DAC-56639 JANUARY 1969

HUNTINGTON BEACH

NARRATIVE END ITEM REPORT
SATURN S-IVB-508

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY

MCDONNELL DOUGLAS
CORPORATION

HUNTINGTON BEACH

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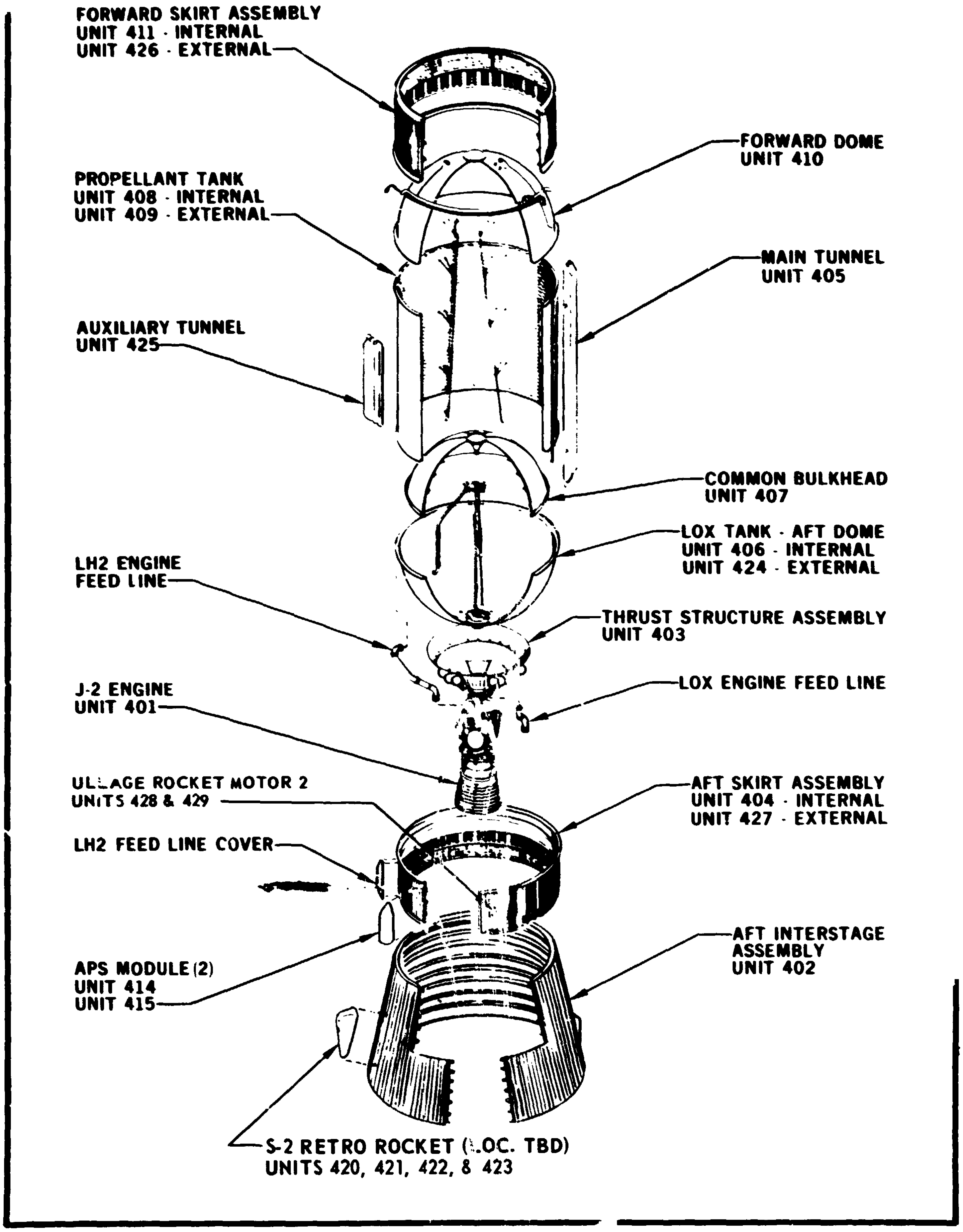


Exploded View of S-IVB Stage for Saturn V

ABSTRACT

The Narrative End Item Report contained herein is a narrative summary of the McDonnell Douglas Astronautics Company (MDAC), Western Division and Space Systems Center test records relative to the Saturn S-IVB-508 Flight Stage (MDAC P/N 1A39300-523, S/N 508).

Narrations are included on those 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 is also included There is no provision to update or revise this volume of the NEIR after initial release.

Descriptors

NEIR
Documentation
Configuration
Significant Items
Stage Checkout
Manufacture and Test

PREFACE

This Narrative End Item Report is prepared by the Reliability Assurance Directorate of the McDonnell Douglas Astronautics Company (MDAC), Western Division, for the National Aeronautics and Space Administration under contract NAS/-101. This report is presented in response to re. .rements of NPC 200-2, paragraph 14.2.4, and is issued in accordance with MSFC-DRL-021, Contract Data Requirements, which details the contract data required from MDAC. The report summarizes the period of initial stage acceptance testing at the MDAC Space Systems Center, Huntington Beach, California, and transfer to the MDAC Sacramento Test Center (STC), Sacramento, California.

The period of stage testing at STC, and turnover to the Florida Test Center (FTC), Cape Kennedy, Florida, will be covered by the Sacramento Narrative End Item Report, Saturn S-IVB-508, Report DAC-56640.

CONTENTS

CONTENTS (Continued)

CONTENTS (Continued)

APPENDIX I

APPENDIX II

APPENDIX III

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, 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, and data on time/cycle significant items.
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.

APPENDICES:

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

II. 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.

III. FLIGHT CRITICAL ITEMS INSTALLED AT TRANSFER. A listing of those flight critical items installed on the stage at the time of transfer to the Sacramento Test Center.

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 proce ., 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

1.4 (Continued)

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.

1.5 Stage Shipment

Transfer of the Saturn S-IVB-508 stage, for shipment to the Sacramento Test Center, was made on 30 December 1968 at the Space System Center, Huntington Beach. A letter, A3-131-KYAO-L-5633, dated 27 August 1968, from the McDonnell Douglas Astronautics Company - Western Division Contracts Manager to the NASA/MSFC Resident Management Office Contracts Manager, I-CO-SD/MDAC, covered the submittal of documentation for purposes of technical transfer of the stage to STC. The letter is referenced on the stage transfer paper, Form 68-67A, which is included in the Stage Log Book (reference Volume I, Part I, Section I).

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 (SSC) are summarized in paragraphs 2.1 and 2.2, respectively. The Final Inspection, Weight and Balance, and Preshipment Preparations are summarized in paragraphs 2.3, 2.4, and 2.5, respectively. Narrations on these tests and operations are presented in section 4.

Paragraph 2.6 summarizes any incomplete failure and rejection reports that were transferred open at the time of stage transfer from SSC to STC. Paragraph 2.7 summarizes any testing that was not completed prior to stage transfer, and any retesting that will be required.

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 8 and 9 August 1967, verified that the tank assembly could withstand the required test pressures without leakage or damage.

The propellant tanks leak check, conducted on 16 and 17 August 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 5 on 22 January 1968. Checkout of the stage systems started on 30 January 1968, and was completed on 29 May 1968, after 86 working days of activity. A total of 38 checkout procedures involving the stage systems were accomplished during this period. The stage was removed from the VCL on 26 June 1968. Narrations on the checkout procedures are presented in paragraph 4.2, in the order in which the tests were started. 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.

2.2 (Continued)

Prior to turning on the stage power, checks were made of the forward skirt thermoconditioning system, the stage wiring continuity and compatibility, the engine alignment, the cryogenic temperature sensors, the umbilical interface compatibility, and the aft skirt and interstage purge and thermoconditioning system. No major stage problems were encountered during these checks, although several procedure revisions were made. Two FARR's, written during the wiring continuity check, reworked a wire harness and replaced two connectors and a relay module. One FARR, written during the umbilical interface check, accepted another relay module after a recheck. These FARR's, and other FARR's noted below, are summarized in the applicable narration, and in Table II of Appendix II.

The propulsion component internal leak check and the fuel tank pressurization system leak check were also accomplished prior to stage power turn on. No major problems were encountered during these checks, although four leaks were found and corrected during the latter check, no FARR's were written. Several procedure revisions were made.

Power was first applied to the stage on 16 February 1968, with the initiation of the stage power setup and turn off procedures. No significant problems were encountered, although uninstalled and improperly adjusted items resulted in some malfunction indications during the first attempts. These minor problems were later corrected. Several procedure revisions were made, and one FARR was written to replace a relay module during subsequent use of the power setup procedure.

The signal conditioning equipment setup and the telemetry and range safety antenna system check were accomplished after numerous procedure revisions were made. No stage problems were encountered, and no FARR's were written. Most of the hydraulic system fill, flush, bleed, and fluid samples procedure was accomplished after some procedure revisions were made, and after two FARR's replaced the quick-disconnect on the auxiliary hydraulic pump and the air fill valve on the hydraulic accumulator/reservoir assembly. The procedure was satisfactorily completed after the all systems test was finished.

2.2 (Continued)

A series of manual and automatic tests were accomplished on the various stage electrical systems, with procedure revisions made as necessary. The propulsion system control console/stage compatibility check was accomplished with no significant problems, and with no FARR's written. The level sensor and control unit calibration was completed and was then reaccomplished using a revised procedure. One FARR replaced the LH_2 overfill control unit during this test. The DDAS calibration procedure was accomplished with no problems and with no FARR's written. Following the replacement of the remote analog submultiplexer (RASM) during the DDAS procedure, the RASM test part of the calibration was repeated, again with no problems. The power distribution system automatic checkout was completed after one FARR replaced the LH_2 chilldown inverter. The DDAS automatic checkout was completed after five FARR's replaced a channel calibration decoder, the remote analog submultiplexer, two pressure transducers, and the propellant utilization voltage monitor module. The auxiliary propulsion system (APS) simulator checkout and the propellant utilization calibration procedure were accomplished with no significant problems, and with no FARR action required.

A series of manual leak checks were performed to locate and correct any leakages in the stage pneumatic and pressurization systems. Revisions were made to these procedures as necessary. The pneumatic control system leak check was completed after four leakages were corrected. The cold helium system leak check located and corrected several leakages. No FARR's were written during either of these checks. The propellant tanks system leak check was completed after one leak was corrected. One FARR was written during this check because of nicks on the desiccant port flange. This condition was acceptable, as it did not prevent a good seal. An automatic propellant tank differential pressure scan was accomplished in conjunction with the manual propellant tanks leak check with no significant problems and with no FARR's written, although several procedure revisions were made. The J-2 engine system and the repressurization system were leak checked with four leaks corrected and with no FARR's written.

2.2 (Continued)

The exploding bridgewire (EBW) system and the propellant utilization system automatic checkouts were accomplished with no significant problems and with no FARR's written. The range safety receiver and system checkouts were completed after the correction of minor operating problems. No significant problems were encountered, and no FARR's were written. Several revisions were made to these procedures as required.

After the temporary installation of the APS modules onto the stage, the APS manual systems check was initiated and the APS module automatic check was accomplished. One leak was corrected during the manual check, and two FARR's were written during the automatic check, one to rework a debonded mounting flange and one to reject the control relay modules for defective operation. The relay modules were retained as interim use parts and were to be replaced later. Numerous revisions were made to these two new procedures. The manual check was completed after the all systems test was accomplished.

The hydraulic system automatic checkout was accomplished with no significant problems, although two procedure revisions were written. The propulsion system automatic checkout was satisfactorily completed after the correction of several minor problems, and the replacement of a temperature bridge by one FARR. Several revisions were made to the procedure.

The EMC RF signature and transient detection procedure was accomplished after a number of problems were corrected, including EMC detector mounting difficulties. This was the first use of this procedure, and sixty-two revisions were required. The radiated spectrum signature part of the procedure was deleted, as it would be accomplished at STC after a single sideband transmitter was installed on the stage. The conducted interference part of the procedure was completed, with two FARR's written to correct connector problems. The umbilicals-in part of the all systems test was performed to control the operation of the stage systems during the EMC procedure.

The individual systems tests were completed by the middle of May, and the final all systems test was accomplished on 17 and 20 May 1968. The umbilicals-in part of the test was completed on the first attempt, while the umbilicals-out

2.2 (Continued)

part of the test was completed on the fourth attempt; after the GSE checkout batteries were replaced to correct voltage problems. Fifty revisions were made to the procedure. No particular stage problems were noted during the test, but subsequent data evaluation indicated several out-of-tolerance conditions. Some of these conditions were attributed to defects in the GSE magnetic recording tape, but two FARR's were written to cover other problems. After the completion of the all systems test, the final hydraulic system shutdown operations were completed, the APS modules were removed from the stage, and the final thermoconditioning system post checkout procedure was accomplished between 24 and 28 May 1968, with no problems.

2.3 Final Inspection

A final inspection was accomplished by MDAC and AFQC personnel on all stage mechanical and electrical areas to locate and correct any remaining discrepancies. The inspection was completed on 19 December 1968, and was made to verify that the stage was in satisfactory condition for shipment to STC.

A total of 127 defects were noted during the inspection, of which 93 were in the mechanical areas and 34 were in the electrical areas. All of these discrepancies were corrected before the stage was shipped. However, some discrepancies were recapped to FARR's 500-568-631, 500-445-734, and 500-639-113 for corrective action. See paragraph 4.3 for additional details concerning the final inspection.

2.4 Weight and Balance

Following the final inspection, the stage was rotated to a horizontal position, and prepared for the weight and balance operation. On 18 December 1968 the stage was weighed by means of a three point electronic weighing system. Three electronic load cells, one aft and two forward, measure 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 26,897.3 pounds, the stage weight corrected for Standard Gravity in a vacuum was 26,960.9 pounds, and the stage longitudinal center of gravity was located at station 329.6. Paragraph 4.4 presents a more detailed narration on these operations.

2.5 Preshipment Purge

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 -32°F for the LH_2 system, and -34°F for the LOX system. The necessary desiccants were installed to maintain the proper stage environment during the air transport operations. Paragraph 4.5 presents a more detailed narration on this operation.

2.6 Incomplete FARR's

The following FARR's were incomplete at the time the stage was transferred to STC.

a. FARR 500-639-105 noted during inspection of the retainer rings on the oxidizer turbine bypass valve, P/N 409940, S/N 4093594, of the J-2 engine, P/N 103826, S/N 2122, that the gate end of link to piston pin is corroded.

b. FARR 500-639-113 noted that the LOX flowmeter, P/N 1A89104-507, S/N 31595, metal foil identification plate was not legible per DPS requirements. The FARR was dispositioned to remove the existing nameplate and replace it with a plate properly identified per 1A89104.

c. FARR 500-639-156 noted that two holes drilled in the bracket, P/N 1B57145-50, should have been drilled on the assembly to permit installing the coolant return line in an unrestrained position.

d. FARR 500-639-164 noted that it was suspected that the wrong type of spring may have been installed in the solenoid of the regulator, P/N 1B51753-511, S/N 19, of the module assembly, P/N 1B67193-507, S/N 018. The module assembly is installed in the forward skirt.

2.7 Incomplete Tests and Retest Requirements

There were no incomplete H&CO's. All VCL stage checkout procedures were activated and completed.

Subsequent to VCL checkout, various modifications were made to the stage. A detailed listing of these modifications and the AO, FARR, and removal work accomplished is provided by letter A3-850-KYCO-L-5782, dated 30 December 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.

Paragraph 4.6 comments upon the retesting that will be required at STC to verify the acceptability of the accomplished stage modifications.

3.0 STAGE CONFIGURATION

The paragraphs of this section define the configuration of the stage, and note the applicable variations. Paragraph 3.1 discusses the means used to verify the stage configuration; paragraph 3.2 describes those flight critical items which deviate from the stage design; and paragraph 3.3 contains those variations in stage configuration which represent changes in the scope of the program.

A listing, in tabular form, of all time/cycle significant items on the stage, along with the accumulated time/cycles for each item, is included in paragraph 3.4.

Existing contractual configuration control papers are referenced wherever possible.

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 508, revision A, dated 18 July 1968. 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.

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

3.2 (Continued)

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.

3.2.1 LOX and LH_2 Fill and Drain Valves

SEO 1A48240-007 authorized the removal of the existing bonded insert and O-ring from the electrical connectors, leak testing of the receptacles, and subsequent installation of an unbonded insert and O-ring for the LOX and LH_2 fill and drain valves, P/N 1A48240-505, S/N's 0132 and 0130, respectively. The unbonded inserts were installed to minimize cracking of the inserts and glass insulation at cryogenic temperatures, in accordance with NASA change order 1602.

3.2.2 Fuel Tank Vent and Relief Valve

SEO 1A48257-006 authorized the same replacement of the bonded insert with an unbonded insert, as described in paragraph 3.2.1, for the fuel tank vent and relief valve, P/N 1A48257-511, S/N 0058.

3.2.3 Directional Control Fuel Vent Valve

SEO 1A49988-003 accomplished the unbonded insert substitution, described in paragraph 3.2.1, for the directional control fuel vent valve, P/N 1A49988-501, S/N 0031, to minimize cracking at cryogenic temperatures.

3.2.4 Hydraulic Yaw Actuator Assembly

SEO 1A66248-012A authorized replacement of electrical connectors, P/N's 061-45703 and 061-45704, with connectors, P/N's 061-44051 and 061-44052, for hydraulic yaw actuator, P/N 1A66248-507, S/N 66. The bayonet studs on the electrical connectors, P/N's 061-45703 and 061-45704, were being sheared off under normal usage.

3.2.5 Chilldown Inverter Electronic Assembly

SEO 1A74039-016A authorized a reverse current test, a forward voltage test, a zener voltage differential test, and a surge current test on the chilldown inverter electronics assembly diode, P/N 1B52278-1, for chilldown inverter, P/N 1A74039-517, S/N's 074 and 075, to provide diodes that would meet their environmental requirements.

3.2.6 Actuation Control Modules

SEO 1B66692-004 authorized correction of electrical designations stamped in error on the actuation control modules, P/N 1B66692-501, S/N's 20, 128, and 132.

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 3.3.1 lists those SC's and ECP's which were incorporated in the initial design of the stage. Paragraph 3.3.2 lists and briefly describes those SC's and ECPs 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.

3.3.1 Scope Changes and Engineering Change Proposals Incorporated in the Initial Design

SC 1011B	SC 1100C	SC 1200	SC 1306
SC 1015	SC 1102A	SC 1204	SC 1354
SC 1016B	SC 1104A	SC 1211A	SC 1363
SC 1022B	SC 1115	SC 1221A	SC 1364
SC 1024	SC 1139A	SC 1230	SC 1390

3.3.1 (Continued)

SC 1026A	SC 1151	SC 1232A	SC 1397
SC 1027B	SC 1152	SC 1243	SC 1400
SC 1030A	SC 1167	SC 1266	SC 1402
SC 1031A	SC 1176	SC 1270	ECP X004
SC 1036B	SC 1180A	SC 1276	ECP X005
SC 1057	SC 1185	SC 1277	ECP X011
SC 1058	SC 1188	SC 1278A	ECP X012
SC 1075B	SC 1195A	SC 1280	ECP X043
SC 1092A	SC 1196	SC 1282	ECP X076
SC 1093B	SC 1198	SC 1294	ECP X095
SC 1096		SC 1295	ECP X105
SC 1098B			ECP X133
			ECP X147

3.3.2 Scope Changes and Engineering Change Proposals Incorporated and Verified Prior to Transfer

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.

3.3.2 (Continued)

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.

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 X198, authorized by CCO's 658 and 692, provided for revisions to the engine thrust OK circuits.

3.3.2 (Continued)

aa. ECP X199, authorized by CCO's 634 and 691, provided for redesign of the APS modules.

ab. ECP X204, authorized by CCO's 650, 661, 670, and 708, provided for deleting the pad safety and minimum liftoff pressure switches.

ac. ECP X209, authorized by CCO 847, provided for revisions to the forward skirt paint requirements.

ad. ECP X217, authorized by CCO 698, provided for the use of black teflon hoses for the hydraulic system.

ae. ECP X218, authorized by CCO 742, provided for the release of the enlarged LH_2 forward dome manhole.

af. ECP X226, authorized by CCO 690, provided for the implementation of the Apollo coordinate system standards.

ag. ECP X239, authorized by CCO 729, provided for the implementation of the safing engine start circuits.

ah. ECP X255, authorized by CCO 645, provided for the thermal insulation of the Model II switch selectors.

ai. ECP X259, authorized by I-V-S-IVB-TD-66-16, provided for modification of the LH_2 tank probe.

aj. ECP X262, authorized by CCO's 813 and 853, provided for modification of the EDS cutoff circuits.

ak. ECP X264, authorized by CCO 781, provided for deleting the rate gyro and accelerometers.

al. ECP X267, authorized by letter I-CO-SD-[illegible]-31-66, provided for test code plugs for the stage.

am. ECP 0271, authorized by CCO 798, provided for range safety system measurement requirements.

an. ECP 0273, authorized by CCO's 837 and 861, provided for the deletion of the LH_2 tank translunar vent termination pressure switch.

ao. ECP 0277, authorized by CCO 801, provided for the deletion of the pyrotechnic dispersion system.

ap. ECP 0281, authorized by letters I-CO-SD-L-192-66 and -L-380-66, provided for a common stage coolant system design effort.

aq. 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.

ar. ECP 0304, authorized by CCO 977, provided for the deletion of the vent termination pressure switch.

as. 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.

3.3.2 (Continued)

at. ECP 0318, authorized by CCO 956, provided for modification of the range safety controller safing plug.

au. ECP 0322, authorized by letter I-CO-S-IVB-6-319, provided for modification of the control relay packages.

av. ECP 0341-1, a compatibility ECP, provided for replacement of the low pressure cold gas check valve.

aw. ECP 0354, a compatibility ECP, provided for a thermal barrier for the ambient helium fill module.

ax. ECP 0364, a compatibility ECP, provided for the addition of a check valve to the APS helium supply line.

ay. ECP 0441, authorized by CCO 934, provided for reworking the remote analog submultiplexer.

az. ECP 0443-1R1, authorized by CCO 1045, provided for a hazardous gas detection system.

ba. ECP 0444R1, a compatibility ECP, provided for installing wiring in branched wire harness 403W4.

bb. ECP 0449, a compatibility ECP, provided for modification of the forward skirt thermoconditioning panels.

bc. ECP 0450, a compatibility ECP, provided for changes to the auxiliary tunnel covers.

bd. ECP 0466, authorized by letter I-CO-S-IVB-6-805, provided for modification of the propellant utilization static inverter-converter capability.

be. ECP 0479, a compatibility ECP, provided for wiring changes in the PAM inputs to the DDAU.

bf. ECP 0481, a compatibility ECP, provided for changes in the hi-lock bolts in the aft skirt.

bg. ECP 0486, authorized by letter I-CO-S-IVB-6-1459, provided for the replacement of diodes in the inverter-converter.

bh. ECP 0488, a compatibility ECP, provided for the installation of the forward dome ullage pressure transducer.

bi. ECP 0490, a compatibility ECP, provided for the redesign of checkout valve, P/N 1B53817.

bj. ECP 0493R2, a compatibility ECP, provided for redesign of the LH_2 and LOX chilldown system shutoff valves.

bk. ECP 0505R1, a compatibility ECP, provided for modification of the breakpoint amplifier module.

bl. ECP 0506, a compatibility ECP, provided for the addition of operational telemetry measurement D225.

3.3.2 (Continued)

bm. ECP 0510, a compatibility ECP, provided for the installation of coaxial cable assembly 411W212.

bn. ECP 0511, a compatibility ECP, provided for the redesign of the LH_2 chilldown pump shutoff line.

bo. ECP 0522, authorized by CCO 1079, provided for redesigning the hydraulic actuator bolt rod end.

bp. ECP 0533, a compatibility ECP, provided for the installation of hydraulic accumulator/reservoir temperature and pressure transducers.

bq. ECP 0534, a compatibility ECP, provided for replacement of the tank relief valves.

br. ECP 0535, a compatibility ECP, provided for modification of the LH_2 and LOX tank electrical feedthroughs.

bs. ECP 0542, authorized by letter I-CO-S-IVB-6-874, provided for changes in the Model II PCM RF assembly.

bt. ECP 0547, authorized by CCO's 966 and 1122, provided for redesigning the bi-level summing network module.

bu. ECP 0557R1, authorized by letter I-CO-S-IVB-1037, provided for redesigning the APS helium pressure regulator.

bv. ECP 0565, a compatibility ECP, provided for redesigning the fill and drain valve.

bw. ECP 0575, a compatibility ECP, provided for reworking the auxiliary hydraulic pump assembly.

bx. ECP 0581R1, authorized by CCO 1063, provided for OK bypass command circuits.

by. ECP 0590, a compatibility ECP, provided for replacing the multiplexer and switch selector shrouds.

bz. ECP 0592R3, a compatibility ECP, provided for deletion of the APS helium fill module.

ca. ECP 0597-1, authorized by letter I-CO-S-IVB-6-1271, provided for redesigning the propellant fill and drain umbilical disconnects.

cb. ECP 0600, a compatibility ECP, provided for reworking the check valve for the engine driven pump.

cc. ECP 0601, authorized by CCO 993, provided for lock wiring nuts on the propellant system.

cd. ECP 0605, a compatibility ECP, provided for vibration isolation of the EDS transducers.

ce. ECP 0613R1, authorized by letter I-CO-S-IVB-6-1176, provided for replacement of the bolts in the hydraulic hose support brackets.

3.3.2 (Continued)

cf. ECP 0630, a compatibility ECP, provided for the reconfiguration of the LOX inlet duct.

cg. ECP 0633, a compatibility ECP, provided for rework of the LH_2 propellant duct resilient mount.

ch. ECP 0634, a compatibility ECP, provided for revisions to the emergency detection system.

ci. ECP 0638-1, authorized by letter I-CO-S-IVB-6-1262, provided for replacement of the APS quick disconnects.

cj. ECP 0639, a compatibility ECP, provided for the relocation of a pressure transducer.

ck. 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.

cl. ECP 0651, a compatibility ECP, provided for adding a core reset resistor to the chilldown inverter.

cm. ECP 0653, a compatibility ECP, provided for revisions to the umbilical panel markings.

cn. ECP 0663, a compatibility ECP, provided for the reconfiguration of the LH_2 inlet duct.

co. ECP 0672, a compatibility ECP, provided for redesigning the pneumatic power control module.

cp. ECP 0677, a compatibility ECP, provided for redundant relays for the 70 pound thrust ullage engine start.

cq. ECP 0678, a compatibility ECP, provided for an RF bond for the forward skirt junction box assembly.

cr. ECP 0680, authorized by letter I-CO-S-IVB-6-1380, provided for a measurement of the inverter-converter 21 vdc output.

cs. ECP 0681, authorized by letter I-CO-S-IVB-7-680, provided for checkout of the spare depletion sensor.

ct. ECP 0685, a compatibility ECP, provided for replacement of the aft support for the hydraulic accumulator/reservoir.

cu. ECP 0686, a compatibility ECP, provided for the deletion of the LH_2 depletion sensor time delay module.

cv. ECP 0688, authorized by CCO 1031, provided for modifications to the aft umbilical.

cw. ECP 0689, a compatibility ECP, provided for redesigning the vent and relief valve.

cx. ECP 0699, a compatibility ECP, provided for purging the LOX ullage sensor line.

3.3.2 (Continued)

cy. ECP 0801, a compatibility ECP, revised the transducer mounting for measurement D055.

cz. ECP 0808, a compatibility ECP, provided for a revised installation for the measurement D55 transducer.

da. ECP 0809, a compatibility ECP, provided for modification of the wire harness for power input measurement K169.

db. ECP 0814, a compatibility ECP, provided for rework of the plenum environmental segment.

dc. ECP 0944R2, a compatibility ECP, provided for modification of the thermoconditioning system supply line supports.

dd. ECP 0953R1, a compatibility ECP, provided for eight additional ullage rocket jettison two-fuse Velcro clamps.

de. ECP 0958R1, a compatibility ECP, provided for capping the APS module orifices.

df. ECP 0962R1, a compatibility ECP, provided for the addition of caterpillar grommets for the LOX tank confined detonating fuse.

dg. ECP 0963R1, authorized by CCO 1613, provided for relocating the cable clamps for the ASI line.

dh. ECP 0973R2, a compatibility ECP, provided for corrections to connector mating reference designations.

di. ECP 0983R1, a compatibility ECP, provided for having the chilldown shutoff valve LOX compatible.

dj. ECP 0984R1, a compatibility ECP, 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 2019R1, a compatibility ECP, provided for redesigning the continuous vent system.

dm. ECP 2027, a compatibility ECP, provided for the replacement of the feedthrough coaxial socket contacts.

dn. ECP 2033, a compatibility ECP, provided for the power control and engine pump pipe assemblies.

do. ECP 2040, a compatibility ECP, provided for additional operational measurements.

dp. ECP 2046, a compatibility ECP, provided for the relocation of a pressure transducer.

dq. ECP 2048R1, authorized by CCO 1128, provided for modification of the continuous vent module bypass valve open talkback.

3.3.2 (Continued)

dr. ECP 2049R2, a compatibility ECP, provided for the installation of the actuation control modules.

ds. ECP 2051, a compatibility ECP, provided for reconfigurating the cold helium dump module.

dt. ECP 2053, a compatibility ECP, provided for substitution of the diodes in the chilldown inverter.

du. ECP 2054-1, authorized by TAN 10469R53, provided for the APS propellant tank recirculation system.

dv. ECP 2061, authorized by "make work", provided for the replacement of the auxiliary hydraulic pump seal.

dw. ECP 2073, a compatibility ECP, 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, a compatibility ECP, provided for reworking the auxiliary hydraulic pump assembly.

ea. ECP 2092, a compatibility ECP, 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, a compatibility ECP, provided for the reconfiguration of the pneumatic actuator.

ee. ECP 2117R1, a compatibility ECP, provided for the installation of a check valve in the actuation control modules.

ef. ECP 2120, authorized by CCO 1185, provided for the reconfiguration of the pneumatic power control module.

eg. ECP 2124R1, a compatibility ECP, provided for reconfigurating the LOX chilldown pump.

eh. 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.

ei. ECP 2132, a compatibility ECP, provided for reconfigurating the Model II RF assembly.

ej. ECP 2133, authorized by letter I-CO-S-IVB-7-183, provided for reconfigurating the Model II RF assembly.

3.3.2 (Continued)

ek. ECP 2134R1, authorized by CCO's 1170 and 1401, provided for the replacement of printed circuit boards in the Model 270 multiplexers.

el. ECP 2160R1, a compatibility ECP, provided for replacing the coaxial contacts on the internal cryogenic plugs.

em. ECP 2169, a compatibility ECP, provided for relocating the common bulkhead pressure transducer.

en. ECP 2174R1, a compatibility ECP, provided for transducer installations in the LOX and LH_2 chilldown return ducts.

eo. ECP 2175, a compatibility ECP, provided for a LOX chilldown pump bypass orifice.

ep. ECP 2176R1, a compatibility ECP, provided for the rerouting of coaxial cables.

eq. ECP 2180R2, a compatibility ECP, provided for redesigning the LOX relief valve, P/N 1A49590-515.

er. ECP 2183, a compatibility ECP, provided for reworking the burst disc in the fuel chill duct.

es. ECP 2184, a compatibility ECP, provided for reworking the burst disc in the fuel low pressure feed duct.

et. ECP 2188R2, authorized by CCO 1241, provided for revisions to the dual repressurization system.

eu. ECP 2189, authorized by letter I-CO-S-IVB-7-528, provided for reworking the LH_2 PU probe lower mount assembly.

ev. ECP 2193, a compatibility ECP, provided for the replacement of NAS 1351 passivated screws.

ew. ECP 2204R2, authorized by letters I-CO-S-IVB-7-456 and -724, provided for removal of the repressurization module relief valve.

ex. ECP 2206, authorized by CCO's 1226, 1282, and 1297, provided for a bearing change in the LH_2 chilldown pump.

ey. ECP 2226R1, a compatibility ECP, provided for propellant utilization system initial conditions.

ez. ECP 2234R2, a compatibility ECP, provided for reconfigurating the fuel relief valve.

fa. ECP 2235R1, authorized by CCO 1406, provided for a change in the 2 amp relays.

fb. ECP 2242, a compatibility ECP, provided for a propellant utilization system component oven.

fc. ECP 2244, a compatibility ECP, provided for reconfigurating the power control module.

3.3.2 (Continued)

fd. ECP 2247, a compatibility ECP, provided for a change in a heat sink installation.

fe. ECP 2248, a compatibility ECP, provided for reconfigurating the continuous vent module.

ff. ECP 2249, a compatibility ECP, provided for reworking the APS propellant control module.

fg. ECP 2251, a compatibility ECP, provided for readjusting the APS check valve torque value.

fh. ECP 2252, a compatibility ECP, provided for reconfigurating the check valve in the cold helium dump module.

fi. ECP 2253-1R3, a compatibility ECP, changed the seal and retainer on the flight half of the LH_2 vent line quick-disconnect.

fj. ECP 2258, authorized by letter I-CO-S-IVB-7-646, provided for changes in zener diode callouts.

fk. ECP 2261R1, authorized by CCO 1384, provided for O_2H_2 burner LOX manifold shutdown valve position talkback.

fl. ECP 2262R3, a compatibility ECP, provided for changes and weld joint redesign for the APS pressure vessel, P/N 1B39317.

fm. ECP 2265, authorized by letter I-CO-S-IVB-7-1030, provided for the replacement of the flexible couplings in the forward skirt.

fn. ECP 2269, a compatibility ECP, provided for reworking the chill system shutoff valve.

fo. ECP 2271, authorized by CCO 1280, permitted lengthening of the S-IVB/IU ground cable.

fp. ECP 2270R1, a compatibility ECP, provided for testing of the chilldown inverters.

fq. ECP 2273R1, a compatibility ECP, provided for doors in the aft skirt and interstage for drag-in cables.

fr. ECP 2275, a compatibility ECP, provided for pressure vessel changes.

fs. ECP 2277R2, a compatibility ECP, provided for a plenum chamber in the pneumatic control system.

ft. ECP 2279, a compatibility ECP, provided for the sealant for the range safety and telemetry antennas.

fu. ECP 2292, a compatibility ECP, provided for the use of insulating washers on diode modules.

fv. ECP 2295, a compatibility ECP, provided for the replacement of a hand valve.

fw. ECP 2298R1, authorized by CCO 1680, provided for the J-2 engine start tank emergency vent system control.

3.3.2 (Continued)

fx. ECP 2301R1, authorized by CCO's 1429 and 1666, provided for an increase in the propellant utilization system boil-off bias.

fy. ECP 2304, authorized by CCO's 1352 and 1383, provided for modifications to the LOX tank repressurization control module.

fz. ECP 2305, authorized by CCO 1352 and 1383, provided for modification of the repressurization control module.

ga. ECP 2308, a compatibility ECP, provided for a locking device on the fuel duct vacuum valve.

gb. ECP 2309, a compatibility ECP, provided for reconfigurating the LH_2 chill system supply duct.

gc. ECP 2311R2, authorized by CCO 1522, provided for modification of the LH_2 pressurization system.

gd. ECP 2312, a compatibility ECP, provided for the replacement of the servo-bridge transmission motor.

ge. ECP 2319, authorized by letter I-CO-S-IVB-7-794, provided for the installation of an orifice in the LOX repressurization system.

gf. ECP 2325R1, authorized by CCO 1426, provided for redesigning the low pressure helium module.

gg. ECP 2326, a compatibility ECP, provided for strengthening wire support panels.

gh. ECP 2329, a compatibility ECP, provided for a pipe assembly for the power control module.

gi. ECP 2330R2, authorized by CCO 1528, provided for a propellant utilization system oven monitor.

gj. ECP 2339, authorized by CCO 1491, provided for a redundant pressure measurement.

gk. ECP 2360, authorized by letter I-CO-S-IVB-7-1136, provided for installing larger spacers under the actuation control modules.

gl. ECP 2419R1, a compatibility ECP, provided for replacing the solenoid in the continuous vent module.

gm. ECP 2424R2, authorized by CCO 1625, provided for a redundant command to the continuous vent valves.

gn. ECP 2434, authorized by CCO 1494, provided for bolts for attaching the J-2 engine to the stage.

go. ECP 2454, authorized by CCO 1430, provided for modification of the range safety controller safing plug.

gp. ECP 2469, authorized by CCO 1553, provided for replacing the power supply card in the remote digital submultiplexer.

3.3.2 (Continued)

gq. ECP 2483R1, authorized by CCO 1556, provided for the S-IVB paint change.

gr. ECP 2485R2, authorized by CCO 1562, provided for modifications to the division module of the remote analog submultiplexer.

gs. ECP 2500R1, authorized by CCO 1539, provided for the replacement of pressure switch lines.

gt. ECP 2509R1, authorized by CCO 1593, added additional O_2H_2 burner instrumentation.

gu. ECP 2545R1, authorized by CCO 1561, provided for the removal of the LOX tank repressurization check valve.

gv. ECP 2566, authorized by CCO 1844, provided for electrical design changes.

gw. ECP 2572, authorized by CCO 1324, provided for rework of the tunnel disconnect connect.

gx. ECP 2574R1, authorized by CCO 1649, provided for modifications to the LOX heat exchanger bypass valve circuits.

gy. ECP 2584, authorized by CCO 1491, provided for the rework and the addition of oblative insulation.

gz. ECP 2614R1, a compatibility ECP, provided for pressure transducer locations.

ha. ECP 2630, a compatibility ECP, provided for removing the orifice from the actuation control module inlet.

hb. ECP 2641R1, authorized by CCO 1654, provided for the LOX tank pressure control module spring change.

hc. ECP 2642R1, authorized by CCO 1654, provided for the cold helium dump module spring change.

hd. ECP 2645R2, a compatibility ECP, provided for capping the calibration port of the calips pressure switches.

he. ECP 2652R2, authorized by CCO 1714, provided for the procurement of PU oven components.

hf. ECP 2656, authorized by CCO 1684 and letter I-CO-S-IVB-8-087, provided for the redesign of the plenum valve assembly.

hg. ECP 2698, authorized by CCO 1718, provided for potentiometer bridge reconfiguration.

hh. ECP 2679, a compatibility ECP, provided for the propellant control valve vent valve modification.

hi. ECP 2790, a compatibility ECP, provided for changing the Korotherm thickness.

3.3.2 (Continued)

hj. ECP 2793, a compatibility ECP, provided for modifications to the helium fill module thermal protection.

hk. ECP 2802, authorized by CCO 1778, provide for the LH_2 probe rework.

hl. ECP 2803, a compatibiliity ECP, provided for reworking a tunnel cover.

hm. ECP 2867, a compatibility ECP, provided for the LH_2 chilldown pump modification.

hn. ECP 2886, authorized by TAN's 11599R1 and 11702, provided for the replacement of the conoseal gaskets in the LOX pressurization system.

ho. ECP 2901, authorized by CCO 1896, provided for the J-2 engine bolt replacement.

hp. ECP 2936, a compatibility ECP, provided the LOX vent valve support change.

hq. ECP 5015R2, authorized by CCO 1406, provided for metal dust covers for electrical plugs.

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	1137	3 cycles	50 cycles
Helium Storage Sphere	1175	3 cycles	50 cycles
	1181	2 cycles	50 cycles
	1211	2 cycles	50 cycles
	1212	2 cycles	50 cycles
	1213	2 cycles	50 cycles
	1215	2 cycles	50 cycles
	1217	2 cycles	50 cycles
	1219	2 cycles	50 cycles
1A49421-507 LH_2 Chilldown Pump	154	No Data Available**	100 hours
1A49423-507 LOX Chilldown Pump	1871	1.16 hours	20 hours

**Recent addition to 1B55425, no data kept on this unit to date.

3.4 (Continued)

Part Number and Part Name	Serial Number	Accumulated Measurement	Engineering Limit
1A59562-505	5018	355 cycles	5,000 cycles
PU Bridge Potentiometer	5020	383 cycles	5,000 cycles
1A6624-511	XA58912	14.5 hours	120 hours
Auxiliary Hydraulic Pump		47 cycles	300 cycles
1B76452-511	20	114 cycles	100,000 cycles
Control Relay Package	17	87 cycles	100,000 cycles
G.F.P. Items (1B55423 G):			
40M39515-113	292	20 firings	1,000 firings
EBW Firing Unit	293	14 firings	1,000 firings
	298	44 firings	1,000 firings
	299	16 firings	1,000 firings
40M39515-119	554	29 firings	1,000 firings
EBW Firing Unit	555	26 firings	1,000 firings
50M10697	182	17.2 hours	2,000 hours
Command Receiver	189	16.5 hours	2,000 hours
50M10698	0039	110.2 hours	2,000 hours
Range Safety Decoder	0181	20.8 hours	2,000 hours
50M67864-5	178	64,011 cycles	250,000 cycles
Switch Selector			
103826	J-2122		
J-2 Engine (for gimbal cycles)*			
a. Customer connect lines and inlet ducts		0.51 percent	250-10,000 cycles
b. Gimbal bearing		0.49 percent	250-10,000 cycles
c. Firing time		351.0 seconds	3,750 seconds
d. Helium Regulator (P/N 558130)			Not established

*These data include all engine gimbal cycles at SSC, plus cycles brought forward from Rocketdyne records. The cycle data is expressed as a percent o[illegible] 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.

4.0 NARRATIVE

A detailed 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; and 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 A271264). 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 J)

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 508, without the thrust structure installation, P/N 1A39312, the LOX sump installation, P/N 1A39154, or the LH_2 door installation, P/N 1B64441.

The hydrostatic proof test was accomplished on 8 and 9 August 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

4.1.1 (Continued)

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.

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.

4.1.1 (Continued)

No major discrepancies or problems were encountered during this test, and no FARR's were written. Three revisions were made to the procedure:

a. Two revisions changed the outer tank fill operation to verify that GSE panel indicator F17 indicated LOW (LOX 99.6 foot level), rather than LOW (LOX 81.0 foot level), and indicator F8 indicated CLEAR, rather than HI.

b. One revision noted that the test was halted during the initial LOX tank fill operation because of leakage at the conoseal of the GSE 11 inch LOX tank fill line. The test was restarted after the conoseal was replaced.

4.1.2 Propellant Tanks Leak Check (1B38414 J)

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 structural items to the tank assembly. The item tested by this procedure was tank assembly, P/N 1A39303-535, S/N 508.

The leak check was initiated on 16 August 1967, using test procedure A659-1B38414-1-PATP30, and was completed on 17 August 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, and 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 3.2 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 the LOX tank to 12.1 psig, 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

4.1.2 (Continued)

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 10.2 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, 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. 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. No revisions were made to the procedure.

4.2 Stage Checkout - SSC/VCL

This paragraph details the tests performed on the stage in the Vehicle Checkout Laboratory (VCL) at the Space Systems Center, prior to transfer of the stage for shipment to the Sacramento Test Center. The stage was placed in tower 5 of the VCL on 22 January 1968. System checkcuts were initiated on 30 January 1968, and continued until 29 May 1968. Checkout activity was active for 86 working days during this period. All tests required by the End Item Test Plan, 1B6668[illegible], dated 8 August 1967, were activated and completed.

At the time of the final all systems simulated flight test, two items were not installed, and three other items were considered interim use parts. The missing items were the 70 pound thrust ullage engines, P/N's 15-210001, which were not installed in either APS module. The interim use parts were the APS attitude control relay modules, P/N 50M35076-1, S/N 335, and P/N 1B57731-1, S/N 361, and the J-2 engine LOX augmented spark ignitor pipe assembly, P/N 410117-11.

Paragraphs 4.2.1 through 4.2.38 contain information on the individual tests conducted, and are presented in the sequential order of testing.

4.2.1 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 1B38426-515, and the GSE Model DSV-4B-359 thermoconditioning servicer, P/N 1A78829-1.

The checkout of the forward skirt thermoconditioning system was started on 30 January 1968, and was completed and accepted on 6 February 1968, after 6 days of activity.

After the preliminary setup of the Model 359 GSE servicer and an inspection of the forward skirt thermoconditicning system for open bolt holes and properly torqued bolts, the thermoconditioning system was purged with freon gas, and then pressurized to 32 ± 1 psig with freon. A system leak check was conducted

4.2.1 (Continued)

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 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 the few contaminant particles in the coolant were well within acceptable limits. The specific gravities of the samples were 0.903 and 0.900, at a temperature of 60°F each.

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 ±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 14.55 psid to 14.8 psid. The supply (inlet) temperature varied from 58°F to 62°F, and the return (outlet) temperature varied from 59°F to 63°F.

Finally, an air content test was performed by stabilizing the thermoconditioning system coolant static pressure at 20 ±0.5 psig, and draining sufficient fluid from the system to reduce the static pressure by 15 ±0.5 psig. The quantity of fluid drained was measured as 45 cc, acceptably less than the 48 cc maximum permissible quantity for the five cold plate configuration of the thermoconditioning system.

Engineering comments indicated that all parts were installed at the start of the test. No stage discrepancies or problems were noted during the test and no FARR's were written. No revisions were made to the procedure.

One GSE problem occurred on the second day of activity, when the temperature switch in the Model 359 servicer failed to maintain the proper coolant temperature. IIS 378208 noted that the coolant temperature was 66°F, when it

4.2.1 (Continued)

should have been 60 $\pm 2°F$. One replacement switch also failed to maintain the proper temperature, and two other replacement switches leaked coolant. The problem was corrected on the fifth day of activity when a fourth replacement switch operated satisfactorily.

4.2.2 Continuity Compatibility Check (1B59780 E)

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 5 February 1968, the procedure was completed on 15 February 1968, after a total of 9 days of activity. The procedure was certified and accepted on 28 February 1968.

Stage wiring continuity was verified by a total of 2083 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. There were 1973 of the measurements within the original resistance requirement of 1.0 ohm or less. For an additional 78 measurements, indications between 1.0 and 3.0 ohms were acceptable because of the length and type of wire involved. Another 32 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 there were no parts shortages affecting this test. Several problems were encountered and satisfactorily resolved during the test. Three high resistance measurements were corrected by disconnecting and remating connector plugs. One incorrect reading resulted from a wiring change, and was corrected by a procedure revision. Several wire harnesses were reworked to the proper configuration to resolve other problems. Two FARR's

4.2.2 (Continued)

were also written during this test:

a. FARR A271264 noted three problems. Wire 4P9A22 was severed at contact 404W7P23-B on wire harness, P/N 1B66971-1, S/N 8257. This was reworked to an acceptable condition. The resistance through connector 404A3W1P10 on wire harness, P/N 1B66966-1, S/N 3, varied from 0.1 to 4.5 ohms when the connector was mated to receptacle J1 on relay module 404A3A10, P/N 1B39550-513, S/N 13. This exceeded the 1.0 ohm maximum resistance limit. The connector, P/N 1A97494-583, was rejected by FARR A271267, and a replacement was installed and accepted. The resistance through connector 404A2W1P24 on wire harness, P/N 1B67271-1, S/N 3, varied from 0.1 to 3.1 ohms when the connector was mated to bus module 404A2A24, P/N 1B51354-513, S/N 14. This exceeded the 1.0 ohm maximum resistance limit. The connector, P/N 1A97494-587, was rejected by FARR A271268 and a replacement was installed and accepted.

b. FARR A271266 rejected 50 ampere relay module 411A99A10A2, P/N 1A74890-501, S/N 139, for a resistance of 2.0 ohms between J3-H and J1-x, w, s, and r, exceeding the 0.5 ohms maximum limit. A new module, S/N 145, was installed and accepted for use.

Ten revisions were made to the procedure:

a. Two revisions noted the 78 measurements that were acceptable at 1.0 ohm to 3.0 ohms, because of the wire types and lengths, and the 32 measurements that were acceptable at 50 ±5 ohms, because the measurements were made through modules containing 49.9 ohm resistors.

b. One revision added a general note to verify that connectors 404W7P9 and 404W7P10 were coiled and stowed prior to testing, as required by EWO 32960.

c. One revision changed an end point reference to be 404W004J1-18 rather than 404W004J1-U, as listed, to correct a computing error.

d. One revision changed the end points for five measurements, and added two new measurements, to incorporate wiring changes accomplished by EWO 32983 (WRO 3653) after the procedure was released.

e. Five revisions changed the end points for four measurements because the umbilical carriers were installed at the time of the test, and for one measurement because the GSE cables were installed at the time of the test.

4.2.3 Forward Skirt Thermoconditioning System Operating Procedure (1B42124 B)

This manual procedure controlled the setup and normal daily operation of the GSE thermoconditioning servicer, P/N 1A78829-1, used to supply water/methanol coolant to the forward skirt thermoconditioning system, P/N 1B38426-515. The

4.2.3 (Continued)

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 6 February 1968, the procedure was used as required until 24 May 1968, and was certified and accepted on 29 May 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 power was applied to the servicer.

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 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 Postcheckout Procedure, H&CO 1B62965, (reference paragraph 4.2.38).

4.2.3. (Continued)

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

4.2.4 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 J2122; the hydraulic pitch actuator, P/N 1A66248-507, S/N 77; the hydraulic yaw actuator, P/N 1A66248-507-012, S/N 66; and the stage, P/N 1A39300-523, S/N 508.

The engine alignment verification was satisfactorily accomplished on 7 February 1968, and was accepted on 8 February 1968.

A Wild N-3 alignment scope was first used to determine the difference in elevation of datum plane "G" at four locations around the stage periphery. Datum plane "G" was defined as the mating surface between the aft skirt and the handling ring. The elevations at the four locations were determined to be 2.000 inches, 1.990 inches, 2.020 inches, and 1.995 inches. The maximum deviation between any two locations was 0.030 inch, well within the 0.062 inch maximum deviation limit.

The engine exit plane alignment fixture, P/N 1B54581-1, was positioned and attached to the J-2 engine exit flange, and two clinometers, P/N 1B29613-1, were positioned on the machined surface block of the fixture. From the clinometer readings, the pitch plane adjusted angle was found to be 6.8 minutes low toward stage position I, and the yaw plane adjusted angle was found to be 5.3 minutes low toward stage position IV. From these measurements, the adjusted exit plane inclination angle was determined to be 8.6 minutes, with the low quadrant between stage positions I and IV. This exit plane inclination was well within the maximum inclination limit of 21 minutes.

4.2.4 (Continued)

As the inclination angle was acceptable, no adjustment of either hydraulic actuator was required. For each of the actuators, the engine log book length, the adjusted actuator length, and the final actuator length, were obtained from the data tags provided by the pre-installation actuator adjustment procedure, drawing 1B66209, and recorded. For the pitch hydraulic actuator, S/N 77, these lengths were 23.002 inches, 22.965 inches, and 22.966 inches, respectively. For the yaw hydraulic actuator, S/N 66, these lengths were 22.998 inches, 22.962 inches, and 22.966 inches, respectively.

Engineering comments indicated that all parts were installed at the start of the test. No discrepancies were noted during the test. No FARR's were written, and no revisions were made to the procedure.

4.2.5 Propulsion Component Internal Leak Check (1B59455 A)

The propulsion component 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 7 February 1968, and was accepted on 8 February 1968.

Reverse seat leakage tests were conducted on the six pneumatic control system check valves, P/N 1B51361-1, S/N's 288, 335, 363, 384, 386, and 402; the ambient helium fill module, P/N 1A57350-507, S/N 234; the LH_2 tank pressurization system check valve, P/N 1B65673-1, S/N 30; the two LOX tank pressurization system check valves, P/N 1B40824-507, S/N's 125 and 131; the LOX repressurization system check valve, P/N 1B40824-505, S/N 193; the LOX and LH_2 burner line check valves, P/N 1B40824-507, S/N's 128 and 129; and the LOX and LH_2 repressurization module check valves, P/N 1B51361-501, S/N's 318 and 320.

All components tested were installed in the pneumatic control system prior to beginning the test and were reinstalled at the conclusion of the test.

The check valve reverse pressure seat leakage tests were accomplished by connecting a helium source to the outlet of the check valve, using an appropriate 0 to 60 psig, 0 to 600 psig, or 0 to 5000 psig pressure gauge, and attaching a flowmeter to the inlet of the valve to determine the leakage after 1 minute

4.2.5 (Continued)

of pressurization. Check valves, P/N 1B51361-1, were tested at 1500 ±100 psig, with a 10 scim maximum allowable leakage, and check valves, P/N 1B40824-507, were tested at 1500 ±100 psig, with a 1 scim maximum allowable leakage. Check valves, P/N 1B51361-501, were tested at 1500 ±100 psig and 28 ±3 psig, with 10 scim maximum allowable leakage at each pressure. Check valve, P/N 1B40824-505, was tested at 825 ±25 psig and 28 ±3 psig, with 20 scim maximum allowable leakage at each pressure. Check valve, P/N 1B65673-1, was tested at 300 psig and 28 ±3 psig, with 10 scim maximum allowable leakage at each pressure. The ambient helium fill module, P/N 1A57350-507, was tested by pressurizing the module outlet to 1500 ±100 psig, and determining the combined leakage at the module inlet and vent. The maximum allowable combined leakage was 10 scim.

The leak check was successfully passed by all components. The only leakage noted was 0.3 scim through check valve, P/N 1B51361-1, S/N 402, well within the 10 scim allowable limit.

Engineering comments noted that there were no parts shortages affecting this test. No problems were encountered, and no FARR's were written. One revision was made to the procedure, to correct typing errors. One of the pressure gauges was to be 0 to 5000 psig, rather than 0 to 500 psig as listed, and the ambient helium fill module was to be P/N 1A57350-507, rather than -570 as listed.

4.2.6 Cryogenic Temperature Sensor Verification (1B64678 C)

This manual procedure verified the operation and calibration of each cryogenic temperature sensor on the stage for which the normal operating range did not include ambient (room) temperature. These cryogenic temperature sensors are basically platinum resistance elements for which the resistance changed with the temperature according to the Callendar - Van Dusen equation.

The procedure was accomplished on 9 and 12 February 1968, and was accepted on 14 February 1968. On 23 February 1968, a second issue of the procedure was initiated to check three additional sensors. A problem with the test equipment delayed these checks until 6 March 1968, and the second issue was completed on

4.2.6 (Continued)

this date, and was accepted on 7 March 1968. The second issue of the procedure covered only the three added sensors, and did not affect the measurements made by the first issue.

For each sensor tested, the procedure specified a resistance value at 32°F and a sensitivity value. Using these values and the measured ambient temperature, the expected ambient temperature resistance was calculated for each sensor. The applicable resistance tolerance was also calculated for each sensor. This tolerance was 5 percent of the expected resistance, except for eleven specified sensor types which were allowed a 7 percent tolerance. The actual ambient resistance of each sensor was then measured and verified to be within the applicable tolerance of the expected resistance. The sensor wiring was verified to be correct by shorting out the sensor element, measuring the continuity resistance, and verifying that this was 5.0 ohms or less. Test Data Table 4.2.6.1 shows the measured and calculated values for each sensor involved in this test.

Engineering comments noted that there were no parts shortages affecting this test. No stage problems were encountered during the test, and no FARR's were written. One revision was made to the first issue of the procedure, to delete testing of the sensors for measurements CO 384 and CO 391, as these measurements were used only on Stages 503 through 505. Four revisions were made to the second issue of the procedure:

a. One revision added three temperature sensor measurements for the O_2H_2 burner voter circuit, as these measurements were not in the first issue of the procedure.

b. One revision deleted the measurement number listings for the three added sensors, as none were assigned.

c. One revision deleted the requirement for all sensor measurements that were previously accomplished by the first issue.

d. One revision provided for rewiring test adapter cable, P/N 1B64095-1, to perform the measurements on the three O_2H_2 burner voter sensors. Because of a difference in sensor wiring, the only available adapter cable could not be used until the cable wiring was changed.

4.2.6. t Data Table, Cryogenic Temperature Sensor Verification

Meas	Sensor			Temp	Resistance (ohms)			
Number	P/N	S/N	Ref Desig	(°F)	Meas	Calc	+Tol	Cont
CO 003	1B34473-1	320	403MT686	72.5	5200.	5445.5	381.19	1.2
CO 004	1B34473-501	340	403MT687	72.5	1530.	1524.74	76.24	1.3
CO 005	1A67863-503	852	405MT612	72.5	547.	544.55	27.23	1.6
CO 009	1A67863-535	1187	403MT653	72.5	221.	217.82	10.9	1.7
CO 015	1A67863-509	1151	410MT603	75.	1530.	1532.44	76.62	1.1
CO 040	1A67862-505	604	406MT613	72.5	1520.	1503.12	75.16	1.3
CO 052	1A67862-513	563	408MT612	75.	5180.	5473.0	383.11	1.8
CO 057	1A67862-501	554	406MT606	72.5	547.	544.55	27.23	1.2
CO 059	1A67862-517	571	406MT611	72.5	546.	544.5	27.23	1.4
CO 133	NA5-27215T5	-	401(3MTT17)	72.5	1370.	1367.78	68.39	0.7
CO 134	NA5-27215T5	-	401(3MTT16)	72.5	1361.	1367.78	68.39	0.7
CO 159	1A67863-519	1212	424MT610	72.5	220.	217.82	10.9	1.0
CO 161	1A67863-537	1254	404MT733	72.5	5240.	5445.5	381.19	0.8
CO 208	1A67863-503	751	405MT605	72.5	548.	544.55	27.3	1.5
CO 230	1A67863-509	1183	403MT706	72.5	1530.	15[illegible].74	76.24	1.2
CO 231	1A67863-529	1167	403MT707	72.5	547.	544.55	27.22	1.2
CO 256	1B37878-501	1505	409MT646	74.	1530.	1529.36	76.47	1.0
CO 257	1B37878-501	1424	409MT647	75.	1530.	1532.44	76.62	0.8
CO 368	1A67862-505	605	406MT650	72.5	1499.	1503.12	75.16	1.0
CO 369	1A67862-505	271	406MT661	72.5	1513.	1503.12	75.16	1.0
CO 370	1A67862-533	610	408MT735	75.	5200.	5473.0	383.11	1.6
CO 371	1A67862-533	635	40[illegible]MT736	74.5	5200.	5467.5	273.38	1.5
* -	1B37878-507	1762	403A20	68.	5190.	5396.	377.7	0.7
* -	1B37878-507	1599	403A21	68.	5194.	5396.	377.7	0.8
* -	1B37878-507	1729	403A22	68.	5192.	5396.	377.7	0.8

* Second Issue Measurement

4.2.7 Umbilical Interface Compatibility Check (1B59782 F)

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 13 February 1968, and was accepted on 14 February 1968. One measurement was reaccomplished on 21 February 1968 during the disposition of FARR A271295, below, and the procedure was reaccepted on 15 March 1968. A series of resistance checks were made at specified test points on the Model DSV-4B-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 7.1. Test point 463A1A5J43-FF was used as the common test point for all measurements.

Engineering comments indicated that all parts were installed at the start of this procedure. No problems or malfunctions were encountered during the test, and no revisions were made to the procedure. After the test was completed, IIS 378317 was written for unauthorized cycling of a motor driven switch to obtain an acceptable resistance reading during the test. FARR A271295 rejected relay module 404A2A7, P/N 1A74890-501, S/N 113, for an initial resistance of 19 ohms on the engine control bus power on line, exceeding the 5 to 15 ohms limit. The relay module was cycled twice to verify that it operated properly, and the engine control bus power on resistance at test point 463A2CB-11-2 was remeasured and found to be acceptable, as shown in Test Data Table 4.2.7.1. The relay module was then accepted for use.

4.2.7.1 Test Data Table, Umbilical Interface Compatibility Check

Test Point	Function	Meas. Ohms	Limit Ohms
Reference Designation 463A2			
A2J29-C	Cmd, Ambient Helium Sphere Dump	30.0	10-60
CB-8-2	Cmd, Engine Ignition Bus Power Off	Inf	Inf
CB-9-2	Cmd, Engine Ignition Bus Power On	15.0	5-15
CB-10-2	Cmd, Engine Control Bus Power Off	Inf	Inf

4.2.7.1 (Continued)

Test Point	Function	Meas. Ohms	Limit Ohms
Reference Designation 463A2			
CB-11-2	Cmd, Engine Control Bus Power On	7.0	5-15
A2J29-N	Cmd, Engine Helium Emergency Vent Control On	50.0	10-60
A2J29-P	Cmd, Fuel Tank Repress. Helium Dump Valve Open	37.0	10-60
A2J29-Y	Cmd, Start Tank Vent Pilot Valve Open	22.0	10-60
CB-4-2	Cmd, LOX Tank Cold Helium Sphere Dump	33.0	10-60
A2J29-c	Cmd, LOX Tank Repress. Helium Sphere Dump	39.0	10-60
A2J29-h	Cmd, Fuel Tank Vent Pilot Valve Open	65.0	10-300
	(Same, reverse polarity)	Inf	500K min
A2J29-i	Cmd, Fuel Tank Vent Valve Boost Close	65.0	10-80
	(Same, reverse polarity)	Inf	500K min
A2J29-q	Cmd, Ambient He Supply Shutoff Valve Close	24.0	10-60
A2J30-H	Cmd, Cold He Supply Shutoff Valve Close	1.3K	1.5K max
	(Same, reverse polarity)	Inf	Inf
A2J30-W	Cmd, LOX Vent Valve Open	60.0	10-80
	(Same, reverse polarity)	Inf	500K min
A2J30-X	Cmd, LOX Vent Valve Close	60.0	10-80
	(Same, reverse polarity)	Inf	500K min
A2J30-Y	Cmd, LOX and Fuel Prevalve Emergency Close	60.0	10-80
	(Same, reverse polarity)	Inf	500K min
A2J30-Z	Cmd, LOX and Fuel Chilldown Pilot Valve Open	60.0	10-80
	(Same, reverse polarity)	Inf	500K min
A2J30-b	Cmd, LOX Fill & Drain Valve Boost Close	32.0	10-40
A2J30-c	Cmd, LOX Fill & Drain Valve Open	32.0	10-40
A2J30-d	Cmd, Fuel Fill & Drain Valve Boost Close	32.0	10-40
A2J30-e	Cmd, Fuel Fill & Drain Valve Open	32.0	10-40
A2J42-F	Meas, Bus +4D111 Regulation	140.0	100 min
A2J35-y	Meas, Bus +4D141 Regulation	210.0	50 min
A2J6-AA	Sup, 28v Bus +4D119 Aft Talkback Power	100.0	60-120
Reference Designation 463A1			
A5J41-A	Meas, Bus +4D131 Regulation	24.0	20 min
A5J41-E	Meas, Bus +4D121 Regulation	2.3K	1.6K min
A5J53-AA	Sup, 28v +4D119 Forward Talkback Power	70.0	60-100

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

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

4.2.8 (Continued)

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 akirt and interstage thermoconditioning and purge system installation, P/N 1A67979-515, and the GSE Model DSV-4B-651 aft skirt ventilation system kit, P/N 1B38121-1.

This checkout procedure was initiated on 14 February 1968, and was completed and accepted on 15 February 1968. Preoperation 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 flanged duct, P/N 1A67978, was disconnected from the thrust structure and helium bottle 6, and the two open ends of the duct were sealed. 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, and the main manifold orifices in the station 241 frame, the hydraulic system accumulator reservoir shroud ventilation holes, the thrust structure supply duct, and the helium bottle shroud supply duct were sealed. From the measured metering duct orifice pressure difference of 20.0 inches of water, and the main manifold pressure of 3.8 inches of water, it was determined that the leakage and fairing purge area was 3.5 square inches.

For the helium bottle shroud flow test, a 2.1 inch diameter orifice, P/N 1B38983-507, was installed, the flanged duct, P/N 1A67978, was unsealed and connected to helium bottle 6, the main manifold orifices in the station 241 frame and the thrust structure supply duct were sealed, and the hydraulic system accumulator reservoir shroud ventilation holes and helium bottle shroud supply duct were opened. From the metering duct pressure difference of 21.5 inches of water and the main manifold pressure of 2.8 inches of water, the gross helium

4.2.8 (Continued)

bottle shroud purge area was found to be 9.4 square inches. Subtracting the leakage and fairing purge area, the net helium bottle shroud purge area was 5.9 square inches, well within the 6.8 $\pm$1.2 square inches requirement. The flanged duct was disconnected from the helium bottle and resealed.

For the thrust structure flow test, a 2.1 inch diameter orifice, P/N 1B38983-507, was installed, the flanged duct, P/N 1A67978, was unsealed and connected to the thrust structure, the main manifold orifices in the station 241 frame, the hydraulic system accumulator reservoir shroud ventilation holes, and the helium bottle shroud supply duct were sealed, and the thrust structure supply duct was opened. From the metering duct pressure difference of 20.0 inches of water and the main manifold pressure of 4.2 inches of water, it was determined that the gross thrust structure purge area was 7.4 square inches. Subtracting the previously determined leakage and fairing purge area, the net thrust structure purge area was 3.9 square inches, well within the 4.1 $\pm$1.0 square inches requirement. The flanged duct was disconnected from the thrust structure and resealed.

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 and the helium bottle shroud supply duct were sealed. From the metering duct pressure difference of 4.8 inches of water and the main manifold pressure of 2.0 inches of water, the gross main manifold purge area was found to be 45.25 square inches. Subtracting the leakage and fairing purge area, the net main manifold purge area was 41.75 square inches, well within the 44.2 $\pm$6.0 square inches requirement.

At the completion of the test, both open ends of the flanged duct, P/N 1A67978, were unsealed, and the duct was reconnected to the thrust structure and helium bottle 6. The Model 651 ventilation system was disconnected from the stage, and the stage was returned to the pre-test condition.

4.2.8 (Continued)

Engineering comments indicated that there were no part shortages affecting the test. No discrepancies were noted during the test, and no FARR's were written. No revisions were made to the procedure.

4.2.9 Fuel Tank Pressurization System Leak Check (1B59456 C)

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 on 15 and 16 February 1968, and was accepted on 16 February 1968. Subsequent to this, the transducer for measurement C231, which was removed for the leak check , was reinstalled on 20 February 1968. The facilities pneumatic lines were connected to the stage aft umbilical carrier 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 397.5 psig, and, after a 30 minute delay, was remeasured as 395.5 psig, meeting the pressure decay requirement for 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 $\pm$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

4.2.9 (Continued)

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 then pressurized with helium and leak checked, and it was verified that there was no leakage past the LH_2 pressure switch diaphragms. At the completion of this check, the system was vented, and the test setups were removed.

Four leaks were located and satisfactorily corrected during this test:

a. Leaks at the downstream B-nut of pipe assembly, P/N 1B63063-1; at the upstream B-nut of pipe assembly, P/N 1B63062-1; and at the upstream B-nut of pipe assembly, P/N 1B66843-1, were all corrected by retorqueing the B-nuts.

b. A leak at the downstream B-nut of pipe assembly, P/N 1B67829-1, was corrected by replacing the adaptor orifice.

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

a. One revision deleted reconnection of the repressurization pipe assemblies, P/N's 1B58858-1 and 1B58859-1, to the LH_2 pressurization pipe assembly, P/N 1B66824-1. These lines were to be left disconnected until the repressurization system leak check, to prevent unseating of the shutoff valves during other tests.

b. One revision added a step to the test setup, to disconnect and plug pipe assembly, P/N 1B62874-1, at its connection to pipe assembly, P/N 1B66843-1, and to cap the latter. This was to prevent gas from passing through the burner solenoid valves by way of the pilot bleed line, P/N 1B62874-1, from the cold helium spheres.

c. One revision changed the O_2H_2 burner setup to connect flex lines from the calibration port of the 1st stage helium blanket gauge on the vehicle monitor panel (VMP) to a test gauge and the burner inlet line, rather than connecting flex lines from the facility helium supply to the gauge and burner inlet. This was required as the facility helium supply connection was being used for a fuel tank prevalve change, and the VMP was readily available.

4.2.10 Stage Power Setup (1B66560 C)

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 sequence. Once the procedure was successfully accomplished, it was used to establish initial conditions during subsequent automatic procedures throughout the VCL testing. The procedure also included an initial conditions scan routine that could be used at any time to verify that the stage was prepared for checkout, without accomplishing the entire setup procedure.

This procedure was initially conducted on 16 February 1968, with several minor malfunctions caused by an uninstalled valve, unadjusted point level sensor control units, and an incorrectly positioned directional vent valve. As these problems would be corrected during subsequent operations, the procedure was considered satisfactory for further use. After the problems were corrected, the procedure was satisfactorily accomplished by a second attempt on 29 February 1968. During subsequent use of the procedure, a 50 amp relay module, P/N 1A74890-501, S/N 142, failed as noted on FARR 500-238-011, and a replacement module was installed. The procedure was then re-accomplished by the third attempt on 12 March 1968, and was accepted on the same date. The following narration and the measurement values shown in Test Data Table 4.2.10.1 are from this third attempt.

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. The bus 4D119 talkback power was turned on, and the prelaunch checkout group was turned off. The forward and aft power buses were transferred to external power. The sequencer power, the engine control bus power, the engine ignition bus power, the APS bus 1 and bus 2 power, and the propulsion level sensor power, were all verified to be off. The range safety system 1 and 2 receiver power 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.

4.2.10 (Continued)

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. A series of steps then set the switch selector functions to their proper states.

The 70 pound ullage engine reset indication, the LH_2 continuous vent valve reset and overboard valve closed indications, the LH_2 and LOX repressurization mode reset indication, the LH_2 and LOX repressurization control valve reset indication, and the O_2H_2 burner propellant valve reset indication were all verified to be on.

The propellant utilization boiloff bias was verified to be off. The C_2H_2 burner spark systems 1 and 2 were measured, and it was verified that the O_2H_2 burner LOX valve, LOX shutdown valve, and LH_2 valve, and the LH_2 control vent orifice bypass valve, were closed.

The forward bus 1 quiescent current was measured. The PCM system group was turned on and the group current was measured. The bus 4D121 28 vdc power was turned on, and the forward bus 2 current and voltage were measured. The prelaunch checkout group was turned on and the current was measured. The DDAS ground station selector switch was manually set to position 1, and it was verified that the ground station was in syncronization.

The EBW pulse sensor power was then turned off, and the cold helium supply shutoff valve was closed. The bus 4D111 28 vdc power was turned on, and the aft bus 1 current and voltage were measured. The sequencer power was turned on and the current was measured. The forward and aft battery load tests were then turned off, and the stimuli conditioner was reset.

A series of checks then verified that the various stage electrical functions were properly off or on, and that the stage valves were properly open or closed, as required for subsequent stage operations. A final series of checks measured the 5 vdc excitation module voltages, the range safety system EBW firing unit charging voltages, the aft bus 2 voltage, the forward and aft bus battery voltages, and the component test power voltage. This completed the stage power setup.

4.2.10 (Continued)

Following the completion of the stage power setup, the initial conditions scan part of the procedure was accomplished. This verified that the stage electrical functions were properly off or on, that the stage valves were properly open or closed, and that various stage voltages were within the proper limits for subsequent checkout operations.

Engineering comments noted that the LH_2 tank prevalve 427A6, P/N 1A49968-507, was not installed at the start of this test. A valve, S/N 123, was installed on 28 February 1968, and was satisfactorily tested during the second attempt. It was also noted that the 50 ampere relay module 404A2A7, P/N 1A74890-501, S/N 113, was disconnected at the start of the test because of FARR A271295 (reference paragraph 4.2.7, Umbilical Interface Compatibility Check). This did not affect the test, as the module was not energized during the power setup. The FARR was dispositioned and the module was reconnected prior to the third attempt of this test.

As noted, one FARR was written during the use of this procedure to prepare for another automatic test. FARR 500-238-011 rejected 50 ampere relay module, P/N 1A74890-501, S/N 142, because the sequence power motor driven switch, P/N 1A88061-1, S/N 361, failed to operate properly. A new relay module, P/N 1A74890-501, S/N 138, was installed and satisfactorily tested during the third attempt of this test.

Seven revisions were made to the procedure:

a. One revision deleted the Model DSV-4B-298 monochrome system status display, P/N 1B37968-1, from the End Item Equipment list, as it was not used in this test.

b. One revision deleted two steps to reset and later set SIM channel 26 during the relay matrix reset routine. As the GSE power was not turned off at this point, it was not necessary to temporarily deactivate the GSE power low voltage monitor, SIM channel 26.

c. One revision changed a step in the initial conditions scan to set SIM channel 24, rather than SIM channel 22 as listed, to set the correct channel.

4.2.10 (Continued)

d. One revision deleted two steps to verify and printout that the EBW pulse sensor power was OFF, and added a breakpoint after aft bus 1 was turned on to permit manual verification that the EBW pulse sensor power off indication, function number 2614, was ON. This was necessary as the EBW pulse sensor power could not be verified until aft bus 1 was turned on.

e. Two revisions modified the pre-test setup of the Model DSV-4B-123 DDAS ground station. Inside the simulator, the SYNC ERRORS/OFF switch was set to the OFF position, to permit use of the simulator during troubleshooting. On the digital signal synchronizer, the VCO-XTAL control was set to VCO, rather than to XTAL as listed, and the SERVO OPEN/CLOSED control was set to CLOSED, to prevent the computer from getting an intermittent out-of-synchronization indication when the ground station was actually synchronized.

f. One revision changed the expected value of the initial voltage measurements of the power supplies for forward buses 1 and 2, and aft bus 1, from 28.0 ±0.5 vdc to be 26.8 ±0.5 vdc, to compensate for remote sensing of the power supplies.

4.2.10.1 Test Data Table, Stage Power Setup

Function	Measurement	Limits
Forward Bus 1 Initial Current (amp)	5.50	20.0 max
Forward Bus 1 Voltage (vdc)	28.04	28.0 ±2.0
O_2H_2 Burner Spark System 1 (vdc)	0.00	0.0 ±0.5
O_2H_2 Burner Spark System 2 (vdc)	0.00	0.0 ±0.5
Forward Bus 1 Quiescent Current (amp)	0.70	5.0 max
PCM System Group Current (amp)	4.30	5.0 ±3.0
Forward Bus 2 Current (amp)	0.10	2.0 max
Forward Bus 2 Voltage (vdc)	28.04	28.0 ±0.5
Prelaunch Checkout Group Current (amp)	1.20	1.0 ±3.0
Aft Bus 1 Current (amp)	0.20	2.0 max
Aft Bus 1 Voltage (vdc)	27.96	28.0 ±0.5
Sequencer Current (amp)	- 0.10	0.0 ±3.0
Aft 5 vdc Excit. Module (vdc)	4.99	5.0 ±0.030
Forward 1 5 vdc Excit. Module (vdc)	5.01	5.0 ±0.030
Forward 2 5 vdc Excit. Module (vdc)	5.00	5.0 ±0.030
1 EBW Firing Unit Charging Voltage (vdc)	0.00	0.0 ±1.0
2 EBW Firing Unit Charging Voltage (vdc)	0.00	0.0 ±1.0
Aft Bus 2 Voltage (vdc)	0.00	0.0 ±1.0
Forward Bus 1 Battery Voltage (vdc)	0.00	0.0 ±1.0
Forward Bus 2 Battery Voltage (vdc)	0.04	0.0 ±1.0
Aft Bus 1 Battery Voltage (vdc)	0.00	0.0 ±1.0
Aft Bus 2 Battery Voltage (vdc)	0.00	0.0 ±1.0
Component Test Power Voltage (vdc)	0.04	0.0 ±1.0

4.2.11 Stage Power Turnoff (1B66561 C)

This procedure shut down the stage power distribution system after the completion of various stage system checkout procedures, and returned the stage to the de-energeized condition.

To ensure that the procedure would deactivate the stage power, it was initially conducted on 16 February 1968, after the first application of power to the stage. This attempt had several minor malfunction indications caused by an uninstalled LH_2 tank prevalve, unadjusted point level sensor control units, and an incorrectly positioned directional vent valve. As these problems would be corrected during subsequent operations, the procedure was considered satisfactory for stage shutdown use. After the problems were corrected, the procedure was satisfactorily completed by the second attempt on 29 February 1968, and was accepted on 12 March 1968.

After verification that the talkback, forward bus 1, aft bus 1, and sequencer powers were all on, the switch selector functions were turned off, and a series of checks verified that the stage functions were in the proper de-energized stage, and that the stage bus powers were off. The EBW pulse sensor power was turned off, the range safety receiver power and EBW firing unit power were transferred to external, and the safe and arm device was verified to be in the safe condition. The talkback power was turned off, and the matrix magnetic latching relays were reset, completing the stage power turnoff. The switch selector was used 47 times during the procedure.

Engineering comments noted that the LH_2 tank prevalve 427A6, P/N 1A49968-507, was not installed at the start of this test. Valve, S/N 123, was installed on 28 February 1968, and was satisfactorily tested. No problems were encountered during the second attempt, and no FARR's were written. Three revisions were made to the procedure:

a. One revision deleted the Model DSV-4B-298 monochrome system status display, P/N 1B37968-1, from the End Item Equipment list, as it was not used during this test.

b. One revision changed a buffer table entry to be "DS2/SW S RF ASSY PWR (CH 67)" rather than "DS2/SW S PCM RF ASSY PWR (CH 65)" as listed, to correct a test requirements drawing error.

c. One revision deleted a step to reset SIM channel 26 at the end of the power turnoff. This SIM channel, for GSE power supply low voltage, should not be reset unless the GSE power was turned off.

4.2.12 Signal Conditioning Setup (1B64681 D)

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 4.2.12.1. During computer holds, this procedure was also used as required to troubleshoot instrumentation problems.

The procedure was initiated on 16 February 1968, and the excitation module calibrations were completed by 20 February 1968, after 2 days of activity. The procedure was then held open for use as required during subsequent VCL activity. Additional calibrations were accomplished on 4 days of activity between 29 February and 19 March 1968, and the procedure was closed out and accepted on 29 May 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 ±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 ±100 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.

4.2.12 (Continued)

Three 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 temperature measurement was calibrated by adjusting the temperature bridge and the associated dc amplifier. This was the propellant utilization oven stability monitor, measurement N63, temperature bridge 411A61A214, P/N 1B68861-1, S/N 170, and dc amplifier 411A61A226, P/N 1A82395-1, S/N 2571. The dc amplifier zero control, and the temperature bridge potentiometer, were initially adjusted for a 0.000 ±0.005 vdc output with a low level calibration signal applied. With a high level calibration signal applied, the dc amplifier gain control was adjusted to obtain a gain output of 4.00 vdc, meeting the 4.000 ±0.005 vdc limits. With a low level calibration signal again applied, the dc amplifier zero control was adjusted to obtain a zero output of 0.00 vdc, meeting the 0.000 ±0.005 vdc limits.

Two expanded scale voltage monitor modules were calibrated by calibrating the associated dc amplifiers. These were the static inverter-converter 5 vdc monitor, measurement M4, expanded scale voltage module 411A61A255, P/N 1A95181-1, S/N 118, and dc amplifier 411A61A254, P/N 1A82395-1, S/N 2447; and the static inverter-converter 21 vdc monitor, measurement M23, expanded scale voltage module 411A61A253, P/N 1A95181-501, S/N 133, and dc amplifier 411A61A252, P/N 1A82395-503, S/N 527. With a low level calibration input, the dc amplifier zero control was adjusted to obtain a zero output of 0.000 ±0.005 vdc. With a high level calibration input, the dc amplifier gain control was adjusted to obtain the proper gain output for the particular amplifier. As shown in the Test Data Table, the final values measured for each amplifier were within the proper limits.

4.2.12 (Continued)

Two 400 Hz expanded scale frequency to dc converters were calibrated, as shown in the Test Data Table. With a high level calibration signal of 410 ±0.05 Hz applied, the frequency to dc converter was adjusted to obtain an output of 5.00 ±0.01 vdc. With a low level calibration signal of 390 ±0.05 Hz applied, the converter was adjusted to obtain an output of 0.00 ±0.01 vdc. As shown in the Test Data Table, the final values measured for each module were within the required limits.

Engineering comments noted that temperature bridge module 411A61A226, P/N 1B68861-1, was not installed at the start of this test, but was installed and tested during the test. No stage problems were encountered during this procedure, and no FARR's were written. One minor problem with a GSE power supply was corrected during the test. Eight revisions were made to the procedure:

a. One revision added a preliminary step to measure the auxiliary hydraulic pump motor container ambient gas pressure, measurement D209, function number 2401. This ambient pressure had to be measured before any hydraulic system procedures were started, as the pressure could not be bled down once the hydraulic system was pressurized. The ambient pressure was measured as -0.262 psig, within the 0.0 ±1.2 psig limits.

b. One revision corrected a typing error to show that the Model DSV-4B-279 instrumentation checkout unit console assembly was P/N 1B28115-1, rather than P/N 1B2[illegible]115-1, as listed.

c. Three revisions corrected errors in the procedure test tables. The multiplexer matrix points for measurement N55 were corrected to be CP1-647 and DP1-887, rather than CP1-888 and DP1-658, as listed. The callouts for measurement C382 were changed to be aft rack 404A64, rather than 404A66; channel decoder connection J1 to 404W206P4, rather than 404W206P7; and bridge, P/N 1B63306-529, location A225, connection J2 to 404A64W200P25, rather than bridge, P/N 1B63306-525, location A205, connection J2 to 404A66W200P5. The effectivity of measurement N63 was corrected to be both S-IB and S-V stages, rather than S-IB stages only.

d. One revision deleted an existing test equipment hookup instruction paragraph and substituted a new paragraph specifying the particular stage and GSE cables involved, and providng inspection verification of the removal and installation of the cables. The original paragraph did not provide for this verification.

4.2.12 (Continued)

e. Two revisions noted that the calibration of measurement N63 and a recalibration of measurement M29 were accomplished using the STC Beta Test setup instead of the VCL test setup. The Model DSV-4B-279 instrumentation checkout console assembly, required for VCL calibration operations, had been disconnected from the stage multiplexer before these calibrations were conducted, and the Beta test setup was the most expeditious way to perform the calibrations. It was also noted that measurement M29 required recalibration because it had drifted out-of-tolerance after a previous calibration.

4.2.12.1 Test Data Table, Signal Conditioning Setup

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

Reference Location	S/N	5vdc Out. (vdc)	-20 vdc Out. (vdc)	ac Output (vpp)	Hz
411A99A33	194	4.998	-20.000	10	2056
411A98A2	192	4.998	-19.998	10	2073
404A52A7	163	5.001	-20.000	10	2055

20 Volt Excitation Module, P/N 1A74036-1.2

Reference Location	S/N	20 vdc Output (vdc)
411A61A242	335	20.000
404A62A241	322	20.001
404A63A241	316	20.001
404A64A241	327	20.001
404A65A241	321	20.002
404A63A233	323	20.001

Temperature Bridge Calibration

Meas. No. and Fucntion	P/N	S/N	Reference Location	Output (mvdc) Low	High
C6 - GH_2 Start Bottle Temperature	1A98088-501	87	404A64A207	0.00	24.26
C7 - Engine Control Helium Temp.	1A98088-501	91	404A64A208	-0.04	24.17

4.2.12.1 (Continued)

Meas. No. and Function	P/N	S/N	Reference Location	Output (mvdc) Low	High
C199 - Thrust Chamber Jacket Temp.	1A98088-1	65	404A64A209	-0.04	24.21

Expanded Scale Voltage Calibration

Meas. No. and Function	Measured	Limits
M4 - Static Inverter-Converter 5 vdc Monitor		
Amplifier Zero Output (vdc)	0.002	0.000 ±0.005
Amplifier Gain Output (vdc)	4.000	4.000 ±0.005
M23 - Static Inverter-Converter 21 vdc Monitor		
Amplifier Zero Output (vdc)	0.002	0.000 ±0.005
Amplifier Gain Output (vdc)	2.285	2.285 ±0.005

400 Hz Expanded Scale Frequency to DC Converter Calibration

Meas. No. and Function	P/N	S/N	Reference Location	Output (vdc) 390 Hz	410 Hz
M12 - Static Inv-Conv Freq	1B37523-501	85	404A65A233	0.006	5.002
M29 - LOX C/D Inv Freq	1B37523-501	84	404A65A209	-0.003	5.004

4.2.13 Telemetry and Range Safety Antenna System (1B64679 D)

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 power function was checked. The items involved in this test included:

Part Name	Reference Location	P/N	S/N
PCM RF Assembly	411A64A200	1B65788-1	18001
Bi-Directional Coupler	411A64A204	1A69214-503	20010

4.2.13 (Continued)

Part Name	Reference Location	P/N	S/N
Coaxial Switch	411A64A202	1A69213-1	77
Power Divider	411A64A201	1A69215-501	52
Telemetry Antennas	411E200 & E201	1A69206-501	75 & 76
Reflected Power Detector	411MT744	1A74776-501	290
Forward Power Detector	411MT728	1A74776-503	302
Dummy Load	411A64A203	1A84057-1	817
Directional Power Divider	411A97A56	1B38999-1	36
Hybrid Power Divider	411A97A34	1A74778-501	42
Range Safety Antennas	411E56 & E57	1A69207-501.1	60 & 61

Initiated on 19 February 1968, the checkout was completed on 27 February 1968, after 6 days of activity. The procedure was certified as acceptable on 7 March 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 4.2.13.1, 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 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.

4.2.13 (Continued)

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 hybird 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 and carrier deviation were measured. The transmitter output power was then measured using a Bird RF power meter. With the transmitter reconnected to the system, the forward power detector output was measured and verified to be within ±3 percent 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 percent of the forward power. The output of the reflected power detector was then measured and verified to be within ±3 percent of the detector calibration requirement for the measured reflected power. The validity of the power detector measurements was then checked by verifying that the signal conditioning amplifiers for the detectors were adjusted for the proper gain. The telemetry RF system reflected power and transmitter output power were then measured through the AO and BO telemetry multiplexers.

4.2.13 (Continued)

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

Engineering comments noted that there were no parts shortages affecting this test. No stage problems were encountered during the test, and no FARR's were written. Two minor problems were encountered involving the test equipment. An incorrect dummy load was initially used, resulting in high insertion loss measurements, and the GSE thermoconditioning servicer failed to maintain the correct coldplate temperature at one point. Both of these problems were corrected.

Twenty revisions were made to the procedure:

a. One revision deleted a requirement to check the test articles for compliance with the applicable manufacturing, installation, and assemly drawings, as this was a duplication of the manfacturing effort

b. Three revisions added two Microlab TA-5FT 50 ohm dummy loads to the Non-End Item Equipment list, and added two notes to use the dummy loads to simulate the range safety antennas whenever any antenna or receiver cable was left disconnected during the procedure. The transmission lines had to terminate in 50 ohm loads to maintain an operational system.

c. One revision changed a reference measurement from 0 ±1 db to be 0 ±0.1 db, to correct a typing error and give the correct tolerance.

d. Two revisions changed the procedure at two places to turn off the system power before disconnecting any transmission cables, and to turn the power back on before proceeding with the tests.

e. Four revisions added a Bird Model 61 RF power meter to the Non-End Item Equipment list, and modified the PCM transmitter checks to connect this power meter, measure the transmitter output power, and disconnect the power meter. This output power measurement replaced the list measurement using a dummy load and an HP431B power meter, to give more accurate reading.

f. One revision changed the requirement that the stage thermoconditiong system coldplate temperature be stabilized at 55 ±5°F during the PCM transmitter power checks, to require that the temperature be stabilized at 59 ±5°F. This was to permit more accurate readings.

4.2.13 (Continued)

g. One revision changed the tolerance on the AO and BO telemetry multiplexer measurements of the PCM transmitter output power to be ±1.00 watt, rather than ±1.05 watts as listed, to provide an acceptable checkout tolerance.

h. One revision added a step to disconnect the transmitter output cable from the dummy load after the transmitter frequency measurements were made, as the cable had to be connected to other test equipment for subsequent tests.

i. Two revisions added, and corrected, steps to verify the gain adjustment of the power detector signal conditioning amplifiers by checking the GSE numeric readout for measurements N18 and N55, function numbers 2024 and 2105, under high and low RACS conditions. Verification of the amplifier calibrations was required, as the regular verification during the DDAS checkout would not be accomplished until after this procedure.

j. Two revisions added, and corrected, steps to accomplish an FM/FM transmitter check, to verify the RF assembly power and current, and the operation of the RF silence command.

k. One revision deleted the Model DSV-4B-298 monochrome system status display P/N 1B37968-1, from the End Item Equipment list, as the unit was under design evaluation and was not ready for checkout use.

l. One revision changed the PCM transmitter carrier deviation calculation to be $(f_2 - f_1)/2$, rather than $(f_1 - f_2)/2$ as listed, because upper bandedge frequency f_2 is always greater than lower bandedge frequency f_1.

4.2.13.1 Test Data Table, Telemetry and Range Safety Antenna System

Function	Measurement	Limits
Test Cable Calibration		
VSWR at 258.5 MHz	18.0	*
VSWR at 450.0 MHz	11.0	*
Telemetry System Tests		
Insertion Loss to Antenna 1 (db)	4.9	6.7 max
Insertion Loss to Antenna 2 (db)	4.7	6.7 max
Antenna Line Phase Difference (deg)	6.46	30.0 max
VSWR to Antenna 1	1.16	1.7 max
VSWR to Antenna 2	1.37	1.7 max
System Closed Loop VSWR	1.27	1.5 max
System Open Loop VSWR	1.34	1.7 max

*Limits Not Specified

4.2.13.1 (Continued)

Function	Measurement	Limits
Range Safety System Tests		
Transmission Line Continuity Resistance		
Receiver 1 to Antenna 1 (ohms)	0.3	0.5 max
Receiver 1 to Antenna 2 (ohms)	0.2	0.5 max
Receiver 2 to Antenna 1 (ohms)	0.3	0.5 max
Receiver 2 to Antenna 2 (ohms)	0.2	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)	31.9	25.0 min
Receiver 1 to Antenna 1 Loss (db)	5.0	6.0 max
Receiver 1 to Antenna 2 Loss (db)	5.3	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)	25.7	24.0,+1.9,-1.5
Receiver 2 to Checkout Connector Loss (db)	23.8	24.0,+1.9,-1.5
Closed Circuit Checkout Cable Loss (db)	1.0	1.5 max
VSWR Checks		
Power Divider to Antenna 1 ne VSWR	1.5	1.7 max
Power Divider to Antenna 2 ne VSWR	1.5	1.7 max
Receiver 1 System VSWR	1.38	1.7 max
Receiver 2 System VSWR	1.45	1.7 max
PCM Transmitter RF Tests		
Center Frequency (MHz)	258.507	258.500 ±0.026
Carrier Deviation (kHz)	36.0	36.0 ±3.0
Output Power (watts)	21.0	12.75 to 25.25
Forward Power Detector Output (millivolts)	96.0	9[illegible] ±2.9
Forward Power Detector Output (millivolts)	83.4	
Equivalent Forward Power (watts)	18.18	
Reflected Power (watts)	1.95	2.0 ±0.2
Reflected Power Detector Output (millivolts)	6.4	6.3 ±0.2
Reflected Power, AO (watts)	1.986	1.95 ±0.21
Reflected Power, BO (watts)	1.980	1.95 ±0.21
Transmitter Output Power, AO (watts)	20.76	21.0 ±1.00
Transmitter Output Power, BO (watts)	20.76	21.0 ±1.00

*Limits Not Specified

4.2.14 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 X458912; the engine driven hydraulic pump, P/N 1A66240-505, S/N X457813; the accumulator/reservoir assembly, P/N 1B29319-519, S/N 26; the pitch hydraulic actuator, P/N 1A66248-507, S/N 77; and the yaw hydraulic actuator, P/N 1A66248-507-012, S/N 66.

This procedure was initiated on 20 February 1968, and was completed, except for the preshipment preparations, by 1 March 1968. The procedure was then held open for use during automatic testing, with additional testing being accomplished between 25 April and 1 May 1968 due to the replacement of the auxiliary hydraulic pump quick disconnect and the accummulator/reservoir air fill valve (reference FARR's 500-238-127 and 500-238-143). At the completion of stage testing, the preshipment preparations, were accomplished on 27 May 1968, and the procedure was accepted on 4 June 1968. The procedure was active on 12 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 ±50 psig, and a leak check of the auxiliary pump purge system verified that there was no leakage. An air tank decay check was conducted concurrent with other checks in the procedure. The air tank pressure was measured as 459.6 psia at the start of the test. After 24 hours, the tank pressure was measured as 450.3 psia, down 9.3 psi, well within the 120 psi decay limit for a 24 ±1 hour period.

4.2.14 (Continued)

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 function, as shown in Test Data Table 4.2.14.1.

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 99.2 percent, and the maximum empty reservoir oil level was measured as 0.002 percent, both within the acceptable limits of 100 ±2 percent and 0 ±2 percent, 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 2350 psig required for the ambient air temperature of 70°F. 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 was then reduced to 1000 ±100 psig, the air tank pressure was verified to be 450 ±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.

4.2.14 (Continued)

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 ± 100 psig, using the HPU, and the gimbal control unit was used to cycle the pitch and yaw actuators with ±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 turned off after the samples were obtained.

For the hydraulic system air content test, the system was pressurized to 3650 ±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 reattached to the stage, and preparations were made for a square pattern slew check. The HPU was used to pressurize the hydraulic system to 1000 ±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 ±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 ±100 psig for 3 minutes. The oil

4.2.14 (Continued)

temperature was measured as 78°F, and the required amount of fluid, 250 milliliters for this temperature, was drained from the reservoir bleed valve.

For a check of the hydraulic system transducers, the hydraulic system functions were checked as shown in the Test Data Table, 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 stage automatic testing.

During subsequent stage testing, a leak was found at the auxiliary hydraulic pump quick disconnect, as noted by FARR 500-238-127 below and the accumulator/reservoir air fill valve was broken off, as noted by FARR 500-238-143. After the disconnect and air fill valve were replaced, parts of the procedure were repeated to reverify that the HPU and hydraulic system cleanliness was acceptable, that the accumulator/reservoir was properly charged, and that the system did not leak and was properly bled. The thermal expansion compensation was repeated, and the hydraulic system was accepted for further testing.

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 and corrected during the test, as noted on IIS 378323. One GSE problem occurred at the start of the test when the HPU leaked at the quick-disconnect fitting for the hydraulic fluid return line. The quick-disconnect fitting, P/N 1B26500-507, was replaced and the test was continued. The two previously noted stage hydraulic system problems were covered by the following FARR's:

a. FARR 500-238-127 rejected the coupling half quick-disconnect, P/N 1A68498-517, on the auxiliary hydraulic pump, for leaking hydraulic fluid overboard. The defective coupling half was removed, and a new unit was installed and accepted for use.

4.2.14 (Continued)

b. FARR 500-238-143 noted that the high pressure air fill valve, P/N 1B31295-1, S/N 95, on the hydraulic accumulator/reservoir, P/N 1B29319-519, S/N 26, was twisted off at the thread relief. The defective valve was removed, and a new valve, S/N 126, was installed and accepted for use.

Three revisions were made to the procedure:

a. One revision added the motor canister pressure and the air bottle pressure, function numbers 2401 and 2403 respectively, to the list of hydraulic system measurements made with the system unpressurized. This was to monitor the air systems transducer.

b. Two revisions noted the parts of the procedure that were repeated after the replacement of the auxiliary hydraulic pump quick-disconnect and the accumulator/reservoir fill valve.

4.2.14.1 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)	260.0	275.0 ±25.0
Reseat Pressure, Ground Return (psig)	255.0	240.0 min
Relief Pressure, Overboard (psig)	275.0	275.0 ±25.0
Reseat Pressure, Overboard (psig)	260.0	240.0 min
High Pressure Relief Valve		
System Hydraulic Pressure (psig)	4300.0	4400.0 max
Return Pressure (psig)	274.0	*
Differential Pressure (psi)	4027.0	3900.0 min
Accumulator High Pressure Relief Valve Checks		
System Internal Leakage (gpm)	0.65	0.8 max
Relief Valve Cracking Pressure (psig)	4200.0	*
Reservoir Pressure (psig)	265.0	*
Differential Cracking Pressure (psi)	3935.0	4100.0 max
Relief Valve Reseating Pressure (psig)	4100.0	*
Reservoir Pressure (psig)	260.0	*
Differential Reseating Pressure (psi)	3840.0	3760.0 min

*Limits Not Specified

4.2.14.1 (Continued)

Function	Measurement	Limit
Hydraulic System Unpressurized		
Aft 5v Excitation Module (vdc)	5.001	5.00 ±.03
Hydraulic System Pressure (psia)	1366.0	1400.0 approx
Hydraulic Pump Inlet Oil Temperature (°F)	78.8	approx ambient
Reservoir Oil Pressure (psia)	71.0	55.0 min.
Accumulator GN_2 Pressure (psia)	2305.0	2350.0 approx
Accumulator GN_2 Temperature (°F°)	72.0	approx ambient
Reservoir Oil Level (%)	89.8	85.0 min
Reservoir Oil Temperature (°F)	79.2	approx ambient
Motor Canister Pressure (psig)	13.42	8.8 to 33.7
Air Bottle Pressure (psig)	446.1	450.0 ±50.0
Hydraulic System Pressurized		
Aft 5v Excitation Module (vdc)	5.002	5.00 ±0.03
Hydraulic System Pressure (psia)	3582.0	3650.0 ±150.0
Hydraulic Pump Inlet Oil Temperature (°F)	87.4	approx ambient
Reservoir Oil Pressure (psia)	164.5	180.0 ±20.0
Accumulator GN_2 Pressure (psia)	3578.0	syst press. ±100
Accumulator GN_2 Temperature (°F)	72.0	approx ambient
Reservoir Oil Level (%)	39.5	25.0 min
Reservoir Oil Temperature (°F)	82.7	approx ambient
T/M Pitch Actuator Position (deg)	-0.002	0.0 ±0.236
T/M Yaw Actuator Position (deg)	-0.003	0.0 ±0.236

*Limits Not Specified

4.2.15 Propulsion System Control Console/Stage Compatibility (1B59454 D)

The Model DSV-4B-234 propulsion system control console, P/N 1A64728-1, 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 20 February 1968, the procedure was completed on 29 February 1968, after 6 days of activity, and was accepted on 29 February 1968. The proper actuation and deactuation of the solenoid valves was verified by listening for audible valve operation at the appropriate modules, and verifying that the correct indicator lights came on at the Mainstage Propulsion Manual Control Panel of the control console.

In the forward skirt area, the valves checked were the main fuel tank 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 pre-valve 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.

4.2.15 (Continued)

In the thrust structure area, the valves checked were the main oxidizer tank vent valve open/close solenoid valve 403A75A1L1 and boost close solenoid valve 403A75A1L2; the control helium shutoff valve close/open solenoid valve 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 there were no parts shortages affecting this test. Some problems with the O_2H_2 burner tip electrode installation, per drawing 1B67337, were satisfactorily resolved. Solenoid valve 403A15L1, for the O_2H_2 burner LOX propellant valve, gave no audible response, but was not rejected as an audible response was not a requirement of the valve specification control drawing. When a procedure revision checked the solenoid valve with pneumatic pressure applied, the normal operating condition for the valve, an audible response was obtained. This satisfactorily verified the valve operation and the control console compatibility. No FARR's were written during this test.

4.2.15 (Continued)

Four revisions were made to the procedure:

a. One revision deleted the O_2H_2 burner exciter ignition system, P/N 1B59986, and the igniter tips, P/N 89181, from the Time/Cycle Significant Items paragraph, and deleted another note indicating that they were cycle significant. These items were no longer cycle significant, per the "G" change of the Time/Cycle Significant Items drawing, 1B55424.

b. One revision corrected a typing error by changing one reference location to be (403 A73 A1 L1), rather than (402 A73 A1 L1) as listed.

c. One revision changed the check of solenoid valve 403A15L1, for the O_2H_2 burner LOX propellant valve, to apply pneumatic pressure before audibly verifying the valve operation, as the solenoid valve gave no audible response when pneumatic pressure was not applied.

d. One revision deleted the S-IB vehicle structures assembly, P/N 1A74634-1, from the End Item Requirements list, as the drawing for the S-IB stage did not contain any of the components tested by this procedure.

4.2.16 Level Sensor and Control Unit Calibration (1B64680 C)

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 4.2.16.1.

The procedure was initially accomplished on 20 and 21 February 1968. Subsequent to this, a procedure revision was written to provide a more practical sequence of operations. The procedure was reaccomplished per this revision on 12 March 1968, and was accepted on 13 March 1968. 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.

4.2.16 (Continued)

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 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 deactiviation 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 affecting this test. One problem was encountered during the test, and one FARR was written. When the test was reaccomplished per the procedure revision, all of the control units, except one, were acceptable without readjustment. The LH_2 liquid level L19 control unit, 411A61A221, was satisfactorily readjusted with no problems. FARR A271209, written during the initial accomplishment of the test, rejected the LH_2 overfill control unit 411A92A24, P/N 1A68710-509, S/N D2. As noted by IIS 376221, control R1 could not be adjusted for proper operation. The defective control unit was removed and scrapped, and a new control unit, S/N C100, was installed and accepted for use.

4.2.16 (Continued)

Five revisions were made to the procedure:

a. One revision changed two paragraph references to be paragraph 4.2.1.10, rather than paragraph 4.2.1.6 as listed, as the procedure paragraphs had been renumbered.

b. Two revisions added a step to verify that the activate light was OFF at one point after the Test Operator Control Console ACTIVATE-OFF switch was set to OFF, and then deleted this step because use of the console was deleted by another revision.

c. One revision changed the procedure to provide a more practical operational sequence, and repeated the test to verify all of the control units. In general the revised procedure turned the stage aft bus 1 and talkback power on and off at the Electrical Networks Control Console, and deleted use of the Test Operator Control Console ACTIVATE-OFF switch for this purpose. As the control units had been adjusted previously, each was checked for acceptable operation and readjusted only if necessary. The precision capacitor was set to 4 picofarads at the start of each check, and decreased from this value to obtain relay deactivation.

d. One revision changed a test cable designation to be P/N 1B55715-527, rather than P/N 1B55715-505 as listed, for use with the test assembly, P/N 1B50928-1. The A3-VCL required test cables 6 feet long; however, the -505 cable was only 2 feet long.

4.2.16.1 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	D73	A61A217	-509	C42	0.5049	0.5	0.5050	0.9
Liq Lev L18	MT733	-507	D84	A61A219	-509	C43	0.5076	0.5	0.5078	0.9
Liq Lev L19	MT734	-507	D90	A61A221	-509	C46	0.659	0.5	0.663	0.9
Pt Lev 1	A2C1	-507	C1	A92A25	-509	C27	0.583	0.5	0.589	0.9
Pt Lev 2	A2C2	-507	C4	A92A26	-509	C38	0.552	0.5	0.556	0.9
Pt Lev 3	A2C3	-507	C5	A92A27	-509	C39	0.550	0.5	0.555	0.9
Pt Lev 4	A2C4	-507	C9	A61A201	-509	C40	0.801	0.5	0.804	0.9
Fastfill	A2C5	-1	D136	A92A43	-509	D71	0.648	0.5	0.658	0.9
Overfill	*	*	*	A92A24	-509	C100	0.980	0.9	0.982	1.3

*Part of LH_2 Mass Probe, P/N 1A48431-509, S/N E8, Location 408A1

4.2.16.1 (Continued)

Function	Sensor, P/N 1A68710 Ref Loc	Dash P/N	S/N	Control Unit, P/N 1A68710 Ref Loc.	Dash P/N	S/N	Deact Cap (pf) Meas	Min	React Cap (pf) Meas	Max
LOX Tank	406			404						
Liq Lev L14	MT657	-1	C33	A63A221	-511	C18	1.462	1.3	1.468	1.7
Liq Lev L15	MT658	-1	C32	A63A206	-511	C17	1.475	1.3	1.480	1.7
Liq Lev L16	MT659	-1	C36	A63A223	-511	C20	1.443	1.3	1.447	1.7
Pt Lev 1	A2C1	-1	C5	A72A1	-511	C40	1.439	1.3	1.440	1.7
Pt Lev 2	A2C2	-1	D120	A72A2	-511	C33	1.402	1.3	1.405	1.7
Pt Lev 3	A2C3	-1	D132	A72A3	-511	C42	1.438	1.3	1.441	1.7
Pt Lev 4	A2C4	-1	D135	A63A227	-511	C22	1.442	1.3	1.444	1.7
Fastfill	A2C5	-1	C18	A72A5	-511	C45	1.462	1.3	1.464	1.7
Overfill	**	**	**	A72A4	-511	C24	2.059	1.9	2.061	2.3

4.2.17 Digital Data Acquisition System Calibration, Automatic (1B66563 D)

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 6700083; the CP1-BO time division multiplexer, P/N 1B65897-1, S/N 8; the DP1-BO time division multiplexer, P/N 1B65897-501; S/N 6; the remote digital submultiplexer (RDSM), P/N 1B66051-1, S/N 3; and the low level remote analog submultiplexer (RASM), P/N 1B66050-501, S/N 1.

The procedure was satisfactorily accomplished by the first attempt on 21 February 1968. Subsequent to this, the remote analog submultiplexer, P/N 1B66050-1, S/N 2, failed during the DDAS automatic test, H&CO 1B66564, and was rejected by FARR A271274 (reference paragraph 4.2.20). A new RASM, P/N 1B66050-501, S/N 1, was installed, and a second attempt of this calibration procedure was accomplished on 6 March 1968, to repeat only the RASM portion of the test. The procedure was accepted on 20 March 1968. The following narration covers the first attempt for all except the RASM check, and the second attempt for the RASM check only.

**Part of LOX Mass Probe, P/N 1A48430-511, S/N C4, Location 406A1

4.2.17 (Continued)

The stage power setup, H&CO 1B66560, was accomplished to establish initial conditions 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 measured as 72,003 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 as 633 kHz at 2.8 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 as 567 kHz at 2.9 vrms, within the acceptable limits of 556.8 kHz to 576.8 kHz at greater than 2.2 vrms. The frequency differential was calculated as 65 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 [illegible]er for a digital word of corresponding ones or zeros. The RASM was verified by inserting voltages from 0 to 30 millivolts, which were amplified at the output to be 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 4.9 amperes, within the 4.5 ±3.0 amperes limits.

4.2.17 (Continued)

Engineering comments noted that there were no parts shortages affecting this test. No stage problems were encountered during either attempt of the test, and no FARR's were written. Engineering comments noted several operational problems that occurred during the first test attempt. Some CP1-BO multiplexer channels initially indicated out-of-tolerance malfunctions because two GSE power supplies were not turned on, and some RASM channels initially indicated out-of-tolerance malfunctions because of a faulty ground hookup and test setup. Both units were satisfactorily tested after these problems were corrected. One typeout error message occurred because an attempt was made to delete a step that had previously been deleted, and one program backup was repeated to reverify the PCM transmitter current. During the second test attempt, it was noted that the installation of an RASM, P/N 66050-501, in place of an RASM, P/N 1B66050-1, did not affect the performance of the DDAS calibration RASM test. It was also noted that several malfunction indications that occurred during the preliminary stage power setup procedure did not affect the DDAS calibration procedure.

Ten revisions were made to the procedure:

a. Two revisions changed the RASM test setup figure for better operation, and to use a battery and voltage divider network instead of an EPSCO UR 607-2 power supply, as the EPSCO power supply generated noise which could not be tolerated in the RASM test.

b. One revision changed the list of required test cables to include cables, P/N's 1B48150, 1B58151, and 1B66556; and added a note to indicate that the -501 configuration of all test cables was to be used at SSC, and the -1 configuration was to be used at STC. The revision also deleted the -1 identification from two cable part number callouts in subsequent setup instructions. This was to make the procedure agree with the test requirements drawing.

c. One revision added a note to the 600 kHz VCO test manual operations to short out the test leads to obtain zero volt inputs. This speeded up the test by making it unnecessary to measure the zero volt inputs.

d. Two revisions changed the PCM transmitter current measuring operation. After the PCM RF assembly power was turned on, the delay before measuring the current was changed to be 50 milliseconds, rather than

4.2.17 (Continued)

180 seconds, to verify that the current was within tolerance immediately after the initial transient caused by turning on the transmitter. After this measurement was completed, a breakpoint was added and, after a 30 second delay, the current was manually monitored to verify that it remained in tolerance during the transmitter warmup.

e. One revision deleted the Model DSV-4B-298 monochrome system status display, P/N 1B37968-1, from the End Item Requirement list, as the unit was in design evaluation and was not ready for use.

f. One revision changed the 600 kHz VCO test setup figure to use an EPSCO UR607-2 power supply rather than CEC 3-132 power supply, as the only available CEC 3-132 power supply was unstable. The EPSCO power supply was an equivalent item.

g. One revision changed the CP1-BO and DP1-BO multiplexer test setup figures to use a Fluke Model 883A differential voltmeter rather than a Fluke Model 823A differential voltmenter. No Fluke Model 823A was available, and the Model 883A was equivalent.

h. One revision specified those parts of the procedure that were repeated to test the replacement RASM. This included only the initial setups, the RASM test, and the shutdown operations.

4.2.18 Pneumatic Control System Leak Check (1B59457 C)

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.

Initiated on 21 February 1968, the procedure was completed on 28 February 1968, after 4 days of activity, and was accepted on 5 March 1968. In general, the test was accomplished by pressurizing the pneumatic control system with gaseous helium, and using a USON lead detector as the primary method of detecting leakage. Leak test bubble fluid was used when required as a secondary detection method, and gross leakage was located by listening for audible escaping gas.

The stage test configuration was established by capping various supply and purge lines to isolate the pneumatic control system. The backup pressure switches checkout lines were pressurized to about 100 psia, and it was verified that there was no gross leakage. The checkout lines were then pressurized to 550 ± 50 psia and leak checked. With the pressure switch sense lines temporarily disconnected, it was verified that there was no leakage at the sense port of each pressure switch. At the completion of these checks, the checkout lines were vented to ambient pressure.

The pneumatic control sphere was pressurized to 1750 ± 50 psia for an integrity check, with checks made at several pressures to verify that there was no gross leakage. The integrity pressure was held for 3 minutes, then the pneumatic control sphere was vented to 1500 ± 100 psia and the control sphere supply lines and purge lines were leak checked. The pneumatic control shutoff valve seat leakage was measured as zero scim, meeting the 5 scim maximum allowable leakage limit.

4.2.18 (Continued)

Leak checks were conducted on the pneumatic control module and the engine pump purge control module, and the engine pump purge valve open flowrate was measured as 6.5 scfm, meeting the 6.0 $\pm$0.5 scfm limits. The pneumatic control sphere was vented to between 225 and 250 psig and the control module supply lines were leak checked. The leakage at the pneumatic control module vent port was measured as zero scim, the start tank vent valve was closed, and after 2 minutes of venting at the control module the vent port leakage was remeasured as 0.5 scim. Both of these measurements were within the 1 scim maximum limit. The pneumatic control sphere was then repressurized to 550 $\pm$50 psia.

Leak checks were then conducted on the remaining pneumatic supply lines, and on the following components of the system: the LOX chilldown pump and the pump purge control module; the LOX and LH_2 prevalves and chilldown shutoff valves, and the actuation control module for these valves; the LOX and LH_2 vent and relief valves and their actuation control modules; the LOX and LH_2 fill and drain valves and their actuation control modules; the O_2H_2 burner LOX and LH_2 propellant valves and LOX shutoff valve, and their actuation control modules; the directional control valve and its actuation control module; and the LH_2 continuous vent valve and its actuation control module.

During the check of the LOX chilldown pump purge module, with the pneumatic control shutoff valve open, the flow through the module was measured as 43 scim, within the 36.6 +12.2, -3.6 scim limits, and the flow through the module bypass line was measured as 7.5 scim, within the 10 $\pm$3 scim limits. During the check of the LOX and LH_2 chilldown shutoff valves and actuation control module, the chilldown valve actuation control was pressurized to 500 $\pm$10 psig through the vent port, and the pressure was measured as 490 psig. After a 30 minute delay, the pressure was remeasured as 488.5 psig, meeting the 1 psi per minute allowable decay rate.

4.2.18 (Continued)

During the leak checks, leakage measurements were made at the vent porrs of the actuation control modules, and seal leakage measurements were made at various valves. All of these measurements were zero scim or sccm except the following: the LOX chilldown pump seal leakage was 0.6 scim at the overboard drain vent, within the 8 scim maximum limit; the actuation control module for the LOX and LH_2 prevalves and chilldown shutoff valves leaked 4 sccm at valve A (L2) with the valves open, within the 100 sccm maximum limit; the LOX prevalve piston seal leakage was 0.5 scim, within the 300 scim maximum limit; and leakage at the mating flanges of the continuous vent module and the bypass valve pneumatic actuator was 1.0 scim, within the 6.1 scim maximum limit.

After the above leak checks were accomplished, the pneumatic control sphere was pressurized to 1450 $\pm$50 psia, and the pneumatic system purge lines were leak checked. For a system pressure decay check with the pneumatic valves de-actuated, the pneumatic control sphere temperature and pressure were measured as 103°F and 1464 psia, and were remeasured after a 30 minute delay as 97°F and 1453 psia. With the pneumatic valves actuated, the control sphere temperature and pressure were measured as 92°F and 1430 psia, and were remeasured after another 30 minute delay as 90°F and 1427 psia. These results were acceptable, and the system was returned to the pre-test configuration, completing the procedure.

Engineering comments noted that there were no parts shortages affecting this test. Four leaks were found and corrected during the test, no other problems were encountered, and no FARR's were written. The four leaks were:

a. Pipe assembly, P/N 1B66247-1, leaked at the seal to the control sphere and adapter. The conoseal and O-ring were replaced to correct the leak.

b. Pipe assembly, P/N 1B63263-1, leaked at the B-nut connection to a backup pressure switch. The B-nut was retorqued to correct the leak.

c. The engine pump purge module, P/N 1A58347-505, S/N 81, leaked at the flange connection of pipe assembly, P/N 1B67224-1. The conoseal and O-ring were replaced to correct the leak.

d. Pipe assembly, P/N 1B59288-1, leaked at the connection to the actuation control module for the LH_2 fill and drain valve. The adapter was replaced at the actuation control module to correct the leak.

4.2.18 (Continued)

Eleven revisions were made to the procedure:

a. Two revisions corrected typing errors to show a proper part number and valve designation, and two proper OLSTOL command bit patterns.

b. Two revisions added requirements to measure leakage at the mating flanges of the continuous vent module and the bypass valve pneumatic actuator, to cover a new leak test requirement, and to measure leakage past the ground side piston actuator seal at the housing vent port of the directional control valve, to correct a procedure omission.

c. One revision changed the maximum allowable leakage past the flight side piston actuator seal at the housing vent port of the directional control valve to be 100 scim rather than 50 sccm as listed, to reflect the leakage rate authorized by the "AC" change of drawing 1A49988.

d. One revision deleted a check for leakage through the shaft seal vent port of the O_2H_2 burner LOX propellant valve, as the vent port was inaccessible.

e. Five revisions changed the test setup to connect portable test gauges to monitor stage pressures while the Model DSV-4B-661 vehicle monitor panel, P/N 1B40536-1, was temporarily out of service, to disconnect the portable gauges when the Model 661 was returned to service, and to reconnect the portable gauges when the Model 661 was again taken out of service; added a step to disconnect the portable test gauges at the end of the test, to return the stage to the original condition; and added a step to reconnect the Model 661 after it was recertified, for use during subsequent stage testing.

4.2.19 Power Distribution System (1B66562 D)

The automatic checkout of the stage power distribution system vertified 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.

4.2.19 (Continued)

Initiated on 22 February 1968, the procedure was completed by the third attempt on 13 March 1968, after 4 days of activity, and was accepted on 14 March 1968. The first attempt was not acceptable because of out-of-tolerance voltages from the LH_2 chilldown inverter. After additional troubleshooting, this unit was rejected by FARR A271270, below, and a new inverter was installed. The second attempt was acceptable, but a subsequent adjustment of the signal conditioning module for measurement M29, the LOX chilldown inverter frequency, required that the test be reaccomplished. The following narration and Test Data Table 4.2.19.1 covers the acceptable third attempt.

The stage power setup, H&CO 1366560, was accomplished to establish initial conditions 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, and voltage with the power off. For a check of the emergency detection 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 and BO multiplexer engine cutoff signal indications (K13); and that with the EDS 1 signal turned off, the engine ready bypass turned off the 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 valve was measured to determine the cutoff signal delay time. Each

4.2.19 (Continued)

of the point level sensors was then verified to respond 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 engine control bus power was then turned off and the bus voltage was measured.

The propellant utilization inverter and electrical power current was measured while the power was temporarily turned on. The PCM RF assembly power current was then measured, and the PCM/FM transmitter output power was measured through the AO and BO multiplexers. With the telemetry RF silence command turned on, the RF group was verified to be off, the PCM/FM 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 $\pm$2.0 vdc with the gyro turned on, and 0.0 $\pm$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 LOX and LH_2 chilldown inverter tests, measurements were made of the input current, the output voltages through both hardwire and telemetry, and the operating frequency through telemetry, for each inverter.

4.2.19 (Continued)

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 0.866 seconds of running time during this attempt, and that the switch selector had been used 29 times.

Engineering comments noted that an interim use control relay module, P/N 50M35076-1, S/N 335, was installed at reference location 404A51A4 in place of a control relay module, P/N 1B57731-1. The interim use module would be replaced prior to STC prefiring activities. As noted, one FARR was written during this test. FARR A271270 rejected the LH_2 chilldown inverter, P/N 1A74039-517-016, S/N 73, for out-of-tolerance voltages. Phase AB was 51.54 vac, and phase AC was 51.28 vac, both outside of the 55.0 $\pm$3.0 vac limits. The defective inverter was removed, and a new inverter, S/N 75, was installed and accepted for use.

Eight revisions were made to the procedure:

a. One revision deleted the hardwire frequency checks of the LOX and LH_2 chilldown inverters, as the period counter in the Model DS4-4B-131 response signal conditioner, P/N 1A59947-1, was inoperative due to a design problem. The frequencies were measured by telemetry during the test.

4.2.19 (Continued)

b. Four revisions changed the tolerance on several voltage measurements: The engine bus voltage was to be 0.0 ±0.45 vdc when the bus was off, and the component test power voltage was to be 0.0 ±1.0 vdc when the power was off, rather than the 0.0 ±2.0 vdc listed for these measurements; the switch selector monitor (K128) voltage was to be 2.0 ±0.425 vdc, rather than 2.0 ±1.0 vdc as listed, to provide a more realistic tolerance; and the tolerance on the chilldown inverter hardwire voltage measurements was to be +2.0, -4.5 vac rather than ±3.0 vac as listed, to compensate for voltage drops in the GSE cables and noise spikes which were present when the voltage monitoring circuit was not loaded by a multiplexer.

c. One revision corrected two print statements to printout the LOX and LH_2 chilldown pump currents. As written, the statements printed out the aft bus 2 power supply current as measured before the chilldown inverters were turned on.

d. One revision made a special data run to verify that the LOX and LH_2 chilldown pump currents were within tolerance. As noted by the previous revision, the data printout showed the bus current instead of the pump currents. Current measurements made before and after the chilldown inverters were turned on were used to determine the pump currents, as shown in Test Data Table 4.2.19.1, and the currents were verified to be acceptable.

e. One revision deleted the Model DSV-4B-298 monochrome system status display, P/N 1B37968-1, from the End Item Requirements list, as it was not used during this procedure.

4.2.19.1 Test Data Table, Power Distribution System

Function	Measurement	Limits
Engine Control Bus Current (amps)	0.200	2.0 ± 2.0
Engine Control Bus Voltage (vdc)	27.691	28.0 ± 2.0
APS Bus Current (amps)	0.700	1.5 ± 3.0
Engine Ignition Bus Current (amps)	0.301	0.0 ± 2.0
Engine Ignition Bus Voltage, Bus On (vdc)	27.845	28.0 ± 2.0
Engine Ignition Bus Voltage, Bus Off (vdc)	-0.062	0.0 ± 0.45
Component Test Power Current (amps)	-0.200	0.0 ± 2.0
Component Test Power Voltage, Power On (vdc)	27.999	28.0 ± 2.0
Component Test Power Voltage, Power Off (vdc)	0.000	0.0 ± 1.0
Engine Control Bus Voltage, EDS 2 On (vdc)	-0.030	0.0 ± 0.45
Engine Control Bus Voltage, EDS 2 Off (vdc)	27.753	28.0 ± 2.0
Propellant Level Sensor Power Current (amps)	-0.700	1.0 ± 2.0
Engine Cutoff LOX Depletion Timer (seconds)	0.549	0.560 ± 0.025
Engine Control Bus Voltage, Bus Off (vdc)	-0.092	0.0 ± 2.0
PU Inverter and Electrical Power Current (amps)	4.500	3.0 ± 2.0
PCM RF Assembly Power Current (amps)	4.801	4.5 ± 3.0
PCM/FM Transmitter Output Power, AO (watts)	18.886	10.0 min

4.2.19.1 (Continued)

Function	Measurement	Limits
PCM/FM Transmitter Output Power, BO (watts)	18.886	10.0 min
PCM/FM Transmitter Output Power (RF Silence On) (watts)	-0.178	0.0 ± 2.0
Switch Selector Output Monitor (K128) (vdc)	2.107	2.0 ± 0.425
PCM/FM Transmitter Output Power (RF Silence Off) (watts)	18.797	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)	55.679	56.0 ± 1.0

Chilldown Inverter Tests

Function	LOX Inv.	LH_2 Inv.	Limits
Inverter Current (amps)	22.8	22.4	20.0 ± 5.0
Phase AB Voltage, Hardwire (vac)	51.868	51.804	55.4, +2.0,-4.5
Phase AC Voltage, Hardwire (vac)	51.479	51.479	55.4, +2.0,-4.5
Phase A1B1 Voltage, Hardwire (vac)	52.129	51.933	55.4, +2.0,-4.5
Phase A1C1 Voltage, Hardwire (vac)	51.608	51.349	55.4, +2.0,-4.5
Phase AB Voltage, Telemetry (vac)	55.465	55.266	55.4 ± 3.0
Phase AC Voltage, Telemetry (vac)	55.465	55.465	55.4 ± 3.0
Frequency, Telemetry (Hz)	400.1	400.3	400.0 ± 4.0

Function	Measurement	Limits
Forward Bus 1 Battery Simulator Voltage (vdc)	28.04	28.0 ± 2.0
Forward Bus 2 Battery Simulator Voltage (vdc)	28.08	28.0 ± 2.0
Aft Bus 1 Battery Simulator Voltage (vdc)	28.00	28.0 ± 2.0
Aft Bus 2 Battery Simulator Voltage (vdc)	56.00	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)	0.00	0.0 ± 1.0
Bus 4D10 ESE Load Bank Voltage (vdc)	0.00	0.0 ± 1.0
Forward Bus 1 Internal Voltage (vdc)	28.16	28.0 ± 2.0
Forward Bus 2 Internal Voltage (vdc)	28.00	28.0 ± 2.0
Aft Bus 1 Internal Voltage (vdc)	28.04	28.0 ± 2.0
Aft Bus 2 Internal Voltage (vdc)	55.84	56.0 ± 4.0
Forward Bus 1 External Voltage (vdc)	27.92	28.0 ± 2.0
Forward Bus 2 External Voltage (vdc)	28.08	28.0 ± 2.0
Aft Bus 1 External Voltage (vdc)	27.92	28.0 ± 2.0
Aft Bus 2 External Voltage (vdc)	55.84	56.0 ± 4.0
Forward Bus 1 Battery Simulator Voltage (vdc)	0.00	0.0 ± 1.0
Forward Bus 2 Battery Simulator Voltage (vdc)	0.00	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)	1.000	[illegible] ± 2.0
Range Safety Receiver 2 Current (amps)	-0.500	0.0 ± 2.0

4.2.20 Digital Data Acquisition System (1B66564 D)

The digital data acquisition system (DDAS) test verified the operational status of the stage data channels. The outputs of the channels were checked by the DC24A computer to ensure that they were within the specified tolerances. All channels tested were checked for the proper output under ambient conditions, while those channels having a signal insertion (calibration) capability were also checked with the applicable high or low mode calibration signal supplied by the remote automatic calibration system (RACS). The proper operations of the signal conditioning units and associated amplifiers, and the command calibration channel decoder assemblies, were verified during these checks. Additional PCM RF checks verified the proper operation of the telemetry system PCM FM transmitter and antenna system.

The items tested by this procedure included the PCM/DDAS assembly, P/N 1B65792-1, S/N 6700083; the CP1-B0 time division multiplexer, P/N 1B65897-[illegible], S/N 8; the DP1-B0 time division multiplexer, P/N 1B65897-501, S/N 6; the remote digital submultiplexer (RDSM), P/N 1B66051-1, S/N 3; the low level remote analog submultiplexer (RASM), P/N 1B66050-501, S/N 1; and the PCM RF assembly, P/N 1B65788-1, S/N 18001.

The first attempt to run the test procedure was on 26 February 1968. Five attempts were required before the test was successfully completed on 25 March 1968. The procedure was active for 12 days, which included troubleshooting of the malfunctions encountered. The procedure was accepted on 7 May 1968.

The stage power setup, H&CO 1B66560, was accomplished to establish initial conditions for the test. The telemetry system PCM RF test was conducted first. This verified that the PCM FM transmitter RF output power, the telemetry system reflected RF power, and the system VSWR, were all within the acceptable limits. The output and reflected powers were measured through both telemetry multiplexers. RACS high and low mode calibration checks were then made of the aft 5 volt excitation module, measurement M25. During the above checks, data was transmitted both by telemetry and by the ground monitor hardwire circuits.

4.2.20 (Continued)

The CP1-BO and DP1-BO multiplexer data channels were tested next, except for special channels which were checked separately. Each channel tested was verified to have the proper output for the ambient conditions. For those channels having a calibration capability, the applicable RACS high or low mode calibration commands were applied, and the channel calibration output was verified to be within tolerance.

The special channel tests were then conducted. A 400 Hz GSE calibration signal was used to check the data channels for the static inverter-converter frequency, the LH_2 and LOX chilldown inverter frequencies, and the LOX and LH_2 circulation pump flowrates. A 100 Hz GSE calibration signal was used to check the data channels for the LOX and LH_2 flowmeters, and a 1500 Hz GSE calibration signal was used to check the data channels for the LOX and LH_2 pump speeds. An APS multiplexer test and a J-2 engine pressures multiplexer test then checked those data channels associated with the APS and J-2 engine functions. The appropriate RACS high and low mode calibration checks were accomplished during the special channel checks and the APS and J-2 engine channel tests.

An umbilical measurements test completed the procedure by checking the umbilical data channels for the common bulkhead pressure, the LH_2 and LOX ullage pressures, and the LH_2 and LOX emergency detection system transducer pressures. The common bulkhead and LH_2 ullage pressure data channels were also checked with their 20 and 80 percent calibration voltages.

The first attempt to perform the test was not acceptable because of several out-of-tolerance measurements, and the failure of a channel calibration decoder. The decoder was replaced and several digital data tape changes were made to correct measurement malfunctions. The second attempt was not acceptable because of numerous malfunction indications. Troubleshooting on these problems included adjusting signal conditioning modules and replacing the remote analog submultiplexer and the transducer for the hydraulic accumulator GN_2 pressure, measurement D43. The third attempt was not acceptable because of six malfunction indications. Eight other out-of-tolerance conditions were acceptable after a procedure revision changed the tolerance requirements.

4.2.20 (Continued)

Troubleshooting following this attempt included the adjustment of several signal conditioning modules, and the replacement of the transducer for the J-2 engine regulator outlet pressure, measurement D18, and a propellant utilization voltage monitor module. The fourth attempt was not acceptable because of three malfunctions caused by program problems. These were corrected and the fifth attempt was accomplished. Several malfunction indications occurred during this attempt, but these were all acceptable and were accounted for by procedure revisions. The fifth attempt was considered an acceptable performance of the test.

Engineering comments noted that the LH_2 prevalve, P/N 1A49968-507, was not installed at location 427A6 at the start of the test. The prevalve was installed and tested prior to the completion of the test. As noted, numerous problems were encountered during this test. These were all satisfactorily resolved by adjusting signal conditioning modules, replacing defective items, or making revisions to the digital data tape and the procedure. Five FARR's were written during the test to correct problems noted on IIS 378228:

a. FARR A271272 noted that channel calibration decoder 411A61A259, P/N 1A74053-503, S/N 318, failed to provide the proper high and low RACS output signals. The decoder was removed and a new unit, S/N 244, was installed and accepted for use.

b. FARR A271274 rejected the remote analog submultiplexer 404A60A201, P/N 1B66050-1, S/N 2. The RASM output was 2.533 vdc during the high RACS calibration, when it should have been 4.000 $\pm$0.075 vdc. The defective unit was removed and a new RASM, P/N 1B66050-501, S/N 1, was installed and accepted for use.

c. FARR 500-238-038 rejected pressure transducer 403MT606, P/N 1B37356-513, S/N 137-28, for the hydraulic accumulator GN_2 pressure, measurement D43, as the calibration information provided for the transducer was not sufficient for data reduction. The transducer was removed and a new transducer, S/N 352-2, was installed and accepted for use.

d. FARR 500-238-046 noted that pressure transducer, P/N NA5-27412-T7LT, S/N 5895A, for the J-2 engine regulator outlet pressure, measurement D18, had an output of -2.685 psia. The output should have been 14.7 $\pm$1.1 psia. The defective unit was removed and a new transducer, S/N 6653A, was installed and accepted for use.

4.2.20 (Continued)

e. FARR 500-238-071 rejected propellant utilization voltage monitor module 411A61A241, P/N 1B39022-1-004, S/N 25, for measurement M60. The module low RACS output on channel DP1-B0-04-09 was 0.015 vdc, but should have been 1.000 ±0.100 vdc. The defective module was removed and a new module, S/N 26, was installed and accepted for use.

Twenty-nine revisions were made to the procedure, with one of these voided. The remaining revisions were:

a. Five revisions changed the pre-test and post test manual operations. The thermoconditioning servicer was adjusted to provide a 59 ±5°F cold plate temperature for the PCM RF checks, duplicating the PCM system setup condition; the telemetry signal distribution unit was verified to be set for closed loop operation; all stage systems, except the thermoconditioning and hydraulic systems, were verified to be at ambient conditions as required for the test, and the APS modules were repressurized following the test; the Boonton signal generator on the frequency calibration console was set up before the Model 5245L electronic counter, rather than afterwards, as the generator output was used in adjusting the counter; and a paragraph was added to note that out-of-tolerance pressure measurements should be compared to the actual calibration curve for the transducer, and accepted if the value was within ±2 percent of the curve.

b. Two revisions changed the PCM transmitter output power requirement to be 19.0 ±7.25 watts, rather than 21.75 ±6.75 watts, and changed a printout statement to show the new expected value. This was to be compatible with the antenna system procedure.

c. One revision added an umbilical check of the LOX and LH_2 chilldown differential pressures, measurements D578 and D579, function numbers 204 and 212.

d. One revision changed the pneumatic console 5 volt transducer power supply turn on operation to initially verify that the power supply voltage was 5.01 ±0.2 vdc rather than 5.01 ±0.1 vdc, and then subsequently verify that the power supply voltage, function number 1370, was 5.012 ±0.012 vdc. This allowed the power supply to stabilize.

e. Two revisions deleted the propellant utilization oven indication, measurement K151, from multiplexer channel CP1-B0-09-07, and added the propellant utilization oven stability monitor, measurement N63, function number 2317, to multiplexer channel DP1-B0-05-06, with an expected value of -0.023 ±0.100 vdc. Measurement N63 had replaced measurement K151 on the stage.

f. Three revisions changed the expected value of the auxiliary hydraulic pump motor gas pressure, measurement D209, on multiplexer channel DP1-B0-07-01. As the hydraulic system was to be pressurized during the test, the expected value was changed to be 20.75 ±11.95 psig, rather than 0.0 ±1.2 psig. The expected value in the program

4.2.20 (Continued)

was subsequently changed to be 16.5 ±17.7 psig. It was noted that the actual expected value should be 8.641 psig, the measured pressure, as the auxiliary pump air tank had been reduced to ambient pressure so that measurement D223 would pass the ambient measurement limits, which allowed the motor gas pressure to slowly decay toward ambient pressure.

g. Three revisions changed the expected value of twelve APS pressure measurements to be 14.7 psia rather than 50 psia or 35 psia, and changed the tolerance of ten of these same measurements to be ±8 psia rather than ±10 psia. The APS was at ambient pressure during this test instead of being pressurized.

h. One revision changed the measurements of the PCM transmitter output power and the telemetry system reflected power to measure watts rather than volts.

i. One revision corrected a program error to show the proper re-entry point for a "Go To" command.

j. Two revisions added one machine language statement and changed another to provide the correct channel number printouts for the special channel tests.

k. Two revisions added the omitted tolerances for twenty-two APS and J-2 engine measurements, using values from test requirements drawing 1B64[illegible]87, and noted that the printed out ambient values for these measurements were to be manually verified to be within these tolerances, as an excessive number of program changes would be required to accomplish this verification automatically.

l. One revision changed the expected value for spare channel DP1-B0-11-09 to be 0.0 ±0.150 vdc, rather than 0.0 ±0.075 vdc. Intended for measurement D241 in the future, the channel had the stage wiring installed and connected, although no transducer was installed. This unterminated wiring caused a higher noise level.

m. One revision increased the delay time during the special channels RACS test to be 60 seconds, rather than 300 milliseconds, to allow more warm up time for the expanded scale frequency measurements.

n. One revision changed the expected value of the common bulkhead pressure, measurement D237, to be 14.7 ±0.5 psia, rather than 0.0 ±0.5 psia, as the common bulkhead was at ambient pressure during the test.

o. One revision deleted the Model DSV-4B-298 monochrome system status display, P/N 1B37968-1, from the End Item Equipment list, as the unit was not operational.

p. One revision changed the nominal high RACS calibration voltage of the LH_2 tank helium bottle repressurization pressure, measurement D20, to be 3.910 ±0.100 vdc, rather than 4.000 ±0.100 vdc. The nominal value for this measurement was changed to the bench test value for greater accuracy in measuring the function.

4.2.21 Auxiliary Propulsion System Simulator Checkout (1B66569 D)

Before the installation of the auxiliary propulsion system modules, this automatic 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 361, at reference location 404A71A19, and interim use package, P/N 50M35076-1, S/N 335, at reference location 404A51A4.

The procedure was satisfactorily accomplished by the first attempt on 27 February 1968, and was accepted on 4 March 1968. The data in this narration and in Test Data Table 4.2.21.1 are from this first attempt.

After initial conditions were established by the stage power setup, H&CO 1B66560, the GSE IU substitute -28 vdc power supply was turned on and measured at -30.24 vdc, within the -28.5 $\pm$2.5 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 A0 and B0 instrumentation multiplexers.

The attitude control nozzle command was then turned off and the valve open indication voltage was again measured through the A0 multiplexer. 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.

4.2.21 (Continued)

Engineering comments noted that an interim use attitude control relay module, P/N 50M35076-1, S/N 335, was installed at reference location 404A51A4 in place of a flight use module, P/N 1B57731-1. The interim use part was to be replaced by a flight use part prior to STC prefiring testing. It was also noted that the LH_2 prevalve was not installed at the time of this test. This caused a malfunction printout during the preliminary stage power setup, but did not affect the APS test. No problems were encountered during the test, and no FARR's were written. One revision was made to the procedure, to delete the Model DSV-4B-298 monochrome system status display, P/N 1B37968-1, from the End Item Equipment list, as the display was not used during this test.

4.2.21.1 Test Data Table, Auxiliary Propulsion System

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	4.31	4.36	4.2 ±0.30
	Off	1-1 or 1-3	0.00	-	0.0 ±0.25
Nozzle I II	On	1-1 or 1-3	4.33	4.37	4.2 ±0.30
	Off	1-1 or 1-3	-0.00	-	0.0 ±0.25
Nozzle I P	On	1-2	4.26	4.31	4.2 ±0.30
	Off	1-2	0.00	-	0.0 ±0.25
Nozzle III II	On	2-1 or 2-3	4.10	4.16	4.0 ±0.30
	Off	2-1 or 2-3	0.00	-	0.0 ±0.25
Nozzle III IV	On	2-1 or 2-3	4.09	4.14	4.0 ±0.30
	Off	2-1 or 2-3	0.00	-	0.0 ±0.25
Nozzle III P	On	2-2	4.17	4.18	4.0 ±0.30
	Off	2-2	0.00	-	0.0 ±0.25

4.2.22 Propellant Utilization System Calibration (1B64367 H)

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 18; propellant utilization electronics assembly 411A92A6, P/N 1A59358-529, S/N 33; LOX mass probe, P/N 1A48430-511, S/N C4; and LH_2 mass probe, P/N 1A48431-509, S/N E8.

The calibration procedure was accomplished on 28 and 29 February 1968, with an additional oscilloscope check of the 1 volt error signal waveform made on 1 March 1968. This check showed that other than 50 millivolt peak-to-peak noise spikes, the signal was stable and acceptable. On 8 March 1968, the procedure was reactivated to adjust the PUEA fuel bias R7 potentiometer, to correct a problem noted during the propellant utilization system automatic checkout, H&CO 1B66567, (reference paragraph 4.2.28). The procedure was accepted on 11 March 1968. Measurements and ratiometer settings made during the test appear in Test Data Table 4.2.22.1.

Atmospheric conditions in the test area were measured before the calibration was started. 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 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 ratiometer, at settings of 0.02034 for the LH_2 bridge and 0.02012 for the LOX meter for the LH_2 bridge and the PUEA R1 potentiometer for the LOX bridge. Simulated full conditions were then established with the PUT/S,

4.2.22 (Continued)

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 LOX and LH_2 empty ratiometer settings, -0.00001, was multiplied by 98.4 vdc to give a reference voltage of -0.000984 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 adjustment, 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 0.011 vdc under simulated empty conditions, and as 10.543 vdc under bias internal test conditions. The fuel boiloff bias voltage was the difference between these measurements, 10.532 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,

4.2.22 (Continued)

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 19.950 vdc.

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. These voltages were 22.57 vdc and 22.55 vdc, respectively, meeting the 21.52 to 25.52 vdc requirements. This completed the propellant utilization system calibration. It was subsequently discovered that the procedure neglected to re-establish the fuel boiloff bias adjustment following the fuel boiloff bias limitation check, leaving the PUEA fuel bias R7 potentiometer set fully counterclockwise. A revision corrected this omission, and the bias adjustment was accomplished to properly set the PUEA R7 potentiometer.

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

a. Two revisions added several steps to monitor the PU oven temperature at the GSE numeric readout panel, function number 2317, measurement N63, to verify that the temperature increased to some stable value after the power was turned on.

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

c. Two revisions changed the fuel boiloff bias adjustment C1 capacitance value, as listed in the "data value or instruction" table, and the fuel boiloff bias limitation check requirements, because of a design change in the PUEA boiloff bias circuits. During the bias adjustment the C1 capacitance value was to be 244 picofarads, rather than 227 picofarads as listed in the table. During the bias limitation check, the PUEA fuel bias R7 potentiometer was adjusted fully counterclockwise, rather than fully clockwise, and the null value of capacitor C1 was to be 48 picofarads minimum, rather than 25.31 picofarads minimum.

4.2.22 (Continued)

d. Five revisions corrected minor procedure and typing errors, to include P/N 1A66212-507, as well as -505; to verify that the stage power setup or initial conditions scan had been completed before starting the test, rather than to perform the power setup; to show the correct paragraph references in the test record table; to show that frequency counter-HP521C or equivalent, rather than only HP521C, and megger - General Radio 1862B, rather than 1862C, were required Non-End Items for the test; and to correct the algebriac subtraction used to determine the fuel boiloff bias voltage.

e. One revision deleted the Model DSV-4B-298 monochrome system status display, P/N 1B37963-1, from the End Item Equipment list, as it was not used in the test.

f. One revision added a note to disconnect stage connector 411W6P37 from receptacle J-2 on the static inverter-converter 411A92A7 during the initial equipment setup, as the PUT/S voltage breakout box connected to this receptacle.

g. One revision corrected a procedure omission, to re-establish the fuel boiloff bias adjustment (PUEA R7 potentiometer) following the bias limitation check. As this omission was not noted until after the test was completed, the revision provided for repeating those parts of the test necessary to accomplish the adjustment.

4.2.22.1 Test Data Table, Propellant Utilization System Calibration

Pre-Test Atmospheric Conditions

Temperature: 75°F

Pressure: 29.99 in. of Hg.

Relative Humidity: 71 percent

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		
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

4.2.22.1 (Continued)

Static Inverter-Converter Measurements

Function	Measurements	Limits
5.0 vdc Output Voltage (vdc)	4.909	4.50 to 5.10
21.0 vdc Output Voltage (vdc)	21.625	20.00 to 22.50
28.0 vdc Output Voltage (vdc)	27.273	26.00 to 30.00
117 vdc Output Voltage (vdc)	121.55	115.0 to 122.5
115 vrms Monitor Voltage (vdc)	2.718	2.23 to 3.18
Test Point 2 Voltage (vdc)	21.756	20.0 to 22.5
V/P Excitation Voltage (vdc)	50.427	49.106 to 52.267
Operating Frequency (Hz)	400.7	394. to 406

Data Acquisition

Function	PUT/S Ratiometer	Limits
LH_2 Empty	0.00025	0.00000 to 0.00168
LOX Empty	0.00024	0.00000 to 0.00168
LH_2 Full	0.84116	0.83940 to 0.84276
LOX Full	0.84121	0.83940 to 0.84276

Bridge Slew Checks

Function	PUT/S Ratiometer	Limits
LH_2 1/3 Slew	0.27558	*
LH_2 2/3 Slew	0.56413	*
LOX 1/3 Slew	0.26907	*
LOX 2/3 Slew	0.56495	*

LH_2 Bridge Linearity Check

PUT/S C1 Value	PUT/S Ratiometer	Limits
42.00 pf	0.16758	0.16653 to 0.16990
84.00 pf	0.33524	0.33475 to 0.33811
126.00 pf	0.50378	0.50297 to 0.50633
168.00 pf	0.67229	0.67118 to 0.67455
210.00 pf	0.84147	0.83940 to 0.84276

LOX Bridge Linearity Check

PUT/S C2 Value	PUT/S Ratiometer	Limits
25.60 pf	0.16715	0.16653 to 0.16990
51.20 pf	0.33522	0.33475 to 0.33811
76.80 pf	0.50351	0.50297 to 0.50633
102.40 pf	0.67184	0.67118 to 0.674 5
128.00 pf	0.84126	0.83940 to 0.84276

*Limits Not Specified

4.2.23 Cold Helium System Leak Check (1B59458 C)

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 tanks. The particular items involved in this test included the cold helium spheres, P/N 1A48858-1, S/N's 1137, 1175, 1181, 1211, 1212, 1213, 1215, 1217, and 1219; the plenum sphere, P/N 1A49991-1, S/N 63; the cold helium dump module, P/N 1B57781-503-003, S/N 4; the LOX tank pressurization control module, P/N 1B42290-505, S/N 12; the LOX chilldown pump purge pressure switch S4, P/N 1B52624-515, S/N 44; the LOX prepressurization flight control pressure switch S8, P/N 1B52624-515, S/N 45; and the associated plumbing and manifold assemblies. The procedure also checked the dual repressurization system, including the O_2H_2 burner, P/N 1B62[illegible]-509-009, S/N 10.

Initiated on 29 February 1968, the procedure was completed on 4 March 1968, after 3 days of activity, and was accepted on 8 March 1968. 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 ±10 psig and the connections were leak checked. For a helium coil pressure decay check the pressure was measured as 401 psig both before and after a 30 minute delay, showing that there was no 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 50 ±5 psia and leak checked. The pressure switch sense lines were disconnected and it was verified that there was no leakage at the switch sense ports. The pressure switch sense lines were reconnected, and the checkout line was vented to ambient.

4.2.2[illegible] (continued)

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 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 ±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 du[illegible] [illegible] relief valve was measured as less than the 12.5 scim maximum leakage limit.

The cold helium shutoff valve were then 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, no other problems were encountered during the test, and no FARR's were written. The following leaks were corrected during the test:

a. Leaks at both sides of two unions, P/N MC160, one between pipe assemblies, P/N's 1B66828-1 and 1B52413-1, and one between pipe assemblies, P/N's 1B52413-1 and 1B52439-1, were corrected by tightening the union fittings.

4.2.23 (Continued)

b. Leaks at the upstream B-nuts of pipe assemblies, P/N's 1B67672-1, 1B67609-1, and 1B67464-1, and at both the upstream and downstream B-nuts of pipe assembly, P/N 1B67094-1, were all corrected by retorquing the B-nuts.

c. A leak at the surge tank adapter, P/N 1B52432-503, was corrected by replacing the conoseal and O-ring, and placing washers under the heads of the overlength mounting bolts.

d. Leaks at two unions, P/N MC160C8, were corrected by replacing the unions.

e. A leak at the seal of the LOX tank pressurization control module adapter, P/N 1B56436-501, was corrected by replacing the seal.

f. Leaks at the B-nuts of pipe assembly, P/N 1B67466-1, were corrected by installing a new pipe assembly and a new union.

Five revisions were made to the procedure:

a. One revision deleted two steps, one during the stage setup to disconnect and plug pipe assembly, P/N 1B66843-1, at its junction with the LH_2 pressurization line, P/N 1B66824-1, and one after completion of the test to reconnect the two pipe assemblies, as pipe assembly, P/N 1B66843-1, was not accessible. The LH_2 pressurization line was allowed to pressurize during the O_2H_2 burner checks and was vented at the completion of the test.

b. One revision changed a pipe assembly reference to be P/N 1B69840-1, rather than P/N 1B66839-1 as listed at two places, as the pipe assembly was changed per the "N" revision of drawing 1B58005.

c. Two revisions changed the stage setup to connect portable test gauges to monitor the cold helium spheres pressure and the cold helium discharge pressure while the Model DSV-4B-661 vehicle monitor panel was temporaily out of service, and to reconnect the Model 661 when it was returned to service.

d. One revision added a step to leak check from the outlet of the burner pipe assembly, P/N 1B67829-1, to pipe assembly, P/N 1B66824-1, to correct a procedure omission.

4.2.24 Propellant Tanks System Leak Check (1B59459 D)

This manual leak check procedure verified the integrity of the stage propellant tanks and associated plumbing the common bulkhead vacuum monitoring system, and the vacuum jacketed ducts. The propellant tank differential pressure scan, H&CO 1B74681 (reference paragraph 4.2.35), was run in conjunction with the propellant tanks pressurization parts of this procedure, to verify that the tank pressures and the common bulkhead differential pressure remained within acceptable limits. The particular items checked by this procedure included the LOX and LH_2 tank assembly, P/N 1A39303-535, S/N 508, and those items shown in Test Data Table 4.2.24.1.

Initiated on 1 March 1968, the procedure was completed on 2 April 1968, after 8 days of activity, and was accepted on 4 April 1968. In general, the leak check was accomplished by pressurizing the system with gaseous helium and using a USON leak detector and leak detection bubble solution to locate leakages.

A vacuum check of the jacketed ducts was accomplished first. A theromcouple vacuum gauge meter, P/N 1A94433-501, S/N 2, was connected to the vacuum sensing thermocouple probe built into each duct, and the vacuum reading was verified to be 250 microns of mercury or less. The particular ducts checked, and the measured vacuums, are shown in the Test Data Table.

The common bulkhead vacuum monitoring system was leak checked next. The test setup was made and the common bulkhead was pressurized to 2.5 ±0.5 psig. The system was then leak checked from the aft umbilical disconnect to the common bulkhead, and to the transducers for measurements D545 and D237. The common bulkhead was vented to ambient pressure after completion of the leak check.

The O_2H_2 burner was leak checked next. The test setup was made, the pneumatic control sphere was pressurized to between 500 and 750 psig, and the proper operation of the burner LOX and LH_2 propellant valves and LOX shutdown valve was verified. The burner system was pressurized to 5.0 ±0.5 psig, and leak checks were accomplished on the connections of the burner propellant lines,

4.2.24 (Continued)

inlet and outlet, injectors, and fittings. The burner and the pneumatic control sphere were vented to ambient after the leak checks were completed.

The test setup was then made for the propellant tanks tests, the pneumatic control sphere was pressurized to 700 ±50 psia, and the proper operation of the LH_2 propellant valve and LOX shutdown valve was verified. The LOX and LH_2 tanks were purged with helium for a 50 minute period, and then pressurized to 12 psig in the LOX tank and 11.5 psig in the LH_2 tank. These pressures were maintained for 3 minutes for an integrity check. The tanks were then vented to 10 psig in the LOX tank and 9.5 psig in the LH_2 tank, and gas samples were taken to determine if the helium content of the tanks was sufficient for subsequent leak checks. Additional tank purging, venting, pressurizing, and sampling was accomplished as required until the gas samples showed greater than 75 percent helium by volume.

The tanks were then pressurized to 10 psig in the LOX tank and 9.5 psig in the LH_2 tank. A flowmeter was used to measure the leakage at various valves, as shown in the Test Data Table, and leak checks were accomplished on the various connections of the LOX and LH_2 tank systems. During the LH_2 tank check, the propulsive and nonpropulsive vent pressures were measured with the LH_2 vent valve both closed and open, as shown in the Test Data Table, to obtain sample transducer readings in a closed system. At the completion of the leak checks the tanks were vented to ambient pressure. After the correction of the one leak noted below, the tanks were repressurized while the repair was leak checked. The tanks were then vented to ambient pressure and the stage was returned to the pre-test condition.

Engineering comments noted that there were no parts shortages affecting this test. One leak was found and corrected during the test. Recirculation duct, P/N 1A49966-503, leaked at the connection to the LH_2 prevalve. The seal was replaced, satisfactorily correcting the leak. FARR 500-238-089 noted that the desiccant port flange, P/N MFC 59657-150S, on pipe assembly, P/N 1B67025-1,

4.2.24 (Continued)

had a nick in the outer rim. This damage occurred during the LH_2 tank desiccant installation following the test. The condition was acceptable, as the damaged area was outside of the sealing surface and did not prevent a good seal.

Six revisions were made to the procedure:

a. One revision added two steps to measure and record the proplusive vent and nonpropulsive vent pressures with the LH_2 vent valve closed and open, to obtain sample transducer readings for a closed system.

b. One revision provided special instructions for maintaining the helium content of the tanks during an overnight hold. The tank pressures were vented to 2 psig in the LH_2 tank and 5 psig in the LOX tank at the start of the hold, monitored to verify that the pressures remained at 2 $\pm$1.5 psig and 5 $\pm$1 psig during the hold, and then repressurized to the required test pressures at the end of the hold.

c. One revision waived the 75 percent helium content requirement for the retest of the corrected leak at the LH_2 prevalve, and accomplished the retest using leak detection solution.

d. Two revisions modified the method of obtaining the required helium concentration for the initial propellant tanks leak check. Rather than repeatedly venting and repressurizing the tanks, they were purged with helium for several hours, until the helium concentration was acceptable.

e. One revision changed one step to disconnect the electrical connectors from the LOX tank vent actuation control module opening solenoid, 403A75A1L1, and the LH_2 tank vent actuation control module opening solenoid, 411A2L1, rather than from solenoid 403A75A1L1 only, to ensure that both tanks were in the same venting mode at the same time.

4.2.24.1 Test Data Table, Propellant Tanks System Leak Check

Vacuum Duct Leak Checks

Part	P/N	S/N	Vacuum (Microns of Hg)
LH_2 Engine Feed Duct	1A49320-503-003	18	20.1
LH_2 Engine Feed Duct	1A49320-513	35	32.0
LH_2 Chilldown Supply Duct	1A49966-503	30	37.0
LH_2 Burner Feed Duct	1B65206-503	16	13.0
LH_2 Burner Feed Duct	1B59005-501	17	3.0
LOX Burner Feed Duct	1B59009-501	22	4.5

4.2.24.1 (Continued)

Flowmeter Leakage Measurements

Part	Leakage	Measurement (Scim)	Limits (Scim)
LH_2 Fill and Drain Valve	Blade Shaft Seal	1.4	6.1 max
LH_2 Fill and Drain Valve	Main Seal	0.	100. max
LOX Fill and Drain Valve	Blade Shaft Seal	0.	6.1 max
LOX Fill and Drain Valve	Main Seal	0.	100. max
LOX Chilldown Pump	Seal	0.	75. max
LOX Prevalve	Shaft Seal	0.	100. max
LOX Vent and Relief Valve	Combined Seal	200.	None
LOX Vent and Relief Valve	Piston Seal	0.	2.40 max
O_2H_2 Burner Propellant Valves	Combined Main Seal	0. sccm	300. sccm max
LH_2 Prevalve	Shaft Seal	0.	100. max
LH_2 Vent and Relief Valve	Combined Main Seal	0.	480. max
LH_2 Vent and Relief Valve	Piston Seal	0. scfm	4. scfn max
LH_2 Directional Control Valve	Flight Position Seal	2.	300. max
LH_2 Directional Control Valve	Ground Position Seal	1.3	300. max
LH_2 Continuous Vent Valve	Combined Internal	0.	350. max

LH_2 Tank Vent Pressure Readings

Meas. No.	Function	Vent Valve Closed	Vent Valve Open
D181	Continuous Vent 1 Pressure (psia)	24.32	24.15
D182	Continuous Vent 2 Pressure (psia)	24.37	24.26
D183	Nonpropulsive Vent 1 Pressure (psia)	14.99	24.15
D184	Nonpropulsive Vent 2 Pressure (psia)	[illegible].14	24.12
	LH_2 Tank Gauge Pressure (psig)	-	9.5

4.2.25 J-2 Engine System Leak Check (1B59461 C)

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 checks 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 4 March 1968, the procedure was completed on 13 March 1968, after 6 days of activity. Following this, on 21 and 22 March 1968, parts of the procedure were used to leak check the sense line for the measurement D18 transducer, after Rocketdyne rewelding operations on this line. The procedure was accepted on 4 April 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, 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 pneumatic control sphere was pressurized to between 225 and 250 psig, and the thrust chamber was pressurized to 30 ±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.

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 ±10 psig and leak checked. For a pressure switch pressure decay check, the checkout line pressure was measured as 500 psig, and remeasured as 500 psig after a 1 hour delay period. The checkout line was then vented to ambient, and the pneumatic control sphere was pressurized to 245, +10, -20, psig.

4.2.25 (Continued)

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 ±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 ±25 psia, the start tank 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 ±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 ±50 psia and leak checks were conducted on the sphere fill and outlet lines. The control sphere was vented to ambient, then repressurized to between 225 and 250 psig for the remaining system leak checks. During these leak checks the mainstage control, helium control, ignition phase contols, 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 normal accomplishment of the procedure. During the leak check of the rewelded sense line for the measurement D18 transducer, a leak was found at the upper sleeve weld. The line was again rewelded and no further leaks were found. No FARR's were written during this test. Five revisions were made to the procedure:

a. One revision changed two steps to properly leak check the start tank repressurization line. The line downstream of the check valve was checked when it was pressurized during the engine leak check, and the line upstream of the check valve was checked, when it was pressurized during the thrust chamber leak check.

4.2.25 (Continued)

b. One revision changed two steps to use a Magnaflux black light or equivalent to inspect the injector face for contamination both before and after the thrust chamber leak check. A visual inspection would not reveal any contaminants unless the black light equipment was used.

c. One revision deleted a post-test step to remove a hand valve and adapter from the LH_2 tank pressurization line, as the hand valve was required for additional tests.

d. One revision changed two steps during the test setup and post-test operations, to indicate that the repressurization system was not to be isolated from the pneumatic control system. The repressurization system leak check, H&CO 1B59460, had been completed out-of-sequence, and isolating the system during this test would require that it be retested.

e One revision added instructions to two steps in the test setup and post-test operations. When the Rocketdyne throat plug, P/N G3120, was installed, soap solution, P/N AMS 3159, was used around the contact area if the plug would not seal. When the throat plug was removed, the plug and the thrust chamber area were cleaned with trichlorethylene solution. These steps were required as the plug would not seal properly. An Engineering comment on this subject noted that although the soap solution was used, no sealant was permitted, and none would be used for subsequent plug installations. After the cleaning operation, a black light inspection of the thrust chamber area showed that the area was clean.

4.2.26 Repressurization System Leak Check (1B59460 B)

This manual procedure leak checked the repressurization system prior to automatic checkout activities. 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 49; the LH_2 tank repressurization control module 403A73A4, P/N 1B56653-513, S/N 48; seven ambient helium storage spheres, P/N 1B66868-501, two for LOX tank repressurization, S/N's 38 and 40, and five for LH_2 tank repressurization, S/N's 28, 36, 39, 41, and 42; 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.

Initiated on 5 March 1968, the procedure was completed on 6 March 1968, and was accepted on 7 March 1968. In general, the test was accomplished by pressurizing

4.2.26 (Continued)

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 to 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 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 repressurization spheres dump valve 403A74A3L1, S/N 2207, and the LH_2 repressurization spheres dump valve 403A73A4L1, S/N 2194, both had zero scim seal leakages, meeting the 12 scim allowable leakage limits for these valves. The LOX control shutoff valves 403A74A3L2 and L3, S/N's 2196 and 2031, had a 4.9 scim combined seat leakage, while the LH_2 control shutoff valves 403A73A4L2 and L3, S/N's 2030 and 2197, 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 there were no parts shortages affecting the test. Three leaks were found and corrected during the procedure. Leaks at the B-nut of cap assembly, P/N MC177C4W, on manifold assembly, P/N 1B56657-501;

4.2.26 (Continued)

at the upstream B-nut of pipe assembly, P/N 1B58841-1; and at the downstream B-nut of pipe assembly, P/N 1B58857-1, were all corrected by retorquing the B-nuts. One GSE problem occurred when the facilities hardline vent broke at the VCL tower ceiling during the venting after the sphere integrity test. No stage damage occurred, and venting was accomplished after short vent pipes were installed at the repressurization modules. No other problems were encountered, and no FARR's were written.

Three revisions were made to the procedure, with one of these voided.

a. One revision added a setup step to remove pipe assembly, P/N 1B58847-1, from the LOX and LH_2 repressurization modules, and to connect the plumbing venting setup between the elbows, P/N MC248C8N, on the modules and the hardline vent pipe on the VCL engine deck. This was to use the newly installed hardline vent system and plumbing system to vent gases from the stage outside of the tower.

b. One revision deleted a shutdown step that would remove a test adapter and hard valve from the LOX pressurization line and reconnect pipe assemblies, P/N's 1B55285-1 and 1B67049-1. The LOX pressurization line was to remain disconnected for subsequent testing.

4.2.27 Exploding Bridgewire System (1B66566 D)

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	292
EBW Firing Unit	404A47A2	40M39515-113	298
Pulse Sensor *	404A47A4A1	40M02852	551
Pulse Sensor *	404A47A4A2	40M02852	517
* On Pulse Sensor Bracket Assembly	404A47A4	1B52640-1	10

4.2.27 (Continued)

Part Name	Ref Location	P/N	S/N
Ullage Rocket Jettison System			
EBW Firing Unit	404A75A1	40M39515-113	299
EBW Firing Unit	404A75A2	40M39515-113	293
Pulse Sensor **	404A75A10A1	40M02852	532
Pulse Sensor **	404A75A10A2	40M02852	583
** On Pulse Sensor Bracket Assembly	404A75A10	1A97791-501	5

This procedure was accomplished on 6 March 1968, and was accepted on 7 March 1968. Throughout this procedure, the charged condition of each EBW firing unit was determined by verifying that the firing unit voltage indication measured 4.2 ±0.3 vdc, while the uncharged or discharged condition was determined by verifying that the voltage indication measured 0.0 ±0.3 vdc or, during the firing unit disable test only, 0.2 ±0.3 vdc.

The stage power setup, H&CO 1B66560, was accomplished to establish initial conditions. 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.

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 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.

During this part of the test, a special check was made for crosstalk between the fire ullage ignition and fire ullage jettison commands. The charge ullage

4.2.27 (Continued)

ignition command was left on after the ignition firing units were checked, causing the ignition firing units to be charged at the time the jettison firing units were charged. After it was verified that the fire ullage jettison command did not fire the ullage ignition firing units, the fire ullage ignition command was again turned on, and the proper firing of the ignition firing units was verified at the GSE numeric readout panel.

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, each of the ignition firing units was fired 2 times, and each of the jettison firing units was fired 1 time.

Engineering comments noted that there were no parts shortages affecting this test. No problems were encountered during this test, and no FARR's were written. One revision was made to the procedure, to add the steps necessary to accomplish the check for crosstalk between the ignition and jettison firing commands.

4.2.28 Propellant Utilization System (1B66567 D)

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	33
Static Inverter-Converter	411A92A7	1A66212-507	18
LOX Mass Probe	406A1	1A48430-511	C4
LH_2 Mass Probe	408A1	1A48431-509	E8
LOX Overfill Sensor	(Part of LOX Mass Probe)		
LOX Overfill Control Unit	404A72A4	1A68710-511	C24
LOX Fast Fill Sensor	406A2C5	1A68710-1	C18
LOX Fast Fill Control Unit	406A72A5	1A68710-511	C45
LH_2 Overfill Sensor	(Part of LH_2 Mass Probe)		
LH_2 Overfill Control Unit	411A92A24	1A68710-509	C100
LH_2 Fast Fill Sensor	408A2C5	1A68710-1	D136
LH_2 Fast Fill Control Unit	411A92A43	1A68710-509	D71

Initiated on 7 March 1968, the procedure was completed by the second attempt on 8 March 1968, after 2 days of activity, and was accepted on 11 March 1968. The first attempt was not acceptable because of an out-of-tolerance boiloff bias voltage. It was found that the bias had not been adjusted during the propellant utilization system calibration because of a procedure omission (Reference paragraph 4.2.22). The bias was properly adjusted, and the digital data tape (DDT) curve for this function was corrected for the second attempt. The operation and test results of the system per this second attempt are discussed in this paragraph and Test Data Table 4.2.28.1.

After the stage power setup, H&CO 1B66560, was accomplished, 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-converter and electronics, then the forward bus 2 voltage and the static inverter-converter

4.2.28 (Continued)

output voltages and operating frequency were all measured. The PU temperature indication was monitored at the GSE numeric readout panel to verify that it increased to some stable value after the PU power was turned on.

The bridge 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.

The PU loading test followed. The LH_2 boiloff bias signal voltage was measured with the boiloff bias cutoff turned on, and with the cutoff turned off. The GSE loading potentiometer power was turned on, and the voltage was 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 both 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 positio s 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

4.2.28 (Continued)

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.

For a final test, the PU valve hardover position command was turned on, and the PU system ratio valve position was measured as -28.3 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 switch selector had been 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 problems were encountered during the second attempt, and no FARR's were written against the procedure. Four revisions were made to the procedure:

a. One revision changed the tolerance on the LH_2 boiloff bias voltage measurement from ± 1 vdc to +2, -0 vdc. The nominal bias voltage obtained during the calibration procedure, H&CO 1B64367, was not measured at the same point on the PUEA summing network as the M10 measurement obtained during this automatic procedure, with M10 always greater by about 1 vdc.

b. One revision changed the tolerance on the PU coarse loading potentiometer voltages from +0.2 vdc to ∓ 0.6 vdc.

c. One revision deleted checks of the PU oven indication, measurement K151, and added steps to monitor the PU temperature indication on the GSE numeric readout panel, to verify that the temperature increased to some stable value after the PU power was turned on. The temperature indication, measurement N63, function Number 2317, replaced the oven indication, measurement K151.

d. One revision deleted the Model DSV-4B-298 monochrome system status display, P/N 1B37968-1, from the End Item Equipment list, as the unit was under design evaluation and was not ready for checkout use.

4.2.28.1 Test Data Table, Propellant Utilization System

Loaded Values (From H&CO 1B64367)

LOX Empty Ratio	0.000	LH_2 Empty Ratio	0.000
LOX Wiper Ratio	0.021	LH_2 Wiper Ratio	0.020
LOX 1/3 Bridge Slew Ratio	0.269	LH_2 1/3 Bridge Slew Ratio	0.275
LOX 2/3 Bridge Slew Ratio	0.565	LH_2 2/3 Bridge Slew Ratio	0.563
LH_2 Boiloff Bias Voltage	10.532 vdc		

Computed Coarse Mass Voltages (vdc)

LOX Empty	0.00	LH_2 Empty	0.000
LOX 1/3 Mass	1.343	LH_2 1/3 Mass	1.377
LOX 2/3 Mass	2.827	LH_2 2/3 Mass	2.817

Computed Fine Mass Voltages (vdc)

LOX Empty	2.051	LH_2 Empty	1.953
LOX 1/3 Mass	1.685	LH_2 1/3 Mass	1.011
LOX 2/3 Mass	2.588	LH_2 2/3 Mass	2.783

Computed Loading Voltages (vdc)

LOX Empty	0.000	LH_2 Empty	0.000
LOX 1/3 Coarse Mass	7.520	LH_2 1/3 Coarse Mass	7.711

PU System Power Test

Function	Measurement	Limits
Forward Bus 2 Voltage (vdc)	28.52	28.0 ±2.0
Inv.-Conv. 115 vrms Output (vrms)	114.461	115.0 ±3.4
Inv.-Conv. 21 vdc.Output (vdc)	21.819	21.25 ±1.25
Inv.-Conv. 5 vdc Output (vdc)	4.960	4.8 ±0.3
Inv.-Conv. Operating Frequency (Hz)	400.828	400.0 ±6.0

Bridge Balance and Ratio Valve Null Test

Function	AO Multi.	BO Multi.	Limits
Ratio Valve Position (deg)	0.078	-	0.0 ±3.0
LOX Coarse Mass Voltage (vdc)	-0.005	-0.005	0.000 ±0.1
LOX Fine Mass Voltage (vdc)	1.797	1.787	2.051 ±0.4
LH_2 Coarse Mass Voltage (vdc)	0.000	-0.010	0.000 ±0.1
LH_2 Fine Mass Voltage (vdc)	1.904	1.899	1.953 ±0.4

4.2.28.1 (Continued)

PU Loading Test

Function	Measurement	Limits
LH_2 Boiloff Bias Voltage, On (vdc)	12.261	10.532 +2.0, -0.0
LH_2 Boiloff Bias Voltage, Off (vdc)	0.492	0.0 ±2.5
GSE Power Supply Voltage (vdc)	28.118	28.0 ±2.0

Loading Potentiometer Function	LOX Pot.	LH_2 Pot.	Limits
Sense Voltage, GSE Power On (vdc)	28.079	28.039	GSE Pwr ±0.4
Signal Voltage, Relays Off (vdc)	0.000	0.027	Load Volt ±0.5
Signal Voltage, Relays On (vdc)	7.383	7.602	Load Volt ±0.6
Signal Voltage, Relays Off (vdc)	0.000	0.000	Load Volt ±0.5
Sense Voltage, GSE Power Off (vdc)	-0.399	-0.439	0.0 ±0.75

Servo Balance Bridge Gain Test

Function	AO Multi.	BO Multi.	Limits
Ratio Valve Position (deg)	0.078	-	0.078 ±1.5
LOX Coarse Mass Voltage (vdc)	-0.005	0.000	0.000 ±0.1
LOX Fine Mass Voltage (vdc)	1.777	1.768	2.051 ±0.4
LH_2 Coarse Mass Voltage (vdc)	-0.005	-0.010	0.000 ±0.1
LH_2 Fine Mass Voltage (vdc)	1.899	1.885	1.953 ±0.4
1/3 Checkout Relays On			
Ratio Valve Position (deg)	0.487	-	0.078 ±1.5
LOX Coarse Mass Voltage (vdc)	1.338	1.333	1.343 ±0.1
LOX Fine Mass Voltage (vdc)	1.543	1.543	1.685 ±0.4
LH_2 Coarse Mass Voltage (vdc)	1.367	1.362	1.377 ±0.1
LH_2 Fine Mass Voltage (vdc)	0.898	0.894	1.011 ±0.4
2/3 Checkout Relays On			
Ratio Valve Position (deg)	0.965	-	0.078 ±1.5
LOX Coarse Mass Voltage (vdc)	2.817	2.817	2.827 ±0.1
LOX Fine Mass Voltage (vdc)	2.363	2.358	2.588 ±0.4
LH_2 Coarse Mass Voltage (vdc)	2.813	2.817	2.817 ±0.1
LH_2 Fine Mass Voltage (vdc)	2.461	2.461	2.783 ±0.4
2/3 Checkout Relays Off			
Ratio Valve Position (deg)	0.487	-	0.078 ±1.5
LOX Coarse Mass Voltage (vdc)	1.343	1.338	1.343 ±0.1
LOX Fine Mass Voltage (vdc)	1.567	1.558	1.685 ±0.4
LH_2 Coarse Mass Voltage (vdc)	1.362	1.362	1.377 ±0.1
LH_2 Fine Mass Voltage (vdc)	0.889	0.889	1.011 ±0.4

4.2.28.1 (Continued)

<u>1/3 Checkout Relays Off</u>			
Ratio Valve Position (deg)	0.010		0.078 ±1.5
LOX Coarse Mass Voltage (vdc)	0.010	-0.010	0.000 ±0.1
LOX Fine Mass Voltage (vdc)	1.777	1.772	2.051 ±0.4
LH_2 Coarse Mass Voltage (vdc)	0.000	0.000	0.000 ±0.1
LH_2 Fine Mass Voltage (vdc)	1.899	1.895	1.953 ±0.4

PU Valve Movement Test

Function	Measurement	Limits
<u>50 Second Plus Valve Slew</u>		
Ratio Valve Position, AO (deg)	0.010	0.078 ±1.50
Ratio Valve Position, BO (deg)	0.010	0.078 ±1.50
+1 vdc System Test Valve Pos. Signal (vdc)	0.999	1.00 ±0.03
V1, Position at T+3 Seconds (deg)	4.159	2.037 to 6.351
V2, Position at T+5 Seconds (deg)	5.250	2.659 to 7.396
V3, Position at T+8 Seconds (deg)	5.795	2.977 to 7.396
V4, Position at T+20 Seconds (deg)	6.000	5.226 to 7.396
V5, Position at T+50 Seconds (deg)	6.068	5.226 to 7.296
<u>50 Second Minus Valve Slew</u>		
Ratio Valve Position, AO (deg)	0.08	0.078 ±1.50
-1 vdc System Test Valve Error Signal (vdc)	-0.994	-1.0 ±0.03
V1, Position at T+3 Seconds (deg)	-3.885	-2.037 to -6.351
V2, Position at T+5 Seconds (deg)	-4.771	-2.659 to -7.396
V3, Position at T+8 Seconds (deg)	-5.317	-2.977 to -7.396
V4, Position at T+20 Seconds (deg)	-5.521	-5.226 to -7.396
V5, Position at T+50 Seconds (deg)	-5.521	-5.226 to -7.296

PU Activate Test

Function	AO Multi.	BO Multi.	Limits
Ratio Valve Position (deg)	0.010	0.078	0.078 ±1.50
LCX Coarse Mass Voltage, Relay On (vdc)	1.343	1.338	1.343 ±0.1
Ratio Valve Position, PU On (deg)	31.576	31.576	20.0 min.
Ratio Valve Position, PU Off (deg)	0.351	0.282	15.0 max.
LOX Coarse Mass Voltage, Relay Off (vdc)	0.000	0.010	0.000 ±0.1
Ratio Valve Position (deg)	0.078	0.078	0.078 ±1.5
LH_2 Coarse Mass Voltage, Relay On (vdc)	1.367	1.362	1.377 ±0.1
Ratio Valve Position, PU On (deg)	-28.214 .	-28.214	-20.0 max.
Ratio Valve Position, PU Off (deg)	0.21	-	-15.0 min.
LH_2 Coarse Mass Voltage, Relay Off (vdc)	-0.005	-0.005	0.000 ±0.01
Ratio Valve Position (deg)	0.078	0.146	0.078 ±1.5

4.2.29 Range Safety Receiver Checks (1B66565 C)

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:

Part Name	Ref. Location	P/N	S/N
Range Safety Receiver 1	411A97A14	50M10697	182
Range Safety Receiver 2	411A97A18	50M10697	189
Secure Command Decoder 1	411A99A1	50M10698	181
Secure Command Decoder 2	411A99A2	50M10698	39

Initiated on 8 March 1968, the procedure was completed by the first attempt on 12 March 1968, after 2 days of activity, and was accepted on 20 March 1968. The following narration and Test Data Table 4.2.29.1 cover the acceptable first attempt.

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 30.6 db for range safety system 1, and 31.4 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 60.00 $\pm$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 by the stage power setup, H&CO 1B66560, 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

4.2.29 (Continued)

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 percent 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 percent 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 telemetry reference 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 telemetry reference AGC voltage was again obtained. 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 midpoint of these frequencies. For the -60 db bandwidth check, this procedure was 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 -63.8 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,

4.2.29 (Continued)

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 -84.4 dbm, as requested by the computer typeout. This gave input levels increasing from -115.0 dbm for receiver 1, and increasing from -115.8 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 -71 dbm. The AGC voltage of the other 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 -69 dbm. The test set antenna coaxial switch was returned to the first test position, and the test set output level was set at -81.5 dbm for the automatic open loop RF checks.

Under open loop conditions, the low level signal strength (AGC telemetry voltage) of receiver 1 was 3.32 vdc, while that of receiver 2 was 3.62 vdc. The range safety commands were transmitted from the GSE test set, and checks

4.2.29 (Continued)

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 2 hours 22 minutes 38.742 seconds running time during this attempt, and that the switch selector had been used 2 times.

Engineering comments noted that there were no part shortages affecting the test. No stage problems were encountered during the test, and no FARR's were written.

Several minor operating problems were encountered during the test, as noted by Engineering comments. The AGC calibration and drift checks were conducted twice, as malfunction messages during the first check indicated several out-of-tolerance AGC drift measurements. These were caused by the wrong output levels being set at the GSE destruct system test set during the AGC calibration checks. It was also noted that due to a format error, the malfunction messages printed incorrect dbm values, but that the correct dbm values could be determined from the printout data. When the program was backed up to rerun the AGC checks, the computer printer malfunctioned, and the printout paper was torn. This was corrected, and the AGC checks were repeated satisfactorily. Another problem occurred during the open loop RF checks when the RF distribution system 2 was not set on command. The PAM ground station was manually reset, and the distribution system then set properly.

4.2.29 (Continued)

Six revisions were made to the procedure:

a. Two revisions modified the setup of the Model DSV-4B-136 destruct system test set to allow the signal generator to warm up for 3 hours before use, rather than 30 minutes as listed, and to note that when adjusting the frequency setting, the setting must be approached from the low frequency side. This was to provide the warmup time required by the vendor manual, and to add an omitted statement.

b. One revision added two breakpoints during the initial turn-on of the range safety receivers, and manually verified that function numbers 1020 and 1021, the range safety system off command received indications, were both off. This verified the proper operation of the range safety system controller safing plug.

c. One revision corrected the data table for the manual RF bandwidth checks to add the omitted "less than" and "greater than" symbols to the bandedge measurement designations.

d. One revision deleted the use of the TAC-50 attenuator calibration curve during the test cable attenuation measurement operation at STC, as the change in attenuation was measured and recorded directly by the procedure, and the calibration curve was not required.

e. One revision deleted the Model DSV-4B-298 monochrome system status display, P/N 1B37968-1, from the End Item Requirements list, as the unit was undergoing design review, and was not operable for this checkout.

4.2.29.1 Test Data Table, Range Safety Receiver Checks

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

Test Set Output (dbm)	Receiver 1 Input (dbm)	AGC 1 (%) Run 1	AGC 1 (%) Run 2	AGC 1 (%) Drift	Receiver 2 Input (dbm)	AGC 2 (%) Run 1	AGC 2 (%) Run 2	AGC 2 (%) Drift
-96.4	-127.0	8.81	8.81	0.00	-127.8	13.42	13.83	0.41
-89.4	-120.0	9.12	9.02	0.10	-120.8	14.04	13.83	0.21
-84.4	-115.0	9.43	9.43	0.00	-115.8	14.96	14.77	0.20
-79.4	-110.0	10.96	10.96	0.00	-110.8	17.23	17.52	0.29
-74.4	-105.0	15.27	15.18	0.10	-105.8	23.79	24.20	0.41
-69.4	-100.0	25.12	24.80	0.31	-100.8	39.38	39.38	0.00
-64.4	- 95.0	44.20	44.10	0.10	- 95.8	61.43	61.74	0.31
-59.4	- 90.0	66.54	66.54	0.00	- 90.8	72.19	72.19	0.00
-54.4	- 85.0	71.78	71.78	0.00	- 85.8	73.83	73.83	0.00
-49.4	- 80.0	72.91	72.91	0.00	- 80.8	74.45	74.55	0.10
-44.4	- 75.0	73.42	73.13	0.29	- 75.8	74.77	74.77	0.00
-39.4	- 70.0	73.54	73.54	0.00	- 70.8	74.86	74.96	0.10

4.2.29.1 (Continued)

-3 db RF Bandwidth Check

Function	Receiver 1	Receiver 2	Limits
Reference Voltage (AGC) (vdc)	1.96	2.00	2.0 ±0.1
Reference RF Power Level (dbm)	-66.0	-70.0	*
Upper Bandedge Frequency (MHz)	450.167	450.148	*
Lower Bandedge Frequency (MHz)	449.851	449.833	*
-3 db Bandwidth (kHz)	316.0	315.0	340.0 ±30.0
Bandwidth Centering (MHz)	450.009	449.991	450.0 ±0.0338

-60 db RF Bandwidth Check

Function	Receiver 1	Receiver 2	Limits
Reference Voltage (AGC) (vdc)	1.96	2.00	2.0 ±0.1
Reference RF Power Level (dbm)	-66.0	-70.0	*
Upper Bandedge Frequency (MHz)	450.530	450.547	*
Lower Bandedge Frequency (MHz)	449.549	449.539	*
-60 db Bandwidth (MHz)	0.981	1.008	1.2 max.

Deviation Sensitivity Check

Range Safety Command	Minimum Deviation (kHz) Receiver 1	Minimum Deviation (kHz) Receiver 2
Arm and Engine Cutoff	15.0	12.5
Propellant Dispersion	15.0	10.0
Range Safety System Off	15.0	12.5

RF Sensitivity Check

Range Safety Command	Minimum Input Level (dbm) Receiver 1	Minimum Input Level (dbm) Receiver 2
Arm and Engine Cutoff	-105.0	-105.8
Propellant Dispersion	-105.0	-105.8
Range Safety System Off	-105.0	-105.8

*Limits Not Specified

4.2.30 Range Safety System (1B66568 D)

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	Ref. Location	P/N	S/N
Range Safety Receiver 1	411A97A14	50M10697	182
Range Safety Receiver 2	411A97A18	50M10697	189
Secure Command Decoder 1	411A99A1	50M10698	181
Secure Command Decoder 2	411A99A2	50M10698	39
Secure Command Controller 1	411A97A13	1B33084-503	19
Secure Command Controller 2	411A97A19	1B33084-503	20
RS System 1 EBW Firing Unit	411A99A12	40M39515-119	555
RS System 2 EBW Firing Unit	411A99A20	40M39515-119	554
RS System 1 EBW Pulse Sensor	411A99A31*	40M02852	382
RS System 2 EBW Pulse Sensor	411A99A32*	40M02852	164
Safe and Arm Device	411A99A22*	1A02446-503	-
Directional Power Divider	411A97A56	1B38999-1	36
Hybrid Power Divider	411A97A34	1A74778-501	42
*Installed in Pulse Sensor Assembly	411A99A31/A32	1B29054-501	8

This procedure was satisfactorily accomplished by the first attempt on 13 March 1968, and was accepted on 19 March 1968. Values measured during the test are shown in Test Data Table 4.2.30.1. Initial conditions were established for the test by the stage power setup, H&CO 1B66560, 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.

4.2.30 (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 and the bus voltage was measured. Verification was made 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 unit receiver 1 arm and engine cutoff indication was verified to again be off. The EBW firing unit arm and engi

4.2.30 (Continued)

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 and the bus voltage was measured. Verification was made 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 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

4.2.30 (Continued)

the system under test, the firing unit charging voltage indication was measured, and the pulse sensor was verified to be on. The firing unit charging voltage indication was then verified to be 4.2 $\pm$0.3 vdc. The propellant dispersion cutoff command inhibit was 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 2 minutes 33.152 seconds of running time during 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 parts shortages affecting this test. No significant problems were encountered during the test, and no FARR's were written. Six revisions were made to the procedure:

4.2.30 (Continued)

a. Two revisions affected the setup of the Model DSV-4B-136 destruct system test set. A note was added to indicate that the signal generator frequency setting was to be approached from the low frequency side, to comply with the vendor instruction manual; and the signal generator warmup time was to be 3 hours, rather than 30 minutes, as listed, to achieve maximum stability.

b. One revision added two breakpoints during the propellant dispersion test, after the pulse sensors were verified to be on, and manually verified that the EBW firing unit charging voltage indications, function numbers 1037 for system 1 and 1040 for system 2, were 4.2 ±0.3 vdc. This verified that the firing units properly recharged after they were fired by the propellant dispersion command.

c. One revision corrected the EBW firing unit arm and engine cutoff test for range safety system 2, to agree with the test requirements. Three "if" statement transfer conditions were changed to cause malfunction printouts if the engine control bus voltage was not 28 ±2.0 vdc, rather than not 0.0 ±2.0 vdc, and if the engine cutoff signal indication was off at the AO and BO multiplexer, rather than if it was on.

d. One revision corrected a typeout statement to reference paragraph 4.1 for the test set setup, rather than paragraph 4.2.1, to specify the correct paragraph.

e. One revision deleted the Model DSV-4B-298 monochrome system status display, P/N 1B37968-1, from the End Item Requirements list, as the unit was not in service during this test.

4.2.30.1 Test Data Table, Range Safety System

Function	Measured Value (vdc)	Limits (vdc)
Forward Bus 1 Battery Simulator	27.999	28.0 ±2.0
Forward Bus 2 Battery Simulator	28.079	28.0 ±2.0
External/Internal Power Transfer Test		
External Power On		
System 1 Charging Voltage Indication	4.274	4.2 ±0.3
System 1 Firing Unit Indication	4.261	4.2 ±0.3
System 2 Charging Voltage Indication	4.255	4.2 ±0.3
System 2 Firing Unit Indication	4.240	4.2 ±0.3

4.2.30.1 (Continued)

Function	Measured Value (vdc)	Limits (vdc)
Internal Power		
System 1 Charging Voltage Indication	4.279	4.2 ±0.3
System 2 Charging Voltage Indication	4.255	4.2 ±0.3
External Power Off		
System 1 Charging Voltage Indication	0.050	0.3 max
System 2 Charging Voltage Indication	0.050	0.3 max
Firing Unit Arm and Engine Cutoff Test		
Engine Control Bus Voltage	27.691	28.0 ±2.0
Receiver 1 Signal Strength Indication	3.636	3.75 ±1.25
Receiver 2 Signal Strength Indication	3.728	3.75 ±1.25
System 1 Arm and Engine Cutoff Test		
Firing Unit Charging Voltage Indication	4.279	4.2 ±0.3
Engine Control Bus Voltage, Bus Off	-0.062	0.0 ±2.0
Engine Control Bus Voltage, Bus On	27.72	28.0 ±2.0
External Power Off		
System 1 Charging Voltage Indication	0.050	0.3 max
System 2 Charging Voltage Indication	0.050	0.3 max
System 2 Arm and Engine Cutoff Test		
Firing Unit Charging Voltage Indication	4.260	4.2 ±0.3
Engine Control Bus Voltage	27.753	28.0 ±2.0
Propellant Dispersion Test		
System 1 Propellant Dispersion Test		
Charging Voltage Indication (Pulse Sensor Off)	4.279	4.2 ±0.3
Charging Voltage Indication (Pulse Sensor On)	1.329	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)	1.305	3.0 max

4.2.31 Auxiliary Propulsion System Checkout (1B69403 NC)

After the installation of the auxiliary propulsion system (APS) modules onto the stage, this manual procedure ensured that the modules operated properly. and that there was no excessive leakage in the system. The ability of the GSE propulsion control console to control the solenoid valves in the APS modules was also verified. APS modules, P/N 1A83918-535, S/N's 508-1 and 508-2, were tested by this procedure.

Initiated on 13 March 1968, after the APS module installation was accomplished, this procedure was completed on 27 May 1968 and was accepted on 4 June 1968. The procedure was active on 5 days during this period. After the completion of this procedure, the APS modules were removed from the stage for separate shipment to STC.

The test first verified the proper operation of the solenoid valves in the APS modules, and determined that the GSE Model DSV-4B-234 propulsion control console, P/N 1A65728-1, could control the valves for test operations. The console control switches were used to open and close the ullage vent, the emergency ullage vent, the recirculation valve, and the transfer valve, for the fuel and oxidizer propellant systems in each APS module. Proper operation of the valves was verified by gas flow when the ullage vents and recirculation valves were opened, and by audibly verifying valve solenoid actuation or deactuation for the other checks. The console indicator lights were also verified to operate properly.

In each APS module, the propellant and ullage systems were then pressurized with nitrogen gas to establish blanket pressures of 23 $\pm$3 psig for the fuel and oxidizer propellant systems, and 35 $\pm$5 psig for the ullage system. These blanket pressures were maintained throughout the test operations, except when other pressures were required during specific tests.

For a check of the fuel and ozidizer propellant control modules in each APS module, nitrogen gas at 23 $\pm$3 psig pressure was applied at the transfer port

4.2.31 (Continued)

of each control module. With the module transfer valve and recirculation valve both open, it was verified that gas flowed through the propellant system and out of the recirculation vent port. It was then verified that closing the recirculation valve stopped the gas flow through the recirculation lines, and that closing the transfer valve stopped the gas flow into the propellant system. After these checks were completed, the fuel and oxidizer propellant systems were repressurized to the 23 ±3 psig blanket pressures.

A check of the helium low pressure modules and the ullage system of each APS module was accomplished next. The ullage systems were vented to ambient pressure, and then pressurized to between 50 and 75 psig with helium. The ullage vents and emergency ullage vents in the fuel and oxidizer helium low pressure modules were opened and closed while it was verified that helium flowed from the ullage vent ports only when a vent was open. The helium bottles were then pressurized to 1750 ±50 psig for an integrity check, while the helium regulator outlet pressures were monitored to verify that the regulator properly limited the ullage helium pressure. After 3 minutes at the integrity pressure, the helium bottles were vented to 1500 ±100 psig, and the stage part of the helium supply line was leak-checked from the aft umbilical to the helium fill connection of each APS module. At the completion of this check the ullage systems were vented to ambient pressure, and the ullage blanket pressures were re-established as before, using nitrogen gas.

The APS modules were then prepared for use in the APS automatic checkout procedure, H&CO 1B69571 (paragraph 4.2.32), and the all-systems test procedure, H&CO 1B66571 (paragraph 4.2.36). The test setups were made and verified, and the required gas pressures were supplied from the GSE. For the all-systems test, the APS engine throat plugs were installed prior to the test, and were removed after the test. After these tests were completed, the module desiccants were replaced, and the blanket pressures were re-established as before.

Low pressure decay checks were then conducted on the fuel and oxidizer propellant systems of each APS module. The systems were vented to ambient pressure and repressurized to 23 ±3 psig with helium. The pressure loss over

4.2.31 (Continued)

a 1-hour period was then measured, as shown in Test Data Table 4.2.31.1. At the end of this check, the fuel and oxidizer systems were vented to ambient, and the blanket pressures were re-established.

The APS modules were then prepared for removal from the stage. After all electrical connections had been removed from the modules, a final diode integrity check was accomplished. In this check a Hewlett Packard 410B VTVM was used to measure the resistance between the connector pins of each APS module, as shown in the Test Data Table.

Engineering comments noted that the 70-pound thrust ullage engine, P/N 15-210001, was not installed in either APS module during this test. The attitude control relay modules, 404A71A19, P/N 1B57731-1, S/N 361, and 404A51A4, P/N 50M35076-1, S/N 335, were both interim use parts (reference FARR 500-238-101, paragraph 4.2.32). One leak was noted during this test, at a test setup connection in the fuel supply line in APS module, S/N 508-1. A Voi-Shan seal was installed, correcting the leak. No other problems were encountered during the test, and no FARR's were written.

Twenty-one revisions were made to the procedure:

a. One revision modified the initial CSE equipment setup, and added the checkouts that verified the ability of the Model DSV-4B-234 propulsion control console to control the APS solenoid valves. The Model 234 console could be manually checked out only with the APS modules installed on the stage.

. One revision deleted unnecessary parts of the procedure, and changed other parts, to agree with changes in the APS bladder servicing instructions, 1B67661.

c. One revision added a requirement to monitor the helium regulator outlet pressure, measurement D37 for APS module 1 or measurement D38 for APS module 2, while the helium bottles were being pressurized to the integrity pressure, to verify that the regulator lockup pressure was maintained. This was a precaution to permit corrective action if the regulator allowed high pressure down stream.

d. Five revisions made numerous minor changes, modifications, and additions, to refine the procedure for the first use.

4.2.31 (Continued)

e. Two revisions changed the preparations for the all systems test. An instruction was added to install the throat plugs from the Model 770 kit into the engines of APS modules 1 and 2, to provide the proper setup. A note was also added to remove the throat plugs and reinstall the desiccant covers if the all systems test was to be inactive for a period of 72 hours or longer, and to reinstall the throat plugs before restarting the test. This was to ensure the minimum exposure of the APS engines to possible corrosion and contamination.

f. Six revisions modified the low pressure decay checks. Three steps were deleted, as they were not required; the GSE helium supply pressure was regulated at 200 ±5 psig, rather than the specified 50 ±5 psig, as 50 psig was not enough to operate the 60 psig portable test gauge; and the pressure loss was measured over a 1 hour period, rather than the specified 8 hour period, as report 4B-6310, APS System Leak Check Pressure Decay - SV, gave an overall leakage rate of 15 psig in 1 hour. The more stringent leakage limit of 5 psig in 1 hour was used in this test.

g. Five revisions modified the diode integrity checks. The setup instructions were changed to include wire harness identification, 414W1 in APS module 1 and 415W1 in APS module 2; and the required resistance of two measurements in each module were changed to be 17 ±7 ohms, rather than 12 +6,-2 ohms, because the ullage engine was not installed in either module.

4.2.31.1 Test Data Table, Auxiliary Propulsion System Checkout

Low Pressure Decay Check

	Pressure Meas. (psig)		Pressure Loss (psi)	
Function	Start	End	Meas.	Limit
APS 1 Fuel System	24.1	22.9	1.2	5.0
APS 1 Oxidizer System	25.6	25.6	0.0	5.0
APS 2 Fuel System	25.4	25.3	0.1	5.0
APS 2 Oxidizer System	24.4	24.4	0.0	5.0

Diode Integrity Check, APS 1, Wire Harness 414W1

Connector and Pin		Resistance (ohms)	
From (-)	To (+)	Measured	Limits
P6-c	P6-L	4.6	4.5 ±2.0
P6-d	P6-L	4.6	4.5 ±2.0
P6-e	P6-L	4.8	4.5 ±2.0
P6-f	P6-L	4.4	4.5 ±2.0
P6-b	P6-M	3.8	4.5 ±2.0
P6-a	P6-L	4.1	4.5 ±2.0
P6-T	P6-J	4.2	4.5 ±2.0
P6-U	P6-J	3.8	4.5 ±2.0
P6-P	P7-H	20.0	17.0 ±7.0
P6-N	P6-K	22.0	17.0 ±7.0

4.2.31.1 (Continued)

Diode Integrity Check, APS 2, Wire Harness 415W1

Connector and Pin		Resistance (ohms)	
From (-)	To (+)	Measured	Limits
P6-c	P6-L	4.7	4.5 ±2.0
P6-d	P6-L	4.7	4.5 ±2.0
P6-e	P6-L	4.7	4.5 ±2.0
P6-f	P6-L	4.7	4.5 ±2.0
P6-b	P6-M	3.9	4.5 ±2.0
P6-a	P6-L	4.2	4.5 ±2.0
P6-T	P6-J	4.6	4.5 ±2.0
P6-U	P6-J	4.0	4.5 ±2.0
P6-P	P7-H	20.0	17.0 ±7.0
P6-N	P6-K	20.0	17.0 ±7.0

4.2.32 Auxiliary Propulsion System Module (1B69571 NC)

This automatic procedure verified that the telemetry outputs from each auxiliary propulsion system (APS) module were correct, and that the fuel and oxidizer solenoid valves for each engine in the module were operating properly. Oscillograph records were made of the current and voltage of each of the four series-parallel fuel valves and four series-parallel oxidizer valves for each engine. From these records the valve opening current signature and valve closing voltage signature were determined for each valve for comparison with previous post-manufacturing data. A stage wiring verification check was also accomplished. The items involved in this test were the APS modules, P/N 1A83918-535, S/N's 508-1 and 508-2.

Initiated on 15 March 1968, the procedure was completed by the fourth attempt on 8 April 1968, after 6 days of activity, and was accepted on 10 May 1968. The first three attempts were not acceptable because of problems with the valve signature oscillograph records, and with the installation of the engine throat plugs. The valve signature problems were traced to defective control relay modules. As noted by FARR 500-238-101, the relay modules were temporarily accepted as interim use parts only, and continued in use for subsequent testing. The engine throat plug installation was satisfactorily accomplished after the throat plug fixtures became available. This narration and Test Data Table 4.2.32.1 cover the acceptable fourth attempt. The valve signature data resulting from the oscillograph records is also presented in the Test Data Table.

4.2.32 (Continued)

The stage power setup, H&CO 1B66560, was accomplished to establish initial conditions for the test. The APS checkout procedure, H&CO 1B69403 (paragraph 4.2.31), prepared the APS modules for the test, and supplied the 195 ±10 psig pressure for the module fuel and oxidizer propellant systems. Verification was made that the engine covers and desiccants were removed, and that the engine throat plugs were not installed. Each APS module was tested separately, starting with APS module 1.

The instrument unit (IU) substitute -28 vdc power was turned on and measured, and the APS bus power was turned on. An APS function scan then measured the attitude control helium pressure, the helium regulator outlet pressure, the helium bottle gas temperature, the attitude control oxidizer and fuel temperatures, and the fuel and oxidizer ullage volume pressures and supply manifold pressures.

Each of the three attitude control engines in the APS module was then individually tested to verify the operation of the fuel and oxidizer valves. The four series-parallel fuel valves and four series-parallel oxidizer valves for each engine were tested under two test conditions. For the first test condition, the two upstream fuel valves and the two upstream oxidizer valves were loaded with the differential pressure between the pressurized fuel and oxidizer supply manifolds and the ambient pressure engine chamber. This test condition was set up manually, by using the GSE APS checkout test assembly to momentarily open only the downstream fuel and oxidizer valves. For the second test condition, the two downstream fuel valves and two downstream oxidizer valves were loaded with the differential pressure by similarly opening only the upstream valves. After each test condition was set, an automatic engine valve test was conducted twice, with all eight valves simultaneously opened and closed by the attitude control nozzle commands for the engine under test.

4.2.32 (Continued)

During each automatic test, oscillograph records were made of the current and voltage for each of the eight valves; measurements were made of the aft bus 1 voltage and the engine valve open indication voltage for the closed and open positions; and the valve open indication, the attitude control chamber pressure, and the fuel and oxidizer manifold pressures, were monitored during the valve movement to verify that they remained acceptable. The oscillograph records from the first automatic test for each test condition were later evaluated to determine the individual valve opening current signature and closing voltage signature. The second automatic test for each test condition supplied engineering information, but could not be used to determine valve signatures as the required differential pressure load was no longer applied.

After all three attitude control engines in the APS module were tested, the APS bus power was turned off, and the manual set up was accomplished to prepare for the stage wiring configuration check. The pressure in the module fuel and oxidizer propellant systems was reduced to 23 ± 3 psig, the stage wiring was returned to the flight configuration, the upstream valves of all three engines were loaded with the differential pressure, and throat plugs were installed in all three attitude control engines. The APS bus power was turned back on, and the fuel and oxidizer supply manifold pressures were measured. Each of the attitude control engines in the module was then checked by repeating the automatic engine valve test. After these checks were completed, the APS bus power and the IU substitute -28 vdc power were turned off. The APS module was then secured from the test by H&CO 1B69403. After the test of APS module 1 was completed, the same tests were conducted on APS module 2.

Engineering comments noted that the 70 pound thrust ullage engines, P/N 15-210001, were not installed in either APS module during this test. The APS throat plug fixtures, P/N 1B62371, were not installed at the start of the test, but were installed and accepted prior to the completion of the test. It was also noted that a control relay module, P/N 50M35076-1, S/N 335, was installed at reference location 404A51A4, as an interim use part in place of a control relay module, P/N 1B57731-1. As noted below by FARR 500-238-101, the other

4.2.32 (Continued)

control relay module, P/N 1B57731-1, S/N 361, at reference location 404A71A19, was also considered as interim use part. Both control relay modules were to be replaced before stage flight use. No particular problems were encountered during the acceptable fourth attempt. Two FARR's were written during this procedure:

a. FARR 500-238-097 noted that the shroud mounting flange, P/N 1B33669-1, was debonded from the engine thrust nozzle exit on engine 1, P/N 1A39597-509, S/N 810. The defect was reworked to an acceptable condition per Engineering instructions.

b. FARR 500-238-101 noted that the waveform analysis showed that the APS module valve closing time was 13 milliseconds, exceeding the 11 milliseconds maximum limit. It was found that the control relay modules, P/N 1B57731-1, S/N 361, and P/N 50M35076-1, S/N 335, were defective. Both relay modules were accepted as interim use parts only, and were to be replaced later.

Five revisions were made to the procedure:

a. Two revisions deleted all parts of the procedure involving the 70 pound thrust ullage engines, as the ullage engines were not installed in either APS module, and were not tested.

b. One revision deleted the requirement to vent the fuel and oxidizer propellant systems during the manual set up for the stage wiring verification, as reducing the GSE pressure regulator setting to 23 $\pm$3 psig adjusted the pressure without venting.

c. One revision corrected the wording of two statements to indicate that they were used to secure from the automatic test, not to secure the APS modules.

d. One revision deleted the Model DSV-4B-298 monochrome system status display, P/N 1B37968-1, from the End Item Equipment list, as the unit was not operational.

4.2.32.1 Test Data Table, Auxiliary Propulsion System Module

APS Module 1

Function	Meas.	AO Mult.	BO Mult.	Limits
IU Sub -28 vdc Power (vdc)	-29.48			-28.5 ±2.5
APS 1 Scan				
Helium Bottle Press (D35)(psia)		57.3	53.5	100.0 max
He Reg Outlet Press (D37)(psia)		51.1	50.6	50.0 ±15.0
He Bottle Gas Temp (C23)(°F)	69.5			*
Oxid Temperature (C132)(°F)		68.3	68.2	*
Fuel Temperature (C136)(°F)		67.1	66.7	*
Fuel Ullage Press (D97)(psia)	48.4			50.0 ±15.0
Oxid Ullage Press (D98)(psia)	48.0			50.0 ±15.0
Fuel Manifold Press (D70)(psia)	203.4			210.0 ±15.0
Oxid Manifold Press (D71)(psia)	202.9			210.0 ±15.0
Wiring Verification				
Fuel Manifold Press (D70)(psia)	37.97			38.0 ±15.0
Oxid Manifold Press (D71)(psia)	35.79			38.0 ±15.0

APS 1 Valve Movement

	Test Condition 1		Test Condition 2		Wiring
Function	Test 1	Test 2	Test 1	Test 2	Verif
Engine 1-1					
Aft Bus 1 Voltage (vdc)	27.958	28.239	28.199	27.879	27.999
Valve Open Ind (Closed)(vdc)	0.000	-0.005	-0.005	-0.010	-0.005
Valve Open Ind (Open)(vdc)	3.933	3.933	3.933	3.923	4.102
Engine 1-2					
Aft Bus 1 Voltage (vdc)	27.999	27.958	28.039	28.199	28.079
Valve Open Ind (Closed)(vdc)	-0.005	-0.005	-0.005	-0.005	-0.005
Valve Open Ind (Open)(vdc)	3.855	3.851	3.846	3.846	4.056
Engine 1-3					
Aft Bus 1 Voltage (vdc)	28.039	27.958	27.958	27.958	28.079
Valve Open Ind (Closed)(vdc)	-0.005	-0.005	-0.005	-0.005	-0.005
Valve Open Ind (Open)(vdc)	3.887	3.871	3.871	3.876	4.071

*Limits Not Specified

4.2.32.1 (Continued)

APS Module 2

Function	Meas.	AO Mult.	BO Mult.	Limits
IU Sub -28 vdc Power (vdc)	-29.84			-28.5 ±2.5
APS 2 Scan				
Helium Bottle Press (D36)(psia)		49.6	49.6	100.0 max
He Reg Outlet Press (D38)(psia)		49.3	49.8	50.0 ±15.0
He Bottle Gas Temp (C187)(°F)	69.5			*
Oxid Temperature (C22)(°F)		67.8	67.6	*
Fuel Temperature (C21)(°F)		68.6	68.4	*
Fuel Ullage Press (D100)(psia)	50.6			50.0 ±15.0
Oxid Ullage Press (D99)(psia)	48.0			50.0 ±15.0
Fuel Manifold Press (D72)(psia)	202.9			210.0 ±15.0
Oxid Manifold Press (D73)(psia)	206.4			210.0 ±15.0
Wiring Verification				
Fuel Manifold Press (D72)(psia)	38.0			38.0 ±15.0
Oxid Manifold Press (D73)(psia)	40.6			38.0 ±15.0

APS 2 Valve Movement

	Test Condition 1		Test Condition 2		Wiring
Function	Test 1	Test 2	Test 1	Test 2	Verif
Engine 2-1					
Aft Bus 1 Voltage (vdc)	28.158	27.958	28.118	28.239	27.958
Valve Open Ind (Closed)(vdc)	-0.005	0.005	0.000	-0.005	0.000
Valve Open Ind (Open)(vdc)	3.748	3.738	3.759	3.753	3.943
Engine 2-2					
Aft Bus 1 Voltage (vdc)	28.118	28.118	28.079	28.118	28.158
Valve Open Ind (Closed)(vdc)	-0.005	-0.005	-0.005	-0.010	-0.005
Valve Open Ind (Open)(vdc)	3.738	3.748	3.759	3.748	3.912
Engine 2-3					
Aft Bus 1 Voltage (vdc)	27.958	28.239	27.958	28.158	28.039
Valve Open Ind (Closed)(vdc)	-0.005	-0.005	-0.005	-0.005	0.000
Valve Open Ind (Open)(vdc)	3.702	3.707	3.687	3.691	3.846

*Limits Not Specified

4.2.32.1 (Continued)

Valve Current and Voltage Signatures

Legend: Condition 1 - Upstream Valves L1, L2, L5, and L6 loaded
Condition 2 - Downstream Valves L3, L4, L7, and L8 loaded

Opening Current Signature
A - Valve to valve opening variation of a parallel set, L1-L2, L3-L4, L5-L6, or L7-L8 (5 msec max)
B - Opening poppet travel time (1 to 4 msec)
C - Opening time, unloaded (25 msec max)
D - Opening time, loaded (25 msec max)
E - Steady state current (1.3 amp max)
F - Pull-in current (80% of E, max)
N/A - Measurement not applicable

Closing Voltage Signature
M - Closing time (11 msec max)
P - Negative voltage to suppression (-60 ±10 vdc)
R - First valve to last valve closing variation, four valves, L1-L2-L3-L4 or L5-L6-L7-L8 (3 msec max)

APS 1 Engine 1-1 Valve Signatures

Function	L1	L2	L3	L4	L5	L6	L7	L8
Condition 1								
A (msec)	(1.25)		(0.00)		(0.75)		(1.25)	
B (msec)	2.25	2.25	2.0	1.75	2.5	1.75	2.5	2.0
C (msec)	N/A	N/A	10.0	10.0	N/A	N/A	11.0	10.0
D (msec)	20.0	21.0	N/A	N/A	20.0	21.0	N/A	N/A
E (amp)	1.1	1.0	1.25	1.075	1.0	1.0	0.98	0.925
F (amp)	0.775	0.73	0.35	0.35	0.725	0.745	0.40	0.34
M (msec)	7.5	7.5	9.5	7.5	6.5	6.5	7.5	7.5
P (vdc)	60.0	60.0	61.0	57.5	65.0	67.5	62.5	66.0
R (msec)	(2.0)				(1.0)			
Condition 2								
A (msec)	(1.00)		(0.25)		(0.00)		(0.25)	
B (msec)	2.0	2.0	1.25	1.50	2.0	2.0	1.5	1.5
C (msec)	8.5	10.0	N/A	N/A	12.5	13.0	N/A	N/A
D (msec)	N/A	N/A	19.0	18.0	N/A	N/A	19.0	18.0
E (amp)	1.1	1.0	1.0	1.05	1.0	0.98	1.01	1.0
F (amp)	0.40	0.40	0.70	0.70	0.37	0.37	0.77	0.70

4.2.32.1 (Continued)

Function	L1	L2	L3	L4	L5	L6	L7	L8
M (msec)	8.0	8.0	8.5	7.5	7.0	6.0	7.0	7.0
P (vdc)	58.0	58.0	62.0	58.5	65.0	67.5	65.0	67.5
R (msec)	(1.0)				(1.0)			

Wiring Verification

Function	L1	L2	L3	L4	L5	L6	L7	L8
M (msec)	8.5	7.5	7.5	8.0	6.5	6.5	7.5	7.0
P (vdc)	57.0	57.0	64.0	57.0	65.0	67.0	64.0	67.0
R (msec)	(1.0)				(1.0)			

APS 1 Engine 1-2 Valve Signatures

Function	L1	L2	L3	L4	L5	L6	L7	L8
Condition 1								
A (msec)	(0.5)		(1.0)		(1.0)		(1.0)	
B (msec)	2.0	2.75	2.0	2.0	2.0	2.5	2.0	2.5
C (msec)	N/A	N/A	8.5	10.0	N/A	N/A	9.0	10.0
D (msec)	18.5	18.5	N/A	N/A	20.0	19.5	N/A	N/A
E (amp)	1.15	1.05	1.02	1.10	1.01	1.02	1.05	1.01
F (amp)	0.77	0.80	0.34	0.38	0.71	0.70	0.38	0.36
M (msec)	7.5	7.0	6.5	7.0	7.5	7.5	7.0	10.0
P (vdc)	57.0	65.0	55.0	57.0	60.0	67.0	60.0	57.0
R (msec)	(1.0)				(3.0)			
Condition 2								
A (msec)	(0.0)		(0.5)		(0.5)		(0.5)	
B (msec)	2.0	1.5	1.0	1.5	2.0	2.0	2.5	2.0
C (msec)	9.0	8.5	N/A	N/A	9.5	9.0	N/A	N/A
D (msec)	N/A	N/A	18.0	18.0	N/A	N/A	20.0	20.0
E (amp)	1.12	1.02	1.00	1.08	1.0	1.01	1.01	1.01
F (amp)	0.38	0.35	0.64	0.71	0.35	0.35	0.71	0.71
M (msec)	7.5	7.0	6.5	8.0	8.0	7.5	7.5	10.0
P (vdc)	57.0	67.0	54.0	56.0	60.0	67.0	60.0	60.0
R (msec)	(1.5)				(2.5)			

4.2.32.1 (Continued)

Function	L1	L2	L3	L4	L5	L6	L7	L8
Wiring Verification								
M (msec)	8.0	7.0	7.0	7.0	8.0	8.0	8.0	11.0
P (vdc)	58.0	67.0	55.0	57.0	61.0	67.0	60.0	60.0
R (msec)	(	1.0		)	(	3.0		)

APS 1 Engine 1-3 Valve Signatures

Function	L1	L2	L3	L4	L5	L6	L7	L8
Condition 1								
A (msec)	(1.0	)	(0.0	)	(0.5	)	(1.5	)
B (msec)	2.0	2.0	2.5	2.5	2.0	3.0	2.5	2.5
C (msec)	N/A	N/A	10.0	9.5	N/A	N/A	9.5	11.0
D (msec)	21.0	20.0	N/A	N/A	19.0	20.0	N/A	N/A
E (amp)	1.10	1.01	0.95	1.01	0.98	0.98	1.0	0.99
F (amp)	0.825	0.700	0.370	0.350	0.700	0.680	0.350	0.400
M (msec)	8.0	7.5	6.0	7.5	7.0	7.0	7.5	7.0
P (vdc)	60.0	58.0	64.0	57.0	60.0	60.0	62.0	65.0
R (msec)	(	2.0		)	(	0.5		)
Condition 2								
A (msec)	(1.0	)	(0.50	)	(0.5	)	(0.0	)
B (msec)	2.0	2.5	2.0	2.5	2.0	2.0	2.5	1.5
C (msec)	8.0	9.5	N/A	N/A	9.0	9.0	N/A	N/A
D (msec)	N/A	N/A	20.0	20.0	N/A	N/A	20.0	20.0
E (amp)	1.1	1.01	0.98	1.05	0.99	0.99	1.00	1.00
F (amp)	0.38	0.36	0.72	0.71	0.35	0.35	0.72	0.75
M (msec)	7.0	7.5	7.5	8.0	7.0	7.0	8.0	8.0
P (vdc)	62.0	60.0	62.0	57.0	60.0	58.0	62.0	64.0
R (msec)	(	1.0		)	(	1.0		)
Wiring Verification								
M (msec)	7.5	8.0	6.5	8.0	7.5	7.0	8.0	8.0
P (vdc)	60.0	60.0	64.0	57.0	62.0	60.0	62.0	64.0
R (msec)	(	1.5		)	(	1.0		)

4.2.32.1 (Continued)

APS 2 Engine 2-1 Valve Signatures

Function	L1	L2	L3	L4	L5	L6	L7	L8
Condition 1								
A (msec)	(0.5)		(1.0)		(0.2)		(1.5)	
B (msec)	1.5	2.5	3.0	2.0	2.0	2.0	2.5	2.0
C (msec)	N/A	N/A	11.0	10.0	N/A	N/A	11.5	10.0
D (msec)	20.0	19.5	N/A	N/A	19.5	19.0	N/A	N/A
E (amp)	1.1	1.0	0.97	1.03	0	0.96	1.0	1.01
F (amp)	0.78	0.70	0.30	0.39	0.70	0.67	0.41	0.38
M (msec)	9.0	8.75	8.75	8.3	7.75	8.5	8.6	8.2
P (vdc)	63.0	62.0	57.0	54.0	59.0	57.0	62.0	67.0
R (msec)	(0.7)				(0.85)			
Condition 2								
A (msec)	(2.0)		(1.0)		(2.5)		(0.5)	
B (msec)	2.0	2.0	2.0	2.5	2.5	2.0	1.5	2.0
C (msec)	11.0	9.0	N/A	N/A	10.5	9.0	N/A	N/A
D (msec)	N/A	N/A	19.0	18.0	N/A	N/A	20.5	20.0
E (amp)	1.1	1.02	0.99	1.04	1.0	0.98	1.02	1.02
F (amp)	0.45	0.41	0.71	0.70	0.40	0.32	0.77	0.70
M (msec)	9.5	9.8	9.0	8.75	7.5	7.0	7.9	8.3
P (vdc)	65.0	60.0	53.0	51.0	59.0	57.0	62.0	70.0
R (msec)	(1.05)				(1.3)			
Wiring Verification								
M (msec)	11.0	9.8	8.8	9.1	7.1	8.5	8.3	7.8
P (vdc)	62.5	60.0	57.0	54.0	60.0	56.0	61.0	65.0
R (msec)	(2.2)				(1.4)			

APS 2 Engine 2-2 Valve Signatures

Function	L1	L2	L3	L4	L5	L6	L7	L8
Condition 1								
A (msec)	(0.8)		(0.8)		(1.0)		(1.1)	
B (msec)	1.9	2.4	2.8	2.7	2.0	1.9	2.3	2.5

4.2.23.1 (Continued)

Function	L1	L2	L3	L4	L5	L6	L7	L8
C (msec)	N/A	N/A	9.0	9.8	N/A	N/A	10.1	9.0
D (msec)	18.0	17.2	N/A	N/A	18.1	19.1	N/A	N/A
E (amp)	1.10	1.03	1.00	1.07	1.0	1.0	1.0	1.02
F (amp)	0.78	0.69	0.35	0.41	0.70	0.74	0.40	0.38
M (msec)	7.0	7.1	7.5	7.0	7.0	8.5	8.5	8.8
P (vdc)	61.0	56.0	55.0	59.0	55.0	65.0	60.0	63.0
R (msec)	(0.5)				(1.8)			
Condition 2								
A (msec)	(1.0)		(0.6)		(2.0)		(0.4)	
B (msec)	2.4	2.3	2.0	1.6	2.0	2.4	2.0	2.0
C (msec)	9.5	8.5	N/A	N/A	9.0	11.0	N/A	N/A
D (msec)	N/A	N/A	18.0	18.6	N/A	N/A	18.0	17.6
E (amp)	1.10	1.04	1.01	1.08	1.0	1.0	1.0	1.02
F (amp)	0.44	0.35	0.68	0.79	0.38	0.46	0.70	0.71
M (msec)	8.1	8.1	9.8	7.5	9.4	8.2	8.8	9.2
P (vdc)	60.0	55.0	52.0	60.0	56.0	65.0	61.0	62.0
R (msec)	(1.6)				(1.0)			
Wiring Verification								
M (msec)	8.0	8.5	8.4	8.0	8.5	9.1	8.8	9.0
P (vdc)	60.0	55.0	52.5	57.0	55.0	65.0	60.0	62.5
R (msec)	(0.5)				(0.6)			

APS 2 Engine 2-3 Valve Signatures

Function	L1	L2	L3	L4	L5	L6	L7	L8
Condition 1								
A (msec)	(0.5)		(0.7)		(0.9)		(0.6)	
B (msec)	2.5	2.0	1.3	2.3	2.2	2.1	1.6	1.8
C (msec)	N/A	N/A	8.8	9.5	N/A	N/A	9.6	9.0
D (msec)	19.5	19.0	N/A	N/A	19.0	19.9	N/A	N/A
E (amp)	1.10	1.0	1.0	1.04	1.08	0.99	1.0	1.03
F (amp)	0.78	0.70	0.36	0.40	0.67	0.70	0.40	0.38

4.2.32.1 (Continued)

Function	L1	L2	L3	L4	L5	L6	L7	L8
M (msec)	8.5	9.8	9.5	8.4	8.2	7.8	9.6	8.1
P (vdc)	65.0	55.0	52.5	55.0	60.0	67.0	60.0	67.0
R (msec)	(1.4)				(1.8)			
Condition 2								
A (msec)	(0.6)		(1.1)		(0.0)		(0.9)	
B (msec)	1.5	1.1	1.0	1.9	2.0	2.0	2.0	2.1
C (msec)	8.7	8.1	N/A	N/A	9.0	9.0	N/A	N/A
D (msec)	N/A	N/A	17.9	19.0	N/A	N/A	20.0	19.1
E (amp)	1.10	1.0	1.0	1.05	1.0	0.92	1.0	1.02
F (amp)	0.42	0.37	0.71	0.77	0.34	0.38	0.77	0.70
M (msec)	8.4	10.0	9.0	7.9	6.8	7.0	8.4	7.8
P (vdc)	66.0	54.0	52.5	56.0	61.0	66.0	60.0	67.0
R (msec)	(2.1)				(1.6)			
Wiring Verification								
M (msec)	9.0	9.1	8.8	8.0	7.8	7.1	8.5	8.1
P (vdc)	65.0	55.0	53.0	55.0	60.0	66.0	60.0	67.0
R (msec)	(1.0)				(1.4)			

4.2.33 Hydraulic System (1B66570 C)

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 1A66240-505, S/N X457813; the auxiliary hydraulic pump, P/N 1A66241-511, S/N X458912; the accumulator/reservoir assembly, P/N 1B29319-519, S/N 26; the hydraulic pitch actuator 401A1A1, P/N 1A66248-507, S/N 77; and the hydraulic yaw actuator 401A2A1, P/N 1A66248-507-012, S/N 66.

Initiated on 15 March 1968, the procedure was completed by the second attempt on 19 March 1968, after 2 days of activity, and was accepted on 20 March 1968. The first attempt was not acceptable because the yaw actuator did not center at the required neutral position. It was found that the Model DSV-4B-130 stimuli signal conditioner, P/N 1A59946-1, was providing a 0.5 volt signal from the yaw function generator when the signal should have been zero volts. A constant current amplifier printed circuit card was replaced in the yaw function generator to correct the problem. Those function values measured during the second attempt are presented in Test Data Table 4.2.33.1. 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 to establish initial conditions 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. Special measurements were made of the auxiliary hydraulic pump motor gas pressure and air tank pressure, measurements D209 and D223.

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

4.2.33 (Continued)

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.

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, the voltage of the IU substitute 5 volt power supply and the aft 5 volt excitation module and the actuator position signals 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.

4.2.33 (Continued)

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.

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 movement. 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. Special measurements were again made of the auxiliary hydraulic pump motor gas pressure and air tank pressure.

4.2.33 (Continued)

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 24 minutes, 42.251 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 the test. No stage problems were encountered during the test, and no FARR's were written. Two GSE problems occurred during the test. The function generator problem during the first attempt was previously commented on. During the second attempt, the DDAS ground station dropped out of synchronization momentarily during a special function number measurement. Synchronization was regained and the test continued with no further problems. Two revisions were made to the procedure:

a. One revision changed the tolerance on the aft 5 volt excitation module voltage to be ± 0.03 vdc rather than ± 0.05 vdc, and at two normal halt points added special OLSTOL measurements of function numbers 2401 and 2403, the auxiliary hydraulic pump motor gas pressure and air tank pressure, measurements D209 and D223.

b. One revision deleted the Model DSV-4B-298 monochrome system status display, P/N 1B37968-1, from the End Item Equipment list, as the unit was not operational.

4.2.33.1 Test Data Table, Hydraulic System

Function	Measurement	Limits
IU Substitute 5 volt Power Supply (vdc)	5.00	5.00 ± 0.05
Aft 5 volt Excitation Module (vdc)	4.99	5.00 ± 0.03
Hydraulic System Unpressurized		
Reservoir Oil Pressure (psia)	71.14	*
Accumulator GN_2 Pressure (psia)	2318.25	*
Accumulator GN_2 Temperature (°F)	60.02	*
Reservoir Oil Level (%)	86.84	*
Pump Inlet Oil Temperature (°F)	60.41	*
Reservoir Oil Temperature (°F)	59.63	*
Aft Bus 2 Current (amp)	0.20	*
Gaseous Nitrogen Mass (lb)	1.928	1.925 ± 0.2
Corrected Reservoir Oil Level (%)	98.4	95.0 min.
Aux. Hyd. Pump Motor Gas Pressure, D209 (psig)	13.027	*
Aux. Hyd. Pump Air Tank Pressure, D223 (psia)	446.797	*
Engine Centering Test, Locks On, System Unpressurized		
T/M Pitch Actuator Position (deg)	-0.02	*
IU Pitch Actuator Position (deg)	-0.01	*
T/M Yaw Actuator Position (deg)	0.02	*
IU Yaw Actuator Position (deg)	0.04	*
IU Substitute 5 volt Power Supply (vdc)	5.00	*
Aft 5 volt Excitation Module (vdc)	4.99	*
Pitch Actuator Signal (ma)	0.05	*
Yaw Actuator Signal (ma)	0.00	*
Corrected T/M Pitch Actuator Position (deg)	-0.024	-0.236 to 0.236
Corrected IU Pitch Actuator Position (deg)	-0.015	-0.236 to 0.236
Corrected T/M Yaw Actuator Position (deg)	0.024	-0.236 to 0.236
Corrected IU Yaw Actuator Position (deg)	0.044	-0.236 to 0.236
Aft Bus 2 Voltage (vdc)	55.76	56.0 ± 4.0
Aft Bus 2 Current (amp)	60.80	55.0 ± 30.0
Hyd. System 4 Second Press. Change (psia)	284.8	200.0 min.
Engine Centering Test, Locks Off, System Pressurized, No Excitation Signal		
T/M Pitch Actuator Position (deg)	0.03	*
IU Pitch Actuator Position (deg)	0.03	*
T/M Yaw Actuator Position (deg)	-0.01	*
IU Yaw Actuator Position (deg)	0.01	*
IU Substitute 5 volt Power Supply (vdc)	4.99	*
Aft 5 volt Excitation Module (vdc)	4.99	*
Pitch Actuator Signal (ma)	0.05	*
Yaw Actuator Signal (ma)	0.00	*

* Limits Not Specified

4.2.33.1 (Continued)

Function	Measurement	Limits
Corrected T/M Pitch Actuator Position (deg)	0.021	-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)	-0.006	-0.517 to 0.517
Corrected IU Yaw Actuator Position (deg)	0.021	-0.517 to 0.517

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

Function	Measurement	Limits
Hydraulic System Pressure (psia)	3581.75	*
Reservoir Oil Pressure (psia)	163.66	*
Accumulator GN_2 Pressure (psia)	3575.75	*
Accumulator GN_2 Temperature (°F)	76.45	*
Reservoir Oil Level (%)	35.66	*
Pump Inlet Oil Temperature (°F)	71.75	*
Reservoir Oil Temperature (°F)	69.01	*
Aft Bus 2 Current (amp)	44.80	*
T/M Pitch Actuator Position (deg)	0.04	*
IU Pitch Actuator Position (deg)	0.01	*
T/M Yaw Actuator Position (deg)	0.00	*
IU Yaw Actuator Position (deg)	0.01	*
IU Substitute 5 volt Power Supply (vdc)	5.00	*
Aft 5 volt Excitation Module (vdc)	4.99	*
Pitch Actuator Signal (ma)	0.05	*
Yaw Actuator Signal (ma)	0.00	*
Corrected T/M Pitch Actuator Position (deg)	0.037	-0.517 to 0.517
Corrected IU Pitch Actuator Position (deg)	0.015	-0.517 to 0.517
Corrected T/M Yaw Actuator Position (deg)	0.009	-0.517 to 0.517
Corrected IU Yaw Actuator Position (deg)	0.015	-0.517 to 0.517

Pitch 0 to -3 Degree Step Response - Engine Slew Rate: 14.9 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	-0.060	4.999
0.027	-20.020	-0.418	5.000
0.055	-20.020	-0.765	5.000
0.083	-20.020	-1.140	5.000
0.111	-19.971	-1.587	5.000
0.139	-20.020	-2.020	5.000
0.167	-20.020	-2.352	5.000
0.195	-20.020	-2.611	4.990
0.223	-20.020	-2.741	5.000
0.252	-20.020	-2.784	5.000
0.280	-20.020	-2.813	4.990
0.308	-20.020	-2.842	5.000

* Limits Not Specified

4.2.33.1 (Continued)

Pitch -3 to 0 Degree Step Response - Engine Slew Rate: 13.1 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	-2.969	4.999
0.026	0.049	-2.582	5.000
0.055	0.000	-2.207	4.990
0.083	C.000	-1.875	5.000
0.110	0.000	-1.500	5.000
0.139	0.000	-1.067	5.000
0.167	0.000	-0.648	5.000
0.195	0.049	-0.317	5.000
0.224	0.000	-0.144	5.000
0.252	-0.049	-0.058	5.000
0.279	0.000	-0.043	5.000
0.308	0.000	-0.058	4.990

Pitch 0 to +3 Degree Step Response - Engine Slew Rate: 13.1 deg/sec

Time from Start (sec)	Pitch Excitation Signal (ma)	IU Pitch Actuator Pot. Pos. (deg)	IU 5 volt Power Supply (vdc)
0.000	0.000	-0.015	4.999
0.027	19.922	0.332	5.000
0.055	19.922	0.679	4.990
0.083	19.922	1.039	5.000
0.111	19.922	1.429	5.000
0.139	19.922	1.848	5.005
0.167	19.922	2.280	5.000
0.195	19.922	2.598	4.990
0.223	19.922	2.785	5.000
0.252	19.922	2.900	5.000
0.280	19.922	2.930	4.990
0.308	19.922	2.973	5.000

Pitch +3 to 0 Degree Step Response - Engine Slew Rate: 14.1 deg/sec

Time from Start (sec)	Pitch Excitation Signal (ma)	IU Pitch Actuator Pot. Pos. (deg)	IU 5 volt Power Supply (vdc)
0.000	19.949	3.074	4.994
0.027	0.000	2.685	5.005
0.056	0.000	2.251	4.990
0.083	0.000	1.891	5.000
0.112	0.000	1.458	5.000
0.141	0.000	1.011	5.000
0.168	-0.049	0.636	5.000
0.196	0.000	0.376	5.000
0.225	0.049	0.231	4.990
0.252	0.000	0.159	5.000
0.280	0.000	0.116	5.000
0.309	0.049	0.087	5.000

4.2.33.1 (Continued)

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

Time from Start (sec)	Yaw Excitation Signal (ma)	IU Yaw Actuator Pot. Pos. (deg)	IU 5 volt Power Supply (vdc)
0.000	0.000	0.000	4.999
0.027	-19.922	-0.477	5.000
0.056	-19.922	-0.866	5.000
0.083	-19.922	-1.299	5.000
0.111	-19.922	-17.46	5.000
0.140	-19.922	-2.237	5.000
0.167	-19.922	-2.641	5.000
0.196	-19.922	-2.915	5.000
0.225	-19.922	-3.060	5.000
0.252	-19.922	-3.117	4.990
0.280	-19.922	-3.117	5.000
0.309	-19.922	-3.117	5.000

Yaw -3 to 0 Degree Step Response - Engine Slew Rate: 15.9 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.[illegible]99	-3.210	4.999
0.026	-0.049	-2.728	5.000
0.055	0.000	-2.353	4.990
0.083	0.000	-1.948	5.005
0.110	0.000	-1.458	4.990
0.139	0.000	-0.981	5.000
0.167	-0.049	-0.549	5.000
0.194	-0.049	-0.304	5.000
0.223	0.000	-0.145	4.990
0.252	0.000	-0.072	5.000
0.279	-0.049	-0.029	5.000
0.308	-0.049	-0.029	5.000

Yaw 0 to +3 Degree Step Response - Engine Slew Rate: 15.0 deg/sec

Time from Start (sec)	Yaw Excitation Signal (ma)	IU Yaw Actuator Pot. Pos. (deg)	IU 5 volt Power Supply (vdc)
0.000	0.000	0.060	4.999
0.026	19.922	0.476	5.000
0.055	19.922	0.865	4.990
0.083	19.922	1.284	5.000
0.110	19.922	1.731	5.000
0.139	19.922	2.207	5.000
0.167	19.922	2.626	5.000
0.194	19.922	2.886	5.005
0.223	19.922	3.029	5.000
0.252	19.922	3.131	5.000
0.279	19.922	3.174	5.000
0.308	19.922	3.203	5.000

4.2.33.1 (Continued)

Yaw +3 to 0 Degree Step Response - Engine Slew Rate: 15.3 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	3.314	4.994
0.027	0.000	2.770	5.000
0.055	0.000	2.395	5.000
0.083	0.000	1.977	5.000
0.111	-0.049	1.515	5.000
0.139	0.049	1.038	5.000
0.167	-0.049	0.591	5.000
0.196	-0.049	0.273	5.000
0.224	-0.049	0.129	5.000
0.252	-0.049	0.086	5.000
0.280	0.000	0.071	4.990
0.308	-0.049	0.086	5.000

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

Function	Measurement	Limits
Hydraulic System Pressure (psia)	3588.31	*
Reservoir Oil Pressure (psia)	169.33	*
Accumulator GN_2 Pressure (psia)	3586.69	*
Accumulator GN_2 Temperature (°F)	68.22	*
Reservoir Oil Level (%)	37.78	*
Pump Inlet Oil Temperature (°F)	126.02	*
Reservoir Oil Temperature (°F)	109.45	*
Aft Bus 2 Current (amps)	48.20	*
T/M Pitch Actuator Position (deg)	0.01	*
IU Pitch Actuator Position (deg)	0.00	*
T/M Yaw Actuator Position (deg)	0.02	*
IU Yaw Actuator Position (deg)	0.04	*
IU Substitute 5 volt Power Supply (vdc)	5.01	*
Aft 5 volt Excitation Module (vdc)	4.99	*
Pitch Actuator Signal (ma)	0.00	*
Yaw Actuator Signal (ma)	0.00	*
Corrected T/M Pitch Actuator Position (deg)	0.006	-0.517 to 0.517
Corrected IU Pitch Actuator Position (deg)	0.015	-0.517 to 0.517
Corrected T/M Yaw Actuator Position (deg)	0.024	-0.517 to 0.517
Corrected IU Yaw Actuator Position (deg)	0.029	-0.517 to 0.517
Aux. Hyd. Pump Motor Gas Pressure, D209 (psig)	20.425	*
Aux. Hyd. Pump Air Tank Pressure, D223 (psia)	448.219	*

* Limits Not Specified

4.2.34 Propulsion System Test (1B66572 D)

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 19 March 1968, the procedure was completed on 26 March 1968, after 5 days of activity, and was accepted on 4 April 1968. The sections of the procedure are presented in order. Measurements made during the procedure are shown in Test Data Table 4.2.34.1.

Section one, the ambient helium system test, was accomplished by the first attempt on 19 March 1968 with no major problems.

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.

4.2.34 (Continued)

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 puressure switch and control valve was verified, as was tne 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 716.05 psia, and the control helium regulator discharge pressure was measured as 531.19 psia, within the 515.0 $\pm$50.0 psia limits. A series of checks then verified the operation of the pneumatically controlled LH_2 and LOX vent valves, fill and drain valves, prevalves, and chilldown 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 two, the pressurization systems check, was generally accomplished by the second attempt on 21 March 1968, although a partial third attempt was accomplished on 26 March 1968. The first attempt was not acceptable because of several program problems and a temperature bridge malfunction. FARR 500-238-062 replaced the temperature bridge, and program changes were made to correct the other problems. The second attempt was generally acceptable, although several minor problems were encountered and corrected, and the cold helium regulator did not pass the high flowrate check. Using the high flowrate orifice, P/N S0772C12-240, the cold helium sphere pressure could not maintain the required regulator inlet pressure, causing the regulator outlet pressure to fall below the tolerance limit before the sphere pressure had decreased to the specified test limit. The cold helium regulator low flowrate check using orifice, P/N S0772C12-204, was acceptable. For the partial third attempt,

4.2.34 (Continued)

the cold helium sphere pressure test limit was increased for the cold helium regulator high flowrate check, and this check was satisfactorily completed. The only other check conducted by this attempt was a reverification of the LH_2 tank step pressure measurements. An out-of-tolerance measurement that occurred during the first attempt was not repeated, and was attributed to noise.

The cold helium sphere pressure was verified to be 825 $\pm$25 psia, as measured through both telemetry multiplexers, and the cold helium dump valve and shut-off 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 cold helium regulator was checked to verify that the proper outlet pressure could be maintained as the cold helium sphere pressure decreased. For a high flowrate check with test orifice S0772C12-240 installed, the regulator outlet pressure dropped from 385.55 psia at a sphere pressure of 800.98 psia, to 357.73 psia at a sphere pressure of 743.70 psia. This was considered to acceptably meet the requirement of a 358 psia minimum outlet pressure at a 740 psia sphere pressure. The outlet pressure then continued to drop to 244.81 psia at a sphere pressure of 503.12 psia. For a low flowrate check with test orifice S0772C12-204 installed, the regulator outlet pressure dropped from

4 (Continued)

398.65 psia at a sphere pressure of 781.89 psia, to 378.46 psia at a sphere pressure of 682.59 psia. This acceptably met the requirement of a 358 psia minimum outlet pressure at a 690 psia sphere pressure. The outlet pressure then continued to drop to 292.81 psia at a sphere pressure of 506.94 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 thr the J-2 engine check, was accomplished by the first attempt on 22 March 1968. During this attempt, the prevalves initially failed to open properly, as a capped tee on the prevalve actuation control module caused a back pressure that prevented prevalve operation. After the cap was removed, the prevalve operation was accomplished with no other problems.

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 both 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 veri ied that the simulated mainstage OK signal opened the LH_2 and LOX prevalves, that the switch selector engine cutoff signal operated properly and

4.2.34 (Continued)

closed the prevalves, and that removing the cutoff signal reopened the prevalves. The proper operation of the switch selector engine start and LH_2 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 1453.44 psia 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 422.94 psia through both multiplexers when the helium control solenoid valve was opened.

4.2.34 (Continued)

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 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 423.71 psia at the time of engine start.

Engineering comments noted that there were no parts shortages affecting this test, and also noted various problems encountered during the test, and the corrective action, as previously mentioned under the individual section narrations. One FARR was written during the procedure, as previously noted. FARR 500-238-062 noted that temperature bridge 404A71A2, P/N 1B65331-1-002, S/N 106, had a constant 13 vdc output with the simulate command on or off. The output should have been zero vdc with the simulate command on, and 20 vdc with the command off. The defective unit was removed, and temperature bridge, P/N 1B65331-1, S/N 68, was installed and accepted for use.

Twenty-five revisions were made to the procedure:

a. Three revisions changed or added time delays during the O_2H_2 burner operation. The delays after the spark systems were turned on were changed to be 100 milliseconds, as the specified 70 milliseconds was marginal; a 100 millisecond delay was added to allow the voter regulator circuit to respond; and a breakpoint was added to ensure a 2 second delay to provide the minimum 85 milliseconds required to reset the burner propellant valves relay.

b. One revision added a 2 second time delay to allow the LOX pressurization flight switch to respond after switch selector commands closed the LOX repressurization control valve.

c. Two revisions changed the Non-End Item Equipment list and a manual installation instruction to call out test orifice S0772C12-240, rather than S0772C12-224 as listed, because of a change in the test orifice diameter.

4.2.34 (Continued)

d. Two revisions modified the cold helium regulator check. The cold helium sphere lower pressure limit for proper regulator operation was changed from 625 psia to be 690 psia, and then to be 740 psia for the repeated high flowrate check. The lower sphere pressures did not provide the regulator inlet pressure required for proper regulator operation.

e. Three revisions changed one print statement, and changed and partially deleted one other print statement, to correct program errors.

f. One revision disabled SIM channel 41 at two places in the program, and enabled it at two subsequent places, so that a SIM interrupt would not occur if the O_2H_2 burner system caused a temporary overvoltage on aft bus 1.

g. One revision added several steps to the O_2H_2 burner spark systems check to prevent voltage transients on aft bus 1 from damaging the engine. For this purpose, the aft bus 1 backup power supply was used instead of the normal power supply, and the EBW pulse sensor power was turned on to load the bus.

h. One revision documented seven ALCO statements and three breakpoints required to implement the program changes covered by five other revisions.

i. Two revisions modified the manual test setup instructions. The installation of the test adapter for the cold helium regulator flow check was changed to cover the presence of a previously installed hand valve on pipe assembly, P/N 1B55285, on the LOX pressurization line; and an open ended plastic bag was installed over the tee at the prevalve actuation module vent ports, so that the tee was open for gas flow while remaining free from contamination.

j. One revision modified the LOX repressurization control valves check to use changes in the cold helium sphere pressure, measurement D16, to verify proper valve operation, rather than using the pickup and dropout of the LOX prepressurization flight control pressure switch. The existing method could not be used for Stage 508, as changes from previous stages included a lower regulated helium pressure, and a higher pressure switch operating pressure.

k. One revision reran the cold helium regulator high flowrate check using the 740 psia helium sphere lower pressure limit set by a previous revision, and also repeated the LH_2 tank step pressure check to reverify a pressure reading that had previously failed due to noise.

l. One revision added a step to vent any pressure accumulated in the repressurization spheres during the LH_2 tank pressure switch test. This unwanted pressure accumulated because the design of the repressurization control module interlocking system allowed leakage under the valve seats.

4.2.34 (Continued)

m. Two . visions deleted measurement tolerances during the J-2 engine sequence check, to accept out-of-tolerance printouts. Oscillograph records showed that the measurements were within tolerance, but the time lag in the computer updating process, and the last digit uncertainty due to the computer binary transfer, caused the marginal values to be printed out as malfunctions.

n. Two revisions deleted the Model DSV-4B-298 monochrome system status display, P/N 1B37968-1, from the End Item Equipment list, as the unit was inoperative pending design modifications; and deleted the exciter-igniter tips from the Cycle Significant Items list, as memo A3-860-KDLD-M526 and the G change to drawing 1B55424 specified that the exciter-igniter system and tips were no longer cycle significant.

o. One revision ran a special engineering evaluation test, using parts of the J-2 engine check, to investigate the possibility of triggering K8 or K96 during the spark exciter test. The test results were used for immediate engineering evaluation, and were not included as part of the procedure test results.

p. One revision modified a pressure change limit to be 9 psi rather than 10 psi, as the existance of the pressure change verified the proper operation of a step pressure valve, while the actual amount of the change was not important.

4.2.34.1 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)	52.938	35.347	35.039	300.0 max
Pickup Pressure (psia)	40.11	40.06	40.11	41.5 max
Depressurization Time (sec)	16.293	9.068	8.944	180.0 max
Dropout Pressure (psia)	39.13	39.23	39.13	37.5 min
Deadband (psi)	0.98	0.83	0.98	0.3 min
Engine Pump Purge Pressure Switch				
Pickup Pressure (psia)	123.47	123.47	122.68	136.0 max
Dropout Pressure (psia)	110.19	108.63	110.19	99.0 min
Deadband (psi)	13.28	14.84	12.49	3.0 min
Control Helium Regulator Backup Pressure Switch				
Pressurization Time (sec)	19.719	19.779	20.146	180.0 max
Pickup Pressure (psia)	602.219	603.000	603.000	600.0 ±21.0
Depressurization Time (sec)	5.173	5.156	5.063	180.0 max
Dropout Pressure (psia)	490.39	491.95	492.73	490.0 ±31.0

4.2.34.1 (Continued)

Pneumatically Controlled Valve Checks

	Operating Times (sec)					
Valve	Open	Total Open	Close	Total Close	Boost Close	Total Boost Cl.
LH_2 Vent Valve	0.021	0.077	0.227	0.480	0.093	0.250
LOX Vent Valve	0.022	0.077	0.133	0.375	0.066	0.235
LOX Fill and Drain Valve	0.158	0.286	0.745	2.367	0.418	0.957
LH_2 Fill and Drain Valve	0.117	0.233	0.646	1.898	0.336	0.816
LOX Prevalve	1.328	1.966	0.224	0.382	-	-
LH_2 Prevalve	1.426	2.070	0.272	0.412	-	-
LOX C/D Shutoff Valve	0.195	0.899	0.031	0.148	-	-
LH_2 C/D Shutoff Valve	0.142	0.845	0.023	0.130	-	-
LH_2 Cont. Vent Orifice Bypass Valve	0.009	-	0.008	0.202	-	-
Burner LH_2 Propellant Valve	0.039	0.143	0.038	0.128	-	-
Burner LOX Propellant Valve	0.066	0.170	0.176	0.182	-	-
Burner LOX Shutdown Valve	0.007	0.072	0.007	0.074	-	-

	Flight Pos.	Total Flight Pos.	Gnd Pos.	Total Gnd Pos.
LH_2 Directional Vent Valve	0.104	0.222	0.251	0.397

Section 2, Pressurization System Check

Pressure Switch Checks

	Measured Value			
Function	Test 1	Test 2	Test 3	Limits
Cold Helium Regulator Backup Pressure Switch				
Pressurization Time (sec)	15.551	14.851	15.007	180.0 max
Pickup Pressure (psia)	477.180	475.625	477.180	467.5 ±23.5
Depressurization Time (sec)	6.568	6.469	6.401	180.0 max
Dropout Pressure (psia)	381.0	382.0	382.0	362.5 ±33.5
LOX Tank Repressurization Backup Pressure Switch				
Pressurization Time (sec)	14.772	14.609	14.561	180.0 max
Pickup Pressure (psia)	474.9	475.6	474.9	467.5 ±23.5
Depressurization Time (sec)	6.447	6.486	6.414	180.0 max
Dropout Pressure (psia)	383.1	382.3	383.1	362.5 ±33.5
LH_2 Tank Repressurization Backup Pressure Switch				
Pressurization Time (sec)	15.072	14.341	14.291	180.0 max
Pickup Pressure (psia)	472.5	473.3	472.5	467.5 ±23.5
Depressurization Time (sec)	6.811	6.808	6.781	180.0 max
Dropout Pressure (psia)	375.3	376.1	376.1	362.5 ±33.5

4.2.34.1 (Continued)

Function	Measured Value Test 1	Test 2	Test 3	Limits
LOX Tank Ground Fill Pressure Switch				
Pressurization Time (sec)	45.321	38.034	33.926	180.0 max
Pickup Pressure (psia)	40.37	40.32	40.32	41.0 max
Depressurization Time (sec)	11.227	10.174	9.897	180.0 max
Dropout Pressure (psia)	38.92	39.03	38.92	37.5 min
Deadband (psi)	1.45	1.29	1.40	0.5 min
LH_2 Flight Control and Ground Fill Pressure Switches				
Manifold Press. Time (sec)	59.014	49.000	48.886	180.0 max
Manifold Depress. Time (sec)	133.101	129.312	129.585	180.0 max
Flight Control Pickup (psia)	30.60	30.50	30.50	31.5 max
Flight Control Dropout (psia)	28.13	28.13	28.03	27.8 min
Flight Control Deadband (psi)	2.47	2.37	2.47	0.5 min
Ground Fill Pickup (psia)	33.58	33.53	33.48	34.0 max
Ground Fill Dropout (psia)	31.27	31.42	31.32	30.8 min
Ground Fill Deadband (psi)	2.32	2.11	2.16	0.5 min

Section 3, J-2 Engine Checks

Engine Timer Checks

Function	Delay Time (sec)	Limits (sec)
Engine Ignition Timer	0.448	0.450 ±0.030
Helium Delay Timer	0.988	1.000 ±0.110
Sparks De-Energized Timer	3.295	3.300 ±0.200
Start Tank Discharge Timer	1.013	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)	507.86	506.29	506.29	515.0 +36.0
Dropout Pressure (psia)	449.27	449.27	450.05	PU-62.5 ±48.5
Mainstage OK Pressure Switch 2				
Pickup Pressure (psia)	519.92	517.58	519.14	515.0 ±36.0
Dropout Pressure (psia)	446.09	445.31	444.52	PU-62.5 ±48.5

4.2.34.1 (Continued)

Valve Position Measurements

Function	Position (%)	Limit (%)
Main LH_2 Valve Closed	9.90	10 ±10
Main LH_2 Valve Open	90.90	90 ±10
Main LH_2 Valve Reclosed	10.10	Closed ±1
Start Tank Discharge Valve Closed	12.30	10 ±10
Start Tank Discharge Valve Open	91.00	90 ±10
Start Tank Discharge Valve Reclosed	12.20	Closed ±1
Gas Generator Valve Closed	10.70	10 ±10
Gas Generator Valve Open	90.20	*
Gas Generator Valve Plateau	47.29	65 max
Gas Generator Valve Reclosed	10.70	Closed ±1
Main LOX Valve Closed	11.90	10 ±10
Main LOX Valve 1st Ramp	24.20	*
Main LOX Valve T/M Open Indication	80.60	*
Main LOX Valve Open	90.70	90 ±10
Main LOX Valve Final Open	90.60	*
Main LOX Valve Open Difference, T/M to Final	10.00	*
Main LOX Valve Reclosed	12.10	Closed ±1
LOX Turbine Bypass Valve Open	90.60	90 ±10
LOX Turbine Bypass Valve Closed	12.50	10 ±10
LOX Turbine Bypass Valve Reopened	90.50	Open ±1

* Limits not specified

Engine Sequence Check

Function	Start Time (sec)	Oper. Time (sec)	Total Time (sec)
Engine Start			
Ignition Phase Solenoid Command Talkback	-	0.015	-
Control Helium Solenoid Command Talkback	-	0.022	-
ASI LOX Valve Open	-	0.048	-
Main LH_2 Valve Open	0.046	0.083	0.129
LOX Bleed Valve Closed	-	0.069	-
LH_2 Bleed Valve Closed	-	0.077	-
Start Tank Discharge Timer	-	1.006	-
Start Tank Discharge Valve Open	0.091	0.085	0.176
Mainstage Control Solenoid Energize	-	1.459	-
Ignition Phase Timer	-	0.453	-
Start Tank Discharge Control Solenoid Off	-	0.007	-
Main LOX Valve 1st Stage (Ramp) Open	0.061	0.025	0.086

*Limits Not Specified

4.2.34.1 (Continued)

Function	Start Time (sec)	Oper. Time (sec)	Total Time (sec)
Gas Generator Valve LOX Poppet Open	0.137	0.058	0.194
Start Tank Discharge Valve Closed	0.128	0.248	0.376
LOX Turbine Bypass Valve Closed	0.203	0.273	0.477
LOX Turbine Bypass Valve 80% Travel	-	0.439	-
Main LOX Valve 2nd Stage Open	0.626	1.814	2.440
Spark System Off Timer	-	3.304	-
Engine Cutoff			
Ignition Phase Control Solenoid Off	-	0.006	-
Mainstage Control Solenoid Off	-	0.031	-
ASI LOX Valve Closed	0.025	-	-
Main LOX Valve Closed	0.061	0.121	0.182
Main LH_2 Valve Closed	0.079	0.228	0.307
Gas Generator Valve Closed	0.070	0.246	0.316
Gas Generator Valve LOX Poppet Closed	-	0.024	-
LOX Turbine Bypass Valve Open	0.257	0.604	0.860
Helium Control Solenoid De-energize Timer	-	0.994	-
LOX Bleed Valve Open	7.972	-	-
LH_2 Bleed Valve Open	9.130	-	-

4.2.35 Propellant Tank Differential Pressure Scan (1B74681 NC)

This automatic procedure, accomplished in conjunction with the manual propellant tanks system leak check, H&CO 1B59459, (reference paragraph 4.2.24), continuously verified that the LOX and LH_2 tank pressures, the common bulkhead pressure, and the differential pressure across the common bulkhead, all remained within the required limits during the entire period the propellant tanks were pressurized for the integrity check and manual leak checks.

The first attempt of this procedure was accomplished on 27 and 28 March 1968, during the initial integrity pressure check and leak check of the propellant tanks system. A second attempt of the procedure was accomplished on 2 April 1963, during the retest of a corrected leakage. The procedure was accepted on 9 April 1968.

4.2.35 (Continued)

The stage power setup, H&CO 1B66560, was accomplished to establish initial conditions for the test. An ambient conditions check was made before the manual tank pressurization was started. The power was turned on for the LH_2 and LOX tank ullage pressure transducers and the common bulkhead pressure transducer. The LH_2 ullage pressure, measurement D576, the LOX ullage pressure, measurement D577, and the common bulkhead pressure, measurement D545, were verified to be ambient, 14.7 $\pm$1.0 psia for the ullage pressures and 14.7 $\pm$0.5 psia for the common bulkhead pressure. Initial measurements were then made of the pump inlet pressures, EDS transducer and ullage pressures, and tank inlet pressures for both the LH_2 and LOX tanks, and of the common bulkhead internal pressure.

The differential scan was then activated for use while the tanks were pressurized by the manual leak check procedure. During this scan, repetitive measurements were made of the LH_2 and LOX tank ullage pressures and the common bulkhead pressure. As long as both ullage pressures remained less than 15.7 psia, the tanks were considered to be at ambient pressure, and the common bulkhead pressure was verified to be less than 15.2 psia. After every one thousand measurement cycles, a printout was made of the measured LH_2 and LOX tank ullage pressures and the common bulkhead pressure.

Once either ullage pressure exceeded 15.7 psia, the differential pressure across the common bulkhead was determined as the difference between the LOX ullage pressure and the LH_2 ullage pressure. Verification was then made that the LH_2 ullage pressure did not exceed the LOX ullage pressure; that the differential pressure did not exceed 10.0 psi if the LOX ullage pressure was less than 25.0 psia or 2.0 psi if the LOX ullage pressure was greater than 25.0 psia; that the LOX and LH_2 ullage pressures did not exceed the maximum integrity pressure limits of 27.3 psia and 27.1 psia, respectively; and that the common bulkhead pressure did not exceed 16.2 psia. After every one thousand measurement cycles, a printout was made of the measured LH_2 and LOX tank ullage pressures, the common bulkhead pressure, and the differential pressure; and measurements were made of the pump inlet pressures, EDS transducer

4.2.35 (Continued)

and ullage pressures, and tank inlet pressures for both the LH_2 and LOX tanks, and of the common bulkhead internal pressure. The differential scan was terminated after the LH_2 and LOX tanks were vented to ambient pressure at the completion of the manual leak check procedure.

No parts shortages were noted that affected this test. Some minor problems were encountered during the first attempt of the procedure. At one point the differential pressure was 2.361 psi when it should have been 2.0 psi maximum. The LOX tank pressure was adjusted to correct this. A computer failure at another point required reloading the executive tape and re-entering the scan procedure. No problems were encountered during the second attempt of the procedure. No FARR's were written against the test. Nine revisions were made to the procedure:

a. One revision changed two statements to cause the measurement printouts to occur after one thousand measurement cycles, rather than after one hundred measurement cycles as listed, to reduce the number of printout operations required during the differential pressure scan.

b. One revision changed the requirement on the differential pressure across the common bulkhead to be greater than -1.5 psi rather than greater than 0.0 psi, to allow for noise level tolerances.

c. One revision changed the tolerance on the GSE 28 vdc power supply voltages to be 28.0 $\pm$0.5 vdc, rather than 28.0 $\pm$0.8 vdc as listed, to conform with the A3 electrical requirements.

d. One revision changed the End Item Equipment list to delete the Model DSV-4B-298 monochrome system status display, P/N 1B37968-1, as it was inoperative, and to add the Model DSV-4B-296 telemetry signal distribution unit, P/N 1B41812-1, as it was needed to transmit the stage 600 kHz VCO signal to the DDAS ground station.

e. One revision changed a print statement to be "print 1H/2 ..." rather than "print 1H/4 ...", to double space the printout rather than starting the printout at the top of a new page.

f. One revision added a special check after the differential scan had been entered. The proper setup of the Model 238 recorder was checked by turning the LOX and LH_2 ullage pressure transducer power supplies off and on.

g. One revision added an instruction that the test could be exited by enabling a conditional hold, entering OLSTOL, going to step 66, and resuming to execute an end card. This method was used to terminate the test, as it was a valid exit which did not affect the test results.

4.2.35 (Continued)

h. Two revisions added instructions to bypass the initial pressure scan if the system was already pressurized when the differential scan was entered, and to bypass both the transducer power turn on routine and the initial pressure scan if the system was already pressurized and the transducer powers were already turned on. The initial pressure scan would not pass if the system was already pressurized when it was attempted.

4.2.36 EMC Radio Frequency Signature and Transient Detection (1B64709 N/C)

This procedure verified the electro magnetic compatibility (EMC) of the stage by means of a radiated spectrum signature test and a conducted interference test. The radiated spectrum signature test verified that the operation of the stage telemetry transmitter did not cause any RF interference at frequencies that would adversely affect the various Apollo and Saturn Vehicle receivers. The conducted interference test verified tha the operation of the stage systems and equipment did not cause excessive transient signals on the stage electrical wiring, that a six decibel safety margin level was maintained at various critical points in the stage equipment, and that there were RF interference signals within 0.5 MHz of the stage range safety receiver fundamental frequency. The umbilic s-in part of the all systems test, H&CO 1B66571 (reference paragraph 4.2.37), was performed in conjunction with this procedure to control the operation of the stage systems during the conducted interference test.

The procedure was initiated on 4 April 1968 and was completed on 15 May 1968. During this period, the procedure was active on 17 days for stage and GSE setup, EMC detector installation, test activities, and troubleshooting. The procedure was accepted on 3 June 1968. As noted by a procedure revision, the radiated spectrum signature test was not accomplished at this time, but was to be conducted at STC.

To start the conducted interference test, the umbilicals-in all systems test was accomplished as described paragraph 4.2.37. This provdied baseline data to verify the proper operation of the stage systems. After a limited data evaluation indicated that the baseline data was acceptable, the special interference test equipment was installed.

4.2.36 (Continued)

An Empire Model NF-105 radio interference and field intensity (RIFI) meter, and a Stoddart Model NM-52A RIFI meter, were connected at the inputs of range safety receivers 1 and 2, respectively, and were adjusted to measure RF interference at the 450 MHz range safety frequency. The cables, J-boxes, and EMC 6db and transient detectors from the Model DSV-4B-723 EMC cable accessory kit, P/N 1B57890-1, were then installed. Breakout adapter cables were connected between the stage wiring and some 29 items of stage electrical equipment, and some 37 EMC detectors were connected to the breakout cables, with the detector outputs connected to the digital events recorder (DER) through the J-boxes. Each detector was individually checked to verify that it was operating properly and that the DER was responding properly to the detector output signal.

After the EMC detectors were installed and accepted for use, the umbilicals-in all systems test was again accomplished. During this performance, the RIFI meters were manually monitored for any indication of RF signals more than 3 db above ambient at the range safety frequency, and the EMC detectors automatically monitored the stage electrical system for conducted interference transients and noise exceeding the 6 db safety margin. At the completion of the all systems test performance, the EMC detectors were again individually checked to verify that they were still operating properly and that the DER was still responding properly to the detector output signals. After all testing was completed, the test equipment and cables were all removed, and the stage wiring was reconnected to the original configuration.

The test data indicated that range safety receiver 1 had two instances of RF interference during the test, while range safety receiver 2 had thirteen instances of interference. For receiver 1, the carrier (average) interference measurements were 19 and 18 db, while the peak interference measurements were 28 and 26 db. For receiver 2, the CW average interference measurement ranged from 4 to 8 db, while the CW peak interference measurement ranged from 2 to 7 db. These indications were acceptable. Some EMC interference was recorded, as noted below, but no unacceptable interference was encountered.

4.2.36 (Continued)

All stage items affected by this procedure were installed at the time or the test. Engineering comments noted that although the GSE Model DSV-4B-723 detector kit, P/N 1B59890-1, was not available when the procedure was initiated, the kit subsequently became available and the detectors were installed for the test. One EMC detector, P/N 1B69361-505, S/N 30, used to monitor the liquid level sensor power at location 411A99A10A22, was noted as a shortage item later in the test, after an incorrect connection applied 28 vdc across the detector grounding circuit, fusing a ground wire. No replacement was available, so this measurement was postponed until the final all systems test when it was accomplished using a similar detector.

A number of problems were encountered during this first use of the EMC procedure, as noted on IIS 377761. Many of the detector mounting brackets required modification, as they were designed to attach to a tooling ring rather than to the GSE handling ring used during checkout. As a result of the bracket changes, many of the detector ground straps and breakout cables were too short and also had to be modified. Other problems corrected during the equipment setup included incorrectly wired cables and incorrect types of connectors.

Three attempts were required to complete the umbilicals-in all systems test to establish the baseline data, because of GSE and program problems. The conducted interference test required two additional attempts of the all systems test, as detector problems terminated the first attempt. As previously noted, one detector was damaged by an incorrect connection. Ten other detectors and the associated stage wiring were inspected for possible overheating, but no evidence of damage was found. A connector problem was corrected by FARR 500-238-160, and some GSE and program problems were also corrected. During the acceptable second attempt, it was noted that the EMC detectors loaded the range safety EBW firing unit circuits, causing low voltage measurements.

4.2.36 (Continued)

Evaluation of the data from the baseline and interference test indicated several additional problems. Three measurements had excessive noise during the chilldown inverter operation. This was to be corrected by ECP action. Several out-of-tolerance conditions were attributed to defects in the magnetic recording tape and to the use of the wrong calibration curves during data reduction; one APS engine did not vent properly because a piece of tape was left on the throat plug vent port; and the EMC detectors monitoring APS buses 1 and 2 both cycled when the aft bus 1 power was turned off because of a GSE relay problem. These conditions were all acceptable. One other measurement problem was corrected by FARR 500-238-178.

As noted, two stage FARR's were written during this test:

a. FARR 500-238-160 noted a damaged pin K and a punctured grommet in connector P21 on wire harness, P/N 1B66969-1, at location 411A99A10; and a bent pin K in the mating connector J1 of module, P/N 1B57771-559. Connector P21 was replaced, and the bent pin was straightened. The rework was acceptable.

b. FARR 500-238-178 noted that connector P2 on the cable of transducer kit, P/N 1B40242-597, S/N 597-1, had a bent connector shell and a loose connector backshell. Connector P2 was replaced. The rework was acceptable.

Sixty-two revisions were made to the procedure:

a. One revision changed an applicable document reference to be MIL-B-5087A, the approved specification, rather than MIL-B-5087B as listed.

b. One revision changed the test equipment warmup time requirement to be 45 minutes, rather than 5 to 10 minutes, to allow sufficient warmup time.

c. Three revisions changed the RF transmission line connections to the RIFI meters. The CB-105 line was to connect to the NF-105 meter, while a 90933-1 line, rather than a 90933-8 line as listed, was to connect to the NM-52A meter. This was the opposite of the listed incorrect connections.

d. Four revisions added a requirement to install the EMC equipment for the conducted interference tests; provided for the adapter brackets and grounding strap modifications required to mount the EMC detectors on the GSE handing ring rather than the tooling ring; and corrected cable callouts and ground connections.

4.2.36 (Continued)

e. Two revisions changed two steps during the EMC detector checkouts to verify that only the listed function numbers of the detectors checked were printed by the DLR, in the order in which the detectors were checked.

f. One revision added a note that no movement was allowed in the forward skirt area during the radiated spectrum signature test, as movement could generate noise in the RF detection equipment.

g. One revision changed a step at the start of the radiated spectrum signature test to obtain a reference measurement of the forward bus 1 power supply current, and to delete reference to a Model DSV-4B-161, as there was no such unit.

h. Three revisions deleted steps to turn on and verify the telemetry RF group transfer ground monitor at the start of the radiated signature test, and to turn it off at the end of the test. The ground monitor should remain off to permit open loop transmission during this test.

i. Two revisions added notes to clarify which meter scale was to be read on the NF-105 RIFI meter, and which test routine were to be used in making specific field strength measurements during the radiated signature test.

j. Three revisions made corrections to specify the proper connector to use when calibrating the NF-105 RIFI meter, to specify the proper connection during a signal substitution frequency measuring routine, and to use a calibration chart usage example that was consistent with the procedure.

k. Two revisions corrected two frequencies that required field strength measurements to be 4.994 MHz and 4939.806 MHz, rather than 4.944 MHz and 4940.806 MHz as listed, to agree with test plan SM-47376, dated February 1968.

l. Three revisions deleted steps that were accomplished at other points in the procedure.

m. One revision deleted a step from the radiated spectrum signature test, and added an identical step to the conducted interference test. The step performed calculations involving data on the secure range safety receivers that was collected during the latter test.

n. One revision added a step to verify that the telemetry transmitter output power was 19.00 ±7.25 watts, after a 3 minute warmup period, to ensure that the power was correct before the test continued.

o. One revision corrected the radiated spectrum signature test field strength measurement routine to improve and correct the measurement, to specify the minimum signal level to be measured, and to eliminate measurements of non-stage RFI.

4.2.36 (Continued)

p. One revision added a step to ensure the proper setting of the impulse generator fine contact adjustment during the standard gain measurement routine for the NF-105 RIFI meter.

q. One revision corrected procedure Table A, the list of stage cable connectors involved in the conducted interference test, to specify the proper reference location for five entries.

r. One revision added two Empire Devices tripods, one each of P/N's TP-105-A and TP-112, to the Non-End Item Equipment list, for use in this procedure.

s. One revision completely deleted the radiated spectrum signature test, as it was to be accomplished at STC after the single sideband transmitter was installed. All of the test equipment required for this test was also deleted from the Non-End Item Equipment list.

t. Seven revisions added instructions for the EMC detector setup for the conducted interference test. Before the detectors were connected, the detector power supplies were adjusted to 28 ±0.1 vdc, to prevent overvoltage; the J-box power cables were connected; the DER EMC channels were checked through the J-boxes and cables; and it was verified that the DER responded to 2 millisecond pulses applied at the detector outputs. After the detectors were connected, the power supply voltages were readjusted to 28 ±0.1 vdc; it was verified that the power supply ripple was less than 10 millivolts; and it was verified that the detector self-test conditions did not feed voltage back to the stage systems.

u. One revision added requirements to make field strength measurements in the frequency ranges of 47.5 to 60 MHz, and 225 to 300 MHz. These bands had been omitted from the radiated spectrum signature test.

v. Two revisions changed a requirement to verify that the EMC detectors had been certified within 15 days prior to use, rather than certified 7 days prior to use, to clarify the requirement and because the detectors would be in use more than 7 days.

w. One revision changed the plug designations on a hook up figure to agree with the wiring harness drawing, 1B69204.

x. Eleven revisions modified procedure Table B, the EMC breakout and drag-in cable connections table, and procedure Table C, the EMC detector calibration table. Incorrect reference locations, cable and connector designations, and function numbers were corrected; nine omitted entries were added; and adapter cables were added as required to compensate for the changes in detector mounting.

y. One revision added steps to the radiated spectrum signature test to record the frequency and tuning head band for each measurement during the signal substitution frequency measuring routines.

4.2.36 (Continued)

z. One revision added a step to reconnect the range safety RF cables at the completion of the EMC tests.

aa. Two revisions added the steps to accomplish an end-to-end EMC detector response verification, both before and after the conducted interference test.

ab. One revision deleted the use of EMC detector module A22 because of a problem with the detector or the associated cable. A detector was to be installed during the all systems test to monitor the function.

ac. One revision changed an instruction for using the NM-52A RIFI meter to refer to the "Field Intensity Position", and the "Peak Position", rather than the "CW Average Position" and the "CW Peak Position", to use the same nomenclature as was used on the unit itself.

ad. One revision changed a requirement that the DER tapes become part of the EMC test data to require that the tapes be evaluated and retained by TP&E Engineering, as the DER data is for engineering evaluation and should be retained by engineering.

4.2.37 <u>All Systems Test (1B66571 E)</u>

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 gimabling, 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 troubleshooting and safing operations. During the umbilicals-out test, the umbilical cables were ejected at simulated liftoff, to verify the proper operation of all onboard 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.

4.2.37 (Continued)

As noted in paragraph 4.2.36, the umbilicals-in all systems test was performed as part of the EMC RF signature and transient detection procedure, H&CO 1B64709, to provide control of the stage systems during the conducted interference test. For this purpose, the all systems test was initiated on 17 April 1968, and was completed on 15 May 1968, after 7 days of activity. This use of the procedure was accepted on 13 June 1968

The final all systems test was accomplished on 17 and 20 May 1968, and was accepted on 21 June 1968. The umbilicals-in part of the test was completed by the first attempt on 17 May 1968, while the umbilicals-out part of the test was completed by the fourth attempt on 20 May 1968. The second and third attempts were considered umbilicals-out attempts, but both were terminated prior to umbilical ejection because of problems with the GSE checkout batteries. The batteries were replaced for the fourth attempt.

The various measurements made during the acceptable umbilicals-in and umbilicals-out tests are presented in Test Data Table 4.2.37.1. 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 to establish initial conditions. The all systems test stage power setup check was then conducted. During this check, power was applied to the propellant utilization inverter and electronics, the EBW pulse sensors, the engine control and ignition buses, the component test power, the APS buses, and aft bus 2, while various currents and voltages were measured. The EBW ullage rocket firing unit disable command was turned on, as were the propellant dispersion cutoff command inhibits for both range safety receivers. The common bulkhead pressure, the LH_2 ullage pressure, and the 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.

4.2.37 (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. A series of checks on both APS modules verified that the APS fuel and oxidizer supply manifold pressures were 38 $\pm$ 15 psia, and that the APS fuel and oxidizer ullage volume pressures were 50 $\pm$ 15 psia. The LOX chilldown pump purge and engine pump purge sequence was 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 sensors, 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. The PCM FM transmitter output power was measured with the silence command on and again with the silence command off. 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, the engine cutoff and the nonprogrammed engine cutoff indications were both verified to be off, but during the umbilicals-out test, the engine cutoff command was turned on and the non-programmed engine cutoff indication was verified to be off.

4.2.37 (Continued)

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 auxiliry hydraulic pump was then turned on to pressurize the system, the system pressure increase over a 4 second period was verified to be over 200 psi, 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 of 402.700 Hz during the umbilicals-in test and 402.600 Hz during the umbilicals-out test. The reference voltages were also measured 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 propellant utilization system oven voltage was measured, to verify that the oven temperature had increased since the propellant utilization system power was originally turned on. The LOX and LH_2 chilldown pumps were turned on, and the chilldown inverter currents were measured. The inverter voltages were measured by the hardwire monitoring circuits, and the 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 percent calibration voltages, and the ambient pressures after each calibration; the LOX ullage pressure; the LH_2 and LOX emergency detection system pressure; and the LH_2 and LOX chilldown pump differential pressures. The rate gyro was then turned on, and a telemetry and RACS 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

4.2.37 (Continued)

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.

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, their low level signal strength indications were measured, and the current for each receiver was 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 preseparation 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.

4.2.37 (Continued)

APS roll checks 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 while the APS engine 1-1 and 2-1 valve open indications and attitude control chamber pressures were measured for each condition. Attitude control nozzles I II and III IV were then turned on and off while the APS engine 1-3 and 2-3 valve open indications and attitude control chamber pressures 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 LH_2 first burn relay was also turned on. 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, 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 4.2.33), the measured data are 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

4.2.37 (Continued)

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 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, and the cold helium control valve inlet, 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 cutoff was then accomplished, the engine control helium sphere pressure was measured, 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. During the coast period, 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 then completed. The LH_2 boiloff bias signal voltage was measured, then remeasured with the propellant utilization boiloff bias cutoff turned on.

The engine restart preparations were conducted next. The LH_2 continuous vent valves were 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. During the LH_2 sequence, it was

4.2.37 (Continued)

verified that pick up of the LH_2 pressurization switch turned on the ullage engine commands when the O_2H_2 burner voting circuit was enabled. The cold helium sphere pressure and the LOX repressurization spheres pressure were measured after these sequences were completed. The LOX tank ambient repressurization sequence was then accomplished, with the cold helium sphere pressure measured before the sequence, and the LOX repressurization spheres pressure measured during the sequence. 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 LH_2 tank repressurization helium sphere pressure measured during the sequence. With the propellant utilization valve hardover position command on, the ratio valve position was 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 engine control helium sphere pressure measured. The simulated ignition detected indication and the simulated mainstage OK indication were turned on to simulate a satisfactory engine restart, and the LH_2 second burn relay was turned on. 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 with the engine control helium sphere pressure measured, the simulated ignition detected indication and the LH_2 second burn relay were 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, the operating time of the LOX depletion engine cutoff timer was measured for each combination of LOX sensors.

4.2.37 (Continued)

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, 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.

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 and control chamber pressures 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 and control chamber pressures 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 and control chamber pressures 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 18.298 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 50 minutes 12.0 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 161 times. During the umbilicals-out test, the auxiliary hydraulic pump accumulated 1 cycle and 27 minutes 2.987 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 35 minutes 0.5 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 150 times.

4.2.37 (Continued)

Engineering comments noted that the APS 70 pound thrust ullage engines, P/N 15-210001, were not installed in either APS module at the time of this test. It was also noted that interim use attitude control relay modules, P/N 50M35076-1 S/N 335, and P/N 1B57731-1, S/N 361, were installed at reference locations 404A51A4 and 404A71A19, in place of flight use attitude control relay modules, P/N 1B57731-1. An interim use LOX ASI pipe, P/N 410117-11, was installed on the J-2 engine. These interim use items were to be replaced prior to acceptance firing at STC.

No major stage problems were encountered during this procedure, although several GSE problems were resolved. Data evaluation following the all systems test indicated problems with several measurements. Noise spikes on the data traces for ten measurements, and unexpected cycling indications for four events, were attributed to magnetic tape discrepancies, as the problems appeared on the DDAS data track of the tape, but did not appear on the PCM data track of the same tape. Other noted problems were covered by the following FARR's:

a. FARR 500-238-194 rejected temperature bridge module 404A64A218, P/N 1A82274-619, S/N 3208, for measurement C229, the LOX tank diffuser inlet gas temperature. The module had no continuity, indicating an open internal relay. The defective module was removed, and a new module, S/N 3211, was installed, tested, and accepted for use.

b. FARR 500-238-208 noted several problems. Measurement M60, the propellant utilization voltage monitor module 411A61A241, P/N 1B39022-1-004, S/N 26, had a 4 percent peak-to-peak noise level for more than the 1 second acceptable duration. Also, the LH_2 point level sensor 408A2C4, P/N 1A68710-507, S/N C9, and the overfill sensor at location 408A1C2 on the LH_2 mass probe, P/N 1A48431-509, S/N E8, were affected by transient voltages, and cycles unexpectedly when the safe and arm device 411A99A22, P/N 1A02446-503, S/N 48, was armed. The noted conditions were acceptable without rework, as ECP and WRO action was previously instigated to correct the problems.

Fifty revisions were made to the procedure for the following:

a. One revision deleted the Model DSV-4B-298 monochrome system status display, P/N 1B37968-1, from the required End Item Equipment list, as the unit was inoperative pending design modifications.

4.2.37 (Continued)

b. Five revisions modified the propulsion system manual setup operations to correct the setup, to accomplish the steps at the proper point in the procedure, and to differentiate between the APS setups used at the SSC and STC VCL's.

c. Three revisions added steps to the post-test instructions, to properly return the stage to the flight configuration, and to prepare the APS modules for removal.

d. One revision deleted all measurements of the APS ullage engine pressures, as the ullage engines and the accompanying pressure transducers were not installed.

e. Eight revisions corrected various minor program and procedure errors.

f. One revision deleted the hardwire frequency measurements on the LOX and LH_2 chilldown inverters, as the period counter in the GSE Model DSV-4B-131 response signal conditioner was inoperative because of a design problem. The frequencies were satisfactorily measured by telemetry.

g. Two revisions modified the pressure requirements for the cold helium sphere pressure and the LOX and LH_2 system pressure switch pressures during a repressurization control valve check. Because of the location of the cold helium sphere pressure transducer, a higher sphere pressure or longer wait times were required for proof that the LH_2 and LOX repressurization control valves properly opened.

h. One revision modified the setup of the GSE Model DSV-4B-123 DDAS ground station, to reduce the possibility of the ground station going out of synchronization.

i. Three revisions modified the procedure for use with the EMC test only, then deleted these modifications for the final all systems test. To permit EMC field strength measurements at the range safety operating frequency, the GSE range safety transmitter was not turned on during the test setup, and the prelaunch range safety receiver low level signal strength measurements were deleted. Just prior to the range safety system engine cutoff and propellant dispersion tests, the transmitter was turned on and the signal strength measurements were accomplished. In addition, the EBW firing unit charge voltage indications were charged to 3.3 $\pm$ 0.3 vdc rather than 4.2 $\pm$ 0.3 vdc, to allow for measurement loading by the EMC detectors.

j. One revision, affecting the umbilicals-in test only, turned off the external aft bus 1 power supply prior to the O_2H_2 burner spark system test. This prevented the GSE power supply regulation circuit from applying an overvoltage to the engine control package during the spark test.

4.2.37 (Continued)

k. Two revisions added the special cables and vehicle simulators installation drawing 1B66555, and the APS subsystem checkout drawing (A3 only), 1B69403, to the Applicable Documents list for use during this procedure.

l. Two revisions changed the setup of the GSE Model DSV-4B-136 destruct system test set, to allow a 3 hour warmup period rather than 30 minutes as specified, and to properly set the antenna coaxial switch.

m. One revision specified that the cold plate temperature, measured during the test setup, was to be monitored on the output temperature gauge.

n. Three revisions corrected measurement limits and tolerances. The PCM/FM transmitter output power was to be 19.0 $\pm$ 7.25 watts at two places, rather than 11.75 $\pm$ 7.25 watts at one place and 19.75 $\pm$ 7.25 watts at the other. The O_2H_2 burner spark system 1 and 2 monitors were to be 0.0 $\pm$ 0.1 vdc at four places, rather than 0.0 $\pm$ vdc, to meet the 2 percent noise tolerance requirement for the EMC test. The GSE stage 4 line pressure was to be 1500 $\pm$ 50 psia at one point, rather than 1550 $\pm$ 50 psia as listed.

o. Three revisions made minor corrections to the setup of the GSE DDAS and PCM receivers and the Model DSV-4B-127 tape recorders, to be compatible with the individual GSE test procedures, and to the setup of the GSE Model DSV-4B-128 frequency calibration unit, to prevent RF feedthrough from affecting the DDAS data.

p. One revision modified the umbilicals-in test to verify that half of the normal O_2H_2 burner shutdown did not turn on the APS ullage engines.

q. One revision added checks to verify that the air tank pressure, measurement D223, was between 65 and 500 psia, and that the motor gas pressure, measurement D209, was 21 $\pm$ 12 psig, when the auxiliary hydraulic pump was off and later when the pump was on.

r. One revision deleted a "post backup" step, as the backup could not be called because of a mission control character.

s. Two revisions added delay times at two places in the program, to provide a 50 millisecond delay between a command and a measurement, and to provide a 100 millisecond delay to allow a system to stabilize after a turn on command.

t. One revision added an initial step to set a program flag, identified as PAMFLAG, equal to 1, to allow the numeric readouts access to the PAM data.

4.2.37 (Continued)

u. One revision modified the umbilicals-out test to repressurize the cold helium spheres to greater than 810 psia during the repressurization control valves checks. This ensured enough gas for a 50 pound blowdown check to verify the open condition of the LH_2 and LOX cryogenic repressurization control valves.

v. Two revisions changed pressure limits. At one point, the LOX motor container pressure was to be greater than 34 psia rather than 35 psia, to compensate for the higher initial pressure in the pneumatic pressure line. At two places, the LOX system pressure switch supply pressure was to be greater than 36 psia, rather than 38 psia or 37.5 psia, to minimize the flow of gas before the switch actuated.

w. One revision modified the umbilicals-in test, to provide setup and removal instructions for an EMC transient detector on the level sensor power circuit. This transient measurement was deleted during the EMC test because of a faulty detector. The measurement was satisfactorily completed during the umbilicals-in test using a different detector.

x. One revision added a step to manually repressurize the GSE stage 8 dome to 48 +5, -3 psia before resuming the test after a fault routine. This provided the required supply pressure so that the flight control pressure switch picked up within the allotted time.

y. Two revisions to the umbilicals-in test accepted apparent out-of-tolerance measurements. The common bulkhead internal pressure, measurement D237, was acceptable at 14.067 psia, rather than 14.7 ± 0.5 psia, as there was a partial vacuum in the common bulkhead at the time of the umbilicals-in test. The bulkhead was vented to ambient pressure prior to the umbilicals-out test. The LH_2 differential pressure, measurement D579, was acceptable at -31.250 ± 1.2 psia, rather than 0.0 ± 1.2 psia, as the measurement indicated a malfunction of the GSE response signal conditioner. Investigation showed that telemetry measurement D218, also at the same pressure and carried by the same GSE relay, dropped out at the same time. The measurement functioned properly during the umbilicals-out test.

4.2.37.1 Test Data Table, All-Systems Test

Funtion	Umbil.-In	Umbil.-Out	Limits
Power Setup Check			
PU Power On			
PU Inv and Elect Current (amps)	3.800	3.700	5.0 max
PU Oven Voltage (vdc)	-0.123	-0.123	0.0 ± 0.3
Engine Control Bus On			
Aft Bus 1 Current (amps)	1.600	1.500	2.7 ± 3.0
Aft Bus 1 Voltage (vdc)	27.96	28.04	28.0 ± 2.0
Engine Control Bus Voltage (vdc)	27.722	27.783	Bus 1 ± 1.0
Component Test Power On			
Component Test Power Voltage (vdc)	27.958	27.958	Bus 1 ± 1.0
Engine Ignition Bus On			
Aft Bus 1 Current (amps)	1.899	1.800	2.7 ± 3.0
Aft Bus 1 Voltage (vdc)	27.999	27.958	28.0 ± 2.0
Engine Ignition Bus Voltage (vdc)	27.783	27.783	Bus 1 ± 1.0
APS Bus On			
Aft Bus 1 Current (amps)	2.300	2.100	2.7 ± 3.0
Aft Bus 2 On			
Aft Bus 2 Current (amps)	0.199	0.600	5.0 max
Aft Bus 2 Voltage (vdc)	56.317	56.638	56.0 ± 4.0

4.2.37.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
Propulsion System Setup Check			
Amb He Pneu Sphere Press D236 (psia)	693.63	708.58	700.0 ± 50.0
Cold Helium Sphere Pressure D016 (psia)	816.25	827.70	825.0 ± 25.0
Control Helium Supply Pressure D019 (psia)	1457.03	1485.69	1450.0 min
Cont He Reg Discharge Press D014 (psia)	526.22	531.19	515.0 ± 50.0
LH_2 Repress He Sphere Press D020 (psia)	622.58	652.48	*
LOX Repress He Sphere Press D088 (psia)	734.77	753.45	*
LH_2 Prepressurization Sequence			
LH_2 Press Control Module GH_2 Press D104 (psia)	57.55	54.28	50.0 min
EBW and Telemetry Checks			
PCM RF Assembly Current (amps)	4.601	4.200	4.5 ± 3.0
PCM/FM Transmitter Output Power:			
RF Silence On (watts)	-0.18	**	2.0 max
RF Silence Off (watts)	20.79	**	10.0 min
T/M Antenna 1 Forward Power (watts)	20.849	20.938	19.0 ± 7.25
T/M RF Sys Reflected Power (watts)	0.031	0.019	3.08 max
T/M System Closed Loop VSWR	1.080	1.061	2.0 max
Inv-Conv 115 vac Output (vac)	114.41	114.41	115.0 ± 3.45
Inv-Conv 5 vdc Output (vdc)	5.01	5.00	4.9 ± 0.2
Inv-Conv 21 vdc Output (vdc)	22.00	21.95	21.25 ± 1.25
Inv.-Conv Operating Frequency (Hz)	402.37	402.14	400.0 ± 6.0

* Limits not specified
** Measurement not applicable

4.2.37.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
Hydraulic System Checks			
Reservoir GN_2 Mass (lbs)	1.966	1.952	1.925 ± 0.2
Corrected Reservoir Oil Level (%)	95.5	97.7	95.0 min
Hydraulic System Unpressurized			
Hydraulic System Pressure (psia)	1369.031	1372.313	*
Accumulator GN_2 Pressure (psia)	2378.250	2411.000	*
Accumulator GN_2 Temperature (°F)	63.925	74.486	*
Reservoir Oil Temperature (°F)	63.925	76.057	*
Reservoir Oil Level (%)	86.590	88.084	*
Reservoir Oil Pressure (psia)	75.500	73.756	*
Pump Inlet Oil Temperature (°F)	63.929	74.883	*
T/M Yaw Actuator Position (deg)	1.298	1.288	*
Corrected T/M Yaw Act. Pos (deg)	1.296	1.296	*
IU Yaw Actuator Position (deg)	1.350	1.334	*
Corrected IU Yaw Act. Pos (deg)	1.350	1.342	*
T/M Pitch Actuator Position (deg)	-0.237	-0.253	*
Corrected T/M Pitch Act. Pos (deg)	-0.244	-0.260	*
IU Pitch Actuator Position (deg)	-0.254	-0.254	*
Corrected IU Pitch Act. Pos (deg)	-0.254	-0.261	*
IU Substitute 5v Power Supply (vdc)	4.999	4.994	*
Aft 5v Excitation Module (vdc)	4.995	4.994	*
Aft Bus 2 Current (amps)	0.399	0.199	*
Hydraulic System Pressurized			
Hydraulic System Pressure (psia)	3581.750	3581.750	*
Accumulator GN_2 Pressure (psia)	3578.438	3570.313	*
Accumulator GN_2 Temperature (°F)	85.072	95.676	*
Reservoir Oil Temperature (°F)	64.314	76.840	*
Reservoir Oil Level (%)	38.026	40.392	*
Reservoir Oil Pressure (psia)	166.277	166.277	*
Pump Inlet Oil Temperature (°F)	63.929	76.061	*
T/M Yaw Actuator Position (deg)	0.002	-0.013	*
Corrected T/M Yaw Act. Pos (deg)	0.009	-0.006	*
IU Yaw Actuator Position (deg)	0.015	0.029	*
Corrected IU Yaw Act. Pos (deg)	0.015	0.029	*
T/M Pitch Actuator Position (deg)	0.061	0.044	*
Corrected T/M Pitch Act. Pos (deg)	0.054	0.037	*
IU Pitch Actuator Position (deg)	0.060	0.045	*
Corrected IU Pitch Act. Pos (deg)	0.060	0.045	*
IU Substitute 5v Power Supply (vdc)	4.999	4.999	*
Aft 5v Excitation Module (vdc)	4.995	4.994	*
Aft Bus 2 Current (amps)	46.399	47.000	*

* Limits not specified

4.2.37.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
FRATS Calibration			
LOX Circ Pump Flowrate Ind (vdc)	3.876	-	3.886 ± 0.100
	-	3.887	3.886 ± 0.100
LH_2 Circ Pump Flowrate Ind (vdc)	3.882	-	3.886 ± 0.100
	-	3.882	3.886 ± 0.100
Static Inv-Conv Freq Ind (vdc)	3.174	-	3.175 ± 0.100
	-	3.174	3.149 ± 0.100
LH_2 C/D Inv Freq Ind (vdc)	3.122	-	3.175 ± 0.100
	-	3.117	3.149 ± 0.100
LOX C/D Inv Freq Ind (vdc)	3.087	-	3.175 ± 0.100
		3.087	3.149 ± 0.100
LOX Flowmeter Indication (vdc)	1.656	1.661	1.667 ± 0.100
LH_2 Flowmeter Indication (vdc)	1.666	1.671	1.667 ± 0.100
LOX Pump Speed Indication (vdc)	3.169	3.164	3.125 ± 0.100
LH_2 Pump Speed Indication (vdc)	1.267	1.261	1.250 ± 0.100
Telemetry RF and PU Oven Checks			
T/M Antenna 1 Forward Power (watts)	21.474	20.938	19.0 + 7.25
T/M RF Sys Reflected Power (watts)	1.747	0.466	3.08 max
T/M System Open Loop VSWR	1.797	1.351	3.0 max
PU Oven Voltage Increase (vdc)	1.600	1.589	0.3 min
LOX Chilldown Inverter Checks			
Inverter Current (amps)	21.20	19.20	20.0 ± 5.0
Aft Bus 2 Voltage (vdc)	55.76	55.04	*
Phase AB Voltage, Hardwire (vac)	55.9	55.1	Bus 2 ± 3.0
Phase AC Voltage, Hardwire (vac)	55.1	54.7	Bus 2 ± 3.0
Phase A1B1 Voltage, Hardwire (vac)	55.8	55.1	Bus 2 ± 3.0
Phase A1C1 Voltage, Hardwire (vac)	56.0	55.2	Bus 2 ± 3.0
Inverter Frequency, Telemetry (Hz)	399.9	399.4	400.0 ± 4.0
Phase AB Voltage, Telemetry (vac)	55.1	54.6	Bus 2 ± 3.0
Phase AC Voltage, Telemetry (vac)	55.3	54.6	Bus 2 ± 3.0

*Limits not specified

4.2.37.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
LH_2 Childown Inverter Checks			
Inverter Current (amps)	21.20	22.40	20.0 ± 5.0
Aft Bus 2 Voltage (vdc)	55.28	54.64	*
Phase AB Voltage, Hardwire (vac)	55.31	54.53	Bus 2 ± 3.0
Phase AC Voltage, Hardwire (vac)	55.31	54.47	Bus 2 ± 3.0
Phase A1B1 Voltage, Hardwire (vac)	55.44	54.73	Bus 2 ± 3.0
Phase A1C1 Voltage, Hardwire (vac)	55.25	54.47	Bus 2 ± 3.0
Inverter Frequency, Telemetry (Hz)	400.0	399.7	400.0 ± 4.0
Phase AB Voltage, Telemetry (vac)	55.2	54.6	Bus 2 ± 3.0
Phase AC Voltage, Telemetry (vac)	55.3	54.6	Bus 2 ± 3.0
Pressure Measurements			
Common Bulkhead Pressure (psia)	14.067+	14.368	14.7 ± 0.5
Common Bulkhead 20% Calib (vdc)	1.034	1.060	1.0 ± 0.1
Common Bulkhead Amb Press (psia)	14.521	14.786	14.7 ± 0.5
Common Bulkhead 80% Calib (vdc)	4.015	4.020	4.0 ± 0.1
Common Bulkhead Amb Press (psia)	14.521	14.813	14.7 ± 0.5
LH_2 Ullage Pressure (psia)	14.659	14.712	14.7 ± 1.0
LH_2 Ullage 20% Calib (vdc)	1.024	1.024	1.0 ± 0.1
LH_2 Ullage Amb Press (psia)	14.712	14.659	14.7 ± 1.0
LH_2 Ullage 80% Calib (vdc)	4.005	4.010	4.0 ± 0.1
LH_2 Ullage Amb Press (psia)	14.712	14.712	14.7 ± 1.0
LOX Ullage Pressure (psia)	14.879	14.879	14.7 ± 1.0
LH_2 EDS Transducer 1 Press (psia)	14.5	14.5	14.7 ± 1.0
LH_2 EDS Transducer 2 Press (psia)	15.0	14.7	14.7 ± 1.0
LOX EDS Transducer 1 Press (psia)	14.4	14.2	14.7 ± 1.0
LOX EDS Transducer 2 Press (psia)	[illegible]	14.7	14.7 ± 1.0
LH_2 C/D Pump Diff Press (psid)	-31.250+	0.124	0.0 ± 1.2
LOX C/D Pump Diff Press (psid)	-0.563	-0.563	0.0 ± 1.2
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)	28.28	**	28.0 ± 2.0
Aft Bus 1 Batt Sim (Bus 4D10)(vdc)	28.04	**	28.0 ± 2.0
Aft Bus 2 Batt Sim (Bus 4D40)(vdc)	55.84	**	56.0 ± 4.0
Bus 4D20 ESE Load Bank (vdc)	0.00	**	0.0 ± 1.0
Bus 4D40 ESE Load Bank (vdc)	0.00	**	0.0 ± 1.0
Bus 4D30 ESE Load Bank (vdc)	0.04	**	0.0 ± 1.0
Bus 4D10 ESE Load Bank (vdc)	0.08	**	0.0 ± 1.0
Fwd Bus 1 C/O Batt (Bus 4D30)(vdc)	**	30.16	29.5 ± 1.5
Fwd Bus 2 C/O Batt (Bus 4D20)(vdc)	**	30.32	29.5 ± 1.5
Aft Bus 1 C/O Batt (Bus 4D10)(vdc)	**	29.96	29.5 ± 1.5
Aft Bus 2 C/O Batt (Bus 4D40)(vdc)	**	62.00	60.5 ± 1.5
Com Bulkhead Press Transducer (vdc)	0.000	-0.005	0.0 ± 0.353

* Limits not specified
\+ See Revision y
**Measurement not applicable

4.2.37.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
Final Prelaunch Checks			
LH_2 Ullage Press Transducer (vdc)	0.005	0.000	0.0 ± 0.353
LOX Ullage Press Transducer (vdc)	0.124	0.124	0.0 ± 0.353
Fwd Bus 1 Internal (Bus 4D31)(vdc)	27.92	29.68	28.0 ± 2.0
Fwd Bus 2 Internal (Bus 4D21)(vdc)	27.88	28.96	28.0 ± 2.0
Aft Bus 1 Internal (Bus 4D11)(vdc)	28.04	29.72	28.0 ± 2.0
Aft Bus 2 Internal (Bus 4D41)(vdc)	55.28	55.68	56.0 ± 4.0
Receiver 1 Low Level Signal (vdc)	3.66	3.63	2.5 min
Receiver 2 Low Level Signal (vdc)	3.76	3.74	2.5 min
Receiver 1 Current (amps)	0.30	-0.10	0.0 ± 2.0
Receiver 2 Current (amps)	0.10	-0.10	0.0 ± 2.0
LH_2 EDS 1 Ullage Pressure (psia)	14.30	14.36	14.7 ± 1.0
LH_2 EDS 2 Ullage Pressure (psia)	14.69	14.75	14.7 ± 1.0
LOX EDS Ullage Pressure (psia)	14.17	14.17	14.7 ± 1.0
LOX EDS 2 Ullage Pressure (psia)	14.69	14.69	14.7 ± 1.0
LH_2 EDS 1 Transducer Press (psia)	14.41	14.47	14.7 ± 1.0
LH_2 EDS 2 Transducer Press (psia)	14.85	14.91	14.7 ± 1.0
LOX EDS 1 Transducer Press (psia)	14.41	14.35	14.7 ± 1.0
LOX EDS 2 Transducer Press (psia)	14.85	14.85	14.7 ± 1.0
APS Roll Checks			
IU Substitute -28 Volt Power (vdc)	-28.118	-29.399	-28.5 ± 2.5
Control Nozzles I IV and III II On			
Engine 1-1 Valve Open Ind (vdc)	3.98	4.17	*
Engine 2-1 Valve Open Ind (vdc)	3.81	3.96	*
Engine 1-1 Chamber Press (Open) (psia)	33.44	32.58	*
Engine 2-1 Chamber Press (Open) (psia)	35.15	35.36	*
Control Nozzles I IV and III II Off			
Engine 1-1 Valve Open Ind (vdc)	-0.01	0.00	0.0 ± 0.25
Engine 2-1 Valve Open Ind (vdc)	0.00	0.00	0.0 ± 0.25
Engine 1-1 Chamber Press (Closed) (psia)	17.20	15.28	*
Engine 2-1 Chamber Press (Closed) (psia_	18.91	18.70	*
Control Nozzles I II and III IV On			
Engine 1-3 Valve Open Ind (vdc)	3.94	4.12	*
Engine 2-3 Valve Open Ind (vdc)	3.75	3.91	*
Engine 1-3 Chamber Press (Open) (psia)	31.94	33.65	*

* Limits not specified

4.2.37.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
APS Roll Checks (cont'd)			
Engine 2-3 Chamber Press (Open) (psia)	25.53	27.67	*
Control Nozzles I II and III IV Off			
Engine 1-3 Valve Open Ind (vdc)	0.00	-0.00	0.0 ± 0.25
Engine 2-3 Valve Open Ind (vdc)	0.00	-0.00	0.0 ± 0.25
Engine 1-3 Chamber Press (Closed) (psia)	15.28	15.49	*
Engine 2-3 Chamber Press (Closed) (psia)	12.07	12.93	*
Hydraulic Gimbal Step Response Check			
Ratio Valve Pos (Relay Off) (deg)	-0.47	-0.26	0.0 ± 1.5
Hydraulic System Pressure (psia)	3582.0	3592.0	3575.0 ± 75.0
Ratio Valve Pos (Relay On) (deg)	31.58	31.64	20.0 min
Hydraulic Gimbal 0.6 Hz Check			
Ratio Valve Pos (Relay Off) (deg)	1.03	1.24	Previous ± 1.5
Hydraulic System Pressure (psia)	3585.0	3582.0	3575.0 ± 75.0
Pitch Act Piston Pos, AO (deg)	0.044	0.061	0.0 ± 0.517
Pitch Act Piston Pos, BO (deg)	0.044	0.076	0.0 ± 0.517
Yaw Act Piston Position, AO (deg)	0.033	0.064	0.0 ± 0.517
Yaw Act Piston Position, BO (deg)	0.018	0.080	0.0 ± 0.517
Engine Pitch Position, IU (deg)	0.029	0.045	0.0 ± 0.517
Engine Yaw Position, IU (deg)	0.060	0.074	0.0 ± 0.517
Hydraulic System Pressurized			
Hydraulic System Pressure (psia)	3591.500	3581.750	*
Accumulator GN_2 Pressure (psia)	3578.438	3575.750	*
Accumulator GN_2 Temperature (°F)	71.355	74.486	*
Reservoir Oil Temperature (°F)	76.840	125.621	*
Reservoir Oil Level (%)	35.909	43.630	*
Reservoir Oil Pressure (psia)	170.207	168.457	*
Pump Inlet Oil Temperature (°F)	93.715	145.004	*
T/M Yaw Actuator Position (deg)	0.049	0.064	*
Corrected T/M Yaw Act Pos (deg)	0.049	0.071	*
IU Yaw Actuator Position (deg)	0.060	0.089	*
Corrected IU Yaw Act Pos (deg)	0.060	0.096	*
T/M Pitch Actuator Position (deg)	0.061	0.061	*
Corrected T/M Pitch Act. Pos. (deg)	0.061	0.054	*
IU Pitch Actuator Position (deg)	0.029	0.045	*
Corrected IU Pitch Act. Pos. (deg)	0.029	0.038	*
IU Substitute 5v Power Supply (vdc)	4.999	4.994	*

* Limits not specified

4.2.37.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
Hydraulic System Pressurized (cont'd)			
Aft 5v Excitation Module (vdc)	4.996	4.993	*
Aft Bus 2 Current (amps)	45.399	**	*
Aft Checkout Battery 2 Current (amp)	**	51.199	*
Ratio Valve Pos. (Relay On) (Deg)	-28.146	-28.077	-20.0 max
First Burn and Coast Period			
LOX Press. Module He. Press. D105:			
Cold He. Supply Open (psia)	291.727	299.906	*
LOX Press. Sw Supply Closed (psia)	165.160	171.703	*
Cold He. Control Valve Inlet Press. D225:			
Cold He. Supply Open (psia)	273.72	279.72	*
LOX Press. Sw Supply Closed (psia)	106.79	109.52	*
LH_2 Press. Module He. Press. D104:			
LH_2 Prepress Supply Open (psia)	116.47	111.02	*
LH_2 Press. Sw Supply Closed (psia)	81.56	77.19	*
LH_2 First Burn Relay Off (psia)	59.74	57.55	*
Control He. Sphere Press. D109 (psia)	1371.125	1392.594	*
LOX Mtr Container He. Press D103 (psia)	44.52	44.84	35 to 45
LH_2 Boiloff Bias Signal M10:			
Bias Cutoff Off (vdc)	0.32	0.48	0.0 ± 2.5
Bias Cutoff On (vdc)	12.338	11.922	10.0 min
Engine Restart Preparations			
Before Repressurization			
LOX Repress Sphere Press. D88 (psia)	723.53	749.72	*
Cold He. Sphere Press. D16 (psia)	697.86	720.78	*
After Cryogenic Repressurization			
Cold He. Sphere Press. D16 (psia)	613.84	655.86	*
LOX Repress Sphere Press. D88 (psia)	723.53	749.72	*
Before Ambient Repressurization			
Cold He. Sphere Press. D16 (psia)	621.48	655.86	*
During LOX Ambient Repressurization			
LOX Repress Sphere Press. D88 (psia)	592.67	667.45	*
Same, after 30 second delay (psia)	618.83	678.67	Previous ± 75

* Limits not specified
**Measurement not applicable

4.2.37.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
Engine Restart Preparations			
Chilldown Pumps On			
LOX C/D Inv. Phase AB Voltage (vac)	55.833	59.214	50.0 min
LOX C/D Inv. Phase AC Voltage (vac)	55.443	58.889	50.0 min
LOX C/D Inv. Phase A1B1 Voltage (vac)	55.899	59.083	50.0 min
LOX C/D Inv. Phase A1C1 Voltage (vac)	55.964	59.214	50.0 min
LH_2 C/D Inv. Phase AB Voltage (vac)	55.379	57.394	50.0 min
LH_2 C/D Inv. Phase AC Voltage (vac)	55.379	57.394	50.0 min
LH_2 C/D Inv. Phase A1B1 Voltage (vac)	55.443	57.394	50.0 min
LH_2 C/D Inv. Phase A1C1 Voltage (vac)	55.313	57.394	50.0 min
During LH_2 Ambient Repressurization			
LH_2 Tank Repress He. Sphere Press D20 D20 (psia)	271.1	323.4	*
Same, after 30 second delay (psia)	297.3	360.8	Previous ± 75
Chilldown Pumps Off			
LH_2 C/D Inv. Frequency (H3)	389.5	389.5	390.0 ± 1.0
LH_2 C/D Inv. Phase AB Voltage (vac)	0.00	0.00	0.0 ± 1.5
LH_2 C/D Inv. Phase AC Voltage (vac)	0.00	0.00	0.0 ± 1.5
LOX C/D Inv. Frequency (H3)	389.5	389.5	390.0 ± 1.0
LOX C/D Inv. Phase AB Voltage (vac)	-0.13	0.00	0.0 ± 1.5
LOX C/D Inv. Phase AC Voltage (vac)	0.00	0.00	0.0 ± 1.5
Engine Restart			
Control He. Sphere Press (psia)	1116.94	1156.31	*
LH_2 Second Burn Repressurization			
LH_2 Press Module He. Press. D104:			
LH_2 Prepress Supply Open (psia)	107.744	109.926	*
LH_2 Press. Sw Supply Closed (psia)	71.736	73.918	*
Engine Cutoff			
Control He Sphere Press (psia)	1335.34	1356.81	*

Function			
LOX Depletion Timer Check			
LOX Sensors 1 and 2 Dry (sec)	0.544	**	0.560 ± 0.025
LOX Sensors 1 and 3 Dry (sec)	0.539	**	0.560 ± 0.025
LOX Sensors 2 and 3 Dry (sec)	0.536	**	0.560 ± 0.025

* Limits not specified
**Measurement not applicable

4.2.37.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
APS Yaw and Pitch Checks			
Control Nozzles I IV and III IV On			
Engine 1-1 Valve Open Ind (vdc)	3.871	4.107	*
Engine 2-3 Valve Open Ind (vdc)	3.641	3.855	*
Engine 1-1 Chamber Press (Open) (psia)	30.661	29.807	*
Engine 2-3 Chamber Press (Open) (psia)	23.824	24.892	*
Control Nozzles I IV and III IV Off			
Engine 1-1 Valve Open Ind (vdc)	-0.005	0.000	0.0 ± 0.25
Engine 2-3 Valve Open Ind (vdc)	-0.005	0.000	0.0 ± 0.25
Engine 1-1 Chamber Press (closed) (psia)	15.063	14.850	*
Engine 2-3 Chamber Press (closed) (psia)	12.072	12.927	*
Control Nozzle I II and III II On			
Engine 1-3 Valve Open Ind (vdc)	3.825	4.076	*
Engine 2-1 Valve Open Ind (vdc)	3.687	3.917	*
Engine 1-3 Chamber Press (Open) (psia)	29.807	31.089	*
Engine 2-1 Chamber Press (Open) (psia)	31.943	32.370	*
Control Nozzles I II and III II Off			
Engine 1-3 Valve Open Ind (vdc)	-0.010	-0.005	0.0 ± 0.25
Engine 2-1 Valve Open Ind (vdc)	-0.005	0.000	0.0 ± 0.25
Engine 1-3 Chamber Press (closed) (psia)	15.063	15.918	*
Engine 2-1 Chamber Press (Closed) (psia)	17.627	16.986	*
Control Nozzle I P On			
Engine 1-2 Valve Open Ind (vdc)	3.882	4.102	*
Engine 1-2 Chamber Press (Open) (psia)	35.789	34.508	*
Control Nozzle I P Off			
Engine 1-2 Valve Open Ind (vdc)	-0.005	0.000	0.25 max
Engine 1-2 Chamber Press (closed) (psia)	19.123	17.627	*
Control Nozzle III P On			
Engine 2-2 Valve Open Ind (vdc)	3.759	3.953	*
Engine 2-2 Chamber Press (Open) (psia)	32.370	32.798	*

* Limits Not Specified

4.2.37.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
APS Yaw and Pitch Checks (Cont'd)			
Control Nozzle III P Off			
Engine 2-2 Valve Open Ind (vdc)	-0.005	0.000	0.25 max
Engine 2-2 Chamber Press (Closed) (psia)	15.704	16.132	*

*Limits Not Specified

4.2.38 Forward Skirt Thermoconditioning System Postcheckout Procedure (1B62965 D)

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. These activities were accomplished between 24 and 28 May 1968, with Engineering review and acceptance occurring on 28 May 1968.

The GSE 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.

4.2.38 (Continued)

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 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 test, and no FARR's were written. No revisions were made to the procedure.

4.3 Final Inspection

After the completion of stage acceptance testing and final manufacturing operations, a final inspection was conducted by MDAC and AFQC personnel on all stage mechanical and electrical areas to locate and correct any remaining discrepancies, and to verify that the stage was in satisfactory condition for the preshipment operations and transfer to STC. This final inspection was conducted between 16 August and 19 December 1968, and the results and necessary rework were accepted on 26 December 1968.

Altogether, 127 defects were found. Of these 34 were of an electrical nature, and 93 were mechanical. The electrical discrepancies included loose, damaged, and missing clamps; wire harnesses and cables riding structural parts and other components, bent too sharp, and lacking slack; unremoved inspection stickers; rubber bands under grounding straps and panels; upside-down flight control arrows; damaged and extra bonding straps; damaged and missing seals, anti-tamper seals, and identification stickers; unused and damaged standoffs; and unpainted and unchromated ground studs. Those defects of a mechanical nature included missing, damaged, and loose parts, identification bands, anti-tamper seals, and decals; excessive sealant; missing, loose, and incorrectly installed safety wire; misaligned parts; dirt, foreign material, rust, corrosion, discoloration, hydraulic oil, and tape residue in several places; parts riding the structure and other parts; dings and gouges; and areas requiring paint touchup.

Most of these discrepancies were resolved immediately. However, the following defects were recapped to FARR's for correction:

a. FARR 500-568-631 noted that the screws on the main tunnel cover at the slotted holes should have washers. Washers were installed at the main tunnel cover slotted holes. The rework was acceptable to Engineering for use.

b. FARR 500-445-734 noted that duct assembly, P/N 1A87436-501, had rust adjacent to the weld seam and that there was foreign material inside the duct assembly. The duct assembly was removed and sent to the LOX clean room for service per DPS 43000. The duct assembly was reinstalled after LOX cleaning.

c. FARR 500-639-113 noted that the metal foil identification plate on the LOX flowmeter, P/N 1A89104-507, S/N 31595, was not legible per DPS requirements. The FARR was dispositioned to remove and replace the metal foil identification plate; however, the work was not accomplished at SSC and the FARR was shipped as an open item.

4.4 Weight and Balance Procedure (1B64539 C)

This procedure measured the stage weight with an accuracy of $\pm$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 18 December 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 23 December 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 4.4.1. The stage was then lowered back onto the cradles, the load cells 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 26,897.3 pounds, the weight at Standard Gravity in a vacuum was 26,960.9 pounds, and the longitudinal center of gravity was at station 329.6.

4.4 (Continued)

No parts were short during this procedure, no revisions were written, and no problems were encountered.

4.4.1 Test Data Table, Weight and Balance Procedure

Air Density Data

Time	Barometric Press. (in. Hg)	Relative Humidity (%)	Dry Bulb Temp (°F)
21:00	30.005	42	64
21:30	29.998	42	64
22:00	29.990	41	64
22:30	29.983	41	64

Calculated Air Density: 0.07571 pounds per cubic foot.

Load Cell Collected Data

Reaction Load Cell	Aft (R1)	Forward (R2)	Forward (R3)
Serial Number	36234	34182	34184
Capacity (pounds)	25,000	10,000	10,000
Run 1 Reading (%)	79.648	37.641	39.869
Run 2 Reading (%)	79.676	37.560	39.902
Run 3 Reading (%)	79.682	37.581	39.878
Average Reading (%)	79.669	37.594	39.883
Calibration Correction	0.764	0.257	0.294
Corrected Reading (%)	80.433	37.851	40.177
Reaction (pounds)	20,108.3	3,785.1	4,017.7

Weight Determination (pounds)

Aft Reaction R1	20,108.3
Forward Reaction R2	3,785.1
Forward Reaction R3	4,017.7
Total Reactions as recorded	27,911.1
Minus Weighing Equipment "Tare"	-1,013.8
Shipping and Handling Weight	26,897.3
Plus Gravitational Correction	+ 29.8
Plus Buoyancy Correction	+ 33.8
Weight at Standard Gravity in a vacuum	26,960.9

4.4 (Continued)

Longitudinal Center of Gravity

Reaction R1 Moment at Sta. 189.3	3,806,501.19
Reaction R2 Moment at Sta. 684.0	2,589,008.40
Reaction R3 Moment at Sta. 684.0	2,748,106.80
Moment Sum	9,143,616.39
Tare Moment	- 278,870.75
Moment Sum Less Tare	8,864,745.64

As weighed Center of Gravity = Station 329.6
(Moment Sum Less Tare divided by Total Reactions Less Tare)

4.5 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.

After some hardware removal and installation work on 26 November 1968, the procedure was satisfactorily performed between 18 and 21 December 1968, and was accepted on 31 December 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, P/N 1B61117-1, was prepared for operation, a GN_2 heater was setup to warm the nitrogen gas used for the LH_2 tank purge, 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, nonpropulsive vent, and 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 -34°F for the

4.5 (Continued)

LOX system, and -32°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.

Several parts had been removed at the time this procedure was accomplished, including the actuation control modules for the LH_2 continuous vent valve and the LH_2 directional valve. Some procedure changes were necessary to compensate for these shortages, but no particular problems were encountered and no FARR's were written. Thirty-six revisions were made to the procedure:

a. Six revisions added new steps and illustrations, and changed existing steps and illustrations, to provide purging of the LOX non-propulsive vent valve, as the procedure did not include this operation.

b. Five revisions added steps and modified the existing procedure to provide for the hookup and operation of the GN_2 heater used to warm the nitrogen gas for the LH_2 tank purge.

c. Three revisions corrected four dewpoint temperature references to be -30°F, rather than the incorrectly specified -35°F.

d. Two revisions added a warning note and an operation step that had been omitted in error.

e. Four revisions changed various hardware callouts to agree with changes in the stage hardware.

f. Four revisions added one step, deleted another step, and made minor changes to two other steps, to permit proper operation of the procedure.

g. Nine revisions modified the procedure to compensate for parts shortages that existed at the time of the purge operations. One step was added, other steps were deleted, and several steps were changed, renumbered, and resequenced to provide proper operation.

4.5 (Continued)

h. Two revisions changed the designation of some molecular sieve desiccant material to be "type 5A30, same as type FAXW", rather than "type 4AXW or 5AWX", as specified. This was to agree with a designation coding change used by the material vendor, U.C.C. Linde Division.

i. One revision changed a step to leave the protective wrapping on the face of the LOX tank relief valve, rather than to remove the wrapping as specified, to provide continued protection for the valve.

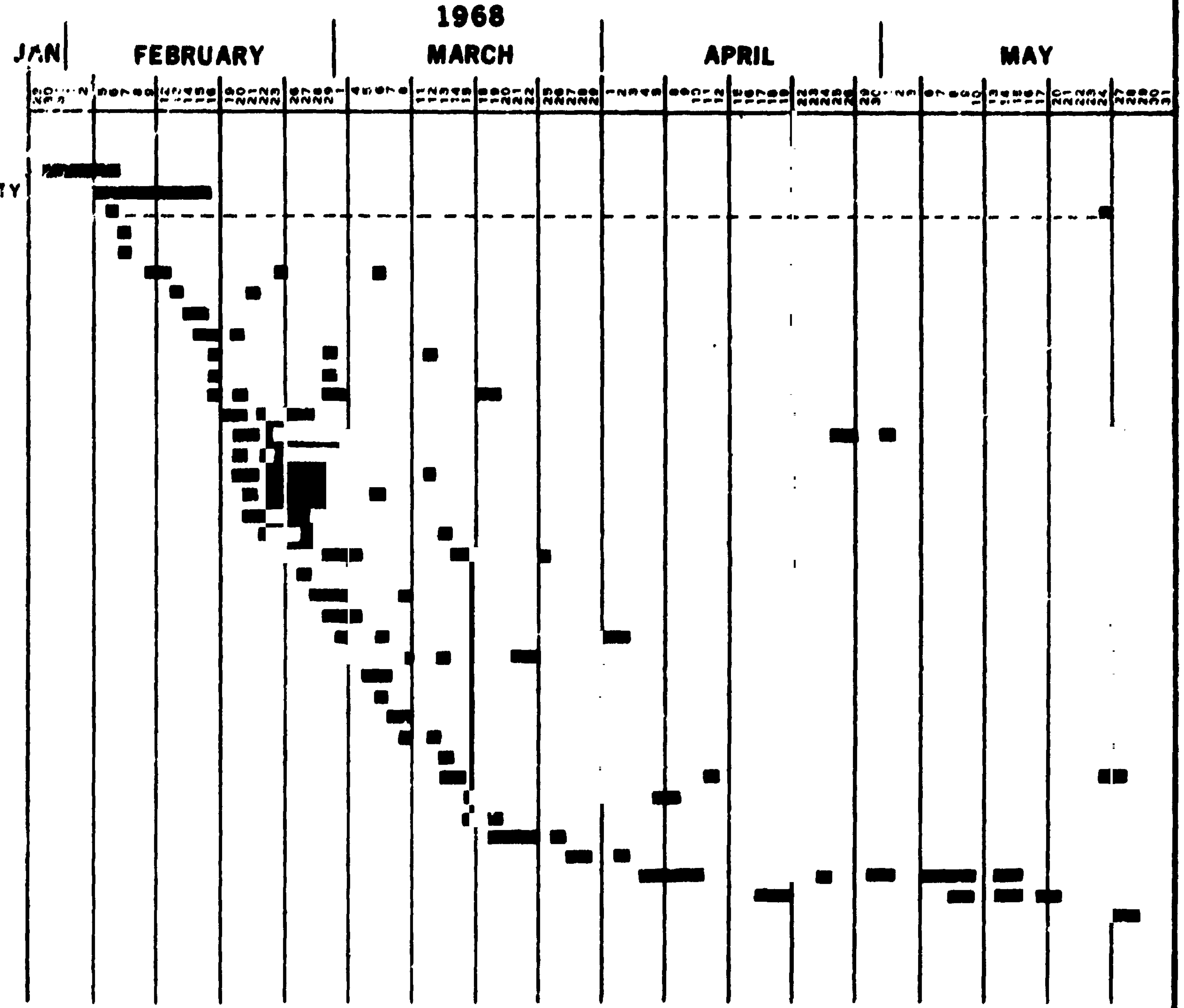
4.6 Retest Requirements

As noted in paragraph 2.7, various modifications were accomplished on the stage subsequent to VCL checkout and additional modifications were scheduled at STC prior to stage acceptance firing. The completion of the following system checkout procedures was required at STC, prior to the acceptance firing, to verify all of the modifications:

1B41005	Hydraulic System Setup and Operate
1B41955	Thermoconditioning System Checkout and Operation
1B49236	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
1B64316	Umbilical Interface Compatibility
1B64367	Propellant Utilization System Manual Calibration
1B64678	Cryogenic Temperature Sensor Verification
1B64679	T/M and Range Safety Antenna System
1B64680	Level Sensor and Control Unit Calibration
1B71877	Propulsion System Leak Check
1B75537	Single Sideband System Checkout

Most of the above tests are part of the normally planned STC prefire testing.

508 SSC VCL TESTING SEQUENCE



PARA		PROCEDURE
4.2.1	1B41926	FWD SKIRT T/C C/O
4.2.2	1B59780	CONTINUITY COMPATIBILITY
4.2.3	1B42124	FWD SKIRT T/C OPER
4.2.4	1B39095	ENGINE ALIGNMENT
4.2.5	1B59455	PROP COMP INTL L/C
4.2.6	1B64678	CRYO TEMP SENSOR VERIF
4.2.7	1B59782	UMBILICAL I/F COMPAT
4.2.8	1B40544	AFT SKIRT PURGE
4.2.9	1B59456	FUEL TK PRESS SYS L/C
4.2.10	1B66560	STAGE POWER SETUP
4.2.11	1B66561	STAGE POWER TURNOFF
4.2.12	1B64681	SIGNAL COND SETUP
4.2.13	1B64679	T/M & RS ANTENNA SYS
4.2.14	1B40973	HYD SYS FILL & BLEED
4.2.15	1B59454	PROP SYS CONSOLE C/O
4.2.16	1B64680	LEV SENS CONT CALIB
4.2.17	1B66563	DDAS CALIB
4.2.18	1B59457	PNEU CONT SYS L/C
4.2.19	1B66562	POWER DISTRIB SYS
4.2.20	1B66564	DDAS
4.2.21	1B66569	APS SIMULATOR C/O
4.2.22	1B64367	PU SYS CALIB
4.2.23	1B59458	COLD HE SYS L/C
4.2.24	1B59459	PROP TK SYS L/C
4.2.25	1B59461	J-2 ENGINE SYS L/C
4.2.26	1B59460	REPRESS SYS L/C
4.2.27	1B66566	EBW SYSTEM
4.2.28	1B66567	PU SYSTEM
4.2.29	1B66565	RANGE SAFETY RCVR C/O
4.2.30	1B66568	RANGE SAFETY SYS
4.2.31	1B69403	APS SYSTEM C/O
4.2.32	1B69571	APS MODULE C/O
4.2.33	1B66570	HYDRAULIC SYSTEM
4.2.34	1B66572	PROPULSION SYSTEM
4.2.35	1B74681	PROP TK PRESS SCAN
4.2.36	1B64709	EMC RF SIGNATURE
4.2.37	1B66571	ALL SYSTEMS
4.2.38	1B62965	FWD SKIRT T/C POST C/O

■ INDICATES SECOND ISSUE

TABLE I. FAILURE AND REJECTION REPORTS OF PERMANENT NONCONFORMANCES, STRUCTURAL ASSEMBLES

Section 1. Propellant Tank Assembly, P/N 1A39303-535

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A261465 8-4-67	A visual inspection revealed two tool marks 5/16 in. long, 0.012 in. wide, and 0.007 in. deep, in segment 4 of the forward dome, between weld seams 4 and 5.	The tool marks were blended and smoothed per Engineering instruction without increasing the depth of the defects. The reworked area was touched up with alodine per DPS 41410. The rework was acceptable for use.
A261505 8-22-67	A visual inspection revealed numerous voids in the debris shroud assembly, P/N 1B56480-401, some halfway and some completely through the bondline.	The voids were filled and the unbonded areas were rebonded per DPS 32340. The rework was acceptable for use.
A261508 9-28-67	Installation of percussion weld stud, P/N S0717A428-7, per FARR A261537, failed to weld, causing a total crater depth of 0.065 in.	The defective area was spotfaced to a 5/8 in. diameter, which removed the weld material and provided a smooth surface. The stud was installed per 1A39303 and DPS 14170. The rework was acceptable for use.
A261516 11-17-67	a. The hardness control specimens prepared for liner installations, P/N's 1A93131-7 and 1A93131-37, were not cured in the same environments as the liners.	a. A Shore hardness test was made on the liners per DPS 22301 and were acceptable to Engineering for use.
	b. Liners, P/N's 1A93131-7 and 1A93131-37, had 2 to 6 in. overlaps, and excessive wrinkles, and had not been trimmed per 1A93131.	b. Acceptable to Engineering for use.

TABLE I, Section 1 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A261531 8-22-67	A visual inspection revealed that the anodized surface inside the LH_2 tank had been removed at several places and some areas were covered with a white residue powder.	The res[illegible] was removed with fine grit pap[illegible] o a maximum depth of 0.0005 in. The rework was acceptable to Engineering for use.
A261532 8-22-67	Dye penetrant inspection revealed that the helium support fitting weld, P/N 1B28699-1, had a 1/8 in. linear indication.	The defect was ground out per Engineering instructions and dye checked per DPS 15101. The rework was acceptable to Engineering for use.
A261533 8-23-67	Percussion stud weld, P/N S0717A428-4, failed to meet the 40 pound torque requirements per 1A39303, and broke off at the weld.	The wrong sized spotface was used to remove the remaining portion of the stud, cutting a spotfaced area 9/16 by 5/32 by 0.040 in. deep. FARR A261534 was written to provide further disposition to eliminate this defect.
A261534 8-24-67	The spotface for the percussion weld stud, P/N S0717A428-4, per FARR A261533 was oblong shaped 9/16 by 15/32 in. and should have been 3/8 in. diameter.	The spotface was cleaned up by spotfacing to a 5/8 in. diameter and a depth of 0.030 in. The rework was acceptable for use.
A261535 9-6-67	Tile, P/N 1A89420-1, was trimmed to fit at weld seams 1 through 9 inside of LH_2 tank. Trimming was not authorized.	Acceptable to Engineering for use.

TABLE I, Section 1 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A261536 9-7-67	The shiplap on tile, P/N 1A82328, was cut off inside the LH_2 forward dome segment 4 at seven places.	The edge of the tile was trimmed to reform the shiplap 3/8 to 1/2 in. wide. 3-D foam tile was installed of sufficient width on seam 4 to meet the requirements of the drawing and DPS 23003. The rework was acceptable for use.
A261537 9-11-67	The percussion weld stud, P/N S0717A428-7, was broken off at weld inside the LH_2 tank adjacent to weld seam 2.	The weld material was removed and a smooth surface was obtained by spotfacing a 7/16 in. diameter area. A new percussion weld stud was installed per drawing requirements. (Reference FARR A261508).
A261539 9-16-67	Cylinder seams 1 through 7 did not meet the tensil bond requirements for glass and tile per DPS 23003. Test Report 46150 specimen, S/N 24, showed a minimum of 56 psi and an average of 71 psi and should be 100 psi minimum with an average of no less than 150 psi.	A 2 in. diameter area of glass liner was removed at 2 places on each cylinder seam. Freshly grit-blasted aluminum plugs 1 1/2 in. 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.

TABLE I, Section 1 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A261541 9-27-67	The 3D tile inside the LH_2 tank had irregular shaped areas that were raised above the normal contour and felt spongy when depressed.	In areas identified by Engineering as not acceptable for use, the glass liner and 3D tile were removed and replaced per DPS 23003. In other raised or blistered areas, the glass liner was removed and the insulation was smoothed out by sanding with 40 to 80 grit paper. The glass liner was reinstalled per Engineering instructions and DPS 23003. The rework was acceptable for use.
A261542 10-09-67	a. The foam tile was distorted at 14 places due to blistering at segments 1,5,6, and 9 on the forward dome; segments 2, 3, and 5 on the cylinder wall; and segments 2 and 9 on the aft dome. b. The foam tile, P/N 1A82310-501, was out of contour 1/8 in. with adjacent tile areas, at one place on cylinder segment 2.	a and b. Acceptable to Engineering for use.
A261543 10-10-67	The insulation tile, P/N 1A89283-1, was distorted, soft, and spongy at three places on segment 9 on the aft dome.	The defects were removed by reworking the tile per Engineering instructions and DPS 23003. The rework was acceptable to Engineering for use.

TABLE 1, Section 1 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A261544 10-11-67	A visual inspection of the Velcro tape installation on the ring segment assembly, P/N 1B56515, revealed the following defects: a. The dimension between the Velcro tapes was 0.437 to 0.500 in. throughout 85 per cent of the circumference of the installation. The dimension should have been 0.750 $\pm$ 0.030 in. b. The aft Velcro tape installation was 0.250 to 0.375 in. forward of the tooling location (ATP1 #1 tool) for 85 per cent of the circumference. c. The aft Velcro tape installation had adhesive smeared on the fastener surface at a splice, in an area 4 in. long. The forward Velcro tape installation had adhesive smeared on fastener surface at a splice in an area 2 in. long.	a, b, and c. Acceptable to Engineering for use.
A261545 10-12-68	A visual inspection of supports, P/N 1A39644-1, showed the following defects: a. Three supports were mislocated at cylinder segment 6. One support was 6-3/8 in. from point B and should have been 7 $\pm$ 0.025 in. Another support was 10-1/4 in. from point B and should have been 11 $\pm$ 0.025 in. Another support was 5-3/8 in. from the centerline of the probe support and should have been 5 $\pm$ 0.025 in. Refer to 1B58100W. b. Ten supports throughout the area had gaps at the bondline. Tension load tests were performed on the noted supports and no failures occurred.	a. Acceptable to Engineering for use. b. The gaps were filled with Lefkoweld per DPS 23003. The rework was acceptable to Engineering for use.

TABLE I, Section 1 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A271146 11-1-67	Wire harness, P/N 1B58247-1 was routed to the 4th clamp from the feedthrough and should have been routed to the 5th clamp. Refer to 1B42499.	Acceptable to Engineering for use.
500-073-284 10-23-67	Bracket, P/N 1B58101-1, was mislocated 5-1/8 in. aft and 1/4 in. clockwise from the correct location. Refer to 1B58100.	The bracket was removed and reinstalled at the correct location per Engineering instructions. The rework was acceptable for use.
500-073-314 11-1-67	The glass liner at forward dome segment 3 had a puncture and depression 1 by 1 by 0.250 in. deep, located 5 in. forward of the deflector ring.	The defect was repaired per Engineering instructions and DPS 23003. The rework was acceptable for use.
500-073-331 11-4-67	During the glass liner and insulation cure for the repair noted on FARR 500-073-314, the No. 4 thermometer readings were erratic after the first 4 hours of the cure. The readings ranging between 110°F and 160°F.	Acceptable to Engineering for use.
500-073-411 11-14-67	The anti-vortex screen, P/N 1B55445-1, has two NAS1003-1 bolts installed to secure clips, P/N 1B55445-29. The clips are installed in the reverse order of the blueprint instructions to provide clearance with the LOX tank door opening flange.	Acceptable to Engineering for use.
500-073-438 11-14-67	The hole pattern did not align in the ring half, P/N 1B56512-1, and the support, P/N 1B63933-1. Two holes were mismatched 1/16 to 3/32 in. and the two 106263-3A bolts could not be installed.	The two 0.218/0.227 in. holes in the ring half were elongated to match the holes in the support and the 106263-3A bolts were installed. The remaining holes in the ring half were drilled to 0.312 in. The rework was acceptable for use.

TABLE I, Section 1 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-073-446 11-15-67	Pin 2 in connector, P/N 1B37872-1, was bent approximately 30 degrees. This connector is part of the mass probe assembly, P/N 1A48430-511, S/N C4.	Pin 2 was straightened per DPS 54002. The rework was acceptable to Engineering for use.
500-074-051 11-21-67	The forward interface attach angle at the forward skirt had numerous scratches and gouges ranging in depth from 0.001 to 0.005 in. with metal roll and burrs on edges of scratches.	The scratches and gouges were smoothed out with 400 grit paper and treated with alodine per DPS 41410. The rework was acceptable for use.
500-074-116 11-30-67	The anti-tamper seals were broken on the bolt heads securing the inlet cover plate to the cold helium spheres, on the first and third bottles from the top at the auxiliary tunnel. The cleanliness requirements per DPS 43000 were questionable.	The cover plates were removed and the interior of the spheres were inspected. No contamination was found and the spheres were acceptable to Engineering for use.
500-074-159 12-6-67	The LH_2 tank pressurization pipe assembly, P/N 1B64168-1, has a 1/16 in. flat spot located 6 in. from the upstream end.	Acceptable to Engineering for use without rework.
500-074-256 12-28-67	On the LOX chilldown return duct assembly, P/N 1A87736-501, the tee, P/N 1A86607-501, is welded 34 degrees counterclockwise out of rotation.	Acceptable to Engineering for use.
500-148-713 12-1-67	The attitude control auxiliary propulsion engine, P/N 1A39597-509, S/N 733, had the insulation damaged 2 places on solenoid valve L4.	The damaged insulation was repaired per DPS 54010. The rework was acceptable for use.

TABLE I, (Continued)

Section 3. Cylindrical Tank Assembly, P/N 1A39306-511

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A242833 2-7-67	A dye check inspection of the cylindrical tank aft ring assembly, P/N 1A39306-33.1, S/N 020, showed six grindouts with no defects, and visual inspection showed depths to a maximum of 0.035 in.	Acceptable to Engineering for use.
A248545 3-21-67	During welding of cylinder seam 3, the welder stopped at 62 3/4 in. from the aft end causing a crater.	Seam 3 was tack welded beyond the skin trim line and X-rayed. Segment 4 was removed by trimming the weld from the adjoining edge of segment 3, which was rechamfered and dye checked. The dye check was acceptable after grindout of a minute crack. A new segment 4 was trimmed to maintain land width. A preproduction panel weld sample per DPS 14052 was acceptable. Visual, dye penetrant, and X-ray inspection after rewelding seam 3 were acceptable to Engineering.
A253728 5-22-67	The helium bottle support fitting, P/N 1A39306-411, had an area 5 1/2 in. by 6 in. covered with black discoloration spots on the inside surface of the waffle pattern.	The discoloration was removed by scraping and grinding to a depth of 0.005 in. The area was cleaned and a coat of Lefkoweld primer was applied. The rework was acceptable for use.
A257982 6-4-67	During welding of cylinder seam 2, the welder stopped at 69 3/4 in. from the forward end, was then restarted and continued for 18 1/2 in. before stopping again. X-ray inspection showed cracks and lack of penetration at 69 3/4 in. and 88 1/4 in. from the forward end of the weld seam.	The weld defects were ground out per Engineering instructions and the weld was completed per DPS 14052 and drawing requirements. The rework was acceptable for use.

TABLE I (Continued)

Section 2. Forward Dome, P/N 1B64442-503

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A253711 5-16-67	A visual inspection of forward dome segment 3, P/N 1B63311-1, revealed the following defects: a. Several scratches near the centerline of the segment, 41 in. from the forward end with a depth of 0.001 in. b. Dark discoloration spots on the outside anodized surface in a 12 in. by 20 in. area.	a. The sharp edges were smoothed to an acceptable condition and the reworked area was touched up with primer. b. The discolored area was touched up with primer.
A253732 3-23-67	Forward dome segment 2, P/N 1B64442-413, had several scratches on the outside surface.	The sharp edges were smoothed to an acceptable condition and the reworked area was touched up with primer.
A253756 5-31-67	Pressure sensor fitting "DD" has a blended area 1/2 in. by 1/16 in. by 0.020 in. deep at the fitting to segment fillet weld.	Acceptable to Engineering for use.
A253766 6-2-67	a. The outside anodized surface of segment 7 had several scratches to a depth of 0.001 in. b. Discoloration at eleven places on the inside surface of segment 7 appears to be chromic acid stains.	a. The sharp edges were smoothed to an acceptable condition and the reworked area was touched up with primer. b. Acceptable to Engineering for use.

TABLE I, Section 2 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A266607 6-16-67	A visual inspection of the forward dome meridian weld, P/N 1B64442-423, revealed the following defects:	
	a. Several blendouts at inner weld pads adjacent to seam 19.	a. Acceptable to Engineering for use.
	b. A ridge 0.012 in. high by 5/32 in. wide at the inner side of segment 9.	b. The ridge was scraped and smoothed flush with the parent metal. The rework was acceptable for use.
	c. Several scratches, scuff marks, and pasajell spatters on the inside anodized surface of segments 2 and 5.	c. All sharp edges were smoothed to an acceptable condition. The pasajell spatters were acceptable to Engineering for use.
	d. A scratch, 2 in. long by 0.001 in. deep in the anodized outside surface of segment 1.	d. All sharp edges were smoothed to an acceptable condition and touched up with primer.
	e. A depression, 1/8 in. by 3/32 in. by 0.025 in. deep in the inner surface of segment 9.	e. The depression was smoothed and blended without increasing the depth of the defect. The rework was acceptable for use.
A266625 6-27-67	Ovality, per QFC 578 and computer check, was 0.046 in. on the forward dome flange installation. Maximum ovality should be 0.022 in.	Acceptable to Engineering for use.
A266626 6-27-67	A planes and radii check revealed that the concentricity of the flange, P/N 1B63182, T.I.R. is 0.258 in. and should be 0.250 in.	Acceptable to Engineering for use.
A266629 6-28-67	The forward dome flange installation, P/N 1B64442-421, had several scratches inside the tank between weld seams 6 and 7.	The sharp edges were smoothed to an acceptable condition and the reworked area was touched up with alodine. 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
A257964 7-5-67	The outside surface of aft dome segments 1, 3, 5, 6, and 9 had several brown spatters varying in size from 1/32 to 1/4 in.	The acid was removed and the areas checked with litmus paper to ensure a neutral condition. The bare spots were touched up with alodine and primed. The rework was acceptable for use.
A257965 7-5-67	The outside surface of aft dome segment 5 had a sharp cut, 0.20 in. long by 0.004 in. deep.	The area was blended as required to remove the defect, and a smooth surface finish obtained. The rework was acceptable.
A266609 6-17-67	Visual inspection showed the following defects in the LOX tank common bulkhead installation: a. Tap fitting, P/N 1B29959-1, is 1 in. from the seam weld and should be 1 1/2 in. b. Tap fitting, P/N 1B29958-501, is 1 13/32 in. from tap fitting, P/N 1B29959-1, and should be 1 1/2 in.	a. and b. Acceptable to Engineering for use.
A266611 6-19-67	Ten mismatches occurred between the thrust structure attach angles, P/N 1A66946-1. The maximum mismatch was 0.021 in. the maximum tolerance is 0.010 in.	The attach angles were reworked per SEO 1A39307-010. The rework was acceptable for use.

TABLE I Section 4 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A266612 6-20-67	Eight holes for hi-lok bolts at the LOX tank bulkhead attachment were elongated and oversize from 0.250 to 0.254 in. at five locations. The holes should be 0.2465 to 0.2475 in.	The oversize holes were drilled and reamed to 0.2595 to 0.265 in., and 1/64 in. oversize hi-lok bolts were installed. The rework was acceptable.
A266616 6-21-67	a. The inside anodized surface of LOX tank segments 2 and 3 on the aft dome had a red discoloration from sealant between the flange and thrust angle attachments.	a. The discoloration was removed by light sanding and the reworked areas were touched up with alodine.
	b. The inside anodized surface of the LOX tank has intermittent alodine spatter spots.	b. Acceptable to Engineering for use.

TABLE I (Continued)

Section 5. Common Bulkhead Assembly, P/N 1A39309-501

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A249171 4-5-67	A visual inspection of the ring to face weld revealed the following defects:	
	a. A gouge 3/8 in. long by 0.011 in. deep at the edge of the weld, 16 in. from seam 6.	a. The gouge was smoothed out and blended. The rework was acceptable for use after dye check.
	b. Several scratches adjacent to the weld between seams 9 and 1, with a maximum depth of 0.002 in.	b, c, d, and e. The defects were smoothed out to an acceptable condition.
	c. Several scraper marks on the weld between seams 6 and 7.	
	d. Two gouges adjacent to the weld between seams 6 and 7, with a maximum depth of 0.002 in.	
	e. Indentations adjacent to the weld between seams 7 and 8, with a maximum depth of 0.002 in.	
	f. Blended area with a maximum depth of 0.005 in. on the outer side of meridian seam 9.	f. Acceptable to Engineering for use.
	g. Several black discoloration spots in the ring to face weld area.	g. The discoloration was removed by light sanding. The rework was acceptable for use.
A253626 4-19-67	Pasajell and caustic etch spatter were noted on the anodized outside surface of the centerplate weld.	The defective area were sanded down to the bare metal and touched up with alodine. The rework was acceptable for use.

TABLE I, Section 5 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A253763 6-2-67	The alodine treatment of all inside welds and bare areas on the inside and outside surfaces of the common bulkhead assembly did not conform to DPS 41410.	The defective area were cleaned with MEK and touched up with alodine per DPS 41410.
A253770 6-5-67	The common bulkhead assembly had a circumferential raised area on the forward face 1 in. to 1 1/4 in. wide with a maximum height of 0.040 in.	Acceptable to Engineering for use.
A253778 6-7-67	The common bulkhead assemb'y, on the LH_2 side, is treated with a chemical film on the surface which will be adhesive bonded.	Acceptable to Engineering for use.
A256851 5-1-67	The honeycomb core at the common bulkhead has a thickness of 1.876 to 1.943 in. at several places. Maximum allowable thickness is 1.87[illegible] in.	Acceptable to Engineering for use.

TABLE I, (Continued)

Section 6. Aft Dome Assembly, P/N 1B63286-1

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A253649 4-25-67	On aft dome segment 2, P/N 1B63286-421, S/N 07, a dye check of the outside weld on fitting "BB" showed No. 3 porosity.	The defect was removed by grinding out the weld to the set up line. The ground out area was mechanically rewelded. After X-ray and dye check the rework was acceptable for use.
A253659 4-28-67	An inspection of the aft dome segment 3 fitting installation, P/N 1B63286-423, revealed the following defects:	a and d. Acceptable to Engineering for use.
	a. A 6 in. can adjacent to fitting "AA" with a maximum deviation from contour of 0.145 in.	b. The sharp edges were smoothed to an acceptable condition and the reworked area was touched up with primer.
	b. Several scratches on the outside surface at the aft end of the segment with a maximum depth of 0.002 in.	c. The chafed area was smoothed to an acceptable condition and touched up with primer.
	c. Anodized surface was chafed in a 1 1/4 in. by 8 in. area adjacent to "AA" fitting.	
	d. A 5/8 in. by 21 in. stain on the outside surface of segment 6 near the aft end.	
A253665 5-1-67	The inside surface of segment 3, P/N 1B63286-423, had two raised areas with a maximum height of 0.005 in. at the mating area where segment 3 secures to the machined surface of the bulkhead rings.	The raised areas were scraped flush with the adjacent material. The rework was acceptable for use.
A253669 5-2-67	On aft dome segment 2, P/N 1B36286-421, S/N 07, a dye check of the outside weld at "BB" fitting showed lack of fusion.	Since the "BB" fitting had previously been rewelded twice per FARR A253649, the fitting was scrapped and a new fitting was installed per drawing.

TABLE I, Section 6, (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A253684 5-5-67	On aft dome segment 6, P/N 1B63286-425, S/N 037, X-ray 67-B39 of the LOX PU probe tube "KK" inside weld showed less dense inclusions.	Acceptable to Engineering for use.
A253723 5-19-67	a. On the aft dome fitting installation segment 9, P/N 1B63286-431, S/N 011, X-ray 67-B39 of the "EE" fitting outside weld showed less dense inclusion. b. Dye check of the "EE" fitting inside weld showed No. 3 porosity.	a. Acceptable to Engineering for use. b. The defects were removed by grinding. After dye check the rework was acceptable to Engineering for use.
A253745 5-29-67	The 6 in. diameter can, noted on FARR A253659, adjacent to the "AA" fitting on the aft dome had increased to 10 in. by 10 in. by 0.218 in., after the meridian seam weld was completed.	Acceptable to Engineering for use.
A253767 6-5-67	On the aft dome segment 1, X-ray 67-B39 of the "AF" elbow showed more dense inclusions.	The defects were removed by grinding. The ground out area was rewelded. X-ray of the reworked area showed no defects and was acceptable for use.
A253768 6-5-68	X-ray 67-B39 showed scattered porosity, cluster porosity, and concentrated porosity in the "BB" elbow weld on aft dome segment 2.	Acceptable to Engineering for use.
A253769 6-7-67	X-ray 67-B39 of the "UU" elbow weld, on aft dome segment 4, showed linear porosity and cluster porosity.	The cluster porosity was acceptable to Engineering for use. The linear porosity was ground out and rewelded. X-ray of the reworked area showed no defects and was acceptable for use.

TABLE I, Section 6 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A253775 6-5-67	Segment 4 of the aft dome assembly was P/N 1B63286-41, made from the detail dome segment, P/N 1B63287-501, with a thickness of 0.220 ± 0.005 in. at the entire forward end of the segment, but it should have been, P/N 1B63286-35, made from the detail dome segment, P/N 1B63287-1, with a thickness of 0.220 ± 0.005 in. at the meridian seam areas only and a thickness of 0.191 ± 0.005 in. at the remainder of the forward end.	The forward end of segment 4 was reworked per SEO 1B63286-001A and the rework was acceptable for use.
A253776 6-6-67	The flatness of the outside flange of the LH_2 feedline elbow "EE", after welding, was 0.018 in. but should be 0.015 in. per 1B63286.	Acceptable to Engineering for use.
A253781 6-7-67	The aft left hand stud, P/N S0717A428-4, on segment 6 broke off during torque test per 1B63286.	The remaining portion of the stud and weld was removed by spotfacing a smooth surface. A new stud was installed per drawing and was acceptable for use.
A253782 6-8-67	a. The inner anodized surface of segment 3 had a gouge 3/8 in. long by 0.006 in. deep located 9 1/2 in. from seam 2. b. The inner anodized surface of segment 3 had intermittent scratches with a maximum depth of 0.002 in. in a 3 by 15 in. area located 30 in. from the flange weld at the center of the segment.	a and b. The gouge and scratches were smoothed and blended without increasing depth of defects. The reworked areas were touched up with alodine. The rework was acceptable to Engineering for use.

TABLE I, Section 6 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A253786 6-9-67	a. A contour check showed that out-of-tolerance conditions exist at 82 degrees latitude and at longitude: 140 degrees is 0.073 in. and should be -0.100 to 0.400 in. 160 degrees is 0.044 in. and should be -0.100 to 0.400 in. 180 degrees is 0.006 in. and should be -0.100 to 0.400 in. 240 degrees is 0.021 in. and should be -0.100 to 0.400 in. 260 degrees is 0.058 in. and should be -0.100 to 0.400 in.	a, b and c. Acceptable to Engineering for use.
	b. A contour check at 82 degrees latitude showed that the average contour is -0.124 in. and should be -0.190 to -0.310 in.	
	c. A contour check at 50 degrees latitude showed that the average contour is +0.078 and should be ± 0.060.	
A253787 6-9-67	a. The inside area of meridian seam 1 adjacent to the weld pad area, which was reworked per SEO 1B63286-001, has a thickness of 0.181 in. at some areas and should be a minimum thickness of 0.191 in.	a and b. Acceptable to Engineering for use.
	b. Same condition as above exists at reworked area on meridian seam 3.	
A253791 6-12-67	Flange, P/N 1B63036-1, had ink indentification markings on the inside surface.	DPM 990 stripper was applied until only a faint trace of the markings was visible. The rework was acceptable to Engineering for use.

TABLE I, (Continued)

Section 7. Forward Skirt Assembly, P/N [illegible]264-511

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A271107 9-20-67	The forward skirt skin, P/N 1A39264-3, had a 3/8 in. crack through the skin at station 586 near stringers 91 and 92.	No. 30 stop holes were drilled at each end of the crack and a 2-3/4 in. by 5 in. doubler of the same gage and material as the skin was installed over the defective area. The rework was acceptable for use.
A271114 9-22-67	A 0.020 in. gap exists at plane "A" between the aft face plate and the jig lid. Maximum tolerance is 0.015 in. The defect is located at stringer 26.	Acceptable to Engineering for use.
A271120 9-26-67	The forward skirt skin, P/N 1A39264-87, has a 1/32 in. by 3/4 [illegible]. ding at station 560 near stringer 78.	After etch and dye check showed no indication of cracks the defect was acceptable to Engineering for use.
500-070-072 10-2-67	Frame, P/N 1A49629, was deformed 16 places to provide adequate clearance for legs of supports, P/N 1B54215.	Acceptable to Engineering for use.
500-070-145 10-4-67	Stringer 4, P/N 1A39264-719, had several small dings, gouges, and sharp dents from station 584 to station 587.	The defects were smoothed out and blended using No. 400 grit paper without exceeding the original depth of the defects. A dye check showed no indication of cracks. The reworked area was touched up with alodine and primed. The rework was acceptable for use.

TABLE I, Section 7, (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-074-094 11-28-67	a. Pins A and D in connector P23 on wire harness, P/N 1B58318-1, were bent and the rubber grommet was torn.	a. Connector P23 was removed and replaced. After continuity and megger checks, the rework was acceptable for use.
	b. Pin D in connector J1 was bent. Connector J1 is located at the module test port and mates with connector P23.	b. Pin D in connector J1 was straightened to facilitate proper alignment. The rework was acceptable for use.

TABLE I, (Continued)

Section 8. Aft Skirt Assembly, P/N 1A39295-513

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A261494 6-9-67	Panel assembly, P/N 1A39295-425-1, S/N 50, has 117 BJ5 rivets with 5/16 in. edge distance and 16 BJ5 rivets with 9/32 in. edge distance. The edge distance should be 3/8 in.	Acceptable to Engineering for use.
A261495 8-4-67	Panel assembly, P/N 1A39295-419-1, S/N 014, has 102 BJ5 rivets with 5/16 in. edge distance. The edge distance should be 3/8 in.	Acceptable to Engineering for use.
A261499 8-8-67	Aft skirt panel assembly, P/N 1A39295-431-1, S/N 013, has 158 BJ5 rivets with 5/16 in. edge distance. The edge distance should be 3/8 in.	Acceptable to Engineering for use.
A261500 8-8-67	Aft skirt panel assembly, P/N 1A39295-433-1, S/N 014, has 227 BJ5 rivets with 5/16 in. edge distance. The edge distance should be 3/8 in.	Acceptable to Engineering for use.
A270826 8-9-67	Aft skirt panel assembly, P/N 1A39295-437-2, S/N 012, has 47 BJ5 rivets with 5/16 in. edge distance and 20 BJ5 rivets with 1/4 in. edge distance. The edge distance should be 3/8 in.	Acceptable to Engineering for use.
A270827 8-10-67	Aft skirt panel assembly, P/N 1A39295-439-2, S/N 012, has 70 BJ5 rivets with 5/16 in. edge distance. The edge distance should be 3/8 in.	Acceptable to Engineering for use.
A270828 8-10-67	Aft skirt panel assembly, P/N 1A39295-423-2, S/N 014, has 149 BJ5 rivets with 5/16 in. edge distance. The edge distance should be 3/8 in.	Acceptable to Engineering for use.

TABLE I, Section 8, (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A270829 8-10-67	Aft skirt panel assembly, P/N 1A39295-435-2, S/N 014, has 167 BJ5 rivets with 5/16 in. edge distance. The edge distance should be 3/8 in.	Acceptable to Engineering for use.
A270830 8-10-67	Aft skirt panel assembly, P/N 1A39295-441-1, S/N 014, has 175 BJ5 rivets with 5/16 in. edge distance. The edge distance should be 3/8 in.	Acceptable to Engineering for use.
A271125 9-28-67	An inspection of the inside area of the aft skirt assembly revealed the following defects:	
	a. Indentation in skin, 1 in. long by 0.008 in. deep, near stringer 90 and ring plane 286.	a, b, and c. The indentations were etched and dye checked and revealed no defects. Acceptable to Engineering for use.
	b. Indentation in skin, 3/8 in. long by 0.009 in. deep, near stringer 92 and ring plane 286.	
	c. Indentation in skin, 3/8 in. long 0.004 in. deep near stringer 94 and ring plane 286.	
	d. Six cuts in skin within a 2 in. area with a maximum length of 1/8 in. and a maximum depth of 0.007 in. Located near stringers 90 and 91 and ring plane 286.	d. The defects were deburred, blended and smoothed out with 400 grit paper without exceeding original depth of defect. The reworked area was treated with alodine and primed. The rework was acceptable to Engineering for use.
	e. Chips embedded in sealant throughout area.	e. All loose metal chips were removed from the sealant with a stiff bristled brush.

TABLE I, Section 8, (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-070-552 10-24-67	Pin r in connector J1 on wire harness, P/N 1B67271-1, was recessed and damaged.	Connector J1 was removed and replaced. See FARR 500-070-587 for additional rework.
500-070-587 10-26-67	Pins E, Z, and n in connector J1 on wire harness, P/N 1B67271-1 recessed, after being mated to connector P1. Defect occurred after rework per FARR 500-070-552.	Connector J1 was removed and pins E, Z, n, and f were replaced per DPS 54002-5 and Engineering instructions. After continuity and megger checks, the rework was acceptable for use.
500-070-595 10-27-67	Pipe assembly, P/N 1A38423-505, was not formed properly and would not align with the blind nut and clamping holes.	The pipe assembly was secured to intercostal at stringer 13 per Engineering instructions and was acceptable for use.

TABLE I, (Continued)

Section 9. Thrust Structure, P/N 1A39316-517

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A271104 9-18-67	Thrust structure skin, P/N 1A68349-501, had a 1/4 in. crack at the edge of a rivet hole. Located 35 in. aft of the forward attach angle at stringer 15.	The crack was removed by spotfacing a 3/16 in. diameter hole through the skin. A filler and doubler of the same gauge and material as the skin was installed per Engineering instructions. The rework was acceptable for use.
A271188 9-12-67	Tee, P/N 1A39316-147, is not worked per "DA" change. Two 0.190/0.195 in. holes are located 15 1/2 + 1 1/8 in. from the forward face plate of the attach angle, but should be 14 1/2 + 1 1/2 in.	Acceptable to Engineering for use.
A271190 9-12-67	a. Stringer 21, P/N 1A39316-141, had 5 holes drilled to 3/16 in. diameter and countersunk. Drawing calls for BJ5 rivets. Defects were located 23 to 30 in. aft of the attach angle adjacent to stringer 21A.	a. Flush AD rivets were installed at 4 places.
	b. Support, P/N 1A49613-17, should pick up one of the countersunk 3/16 in. holes as noted in item (a) above, 29 9/16 in. from end of stringer.	b. A conical filler was made from the head of a 3/16 in. diameter AD flush rivet, drilled to 3/16 in. The support was secured with a 3/16 in. diameter AD universal head rivet and the conical filler was used to fill the counter sunk portion of the hole. The rework was acceptable.
500-070-021 9-29-67	Two supports, P/N 1B32740-1, were mislocated. One was located 5 1/4 in. from the attach angle face, but should have been 5.75 in. The other was located 10 3/8 in. from the attach angle face, but should have been 9.68 in.	The supports were relocated per blueprint and the 5 mislocated holes were plugged per Engineering instructions. The rework was acceptable for use.

TABLE I, Section 9, (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-070-609 10-31-67	One No. 21 hole was drilled through the radius of angle, P/N 1A93016-23, and the upper surface of the custom connect panel.	The mislocated No. 21 hole through the panel and angle was plugged with a double flushed rivet per Engineering instructions. A new No. 21 hole was located and drilled 5/32 in. to the right of the mislocated hole. The rework was acceptable for use.

TABLE II. PERMANENT NONCONFORMANCES AND FUNCTIONAL FAILURE AND REJECTION REPORTS DURING STAGE SYSTEM CHECKOUTS

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A261191 6-7-68	a. External standoff support, P/N 1B37286-501, was broken off at stringer 21A.	a. The remaining portions of the support was removed and a bead of DPM 3331 sealant was applied around the shank of the exposed rivet per DPS 25081.
	b. External standoff support, P/N 1A49613-11, was cracked forward of rivet at stringer 20.	b. The area around the support, support base, and rivet head was cleaned per DPS 30000 and a bead of DPM 3331 sealant was applied around the edge of the support base and rivet head. The rework was acceptable for use.
A261192	The support bracket, P/N 1B54093-53, is located 3 9/32 in. from edge of panel assembly, P/N 1B54093-51, but should be 3 19/32 in.	Acceptable to Engineering for use without rework.
A261193 6-24-68	a. The conductors on wire harness 411W17, P/N 1B68989-1, at connector P12 were too short. This condition caused the wire harness to ride the sharp edge of the back shell. The wire harness is located in the aft skirt at stringer 24.	a and b. The wire harness clamps were loosened, the string ties were cut, and the wires were re-positioned, retied, and re-clamped to relieve excessive stress. The rework was acceptable to Engineering for use.
	b. The conductors on wire harness 411W17, P/N 1B68989-1, at connectors P1 and P3 were too long. This condition caused preload on the wire harness and distortion of the pin holes at the rubber grommets.	

TABLE II. (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A261196 6-25-68	The bus connector module, P/N 1A96707-501, S/N 0546, was subjected to 500 volts DC at pin W in connector P4 of wire harness 404W201. No voltage should have been applied to the unit.	Acceptable to Engineering for use without rework.
A261199 6-27-68	Connector P33 on wire harness, P/N 1B58318-1, has a hole in the grommet between pins C and D. Connector P33 mates with pressure switch 411S4J7 and is located in the forward skirt at stringer 27.	The damaged connector was removed and a new connector was installed, tested, and accepted for use.
A271264 2-12-68	The following defects were noted during the continuity compatibility check, H&CO 1B59780: a. Wire 4P9A22 was severed behind contact 404W7P23-B on wire harness, P/N 1B66971-1, S/N 8257. P23 mates with 424A1S2J1 at the LOX vent valve. b. The resistance through connector 404A3W1-P10 on wire harness, P/N 1B66966-1, S/N 3, varied from 0.1 to 4.5 ohms, when the connector was being mated to J1 on module 404A3A10, P/N 1B39550-513, S/N 13. The resistance should have been 1.0 ohms or less. c. The resistance through connector 404A2W1-P24 on wire harness, P/N 1B67271-1, S/N 3, varied from 0.1 to 3.1 ohms when the connector was being mated to bus module 404A2A24, P/N 1B51354-513, S/N 14. The resistance should have been 1.0 ohms or less.	a. The end of the wire was re-stripped and the pin was re-installed. The rework was acceptable to Engineering for use. b and c. The connectors, P10 and P24 were removed and replaced. The rework was acceptable to Engineering for use.

TABLE II. (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A271265 2-13-68	The voter-regulator module, P/N 1B66988-1, S/N 11, was tested to procedure A659-1B66988-PATPI-B-T2 which contained erroneous test instructions and values. The module should have been tested per the noted procedure, updated per A659-EO-change T4.	The voter-regulator, S/N 11, was removed and a new unit, S/N 015, was installed.
A271266 2-14-68	The 50 amp relay module, P/N 1A74890-501, S/N 0139, measured 2.2 ohms, but should have been 1.0 ohms or less. The defect was noted during the continuity/compatibility check, H&CO 1B59780-1. Subsequent trouble-shooting of connector J3 revealed that the resistance between pin H and pins x, w, s, and r was 2.0 ohms, but should have been 0.5 ohms or less per 1A87210-1.	The defective 50 amp relay module, S/N 0139, was removed and a new unit. S/N 145, was installed.
A271269 2-21-68	The LH_2 overfill sensor controller, P/N 1A68710-509, S/N D-2, failed to adjust R1 from 0 $\pm$ 1 vdc to 28 $\pm$ 2 vdc. The defect was noted during the level sensor and control unit calibration per H&CO 1B64680.	The defective sensor controller, S/N D-2, was removed and scrapped. A new unit, S/N C-100, was installed.
A271270 2-23-68	The chilldown inverter, P/N 1A74039-517-016A, S/N 073, voltage phases AB and AC measured 51.54 and 51.28 vdc respectively, but should have been 55 $\pm$ 3 vdc. The defect was noted during the power distribution system test per H&CO 1B66562.	The chilldown inverter, P/N 1A74039-517-016A, S/N 073, was removed and a new unit, S/N 075, was installed. The removed inverter, S/N 073, was bench tested and accepted for future use.
A271271 2-26-68	On the LH_2 prevalve, P/N 1A49968-507, S/N 123, the keyway on connector A6J1 was broken off.	The electrical connector, A6J1, was removed and returned to the vendor for rework or replacement. A new connector was installed on the LH_2 prevalve.

TABLE II. (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A271272 2-27-68	When the high and low RACS commands were received at the channel decoder assembly, P/N 1A74053-503, S/N 318, no RACS signal to the transducer was generated. The defect was noted during the DDA system test, per H&CO 1B66564.	The channel coder assembly, S/N 318, was removed and returned to vendor for rework and a new unit, S/N 244 was installed.
A271273 2-27-68	The electrode was bent at the igniter tip attach point on exciter assembly, P/N 1B59996-503, S/N 049. The defect was noted during the spark igniter tip installation per 1B67337.	The defective exciter assembly, S/N 049, was removed and a new exciter assembly, S/N 061, was installed.
A271274 3-4-68	The submultiplexer, P/N 1B66050-1, S/N 02, high RACS command was 2.533 vdc and should be 4.000 $\pm$ 0.075 vdc. The defect was noted during the DDA system test per H&CO 1B66564.	The defective submultiplexer, S/N 02 was removed and a new unit, P/N 1B66050-501, S/N 1, was installed.
A271275 3-5-68	Pipe assembly, P/N 1B67466-1, had a helium leak at the upstream end caused by scratches on the sealing surface of the flare. The defect was noted during the cold helium system leak check per H&CO 1B59458.	The defective pipe assembly was removed and replaced with a new unit. Leak check revealed no leakage and the rework was acceptable for use.
A271295 2-15-68	The 50 amp relay module, P/N 1A74890-501, S/N 0113, indicated 19 ohms, but should have been 5 to 15 ohms. The defect was noted during the umbilical interface compatibility test per H&CO 1B59782.	The 50 amp relay module, S/N 0113, was cycled several times and the resistance was noted to be 9 ohms. The unit was acceptable to Engineering for use without rework.

TABLE II. (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A271299 3-6-68	Pins j, G, and Y were bent in connector J4 on the control relay package, P/N 50M35076-1, S/N 335.	The bent pins were straightened per DPS 54002. The rework was acceptable to Engineering for use.
500-197-340 7-9-68	During the curing cycle of plate, P/N 1A39295-17, located between stringers 62 and 63, and plate, P/N 1A39295-17, located between stringers 134 and 135, the curing temperature of 77 ± 7°F was recorded every 30 minutes for a period of 6 hours and 30 minutes. The temperature should have been recorded every 15 minutes for a period of 24 hours.	The old fillets were removed and new fillets were applied per 1A39295. A temperature of 77 ± 7°F was maintained and recorded every 15 minutes for a period of 24 hours. The rework was acceptable for use.
500-238-011 3-12-68	The sequence power motor driven switch, P/N 1A88061-1, S/N 361, mounted on the 50 amp relay module, P/N 1A74890-501, S/N 0142, failed to turn power on. The defect was noted during the stage power setup per H&CO 1B66560.	The defective switch, S/N 0142, was removed and a new unit, S/N 138, was installed.
500-238-020 3-14-68	The voter regulator module, P/N 1B66988-1, S/N 011, was tested to procedure A659-1B66988-PATPI-D-T2, which contained some erroneous test instructions and values. The module should have been tested to this same procedure corrected per EO A659, change T4.	The voter regulator module, S/N 011, was successfully tested to procedure A659-1B66988-PATPI-D-T4 and was acceptable to Engineering for use.
500-238-046 3-18-68	The engine regulator output transducer, P/N NA5-27412-T7LT, S/N 5895A, had an output of -2.685 psia, but should have been 14.7 ± 1.1 psia. The defect was noted during DDA system check per H&CO 1B66564.	The defective transducer, S/N 5895A, was removed and replaced by a new unit, S/N 6653A.

TABLE II. (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-238-054 3-19-68	Rocket engine, P/N 103826, S/N J-2122, had suspected contamination on interior of thrust chamber, injector face, and throat.	The contaminated areas were cleaned with tricloroethylene. The rework was acceptable to Engineering for use.
500-238-062 3-21-68	Bridge module, 404A71A2, P/N 1B65331-1-002, S/N 0106, had a constant output of 13 volts, but should have been zero volts when the simulate command was on and 20 volts when the simulate command was off. The defect was noted during the propulsion system test per H&CO 1B66572.	The defective module, S/N 0106 was removed and scrapped. A new module, S/N 0028, was installed and tested acceptably.
500-238-071 3-21-68	The PU voltage monitor module, P/N 1B39022-1-004, S/N 025, low RACS indication was 0.015 vdc, but should have been 1.000 $\pm$ 0.100 vdc at channel DPI-B0-04-09, measurement No. M60. The defect was noted during the DDA system test per H&CO 1B66564.	The defective module, S/N 025, was removed and scrapped. A new module, S/N 026, was installed and tested acceptably.
500-238-089 4-1-68	The dessicant port flange, P/N MFC 59657-150S, on pipe assembly, P/N 1B67025-1, has a nick on the outer flange.	Acceptable to Engineering for use without rework.
500-238-097 4-8-68	The shroud mounting flange, P/N 1B33669-1, was debonded from the engine thrust nozzle exit at engine No. 1, P/N 1A39597-509, S/N 810. The defect was noted during the installation of the throat plug kit per 1B69571.	The defect was reworked per Engineering instructions. The rework was acceptable for use.
500-238-101 4-11-68	The waveform analysis showed that valve closing time on the auxiliary propulsion system modules was 13 msec, but should have been 11 msec maximum. Troubleshooting revealed a defective control relay module, P/N 1B57731-1 S/N 361, and a defective control relay module, P/N 50M35076-1, S/N 335.	The defective control relay modules S/N 361 and 335, were acceptable to Engineering as interim use parts only and must be replaced by new configuration parts prior to static firing.

TABLE II. (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-238-119 4-11-68	The 3/8 in. oxygen pipe, P/N 410117-11, attached to the forward end of the thrust chamber dome had part number identification eroded into the tube metal causing damage to surface metal.	The defective line was acceptable for use as an interim use part during the J-2 engine system leak check per H&CO 1B59461, and to facilitate stage schedule. The defective line will be removed and replaced prior to static firing.
500-238-127 4-26-68	The coupling half quick-disconnect, P/N 1A68498-517, on the auxiliary hydraulic pump leaked hydraulic fluid overboard. The defect was noted during the hydraulic system fill, flush, bleed, and fluid samples test per H&CO 1B40973.	The defective coupling half quick disconnect was removed and replaced with a new unit.
500-238-143 4-30-68	The high pressure air fill valve, P/N 1B31295-1, S/N 95, installed on hydraulic reservoir, P/N 1B29319-519, S/N 00026, was twisted off at the thread relief. The defect was noted during hydraulic system, fill, flush, bleed, and fluid samples check per H&CO 1B40973.	The defective valve, S/N 95, was removed and replaced with a new unit, S/N 126.
500-238-160 5-10-68	a. Female pin K was damaged and the grommet was punctured in connector P21 located on wire harness, P/N 1B66969-1, on the forward skirt at 411A99A10.	a. The defective connector P21 was removed and replaced with a new connector. The rework was acceptable for use.
	b. Pin K in connector J1 of module, P/N 1B57771-559, was bent. The connector is located in area A21.	b. Pin K was straightened per DPS 54002. The rework was acceptable for use.

TABLE II. (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
5C0-238-178 5-16-68	Connector P2 on the transducer kit cable of transducer kit, P/N 1B40242-597, S/N 597-1, had the connector shell bent and the connector backshell was loose. The defect was noted during the EMC test per H&CO 1B64709.	The defective connector, P2, was removed and a new connector was installed. The rework was acceptable for use.
500-238-194 5-24-68	Bridge module, P/N 1A82274-619, S/N 03208, showed no continuity, indicating an open relay inside the unit. The defect was noted during the all systems test per H&CO 1B66571.	The defective module, P/N 1A82274-619, S/N 03208, was removed and a new unit, S/N 03211, was installed.
500-238-208 6-4-68	a. The P.U. voltage monitor module, P/N 1B39022-1-004, S/N 026, at location 411A61A241 had a noise level of 4 percent peak-to-peak for more than 1 second and should not have exceeded a 1 second duration. b. The LH_2 point level sensor, P/N 1A68710-507, S/N 09, located at 408A2C4, and the LH_2 not overfill sensor, P/N 1A48431-509, S/N 08, located at 408A1C2 were affected by transient voltages and cycled unexpectedly when the safe and arm device was armed. The defect occured during the all systems test per H&CO 1B66571.	a and b. Acceptable to Engineering for use without rework as ECP and WRO action was previously instigated to correct the problems.

TABLE II. (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-238-216 6-25-68	The auxiliary propulsion assembly, P/N 1A83918-535, S/N 508-1, had a fuzz leak on the balance valve adapter to the block assembly, P/N 8400-471036-2, S/N 34. The defect was noted during the APS bladder checkout procedure per 1B67661.	The balance valve adapter was tightened per Engineering instructions and releak checked. This rework was acceptable for use.
500-353-937 7-30-68	The LH_2 NPV adapter, P/N 1B59264-1, is rotated 45 degrees from the blueprint position. The unit is located on the forward skirt between stringers 101 and 102.	Acceptable to Engineering for use without rework.
500-355-042 6-28-68	The J1 connector on the LH_2 ground fill 2nd burn, flight control prepressure and repressure switch, P/N 1B52624-513, had the D pin bent more than 90 degrees.	The defective switch was removed and replaced. The rework was acceptable.
500-355-140 7-29-68	The vent duct middle support bracket, P/N 1B69222-1, has a gouge 3/8 in. long by 3/16 in. by 1/16 in. deep. Located over the helium sphere 8 position at thrust cone stringers 20 1/8 and 20 1/4.	A doubler was fabricated and installed over the gouged area. The rework was acceptable.
500-445-700 8-5-68	a. Head of pin J was flattened in connector P98 at wire harness 404W208, P/N 1B68993-1. Located at aft skirt panel 404A61.	a. Pin J was removed and a new pin was installed in connector P98. The rework was acceptable for use.
	b. Pin FF was recessed in connector P1 at wire harness 404W203, P/N 1B67089-1. Located at aft stringer 30.	b. Pin FF was removed and a new pin was installed in connector P1. Refer to FARR 500-445-785 for additional discrepancies and rework to connector P1 and pin FF.
500-445-726 8-13-68	A scratch, 0.250 in. long and 0.009 in. deep, was found on the external surface of the LH_2 tank assembly, located 37 in. to the left of weld seam 3 and 46 in. forward of the aft skirt forward flange.	The scratch was polished out with No. 400 grit paper without exceeding the original depth. The rework was acceptable for use.

TABLE II. (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-445-734 8-16-68	Duct, P/N 1A87436-501, had rust adjacent to the weld seam and foreign material was found inside the duct. Located on forward skirt at stringer 102.	The two adapters, P/N 1B59264-1; the ducts, P/N's 1A87436-501, 1A87436-502, 1A87234-1, 1A87234-2, and 1A87755-501; and the tee assembly, P/N 1A49982-1, were removed and cleaned in accordance with DPS 43150. The parts were re-installed in accordance with DPS 43000 and 43150. The rework was acceptable.
500-445-742 8-30-68	Forward skirt stringer No. 40 has a crack 1/2 in. long, located 58 1/2 in. from forward end.	The crack was "stop drilled" and an angle doubler was fabricated and installed over the stringer in accordance with Engineering instructions. The rework was acceptable.
500-445-751 10-17-68	The following isolators were debonded: a. At station 212, stringer 14, isolator, P/N 1B54125-1 was debonded 0.312 inch. b. At station 200, stringer 143, isolator, P/N 1B54123-1 was debonded 0.375 inch. The maximum debonding allowable is 0.250 inch.	a. The discrepant isolator was removed and isolator, P/N 1B54125-001 was installed and accepted by Engineering for use. b. The discrepant isolator was removed and isolator, P/N 1B54123-001 was installed and accepted by Engineering for use.
500-445-769 9-4-68	The 0.1875 in. alignment holes in the inner forward electrode and the inner aft electrode were misaligned from inboard to outboard by 1/32 in. on the fuel sensor probe, P/N 1A48431-513, in the LH_2 tank.	The fuel mass probe was reworked per Engineering instructions to comply with 1B29640. The rework was acceptable to Engineering for use.

TABLE II. (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-445-777 9-9-68	The eight LH_2 tank inside brackets, P/N 1A39644-1, are mislocated. The overall dimension 75.50 inches was within tolerances; however, proper installation of the left hand jumper, P/N MS25083-2BB94, could not be made.	An additional bracket was installed 1 1/2 inches aft of the foremost bracket to facilitate installation of the jumper. The rework was acceptable.
500-445-785 9-12-68	a. Pin FF in the rubber grommet of connector P1 of the wire harness, P/N 1B67089-1, reference designation 404W203, was recessed.	a. The FF contact was removed and replaced per drawing requirements. The rework was acceptable.
	b. The rubber grommet at pin I of connector P1 of the wire harness, P/N 1B67089-1, reference designation, 404W203, was punctured.	b. Connector P1 was removed and replaced. The rework was acceptable.
500-445-815 9-19-68	The duct, P/N 1A87755-501, removed from the stage per FARR 500-445-734, had a white substance of unknown origin internally, and a brown discoloration on the welds.	The duct was cleaned and processed per DPS 43000, and packaged and identified per DPS 62180.
500-445-823 9-20-68	The rubber grommet of the P94 connector of wire harness, P/N 1B68993-1, reference designation, 404W208, was punctured adjacent to sockets d and v.	The damaged connector was removed, replaced, and retested. The rework was acceptable.
500-445-831 9-23-68	The resin mixing requirements of DPS 32330 were not complied with during installation of the fitting, P/N 1B69904-1, and two supports, P/N 1B69608-9, in the aft dome area. The pot life of the two resin mixes were exceeded by 15 minutes and 19 minutes, respectively.	Lap shear and "T" peel tests were performed to determine the acceptability of the installation of the fitting and the supports. The results of the tests were acceptable to Engineering.

TABLE II. (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-445-840 9-25-68	Two clips, P/N 1B37889-529, on the aft dome near seam 1 were erroneously removed.	The clips were replaced and located to B/P dimensions.
500-445-866 9-26-68	The insulation of the white wire, P/N P1400E20, was damaged exposing the wire, which terminates in socket P of connector P5 of wire harness, P/N 1B76263-1, reference designation 404W201.	The wire was repaired per DPS 54010. The rework was acceptable to Engineering.
500-445-874 9-26-68	During the 24 hour elevated temperature cure cycle (150°F to 170°F) the following discrepancies occurred: a. The support, P/N 1B69608-9, on the aft dome on the left hand side of seam 7 reached a maximum of 179°F for 15 minutes. b. The fitting, P/N 1B69904-1, on the aft dome between seams 8 and 9 reached a maximum of 190°F for 20 minutes. c. The fitting, P/N 1B69904-1, on the aft dome at seam 4 reached a maximum of 180°F for 5 minutes.	Lap shear and "T" peel coupon tests were performed to determine the acceptability of items a, b, and c. Items a, b, and c, were accepted by Engineering as a result of the tests.
500-445-882 10-8-68	The rubber grommet of connector P32 of wire harness, P/N 1B68987-1F, 404A3W1, was punctured at pin hole v.	Connector P32 was removed, replaced, and retested. The rework was acceptable to Engineering.
500-445-891 10-2-68	During the clip bonding per AO 1B54540 M on the aft dome, the maximum relative humidity was exceeded between bonding cures.	The bonded clips were acceptable to Engineering for use.

TABLE II. (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-445-912 10-8-68	The LH_2 feed duct, P/N 1A49320-513, S/N 35, has two dings in the outer convolutes. The ding in the third convolute aft of the forward end is 1.125 in. long by 0.317 in. width by 0.093 in. deep. The ding in the eleventh convolute aft of the forward end is 0.500 in. long by 0.250 in. wide by 0.081 in. deep.	A ye penetrant inspection of the discrepant area to determine if the dings had caused cracks to occur and penetrate through the convolutes was negative. The duct was accepted for use.
500-445-947 10-10-68	Duct assembly, P/N 1A68611-501-001A, has two dings in the "most forward" convolution of the "A" bellows. One ding is 0.750 in. wide by 0.043 in. deep. The other ding is 0.625 in. long by 0.250 in. wide by 0.062 in. deep.	A dye penetrant inspection of the discrepant area to determine if the dings had caused cracks to occur and penetrate the bellows was negative. The bellows were accepted for use.
500-445-963 10-14-68	Pin f of the J4 connector on the control relay package, P/N 50M35076-1, was bent approximately 0.031 inch from the true center position.	The bent pin was straightened per DPS 54002. The rework was acceptable to Engineering for use.
500-446-005 10-16-68	Isolator, P/N 1B32256-1, was debonded for 0.5 inch. The isolator was located on the signal conditioning rack, P/N 1B55689-515, S/N 016.	The discrepant isolator was removed, scrapped, and replaced with P/N 1B32256-001A per SEO 1A95641-004. The rework was acceptable.
500-447-842 9-13-68	The duct, P/N 1A87436-502, removed from the stage per FARR 500-445-734, had a white substance of unknown origin and other foreign material internally.	The duct was cleaned and processed per DPS 43000. The rework was acceptable.
500-447-851 9-13-68	The tee, P/N 1A49987-1, removed from the duct, P/N 1A87436-501, rejected per FARR 500-445-734, had unknown white substance and foreign material internally.	The tee was cleaned and processed per DPS 43000, and packaged and identified per DPS 62180. The rework was acceptable.

TABLE II. (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-447-869 9-13-68	The duct, P/N 1A87234-1, removed from the stage per FARR 500-445-734, had a white substance of unknown origin and other foreign material internally.	The duct was cleaned and processed per DPS 43000. The rework was acceptable.
500-447-877 9-13-68	The duct, P/N 1A87234-2, removed from the stage per FARR 500-445-734, had a white substance of unknown origin and other foreign material internally.	The duct was cleaned and processed per DPS 43000. The rework was acceptable.
500-447-885 9-13-68	The duct, P/N 1A87436-501, removed per FARR 500-447-885, had white substance of unknown origin and other foreign material internally.	The duct was cleaned and processed per DPS 43000, and packaged and identified per DPS 62180. The rework was acceptable.
500-568-631 11-12-68	The heads of the NAS1403-1 screws did not contact both sides of the slotted holes in the tunnel cover, P/N 1B39128-1.	Washers were placed under the screw heads per 1A39313, change "AF". The rework was acceptable to Engineering for use.
500-638-851 10-25-68	Two angles, P/N's 1A81820-7 and -9, were erroneously installed 3.750 inches from the forward end of stringers 23A and 23 1/4.	The angles were removed; then re-installed in conformance with B/P requirements. The resultant extra holes were plug with AD rivet material. The rework was accept-able.
500-638-869 10-28-68	Pin hole H of the rubber grommet of the J5 receptacle of the wire harness, P/N 1B74453-1, 404W6, was split 1/8 inch in length.	The J5 connector was removed and replaced. The rework was accept-able to Engineering for use.

TABLE II. (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-638-893 11-1-68	Eight spherical washer sets, P/N A40732, on the O2-H2 burner assembly, P/N 1B62600-509-009C, S/N 010, were 3/32 inch thick, but should be 3/16 inch thick per Siewek Tool Catalog 10491 and SCD 1B63780 G.	The washers were removed and replaced. The rework was acceptable to Engineering for use.
500-638-915 11-8-68	Valve, P/N 1A48312-505-001A, S/N 0017, showed evidence of internal contamination. There were dark particles and white residue of an unknown substance. The valve was removed from the stage per WRO S-IVB 4560 R1.	The defective part was removed from the stage and sent to the vendor for rework. The replacement part, P/N 1A48312-517, S/N 0049, was installed and accepted by Engineering for use.
500-638-923 11-8-68	Elbow, P/N 1A77116-1, showed evidence of internal contamination. There were dark particles and white residue of unknown substance. The elbow was removed from the stage per WRO S-IVB 4560 R1.	The discrepant part was sent to the LOX clean room for cleaning per DPS 43000, and packaging per DPS 62180. A new elbow assembly was installed and accepted by Engineering for use.
500-638-931 11-8-68	Duct assembly, P/N 1A68611-501-001A, showed evidence of internal contamination. There was white residue of unknown substance in the duct. The duct was removed from the stage per WRO S-IVB 4560 R1.	The discrepant duct assembly was removed and sent to the LOX clean room for cleaning per DPS 43000, and repackaging per DPS 62180. A new duct assembly was installed and accepted by Engineering for use.
500-638-958 11-11-68	Tee, P/N 1B69768-1, removed from the stage per WRO 4560 R1, showed evidence of internal contamination. There were large particles of an unknown substance inside the tee.	The contaminated tee was routed to the LOX clean room for cleaning per DPS 43000. A replacement tee was installed on the stage.

TABLE II. (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-638-966 11-2C 68	While changing the attach angle bolts at the forward and aft skirt join to cylinder tank interfaces, the washers had to be forced loose from the ablative coating causing damage to the coating around the bolts.	The damaged areas were reworked by applying epoxy primer, DPM 2232; two coats of white enamel, DPM 408L37875; one light coat of silicone primer, DPM 3486-7; and four heavy brush coats of silicone, DPM 3486-5 per DPS 42000. The rework was acceptable to Engineering for use.
500-638-982 11-26-68	The pressure transducer, P/N 1B43324-617, S/N 63-5, and the pipe assembly, P/N 1B69573-1 located 15 inches aft of the thrust attach angle between stringers 18A and 18 1/4, were suspected of being contaminated. The transducer and pipe assembly had been left open to contaminated air for an 8 day period.	The transducer and pipe assembly were removed and replaced. The replacement parts were tested satisfactorily and were accepted by Engineering.
500-638-991 11-26-68	Wire harness 410W200, P/N 1B76718-1, was cut through the outer insulation to the shielding. The cut was 1/8 inch in length.	The cut was repaired in accordance with DPS 54010. The rework was acceptable to Engineering for use.
500-639-008 11-26-68	Wire harness 405W2, P/N 1B66973-1, had a puncture hole in the rubber grommet of the P2 connector, and pin P of the P2 connector was cut and damaged.	The connector was removed and replaced and pin P was removed and replaced. The rework was acceptable to Engineering for use.
500-639-032 12-05-68	Wire harness 404A3W1, P/N 1B74668-1, had a puncture hole in the rubber grommet of the P28 connector, and pin GG of the J1 bus connector was bent at a 30 degree angle.	The damaged connector was removed and replaced, and the bent pin was straightened per DPS 54002. The rework was acceptable to Engineering for use.

TABLE II. (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-639-041 12-10-68	a. Wire harness 411A99A10W1, P/N 1B68988-1, had a puncture hole in the rubber grommet of connector P24 at pin holes HH and H.	a. The connector was removed and replaced. The rework was acceptable to Engineering for use.
	b. Pins GG and H of bus connector J1 were bent at a 40 degree angle. Located at the panel, 411A99, at stringer 26.	b. The bent pins were straightened per DPS 54002. The rework was acceptable to Engineering for use.
500-639-083 12-14-68	a. The gas helium pipe assembly, P/N 1B58009-001-3, had a nick (0.20 inch long by 0.10 inch wide by 0.007 inch deep) 3 inches outboard from stringer 23A.	a. The pipe assembly was removed and replaced. The connections were leak checked after installation. The rework was acceptable to Engineering for use.
	b. Stringer, P/N 1A39316-139, had a 0.205 inch hole through it.	b. The hole was plugged with AD rivet material. The rework was acceptable to Engineering for use.

APPENDIX III

FLIGHT CRITICAL ITEMS INSTALLED AT TURNOVER

The flight critical items (FCI), as designated by DRW 1B53279K, that were installed on the stage at the time of transfer to STC for acceptance firing are listed in the following tabulation:

P/N	S/N	Ref. Location	Name
1A48240-505-007	0132	404A7	Fill and drain valve
1A48240-505-007	0130	427A8	Fill and drain valve
1A48257-525	0036	411A1	LH_2 vent and relief valve
1A48312-513	0049	424A1	LOX vent and relief valve
1A48430-511	C4	406A1	LOX mass probe
1A48431-513	C7/C6	408A1	LH_2 mass probe
1A48857-503	39	403A73	Control helium tank
1A48858-1	1137	Bnk 2 Pos 1	Helium sphere, cold
1A48858-1	1175	Bnk 1 Pos 5	Helium sphere, cold
1A48858-1	1181	Bnk 2 Pos 4	Helium sphere, cold
1A48858-1	1211	Bnk 1 Pos 2	Helium sphere, cold
1A48858-1	1212	Bnk 2 Pos 2	Helium sphere, cold
1A48858-1	1213	Bnk 2 Pos 3	Helium sphere, cold
1A48858-1	1215	Bnk 1 Pos 4	Helium sphere, cold
1A48858-1	1217	Bnk 1 Pos 3	Helium sphere, cold
1A48858-1	1219	Bnk 1 Pos 1	Helium sphere, cold
1A49421-507	154	427A3	LH_2 aux chilldown pump
1A49423-507	1871	424A4	LOX aux chilldown pump
1A49964-501	261	424 (LOX)	Chill system check valve
1A49964-501	289	427 (LH_2)	Chill system check valve
1A49965-523-012A	0301	424A41	Chill system shucoff valve
1A49965-525-013B	0205	424A4	Chill system shutoff valve
1A49968-519	135	404A44	Prop. tank shutoff valve
1A49968-521	024	424A6	Prop. tank shutoff valve
1A49991-1	63	403A74	Tank, comp. gas, cold helium
1A49991-1	-	403A6	Tank, comp. gas, cold helium
1A57350-507	0234	403A73A13	Helium fill module
1A58345-523	1037	403A73A1	Module, pneumatic pwr control
1A58347-513	26	403A75A2	Engine pump prg cont mod
1A59358-525	036	411A92A6	PU electronics assembly
1A66212-507	018	411A92A7	Inv-conv elect. assy
1A66240-503	X457813	401A11S1, S2	Engine driven pump, hydraulic
1A66241-511	X458912	403B1	Aux hydraulic pump
1A66248-505	77	403A71L1	Hydraulic actuator assy
1A66248-505-011A	66	403A72L1	Hydraulic actuator assy
1A68085-505	0146	411A99A10A1	300 amp pwr transfer switch
1A68085-505	0136	404A45A1	300 amp pwr transfer switch
1A68085-505	0117	404A2A1	300 amp pwr transfer switch
1A74039-517-016A	075	404A74A2	Chilldown inv. elect. assy

Appendix III (Continued)

P/N	S/N	Ref. Location	Name
1A74039-517-016A	074	404A74A1	Chilldown inv. elect. assy
1A74211-515	0628	404A45A9	2 amp relay module
1A74211-515	0721	404A3A41	2 amp relay module
1A74211-515	0724	404A3A19	2 amp relay module
1A74211-515	0725	404A3A17	2 amp relay module
1A74211-515	0726	411A99A10A11	2 amp relay module
1A74211-515	0727	411A99A10A13	2 amp relay module
1A74211-515	0728	404A45A10	2 amp relay module
1A74211-515	0729	404A3A48	2 amp relay module
1A74211-515	0730	411A99A10A12	2 amp relay module
1A74211-515	0731	404A45A8	2 amp relay module
1A74211-515	0742	404A45A7	2 amp relay module
1A74216-503	0376	411A99A10A6	Mag latch relay module
1A74216-503	0520	404A45A5	Mag latch relay module
1A74216-503	0487	404A3A13	Mag latch relay module
1A74216-503	0510	404A3A22	Mag latch relay module
1A74216-503	0511	404A3A21	Mag latch relay module
1A74218-505	0675	411A99A10A10	10 amp relay module
1A74218-509	0668	404A45A11	10 amp relay module
1A74218-509	0587	404A2A2	10 amp relay module
1A74218-515	0585	404A3A12	10 amp relay module
1A74218-515	0586	404A3A49	10 amp relay module
1A74218-515	0608	404A3A44	10 amp relay module
1A74218-515	0610	404A3A14	10 amp relay module
1A74218-515	0683	404A3A20	10 amp relay module
1A74765-507	226	401A11S1	Hyd syst thermal switch
1A74890-501	0081	404A2A7	50 amp relay module
1A74890-501	0140	404A45A2	50 amp relay module
1A7 390-501	0138	404A2A10	50 amp relay module
1A7 90-501	0145	411A99A10A2	50 amp relay module
1A74890-501	0141	404A2A9	50 amp relay module
1A77310-503.1	0192	411A98A2	5 volt excitation module
1A77310-503.1	0194	411A99A33	5 volt excitation module
1A77310-503.1	0163	404A52A7	5 volt excitation module
1A86847-513	051	401A11S1, S2	Hyd pump thermal isol assy
1B29319-519	00026	403A46	Accum/reservoir assy
1B32647-505	070	404A45A3	Hyd pwr unit start switch
1B33084-503	020	411A97A19	RS controller assy
1B33084-503	013	411A97A13	RS controller assy
1B39037-501	130	401	Eng installation bolts
1B39037-501	147	401	Eng installation bolts
1B39037-501	152	401	Eng installation bolts
1B39037-501	181	401	Eng installation bolts
1B39037-501	193	401	Eng installation bolts
1B39037-501	196	401	Eng installation bolts
1B39550-515	013	404A3	Sequencer mounting assy
1B39975-501	0288	404A3A1	Diode module

Appendix III (Continued)

P/N	S/N	Ref. Location	Name
1B39975-501	0295	404A2A17	Diode Module
1B39975-501	0346	404A2A16	Diode module
1B39975-501	0383	404A3A3	Diode module
1B39975-501	0384	404A3A5	Diode module
1B39975-501	0385	404A3A39	Diode module
1B39975-501	0386	404A3A37	Diode module
1B39975-501	0388	404A3A43	Diode module
1B39975-501	0383	404A3A3	Diode module
1B39975-501	0384	404A3A5	Diode module
1B40604-1.2	088	404A2A34	Diode assy module
1B40604-1.2	0156	404A3A7	Diode assy module
1B40604-1.2	0159	404A3A42	Diode assy module
1B40604-1.2	0164	404A3A51	Diode assy module
1B40604-1.2	0162	404A3A50	Diode assy module
1B40824-507.1	129	403 Str 9A	Check valve
1B40824-507.1	128	403 Str 9-3/4	Check valve
1B40824-507.1	131	403 Str 5A	Check valve
1B40824-507.1	125	403A74A4	Check valve
1B40887-501	0269	404A3A16	10 amp mag latch relay mod
1B40887-501	0272	404A2A15	10 amp mag latch relay mod
1B40887-501	0273	411A99A10A4	10 amp mag latch relay mod
1B40887-501	0274	404A3A2	10 amp mag latch relay mod
1B40887-501	0326	404A45A6	10 amp mag latch relay mod
1B40887-501	0328	404A3A46	10 amp mag latch relay mod
1B40887-501	0329	404A3A10	10 amp mag latch relay mod
1B40887-501	0340	404A3A18	10 amp mag latch relay mod
1B40887-501	0341	404A3A4	10 amp mag latch relay mod
1B40887-501	0342	411A99A10A5	10 amp mag latch relay mod
1B40887-501	0343	404A3A6	10 [illegible] latch relay mod
1B40887-501	0344	404A3A8	10 amp mag latch relay mod
1B40887-501	0349	404A3A58	10 amp mag latch relay mod
1B40887-501	0501	404A3A57	10 amp mag latch relay mod
1B42290-505	0012	403A74A1	LOX press. control module
1B51211-505	015	404A45	Aft 56 volt pwr dist assy
1B51354-507	014	404A2	Aft 28 volt pwr dist assy
1B51379-511	013	411A99A10	[illegible] dist mount assy
1B51753-511	019	411A32	[illegible] vent reg & S/D valve
1B52623-515	020	403S2	Pressure switch
1B52624-511	030	411S2	Pressure switch
1B52624-511	031	411S4	Pressure switch
1B52624-515	45	403S8	Pressure switch
1B52624-517	021	403S3	Pressure switch
1B52624-519	48	403S1	Pressure switch
1B52624-519	47	403S5	Pressure switch
1B52624-519	53	403S6	Pressure switch
1B53920-501	047	403A73	Chill feed duct check valve
1B53920-503	059	LOX C/D duct	Chill feed duct check valve

Appendix III (Continued)

P/N	S/N	Ref. Location	Name
1B53920-503	068	LH_2 C/D duct	Chill feed duct check valve
1B55200-505	1042	403A73A3	LH_2 tank press cont mod
1B55408-503	025	Str 13-14	Compressed air tank
1B57781-507	0037	403A74A2	Cold helium fill module
1B58006-401	63	403A74	1A49991, teflon wrapped
1B59010-509	126	427A7	Pneu prop. control valve
1B62600-529-009C	010	403 Str 10-3/4	O_2H_2 welded burner assy
1B62778-503	00009	403A6	Helium plenum & valve assy
1B62778-503	00010	403A7	Helium plenum & valve assy
1B65319-503	015	404A70A1	Sw sel emissivity cont assy
1B66639-515	040	403A19	Pneu latching actuator assy
1B66639-501	008	411A32L1	Pneu latching actuator assy
1B66692-501	127	404A44	Actuation control module
1B66692-501	118	404A43	Actuation control module
1B66692-501	10	403A15	Actuation control module
1B66692-501	134	403A17	Actuation control module
1B66692-501	175	403 Str 14	Actuation control module
1B66692-501	126	403A75A1	Actuation control module
1B66692-501	111	404A9	Actuation control module
1B66692-501-004	20	411A30-17	Actuation control module
1B66692-501-004	128	411A3-17	Actuation control module
1B66692-501-004	132	411A2-13	Actuation control module
1B66868-501	39	Pos 8 Str 20	Ambient helium sphere
1B66868-501	36	Pos 9 Str 23	Ambient helium sphere
1B66868-501	28	Pos 10 Str 24A	Ambient helium sphere
1B66868-501	38	Pos 1 Str 6A	Ambient helium sphere
1B66868-501	40	Pos 2 Str 7A	Ambient helium sphere
1B66868-501	41	Pos 7 Str 18	Ambient helium sphere
1B66868-501	37	Pos 6 Str 17	Ambient helium sphere
1B66868-501	42	Pos 5 Str 12	Ambient helium sphere
1B66988-1	15	404A71A1	Voter regulator module
1B67598-501	130	403 Str 7	Pneumatic check valve
1B67598-501	140	404 Str 22	Pneumatic check valve
1B67598-501	141	404 Str 22	Pneumatic check valve
1B67598-501	143	404 Str 22	Pneumatic check valve
1B67598-501	146	403 Str 7	Pneumatic check valve
1B67598-501	147	403 Str 9A	Pneumatic check valve
1B67598-503	82	403A74A3	Pneumatic check valve
1B67598-503	102	403A33A4	Pneumatic check valve
1B69030-501	0024	424A9	LOX NPV control valve
1B69514-501	012	404A3A9	Isolation diode module
1B69514-501	042	411A99A8	Isolation diode module
1B69514-501	030	404A3A55	Isolation diode module
1B69550-501	00016	403A74A3	Repress. control module
1B69550-501	00046	403A73A4	Repress. control module
1B74535-1	0008	Fwd Skirt	LH_2 tank latching relief valve
1B76452-501	17	404A51A4	Control relay package

Appendix III (Continued)

P/N	S/N	Ref. Location	Name
1B76452-501	20	404A71A19	Control relay package
7851823-503	1094	Pos 2 at umb	Helium control disconnect
7851823-503	1096	Pos 1 at umb	Helium control disconnect
7851844-501	66	10" from F&D	Cold helium disconnect
7851861-1	60	427	LH_2 tank press. disconnect
40M39515-113	292	404A47A1	EBW firing unit
40M39515-113	293	404A75A2	EBW firing unit
40M39515-113	298	404A47A2	EBW firing unit
40M39515-113	299	404A75A1	EBW firing unit
40M39515-119	554	411A99A20	EBW firing unit
40M39515-119	555	411A99A12	EBW firing unit
103826	2122	401	J-2 engine