relief Valve	1A48257-511 1A49591-533-016	59 166	Combined Main Seal 4.75 s(
LH_2 Directional Control Valve	1A49988-501	34	Shaft Seal 3.5 scim
LH_2 Prevalve	1A49968-509	146	Shaft Seal 0 scim

4.2.30 Hydraulic System (1B66570 B)

This automatic procedure verified the integrity of the stage hydraulic system, and demonstrated the capability of the system to provide engine centering and control during powered flight. The test involved all components of the stage hydraulic system, including the hydraulic pump, P/N 1A66240-503, S/N X123108; the auxiliary hydraulic pump, P/N 1A66241-511, S/N X458911; the accumulator/reservoir assembly, P/N 1B29319-519, S/N 33; the hydraulic pitch actuator 403A71L1, P/N 1A66248-507, S/N 81; and the hydraulic yaw actuator 403A72L1, P/N 1A66248-507, S/N 30.

Initially accomplished by the first attempt on 20 December 1967, the procedure was satisfactorily repeated by the second attempt on 10 January 1968, and was accepted on 12 January 1968. The second attempt was required by the replace-

4.2.30 (Continued)

ment of the hydraulic pitch actuator, P/N 1A66248-507, S/N 78, by FARR A271279 during the hydraulic system fill, flush, bleed, and fluid sample procedure, H&CO 1B40973. A new actuator, S/N 81, was installed, tested, and accepted for use.

Those function values measured during the second attempt are presented in Test Data Table 4.2.30.1. All of these values were acceptable and were within general design requirements, although specific limit requirements were not defined in the procedure for most of the measurements.

The stage power setup, H&CO 1B66560, was accomplished, and initial conditions were established for the test. The instrument unit (IU) substitute 5 volt power supply was turned on and its voltage was measured, and the aft 5 volt excitation module voltage was measured. Measurements were made of various hydraulic system functions with the hydraulic system unpressurized. Measurements were also made to determine the accumulator/reservoir gaseous nitrogen mass and corrected oil level.

The methods of controlling the auxiliary hydraulic pump were checked next. After verification that a power cable was connected to the auxiliary hydraulic pump motor, the aft bus 2 power supply was turned on and the bus voltage was verified to be 56.0 $\pm$4.0 vdc. The coast mode operation was checked by applying dry ice to the coast mode thermal switch and verifying that the low temperature caused the thermal switch to turn the auxiliary pump on when the auxiliary hydraulic pump coast command was turned on. The dry ice was removed, and it was verified that the increased temperature caused the thermal switch to turn the pump back off. The coast command and the aft bus 2 power supply were turned off, and the bus voltage was verified to be 0.0 $\pm$1.0 vdc. During the remaining pump control checks, only the auxiliary hydraulic pump motor ON indication was checked, as the pump did not run while the aft bus 2 power was off. The flight mode operation was checked by verifying that turning the auxiliary hydraulic pump flight command on and off properly turned the auxiliary pump on and off. The manual mode operation was checked by verifying that the auxiliary pump could be properly turned on and off at the GSE mechanical systems panel when the GSE was in the manual mode.

4.2.30 (Continued)

The engine centering tests were then conducted. The first test was conducted with the actuator position locks on and with the hydraulic system unpressurized. The actuator positions and the voltage of the IU substitute 5 volt power supply and the aft 5 volt excitation module were measured, and the corrected actuator positions were determined. The pitch and yaw actuator locks were then removed, and the aft bus 2 power was turned on and the voltage was measured. The auxiliary hydraulic pump was turned on in the automatic mode, and the aft bus 2 current was measured. The increase in hydraulic system pressure over a 4 second period was measured, and the various hydraulic system functions were verified to be within their proper operating limits.

With the hydraulic system pressurized, the second engine centering test was conducted with the actuator locks off and with no excitation signal applied to the actuators. The test measurements were repeated as before, and the corrected actuator positions were again determined. A zero excitation signal was then applied to the actuators, the hydraulic system functions were measured, the actuator position measurements were repeated, and the corrected actuator positions were again determined.

A clearance, linearity, and polarity check was accomplished next. The actuators were individually extended to their stops, then retracted, causing the engine to move out to its extremes of travel, 0 degrees to $\pm 7\ 1/2$ degrees, in a square pattern, counterclockwise as viewed from the engine bell. The engine was then returned to its 0 degree centered position. As the engine was sequenced through the square pattern, a clearance check verified that there was no interference to engine motion within the gimbal envelope. A comparison of the hydraulic servo engine positioning system command and response signals verified that the response movement was of the correct polarity and magnitude to agree with the command signal, and met the requirements for movement linearity. Checks of the hydraulic system pressure and reservoir oil pressure when the actuators were at their extremes and when they were returned to neutral, verified that these pressures remained acceptable.

4.2.30 (Continued)

Transient response tests were conducted next. Step commands were separately applied to the pitch and yaw actuators, causing each actuator to individually move the engine from 0 degrees to -3 degrees, from -3 degrees to 0 degrees, from 0 degrees to +3 degrees, and from +3 degrees to 0 degrees. The engine response was observed visually and audibly for unwanted oscillations, and the actuator responses were recorded during the engine movements. The engine slew rates were computed for each of the step movements. The Test Data Table shows the computed slew rates and representative actuator response values for the initial period of each check. The values measured were all acceptable and within general design requirements, although specific limits were not discernible from the procedure.

After the transient response test was completed, final measurements were made of the hydraulic system functions and the engine centering functions with the hydraulic system pressurized, the actuator locks off, and no excitation signals applied to the actuators.

The procedure was completed by turning off the auxiliary hydraulic pump, aft bus 2, and the IU substitute 5 volt power supply. The pitch and yaw actuator locks were then replaced. The computer printout noted that during this procedure the switch selector was used 4 times; the auxiliary hydraulic pump accumulated 2 cycles and 21 minutes 57.260 seconds running time; and the engine accumulated 1.5 cycles of 7.5 degrees amplitude and 1 cycle of 3 degrees amplitude in the pitch plane, and 1 cycle at each amplitude in the yaw plane.

Engineering comments noted that there were no parts shortages affecting this test. No major problems were encountered during the test, and no FARR's were written. One minor problem was noted by an Engineering comment. The hydraulic reservoir pressure of 248.33 psia, measured during the initial hydraulic system unpressurized check, exceeded the normal expected pressure of 70 psia. This was the result of the reservoir being almost completely filled, as shown by the corrected reservoir oil level of 109.4 per cent, rather than only partly filled as was normal. As soon as this condition was noted, hydraulic fluid was bled from the reservoir according to the requirements of the hydraulic system fill,

4.2.30 (Continued)

flush, bleed, and fluid sample procedure, H&CO 1B40973. The performance of the hydraulic system was not affected, as the condition was corrected before the auxiliary hydraulic pump was first started and before any engine gimbaling occurred. Two revisions were made to the procedure for the following:

a. One revision added the cycle significant switch selector, P/N 50M67864-5, to the Running Time/Cycle Record paragraph, and noted that the on-off cycles should be recorded, and that the total number of accumulated cycles would be printed out on the line printer and typewriter at the end of the test.

b. One revision changed a subroutine to verify that the hydraulic pump inlet temperature (C50PIT) was less than 190°F, rather than the reservoir oil temperature (C51ROT), to correct a program error.

4.2.30.1 Test Data Table, Hydraulic System

Function	Measurement	Limits
IU Substitute 5 volt Power Supply (vdc)	5.04	5.00 ± 0.05
Aft 5 volt Excitation Module (vdc)	5.00	5.00 ± 0.05
Hydraulic System Unpressurized		
Reservoir Oil Pressure (psia)	248.33	*
Accumulator GN_2 Pressure (psia)	2334.63	*
Accumulator GN_2 Temperature (°F)	77.23	*
Reservoir Oil Level (%)	98.92	*
Pump Inlet Oil Temperature (°F)	66.27	*
Reservoir Oil Temperature (°F)	69.40	*
Aft Bus 2 Current (amp)	0.40	*
Gaseous Nitrogen Mass (lb)	1.880	1.925 ± 0.2
Corrected Reservoir Oil Level (%)	109.4	95.0 min
Engine Centering Test, Locks On, System Unpressurized		
T/M Pitch Actuator Position (deg)	-0.00	*
IU Pitch Actuator Position (deg)	-0.07	*
T/M Yaw Actuator Position (deg)	0.03	*
IU Yaw Actuator Position (deg)	0.09	*
IU Substitute 5 volt Power Supply (vdc)	5.03	*
Aft 5 volt Excitation Module (vdc)	5.00	*
Pitch Actuator Signal (ma)	0.00	*
Yaw Actuator Signal (ma)	-0.05	*

* Limits Not Specified

4.2.30.1 (Continued)

Engine Centering Test, Locks On, System Unpressurized (Continued)

Function	Measurement	Limits
Corrected T/M Pitch Actuator Position (deg)	0.006	-0.236 to 0.236
Corrected IU Pitch Actuator Position (deg)	-0.022	-0.236 to 0.236
Corrected T/M Yaw Actuator Position (deg)	0.025	-0.236 to 0.236
Corrected IU Yaw Actuator Position (deg)	0.037	-0.236 to 0.236
Aft Bus 2 Voltage (vdc)	55.28	56.0 ± 4.0
Aft Bus 2 Current (amp)	56.00	55.0 ± 30.0
Hyd. System 4 Second Press. Change (psia)	268.4	200.0 min

Engine Centering Test, Locks Off, System Pressurized, No Excitation Signal

Function	Measurement	Limits
T/M Pitch Actuator Position (deg)	-0.03	*
IU Pitch Actuator Position (deg)	-0.07	*
T/M Yaw Actuator Position (deg)	0.02	*
IU Yaw Actuator Position (deg)	0.10	*
IU Substitute 5 volt Power Supply (vdc)	5.03	*
Aft 5 volt Excitation Module (vdc)	5.00	*
Pitch Actuator Signal (ma)	0.05	*
Yaw Actuator Signal (ma)	-0.05	*
Corrected T/M Pitch Actuator Position (deg)	-0.033	-0.517 to 0.517
Corrected IU Pitch Actuator Position (deg)	-0.030	-0.517 to 0.517
Corrected T/M Yaw Actuator Position (deg)	0.018	-0.517 to 0.517
Corrected IU Yaw Actuator Position (deg)	0.061	-0.517 to 0.517

Hydraulic System Pressurized, Locks Off, Zero Excitation Signal Applied to Actuators

Function	Measurement	Limits
Hydraulic System Pressure (psia)	3598.06	*
Reservoir Oil Pressure (psia)	168.02	*
Accumulator GN_2 Pressure (psia)	3567.56	*
Accumulator GN_2 Temperature (°F)	91.36	*
Reservoir Oil Level (%)	38.15	*
Pump Inlet Oil Temperature (°F)	79.98	*
Reservoir Oil Temperature (°F)	78.80	*
Aft Bus 2 Current (amp)	44.20	*
T/M Pitch Actuator Position (deg)	-0.02	*
IU Pitch Actuator Position (deg)	-0.07	*
T/M Yaw Actuator Position (deg)	0.02	*
IU Yaw Actuator Position (deg)	0.09	*
IU Substitute 5 volt Power Supply (vdc)	5.03	*
Aft 5 volt Excitation Module (vdc)	5.00	*
Pitch Actuator Signal (ma)	0.05	*
Yaw Actuator Signal (ma)	0.00	*

*Limits Not Specified

4.2.30.1 (Continued)

Hydraulic System Pressurized, Locks Off,
Zero Excitation Signal Applied to Actuators (Continued)

Function	Measurment	Limits
Corrected T/M Pitch Actuator Position (deg)	-0.010	-0.517 to 0.517
Corrected IU Pitch Actuator Position (deg)	-0.022	-0.517 to 0.517
Corrected T/M Yaw Actuator Position (deg)	0.010	-0.517 to 0.517
Corrected IU Yaw Actuator Position (deg)	0.037	-0.517 to 0.517

Pitch 0 to -3 Degree Step Response - Engine Slew Rate: 15.8 deg/sec

Time from Start (sec)	Pitch Excitation Signal (ma)	IU Pitch Actuator Pot. Pos. (deg)	IU 5 volt Power Supply (vdc)
0.000	0.000	-0.135	5.029
0.027	-19.971	-0.577	5.034
0.056	-19.971	-1.024	5.044
0.083	-20.020	-1.399	5.029
0.112	-19.971	-1.904	5.024
0.141	-19.971	-2.337	5.034
0.168	-20.020	-2.697	5.034
0.196	-19.971	-2.886	5.029
0.226	-19.971	-3.016	5.034
0.253	-19.971	-3.044	5.039
0.282	-19.922	-2.986	5.039
0.311	-19.971	-3.087	5.039

Pitch -3 to 0 Degree Step Response - Engine Slew Rate: 15.1 deg/sec

Time from Start (sec)	Pitch Excitation Signal (ma)	IU Pitch Actuator Pot. Pos. (deg)	IU 5 Volt Power Supply (vdc)
0.000	-20.000	-3.225	5.034
0.027	0.049	-2.669	5.034
0.056	0.000	-2.309	5.029
0.084	0.049	-1.919	5.034
0.112	0.049	-1.457	5.034
0.141	-0.049	-0.995	5.029
0.168	0.000	-0.577	5.029
0.197	0.049	-0.331	5.034
0.226	0.049	-0.216	5.034
0.253	0.000	-0.144	5.034
0.281	0.049	-0.129	5.034
0.311	0.049	-0.129	5.034

4.2.30.1 (Continued)

Pitch 0 to +3 Degree Step Response - Engine Slew Rate: 14.7 deg/sec

Time from Start (sec)	Pitch Excitation Signal (ma)	IU Pitch Actuator Pot. Pos. (deg)	IU 5 volt Power Supply (vdc)
0.000	0.050	-0.089	5.034
0.026	19.873	0.390	5.034
0.055	19.873	0.779	5.034
0.084	19.824	1.169	5.015
0.111	19.824	1.616	5.024
0.140	19.824	2.078	5.039
0.168	19.824	2.482	5.034
0.196	19.824	2.742	5.034
0.225	19.824	2.887	5.034
0.253	19.824	2.930	5.029
0.281	19.922	2.930	5.034
0.310	19.824	2.973	5.034

Pitch +3 to 0 Degree Step Response - Engine Slew Rate: 17.2 deg/sec

Time from Start (sec)	Pitch Excitation Signal (ma)	IU Pitch Actuator Pot. Pos. (deg)	IU 5 volt Power Supply (vdc)
0.000	19.850	3.045	5.034
0.029	0.049	2.396	5.034
0.060	0.049	1.891	5.034
0.087	0.098	1.473	5.034
0.116	0.049	0.996	5.024
0.145	0.049	0.578	5.039
0.172	0.098	0.274	5.034
0.201	0.049	0.116	5.034
0.229	0.049	0.087	5.034
0.257	-0.098	-0.014	5.039
0.285	0.049	-0.043	5.039
0.314	0.049	-0.058	5.034

4.2.30.1 (Continued)

Yaw 0 to -3 Degree Step Response - Engine Slew Rate: 13.7 deg/sec

Time from Start (sec)	Yaw Excitation Signal (ma)	IU Yaw Actuator Pot. Pos. (deg)	IU 5 volt Power Supply (vdc)
0.000	-0.050	0.135	5.034
0.027	-19.971	-0.347	5.034
0.056	-19.971	-0.736	5.034
0.084	-19.922	-1.097	5.034
0.112	-19.971	-1.530	5.034
0.141	-19.971	-1.978	5.034
0.169	-19.971	-2.353	5.034
0.197	-19.971	-2.627	5.029
0.226	-19.971	-2.785	5.034
0.254	-19.971	-2.800	5.034
0.282	-19.971	-2.828	5.034
0.311	-20.020	-2.828	5.039

Yaw -3 to 0 Degree Step Response - Engine Slew Rate: 15.2 deg/sec

Time from Start (sec)	Yaw Excitation Signal (ma)	IU Yaw Actuator Pot. Pos. (deg)	IU 5 volt Power Supply (vdc)
0.000	-19.949	-2.955	5.039
0.026	-0.098	-2.453	5.034
0.056	-0.098	-2.121	5.034
0.084	-0.146	-1.688	5.034
0.111	-0.146	-1.227	5.034
0.141	-0.146	-0.766	5.039
0.169	-0.098	-0.390	5.059
0.196	-0.098	-0.116	5.034
0.226	-0.098	0.014	5.034
0.254	-0.146	0.028	5.034
0.281	-0.146	0.071	5.034
0.311	0.098	0.058	5.034

Yaw 0 to +3 Degree Step Response - Engine Slew Rate: 15.4 deg/sec

Time from Start (sec)	Yaw Excitation Signal (ma)	IU Yaw Actuator Pot. Pos. (deg)	IU 5 volt Power Supply (vdc)
0.000	-0.100	0.149	5.044
0.026	19.531	0.577	5.034
0.056	19.775	0.952	5.034
0.084	19.775	1.370	5.024
0.111	19.873	1.817	5.034
0.141	19.482	2.294	5.015
0.169	19.824	2.684	5.029
0.196	19.824	2.929	5.034
0.226	19.824	3.029	5.034
0.254	19.824	3.116	5.049
0.281	19.775	3.159	5.024
0.311	19.873	3.174	5.034

4.2.30.1 (Continued)

Yaw +3 to 0 Degree Step Response - Engine Slew Rate: 13.9 deg/sec

Time from Start (sec)	Yaw Excitation Signal (ma)	IU Yaw Actuator Pot. Pos. (deg)	IU 5 volt Power Supply (vdc)
0.000	19.850	3.314	5.024
0.028	-0.146	2.784	5.029
0.056	-0.098	2.424	5.039
0.084	-0.244	2.020	5.034
0.112	-0.098	1.602	5.049
0.142	-0.098	1.183	5.029
0.169	0.000	0.750	5.034
0.198	-0.098	0.447	5.034
0.227	-0.146	0.288	5.034
0.254	0.000	0.216	5.034
0.283	-0.049	0.230	5.039
0.312	-0.098	0.201	5.015

Final Hydraulic System and Engine Centering Test
System Pressurized, Locks Off, No Excitation Signal

Function	Measurement	Limits
Hydraulic System Pressure (psia)	3611.19	*
Reservoir Oil Pressure (psia)	171.95	*
Accumulator GN_2 Pressure (psia)	3583.94	*
Accumulator GN_2 Temperature (°F)	75.67	*
Reservoir Oil Level (%)	38.28	*
Pump Inlet Oil Temperature (°F)	127.99	*
Reservoir Oil Temperature (°F)	113.39	*
Aft Bus 2 Current (amps)	45.00	*
T/M Pitch Actuator Position (deg)	-0.05	*
IU Pitch Actuator Position (deg)	-0.13	*
T/M Yaw Actuator Position (deg)	0.11	*
IU Yaw Actuator Position (deg)	0.16	*
IU Substitute 5 volt Power Supply (vdc)	5.03	*
Aft 5 volt Excitation Module (vdc)	5.00	*
Pitch Actuator Signal (ma)	0.05	*
Yaw Actuator Signal (ma)	0.05	*
Corrected T/M Pitch Actuator Position (deg)	-0.049	-0.517 to 0.517
Corrected IU Pitch Actuator Position (deg)	-0.083	-0.517 to 0.517
Corrected T/M Yaw Actuator Position (deg)	0.111	-0.517 to 0.517
Corrected IU Yaw Actuator Position (deg)	0.112	-0.517 to 0.517

*Limits Not Specified

4.2.31 Range Safety System (1B66568 C)

The automatic checkout of the range safety system verified the system external/internal power transfer capability; and the capability of the system to respond to the propellant dispersion inhibit and trigger commands, the engine cutoff command, and the system off command. The items involved in this test included the following:

Part Name	Reference Location	P/N	S/N
Range Safety Receiver 1	411A97A14	50M10697	118
Range Safety Receiver 2	411A97A18	50M10697	185
Secure Command Decoder 1	411A99A1	50M10698	46
Secure Command Decoder 2	411A99A2	50M10698	26
Secure Command Controller 1	411A97A13	1B33084-503	18
Secure Command Controller 2	411A97A19	1B33084-503	17
RS System 1 EBW Firing Unit	411A99A12	40M39515-119	452
RS System 2 EBW Firing Unit	411A99A20	40M39515-119	550
RS System 1 EBW Pulse Sensor	411A99A31*	40M02852	158
RS System 2 EBW Pulse Sensor	411A99A32*	40M02852	597
Safe and Arm Device	411A99A22*	1A02446-503	100
Directional Power Divider	411A97A56	1B38999-1	43
Hybrid Power Divider	411A97A34	1A74778-501	31
*Installed in Pulse Sensor Assembly	411A99A31/A32	1B29054-501	7

This procedure was initially accomplished by the second attempt on 20 December 1967, and was accepted on 27 December 1967. Some incorrect pulse sensor states that occurred during the first attempt were corrected for the second attempt. On 25 January 1968, the range safety system 2 decoder 411A99A2, P/N 50M10698, S/N 177, malfunctioned during the all systems test, H&CO 1B66571, and another decoder, S/N 26, was installed. (Reference FARR A271290, paragraph 4.2.33.) A second issue of this procedure was accomplished by the first attempt on 26 January 1968, to recheck the range safety system, and was accepted on 31 January 1968. Values measured during the second issue of the test are shown in Test Data Table 4.2.31.1.

Initial conditions were established for the test, and the GSE Model DSV-4B-136 destruct system test set, P/N 1A59952-1, was set up for closed loop operation at 450 MHz with a -50 dbm output level and a 60 kHz deviation. The forward bus 1 and bus 2 battery simulators were turned on, both receivers were verified to be OFF, and the battery simulator voltages were measured.

4.2.31 (Continued)

The external/internal power transfer test was then started. Both EBW firing units were verified to be OFF, and external power was turned on for both receivers and both firing units. The firing unit charging voltage indications and the firing unit indications were measured for both range safety systems. The propellant dispersion cutoff command inhibit was then turned on for both receivers. Both firing units were transferred to internal power, and the external power for the units was turned off. Both units were verified to be ON, and the charging voltage indications were measured. Both firing units were transferred back to external power and verified to be OFF, and the firing unit charging voltage indications were again measured. The external power for both receivers was turned off, and the receivers were verified to be OFF. The receivers were transferred to internal power and verified to be ON, then transferred back to external power and verified to be OFF. Finally, both receivers were transferred back to internal power and again verified to be ON.

The EBW firing unit arm and engine cutoff test was conducted next. The engine control bus power was turned on, the bus voltage was measured, and the low level signal strength indications were measured for both receivers. The EBW firing unit arm and engine cutoff command was turned on and verified to be received by range safety system 1. The system 1 firing unit charging voltage indication was measured. Verification was made that the engine cutoff indications were OFF at the umbilical and through the AO and BO telemetry multiplexers; that the non-programmed engine cutoff indication was OFF; and that the instrument unit receiver 1 arm and engine cutoff indication was OFF. The receiver 1 propellant dispersion cutoff command inhibit was then turned off, and the instrument unit receiver 2 arm and engine cutoff indication was verified to be OFF. Verification was made that the engine control bus power was then OFF; that the engine cutoff indications were still OFF at the umbilical and through both multiplexers; that the non-programmed engine cutoff indication was still OFF; and that the instrument unit receiver 1 arm and engine cutoff indication was then ON. The receiver 1 propellant dispersion cutoff command inhibit was turned back on, and the instrument

4.2.31 (Continued)

unit receiver 1 arm and engine cutoff indication was verified to again be OFF. The EBW firing unit arm and engine cutoff command was turned off. The engine control bus power was turned back on and the bus voltage was measured. Both firing units were transferred to external power and verified to be OFF, and the charging voltage indications were measured.

The EBW firing unit arm and engine cutoff command was turned back on and verified to be received by range safety system 2. The system 2 firing unit charging voltage indication was measured. Verification was made that the engine cutoff indications were OFF at the umbilical and through the AO and BO telemetry multiplexers; that the non-programmed engine cutoff indication was OFF; and that the instrument unit receiver 2 arm and engine cutoff indication was OFF. The receiver 2 propellant dispersion cutoff command inhibit was turned off, and the instrument unit receiver 1 arm and engine cutoff indication was verified to be OFF. Verification was made that the engine control bus power was still ON; that the engine cutoff indication was then ON at the umbilical and through both multiplexers; that the non-programmed engine cutoff indication was then ON; and that the instrument unit receiver 2 arm and engine cutoff indication was ON. The receiver 2 propellant dispersion cutoff command inhibit was turned back on, and the instrument unit receiver 2 arm and engine cutoff indication was verified to again be OFF. The EBW firing unit arm and engine cutoff command was turned off. The engine ready bypass was turned on, and the engine cutoff indication was verified to be OFF at the umbilical.

The EBW pulse sensor power and pulse sensor self test were turned on and both range safety pulse sensors were verified to be SET. The pulse sensor reset was turned on, and both pulse sensors were verified to be RESET. Each of the range safety systems was individually tested by the following steps, starting with system 1. The propellant dispersion command was turned on and verified to be received by the receiver under test. The appropriate firing unit charging voltage indication was measured, and the appropriate pulse sensor was verified

4.2.31 (Continued)

to be OFF. The propellant dispersion command was turned off, the propellant dispersion cutoff command inhibit for the receiver under test was turned off, and the propellant dispersion command was turned back on. For the system under test, the firing unit charging voltage indication was measured, and the pulse sensor was verified to be ON. The propellant dispersion cutoff command inhibit was then turned back on and the propellant dispersion command was turned off. The above steps were then repeated to test system 2. After the test of system 2, the propellant dispersion cutoff command inhibit was turned off for both receivers, and the engine control bus power was verified to be OFF.

The range safety system off test was conducted next. The range safety system off command was turned on, and power for receiver 1 and the system 1 EBW firing unit was verified to be OFF. The range safety system off command was turned off, receiver 2 was transferred to internal power, the range safety system off command was turned back on, and the power for receiver 2 and the system 2 EBW firing unit was verified to be OFF. The range safety system off command was then turned back off.

The safe and arm device was tested next. The safe-arm safe command was turned on, the safe indication was verified to be ON, and the arm indication was verified to be OFF. The safe-arm arm command was turned on, the safe indication was verified to be OFF, and the arm indication was verified to be ON. The safe-arm safe command was turned back on, and again the safe indication was verified to be ON, and the arm indication was verified to be OFF.

This completed the range safety system tests, and the shutdown operations were accomplished. The computer printout indicated that each of the two range safety receivers and two secure decoders had accumulated 1 minute 10.343 seconds of running time during the second issue of the procedure, each of the range safety EBW firing units had been cycled 1 time, and the switch selector had been used 1 time.

Engineering comments noted that there were no part shortages affecting either issue of the test. No significant problems were encountered during the test,

4.2.31 (Continued)

and no FARR's were written. One revision was made to the procedure affecting both issues, to delete a statement from the pulse sensor self test sub-routine, as it erroneously called for the execution of an unrequired command test.

4.2.31.1 Test Data Table, Range Safety System

Function	Measured Value (vdc)	Limits (vdc)
Forward Bus 1 Battery Simulator	28.639	28.0 ± 2.0
Forward Bus 2 Battery Simulator	28.438	28.0 ± 2.0
External/Internal Power Transfer Test		
External Power On		
System 1 Charging Voltage Indication	4.209	4.2 ± 0.3
System 1 Firing Unit Indication	4.204	4.2 ± 0.3
System 2 Charging Voltage Indication	4.265	4.2 ± 0.3
System 2 Firing Unit Indication	4.266	4.2 ± 0.3
Internal Power		
System 1 Charging Voltage Indication	4.215	4.2 ± 0.3
System 2 Charging Voltage Indication	4.270	4.2 ± 0.3
External Power Off		
System 1 Charging Voltage Indication	0.039	0.3 max
System 2 Charging Voltage Indication	0.039	0.3 max
Firing Unit Arm and Engine Cutoff Test		
Engine Control Bus Voltage	28.061	28.0 ± 2.0
Receiver 1 Signal Strength Indication	3.677	3.75 ± 1.25
Receiver 2 Signal Strength Indication	3.789	3.75 ± 1.25
System 1 Arm and Engine Cutoff Test		
Firing Unit Charging Voltage Indication	4.225	4.2 ± 0.3
Engine Control Bus Voltage	28.06	28.0 ± 2.0
External Power Off		
System 1 Charging Voltage Indication	0.050	0.3 max
System 2 Charging Voltage Indication	0.039	0.3 max
System 2 Arm and Engine Cutoff Test		
Firing Unit Charging Voltage Indication	4.274	4.2 ± 0.3

4.2.31.1 (Continued)

Function	Measured Value (vdc)	Limits (vdc)
Propellant Dispersion Test		
System 1 Propellant Dispersion Test		
Charging Voltage Indication (Pulse Sensor OFF)	4.225	4.2 ± 0.3
Charging Voltage Indication (Pulse Sensor ON)	1.534	3.0 max
System 2 Propellant Dispersion Test		
Charging Voltage Indication (Pulse Sensor OFF)	4.270	4.2 ± 0.3
Charging Voltage Indication (Pulse Sensor ON)	1.479	3.0 max

4.2.32 Propulsion System Test (1B66572 C)

This automatic procedure performed the integrated electromechanical functional tests of the stage propulsion system. The procedure was divided into three sections, each of which was performed separately. The first section of the test checked the ambient helium system, and included functional checks of the pneumatic control system, the LOX and LH_2 tank repressurization systems, and various pressure switches. The second section of the test performed functional checks on the LOX and LH_2 tank pressurization systems. The third section of the test was a four part check of the J-2 engine system, including individual testing of the engine functions and a combined automatic check of engine operation. Initiated on 3 January 1968, the procedure was completed on 12 January 1968, after 8 days of activity, and was accepted on 31 January 1968. The sections of the procedure are presented in order. Measurements made during the procedure are shown in Test Data Table 4.2.32.1.

Section 1, the ambient helium system test, was completed on the first attempt; however, due to malfunctions encountered certain segments of the test were repeated. An indication of the LOX prevalve closed position was not received, nor did the LH_2 ground overpressurization pressure switch pick up. The LOX prevalve closed position malfunction was caused by a defective switch in the valve. The valve condition was noted on IIS 378231, with a recap on FARR A271281, which removed the valve, P/N 1A49968-509, S/N 124, and replaced it with S/N 146.

4.2.32 (Continued)

Segments 4 and 5 were rerun to check out the replacement valve. Malfunction of the LH_2 ground overpressurization pressure switch was caused by excessive leakage at a quick-disconnect. The leak at the quick-disconnect was repaired, the program backed up, and successfully rerun. A rerun of segment 3 was required by revision 29 of the area control document, 1B67506, and by revision 21 of this test procedure. It was necessary to repeat the timing check of the LOX fill and drain valve, which was removed and replaced during the operation of the propellant tank leak check procedure, reference paragraph 4.2.29.

Measurements through the AO and BO telemetry multiplexers verified that the ambient helium pneumatic control sphere and the LH_2 and LOX tank repressurization spheres were all pressurized to 700 $\pm$50 psia, and the control helium regulator discharge pressure was verified to be 515 $\pm$50 psia. A series of checks then verified the proper operation of the ambient helium sphere dump valve, the control helium supply shutoff valve, and the engine pump purge control valve. The LOX chilldown pump purge control module, dump valve, and control valve were verified to operate properly, and the operation of the LOX chilldown pump purge pressure switch was verified by measurements made three times, as shown in the Test Data Table. The LH_2 and LOX repressurization control modules, dump valves, and control valves were then verified to operate properly.

A series of checks then verified the proper operation of the flight control pressure switches, the repressurization interlock functions, the O_2H_2 burner propellant valves, spark system, and voting circuits, and the repressurization control valves. The operation of the engine pump purge pressure switch and control valve was verified, as was the operation of the control helium regulator backup pressure switch and the control helium shutoff valve. Measurements were made three times on each of the pressure switches, as shown in the Test Data Table.

The ambient helium spheres were then repressurized, the control helium sphere pressure was measured as 712.31 psia, and the control helium regulator discharge pressure was measured as 517.70 psia, within the 515.0 $\pm$50.0 psia limits. A series of checks then verified the operation of the pneumatically

4.2.32 (Continued)

controlled LH_2 and LOX vent valves, fill and drain valves, prevalves, and childdown shutoff valves; the LH_2 directional vent valve; the LH_2 continuous vent and relief override valve and orifice bypass valve; and the O_2H_2 burner LH_2 and LOX propellant valve and LOX shutdown valve. Operating times for the various valves were measured as shown in the Test Data Table. Switch selector control of the valves was also verified. This completed the first section of the procedure.

Section 2, the pressurization systems check, was completed; however, there were several malfunctions. The malfunctions were corrected by opening tolerances, correcting program errors, and, after a manual check of the pressure switches to verify their proper operation, writing variation revisions to the procedure. To automatically check out the pressure switches segment 3 was rerun per revision 17.

The cold helium sphere pressure was measured at 823.89, within the 825 $\pm$25 psia limits, as measured through both telemetry multiplexers, and the cold helium dump valve and shutoff valve were verified to operate properly. The operation of the cold helium regulator backup pressure switch was verified by making measurements three times, as shown in the Test Data Table, and by verifying that the switch properly controlled the cold helium shutoff valve. The LOX and LH_2 repressurization control valves were verified to operate properly, and the operation of the LOX and LH_2 tank repressurization backup pressure switch interlocks was verified by making measurements three times, as shown in the Test Data Table, and by verifying that the switches properly controlled the LOX and LH_2 repressurization control valves.

The proper operation of the O_2H_2 burner spark ignition system was then verified. The LOX tank pressure switches, the cold helium shutoff valve, and the cold helium heat exchanger bypass valve were all verified to operate properly, with measurements made three times on the LOX tank ground fill pressure switch, as shown in the Test Data Table. The proper operation of the cold helium regulator was then verified by determining that the regulator output pressure dropped from 407.92 psia to 358.27 psia, above the 358 psia minimum limit, while the cold helium spheres pressure dropped from 804.80 psia to 682.59 psia with test orifice S0772C12-240 installed in the test

4.2.32 (Continued)

adapter. However, the regulator output pressure began printing an out-of-tolerance note although the cold helium spheres pressure was at 682.59 psia. Test orifice S0772C12-204 was installed in the test orifice and the test was recycled. The cold helium regulator pressure, during this test, dropped from 420.48 psia to 389.92 psia, within the 358 psia minimum limit, while the cold helium spheres pressure dropped from 804.80 psia to 621.48 psia.

The proper operation of the LH_2 tank pressurization system step pressure valve and bypass control valve was verified; the LH_2 flight control and ground fill pressure switches were verified to operate properly by measurements made three times, as shown in the Test Data Table; and the proper control of the step pressure valve and repressurization control valve by the pressure switches was verified. The cold helium spheres were then vented and a final series of checks verified the proper operation of the O_2H_2 burner voting circuit, temperature sensors, and repressurization control valves with the cold helium spheres at ambient pressure.

Section 3, the J-2 engine check, was completed on the first run; however, a rerun per revision 8, of segments 4 and 5, was made to incorporate measurements of the gas generator valve plateau and more precisely measure the main LOX valve first ramp end points.

The LH_2 and LOX vent valves were opened to vent the propellant tanks to ambient pressure. The O_2H_2 burner spark systems 1 and 2, the emergency detection systems 1 and 2 engine cutoffs, the repressurization control valves, and the O_2H_2 burner propellant valves were all verified to operate properly. The LH_2 and LOX prevalves and chilldown shutoff valves were then closed. A series of checks then verified that the engine spark ignition systems, 1 and 2, properly caused thrust chamber and gas generator sparks.

The engine start tank was pressurized, the proper operation of the start tank vent valve was verified, and the start tank was vented back to ambient pressure. For an engine cutoff test the engine ready signal was verified to be on, it was verified that the simulated mainstage OK signal opened the LH_2 and LOX prevalves, that the switch selector engine cutoff signal operated properly and closed the prevalves, and that removing the cutoff signal reopened the prevalves. The proper operation of the switch selector engine start and LH_2

4.2.32 (Continued)

injector temperature detector bypass commands was verified, and the engine ignition timer was measured as shown in the Test Data Table.

The next series of checks verified that the aft separation simulation 1 and 2 signals individually inhibited the engine start, and then verified the proper operation of the LH_2 injector temperature detector bypass, the start tank discharge control indication, the ignition detected indication, and the helium control solenoid valve. During these checks, measurements were made of the helium delay timer, the sparks de-energized timer, and the start tank discharge timer, as shown in the Test Data Table.

A series of checks next verified the proper operation of the mainstage OK pressure switches 1 and 2, with measurements made three times as shown in the Test Data Table, and verified that the pickup of either switch turned off the engine thrust OK 1 and 2 indications, and that, after a dry engine start sequence, the pick up of either switch would maintain the engine in mainstage. It was also verified that the dropout of both pressure switches turned on the engine thrust OK indications and caused engine cutoff.

The helium control sphere was pressurized to 1464.531 psia, meeting the 1450 psia minimum limit, for the engine solenoid valve component checks. A series of checks then verified that opening and closing the helium control solenoid valve caused the LH_2 and LOX bleed valves to close and open; that opening and closing the ignition phase control solenoid valve caused the engine augmented spark ignitor (ASI) LOX valve and the engine main LH_2 valve to open and close; that the start tank discharge solenoid valve opened and closed properly; and that opening and closing the mainstage control solenoid valve caused the gas generator valve and main LOX valve to open and close, and the LOX turbine bypass valve to close and open. During these checks, valve position measurements were made as shown in the Test Data Table, and the engine regulator outlet pressure was measured as 423.84 psia through both multiplexers, when the helium control solenoid valve was opened.

For the final engine sequence check, the entire engine system was verified to be ready for the check, and a completely automatic repetition of the previous engine system checks was accomplished by giving the necessary commands to

4.2.32 (Continued)

cause engine start and cutoff. Throughout the automatic sequence, the system responses were verified to be within predetermined limits. Various operating times were measured during the sequence, as shown in the Test Data Table, to verify the proper operation of the system component items. Also, the engine regulator outlet pressure was measured as 421.52 psia at the time of engine start.

Engineering comments noted that there were three transducers, P/N NA5-26323T6, not installed for measurements C1, C2, and C215. However, IUM transducers, P/N NA5-27323T3, were installed for test purposes. The flight parts will be installed prior to static firing at STC. The various problems encountered during the test and the corrective action taken to resolve them were also noted, as mentioned under the individual section narrations.

Twenty-three revisions were made to the procedure for the following:

a. One revision added the ignition system exciter, P/N 1B59986, to the Time Significant Item list to correct a procedure omission.

b. One variation revision connected a 0 to 1000 psi gauge to the adapter on the LOX pressurization line to monitor the orifice inlet during the flow test.

c. One variation revision disable SIM channel 41 at steps 2103771 and 2204214, and enabled it at steps 2104102 and 2204273 to prevent a SIM interrupt on aft bus 1 by the O_2H_2 burner spark system.

d. One revision changed the test orifice installed in the test adapter from S0772C12-224 to S0772C12-240 to comply with the test orifice diameter change.

e. One variation revision turned off the aft bus 1 power supply at one step and turned it on at a later step, in order to prevent voltage transients on aft bus 1, caused by O_2H_2 burner spark system, from damaging the engine control package.

f. One variation revision changed the gas generator valve plateau measurement tolerance from 0.040 psia to 0.050 psia.

g. One variation revision changed the tolerances for the main LOX valve, in order to more precisely define the end points.

h. One variation revision set forth the requirements for a repeat at the J-2 engine sequence of section 3 to incorporate revisions 6 and 7.

i. One revision corrected a program error.

4.2.32 (Continued)

j. One revision accepted the oscillograph trace of the start tank discharge valve timing rather than the computer printout, because the computer printout was in error, although the valve timing was correct.

k. One variation revision provided for a rerun of segments four and five of section 1 to time the new LOX prevalve that was installed.

l. One revision deleted a variation revision, which had deleted another revision (revision c above) and attempted to prevent system transients from causing a shift to back up supply voltage during the O_2H_2 burner spark test. The method in the variation revision did not provide a sufficient load on the batteries to prevent an interrupt.

m. One revision changed the upper tolerance for the cold helium sphere pressure from 625 psia to 690 psia, because the regulator operation required a higher pressure to allow for pressure drop to LOX pressurization module inlet.

n. One revision increased the delay time tolerance of the O_2H_2 burner spark exciter monitor from 70 milliseconds to 100 milliseconds, because it was too marginal.

o. One variation revision provided instructions to manually verify the LH_2 pressure switches, because the computer was not able to measure the pressure because of GSE configuration.

p. One variation revision repeated segment three of section 2 to recheck the O_2H_2 burner voter regulator module.

q. One revision added a 100 millisecond time delay to allow regulator voter circuit response.

r. One revision added a 2 second delay to allow the LOX repressurization pressure switch to change state after the switch selector command.

s. One variation revision deleted the steps for the automatic separation of the LH_2 system pressure switch supply pressure and directed that the manual pickup and dropout data from revision 15 be used. This was necessary because the GSE configuration prevented an accurate measurement.

t. One variation revision reran segments three and five of section 1 to check the timing of the new LOX fill and drain valve installation.

u. One variation revision deleted the LH_2 pressure switch pickup and deadband measurements from the segment three, section 1 rerun (reference t above).

v. One revision deleted several steps that were substituted by another revision.

4.2.32.1 Test Data Table, Propulsion System Test

Section 1, Ambient Helium Test

Pressure Switch Checks

Function	Measured Value Test 1	Test 2	Test 3	Limits
LOX Chilldown Pump Purge Pressure Switch				
Pressurization Time (sec)	67.406	46.083	49.113	300.0 max
Pickup Pressure (psia)	40.17	39.91	39.91	41.5 max
Depressurization Time (sec)	26.268	12.827	12.112	180.0 max
Dropout Pressure (psia)	38.96	39.07	39.12	37.5 min
Deadband (psi)	1.21	0.84	0.79	0.3 min
Repress System Interlocks				
LOX Repress Helium Sphere Press (psia)	645.0			
Burner Spark No. 1 On OK (vdc)	2.98			2.7 min.
Burner Spark No. 2 On OK (vdc)	3.03			2.7 min.
Engine Pump Purge Pressure Switch				
Pickup Pressure (psia)	119.93	118.37	118.37	136.0 max
Dropout Pressure (psia)	107.47	108.25	109.03	99.0 min
Deadband (psi)	12.46	10.13	9.35	3.0 min
Control Helium Regulator Backup Pressure Switch				
Pressurization Time (sec)	17.909	17.047	17.518	180.0 max
Pickup Pressure (psia)	605.234	601.328	602.109	600.0 ±21.0
Depressurization Time (sec)	3.874	3.918	3.867	180.0 max
Dropout Pressure (psia)	499.30	498.50	498.50	490.0 ±31.0

Pneumatically Controlled Valve Checks

Valve	Operating Times (sec) Open	Total Open	Close	Total Close	Boost Close	Total Boost Cl.
LH_2 Vent Valve	0.021	0.077	0.230	0.475	0.084	0.228
LOX Vent Valve	0.027	0.082	0.145	0.412	0.080	0.271
LOX Fill and Drain Valve	0.154	0.263	0.740	2.343	0.430	0.970
LH_2 Fill and Drain Valve	0.073	0.158	0.495	1.354	0.244	0.548
LOX Prevalve	1.264	1.878	0.254	0.396		
LH_2 Prevalve	1.266	1.904	0.253	0.397		
LOX C/D Shutoff Valve	0.115	0.855	0.016	0.130		
LH_2 C/D Shutoff Valve	0.193	0.825	0.030	0.138		
LH_2 Cont. Vent Orifice Bypass Valve	0.007	*	0.008	0.063		
Burner LH_2 Propellant Valve	0.040	0.143	0.047	0.137		
Burner LOX Propellant Valve	0.088	0.207	0.093	0.207		
Burner LOX Shutdown Valve	0.008	0.077	0.007	0.074		

*No value given

4.2.32.1 (Continued)

	Flight Pos.	Total Flight Pos.	Gnd Pos.	Total Gnd Pos.
LH_2 Directional Vent Valve	0.078	0.195	0.228	0.380

Section 2, Pressurization System Check

Pressure Switch Checks

Function	Measured Value Test 1	Test 2	Test 3	Limits
Cold Helium Regulator Backup Pressure Switch				
Pressurization Time (sec)	21.563	21.164	21.371	180.0 max
Pickup Pressure (psia)	472.805	472.805	472.805	467.5 $\pm$23.5
Depressurization Time (sec)	8.250	8.266	8.276	180.0 max
Dropout Pressure (psia)	372.0	371.0	371.0	362.5 $\pm$33.5
LOX Tank Repressurization Backup Pressure Switch				
Pressurization Time (sec)	20.647	20.210	20.268	180.0 max
Pickup Pressure (psia)	468.1	466.6	466.6	467.5 $\pm$23.5
Depressurization Time (sec)	8.069	8.075	8.051	180.0 max
Dropout Pressure (psia)	372.3	370.8	370.8	362.5 $\pm$33.5
LH_2 Tank Repressurization Backup Pressure Switch				
Pressurization Time (sec)	21.586	20.902	21.004	180.0 max
Pickup Pressure (psia)	472.8	471.3	472.0	467.5 $\pm$23.5
Depressurization Time (sec)	8.533	8.521	8.462	180.0 max
Dropout Pressure (psia)	366.1	369.2	367.6	362.5 $\pm$33.5
LOX Tank Ground Fill Pressure Switch				
Manifold Press Time (sec)	55.163	45.716	47.476	180.0 max
Pickup Pressure (psia)	40.27	40.27	40.17	41.0 max
Depressurization Time (sec)	18.538	15.674	15.177	180.0 max
Dropout Pressure (psia)	38.54	38.38	38.49	37.5 min
Deadband (psia)	1.73	1.89	1.68	0.5 min.
LH_2 Flight Control and Ground Fill Pressure Switches				
Manifold Press. Time (sec)	126.463	106.422	102.429	180.0 max
Manifold Depress. Time (sec)	83.144	93.522	91.90	180.0 max
Flight Control Pickup (psia)	30.2	30.2	30.2	31.5 max
Flight Control Dropout (psia)	28.2	28.2	28.2	27.8 min
Flight Control Deadband (psi)	2.0	2.0	2.2	0.5 min
Ground Fill Pickup (psia)	33.5	33.4	33.4	34.0 max
Ground Fill Dropout (psia)	31.3	31.3	31.3	30.8 min
Ground Fill Deadband (psi)	2.2	2.1	2.1	0.5 min

4.2.32.1 (Continued)

Pressure Switch Checks

Function	Measured Value Test 1	Test 2	Test 3	Limits
Burner Spark System Checks				
Exciter No. 1 On Indication (vdc)	2.88	-	-	2.7 min
Exciter No. 1 Off (Umb)(vdc)	1.00	-	-	2.0 max
Exciter No. 2 Off (Umb)(vdc)	0.92	-	-	2.0 max
Exciter No. 1 On OK (Umb)(vdc)	3.00	-	-	2.7 min
Exciter No. 2 On OK (Umb)(vdc)	3.07	-	-	2.7 min
Exciter No. 1 Ind On T/M M0074 (vdc)	3.31	-	-	2.7 min
Exciter No. 2 Ind On T/M M0073 (vdc)	3.32	-	-	2.7 min
Exciter No. 1 Off to T/M M00074 (vdc)	0.04	-	-	0.0 ± 0.2
Exciter No. 2 Off to T/M M0073 (vdc)	0.03	-	-	0.0 ± 0.2

Section 3, J-2 Engine Checks

Engine Timer Checks

Function	Delay Time (sec)	Limits (sec)
Engine Ignition Timer	0.449	0.450 ±0.030
Helium Delay Timer	0.985	1.000 ±0.110
Sparks De-Energized Timer	3.265	3.300 ±0.200
Start Tank Discharge Timer	1.006	1.000 ±0.040

Pressure Switch Checks

Function	Measured Value Test 1	Test 2	Test 3	Limits
Mainstage OK Pressure Switch 1				
Pickup Pressure (psia)	510.71	510.71	509.93	515.0 ±36.0
Dropout Pressure (psia)	430.09	430.09	431.65	PU-62.5 ±43.5
Mainstage OK Pressure Switch 2				
Pickup Pressure (psia)	523.44	521.88	521.88	515.0 ±36.0
Dropout Pressure (psia)	461.13	461.13	461.13	PU-62.5 ±43.5

4.2.32.1 (Continued)

Section 3 (Continued)

Valve Position Measurements

Function	Position (%)	Limit (%)
Main LH_2 Valve Closed	10.40	10 ±10
Main LH_2 Valve Open	90.40	90 ±10
Main LH_2 Valve Reclosed	10.30	Closed ±1
Start Tank Discharge Valve Closed	11.80	10 ±10
Start Tank Discharge Valve Open	89.00	90 ±10
Start Tank Discharge Valve Reclosed	11.90	Closed ±1
Gas Generator Valve Closed	12.40	10 ±10
Gas Generator Valve Open	89.10	*
Gas Generator Valve Plateau	50.49	65 max
Gas Generator Valve Reclosed	12.60	Closed ±1
Main LOX Valve Closed	8.70	10 ±10
Main LOX Valve 1st Ramp	21.90	*
Main LOX Valve T/M Open Indication	79.40	*
Main LOX Valve Open	89.80	90 ±10
Main LOX Valve Final Open	89.60	*
Main LOX Valve Open Difference, T/M to Final	10.20	*
Main LOX Valve Reclosed	8.90	Closed ±1
LOX Turbine Bypass Valve Open	89.90	90 ±10
LOX Turbine Bypass Valve Closed	10.20	10 ±10
LOX Turbine Bypass Valve Reopened	89.80	Open ±1

Engine Sequence Check

Function	Start Time (sec)	Oper. Time (sec)	Total Time (sec)
Engine Start			
Ignition Phase Solenoid Command Talkback	-	0.014	-
Control Helium Solenoid Command Talkback	-	0.021	-
ASI LOX Valve Open	-	0.049	-
Main LH_2 Valve Open	0.046	0.085	0.131
LOX Bleed Valve Closed	-	0.067	-
LH_2 Bleed Valve Closed	-	0.076	-
Start Tank Discharge Timer	-	1.006	-
Start Tank Discharge Valve Open	0.076	0.105	0.181
Mainstage Control Solenoid	-	1.455	-
Energize	-	1.455	-
Ignition Phase Timer	-	0.449	-
Start Tank Discharge Control Solenoid Off	-	0.007	-
Main LOX Valve 1st Stage (Ramp) Open	0.058	0.047	0.104
Gas Generator Valve LOX Poppet Open	0.139	0.053	0.191
Start Tank Discharge Valve Closed	0.129	0.279	0.408

*Limits not specified

4.2.32.1 (Continued)

Section 3 (Continued)

Function	Start Time (sec)	Oper. Time (sec)	Total Time (sec)
LOX Turbine Bypass Valve Closed	0.200	0.266	0.466
LOX Turbine Bypass Valve 80% Travel	-	0.434	-
Main LOX Valve 2nd Stage Open	0.648	1.841	2.489
Spark System Off Timer	-	3.299	-
Engine Cutoff			
Ignition Phase Control Solenoid Off	-	0.006	-
Mainstage Control Solenoid Off	-	0.032	-
ASI LOX Valve Closed	0.025	-	-
Main LOX Valve Closed	0.063	0.130	0.193
Main LH_2 Valve Closed	0.085	0.230	0.315
Gas Generator Valve Closed	0.073	0.252	0.325
Gas Generator Valve LOX Poppet Closed	-	0.021	-
LOX Turbine Bypass Valve Open	0.258	0.581	0.839
Helium Control Solenoid De-energize Timer	-	0.984	-
LOX Bleed Valve Open	8.917	-	-
LH_2 Bleed Valve Open	10.618	-	-

4.2.33 All Systems Test (1B66571 D)

After all individual system checkouts were completed, the all systems test demonstrated the combined operation of the stage electrical, hydraulic, propulsion, instrumentation, and telemetry systems under simulated flight conditions. Where practical, the checkout followed the actual flight sequence of prelaunch operations, simulated liftoff, ullage firing, engine start, hydraulic gimbaling, engine cutoff, coast period, engine restart and cutoff, attitude control, and stage shutdown. The procedure was conducted twice, once for the umbilicals-in test, and again for the umbilicals-out test. During the umbilicals-in test, the umbilical cables were left connected during the entire procedure, to permit monitoring of the umbilical talkbacks, and to provide complete stage control for trouble shooting and safing operations. During the umbilicals-out test, the umbilical cables were ejected at simulated liftoff, to verify the proper operation of all on-board systems with the umbilicals disconnected. After the completion of the all systems test, the umbilicals were reconnected, and the stage was shut down and completely reset to the proper condition for subsequent shipment to STC.

4.2.33 (Continued)

The all systems test was initiated on 19 January 1968, and was active for 4 days. The umbilicals-in part of the test was completed by the third attempt on 23 January 1968, the umbilicals-out part of the test was completed by the seventh attempt on 29 January 1968. The procedure was accepted following the test data review meetings held on 30 January and 1 February 1968.

The first and second attempts, made with the umbilicals in, were not acceptable because of numerous malfunctions caused by program errors, GSE and computer problems, and operator errors. After these problems were corrected, the third attempt was satisfactorily accomplished with the umbilicals in, although some out-of-tolerance conditions were noted, as discussed later. The fourth through the sixth attempts, made with the umbilicals out, were terminated because of problems with the GSE, the range safety No.2 decoder, and program problems. The seventh attempt was satisfactorily accomplished with the umbilicals out, although again there were some out-of-tolerance measurements as discussed later.

The various measurements made during the acceptable umbilicals-in and umbilicals -out tests are presented in Test Data Table 4.2.33.1. All of these measurements were acceptable and within design requirements, unless otherwise noted, although specific test limits were not defined by the procedure for some of the measurements.

Prior to starting the all systems automatic procedure, the GSE electrical systems and the stage propulsion system were manually set up, and the stage power setup procedure, H&CO 1B66560, was accomplished. Initial conditions were then established, and the stage power setup test was conducted. During this test, power was applied to the propellant utilization inverter and electronics, the EBW pulse sensors, the engine control and ignition buses, the APS buses, and aft bus 2, while various currents and voltages were measured. The EBW ullage rocket firing unit disable command, and the propellant dispersion cutoff command inhibit for both range safety receivers, were also turned on, and the common bulkhead pressure, LH_2 ullage pressure, and LOX ullage pressure were all verified to be greater than 5 psia. The proper operation of the switch selector was verified during the umbilicals-in test only.

4.2.33 (Continued)

The manual setup of the propulsion system was verified, the propulsion system initial conditions were established, and the various helium supply pressures were measured. The LOX chilldown pump purge and engine pump purge sequences were then accomplished.

The next series of prelaunch checks verified that the LOX and LH_2 vent valves and fill and drain valves opened properly on command, and that the LOX and LH_2 point level sensors, fast fill sensors, and overfill sensors all responded properly to simulated wet conditions. The simulated wet conditions were left on for all except the overfill sensors, to simulate loaded propellant tanks. The proper operation of the LOX and LH_2 chilldown shutoff valves, prevalves, and vent valves was verified, and the LOX and LH_2 tank prepressurization sequences were accomplished. The LH_2 pressure control module pressure was measured during the last sequence. The LOX and LH_2 fill and drain valves were then closed, the proper operation of the LH_2 directional vent valve was verified, and the valve was set to the ground position.

The EBW and telemetry prelaunch checks were conducted next. A pulse sensor self test verified the proper operation of the ullage rocket and range safety EBW firing unit pulse sensors. The PCM RF assembly was then turned on and the current was measured. During the umbilicals-in test only, a check verified that the telemetry RF silence command properly turned off the PCM RF assembly. During both tests, a telemetry calibration and a RACS calibration were then accomplished. The PCM FM transmitter RF power was measured as the telemetry antenna 1 forward power, the telemetry RF system reflected power was measured, and the telemetry system closed loop VSWR was determined. Measurements were also made of the static inverter-converter output voltages and operating frequency. During the umbilicals-in test only, the engine cutoff and the non-programmed engine cutoff indications were both verified to be OFF, while during the umbilicals-out test only, the engine cutoff command was turned on and only the non-programmed engine cutoff indication was verified to be OFF.

The hydraulic system prelaunch checks were conducted next. The pitch and yaw actuator locks were removed, the hydraulic reservoir gaseous nitrogen mass and corrected oil level were measured, and the hydraulic system functions were measured with the hydraulic system unpressurized. The auxiliary hydraulic

4.2.33 (Continued)

pump was then turned on to pressurize the system, the system pressure increase over a 4 second period was measured, and the hydraulic system functions were remeasured with the system pressurized.

The stage and GSE were then set for open loop telemetry operation by turning on the RF distribution system 2 and setting the PCM ground station for open loop reception. A flow rate and turbine speed (FRATS) calibration measured the reference indication voltages for the LOX and LH_2 circulation pump flowrates, the static inverter-converter frequency, and the LH_2 and LOX chilldown inverter frequencies, using a 400 Hz GSE calibration frequency during the umbilicals-in test and during the umbilicals-out test; for the LOX and LH_2 flowmeters, using a 100 Hz GSE calibration frequency; and for the LOX and LH_2 pump speeds, using a 1500 Hz GSE calibration frequency. The telemetry system forward and reflected RF powers were then measured, and the telemetry system open loop VSWR was determined. The LOX and LH_2 chilldown pumps were turned on, and the chilldown inverter currents were both verified to be 23 $\pm$5.0 amperes. Verification was made that the chilldown inverter voltages were acceptable as measured by the hardwire monitoring circuits, and the inverter operating frequencies were manually measured as 400 Hz each, meeting the 400 $\pm$4 Hz limits. The LH_2 and LOX chilldown inverter operating frequencies and output voltages were then measured by telemetry.

A series of measurements were then made of the common bulkhead pressure and the LH_2 ullage pressure, their 20 and 80 per cent calibration voltages and the ambient pressures after each calibration, the LOX ullage pressure, and the LH_2 and LOX emergency detection system pressures. The rate gyro was then turned on, and a RACS and telemetry calibration was performed.

The final prelaunch checks were then started. During the umbilicals-in test, the battery simulators were turned on, and measurements were made of the battery simulator voltages and the electrical support equipment load bank voltages. During the umbilicals-out test, the checkout batteries were turned on, and the checkout battery voltages were measured. The transducers for the common bulkhead pressure and the LH_2 and LOX ullage pressures were all turned off, and the transducer output voltages were measured. The LH_2 and LOX fast fill sensor simulated wet conditions were then turned off.

4.2.33 (Continued)

The forward and aft power buses were transferred to internal, and the bus voltages were measured. Both range safety receivers were transferred to internal power, and their low level signal strength indications were measured. The EBW ullage rocket firing unit disable command was turned off, the range safety system safe and arm device was set to the ARM condition, the DDAS antenna input was turned on, and the propellant dispersion cutoff command inhibit was turned off for both range safety receivers. It was verified that the open loop PCM RF signal was being received at the PCM and DDAS ground stations. The cold helium supply shutoff valve was opened. For the umbilicals-out test only, the external power was turned off for the talkback bus, the forward and aft power buses, and the range safety receivers and EBW firing units; the aft and forward umbilicals were ejected and visually verified to be disconnected, and the local sense indications were verified to be ON. For the umbilicals-in test only, the external powers were all left on, it was verified that the umbilicals remained connected, and the local sense indications were verified to be OFF. The emergency detection system ullage pressures were then measured for both tests. The prelaunch checks were completed with simulated liftoff.

Following the simulated liftoff, a telemetry calibration was accomplished, and the pre-separation checks were conducted. The two ullage rocket ignition EBW firing units were charged. The LH_2 and LOX prevalves were opened and reclosed, and the LH_2 chilldown pump was turned off. The fire ullage ignition command was turned on, and it was verified that the two ullage ignition EBW firing units responded properly and that the ullage ignition pulse sensors were ON. The aft separate simulation 1 and 2 signals were then turned on to simulate stage separation. During the above part of the umbilicals-in test only, additional checks verified that the ullage rocket firing unit disable command prevented the ignition EBW firing units from charging, and discharged the previously charged firing units while preventing them from firing.

APS roll and engine start checks were conducted following the simulated stage separation. The instrument unit (IU) substitute -28 volt power was turned on and measured. For the APS roll checks, attitude control nozzles I IV and III II were turned on and off, and attitude control nozzles I II and III IV were turned on and off, while the APS engine 1-1 1-3 and 2-1 2-3 valve open indications were measured for each condition. The LOX chilldown pump was then turned off, and the LH_2 and LOX chilldown shutoff valves were opened and reclosed. The engine start sequence was then accomplished, with the simulated ignition detected indication and the simulated mainstage OK indication turned on to simulate a satisfactory engine start. The two ullage rocket jettison EBW firing units were charged, the fire ullage jettison command was turned on, and it was verified that both ullage jettison firing units responded properly and that the ullage jettison pulse sensors were ON. During this part of the umbilicals-in test only, additional checks verified that the ullage rocket firing unit disable command prevented the jettison EBW firing units from charging, and discharged the previously charged firing units while preventing them from firing.

Following the engine start sequence, the hydraulic gimbal and propellant utilization valve slew checks were conducted, starting with the step response gimbal and LOX valve slew checks. The propellant utilization system ratio valve position and the hydraulic system pressure were both measured, and the LOX bridge 1/3 checkout relay was turned on. A series of step response gimbal checks were conducted for 0 to -3 degrees, -3 to 0 degrees, 0 to +3 degrees, and +3 to 0 degrees, in the pitch and yaw planes. As the results of these checks were compatible with the results of the same checks during the hydraulic system automatic checkout, H&CO 1B66570, (reference paragraph 4.2.22), the measured data is not repeated. Following the gimbal sequence, the propellant utilization system ratio valve position was again measured, and the LOX bridge 1/3 checkout relay was turned off. A 0.6 Hz gimbal and LH_2 propellant utilization valve slew check was conducted next. The propellant utilization system ratio valve position and the hydraulic pressure were measured, and the LH_2 bridge 1/3 checkout relay was turned on. A 0.5 degree gimbal signal, at 0.6 Hz, was applied in the pitch and yaw planes. The engine position command currents and resulting instrument unit actuator piston positions were found to be within the required limits throughout the cycling in both planes, for the umbilicals-in and umbilicals-out tests. At the completion of the gimbal sequences, the hydraulic actuator piston positions and the engine pitch and yaw positions were measured, and the hydraulic system functions were measured

4.2.33 (Continued)

with the hydraulic system pressurized. The propellant utilization system ratio valve position was measured, and the LH_2 bridge 1/3 checkout relay was turned off.

The first burn and coast period sequences were conducted next. During the first burn pressurization, the helium pressure of the LOX and LH_2 pressurization control modules were measured while the helium supply valves were temporarily open, and again after the pressure switch supplies were closed and the flight control pressure switches were verified to be OFF. The engine cut-off was then accomplished, the auxiliary hydraulic pump was set for coast mode operation, the LH_2 first burn relay was turned off, and the LH_2 pressurization control module helium pressure was again measured. The LOX chilldown pump purge was started, and the LOX pump motor container helium pressure was measured. The coast period command was turned on, the LOX flight pressurization system was turned off, and the engine pump purge was started. The simulated ignition detected and simulated mainstage OK indications were turned off to complete the first burn sequence.

The engine restart preparations were conducted next. The 70 pound ullage engine command 1 was turned on and off, the LH_2 continuous vent valves were opened, and the ullage engine command 2 was turned on and off. The engine pump purge was completed. The LH_2 boiloff bias signal voltage was measured, then remeasured with the propellant utilization boiloff bias cutoff turned on. The LH_2 continuous vent valves were then closed, and the LOX repressurization spheres and cold helium spheres pressures were measured.

The O_2H_2 burner spark excitation systems were verified to operate properly. The proper operation of the LOX and LH_2 repressurization control valves was verified, and the LOX and LH_2 tank cryogenic repressurization sequences were accomplished. The cold helium sphere pressure and the LOX repressurization spheres pressure were measured, and the LOX tank ambient repressurization sequence was accomplished. The LOX and LH_2 chilldown pumps were turned on, and the chilldown inverter voltages were measured. The LH_2 tank ambient repressurization sequence was then accomplished. With the propellant utilization valve hardover position command on, the ratio valve position was

4.2.33 (Continued)

verified to be less than -20 degrees. The LH_2 and LOX chilldown pumps were turned off, and the inverter operating frequencies and voltages were measured. The cold helium supply shutoff valves were then opened, completing the restart preparations.

The engine restart sequence was accomplished, with the simulated ignition detected indication and the simulated mainstage OK indication turned on to simulate a satisfactory engine restart. The cold helium supply shutoff valves were closed to complete the restart sequence. An LH_2 second burn repressurization sequence was accomplished, with the LH_2 pressurization control module helium pressure measured with the prepressurization supply open, and again after the pressure switch supply was closed. The engine cutoff was then accomplished, the simulated ignition detected indication was turned off, and the coast period command was turned on.

A series of checks verified that a dry condition of any one LOX or LH_2 point level sensor would not cause engine cutoff, but that a dry condition of any two LOX sensors or any two LH_2 sensors would cause engine cutoff. The sensors were checked by turning off the simulated wet conditions for the combinations of LOX and LH_2 sensors. During the umbilicals-in test only, the operating time of the LOX depletion engine cutoff timer was measured for each combination of LOX sensors.

The emergency detection system and range safety system tests were accomplished next. Verification was made that each of the emergency detection system 1 and 2 engine cutoff commands properly caused engine cutoff. A series of checks then verified that the range safety EBW firing unit arm and engine cutoff command properly charged the range safety firing units and caused engine cutoff, and that the range safety propellant dispersion command properly fired the range safety EBW firing units. During the umbilicals-in test only, additional checks verified that the range safety 1 and 2 receiver propellant dispersion cutoff command inhibits properly prevented engine cutoff and EBW firing unit operation. As a final range safety system test, it was verified that the range safety system off command properly turned off both range safety receivers.

4.2.33 (Continued)

A series of APS yaw and pitch attitude control checks were conducted next. The APS attitude control nozzles I IV and III IV were turned on and off while the APS engine 1-1 and 2-3 valve open indications were measured for each condition. Attitude control nozzles I II and III II were turned on and off while the engine 1-3 and 2-1 valve open indications were measured, and attitude control nozzles I P and III P were individually turned on and off while the engine 1-2 and 2-2 valve open indications were individually measured. After a final telemetry calibration, the stage shutdown was accomplished to complete the all systems test.

The computer printout showed that during the umbilicals-in test, the auxiliary hydraulic pump accumulated 2 cycles and 7 minutes 21.873 seconds of running time; the J-2 engine accumulated 1 cycle each in the pitch and yaw gimbal planes at 3 degrees amplitude; the range safety system running time was 31 minutes 41.870 seconds; each of the ullage and range safety EBW firing units was cycled 1 time; the propellant utilization LOX and LH_2 bridge potentiometers were each cycled 1 time; and the switch selector was used 162 times. During the umbilicals-out test, the auxiliary hydraulic pump accumulated 1 cycle and 28 minutes 29.643 seconds of running time; the J-2 engine accumulated 1 cycle each in the pitch and yaw gimbal planes at 3 degrees amplitude; the range safety system running time was 45 minutes 5.899 seconds; each of the ullage and range safety EBW firing units was cycled 1 time; the propellant utilization LOX and LH_2 bridge potentiometers were each cycled 1 time; and the switch selector was used 152 times.

Engineering comments noted that three temperature transducers, P/N NA5-27323T6, were not installed on the J-2 engine at the time of the all systems test. These transducers were for measurement C1, the fuel turbine inlet temperature; measurement C2, the oxidizer turbine inlet temperature; and measurement C215, the oxidizer turbine outlet temperature. Three interim use temperature transducers, P/N NA5-27323T3, were installed for these measurements. The flight use transducers are to be installed prior to stage acceptance firing at STC. It was also noted that the aft skirt helium burner feed duct, P/N 1B65206-503, was not installed at the start of testing, but that it was installed and tested on 25 January 1968.

4.2.33 (Continued)

Engineering comments further noted that:

a. Failure of the LH_2 system pressure switch supply pressure to rise to 32 psia in 240 seconds was caused by a small leak at the ground half of a quick disconnect. The source pressure was raised from 48 psia to (55 psia to compensate for the leak. A subsequent step (the GSE stage 7 pressure) was out-of-tolerance as a result of the increase in the supply pressure for the LH_2 system pressure switch. The stage 7 pressure was manually set and passed on retry. Also the LH_2 tank control valve enable indication did not come on within 30 seconds and was likewise corrected by raising the GSE stage 7 pressure.

b. A change by a revision of the LH_2 system pressure switch supply pressure from greater than 32 to greater than 30 was not used during the umbilicals-in run because the LH_2 repressurization control valves were closed by the pressure switch pickup in both cases.

c. Another change, by a revision, of the O_2H_2 burner spark exciter time delay from 1 second to 2 seconds was not made during the umbilicals-in run because the actual value used (1 second) was within the 2 second tolerance.

d. A SIM interrupt on the LH_2 system checkout supply greater than 60 psia was caused by a gradual build up of pressure over a relatively long period of time. The GSE stage (7) was reset and the test was resumed. The all systems test was not affected.

A review of the all systems telemetry data and digital events recorder output indicated several discrepancies that are included on FARR tags A271296 and A271292. To identify the cause of these problems, additional testing activities were started on 2 February and were completed on 14 February 1968. The results of these tests are:

A. Problems indicated by DER:

1. Measurement K96, start tank discharge valve, cycled several times out-of-sequence. This problem was caused by a malfunction of the engine control assembly (ECA) which allowed noise spikes to exist at random on K96 during engine ignition. The ECA was dispositioned by FARR A271292.

2. Measurement K8, engine ignition detector cycled several times out-of-sequence. This problem was caused by the K8 circuitry being triggered by noise spikes occurring on aft bus 1 during burner ignition. The noise spikes, as seen at that time on aft bus 1, were within acceptable limits.

4.2.33 (Continued)

3. The LOX fast fill sensor tripped when the LOX vent valve cycled closed. Noise spikes generated by the valve's positional switches were sufficient to cause the sensor controller to operate.
4. The LH_2 fast fill tripped when the range safety safe and arm device cycled.

B. Problems as determined by review of the telemetry data:

1. Measurement M60 experienced an RFI shift downward in excess of 2 per cent. An improvement of the measurement harness shielding is required to reduce this effect.
2. Measurement M25 experienced an out-of-tolerance shift during chilldown inverter operation. This problem was resolved as caused by common grounds between the measurement and the inverters.
3. Measurements D1 and D18 experienced chilldown inverter noise in excess of 2 per cent. This problem is covered on FARR A271296.

In addition to the RFI problem with M60, N18 and N55 (transmitter forward and reflected power), contain RFI in excess of 2 per cent. This has previously been reported on prior stages as an environmental problem which is eliminated upon staging.

A discrepancy concerned excess moisture content of the LOX Tank found during dew point tests (FARR A271227). The LOX Tank Ullage Pressure Lines, P/N 1B66720-1, P/N 1B63259-1 and P/N 1B66632-1 contained water. Corrective action required purging the LOX tank system through the tank ullage lines; replacement of transducers D179, D180, and D577; and replacement of pressure switch 403S8. The affected systems were tested in the appropriate subsystem tests.

The following FARR's were written during the all system tests:

a. FARR A271289 noted that the gas pressure regulator leaked at the auxiliary hydraulic pump, P/N 1A66241-511, S/N X458911. The O-rings for the gas pressure regulator were removed and replaced.
b. FARR A271290 rejected the range safety decoder, P/N 50M10698, S/N 0177, because of a suspected malfunction which indicated a 4.27 vdc charging voltage for the EBW firing unit. The decoder, S/N 0177, was removed and replaced by S/N 0026. Also the J1 connector had bent pins.
c. FARR A271291 rejected the connector P12, P/N STK06-445, on wire harness, P/N 1B56379-1, because of bent and missing pins. The defective connector was removed and replaced by a new connector.

4.2.33 (Continued)

d. FARR A271292 rejected the electrical control assembly, P/N 502670-51, S/N 4091614, because of unscheduled on and off cycles for measurements K8 and K96. The defective assembly, S/N 4091614, was removed.

There were forty-six revisions written against the procedure; however, two were voided. The remaining were:

a. One revision changed the LH_2 boiloff bias signal voltage from less than 4 vdc to less than 10 vdc to be consistent with actual value.

b. One revision changed the loop bandwith switch per cent position from 0.08 per cent to 0.005 per cent to reduce the possibility of the DDAS ground station going out of sync.

c. One revision changed the equation for the hydraulic reservoir oil temperature to permit the use of hotter oil before venting.

d. One revision changed the engine control bus voltage tolerance from 0 ± 3 vdc to 0 ± 2 vdc because the tolerance used in the DDAS is 2.0 volts.

e. To be consistent with the tolerance used in the APS substitute for the 28 vdc IU supply a revision changed the not equal voltage expected from 28 ± 3 vdc to -28.5 ± 2.5 vdc.

f. One revision deleted step F of paragraph 4.2 and added a substep (14) of step d of paragraph 4.2. The added step set the airborne tape unit test switch to disable at the CIU panel, because the switch was at the DDAS ground station -123 not the -118 panel.

g. One revision changed the location called out for the test stand select DDAS switch, the SDU input switch, and the attenuators from the DDAS ground station (-123) to the T/M frequency calibration unit (-128), because they are in the -128 not the -123.

h. One revision corrected the Ready-Off switch position nomenclature from transfer to Ready.

i. One revision changed a time delay from 200 milliseconds to 3 seconds to allow the propellant level sensor transistor power circuitry to stabilize before application of wet commands.

j. One variation revision, for the umbilicals-in only, set a break point at step 6012134 to permit turning off the aft 1 GSE power supply at the TOC. The O_2H_2 burner spark exciter test must be performed using the backup battery. The spark exciter firings apparently caused a voltage drop on the aft 1 sense line, for which the GSE power supply tried to compensate, thus the voltage on the bus goes higher than 31 volts. This could cause damage to the engine control package.

k. One variation revision reconnected the LOX chilldown pump purge module bypass pipe assembly, P/N 1B67710-1, to tee, in order to return the system to the flight configuration.

4.2.33 (Continued)

l. One revision disconnected the start tank fill supply flex hose from the aft umbilical disconnect part 4 to preclude pressurizing the start tank.

m. One variation revision added several steps to define propulsion system securing requirements.

n. One revision deleted a step turning on the GSE power supply because it was already on.

o. One variation revision deleted the requirement for the line printer to print out helium control solenoid cycles, because the present program does not have that capability.

p. Six revisions corrected program and procedure errors.

q. One revision deleted the requirement to reset SIM channel 22 during matrix reset as the GSE power supply was not off.

r. One revision added the telemetry system control console, P/N 1A65726-1, Model DSV-4B-232 as an optional end item.

s. One revision added a halt at step 6007621 to permit a review of a malfunction and to retest.

t. One variation revision deleted the GSE hardwire measurement of the childown inverter frequencies since the GSE period counter was not operational.

u. One variation revision (at halt step 6012320) was written for umbilicals-out only to remove the 28 volt command "switch selector checkout indication enable" from the umbilical before ejection.

v. One variation revision (at halt step 6012320) verified that the spark exciter units were pressurized before making burner spark checks.

w. One variation revision (step 6030730) executed stage power turn on to check bus currents before executing stage power turnoff, because stage power turnoff cannot check bus current.

x. One revision added a step to verify that the Remote-Local switch, on the instrumentation checkout unit, was set to Remote. The instrumentation checkout unit, P/N 1B28115, Model DSV-4B-279, was also added to the Mandatory End Item list.

y. One revision added a step to immediately set SIM channel 22 at halt step 6007724 if the auxiliary hydraulic pump does not come on during this fault routine.

z. One revision immediately set SIM channel 22 after step 6010105 and to reset it immediately after step 6010110. SIM channel 22 must be set after aft bus 2 is turned on and reset before aft bus 2 is turned off.

aa. Two revisions provided for resetting SIM channel 22 during turn on of the auxiliary hydraulic pump because of transient loading.

4.2.33 (Continued)

ab. One revision added instructions to:

1. Ensure that the O_2H_2 burner exciters were not on for more than 5 seconds and off for a minimum of 5 minutes between cycles.
2. Ensure that the engine control helium bottle pressure is either greater than 1400 psia or less than 100 psia before energizing the helium control solonoid.
3. Ensure that the engine helium control bottle pressure is less than 100 psia before de-energizing the helium control solenoid, except during the automatic sequence checks.

ac. One revision changed the LH_2 chilldown valve tolerances to account for the voltage drop in the GSE cables and the noise spikes present in the voltage monitoring circuits when not loaded by a multiplexer.

ad. One variation revision (umbilicals-in) provided instructions to use GSE power instead of battery power after the O_2H_2 burner spark test.

ae. One variation revision changed pressure tolerances of the LH_2 pressure switch checkout system to make it compatible with the pickup value of the stage LH_2 flight control pressure switch.

af. One revision added a 10 second time delay to allow the LH_2 boiloff bias signal voltage to build up and to be consistent with the PU automatic procedure.

ag. One revision (umbilicals-in) added delays to allow the stage bus talkbacks to go off after turning off the buses.

ah. One revision changed the bus at which the chilldown system was measured from bus 4D11 to bus 4D10, because bus 4D11 could not be measured during umbilicals-out.

ai. One revision deleted the use of the PCM ground station RF switch since it was not in use.

aj. One revision (umbilicals-out) added, "halt, reset stage repress system mode select" to correct a procedure omission.

ak. One variation revision (umbilicals-out) increased the GSE stage 7 pressure tolerance 2 psia to compensate for a small leak in the ground half of a disconnect.

al. One variation revision (umbilicals-in) deleted the step, "If T/M RF group transfer ground monitor command is reset, go to F315," because the isolator card was no good. The isolator card was replaced before umbilicals-out was run.

am. One variation revision increased the LOX chilldown pump simulator amps from 20 ± 5 to 23 ± 5 amps in order to ensure a nominal steady current of 20 amps.

4.2.33.1 Test Data Table, All Systems Test

Function	Umbil.-In	Umbil.-Out	Limits
Power Setup			
PU Inv and Elect. Current (amps)	3.1	4.0	5.0 max
Aft Bus 1 Current (Eng Cont Bus On) (amps)	1.80	1.90	2.7 $\pm$3.0
Engine Control Bus Voltage (vdc)	28.20	28.16	28.0 $\pm$2.0
Aft Bus 1 Current (Eng Ign Bus On) (amps)	2.00	2.10	2.7 $\pm$3.0
Aft Bus 1 Voltage (vdc)	28.20	28.24	28.0 $\pm$2.0
Engine Ignition Bus Voltage (vdc)	27.84	27.81	Bus 1 $\pm$1.0
Aft Bus 1 Current (APS Bus On) (amps)	2.60	2.70	2.7 $\pm$3.0
Aft Bus 2 Current (amps)	0.20	0.80	5.0 max
Aft Bus 2 Voltage (vdc)	56.72	56.96	56.0 $\pm$4.0
Propulsion System Setup			
Amb He Pneu Sphere Press. D236 (psia)	723.53	723.53	700.0 $\pm$50.0
Cold Helium Sphere Press. D016 (psia)	827.70	812.44	825.0 $\pm$25.0
Eng Cont He Supply Press. D019 (psia)	1514.78	1550.72	900.0 min
Cont He Reg Discharge Press. D014 (psia)	520.55	517.00	515.0 $\pm$50.0
LH_2 Repress. He Sphere Press. D020 (psia)	652.48	630.05	*
LOX Repress. He Sphere Press. D088 (psia)	753.45	753.45	*
LH_2 Prepressurization Sequence			
LH_2 Press. Control Module GH_2 Press. D104 (psia)	65.19	†16.09	50.0 min
EBW and Telemetry Checks			
PCM RF Assembly Current (amps)	3.900	4.101	4.5 $\pm$3.0
T/M Antenna 1 Forward Power (watts)	24.299	24.745	21.75 $\pm$6.75
T/M RF System Reflected Power (watts)	0.283	0.303	3.08 max
Telemetry System Closed Loop VSWR	1.241	1.248	2.0 max
Inv-Conv 115 vac Output (vac)	114.92	115.11	115.0 $\pm$3.45
Inv-Conv 5 vdc Output (vdc)	4.96	4.98	4.8 $\pm$0.3
Inv-Conv 21 vdc Output (vdc)	21.71	21.79	21.25 $\pm$1.25
Inv-Conv Operating Frequency (Hz)	400.01	400.52	400.0 $\pm$6.0

*Limits Not Specified

†Ambient reading due to quick-disconnect leakage (see Engineering comments a.)

4.2.33.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
Hydraulic System Checks			
Reservoir GN_2 Mass (lbs)	1.924	1.915	1.925 ±0.2
Corrected Reservoir Oil Level (%)	98.4	98.8	95.0 min
Hydraulic System Unpressurized			
Hydraulic System Pressure (psia)	1372.31	1372.31	*
Accumulator GN_2 Pressure (psia)	2375.56	2291.00	*
Accumulator GN_2 Temperature (°F)	73.70	56.89	*
Reservoir Oil Temperature (°F)	75.76	63.14	*
Reservoir Oil Level (%)	88.95	87.83	*
Reservoir Oil Pressure (psia)	77.25	75.06	*
Pump Inlet Oil Temperature (°F)	73.32	59.63	*
T/M Yaw Actuator Position (deg)	1.33	1.40	*
Corrected T/M Yaw Act. Pos (deg)	1.326	1.380	*
IU Yaw Actuator Position (deg)	1.42	1.45	*
Corrected IU Yaw Act. Pos (deg)	1.381	1.385	*
T/M Pitch Actuator Position (deg)	0.03	0.08	*
Corrected T/M Pitch Act. Pos (deg)	0.036	0.091	*
IU Pitch Actuator Position (deg)	-0.01	0.03	*
Corrected IU Pitch Act. Pos (deg)	0.022	0.087	*
IU Substitute 5v Power Supply (vdc)	5.02	5.04	*
Aft 5v Excitation Module (vdc)	5.00	5.01	*
Aft Bus 2 Current (amps)	0.00	0.20	*
Hydraulic System Pressurized			
Hyd System 4 Second Press. Change (psia)	275.0	297.9	200.0 min
Hydraulic System Pressure (psia)	3598.06	3601.38	*
Accumulator GN_2 Pressure (psia)	3578.44	3575.75	*
Accumulator GN_2 Temperature (°F)	94.11	81.54	*
Reservoir Oil Temperature (°F)	75.67	62.75	*
Reservoir Oil Level (%)	40.39	36.03	*
Reservoir Oil Pressure (psia)	167.15	166.71	*
Pump Inlet Oil Temperature (°F)	74.88	63.54	*
T/M Yaw Actuator Position (deg)	0.08	0.14	*
Corrected T/M Yaw Act. Pos (deg)	0.072	0.143	*
IU Yaw Actuator Position (deg)	0.13	0.13	*
Corrected IU Yaw Act. Pos (deg)	0.075	0.112	*
T/M Pitch Actuator Position (deg)	-0.05	-0.14	*
Corrected T/M Pitch Act. Pos (deg)	-0.041	-0.143	*
IU Pitch Actuator Position (deg)	-0.12	-0.09	*
Corrected IU Pitch Act. Pos (deg)	-0.060	-0.066	*
IU Substitute 5v Power Supply (vdc)	5.04	5.01	*
Aft 5v Excitation Module (vdc)	5.00	5.00	*
Aft Bus 2 Current (amps)	44.00	43.00	*

*Limits Not Specified

4.2.33.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
FRATS Calibration			
LOX Circ Pump Flowrate Ind (vdc)	3.866	-	3.890 $\pm$0.100
	-	3.851	3.893 $\pm$0.100
LH_2 Circ Pump Flowrate Ind (vdc)	3.855	-	3.890 $\pm$0.100
	-	3.851	3.893 $\pm$0.100
Static Inv-Conv Freq Ind (vdc)	2.718	-	2.675 $\pm$0.100
	-	2.677	2.649 $\pm$0.100
LH_2 C/D Inv Freq Ind (vdc)	2.646	-	2.675 $\pm$0.100
	-	2.615	2.649 $\pm$0.100
LOX C/D Inv Freq Ind (vdc)	2.687	-	2.675 $\pm$0.100
	-	2.656	2.649 $\pm$0.100
LOX Flowmeter Indication (vdc)	1.702	1.697	1.667 $\pm$0.100
LH_2 Flowmeter Indication (vdc)	1.687	1.682	1.667 $\pm$0.100
LOX Pump Speed Indication (vdc)	3.174	3.164	3.125 $\pm$0.100
LH_2 Pump Speed Indication (vdc)	1.287	1.287	1.250 $\pm$0.100
Telemetry RF Checks			
T/M Antenna 1 Forward Power (watts)	26.262	26.381	21.75 $\pm$6.75
T/M RF System Reflected Power (watts)	0.126	1.816	3.08 max
Telemetry System Open Loop VSWR	1.148	1.711	3.0 max
Chilldown Inverter Telemetry Checks			
LH_2 C/D Inv Frequency (Hz)	400.1	400.6	400.0 $\pm$4.0
LH_2 C/D Inv Phase AB Volt. (vac)	55.4	54.6	*
LH_2 C/D Inv Phase AC Volt. (vac)	55.4	54.5	*
LOX C/D Inv Frequency (Hz)	399.7	400.1	400.0 $\pm$4.0
LOX C/D Inv Phase AB Volt. (vac)	55.2	54.3	*
LOX C/D Inv Phase AC Volt. (vac)	55.2	54.3	*
Pressure Measurements			
Common Bulkhead Pressure (psia)	14.813	14.418	14.7 +2.0, -15.5
Common Bulkhead 20% Calib (vdc)	1.029	1.015	1.0 $\pm$1.0
Common Bulkhead Amb Press. (psia)	14.866	14.286	14.7 $\pm$0.5
Common Bulkhead 80% Calib (vdc)	4.024	4.010	4.0 $\pm$0.1
Common Bulkhead Amb Press. (psia)	14.813	14.418	14.7 $\pm$0.5
LH_2 Ullage Pressure (psia)	14.727	14.727	14.7 +4.8, -1.0
LH_2 Ullage 20% Calib (vdc)	1.029	1.034	1.0 +0.3, -0.1
LH_2 Ullage Amb Press. (psia)	14.727	14.885	14.7 $\pm$0.5
LH_2 Ullage 80% Calib (vdc)	4.024	4.024	4.0 $\pm$0.1
LH_2 Ullage Amb Press. (psia)	14.727	14.832	14.7 $\pm$0.5
LOX Ullage Pressure (psia)	14.502	14.714	14.7 $\pm$1.0

*Limits Not Specified

4.2.33.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
LH_2 EDS Transducer 1 Press. (psia)	15.1	15.1	14.7 ±1.0
LH_2 EDS Transducer 2 Press. (psia)	14.8	14.4	14.7 ±1.0
LOX EDS Transducer 1 Press. (psia)	14.8	14.7	14.7 ±1.0
LOX EDS Transducer 2 Press. (psia)	15.2	15.1	14.7 ±1.0
Final Prelaunch Checks			
Fwd Bus 1 Batt. Sim. (Bus 4D30) (vdc)	28.24	**	28.0 ±2.0
Fwd Bus 2 Batt. Sim. (Bus 4D20) (vdc)	28.24	**	28.0 ±2.0
Aft Bus 1 Batt. Sim. (Bus 4D10) (vdc)	28.28	**	28.0 ±2.0
Aft Bus 2 Batt. Sim. (Bus 4D40) (vdc)	56.00	**	56.0 ±4.0
Bus 4D20 ESE Load Bank (vdc)	-0.04	**	0.0 ±1.0
Bus 4D40 ESE Load Bank (vdc)	0.00	**	0.0 ±1.0
Bus 4D30 ESE Load Bank (vdc)	0.00	**	0.0 ±1.0
Bus 4D10 ESE Load Bank (vdc)	0.00	**	0.0 ±1.0
Fwd Bus 1 C/O Batt. (Bus 4D30) (vdc)	**	30.20	30.0 ±2.0
Fwd Bus 2 C/O Batt. (Bus 4D20) (vdc)	**	30.44	30.0 ±2.0
Aft Bus 1 C/O Batt. (Bus 4D10) (vdc)	**	30.00	30.0 ±2.0
Aft Bus 2 C/O Batt. (Bus 4D40) (vdc)	**	62.08	60.0 ±4.0
Common Bulkhead Press. Transducer (vdc)	-0.020	0.005	0.0 ±0.353
LH_2 Ullage Press. Transducer (vdc)	0.000	0.000	0.0 ±0.353
LOX Ullage Press. Transducer (vdc)	0.119	0.104	0.0 ±0.353
Fwd Bus 1 Internal (Bus 4D31) (vdc)	27.80	29.92	28.0 ±2.0
Fwd Bus 2 Internal (Bus 4D21) (vdc)	27.72	29.44	28.0 ±2.0
Aft Bus 1 Internal (Bus 4D11) (vdc)	29.04	29.76	28.0 ±2.0
Aft Bus 2 Internal (Bus 4D41) (vdc)	55.52	58.00	56.0 ±4.0
Receiver 1 Low Level Signal (vdc)	3.63	3.68	2.5 min
Receiver 2 Low Level Signal (vdc)	3.51	3.65	2.5 min
LH_2 EDS 1 Ullage Pressure (psia)	14.97	14.72	14.7 ±1.0
LH_2 EDS 2 Ullage Pressure (psia)	14.63	14.51	14.7 ±1.0
LOX EDS 1 Ullage Pressure (psia)	14.60	14.72	14.7 ±1.0
LOX EDS 2 Ullage Pressure (psia)	15.23	15.11	14.7 ±1.0
APS Roll Checks			
IU Substitute -28 volt Power (vdc)	-29.199	-29.318	-28.0 ±2.0
Attitude Control Nozzles I IV and III II On			
Engine 1-1 1-3 Valve Open Ind (vdc)	4.199	4.354	4.3 ±0.250
Engine 2-1 2-3 Valve Open Ind (vdc)	4.117	4.281	4.1 ±0.250
Attitude Control Nozzles I IV and III II Off			
Engine 1-1 1-3 Valve Open Ind (vdc)	0.005	0.000	0.0 ±0.25
Engine 2-1 2-3 Valve Open Ind (vdc)	0.005	0.000	0.0 ±0.25
Attitude Control Nozzles I II and III IV On			
Engine 1-1 1-3 Valve Open Ind (vdc)	4.163	4.322	4.3 ±0.250
Engine 2-1 2-3 Valve Open Ind (vdc)	4.128	4.281	4.1 ±0.250

**Measurement Not Applicable

4.2.33.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
Attitude Control Nozzles I II and III IV Off			
Engine 1-1 1-3 Valve Open Ind (vdc)	0.000	0.000	0.0 ±0.25
Engine 2-1 2-3 Valve Open Ind (vdc)	0.005	0.000	0.0 ±0.25
Hydraulic Gimbal Step Response Check			
Ratio Valve Pos. (Relay Off) (deg)	0.15	0.15	0.0 ±1.5
Hydraulic System Pressure (psia)	3595.0	3624.0	3500.0 min
Ratio Valve Pos. (Relay On) (deg)	32.94	32.87	20.0 min
Hydraulic Gimbal 0.6 Hz Check			
Ratio Valve Pos. (Relay Off) (deg)	1.37	1.24	0.0 ±1.5
Hydraulic System Pressure (psia)	3605.0	3624.0	3500.0 min
Pitch Act. Piston Pos., AO (deg)	-0.064	-0.018	0.0 ±0.517
Pitch Act. Piston Pos., BO (deg)	-0.033	-0.018	0.0 ±0.517
Yaw Act. Piston Position, AO (deg)	0.096	0.143	0.0 ±0.517
Yaw Act. Piston Position, BO (deg)	0.080	0.096	0.0 ±0.517
Engine Pitch Position, IU (deg)	-0.104	-0.104	0.0 ±0.517
Engine Yaw Position, IU (deg)	0.135	0.180	0.0 ±0.517
Hydraulic System Pressurized			
Hydraulic System Pressure (psia)	3607.94	3598.06	*
Accumulator GN_2 Pressure (psia)	3586.69	3586.69	*
Accumulator GN_2 Temperature (°F)	81.15	69.40	*
Reservoir Oil Temperature (°F)	88.21	119.30	*
Reservoir Oil Level (%)	38.65	38.03	*
Reservoir Oil Pressure (psia)	171.52	169.77	*
Pump Inlet Oil Temperature (°F)	103.94	129.18	*
T/M Yaw Actuator Position (deg)	0.10	0.14	*
Corrected T/M Yaw Act. Pos. (deg)	0.088	0.143	*
IU Yaw Actuator Position (deg)	0.15	0.16	*
Corrected IU Yaw Act. Pos. (deg)	0.098	0.112	*
T/M Pitch Actuator Position (deg)	-0.05	-0.03	*
Corrected T/M Pitch Act. Pos. (deg)	-0.041	-0.033	*
IU Pitch Actuator Position (deg)	-0.09	-0.09	*
Corrected IU Pitch Act. Pos. (deg)	-0.037	-0.037	*
IU Substitute 5v Power Supply (vdc)	5.03	5.03	*
Aft 5v Excitation Module (vdc)	5.00	5.00	*
Aft Bus 2 Current (amps)	42.40	**	*
Aft Checkout Battery 2 Current (amp)	**	45.20	*
Ratio Valve Pos. (Relay On) (deg)	-27.737	-27.737	-20.0 max

* Limits Not Specified
**Measurement Not Applicable

4.2.33.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
First Burn and Coast Period			
LOX Press. Module Helium Pressure D105:			
Cold Helium Supply Open (psia)	276.445	258.445	*
LOX Press. Sw. Supply Closed (psia)	155.344	143.887	*
LH_2 Press. Module Helium Pressure D104:			
LH_2 Prepress. Supply Open (psia)	129.57	120.84	*
LH_2 Press. Sw. Supply Closed (psia)	78.29	94.65	
LH_2 First Burn Relay Off (psia)	65.19	66.28	*
LOX Motor Container He Press D103 (psia)	43.70	43.70	*
Engine Restart Preparations			
LH_2 Boiloff Bias Signal M010:			
Bias Cutoff Off (vdc)	0.62	0.58	0.0 $\pm$2.5
Bias Cutoff On (vdc)	11.769	11.922	4.0 min
LOX Repress. Spheres, D088 (psia)	742.23	738.50	*
Cold Helium Spheres, D016 (psia)	655.86	621.48	*
Cold Helium Spheres, D016 (psia)	537.47	645.00	*
LOX Repress. Spheres, D088 (psia)	674.92	659.97	*
Chilldown Pumps On			
LOX C/D Inv Phase AB Volt. (vac)	52.2	55.4	50.0 min
LOX C/D Inv Phase AC Volt. (vac)	51.9	55.2	50.0 min
LOX C/D Inv Phase A1B1 Volt. (vac)	52.5	55.9	50.0 min
LOX C/D Inv Phase A1C1 Volt. (vac)	51.9	55.3	50.0 min
LH_2 C/D Inv Phase AB Volt. (vac)	51.7	54.3	50.0 min
LH_2 C/D Inv Phase AC Volt. (vac)	51.5	54.1	50.0 min
LH_2 C/D Inv Phase A1B1 Volt. (vac)	51.9	54.4	50.0 min
LH_2 C/D Inv Phase A1C1 Volt. (vac)	51.3	54.0	50.0 min
Chilldown Pumps Off			
LH_2 C/D Inv Frequency (Hz)	389.5	389.5	390.0 $\pm$1.0
LH_2 C/D Inv Phase AB Volt. (vac)	0.00	-0.07	0.0 $\pm$1.5
LH_2 C/D Inv Phase AC Volt. (vac)	0.13	-0.07	0.0 $\pm$1.5
LOX C/D Inv Frequency (Hz)	389.5	389.5	390.0 $\pm$1.0
LOX C/D Inv Phase AB Volt. (vac)	0.00	-0.07	0.0 $\pm$1.5
LOX C/D Inv Phase AC Volt. (vac)	0.00	-0.07	0.0 $\pm$1.5

*Limits Not Specified

4.2.33.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
LH2 Second Burn Repressurization			
LH2 Press. Module Helium Pressure D104:			
LH_2 Prepress. Supply Open (psia)	130.656	103.656	*
LH_2 Press. Sw. Supply Closed (psia)	78.285	94.648	*
LOX Depletion Timer Check			
LOX Sensors 1 and 2 Dry (sec)	0.542	**	0.560 $\pm$0.025
LOX Sensors 1 and 3 Dry (sec)	0.541	**	0.560 $\pm$0.025
LOX Sensors 2 and 3 Dry (sec)	0.537	**	0.560 $\pm$0.025
APS Yaw and Pitch Checks			
Attitude Control Nozzles I IV and III IV On			
Engine 1-1 Valve Open Ind (vdc)	4.25	4.32	4.3 $\pm$0.25
Engine 2-3 Valve Open Ind (vdc)	4.18	4.25	4.1 $\pm$0.25
Attitude Control Nozzles I IV and III IV Off			
Engine 1-1 Valve Open Ind (vdc)	0.00	0.00	0.0 $\pm$0.25
Engine 2-3 Valve Open Ind (vdc)	0.00	0.00	0.0 $\pm$0.25
Attitude Control Nozzles I II and III II On			
Engine 1-3 Valve Open Ind (vdc)	4.18	4.27	4.3 $\pm$0.25
Engine 2-1 Valve Open Ind (vdc)	4.15	4.24	4.1 $\pm$0.25
Attitude Control Nozzles I II and III II Off			
Engine 1-3 Valve Open Ind (vdc)	0.01	0.00	0.0 $\pm$0.25
Engine 2-1 Valve Open Ind (vdc)	0.00	0.00	0.0 $\pm$0.25
Attitude Control Nozzle I P On			
Engine 1-2 Valve Open Ind (vdc)	4.31	4.43	4.3 $\pm$0.25
Attitude Control Nozzle I P Off			
Engine 1-2 Valve Open Ind (vdc)	0.00	0.00	0.0 $\pm$0.25
Attitude Control Nozzle III P On			
Engine 2-2 Valve Open Ind (vdc)	4.17	4.28	4.1 $\pm$0.25
Attitude Control Nozzle III P Off			
Engine 2-2 Valve Open Ind (vdc)	0.00	0.00	0.0 $\pm$0.25

* Limits Not Specified
**Measurement Not Applicable

4.2.34 Forward Skirt Thermoconditioning System Post-Checkout Procedure (1B62965 C)

This procedure secured the forward skirt thermoconditioning system following VCL automatic checkout activities, and consisted of a system cleanliness check, a drain and dry procedure, a leak check, and preparations for stage shipment to STC.

The procedure was initiated on 1 February 1968, with only a cleanliness check accomplished on the date. Because of trouble shooting and all systems test activities on the stage, the procedure was then held open until 16 February 1968. The cleanliness check was then re-accomplished, and the procedure was completed on 19 February 1968, and was accepted on 20 February 1968.

The Model DSV-4B-359 thermoconditioning servicer, P/N 1A78829-1, was verified to be properly set up and connected to the stage thermoconditioning system. A visual inspection verified that there was no leakage within the servicer, at the coolant supply and return hose assemblies, P/N's 1B37641-1 and -501, leading to the stage, or within the stage thermoconditioning system.

The system cleanliness check began with an inspection of the cold plates for open mounting holes and improperly torqued bolts. Coolant was circulated through the system, and 1000 milliliter samples of the water/methanol coolant solution were drawn from the fluid sample pressure valve and the fluid sample return valve, after one pint of fluid had been drawn from each valve to purge the valves of possible impurities. The samples were then analyzed for cleanliness per 1P00093, and were found to be acceptable.

For the drain and dry procedure, the stage thermoconditioning system was purged with gaseous nitrogen for 35 minutes, the remaining coolant fluid was drained from the fluid sample pressure and return valves and the air test valve, and gaseous nitrogen was flowed through the system for another 2-1/2 hours. The system moisture content was then verified to be less than 4430 parts per million of water/methanol vapor, equivalent to a 25°F dewpoint.

The stage thermoconditioning system was then purged with freon gas and pressurized to 32 ± 1 psig for a leak check. All system B-nuts and fittings, manifold weld areas, panel inlet and outlet boss welds, and manifold flexible

4.2.34 (Continued)

bellows were leak checked using a gaseous leak detector, P/N 1B37134-1, with the sensitivity switch set to 1 on the R12-OZ/YR scale. No leaks were found in any of these areas.

The thermoconditioning system was then purged with gaseous nitrogen, and the system dewpoint was again verified to be 25°F or less. The system was then depressurized, the GSE servicer was shut down, disconnected from the stage, and secured, and the stage thermoconditioning system was secured and sealed for subsequent stage shipment.

Engineering comments noted that there were no parts shortages affecting this test. No problems were encountered during the tests, and no FARR's were written. One revision was made to the procedure final stage securing, to permit the stage quick-disconnects to be protected by either dust caps or plastic bags, rather than only by dust caps.

SECTION 5

POSTRETENTION

5.0 POSTRETENTION

This section presents the activities performed on the stage during and after retention at Huntington Beach. Information regarding the stage transfer to STC is presented in paragraph 5.1. Paragraph 5.2 summarizes the retention and postretention activities, while paragraph 5.3 provides information on the stage configuration, including time/cycle significant items. Paragraph 5.4 narrates on those tests performed on the stage during retention, postretention, and preparation for shipment. The stage retest requirements, and tabulations of post checkout FARR's and flight critical items installed at shipment, are presented in paragraphs 5.5, 5.6, and 5.7, respectively.

5.1 Stage Shipment

Transfer of the Saturn DSV-4B-1-1 (S-IVB-507) stage, for transport to the Sacramento Test Center, was made on 7 August 1968 at the Space Systems Center, Huntington Beach. A letter A3-131-KYAO-L-3698, dated 6 August 1968, from the McDonnell Douglas Astronautics Company Contracts Manager to the NASA/MSFC Resident Management Office, I-CO-SD/DAC, covered the submittal of documentation for purposes of technical transfer of the stage to STC. A copy of that letter and accompanying documentation is included in the Stage Log Book (reference Volume I, Part I, Section I).

5.2 Summary

Those activities that occurred during the stage retention and postretention periods are summarized in paragraphs 5.2.1 and 5.2.2, respectively.

5.2.1 Retention Activities

During the retention period, various modifications and rework activities were accomplished on the stage. This included FARR disposition reworks, the activities normally scheduled for completion at SSC, and certain jobs scheduled for completion at STC that were accomplished at SSC because of the available time. (Reference paragraph 5.3.1.)

Some manufacturing tests were accomplished to verify the acceptability of the modifications and reworks, but no stage systems checkouts were conducted during this period.

5.2.2 Postretention Activities

Following the retention period, the stage was removed from storage and prepared for shipment to the Sacramento Test Center for subsequent testing. No system checkout procedures were conducted during this period. The stage shipment preparations included a final inspection, a stage weight and balance procedure, and a preshipment GN_2 purge. Paragraph 5.4 contains more detailed narratives on these activities.

The final inspection of the stage was accomplished to locate and correct any remaining stage discrepancies. Prior to stage retention, a final inspection was conducted between 22 February and 28 March 1968, with a total of 152 defects noted. Of these, 102 were in mechanical areas and 50 were in electrical areas. All of these discrepancies were corrected before the stage went into storage. During the preshipment operations, the final inspection was reaccomplished between 30 July and 6 August 1968, with a total of 356 defects noted, 268 in the mechanical areas and 88 in the electrical areas. All of these discrepancies were corrected before the stage was shipped, with one FARR written to cover seven defects that could not be immediately corrected. Paragraph 5.4.2 presents a more detailed narration on the final inspection.

During the preshipment operation, the stage was rotated to a horizontal position, and prepared for the weight and balance operation. On 2 August 1968 the stage was weighed by means of a three point electronic weighing system. Three electronic load cells, one aft and two forward, measured the reaction forces of the otherwise unsupported stage. The reaction force measurements were then used to determine that the stage shipping and handling weight was 26,871.8 pounds, the stage weight corrected for Standard Gravity in a vacuum was 26,934.6 pounds, and the stage longitudinal center of gravity was located at station 329.4. Paragraph 5.4.3 presents a more detailed narration on these operations.

The final operation before the stage was shipped to STC was the preshipment purge. Gaseous nitrogen was used to purge the stage systems to dewpoints of -30°F for the LH_2 system, and -31°F for the LOX system. The necessary

5.2.2 (Continued)

desiccants were installed to maintain the proper stage environment during the air transport operations. Paragraph 5.4.4 presents a more detailed narration on this operation.

5.3 Stage Configuration

This paragraph presents the variations to the basic stage configuration existing at the time of stage transfer to STC. Paragraph 5.3.1 comments on modifications made after VCL checkout of the stage; paragraph 5.3.2 describes those flight critical items which deviate from the stage design; and paragraph 5.3.3 contains those variations in stage configuration which represent changes in the scope of the program.

A listing of all time/cycle significant items on the stage, along with the accumulated time/cycles for each, is presented in paragraph 5.3.4.

5.3.1 Post Checkout Modifications

Subsequent to VCL checkout, various modifications were made to the stage during the retention period at Huntington Beach. A detailed listing of these modifications and the AO, FARR, and removal work accomplished, is provided by letter A3-850-KYCO-L-3751, dated 7 August 1968, from the Saturn Program Production Director of McDonnell Douglas Astronautics Company, Western Division, to the NASA/MSFC Resident Management Office. This letter also noted additional modifications that were to be accomplished at STC.

In general, these modifications included the rework required to clear FARR dispositions; such normally scheduled activity as work on the nonpropulsive vent system, the telemetry and instrumentation system, the O_2H_2 burner, the chilldown installations, and various wire harnesses; and certain jobs normally scheduled for STC that were accomplished at SSC because of the available time. WRO 4410 identified these transferred jobs and authorized the work at SSC.

Paragraph 5.5 comments upon the retesting that will be required at STC to verify the acceptability of the accomplished stage modifications.

5.3.2 Stage Variations - Flight Critical Items

Identification of components and assemblies which are variations to the stage design is accomplished by including the serial engineering order (SEO) dash number after the part number. Those flight critical items which are installed in the stage with SEO variations are reviewed in this paragraph. A description of the variation, along with part number and serial number, is presented for each part.

5.3.2.1 Fill and Drain Valve (1A48240-505-007)

Rework SEO 1A48240-007 modified the fill and drain valves, P/N 1A48240-505-007, S/N's 113 and 128, to minimize cracking of the valve electrical connector inserts and glass insulation at cryogenic temperatures. The existing bonded inserts and O-rings were removed from the connectors, and unbonded inserts and O-rings were installed.

5.3.2.2 Fuel Tank Vent and Relief Valve (1A48257-511-006)

Rework SEO 1A48257-006 modified the fuel tank vent and relief valve, P/N 1A48257-511-006, S/N 59, to minimize cracking of the valve electrical connector insert and glass insulation at cryogenic temperatures. The existing bonded insert and O-ring were removed from the connector, and an unbonded insert and O-ring were installed.

5.3.2.3 Oxidizer Tank Vent and Relief Valve (1A48312-505-008)

Rework SEO 1A48312-008 modified the oxidizer tank vent and relief valve, P/N 1A48312-505-008, S/N 24, to minimize cracking of the valve electrical connector insert and glass insulation at cryogenic temperatures. The existing bonded insert and O-ring were removed from the connector, and an unbonded insert and O-ring were installed.

5.3.2.4 Chill System Shutoff Valve (1A49965-523-012)

Rework SEO 1A49965-012 modified the LH_2 chill system shutoff valve, P/N 1A49965-523-012, S/N 106, to minimize cracking of the valve electrical connector insert and glass insulation at cryogenic temperatures. The existing bonded insert and O-ring were removed from the connector, and an unbonded insert and O-ring were installed.

5.3.2.5 Chill System Shutoff Valve (1A49965-529-013B)

Rework SEO 1A49965-013B modified the LOX chill system shutoff valve, P/N 1A49965-529-013B, S/N 502, by removing the existing Drilube 822 lubricant from all areas that would be in direct contact with the liquid oxygen. This was necessary as the Drilube 822 was no longer LOX compatible. The valve was relubricated with Krytox 240AC lubricant that met the requirements of 1P20112.

5.3.2.6 Prevalve (1A49968-507-009-010 and -509-009-010)

Rework SEO 1A49968-009 modified the LH_2 prevalve, P/N 1A49968-507-009-010, S/N 146, and the LOX prevalve, P/N 1A49968-509-009-010, S/N 136, to minimize cracking of the valve electrical connector inserts and glass insulation at cryogenic temperatures. The existing bonded inserts were removed from the connectors, and unbonded inserts were installed.

Rework SEO 1A49968-010 modified the same prevalves to improve the valve response time and to prevent cryopumping into the shaft seal port. The existing 0.047 inch diameter actuation port orifice, P/N 527112, was replaced with a 0.078 inch diameter orifice, P/N 527531, and a new vent valve, P/N 527527, was installed in the shaft seal vent port.

5.3.2.7 Chilldown Inverter Electronics Assembly (1A74039-517-016A)

Rework SEO 1A74039-016A modified the chilldown inverter electronics assemblies, P/N 1A74039-517-016A, S/N's 71 and 72, to ensure that the installed zener diode, P/N 1B52278-1, would meet the environmental and operational requirements. The diode, CR13 in the assembly circuit, was checked by reverse current, forward voltage, zener voltage, and surge current tests.

5.3.2.8 Propellant Control Pneumatic Valve (1B59010-503-010)

Rework SEO 1B59010-010 modified the propellant control pneumatic valves, P/N 1B59010-503-010, S/N's 126 and 128, by removing three vent valves, P/N 527152, from each pneumatic valve because they did not provide positive retention of the spring retainer. Three new vent valves, P/N 527527, were installed as replacements.

5.3.2.9 Oxygen-Hydrogen Burner Assembly (1B62600-509-009C)

Rework SEO 1B62600-009C modified the O_2H_2 burner assembly, P/N 1B62600-509-009C, S/N 14, because a redesigned nozzle assembly was not available. The rework included the installation of an orifice, P/N 1B67799-1, and an injector assembly, P/N 1B67723-1; the alignment of the nozzle assembly, P/N 1B63780-1; changes in a pipe assembly to provide clearance for a transducer; and the capping of an unrequired back pressure system connection port.

5.3.3 Scope Change and Engineering Change Proposal Verification

Scope changes (SC's) and engineering change proposals (ECP's), with applicable verification data, are listed on Form DD829-1, which is included in the Stage Log Book. Paragraph 5.3.3.1 lists those SC's and ECP's which were incorporated in the initial design of the stage. Paragraph 5.3.3.2 lists and briefly describes those SC's and ECP's which were incorporated and verified prior to stage shipment to STC. Those SC's and ECP's which are verified at STC, and those which will be incorporated and verified subsequent to stage turnover to NASA, will be described in the Narrative End Item Report covering STC activities on this stage.

5.3.3.1 Scope Changes and Engineering Change Proposals Incorporated in the Initial Design

SC 1016B	SC 1195A
SC 1024	SC 1211A
SC 1027B	SC 1232A
SC 1075B	SC 1266
SC 1096	SC 1278A
SC 1104A	SC 1282
SC 1115	SC 1295
SC 1151	SC 1306
SC 1152	SC 1354
SC 1167	SC 1363
SC 1176	SC 1364
SC 1185	SC 1390
	SC 1397

5.3.3.2 <u>Scope Changes and Engineering Change Proposals Incorporated and Verified Prior to Transfer</u>

The following SC's and ECP's were incorporated during stage manufacture or prior to stage shipment to STC. They were substantiated as being incorporated by Douglas and AFQA personnel, and are listed as previously complied with (PCW) on Form DD829-1.

a. SC 1045B, authorized by CCO 118, provided for the thermoconditioning system for the forward skirt electronics.

b. SC 1124, authorized by CCO 259, provided for a closed loop checkout capability in the safety command RF system.

c. SC 1153A, authorized by CCO's 163 and 280, provided for a redesign of the propellant dispersion system.

d. SC 1187, authorized by CCO's 136, 172, and 330, provided for the use of MSFC furnished control accelerometers and rate gyro.

e. SC 1189, authorized by CCO's 111 and 126, provided for additional coast period requirements.

f. SC 1193, authorized by CCO 156, provided for revisions to the LOX tank vent line.

g. SC 1203, authorized by CCO 168, provided for RPM measurements on the LOX and LH_2 turbopumps.

h. SC 1204, authorized by CCO's 171, 220, 360, and 371, provided for the modification of the complete telemetry system.

i. SC 1205, authorized by CCO 173, provided for additional electrical interface connectors.

j. SC 1207, authorized by CCO's 197, 213, 330, 343, and 414, provided for modifications to the propellant utilization system.

k. SC 1218, authorized by CCO 202, provided for the chilldown system recirculation pump and motor.

l. SC 1219, authorized by CCO 201, provided for the APS control relay package.

m. SC 1221A, authorized by CCO 210, provided for the redesign of the APS modules for the ullage engine system.

n. SC 1241, authorized by CCO 222, provided for additional sensing elements in the engine cutoff system.

o. SC 1274, authorized by CCO's 264 and 330, provided for power supply short circuit protection.

p. SC 1276, authorized by CCO's 267, 273, and 295, provided for electrical interface connectors.

5.3.3.2 (Continued)

q. SC 1277, authorized by CCO 265, provided for the installation of an emergency detection system.

r. SC 1297A, authorized by CCO's 284 and 330, provided for venting of the forward skirt.

s. SC 1304, authorized by CCO 288, provided for redesigning the hydrogen fuel tank.

t. SC 1312, authorized by I-V-S-IVB-TD-64-101, provided for reduced tolerance on dome segments.

u. SC 1326, authorized by CCO's 279, 496, and 595, provided for recirculation chilldown pressure measurements.

v. SC 1376A, authorized by CCO's 395 and 467, provided for the reduction of trapped propellants at stage burnout.

w. SC 1383A, authorized by letters I-CO-SD-L-1037 and -1616, provided for the incorporation of dual diaphragm pressure switches with a calibration capability

x. ECP X056, authorized by CCO's 413 and 572, provided for assigning consecutive reference designation numbers to stage relays.

y. ECP X154, authorized by CCO's 543 and 612, provided for the design and procurement of the control relay package.

z. ECP X171, authorized by CCO's 79 and 582, provided for flared tubing for the stage.

aa. ECP X198, authorized by CCO's 658 and 692, provided for revisions to the engine thrust OK circuits.

ab. ECP X199, authorized by CCO's 634 and 691, provided for redesign of the APS modules.

ac. ECP X204, authorized by CCO's 650, 661, 670, and 708, provided for deleting the pad safety and minimum liftoff pressure switches.

ad. ECP X209, authorized by CCO 847, provided for revisions to the forward skirt paint requirements.

ae. ECP X217, authorized by CCO 698, provided for the use of black teflon hoses for the hydraulic system.

af. ECP X221, authorized by CCO 693, provided for the redesign of the APS Gemini engine nozzle supports.

ag. ECP X226, authorized by CCO 690, provided for the implementation of the Apollo coordinate system standards.

ah. ECP X239, authorized by CCO 729, provided for the implementation of the safing engine start circuits.

ai. ECP X255, authorized by CCO 645, provided for the thermal insulation of the Model II switch selectors.

5.3.3.2 (Continued)

aj. ECP X259, authorized by I-V-S-IVB-TD-66-16, provided for modification of the LH_2 tank probe.

ak. ECP X262, authorized by CCO's 813 and 853, provided for modification of the EDS cutoff circuits.

al. ECP X264, authorized by CCO 781, provided for deleting the rate gyro and accelerometers.

am. ECP X267, authorized by letter I-CO-SD-L-131-66, provided for test code plugs for the stage.

an. ECP 0271, authorized by CCO 798, provided for range safety system measurement requirements.

ao. ECP 0273, authorized by CCO's 837 and 861, provided for the deletion of the LH_2 tank translunar vent termination pressure switch.

ap. ECP 0277, authorized by CCO 801, provided for the deletion of the pyrotechnic dispersion system.

aq. ECP 0281, authorized by letters I-CO-SD-L-192-66 and -L-380-66, provided for a common stage coolant system design effort.

ar. ECP 0302, authorized by CCO's 886 and 942, provided for the design of an LH_2 slosh filter for the propellant utilization system, and a guidance system computer M/F filter.

as. ECP 0304, authorized by CCO 977, provided for the deletion of the vent termination pressure switch.

at. ECP 0314, authorized by letters I-CO-S-IVB-6-310, and I-CO-SD-L-257-66 and -329-66, provided for rework and installation of the Model II switch selector.

au. ECP 0318, authorized by CCO 956, provided for modification of the range safety controller safing plug.

av. ECP 0322, authorized by letter I-CO-S-IVB-6-319, provided for modification of the control relay packages.

aw. ECP 0341, authorized by "make work", provided for replacement of the low pressure cold gas check valve.

ax. ECP 0354, authorized by "make work", provided for a thermal barrier for the ambient helium fill module.

ay. ECP 0364, authorized by "make work", provided for the addition of a check valve to the APS helium supply line.

az. ECP 0441, authorized by CCO 934, provided for reworking the remote analog submultiplexer.

ba. ECP 0443-R1, authorized by CCO 1045, provided for a hazardous gas detection system.

bb. ECP 0444-R1, authorized by "make work", provided for installing wiring in branched wire harness 403W4.

5.3.3.2 (Continued)

bc. ECP 0449, authorized by "make work", provided for modification of the forward skirt thermoconditioning panels.

bd. ECP 0450, authorized by "make work", provided for changes to the auxiliary tunnel covers.

be. ECP 0466, authorized by letter I-CO-S-IVB-6-805, provided for modification of the propellant utilization static inverter-converter capability.

bf. ECP 0479, authorized by "make work", provided for wiring changes in the PAM inputs to the DDAU.

bg. ECP 0481, authorized by "make work", provided for changes in the hi-lock bolts in the aft skirt.

bh. ECP 0486, authorized by letter I-CO-S-IVB-6-1459, provided for the replacement of diodes in the inverter-converter.

bi. ECP 0488, authorized by "make work", provided for the installation of the forward dome ullage pressure transducer.

bj. ECP 0490, authorized by "make work", provided for the redesign of checkout valve, P/N 1B53817.

bk. ECP 0493-R2, authorized by "make work", provided for redesign of the LH_2 and LOX chilldown system shutoff valves.

bl. ECP 0505, authorized by "make work", provided for modification of the breakpoint amplifier module.

bm. ECP 0506, authorized by "make work", provided for the addition of operational telemetry measurement D225.

bn. ECP 0510, authorized by "make work", provided for the installation of coaxial cable assembly 411W212.

bo. ECP 0511, authorized by "make work", provided for the redesign of the LH_2 chilldown pump shutoff line.

bp. ECP 0522, authorized by CCO 1079, provided for redesigning the hydraulic actuator bolt rod end.

bq. ECP 0533, authorized by "make work", provided for the installation of hydraulic accumulator/reservoir temperature and pressure transducers.

br. ECP 0534, authorized by "make work", provided for replacement of the tank relief valves.

bs. ECP 0535, authorized by "make work", provided for modification of the LH_2 and LOX tank electrical feedthroughs.

bt. ECP 0542, authorized by letter I-CO-S-IVB-6-874, provided for changes in the Model II PCM RF assembly.

bu. ECP 0547, authorized by CCO's 966 and 1122, provided for redesigning the bi-level summing network module.

5.3.3.2 (Continued)

bv. ECP 0557-R1, authorized by letter I-CO-S-IVB-1037, provided for redesigning the APS helium pressure regulator.

bw. ECP 0565, authorized by "make work", provided for redesigning the fill and drain valve.

bx. ECP 0575, authorized by "make work", provided for reworking the auxiliary hydraulic pump assembly.

by. ECP 0581-R1, authorized by CCO 1063, provided for OK bypass command circuits.

bz. ECP 0590, authorized by "make work", provided for replacing the multiplexer and switch selector shrouds.

ca. ECP 0592-R3, authorized by "make work", provided for deletion of the APS helium fill module.

cb. ECP 0597, authorized by letter I-CO-S-IVB-6-1271, provided for redesigning the propellant fill and drain umbilical disconnects.

cc. ECP 0600, authorized by "make work", provided for reworking the check valve for the engine driven pump.

cd. ECP 0601, authorized by CCO 993, provided for lock wiring nuts on the propellant system.

ce. ECP 0605, authorized by "make work", provided for vibration isolation of the EDS transducers.

cf. ECP 0613-R1, authorized by letter I-CO-S-IVB-6-1176, provided for replacement of the bolts in the hydraulic hose support brackets.

cg. ECP 0630, authorized by "make work", provided for the reconfiguration of the LOX inlet duct.

ch. ECP 0633, authorized by "make work", provided for rework of the LH_2 propellant duct resilient mount.

ci. ECP 0634, authorized by "make work", provided for revisions to the emergency detection system.

cj. ECP 0638, authorized by letter I-CO-S-IVB-6-1262, provided for replacement of the APS quick disconnects.

ck. ECP 0639, authorized by "make work", provided for the relocation of a pressure transducer.

cl. ECP 0648, authorized by letter I-CO-S-IVB-6-1327, provided for the deletion of the relief valve function from the ambient helium fill module.

cm. ECP 0651, authorized by "make work", provided for adding a core reset resistor to the chilldown inverter.

cn. ECP 0653, authorized by "make work", provided for revisions to the umbilical panel markings.

5.3.3.2 (Continued)

co. ECP 0663, authorized by "make work", provided for the reconfiguration of the LH_2 inlet duct.

cp. ECP 0672, authorized by "make work", provided for redesigning the pneumatic power control module.

cq. ECP 0677, authorized by "make work", provided for redundant relays for the 70 pound thrust ullage engine start.

cr. ECP 0678, authorized by "make work", provided for an RF bond for the forward skirt junction box assembly.

cs. ECP 0680, authorized by letter I-CO-S-IVB-6-1380, provided for a measurement of the inverter-converter 21 vdc output.

ct. ECP 0681, authorized by letter I-CO-S-IVB-7-680, provided for checkout of the spare depletion sensor.

cu. ECP 0685, authorized by "make work", provided for replacement of the aft support for the hydraulic accumulator/reservoir.

cv. ECP 0686, authorized by "make work", provided for the deletion of the LH_2 depletion sensor time delay module.

cw. ECP 0688, authorized by CCO 1031, provided for modifications to the aft umbilical.

cx. ECP 0689, authorized by "make work", provided for redesigning the vent and relief valve.

cy. ECP 0699, authorized by "make work", provided for purging the LOX ullage sensor line.

cz. ECP 0808, authorized by "make work", provided for a revised installation for the measurement D55 transducer.

da. ECP 0809, authorized by "make work", provided for modification of the wire harness for power input measurement K169.

db. ECP 0814, authorized by "make work", provided for rework of the plenum environmental segment.

dc. ECP 0943, authorized by "make work", provided for modification of the signal conditioning panel assembly.

dd. ECP 0944-R2, authorized by "make work", provided for modification of the thermoconditioning system supply line supports.

de. ECP 0958-R1, authorized by "make work", provided for capping the APS module orifices.

df. ECP 0962-R1, authorized by "make work", provided for the addition of caterpillar grommets for the LOX tank confined detonating fuse.

dg. ECP 0963-R1, authorized by CCO 1613, provided for relocating the cable clamps for the ASI line.

5.3.3.2 (Continued)

dh. ECP 0973-R2, authorized by "make work", provided for corrections to connector mating reference designations.

di. ECP 0983-R1, authorized by "make work", provided for having the childown shutoff valve LOX compatible.

dj. ECP 0984-R1, authorized by "make work", provided for the replacement of a battery ground strap.

dk. ECP 1008, authorized by CCO 1074, provided for modifications to the redundant EDS J-2 engine cutoff.

dl. ECP 2019-R1, authorized by "make work", provided for redesigning the continuous vent system.

dm. ECP 2027, authorized by "make work", provided for the replacement of the feedthrough coaxial socket contacts.

dn. ECP 2033, authorized by "make work", provided for the power control and engine pump pipe assemblies.

do. ECP 2037-R2, authorized by "make work", provided for reworking the main hydraulic pump compensation attachment.

dp. ECP 2040, authorized by "make work", provided for additional operational measurements.

dq. ECP 2046, authorized by "make work", provided for the relocation of a pressure transducer.

dr. ECP 2048-R1, authorized by CCO 1128, provided for modification of the continuous vent module bypass valve open talkback.

ds. ECP 2049-R2, authorized by "make work", provided for the installation of the actuation control modules.

dt. ECP 2051, authorized by "make work", provided for reconfigurating the cold helium dump module.

du. ECP 2053, authorized by "make work", provided for substitution of the diodes in the chilldown inverter.

dv. ECP 2061, authorized by "make work", provided for the replacement of the auxiliary hydraulic pump seal.

dw. ECP 2073, authorized by "make work", provided for painting the hydraulic actuators.

dx. ECP 2079, authorized by CCO's 1231 and 1318, provided for rain baffles for the environmental control system vents.

dy. ECP 2090, authorized by letter I-CO-S-DAC-L-403-67, provided for redesigning the directional control valve.

dz. ECP 2091, authorized by "make work", provided for reworking the auxiliary hydraulic pump assembly.

5.3.3.2 (Continued)

ea. ECP 2092, authorized by "make work", provided for the reconfiguration of the bus connectors.

eb. ECP 2096, authorized by CCO 1198, provided for modification of the continuous vent system hardwire talkback.

ec. ECP 2109, authorized by letter I-CO-S-IVB-7-146, provided for an O_2H_2 propellant talkback.

ed. ECP 2112, authorized by "make work", provided for the reconfiguration of the pneumatic actuator.

ee. ECP 2117-R1, authorized by "make work", provided for the installation of a check valve in the actuation control modules.

ef. ECP 2124-R1, authorized by "make work", provided for reconfigurating the LOX chilldown pump.

eg. ECP 2130, authorized by letters I-CO-S-IVB-7-346 and I-CO-S-IVB-7-1238, provided for eddy current testing of the ambient helium tanks.

eh. ECP 2132, authorized by "make work", provided for reconfigurating the Model II RF assembly.

ei. ECP 2133, authorized by letter I-CO-S-IVB-7-183, provided for reconfigurating the Model II RF assembly.

ej. ECP 2134, authorized by CCO's 1170 and 1401, provided for the replacement of printed circuit boards in the Model 270 multiplexers.

ek. ECP 2160-R1, authorized by "make work", provided for replacing the coaxial contacts on the internal cryogenic plugs.

el. ECP 2169, authorized by "make work", provided for relocating the common bulkhead pressure transducer.

em. ECP 2174-R1, authorized by "make work", provided for transducer installations in the LOX and LH_2 chilldown return ducts.

en. ECP 2175, authorized by "make work", provided for a LOX chilldown pump bypass orifice.

eo. ECP 2176-R1, authorized by "make work", provided for the rerouting of coaxial cables.

ep. ECP 2180-R2, authorized by "make work", provided for redesigning the LOX relief valve, P/N 1A49590-515.

eq. ECP 2183, authorized by "make work", provided for reworking the burst disc in the fuel chill duct.

er. ECP 2184, authorized by "make work", provided for reworking the burst disc in the fuel low pressure feed duct.

es. ECP 2188-R2, authorized by CCO 1241, provided for revisions to the dual repressurization system.

5.3.3.2 (Continued)

et. ECP 2189, authorized by letter I-CO-S-IVB-7-528, provided for reworking the LH_2 PU probe lower mount assembly.

eu. ECP 2193, authorized by "make work", provided for the replacement of NAS 1351 passivated screws.

ev. ECP 2204-R2, authorized by letters I-CO-S-IVB-7-456 and -724, provided for removal of the repressurization module relief valve.

ew. ECP 2206, authorized by CCO's 1226, 1282, and 1297, provided for a bearing change in the LH_2 chilldown pump.

ex. ECP 2226-R1, authorized by "make work", provided for propellant utilization system initial conditions.

ey. ECP 2234-R2, authorized by "make work", provided for reconfigurating the fuel relief valve.

ez. ECP 2235, authorized by CCO 1406, provided for a change in the 2 amp relays.

fa. ECP 2242, authorized by "make work", provided for a propellant utilization system component oven.

fb. ECP 2244, authorized by "make work", provided for reconfigurating the power control module.

fc. ECP 2247, authorized by "make work", provided for a change in a heat sink installation.

fd. ECP 2248, authorized by "make work", provided for reconfigurating the continuous vent module.

fe. ECP 2249, authorized by "make work", provided for reworking the APS propellant control module.

ff. ECP 2251, authorized by "make work", provided for readjusting the APS check valve torque value.

fg. ECP 2252, authorized by "make work", provided for reconfigurating the check valve in the cold helium dump module.

fh. ECP 2258, authorized by letter I-CO-S-IVB-7-646, provided for changes in zener diode callouts.

fi. ECP 2262-R3, authorized by "make work", provided for changes and weld joint redesign for the APS pressure vessel, P/N 1B39317.

fj. ECP 2265, authorized by letter I-CO-S-IVB-7-1030, provided for the replacement of the flexible couplings in the forward skirt.

fk. ECP 2269, authorized by "make work", provided for reworking the chill system shutoff valve.

fl. ECP 2270-R1, authorized by "make work", provided for testing of the chilldown inverters.

5.3.3.2 (Continued)

fm. ECP 2273-R1, authorized by "make work", provided for doors in the aft skirt and interstage for drag-in cables.

fn. ECP 2275, authorized by "make work", provided for pressure vessel changes.

fo. ECP 2277-R2, authorized by "make work", provided for a plenum chamber in the pneumatic control system.

fp. ECP 2279, authorized by "make work", provided for the sealant for the range safety and telemetry antennas.

fq. ECP 2292, authorized by "make work", provided for the use of insulating washers on diode modules.

fr. ECP 2295, authorized by "make work", provided for the replacement of a hand valve.

fs. ECP 2301-R1, authorized by CCO's 1429 and 1666, provided for an increase in the propellant utilization system boil-off bias.

ft. ECP 2304, authorized by CCO's 1352 and 1383, provided for modifications to the LOX tank repressurization control module.

fu. ECP 2308, authorized by "make work", provided for a locking device on the fuel duct vacuum valve.

fv. ECP 2309, authorized by "make work", provided for reconfigurating the LH_2 chill system supply duct.

fw. ECP 2312, authorized by "make work", provided for the replacement of the servo-bridge transmission motor.

fx. ECP 2319, authorized by letter I-CO-SIVB-7-794, provided for the installation of an orifice in the LOX repressurization system.

fy. ECP 2325-R1, authorized by CCO 1426, provided for redesigning the low pressure helium module.

fz. ECP 2326, authorized by "make work", provided for strengthening wire support panels.

ga. ECP 2329, authorized by "make work", provided for a pipe assembly for the power control module.

gb. ECP 2330-R2, authorized by CCO 1528, provided for a propellant utilization system oven monitor.

gc. ECP 2339, authorized by CCO 1491, provided for a redundant pressure measurement.

gd. ECP 2360, authorized by letter I-CO-SIVB-7-1136, provided for installing larger spacers under the actuation control modules.

ge. ECP 2419-R1, authorized by "make work", provided for replacing the solenoid in the continuous vent module.

5.3.3.2 (Continued)

gf. ECP 2424-R2, authorized by CCO 1625, provided for a redundant command to the continuous vent valves.

gg. ECP 2434, authorized by CCO 1494, provided for bolts for attaching the J-2 engine to the stage.

gh. ECP 2454, authorized by CCO 1430, provided for modification of the range safety controller safing plug.

gi. ECP 2469, authorized by CCO 1553, provided for replacing the power supply card in the remote digital submultiplexer.

gj. ECP 2485-R2, authorized by CCO 1562, provided for modifications to the division module of the remote analog submultiplexer.

gk. ECP 2500-R1, authorized by CCO 1539, provided for the replacement of pressure switch lines.

gl. ECP 2545-R1, authorized by CCO 1561, provided for the removal of the LOX tank repressurization check valve.

gm. ECP 2574-R1, authorized by CCO 1649, provided for modifications to the LOX heat exchanger bypass valve circuits.

gn. ECP 2630, authorized by "make work", provided for removing the orifice from the actuation control module inlet.

go. ECP 2645-R2, authorized by "make work", provided for capping the calibration port of the calips pressure switches.

gp. ECP 2790, authorized by "make work", provided for changing the Korotherm thickness.

gq. ECP 2793, authorized by "make work", provided for modifications to the helium fill module thermal protection.

gr. ECP 2803, authorized by "make work", provided for reworking a tunnel cover.

gs. ECP 5015-R2, authorized by "make work", provided for metal dust covers for electrical plugs.

5.3.4 Time/Cycle Significant Items

Twenty-nine items installed on the stage are time/cycle significant as defined by design requirements drawings 1B55423, Government Furnished Property Time/Cycle Significant Items, and 1B55425, Reliability Time/Cycle Significant Items. The following table lists these items, along with the time/cycles accrued on each at the time of stage transfer to STC, and the maximum allowable limits prescribed by Engineering.

Part Number and Part Name	Serial Number	Accumulated Measurement	Engineering Limit
Reliability Items (1B55425 P)			
1A48858-1 Helium Storage Sphere	1168	2 cycles	50 cycles
	1173	2 cycles	50 cycles
	1180	2 cycles	50 cycles
	1185	2 cycles	50 cycles
	1187	2 cycles	50 cycles
	1191	2 cycles	50 cycles
	1194	2 cycles	50 cycles
	1216	2 cycles	50 cycles
	1218	2 cycles	50 cycles
1A49421-505 LH_2 Childown Pump	190	1.9 hours (cryo)	100 hours (cryo)
		0 minutes (dry)	40 minutes (dry)
		0 cycles (amb)	10 cycles (amb)
1A49423-507 LOX Childown Pump	1868	67 minutes	1200 minutes
1A59562-509 PU Bridge Potentiometer	5010	365 cycles	5000 cycles
	5011	371 cycles	5000 cycles
1A66241-511 Auxiliary Hydraulic Pump	X458911	12.2 hours	120 hours
		34 cycles	300 cycles
1B57731-1 Control Relay Package	359	151 cycles	100,000 cycles
	360	124 cycles	100,000 cycles
G.F.P. Items (1B55423 G)			
40M39515-113 EBW Firing Unit	259	45 firings	1000 firings
	260	39 firings	1000 firings
	290	30 firings	1000 firings
	291	30 firings	1000 firings
40M39515-119 EBW Firing Unit	452	44 firings	1000 firings
	550	44 firings	1000 firings

5.3.4 (Continued)

Part Number and Part name	Serial Number	Accumulated Measurement	Engineering Limit
50M10697 Command Receiver	185	19.8 hours	2000 hours
	188	19.0 hours	2000 hours
50M10698 Range Safety Decoder	0026	83.0 hours	2000 hours
	0046	46.2 hours	2000 hours
50M67864-5 Switch Selector	167	66,449 cycles	250,000 cycles
103826 J-2 Engine (for gimbal cycles)*	J-2119		
a. Customer connect lines and inlet ducts		2.43%	250-10,000 cycles
b. Gimbal bearing		2.78%	250-10,000 cycles
c. Firing time		346.1 seconds	3,750 seconds
d. Helium Regulator (P/N 558130-21)		95 cycles	Not established

*This data includes all engine gimbal cycles at SSC, plus cycles brought forward from Rocketdyne records. The cycle data is expressed as a percent of design limits based on the gimbal angle, and can vary from 250 to 10,000 + cycles as noted. The indicated percentages were computed from the Engine Log Records utilizing the graph per Rocketdyne Rocket Engine Data Manual R-3825-1.

5.4 Narratives

This paragraph presents narrations on the stage checkouts accomplished following the stage retention at SSC. Paragraph 5.4.1 comments on any postretention system checkouts accomplished to verify stage modifications; paragraph 5.4.2 covers the stage final inspection; and paragraphs 5.4.3 and 5.4.4 narrate on the stage weight and balance operation and the preshipment GN_2 purge.

5.4.1 Postretention Testing

No system checkouts were accomplished following the stage retention period. All modifications made to the stage were to be tested at STC, as indicated by the retest requirements in paragraph 5.5.

5.4.2 Final Inspection

A final inspection was accomplished by McDonnell Douglas and AFQC personnel on all stage mechanical and electrical areas to locate and correct any remaining

5.4.2 (Continued)

discrepancies. The inspection was initially accomplished between 22 February 1968 and 28 March 1968, to verify that the stage was in satisfactory condition for storage and retention. A total of 152 defects were noted during this inspection, 102 in the mechanical areas, and 50 in the electrical areas. These defects were corrected, and the inspection and all reworks were accepted by 28 March 1968.

Following the removal of the stage from storage, the final inspection was repeated between 30 July 1968 and 6 August 1968, to verify that the stage was in satisfactory condition for the preshipment operations and transfer to STC. A total of 356 defects were noted during this repeat inspection, 268 in the mechanical areas, and 88 in the electrical areas. The inspection results, and the corrective action reworks, were all accepted by 6 August 1968.

Most of these discrepancies were corrected immediately. However, the following defects were recapped to FARR 500-445-653 for corrective action: Sensor cable 425MT601, P/N 1B40242-99, and coaxial cables, P/N's 1B40242-615, -581, and -589, S/N's 615-6, 581-1, and 589-3, respectively, all had damaged insulation.

The shields of these cables were not damaged. The cables were repaired to an acceptable condition per DPS 54010. In addition, standoff, P/N 1B66222-63, was cracked under a rivet head; duct, P/N 1A87234-1, had two dings; and frame, P/N 1A49629-501, had an elongated hole. These discrepancies were acceptable to Engineering without rework.

5.4.3 Weight and Balance Procedure (1B64539 C)

This procedure measured the stage weight with an accuracy of ±0.1 percent, using a three point electronic weighing system, and determined the longitudinal center of gravity of the stage. The measured stage weight was corrected for gravity and air buoyancy forces to determine the weight at Standard Gravity in a vacuum. The procedure was satisfactorily accomplished on 2 August 1968, after the stage was rotated to a horizontal position and placed on the weighing cradles, P/N 1A68719-1. The procedure was accepted on 6 August 1968.

Before starting the weighing operation, the electronic weighing system, P/N 1A57907-1, was set up and calibrated. Three load cell assemblies, P/N CMU-1204 or 1B38965-1 and -501, were connected to the load cell readout indicator, P/N CMU-1204, checked for linearity and stability by the use of the indicator standardizer, and adjusted for a zero setting. The stage was verified to be level within 0.250 inches over the axial distance between stations 554.702 and 286.147. The dry bulb temperature, barometric pressure and relative humidity were measured in the weighing area, for use in determining the air density. These measurements were repeated every half hour throughout the weighing operation.

Using the hand pumps on the aft jack, P/N 1A93232-1, and the two forward glide-aire jacks, P/N 1A83320-1, the stage was raised to just clear the cradles, and leveled to the previous limit. Regulator air pressure was applied to the forward glide-aire jacks to permit self-adjustment of the stage, and the stage levelness was reverified. After allowing 10 minutes for load cell creep stabilization, load cell readings were taken as shown in Test Data Table 5.4.3.1. The stage was then lowered back onto the cradles, the load cells

5.4.3 (Continued)

were allowed to creep stabilize again, and the load cell zero was rechecked and adjusted if necessary. The weighing procedure was repeated three times, and the average reading for each load cell was determined and corrected for calibration. From the capacity of each load cell, and the load cell reading, the reaction force on each load cell was determined. These reaction forces were then used to determine the stage shipping and handling weight, the stage weight at Standard Gravity in a vacuum, and the longitudinal center of gravity. As shown in the Test Data Table, the stage shipping and handling weight was 26,871.8 pounds, the weight at Standard Gravity in a vacuum was 26,934.6 pounds, and the longitudinal center of gravity was at station 329.4.

No parts were short during this procedure, no revisions were written, and no problems were encountered.

5.4.3.1 Test Data Table, Weight and Balance Procedure

Air Density Data

Time	Barometric Press. (in. Hg)	Relative Humidity (%)	Dry Bulb Temp (°F)
19:30	29.885	68.0	73.0
20:00	29.895	64.0	74.0
20:30	29.905	64.0	74.0
21:00	29.915	64.0	73.0
21:30	29.925	62.0	73.0

Calculated Air Density: 0.0739 pounds per cubic foot.

Load Cell Collected Data

Reaction Load Cell	Aft (R1)	Forward (R2)	Forward (R3)
Serial Number	36247	34186	34184
Capacity (pounds)	25,000	10,000	10,000
Run 1 Reading (%)	79.647	37.830	39.492
Run 2 Reading (%)	79.661	37.893	39.402
Run 3 Reading (%)	79.663	37.944	39.328
Average Reading (%)	79.657	37.889	39.407
Calibration Correction	0.744	0.290	0.267
Corrected Reading (%)	80.401	38.179	39.674
Reaction (pounds)	20,100.3	3,817.9	3,967.4

5.4.3.1 (Continued)

Weight Determination (pounds)

Aft Reaction R1	20,100.3
Forward Reaction R2	3,817.9
Forward Reaction R3	3,967.4
Total Reactions as recorded	27,885.6
Minus Weighing Equipment "Tare"	- 1,013.8
Shipping and Handling Weight	26,871.8
Plus Gravitational Correction	+ 29.8
Plus Buoyancy Correction	+ 33.0
Weight at Standard Gravity in a vacuum	26,934.6

Longitudinal Center of Gravity

Reaction R1 Moment at Sta. 189.3	3,804,986.79
Reaction R2 Moment at Sta. 684.0	2,611,443.60
Reaction R3 Moment at Sta. 684.0	2,713,701.60
Moment Sum	9,130,131.99
Tare Moment	- 278,870.75
Moment Sum Less Tare	8,851,261.24

As weighed Center of Gravity = Station 329.4
(Moment Sum Less Tare divided by Total Reactions Less Tare)

5.4.4 GN_2 - Electrical Air Carry Preshipment Purge (1B65783 J)

Just prior to stage shipment, this procedure purged the stage to a dewpoint of -30°F (235 ppm by volume) or less, using gaseous nitrogen, and installed the necessary desiccants for stage air carry shipment. The desiccants maintained a clean, dry environment and a safe differential pressure during air transportation.

The procedure was satisfactorily performed between 2 and 6 August 1968, and was accepted on 6 August 1968. The purge preparations started with the installation of the LOX and LH_2 desiccant support assemblies, P/N's 1B61272-1 and 1B61270-1. The LOX bellows, P/N 1A49971-501, and the LOX and LH_2 disconnects, P/N's 1A49970-503 and 1B66932-501, were removed for separate shipment with the stage. Covers and desiccators were installed at the LOX and LH_2 fill and drain vents, the LH_2 propulsive, non-propulsive, and ground vents, the LOX propulsive and non-propulsive vents, and the O_2H_2 burner nozzle.

The Model 1865 purge unit, 1B61117-1, was prepared for operation, and the electrical and pneumatic purge connections were made on the stage and between the purge unit and the stage. The engine LOX chilldown line and LH_2 feed duct, the LH_2 pressurization line, the LH_2 propulsive vent, non-propulsive vent, and

5.4.4 (Continued)

ground vent, the LOX propulsive vent and non-propulsive vent, the O_2H_2 burner LOX and LH_2 ducts, and the LOX and LH_2 propellant tanks were all purged with gaseous nitrogen. The final dewpoints attained were -31°F for the LOX system, and -30°F for the LH_2 system. During the tank purges, the LH_2 tank door was removed for separate shipment with the stage, and a manifold, P/N 1B61027-1, was installed in its place. Also, the LOX tank desiccant breather, P/N 1A79691-1, and the four LH_2 tank desiccant breathers, P/N 1A79691-501, were prepared, filled with desiccant material, and installed.

After the satisfactory completion of the purge operation, the purge unit was disconnected from the stage and secured. The aft skirt dust cover, P/N 1B61077-1, and the forward skirt dust cover, P/N 1B61099-1, were then installed to complete the procedure.

There were no parts shortages affecting this test. No particular problems were encountered, and no FARR's were written. Sixteen revisions were made to the procedure:

a. Three revisions added steps to prepare and purge the LOX non-propulsive vent, as these instructions were not included in the procedure.
b. Eight revisions changed steps to update the procedure and correct procedure errors, and added an omitted step.
c. One revision changed a step to ensure that an applied voltage was maintained at 28 ±4 vdc.
d. One revision modified some hose connections to bypass the pneumatic pressurization line regulator module, as the module had been removed from the stage.
e. One revision changed a part number reference to reflect the actual part installed.
f. One revision deleted a step to close the LH_2 propulsive vent, as the vent duct was to be left open to permit pressure equalization.
g. One revision deleted the interim container reactivation, as the operation was not applicable.

5.5 Retest Requirements

As noted in paragraph 5.3.1, various modifications were accomplished on the stage during the SSC retention period, and additional modifications were scheduled at STC prior to stage acceptance firing. The retesting required to verify the acceptability of these modifications included manufacturing tests,

5.5 (Continued)

and stage system checkouts. Some manufacturing tests were completed at SSC, with the remainder scheduled for STC, but no additional stage checkout procedures were accomplished at SSC prior to stage shipment. The completion of the following system checkout procedures was required at STC, prior to the acceptance firing, to verify all of the modifications.

1B41955	Thermoconditioning System Checkout and Operation
1B49286	Common Bulkhead Vacuum Check
1B55813	Stage Power Setup
1B55814	Stage Power Turnoff
1B55815	Power Distribution System
1B55816	DDAS Calibration
1B55817	DDAS Automatic Checkout
1B55819	Range Safety Receiver Automatic Checkout
1B55821	Range Safety System Automatic Checkout
1B55822	EBW System Automatic Checkout
1B55823	Propellant Utilization System Automatic Checkout
1B55824	Hydraulic System Automatic Checkout
1B55825	APS (Simulator) Automatic Checkout
1B62753	Propulsion System Automatic Checkout
1B64368	Propellant Utilization System Manual Calibration
1B64678	Cryogenic Temperature Sensor Verification
1B71877	Propulsion System Leak Check
1B75537	Single Sideband System Checkout

Most of the above tests are part of the normally planned STC prefire testing.

5.6 Post Checkout FARR's

This paragraph presents those FARR's which were generated and active against stage components during the SSC retention period following stage VCL checkout. Paragraph 5.6.1 summarizes those incomplete FARR's that were transferred open at the time of stage transfer to STC. Paragraph 5.6.2 presents the post checkout FARR's in tabular form.

5.6.1 Incomplete FARR's

Four FARR's were transferred open at the time the stage was transferred to STC:

A271292	The engine control assembly, P/N 502670-51, S/N 4091614, on the J-2 engine, was suspected of malfunctioning during the all systems test. The engine control assembly was replaced, and this FARR was transferred open for testing of the replacement assembly at STC.
A271296	During the all systems test, six measurements exceeded the noise level requirements of SM-47376, and two level sensors cycled unexpectedly due to transient noise. The conditions were acceptable to Engineering, but were not acceptable to NASA. This FARR was transferred open for further disposition.
500-071-125	Tube assembly, P/N 703098, on the J-2 engine, had a bend at the stub end, causing a preload on a weld joint, and also had a flat area near the weld. The tube assembly was replaced. This FARR was transferred open for leak checking of the new tube.
500-445-661	The test record information for EBW firing unit 404A75A1, P/N 40M39515-113, S/N 259, could not be retrieved from QDR files as required. The EBW firing unit was to be removed, replaced, and retested at STC. This FARR was transferred open for disposition.

5.6.2 Tabulated Post Checkout FARR's

The following table presents those FARR's that were generated and active against stage components during the SSC retention period.

FARR No.	Description of Defects	Disposition
A261183 5-24-68	Four supports, P/N 1B57158-9, and four supports, P/N 1B57158-10, installed on the forward dome, should have been P/N's 1B57158-3 and 1B57158-4, respectively.	Acceptable to Engineering for use without rework.
A261187 5-29-68	Twelve supports, P/N 1B37888-537, were installed on the auxiliary tunnel. An EO change had deleted the requirement for the supports, and they should not have been installed.	The excess supports were removed per DPS 32330, and the area was finished per B/P and specifications. The rework was acceptable.
A261198 6-28-68	It was suspected that the J3 receptacles on the 50 amp relay modules, P/N 1A74890-501, S/N's 127, 131, 133, 136, and 137, were not potted with 1P20074 compound prior to final encapsulation, as required by general note No. 7 on installation drawing 1A89639.	Acceptable to Engineering for use without rework. Refer to SEO 1A74890-003.
A261200 6-27-68	During installation of the LH_2 probe, P/N 1A48431-513, S/N C-2, the mating ends were completely joined before they should have been, and the No. 7 locking pin holes were not properly aligned.	With the retainer pin in place, the probe was tapped lightly in the direction of the joint until the locking pin holes were aligned. A teflon block was used to protect the probe during this operation. The locking pin was then inserted, and installation was acceptably completed per B/P.
A271292 2-8-68	On the J-2 engine, P/N 103826, S/N J-2119, the engine control assembly, P/N 502670-51, S/N 4091614, was suspected of malfunctioning during the VCL all systems test, H&CO 1B66571. Data evaluation showed that measurements K96 and K8 had unscheduled on and off cycles when the engine ignition spark and the helium heater burner ignition spark, respectively, were on.	A test using an external substitute control assembly was not conclusive. Troubleshooting confirmed the malfunctions, and showed that the start tank discharge control solenoid circuit had 20 vpp spikes when the solenoid was simulated by a 30 ohm resistance. The engine control assembly was removed for further troubleshooting, and a new assembly was installed. This FARR was transferred open to STC for testing of the newly installed control assembly.

5.6.2 (Continued)

FARR No.	Description of Defects	Disposition
A271293 2-13-68	The voter-regulator module, P/N 1B66988-1D, S/N 10, was tested to A659-1B66988-PATPI-B-T2, which contained erroneous test instructions and values. The unit should have been tested to corrected procedure A659-1B66988-PAPTI-B-T4.	The defective voter-regulator module, S/N 10, was removed and a new unit, S/N 17, which was tested per A659-1B66988-PATPI-B-T4, was installed.
A271296 2-19-68	SM-47376, used by the TP&E committee for evaluating the telemetry test data resulting from the all systems test, H&CO 1B66571, specified that the noise level of any measurement should not exceed 2 to 5 percent peak-to-peak for over a 1 second duration. The following measurements exceeded the 1 second duration: a. Measurements D1, D18, and M25 exceeded the noise limitations due to the chilldown inverter operation. b. Measurements M60, N55, and N18 exceeded the noise limitations due to radio frequency interference. c. The LOX and LH_2 tank fast fill sensors cycled unexpectedly due to transients from the LOX vent valve actuation and a safe and arm device command, respectively.	The measurements were acceptable to Engineering, but were not acceptable to NASA. This FARR was transferred open to STC for further disposition.

FARR No.	Description of Defects	Disposition
500-071-117 2-23-68	The following defects were noted in the aft skirt area: a. On burner assembly, P/N 1B62600-513, the weld was broken on a 1/8 in. pipe assembly mounting to valve assembly, P/N 1B66639-503. b. Panel assembly, P/N 1B54087-1, had two gouges at the lower edge, 11/32 in. long by 1/16 in. deep.	a. The defective valve was removed, and a new valve was installed and accepted for use. b. The gouged area was treated with zinc chromate primer, and was acceptable to Engineering for use without other rework.
500-071-125 2-27-68	On the J-2 engine, P/N 103826, S/N J-2119, tube assembly, P/N 703098, had a 16 deg bend at the end of the stub, causing a preload on a weld joint, and also had a 1-1/2 by 1/4 in. flatness area located 3 in. below the weld.	The tube assembly was removed, and a new tube was installed. This FARR was transferred open to STC for leak checking the new tube.
500-071-133 2-27-68	The following defects were noted on J-2 rocket engine, P/N 103826, S/N J-2119: a. Interface line assemblies, P/N's NA5-260127-1, NA5-26014-1, NA5-26944-1, and the inlet side of valve assembly, P/N 557848, had evidence of corrosion in the vicinity of the weld joints. b. Wire harness, P/N 503173-131, had a damaged seal inside a connector. c. Wire harness, P/N 4W4P157/4MTT71/HOT2, had a separation between the 90 degree elbow and the harness potting. d. Wire harness, P/N 1B66971-1, had an improper wire length at connector 404W7P-41.	a. The corrosion areas were cleaned off with a bristle brush and trichloroethylene, then wiped dry with a clean cloth. The rework was acceptable for use. b. The damaged seal was removed and replaced by a new part. c. Aerospace sealant, Dow Corning 92-018, was applied to the separated area. The rework was acceptable for use. d. Acceptable to Engineering for use without rework.

FARR No.	Description of Defects	Disposition
500-071-168 3-28-68	In the forward dome area, the cable assembly of matched transducer set, P/N 1B40242-535, S/N 535-3, had torn insulation at 3 places. The largest damaged area was 1/8 by 1/16 in.	The cable assembly was acceptably repaired by wrapping the damaged areas with teflon tape per DPS 54010.
500-071-176 4-1-68	In the forward skirt, twenty-seven drain holes through angle, P/N 1A53608-1, were drilled to 0.375 in. diameter, but should have been 0.310 to 0.319 in. diameter.	Acceptable to Engineering for use.
500-071-206 4-18-68	The oxidizer vent valve, P/N 1A48312-505, S/N 0037, was contaminated with foreign material inside the valve.	The defective valve, S/N 0037, was removed and a new valve, P/N 1A48312-505-008, S/N 0024, was installed. The defective valve was then returned to the vendor for recleaning and retesting.
500-071-214 4-18-68	The oxidizer relief valve, P/N 1A49590-515, S/N 556, was contaminated with foreign material inside the valve.	The defective valve, S/N 556, was removed and a new valve, P/N 1B69030-1, S/N 0010, was installed. The defective valve was returned to the vendor for recleaning and retesting.
500-071-222 4-23-68	On the O_2H_2 burner, P/N 1B62600-509-009, S/N 014, the installed injector, P/N 1B67723-1, S/N 08, had been previously scrapped at STC.	The injector plate was to be removed, and a new plate installed, by AO action. The burner was designated an interim use material (IUM) part until this was accomplished.
500-071-249 4-30-68	At panel 13 in the forward skirt area, wire D1707A22-white, in wire harness 410W200, P/N 1B58252-1, S/N 8001, was severed 1 in. from connector P18. The wire should have terminated at pin A in the connector.	The severed wire was reterminated, tested, and accepted for use.

FARR No.	Description of Defects	Disposition
500-242-086 7-3-68	In wire harness 403W8 at thrust structure module tray 403A73, conductor 5NK16A20GA, running from connector P1 to diode module A9, was cut through the outer insulation to the wires.	Module A9, P/N 1B54522-1, was removed and a new module was installed and accepted for use.
500-445-513 7-5-68	On wire harness 404A3W1, P/N 1B68981-1, connector P53 had a hole in the rubber grommet near pin Z. Pin Z in the mating bus connector, P/N 1B57771-557, was bent approximately 50 degrees.	Defective connector P53 was removed, and a new connector was installed. Pin Z in the bus connector was straightened per DPS 54002. After continuity and insulation resistance checks, the reworks were accepted for use.
500-445-521 7-16-68	Support, P/N 1B69608-9, had two elongated holes, 0.625 by 0.500 in. in size, and support, P/N 1B37762-1, had two elongated holes, 0.920 by 0.815 in. in size. All of these holes should have been 0.498/0.507 in. in diameter.	Support, P/N 1B69608-9, was acceptable for use. Support, P/N 1B37762-1, was removed and replaced per DPS 32330 and the B/P. The mylar covering was replaced per DPS 22301 to meet B/P requirements, and the rework was acceptable for use.
500-445-530 7-16-68	Duct assembly, P/N 1A87436-502, had walnut grit in the upstream and downstream ends, and discoloration on the weld seams at both ends. Adaptor, P/N 1B59264-1, had pits and oxidation throughout the interior. Duct assembly, P/N 1A87234-2, had walnut grit in both ends, and an unknown substance on the duct flange. Tee assembly, P/N 1A49987-1, and duct assemblies, P/N's 1A87234-1 and 1A87436-501, had grit dust contamination as far as was visible. Valve, P/N 1A49988-501, S/N 34, also had fine dust particle contamination.	All of the noted dirty and contaminated parts were removed and replaced with clean parts. Duct, P/N 1A87755-501, connecting the tee assembly and the valve, was also replaced, although it was not visibly contaminated. Cleanliness was maintained per DPS 43150 during the rework. The replaced components were retested and accepted for use.

FARR No.	Description of Defects	Disposition
500-445-548 7-17-68	Sensor, P/N 1B40242-11, S/N 281, of matched sensor set, P/N 1B40242-591, S/N 591-2, and transducer, P/N 1B37878-501, S/N 1417, were contaminated by walnut grit dust. The sensor and transducer were removed from duct, P/N 1B44575-2, which was contaminated with the grit dust, and were to be reinstalled in duct, P/N 1B44575-502.	The transducer, P/N 1B37878-501, S/N 1417, was cleaned and retested by FARR 500-445-572, and then reinstalled in the new duct. Matched sensor set, P/N 1B40242-591, S/N 591-2, was removed and dispositioned by FARR 500-445-564. A new sensor set was installed. The rework was acceptable for use.
500-445-556 7-19-68	Panel, P/N 1B31967-509, had a 0.190/0.195 in. diameter hole drilled through both the face side and the far side. The hole should have been through the face sheet only.	Acceptable to Engineering for use.
500-445-564 7-19-68	Sensor, P/N 1B40242-11, S/N 281, of cryogenic pressure transducer set, P/N 1B40242-591, S/N 591-2, was contaminated with walnut grit dust. (Ref. FARR 500-445-548). Transducer set, S/N 591-2, consisted of amplifier, S/N 512, sensor, S/N 281, and cable S/N 591-2 P2.	The transducer set was removed from the stage. The sensor was then cleaned per DPS 43002, and the transducer set was retested per A659-1B40242-1-PATP1 and accepted for further use.
500-445-572 7-19-68	Cryogenic temperature transducer, P/N 1B37878-501, S/N 1417, was contaminated by walnut grit dust. (Ref FARR 500-445-548)	The transducer was cleaned per DPS 43002, retested per B/P and specification 1B37878, and accepted for use.
500-445-599 7-22-68	In the aft thrust structure area, support, P/N 1B37762-1, had two elongated holes. The top hole was 15/16 by 3/4 in., and the bottom hole was 3/4 by 3/4 in. Both holes should have been 1/2 in. diameter. The holes would need to be elongated about 3/16 in. more to align the supported duct assembly with a valve connection. (This was a repetitive problem, reference FARR 500-445-521).	The support was removed and replaced per DPS 32330 and B/P requirements. The surrounding mylar was reinstalled per DPS 22301 to meet B/P requirements.

FARR No.	Description of Defects	Disposition
500-445-602 7-24-68	On wire harness 404W208, P/N 1B68993-1, solder pins A and B in plug P195 shorted out during an insulation resistance test using a 500 vdc megohmeter. The resistance should have been 100 megohms minimum.	Connector P195, P/N MS 3116E8-4S, was removed, and a new connector was installed, checked for continuity and insulation resistance, and accepted for use.
500-445-611 7-24-68	The propulsive vent system had a suspected contamination problem with the following parts: Module, P/N 1B67193-507 Elbow, P/N 1B53036-1 Tee, P/N 1B44572-1 Ducts, P/N 1B44573-1 and -2 Ducts, P/N 1B44574-1 and -2	A visual inspection, plus the use of Wattman filter paper wetted with deionized water, confirmed the contamination. The noted parts were removed and replaced by clean parts. Pipe assemblies, P/N's 1B74296-1 and 1B74297-1, were also replaced.
500-445-629 7-25-68	On wire harness 404W7, P/N 1B74463-1, wire Q126A22 was damaged, exposing the conductor. This wire terminated at pin c of connector P3.	The damaged wire was removed, and a new wire was installed, checked for continuity and insulation resistance, and accepted for use.
500-445-637 7-27-68	Support, P/N 1B76087-9, was lacking one nutplate, P/N NAS 684C3. Per B/P 1B69608, there should have been two nutplates, but only one was installed.	A blind nut was installed in the existing hole per DPS 13251. The rework was acceptable.
500-445-645 7-28-68	On wire harness 403W8, P/N 1B74669-1, pin C of plug P25 extended out beyond the face of the rubber grommet. On sensor cable 403MT-754, P/N 1B40242-105, pin H of plug P3 was recessed below the rubber grommet. Both defective plugs were located at thrust structure panel 403A74.	Both plugs were disassembled, the pins were reinstalled in the correct position, and the plugs were reassembled and accepted for use.

FARR No.	Description of Defects	Disposition
500-445-653 7-30-68	The following defects were noted during final inspection: a. Sensor cable 425MT601, P/N 1B40242-99, had the shield showing through the outer insulation. The shield was not damaged. b. Coaxial cable, P/N 1B40242-615, S/N 615-6, had four 1/16 in. holes in the insulation. The shield strands were not damaged. c. Coaxial cable, P/N 1B40242-581, S/N 581-1, had a 1/2 in. long by 1/16 in. wide cut in the insulation. The shield strands were not damaged. d. Coaxial cable, P/N 1B40242-589, S/N 589-3, had a 1/16 in. hole in the insulation. The shield strands were not damaged. e. Standoff, P/N 1B66222-63, was cracked under a rivet head. f. Duct, P/N 1A87234-1, had two sharp dings, both 0.040 in. deep. g. Frame, P/N 1A49629-501, had a No. 10 tooling hole elongated to 5/16 in.	a, b, c, and d. The damaged cables were repaired per DPS 54010 to an acceptable condition. e, f, and g. Acceptable to Engineering for use.
500-445-661 8-2-68	Test record sheets 18, 19, and 20, of form X60-999 for EBW firing unit 404A75A1, P/N 40M39515-113, S/N 259, could not be retrieved from Quality Data and Reporting files, as required.	The EBW firing unit was to be removed, replaced, and retested at STC. This FARR was transferred open to STC for disposition.

FARR No.	Description of Defects	Disposition
500-445-670 8-2-68	Fill assembly, P/N 1A78053-1, and valve, P/N 1A48240-505, S/N 122, were contaminated with walnut shell dust.	The fill assembly was removed, cleaned, and reinstalled. The valve, and pipe assembly, P/N 1B66772-1, were removed, and a clean replacement valve and pipe assembly were installed.

5.7 Flight Critical Items Installed at Transfer

The flight critical items (FCI) installed on the stage at the time of transfer to STC are listed in the following tabulation:

P/N	S/N	Ref Location	Name
1A48240-505-007	113	427A8 S1, S2	Fill and drain valve
1A48240-505-007	128	404A7 S1, S2	Fill and drain valve
1A48257-511-006	59	411A1 S1, S2	LH_2 vent and relief valve
1A48312-505-008	24	424A9	LOX vent and relief valve
1A48430-511	C3	406A1	LOX mass probe
1A48431-513	C2	408A1	LH_2 mass probe
1A48857-503	49	403A73	Control helium tank
1A48858-1	1168	Bnk 2 Pos 7	Helium sphere
1A48858-1	1173	Bnk 2 Pos 9	Helium sphere
1A48858-1	1180	Bnk 1 Pos 5	Helium sphere
1A48858-1	1185	Bnk 1 Pos 2	Helium sphere
1A48858-1	1187	Bnk 1 Pos 1	Helium sphere
1A48858-1	1191	Bnk 1 Pos 2	Helium sphere
1A48858-1	1194	Bnk 1 Pos 4	Helium sphere
1A48858-1	1216	Bnk 2 Pos 10	Helium sphere
1A48858-1	1218	Bnk 2 Pos 8	Helium sphere
1A49421-505	190	427A41	LH_2 aux chilldown pump
1A49423-507	1868	424A4, A2	LOX aux chilldown pump
1A49591-533	166	411	LH_2 tank relief valve
1A49964-501	275	424 (LOX)	Chill system check valve
1A49964-501	291	427 (LH_2)	Chill system check valve
1A49965-523-012	106	424A3	Chill system shutoff valve
1A49965-529-013B	502	404A4 S1, S2	Chill system shutoff valve
1A49968-507-009-010	146	427A6	Prop tank shutoff valve
1A49968-509-009-010	136	424A6	Prop tank shutoff valve
1A49988-509	5	411A29	LH_2 directional vent valve
1A49991-1	45	403A6	Cold helium tank
1A49991-1	53	403A74	Cold helium tank
1A57350-507	204	403A5	Helium fill module
1A58347-505	7	403A73A2	Engine pump purge cont mod
1A59358-529	32	411A92A6	Prop util elect assy
1A66212-507	23	411A92A7	Inv-conv elect assy
1A66240-503	X123108	401A11S1, S2	Engine driven pump
1A66241-511	X458911	403B1	Aux hydraulic pump
1A66248-507	30	403A72L1	Hydraulic actuator assy
1A66248-507	81	403A71L1	Hydraulic actuator assy
1A68085-505	87	404A45A1	300 amp pwr transfer switch
1A68085-505	107	411A99A10A1	300 amp pwr transfer switch
1A68085-505	115	404A2A1	300 amp pwr transfer switch
1A74039-517-016A	71	404A74A2	Chilldown inverter elec assy
1A74039-517-016A	72	404A74A1	Chilldown inverter elec assy
1A74211-509	642	404A3A41	2 amp relay module

5.7 (Continued)

P/N	S/N	Ref Location	Name
1A74211-509	643	404A2A6	2 amp relay module
1A74211-509	644	404A3A19	2 amp relay module
1A74211-509	645	404A2A8	2 amp relay module
1A74211-509	667	404A3A48	2 amp relay module
1A74211-509	668	404A3A17	2 amp relay module
1A74211-509	677	411A99A10A11	2 amp relay module
1A74211-509	685	404A45A7	2 amp relay module
1A74211-509	686	404A45A9	2 amp relay module
1A74211-509	687	404A45A10	2 amp relay module
1A74211-509	688	404A45A8	2 amp relay module
1A74216-503	375	404A3A23	Mag latch relay module
1A74216-503	480	404A3A13	Mag latch relay module
1A74216-503	484	411A99A10A6	Mag latch relay module
1A74216-503	499	404A3A21	Mag latch relay module
1A74216-503	504	404A45A5	Mag latch relay module
1A74216-509	694	411A99A10A10	Mag latch relay module
1A74218-509	582	404A3A49	10 amp relay module
1A74218-509	591	404A3A44	10 amp relay module
1A74218-509	635	404A3A14	10 amp relay module
1A74218-509	636	404A3A20	10 amp relay module
1A74218-509	637	404A3A12	10 amp relay module
1A74218-509	646	411A99A10A12	10 amp relay module
1A74218-509	693	404A2A2	10 amp relay module
1A74218-509	695	404A45	10 amp relay module
1A74765-507	231	401A11S1	Hyd Sys thermal switch
1A74890-501	127	404A2A10	50 amp relay module
1A74890-501	131	404A2A9	50 amp relay module
1A74890-501	133	404A2A7	50 amp relay module
1A47890-501	136	411A99A10A2	50 amp relay module
1A74890-501	137	404A45A2	50 amp relay module
1A77310-503.1	144	411A99A33	5 volt excitation module
1A77310-503.1	174	404A52A7	5 volt excitation module
1A77310-503.1	191	411A98A2	5 volt excitation module
1A86847-509	62	401A11S1, S2	Hyd pump thermal isol assy
1B29319-519	33	403A46S1	Accum/reservoir assy
1B32647-505	71	404A45A3	Hyd pwr unit start switch
1B33084-503	17	411A97A19	RS controller assy
1B33084-503	18	411A97A13	RS controller assy
1B39037-501	115	J-2 attach	Eng installation bolt
1B39037-501	117	J-2 attach	Eng installation bolt
1B39037-501	121	J-2 attach	Eng installation bolt
1B39037-501	124	J-2 attach	Eng installation bolt
1B39037-501	125	J-2 attach	Eng installation bolt
1B39037-501	126	J-2 attach	Eng installation bolt
1B39550-529	12	404A3	Sequencer mounting assy

5.7 (Continued)

P/N	S/N	Ref Location	Name
1B39975-501	289	404A2A16	Diode module
1B39975-501	291	404A2A17	Diode module
1B40604-1.2	62	411A99A10A35	Diode assy module
1B40604-1.2	123	404A2A34	Diode assy module
1B40604-1.2	153	404A3A7	Diode assy module
1B40604-1.2	154	404A3A50	Diode assy module
1B40604-1.2	155	404A3A42	Diode assy module
1B40604-1.2	157	404A3A51	Diode assy module
1B40824-507.1	120	403	Check valve
1B40824-507.1	121	403	Check valve
1B40824-507.1	123	403	Check valve
1B40824-507.1	124	403A74	Check valve
1B40887-501	253	404A3A16	10 amp mag latch relay mod
1B40887-501	255	404A3A10	10 amp mag latch relay mod
1B40887-501	267	404A3A2	10 amp mag latch relay mod
1B40887-501	268	404A3A6	10 amp mag latch relay mod
1B40887-501	319	404A2A15	10 amp mag latch relay mod
1B40887-501	320	404A45A6	10 amp mag latch relay mod
1B40887-501	321	404A3A18	10 amp mag latch relay mod
1B40887-501	324	404A3A46	10 amp mag latch relay mod
1B40887-501	325	411A99A10A4	10 amp mag latch relay mod
1B40887-501	337	404A3A8	10 amp mag latch relay mod
1B40887-501	338	404A3A4	10 amp mag latch relay mod
1B40887-501	348	411A99A10A5	10 amp mag latch relay mod
1B42290-507	47	403A74A1	LOX press control module
1B51211-505	14	404A45	Aft 56 volt pwr dist assy
1B51354-513	13	404A2	Aft 28 volt pwr dist assy
1B51361-1	360	404	H_2 vent purge check valve
1B51361-1	377	404	H_2 vent purge check valve
1B51361-1	385	404	H_2 vent purge check valve
1B51361-1	390	403	H_2 vent purge check valve
1B51361-1	398	404	H_2 vent purge check valve
1B51361-501	319	403A74A3	H_2 vent purge check valve
1B51361-501	408	403A73A4	H_2 vent purge check valve
1B51379-521	12	411A99A10	Fwd pwr dist mount assy
1B52624-513	25	411S4	Pressure switch
1B52624-513	27	411S2	Pressure switch
1B52624-515	55	403S8	Pressure switch
1B52624-519	20	403S5	Pressure switch
1B52624-519	34	403S1	Pressure switch
1B52624-519	36	403S6	Pressure switch
1B53920-501	41	403 (LH_2)	Chill feed duct check valve
1B53920-503	62	427 (LH_2)	Chill feed duct check valve
1B53920-503	63	424 (LOX)	Chill feed duct check valve
1B55200-505	1018	403A73A3	LH_2 press control module

5.7 (Continued)

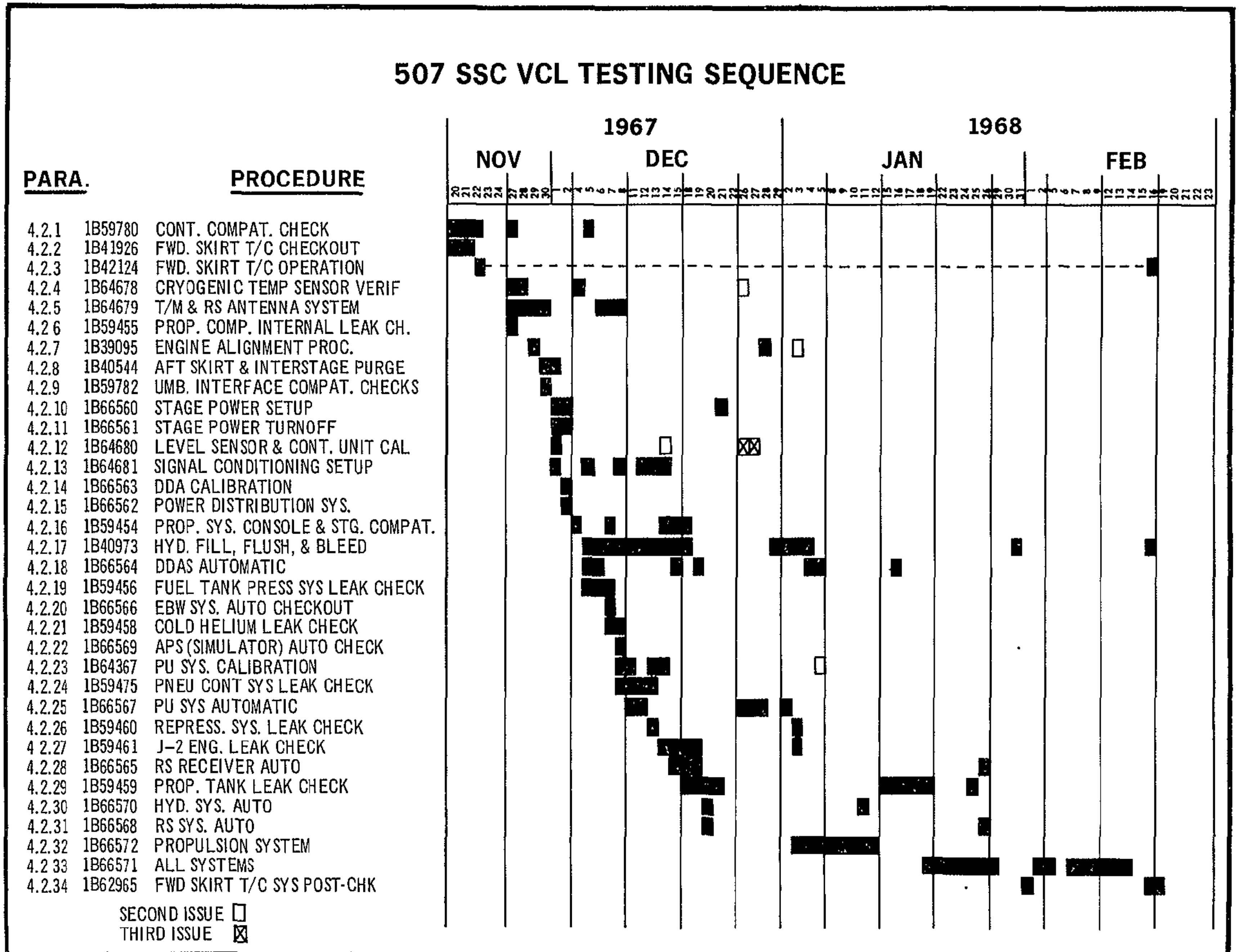
P/N	S/N	Ref Location	Name
1B55408-503	2012	—	Compressed air tank
1B57731-1	359	404A71A19	Control relay package
1B57731-1	360	404A51A4	Control relay package
1B57781-507	10	403A74A2	Cold helium fill module
1B58006-401	53	403A74	1A49991, teflon wrapped
1B59010-503-010	126	427A7	Pneu prop control valve
1B59010-503-010	128	424A7	Pneu prop control valve
1B62600-509-009C	14	403	O_2H_2 welded burner assy
1B62778-503	14	403A6	Helium plenum and valve assy
1B62778-503	38	403A7	Helium plenum and valve assy
1B65319-503	14	404A70A1	Sw Sel emissivity cont assy
1B65673-1	21	—	Cold helium check valve
1B66230-505	1018	403A73A3	Calibrated LH_2 press con mod
1B66639-503	31	403	Pneu latching actuator assy
1B66639-503	32	403	Pneu latching actuator assy
1B66692-501	97	411A3-17	Actuation control module
1B66692-501	99	411A30-17	Actuation control module
1B66692-501	100	404A44	Actuation control module
1B66692-501	102	411A2-13	Actuation control module
1B66692-501	103	403A15	Actuation control module
1B66692-501	107	404A43	Actuation control module
1B66692-501	108	404A9	Actuation control module
1B66692-501	109	403A75A1	Actuation control module
1B66692-501	110	404A17	Actuation control module
1B66692-501	177	403	Actuation control module
1B66868-501	15	Tank pos 9	Amb helium storage sphere
1B66868-501	18	Tank pos 10	Amb helium storage sphere
1B66868-501	26	Tank pos 7	Amb helium storage sphere
1B66868-501	31	Tank pos 1	Amb helium storage sphere
1B66868-501	32	Tank pos 5	Amb helium storage sphere
1B66868-501	33	Tank pos 8	Amb helium storage sphere
1B66868-501	34	Tank pos 6	Amb helium storage sphere
1B66868-501	35	Tank pos 2	Amb helium storage sphere
1B67193-507	16	411A32L1	Continuous vent control mod
1B67481-1	77	411A3-17	Check valve assembly
1B67481-1	83	411A3-17	Check valve assembly
1B67481-1	92	411A30-17	Check valve assembly
1B67481-1	129	411A30-17	Check valve assembly
1B67481-1	146	403A15	Check valve assembly
1B67481-1	150	403A15	Check valve assembly
1B67481-1	175	403A75A1	Check valve assembly
1B67481-1	188	403A75A1	Check valve assembly
1B67481-1	205	411A2-13	Check valve assembly
1B67481-1	219	411A2-13	Check valve assembly
1B67481-1	621100	404A44L1	Check valve assembly

5.7 (Continued)

P/N	S/N	Ref Location	Name
1B67481-1	621135	404A9L1	Check valve assembly
1B67481-1	621145	404A43L1	Check valve assembly
1B67481-1	804155	403	Check valve assembly
1B67481-1	7062129	404A9L2	Check valve assembly
1B67481-1	7062136	404A17L1	Check valve assembly
1B67481-1	7062146	404A17L2	Check valve assembly
1B67481-1	7062150	404A44L2	Check valve assembly
1B67481-1	7062168	404A43L2	Check valve assembly
1B67481-1	8010562	403L2	Check valve assembly
1B67481-1	8010563	403L1	Check valve assembly
1B67598-501	46	403	Pneumatic check valve
1B67598-503	11	403A74A3	Pneumatic check valve
1B67598-503	24	403A73A4	Pneumatic check valve
1B69550-1	26	403A74A3	Repress control module
1B69550-1	27	403A73A4	Repress control module
7851823-503	1083	APS He inlet	Helium control disconnect
7851823-503	1088	APS He inlet	Helium control disconnect
7851844-501	13	427	Cold helium disconnect
7851861-1	55	427	LH_2 tank press disconnect
40M39515-113	259	404A75A1	EBW firing unit
40M39515-113	260	404A75A2	EBW firing unit
40M39515-113	290	404A47A1	EBW firing unit
40M39515-113	291	404A47A2	EBW firing unit
40M39515-119	452	411A99A12	EBW firing unit
40M39515-119	550	411A99A20	EBW firing unit
103826	J2119	401	J-2 engine

APPENDIX I

TESTING SEQUENCE


507 SSC VCL TESTING SEQUENCE
1967
1968
NOV
DEC
JAN
FEB
PARA.
PROCEDURE
4.2.1 1B59780 CONT. COMPAT. CHECK
4.2.2 1B41926 FWD. SKIRT T/C CHECKOUT
4.2.3 1B42124 FWD. SKIRT T/C OPERATION
4.2.4 1B64678 CRYOGENIC TEMP SENSOR VERIF
4.2.5 1B64679 T/M & RS ANTENNA SYSTEM
4.2.6 1B59455 PROP. COMP. INTERNAL LEAK CH.
4.2.7 1B39095 ENGINE ALIGNMENT PROC.
4.2.8 1B40544 AFT SKIRT & INTERSTAGE PURGE
4.2.9 1B59782 UMB. INTERFACE COMPAT. CHECKS
4.2.10 1B66560 STAGE POWER SETUP
4.2.11 1B66561 STAGE POWER TURNOFF
4.2.12 1B64680 LEVEL SENSOR & CONT. UNIT CAL.
4.2.13 1B64681 SIGNAL CONDITIONING SETUP
4.2.14 1B66563 DDA CALIBRATION
4.2.15 1B66562 POWER DISTRIBUTION SYS.
4.2.16 1B59454 PROP. SYS. CONSOLE & STG. COMPAT.
4.2.17 1B40973 HYD. FILL, FLUSH, & BLEED
4.2.18 1B66564 DDAS AUTOMATIC
4.2.19 1B59456 FUEL TANK PRESS SYS LEAK CHECK
4.2.20 1B66566 EBW SYS. AUTO CHECKOUT
4.2.21 1B59458 COLD HELIUM LEAK CHECK
4.2.22 1B66569 APS (SIMULATOR) AUTO CHECK
4.2.23 1B64367 PU SYS. CALIBRATION
4.2.24 1B59475 PNEU CONT SYS LEAK CHECK
4.2.25 1B66567 PU SYS AUTOMATIC
4.2.26 1B59460 REPRESS. SYS. LEAK CHECK
4.2.27 1B59461 J–2 ENG. LEAK CHECK
4.2.28 1B66565 RS RECEIVER AUTO
4.2.29 1B59459 PROP. TANK LEAK CHECK
4.2.30 1B66570 HYD. SYS. AUTO
4.2.31 1B66568 RS SYS. AUTO
4.2.32 1B66572 PROPULSION SYSTEM
4.2.33 1B66571 ALL SYSTEMS
4.2.34 1B62965 FWD SKIRT T/C SYS POST-CHK
SECOND ISSUE
THIRD ISSUE

APPENDIX II

TABLES

TABLE I. FAILURE AND REJECTION REPORTS OF
PERMANENT NONCONFORMANCES, STRUCTURAL ASSEMBLIES

Section 1. Propellant Tank Assembly, P/N 1A39303-535

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A243998 7-21-67	During cure of the tile and glass liner installation in the LH_2 tank aft dome at segment 8, segment 9, and seam 7, there was a vacuum leak for a period of 1/2 hour with a vacuum reading of 24 in. hg. Leaks in the PVC bag should be sealed within 15 minutes and pressure should be maintained at 20 in. hg during cure of tile and liner per DPS 23003.	A 2 in. diameter area of glass liner was removed at five random areas. Freshly grit blasted aluminum plugs 1 1/2 in. diameter were bonded to the exposed foam per engineering instructions. When cured, the foam was carefully cut vertically around the edge of the plugs. A special plug pull test was performed under the direction of MR and PM Engineering. Test results were acceptable to Engineering for use.
A248747 7-7-67	Weld seam 4 at aft dome was 0.015 in. above the parent metal and interferes with installation of support, P/N 1B37888-529.	The base of the support was reworked to accommodate the weld seam. The rework was acceptable to Engineering for use.
A248991 5-11-67	Elapsed time since cleaning prior to welding was 72 hours and 45 minutes. Should be no more than 72 hours per DPS 14052-5.	Aft dome was disassembled from cylinder, cleaned per DPS 41006, and reassembled. Aft dome-to-cylinder tank weld was performed within time limitation.
A257848 5-31-67	A dye check inspection of the aft dome-to-ring weld after milling showed intermittent linear dye check indications between aft dome weld seams 1 and 2, 5 and 6, 6 and 7, 7 and 8, 8 and 9, and 9 and 1.	Acceptable to Engineering for use.

TABLE I, Section 1 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A257858 5-5-67	Cylindrical tank assembly, P/N 1A39306-1, plane B was 0.060 in. out of perpendicular to plane A, should be maximum of 0.050 in.	The ring plane was shimmed to maintain the 0.050 in. tolerance required to maintain true cylinder centerline per blueprint requirement.
A257884 5-22-67	Aft dome-to-cylinder outside weld area exceeded the permissable time limit of 7 days between cleaning and production welding.	The weld area was blown down with dry N2 gas and vacuumed immediately prior to welding. This procedure was acceptable to Engineering.
A257952 6-6-67	a. The outer surface of the forward dome skin had a scratch 18 in. long, 1/32 in. wide, and 0.001 to 0.004 in. deep through anodic coating in segment 8. b. The forward dome skin had a scratch 12 in. long, 1/32 in. wide, and 0.003 in. deep through anodic coating in segment 2.	a and b. The scratches were blended and smoothed to an acceptable condition. The reworked area was touched up with alodine per DPS 41410.
A257955 6-7-67	Forward dome segment 4 had splattered acid stains on a 3 square foot area 12 in. forward of the bolting ring. Corrosion was suspected.	The acid stains were removed by wiping with rags moistened with water until a litmus paper check showed no acid remained. The stained areas were repainted per F-289 and accepted for use.
A261442 8-28-67	The C3 and C4 transducers inside the aft end of the LH_2 tank are located 13/16 in. and 21/32 in. respectively from face of anti-vortex screen to centerline of transducers with full adjust, this dimension should be $1 \pm 1/32$ in.	Acceptable to Engineering for use.

TABLE I, Section 1 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A261445 8-31-67	On the LH_2 tank cylinder segments numerous scattered and irregular shaped areas in the insulation tile sections with glass liner were raised approximately 1/16 in. above normal contour and were spongy when depressed where normal insulation is firm.	Random plug tests were performed on the insulation and glass liner to determine the bond tensile strength of the insulation and glass liner. The insulation in the defective areas was removed and replaced per Engineering instructions and DPS 23003. The rework was acceptable for use.
A261501 7-28-67	Strap assembly, P/N 1A39313-401-2, located in the upper RH portion of the main tunnel, had a void at the tip of the LH ear extending into the bond line.	The strap assembly was removed and reinstalled per drawing requirements and DPS 32330.
A261504 8-8-67	a. Two strap assemblies, P/N 1A39313-401-2, located in the main tunnel, were mislocated 1/8 in. too low. All straps should be parallel through entire length of the tunnel. b. Clamp assembly, P/N 1B50529-1, located in the main tunnel, is turned 7/32 in. out of parallel.	a. The two strap assemblies were removed and reinstalled in the correct location per drawing requirements and DPS 32330. b. Acceptable to Engineering for use.
A261526 7-31-67	An unauthorized removal of 1B66675-1 tile pads resulted in partial tiles and Lefkoweld adhesive remaining on the following segments: 7 pieces at segment 1; 7 pieces at segment 4; 2 pieces at segment 2; and 2 pieces at segment 9.	The high areas of the remaining partial tiles and Lefkoweld adhesive were removed by sanding with 180-240 grit paper. New 3D tiles, glass liners, and applicable coupons were bonded and cured per DPS 23003 and Engineering instructions. The rework was acceptable to Engineering for use.

TABLE I, Section 1 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A261527 8-8-67	The bond tensile strength of specimen 21 at segment 5 averaged 121 psi and included a minimum value of 40 psi. Specimen 28 at tank cylinder seams 3, 4, and 5 averaged 230 psi and included a minimum value of 82 psi. The tensile requirements per DPS 23003 are 150 psi or more average value with no value below 100 psi.	A 2 in. diameter area of glass liner was removed at 5 random areas on segment 5. Freshly grit blasted aluminum plugs 1 1/2 in. diameter were bonded to the exposed foam per Engineering instructions. When cured, the foam was carefully cut vertically around the edge of the plugs. A special plug pull test was performed under the direction of MR & PM Engineering. Test results were acceptable to Engineering for use.
A261529 8-14-67	Numerous gaps in the LH_2 tank insulation have been filled with MIL-Y-1140 glass fiber and 1P20075 adhesive. Gaps should have been filled per DPS 23003, paragraph 6.6.3 or 1A89613 L, general note 5, as applicable.	Acceptable to Engineering for use.
A261530 8-15-67	a. The bellmouth flange liner at dome segment 9 is bridged over the tile 3/8 in. high and 3/4 in. wide and filled with gap filler, should be filled with 3D foam strips and gap filler per DPS 23003. b. A gap in excess of 1/4 in. wide at aft dome segment 7 between stop off tile and bolsa was gap filled, and should be filled with 3D foam strips and gap filler per DPS 23003.	a,b, and c. All defects were acceptable to Engineering for use without rework.

TABLE I, Section 1 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A261530 (Continued)	c. The tile pad bonded on common dome, P/N 1B66675-1, at Vee block area is not gap filled per 1A89613L, zone 19, view G, and should be gap filled in bridged area of liner from end of tile to common dome per general note 6. Bridged area is in excess of 1/16 in. wide. This condition exists over 60 per cent of Vee block area.	
A261540 9-26-67	The glass liner inside the LH_2 tank has the following discrepancies:	a through h. All defects were acceptable to Engineering for use without rework.
	a. Delaminations varying from 1/2 in. to 4 in. diameter, 37 places at forward dome, 63 places at cylinder walls, and 4 places at aft cone.	
	b. Excessive overlap from 1 1/2 in. to 4 in., 3 places at forward dome, 11 places at cylinder walls, and one place at aft cone.	
	c. Insufficient overlap from 1/4 in. to 1/2 in., 12 places at forward dome, 11 places at cylinder walls, and one place at aft cone.	
	d. Foreign material under liner, 8 places at forward dome and 14 places at cylinder walls.	
	e. Unglassed tile, 5 places at forward dome, 28 places at cylinder walls, and 3 places at aft cone.	

TABLE I, Section 1 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A261540 (Continued)	f. Missing rub coat, one place at cylinder wall. g. Cold set rework should be vacuum rework, one place at forward dome and one place at forward dome ring. h. Loose glass liner around studs, 10 places at cylinder walls.	
A270884 8-24-67	The support installation, P/N 1B58100Y, is not installed per drawing as measured on centerline of clips from point A as follows: a. The 202.25 in. dimension should be 200.64 $\pm$ 0.250 in. per EO Y, view A. b. The 23rd clip is 1 in. out of alignment c. The center spacing between 22 clips do not maintain correct spacing per EO Y.	a,b, and c. All defects acceptable to Engineering for use without rework.
A271153 9-18-67	Inside the LH_2 tank, the stud fitting, P/N 1B55693-1, for the baffle and deflector installation, thirty-five places, had glass liner removed to 1 1/8 in. exposing the outer edge of flat base. Should be 1/16 $\pm$ 1/16 in. from knurled diameter of stud. Refer to 1A78175Y.	An additional doubler was fabricated and installed at each incorrectly trimmed area per drawing requirements and DPS 23003. The rework was acceptable for use.

TABLE I, Section 1 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-070-374 10-2-67	Stud, P/N SO 717A428-5, was broken. Stud was located inside LOX tank at aft end of segment, P/N 1B63286-33, adjacent to weld seam 6.	The remainder of the stud and weld material was removed and a smooth surface was obtained by spotfacing to a 7/16 in. diameter with a 0.062 radius to a maximum depth of 0.040 in. A new stud was installed per drawing requirements. The rework was acceptable for use.
500-070-391 10-3-67	The anti-vortex screen, P/N 1A48633-503, had discoloration at interior and exterior areas.	The anti-vortex screen was removed and replaced by an acceptable part.
500-070-421 10-4-67	Numerous delaminations between liner, P/N 1A78175-3, and tile throughout inside of LH_2 tank, that vary in size from 1 in. diameter to 24 in. diameter.	The delaminated areas were rebonded per Engineering instructions and DPS 23003. The rework was acceptable for use.
500-070-447 10-9-67	After the second elevated cure cycle, the glass impregnated fabric covering the foam insulation on the LH_2 feed duct was blistered and crystalized causing the resin to peal off and the foam to recede.	The glass epoxy and foam insulation was removed per Engineering instructions. New insulation and lining was installed per DPS 22001, DPS 21004, and 1A39322. The rework was acceptable for use.
500-070-455 10-9-67	The 3D tile number 23 located in the LH_2 tank at segment 9 was damaged while removing glass liner, P/N 1A89283-1.	The 3D tile was removed and replaced per Engineering directions and DPS 23003. The rework was acceptable for use.

TABLE I, Section 1 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-070-480 10-16-67	The inside surfaces of ring segment attach fittings, P/N 1B56515-1, have been cut by threads of end rod, P/N BRE 5577. Some places were cut to approximate depth of 0.010 in. and other places were scratched and marred sufficiently to remove the anodic and cause edge burrs.	Acceptable to Engineering for use.
500-070-498 10-18-67	a. Weld seams 1 and 8 on the common dome bulkhead forward face had dark discoloration areas 10 to 20 in. long. b. Segment 7 had a 6 by 8 in. area of discoloration near weld seam 7.	a and b. The discoloration was removed with 400 grit paper and the reworked area was treated with alodine per DPS 41410. The rework was acceptable for use.
500-070-501 10-18-67	A visual inspection inside the LH_2 tank revealed a cut through the liner and tile, 2 in. by 3/8 in. by 1/4 in. deep, adjacent to seam 6 on the forward dome.	The liner and tile were repaired per DPS 23003. The rework was acceptable for use.
500-073-268 10-23-67	The resin was still wet on the LH_2 feed duct impregnated glass fabric covering after cure.	The glass fabric lining was removed and replaced per DPS 21004 and applicable drawing specifications.
A271135 10-24-67	a. One extra 0.2495/0.2515 hole was drilled through attach flange of thrust structure 2.764 in. from forward end of stringers 21 3/4 and 22.	a. A 106264-9A bolt, SO 148A050-26J washer, and NS 102884-048 nut was installed in the extra hole and the washer was trimmed to clear adjacent clip.

TABLE I, Section 1 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A271135 (Continued)	b. Two holes through attach angle at forward end of thrust structure were drilled to 0.280 in. and should be 0.2495/0.2515 in.	b. The oversized holes were acceptable to Engineering for use.
	c. A deep gouge located near the edge of the attach angle was 0.010 in. deep.	c. The gouge was deburred and smoothed to provide a flat mating surface. The rework was acceptable to Engineering for use.
A271141 10-27-67	Wire harness, P/N 1B67208-1 was 150 3/4 in. long and should be 38 in. long.	Connector P36 was removed and wire was cut to correct length and reterminated to connector P36. After megger and continuity checks, rework was acceptable.
A271148 11-7-67	Tee, P/N 1A86607-501, on the tee duct assembly, P/N 1A87736-501, is welded 34 degrees counterclockwise out of rotation and interferes with installation of transducer, P/N 1A67863-519.	Acceptable to Engineering for use.
A271149 11-03-67	The liquid level transducer and control unit, P/N 1A68710-511, S/N D-67, was subjected to 500 VDC from megohmmeter during meg test at pin 11 on connector J1. Transducer should not be subjected to high voltage.	The liquid level transducer and control unit, S/N D-67, was removed and replaced by S/N C-53.

TABLE I (Continued)

Section 2. Forward Dome, P/N 1B64442-503

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A249118 3-17-67	The J-J clip-to-segment 2 inside weld showed a lack of fusion and undersized fillet.	The defective areas of the weld were chipped out and ground down to the setup line and mechanize rewelded. After X-ray, etch, and dye check, the rework was acceptable to Engineering for use.
A249127 3-18-67	X-ray 67-B27 of the LH_2 pressure port flange fitting-to-segment 4 weld showed a 0.065 in. void at root of weld and a void with tail.	The 0.065 in. void was acceptable to Engineering for use. The void with tail was ground out to setup line and mechanically rewelded. The rewelded area was scraped and smoothed to remove linear indications. After weld was X-rayed, etched, and dye checked, the rework was acceptable.
A249132 3-20-67	X-ray 67-B27 of the F-F fitting-to-segment outside weld showed less dense inclusions and a dye check showed number 3 porosity and linear indication.	The weld was ground down to the setup line in the defective areas and mechanically rewelded. After X-ray, etch, and dye check the rework was acceptable to Engineering for use.
A249190 4-14-67	The ovality of inside flange of F-F LH_2 vent fitting after welding fitting to segment 2 is 0.013 in. and should be 0.010 in. maximum per 1B64442.	Acceptable to Engineering for use.

TABLE I, Section 2 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A249193 4-17-67	Anodized surface of segment 3 had ten scratches with a maximum depth of 0.0015 in., also a brown discoloration spot on outside anodized surface in a 1 1/2 X 6 in. area.	Sharp edges of all scratches were broken and smoothed up to an acceptable condition. All reworked areas were touched up with alodine per DPS 41410. Discoloration spots were acceptable to Engineering for use.
A249200 4-19-67	Inside surface of segment 5 had a defect 1 1/2 in. long, 5/32 in. wide, and 0.003 in. deep.	The defect was scraped and smoothed to a depth of 0.005 in. and was acceptable for use.
A253628 4-19-67	Outside surface of segment 4 had a cold lap 0.002 in. high with a porous condition in a 3/8 X 1 in. area.	The defect was scraped out and smoothed up. After etch and dye check the rework was acceptable for use.
A253641 4-24-67	Visual inspection of forward dome showed inside surface of segment 3 had a pit 0.010 in. deep near seam 12; inside surface of segment 2 had a scratch 8 in. long and 0.002 in. deep adjacent to seam 12, also a scratch 1 1/4 in. long and 0.002 in. deep across inside weld pad at seam 1; inside surface of segment 3 had a scratch 1/4 in. long and 0.002 in. deep and a depression 0.002 in. deep adjacent to seam 2.	All defects were blended out and polished to an acceptable condition. The depth of the 0.010 in. pit was not increased during rework.
A253646 4-25-67	a. Stepped area 0.014 in. to 0.018 in. high, 1/2 in. wide, and 76 in. long on inside surface of segment 9 at aft end has a thickness of 0.149 in. to 0.153 in. and the thickness of the adjacent area is 0.135 in.	a and b. The stepped areas were ground flush with the adjacent areas. The rework was acceptable for use.

TABLE I, Section 2 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A253646 (Continued)	b. Stepped area 0.006 in. to 0.010 in. high, 1/2 in. wide, and 76 in. long on inside surface of segment 2 at aft end has a thickness of 0.142 in. to 0.146 in. and the thickness of the adjacent area is 0.134 in. to 0.137 in.	
A253647 4-25-67	Visual inspection of forward dome showed outside anodized surface of segment 8 had scratches and scuff marks with depth of 0.001 in. maximum; outside surface of segment 5 had anodic scuffed off in a 1/8 X 3 in. area; outside anodized surface of segment 2 had scratches, and scuff marks with a depth of 0.001 in. maximum; inside anodized surface of segments 1, 2, and 8 had brown discoloration spots 3/8 X 3/4 in. maximum size.	All scratches were polished out to an acceptable condition and touched up with alodine per DPS 41410. All scuff marks and discoloration spots were acceptable to Engineering for use.
A253683 5-5-67	The ovality of diameters of flange after welding to dome is 0.056 in. and should be a maximum of 0.022 in. per 1B64442.	Acceptable to Engineering for use.
A253687 3-8-67	Planes and radii check of forward dome showed the following defects: a. The concentricity of flange is 0.527 in. and should be 0.250 in. per QEC 1076B. b. Dimension B of the D-D fitting is -0.300 in. and should be + 0.250 in. per QEC 1076B.	a, b, c & d. All defects were acceptable to Engineering for use without rework.

TABLE I, Section 2 (Continued)

FARR NO.		DESCRIPTION OF DEFECTS	DISPOSITION
A253687 (Continued)	c.	Dimension B of the F-F fitting is -0.312 in. and should be + 0.250 in. per QEC 1076B.	
	d.	Contour is out of tolerance +0.006 in. at 30° latitude, 0° longitude; -0.015 in. at 30° latitude, 20° longitude; -0.035 in. at 30° latitude, 40° longitude; -0.007 in. at 30° latitude, 60° longitude; -0.015 in. at 30° latitude, 80° longitude; -0.010 in. at 30° latitude, 160° longitude; -0.006 in. at 78° latitude, 60° longitude.	

TABLE I (Continued)

Section 3. Cylindrical Tank Assembly, P/N 1A39306-511

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A248544 3-20-67	Skin segment 4 had irregular depressions in the land area of long seam 3 varying from flush to 0.0024 in. deep.	The irregular depressions were removed by grinding, scraping, and polishing tc maintain a 10 to 1 width to depth ratio, and not exceeding a depth of 0.010 in. After etch and dye check, the re-work was acceptable to Engineering for use.
A257853 5-3-67	The stud, number 10240, located inside tank at forward end, failed when torqued to 35 in.-pounds. The minimum torque requirement is 40 in.-pounds.	The stud was removed and the pad was spotfaced to a depth of 0.025 ± 0.005 in. depth and a new stud was installed per DPS 14170. The rework was acceptable for use.

TABLE I. (Continued)

Section 4. Liquid Oxygen Tank Assembly, P/N 1A39307-515

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A249187 4-13-67	Forward circumferential weld on LOX tank bulkhead installation, P/N 1A39307-461, terminated at 63 in. near seam 4.	The terminated area of weld was X-rayed and no defects were found. Weld was restarted at the termination point and mechanically completed.
A253630 4-20-67	Hi-lok hole, located in probe clip at bulkhead attachment 6 in. from seam 7, was elongated to 0.253 in. Should be 0.2465 in. to 0.2475 in. diameter.	Hi-lok hole was enlarged to 0.2595 in. diameter and a 1/64 in. oversized Hi-lok was installed.
A253639 4-24-67	The inside surface of the aft dome showed several gouges and scratches adjacent to the aft circumferential weld. Maximum depth of defects were 0.005 in.	All sharp edges were broken and all gouges were smoothed and blended. All scratches were removed by wire brush and sanding. Reworked areas were touched up with alodine per DPS 41410.

TABLE I. (Continued)

Section 5. Common Bulkhead Assembly, P/N 1A39309-501

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A237937 1-13-67	X-ray 66-B134 of lug 6 at the hoist fitting installation, P/N 1A39280-405, showed an elongated void.	Acceptable to Engineering for use.
A237961 1-19-67	The aft common face, P/N 1A39286-403, S/N 508, had numerous nicks, scratches, and scuffed areas in pads adjacent to welds on segments 1,2,3,4;5,6,7,8, and 9. Maximum depth of defects was 0.002 in.	Defects were smoothed and blended to an acceptable condition and touched up with alodine per DPS 41410.
A237970 1-20-67	The following discrepancies were found on the aft common face, P/N 1A39286-403, S/N 508:	
	a. The outside surface of segment 5 had a blended nick, 0.002 in. deep. Located 3/4 in. from seam 5 and 2 1/4 in. forward of aft trim line.	a. Acceptable to Engineering for use.
	b. The outside surface of segment 6 had several pits, 0.003 in. maximum depth. Located 1/2 to 1 1/2 in. from seam 5 and 1 to 1 1/2 in. forward of aft trim line.	b. Pits were blended and polished to a maximum depth of 0.004 in. Rework was acceptable for use.
A237996 1-27-67	A visual inspection of the aft surface of segment, P/N 1A39282-501, showed an unmilled spot 3/16 in. diameter, located 3 in. from seam 3.	The unmilled area was scraped and sanded flush with parent material. The rework was acceptable for use.

TABLE I, Section 5 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A242810 2-2-67	The aft face ring installation, P/N 1A39286-401, S/N 508, had several gouges from 0.003 to 0.007 in. deep, and numerous scratches and tooling marks with a maximum depth of 0.002 in.	All gouges, scratches, and tooling marks were smoothed out to an acceptable condition without increasing depth of defects.
A242816 2-2-67	A visual inspection of the forward common face assembly, P/N 1A39280-403, showed the following: a. Several pits on outside surface of segment 7 with a maximum depth of 0.003 in. b. Several scratches on outside surface of segments 3 and 8 with a depth of 0.001 in. c. Two gouges on outside surface, one each on segments 7 and 8, with a maximum depth of 0.002 in. d. Two small etch spatters on outside surface, one each on segments 4 and 5.	a. Acceptable to Engineering for use. b and c. All sharp edges of the scratches and gouges were smoothed out and polished. All bare spots in anodized areas were touched up with alodine per DPS 41410. d. The bare spots were touched up with alodine per DPS 41410.
A242821 2-3-67	The following discrepancies were found on aft face ring installation, P/N 1A39286-401, S/N 508: a. Anodized inside surface of segment 8 at stepped area adjacent to seam 8 was scuffed and scratched at several places. Maximum depth of scratches was 0.001 in.	a. Sharp edges of the scratches were broken and scuffed areas were smoothed out. Reworked areas were touched up with alodine per DPS 41410.

TABLE I, Section 5 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A242821 (Continued)	b. Anodized inside surface of segment 7 had several Pasajel spatter spots near aft end. Maximum size of spots was 3/4 X 3/32 in.	b. Areas where anodic had been removed were touched up with alodine per DPS 41410.
	c. Anodized inside surface of segment 7 had a black discoloration mark in a 1/8 X 3/16 in. area.	c. Discoloration was removed by light sanding and reworked area was touched up with alodine per DPS 41410.
A242838 2-7-67	The aft common center plate, P/N 1A39286 -501, S/N 508, had an "L" shaped scratch in segment 5, 3/8 in. long and 0.005 in. maximum depth.	The scratch was polished out without increasing depth of defect. After etch and dye check, the rework was acceptable for use.
A242845 2-8-67	A planes and radii check of the aft common bulkhead, P/N 1A39286-501, S/N 508, revealed that several areas were out of tolerance at 82° latitude at center plate weld area; + 0.105 in. at 110° longitude; + 0.095 in. at 120° longitude; 0.086 in. at 130° longitude; -0.045 in. at 270° longitude; -0.710 in. at 280° longitude; -0.715 in. at 290° longitude; -0.730 in. at 300° longitude; -0.740 in. at 310° longitude; -0.745 in. at 320° longitude; -0.707 in. at 330° longitude; -0.656 in. at 340° longitude; -0.630 in. at 350° longitude; -0.615 in. at 360° longitude. Blueprint tolerance is -0.108 to -0.608 in.	Acceptable to Engineering for use.
A242872 2-14-67	A visual inspection of the ring to face assembly weld showed the following: a. Several scratches with maximum depth of 0.002 in. and scraper marks with maximum depth of 0.005 in. adjacent to ring weld on inside and outside surfaces.	a and b. All defects were smoothed and blended. The rework was acceptable for use.

TABLE I, Section 5 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A242872 (Continued)	b. A shaver mark with maximum depth of 0.005 in. adjacent to ring weld on outside surface.	
A249145 3-27-67	A planes and radii check of the common bulkhead showed out of tolerance readings at 32° latitude as follows: -0.507 in. at 280° longitude; -0.510 in. at 300° longitude; -0.514 in. at 320° longitude; and -0.494 in. at 340° longitude. Required tolerances is -0.068 to -0.468 in.	Acceptable to Engineering for use.
A249175 4-7-67	A visual inspection of the forward face showed a ding 3/4 by 5/8 by 0.026 in. deep with short scratches at bottom of ding with maximum depth of 0.002 in.	All sharp edges were broken and defects were smoothed up without increasing depth of the defects. The reworked area was touched up with alodine per DPS 41410. The rework was acceptable for use.

TABLE I, (Continued)

Section 6. Aft Dome Assembly, P/N 1B63286-1

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A237946 1-16-67	The outside anodized surface of segment 2 had multiple scratches near aft dome fitting installation, P/N 1B63286-421.	The scratches were smoothed out without increasing depth to an acceptable condition. Reworked area was finished per Spec. F289.
A237956 1-18-67	The LOX pressure sensor fitting weld at inboard side of segment 7 had a depression 0.250 in. long, 0.125 in. wide and 0.032 in. deep.	After etch and dye check, the depression was acceptable to Engineering for use.
A237975 1-18-67	The outside surface of segment 8 has a brown discoloration spot 1 in. in diameter near R-R fitting.	Acceptable to Engineering for use.
A237985 1-24-67	The exterior surface of segment 6 had a scratch 5 in. long and 0.001 in. maximum depth.	All sharp edges were broken and the crack was smoothed out. Reworked area was finished per Spec. F289.
A242823 2-3-67	The following defects were found on segment 4: a. The inside and outside surfaces had several scratches with a maximum depth. depth of 0.001 in. b. The inside surface had two etch run off spots near C-C and D-D pads. c. The anodized inside surface had a bare area near C-C fitting on the thrust angle.	a. The scratches were buffed and polished to an acceptable condition and touched up with alodine per DPS 41410. b. Acceptable to Engineering for use. c and d. Defective areas were lightly buffed and polished to an acceptable condition and touched up with alodine per DPS 41410.

TABLE I, Section 6 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A242823 (Continued)	d. The outside surface had a 6 X 6 in. chafed area adjacent to D-D fitting.	
A242847 2-9-67	The outside surface of segment 3 had several surface blemishes near weld seam 3.	Defective areas were lightly scraped and sanded to an acceptable condition.
A242853 2-10-67	The outside surface of segment 9 had a scratch 12 in. long and 0.002 in. deep located 46 in. from forward trim line.	All sharp edges were broken and the scratch was smoothed out to an acceptable condition and touched up per Spec. F289.
A242875 2-15-67	The inside surface of segment 8 had a scratch 2 1/4 in. long and 0.022 in. deep near center of segment.	All sharp edges were broken and the scratch was smoothed out to an acceptable condition and touched up per Spec. F289.
A249029 3-1-67	Ovality of flange diameter on segment, P/N 1B63286-25, is 0.0428 in. should be maximum of 0.022 in. per 1B63286, zone 26.	Acceptable to Engineering for use.
A249067 3-13-67	X-ray 67-B4 of E-E elbow weld on segment 9 showed more dense inclusions.	Acceptable to Engineering for use.
A249069 3-13-67	X-ray 67-B4 of B-B elbow weld on segment 2 showed clustered porosity and more dense inclusions.	Acceptable to Engineering for use.
A249070 3-13-67	X-ray 67-B4 of AF-AF elbow weld showed more dense inclusions.	Acceptable to Engineering for use.

TABLE I, Section 6 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A249072 3-14-67	Dye penetrant inspection of V-V elbow weld on segment 4 showed connected porosity on inside and outside welds.	The defects were ground out, cleaned and manually rewelded to an acceptable condition.
A249101 3-14-67	Level sensor stud on inside surface of segment 7 adjacent to flange weld has deformed threads.	Acceptable to Engineering for use.
A249111 3-16-67	The outside surface of V-V elbow at segment 4 had an indentation 3/32 in. diameter X 0.008 in. deep, also intermittent nicks and tool marks with maximum depth of 0.002 in. located adjacent to elbow-to-tube weld.	All sharp edges of nicks were broken and the indentation, nicks, tool marks were smoothed out to an acceptable condition and touched up with alodine per DPS 41410.
A249112 3-16-67	The B-B elbow on segment 2 had the following defects: a. Outside surface of elbow had two scratches 1/2 in. long and 0.002 in. deep and a chatter mark 5/8 in. long and 0.002 in. deep adjacent to elbow-to-tube weld. b. Inside surface of fitting had a depression 0.015 in. deep at elbow-to-tube weld. c. Inside surface of fitting had a gouge 0.005 in. deep at the longitudinal weld.	a. All sharp edges were broken and the scratches and chatter marks were smoothed out and dye checked. The rework was acceptable. b and c. The depression and gouge were smoothed out and dye checked. The rework was acceptable.
A249113 3-16-67	Outside surface of AF-AF elbow on segment 1 had intermittent gouges and scratches with a maximum depth of 0.003 in.	All sharp edges were broken and defects were smoothed and dye checked. Rework was acceptable for use.

TABLE I, Section 6 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A249114 3-16-67	Inside surface of E-E fitting on segment 9 had a depression 0.013 in. deep at juncture of elbow-to-fitting weld, and aft longitudinal weld, gouges adjacent to elbow-to-fitting weld, and a rough area adjacent to radius of inside flange.	Depression, gouges, and rough area were smoothed, dye checked and accepted for use. All reworked areas were touched up with alodine per DPS 41410.
A249122 3-20-67	X-ray 67-B4 of the U-U elbow weld on segment 4 showed connected porosity.	Acceptable to Engineering for use.
A249134 3-21-67	X-ray 67-B4 of the AC-AC elbow on segment 2 showed a lack of fusion.	The defect was ground out and rewelded. The rewelded area was etched, dye checked, and X-rayed. The rework was acceptable to Engineering for use.
A249137 3-22-67	Flatness of inside flange of E-E fitting on segment 9 after welding elbow to fitting is 0.035 in. should be maximum of 0.015 in. per 1B63286.	Acceptable to Engineering for use.
A249150 3-28-67	X-ray 67-B4 of the VV-VV flange-to-elbow weld shows a 0.050 in. void	Acceptable to Engineering for use.
A249159 3-29-67	Planes and radii check showed the following discrepancies. a. At 82° latitude the longitudinal readings were: -0.085 in. at 160°; -0.050 in. at 180°; -0.037 in. at 200°; -0.040 in. at 220°; and -0.068 in. at 240° The longitudinal readings should be -0.100 to -0.400 in.	a thru g. Acceptable to Engineer- for use.

TABLE I, Section 6 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A249159 (Continued)	b. An average of 18 readings at 82° latitude is -0.164 in. and should be -0.90 to -0.310 in.	
	c. The LOX instrumentation probe measurement "A" is 0.231 in. and should be 0.250 in. maximum.	
	d. The LOX chill return measurement "B", maximum minus minimum, is 0.115 in. and should be 0.051 in. maximum.	
	e. The LOX chill pump measurement "D" is 0.046 in. and should be 0.040 in. maximum.	
	f. The LH_2 fill line measurement "B" maximum minus minimum, is 0.145 in. and should be 0.129 in. maximum.	
	g. The LOX helium heater measurement "B", maximum minus minimum, is 0.076 in. and should be 0.051 in. maximum.	

TABLE I (Continued)

Section 7. Forward Skirt Assembly, P/N 1A39264-511

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A261565 9-12-67	Insert securing attach bolt to dummy plug connector, P/N 1B29346-1, was missing on forward end of panel, P/N 1A98147-505 at stringer 25.	A NAS 679C3 nut, in place of the insert, was used to secure the NAS 1303 bolt to the dummy plug connector. The rework was acceptable for use.
A261567 9-12-67	Sleeve, P/N BN330-1032-1, and expander, P/N BB341-1032, at stringer 13 are located 1 3/4 in. from top of frame segment to centerline of hole, should be 1 5/8 ± 1/32 in. The mislocated hole caused interference with installation of thermoconditioning piping.	The piping clamp was relocated and secured to stringer 12. The rework was acceptable for use.
A261572 9-19-67	a. Connector P16, P/N 1A97867-521, of wire harness, P/N 1B66060-1, pin C was recessed 1/2 in.	a. The recessed pins were removed and replaced per DPS 54002-5.
	b. Connectors J1 and J2, P/N 1A97493-583, of wire harness, P/N 1B66969-1, pin H in connector J1 was recessed and pins R and Z in connector J2 were recessed.	b. Connectors J1 and J2 were removed and replaced per FARR 271131. The rework was acceptable for use.
A270838 8-15-67	The forward skirt skin, P/N 1A39264-803, had a 1 in. cracked and distorted area located 50 1/4 in. from aft interface between stringers 15 and 16.	A 1 5/8 in. cutout was made in skin to remove defects. A filler was fabricated of same gage and material as skin to fill the cutout and a 0.040 in. 75 STAL doubler was fabricated and installed to secure filler to skin. Sealant was applied between skin, doubler, and filler per DPS 25081. Alodine was applied per DPS 41410 and area was primed per DPS 42000.

TABLE I, Section 7 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A271086 8-24-67	Twenty four (24) 0.190/0.195 holes were misdrilled at station 623.97 through cap angles, P/N 1A39264-89 at stringers 55, 61, 67, 73, 79, 85, 91, and 97, also cap angles, P/N 1A39264-123 at stringers 56, 58, 59, 63, 65, 69, 71, 75, 77, 81, 83, 87, 89, 93, 95, and 99. Holes should have been drilled at station 621.702.	MS20470 AD6 rivets were installed in all misdrilled 0.190/0.195 holes. The rework was acceptable for use.
A271093 8-28-67	a. Cap angles, P/N 1A39264-89, are deformed a maximum of 0.070 in. aft of fittings, P/N 1A93888-1, at stringers 43, 49, and 61. Cap angles should be flat. b. A 0.091 in. shim is installed between cap angle, P/N 1A39264-89, and ring plane 4 at stringer 67. c. Two open pilot holes at stringer 71 and ring plane 3 attach to intercostal, P/N 1A39264-123. d. Support, P/N 1A39264-101, has short edge distance of 1/8 in. at stringer 17, should be 3/8 in.	a, b and d. Acceptable to Engineering for use. c. An MS 20470 AD5 rivet was added in line of support rivet pattern maintaining proper edge distance.
A271131 10-11-67	a. Connector, P/N 1A97493-583, had damaged locking devices at sockets D, g, and H. b. Connector, P/N 1A97493-583, had damaged locking devices at sockets R and Z.	a and b. Both connectors were removed and replaced. The rework was acceptable for use.

TABLE I, Section 7 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-038-306 9-29-67	Standing leg of extrusion at stringer 57 has been milled to a thickness of 0.043 in. in an area 1 in. wide and 26 in. long. Material thickness should be 0.050 $\pm$ 0.006 in.	Acceptable to Engineering for use.

TABLE I (Continued)

Section 8. Aft Skirt Assembly, P/N 1A39295-513

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A261215 6-15-67	Two lockbolt holes at station 220.750 intermediate frame assembly, P/N 1A87929-407.1, through the outboard frame cap, P/N 1A87929-69, web, P/N 1A87929-83, and tee, P/N 1A87929-93, were drilled and reamed to 0.2005 in. and should be 0.185/0.188 in.	R3007-T6 lockbolts and NAS 1080-6 collars were installed per DPS 13101.
A261564 9-7-67	The conductors on wire harness, P/N 1B58311-1, (404W15) and breakout to P1 and P2 connectors were bird caged.	All wires were pulled down and wires with excessive length were cut and reterminated to eliminate bird cage. After continuity and megger checks, the rework was acceptable for use.
A261568 9-13-67	Pin n in connector J1 was recessed at wire harness, P/N 1B50892-1, S/N 09.	The recessed pin was removed and replaced per DPS 54002-5. After megger and continuity checks, the rework was acceptable for use.
A261569 9-13-67	Wire shielding was exposed at aft end of connectors P2, P3, P4, and P5 at wire harness, P/N 1B67152-1, S/N 9584, located on panel 10 at stringer 98.	Contact 10 was removed and replaced in connectors P3, P4, and P5 and contacts 10 and 11 were removed and replaced in connector P2 per DPS 54002-10. After megger and continuity checks the rework was acceptable for use.
A261573 9-20-67	Connector P33 keyway was off center and would not mate with connector, P/N 5028CE-12-105, at wire harness, P/N 1B67089-1, S/N 07.	Connector P33 was removed, replaced, and contact checked per DPS 54002-2. The rework was acceptable for use.

TABLE I (Continued)

Section 9. Thrust Structure, P/N 1A39316-517

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A261480 7-25-67	Unauthorized 1/8 in. plugs of AD rivet material were installed in skin, P/N 1A68951-1, and panel, P/N 1B52893-15, at stringer 22 1/4 approximately 4 in. aft of forward ring frame. These holes were plugged because they were mislocated and interfered with zee angle, P/N 1B38493.	Acceptable to Engineering for use.
A271112 9-21-67	Two 0.190/0.195 holes in tee, P/N 1A39316-147, are mislocated. The holes are located 15 in. aft of forward attach angle face plate to first hole and 1 1/2 in from first hole to second hole, and should be 14 1/2 in. to first hole and 1 1/2 in. from first hole to second hole.	Acceptable to Engineering for use.

TABLE II. PERMANENT NONCONFORMANCES AND FUNCTIONAL FAILURE AND REJECTION REPORTS DURING STAGE SYSTEM CHECKOUTS

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A261154 12-21-67	With 250 volts applied, each pin of temperature transducer, P/N 1A67862-502, S/N 602, was shorted to case, there should be greater than 50 megohms between any one pin and case.	Transducer, S/N 602, was removed and returned to vendor for rework or replacement. A new transducer, S/N 600, was installed.
A271227 11-20-67	Water was found at three instrumentation bulkhead fittings above LOX tank vent relief valve near stringer 18.	The instrumentation lines were purged per Engineering instructions until dew point readings were in compliance with DPS 43110. Pressure switch, P/N 1B52624-515, S/N 046, was removed and a new switch, S/N 055 was installed. Three pressure transducers, P/N 1B43324-601, S/N's 48-14, 48-15, and 48-16 were removed and replaced with new transducers, S/N's 76-1, 48-9, and 73-1, respectively. The rework was acceptable for use.
A271231 11-28-67	Check valve, P/N 1B40824-505, S/N 149, failed internal leak check. With 28 ± 3 psig applied, reverse leakage was 9400 scim. Valve, S/N 149, was removed and valve, S/N 158, was installed and failed same test. With 28 ± 3 psig applied, reverse leakage was 640 scim. Maximum allowable leakage is 20 scim. Defects were noted during propulsion components internal leak checks, H&CO 1B59455.	Check valves, S/N 149 and S/N 158, were removed and returned to vendor for rework or replacement. A new check valve, S/N 224, was installed and was acceptable for use.
A271232 11-28-67	During system checkout the coaxial cable, P/N 1B58360-501, S/N 9849-3, was loose and turned in the 411W206-P2 connector.	Connector P1 was removed and replaced and connector P2 was reworked per DPS 54006-3. The rework was acceptable.

TABLE II. (Continued)

FARR NO.	DESCRIPTION OFDEFECTS	DISPOSITION
A271233 11-29-67	With 5 ohm loads installed at connectors J1, J2, J4, and J6 on power divider, P/N 1B38999-1, S/N 037, the insertion loss from connector J1 to connector J5 was 22.3 decibels and should have been 24 ± 1.5 decibels. Defect was noted during telemetry and range safety antenna systems check, H&CO 1B64679.	The defective power divider, S/N 037, was removed from the stage for retesting and was replaced by a new power divider, S/N 043.
A271234 12-6-67	Power detector, P/N 1A74776-503, S/N 2-0177, voltage was adjusted to 109 mv. Unable to adjust R6 to 115 ± 3.45 mv. Defect was noted during the telemetry and range safety antenna systems check, H&CO 1B64679.	Power detector, S/N 2-0177, was removed and returned to vendor for rework or replacement. A new power detector, S/N 2-0131, was installed.
A271235	Output voltage of reflected power detector, P/N 1A74776-501, S/N 286, was 0 vdc and should have been 9.1 vdc ± 3 per cent. Defect was noted during the telemetry and range safety antenna systems check, H&CO 1B64679.	Reflected power detector, S/N 286, was removed and returned to vendor for rework or replacement. A new power detector, S/N 2-0131, was installed.
A271236 12-8-67	Module, P/N 1B57781-503-003, S/N 029, had excessive seat leakage of 200 scim. Allowable leakage is 12.5 scim. Defect was noted during cold helium systems leak check, H&CO 1B59458.	Module, S/N 029, was removed and returned to vendor for rework or replacement. A new module, S/N 038, was installed.
A271237 12-8-67	The high pressure relief valve, P/N 1A66242-503, S/N 06177-15,, closed at 3396 psid and should have closed at a minimum of 3760 psid. The malfunction occurred during the hydraulic system fill, flush, bleed, and fluid samples test, H&CO 1B40973.	The defective valve, S/N 06177-15, was removed and a new valve, S/N 06177-38, was installed.

TABLE II. (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A271239 12-8-67	Pipe assembly, P/N 1B58807-1, leaks at connection to pipe assembly, P/N 1B58838, at stringer 8 1/2 on thrust structure. The leak was caused by a 0.001 in. deep gouge on the boss seat. Defect was noted during cold helium system leak check, H&CO 1B59458.	The defective pipe assembly was removed and replaced with a new part.
A271240 12-12-67	Pipe assembly, P/N 1B65099-1, failed leak check due to gall marks on upstream flare. Defect was noted during the pneumatic control system leak check, H&CO 1B59457.	The defects were polished out per Engineering instructions and the pipe assembly was cleaned per DPS 43000. The rework was acceptable for use.
A271241 12-12-7	Pressure switch, P/N 1B52624-515, S/N 50, had a blowing leak through the diaphragm. Defect was noted during pneumatic control system leak check, H&CO 1B59457.	Investigation revealed that the wrong type pressure switch had been installed. Pressure switch, P/N 1B52624-515, S/N 50 was removed and the correct type of switch, P/N 1B52623-515, S/N 58, was installed.
A271242 12-12-7	The liquid level control unit, P/N 1A68710-509, S/N D83, was suspected of malfunctioning because the fast fill indication could not be turned on. The unit could not be adjusted per procedure 1B64680. Defect was noted during the fill, flush, bleed, and fluid samples, hydraulic system check, H&CO 1B66567.	The liquid level control unit, S/N D83 was removed and a new control unit, P/N 1A68710-509, S/N C-66 was installed. The defective control unit was returned to vendor for rework or replacement.

TABLE II. (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A271244 12-14-67	The electrode at the end of the helium heater exciter, P/N 1B59986-503, S/N 048, was bent approximately 10 degrees and was unable to check the spark gap and tip alignment per 1B67337.	The defective helium heater exciter, S/N 048, was removed and a new unit, S/N 029 was installed.
A271245 12-14-67	The electrode at the end of the helium heater exciter, P/N 1B59986-503, S/N 047, was bent approximately 10 degrees and was unable to check the spark gap and tip alignment per 1B67337.	The defective helium heater exciter, S/N 047, was removed and a new unit, S/N 051 was installed.
A271247 12-18-67	The fuel tank ullage transducer kit, P/N 1B40242-599, S/N 599-2, had an ambient output of 21.0 psia and should have been 14.7 ± 1.0 psia. The 20 per cent calibration was 3.989 vdc and should have been 1.0 ± 0.1 vdc. Defects were noted during DDA system check, H&CO 1B66564.	The defective fuel tank ullage transducer kit, S/N 599-2 was removed and a new transducer kit, S/N 599-15 was installed.
A271248 12-19-67	The thrust chamber pressure transducer, P/N NA5-27412T10T, S/N 6434A, low cal was 0.794 vdc and should have been 0.915 vdc; high cal was 3.80 vdc and should have been 3.918 vdc; and ambient was -0.207 vdc and should have been -0.087 vdc.	The defective transducer, S/N 6434A, was removed and a new transducer, S/N 6726A, was installed.
A271249 12-19-67	The main fuel injection pressure transducer, P/N NA5-27412T15T, S/N 6772A, low cal was 0.764 vdc and should have been 0.866; high cal was 3.743 vdc and should have been 3.863 vdc.	The defective transducer, S/N 6772A, was removed and a new transducer, S/N 7999A, was installed.

TABLE II. (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A271250 12-19-67	Pin 17 in connector J6 at the LOX tank electrical feed-thru, P/N 1B37873-521, S/N 06, had intermittent short to case ground. The defect was noted during the DDA system check, H&CO 1B66564.	Transducer, P/N 1A67862-505, S/N 602, reference designation 406MT-661, was removed and a new transducer, S/N 600, was installed. Test per procedure 1B42499 verified that pin 17 was isolated from case ground.
A271258 11-22-67	a. Contact A of P24 on wire harness, P/N 1B67089-1, S/N 6631, ref. designation 404W203, was bent 15 ± 5 degrees.	a. The bent contact was straightened per Engineering instructions. The rework was acceptable for use.
	b. The rubber insert of J4 on wire harness, P/N 67271-1, S/N 2, ref. designation 404A2W1, was punctured between contacts A and B.	b. Acceptable for use without rework.
A271276 12-19-67	a. The LH_2 burner feed duct, P/N 1B65206-503, S/N 10, had a vacuum reading of 1000 microns and should have been 250 microns or less. Defect noted during propellant tanks system leak check, H&CO 1B59459.	a and b. The defective duct assembly, S/N 10 was removed and a new duct assembly, S/N 8 was installed. Refer to FARR A271-282 for subsequent rejection.
	b. Filter installation threads on upstream end of LH_2 burner feed duct were contaminated with particles from removed filter.	
A271277 12-19-67	The threads on attach boss of filter, P/N 1B59008-501, S/N 1036904, were galled. The defect was noted during propellant tanks system leak check, H&CO 1B59459.	The defective threads were reworked per Engineering instructions. The reworked area was cleaned per DPS 43000 and was accepted for use.

TABLE II. (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A271278 12-22-67	a. There was a 5/32 in. hole through the skin at frame station 220 and stringer 13. b. The head of a 1/8 in. rivet was sheared off at frame station 220 and stringer 119.	a and b. Attachments were installed per drawing requirements. The rework was acceptable for use.
A271279 12-28-67	The hydraulic actuator, P/N 1A66248-507, S/N 78, installed at the pitch position, was leaking at the static seal on the rod end at bootstrap pressure of 65 psig. Drops of oil formed on the bolt heads in about 3 days. Defect noted after fill, flush, bleed, and fluid samples hydraulic system test, H&CO 1B40973.	The defective hydraulic actuator, S/N 78, was removed and a new actuator, S/N 81, was installed.
A271280 1-2-68	Flex hose, P/N 1B63006-1, S/N 07380H100048, had gall marks on sealing surface of female flared end and was unable to stop leakage during hydraulic system fill, flush, bleed and fluid samples test, H&CO 1B40973.	The defects were polished out of the flare per DPS 10001 and the rework was acceptable for use.
A271281 1-4-68	The LOX prevalve, P/N 1A49968-509, S/N 124, did not give a close indication. Troubleshooting revealed that there was no continuity between pins 11 and 12 in connector J1 with prevalve in either open or close position. There should be continuity with prevalve in the close position only. Defect was noted during propulsion system test, H&CO 1B66572.	The defective LOX prevalve, S/N 124 was removed and a new prevalve, S/N 146 was installed.

TABLE II. (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A271282 1-4-68	The thermocouple on duct assembly, P/N 1B65206-503, S/N 8, showed an open circuit. Defect noted during propellant tanks system leak check, H&CO 1B59459.	The defective duct assembly, S/N 8, was removed and replaced with a new duct, S/N 15. Refer to FARR A271288 for subsequent rejection.
A271283 1-5-68	Numerous channels on the channel decoder, P/N 1A74053-503, S/N 315, would not accept RACS commands to run mode. Defect noted during the DDA system test, H&CO 1B66564.	The defective channel decoder, S/N 315, was removed and a new decoder, S/N 347 was installed.
A271284 1-5-68	Transducer, P/N 1B40242-583, S/N 583-17, high RACS measured 2.025 vdc and should be 4.000 ± 0.100 vdc; low RACS measured -0.129 vdc and should be 1.000 ± 0.100 vdc; and the ambient measurement was 1461.625 psia and should be 14.700 ± 70 psia. The defect was noted during the DDS system test, H&CO 1B66564.	The defective transducer kit, S/N 583-17, was removed and a new unit, S/N 583-14, was installed.
A271288 1-24-68	The LH_2 feed duct, P/N 1B65206-503, S/N 15, failed leak check. The sealing surface at "J" dimension was 0.359 inch and should be 0.263 ± 0.005 in. Refer to Aeroquip drawing MR 101564. Defect noted during propellant tanks system leak check, H&CO 1B59459.	The defective LH_2 feed duct, S/N 15, was removed and returned to vendor for rework or replacement. A new duct, S/N 18, was installed.

TABLE II. (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A271289 1-25-68	The gas pressure regulator on the auxiliary hydraulic pump, P/N 1A66241-511, S/N X458911, leaked. Allowable leakage is 15 ± 5 psig. The gas pressure regulator leakage was 44.9 psig.	The O-rings in the gas pressure regulator were replaced by the vendor. The rework was acceptable to Engineering for use.
A271290 1-25-68	a. The range safety decoder, P/N 50M10698, S/N 0177, was suspected of malfunction during the DER evaluation for the umbilical-in run. During this run a range safety PD command was received by the DER and failed to go off until the receiver was turned off. This condition was noted when the range safety No. 2 inhibit was on or off. b. At connector J1 on the range safety decoder, pin 37 was slightly bent and pin 30 was badly bent and was riding pin 37. Defects were noted during all systems test, H&CO 1B66571.	a and b. The range safety decoder, S/N 0177, was removed and decoder, S/N 0026, was installed.
A271291 1-25-68	Pin No. 37 was missing from connector P12, P/N STK-06-445, on wire harness assembly, P/N 1B56379-1. Defect was noted during the all systems test, H&CO 1B66571.	The P12 connector was removed and replaced with a new connector. The rework was acceptable for use.
A271294 1-16-68	The LOX fill and drain valve, P/N 1A48240-505, S/N 0041, had a leakage of 23 scim. Maximum allowable leakage is 6.1 scim. Defect was noted during the propellant tanks system leak check, H&CO 1B59459.	The defective LOX fill and drain valve, S/N 0041 was removed and returned to vendor for rework. A new valve S/N 0122 was installed.

TABLE II. (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A271297 2-21-68	Wire, P/N F5170A20GA, to connector P36 on wire harness, P/N 1B66966-1, had a 4 in. split in the outer insulation.	The defective wire was removed and replaced per Engineering instructions. The rework was acceptable for use.
500-071-079 2-25-68	Two strap assemblies, P/N 1B28892-501, were mislocated in the main tunnel area. One strap assembly was located 132 31/32 in. aft of station 554.702 and should be 131 31/32 in. The other strap assembly was located 141 1/2 in. aft of station 554.702 and should be 140 1/2 in.	The mislocated strap assemblies were removed per DPS 32330 and reinstalled to correct blueprint locations. The rework was acceptable for use.
500-071-486 1-2-68	Ten BJ5 rivets were missing from the aft intermediate frame assembly on the aft skirt at station 220.750.	NAS1398D-6 rivets were installed per DPS 13056 in place of the BJ5 rivets. The rework was acceptable for use.

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