SACRAMENTO
NARRATIVE END ITEM REPORT
SATURN S-IVB-507

CDONNELL DOUGLAS ASTRONAUTICS COMPANY

MCDONNELL DOUGLAS
CORPORATION

SACRAMENTO
NARRATIVE END ITEM REPORT
SATURN S-IVB-507

DAC-56623

APRIL 1969

M. A. Aiken for

PREPARED BY: W. M. REITZELL BRANCH CHIEF
QUALITY DATA AND REPORTING
QUALITY ASSURANCE DEPARTMENT

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

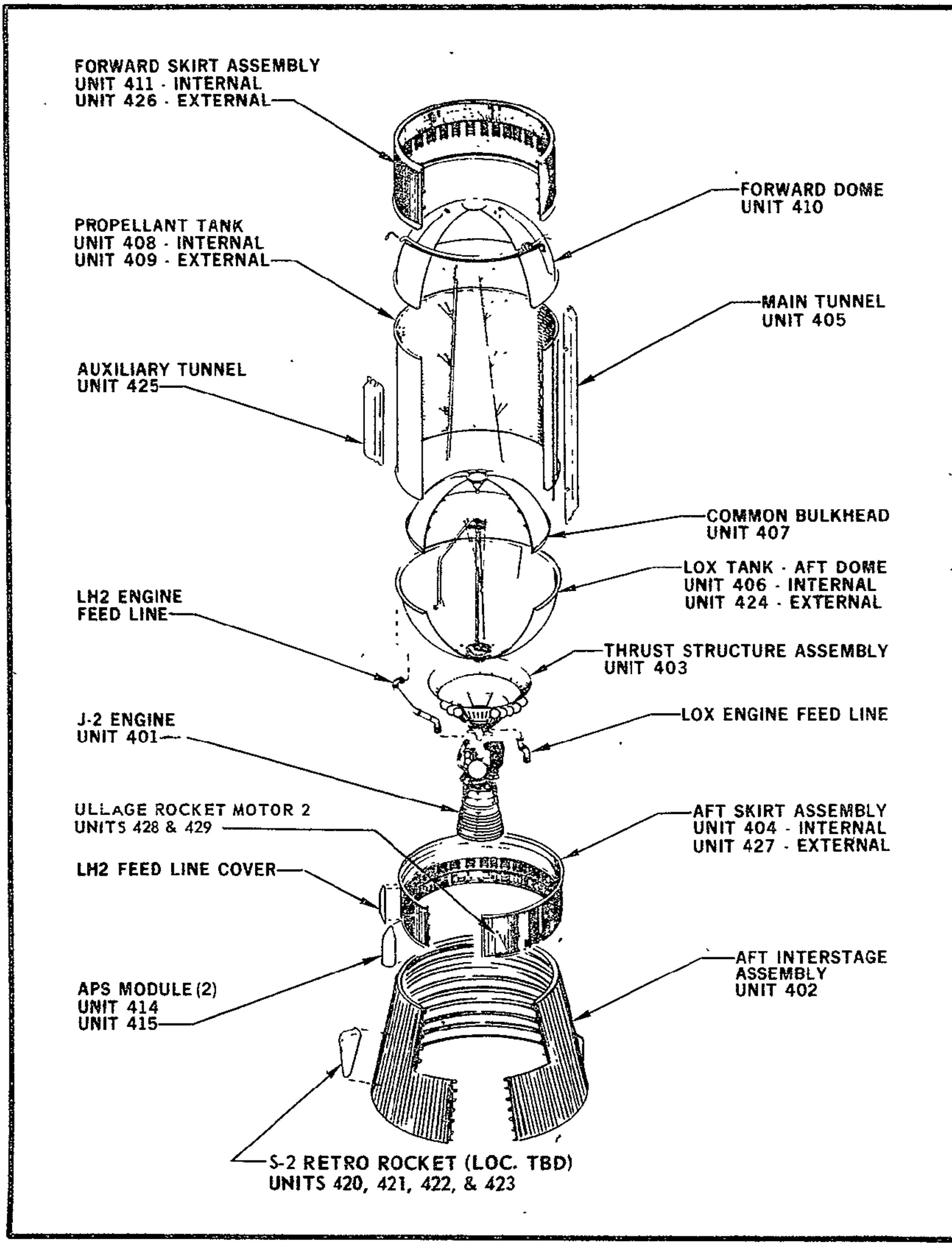
K A Frederiksen

APPROVED BY: K. A. FREDERIKSEN
CHIEF QUALITY ENGINEER
QUALITY ASSURANCE DEPARTMENT

MB Robins for

APPROVED BY: W. W. REASER DIRECTOR
SATURN PROGRAM
PRODUCT ASSURANCE

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY
WESTERN DIVISION
5301 Bolsa Avenue, Huntington Beach, California 92647 (714) 897-0311



Exploded View of S-IVB Stage for Saturn V

ABSTRACT

The Narrative End Item Report (NEIR) contained herein is a narrative summary of the McDonnell Douglas Astronautics Company, Western Division (MDAC-WD), Sacramento Test Center test records relative to the Saturn S-IVB-507 Flight Stage (P/N 1A39300-521, S/N 507).

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

Descriptors

NEIR

Documentation

Configuration

Significant Items

Stage Checkout

Prefire, Abbreviated Postfire, and Deferred Postfire

PREFACE

This Narrative End Item Report is prepared by the Quality Assurance Department of the McDonnell Douglas Astronautics Company, Western Division, for the National Aeronautics and Space Administration under Contract NAS7-101. This report is presented in response to requirements of NPC 200-2, paragraph 14.2.4, and is issued in accordance with MSFC-DRL-021, Contract Data Requirements, which details the contract data required from the MDAC-WD. The report summarizes the period from the initial stage acceptance testing at the MDAC-WD Sacramento Test Center, Rancho Cordova, California, through turnover to the MDAC Florida Test Center, Cape Kennedy, Florida.

The previous period of stage acceptance testing at the MDAC-WD Space Systems Center, Huntington Beach, California, and transfer to the MDAC-WD Sacramento Test Center, was covered by Narrative End Item Report, Saturn S-IVB-507, Douglas Report DAC-56623, dated April 1968, and revised August 1968.

CONTENTS

CONTENTS (Continued)

CONTENTS (Continued)

CONTENTS (Continued)

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 turnover for shipment to the Florida Test Center, Cape Kennedy, Florida.

b. Replacements made during Sacramento Test Center (STC) test and acceptance checkout, including 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 Turnover Data.

2. NARRATIVE SUMMARY. A brief discussion of the 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.

1.2 (Continued)

APPENDICES:

I **Testing Sequence**

Graphic presentation of the order and activity dates of the checkout procedures.

II **Nonconformance Tables**

a. Table I. A compilation of FARR's initiated during prefire checkout.

b. Table II. A compilation of FARR's initiated during countdown and abbreviated postfire checkout.

c. Table III. A compilation of FARR's initiated during deferred postfire checkout.

III **Flight Critical Items**

The flight critical items (FCI's) installed on the stage at the time of turnover to NASA/STC for shipment to FTC.

1.3 Stage Functional Description

A detailed system analysis is beyond the scope of this report. The "S-IVB 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, Vehicle Checkout Laboratory (VCL) test data, and vendor data. FO's and AO's record in sequence all manufacturing processes, procedures, and Quality Control inspection activities. Any problem or discrepancy noted by Inspection and Test personnel is recorded on an IIS for corrective action. Any discrepancy from a drawing requirement is recorded on a FARR by Inspection and Test personnel. The FARR is also used to record the Material Review Board (MRB) disposition applicable to the discrepancy. SEO's may be written to define the rework required by a FARR, to change the effectivity of a drawing, or to change other drawing requirements. Radiographic Inspection Records and X-ray photographs of all weld seams are maintained on file by the contractor. All original data is retained in the contractor's files. Vendor technical data is received on functional purchased parts and also retained in the contractor's files. The majority of the documentation referenced within this report is included in the log book which accompanies the stage.

1.5 Turnover

Turnover of the stage was made on 4 March 1969, at the MDAC-WD Sacramento Test Center. Final acceptance was made by the Air Force Quality Assurance Division Representative, by DD250 (packing sheet No. SM-4272-9). Two letters: A3-131-5.4.3.18-L-596, dated 11 February 1969; and I-CO-S-MDAC-L-79-69 dated 12 February 1969; from the MDAC-WD management to the NASA Resident Manager at STC,

1.5 (Continued)

submitted the documentation necessary to effect turnover. Copies of these letters and the accompanying documentation is included in the stage log book. Acceptance of the Auxiliary Propulsion Modules was effected on separate DD250's.

SECTION 2

NARRATIVE SUMMARY

2.0 NARRATIVE SUMMARY

The following paragraphs present a narrative summary of stage checkout of the S-IVB-507 stage. Stage prefire tests, abbreviated postfire, and deferred postfire tests conducted at the Sacramento Test Center (STC) are summarized in paragraphs 2.1, 2.2, and 2.3 respectively. The Final Inspection, Weight and Balance, and Preshipment Preparations are summarized in paragraphs 2.4, 2.5, and 2.6 respectively. More detailed narrations on these tests and operations are presented in section 4.

Paragraph 2.7 summarizes any tests that were invalidated or not completed prior to stage transfer, and any retesting that will be required. Paragraph 2.8 summarizes the incomplete failure and rejection reports that were transferred open at the time of stage transfer from STC to MSFC/FTC.

2.1 Stage Prefire Acceptance Tests

The S-IVB stage acceptance test program, conducted at the Sacramento Test Center (STC), verified the functional capabilities of the stage systems, at sea level conditions, during static acceptance firing. The stage acceptance firing plan, 1B71775 C, delineated the general philosophies of the STC test programs. Test request 1051 authorized the acceptance firing and delineated the test objectives and requirements. The stage prefire checkouts were designed to ensure a condition of readiness for the stage, facility, and GSE to conduct a successful static acceptance firing program.

The stage was received at the STC on 7 August 1968. The prefire checkouts began on 8 August 1968, and were concluded on 15 October 1968. Twenty-six

2.1 (Continued)

procedures were exercised to ensure the functional capabilities of the stage. Detailed narrations on the prefire checkouts are presented in paragraph 4.1.

Prefire checkouts began with the prefire structural inspection, which resulted in the initiation of one FARR. There were five revisions to the procedure.

The forward skirt thermoconditioning system checkout, the umbilical interface compatibility check, and the APS interface compatibility check were successfully conducted without generating any FARR's. However, a total of three revisions were written against these procedures. Three revisions were written during the umbilical interface compatibility checks, while none were written during the APS interface compatibility check or the forward skirt thermoconditioning system check.

Power was applied to the stage for the first time on 13 August 1968, with the initiation of the stage power setup procedure. Four issues were required. The second issue, on 13 August 1968, was required to verify that the correct shorting plug was installed in the BO multiplexer, P/N 1B58628-1. An incorrec shorting plug resulted in malfunction printouts for the aft 1, forward 1, and forward 2 five volt excitation modules during the first run. A third issue was accomplished on 14 August 1968, to apply power to the stage buses for further stage checkouts. A fourth and final issue was accomplished on 16 August 1968, to include a revision that had been inadvertently omitted from the paper tape changes in the first three issues. No FARR's were written; however, twenty revisions were written to the procedure. The stage power turnoff procedure was successfully demonstrated on 16 August 1968, with the fourth

2.1 (Continued)

issue. The first three issues were unsuccessful due to several malfunctions and procedural problems. No FARR's were initiated and eight revisions were made to the procedure.

The power distribution system test was conducted twice during prefire operations on 14 August and 4 September 1968. The second attempt was required due to the rewiring of the sequencer panel. Two attempts of the second issue were required due to an out-of-tolerance malfunction of the PCM RF assembly. This was attributed to a wire being pulled out of pin A of the 411W200 P4 connector. No FARR's were written, but a total of thirty-one revisions were recorded in both issues of the procedure.

Preliminary propulsion leak and functional checks were successfully completed after the incorporation of one-hundred and two revisions. Four FARR's were generated as a result of this checkout.

Four tests were required to satisfactorily complete prefire DDAS calibration. The initial test was conducted on 15 August 1968, and the second attempt on 16 August 1968, were both aborted due to noise occurring during the RASM portion of the test, which resulted in channel malfunctions. FARR 500-225-416 removed and replaced the RASM, P/N 1B66050-501.1, S/N 09, with P/N 1B66050 -501.1, S/N 05. The third test, conducted on 22 August 1968, also encountered the noise problem, which was isolated to a bad capacitor in the power supply test setup. The faulty capacitor was replaced. The fourth and final test was performed on 4 September 1968, and required eighteen revisions.

2.1 (Continued)

The common bulkhead vacuum system checkout was successfully demonstrated without generating any FARR's. However, thirteen revisions were made to the procedure. The stage and GSE manual controls check required two revisions, and one FARR was written.

The cryogenic temperature sensor verification was successfully accomplished between 19 and 22 August 1968. One problem, reported on FARR 500-376-351, was encountered during the checkout. Three revisions were made to the procedure.

The APS checkout, the EBW checkout, and the level sensor and control unit calibration were accomplished without generating any FARR's. Two revisions were written to the APS checkout, one in the EBW procedure and one in the level sensor calibration procedure.

The range safety receiver check, initiated on 5 September 1968, was completed on 18 September 1968. One FARR and eleven revisions were documented during this checkout. The range safety system automatic checkout also required eleven revisions; however, no FARR's were generated.

Three tests were conducted to verify operation of the DDAS. Test attempts one and two, conducted on 6 September and 19 September 1968, respectively, were not successful because of numerous channel malfunctions due to program errors, improper setups, and interferences by concurrent testing. The third and final test was a successful checkout performed on 27 September 1968. There were no FARR's initiated as a result of DDAS testing. Twenty-six revisions were recorded in the procedure.

2.1 (Continued)

The hydraulic system setup and operation checkout was initiated on 9 September 1968, and completed on 14 October 1968. One problem was encountered during the procedure. FARR 500-373-407 documented leakage through the GN2 accumulator fill valve in the closed position. The valve was removed and replaced. The procedure required twenty revisions for completion.

The propellant utilization (PU) system calibration, the propellant utilization system automatic, the signal conditioning setup, and the hydraulic system automatic checkout were completed without the initiation of any FARR's. The PU system calibration required nine revisions, the PU automatic checkout required eleven revisions. Fourteen revisions were written to the signal conditioning setup, while two revisions were made to the hydraulic system checkout.

The propulsion system test was initiated on 23 September 1968. The first attempt was aborted due to an out-of-tolerance condition of the telemetry data. Investigation revealed a broken ground stud on the stage. Acceptance of the propulsion system was on 2 October 1968, by the second attempt. There were no test discrepancies that resulted in the initiation of FARR's. However, nineteen revisions were made to the procedure.

The manual and automatic test sequences for the performance of the integrated systems test were initiated on 24 September 1968. Four attempts were required to complete the checkout. The first and second attempts were aborted due to computer malfunctions. The third attempt on 26 September 1968, was aborted to numerous malfunction indications. Initial conditions for the fourth and final

2.1 (Continued)

test were established on 27 September 1968. There were no FARR's generated as a result of this checkout. Thirty-two revisions were made to the procedure.

The final prefire propulsion system leak check was accomplished between 8 October and 15 October 1968. Twenty-nine revisions were recorded in the procedure and one FARR was written.

The acceptance firing test, designated countdown 614113, was initiated on 15 October 1968, and was terminated after 432 seconds of successful mainstage operation. A detailed narrative of the acceptance firing is delineated in Douglas Report DAC 61232, dated November 1968.

2.2 Stage Postfire Checkout

Contract change order 1879 delineated an abbreviated postfire checkout in lieu of the checkout required by paragraph 5.5.2.4 of SM 41412, General Test Plan. The following is a brief recap of the abbreviated postfire checkouts accomplished per test request 1051 on Test Stand Beta I.

The abbreviated postfire checkout, following completion of acceptance firing, was initiated on 17 October 1968, with the performance of the stage power setup and the stage power turnoff procedures. No FARR's were written during either procedure. However, the stage power setup required four revisions and the stage power turnoff required three revisions.

The propulsion system leak check was conducted from 17 October through 29 October 1968, to determine leakage which could have resulted from the stage

2.2 (Continued)

acceptance firing. There were no FARR's written as a result of the leak check. Ten revisions were required to complete the procedure.

The structural inspection was initiated on 18 October 1968, and was completed in the VCL on 26 February 1969. FARR 500-226-005 reported that the Korotherm coating on the forward skirt was cracked and peeling. The coating was removed and replaced. There were no other discrepancies documented; however, six revisions were recorded in the procedure.

The integrated system test was conducted on 18 October 1968, and accepted on 23 October 1968. FARR 500-488-704 reported an out-of-tolerance condition of NASA measurement D225. The transducer was removed and replaced. Thirty-two revisions were made to the procedure.

The postfire operation and securing procedure for the hydraulics system was conducted on 22 October 1968, to secure the system to prepare it for shipment to the VCL. FARR 500-488-743 recorded hydraulic fluid leakage at the filter differential pressure indicator mounting flange on the auxiliary hydraulic pump. The leak was repaired by replacing the O-ring and back-up ring. Seven revisions were made to the procedure.

The final prestorage procedure conducted was the forward skirt thermoconditioning system checkout. This prepared the thermoconditioning system for shipment to the VCL. No FARR's were initiated and no revisions were written.

The stage was removed from the test stand on 30 October 1968, and transferred to the VCL for storage preparations.

2.3 Deferred Postfire Acceptance Tests

The deferred postfire acceptance tests were initiated on 6 January 1969, and were completed on 10 February 1969. Twenty-six H&CO's involving the stage systems were performed during these checkouts; however, several of these H&CO's required more than one issue and are combined within one narration. Detailed narrations on the deferred postfire checkouts are presented in paragraph 4.3.

The checkouts began with the performance of the stage and GSE manual controls check on 6 January 1969, to verify that the switches and valves on the test consoles were positioned properly for the functional check; then, the manual controls were operated to ensure their functional capability. There were no stage FARR's initiated as a result of this checkout. Six revisions were written to the procedure.

The umbilical interface compatibility check required two issues. The second issue was necessary to reverify the umbilicals after ejection during the AST. There were no FARR's generated; however, two revisions were made to the procedure.

The stage power setup, the stage power turnoff, and the power distribution systems tests were all completed with no problems that resulted in the initiation of FARR's. The stage power setup required ten revisions, the stage power turnoff required two revisions. The power distribution system checkout was accomplished twice during the deferred postfire checkout. The second issue

2.3 (Continued)

was accomplished to reverify the system after removal and reinstallation, for rework, or an EBW unit. Six revisions were made to the procedure.

The level sensor and control unit calibration was accomplished on 13 January 1969, without requiring FARR's or revisions.

The propulsion system leak checks were performed concurrently with the electrical tests during January and February 1969. A number of leaks were found and those exceeding the allowable limits were corrected. FARR 500-703-296 reported that the cold helium spheres at positions 7 and 8 had bubble leaks. The LH2 tank was entered and the leaks were repaired by tightening the bottle flange bolts. FARR 500-703-300 rejected a reducer, P/N MC169C19W, when it was noted that the seating surface was scratched. The reducer was removed and replaced. FARR 500-703-750 stated that nine purge orifice flow rates were out-of-tolerance. Three orifices were removed and replaced, while the remaining six were scheduled for replacement at the FTC. FARR 500-703-776 reported a bubble leak at the pipe assembly, P/N 1B75772-1, and gave instructions to polish the flare and repair the leak.

The digital data acquisition system calibration, the digital data acquisition system automatic checkout, the exploding bridgewire system checkout, the propellant utilization system calibration, the propellant utilization system automatic checkout, and the hydraulic system setup and securing procedure, were satisfactorily completed with no FARR's written. The digital data acquisition system calibration required five revisions, the digital data acquisition automatic procedure required fifteen revisions, and the EBW checkout was

2.3 (Continued)

accomplished with no revisions. The propellant utilization system calibration had two revisions, while seven were required to complete the propellant utilization automatic checkout. The hydraulic system checkout was completed with no changes.

The single sideband system was accomplished between 22 January 1969, and 8 February 1969. FARR 500-489-880 reported that the SSB translator had out-of-tolerance data. The FARR is scheduled to be resubmitted at the FTC. Fifty-seven revisions were required for the checkout.

The cryogenic temperature sensor verification required a second issue after entry into the LH2 tank to repair leaks at two cold helium spheres. No FARR's were generated and one revision was required.

The hydraulic system automatic checkout and the APS interface compatibility checkout were completed with no FARR's initiated. Both procedures required three revisions. Ten revisions were necessary to accomplish the range safety receiver checkout. FARR 500-489-821 reported that the range safety No. 2 decoder had a voltage leak. The unit was removed and replaced.

The range safety system checkout was accomplished three times. The second test was required after replacement of a pulse sensor per FARR 500-489-812. The third test reverified the system after replacement of a decoder during the range safety receiver checkout. Four revisions were recorded during the final test.

2.3 (Continued)

The APS manual checkout, the APS automatic checkout, the telemetry and range safety antenna systems checkout, and the signal conditioning system setup were accomplished with the initiation of FARR's. The APS manual checkout required four revisions, the APS automatic checkout required six revisions, the telemetry and range safety antenna systems checkout was performed with one change to the checkout, while four revisions were made to the signal conditioning setup.

The propulsion system automatic checkout was initated on 4 February 1969, and completed on 11 February 1969, after twenty revisions were made to the procedure. FARR 500-703-636 reported that the ground fill overpressure pressure switch dropout value was too high. The defective switch was removed and replaced.

The final deferred postfire checkout was the all systems test, initiated and completed on 10 February 1969. No FARR's were written as a result of this test. Fifty-two revisions were made to the procedure.

2.4 Final Inspection

Following the final manufacturing operations and modifications, the final inspection of the stage was accomplished between 20 January and 28 January 1969, to locate and correct any remaining stage discrepancies. A total of four-hundred and four mechanical and electrical area discrepancies were recorded during the inspection, mostly of a minor nature. All except twenty-nine of these discrepancies were cleared to an acceptable condition without

2.4 (Continued)

requiring failure and rejection report action. The remaining problems were noted on FARR's 500-816-015, 500-816-023, 500-815-973, and 500-815-965. The conditions noted on FARR's 500-816-015 and 500-816-023 were accepted by the Material Review Board, and the discrepancy noted on FARR 500-815-973 was repaired. FARR 500-815-965, dealing with residue on a welded pipe assembly, was transferred open to the FTC. A more detailed narration on the final inspection is presented in paragraph 4.4.

2.5 Weight and Balance

The stage was rotated to a horizontal position in preparation for the weight and balance operation. On 25 February 1969, the stage was weighed by means of a three point electronics weighing system. Three electronic load cells, one aft and two forward, measured the reaction forces of the otherwise unsupported stage. The reaction force measurements were then used to determine that the stage shipping and handling weight was 27,044.3 pounds, the stage weight corrected for Standard Gravity in a vacuum was 27,097.0 pounds, and the stage longitudinal center of gravity was located at station 330.5. Paragraph 4.5 presents a more detailed narration on this operation.

2.6 Preshipment Purge

The final operation before the stage was shipped to the FTC was the preshipment purge. Gaseous nitrogen was used to purge the stage systems to dewpoints of -30.0°F for the LH2 system, and -49.0°F for the LOX system. The proper

2.6 (Continued)

desiccants were installed to maintain the proper stage environment during the air transport operations. Paragraph 4.6 presents a more detailed narration on this operation.

2.7 Incomplete Tests and Retesting Requirements

All required prefire, abbreviated postfire, and deferred postfire stage checkouts were accomplished during the stage testing period.

During the period following the stage testing, modifications were made to the stage prior to shipment from STC, and additional modifications were scheduled at FTC. These modifications invalidated parts of the previously accomplished stage testing, including power distribution system, hydraulic system, range safety system checks, propellant utilization system, propulsion system leak and functional checks, single sideband system, propulsion system, EBW system, and the pneumatic control system. MDAC report DAC 61238A, dated 4 March 1969, extensively covered these modifications and the retesting that would be required at FTC to reverify the affected stage systems, and was prepared in accordance with contract change order 2095.

2.8 Incomplete FARR's

Eleven FARR's were not closed at the time of stage shipment to the FTC, and were transferred open with the stage. FARR 500-226-005 reported that the Korotherm coating on the forward interstage was cracked and peeling. FARR 500-489-880 reported that the single sideband telemetry assembly had out-of-tolerance data during the preflight sweep calibration test. FARR 500-608-447 noted that the mounting hardware at the O2H2 burner assembly nozzle, was of

2.8 (Continued)

the improper material. FARR 500-703-296 noted that the cold helium spheres, 7 and 8, had leaks. The leaks were repaired and the spheres were leak checked. The final leak check was scheduled to be accomplished at the FTC. FARR 500-703-644 reported that the LOX chilldown pump purge orifices would not maintain motor case pressure. FARR 500-703-750 reported nine orifices with excessive leakage. Three orifices were removed and replaced and six orifices were scheduled to be removed and replaced at the FTC. FARR 500-703-831 reported that pipe assembly, P/N 1B52479-1, was damaged. FARR 500-704-616 reported that wire harness 404W201, P/N 1B76263-1, was not properly secured. FARR 500-815-876 noted that the pump purge regulator, P/N 1B43320-511, S/N 43-8, and the pressure control helium regulator, P/N 1A72913-557, S/N 482-8, had invalid data. FARR 500-815-965 noted a black residue deposit on the weld area of the pipe assembly boss, P/N 1B38419-503, in the forward interstage. FARR 500-815-990 reported that the LH2 fastfill sensor cycled during the PU mixture ratio check.

SECTION 3

STAGE CONFIGURATION

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; and paragraph 3.2 describes those flight critical items which deviate from the stage design.

A listing, in tabular form, of all time/cycle significant items on the stage, 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 507, revision C, dated 27 January 1969. 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 Quality Assurance Department

3.1 (Continued)

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 was accomplished by including the serial engineering order (SEO) dash number after the part number. Those flight critical items which are installed in the stage with SEO variations are reviewed in this paragraph. A description of the variation, along with part number and serial number, is presented for each part.

3.2.1 Oxidizer Mass Probe

SEO 1A48430-012 authorized reworking the oxidizer mass probe, P/N 1A48430-511, S/N C3, to provide proper insulation resistance equivalent to the -513 configuration.

3.2.2 LH2 Chilldown Shutoff Valve

SEO 1A49965-012 authorized the removal of the existing bonded insert and O-ring from the electrical connector, leak testing of the receptacle, and subsequent installation of an unbonded insert and O-ring for the LH2 chilldown shutoff valve, P/N 1A49965-523, S/N 0106. The unbonded insert was installed to minimize cracking of the insert and glass insulation at cryogenic temperatures, in accordance with NASA Change Order 1602.

3.2.3 LOX Chilldown Shutoff Valve

SEO 1A49965-013B authorized the removal of the valve assembled with Drilube 822, which was no longer LOX compatible, and the installation of LOX chilldown shutoff valve, P/N 1A49965-529, S/N 0502, which was assembled with an acceptable lubricant.

3.2.4 Chilldown Inverter Electronic Assembly

SEO 1A74039-016A modified the chilldown inverter electronics assemblies, P/N 1A74039-517, S/N's 71 and 72, to ensure that the installed zener diode, P/N 1B52278-1, would meet the environmental and operational requirements. The diode, CR13 in the assembly circuit, was checked by reverse current, forward voltage, zener voltage, and surge current tests.

3.2.5 Cold Helium Fill Module

SEO 1B57781-005 provided for special tests of the cold helium fill module, P/N 1B57781-507, S/N 0007, to check for internal leakage after cold temperature operation.

3.2.6 O2H2 Burner Assembly

SEO 1B62600-012 authorized reworking the O2H2 burner assembly, P/N 1B62600 -529, S/N 014, to update it to provide restart capability.

3.2.7 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 97, 99, 100, 103, 107, 108, 109, 110, and 177.

3.3 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/cycle accrued on each at the time of stage transfer to FTC, and the maximum allowable limits prescribed by Engineering.

Part Number and Part Name	Serial Number	Accumulated Measurement	Engineering Limits
Reliability Items (1B55425 R)			
1A48858-1 Helium Storage Sphere	1168	6 cycles	50 cycles
	1173	6 cycles	50 cycles
	1180	6 cycles	50 cycles
	1185	6 cycles	50 cycles
	1187	6 cycles	50 cycles
	1191	6 cycles	50 cycles
	1194	6 cycles	50 cycles
	1216	6 cycles	50 cycles
	1218	6 cycles	50 cycles
1A49421-507 LH2 Chilldown Pump	190	2.3 hours	100 hours total (cryogenic and dry)
		0 min*	40 minutes dry
		0 cycles*	10 cycles (dry starts)
1A49423-509 LOX Chilldown Pump	1868	1.5 hours	20 hours
1A59562-509 PU Bridge Potentiometer	5036	515 cycles	5,000 cycles
	5039	405 cycles	5,000 cycles
1A66241-511 Auxiliary Hydraulic Pump	X458911	20.2 hours	120 hours
		88 cycles	300 cycles
1B57731-501 Control Relay Package	429	85 cycles	100,000 cycles
	430	88 cycles	100,000 cycles

* Accumulated during static firing at STC only. Previous records not available.

3.3 (Continued)

Part Number and Part Name	Serial Number	Accumulated Measurement	Engineering Limits
G.F.P. Items (1B55423 H)			
40M39515-113 EBW Firing Unit	259	58 firings	1,000 firings
	260	52 firings	1,000 firings
	290	45 firings	1,000 firings
	291	45 firings	1,000 firings
40M39515-119 EBW Firing Unit	452	59 firings	1,000 firings
	550	60 firings	1,000 firings
50M10697 Command Receiver	185	84.7 hours	2,000 firings
	188	81.0 hours	2,000 firings
50M10698 Range Safety Decoder	0046	111.1 hours	2,000 hours
	0126	15.7 hours	2,000 hours
50M67864-5 Switch Selector	167	81,131 cycles	250,000 cycles
103826 J-2 Engine	J-2119		
a. Customer connect lines and inlet ducts		15.76%*	250-10,000 cycles
b. Gimbal bearing		13.83%*	250-10,000 cycles
c. Firing time		779.3 seconds	3,750 seconds
d. Helium Regulator (P/N 558130-21)	4091805	143 cycles	None Given

* These data include all engine gimbal cycles at the STC, plus cycles brought forward from the SSC records. The cycle data are expressed as a percent of design limits based on the gimbal angle, and can vary from 250 to 10,000 + cycles, as noted. The indicated percentages were computed from the Engine Log Records utilizing the graph per Rocketdyne Rocket Engine Data Manual R-3825-1.

SECTION 4

NARRATIVES

4.0 NARRATIVE

The paragraphs of this section narrate upon the stage checkout in the chronological order of testing. The major paragraphs comprising the narrative are: 4.1, Stage Prefire Checkout; 4.2, Stage Abbreviated Postfire Checkout; 4.3, Stage Deferred-Postfire Checkout; 4.4, Final Inspection; 4.5, Weight and Balance; 4.6, Preshipment Preparations; 4.7, Incomplete Tests and Retest Requirements; and 4.8, Incomplete FARR's. Each major paragraph is subdivided to the degree required to present a complete historical record of stage checkout.

Nonconformance and functional failures affecting the stage are recorded on FARR's and are referred to by serial numbers throughout the section (e.g., FARR 500-225-491 and 500-488-620). The referenced FARR's are also presented numerically by serial number in Appendix II.

4.1 Stage Prefire Checkout

Stage prefire checkouts began on 8 August 1968, with initiation of the prefire structural inspection, paragraph 4.1.1. The stage prefire checkouts were completed on 15 October 1968, with completion of the final prefire propulsion system leak check, paragraph 4.1.26. All tests required per End Item Test Plan 1B66684, change J, dated 4 May 1968, were activated and completed.

4.1.1 Structural Prefire Inspection (1B40654 B)

Performed between 8 August 1968, and 8 October 1968, this inspection verified that transportation of the stage from the Space System Center to the Sacramento Test Center had no detrimental effect on the structure, and also established the condition of the stage prior to static acceptance firing for comparison with the stage condition subsequent to a full duration static firing program.

Prior to rotating or moving the stage from the horizontal position in which it was shipped, the area between the forward skirt and the forward dome was visually inspected and determined to be free of debris.

After completion of stage installation into the test stand, the forward access kit and the protective cover kit were installed. The thrust structure access doors, P/N 1A68531-3 and P/N 1B68431-4, were removed to facilitate inspection of the thrust structure area. The main and auxiliary tunnel fairing covers; the LH2 feed line fairing assembly, P/N 1B28109; the fill, drain, and chill system fairing assembly, P/N 1B28110; the LH2 chilldown pump line fairing assembly, P/N 1B28111; and the chill system return fairing assembly, P/N 1B28112, were removed to facilitate the inspection in the respective areas. A complete external visual inspection of the stage was conducted and results recorded on QEC 339.

A visual inspection was performed on all adhesive bonded parts for voids, unbond or broken conditions, and all metal to metal bond continuity was verified by the coin tap method as prescribed in DPS 32330.

4.1.1 (Continued)

A visual inspection of the ambient helium storage spheres was accomplished to determine if any out-of-tolerance ding, scratch or finish discrepancy existed.

A radiographic inspection of the forward and aft V-section (the junction of the forward skirt and the forward dome, and the junction of the thrust structure and the aft dome) revealed foreign material in both the forward and aft V-sections. Two NAS679-3 nuts were identified in the forward V-section and two aluminum rivet particles approximately 1/4-inch long in the aft V-section. Both conditions were documented on FARR 500-225-491. The rivet particles were removed from the aft V-section area. Investigation revealed that the nuts detected in the forward V-section area were imbedded in potting compound. This condition was dispositioned as acceptable to engineering.

Additional receiving inspection discrepancies were also recorded and dispositioned on FARR-500-225-491 as follows:

a. Dings detected in the fuel vent duct were dispositioned as acceptable to engineering.

b. Minor abrasion of a flex hose for the gas generator control valve was dispositioned as acceptable.

c. Bracket and tube assembly interference on the engine was corrected by relocating the bracket.

d. Indications of possible tube assembly interference on the engine was dispositioned as acceptable.

e. Indications of foreign material in the engine combustion chamber throat area were dispositioned as acceptable.

f. Debonded areas in the aft dome mylar covering were repaired per DPS 22301.

g. Indications of weld seam corrosion on the O2H2 burner and the cold helium plenum outlet adapter were reworked by cleaning.

4.1.1 (Continued)

h. Torn rubber boots for the J1 and J2 electrical connectors were repaired.

i. One tube assembly clamp at the thrust structure was relocated per B/P.

Five revisions were recorded in the procedure for the following:

a. Three revisions updated the procedure to reflect the current hardware configurations.

b. One revision deleted the fit check for the APS modules, as it is a postfire requirement only.

c. One revision requested sweeping foreign material from the aft V-section prior to performing radiographic inspection.

4.1.2 Forward Skirt Thermoconditioning System Checkout (1B41955 C)

Prior to initiating the prefire automatic checkout of the stage at STC, the forward skirt thermoconditioning system (TCS) was functionally checked to prepare it for operation and to verify that the system was capable of supporting stage checkout operations. The procedure utilized the thermoconditioning servicer, P/N 1A78829-1, which conditioned and supplied the water/methanol heat transfer fluid to the forward skirt TCS, P/N 1B38426-513.

Checkout of the TCS was accomplished between 12 August and 14 August 1968, and was verified as acceptable on 15 August 1968. Preliminary operations included setup and connection of the servicer to the TCS and inspection of the TCS panels for open equipment mounting bolt holes and properly torqued bolts. The TCS was pressurized to 32 ± 1 psig with freon gas and leak checked with the gaseous leak detector, P/N 1B37134-1. The areas checked for leakage included all TCS B-nuts and fittings, manifold weld areas, panel inlet and outlet boss welds, and manifold bellows. No leakage was detected.

The TCS was purged with gaseous nitrogen, then water/methanol fluid was circulated through the system. Water/methanol 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. Particle counts for each micron range were well within the acceptable cleanliness limits specified. The specific gravity and temperature of the fluid were measured with a hydrometer and thermometer, respectively, determining that the water/methanol concentration was within the acceptable mixture range (delta P testing band).

4.1.2 (Continued)

A differential pressure test was conducted to verify correct system geometry and proper flow distribution. The test was accomplished by measuring the differential pressure between the TCS inlet and outlet ports, as well as the inlet and outlet temperatures, while maintaining a water/methanol flow rate of 7.8 ±0.2 gpm. The differential pressure was recorded as 14.7 psid while inlet and outlet temperatures were recorded at 56°F and 58°F, respectively.

The final step consisted of the TCS operation with the servicer at the required temperatures, pressures, and flow rate while visually checking for the leakage of all water lines, internal piping, and supply and return lines to the TCS. No leakage was detected. The TCS operation demonstrated that the system was prepared to support prefire checkout activities on the test stand.

There were no revisions recorded against the procedure, no were any FARR's generated as a result of the checkout.

4.1.3 Umbilical Interface Compatibility Check (1B64316 E)

Prior to connecting the forward and aft umbilical cables for stage power setup, this manual checkout provided the test sequences which were used to check the design specifications and the continuity of the stage umbilical wiring. Accomplished by point-to-point resistance checks of all umbilical circuits, this test ensured that the proper loads were present on all power buses, and that the control circuit resistances for the propulsion valves and safety items on the stage were within the prescribed tolerances.

The procedure was initiated on 12 August 1968, and was accepted on 19 August 1968. A series of resistance checks were made at specified test points on the signal distribution unit, P/N 1A59949-1, using test point terminal 463A1A5-J43FF as the common test point for all measurements. These measurements verified 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 4.1.3.1.

No FARR's were generated as a result of this checkout. There were three revisions written to this procedure as follows:

a. One revision deleted the requirement for a Triplett model 630 multimeter, as this model was not equivalent to the Simpson 260 for diode measurements.

b. One revision corrected a typographical error.

c. One revision accepted the infinite resistance measurement of test points A2J29-J and A2J29-q, as the value was expected since the pneumatic power control module had been removed for rework.

4.1.3.1 Test Data Table, Umbilical Interface Compatibility Check

Reference Designation 463A2

Test Point	Function	Meas. Ohms	Limit Ohms
A2J29-C	Cmd., Ambient Helium Sphere Dump	26	10-60
CB-8-2	Cmd., Engine Ignition Bus Pwr Off	Inf	Inf.
CB-9-2	Cmd., Engine Ignition Bus Pwr On	20	5-100
CB-10-2	Cmd., Engine Control Bus Pwr Off	Inf	Inf
CB-11-2	Cmd., Engine Control Bus Pwr On	12	5-100
A2J29-N	Cmd., Engine He Emerg Vent Control On	45	10-60
A2J29-P	Cmd., Fuel Tnk Repress He Dump Vlv Open	33	10-60
A2J29-Y	Cmd., Start Tnk Vent Pilot Vlv Open	Inf†	10-60
CB-4-2	Cmd., LOX Tank Cold He Sphere Dump	26	10-60
A2J29-c	Cmd., LOX Tnk Repress He Sphere Dump	33	10-60
A2J29-$\bar{h}$	Cmd., Fuel Tnk Vent Pilot Vlv Open	58	10-300
	(Same, reverse polarity)	Inf	500k min
A2J29-$\underline{i}$	Cmd., Fuel Tnk Vent Vlv Boost Close	58	10-80
	(Same, reverse polarity)	Inf	500k min
A2J29-$\underline{q}$	Cmd., Amb He Supply Shutoff Vlv Close	Inf†	10-60
A2J30-$\bar{H}$	Cmd., Cold He Supply Shutoff Vlv Close	1.25k	1.5k max
	(Same, reverse polarity)	Inf	Inf
A2J30-W	Cmd., LOX Vent Valve Open	54	10-80
	(Same, reverse polarity)	Inf	500k min
A2J30-X	Cmd., LOX Vent Valve Close	54	10-80
	(Same, reverse polarity)	Inf	500k min
A2J30-Y	Cmd., LOX & Fuel Prevlv Emerg Close	56	10-80
	(Same, reverse polarity)	Inf	Inf
A2J30-Z	Cmd., LOX & Fuel Chilldown Vlv Close	60	10-80
	(Same, reverse polarity)	Inf	500k min
A2J30-b	Cmd., LOX F&D Valve Boost Close	27	10-40
A2J30-$\bar{c}$	Cmd., LOX F&D Valve Open	27	10-40
A2J30-$\bar{d}$	Cmd. Fuel F&D Valve Boost Close	27	10-40
A2J30-$\bar{e}$	Cmd., Fuel F&D Valve Open	27	10-40
A2J42-$\bar{F}$	Meas. Bus +4D111 Regulation	115	100 min
A2J35-$\underline{y}$	Meas. Bus +4D141 Regulation	750	50 min
42J6-A$\bar{A}$	Sup. 28v Bus +4D119 Talkback Power	80	60-120

Reference Designation 463A1

A5J41-A	Meas. Bus +4D131 Regulation	200	20 min
A5J41-E	Meas. Bus +4D121 Regulation	2.4k	1.6k min
A5J53-AA	Sup. 28v 4D119 Fwd Talkback Pwr	60	60-100

† See revision c

4.1.4 Stage Power Setup (1B55813 H)

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

The procedure was satisfactorily accomplished on 13 August 1968; however, a second performance was accomplished on 13 August 1968, to verify that the correct shorting plug was installed in the BO multiplexer, P/N 1B58628-1. An incorrect shorting plug resulted in malfunction printouts for the aft 1, forward 1, and forward 2 five volt excitation modules during the first run. A third run of the procedure was accomplished on 14 August 1968, to apply power to the stage buses for further stage checkouts. A final run on 16 August 1968, was accomplished to include a revision that had been inadvertently omitted from the paper tape changes in the first three runs. The following narration and the measurement values in Test Data Table 4.1.4.1 are from the last run.

The test started by resetting all of the matrix magnetic latching relays, then verifying that the corresponding command relays were in the proper state. Verification was made that the umbilical connectors were mated and that the LOX and LH2 inverters were disconnected. The bus 4D119 talkback power was turned on, and the prelaunch checkout group power was turned off. The forward power and the aft power buses were transferred to external power. The sequencer

4.1.4 (Continued)

power, engine control bus power, engine ignition bus power, APS bus 1 and bus 2 power, and propellant level sensor power were all verified to be off. The power to the range safety system 1 and 2 receivers and the EBW firing units was transferred to external and verified to be off. The switch selector checkout indication enable and the flight measurement indication enable were turned on.

The forward bus 1, 28 vdc power supply was turned on, and the forward bus 1 initial current and voltage were measured. The range safety safe and arm device was verified to be in the safe condition.

The 70 pound ullage engine relay, the LH2 continuous vent valve relay, the LH2 and LOX repressurization mode relay, the LOX repressurization control valve relay, and the O2H2 burner propellant valve relay were reset. The LH2 continuous vent and relief override valve was verified to be closed.

The propellant utilization boiloff bias was turned off. The O2H2 burner spark system 1 and 2 voltages were measured and recorded. It was verified that the O2H2 burner LOX valve, LOX shutdown valve, LH2 valve, and the LH2 continuous vent orificed bypass valve were closed.

The forward bus 1 quiescent current was measured. The PCM system group was turned on, and the amperage of the PCM system group was measured. The forward bus 2, 28 vdc power supply was turned on, and the forward bus 2 current and voltage were measured. The forward 2 local sensor was verified to be off.

4.1.4 (Continued)

The prelaunch checkout group power was turned on, and the current was measured; then, the DDAS ground station source selector switch was manually set to position 1, and it was verified that the ground station was in synchronization.

The cold helium supply shutoff valve was closed. The aft bus 1, 28 vdc power supply was turned on, and the aft 1 power supply current and voltage were measured. The aft 1 local sensor and the EBW pulse sensor were verified to be off. Sequencer power was then turned on, and its current was measured. The forward and aft battery load tests were turned off and verified to be off.

A series of checks then verified that stage functions were in the proper state. Forty functions were verified to be off, and twenty-three functions were verified to be on. The LOX and LH2 prevalves and chilldown shutoff valves were verified to be open, and the LOX and LH2 vent valves and fill and drain valves were verified to be closed; then, the forward and aft 5 volt exciation module voltages, the range safety EBW firing unit charging voltages, the aft bus 2 voltage, the forward and aft battery simulator voltages, and the component test power voltage were measured.

The initial condition scan portion of the procedure was then functioned. The stage talkback power was turned on; and the forward bus 1, the forward bus 2, and the aft bus 1 voltages were measured. A series of tests then verified that twenty-six functions were on and that fifty-three functions were off. The LOX and LH2 prevalves and chilldown shutoff valves were verified to be open. The LOX and LH2 vent valves and fill and drain valves were verified to be closed.

4.1.4 (Continued)

The aft and forward 5 volt exciation module voltages, the range safety 1 and 2 EBW firing unit charging voltages, the aft bus, and the forward and aft battery simulator voltages were measured. Six commands were verified to be on, and the PU LH2 boiloff bias on indication was verified to be off. The O2H2 burner spark system 1 and 2 monitor voltages were measured; then, the O2H2 burner LOX propellant and shutdown valve, the O2H2 burner LH2 propellant valve and the continuous vent orificed bypass valve were verified to be closed. This completed the initial conditions scan portion of the test.

No FARR's were written as a result of this checkout. There were twenty revisions written against the procedure for the following:

a. Five revisions corrected programming errors by making COAL statements.

b. Two revisions attributed the LH2 continuous vent orificed bypass valve not closed and the O2H2 LH2 valve not closed malfunctions, to the valves being mechanically locked in the open position to support the LH2 tank environment. These valves are functionally operated and the open and closed talkback is verified in the propulsion system automatic procedure, 1B62753. The intent of the stage power setup is not violated if these valves are not in the closed position.

c. One revision deleted the turnoff commands for the LOX chilldown pump purge as the pump purge module had been removed on ECP 2620.

d. One revision added the ALCO changes needed to insure that the single sideband transmitter was off.

e. One revision changed the tolerance of the forward 1, the forward 2, and the aft 1 power supply voltages from 28 $\pm$.5 vdc to 28 $\pm$2.0 vdc, to compensate for the temporary removal of the sense line filters.

f. One revision deleted the reference to the TM system control console. The console is no longer installed in the test control center.

4.1.4 (Continued)

g. One revision stated that the E01 printouts, and the indication of noise on channel 5 was due to improper setup of the response conditioner.

h. One revision attributed the stage power setup not completed printout to the malfunction indications encountered.

i. One revision stated that the SIM interrupt on channel 72 was the result of the cycling of the talkback power after run 1.

j. One revision attributed the out-of-tolerance condition of the aft 1, the forward 1, and the forward 2 five volt excitation modules to an incorrect configuration shorting plug for the BO multiplexer.

k. One revision attributed the forward bus 1 voltage out-of-tolerance condition malfunction to an improper initial setup voltage. The voltage was readjusted and the output was verified to be 28 $\pm$.5 vdc.

l. One revision concerned an ALCO program change required to change a measurement from the power supply current to the secondary battery current in the SIM interrupt routine for SIM channels 31, 32, 34, and 35.

m. One revision authorized the performance of run 2 of stage power setup to verify that the correct shorting plug was installed in the BO multiplexer.

n. One revision concerned the performance of run 3 of stage power setup to continue stage checkout.

o. One revision stated that revision c had been inadvertently omitted from the paper tape changes to runs 1, 2, and 3. The revision was incorporated in run 4.

4.1.4.1 Test Data Table, Stage Power Setup

Function	Measured Value	Limits
Forward Bus 1 Power Supply Current (amps)	1.800	20 max
Bus 4D31 Forward 1 Voltage (vdc)	27.759	28 + 2
02H2 Burner Spark System 1 Voltage (vdc)	-0.015	0 ∓ 0.5
02H2 Burner Spark System 2 Voltage (vdc)	0.079	0 ∓ 0.5
Forward Bus 1 Quiescent Current (amps)	1.699	5 max

4.1.4.1 (Continued)

Function	Measured Value	Limits
PCM System Group Current (amps)	4.500	5 ± 3
Prelaunch Checkout Group Current (amps)	2.100	1 ∓ 3
Aft 1 Power Supply Current (amps)	-1.100	2 max
Aft 1 Power Supply Voltage (vdc)	28.158	28 ± 0.5
Sequencer Power (amps)	0.100	3 max
Aft 5V Excitation Module Voltage (vdc)	4.996	5 ± 0.030
Fwd 1 5V Excitation Module Voltage (vdc)	5.004	5 ∓ 0.030
Fwd 2 5V Excitation Module Voltage (vdc)	4.996	5 ∓ 0.030
Range Safety 1 EBW Firing Unit Chg Voltage (vdc)	0.000	0 ∓ 1
Range Safety 2 EBW Firing Unit Chg Voltage (vdc)	0.020	0 ∓ 1
Bus 4D41 Aft Bus 2 Voltage (vdc)	0.000	0 ∓ 1
Bus 4D30 Fwd Battery 1 Voltage (vdc)	0.079	0 ∓ 1
Bus 4D20 Fwd Battery 2 Voltage (vdc)	0.039	0 ∓ 1
Bus 4D10 Aft Battery 1 Voltage (vdc)	0.000	0 ∓ 1
Bus 4D40 Aft Battery 2 Voltage (vdc)	0.159	0 ∓ 1
Component Test Power Voltage (vdc)	0.600	0 ∓ 1

4.1.5 Stage Power Turnoff (1B55814 G)

The stage power turnoff procedure was used for automatic shutdown of the stage power distribution system, returning the stage to the de-energized condition after completion of the various system checkout procedures during prefire testing of the stage. The procedure deactivated stage relays so that no current flowed from the battery simulators through the stage wiring. All internal/external transfer relays were set to the external condition.

The first demonstration of this procedure was accomplished on 13 August 1968. A second run was accomplished on 14 August 1968, to return the stage to a de-energized condition at the end of the work day. On 15 August 1968, a third run was performed to incorporate two revisions that were not included in the first two runs. A fourth and final demonstration was accomplished on 16 August 1968. Stage power turnoff measurement values for the fourth demonstration are tabulated in Test Data Table 4.1.5.1. Following this, the stage power turnoff

4.1.5 (Continued)

procedure was used to shutdown the stage at the conclusion of the various automatic checkouts conducted during prefire operations.

The automatic stage power turnoff was started with verification that the umbilical connectors were mated and that the flight measurement indication enable was turned on. The bus 4D119 talkback power; the forward bus 1 and aft bus 1, 28 vdc power supplies; and the sequencer power were all verified to be on. The forward bus and aft bus 1 voltages were then measured.

Switch selector functions were then turned off, and a series of checks verified that the stage electrical functions were in the proper state of off or reset. The forward and aft bus power supplies were verified as off, and the forward and aft bus battery simulator voltages were measured. Stage buses were then transferred to external power, and the forward and aft stage bus voltages were measured. The EBW pulse sensor power was turned off, and the range safety receivers and EBW firing units were transferred to external power. The range safety system safe and arm device was verified to be on safe, and the bus 4D119 talkback power was turned off. The matrix magnetic latching relays were then reset, completing this demonstration run for stage power turnoff.

4.1.5 (Continued)

No FARR's were generated as a result of this checkout. Eight revisions were recorded to the procedure for the following:

a. Two revisions concerned the LH2 continuous vent orificed bypass valve and the O2H2 burner LH2 valve "not closed" malfunctions. These valves were mechanically locked in the open position in support of the LH2 tank environment.

b. One revision changed the program to turn the single sideband power off except during range safety receiver check, single sideband checkout, electromagnetic compatibilities checkout, and the all systems test.

c. One revision deleted the turnoff commands for the LOX chilldown pump purge dump valve and the LOX chilldown pump purge continuous valve as the pump purge module was removed per ECP 2620.

d. One revision stated that a second run was required to return the stage to a de-energized condition at the end of the work shift.

e. One revision was required to correct a program error.

f. One revision attributed the aft bus 2 "not off" malfunction to the turnoff command and the measure aft bus 2 voltage command being applied at the same time. A delay of 5 seconds is required for the power supply to decay to zero volts.

g. One revision authorized run 3 to incorporate revisions b and c which were not accomplished during the second run.

4.1.5.1 Test Data Table, Stage Power Turnoff

Function	Measurement	Limits
Forward Bus 1 Voltage, Power On (vdc)	28.079	28 ± 2
Aft Bus 1 Voltage, Power On (vdc)	28.118	28 ± 2
O2H2 Burner Spark System 1 Voltage (vdc)	0.000	0 ± 0.5
O2H2 Burner Spark System 2 Voltage (vdc)	0.034	0 ± 0.5
Forward Bus 1 Battery Simulator Voltage (vdc)	0.039	0 ± 2
Forward Bus 2 Battery Simulator Voltage (vdc)	0.000	0 ± 2
Aft Bus 1 Battery Simulator Voltage (vdc)	0.000	0 ± 2
Aft Bus 2 Battery Simulator Voltage (vdc)	0.000	0 ± 2
Forward Bus 1 Voltage, Power Off (vdc)	0.079	0 ± 1
Forward Bus 2 Voltage, Power Off (vdc)	0.000	0 ± 1
Aft Bus 1 Voltage, Power Off (vdc)	0.039	0 ± 1
Aft Bus 2 Voltage, Power Off (vdc)	0.000	0 ± 1

4.1.6 Power Distribution System (1B55815 H)

The automatic checkout of the stage power distribution system, during prefire operation, verified the capability of the GSE to control power switching to and within the stage and determined that initial static loads within the stage were not excessive. The procedure verified that particular stage relays were energized or de-energized, as required, and that bi-level talkback indications were received at the GSE. Static loading of the various stage systems was determined by measuring the GSE supply current before and after power on of each system.

The power distribution system test was satisfactorily conducted on 14 August 1968. Due to rewiring of the sequencer panel per 1B55397, a second issue was required on 4 September 1968, to verify proper operation of the T/M RF silence, the RF assembly, and the LOX hardwire frequency. The first attempt of the second issue was aborted due to an out-of-tolerance malfunction of the PCM RF assembly. This was attributed to a wire being pulled out of pin A of the 411W200 P4 connector, which blocked the PCM RF assembly on command to the RF transmitter. The discussion that follows and the measurements listed in the Test Data Table 4.1.6.1 are limited to the final test on 4 September 1968.

The initial conditions scan was conducted per the stage power setup, H&CO 1B55813, and initial conditions were established for the test. Starting with engine control bus power on, the current differential for the aft 1 power supply was measured. The engine control bus voltage M6 was measured and determined to be within tolerance. The APS bus power was turned on, and again the current differential for the aft 1 power supply was measured. This operation

4.1.6 (Continued)

was repeated for the engine ignition bus by measuring aft 1 power supply current differential and engine control bus voltage M7. The engine ignition bus power and APS bus power were then turned off and verified.

The engine safety cutoff system (ESCS) power was turned on, and the aft 1 power supply current measured. The component test power was turned on, and the aft 1 power supply current differential and component test power voltage were measured. The component test power was turned off and verified to be off by measurement of the voltage. ESCS power was then turned off.

To check the emergency detection system (EDS), verification was made that the EDS 2 engine cutoff signal turned off the engine control bus power, prevented it from being turned back on, and also turned on the instrument unit (IU) 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 made that the EDS 1 engine cutoff signal turned on the nonprogrammed engine cutoff signal and the AO multiplexer engine cutoff signal indication (K13). With the EDS 1 engine cutoff signal turned off, the engine ready bypass on turned off both the nonprogrammed engine cutoff signal and the AO multiplexer engine cutoff signal indications.

The propellant point level sensor test was started by turning on the propellant level sensor power and measuring the resulting current differential for the forward 1 power supply. Next, each of the four LH2 tank and four LOX tank point level sensors was verified to respond to simulated wet condition on commands within the allowable 300 milliseconds tolerance. A series of checks verified

4.1.6 (Continued)

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 point level sensors 1 and 2, the LOX depletion engine cutoff timer value was measured to determine engine cutoff signal delay time. Each of the point level sensors was verified to respond to simulated wet condition off commands within the allowable 300 milliseconds tolerance. This completed the point level sensor testing.

Verification was made that the engine cutoff command turned on the AO multiplexer engine cutoff signal indication (K13), the engine cutoff indication (K140), and the engine cutoff; and that the nonprogrammed engine cutoff indication was not turned on as a result of the engine cutoff on command. With the engine cutoff command turned off, K140 was verified as off while K13, engine cutoff, remained on until turned off by the engine ready bypass.

The propellant utilization (PU) inverter and electronics power supply current differentials were measured while power was momentarily turned on. The PCM RF assembly power was turned on, the RF group was verified to be on, the power supply differential current was measured, and the PCM RF transmitter output wattage 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 RF transmitter output wattage was measured through the AO multiplexer; the switch selector output monitor voltage (K128) was measured with the PCM RF assembly power, and the switch selector 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 RF transmitter output wattage was again measured through the AO multiplexer.

4.1.6 (Continued)

The rate gyro voltages were manually verified to be 28.0 $\pm$2.0 vdc with gyro power turned on and 0.0 $\pm$2.0 vdc with gyro power turned off. The aft 2 power supply was verified to be within the 56.0 $\pm$1.0 vdc tolerance. Bus 4D141, 56 volt supply was turned on; the voltage was measured; and the aft 2 power supply current was measured. The aft 2 power supply local sense indication was verified to be off. The chilldown pump simulator was connected to the LOX and LH2 chilldown inverters; and for each inverter, measurements were made of the current, the phase voltages, and the operating fequency. The inverter voltages and frequencies were monitored and measured through hardwire and telemetry.

A series of automatic checks verified the operation of the external/internal transfer system for forward buses 1 and 2 and aft buses 1 and 2. The battery simulator voltages and the electrical support equipment load bank voltages were measured initially; then, the power bus voltages were 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 verified that the switch selector register was operating properly and that the instrument unit 28 vdc power supplies were on. Power was turned on to the range safety receivers after they were transferred to external power, and the resulting GSE power supply current differentials were

4.1.6 (Continued)

measured. The range safety EBW firing units were verified to be on when they were transferred to external power and momentarily turned on. This completed the power distribution test.

There were no part shortages affecting the test and no problems resulting in the initiation of FARR's. A total of thirty-one revisions were recorded in both issues of the procedure as follows:

a. Twelve revisions added or changed requirements that were missing or in error.

b. Two revisions attributed the SIM interrupt on channel 47 and a malfunction indication to an operators error.

c. One revision provided instructions for a functional check of the power distribution system associated with the single side-band system, in order to verify that the static load on the power bus was within specified tolerances.

d. One revision changed the power supply voltage tolerance from 28 $\pm$.5 vdc to 28 $\pm$2.0 vdc, as the voltage must be set at 26.7 vdc, without load, due to temporary removal of the sense line filters.

e. One revision attributed the SIM interrupts on channels 14 and 24 to SIM being enabled with stage power off.

f. One revision attributed the LH2 continuous vent orificed by-pass valve "not closed" malfunction to the valve being manually locked in the open position in support of the LH2 tank environment.

g. One revision concerned the O2H2 burner LH2 valve "not closed" printout. The valve was mechanically located between the full open and full closed positions.

h. One revision attributed the propellant level sensor current out-of-tolerance to a noise level of from 1 to 2 percent. The program was looped back and the second reading was within tolerance.

4.1.6 (Continued)

i. One revision stated that the T/M RF silence not on malfunction was due to an incorrectly wired cable assembly, P/N 1B68887. The cable assembly was rewired and no further problems were encountered.

j. One revision attributed the RF assembly off malfunction to reversed wires in plug P2 of cable assembly, P/N 1B67179 E. The problem was corrected.

k. One revision stated that a loose GSE cable connection at the LOX chilldown simulator load caused the LOX and LH2 inverter frequency out-of-tolerance condition.

l. One revision authorized the second performance of the procedure to verify the proper operation of the T/M RF silence, the RF assembly and the LOX chilldown hardwire frequency after rewiring of the sequencer panel per 1B55397.

m. One revision stated that during the initial condition scan the sequencer power was not turned on, resulting in a malfunction printout.

n. One revision stated that the SIM interrupts on channels 83 and 84 were due to the engine restrainer links being dropped to facilitate the pneumatic setup of the engaging pins.

o. One revision concerned the out-of-tolerance condition of the PCM RF assembly and stated that investigation revealed that a wire had pulled out of Pin A of connector 411W200 P4. This prevented the on command from reaching the transmitter.

p. One revision attributed the out-of-tolerance condition of the forward 1 battery and the SIM interrupts on channels 22 and 24 to a circuit breaker being cycled at model 133 to ensure proper setting.

q. Two revisions were written and subsequently voided.

r. One revision was written to clarify a previous revision.

4.1.6.1 Test Data Table, Power Distribution System

Function	Measurement	Limits
Engine Control Bus Current (amps)	0.000	2 + 2
Engine Control Bus Voltage (vdc)	27.845*	Bus 4D11 ∓ 1
APS Bus Current (amps)	1.300	1.5 ∓ 3
Engine Ignition Bus Current (amps)	0.000	0 ∓ 2
Engine Ignition Bus Voltage, On (vdc)	27.783*	Bus 4D11 ∓ 1
Engine Ignition Bus Voltage, Off (vdc)	0.000	0 ∓ 0.45
Component Test Power Current (amps)	0.000	0 ∓ 2
Component Test Power Voltage, On (vdc)	27.999	28 ∓ 2
Component Test Power Voltage, Off (vdc)	0.640	0 ∓ 1
Engine Control Bus Voltage, EDS 2 On (vdc)	0.000	0 ∓ 0.450
Engine Control Bus Voltage, EDS 2 Off (vdc)	27.845*	Bus 4D11 ∓ 1
Propellant Level Sensor Power Current (amps)	0.000	1 ∓ 2
LOX Depletion Engine Cutoff Timer (sec)	0.548	0.560 ∓ 0.025
PU Inverter & Electronics Power Current (amps)	4.100	3 ∓ 2
PCM RF Assembly Power Current (amps)	4.800	4.5 ∓ 3.0
PCM RF Transmitter Output Power, AO (watts)	25.013	10 min
PCM RF Transmitter Output Power, BO (watts)	24.954	10 min
PCM RF Transmitter Output Power, AO T/M RF Silence On (watts)	0.148	0 + 2
Switch Selector Output Monitor, K128 (vdc)	2.133	2 ∓ 0.425
PCM RF Transmitter Output Power, AO T/M RF Silence Off (watts)	24.895	10 min
Aft Bus 2 Current (amps)	0.000	5 max
Aft Bus 2 Voltage (vdc)	55.038	56 ± 1

Chilldown Inverter Tests

Function	LOX Inv.	LH2 Inv.	Limits
Inverter Current (amps)	20.728	20.235	20.0 + 5.0
Phase AB Voltage, Hardwire (vac)	54.431*	54.366*	Bus 4D41 ∓ 3
Phase AC Voltage, Hardwire (vac)	53.715*	53.779*	Bus 4D41 ∓ 3
Phase A1B1 Voltage, Hardwire (vac)	54.300*	54.366*	Bus 4D41 ∓ 3
Phase A1C1 Voltage, Hardwire (vac)	53.584*	54.170*	Bus 4D41 ∓ 3
Frequency, Hardwire (Hz)	400.00	401.00	400.0 ∓ 4.0
Phase AB Voltage, Telemetry (vac)	55.132*	55.465*	Bus 4D41 ∓ 3
Phase AC Voltage, Telemetry (vac)	55.398*	55.665*	Bus 4D41 ∓ 3
Frequency, Telemetry (Hz)	399.883	400.539	400.0 ∓ 4.0

Function	Measurement	Limits
Forward Battery 1 Simulator Voltage (vdc)	28.239	28 + 2
Forward Battery 2 Simulator Voltage (vdc)	27.879	28 ∓ 2
Aft Battery 1 Simulator Voltage (vdc)	28.079	28 ∓ 2
Aft Battery 2 Simulator Voltage (vdc)	56.158	56 ∓ 4

* In Tolerance, Actual Voltage Limits Not Specified

4.1.6.1 (Continued)

Function	Measurement	Limits
Bus 4D20 ESE Load Bank (vdc)	0.039	0 ± 1
Bus 4D40 ESE Load Bank (vdc)	0.000	0 ± 1
Bus 4D30 ESE Load Bank (vdc)	-0.039	0 ± 1
Bus 4D10 ESE Load Bank (vdc)	0.000	0 ± 1
Forward Bus 1 Voltage-Internal (vdc)	27.879	28 ± 2
Forward Bus 2 Voltage-Internal (vdc)	27.799	28 ± 2
Aft Bus 1 Voltage-Internal (vdc)	27.999	28 ± 2
Aft Bus 1 Voltage-External (vdc)	28.079	28 ± 2
Aft Battery 1 Voltage (vdc)	0.239	0 ± 1
Aft Bus 2 Voltage-Internal (vdc)	55.999	56 ±.4
Aft Bus 2 Voltage-External (vdc)	56.398	56 ± 4
Aft Battery 2 Voltage (vdc)	0.319	0 ± 1
Forward Bus 1 Voltage-External (vdc)	27.999	28 ± 2
Forward Battery 1 Voltage (vdc)	0.039	0 ± 1
Forward Bus 2 Voltage-External (vdc)	27.879	28 ± 2
Forward Battery 2 Voltage (vdc)	0.079	0 ± 1
Aft Bus 2 Voltage, Off (vdc)	0.000	0 ± 1
Range Safety Receiver 1 External Power Current (amps)	0.249	0 ± 2
Range Safety Receiver 2 External Power Current (amps)	0.251	0 ± 2

4.1.7 APS Interface Compatibility Checkout (1B49558 B)

Initiated, accomplished, and accepted on 14 August 1968, this manual checkout specified and provided instructions for compatibility and continuity test requirements that were performed subsequent to installation of the auxiliary propulsion system (APS) simulators, P/N 1B56715-1, and prior to the operational checkout of stage systems pertinent to APS circuitry.

The check was started with a visual inspection of all plugs and connectors involved in this test for bent or broken pins and other physical defects. Proper connection between the control relay packages, the aft skirt components, and the APS simulators was verified by point-to-point resistance measurements as shown in Test Data Table 4.1.7.1.

There were no shortages or interim use material items installed at the start of this test, nor were any revisions made to the procedure. No FARR's were generated as a result of this test.

4.1.7.1 Test Data Table, APS Interface Compatibility

Common Test Point: Stage Ground

Test Point	Component Nomenclature	Meas. Ohms	Limit Ohms
404A51A4 J4 A	414A8L1 Eng. 1 Valve A	26	25 ± 5
404A51A4 J4 B	414A8L5 Eng. 1 Valve 1	26	25 ± 5
404A51A4 J4 C	414A8L2 Eng. 1 Valve C	26	25 ± 5
404A51A4 J4 D	414A8L6 Eng. 1 Valve 3	26	25 ± 5
404A51A4 J4 E	414A8L3 Eng. 1 Valve B	26	25 ± 5
404A51A4 J4 F	414A8L7 Eng. 1 Valve 2	26	25 ± 5
404A51A4 J4 G	414A8L4 Eng. 1 Valve D	26	25 ± 5
404A51A4 J4 H	414A8L8 Eng. 1 Valve 4	26	25 ± 5
404A51A4 J4 J	414A10L1 Eng. 3 Valve A	26.5	25 ± 5
404A51A4 J4 K	414A10L5 Eng. 3 Valve 1	26.5	25 ± 5
404A51A4 J4 L	414A10L2 Eng. 3 Valve C	26.5	25 ± 5
404A51A4 J4 M	414A10L6 Eng. 3 Valve 3	26.5	25 ± 5
404A51A4 J4 N	414A10L3 Eng. 3 Valve B	26.5	25 ± 5

4.1.7.1 (Continued)

Test Point	Component Nomenclature	Meas. Ohms	Limit Ohms
404A51A4 J4 P	414A10L7 Eng. 3 Valve 2	26	25 + 5
404A51A4 J4 R	414A10L4 Eng. 3 Valve D	26	25 ∓ 5
404A51A4 J4 S	414A10L8 Eng. 3 Valve 4	26	25 ∓ 5
404A51A4 J4 T	414A9L1 Eng. 2 Valve A	26.5	25 ∓ 5
404A51A4 J4 U	414A9L5 Eng. 2 Valve 1	26	25 ∓ 5
404A51A4 J4 V	414A9L2 Eng. 2 Valve C	26.5	25 ∓ 5
404A51A4 J4 W	414A9L6 Eng. 2 Valve 3	26.5	25 ∓ 5
404A51A4 J4 X	414A9L3 Eng. 2 Valve B	26	25 ∓ 5
404A51A4 J4 Y	414A9L7 Eng. 2 Valve 2	26	25 ∓ 5
404A51A4 J4 Z	414A9L4 Eng. 2 Valve D	26.5	25 ∓ 5
404A51A4 J4 a	414A9L8 Eng. 2 Valve 4	26	25 ∓ 5
404A71A19 J4 A	415A8L1 Eng. 1 Valve A	26	25 + 5
404A71A19 J4 B	415A8L5 Eng. 1 Valve 1	26	25 ∓ 5
404A71A19 J4 C	415A8L2 Eng. 1 Valve C	26	25 ∓ 5
404A71A19 J4 D	415A8L6 Eng. 1 Valve 3	26	25 ∓ 5
404A71A19 J4 E	415A8L3 Eng. 1 Valve B	26	25 ∓ 5
404A71A19 J4 F	415A8L7 Eng. 1 Valve 2	26	25 ∓ 5
404A71A19 J4 G	415A8L4 Eng. 1 Valve D	26	25 ∓ 5
404A71A19 J4 H	415A8L8 Eng. 1 Valve 4	26	25 ∓ 5
404A71A19 J4 J	415A10L1 Eng. 3 Valve A	26	25 ∓ 5
404A71A19 J4 K	415A10L5 Eng. 3 Valve 1	26	25 ∓ 5
404A71A19 J4 L	415A10L2 Eng. 3 Valve C	26	25 ∓ 5
404A71A19 J4 M	415A10L6 Eng. 3 Valve 3	26	25 ∓ 5
404A71A19 J4 N	415A10L3 Eng. 3 Valve B	26	25 ∓ 5
404A71A19 J4 P	415A10L7 Eng. 3 Valve 2	26.5	25 ∓ 5
404A71A19 J4 R	415A10L4 Eng. 3 Valve D	26.5	25 ∓ 5
404A71A19 J4 S	415A10L8 Eng. 3 Valve 4	26.5	25 ∓ 5
404A71A19 J4 T	415A9L1 Eng. 2 Valve A	26	25 ∓ 5
404A71A19 J4 U	415A9L5 Eng. 2 Valve 1	26	25 ∓ 5
404A71A19 J4 V	415A9L2 Eng. 2 Valve C	26	25 ∓ 5
404A71A19 J4 W	415A9L6 Eng. 2 Valve 3	26	25 ∓ 5
404A71A19 J4 X	415A9L3 Eng. 2 Valve B	26	25 ∓ 5
404A71A19 J4 Y	415A9L7 Eng. 2 Valve 2	26	25 ∓ 5
404A71A19 J4 Z	415A9L4 Eng. 2 Valve D	26.5	25 ∓ 5
404A71A19 J4 a	415A9L8 Eng. 2 Valve 4	26.5	25 ∓ 5
404A4 J7 r	414A5L1	600	550 - 650
404A4 J7 d	414A5L1	550	550 - 650
404A4 J7 p	414A6L1	600	550 - 650
404A4 J7 x	414A1L1	600	550 - 650
404A4 J7 f	414A1L1	600	550 - 650
404A4 J7 v	414A2L1	600	550 - 650
404A4 J7 m	414A6L2	550	550 - 650
404A4 J7 t	414A2L2	600	550 - 650
404A4 J7 z	Spare	Inf	10 meg min

4.1.7.1 (Continued)

Test Point		Component Nomenclature	Meas. Ohms	Limit Ohms
404A4	J7 q	415A5L1	600	550 - 650
404A4	J7 c	415A5L1	600	550 - 650
404A4	J7 n	415A6L1	550	550 - 650
404A4	J7 w	415A1L1	600	550 - 650
404A4	J7 e	415A1L1	575	550 - 650
404A4	J7 u	415A2L1	575	550 - 650
404A4	J7 k	415A6L2	575	550 - 650
404A4	J7 s	415A2L2	600	550 - 650
404A4	J7 y	Spare	Inf	10 meg min
404A2A16	J2 B	414A7L1 Eng. 4 Valve A	575	550 - 650
404A2A16	J2 C	414A7L2 Eng. 4 Valve 1	600	550 - 650
404A2A16	J2 A	415A7L1 Eng. 4 Valve A	625	550 - 650
404A2A16	J2 D	415A7L2 Eng. 4 Valve 1	575	550 - 650

4.1.8 Preliminary Propulsion Leak and Functional Check (1B71877 C)

This checkout procedure defined the operations required to perform the leak and functional checks which certified the stage propulsion system preparatory to static firing. All portions pertaining to S-IB stages and postfire operations were deleted. The prefire test sequences performed during this checkout were initiated on 14 August 1968, and were completed on 2 October 1968. Leak check results for the individual propulsion system components are listed in Test Data Table 4.1.8.1.

After preliminary setup operations, the O2H2 burner prefire checks were accomplished. The burner was inspected for external signs of damage or loose equipment. The burner injector faces and igniter tips were inspected for cracks and excessive erosion. The injectors were attached to the burner using safety wire, such that the injector faces and igniter tips were visible for the O2H2 burner sparks check. In addition to obtaining oscillograph record spark traces for both igniters, visual observation of the spark gap verified constant arcing in or around the bore for each igniter during the 5-second application of exciter power. The injectors and feed lines were then installed for the leak checks.

The cold helium fill module was checked for internal leakage and relief valve cracking and reseat pressures. This checkout was made in the LOX service lab per procedure requirement, after which the module was reinstalled on the stage.

The calip pressure switch system checks consisted of 5-minute pressure decay tests for the pressure switch checkout circuits and a 15-minute pressure decay

4.1.8 (Continued)

check of the engine mainstage pressure switch diaphragm. The LOX and LH2 pressure switch checkout circuits were pressurized to 30 ±5 psia for these decay checks, the low pressure switch checkout circuit at 600 ±10 psia, the mainstage pressure switch checkout circuit at 550 ±10 psia, and the mainstage pressure switch diaphragm check at 400 ±10 psig. All decay rates were acceptable, as noted in the test data table. However, it was necessary to replace an aft umbilical quick disconnect, which was found to be leaking while bringing pressures up for the LH2 pressure switch checkout circuit decay check.

Stage integrity checks included high pressure proof tests of stage system spheres after verifying that no audible leakage existed for these systems. The ambient helium system and cold helium systems were checked for audible leakage with the spheres pressurized to 300 ±50 psig. The engine start system was checked audibly with the start tank at 250 ±50 psia. Proof checks were then conducted with the ambient helium control and repressurization spheres pressurized to 3100 ±100 psig for 5 minutes, the engine start tank at 1300 ±25 psig for 2 minutes, the cold helium spheres at 1500 ±50 psia for 5 minutes, and the engine control bottle at 3000 ±50 psig for 2 minutes. Three-cycle checks were also made of the pickup and dropout pressures for the control helium regulator discharge pressure switch and the cold helium regulator backup pressure switch. The LOX and LH2 tank valves were cycled and verified audibly and by talkback. The tank systems were then checked for audible leakage, with the LOX tank pressurized to 5 psig and the LH2 tank at 3 psig. Finally, the LOX and LH2 tanks were pressurized to relief pressures for three-cycle checks of tank vent valve operation.

4.1.8 (Continued)

The ambient helium system leak and flow checks were accomplished next. After an orifice flow verification of the purge system, a reverse leak check of the LOX and LH2 purge check valves, and an external leak check of the purge system were conducted. The ambient helium fill module was checked for internal leakage. The check valves for the ambient helium fill system and the ambient LOX and LH2 repressurization systems were tested for reverse leakage. After a control valve functional check for the ambient LOX and LH2 repressurization modules, internal leak checks of the modules and the pneumatic power control module were performed. The control helium system and the LOX and LH2 ambient repressurization systems were checked for external leakage. The actuation control modules were checked for internal leakage under functional test conditions. Finally, a pressure decay check of the control system was performed over a 30-minute pressure lockup period.

Four external leaks were recorded during the ambient helium system leak checks. Two were corrected by gasket replacement, one by replacement of a union, and another by replacement of a tee. Also, a slightly out-of-tolerance recording for the LH2 fill and drain valve microswitch housing purge flow was accepted by a revision to the procedure as within the reading tolerance of the flowmeter. FARR 500-373-423 documented lack of an orifice in the purge port of the microswitch housing for the LH2 continuous vent module during initial purge flow checks. The microswitch cover was removed and an inspection made for possible internal damage due to purge pressure application without the orifice installed. No damage was found. The switch housing was reinstalled

4.1.8 (Continued)

with a new gasket, the purge orifice was installed, the continuous vent module was functionally checked, and a purge orifice flow check for the microswitch housing was successfully completed.

The engine start system leak and functional checks were started with a drying procedure for the start tank vent valve actuator. This was followed by a leak check of the start tank vent control valve seat and a reverse leak check of the start tank initial fill check valve. After pressurizing the start tank to 500 $\pm$10 psig with helium, the entire start system was checked for external leakage. The start bottle retention test obtained the necessary measurements for start tank temperature and pressure to calculate the helium pound-mass/hour loss. This decay rate for the start bottle was taken over a 60-minute period and was acceptable. The start system check was concluded with leak checks of the tank vent and relief valve, dump valve bellows, and an external leak check of the start tank vent system. FARR 500-373-806 documented unacceptable dump valve bellows leakage. The start tank vent and relief valve, P/N 557848, S/N 4044128, was removed and replaced, and the leak check was repeated successfully. Three external leaks in the start system were corrected by seal replacement.

The LH2 pressurization and repressurization systems tests started with a functional check of the O2H2 burner LH2 repressurization control valves, leak checks of the burner LH2 repressurization control valve seat and pilot bleed valve, and a reverse leak check of the burner LH2 check valve. The LH2 repressurization system was pressurized to 450 $\pm$50 psig and checked for external

4.1.8 (Continued)

leakage. The LH2 pressurization system was checked similarly for external leakage at 450 $\pm$25 psig. In addition, reverse leak checks were performed for the LH2 pressurization module check valve and the LH2 prepressurization check valve. Measurements of leakage rates for the main components of the LH2 repressurization and pressurization systems are listed in the Test Data Table. One leak was detected and corrected by tightening a B-nut connection.

The thrust chamber system was checked for external leakage with the thrust chamber throat plug installed and the system pressurized to 30 $\pm$2 psig. In addition, the LOX dome purge check valve and the thrust chamber jacket purge check valve were tested for reverse leakage. The thrust chamber main oxidizer and fuel valves were tested for drive and idler shaft seal leakage. Two weld leaks were repaired by rewelding tube assemblies for the start tank fill line and the auxiliary instrumentation package. Another leak was corrected by tightening a union.

The LOX pressurization and repressurization systems were tested for reverse leakage of the cold helium bottle check valve, external leak checks of the LOX pressurization system, and the ambient and O2H2 burner LOX repressurization systems. Internal leakage rates were measured for the LOX pressurization module and the burner LOX repressurization module. In addition, reverse leak checks were performed for the LOX repressurization system check valve and the burner LOX repressurization check valve. Leakage rates for the major system components are in the Test Data Table. Two leaks were corrected by tightening B-nuts, and another by seal and O-ring replacement. FARR 500-373-296 recorded acceptance of a minor dent in a tube assembly which occurred during the leak check.

4.1.8 (Continued)

Leak checks were then performed on the LOX tank, the O2H2 burner, and the engine LOX feed system. Internal leak checks of the engine feed system checked for seat leakage of the LOX prevalve and chilldown shutoff valve, the engine LOX bleed valve, the engine main oxidizer valve, and for reverse leakage of the LOX chilldown return check valve. Then the LOX tank and the engine feed system were checked for external leakage. The LOX turbopump was checked for breakaway torque, running torque, and primary seal leakage. The LOX chilldown pump purge leak and pressure checks included a pump canister pressure check, a pump purge shutoff seat leak check, a pump shaft seal leak check, and an external leak check of the pump purge circuit. Next, checks were made for seat leakage through the LOX boiloff valve, the LOX fill and drain valve, and the LOX main fill and replenish valve. The LOX fill and drain valve was also checked for primary shaft seal leakage. The LOX prevalve was checked for shaft seal leakage with the prevalve open and closed.

Leak checks of the O2H2 burner LOX shutdown valve and an external leak check from the LOX tank to the O2H2 burner LOX shutdown valve were performed, completing the LOX propellant system checks. One area of unacceptable leakage was detected and corrected by seal replacement at the LOX fill and drain umbilical connection.

Leak checks were then performed on the LH2 tank and on the O2H2 burner and engine feed systems. Internal leak checks of the engine feed system checked for seat leakage of the LH2 prevalve and chilldown shutoff valve, the engine LH2 bleed valve, the engine main fuel valve, and checked for reverse leakage

4.1.8 (Continued)

of the LH2 chilldown return check valve. The LH2 engine pump drain and purge check valves, the LH2 turbine seal cavity purge check valve, and the LOX turbine seal cavity check valve were checked for reverse leakage. The LH2 engine pump intermediate seal was checked for leakage. The LH2 engine pump drain check valve was also checked for forward flow. Then the LH2 tank and the engine feed system were checked for external leakage. One leak detected at the LH2 chilldown flowmeter outlet flange was corrected by seal replacement.

The LH2 turbopump was checked for breakaway and running torque and for primary seal leakage. The LH2 prevalve shaft seal was leak checked with the valve opened and closed. The LH2 fill and drain valve was checked for shaft seal and seat leakage. The LH2 main fill and replenish valve was checked for seat leakage. Leak checks of the O2H2 burner LH2 propellant valve seat and the LOX shutdown valve seat were made, as well as an external leak check of the O2H2 burner propellant system. One external leak was found and corrected by seal replacement.

Leak and flow checks of the engine gas generator (GG) and exhaust system were conducted next, and included reverse leak checks of the GG LH2 purge check valve, the GG LOX purge check valve, and the GG LOX poppet. Leak checks of the GG propellant valves, the start tank discharge valve gate seal, and the hydraulic pump seal were also performed. A bleed flow check of the LH2 and LOX turbine seal cavity was conducted. External leak checks of the GG and the exhaust system completed this portion of the test. One weld leak at the LH2 GG injector pressure port, GF4, was repaired by rewelding. A leak at the

4.1.8 (Continued)

turbine inlet temperature pickup, TGT3, was corrected by tightening the flange to 50 inch-pounds. Excessive reverse leakage for the GG LOX poppet was corrected with a purge of the poppet prior to a repeat leak check.

Engine pump purge leak and flow checks performed a regulation check of the engine pump purge module discharge pressure, measured the seat leakage of the engine pump purge valve, checked the purge flows of the LOX and LH2 turbine seal cavity bleeds and the fuel pump seal cavity, and verified the GG fuel purge flow at the LH2 turbopump access. An external leak check of the engine pump purge system was also conducted. No unacceptable leakage was recorded.

Leak and flow checks of the engine pneumatics system included the helium control solenoid energized leak checks, the LOX intermediate seal purge flow checks, the ignition phase solenoid energized leak checks, the start tank discharge valve solenoid energized leak checks, the main stage control solenoid energized leak checks, the pressure actuated purge system leak checks, and the engine control bottle fill system leak checks. Also, the engine control bottle retention test was performed to determine the control bottle decay by calculating the helium pound-mass/hour-loss. One external leak for the system was detected and corrected by seal replacement.

The LOX and LH2 vent system leak and flow checks included external leak checks of the LOX vent system and the LH2 ground and flight vent systems, plus internal leak checks of the valves in the systems, including the LOX vent and relief valve, the LOX NPV valve, the LH2 vent and relief valve, the LH2 latching relief valve, the bidirectional vent valve, and the LH2 continuous

4.1.8 (Continued)

vent valve. A summary of the internal leak checks is listed in the Test Data Table. Three areas of external leakage were corrected by replacement of seals and an O-ring. FARR 500-373-466 recorded unacceptable seat leakage in both the flight and ground positions for bidirectional vent valve, P/N 1A49988-513, S/N 0005. The valve was removed and replaced and the repeat leak check was successful, as indicated in the Test Data Table.

The final operation was a "black light" inspection of the thrust chamber injector to detect any hydrocarbon contamination that would tend to restrict injector flow.

Problem areas recorded on FARR tags that resulted from this checkout were limited to those previously discussed. However, one-hundred and two revisions were recorded in the procedure for the following.

a. Twenty-eight revisions concerned changes that were required to update or correct the procedure for errors and missing requirements.

b. Ten revisions were required to update the procedure to the stage configuration.

c. Eighteen revisions were incorporated to leak check hardware which was removed or replaced subsequent to system leak checks.

d. Four revisions added provisions for temporary leak check installations.

e. Two revisions deleted or changed sections that were not required or were affected by stage configuration.

f. Three revisions repeated leak checks and/or test requirements previously accomplished.

g. One revision was required to clarify procedure wording.

4.1.8 (Continued)

h. One revision provided instructions to return to the original configuration after disassembly for leak check purposes.

i. One revision authorized a test gauge substitution for system pressurization.

j. Six revisions added steps required to support concurrent test procedures.

k. One revision provided a helium purge during R/NAA welding on the J-2 engine.

l. Two revisions provided instructions to permit out-of-sequence leak checks.

m. Four revisions were modifications to pressurize systems during leak checks without the use of GSE power.

n. Five revisions concerned investigations of out-of-tolerance leak check measurements.

o. Two revisions provided for temporary removals to verify orifice installation or required configuration.

p. One revision deleted portions of the procedure that were not required because new O2H2 burner injectors were being installed.

q. One revision provided for a special leak check of the LOX feed duct gimbal joints.

r. One revision provided an alternate leak check setup for purposes of convenience.

s. One revision accepted a slightly out-of-tolerance measurement for the LH2 fill and drain valve microswitch housing purge flow based on the reading tolerance of the flowmeter.

t. One revision provided for a purge of the GG LOX poppet to remove foreign material that resulted in excessive reverse leakage.

u. One revision provided a temporary helium purge of the thrust chamber injector fuel and LOX circuits when dust was found on the injector face.

v. One revision modified the procedure to prevent pneumatic control module regulator seat damage.

4.1.8 (Continued)

w. One revision provided for a special replacement and inspection of conoseals at the fuel pressurization module for engineering evaluation of GH2 detection during previous static firings at STC.

x. Six revisions were written and subsequently voided.

4.1.8.1 Test Data Table, Propulsion Leak and Functional Check

Cold Helium Fill Module Relief and Internal Leakage Checks

Function	Measurement			Limits
	Cycle 1	Cycle 2	Cycle 3	
Relief Valve				
Cracking Pressure (psig)	3200	3200	3200	*
Reseat Pressure (psig)	3175	3175	3175	*
Internal Leak Check at 3100 ±100 psig				
(a) Relief Valve Seat Leakage (scim)		0		5 max
(b) Dump Solenoid Seat Leakage (scim) (Pilot Bleed & Seat - Combined)		0		(a+b)
Internal Leak Check at 300 ±50 psig				
(c) Relief Valve Seat Leakage (scim)		0		18 max
(d) Dump Solenoid Seat Leakage (scim) (Pilot Bleed & Seat - Combined)		0		(c+d)

Calip Pressure Switch Leak Checks

Function	Measurement	Limits
Mnstg Press Sw C/O Circuit Decay (psi)	0.6	5.0 max/5 minutes
LOX Press Sw C/O Circuit Decay (psi)	0	0.5 max/5 minutes
LH2 Press Sw C/O Circuit Decay (psi)	0	0.5 max/5 minutes
Low Press Sw C/O Circuit Decay (psi)	0	5.0 max/5 minutes
Eng Mnstg Press Sw Diaph Decay:		
Initial (psig)	400	*
Final (psig)	392	*
Decay (psi)	8	10.0 max/15 minutes

Stage Integrity Checks

Function	Measurement			Limits
Control He Reg Disch P/S:	Run 1	Run 2	Run 3	
Pickup Press (psia)	602	602	602	600 ± 21
Dropout Press (psia)	508	508	508	490 ± 31

* Limits Not Specified

4.1.8.1 (Continued)

Function	Run 1	Run 2	Run 3	Limits
		Measurement		
Cold He Reg Backup P/S:				
Pickup Press (psia)	465.7	465.7	465.7	444 to 491
Dropout Press (psia)	344.7	346.7	346.7	329 to 376
LOX Tank Relief Cycle (psia)	42.5	42.5	42.5	41 to 44
LH2 Tank Relief Cycle (psia)	35.8	35.8	35.8	34 to 37

Purge System Orifice Flow Checks

Function	Measurement	Limits
LOX Tnk Ullage Sense Line Purge (scim)	230.0	432 + 245
LOX F&D Vlv Microsw Housing Purge (scim)	2.5	3.5 ± 2
LOX Nonpropulsive Vent Duct Purge (scim)	260.0	432 ± 245
LH2 F&D Vlv Microsw Housing Purge (scim)	1.3+	3.5 ± 2
LH2 C/D SOV Microsw Purge (scim)	4500	6500 ± 2450
LH2 Prop Valve Microsw Purge (scim)	1.9	3.5 ± 2
LH2 Nonpropulsive Vent Duct Purge (scim)	210.0	432 ± 245
Contin Vent Mod Bellows Purge (scim)	92.0	75 ± 30
Orifice Bypass Vlv Microsw Purge (scim)	4.5	3.5 ± 2
Contin Vent Duct Purge (scim)	280.0	432 ± 245

Purge System Check Valve Leak Checks (P/N 1B67598-501)

Check Valve Function	S/N	Measurement	Limits
LOX Vent Purge (scim)	79	0	10 max
LOX Fill & Drain Purge (scim)	81	0	10 max
LH2 Fill & Drain Purge (scim)	84	0	10 max
LH2 Vent Purge (scim)	80	0	10 max

Ambient He Fill Module Internal Leak Checks (P/N 1A57350-507, S/N 0239)

Function	Measurement	Limits
Check Valve Reverse Leakage (scim)	0	0
Dump Valve Seat Leakage (scim)	0	0

Ambient He Spheres Fill System Check Valves Reverse Leak Checks (P/N 1B67598-501)

Function	S/N	Measurement	Limits
LOX Repress Mod Check Vlv (scim)	-	0	10 max
LH2 Repress Mod Backup Check Valve (scim)	46	7.0	10 max
LH2 Repress Mod Check Vlv (scim)	-	0	10 max
He Fill Mod Backup Check Vlv (scim)	78	0	10 max

\+ Refer to Revision s

4.1.8.1 (Continued)

Ambient Repress Module Control Valve Functional Checks

LOX Repress System

Function	Measurement	Limits
Cont Vlv (L3) Seat Leakage (scim)	0	*
Cont Vlv (L2) Seat Leakage (scim)	0	*
Module Dump Vlv Seat Leakage (scim	0	*
Mod Dump Vlv Pilot Bleed (scim)	0	*
Mod Dump Vlv Seat & Pilot Bleed Leakage (scim)	0	9 max
Cont Vlv (L2) Pilot Bleed Leakage (scim)	0	*
Cont Vlv (L2) Seat & Pilot Bleed Leakage (scim)	0	9 max
Cont Vlv (L3) Pilot Bleed Leakage (scim)	0	*
Cont Vlv (L3) Seat & Pilot Bleed Leakage (scim)	0	9 max

LH2 Repress System

Function	Measurement	Limits
Cont Vlv (L3) Seat Leakage (scim)	0	*
Cont Vlv (L2) Seat Leakage (scim	0	*
Module Dump Vlv Seat Leakage (scim)	0	*
Module Dump Vlv Pilot Bleed Leakage (scim)	0	*
Mod Dump Vlv & Pilot Bleed Seat Lkg (scim)	0	9 max
Mod Cont Vlv (L2) Pilot Bleed Lkg (scim)	0	*
Cont Vlv (L2) Seat & Pilot Bleed Lkg (scim)	0	9 max
Cont Vlv (L3) Pilot Bleed Leakage (scim)	0	*
Cont Vlv (L3) Seat & Pilot Bleed Leakage (scim)	0	9 max

Pneumatic Power Control Module Internal Leak Check (P/N 1A58345-523, S/N 1036)

Function	Measurement	Limits
Control He Shutoff Seat Leakage (scim)	0.0	10 max
Control Module Reg Lockup Press (scim)	535.0	550 max

Actuation Control Module Checks (P/N 1B66692-501)

Module Function	S/N	Normal	Open	Closed	Limits
O2H2 Burner LOX S/D Vlv Control (scim)	103	0	0	0	6 max
O2H2 Burner LH2 Vlv Control (scim)	110	0	0	0	6 max
Orificed Bypass Vlv Control (scim)	07	0	0	0	6 max

* Limits Not Specified

4.1.8.1 (Continued)

Module Function	S/N	Normal	Open	Boost	Limits
LOX Vent Valve Control (scim)	109	0	0	0	6 max
LH2 Fill & Drain Vlv Control (scim)	100	0	0	0	6 max
LOX Fill & Drain Vlv Control (scim)	108	0	0	1	6 max
LH2 Vent Valve Control (scim)	102	0	0	0	6 max

Function	Open	Closed	Limits
LH2 F&D Act Seal Leakage (scim)	0	0.0	350 max
LOX F&D Act Seal Leakage (scim)	0	0.0	350 max
LOX S/D Vlv Act Piston & Shaft Seal Leakage (scim)	0.0	0.2	70 max
LH2 Cont Vent Act Piston & Shaft Seal Leakage (scim	0.0	0.0	20 max

Function	S/N	Normal	Open	Open Latch	Limits
LOX NPV Act Cont Mod (scim)	177	0.0	0.0	0.0	6 max

Function	S/N	Normal	Closed	Limits
Prevlv-C/D Vlv Act Cont Mod (scim)	107	0.0	-	6 max
Prevlv Act Control (scim)	-	-	0.0	6 max
C/D Act Control (scim)	-	-	0.0	6 max
LOX Prevlv Microsw Housing (scim)	-	-	1.2	20 max

Function	S/N	Normal	Flight	Ground	Limits
Bidirect Vent Vlv Act Cont Mod (scim)	99	0.0	0.0	0.0	6 max

Function	S/N	Normal	Open	Latching	Limits
LH2 Latching Relief Vlv Cont Mod (scim)	173	0.0	0.0	0.0	6 max

Pneumatic Control System Decay Checks

Function	Measurement Initial	Measurement Final	Limits
Reg Disch Press - Vlv Pos, Normal (psig)	511	508	*
Reg Disch Press - Vlv Pos, Activated (psig)	518	399	*

* Limits Not Specified

4.1.8.1 (Continued)

Engine Start Tank Leak Checks

Function	Measurement	Limits
Vent Control Solenoid Seat Leakage (scim)	4.0	10 max
Initial Fill, Check Vlv Reverse Lkg (scim)	0.0	2 max
Vent & Relief Valve Seat Leakage (scim)	0.0	2 max
Dump Valve Bellows Leakage (scim)	0.0	0
Bottle Decay (Delta M) (lb-mass/hr)	0.0050	0.0066 max

LH2 Repressurization System Leak Checks

Function	Measurement	Limits
O2H2 Burner Control Vlv Seat Leakage (scim)	0	*
O2H2 Burner Control Vlv Pilot Bleed Lkg (scim)	0	*
O2H2 Burner Module Cont Vlv Int Leakage (scim)	0	12 max
O2H2 Burner Cont Vlv & Check Vlv Rev Lkg (scim)	0	*
O2H2 Burner Check Vlv Reverse Leakage (scim)	0	1 max
O2H2 Burner Coil Leakage (scim)	0	0

LH2 Pressurization System Leak Check

Function	Measurement	Limits
LH2 Press Module Check Vlv Rev Lkg (scim)	0	10 max
LH2 Prepress Check Vlv Rev Lkg (scim)	0	0

Thrust Chamber Checks

Function	Measurement	Limits
LOX Dome		
Purge Check Valve Reverse Lkg (scim)	0	4 max
Main Oxidizer Valve		
Idler Shaft Seal Leakage (scim)	0	10 max
Drive Shaft Seal Leakage (scim)	0	10 max
Main Fuel Valve		
Idler Shaft Seal Leakage (scim)	0	10 max
Drive Shaft Seal Leakage (scim)	0	10 max
Thrust Chamber		
Pressure (psig)	29.0	20 min
Jacket Purge Check Vlv Rev Lkg (scim)	0.6	25 min

* Limits Not Specified

4.1.8.1 (Continued)

LOX Pressurization & Repressurization System Leak Checks

Function	Measurement	Limits
Cold Helium Sphere		
Fill Check Vlv Rev Lkg (scim)	0.0	0
Shutoff Vlv Seat & Pilot Vlv Lkg-High Press (scim)	0.4	11.3 max
Shutoff Vlv Seat & Pilot Vlv Lkg-Low Press (scim)	0.0	12.5 max
Dump Vlv Seat Lkg (scim)	0.0	0
LOX Press Module Internal		
Hot Gas Bypass Vlv Seat & Pilot Bleed Lkg (scim)	80	3000 max
O2H2 Burner LOX Repress System		
Burner Control Valve Seat Leakage (scim)	0.0	*
Burner Control Valve Pilot Bleed Lkg (scim)	0.0	*
Burner Module Control Vlv Internal Lkg (scim)	0.0	12 max
Combined Burner Check Vlv & Cont Vlv Seat Leakage (scim)	0.0	*
Burner Check Vlv Rev Leakage (scim)	0.0	0
Burner Coil Leakage (scim)	0.0	0
Cold Helium System		
LOX Tank Prepress Check Vlv Rev Lkg (scim)	0.0	0

LOX Tank, O2H2 Burner & Engine Feed System Leak Checks

Function	Measurement	Limits
LOX Tank Helium Content		
Top (%)	99.1	75 min
Bottom (%)	99.1	75 min
Engine Feed Sys Internal Leak Checks		
LOX Prevlv & Chilldown Shutoff Vlv Seat & Chilldown Return Check Vlv Lkg (scim)	7.0	*
LOX Chilldown Ret Check Vlv Rev Lkg (scim	2.0	350 max
LOX Prevlv & Chilldown Shutoff Vlv Combined Seat Leakage (scim)	5.0	150 max
LOX Bleed Vlv & Chilldown Return Check Vlv Rev Leakage (scim)	2.0	*
LOX Bleed Vlv Seat Leakage (scim)	0.0	300 max
Main Oxidizer Vlv Seat Leakage (scim)	0.0	10 max
LOX Tank & Engine Feed System Leak Checks		
Oxidizer Pump Speed Pickup Seal Bleed (scim)	0.0	0
LOX Turbopump Checks		
Pump Primary Seal Leakage:		
Max (scim)	200	350 max
Min (scim)	200	*

* Limits Not Specified

4.1.8.1 (Continued)

Function	Measurement	Limits
Turbine Torque:		
Breakaway (in/lbs)	23	1000 max
Running (in/lbs)	18	200 max
LOX Chilldown Pump Purge Flow Checks		
Pump Purge Shutoff Vlv Seat Leakage (scim)	0.0	0
Pump Shaft Seal Flow Tank Pressurized & Purge On (scim)	0.0	50 max
Pump Shaft Seal Flow - LOX Tank Side (scim)	0.0	*
Pump Shaft Seal Flow - Motor Canister Side (scim)	0.0	*
LOX Boiloff Valve Flow Check		
Valve Seat Leakage (scim)	0	10 max
LOX Valves Checks		
Prevalve Shaft Seal Leakage:		
Open Position (scim)	0.0	10 max
Closed Position (scim)	0.0	10 max
Prevalve Actuator Internal Leakage (scim)	3.0	75 max
F&D Vlv Seat Leakage (scim)	0.0	100 max
F&D Vlv Primary Shaft Seal Lkg (scim)	0.0	30 max
LOX Main Fill, Replenish, & Fill & Drain Valve Seat Leakage (scim)	0	*
LOX Main Fill & Replenish Vlvs Seat Lkg (scim)	0	*
O2H2 Burner LOX Shutdown Valve Checks		
Valve Actuator Bellows Lkg (scim)	0.0	*
Valve Seat Leakage (scim)	0.0	50

LH2 Tank, O2H2 Burner & Engine Feed System Leak Checks

Function	Measurement	Limits
LH2 Tank Helium Content		
Top (%)	99.7	75 min
Bottom (%)	99.7	75 min
Engine Feed System Internal Leak Checks		
LH2 Prevlv & Chilldown Shutoff Vlv & C/D Return Check Vlv Rev Lkg (scim)	0.0	*
LH2 C/D Ret Check Vlv Rev Lkg (scim)	0.0	350 max
LH2 Prevlv & C/D Shutoff Vlv Combined Seat Leakage (scim)	0.0	150 max
LH2 Bleed Vlv & C/D Return Check Vlv Rev Leakage (scim)	0.0	*
LH2 Bleed Vlv Seat Leakage (scim)	0.0	300 max
MOV & MFV Combined Seat Leakage (scim)	0.0	*
Main Fuel Vlv Seat Leakage (scim)	0.0	10 max
Engine Purge System Leak Checks		
LH2 Pump Drain Check Vlv Rev Lkg (scim)	3.0	25 max

* Limits Not Specified

4.1.8.1 (Continued)

Function	Measurement	Limits
LH2 Pump Drain Check Vlv Fwd Flow 30 psi (scim)	9.0	30 max
LH2 Pump Drain Check Vlv Fwd Flow 60 psi (scim)	10,000	2420 min
LH2 Pump Purge Check Vlv Rev Lkg (scim)	0.0	25 max
LH2 Pump Intermediate Seal Lkg (scim)	28.0	500 max
LH2 Turbine Seal Cavity Prg Check Vlv Rev Leakage (scim)	3.0	25 max
LOX Turbine Seal Cavity Prg Check Vlv Rev Leakage (scim)	0.0	25 max
<u>LH2 Tank & Engine Feed System Leak Checks</u>		
LH2 Pump Speed Monitor Seal Bleed (scim)	0.0	0
LH2 Low Pressure Duct Pressure (psig)	28.0	30 max
<u>LH2 Turbopump Checks</u>		
LH2 Pump Primary Seal Leakage:		
Max (scim)	52.0	350 max
Min (scim)	10.0	*
Turbine Torque:		
Breakaway (in/lbs)	19.0	1000 max
Running (in/lbs)	19.0	300 max
<u>LH2 Valves Leak Checks</u>		
Prevalve Shaft Seal Leakage:		
Open Position (scim)	0.0	10 max
Closed Position (scim)	0.0	10 max
Fill & Drain Valve Seat Leakage (scim)	0.0	100 max
LH2 Fill & Drain Vlv Primary Shaft Seal Leakage (scim)	0.0	30 max
LH2 Main Fill, Replenish, & Fill & Drain Valves Seat Leakage (scim)	0	*
LH2 Main Fill & Replenish Valves Seat Leakage (scim)	0	*
<u>O2H2 Burner LH2 System Leak Check</u>		
Combined Burner LH2 Prop Vlv & LOX S/D Vlv Seat Leakage (scim)	0.0	*
Burner LH2 Prop Valve Seat Leakage (scim)	0.0	0.7 max

<u>Engine GG and Exhaust System Leak and Flow Tests</u>

Function	Measurement	Limits
GG Fuel Purge Ck Vlv Rev Lkg (scim)	0.0	25 max
LH2 Turbine Seal Leakage (scim)	1850	3000 scim max Above 2nd E&M Lkg Value (1)

* Limits Not Specified
(1) 2nd E&M Leakage Valve = 1220 scim

4.1.8.1 (Continued)

Function	Measurement	Limits
LOX Turbine Seal Leakage (scim)	1.6	350 max
STDV Gate Seal Leakage (scim)	0.0	20 max
OTBV Shaft Seal Leakage (scim)	0.34	15 max
Oxid Manifold Carrier Flange Bleed (scim)	0.0	20 max
GG LOX Poppet Rev Leakage (scim)	250.0	600 max
GG LOX Purge Check Vlv Rev Lkg (scim)	0	15 max
Hydraulic Pump Shaft Seal Lkg (scim)	0.5	228 max
GG LOX Prop Vlv Seat & LOX Pump Shaft Seal Leakage (scim)	3.0	20 max
Combined GG LOX & LH2 Prop Vlv Seat & Pump Shaft Seal Lkg (scim)	5.0	*
GG LH2 Prop Vlv Seat Lkg & Fuel Pump Omni Seal Lkg (scim)	2.0	15 max

Engine Pump Purge Leak Checks

Function	Measurement	Limits
Pump Purge Module Internal Leak Checks		
Purge Valve Seat Leakage (scim)	0.0	12 max
Purge Discharge Pressure (psig)	88	67 to 110
Pump Purge Flow Checks		
GG Fuel Purge Flow (scim)	3700	2400 min
LOX Turbine Seal Purge Flow (scim)	3700	2400 min
LH2 Turbine Seal Purge Flow (scim)	3700	2400 min
Fuel Pump Seal Cavity Purge Flow (scim)	940	200 min

Engine Pneumatics Leak Checks

Helium Control Solenoid Energized Leak Checks		
Low Press Relief Vlv Seat Lkg (scim)	0.0	5 max
Low Press Relief Vlv Pilot Bleed Lkg (scim)	0	10 max
Fast Shutdown Vent Port Diaph Lkg (scim)	0.0	3 max
Press Act Purge Vlv Diaph Lkg (scim)	0.0	3 max
Int Pneu Sys Lkg (He Cont Sol On) (scim)	3	20 max
LOX Pump Intermediate Seal Purge Leak Checks		
Seal Leakage Pump Direction (scim)	15	*
Seal Leakage Turbine Direction (scim)	0	*
Seal Leakage Total (scim)	15	850 max
Seal Purge Check Vlv Overboard Flow (scim)	2850	*
Seal Purge Flow (scim)	2865	1300 to 3500
Ignition Phase Solenoid Energized Leak Checks		
Start Tnk Disch Vlv 4-Way Sol Seat Lkg (scim)	2	15 max
Internal Pneu Sys Lkg (Ign Phase Sol On)(scim)	8	20 max

* Limits Not Specified

4.1.8.1 (Continued)

Function	Measurement	Limits
Start Tank Discharge Valve Solenoid Energized Leak Checks		
STDV 4-Way Sol Seat Lkg (Energized) (scim)	4.5	15 max
Mainstage Control Solenoid Energized Leak Check		
Press Act Fast Shutdown Vlv Seat Lkg (scim)	0.0	10 max
Int Pneu Sys Lkg (Mnstg Sold On) (scim)	10.75	20 max
Pressure Actuated Purge System Leak Check		
Press Act Purge Vlv Vent Seat Lkg (scim)	0.0	10 max
Press Act Purge Vlv Inlet Seat Lkg (scim)	0.0	10 max
MOV Seq Valve Lip & Shaft Seal Lkg (scim)	0.0	*
MOV Seq Valve Lip & OTBV Piston Lkg (scim)	0.0	5 max
Engine Control Bottle Fill System Leak Check		
Eng Cont Bot Fill Check Vlv Rev Lkg (scim)	0.0	3 max
Eng Cont Bot Decay Check (Delta M) (lb-mass/hr)	0.0044	0.036 max

LOX & LH2 Vent System Leak Checks

Function	Measurement	Limits
LOX Vent System Leak Checks		
Combined LOX Vent & Relief Vlv & NPV Seat & Pilot Bleed Lkg (scim)	0.0	160 max
Combined LOX V&R and NPV Seat, Pilot Bleed & Boost Piston Seal Lkg (scim)	330	*
Combined LOX V&R and NPV Boost Piston Seal Lkg (scim)	330	1728 max
LOX Vent Valve Open Act Seal Lkg (scim)	0.0	75 max
LOX NPV Vlv Open Act Piston Seal Lkg (scim)	0.0	150 max
Propulsive Vent System Leak Checks		
Cont Vent & Orifice Bypass Vlv Seat Lkg (scim)	0.0	16 max
LH2 Cont Vent Vlv Act Bellows Lkg (scim)	0.0	0
Nonpropulsive Vent System Leak Checks		
Bidirect Vent Vlv Act Seal & Blade Shaft Seal Lkg - Flight Pos (scim)	0.0	3.5 max
Bidirect Vent Vlv Seat Lkg (Flt Pos) (scim)	0.5	50 max
Bidirect Vent Vlv Act Seal & Blade Shaft Seal Leakage - Ground Pos (scim)	1.2	3.5 max
Ground Vent System Leak Checks		
Combined LH2 V&R & LH2 Latching Vlv Combined Seat & Pilot Bleed Lkg (scim)	5	210 max
Combined LH2 V&R Vlv & LH2 Latching Relief Vlv Seat, Pilot Bleed, & Boost Piston Seal Lkg (scim)	890	*

* Limits Not Specified

4.1.8.1 (Continued)

Function	Measurement	Limits
LH2 V&R Vlv & LH2 Latching Vlv Boost Piston Seal Lkg (scim)	885	1728 max
LH2 Vent Vlv Open Act Seal Lkg (scim)	0.0	75 max
Bidirect Vent Vlv Seat Lkg (Gnd Pos) (scim)	6	50 max
Bidirect Vent Vlv Act Piston Leakage:		
Ground Position (scim)	0.3	3 max
Flight Position (scim)	0.3	3 max
LH2 Latching Relief Vlv Open Act Piston Seal Lkg (scim)	0.0	150 max

* Limits Not Specified.

4.1.9 Digital Data Acquisition System Calibration (1B55816 G)

This procedure provided the manual and automatic operations for the checkout and calibration of the digital data acquisition system (DDAS) and prepared the system for use. The integrity of the DDAS was verified from data inputs through the various multiplexers and the PCM/DDAS assembly to the DDAS ground station. The items involved in this test were the PCM/DDAS assembly, P/N 1B65792-1, S/N 6700089; CP1-BO time division multiplexer, P/N 1B65897-1, S/N 013; DP1-BO time division multiplexer, P/N 1B65897-501, S/N 04; remote digital submultiplexer (RDSM), P/N 1B66051-501, S/N 04; and low level remote analog submultiplexer (RASM), P/N 1B66050-501.1, S/N 05.

Four tests were required to satisfactorily complete prefire DDAS calibration. The initial test was conducted on 15 August 1968. The CP1-BO multiplexer, P/N 1B65897-1, S/N 02, was replaced with P/N 1B65897-1, S/N 013 per FARR 500-225-394 due to channel malfunctions during this test. Also, the RASM portion of the initial test was not successful due to a noise condition causing channel malfunctions.

The second test, performed on 16 August 1968, was a repeat of the RASM test to re-verify the discrepant noise condition using a different power supply. The channel malfunctions due to noise were again experienced, and the RASM, P/N 1B66050-501.1, S/N 09, was removed and replaced with P/N 1B66050-501.1, S/N 05 per FARR 500-225-416. The third test, conducted on 22 August 1968, was again a RASM checkout only for the new assembly. This test also encountered the noise problem, which was isolated to a bad capacitor in the power supply test setup. The capacitor was replaced.

4.1.9 (Continued)

The fourth and final test was performed on 4 September 1968. This was a complete DDAS calibration test which successfully checked out the new RASM and CP1-BO multiplexers. All measurements quoted in this narrative and the description of the checkouts are from the final test.

The stage power was turned on, and the initial conditions scan was conducted for the stage and DDAS per H&CO 1B55813. The 72 kHz bit rate check was made on the PCM data train to ensure that the frequency was within tolerance. The 72 kHz bit rate was measured as 72,005 bits per second, within the 71,975 to 72,025 bits per second limits. The 600 kHz VCO test was accomplished by measuring the band edge frequencies and voltages of the PCM/DDAS VCO output. The upper band edge frequency was measured at 633.98 kHz at 2.87 vrms, within the acceptable limits of 623.2 kHz to 642.2 kHz, at greater than 2.2 vrms. The lower band edge frequency was measured at 567.3 kHz at 2.8 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 66.68 kHz, within the acceptable limits of 60 to 80 kHz.

The next tests performed were the automatic flight calibration checks and the individual multiplexer 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. The DP1-BO multiplexer test was rerun when it was noted that an improper test setup resulted in channel malfunctions. All measured channels were within the required tolerances.

4.1.9 (Continued)

The RDSM was verified by inserting signal levels equivalent to ones (20 vdc) and zeros (0 vdc) into the RDSM input circuits and by checking the output at the computer for a digital word of corresponding ones and zeros. The RASM was verified by inserting signal voltages, 0 to 30 millivolts, which were amplified to an output range of 0 to 5 volts dc corresponding to the 0 to 30 millivolt range 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 1.900 amperes, within the 4.5 ±3.00 amperes limit.

There were no other problem areas resulting in FARR documentation other than those previously described. However, eighteen revisions were recorded in the procedure for following:

a. Five revisions corrected program errors or updated the procedure.

b. One revision authorized changing the tolerance on the 28 vdc power supply voltages from ±0.5 to ±2.0 vdc because of temporary removal of the sense line filters.

c. Two revisions concerned initial conditions scan which had no effect on DDAS testing.

d. One revision was a program change made necessary because the system status display was inoperative during the test.

e. Three revisions authorized the repeat tests described in this narrative.

f. One revision substituted a battery and variable resistors for the specified power supply to provide a more stable voltage.

g. One revision provided changes to resume the final DDAS test after it had been temporarily terminated at the end of a work shift.

4.1.9 (Continued)

h. One revision indicated that SIM interrupts received had occurred because engine restrainer pitch and yaw pins were extended. This did not affect the DDAS test.

i. Three revisions concerned the malfunctions that resulted in the repeat testing, as previously described in this narrative.

4.1.10 Common Bulkhead Vacuum System (1B49286 J)

The purpose of this manual checkout, initiated on 16 August 1968, was to ensure that the common bulkhead, P/N 1A39309-501, was free of leakage conditions and acceptable for propellant loading and static acceptance firing of the J-2 engine.

The test stand vacuum system was isolated from the stage system, and the test stand system set up for checkout. The vacuum pump was operated for 10 minutes, then shut off. After a 15 minute delay, the vacuum system pressure was recorded. At intervals of 1 hour, the pressure was monitored for a pressure rise. No increase in pressure was noted over an 8-hour span.

The test stand system was reconnected to the stage, and preparations for a 96-hour pumpdown of the common bulkhead were made. The evacuation supply was set to evacuate the bulkhead, the vacuum supply and vacuum pump were turned off, and the purge supply and sample supply were verified to be closed. Verification was made that measurement D545, the bulkhead transducer, P/N 1B40242-501, was installed and electrically connected to the monitoring strip charts in the Test Control Center.

It was verified that the common bulkhead quick-disconnect assembly, P/N 1B41065, was properly installed and engaged. Two sample bottles, P/N 1B71532-1, were installed at positions 1 and 2 on the sample bottle rack and sealed into place. The vacuum supply switch was turned on. After 10 minutes, the evacuation supply switch was set to evacuate the bottles; and sample supply switch number 1 was opened. After 5 minutes, sample supply switch number 1 was closed; the evacuation supply switch was set to sample the bulkhead; and sample supply switch

4.1.10 (Continued)

number 1 was re-opened. After 1 minute, sample supply switch number 1 was closed; and the evacuation supply switch was set to evacuate the bulkhead. Bulkhead pressure was monitored every hour for 6 hours with no pressure rise noted. Upon completion of the 6-hour check, the evacuation supply switch was set to evacuate the bottles; and sample supply switch number 2 was opened. After a lapse of 5 minutes, sample supply switch number 2 was closed; the evacuation supply switch was set to sample the bulkhead; and sample supply switch number 2 was opened for 1 minute, then closed. The number 1 and 2 sample bottles were removed from the sample bottle rack and shipped to Material and Methods - Research and Engineering (MM-RE) for analysis.

After 96 hours of vacuum pumpdown, the vacuum supply switch was turned off; the evacuation supply switch was set to evacuate the bottles; then, the 48-hour bulkhead decay check was started. The indicated bulkhead pressure at the start was recorded as 0.2 psia, and no decay in bulkhead pressure was noted. During the decay check, a setup was made for the argon purge test. A bottle of 99.97 percent pure argon was connected to the bulkhead GN2 supply line. The bulkhead GN2 purge hand valve was opened, the evacuation supply switch was set to evacuate the bulkhead, and the purge supply regulator was set to 2.5 psig. The argon purge was run for 96 hours. After the argon purge was completed, the argon bottle was removed, and the bulkhead vacuum system was secured.

The bulkhead leak check was accomplished next. Bulkhead pressure was determined to be 14.9 psia. The LOX tank was pressurized to 30 ± 1 psia, and the

4.1.10 (Continued)

LH2 tank was pressurized to 25 ± 1 psia. This pressure was maintained for 12 hours, while the bulkhead pressure was monitored. No increase in bulkhead pressure was noted, indicating that the bulkhead was free from leakage. The propellant tanks were vented to ambient, and this checkout was certified as acceptable on 15 October 1968.

No FARR's were written as a result of this checkout. There were thirteen revisions written to the procedure for the following:

a. One revision provided instructions to check operation and calibration for the common bulkhead pressure transducer for measurement D0545 and the common bulkhead stand system pressure transducer for measurement D0861.

b. One revision provided for a connection of the stage vacuum system common bulkhead omitted from the procedure.

c. Seven revisions concerned procedure modifications required due to availability of personnel, third shift and holiday shutdown operations, and conflicts caused by electrical power systems modification schedules.

d. One revision authorized a torque check of all tube fittings to determine possibilities for vacuum system leakage.

e. One revision provided instructions to avoid overpressurizing the common bulkhead.

f. Two revisions repeated the 96-hour argon purge because the original purge securing was not per the procedure.

4.1.11 Stage and GSE Manual Controls Check (1B70177 G)

This procedure verified manual control capability for the pneumatic regulators and valves in the propulsion GSE and stage systems. The test consisted of supplying electrical and pneumatic signals to the system components and checking for the proper response utilizing the Test Control Center (TCC) panels.

The manual controls checkout was satisfactorily conducted on 19 August 1968, and was certified as acceptable on 24 September 1968. Preliminary GSE setup operations were initiated to verify that the switches and valves on the test consoles were positioned properly for the functional check. The GSE manual controls were then operated to ensure their functional capability.

The stage control helium system check began by verifying that the LOX repressurization spheres were isolated per H&CO 1B70422 and that the stage purge hand valves were closed. The control helium sphere was pressurized to 100 ± 25 psig and the control sphere dump valve was functioned; then, the sphere was pressurized to obtain control helium regulator discharge pressure at 500 ± 50 psig for the stage valves control check.

The stage valves control check was accomplished by supplying signals manually from the TCC control panels to the stage valve controls in a specified sequence and then verifying correct talkback. In addition, test stand personnel verified stage valve actuation audibly or by touch. Starting at the TCC mainstage propulsion manual control panel, the LH2 and LOX chilldown shutoff valves and the LH2 and LOX prevalves were individually cycled and verified. At the TCC LH2 control panel, the LH2 tank vent and the fill and drain vlaves were cycled open and closed. The LH2 tank vent boost close valve and the LH2 fill and

4.1.11 (Continued)

drain boost close valve were cycled. The LH2 directional vent valve was cycled from the flight to the ground position. Using the TCC LOX control panel, the LOX tank vent and fill and drain valves were cycled open and closed. The LOX tank vent boost close valve and the LOX fill and drain boost close valve were cycled. The cold helium shutoff valve was cycled open and closed. The valves cycled from the TCC stage supply panel included the engine control bottle dump valve, the cold helium bottle dump valve, the start tank dump valve, and the LOX and LH2 repressurization dump valves. The control helium bottle fill valve was then closed.

The stage valves control check was completed at the TCC repressurization control panel by cycling the O2H2 burner LH2 propulsion valve and the LOX shutdown valve.

An LH2 and LOX umbilical purge interlock check was accomplished next. At the LH2 control panel, the LH2 fill and drain valve and the LH2 umbilical drain valve were verified to be closed. The LH2 umbilical purge valve was then opened, and talkback indication was verified. The LH2 fill and drain valve was cycled, and it was verified that the LH2 umbilical purge valve opened and closed. Verification was made that operating the LH2 umbilical drain valve also operated the LH2 umbilical purge valve.

On the LOX control panel, the LOX emergency drain valve was opened, and the LOX fill and drain and the LOX umbilical drain valves were verified to be closed. The LOX umbilical purge valve was positioned to open, and talkback indication was verified. The LOX fill and drain and the LOX umbilical drain

4.1.11 (Continued)

valves were cycled to verify that the LOX umbilical purge valve opened and closed as the drain valves were functioned.

The J-2 engine oscillograph was then set up in preparation for Galvo trace verification during the engine valve funtional check. Preliminary operations included ensuring the LOX and LH2 tanks and the engine start tank were vented to ambient, closing the chilldown shutoff valves and prevalves, and verifying the engine throat plug and injector cover were removed. Power was turned on for engine valve actuation and the engine control helium bottle was pressurized to 1450 ± 50 psig. At the mainstage panel, the helium control solenoid, ignition phase solenoid, and the start tank discharge valve (STDV) solenoid were energized. After each was turned on, verification of proper oscillograph traces was made, respectively, for the helium control solenoid voltage, the main fuel valve (MFV) position, the gas generator (GG) valve position, the STDV solenoid voltage, and the STDV position. Next, the mainstage solenoid valve was energized and oscillograph traces were verified for the solenoid voltage, the main oxidizer valve (MOV) position, and the oxidizer turbine by pass valve (OTBV) position. The solenoid valves were then individually de-energized, the engine control bottle was vented to ambient, and the LOX and LH2 tank vent valves were closed.

The checkout was terminated by securing the test stand pneumatic systems using the TCC control panels and the test stand pneumatics consoles.

FARR 500-225-505 was initiated during the test because the control helium dump module, P/N 1A57350-507, S/N 0204, would not vent control bottle pressure

4.1.11 (Continued)

reliably. Operation of the valve was intermittent during repeated cycles. It was removed and replaced by P/N 1A57350-507, S/N 0214.

There were no other significant problem areas; however, two revisions were recorded in the procedure for the following:

a. One revision corrected improper nomenclature used in the procedure for the O2H2 burner LOX shutdown valve.

b. One revision repeated the manual J-2 engine valve functional check on the oscillograph for additional Galvo channel verification requested for a concurrent test procedure.

4.1.12 Cryogenic Temperature Sensor Verification (1B64678 E)

The calibration and functional capabilities of the cryogenic temperature sensors, for which the normal operating range did not include ambient temperature, were verified by this manual procedure. The sensors, basically platinum resistance elements, indicated changes in temperature as their resistance varied with changes in temperature, in accordance with the Callendar-Van Dusen equation.

Accomplished between 19 and 22 August 1968, the testing and the results obtained were accepted by Engineering on 5 September 1968.

Each sensor was tested at the prevalent ambient temperature. Using the values for resistance at 32°F and sensitivity, which were given for each individual sensor, the expected resistance at room temperature was calculated. The actual resistance was measured, and compared with the calculated value. The measured resistance was required to be within 5 percent of calculated resistance, except for eleven specified sensors which were allowed a 7 percent tolerance. The sensor wiring was verified to be correct by shorting out the sensor element, measuring the continuity resistance, and by verifying that this was 5.0 ohms or less. Test Data Table 4.1.12.1, shows the measured and calculated values for each sensor involved in this test.

Engineering comments indicated that there were no parts shortages affecting this test. One problem, reported on FARR 500-373-351, was encountered during the checkout. Temperature sensor, P/N 1A67862-505, S/N 601, reference location 406MT660, malfunctioned. The sensor was replaced with S/N 630, and satisfactorily

4.1.12 (Continued)

tested. The data appears in the Test Data Table. Three revisions were made to the procedure for the following:

a. One revision performed a continuity measurement of wire harness 404W208, to investigate the out-of-tolerance resistance reading of temperature sensor 406MT660.

b. One revision reverified four parameters associated with the LOX instrumentation probe removal and reinstallation.

c. One revision deleted the cryogenic temperature sensor verification of the gas generator fuel bleed valve sensor 4MTT72. This sensor was not installed on the engine.

4.1.12.1 Test Data Table, Cryogenic Temperature Sensor Verification

Meas. Number	P/N	Sensor S/N	Ref. Desig.	Temp. (°F)	Resistance (ohms) Meas.	Calc.	± Tol.
CO 003	1B34473-1	331	403MT686	71	5183.1	5429	380
CO 004	1B34473-501	351	403MT687	67	1505.8	1507.8	107.8
CO 005	1A67863-503	849	405MT612	71	542.9	542.9	27.1
CO 009	1A67863-535	1105	403MT653	70	216.7	216.7	10.8
CO 015	1A67863-509	1052	410MT603	73	1538.2	1526.2	76.3
CO 040	1A67862-505	597	406MT613	77	1513	1517	75.85
CO 052	1A67862-513	567	408MT612	73	5184	5451	381.5
CO 057	1A67862-501	599	406MT606	77	545.7	549.5	27.5
CO 059	1A67862-517	51445	406MT611	77	546	549.5	27.5
CO 133	NA5-27215T5	13376	401(3MTT17)	77	1392.7	1380	69
CO 134	NA5-27215T5	14196	401(3MTT16)	70	1352.8	1360	68.04
CO 159	1A67863-519	1214	424MT610	70	217.8	216.7	10.8
CO 161	1A67863-537	1197	404MT733	70	5148	5418	379.2
CO 208	1A67863-503	907	405MT605	71	542.9	542.9	27.1
CO 230	1A67863-509	749	403MT706	70	1514	1517	75.8
CO 231	1A67863-529	1170	403MT707	70	541.8	541.8	27.0
CO 256	1B37878-501	1627	409MT646	73	1520	1526.2	76.3
CO 257	1B37878-501	1419	409MT647	73	1520.1	1526.2	76.3
CO 368	1A67862-505	601	406MT660	77	1506	1517	75.85
CO 369	1A67862-505	600	406MT661	77	1509	1517	75.85
CO 370	1A67862-533	631	408MT735	73	5195	5451	361.5
CO 371	1A67862-533	634	408MT736	73	5183	5451	381.5
CO 2030	1B37878-511	1825	404MT760	70	541.8	541.8	27.0
CO 2031	1B37878-511	1822	404MT761	70	541.8	541.8	27
†	1B37878-507	1718	403A20	68	5142	5396	377.7
†	1B37878-507	1708	403A21	68	5140	5396	377.7
†	1B37878-507	1709	403A22	68	5141	5396	377.7

† NASA Measurement No. Not Applicable To O2H2 Burner Voting Circuit

4.1.13 Auxiliary Propulsion System (1B55825 E)

The auxiliary propulsion system test 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 APS simulators, used in place of the APS flight modules for this test, did not functionally simulate the APS modules, but provided suitable loads at the electrical interface to determine that the stage mounted components of the APS functioned properly.

All stage mounted components of the APS were tested, in particular, the attitude control relay packages, P/N 1B57731-1, S/N 360, at reference location 404A51A4 and S/N 359, at reference location 404A71A19. The test was satisfactorily accomplished on 5 September 1968.

After performing initial conditions scan, the GSE IU substitute -28 vdc power supply was turned on. 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 was verified.

The attitude control nozzle command was then turned off, and the valve open indication was again verified. 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 pre-test configuration, thereby completing the test procedure.

4.1.13 (Continued)

No problems were encountered during the APS test, and no FARR's were written as a result of this procedure. Two revisions were recorded in the procedure which affected initial conditions scan, but had no bearing on the APS test.

4.1.13.1 Test Data Table, Auxiliary Propulsion System

Attitude Control Nozzle Command		APS Engine	Valve Open Indication Voltage (vdc) AO Multiplexer	BO Multiplexer	Limits
Nozzle I IV	On	1-1	3.928	3.938	4.0 ± 0.25
	Off	1-1	0.000	-	0.0 ∓ 0.25
Nozzle I II	On	1-3	3.902	3.896	4.0 ± 0.25
	Off	1-3	0.005	-	0.0 ∓ 0.25
Nozzle I P	On	1-2	3.979	3.979	4.0 ± 0.25
	Off	1-2	0.000	-	0.0 ∓ 0.25
Nozzle III II	On	2-1	3.861	3.866	3.9 ± 0.25
	Off	2-1	0.005	-	0.0 ∓ 0.25
Nozzle III IV	On	2-3	3.830	3.830	3.9 ± 0.25
	Off	2-3	0.000	-	0.0 ∓ 0.25
Nozzle III P	On	2-2	3.861	3.855	3.9 ± 0.25
	Off	2-2	0.000	-	0.0 ∓ 0.25

4.1.14 Exploding Bridgewire System (1B55822 F)

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

Part Name	Ref. Location	P/N	S/N
Ullage Rocket Ignition System			
EBW Firing Unit	404A47A1	40M39515-113	290
EBW Firing Unit	404A47A2	40M39515-113	291
Pulse Sensor *	404A47A4A1	40M02852	461
Pulse Sensor *	404A47A4A2	40M02852	456
* On Pulse Sensor Bracket Assy	404A47A4	1B52640-1	00011
Ullage Rocket Jettison System			
EBW Firing Unit	404A75A1	40M39515-113	259
EBW Firing Unit	404A75A2	40M39515-113	260
Pulse Sensor **	404A75A10A1	40M02852	479
Pulse Sensor **	404A75A10A2	40M02852	498
** On Pulse Sensor Bracket Assy	404A75A10	1A97791-501	00006

This procedure was accomplished on 5 September 1968, and was accepted on 13 September 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 $\pm$0.3 vdc, while the uncharged or discharge condition was determined by verifying that the voltage indication measured 0.0 $\pm$0.3 vdc, or during the firing unit disable test, 0.2 $\pm$0.3 vdc.

The stage power setup, H&CO 1B55813, was accomplished and initial conditions were established. An EBW pulse sensor self test was conducted first by verifying that the self test command properly turned on the four EBW pulse sensors and that the reset command properly turned off the pulse sensors.

4.1.14 (Continued)

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

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

A final series of checks verified the operation of the EBW pilot relay by determining that the pilot relay reset indication was off after each of the charge ullage ignition and jettison, and fire ullage ignition and jettison commands were turned on, and that the pilot relay reset indication was on after each command was reset.

4.1.14 (Continued)

Engineering comments noted that all parts were installed at the start of this checkout. No problems were encountered during this test, and no FARR's were written. One revision was made to the procedure to explain that the O2H2 burner LH2 valve "not closed" malfunction indication was attributed to the valve being mechanically located between the full open and full closed positions. This valve was functionally operated in the propulsion system automatic procedure, 1B62753 J. The intent of this procedure was not altered when the valve was not in the closed position, when power was applied or removed from the stage.

4.1.15 Level Sensor and Control Unit Calibration (1B64680 D)

This manual procedure determined that the control units associated with the LOX and LH2 liquid level, point level, fastfill, and overfill sensors were adjusted for operating points within the design calibration limits. The particular items involved in this test are noted in Test Data Table 4.1.15.1. The procedure was accomplished between 5 September and 9 September 1968, and was accepted on 10 September 1968.

A point level sensor manual checkout assembly, P/N 1B50928-1, and a variable precision capacitor, General Radio Type 1422CD, were connected in parallel with the sensor to provide capacitance changes to each control unit simulating sensor wet conditions for calibrations and to establish the control unit operating point. The calibration capacitances were 0.7 $\pm$0.01 picofarads for all LH2 sensors, except the LH2 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 deactivation of the output relay; 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 for the LH2 sensors and for the LOX sensors were recorded in Test Data Table 4.1.15.1 with the appropriate minimum and maximum capacitance limits.

4.1.15 (Continued)

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. With the sensor connected, the relay was verified to be deactivated under normal conditions and activated under test conditions.

There were no parts shortages that affected this test. No problems were encountered during the test, nor were any FARR's written. There was one revision made to the procedure to change the tolerance of the manual measurement voltmeter reading from 0.0 $\pm$1.0 vdc to 0.0 $\pm$2.0 vdc.

4.1.15.1 Test Data Table, Level Sensor and Control Unit Calibration

	Sensor P/N 1A68710			Control Unit P/N 1A68710			Deactivate Cap (pf)		Reactivate Cap (pf)	
Function	Ref. Loc.	Dash P/N	S/N	Ref. Loc.	Dash P/N	S/N	Meas	Min	Meas	Max
LH2 Tank	408			411						
Liq Lev L17	MT732	-507	D91	A61A217	-509	C22	0.620	0.55	0.623	0.85
Liq Lev L18	MT733	-507	D92	A61A219	-509	C28	0.664	0.55	0.666	0.85
Liq Lev L19	MT734	-507	D93	A61A221	-509	C29	0.654	0.55	0.660	0.85
Pt Lev 1	A1C1	-507	D75	A92A25	-509	C30	0.618	0.55	0.623	0.85
Pt Lev 2	A2C2	-507	D85	A92A26	-509	C33	0.672	0.55	0.678	0.85
Pt Lev 3	A2C3	-507	D87	A92A27	-509	C35	0.664	0.55	0.668	0.85
Pt Lev 4	A2C4	-507	D88	A61A201	-509	C20	0.690	0.55	0.696	0.85
Fastfill	A2C5	-1	D123	A92A43	-509	C66	0.712	0.55	0.714	0.85
Overfill	*	*	*	A92A24	-509	C19	0.898	0.85	0.906	1.25

* Part of LH2 Mass Probe, P/N 1A48431-513, S/N C2, Location 408A1

4.1.15.1 (Continued)

	Sensor P/N 1A68710			Control Unit P/N 1A68710			Deactivate Cap (pf)		Reactivate Cap (pf)	
Function	Ref. Loc.	Dash P/N	S/N	Ref. Loc.	Dash P/N	S/N	Meas	Min	Meas	Max
LOX Tank	406			404						
Liq Lev L14	MT657	-1	D140	A63A223	-511	C21	1.446	1.35	1.454	1.65
Liq Lev L15	MT658	-1	D134	A63A206	-511	C5	1.471	1.35	1.477	1.65
Liq Lev L16	MT659	-1	D133	A63A221	-511	C19	1.430	1.35	1.439	1.65
Pt Lev 1	A2C1	-1	C1	A72A1	-511	C12	1.482	1.35	1.490	1.65
Pt Lev 2	A2C2	-1	D107	A72A2	-511	C14	1.472	1.35	1.474	1.65
Pt Lev 3	A2C3	-1	C3	A72A3	-511	C25	1.482	1.35	1.488	1.65
Pt Lev 4	A2C4	-1	D126	A63A227	-511	D134	1.486	1.35	1.494	1.65
Fastfill	A2C5	-1	D81	A72A5	-511	C53	1.462	1.35	1.469	1.65
Overfill	**	**	**	A72A4	-511	C43	2.044	1.95	2.052	2.25

** Part of LOX Mass Probe, P/N 1A48430-511-012, S/N C3, Location 406A1

4.1.16 Range Safety Receiver Checks (1B55819 G)

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

Item	Ref. Location	P/N	S/N
Range Safety Receiver 1	411A97A14	50M10697	188
Range Safety Receiver 2	411A97A18	50M10697	185
Secure Command Decoder 1	411A99A1	50M10698	0046
Secure Command Decoder 2	411A99A2	50M10698	0026

Initiated on 5 September 1968, this checkout was completed and accepted on 18 September 1968.

Several manual operations were accomplished before the automatic phase of the checkout was started. The total cable insertion loss values at the 450 MHz range safety frequency were determined to be 30.6 db for range safety system 1 and 30.8 db for range safety system 2. The destruct system test set, P/N 1A59952-1, was set up at 450 $\pm$0.045 MHz with a -17 dbm output level and a 60 $\pm$0.60 kHz deviation. The stage range safety antennas were disconnected from the directional power divider; and until the open loop RF checks, the 50 ohm loads were connected to the power divider for testing.

The cable insertion loss values were loaded into the computer, initial test conditions were established, the range safety receivers were transferred to

4.1.16 (Continued)

external power and turned on, and the propellant dispersion cutoff command inhibit was turned on.

The receiver AGC calibration checks were conducted next. For each input signal level used in the calibration check, the computer determined the GSE test set output levels required to compensate for the cable insertion loss. Per the computer typeout, the GSE test set was manually adjusted to the appropriate output levels. The computer determined the input signal levels and measured the low level signal strength (AGC telemetry) of each receiver. These AGC measurements, in the 0.0 to 5.0 vdc range, were multiplied by a conversion factor of 20 and presented as percent of full scale values. The difference in AGC values at each step was determined and utilized for the AGC drift check. As shown in Test Data Table 4.1.16.1, 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 $\pm$0.005 MHz, the output level was adjusted to obtain a 2.0 $\pm$0.1 vdc AGC voltage from the receiver under test. The corresponding receiver RF output level was determined, and +20 dbm was added to obtain the RF reference level. The GSE test set output level was increased by 3 db, and the test set frequency was increased to greater than 450 MHz and decreased to less than 450 MHz until the receiver AGC voltage was again 2.0 $\pm$0.1 vdc. The frequencies at which this occurred were measured as the upper and lower -3 db bandedge frequencies. The -3 db bandwidth was found as the difference between these frequencies, and the bandwidth centering

4.1.16 (Continued)

was found as the difference between the midpoint of these frequencies and 450 MHz. For the -60 db bandwidth check, this checkout was repeated, except that the test set output level was increased by 60 db in lieu of 3 db.

For the deviation threshold check, the GSE test set was adjusted to an output of 450 $\pm$0.045 MHz at a level that provided receiver input levels of -93 dbm for receivers 1 and 2. A series of checks determined the minimum input deviation frequency at which each receiver responded to the respective range safety command. For each command, the GSE test set was manually adjusted to a sequence of deviation frequencies increasing from 5 kHz per the computer typeout. At each deviation frequency, the range safety secure command decoders were checked for the presence of the command signal from the appropriate receiver. As shown in the Test Data Table, the receivers responded to all commands at minimum deviation frequencies less than the 50 kHz maximum limit.

For the radio frequency sensitivity checks, the GSE test set was adjusted for an output of 450 $\pm$0.045 MHz with a fixed deviation of 60 $\pm$.5 kHz. A series of checks determined the minimum input signal level at which each receiver responded to the respective range safety commands. For each command, the GSE test set output was manually adjusted to a sequence of levels increasing from -85.5 dbm, as requested by the computer. This gave input levels increasing from -115.0 dbm for receivers 1 and 2. At each input level, the range safety secure command decoders were checked for receipt of the command signal from the appropriate receiver. Both receivers responded to minimum input levels less than the -93 dbm maximum limit.

4.1.16 (Continued)

The 50 ohm loads were disconnected from the stage power divider, and the range safety antennas were reconnected. For the manual open loop check, the GSE test set was adjusted for open loop operation, and the test set antenna coaxial switch was set to test position 1. The test set output level was set at -100 dbm and increased in 1 dbm increments until the AGC voltage of the least sensitive receiver no longer increased. This occurred at an output level of -78 dbm. The AGC voltage of the other receiver was verified to be within 3 vdc of this level. The check was repeated with the test set antenna coaxial switch set to test position 2 with the output level measured as -77 dbm. The test set antenna coaxial switch was returned to the first test position, and the test set output level was set at -87.0 dbm for the automatic open loop RF checks.

Under open loop conditions, the low level signal strength (AGC telemetry voltage) of receiver 1 was 3.59 vdc while that of receiver 2 was 3.59 vdc. The range safety commands were transmitted from the GSE test set, and checks of the secure command decoders indicated the 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 indicated that the receivers responded and were not adversely affected by the PCM RF transmission. The PCM RF assembly power was turned off, and the range safety EBW firing units were transferred to external power. The propellant dispersion cutoff command inhibits were turned off for each receiver, and the range safety receivers were turned off, thus completing the range safety receiver checks.

4.1.16 (Continued)

Engineering comments noted that there were no part shortages affecting the test. FARR 500-026-871 reported that the arm and engine cutoff command was not present at controller unit No. 1. The condition was determined to be caused by random radio frequency interference noise and was acceptable to the Material Review Board.

Eleven revisions were documented against the checkout:

a. Two revisions outlined instructions for troubleshooting to determine the cause of the "arm and engine cutoff command not present at controller unit number 1" malfunction.

b. One revision concerned a NASA request to change the test set output from -63 dbm to -93 dbm.

c. One revision concerned a NASA request to perform the range safety open loop test with the SSB transmitter on.

d. One revision concerned paper tape changes in the stage power setup section of the procedure.

e. One revision attributed the SIM interrupt on channel 67 to the engine safety cutoff command being left on prior to the beginning of the matrix reset. Since the change-of-stage occurred from the reset, the SIM interrupt was generated.

f. One revision stated that the O2H2 burner LH2 valve not closed malfunction was due to the valve being left open prior to the initiation of stage power setup. This valve requires pneumatic power to operate. The position of the valve does not affect the intent of the procedure.

g. One revision concerned a program change required to turn on the common bulkhead pressure transducer power for pressure monitoring.

h. One revision concerned changes in the program required to support the propulsion system leak checks.

i. One revision stated that the malfunctions which occurred during the initial condition scan were due to the leak checks which were being run concurrently.

4.1.16 (Continued)

j. One revision stated that the SIM interrupt on channel 67 was due to the ESCS power and the ESCS enable being manually cycled.

4.1.16.1 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	30.66	30.96	0.29	-127.2	16.29	15.78	0.51
-89.4	-120.0	31.58	30.45	1.13	-120.2	16.50	16.00	0.50
-84.4	-115.0	31.89	31.58	0.31	-115.2	16.70	16.50	0.20
-79.4	-110.0	34.96	34.86	0.10	-110.2	17.52	17.42	0.10
-74.4	-105.0	42.97	42.34	0.63	-105.2	21.21	21.43	0.21
-69.4	-100.0	57.01	57.01	0.00	-100.2	30.55	30.66	0.12
-64.4	-95.0	69.43	69.02	0.41	-95.2	50.35	50.25	0.10
-59.4	-90.0	72.19	72.19	0.00	-90.2	69.22	69.43	0.21
-54.4	-85.0	72.91	72.91	0.00	-85.2	73.83	73.83	0.00
-49.4	-80.0	73.22	73.22	0.00	-80.2	74.96	74.96	0.00
-44.4	-75.0	73.32	73.32	0.00	-75.2	75.47	75.37	0.10
-39.4	-70.0	73.22	73.13	0.10	-70.2	75.78	75.78	0.00

-3 db RF Bandwidth Check

Function	Receiver 1	Receiver 2	Limits
Reference Voltage (AGC) (vdc)	2.00	2.00	2.0 ± 0.1
Reference RF Power Level (dbm)	-95.4	-87.5	-
Upper Band Edge Freq. (MHz)	450.160	450.164	-
Lower Band Edge Freq. (MHz)	449.846	449.833	-
-3 db Bandwidth (kHz)	314.0	331.0	340.0 + 30.0
Bandwidth Centering (MHz)	450.003	449.898	450 ± 0.0338

-60 db RF Bandwidth Check

Function	Receiver 1	Receiver 2	Limits
Reference Voltage (ABC) (vdc)	2.00	2.00	2.0 ± 0.1
Reference RF Power Level (dbm)	-95.4	-87.5	-
Upper Band Edge Freq. (MHz)	450.528	450.541	-
Lower Band Edge Freq. (MHz)	449.551	449.541	-
-60 db Bandwidth (MHz)	0.977	1.000	1.2 max

4.1.16.1 (Continued)

Deviation Sensitivity Check

Range Safety Command	Minimum Deviation (kHz) Receiver 1	Receiver 2
Arm and Engine Cutoff	10.0	10.0
Propellant Dispersion	7.5	7.5
Range Safety System Off	7.5	10.0

RF Sensitivity Check

Range Safety Command	Minimum Input Level (dbm) Receiver 1	Receiver 2
Arm and Engine Cutoff	-95.0	-96.2
Propellant Dispersion	-94.0	-96.2
Range Safety System Off	-95.0	-96.2

4.1.17 Range Safety System (1B55821 H)

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

Part Name	Reference Location	P/N	S/N
Range Safety Receiver 1	411A97A14	50M10697	188
Range Safety Receiver 2	411A97A18	50M10697	185
Secure Command Decoder 1	411A99A1	50M10698	0046
Secure Command Decoder 2	411A99A2	50M10698	0026
Secure Command Controller 1	411A97A13	1B33084-503	018
Secure Command Controller 2	411A97A19	1B33084-503	017
RS System 1 EBW Firing Unit	411A99A12	40M39515-119	452
RS System 2 EBW Firing Unit	411A99A20	40M39515-119	550
RS System 1 EBW Pulse Sensor	411A99A31	40M02852	*
RS System 2 EBW Pulse Sensor	411A99A32	40M02852	*
Safe and Arm Device	411A99A22*	1A02446-503	00100
Directional Power Divider	411A97A56	1B38999-1	043
Hybrid Power Divider	411A97A34	1A74778-501	031
* Installed In Pulse Sensor Assembly	411A99A31/A32	1B29054-501	00007

This procedure was initiated on 6 September 1968, and was accomplished by the third attempt on 16 September 1968. The first attempt was aborted due to a SIM interrupt on channel 24, which was caused by a patch panel at Model 240 being disconnected and reinstalled while an oscillograph galvanometer lamp was being changed. The second attempt, on 13 September 1968, was unsatisfactory due to a procedure omission which was corrected on attempt three, by turning off the O2H2 burner LOX propulsion valve closed command during the relay reset section of the program. Values measured during the test are shown in Test Data Table 4.1.17.1. Initial conditions were established for the test, and the GSE destruct system test set, P/N 1A59952-1, was set up for closed loop

4.1.17 (Continued)

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.

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

4.1.17 (Continued)

indications were off at the umbilical and through the AO and BO telemetry multiplexers, that the nonprogrammed engine cutoff indication was off, and that the instrument unit receiver 1 arm and engine cutoff indication was off. The receiver 1 propellant dispersion cutoff command inhibit was then turned off, and the instrument unit receiver 2 arm and engine cutoff indication was verified to be off. Verification was made that the engine control bus power was then off, that the engine cutoff indications were still off at the umbilical and through both multiplexers, that the nonprogrammed 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 engine cutoff command was turned off. The engine control bus power was turned back on, and the bus voltage was measured. Both firing units were transferred to external power and verified to be off, and the charging voltage indications were measured.

The EBW firing unit arm and engine cutoff command was turned back on and verified to be received by range safety system 2. The system 2 firing unit charging voltage indication was measured. Verification was made that the engine cutoff indications were off at the umbilical and through the AO and BO telemetry multiplexers, that the nonprogrammed 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

4.1.17 (Continued)

be off. Verification was made that the engine control bus power was still on, that the engine cutoff indication was then on at the umbilical and through both multiplexers, that the nonprogrammed 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 the system under test, the firing unit charging voltage indication was measured; and the pulse sensor was verified to be on. The propellant dispersion cutoff command inhibit was then turned back on, and the propellant dispersion command was turned off. The above steps were then repeated to test system 2. After the test of system 2, the propellant dispersion cutoff command inhibit was turned off for both receivers, and the engine control bus power was verified to be off.

4.1.17 (Continued)

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 operation were accomplished.

Engineering comments noted that there were no part shortages affecting this test. No FARR's were initiated as the result of this procedure. Eleven revisions were made to the procedure for the following:

a. One revision concerned a NASA request to verify that the O2H2 burner propellant valve relay reset and the LOX repressurization mode relay reset were off, after turning off the range safety 1 receiver propellant dispersion cutoff command inhibit.

b. One revision authorized performance of the second attempt, after the first attempt was aborted, due to a SIM interrupt on channel 24.

4.1.17 (Continued),

c. One revision explained that the SIM interrupt on channel 24 was caused by a patch panel on Model 240 being disconnected and reinstalled for an oscillograph lamp change.

d. One revision authorized the performance of a special range safety pulse sensor test.

e. One revision concerned the performance of attempt three, as the second attempt was unsatisfactory, due to failure of the O2H2 burner propellant valve relay reset to turn on.

f. One revision corrected the O2H2 burner propellant valve relay reset malfunction by a program change that turned off the O2H2 burner LOX valve closed command.

g. One revision stated that the propellant level sensor power not off malfunction was due to parallel performance of the level sensor setup which requires that the sensor power be on.

h. One revision attributed the failure of the LOX repressurization control valve to reset to the valve being set to support the propulsion system leak checks.

i. One revision concerned the paper tape changes to the program during the stage power setup procedure.

j. Two revisions concerned rerunning a section of an earlier revision.

4.1.17.1 Test Data Table, Range Safety System

Function	Measured Value (vdc)	Limits (vdc)
Forward Bus 1 Battery Simulator	28.118	28.0 ± 2.0
Forward Bus 2 Battery Simulator	28.118	29.0 ± 2.0
External/Internal Power Transfer Test		
External Power On		
System 1 Charging Voltage Indication	4.220	4.2 ± 0.3
System 1 Firing Unit Indication	4.220	4.2 ± 0.3
System 2 Charging Voltage Indication	4.265	4.2 ± 0.3
System 2 Firing Unit Indication	4.256	4.2 ± 0.3
Internal Power		
System 1 Charging Voltage Indication	4.225	4.2 ± 0.3
System 2 Charging Voltage Indication	4.274	4.2 ± 0.3

4.1.17.1 (Continued)

Function	Measured Value (vdc)	Limits (vdc)
External Power Off		
System 1 Charging Voltage Indication	0.055	0.3 max
System 2 Charging Voltage Indication	0.050	0.3 max
Firing Unit Arm and Engine Cutoff Test		
Engine Control Bus Voltage	27.999	28.0 ± 2.0
Receiver 1 Signal Strength Indication	3.630	3.75 ± 1.25
Receiver 2 Signal Strength Indication	3.677	3.75 ± 1.25
System 1 Arm and Engine Cutoff Test		
Firing Unit Charging Voltage Indication	4.225	4.2 ± 0.3
Engine Control Bus Voltage	27.910	28.0 ± 2.0
External Power Off		
System 1 Charging Voltage Indication	0.045	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	4.274	4.2 ± 0.3
Propellant Dispersion Test		
System 1 Propellant Dispersion Test		
Charging Voltage Indication (Pulse Sensor Off)	4.229	4.2 ± 0.3
Charging Voltage Indication (Pulse Sensor On)	1.760	3.0 max
System 2 Propellant Dispersion Test		
Charging Voltage Indication (Pulse Sensor Off)	4.279	4.2 ± 0.3
Charging Voltage Indication (Pulse Sensor On)	1.380	3.0 max

4.1.18 Digital Data Acquisition System (1B55817 K)

The digital data acquisition system (DDAS) test verified the operation of all data channels on the stage except certain data channels that were tested during specific system tests. The GSE D924A computer verified that the output of each channel tested was within the required tolerances. Proper operation was verified for the DDAS signal conditioning equipment and associated amplifiers, the remote automatic calibration system (RACS) and the associated command calibration channel decoder assemblies, and the telemetry transmitter and antenna system. The specific items involved in this test were:

Part Name	Ref. Location	P/N	S/N
PCM/DDAS Assembly	411A97A200	1B65792-1	6700089
CP1-BO Time Division Multiplexer	404A61A200	1B65897-1	013
DP1-BO Time Division Multiplexer	404A61A201	1B65897-501	04
Remote Digital Submultiplexer (RDSM)	404A60A200	1B66051-501	04
Remote Analog Submultiplexer (RASM)	404A60A201	1B66050-501.1	05
PCM RF Assembly	411A64A200	1B65788-1-002	15502

Three tests were conducted to verify the operation of all data channels checked. Test attempts one and two, conducted on 6 September and 19 September 1968, respectively, were not successful because of numerous channel malfunctions. Causes of these malfunctions included programming errors, improper setups, interferences due to concurrent testing, wiring errors, stage hardware electrically disconnected, and unstable pressures due to common bulkhead purging.

The third and final test was a successful checkout performed on 27 September 1968. Measurements quoted and the following narrative test descriptions are from the final test.

4.1.18 (Continued)

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

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

Channels without RACS capability and spare channels were tested by comparing the end item outputs at ambient conditions to tolerance limits. Ambient conditions were defined as 70°F at 14.7 psia, and for bilevel parameters, the normal state of valves or switches during the performance of this test. All channel outputs were measured, and the results were recorded on the line-printer.

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

4.1.18 (Continued)

After establishing initial conditions, the DDAS test started with automatic setup, including turn on of the 5-volt and 28-volt transducer power supplies and reset of the control matrix 8 switch.

Turn of of DDAS input No. 1, common bulkhead pressure transducer 28-volt power, and LOX and LH2 ullage pressure transducer power completed the automatic setup.

The first test performed was the CP1-BO and DP1-BO multiplexer flight calibration checks. 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 for both multiplexers.

The PCM RF test was performed next. The forward and reflected RF output powers of the PCM/DDAS assembly were measured through the CP1-BO and DP1-BO multiplexer telemetry outputs; and the voltage standing wave ratios (VSWR) were determined. The same measurements were also made through the ground monitor outputs for both multiplexers. The CP1-BO multiplexer telemetry readings were: forward power, 25.370 watts; reflected power, 1.608 watts; VSWR, 1.672. The DP1-BO multiplexer telemetry readings were: forward power, 25.399 watts; reflected power, 1.646 watts, VSWR, 1.682. The CP1-BO multiplexer ground monitor readings were: forward power, 24.835 watts; reflected power, 0.744 watts; VSWR, 1.418. The DP1-BO multiplexer ground monitor readings were: forward power, 24.864 watts; reflected power, 0.750 watts; VSWR, 1.420. High and low RACS tests were then conducted on measurement channel CP1-BO-05-10 for the aft 5 volt excitation module voltage, while both

4.1.18 (Continued)

the ground monitor and telemetry outputs were measured. High RACS for telemetry and ground monitor outputs were 3.989 vdc and 3.994 vdc, respectively. Low RACS were -0.005 vdc and 0.000 vdc, respectively, for telemetry and ground monitor outputs. All measurements were within the acceptable tolerances.

The CP1-BO multiplexer test made measurements of the high and low RACS voltages of each channel having calibration capability, and measurements of the ambient outputs in units of temperature, pressure, voltage, current, frequency, event indication, liquid level indication, and position indication, as applicable for the various channels. Output values for each of the CP1-BO multiplexer channels tested were within the required limits.

The DP1-BO multiplexer test was also run, except for special channels, in the same manner as described for the CP1-BO multiplexer. All channel outputs for the test were within tolerance with the exception of the ambient output for measurement C2012. This occurred because the expected ambient value entered into the program was too high. A manual check of the ambient temperature of the ambient helium pneumatic sphere using a thermometer indicated that the ambient output received was within tolerance.

Special channel tests were also conducted. These special channels measured 400 Hz, 100 Hz, and 1500 Hz signals. The 400 Hz test checked the static inverter-converter frequency, the LOX and LH2 chilldown inverter frequencies, and the LOX and LH2 circulation pump flow rates. The LOX and LH2 flowmeter tests at 100 Hz followed the 400 Hz test, and the LOX and LH2 pump speeds were

4.1.18 (Continued)

checked using the 1500 Hz signal. All of the special channels were within the required tolerances of the expected values for the final test.

An APS simulator multiplexer test and a J-2 engine pressures multiplexer test were run to check those channels on both multiplexers that measured the APS simulator and special J-2 engine functions. Measurements were made of the high and low RACS voltages for each of the APS simulator and special J-2 engine channels having calibration capability; and the ambient outputs were measured in $^{\circ}F$ or psia, as appropriate for the channel tested. All APS simulator and J-2 engine special channels were within the required tolerances.

The last check conducted was the umbilical measurements test. Umbilical measurements were made for ambient pressure and voltage checks of the LOX and LH2 chilldown pump differential pressure transducers. After the umbilical checks, these measurements were returned to their respective telemetry channels and verified. Next, a multiplexer test was run for the common bulkhead internal pressure channel including high and low RACS voltages and ambient output pressure. Then, additional umbilical measurements included the 20 percent and 80 percent calibration checks of the common bulkhead pressure and the umbilical LOX and LH2 ullage pressure measurements. Ambient pressure checks of the LOX and LH2 emergency detection system transducers completed the umbilical measurements test. All measurements for the test were within tolerance, and the DDAS was accepted for use.

There were no FARR tags initiated as a result of DDAS testing. Twenty-six revisions were recorded in the procedure for the following:

4.1.18 (Continued)

a. Eleven revisions corrected program and procedure errors.

b. Nine revisions updated the program to the latest requirements.

c. Three revisions concerned the malfunctions that occurred during test attempts one and two, as previously discussed in this narrative.

d. One revision authorized verification of functional operation for K141 and K142, range safety 1 and 2 pulse sensors.

e. One revision explained the channel malfunction for ambient output of measurement C2012 during the DP1-B0 multiplexer test, as previously discussed in this narrative.

f. One revision indicated that an out-of-tolerance measurement for the GSE 5-volt transducer power occurred because the power supply had not been set to the required tolerance. After adjustment, the program was resumed and the voltage measured was within tolerance.

4.1.19 Hydraulic System Setup and Operation (1B41005 B)

The purpose of this manual procedure, initiated on 9 September 1968, and completed on 14 October 1968, was to ensure that the hydraulic system was correctly filled, flushed, bled, and maintained free of contaminants during the hydraulic system operation. The hydraulic system pressures and temperatures were checked for proper operational levels, the hydraulic system transducer circuits were tested for correct operation and response characteristics, and the J-2 engine operational clearance in the aft skirt was established.

Proper operation of the auxiliary hydraulic pump, P/N 1A66241-511, S/N X458911; the hydraulic pitch and yaw actuator assemblies, P/N's 1A66248-507, S/N's 81 and 30; the main hydraulic pump, P/N 1A66240-503, S/N X123108; and the accumulator/reservoir assembly, P/N 1B29319-519, S/N 00033, were verified during checkout activity. There were no part shortages affecting this test.

Prior to operation of the stage hydraulic system, the hydraulic-pumping unit (HPU), P/N 1A67443-1, was checked to ensure that the hydraulic fluid met the cleanliness requirements. The HPU was connected to the stage, utilizing the pressure and return hoses; and the hydraulic fluid was circulated through the stage hydraulic system to ensure that the system was properly filled. Hydraulic fluid samples were taken and certified to be free of contaminants.

The accumulator/reservoir was charged with gaseous nitrogen, and the stage air bottle was charged to a pressure of 475 ± 50 psig. The HPU was turned on; and the pressure compensator turned in the INCR direction until the system hydraulic pressure gauge indicated no further increase in pressure, but was less than 4400 psig. The stage hydraulic system was then checked for leaks. On completion

4.1.19 (Continued)

of the leak check, the pressure compensator on the HPU was turned in the DECR direction until the stage hydraulic system pressure reached 1500 ± 5 psig. The HPU bypass valve was opened, and the stage system pressure was further reduced to 1000 ± 50 psig. The auxiliary hydraulic pump was turned on and verified to be operating properly.

With the midstroke locks installed on the hydraulic actuators, the vernier scales were adjusted to read zero, then the midstroke locks were removed. The HPU was turned on, and the hydraulic system pressure was brought up to 3650 ± 50 psig. The pitch and yaw vernier scales were read, and the values were recorded. The HPU was turned off, and the midstroke locks were reinstalled.

The engine deflection clearance check was accomplished next. The gimbal control unit (GCU), P/N 1B50915, was installed and set up per H&CO 1B53382. The J-2 engine bellows protective covers were removed; and the platform extension, P/N 1B70620, was removed from the engine area. The J-2 engine restrainer and the hydraulic actuator midstroke locks were removed. After an inspection of the engine area for possible interference points, the HPU was turned on; and the stage system pressure was brought up to 1000 psig. The pitch and yaw controls on the GCU were turned in the retract and extend directions. As the controls were moved, it was verified that the pitch and yaw actuators moved in relation to the direction and amplitude of the controls. By returning the pitch and yaw controls to center, the actuators were positioned to center; and the HPU was turned off. The midstroke locks and the J-2 engine bellows protective covers were reinstalled.

4.1.19 (Continued)

Verification and setup of the stage and test control center hydraulic system instrumentation was started by turning on the HPU and adjusting the pressure compensator until the system hydraulic pressure gauge indicated the desired pressure readings. These readings were used to support verification of the system pressure for parameter D549. The reservoir oil level was checked at zero and one hundred percent by parameter L504.

Preparations for the engine gimbal test were started by setting the pitch and yaw manual controls on the GCU to the center position and turning the GCU off. The HPU was turned off, the GCU was disconnected from the actuators, and the stage electrical cables were connected to the actuators. The midstroke locks were removed, and it was verified that the engine area was clear for engine gimbaling tests. The HPU was turned on, and the system pressure increased to 3650 $\pm$50 psig. Various signals were applied to the pitch and yaw actuators, and the resultant voltages were noted and recorded. Upon completion of this series of tests, the HPU was turned off; and the midstroke locks and J-2 engine bellows protective covers were reinstalled.

A check to determine the pressure decay of the stage air bottle was next. The stage air bottle was charged to 450 psig. After a 24 hour period, the pressure was remeasured and found to be 450 psig.

An instrumentation setup was made to provide telemetry parameters for computer interrogation during the hydraulic system automatic checkout. Telemetry connections were made to the reservoir oil pressure transducer, the reservoir oil level transducer, and the pump inlet temperature transducer. After completion

4.1.19 (Continued)

of the hydraulic system automatic checkout, these parameters were disconnected and the hardwire cables were reconnected.

The final engine deflection clearance check was accomplished next. This test provided for gimbaling the engine to its travel extremities and checking the clearance between engine, stage, and test stand structure, with particular emphasis on the clearance of the electrical cables. This section was not performed until the final cable installations and the wrapping had been completed. The GCU was reinstalled, and the engine bellows protective covers were removed. The test stand platform extension was removed from the engine area. The restrainer links and midstroke locks were removed. The auxiliary hydraulic pump was turned on and verified to be operating normally. The pitch manual control and the yaw manual control on the GCU were varied, and the engine deflection clearance test was repeated. After completion of the test, the auxiliary hydraulic pump was turned off; and the midstroke locks and bellows protective covers were reinstalled. The GCU was disconnected and removed, and the stage electrical connectors were reconnected to the actuators.

The simulated static firing support test was accomplished next. This checkout was required to simulate the engine driven hydraulic pump flow capabilities during simulated static firing. The HPU was turned on approximately 20 seconds prior to simulated engine start, and the hydraulic system pressure was set at 3700 psig. After simulated engine cutoff, the HPU was turned off.

The shutdown sequence of this checkout included a final air content test which provided the information necessary for system analysis by discharging a portion of the internal system fluid volume overboard. The volume discharged was

4.1.19 (Continued)

determined to be a function of the fluid temperature measurement to provide space in the reservoir for fluid thermal expansion under ground operating conditions (0°F to 160°F). The HPU was turned on, and the system pressure was increased to 3650 ±50 psig. The bypass valve was opened, and the HPU was then turned off. Verification was made that the return pressure gauge indicated a minimum of 200 psig. The shutoff valve was cycled open and closed until the return pressure was reduced to 180 ±5 psig. An empty 100 ml graduate was placed under the drain port; and by cycling the reservoir drain valve open and closed, the return pressure was decreased to 80 ±5 psig. The volume of fluid bled was less than the 16 milliliters maximum as specified per design requirements.

FARR 500-373-407 documented leakage through the GN2 accumulator fill valve in the closed position. Valve, P/N 1B31295-1, S/N 117, was removed and replaced.

Twenty revisions were made to the procedure for the following:

a. Two revisions were required to update the procedure to the latest configuration.

b. Five revisions clarified or corrected errors in the procedure.

c. Three revisions concerned tests to establish the allowable tolerances for the accumulator/reservoir vent relief valves and the stage air bottle decay rate.

d. One revision authorized verifying that the hydraulic parameters were within the ambient tolerances prior to pressurizing the hydraulic system.

e. One revision authorized changing the slope of the curve for temperature versus hydraulic fluid drained to allow for higher ground operating temperatures which could vent fluid overboard due to thermal expansion.

4.1.19 (Continued)

f. One revision authorized increasing GN2 fill valve torque to the high side of the tolerance to correct fill valve leakage.

g. One revision requested verification that hydraulic system filters were operating properly and were not clogging as evidenced by filter differential pressures.

h. One revision was a request to measure fluid vented from the low pressure relief valve for engineering reference.

i. One revision requested obtaining the system fluid cleanliness level prior to disconnecting the HPU from the stage. The samples were acceptable.

j. One revision requested obtaining fluid samples from the HPU prior to preparations for simulated static firing. The samples were acceptable.

k. Two revisions specified the sequence for the simulated static firing support test.

l. One revision provided a test plan to verify engine side loads and ensure data repeatability.

4.1.19.1 Test Data Table, Hydraulic System Setup and Operation

	Instrumentation			
Test Description	Name	Location	Actual	Requirement
Actuator Position System Unpressurized	Pitch Vernier	Pitch Actuator	0 inches	0 inches
	Yaw Vernier	Yaw Actuator	0 inches	0 inches
	Pitch Vernier	Pitch Actuator	0 inches	Ref. Only
	Yaw Vernier	Yaw Actuator	0 inches	Ref. Only

4.1.19.1 (Continued)

Instrumentation

Test Description	Name	Location	Position	Voltage
Instrumentation Support	Pitch Actuator Position (deg.)	TCC	0	2.498 vdc
			+1	2.155 vdc
			+2	1.818 vdc
			+1	2.165 vdc
			0	2.507 vdc
	Pitch Actuator Position (deg.)	TCC	0	2.507 vdc
			-1	2.848 vdc
			-2	3.190 vdc
			-1	2.847 vdc
			0	2.506 vdc
	Yaw Actuator Position (deg.)	TCC	0	2.530 vdc
			+1	2.862 vdc
			+2	3.195 vdc
			+1	2.866 vdc
			0	2.533 vdc
	Yaw Actuator Position (deg.)	TCC	0	2.533 vdc
			-1	2.202 vdc
			-2	1.873 vdc
			-1	2.196 vdc
			0	2.521 vdc
Stage Air Bottle Decay Check	Air Bottle Pressure	Stage	Start 1250 9-17-68	450 psig *
			Stop 1500 4-19-68	450 psig

* Decay rate established by revision at 5 psi per hour.

4.1.20 Propellant Utilization System Calibration (1B64368 F)

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) to simulate the LOX and LH2 mass probe outputs under varying propellant load conditions. The items involved in this test included the following:

Part Name	Ref. Location	P/N	S/N
Propellant Utilization Electronic Assembly (PUEA)	411A92A6	1A59358-529	032
Static Inverter-Converter	411A92A7	1A66212-507	023
LOX Mass Probe	406A1	1A48430-511-012	C3
LH2 Mass Probe	408A1	1A48431-513	C2
LOX Overfill Sensor	(Part of LOX Mass Probe)		
LOX Overfill Control Unit	404A72A4	1A68710-511	C43
LOX Fastfill Sensor	406A2C5	1A68710-1	D81
LOX Fastfill Control Unit	404A72A5	1A68710-511	C53
LH2 Overfill Sensor	(Part of LH2 Mass Probe)		
LH2 Overfill Control Unit	411A92A24	1A68710-509	C19
LH2 Fastfill Sensor	408A2C5	1A68710-1	D123
LH2 Fastfill Control Unit	411A92A43	1A68710-509	C66

The procedure was initiated on 9 September 1968, and accepted on 13 September 1968. Measurements and ratiometer settings made during the test appear in Test Data Table 4.1.20.1.

Atmospheric conditions in the test area were measured before the calibration was started. Megohm resistance measurements were made on the LH2 and LOX mass probe elements through connector 411W11P1 at the PUEA, using a 50 vdc megohmeter. The PUT/S was connected to the PUEA, then the static inverter-converter

4.1.20 (Continued)

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; the PUEA LH2 and LOX bridge empty condition calibrations were accomplished by nulling the bridge tap voltages with the PUT/S ratiometer at settings of 0.01408 for the LH2 bridge and 0.04038 for the LOX bridge; then, the bridge outputs were nulled by adjusting the PUEA R2 potentiometer for the LH2 bridge and the PUEA R1 potentiometer for the LOX bridge. Simulated full conditions were then established with the PUT/S using a C1 capacitor (LH2) setting of 181.99 picofarads and a C2 capacitor (LOX) setting of 123.35 picofarads, and the ratiometers were set to 0.82193 for the LH2 bridge and 0.82193 for the LOX bridge. To accomplish the PUEA LH2 and LOX bridge full calibrations, the bridge outputs were nulled by adjusting PUEA R4 potentiometer for the LH2 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 by adjusting the PUT/S ratiometer to null the PUEA LH2 and LOX bridge outputs. Bridge slew checks were conducted by establishing simulated 1/3 and 2/3 slew conditions with the PUT/S and by adjusting the PUT/S ratiometer to null the PUEA LH2 and LOX bridge outputs for each condition. For the reference mixture ratio (RMR) calibration, the difference between the previously determined LH2 and LOX empty ratiometer settings, 0.02630, was multiplied by 98.4 vdc to give a V1 reference voltage of 2.588 vdc. Simulated empty

4.1.20 (Continued)

conditions were established with the PUT/S, and the PUEA residual empty bias R6 potentiometer was adjusted to null the RMR bias voltage. Simulated full conditions were then established with the PUT/S, and the PUEA residual full bias R5 potentiometer was adjusted to null the RMR bias voltage. For a fuel boiloff bias calibration, simulated boiloff conditions were established with the PUT/S using a C1 capacitor (LH2) setting of 204.49 picofarads and a C2 capacitor (LOX) setting of 123.35 picofarads. The PUEA fuel bias R7 potentiometer was then adjusted to null the RMR bias voltage.

PUEA LH2 and LOX bridge linearity checks were accomplished by individually setting the PUT/S C1 capacitor (LH2) and C2 capacitor (LOX) to specific values and by 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 2.274 vdc under simulated empty conditions and as 9.87 vdc under bias internal test conditions. The fuel boiloff bias voltage was the difference between these measurements, -7.604 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 LH2 and LOX bridge output voltages. The LH2 voltage was 22.5 vdc and the LOX voltage 22.5 vdc, meeting the 23.52 $\pm$2.0 vdc requirements.

A total of nine revisions were made to the procedure for the following:

4.1.20 (Continued)

a. Three revisions concerned monitoring and recording the PU oven monitor, NASA measurement N63.

b. Two revisions concerned isolating test equipment from the test stand ground system by using isolation transformers.

c. One revision reran the fuel boiloff bias voltage calculations because a multiplication error resulted in an incorrect value for V1 and V2.

d. One revision corrected a program error.

e. One revision corrected a typographical error.

f. One revision deleted a redundant operation.

4.1.20.1 Test Data Table, Propellant Utilization System Calibration

Pre-Test Atmospheric Conditions

Temperature:	78°F
Pressure:	29.92 inches of Hg
Relative Humidity:	45 percent

LH2 Mass Probe Megohm Check - Plug 411W11P1

Function	Resistance (megohms)	Limits (megohms)
LH2 Probe Elements, Pins G to E	80k	1000 min
Pin G to Shield	3k	1000 min
Pin G to Stage Ground	15k	1000 min
Pin G Shield to Stage Ground	15k	1000 min
Pin E to Stage Ground	20k	1000 min
LOX Probe Elements, Pin A to C	50k	1000 min
Pin C to Shield	30k	1000 min
Pin C to Stage Ground	12k	1000 min
Pin C Shield to Stage Ground	11k	1000 min
Pin A to Stage Ground	10k	1000 min

Static Inverter-Converter Measurements

Function	Measurement	Limits
5.0 vdc Output Voltage (vdc)	4.9195	4.75 to 5.05
21.0 vdc Output Voltage (vdc)	21.55	20.00 to 22.50
28.0 vdc Output Voltage (vdc)	27.14	26.00 to 30.00
117 vdc Output Voltage (vdc)	120.90	115.00 to 122.50

4.1.20.1 (Continued)

Function	Measurement	Limits
115 vrms Monitor Voltage (vdc)	2.77	2.23 to 3.18
Test Point 2 Voltage (vdc)	21.68	20.00 to 22.5
V/P Excitation Voltage (vdc)	50.25	48.84 to 51.98
Operating Frequency (Hz)	400.00	394.000 to 406.00

Data Acquisition

Function	PUT/S Ratiometer	Limits
LH2 Empty	0.00017	*
LOX Empty	0.02075	*
LH2 Full	0.82170	*
LOX Full	0.82195	*

Bridge Slew Checks

LH2 1/3 Slew	0.31083	*
LH2 2/3 Slew	0.64108	*
LOX 1/3 Slew	0.28200	*
LOX 2/3 Slew	0.56827	*

LH2 Bridge Linearity Check

PUT/S C1 Value	PUT/S Ratiometer	Limits
36.4 pf	0.15916	0.15774 to 0.16103
72.79 pf	0.32490	0.32338 to 0.32667
109.19 pf	0.49007	0.48902 to 0.49230
145.59 pf	0.65542	0.65465 to 0.65794
181.99 pf	0.82161	0.82029 to 0.82358

LOX Bridge Linearity Check

PUT/S C2 Value	PUT/S Ratiometer	Limits
24.67 pf	0.17977	0.17913 to 0.18242
49.34 pf	0.33996	0.33942 to 0.34271
74.01 pf	0.49973	0.49971 to 0.50300
98.68 pf	0.66005	0.66000 to 0.66329
123.35 pf	0.82167	0.82029 to 0.82358

* Limits Not Specified

4.1.21 Propellant Utilization System (1B55823 H)

This automatic checkout verified the capability of the propellant utilization (PU) system to determine and control the engine propellant flow mixture ratio in a manner that ensured simultaneous propellant depletion. The test also verified the capability of the PU system to provide propellant level information for controlling the fill and topping valves during LOX and LH2 loading operations. The automatic checkout system (ACS) was utilized during testing to function PU system components and to monitor responses. This test involved all components of the stage PU system including:

Part Name	Ref. Location	P/N	S/N
Propellant Utilization Electronics Assy (PUEA)	411A92A6	1A59358-529	032
Static Inverter-Converter	411A92A7	1A66212-507	023
LOX Mass Probe	406A1	1A48430-511-012	C3
LH2 Mass Probe	408A1	1A48431-513	C2
LOX Overfill Sensor		(Part of LOX Mass Probe)	
LOX Overfill Control Unit	404A72A4	1A68710-511	C43
LOX Fastfill Sensor	406A2C5	1A68710-1	D81
LOX Fastfill Control Unit	404A72A5	1A68710-511	C53
LH2 Overfill Sensor		(Part of LH2 Mass Probe)	
LH2 Overfill Control Unit	411A92A24	1A68710-509	C19
LH2 Fastfill Sensor	408A2C5	1A68710-1	D123
LH2 Fastfill Control Unit	411A92A43	1A68710-509	C66

The test was successfully conducted on 10 September 1968. Measurements taken during this test are shown in Test Data Table 4.1.21.1.

After conducting stage power setup per H&CO 1B55813, the ratio values, obtained from the manual PU system calibration procedure, H&CO 1B64368, were loaded into the computer. From these ratio values, nominal test values were computed for the LOX and LH2 coarse mass voltages, fine mass voltages, and loading voltages. After an evaluation of the computer printout, a test of the PU system power

4.1.21 (Continued)

was made. Power was applied to the PU inverter and electronics assemblies, and after a programmed delay to allow the inverter-converter to stabilize, the output voltages and frequency were measured and determined to be within specified limits. After an additional programmed delay for the PU oven temperature to stabilize, as indicated by the PU oven stability monitor output voltage, it was verified that the PUEA amplifier was properly calibrated by measuring the PU oven output voltages through the remote automatic calibration system (RACS).

The servo balance and ratio valve null test was conducted next. The ratio valve position was measured, and the LOX and LH2 coarse and fine mass voltages were measured through the AO and BO instrumentation multiplexers.

The PU loading test followed. The LH2 boiloff bias signal voltage was measured with the boiloff bias cutoff turned on and was verified to be 0.0 $\pm$2.5 vdc with the cutoff turned off. The GSE loading potentiometer power was turned on, and the voltage measured. Measurements were then made of the LOX and LH2 loading potentiometer sense voltages and signal voltages. Measurements of the LOX and LH2 loading potentiometer signal voltages were repeated after the LOX and LH2 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 LH2 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 LH2 coarse and fine mass voltages were measured through the AO and BO telemetry multiplexers. The measurements were repeated with the LOX and LH2 bridge 1/3 checkout relays on, with the bridge

4.1.21 (Continued)

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 LH2 tank overfill and fastfill sensors and their associated control units responded properly under ambient (dry) conditions and under simulated wet conditions of the sensors.

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

The next section of this procedure was the PU activate test. All measurements for this test were made through the AO and BO multiplexers. The ratio valve position was measured; then, the LOX bridge 1/3 checkout relay command was turned on, and the LOX coarse mass voltage was measured. The ratio valve position was remeasured with the PU activate switch turned on and again with it turned off. The LOX bridge 1/3 checkout relay command was turned off, then the LOX coarse mass voltage and the ratio valve position were measured. These steps were repeated using the LH2 bridge 1/3 checkout relay, then measuring the LH2 coarse mass voltage.

The PU valve hardover test was the final checkout of the procedure. The PU valve hardover position command was turned on, and the PU system valve position was measured with the LOX bridge 1/3 checkout relay command and the PU activate switch both on, meeting the position requirement of -20 degrees maximum.

There were no FARR's initiated as a result of this test; however, eleven revisions were recorded in the procedure for the following:

4.1.21 (Continued)

a. Three revisions were written to correct errors in the procedure.

b. One revision changed the time cell loading data from octal to base 10 value, to be compatible with the time cell data format.

c. One revision noted that program changes for stage power setup were the same as those used for the demonstration test of that procedure, H&CO 1B55813.

d. One revision indicated that a malfunction during stage power setup occurred because of concurrent testing and had no bearing on the PU system test.

e. One revision changed the tolerance range from ±1 vdc to ±2 vdc for PU boiloff bias voltage based on letter I-I/1B-SIVB5 -L078.

One revision concerned changing the tolerance of the PU oven monitor voltage from ±0.3 vdc to ±0.075 vdc per ECP 2330-R2 and WRO S-IVB-3653R6.

g. One revision noted that the first attempt to measure the PU oven monitor voltage was out-of-tolerance because the oven monitor amplifier gain was set near the low end of the tolerance. The amplifier was adjusted and then verified per H&CO 1B55817, DDAS automatic test.

h. One revision outlined a special measurement of the system test error signal voltage, per request of the customer.

i. One revision attributed an out-of-tolerance measurement for system test valve position signal during the PU valve movement test to noise which the computer monitored as out-of-tolerance. A special measurement of the system test error signal voltage indicated the measurement to be within tolerance.

4.1.21.1 <u>Test Data Table, Propellant Utilization System</u>

<u>Loaded Ratio Values (from H&CO 1B64368)</u>

LOX Empty Ratio	0.021	LH2 Empty Ratio	0.000
LOX 1/3 Bridge Slew Ratio	0.282	LH2 1/3 Bridge Slew Ratio	0.311
LOX 2/3 Bridge Slew Ratio	0.568	LH2 2/3 Bridge Slew Ratio	0.641
LOX Wiper Ratio	0.039	LH2 Wiper Ratio	0.014

LH2 Boiloff Bias Voltage (vdc) 7.378

4.1.21.1 (Continued)

Computed Coarse Mass Voltages (vdc)

LOX Empty	0.103	LH2 Empty	0.000
LOX 1/3 Mass	1.411	LH2 1/3 Mass	1.553
LOX 2/3 Mass	2.842	LH2 2/3 Mass	3.203

Computed Fine Mass Voltages (vdc)

LOX Empty	4.009	LH2 Empty	1.367
LOX 1/3 Mass	0.342	LH2 1/3 Mass	2.432
LOX 2/3 Mass	2.305	LH2 2/3 Mass	4.780

Computer Loading Voltages (vdc)

LOX Empty	0.574	LH2 Empty	0.000
LOX 1/3 Coarse Mass	7.902	LH2 1/3 Coarse Mass	8.695

PU System Power Test

Function	Measured Value	Limits
Inv-Conv 115 vrms Output (vac)	114.830	115.0 ± 3.4
Inv-Conv 21 vdc Output (vdc)	21.694	21.25 ± 1.25
Inv-Conv 5 vdc Output (vdc)	4.957	4.9 ± 0.2
Inv-Conv Frequency (Hz)	399.805	400.0 ± 6
PU Oven Monitor Voltage Z1 (vdc)	2.235	2.6 ± 2.35
PU Oven Monitor Voltage Z2 (vdc)	2.235	2.235 ± 0.075
PU Oven Monitor Voltage Z3 (vdc)	2.240	2.235 ± 0.075
PU Oven Monitor Voltage - Final (vdc)	2.240	2.235 ± 0.075
PU Oven Monitor Voltage - High RAC (vdc)	3.928	4.0 ± 0.075
PU Oven Monitor Voltage - RACS Run Mode On (vdc)	2.215	2.240 ± 0.075
PU Oven Monitor Voltage - Low RAC (vdc)	0.005	0.0 ± 0.075
PU Oven Monitor Voltage - RACS Run Mode On (vdc)	2.215	2.240 ± 0.075

Bridge Balance and Ratio Valve Null Test

Function	Measured Value	AO Multi	BO Multi	Limits
Ratio Valve Position (deg)	0.624			0.000 ± 1.5
LOX Coarse Mass Voltage (vdc)		0.107	0.103	0.103 ± 0.1
LOX Fine Mass Voltage (vdc)		4.072	4.087	4.009 ± 0.4
LH2 Coarse Mass Voltage (vdc)		0.005	0.000	0.000 ± 0.1
LH2 Fine Mass Voltage (vdc)		1.479	1.470	1.367 ± 0.4

4.1.21.1 (Continued)

PU Loading Test

Function	Measured Value	Limits
LH2 Boiloff Bias Signal Volt. (vdc)	8.72	8.378 + 2.0
GSE Power Supply Voltage (vdc)	29.039	28.0 ± 2.0

Loading Potentiometer Function	LOX Value	LH2 Value	Limits
Sense Voltage, GSE Power On (vdc)	28.958	29.039	29.039 + 0.4
Signal Voltage, Relay Commands	0.574		0.574 ∓ 0.5
Off (vdc)		-0.027	0.0 + 0.5
Signal Voltage, Relay Commands	7.684		7.902 + 0.6
On (vdc)		8.477	8.695 ∓ 0.6
Signal Voltage, Relay Commands	0.602		0.574 ∓ 0.5
Off (vdc)		0.000	0.0 + 0.5
Sense Voltage, GSE Power OFF (vdc)	-0.039	0.000	0.0 ∓ 0.75

Servo Balance Bridge Gain Test

Function	Measured Value	AO Multi	BO Multi	Limits
Ratio Valve Position (deg)	0.624			0.624 + 1.5
LOX Coarse Mass Voltage (vdc)		0.107	0.103	0.103 ∓ 0.1
LOX Fine Mass Voltage (vdc)		4.087	4.063	4.009 ∓ 0.4
LH2 Coarse Mass Voltage (vdc)		0.005	-0.010	0.000 ∓ 0.1
LH2 Fine Mass Voltage (vdc)		1.475	1.455	1.367 ∓ 0.4

1/3 Checkout Relay Commands On

Function	Measured Value	AO Multi	BO Multi	Limits
Ratio Valve Position (deg)	1.033			0.624 + 1.5
LOX Coarse Mass Voltage (vdc)		1.416	1.406	1.411 ∓ 0.1
LOX Fine Mass Voltage (vdc)		0.229	0.215	0.342 ∓ 0.4
LH2 Coarse Mass Voltage (vdc)		1.563	1.553	1.553 ∓ 0.1
LH2 Fine Mass Voltage (vdc)		2.642	2.627	2.432 ∓ 0.4

2/3 Checkout Relay Commands On

Function	Measured Value	AO Multi	BO Multi	Limits
Ratio Valve Position (deg)	1.510			0.624 + 1.5
LOX Coarse Mass Voltage (vdc)		2.852	2.837	2.842 ∓ 0.1
LOX Fine Mass Voltage (vdc)		1.987	1.978	2.305 ∓ 0.4
LH2 Coarse Mass Voltage (vdc)		3.208	3.198	3.203 ∓ 0.1
LH2 Fine Mass Voltage (vdc)		4.834	4.819	4.780 ∓ 0.4

4.1.21.1 (Continued)

Function	Measured Value	AO Multi	BO Multi	Limits
2/3 Checkout Relay Commands Off				
Ratio Valve Position (deg)	1.102			0.624 ± 1.5
LOX Coarse Mass Voltage (vdc)		1.411	1.401	1.411 ± 0.1
LOX Fine Mass Voltage (vdc)		0.215	0.210	0.342 ± 0.4
LH2 Coarse Mass Voltage (vdc)		1.558	1.553	1.553 ± 0.1
LH2 Fine Mass Voltage (vdc)		2.642	2.627	2.432 ± 0.4
1/3 Checkout Relay Commands Off				
Ratio Valve Position (deg)	0.624			0.624 ± 1.5
LOX Coarse Mass Voltage (vdc)		0.112	0.098	0.103 ± 0.1
LOX Fine Mass Voltage (vdc)		4.072	4.077	4.009 ± 0.4
LH2 Coarse Mass Voltage (vdc)		-0.010	-0.005	0.000 ± 0.1
LH2 Fine Mass Voltage (vdc)		1.465	1.460	1.367 ± 0.4

PU Valve Movement Test

Function	Measured Value	Limits
Ratio Valve Position, AO (deg)	0.624	0.624 ± 1.50
Ratio Valve Position, BO (deg)	0.692	0.624 ± 1.50
50 Second Plus Valve Slew, AO Multiplexer		
+1 vdc System Test Valve Position Signal (vdc)	1.010	1.00 ± 0.02
V1, Position at T+3 Seconds (deg)	3.886	2.037 to 6.351
V2, Position at T+5 Seconds (deg)	5.045	2.659 to 7.396
V3, Position at T+8 Seconds (deg)	5.727	2.977 to 7.396
V4, Position at T+20 Seconds (deg)	6.067	5.226 to 7.396
V5, Position at T+50 Seconds (deg)	6.067	5.226 to 7.396
50 Second Minus Valve Slew, AO Multiplexer		
Ratio Valve Position, AO (deg)	0.56	0.624 ± 1.5
-1 vdc System Test Valve Error Signal (vdc)	-0.999	-1.000 ± 0.02
V1, Position at T+3 Seconds (deg)	-3.612	-2.037 to -6.351
V2, Position at T+5 Seconds (deg)	-4.499	-2.659 to -7.396
V3, Position at T+8 Seconds (deg)	-5.044	-2.977 to -7.396
V4, Position at T+20 Seconds (deg)	-5.386	-5.226 to -7.396
V5, Position at T+50 Seconds (deg)	-5.316	-5.226 to -7.396

4.1.21.1 (Continued)

PU Activation Test

Function	AO Multi	BO Multi	Limits
Ratio Valve Position (deg)	0.556	0.624	0.624 ± 1.50
LOX 1/3 Command Relay On			
LOX Coarse Mass Voltage (vdc)	1.411	1.406	1.411 ± 0.1
PU System On			
Ratio Valve Position (deg)	32.871	33.008	20.0 min
PU System Off			
Ratio Valve Position (deg)	0.965	1.033	15.0 max
LOX 1/3 Command Relay Off			
LOX Coarse Mass Voltage (vdc)	0.107	0.107	0.103 + 0.1
Ratio Valve Position (deg)	0.624	0.761	0.624 ± 1.5
LH2 1/3 Command Relay On			
LH2 Coarse Mass Voltage (vdc)	1.558	1.553	1.553 ± 0.1
PU System On			
Ratio Valve Position (deg)	-27.532	-27.396	-20.0 max
PU System Off			
Ratio Valve Position (deg)	0.76	-	-15.0 min
LH2 1/3 Command Relay Off			
LH2 Coarse Mass Voltage (vdc)	0.000	-0.010	0.000 + 0.1
Ratio Valve Position (deg)	0.624	0.761	0.624 ± 1.5

PU Valve Hardover Test

Ratio Valve Position (deg)	-27.668		-20.0 max

4.1.22 Signal Conditioning Setup (1B44474 D)

This procedure calibrated the stage 5 volt and 20 volt excitation modules 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 4.1.22.1.

The procedure was initiated on 10 September 1968, and was certified as completed on 15 October 1968. The stage power setup, H&CO 1B55813, was performed prior to any calibration activity to provide electrical power to the equipment.

Three 5 volt excitation modules were calibrated. The input voltage to each module was verified to be 28 ±0.1 vdc; and each module was adjusted to obtain a 5 vdc output of 5.0 ±0.005 vdc, a -20 vdc output of -20.00 ±0.005 vdc, and an ac output of 10 ±1 volt peak-to-peak at 2000 ±200 Hz. The final values measured, as shown in the Test Data Table, were all within the above limits. The ac output measurements were made with the test switch set to four different positions, sequentially, 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 measured value for each module was within the above limits.

4.1.22 (Continued)

Three temperature bridges required calibration: the PU oven stability monitor, the GH2 start bottle temperature, and the LOX nonpropulsive vent temperature.

Two low gain DC amblifiers and one breakpoint amplifier were functionally checked and calibrated. The pressure readings, at ambient conditions, for the hydraulic reservoir oil pressure, the accumulator GN2 pressure, the auxiliary hydraulic pump motor gas pressure, and the auxiliary hydraulic pump air tank pressure were obtained from the hardwire checkout, H&CO 1B70213, and from the DDAS automatic checkout, H&CO 1B55817.

No part shortages were recorded that affected this test, and no FARR's were generated as a result of this test. Fourteen revisions were made to the procedure for the following:

a. One revision gave instructions to obtain the pressure readings for the hydraulic pressure transducers from the hardwire checkout procedure, H&CO 1B70213, and from the DDAS automatic checkout, H&CO 1B55817.

b. One revision changed the 5 volt excitation module part number callout from P/N 1A77310-1 to P/N 1A77310-503.1.

c. One revision concerned the calibration of three temperature bridges, parameters N063, C006, and M010.

d. One revision corrected a procedure error.

e. One revision added a -503 to the breakpoint amplifier part number callout to match the stage configuration.

f. One revision added measurements N60, RF transmitter power, and N61, reflected power, to the procedure. These parameters were added to the stage as part of the single side band system and were not in the original release of this checkout.

g. One revision gave additional setup instructions for measurement N61.

h. One revision provided instructions to ensure that the low gain amplifiers under test were grounded to the stage signal ground.

4.1.22 (Continued)

i. One revision reran the calibration of measurement N60 as the initial setup was made without proper signal ground.

j. One revision recalibrated the aft 5 volt excitation module after the initial readings were out-of-tolerance.

k. Two revisions corrected typographical errors.

l. One revision gave instructions to readjust the low gain amplifier for measurement M10, fuel boiloff bias voltage, as the parameter was found to be out-of-tolerance during the preverification run of IST.

m. One revision concerned the deletion of the sections of the procedure that were not required. This procedure is used to calibrate only those measurements found to be out-of-tolerance during stage checkout.

4.1.22.1 Test Data Table, Signal Conditioning Setup

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

Reference Location	S/N	5 vdc Output (vdc)	-20 vdc Output (vdc)	ac Output vpp	Hz
411A99A33	0144	4.998	-19.994	10.0	2000
404A52A7	0174	5.000	-20.000	10.0	2005
411A98A2	0191	4.998	-19.999	10.5	2001

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

Reference Location	S/N	20 vdc Output (vdc)
411A61A242	0293	20.004
404A62A241	0294	19.996
404A63A241	0296	20.000
404A64A241	0355	20.003
404A65A241	0370	20.002
404A63A233	0265	20.000

Temperature Bridges

Function	Reference Location	S/N	Measurement	Limits
PU Oven Stability Monitor (1B68861-1)	411A61A214	0181	Low +0.0013 vdc	0 ± .005 vdc
			High +4.0014 vdc	4 ± .005 vdc

4.1.22.1 (Continued)

Function	Reference Location	S/N	Measurement		Limits
Temp GH2 Start Bottle (1A98088-501)	404A64A207	084	Low	0.00 mvdc	0 + 0.05 mvdc
			High	24.2 mvdc	24.0 ± 0.3 mvdc
Temp - LOX NPV Nozzle No. 2 (1B63306-533)	404A64A227	0217	Low	0.00 mvdc	0 + 0.05 mvdc
			High	24.04 mvdc	24.0 ± 0.3 mvdc
Low Gain Amplifiers					
Fuel Boiloff Bias (1A94910-519)	411A61A256	0383	Low	+0.996 vdc	1.0 ± 0.109 vdc
			High	+4.000 vdc	4.0 ± 0.109 vdc
			Run	-0.004 vdc	0.0 ± 0.025 vdc
RF Transmitter Power (1A94910-507)	411A61A205	0377	Low	1.003 vdc	1.0 ± 0.109 vdc
			High	4.000 vdc	4.0 ± 0.005 vdc
			Run	0.0247 vdc	0.0 ± 0.025 vdc
Breakpoint Amplifiers					
Reflected RF Power (1B54875-503)	411A61A206	0105	Low	1.002 vdc	1.0 ± 0.005 vdc
			High	4.000 vdc	4.0 ± 0.005 vdc
			Bias	0.003 vdc	0.0 ± 0.005 vdc

Hydraulic Pressure Transducer Ambient Condition Check

Function	Measurement	Limits
Reservoir Oil Pressure	15.5 psia	14.7 ± 8 psia
GN2 Accumulator Pressure	1394.1 psia	1395 ± 50 psia
Aux Hyd Pump Motor Gas Press	0.851 psig	0 ± 1.2 psig
Aux Hyd Pump Air Tank	15.602 psia	14.7 ± 13 psia

4.1.23 Hydraulic System (1B55824 G)

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 main hydraulic pump, P/N 1A66240-503, S/N X123108; the auxiliary hydraulic pump, P/N 1A66241-511, S/N X458911; the accumulator/reservoir assembly, P/N 1B29319-519, S/N 00033; the hydraulic pitch actuator, P/N 1A66248-507, S/N 81; and the hydraulic yaw actuator, P/N 1A66248-507, S/N 30.

The test was satisfactorily accomplished on 13 September 1968. Those function values measured during the test are presented in Test Data Table 4.1.23.1. 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 1B55813, was accomplished; and initial conditions were established for the test. The instrument unit (IU) substitute 5 volt power supply was turned on and its voltage measured; then, the aft 5 volt excitation module voltage was measured. Measurements were made of various hydraulic system functions with the hydraulic system unpressurized. Measurements were also made to determine the accumulator/reservoir gaseous nitrogen mass and corrected oil level.

The methods of controlling the auxiliary hydraulic pump were checked next. After verifying that a power cable was connected to the auxiliary hydraulic

4.1.23 (Continued)

pump motor, the aft bus 2 power supply was turned on, and the bus voltage was verified to be 56.0 $\pm$4.0 vdc. The coast mode operation was checked by applying dry ice to the coast mode thermal switch and by 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 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 and the voltage of the IU substitute 5 volt power supply and the aft 5 volt excitation module were measured; and the corrected actuator positions were determined. The pitch and yaw actuator locks were removed, 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 determined to be within tolerance. With the hydraulic system

4.1.23 (Continued)

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

A clearance, linearity, and polarity check was accomplished next. The actuators were individually extended to their stops, then retracted causing the engine to move out to its extremes of travel, 0 degrees to $\pm 7\frac{1}{2}$ 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. When the actuators were at their extremes and when they were returned to neutral, checks of the hydraulic system pressure and reservoir oil pressure 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

4.1.23 (Continued)

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.

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.

Engineering comments noted that all parts were installed during this test. There were no discrepancies during the test that resulted in FARR documentation. Two revisions were recorded in the procedure for the following:

a. One revision authorized a program change that would prevent the hydraulic pump from unexpectedly turning on if the thermal switch should pickup after a malfunction.

b. One revision was required to correct an error in the procedure.

4.1.23.1 Test Data Table, Hydraulic System

Function	Measurement	Limits
IU Substitute 5 Volt Power Supply (vdc)	4.99	5.00 + 0.05
Aft 5 Volt Excitation Module (vdc)	5.00	5.00 $\pm$ 0.03

4.1.23.1 (Continued)

Function	Measurement	Limits
Hydraulic System Unpressurized		
Reservoir Oil Pressure (psia)	75.94	*
Accumulator GN2 Pressure (psia)	2296.44	*
Accumulator GN2 Temperature (°F)	63.14	*
Reservoir Oil Level (%)	87.85	*
Pump Inlet Oil Temperature (°F)	67.45	*
Reservoir Oil Temperature (°F)	66.66	*
Aft Bus 2 Current (amp)	0.40	*
Aux Hyd Pump Air Tank Pressure (psia)	451.05	282.5 ± 217.5
Aux Hyd Pump Motor Gas Pressure (psig)	14.73	21 ± 12
Gaseous Nitrogen Mass (lb)	1.898	1.925 ± 0.2
Corrected Reservoir Oil Level (%)	98.6	95.0 min
Engine Centering Test, Locks On, System Unpressurized		
T/M Pitch Actuator Position (deg)	-0.00	*
IU Pitch Actuator Position (deg)	-0.04	*
T/M Yaw Actuator Position (deg)	0.04	*
IU Yaw Actuator Position (deg)	0.03	*
IU Substitute 5 Volt Power Supply (vdc)	5.00	*
Aft 5 Volt Excitation Module (vdc)	5.00	*
Pitch Actuator Signal (ma)	0.10	*
Yaw Actuator Signal (ma)	0.00	*
Corrected T/M Pitch Actuator Position (deg)	-0.002	-0.236 to 0.236
Corrected IU Pitch Actuator Position (deg)	-0.036	-0.236 to 0.236
Corrected T/M Yaw Actuator Position (deg)	0.045	-0.236 to 0.236
Corrected IU Yaw Actuator Position (deg)	0.022	-0.236 to 0.236
Engine Centering Test, Locks Off, System Pressurized No Excitation Signal		
Aft Bus 2 Voltage (vdc)	56.48	56.0 ± 4.0
Aft Bus 2 Current (amp)	60.80	55.0 ∓ 30.0
Hyd System 4 Second Press Change (psia)	320.8	200.0 min
T/M Pitch Actuator Position (deg)	-0.02	*
IU Pitch Actuator Position (deg)	-0.03	*
T/M Yaw Actuator Position (deg)	0.09	*
IU Yaw Actuator Position (deg)	0.09	*
IU Substitute 5 Volt Power Supply (vdc)	5.02	*
Aft 5 Volt Excitation Module (vdc)	5.00	*
Pitch Actuator Signal (ma)	0.05	*
Yaw Actuator Signal (ma)	0.20	*
Corrected T/M Pitch Actuator Position (deg)	-0.018	-0.517 to 0.517
Corrected IU Pitch Actuator Position (deg)	0.000	-0.517 to 0.517
Corrected T/M Yaw Actuator Position (deg)	0.092	-0.517 to 0.517
Corrected IU Yaw Actuator Position (deg)	0.061	-0.517 to 0.517

* Limits Not Specified

4.1.23.1 (Continued)

Function	Measurement	Limits
Hydraulic System Pressurized, Locks Off, Zero Excitation Signal Applied to Actuators		
Hydraulic System Pressure (psia)	3601.38	*
Reservoir Oil Pressure (psia)	166.28	*
Accumulator GN2 Pressure (psia)	3578.44	*
Accumulator GN2 Temperature (°F)	79.97	*
Reservoir Oil Level (%)	36.32	*
Pump Inlet Oil Temperature (°F)	76.45	*
Reservoir Oil Temperature (°F)	75.67	*
Aft Bus 2 Current (amp)	44.80	*
T/M Pitch Actuator Position (deg)	-0.02	*
IU Pitch Actuator Position (deg)	-0.04	*
T/M Yaw Actuator Position (deg)	0.09	*
IU Yaw Actuator Position (deg)	0.10	*
IU Substitute 5 Volt Power Supply (vdc)	5.00	*
Aft 5 Volt Excitation Module (vdc)	5.00	*
Pitch Actuator Signal (ma)	0.10	*
Yaw Actuator Signal (ma)	0.05	*
Corrected T/M Pitch Actuator Position (deg)	-0.018	-0.517 to 0.517
Corrected IU Pitch Actuator Position (deg)	-0.036	-0.517 to 0.517
Corrected T/M Yaw Actuator Position (deg)	0.092	-0.517 to 0.517
Corrected IU Yaw Actuator Position (deg)	0.097	-0.517 to 0.517

Transient Response Tests, Pitch Axis

Time From Start (sec)	Pitch Excitation Signal (ma)	IU Pitch Actuator Pot. Pos. (deg)	IU 5 Volt Power Supply (vdc)
Pitch 0 to -3 Degree Step Response - Engine Slew Rate: 14.8 deg/sec			
0.000	0.050	-0.088	5.005
0.025	-19.922	-0.461	5.010
0.054	-20.020	-0.851	5.010
0.081	-19.873	-1.212	5.005
0.107	-19.873	-1.645	5.010
0.136	-19.873	-2.120	5.010
0.163	-19.922	-2.510	5.005
0.189	-19.873	-2.799	5.010
0.218	-19.922	-3.001	4.990
0.245	-19.922	-3.087	5.010
0.272	-19.873	-3.116	5.010
0.300	-19.873	-3.102	5.010

* Limits Not Specified

4.1.23.1 (Continued)

Time From Start (sec)	Pitch Excitation Signal (ma)	IU Pitch Actuator Pot. Pos. (deg)	IU 5 Volt Power Supply (vdc)
Pitch -3 to 0 Degree Step Response - Engine Slew Rate: 13.7 deg/sec			
0.000	-19.949	-3.103	5.005
0.026	0.000	-2.626	5.010
0.054	0.098	-2.279	5.010
0.081	0.049	-1.947	5.005
0.108	0.049	-1.515	5.005
0.136	0.049	-1.082	5.010
0.163	0.049	-0.692	5.010
0.191	0.049	-0.346	5.010
0.218	0.049	-0.086	5.010
0.245	0.049	0.044	5.010
0.273	0.049	0.049	5.005
0.300	0.098	0.029	5.005
Pitch 0 to +3 Degree Step Response - Engine Slew Rate: 13.9 deg/sec			
0.000	0.100	-0.044	5.015
0.026	19.971	0.434	5.010
0.053	19.971	0.779	5.005
0.081	19.922	1.126	5.000
0.108	19.922	1.544	5.010
0.135	19.971	1.963	5.000
0.163	19.971	2.381	5.005
0.190	19.971	2.698	4.990
0.218	19.971	2.958	5.010
0.245	19.971	3.060	5.005
0.272	19.971	3.074	5.015
0.300	20.020	3.074	5.005
Pitch +3 to 0 Degree Step Response - Engine Slew Rate: 15.5 deg/sec			
0.000	20.000	3.044	5.010
0.026	0.049	2.583	5.010
0.054	0.098	2.223	5.005
0.081	0.049	1.818	5.005
0.108	0.049	1.371	5.010
0.136	0.098	0.924	5.005
0.163	0.049	0.549	5.010
0.190	0.049	0.217	5.010
0.218	0.000	-0.000	5.010
0.245	0.000	-0.086	5.005
0.272	0.000	-0.071	5.010
0.300	0.049	-0.028	5.010

4.1.23.1 (Continued)

Transient Response Tests, Yaw Axis

Time From Start (sec)	Yaw Excitation Signal (ma)	IU Yaw Actuator Pot. Pos. (deg)	IU 5 Volt Power Supply (vdc)
Yaw 0 to -3 Degree Step Response - Engine Slew Rate: 13.1 deg/sec			
0.000	0.000	0.046	5.010
0.026	-19.873	-0.361	5.010
0.054	-19.873	-0.722	5.000
0.080	-19.873	-1.025	5.005
0.108	-19.922	-1.429	5.005
0.136	-19.873	-1.833	5.005
0.162	-19.824	-2.208	5.005
0.190	-19.873	-2.555	5.005
0.218	-19.873	-2.757	5.010
0.245	-19.873	-2.915	5.005
0.272	-19.873	-2.944	5.005
0.300	-19.873	-2.930	5.005
Yaw -3 to 0 Degree Step Response - Engine Slew Rate: 13.4 deg/sec			
0.000	-19.750	-2.894	5.010
0.026	0.000	-2.497	5.005
0.054	0.049	-2.165	5.000
0.081	0.098	-1.775	5.010
0.109	0.000	-1.386	5.005
0.136	0.049	-0.909	5.000
0.163	0.098	-0.506	5.010
0.190	0.098	-0.202	5.010
0.218	0.049	0.028	5.010
0.245	0.049	0.115	5.015
0.272	0.098	0.144	5.010
0.300	0.098	0.101	5.010
Yaw 0 to +3 Degree Step Response - Engine Slew Rate: 14.0 deg/sec			
0.000	0.050	0.104	5.015
0.026	20.020	0.519	5.010
0.054	20.020	0.880	5.000
0.081	19.971	1.270	5.010
0.109	19.971	1.688	5.010
0.136	19.971	2.120	5.005
0.163	20.020	2.539	5.010
0.190	19.971	2.842	5.010
0.218	20.020	3.102	5.010
0.245	20.068	3.174	5.005
0.272	20.020	3.217	5.010
0.300	20.068	3.188	4.990

4.1.23.1 (Continued)

Time From Start (sec)	Yaw Excitation Signal (ma)	IU Yaw Actuator Pot. Pos. (deg)	IU 5 Volt Power Supply (vdc)
Yaw +3 to 0 Degree Step Response - Engine Slew Rate: 12.8 deg/sec			
0.000	20.050	3.207	5.005
0.026	0.049	2.770	5.005
0.055	0.049	2.438	5.010
0.081	0.049	2.106	5.010
0.109	0.049	1.731	5.010
0.137	0.049	1.327	5.010
0.163	0.049	0.908	5.010
0.191	0.098	0.548	5.010
0.219	0.098	0.288	5.005
0.245	0.049	0.115	5.010
0.273	0.000	0.058	5.010
0.301	0.098	0.086	5.010

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

Function	Measurement	Limits
Hydraulic System Pressure (psia)	3601.38	*
Reservoir Oil Pressure (psia)	171.08	*
Accumulator GN2 Pressure (psia)	3589.38	*
Accumulator GN2 Temperature (°F)	72.53	*
Reservoir Oil Level (%)	37.56	*
Pump Inlet Oil Temperature (°F)	122.46	*
Reservoir Oil Temperature (°F)	110.63	*
Aft Bus 2 Current (amps)	44.60	*
Aux Hyd Pump Air Tank Pressure (psia)	452.47	282.5 + 217.5
Aux Hyd Pump Motor Gas Pressure (psig)	21.41	21 ± 12
T/M Pitch Actuator Position (deg)	-0.06	*
IU Pitch Actuator Position (deg)	-0.04	*
T/M Yaw Actuator Position (deg)	0.14	*
IU Yaw Actuator Position (deg)	0.09	*
IU Substitute 5 Volt Power Supply (vdc)	5.01	*
Aft 5 Volt Excitation Module (vdc)	5.00	*
Pitch Actuator Signal (ma)	0.20	*
Yaw Actuator Signal (ma)	0.05	*
Corrected T/M Pitch Actuator Position (deg)	-0.064	-0.517 to 0.517
Corrected IU Pitch Actuator Position (deg)	-0.029	-0.517 to 0.517
Corrected T/M Yaw Actuator Position (deg)	0.140	-0.517 to 0.517
Corrected IU Yaw Actuator Position (deg)	0.075	-0.517 to 0.517

* Limits Not Specified

4.1.24 Propulsion System Test (1B62753 K)

This automatic procedure performed the prefire integrated electromechanical functional tests required to verify the operational capability of the stage propulsion system. For convenience of performance, the test sequences were divided into three sections: The first section checked the ambient helium system and included functional checks of the pneumatic control system and the propellant tanks repressurization system; the second test section checked the propellant tanks pressurization system; and the third section was a four part functional check of the J-2 engine system. The first segment of the J-2 engine checkout tested the spark ignition systems for the J-2 engine thrust chamber and gas generator, the second segment functionally checked the engine cutoff logic and delay timers, the third segment checked the J-2 engine valve sequencing with control helium pressurization, and the final segment was a combined automatic check of the J-2 engine system operation.

The prefire propulsion system testing was initiated on 23 September 1968. The first attempt was aborted due to an out-of-tolerance condition of the telemetry data. Investigation revealed a broken ground stud on the stage. Acceptance of the propulsion system was on 2 October 1968, by the second attempt

Subsequent to establishing initial conditions, testing of the ambient helium system commenced by pressurizing the ambient helium pneumatic control sphere and repressurization spheres to 700 ± 50 psia and setting the stage control helium regulator discharge pressure at 515 ± 50 psia. A series of checks verified the proper operation of the control helium dump valve and the pneumatic

4.1.24 (Continued)

power control module shutoff valve. After verifying the proper operation of the LOX chilldown pump purge control and dump valves, the LOX chilldown pump purge pressure switch checkout was conducted.

The LH2 and LOX repressurization control module dump valves and control valves were verified to operate properly. A series of checks verified the proper functioning of the O2H2 burner spark system and propellant valves.

A three-cycle test of the engine pump purge pressure switch preceded the functional checkout of the engine pump purge valve. The control helium regulator backup pressure switch and the control helium shutoff valve were similarly tested. The control helium sphere was pressurized to 734.76 psia; and the control helium regulator discharge pressure was measured at 563.14 psia, both within acceptable limits. A series of checks verified the operation of the pneumatically controlled valves, including the LH2 and LOX vent valves, fill and drain valves, prevalves, chilldown shutoff valves, the LH2 directional vent valve, the LH2 continuous vent and relief override valve and orificed bypass valve, and the O2H2 burner propellant valves and LOX shutdown valve. The LH2 tank pressurization and continuous vent valve blowdown check completed the ambient helium system test.

Section two, the propellant tanks pressurization systems test, was started with functional checks of the cold helium dump and shutoff valves. The operation of the cold helium regulator backup pressure switch was verified by the three-cycle pressure switch test, as well as by verifying that the switch properly controlled the cold helium shutoff valve.

4.1.24 (Continued)

The LOX and LH2 repressurization control valves were verified to operate properly, and the operation of the LOX and LH2 tank repressurization backup pressure switch interlocks was verified by the three-cycle test and by demonstrating that the switches properly controlled the LOX and LH2 repressurization control valves.

The proper operation of the O2H2 burner spark ignition system was verified. The LOX tank pressure switches, the cold helium shutoff valve, and the cold helium heat exchanger bypass valve were verified to operate properly. Proper control of the LOX main fill valve, the LOX auxiliary tank pressurization valve, the LOX replenish valve, and the LOX repressurization valve by the pressure switches was demonstrated.

The LH2 repressurization and ground fill overpressurization pressure switches were verified to operate properly. Control of the LH2 main fill valve, the LH2 replenish valve, the LH2 auxiliary tank pressure valve, the step pressure valve, and the repressurization control valve by the pressure switches was also demonstrated. After satisfactory completion of the LH2 pressure switch checks, the cold helium system was pressurized to 896.45 psia; and the cold helium sphere blowdown and cold helium regulator low flow test were conducted. The cold helium spheres were vented, and a series of checks verified proper operation for the O2H2 burner voting circuit and burner malfunction temperature sensors. This completed testing of the propellant tanks pressurization systems.

4.1.24 (Continued)

Section three, the J-2 engine functional tests, was conducted next. The LH2 and LOX tanks were vented to ambient, the O2H2 burner spark systems 1 and 2, the emergency detection systems 1 and 2 engine cutoffs, the repressurization control valves, and the O2H2 burner propellant valves were verified to operate properly.

The engine spark test verified proper operation of the thrust chamber augmented spark igniter (ASI) and gas generator spark systems. The engine start tank was pressurized, the proper operation of the start tank vent valve was verified, and the start tank was vented to ambient pressure prior to the engine cutoff test. The engine ready signal was verified to be on, and the simulated mainstage OK signal opened the prevalves. Verification of proper prevalve response to the switch selector engine cutoff signals was made with the prevalves closing to the cutoff signal and opening at signal removal. The engine ignition cutoff test and the LH2 injector temperature detector bypass test were satisfactorily conducted.

The next series of tests verified that the simulated aft separation signals, 1 and 2, individually inhibited engine start and demonstrated proper operation of the LH2 injector temperature detector bypass and start tank discharge control. During these tests, measurements were made of the helium delay timer, the sparks de-energized timer, and the start tank discharge timer.

Three-cycle tests of mainstage OK pressure switches 1 and 2 were conducted. It was 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, pickup of

4.1.24 (Continued)

either switch would maintain the engine in mainstage. It was also demonstrated that dropout of both pressure switches was required to turn on engine thrust OK indications and cause engine cutoff.

The engine helium control sphere was pressurized to 1461.43 psia to conduct the engine valve sequence tests which demonstrated that actuation and deactuation of the helium control solenoid valve caused the LH2 and LOX bleed valves to close and open, that opening and closing the ignition phase control solenoid valve caused the engine augmented spark igniter (ASI) LOX valve and engine main fuel valve to open and close, that the start tank discharge solenoid valve caused the engine augmented spark igniter (ASI) LOX valve and engine main fuel valve to open and close, that the start tank discharge solenoid valve opened and closed, 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.

The final test was the combined automatic functional demonstration of the entire J-2 engine system. The necessary commands were given to initiate engine start and cutoff; and throughout the automatic sequence, the engine system responses were verified to be within the predetermined limits.

Engineering comments indicated that there were no shortages affecting propulsion automatic checkout. There were no test discrepancies that resulted in the initiation of FARR's.

4.1.24 (Continued)

Nineteen revisions were made to the procedure as follows:

a. Two revisions concerned a test to isolate the cause of the engine start command on indication not being received by the computer. The cause of the discrepancy was attributed to the mislocation of a hardwire drag-in cable.

b. Two revisions attributed the failure of the GH2 start bottle to decrease in pressure within 30 seconds to the start tank vent valve actuator line from the pneumatic power control module being disconnected.

c. One revision concerned changes needed to correct the procedure.

d. One revision outlined a functional test for the LH2 continuous vent relief setting.

e. One revision gave instructions to perform a checkout of the start tank emergency vent system.

f. One revision added a checkout for NASA measurements K001, K002, and K155. These parameters were insufficiently checked during the DDAS test, as the systems were at ambient.

g. One revision concerned the out-of-tolerance condition of the T/M data and gave instructions to perform a DDAS test to determine the cause of the trouble, after terminating attempt number 1. Instructions were also given to perform attempt number 2 after correcting the problem.

h. One revision attributed the out-of-tolerance condition of the T/M data to a broken ground stud on the stage.

i. One revision authorized opening the LOX chilldown pump purge hand valve to provide a slight flow through the pneumatic power control module when the stage control sphere was pressurized.

j. One revision authorized running only the section of the procedure necessary to revalidate the T/M data as the out-of-tolerance condition does not affect any other section of the test.

k. One revision stated that the LH2 and LOX sled command power not set malfunction was due to the power not being manually turned on.

l. One revision authorized disconnecting the LH2 propellant valve backup pneumatic flex hose from the actuation module vent port, as the backup solenoid valve was not electrically connected.

4.1.24 (Continued)

m. One revision gave instructions to manually set the stage 1 helium line pressure to 1000 psia as the pressure had increased to 1065 psi

n. One revision concerned verifying the operation of the LH2 latching relief valve as the telemetry cables were not connected at the time of the first test.

o. One revision attributed the out-of-tolerance condition of the stage 4 helium line pressure to a fluctuation of the pressure transducer output.

p. One revision stated that the lack of an open indication for the LH2 auxiliary pressure valve was caused by the auxiliary pressure valve switch being left in the closed position.

q. One revision stated that during the performance of revision j, the turnon of the component test power was bypassed causing a malfunction printout. This malfunction did not affect the results of the test.

4.1.24.1 Test Data Table, Propulsion Test

Section 1 - Ambient Helium Test

Function

Engine Pump Purge Pressure Switch Checkout

	Measured Values			
	Test 1	Test 2	Test 3	Limits
Pickup Pressure (psia)	121.920	120.371	121.920	136.0 max
Dropout Pressure (psia)	110.313	110.313	111.086	99.0 min
Deadband (psid)	11.607	10.059	10.834	3.0 min

Control Helium Regulator Backup Pressure Switch Checkout

Pressurization Time (sec)	65.013	25.597	17.270	180.0 max
Pickup Pressure (psia)	607.797	602.406	601.641	600 + 21
Depressurization Time (sec)	8.964	8.721	9.254	180.0 max
Dropout Pressure (psia)	499.172	499.938	499.938	490 ± 31

4.1.24.1 (Continued)

Pneumatically Controlled Valve Timing Checkout

Valve	Operating Times (sec) Open	Total Open	Close	Total Close	Boost Close	Total Boost Close
LH2 Vent Valve	0.020	0.082	0.207	0.466	0.088	0.231
LOX Vent Valve	0.012	0.071	0.104	0.392	0.066	0.271
LOX F&D Valve	0.129	0.245	0.632	2.074	0.365	0.821
LH2 F&D Valve	0.063	0.157	0.496	1.383	0.237	0.553
LOX Prevalve	1.182	1.776	0.161	0.290	*	*
LH2 Prevalve	1.182	1.791	0.161	0.291	*	*
LOX C/D SOV	0.226	1.063	0.025	0.129	*	*
LH2 C/D SOV	0.264	1.019	0.020	0.136	*	*
LH2 Cont Vent Orif'd Bypass Valve	0.020	0.094	0.007	0.136	*	*
02H2 Burner LH2 Prop	0.028	0.093	0.026	0.105	*	*
02H2 Burner LOX Prop	0.007	0.087	0.007	0.084	*	*
LH2 Latch Rlf Vlv	0.026	0.065	0.126	0.319	0.017	0.192
LOX NPV Vlv	0.026	0.040	0.154	0.391	0.080	0.212

Valve	Flight Position	Total Flt. Position	Ground Position	Total Ground Position
LH2 Directional Vent Valve	0.083	0.177	0.808	1.383

Section 2 - Propellant Tanks Pressurization System Test

Function

Cold Helium Regulator Backup Pressure Switch Checkout

	Measured Values Test 1	Test 2	Test 3	Limits
Pressurization Time (sec)	59.021	42.335	41.762	180 max
Pickup Pressure (psia)	475.300	475.300	475.300	467.5 ± 23.5
Depressurization Time (sec)	13.567	13.526	13.609	180 max
Dropout Pressure (psia)	374.367	374.367	373.586	362.5 ± 33.5

LOX Tank Repressurization Backup Pressure Switch Checkout

	Test 1	Test 2	Test 3	Limits
Pressurization Time (sec)	39.766	40.207	40.929	180 max
Pickup Pressure (psia)	468.359	467.594	467.594	467.5 ± 23.5
Depressurization Time (sec)	13.019	12.934	12.844	180 max
Dropout Pressure (psia)	375.133	374.367	375.898	362.5 ± 33.5

* Not applicable to these valves

4.1.24.1 (Continued)

Section 2 - Propellant Tanks Pressurization System Test (Continued)

Function

LH2 Tank Repressurization Backup Pressure Switch Checkout

	Measured Values Test 1	Test 2	Test 3	Limits
Pressurization Time (sec)	43.041	43.267	43.007	180 max
Pickup Pressure (psia)	475.297	475.297	473.750	467.5 ± 23.5
Depressurization Time (sec)	14.132	14.178	14.188	180 max
Dropout Pressure (psia)	370.508	369.734	372.047	362.5 ± 33.5

LOX Tank Ground Fill Overpressure Pressure Switch Checkout

	Test 1	Test 2	Test 3	Limits
Pressurization Time (sec)	25.665	23.559	14.680	180 max
Pickup Pressure (psia)	40.326	40.274	40.274	41 max
Depressurization Time (sec)	4.840	4.306	4.205	180 max
Dropout Pressure (psia)	38.396	38.291	38.188	27.8 min
Deadband (psid)	1.930	1.983	2.087	0.5 min

LH2 Repressurization Control Pressure Switch Checkout

	Test 1	Test 2	Test 3	Limits
Pressurization Time (sec)	80.821	34.754	21.703	180 max
Pickup Pressure (psia)	30.793	30.584	30.584	31 max
Depressurization Time (sec)	60.208	49.837	47.106	180 max
Dropout Pressure (psia)	29.395	28.499	28.395	27.8 min
Deadband (psid)	2.398	2.085	2.189	0.5 min

LH2 Tank Ground Fill Overpressure Pressure Switch Checkout

	Test 1	Test 2	Test 3	Limits
Pressurization Time (sec)	68.863	29.318	21.909	180 max
Grd. Fill Overpress Pickup Press (psia)	30.480	30.271	30.376	31 max
Depressurization Time (sec)	71.442	54.796	52.118	180 max
Grd. Fill Overpress Dropout Pressure (psia)	28.238	28.238	28.238	27.8 min
Deadband (psid)	2.242	2.033	2.138	0.5 min

Section 3 - J-2 Engine Functional Test (Engine S/N J-2119)

Engine Delay Timer Checkout

Function	Delay Time (sec)	Limits (sec)
Ignition Phase Timer	0.435	0.450 ± 0.030
Helium Delay Timer	0.996	1.000 ∓ 0.110
Sparks De-energized Timer	3.305	3.300 ∓ 0.200
Start Tank Discharge Timer	1.007	1.000 ∓ 0.040

4.1.24.1 (Continued)

Section 3 - J-2 Engine Functional Test (Continued)

Function

Mainstage OK Pressure Switch 1 Checkout

	Measured Values			
	Test 1	Test 2	Test 3	Limits
Pickup Pressure (psia)	515.41	513.86	512.31	515 ± 36
Dropout Pressure (psia)	431.59	433.15	433.92	*
Deadband (psid)	83.81	80.71	79.39	62.5 ± 48.5

Mainstage OK Pressure Switch 2 Checkout

	Test 1	Test 2	Test 3	Limits
Pickup Pressure (psia)	527.66	519.19	518.42	515 ± 36
Dropout Pressure (psia)	469.13	468.36	467.59	*
Deadband (psid)	58.52	50.83	50.83	62.5 ± 48.5

Engine Sequence Check

Function	Start or Delay Time (sec)	Travel Time (sec)	Total Time (sec)
Engine Start			
Cont He Solenoid Command Talkback	**	0.016	**
Ign Phase Cont Solenoid Command Talkback	**	0.010	**
ASI Valve Open	**	0.048	**
Engine LOX Bleed Valve Close	**	0.093	**
Engine LH2 Bleed Valve Close	**	0.067	**
Main Fuel Valve Open	0.084	0.087	0.171
Start Tank Disch Timer	**	1.008	**
Start Tnk Disch Valve Open	0.095	0.152	0.247
Mainstage Cont Solenoid Energized	**	1.463	**
Ignition Phase Timer	**	0.455	**
Start Tnk Disch Cont Solenoid De-energized	**	0.006	**
Main LOX Valve Open	0.638	1.654	2.292
Start Tnk Disch Valve Close	0.216	0.122	0.338
Gas Generator Valve Open	**	0.121	0.214
LOX Turbine Bypass Valve Close	0.027	0.440	0.468
Spark System Off Timer	**	3.320	**

* Limits not specified

** Not applicable or not available

4.1.24.1 (Continued)

Section 3 - J-2 Engine Functional Test (Continued)

Engine Sequence Check (Continued)

Function	Start or Delay Time (sec)	Oper. or Travel Time (sec)	Total Time (sec)
Engine Cutoff			
Ign Phase Cont Solenoid De-energized from Cutoff	**	0.008	**
Mainstage Cont Solenoid De-energized from Cutoff	**	0.016	**
ASI Valve Close	0.038	**	**
Main LOX Valve Close	0.150	0.025	0.176
Main Fuel Valve Close	0.159	0.112	0.271
Gas Generator Valve Close	0.167	0.072	0.239
He Cont De-energized Timer	**	1.002	**
Engine LOX Bleed Valve Open	**	**	8.135
Engine LH2 Bleed Valve Open	**	**	9.676
LOX Turbine Bypass Valve Open	0.321	0.502	0.823

Engine Sequence Data (Oscillograph Records)

Function	Measurements		Limits	
	Delay	Valve Motion	Delay	Valve Motion
Ignition (sec)				
Main Fuel Valve Open	0.040	0.076	0.030-0.090	0.030-0.130
Start Tank Disch Vlv Open	0.085	0.098	0.080-0.120	0.085-0.120
Mainstage (sec)				
GG Valve Fuel				
GG Valve Fuel Open	0.068	0.055	*	*
GG Valve LOX Open	0.139	0.053	0.130-0.150	0.020-0.80
Start Tank Disch Valve Close	0.128	0.240	0.130±0.020	0.215±0.040
MOV 1st Stage Open	0.046	0.052	0.030-0.070	0.025-0.075
MOV 2nd Stage Open	0.640	1.877	0.054-0.680	1.750-1.900
Oxidizer Turbine Bypass Vlv Close	0.203	0.289	*	5.0 max

* Limits not specified
** Not applicable or not available

4.1.24.1 (Continued)

Section 3 - J-2 Engine Functional Test (Continued)

Engine Sequence Data (Oscillograph Records) (Continued)

Function	Measurements Delay	Measurements Valve Motion	Limits Delay	Limits Valve Motion
Cutoff (sec)				
Oxidizer Turbine Bypass Vlv Open	0.215	0.617	*	10.0 max
GG Valve LOX Close	0.052	0.027	0.040-0.100	0.010-0.055
Main Oxid Vlv Closed	0.056	0.124	0.045-0.075	0.105-0.135
Main Fuel Vlv Closed	0.080	0.228	0.065-0.115	0.200-0.250
Bleeds (sec)				
ASI Open	**	0.039	**	100 max
ASI Close	**	0.026	**	100 max
GG Valve LOX Open	**	9.124	**	30.0 max
GG Valve LOX Close	**	0.057	**	0.120 max
GG Valve Fuel Open	**	10.663	**	30.0 max
GG Valve Fuel Close	**	0.047	**	0.120 max
Timers (sec)				
Start Tnk Disch Vlv Decay	0.994	**	0.960-1.040	**
Ignition Phase	0.452	**	0.420-0.480	**
Sparks De-energize	3.300	**	3.10 -3.50	**
Helium Cont De-energize	0.993	**	0.890-1.110	**
Trace Deflections				
Oxid Turbine Bypass Valve 80% (sec)	0.428	**	0.350-0.550	**
Main Oxid Valve (deg)	14.4	**	12-16	**
GG Valve (%)	50.0	**	35-65	**

* Limits not specified

** Not applicable or not available

4.1.25 Integrated System Test (1B55831 H)

The automatic checkout verified the design integrity and operation capability of the SIVB stage and facility systems which were functional during propellant loading and static acceptance firing.

The automatic and manual test sequences performed during this checkout were initiated on 24 September 1968. Four attempts were required to complete the test. The first and second attempts were aborted due to computer malfunctions. The third attempt on 26 September 1968, was aborted due to numerous malfunction indications. Initial conditions for the fourth attempt were established on 27 September 1968. The narration and the test data are taken from the fourth attempt. The stage power setup procedure established initial conditions and systematically applied power to the stage buses and systems required for operation of the test.

The GSE valve functional checkout established an ambient condition in the pneumatic console by bleeding down all regulators and resetting them to predetermined values. All console and sled valves used in propellant loading and static acceptance firing were cycled, and the heat exchanger was functionally checked.

The telemetry and digital data acquisition systems were checked next, with the PCM transmitter operated open loop during this section. The telemetry 5 step calibration high and low RACS, and special calibrations of flows, speed, and frequencies were commanded to provide verification of all calibration techniques. The parameters on the CP1-BO and DP1-BO multiplexers and remote

4.1.25 (Continued)

analog and digital submultiplexers, which were required for loading or firing, were verified by receipt of the proper response through open loop PCM transmissions. During the CP1-BO multiplexer test, thirty-seven functions were verified to be off and twenty functions were verified to be on. The DP1-BO multiplexer test verified seven functions to be off and thirteen functions to be on.

The torch and water test was performed satisfactorily. Following setup of the console GH2 supply, the GH2 igniters, diffuser water, deflection plate water, and aspirator water were functioned in sequence. This series of events verified that proper water pressures and torch ignition signals were received.

During the stage valves and O2H2 burner functional checkouts, the LH2 and LOX vent valves and the fill and drain valves were opened and closed while the valve operating times were measured. Then the LOX and LH2 valves were opened and boosted closed and the boost close times were measured. The LOX and LH2 prevalves and chilldown shutoff valves were closed and opened while the operating times were measured. The LH2 directional vent valve was set to the flight and ground positions while the operating times were measured; then, the simulated O2H2 burner firing flight sequence was conducted.

Engine gimbal testing followed the stage valve functional test. The auxiliary hydraulic system was operated while verifying the proper pressures and levels prior to and after restrainer link disengagement. The J-2 engine received a step gimbal signal, as well as 1/4 and 1/2 degree sinusoidal inputs of 6.0, 5.0, and 7.0 Hz. The checkout proceeded without any malfunctions.

4.1.25 (Continued)

A final dry sequence of the J-2 engine, through the use of simulation commands for ASI ignition and mainstage ignition, was conducted to verify proper engine operation as well as the ESCS spark monitoring circuitry.

The ullage rocket ignition and jettison EBW units were functionally certified by charging and firing into the pulse sensors.

The overfill point level sensors and depletion points level sensors were proven to operate satisfactorily by cycling the sled main fill and replenish valves with 2-out-of-3 depletion sensors verifying the cutoff logic operations. In addition, the individual ability to create a cutoff was proven for the engine lockout component test power and engine lockout GSE power.

The propellant utilization system test verified that the inverter-converter outputs were correct and cycled the PU mass bridge, which created positive and negative error signals for verification of the engine PU valve position.

The stage bus internal power was setup by the use of secondary battery power. The forward internal/external cycle was completed by switching normal telemetry current to forward bus 1 and PU current to forward bus 2. Following the APS and range safety functional checks, the aft bus 1 was cycled from internal and external with stage ambient and APS currents at ambient. The LOX and LH2 chilldown inverters were operated for current and frequency tests; then, aft bus 2 was switched from internal to external. This completed stage testing for the integrated system test.

4.1.25 (Continued)

Engineering status review indicated that all parts were installed at the start of this test, and the procedure was accepted on 1 October 1968.

There were a total of thirty-two revisions made to the two issues of the procedure for the following:

a. Seven revisions added or changed requirements that were missing or in error.

b. Five revisions concerned tolerance changes made to correspond with previously accomplished procedures.

c. Three revisions concerned the PU constants values added to the program via paper tape.

d. Three revisions concerned the out-of-tolerance condition of the cold helium sphere pressure and attributed the condition to program errors.

e. Two revisions deleted power turnon and calibration of the single side band system, as the system was not installed during the prefire checkout period.

f. Two revisions concerned the out-of-tolerance condition of the aft 2 battery voltage and attributed it to a lower than normal charging voltage.

g. One revision concerned the forward secondary battery 2 current out-of-tolerance printout statement. The program measures the forward secondary battery 2 current and retains this value for the printout statement. However, in the "IF" statement that followed, to determine whether or not the value was within tolerance, the parameter was measured again, which was slightly below tolerance, resulting in the malfunction printout, while the measured value was within tolerance.

h. One revision deleted a step to prevent a hold point when the O2H2 burner spark circuits were on.

i. One revision authorized the performance of attempt 4 as attempts 1 and 2 were aborted due to computer malfunctions. Attempt 3 was aborted because of malfunction indications.

4.1.25 (Continued)

j. One revision attributed the failure of the LH2 propulsion valve to open to a program error.

k. One revision explained that a backup in the program was necessary as the restrainer links were left on when they should have been removed.

l. One revision concerned the out-of-tolerance condition of the hydraulic GN2 accumulator pressure. This pressure is a function of temperature, which at the time of measurement was high. The pressure of 2454.625 psia was close to the expected pressure of 2350 ±100 psia.

m. One revision explained that the altitude eject stage 1 GN2 supply not closed malfunction was caused by the remote operating valve, ROV3124 being opened during the propulsion test preparations.

n. One revision stated that an E10 error code was received due to an error in the program.

o. One revision attributed the altitude eject pressure transducer malfunction to a closed transducer valve. The valve was opened, the sequence repeated, and proper operation of the transducer was verified.

p. One revision stated that the out-of-tolerance indication of the GSE transducer power was due to a program error.

4.1.25.1 Test Data Table - Integrated System Test

CP1-B0 Multiplexer Ambient Measurements and High and Low RACS Voltages

Meas. No.	Function	Measurement	Limits
D043	Amb Output	2449.118 psia	2350.000 ± 100.000 psia
M025	Hi RACS Test	3.994 vdc	4.000 ± 0.500 vdc
M025	Lo RACS Test	0.000 vdc	0.000 ± 0.050 vdc
M025	Amb Output	4.996 vdc	5.000 ± 0.030 vdc
D236	Hi RACS Test	3.979 vdc	4.000 ± 0.100 vdc
D236	Lo RACS Test	1.035 vdc	1.000 ± 0.100 vdc
D236	Amb Output	28.044 psia	14.700 ± 70.000 psia
D225	Hi RACS Test	3.994 vdc	4.000 ± 0.100 vdc
D225	Lo RACS Test	1.030 vdc	1.000 ± 0.100 vdc
D225	Amb Output	10.774 psia	14.700 ± 10.000 psia
D016	Hi RACS Test	3.999 vdc	4.000 ± 0.100 vdc

4

4.1.25.1 (Continued)

CP1-BO Multiplexer Ambient Measurements and High and Low RACS Voltages

Meas. No.	Function	Measurement	Limits
D016	Lo RACS Test	1.020 vdc	1.000 ± 0.100 vdc
D016	Amb Output	18.136 psia	14.700 ± 70.000 psia
D019	Hi RACS Test	4.010 vdc	4.015 ± 0.100 vdc
D019	Lo RACS Test	0.999 vdc	1.015 ± 0.050 vdc
D019	Amb Output	20.146 psia	14.700 ± 70.000 psia
D018	Hi RACS Test	4.092 vdc	4.103 ± 0.050 vdc
D018	Lo RACS Test	1.107 vdc	1.103 ± 0.050 vdc
D018	Amb Output	13.499 psia	14.700 ± 15.000 psia
M024	Hi RACS Test	3.974 vdc	4.000 ± 0.050 vdc
M024	Lo RACS Test	0.000 vdc	0.000 ± 0.050 vdc
M024	Amb Output	4.992 vdc	5.000 ± 0.030 vdc
M068	Hi RACS Test	3.989 vdc	4.000 ± 0.050 vdc
M068	Lo RACS Test	-0.005 vdc	0.000 ± 0.050 vdc
M068	Amb Output	4.990 vdc	5.000 ± 0.030 vdc
D017	Hi RACS Test	4.035 vdc	4.035 ± 0.050 vdc
D017	Lo RACS Test	1.040 vdc	1.035 ± 0.050 vdc
D017	Amb Output	14.705 psia	14.700 ± 30.000 psia
G001	Amb Output	-0.551°F	-0.300 ± 0.400°F
G002	Amb Output	0.140°F	0.300 ± 0.400°F
D020	Hi RACS Test	3.948 vdc	4.000 ± 0.100 vdc
D020	Lo RACS Test	0.969 vdc	1.000 ± 0.100 vdc
D020	Amb Output	24.304 psia	14.700 ± 70.000 psia
D177	Amb Output	14.523 psia	14.700 ± 1.000 psia
D178	Amb Output	14.479 psia	14.700 ± 1.000 psia
D088	Hi RACS Test	3.953 vdc	4.000 ± 0.100 vdc
D088	Lo RACS Test	1.005 vdc	1.000 ± 0.100 vdc
D088	Amb Output	31.782 psia	14.700 ± 70.000 psia
D179	Amb Output	14.282 psia	14.700 ± 1.000 psia
D180	Amb Output	15.019 psia	14.700 ± 1.000 psia
L007	Amb Output	47.298 pct	50.000 ± 10.000 pct

DP1-BO Multiplexer Ambient Measurements and High and Low RACS Voltages

Meas. No.	Function	Measurement	Limits
D236	Hi RACS Test	3.994 vdc	4.000 ± 0.100 vdc
D236	Lo RACS Test	1.035 vdc	1.000 ± 0.100 vdc
D236	Amb Output	35.521 psia	14.700 ± 70.000 psia
D043	Amb Output	2454.625 psia†	2350.000 ± 100.000 psia
C138	Hi RACS Test	3.999 vdc	4.000 ± 0.075 vdc
C138	Lo RACS Test	-0.005 vdc	0.000 ± 0.075 vdc
C138	Amb Output	90.174°F	70.000 ± 16.000°F

† See Revision 1

4.1.25.1 (Continued)

DP1-BO Multiplexer Ambient Measurements and High and Low RACS Voltages

Meas. No.	Function	Measurement	Limits
M025	Amb Output	5.005 vdc	5.000 ± 0.030 vdc
D209	Amb Output	14.205 psia	20.750 ± 11.950 psia
M074	Amb Output	0.000 vdc	0.000 ± 0.075 vdc
M073	Amb Output	0.000 vdc	0.000 ± 0.075 vdc
D016	Hi RACS Test	4.015 vdc	4.000 ± 0.100 vdc
D016	Lo RACS Test	1.020 vdc	1.000 ± 0.100 vdc
D016	Amb Output	25.773 psia	14.700 ± 70.000 psia
D014	Amb Output	15.602 psia	14.700 ± 13.000 psia
D019	Hi RACS Test	4.020 vdc	4.021 ± 0.050 vdc
D019	Lo RACS Test	1.005 vdc	1.021 ± 0.050 vdc
D019	Amb Output	20.146 psia	14.700 ± 70.000 psia
M006	Amb Output	27.660 vdc	28.000 ± 2.000 vdc
M007	Amb Output	0.030 vdc	0.000 ± 1.000 vdc
D050	Amb Output	15.384 psia	14.700 ± 3.000 psia
D054	Hi RACS Test	3.994 vdc	4.000 ± 0.100 vdc
D054	Lo RACS Test	1.020 vdc	1.000 ± 0.100 vdc
D054	Amb Output	14.266 psia	14.700 ± 2.000 psia
M024	Hi RACS Test	3.974 vdc	4.000 ± 0.050 vdc
M024	Lo RACS Test	0.000 vdc	0.000 ± 0.050 vdc
M024	Amb Output	4.992 vdc	5.000 ± 0.030 vdc
M068	Hi RACS Test	3.999 vdc	4.000 ± 0.050 vdc
M068	Lo RACS Test	0.000 vdc	0.000 ± 0.050 vdc
M068	Amb Output	4.991 vdc	5.000 ± 0.030 vdc
D017	Hi RACS Test	4.040 vdc	4.041 ± 0.050 vdc
D017	Lo RACS Test	1.040 vdc	1.041 ± 0.050 vdc
D017	Amb Output	16.217 psia	14.700 ± 30.000 psia
C006	Hi RACS Test	4.035 vdc	4.000 ± 0.075 vdc
C006	Lo RACS Test	-0.005 vdc	0.000 ± 0.075 vdc
C006	Amb Output	94.049°F	90.000 ± 18.000°F
D103	Amb Output	14.893 psia	14.700 ± 3.000 psia
G001	Amb Output	-0.598°F	-0.300 ± 0.400°F
G002	Amb Output	0.171°F	0.300 ± 0.400°F
M010	Hi RACS Test	4.005 vdc	4.000 ± 0.060 vdc
M010	Lo RACS Test	1.030 vdc	1.000 ± 0.060 vdc
M010	Amb Output	0.378 vdc	0.000 ± 1.000 vdc
D020	Hi RACS Test	3.958 vdc	4.000 ± 0.100 vdc
D020	Lo RACS Test	0.974 vdc	1.000 ± 0.100 vdc
D020	Amb Output	28.044 psia	14.700 ± 70.000 psia
C231	Hi RACS Test	4.015 vdc	4.000 ± 0.075 vdc
C231	Lo RACS Test	0.015 vdc	0.000 ± 0.075 vdc
C231	Amb Output	-155.555°F	-155.000 ± 8.000°F
C001	Hi RACS Test	4.010 vdc	4.000 ± 0.075 vdc
C001	Lo RACS Test	-0.005 vdc	0.000 ± 0.075 vdc

4.1.25.1 (Continued)

DP1-BO Multiplexer Ambient Measurements and High and Low RACS Voltages

Meas. No.	Function	Measurements	Limits
C001	Amb Output	95.711°F	90.000 + 72.000°F
D177	Amb Output	14.644 psia	14.700 ∓ 1.000 psia
D178	Amb Output	14.538 psia	14.700 ∓ 1.000 psia
D105	Hi RACS Test	3.994 vdc	4.000 ∓ 0.100 vdc
D105	Lo RACS Test	0.999 vdc	1.000 ∓ 0.100 vdc
D105	Amb Output	12.410 psia	14.700 ∓ 10.000 psia
C230	Hi RACS Test	4.004 vdc	4.000 ∓ 0.075 vdc
C230	Lo RACS Test	-0.005 vdc	0.000 ∓ 0.075 vdc
C230	Amb Output	-378.438°F	-379.000 ∓ 4.000°F
D088	Hi RACS Test	3.969 vdc	4.000 ∓ 0.100 vdc
D088	Lo RACS Test	1.010 vdc	1.000 ∓ 0.100 vdc
D088	Amb Output	39.262 psia	14.700 ∓ 70.000 psia
C002	Hi RACS Test	3.994 vdc	4.000 ∓ 0.075 vdc
C002	Lo RACS Test	-0.015 vdc	0.000 ∓ 0.075 vdc
C002	Amb Output	78.252°F	90.000 ∓ 48.000°F
D179	Amb Output	14.402 psia	14.700 ∓ 1.000 psia
D180	Amb Output	15.079 psia	14.700 ∓ 1.000 psia
M026	Amb Output	0.000 vac	0.000 ∓ 0.980 vac
M027	Amb Output	0.000 vac	0.000 ∓ 0.980 vac
M041	Amb Output	0.000 vac	0.000 ∓ 0.980 vac
M040	Amb Output	0.000 vac	0.000 ∓ 0.980 vac
M060	Hi RACS Test	3.979 vdc	4.000 ∓ 0.100 vdc
M060	Lo RACS Test	0.994 vdc	1.000 ∓ 0.100 vdc
M060	Amb Output	2.830 vac	6.000 ∓ 6.000 vac
M061	Hi RACS Test	3.964 vdc	4.000 ∓ 0.100 vdc
M061	Lo RACS Test	1.020 vdc	1.000 ∓ 0.100 vdc
M061	Amb Output	-0.349 vdc	0.000 ∓ 1.200 vdc
L007	Amb Output	47.422 pct	50.000 ∓ 10.000 pct
C199	Hi RACS Test	4.025 vdc	4.000 ∓ 0.075 vdc
C199	Lo RACS Test	-0.005 vdc	0.000 ∓ 0.075 vdc
C199	Amb Output	91.174°F	90.000 ∓ 21.000°F

LOX and LH2 Valve Functional Checks

Function	Measurement		Limits
LH2 & LOX Prevalves	Close Time (sec)	0.342	4.000 max
	Open Time (sec)	1.818	4.000 max
LH2 Vent Valve	Open Time (sec)	0.120	4.000 max
	Close Time (sec)	0.473	4.000 max

4.1.25.1 (Continued)

LOX and LH2 Valve Functional Checks

Function	Measurement		Limits
LOX Vent Valve	Open Time (sec)	0.120	4.000 max
	Close Time (sec)	0.440	4.000 max
LH2 & LOX C/D SOV	Close Time (sec)	0.178	4.000 max
	Open Time (sec)	1.102	4.000 max
LH2 Vent Valve	Open Time (sec)	0.083	4.000 max
	Close Time (sec)	0.446	4.000 max
	Open Time (sec)	0.086	4.000 max
	Close Time (sec)	0.249	4.000 max
LOX Vent Valve	Open Time (sec)	0.087	4.000 max
	Close Time (sec)	0.417	4.000 max
	Open Time (sec)	0.090	4.000 max
	Close Time (sec)	0.417	4.000 max
LH2 Fill & Drain Valve	Open Time (sec)	0.161	4.000 max
	Close Time (sec)	1.378	4.000 max
	Open Time (sec)	0.154	4.000 max
	Close Time (sec)	0.565	4.000 max
LOX Fill & Drain Valve	Open Time (sec)	0.233	4.000 max
	Close Time (sec)	2.053	4.000 max
	Open Time (sec)	0.231	4.000 max
	Close Time (sec)	0.836	4.000 max
LH2 & LOX Prevalves	Close Time (sec)	0.302	4.000 max
	Open Time (sec)	1.820	4.000 max
LH2 & LOX C/D SOV	Close Time (sec)	0.145	4.000 max
	Open Time (sec)	1.074	4.000 max
Dir Vent to Flt Pos	(sec)	0.206	4.000 max
Dir Vent to Grd Pos	(sec)	0.190	4.000 max

Engine Gimbal Step Commands - Restrainer Links Engaged

Position (deg)	Pitch Exc (ma)	Yaw Exc (ma)	TM Pitch Pos(deg)	TM Yaw Pos(deg)	IU Pitch Pos(deg)	IU Yaw Pos(deg)
0° pitch 0° yaw	0.10	0.10	-0.03	0.12	-0.03	0.10

4.1.25.1 (Continued)

Engine Gimbal Step Commands - Restrainer Links Engaged

Position (deg)	Pitch Exc (ma)	Yaw Exc (ma)	TM Pitch Pos(deg)	TM Yaw Pos(deg)	IU Pitch Pos(deg)	IU Yaw Pos(deg)
1° pitch 1° yaw	6.70	0.05	0.70	0.12	0.71	0.12
0° pitch 0° yaw	0.10	0.10	-0.03	0.12	-0.04	0.12
-1° pitch -1° yaw	-6.45	0.10	-1.04	0.14	-1.05	0.10
0° pitch 0° yaw	0.05	0.10	-0.00	0.14	0.01	0.12
0° pitch 0° yaw	0.15	-6.55	-0.05	-0.87	-0.03	-0.88
0° pitch 0° yaw	0.10	0.05	-0.05	0.11	-0.06	0.09
0° pitch 0° yaw	0.10	6.75	-0.05	1.08	-0.04	1.08
0° pitch 0° yaw	0.10	0.05	-0.06	0.11	-0.04	0.10
0° pitch 0° yaw	0.10	0.15	-0.03	0.11	-0.06	0.10
1° pitch 1° yaw	6.75	0.05	0.70	0.14	0.74	0.10
0° pitch 0° yaw	0.10	0.10	-0.03	0.11	-0.04	0.12
-1° pitch -1° yaw	-6.55	0.10	-1.04	0.12	-1.05	0.10
0° pitch 0° yaw	0.05	0.10	-0.02	0.14	-0.03	0.10
0° pitch 0° yaw	0.05	-6.55	-0.03	-0.85	-0.04	-0.83

4.1.25.1 (Continued)

Engine Gimbal Step Commands - Restrainer Links Engaged

Position (deg)	Pitch Exc (ma)	Yaw Exc (ma)	TM Pitch Pos(deg)	TM Yaw Pos(deg)	IU Pitch Pos(deg)	IU Yaw Pos(deg)
0° pitch 0° yaw	0.10	0.05	-0.03	0.11	-0.06	0.10
0° pitch 0° yaw	0.10	6.75	-0.03	1.07	-0.06	1.09
0° pitch 0° yaw	0.10	0.10	-0.03	0.14	-0.04	0.12
1° pitch 1° yaw	6.75	0.10	0.74	0.14	0.71	0.13
0° pitch 0° yaw	0.05	0.10	-0.03	0.12	-0.06	0.12
-1° pitch -1° yaw	-6.55	0.10	-1.04	0.14	-1.03	0.12
0° pitch 0° yaw	0.10	0.10	-0.02	0.14	0.00	0.12
0° pitch 0° yaw	0.10	-6.55	-0.03	-0.83	-0.04	-0.84
0° pitch 0° yaw	0.05	0.05	-0.05	0.12	-0.06	0.10
0° pitch 0° yaw	0.10	6.75	-0.03	1.08	-0.04	1.09
0° pitch 0° yaw	0.10	0.10	-0.03	0.14	-0.06	0.10
0° pitch 0° yaw	0.10	0.05	-0.02	0.14	-0.06	0.15
1° pitch 1° yaw	6.80	0.10	0.97	0.14	1.00	0.12
0° pitch 0° yaw	0.15	0.10	-0.03	0.14	-0.03	0.13

4.1.25.1 (Continued)

Engine Gimbal Step Commands - Restrainer Links Disengaged

Position (deg)	Pitch Exc (ma)	Yaw Exc (ma)	TM Pitch Pos(deg)	TM Yaw Pos(deg)	IU Pitch Pos(deg)	IU Yaw Pos(deg)
-1° pitch -1° yaw	-6.60	0.05	-1.04	0.14	-1.03	0.12
0° pitch 0° yaw	0.20	0.15	-0.02	0.12	-0.03	0.13
0° pitch 0° yaw	0.10	-6.55	-0.03	-0.87	-0.03	-0.87
0° pitch 0° yaw	0.05	0.05	-0.03	0.14	-0.01	0.15
0° pitch 0° yaw	0.15	6.75	-0.03	1.14	-0.06	1.14
0° pitch 0° yaw	0.10	0.10	-0.03	0.14	-0.03	0.12

Engine Gimbal Frequency Response

Axis (deg)	Desired Freq.	Actual Freq.	Time Lag (TR=T2-T1)	Phase Lag (360)(T3)(F)	Cycles Gim'd.	Sample Time
0.25° Ptch	0.60	0.59	0.117	25.028	3.24	1.976
	5.00	4.97	0.030	54.174	11.99	1.975
	7.00	7.06	0.035	89.379	16.36	1.990
0.25° Yaw	0.60	0.58	0.073	15.428	3.21	1.976
	5.00	5.04	0.030	54.975	12.15	1.975
	7.00	7.01	0.036	91.232	16.33	1.999
0.50° Ptch	0.60	0.58	0.092	19.281	3.22	2.008
	5.00	5.00	0.026	47.414	12.02	1.975
	7.00	7.06	0.032	81.931	16.37	1.993
0.50° Yaw	0.60	0.55	0.082	16.293	3.13	1.973
	5.00	5.02	0.039	70.588	12.15	1.976
	7.00	6.65	0.035	84.550	15.43	1.975

4.1.26 Final Prefire Propulsion System Leak Check (1B70175 H)

Final leak checks for the stage propulsion system were conducted prior to acceptance firing after all other stage checkouts had been completed. The primary purpose of the final prefire leak checks was to test for any external leakage that could occur as a result of system disturbance during checkouts conducted after the prefire propulsion system leak check procedure had been completed. Examples of system disturbances that required a repeat of the external leak checks included removal and replacement of instrumentation, replacement of malfunctioning components, and plumbing connections required to facilitate prefire checkouts.

Checkout was initiated on 8 October 1968, and satisfactorily completed on 15 October 1968. Significant measurements recorded during the leak checks are listed in Test Data Table 4.1.26.1.

After the preliminary test equipment was set up, the checkout was started by taking vacuum readings of the stage vacuum jacketed ducts. All vacuum levels measured were acceptable, as listed in the test data table.

Stage ambient helium system leak checks were conducted next with the pneumatic control sphere and the LOX and LH2 ambient helium repressurization spheres pressurized with helium to 1450 ± 50 psig, and the control regulator discharge pressure set at 515 ± 50 psig. These pressures were then locked up and monitored for decay over a 30 minute period. Next, the LOX and LH2 tank prevalves, chilldown valves, vent valves, and the fill and drain valves were actuated with helium pressure from the control pneumatics system while the control

4.1.26 (Continued)

helium regulator discharge pressure was monitored for decay during a 15-minute actuation lockup. Results of the ambient helium system decay checks are listed in the Test Data Table. In addition to the decay checks, the pneumatic actuation control modules were checked for internal leakage by monitoring each module for the 3.0 scim allowable leakage at the vent ports. Checks for external helium leakage with a helium leak detector and bubble solution AMS3159 were conducted for the purge line from the aft skirt tunnel interface to the NPV purge port, and from the tee upstream of the NPV purge port to the continuous vent valve and duct ports. No unacceptable leakage was detected for the ambient helium system.

After the satisfactory completion of the ambient helium systems leak check, the cold helium system was leak checked by pressurizing the cold helium spheres with helium to 950 ± 50 psig, and using the helium leak detector and AMS3159 bubble solution to check all plumbing, including the O2H2 burner portion of the system, for external leakage. No leaks were detected.

After completing setup operations for pressurizing the LOX and LH2 tank assembly, the O2H2 burner nozzle plug was installed in preparation for the burner propellant system leak checks. Pressurizing the LOX and LH2 tank assembly with helium to 5 +0, -1 psig, the O2H2 burner LH2 propellant valve and LOX shutdown valve were checked for internal leakage at the burner nozzle plug monitoring port; no leakage was detected. Next, the burner nozzle plug monitoring port was capped, and the burner propellant valves opened to lockup

4.1.26 (Continued)

pressure between the tank assembly and nozzle plug to conduct external leak checks. The entire O2H2 burner propellant system was then checked externally for leakage from the tank assembly to the burner nozzle plug. No leaks were detected.

The burner propellant valves were then closed and the downstream systems vented in preparation for the LOX and LH2 tank assembly pressure decay checks. These were accomplished by closing all engine and burner propellant supply valves to maintain static helium pressure in the tank assembly and monitor any loss in tank pressures over a 30-minute period. The pressure requirements were 15 +0, -1 psig for the LOX tank and 9 + 1, -0 psig for the LH2 tank. Prior to the decay checks, gas samples were taken from both tanks and analyzed for helium content. Results of the helium concentration check and the pressure decay checks for the LOX and LH2 tanks are listed in Test Data Table 4.1.26.1.

While maintaining LOX tank helium pressure at 15 + 0, -1 psig, the LOX propellant supply line (low pressure duct) to the J-2 engine was pressurized with helium at 15 to 30 psig. The entire LOX propellant supply system, recirculation system, and LOX tank fill and drain line were checked with the helium leak detector and AMS3159 bubble solution for external leakage from the LOX tank downstream to the J-2 engine, including the LOX turbopump and all related pump discharge plumbing. This included the PU valve, main LOX shutoff valve (MOV), ASI valve, and the gas generator oxidizer circuitry terminating at the gas generator oxidizer valve. One external leak at the LOX fill and drain valve was corrected by seal replacement.

4.1.26 (Continued)

After venting the LOX low pressure duct, the LH2 low pressure duct (propellant supply to the J-2 engine) was pressurized with helium at 10 to 30 psig while maintaining LOX tank and LH2 tank pressures at 10 to 15 psig and 10 +0, -1 psig, respectively. The LH2 system for the LH2 tank through the J-2 engine was then checked for external helium leakage, similarly to the LOX system previously described. No leaks were detected.

The J-2 engine thrust chamber throat plug was then installed, and helium pressure at 9 +1, -0 psig was stabilized between the throat plug and the main oxidizer and fuel thrust chamber valves (MOV and MFV) to conduct the thrust chamber leak checks. The entire J-2 thrust chamber system was then checked for external helium leakage. No leaks were found. In addition to external leak checks of the thrust chamber system, the actuator drive and idler shaft seal leak checks were conducted for the thrust chamber valves (MOV and MFV). The results are listed in the Test Data Table.

The J-2 engine start tank was pressurized with helium to 500 $\pm$10 psig to perform the tank decay rate test. After allowing the start tank pressure to stabilize for 2 hours, the start tank temperature and pressure were measured and recorded. After 1 hour, these measurements were repeated to calculate the helium mass decay rate for the start tanks. The calculated decay rate was 0.0050 pounds-mass/hour, which was acceptable based on an allowable mass decay rate of 0.0066 pounds-mass/hour.

The J-2 engine control sphere was then pressurized with helium to between 225 and 250 psia in preparation for engine pneumatic leak checks. The low pressure side leak check was then conducted to determine internal leakage within

4.1.26 (Continued)

the engine pneumatic control package. Leakage rates were measured at the control package common vent port. These rates became increasingly out-of-tolerance with repeated cycles of the ignition phase and main stage solenoids. Investigation revealed the source of the leakage was through the actuator of the engine main fuel valve (MFV). After replacing the MFV, per FARR 500-488 -620, the repeat checks were successful, as noted in the Test Data Table.

Engine control sphere pressure was then increased to 300 $\pm$10 psia, and the helium control solenoid was turned on to pressurize the pressure actuated purge system for external leak checks. No leaks were detected with the helium leak detector or the bubble solution. The engine control sphere pressure was then increased to 1450 $\pm$50 psig for the pneumatic control high pressure side retention test. After allowing the control sphere pressure to stabilize for 1 hour, the control sphere temperature and pressure were measured and recorded to calculate sphere helium mass. This was repeated 1 hour later to obtain a calculated engine control sphere helium mass decay rate of 0.0051 pounds-mass/hour, which was acceptable based on an allowable decay rate of 0.036 pounds-mass/hour.

The LH2 and LOX tanks and the engine systems were then purged, after which gas samples from the tanks were taken to establish the final acceptable pre-fire helium concentration for the propellant tank assembly. The results are listed in the test data table. Tank blanket pressures were then maintained with helium, at 5 + 0, -1 psig for the LOX tank and 3 + 0, -1 psig for the LH2 tank. All systems, except the LOX and LH2 tanks, were vented to ambient and secured.

4.1.26 (Continued)

Final checks were then made to verify that the umbilical hoses required for static firing were installed, and that the unrequired stage umbilical ports were capped off. The checkout was completed by verifying that the required electrical cables were connected to the proper solenoid valves in the LOX and LH2 tank pressurization modules.

FARR 500-488-620 recorded the replacement of the engine MFV because of actuator leakage, as previously described. There were no other discrepancies documented by FARR. However, twenty-nine revisions were recorded in the procedure for the following:

a. One revision provided for an external leak check of a tube assembly, P/N 1B71751-522, in the hardwire system for the ambient LH2 repressurization spheres. The tube assembly had been removed and reworked prior to the leak checks.

b. One revision provided for a leak check of the ground purge system which had been temporarily uncoupled to record purge flow rates.

c. Five revisions concerned performance of concurrent automatic test procedures to verify oxidizer turbine bypass valve actuation after valve modification.

d. One revision provided steps to leak check a new LOX pump primary seal drain line installation.

e. Twelve revisions corrected, clarified, or updated the procedure.

f. Two revisions provided instructions for the checkout of newly installed orifices and leak checks of the installations.

g. One revision provided for leak and functional checks of the pneumatic power control module installed subsequent to performance of the propulsion system leak checks and the propulsion system automatic test (H&CO's 1B71877 and 1B62753).

h. One revision investigated the internal leakage within the engine pneumatic control package during the low pressure side leak check which resulted in the replacement of the engine MFV, as previously described.

4.1.26 (Continued)

i. One revision authorized exchange of the vent port check poppets in the pneumatic power control module.

j. One revision provided for a leak check of the LH2 and LOX repressurization module inlet supply lines which had been temporarily removed.

k. One revision authorized performance of the portions of H&CO's 1B71877 and 1B62753, the propulsion system leak check and automatic test procedures, required to revalidate the engine fuel feed, thrust chamber, and pneumatics systems after replacing the engine MFV, as previously described.

l. One revision performed the engine pneumatic leak checks with the new MFV installed.

m. One revision deleted the final purges for the LOX tank and engine LOX systems because the required 99 percent helium concentration for the LOX tank had been obtained.

4.1.26.1 Test Data Table, Final Prefire Propulsion System Leak Checks

Stage Vacuum Duct Readings

	Reading (Microns)	Limits (Microns)
LH2 LPD Upper	31	Less than 250
LH2 LPD Lower	45	Less than 250
LH2 Recirculation	60	Less than 250
O2H2 Burner LH2 Propellant Upper	8	Less than 250
O2H2 Burner LH2 Propellant Lower	15	Less than 250
O2H2 Burner LOX Propellant	10	Less than 250

Ambient Helium System Pressure Decay Checks

	Initial (psig)	Final (psig)	Limits
Control Helium Sphere Pressure	1400	1400	*
LOX Repressurization Sphere Pressure	1425	1425	*
LH2 Repressurization Sphere Pressure	1360	1360	*
Control Helium Regulator Disch Pressure	538	538	*

Control Pneumatics System Pressure Decay Test

	Initial (psig)	Final (psig)	Limits
Control Helium Regulator Disch Pressure	525	535	*

* Limits not specified

4.1.26.1 (Continued)

LOX and LH2 Tank Helium Concentration

		Reading (percent)	Limits (percent)
LOX Tank:	Top	98.66	75 min
	Bottom	99.03	75 min
LH2 Tank:	Top	99.91	75 min
	Bottom	99.94	75 min

LOX and LH2 Tank Pressure Decay Test

	Initial (psig)	Final (psig)	Limits
LOX Tank	14.5	14.4	*
LH2 Tank	9.25	9.25	*

Thrust Chamber Valve Actuator Shaft Seal Leak Checks

	Measured (scim)	Limits (scim)
MOV Idler	0	3.3 max
MFV Idler	0	3.3 max
MOV 2nd Stage Actuator	0	3.3 max
MFV Actuator	0	3.3 max

Engine Pneumatic Control Package (Low Pressure Side) Leak Checks

	Vent Port Flow (scim)	Limits (scim)
Helium Control Solenoid On	2.3	20 max
Ignition Phase Solenoid On	3.6	20 max
Mainstage Solenoid On	3.0	20 max

Final Helium Concentration Check

		Reading (%)	Limits (%)
LOX Tank:	Top	99.0	99 min
	Bottom	99.0	99 min
LH2 Tank:	Top	99.0	99 min
	Bottom	99.0	99 min

* Limits not specified

4.2 Abbreviated Postfire Acceptance Testing

Stage abbreviated postfire acceptance testing began on 17 October 1968, with the initiation of the stage power setup, paragraph 4.2.1. The abbreviated postfire checkouts were completed on 28 October 1968, with the acceptance of the forward skirt thermoconditioning checkout, paragraph 4.2.7.

4.2.1 Stage Power Setup (1B55813 H)

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

This procedure was successfully accomplished on 17 October 1968. The measurements recorded are shown in Test Data Table 4.2.1.1.

The test was started by resetting all matrix magnetic latching relays and verifying that the corresponding command relays were in the proper state. The umbilical connectors were verified to be mated, and the LOX and LH2 inverters were verified to be disconnected. 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, engine control bus power, engine ignition bus power, APS bus 1 and bus 2 power, and propellant level sensor power were all verified to be off. The power to the range safety

4.2.1 (Continued)

receivers and EBW firing units was transferred to external and verified to be off. The switch selector checkout indication enable and the flight measurement indication enable were both turned on. The bus 4D131, 28 vdc power supply was turned on, and the forward bus 1 initial current and voltage were measured.

The range safety system safe and arm device was verified to be in the SAFE condition. The LH2 latching relief valve was closed. The 70 pound ullage engine relay, the LH2 continuous vent valve relays, the LH2 and LOX repressurization mode relay, and the O2H2 burner propellant valve relay were all verified to be reset. The LH2 continuous vent and relief override valve was verified to be closed, and the LOX repressurization control valve enable was verified to be on. Power was verified to be off for the propellant utilization boiloff bias. The O2H2 burner spark systems 1 and 2 voltages were measured and recorded. The O2H2 burner LOX and LH2 valves and the LH2 continuous vent orificed bypass valve were verified to be closed.

The forward bus 1 quiescent current was measured. The PCM system group power was turned on, and the current was measured and recorded. The forward bus 2, 28 vdc power supply was turned on, and the forward bus 2 current and voltage were measured. The prelaunch checkout group power was turned on, and the current was measured and recorded.

The DDAS ground station source select switch was manually set to position 1, and the ground station was verified to be in synchronization. The cold helium supply shutoff valve was closed. The aft bus 1, 28 vdc power supply was turned on, and the aft bus 1 power supply current and voltage were measured. The

4.2.1 (Continued)

sequencer power was turned on and the current was measured. The forward and aft battery load test off commands were set.

A series of checks then verified that the stage functions were in the proper state. Forty-three functions were verified to be off and twenty-three were verified to be on. The LOX and LH2 prevalves and chilldown shutoff valves were verified as open, and the LOX and LH2 vent valves and fill and drain valves were verified as closed.

The final operations of this automatic procedure measured the forward and aft 5 volt excitation modules, the range safety EBW firing unit charging voltages, the aft bus 2 voltage, the forward and aft battery simulator voltages, and the component test power voltage.

No FARR's were initiated as a result of stage power setup testing. However, four revisions were recorded in the procedure as follows:

a. One revision provided program changes to ensure that the single sideband transmitter was off during the test.

b. One revision corrected program errors for SIM channels 31, 32, 34, and 35. The routines had erroneously required measurement of power supply current instead of battery current.

c. One revision authorized changing the 28 vdc power supply tolerance from ± 1 vdc to 0.5 vdc on the stage buses after bus turn on.

d. One revision authorized program deletions required because the LOX chilldown purge control module had been removed per WRO S-IVB-4104.

4.2.1.1 Test Data Table, Stage Power Setup

Function	Measured Value	Limits
Forward Bus 1 Power Supply Current (amps)	6.399	20 max
Forward Bus 1 Voltage (vdc)	28.158	28 ± 0.5
O2H2 Burner Spark System 1 Voltage (vdc)	-0.005	0 ± 0.5
O2H2 Burner Spark System 2 Voltage (vdc)	0.000	0 ± 0.5
Forward Bus 1 Quiescent Current (amps)	3.000	5 max
PCM System Group Current (amps)	5.301	5 ± 3
Forward Bus 2 Power Supply Current (amps)	0.000	2 max
Forward Bus 2 Voltage (vdc)	27.839	28 ± 0.5
Prelaunch Checkout Group Current (amps)	1.500	1 ± 3
Aft Bus 1 Power Supply Current (amps)	-0.399	2 max
Aft Bus 1 Voltage (vdc)	27.999	28 ± 0.5
Sequencer Power (amps)	0.200	0 ± 3
Aft 5V Excitation Module Voltage (vdc)	4.995	5 ± 0.030
Fwd 1 5V Excitation Module Voltage (vdc)	4.993	5 ± 0.030
Fwd 2 5V Excitation Module Voltage (vdc)	4.995	5 ± 0.030
RS 1 EBW Firing Unit Chg Voltage (vdc)	0.000	0 ± 1
RS 2 EBW Firing Unit Chg Voltage (vdc)	0.000	0 ± 1
Aft Bus 2 Voltage (vdc)	0.159	0 ± 1
Forward Battery 1 Simulator Voltage (vdc)	-0.039	0 ± 1
Forward Battery 2 Simulator Voltage (vdc)	0.039	0 ± 1
Aft Battery 1 Simulator Voltage (vdc)	0.000	0 ± 1
Aft Battery 2 Simulator Voltage (vdc)	0.000	0 ± 1
Component Test Power Voltage (vdc)	0.720	0 ± 1

4.2.2 Stage Power Turnoff (1B55814 G)

The stage power turnoff procedure was used for the automatic shutdown of the stage power distribution system by returning the stage to the de-energized condition after completion of the various system postfire checkout procedures. The procedure deactivated stage relays so that no current flowed from the battery simulators through the stage wiring. All internal/external transfer relays were set to the external condition.

Satisfactory demonstration of this procedure was accomplished and accepted on 17 October 1968. Stage power turnoff measurement values for this demonstration issue are tabulated in Test Data Table 4.2.2.1. Following this, the stage power turnoff procedure was used to shutdown the stage at the conclusion of the various automatic checkouts conducted during postfire operations.

The automatic stage power turnoff was started with verification that the umbilical connectors were mated and that the flight measurement indication enable was turned on. The bus 4D119 talkback power; the forward bus 1 and aft bus 1, 28 vdc power supplies; and the sequencer power were all verified to be on. The forward bus 1 and aft bus 1 voltages were then measured.

Switch selector functions were then turned off, and a series of checks verified that the stage electrical functions were in the proper state of off or reset. The forward and aft bus power supplies were verified as off, and the forward and aft bus battery simulator voltages were measured. Stage buses were then transferred to external power, and the forward and aft stage bus voltages were measured. The EBW pulse sensor power was turned off, and the

4.2.2 (Continued)

range safety receivers and EBW firing units were transferred to external power. The range safety system safe and arm device was verified to be on safe, and the bus 4D119 talkback power was turned off. The matrix magnetic latching relays were then reset, completing this demonstration run for stage power turn-off.

No FARR's were generated as a result of this checkout. Three revisions were recorded to the procedure for the following:

a. One revision provided program changes to ensure that the single sideband transmitter was off during the test.

b. One revision corrected program errors for SIM interrupt channels 31, 32, 34, and 35. The routines had erroneously required measurement of power supply current instead of battery current.

c. One revision authorized program deletions required because the LOX chilldown purge control module had been removed per WRO S-IVB-4104.

4.2.2.1 Test Data Table, Stage Power Turnoff

Function	Measurement	Limits
Forward Bus 1 Voltage, Power On (vdc)	28.079	28 ± 2
Aft Bus 1 Voltage, Power On (vdc)	28.039	28 ± 2
O2H2 Burner Spark System 1 Voltage (vdc)	0.010	0 ± 0.5
O2H2 Burner Spark System 2 Voltage (vdc)	0.039	0 ± 0.5
Forward Bus 1 Battery Simulator Voltage (vdc)	0.000	0 ± 1
Forward Bus 2 Battery Simulator Voltage (vdc)	0.000	0 ± 1
Aft Bus 1 Battery Simulator Voltage (vdc)	0.000	0 ± 1
Aft Bus 2 Battery Simulator Voltage (vdc)	0.159	0 ± 1
Forward Bus 1 Voltage, Power Off (vdc)	0.039	0 ± 1
Forward Bus 2 Voltage, Power Off (vdc)	0.000	0 ± 1
Aft Bus 1 Voltage, Power Off (vdc)	0.000	0 ± 1
Aft Bus 2 Voltage, Power Off (vdc)	0.000	0 ± 1

4.2.3 Final Postfire Propulsion System Leak Check (1B70175 H)

Final leak checks for the stage propulsion system were conducted after the acceptance firing to certify the integrity of the system. The primary purpose of the final postfire leak check was to test for any external leakage that could occur as a result of the static acceptance firing.

Checkout was initiated on 17 October 1968, and completed and certified as acceptable on 29 October 1968. Measurements recorded are listed in Test Data Table 4.2.3.1.

After the preliminary test equipment was set up, the checkout was started by taking vacuum readings of the stage vacuum jacketed ducts. All vacuum levels measured were acceptable, as listed in the test data table.

Stage ambient helium system leak checks were conducted next with the pneumatic control sphere and the LOX and LH2 ambient helium repressurization spheres pressurized with helium to 1450 $\pm$50 psig, and the control regulator discharge pressure set at 515 $\pm$50 psig. These pressures were then locked up and monitored for decay over a 30 minute period. Next, the LOX and LH2 tank prevalves, chilldown valves, vent valves, and the fill and drain valves were actuated with helium pressure from the control pneumatics system while the control helium regulator discharge pressure was monitored for decay during a 15-minute actuation lockup. Results of the ambient helium system decay checks are listed in the Test Data Table. In addition to the decay checks, the pneumatic actuation control modules were checked for internal leakage by monitoring each module for the 3.0 scim allowable leakage at the vent ports. Checks for external

4.2.3 (Continued)

helium leakage with a helium leak detector and bubble solution AMS3159, were conducted for the purge line from the aft skirt tunnel interface to the NPV purge port and from the tee upstream of the NPV purge port to the continuous vent valve and duct ports. No unacceptable leakage was detected for the ambient helium system.

After the satisfactory completion of the ambient helium systems leak check, the cold helium system was leak checked by pressurizing the cold helium spheres with helium to 950 $\pm$50 psig, and using the helium leak detector and AMS3159 bubble solution to check all plumbing, including the O2H2 burner portion of the system, for external leakage. No leaks were detected.

After completing setup operations for pressurizing the LOX and LH2 tank assembly, the O2H2 burner nozzle plug was installed in preparation for the burner propellant system leak checks. Pressurizing the LOX and LH2 tank assembly with helium to 5 + 0, -1 psig, the O2H2 burner LH2 propellant valve and LOX shutdown valve were checked for internal leakage at the burner nozzle plug monitoring port; no leakage was detected. Next, the burner nozzle plug monitoring port was capped, and the burner propellant valves opened to lockup pressure between the tank assembly and nozzle plug to conduct external leak checks. The entire O2H2 burner propellant system was then checked externally for leakage from the tank assembly to the burner nozzle plug. No leaks were detected.

The burner propellant valves were then closed and the downstream systems vented in preparation for the LOX and LH2 tank assembly pressure decay checks. These

4.2.3 (Continued)

were accomplished by closing all engine and burner propellant supply valves to maintain static helium pressure in the tank assembly and monitor any loss in tank pressures over a 30-minute period. The pressure requirements were 15 + 0, -1 psig for the LOX tank and 9 + 1, -0 psig for the LH2 tank. Prior to the decay checks, gas samples were taken from both tanks and analyzed for helium content. Results of the helium concentration check and the pressure decay checks for the LOX and LH2 tanks are listed in Test Data Table 4.2.3.1.

While maintaining LOX tank helium pressure at 15 + 0, -1 psig, the LOX propellant supply line (low pressure duct) to the J-2 engine was pressurized with helium at 15 to 30 psig. The entire LOX propellant supply system, recirculation system, and LOX tank fill and drain line were checked with the helium leak detector and AMS3159 bubble solution for external leakage from the LOX tank downstream to the J-2 engine, including the LOX turbopump and all related pump discharge plumbing. This included the PU valve, main LOX shutoff valve (MOV), ASI valve, and the gas generator oxidizer circuitry terminating at the gas generator oxidizer valve.

After venting the LOX low pressure duct, the LH2 low pressure duct (propellant supply to the J-2 engine) was pressurized with helium at 10 to 30 psig while maintaining LOX tank and LH2 tank pressures at 10 to 15 psig and 10 + 0, -1 psig, respectively. The LH2 system for the LH2 tank through the J-2 engine was then checked for external helium leakage, similarly to the LOX system previously described.

4.2.3 (Continued)

Two external leaks were detected in the propellant supply systems, one in the LOX system, and one in the LH2 system. Both were eliminated by subsequent stage modifications.

The J-2 engine thrust chamber throat plug was then installed, and helium pressure at 30 ±2 psig was stabilized between the throat plug and the main oxidizer and fuel thrust chamber valves (MOV and MFV) to conduct the thrust chamber leak checks. The entire J-2 thrust chamber system was then checked for external helium leakage. No leaks were found. In addition to external leak checks of the thrust chamber system, the actuator drive and idler shaft seal leak checks were conducted for the thrust chamber valves (MOV and MFV). The results are listed in the test data table.

The J-2 engine start tank system was leak checked by pressurizing the tank with helium to 500 ±10 psig and checking all connections for external leakage with the detector and bubble solution. No leaks were found. After allowing the start tank pressure to stabilize for 2 hours, the start tank temperature and pressure were measured and recorded. After 1 hour, these measurements were repeated to calculate the helium mass decay rate for the start tank. The calculated decay rate was 0.00145 pounds-mass/hour, which was acceptable based on an allowable mass decay rate of 0.0066 pounds-mass/hour.

The J-2 engine control sphere was then pressurized with helium to between 225 and 250 psia in preparation for engine pneumatic leak checks. The low pressure side leak check was then conducted to determine internal leakage within the engine pneumatic control package. Leakage rates measured at the pneumatic

4.2.3 (Continued)

control package common vent port were within the acceptable tolerances, as listed in the Test Data Table. Engine control sphere pressure was then increased to 300 ± 10 psia, and the helium control solenoid was turned on to pressurize the pressure actuated purge system for external leak checks. No leaks were detected with the helium leak detector or the bubble solution. The engine control sphere pressure was then increased to 1450 ± 50 psig for the pneumatic control high pressure side retention test. After allowing the control sphere pressure to stabilize for 1 hour, the control sphere temperature and pressure were measured and recorded to calculate sphere helium mass. This was repeated 1 hour later to obtain a calculated engine control sphere helium mass decay rate of 0.0099 pounds-mass/hour, which was acceptable based on an allowable decay rate of 0.036 pounds-mass/hour.

Following completion of the J-2 engine leak checks, the checkout was completed by securing of engine, stage, and the test stand.

There were no discrepancies, documented by FARR, that resulted from this checkout. Ten revisions were recorded in the procedure for the following:

a. Two revisions corrected errors in the procedure.

b. One revision deleted the cold helium system torque checks, as all cold helium system conoseals were scheduled for replacement during the deferred postfire checkout.

c. Two revisions deleted all portions of the procedure that were prefire requirements only.

d. One revision was written and subsequently voided.

e. One revision corrected an error in a previous revision.

4.2.3 (Continued)

f. One revision authorized procedure changes to increase the J-2 engine thrust chamber system leak check pressure from 9 + 1, -0 psig to 30 ±2 psig in order to perform a high pressure leak check of the fuel pressurization module and the main fuel valve outlet.

g. One revision indicated the LH2 tank bottom sample of 74.7 percent helium concentration was acceptable for postfire leak check purposes.

h. One revision provided a test plan to perform a special flow and pressure check of the LH2 cryogenic repressurization control valve pilot bleeds.

4.2.3.1 Test Data Table, Final Postfire Propulsion System Leak Checks

Stage Vacuum Duct Readings

	Reading (Microns)	Limits (Microns)
LH2 LPD Upper	35	Less than 250
LH2 LPD Lower	43	Less than 250
LH2 Recirculation	65	Less than 250
O2H2 Burner LH2 Propellant Upper	9	Less than 250
O2H2 Burner LH2 Propellant Lower	12	Less than 250
O2H2 Burner LOX Propellant	16	Less than 250

Ambient Helium System Pressure Decay Checks

	Initial (psig)	Final (psig)	Limits
Control Helium Sphere Pressure	1450	1450	*
LOX Repressurization Sphere Pressure	1525	1515	*
LH2 Repressurization Sphere Pressure	1425	1405	*
Control Helium Regulator Discharge Pressure	540	540	*

Control Pneumatics System Pressure Decay Test

	Initial (psig)	Final (psig)	Limits
Control Helium Regulator Discharge Pressure	535	540	*

* Limits Not Specified

4.2.3.1 (Continued)

LOX and LH2 Tank Helium Concentration

		Reading (percent)	Limits (percent)
LOX Tank:	Top	98.3	75 min
	Bottom	93.7	75 min
LH2 Tank:	Top	99.4	75 min
	Bottom	74.7†	75 min

LOX and LH2 Tank Pressure Decay Test

	Initial (psig)	Final (psig)	Limits
LOX Tank	15.2	15.0	*
LH2 Tank	9.2	8.7	*

Thrust Chamber Valve Actuator Shaft Seal Leak Checks

	Measured (scim)	Limits (scim)
MOV Idler	0	3.3 max
MFV Idler	0	3.3 max
MOV 2nd Stage Actuator	0	3.3 max
MFV Actuator	0	3.3 max

Engine Pneumatic Control Package (Low Pressure Side) Leak Checks

	Vent Port Flow (scim)	Limits (scim)
Helium Control Solenoid On	5.2	20 max
Ignition Phase Solenoid On	8.0	20 max
Mainstage Solenoid On	5.2	20 max

† Refer to revision g
* Limits Not Specified

4.2.4 Structural Inspection (1B70756 B)

This manual procedure outlined the abbreviated and deferred postfire inspection requirements for the stage. The purpose of the checkout was to verify that static firing and postfire operations were not detrimental to the stage structure and that the stage was structurally ready for flight.

The checkout was performed in part at Beta during the abbreviated postfire checkout from 18 October through 29 October 1968, and then completed during deferred postfire operations at the VCL from 20 February through 26 February 1969.

The checkout was started with an inspection of the LOX and LH2 tank assemblies, the thrust structure, the tunnel areas, and the forward and aft skirt assemblies for cracked or debonded brackets, for cracks or deformations in the skin panels, and for chipped or peeled paint. The external ducts, tubes, and spheres were checked for scratches, dings, and corrosion. Cracked and peeling Korotherm coating on the forward skirt between stringers 13 and 18 and adjacent to the auxiliary tunnel was documented on FARR 500-226-005. The damaged coating was removed per DP 10127 and replaced per DPS 42210.

All bonded supports were verified to be acceptable by performing a "coin tap" test per DPS 32330. The areas inspected included the forward and aft domes, and the main and auxiliary tunnels.

The environmental control plenum, P/N 1B64850, was then inspected for rips and debonded areas, and was found acceptable. This was followed by visual

4.2.4 (Continued)

inspection of the stage air bottle, the control helium, the ambient helium, and cold helium spheres for dings, scratches, or other damage. Internal inspection of the LH2 tank was accomplished per H&CO 1B71972.

The engine position verification procedure was conducted to measure the inclination angle of the pitch and yaw planes in order to determine the plane of the base of the engine bell. Next, the envelope clearance check verified that all forward skirt components did not extend outward more than 8 inches from the outer surface of the LH2 tank forward dome, with the exception of temperature transducer, P/N 1B67863, or extend inward more than 17 1/2 inches from the forward skirt. The thrust structure interior was verified to be clean; all thrust structure doors, tunnel covers, and fairings were installed.

This completed the postfire structural inspection of the stage prior to shipment to FTC.

There were no other discrepancies documented by FARR; however, six revisions were recorded in the procedure for the following:

a. Two revisions were corrections or clarifications of the procedure.

b. Two revisions provided steps required for concurrent testing.

c. One revision deleted the requirement for the APS module fit check, which had been accomplished per H&CO 1B71155.

d. One revision deleted a test stand check previously accomplished by another procedure.

4.2.5 Integrated System Test (1B55831 H)

This postfire automatic checkout verified the design integrity and operational capability of the stage and facility systems which were functional during propellant loading and static acceptance firing. The automatic and manual test sequences performed during this checkout were conducted on 18 October 1968, and were accepted on 23 October 1968.

The stage power setup procedure established initial conditions and systematically applied power to stage buses and systems required for operation of the test.

The GSE valve functional checkout established an ambient condition in the pneumatic console by bleeding down all regulators and resetting them to predetermined values. All console and sled valves used in propellant loading and static acceptance firing were cycled, and the heat exchanger was functionally checked.

The telemetry and DDAS systems were tested next, with the PCM transmitter operated open loop. The telemetry 5-step calibration high and low RACS, and special calibrations of flows, speed, and frequencies were commanded to provide verification of all calibration techniques. The parameters on the CP1-BO and DP1-BO multiplexers and remote analog and digital submultiplexers, which were required for loading or firing, were verified by receipt of the proper response through open loop PCM transmissions. During the CP1-BO multiplexer test, thirty-eight functions were verified to be off, and twenty-one functions were verified to be on. The DP1-BO multiplexer test verified that seven

4.2.5 (Continued)

functions were off, and thirteen were on. DDAS testing was completed with a J-2 engine pressures multiplexer test for those CP1-BO and DP1-BO channels used for engine pressure parameters. Measurements recorded for the multiplexer tests are listed in Test Data Table 4.2.5.1.

During the stage valves and O2H2 burner functional checkouts, the LH2 and LOX vent valves and the fill and drain valves were opened and closed while the valve operating times were measured. Then, the LOX and LH2 valves were opened and boosted closed while the boost close times were measured. The LOX and LH2 prevalves and chilldown shutoff valves were closed and opened while the operating times were measured. The LH2 directional vent valve was set to the flight and ground positions while the operating times were measured; then, a simulated O2H2 burner firing flight sequence was conducted. Valve operating times are listed in the Test Data Table.

Engine gimbal testing followed the stage valve functional test. The auxiliary hydraulic pump was operated while verifying the proper pressures and levels prior to and after restrainer link disengagement. The J-2 engine received a step gimbal signal, as well as 1/4 and 1/2 degree sinusoidal inputs at 0.6, 5.0, and 7.0 Hz. The recorded gimbal measurements are shown in the Test Data Table. A final dry sequence of the J-2 engine, through the use of simulation commands for ASI ignition and mainstage ignition, was conducted to verify proper engine operation as well as the ESCS spark monitoring circuitry.

The ullage rocket ignition and jettison EBW units were functionally certified by charging and firing into the pulse sensors.

4.2.5 (Continued)

The overfill point level sensors and depletion point level sensors were proven to operate satisfactorily by cycling the sled main fill and replenish valves with 2-out-of-3 depletion sensors verifying the cutoff logic to be operational. In addition, the individual ability to create a cutoff was proven for the engine lockout component test power and engine lockout GSE power.

The propellant utilization system test verified that the inverter-converter outputs were correct and cycled the PU mass bridge, which created positive and negative error signals for verification of the engine PU valve position.

The stage bus internal power was setup by the use of secondary battery power. The forward internal/external cycle was completed by switching normal telemetry current to forward bus 1 and PU current to forward bus 2. Following the APS and range safety functional checks, the aft bus 1 was cycled from internal to external with the stage and APS currents at ambient. The LOX and LH2 childown inverters were operated for current and frequency tests; then, aft bus 2 was switched from internal to external. This completed stage testing for the integrated system test.

During the CP1-BO multiplexer test, measurement D225, cold helium control valve inlet pressure, was out-of-tolerance on all channels. The pressure transducer, P/N 1B40242-615, S/N 615-6, was removed and replaced per FARR 500-488-701.

There were no other FARR tags initiated as a result of the test. However, thirty-two revisions were recorded in the procedure for the following:

4.2.5 (Continued)

a. Eleven revisions added or changed requirements that were missing or in error.

b. Four revisions concerned tolerance changes made to correspond with previously accomplished procedures.

c. Two revisions concerned the PU constants values added to the program via paper tape.

d. One revision substituted the voltage tolerance for Test Stand Beta I aft 2 secondary battery in the program, which had specified the Beta III tolerance.

e. Four revisions deleted portions of the program that were prefire requirements only.

f. Two revisions deleted power turnon and calibration for the single sideband system bacause the system had not yet been installed for checkout.

g. One revision deleted a step to prevent a hold point when the O2H2 burner spark circuits were on.

h. One revision authorized removal and replacement of the spent ASI ignition detection probe to accomplish the J-2 engine sequence.

i. Three revisions attributed the out-of-tolerance measurements for aft bus 2 voltage control helium regulator discharge pressure, and LOX chilldown motor canister pressure, to program errors.

j. One revision concerned a GSE malfunction indication that had no bearing on the stage systems.

k. One revision authorized program changes to permit out-of-sequence testing.

l. One revision concerned the malfunction of measurement D225 per FARR 500-488-701, as previously described.

4.2.5.1 Test Data Table, Integrated System Test

CP1-BO Multiplexer Ambient Measurements and High and Low RACS Voltages

Meas. No.	Function	Measurement	Limits
D043	Amb Output (psia)	2252.813	2350.000 + 100.000
M025	Hi RACS Test (vdc)	3.994	4.000 ± 0.050
M025	Lo RACS Test (vdc)	-0.005	0.000 ± 0.050
M025	Amb Output (vdc)	4.992	5.000 ± 0.030
D236	Hi RACS Test (vdc)	3.989	4.000 ± 0.100
D236	Lo RACS Test (vdc)	1.035	1.000 ± 0.100
D236	Amb Output (psia)	28.044	14.700 ± 70.000
D225	Hi RACS Test (vdc)	-0.123†	4.000 ± 0.100
D225	Lo RACS Test (vdc)	-0.123†	1.000 ± 0.100
D225	Amb Output (psia)	-29.050†	14.700 ± 10.000
D016	Hi RACS Test (vdc)	4.015	4.000 ± 0.100
D016	Lo RACS Test (vdc)	1.051	1.000 ± 0.100
D016	Amb Output (psia)	37.232	14.700 ± 70.000
M024	Hi RACS Test (vdc)	3.979	4.000 ± 0.050
M024	Lo RACS Test (vdc)	-0.010	0.000 ± 0.050
M024	Amb Output (vdc)	4.994	5.000 ± 0.030
M068	Hi RACS Test (vdc)	3.989	4.000 ± 0.050
M068	Lo RACS Test (vdc)	-0.005	0.000 ± 0.050
M068	Amb Output (vdc)	4.994	5.000 ± 0.030
G001	Amb Output (°F)	-0.441	-0.300 ± 0.400
G002	Amb Output (°F)	0.548	0.300 ± 0.400
D020	Hi RACS Test (vdc)	3.953	4.000 ± 0.100
D020	Lo RACS Test (vdc)	0.969	1.000 ± 0.100
D020	Amb Output (psia)	20.565	14.700 ± 70.000
D177	Amb Output (psia)	14.523	14.700 ± 1.000
D178	Amb Output (psia)	14.479	14.700 ± 1.000
D088	Hi RACS Test (vdc)	3.964	4.000 ± 0.100
D088	Lo RACS Test (vdc)	1.010	1.000 ± 0.100
D088	Amb Output (psia)	31.782	14.700 ± 70.000
D179	Amb Output (psia)	14.282	14.700 ± 1.000
D180	Amb Output (psia)	15.019	14.700 ± 1.000
L007	Amb Output (%)	47.422	50.000 ± 10.000

DP1-BO Multiplexer Ambient Measurements and High and Low RACS Voltages

D236	Hi RACS Test (vdc)	3.994	4.000 + 0.100
D236	Lo RACS Test (vdc)	1.040	1.000 ± 0.100
D236	Amb Output (psia)	35.521	14.700 ± 70.000
D043	Amb Output (psia)	2255.563	2350.000 ± 100.000
C138	Hi RACS Test (vdc)	4.010	4.000 ± 0.075
C138	Lo RACS Test (vdc)	0.021	0.000 ± 0.075
C138	Amb Output (°F)	56.891	63.000 ± 16.000
M025	Amb Output (vdc)	4.999	5.000 ± 0.030

† Reference FARR 500-488-701

4.2.5.1 (Continued)

Meas. No.	Function	Measurement	Limits
D209	Amb Output (psia)	14.205	20.750 + 11.950
M074	Amb Output (vdc)	0.000	0.000 ∓ 0.075
M073	Amb Output (vdc)	-0.005	0.000 ∓ 0.075
D016	Hi RACS Test (vdc)	4.030	4.000 ∓ 0.100
D016	Lo RACS Test (vdc)	1.066	1.000 ∓ 0.100
D016	Amb Output (psia)	41.050	14.700 ∓ 70.000
D014	Amb Output (psia)	19.147	14.700 ∓ 13.000
M006	Amb Output (vdc)	27.845	28.000 ∓ 2.000
M007	Amb Output (vdc)	0.000	0.000 ∓ 0.450
D050	Amb Output (psia)	15.220	14.700 ∓ 3.000
M024	Hi RACS Test (vdc)	3.994	4.000 ∓ 0.050
M024	Lo RACS Test (vdc)	-0.005	0.000 ∓ 0.050
M024	Amb Output (vdc)	4.995	5.000 ∓ 0.030
M068	Hi RACS Test (vdc)	3.999	4.000 ∓ 0.050
M068	Lo RACS Test (vdc)	-0.005	0.000 ∓ 0.050
M068	Amb Output (vdc)	4.996	5.000 ∓ 0.030
C006	Hi RACS Test (vdc)	4.015	4.000 ∓ 0.075
C006	Lo RACS Test (vdc)	-0.005	0.000 ∓ 0.075
C006	Amb Output (°F)	63.343	63.000 ∓ 18.000
D103	Amb Output (psia)	14.402	14.700 ∓ 3.000
G001	Amb Output (°F)	-0.441	-0.300 ∓ 0.400
G002	Amb Output (°F)	0.563	0.300 ∓ 0.400
M010	Hi RACS Test (vdc)	3.943	4.000 ∓ 0.060
M010	Lo RACS Test (vdc)	1.020	1.000 ∓ 0.060
M010	Amb Output (vdc)	0.365	0.000 ∓ 1.000
D020	Hi RACS Test (vdc)	3.964	4.000 ∓ 0.100
D020	Lo RACS Test (vdc)	0.974	1.000 ∓ 0.100
D020	Amb Output (psia)	24.304	14.700 ∓ 70.000
C231	Hi RACS Test (vdc)	4.020	4.000 ∓ 0.075
C231	Lo RACS Test (vdc)	0.021	0.000 ∓ 0.075
C231	Amb Output (°F)	-155.555	-155.000 ∓ 8.000
C001	Hi RACS Test (vdc)	4.010	4.000 ∓ 0.075
C001	Lo RACS Test (vdc)	-0.005	0.000 ∓ 0.075
C001	Amb Output (°F)	68.563	63.000 ∓ 72.000
D177	Amb Output (psia)	14.644	14.700 ∓ 1.000
D178	Amb Output (psia)	14.599	14.700 ∓ 1.000
D105	Hi RACS Test (vdc)	3.989	4.000 ∓ 0.100
D105	Lo RACS Test (vdc)	0.984	1.000 ∓ 0.100
D105	Amb Output (psia)	10.774	14.700 ∓ 10.000
C230	Hi RACS Test (vdc)	4.005	4.000 ∓ 0.075
C230	Lo RACS Test (vdc)	-0.005	0.000 ∓ 0.075
C230	Amb Output (°F)	-378.438	-379.000 ∓ 4.000
D088	Hi RACS Test (vdc)	3.974	4.000 ∓ 0.100
D088	Lo RACS Test (vdc)	1.015	1.000 ∓ 0.100
D088	Amb Output (psia)	39.262	14.700 ∓ 70.000
C002	Hi RACS Test (vdc)	3.994	4.000 ∓ 0.075

4.2.5.1 (Continued)

Meas. No.	Function	Measurement	Limits
C002	Lo RACS Test (vdc)	-0.015	0.000 + 0.075
C002	Amb Output (°F)	43.838	63.000 ± 48.000
D179	Amb Output (psia)	14.343	14.700 ± 1.000
D180	Amb Output (psia)	15.079	14.700 ± 1.000
M026	Amb Output (vac)	0.000	0.000 ± 0.980
M027	Amb Output (vac)	0.000	0.000 ± 0.980
M041	Amb Output (vac	0.000	0.000 ± 0.980
M040	Amb Output (vac)	-0.066	0.000 ± 0.980
M060	Hi RACS Test (vdc)	4.005	4.000 ± 0.100
M060	Lo RACS Test (vdc)	1.005	1.000 ± 0.100
M060	Amb Output (vac)	2.174	6.000 ± 6.000
M061	Hi RACS. Test (vdc)	3.974	4.000 ± 0.100
M061	Lo RACS Test (vdc)	1.015	1.000 ± 0.100
M061	Amb Output (vdc)	-0.431	0.000 ± 1.200
L007	Amb Output (%)	47.547	50.000 ± 10.000
C199	Hi RACS Test (vdc)	4.015	4.000 ± 0.075
C199	Lo RACS Test (vdc)	-0.005	0.000 ± 0.075
C199	Amb Output (°F)	66.963	63.000 ± 21.000
D054	Hi RACS Test (vdc)	3.994	4.000 ± 0.100
D054	Lo RACS Test (vdc)	1.035	1.000 ± 0.100
D054	Amb Output (psia)	14.593	14.700 ± 2.000

CP1-BO Multiplexer - J-2 Engine Pressures Test

Meas. No.	Function	Measurement	Limits
D019	Hi RACS Test (vdc)	3.994	4.000 + 0.050
D019	Lo RACS Test (vdc)	0.994	1.000 ± 0.050
D019	Amb Output (psia)	16.597	14.700 ± 70.000
D018	Hi RACS Test (vdc)	4.087	4.087 ± 0.050
D018	Lo RACS Test (vdc)	1.103	1.087 ± 0.050
D018	Amb Output (psia)	14.268	14.700 ± 15.000
D017	Hi RACS Test (vdc)	4.030	4.030 ± 0.050
D017	Lo RACS Test (vdc)	1.030	1.030 ± 0.050
D017	Amb Output (psia)	13.193	14.700 ± 30.000

DP1-BO Multiplexer - J-2 Engine Pressures Test

Meas. No.	Function	Measurement	Limits
D017	Hi RACS Test (vdc)	4.035	4.035 + 0.050
D017	Lo RACS Test (vdc)	1.046	1.035 ± 0.050
D017	Amb Output (psia)	16.217	14.700 ± 30.000
D019	Hi RACS Test (vdc)	4.005	4.005 ± 0.050
D019	Lo RACS Test (vdc)	0.994	1.005 ± 0.050
D019	Amb Output (psia)	13.048	14.700 ± 70.000

4.2.5.1 (Continued)

Valve Functional Check

Function	Measurement		Limits
LH2 & LOX Prevlaves	Close Time (sec)	0.347	4.000 max
	Open Time (sec)	1.882	4.000 max
LH2 Vent Valve	Open Time (sec)	0.127	4.000 max
	Close Time (sec)	0.521	4.000 max
LOX Vent Valve	Open Time (sec)	0.124	4.000 max
	Close Time (sec)	0.459	4.000 max
LH2 & LOX C/D SOV	Close Time (sec)	0.182	4.000 max
	Open Time (sec)	1.143	4.000 max
LH2 Vent Valve	Open Time (sec)	0.092	4.000 max
	Close Time (sec)	0.496	4.000 max
	Open Time (sec)	0.094	4.000 max
	Close Time (sec)	0.268	4.000 max
LOX Vent Valve	Open Time (sec)	0.089	4.000 max
	Close Time (sec)	0.422	4.000 max
	Open Time (sec)	0.089	4.000 max
	Close Time (sec)	0.423	4.000 max
LH2 Fill & Drain Valve	Open Time (sec)	0.162	4.000 max
	Close Time (sec)	1.383	4.000 max
	Open Time (sec)	0.157	4.000 max
	Close Time (sec)	0.572	4.000 max
LOX Fill & Drain Valve	Open Time (sec)	0.267	4.000 max
	Close Time (sec)	2.099	4.000 max
	Open Time (sec)	0.234	4.000 max
	Close Time (sec)	0.855	4.000 max
LH2 & LOX Prevalves	Close Time (sec)	0.311	4.000 max
	Open Time (sec)	1.838	4.000 max
LH2 & LOX C/D SOV	Close Time (sec)	0.146	4.000 max
	Open Time (sec)	1.120	4.000 max
LH2 Dir Vent Valve	Dir Vent to Flt Pos (sec)	0.218	4.000 max
	Dir Vent to Grd Pos (sec)	0.189	4.000 max

4.2.5.1 (Continued)

Engine Gimbal Step Commands - Restrainer Links Engaged

Position (deg)	Pitch Exc (ma)	Yaw Exc (ma)	TM Pitch Pos(deg)	TM Yaw Pos(deg)	IU Pitch Pos(deg)	IU Yaw Pos(deg)
0° pitch 0° yaw	0.00	0.10	0.03	0.08	0.01	0.05
1° pitch 1° yaw	6.80	0.00	0.85	0.09	0.87	0.06
0° pitch 0° yaw	0.00	0.10	-0.00	0.09	0.01	0.08
-1° pitch -1° yaw	-6.65	0.00	-0.99	0.08	-0.99	0.09
0° pitch 0° yaw	0.05	0.05	0.01	0.09	0.03	0.08
0° pitch 0° yaw	0.20	-6.60	-0.02	-0.69	0.00	-0.72
0° pitch 0° yaw	0.00	0.00	-0.00	0.11	0.00	0.12
0° pitch 0° yaw	0.20	6.75	0.01	1.08	-0.03	1.09
0° pitch 0° yaw	0.05	0.05	-0.02	0.11	0.00	0.09

Engine Gimbal Step Commands - Restrainer Links Disengaged

Position (deg)	Pitch Exc (ma)	Yaw Exc (ma)	TM Pitch Pos (deg)	TM Yaw Pos(deg)	IU Pitch Pos(deg)	IU Yaw Pos(deg)
0° pitch 0° yaw	0.05	0.05	-0.00	0.09	-0.06	0.12
1° pitch 1° yaw	6.70	0.10	0.99	0.11	1.02	0.15
0° pitch 0° yaw	0.05	0.05	-0.02	0.09	-0.06	0.09
-1° pitch -1° yaw	-6.65	0.05	-1.02	0.11	-1.02	0.09
0° pitch 0° yaw	0.10	0.10	-0.00	0.12	0.01	0.08

4.2.5.1 (Continued)

Engine Gimbal Step Commands - Restrainer Links Disengaged

Position (deg)	Pitch Exc (ma)	Yaw Exc (ma)	TM Pitch Pos(deg)	TM Yaw Pos(deg)	IU Pitch Pos(deg)	IU Yaw Pos(deg)
0° pitch 0° yaw	0.10	-6.65	-0.00	-0.88	0.04	-0.85
0° pitch 0° yaw	0.05	0.00	-0.00	0.12	-0.01	0.10
0° pitch 0° yaw	0.20	6.75	-0.00	1.10	0.00	1.09
0° pitch 0° yaw	0.10	0.10	-0.00	0.09	0.00	0.05

Engine Gimbal Frequency Response

Axis (deg)	Desired Freq(Hz)	Actual Freq-F(Hz)	Time Lag-T (sec)	Phase Lag (360xTxF)	Cycled Gimb'd	Sample Time(sec)
0.25° Ptch	0.60	0.59	0.109	23.279	3.23	1.977
	5.00	5.00	0.042	75.512	12.12	1.977
	7.00	7.01	0.030	76.438	16.23	1.993
0.25° Yaw	0.60	0.58	0.050	10.485	3.19	1.978
	5.00	4.97	0.023	41.941	11.97	1.977
	7.00	7.01	0.024	61.644	16.31	2.008
0.50° Ptch	0.60	0.59	0.087	18.382	3.23	2.007
	5.00	5.07	0.034	61.765	12.13	1.976
	7.00	6.97	0.035	88.163	16.24	2.002
0.50° Yaw	0.60	0.56	0.058	11.650	3.16	1.993
	5:00	5.00	0.036	64.976	12.10	1.979
	7.00	6.97	0.032	80.815	16.12	1.988

4.2.6 Hydraulic System Poststorage Operating and Securing (1B41006 B)

The purpose of this procedure was to obtain postfire closed loop hydraulic fluid samples and to secure the hydraulic system prior to removal of the stage from the test stand for transfer to the VCL.

Checkout was initiated on 22 October 1968, and satisfactorily completed on 28 October 1968. Components of the stage hydraulic system installed during this checkout included the main engine driven hydraulic pump, P/N 1A66240-503, S/N X123108; the auxiliary hydraulic pump, P/N 1A66241-511, S/N X458911; the hydraulic pitch and yaw actuator assemblies, P/N 1A66248-507, S/N's 81 and 30; and the accumulator/reservoir assembly, P/N 1B29319-519, S/N 00033.

Prior to the start of the checkout, the GSE hydraulic pumping unit (HPU), P/N 1A67443-1, was flushed and checked for hydraulic fluid cleanliness, then connected to the stage hydraulic system by pressure and return hoses. The HPU provided high pressure hydraulic fluid to the stage hydraulic system during the checkout.

Prior to this checkout the accumulator/reservoir had been charged with gaseous nitrogen, and the stage auxiliary hydraulic pump air bottle had been charged to a pressure of 475 $\pm$50 psig. Verification was made that all components of the stage hydraulic system were securely installed and that each hydraulic connection was tightened to the proper torque value. All bleed valves were verified to be closed, and all external signs of hydraulic fluid were rinsed from the system.

4.2.6 (Continued)

With the midstroke locks installed on the hydraulic actuators, the auxiliary hydraulic pump was turned on and operated for 6 minutes, bringing the system pressure to the required 3600 $\pm$100 psig. After shutting down the auxiliary pump, closed loop system fluid samples were obtained, for cleanliness evaluation, from the hydraulic actuators and the accumulator outlet sampling valves. High particle counts for the accumulator outlet sample necessitated flushing of the system by operating the HPU for 20 minutes and then taking additional samples from the accumulator outlet and the HPU. Particle counts for the various micron ranges were acceptable for all final samples.

The shutdown sequence of this checkout included a final air content test, which provided information necessary for system analysis by discharging a portion of the internal system fluid volume overboard. The volume discharged was determined to be a function of fluid thermal expansion under ground operation conditions (0°F to 160°F). The HPU was turned on, and the system pressure was increased to 3650 $\pm$50 psig, the bypass valve was opened, and the HPU turned off. Verification was made that the return pressure gauge indicated a minimun of 200 psig. The shutoff valve was cycled open and closed until the return pressure was reduced to 180 $\pm$5 psig. An empty 100 ml graduate was placed under the drain port, and by cycling the reservoir drain valve open and closed, the return pressure was decreased to 80 $\pm$5 psig. The 8 milliliter volume of fluid bled off was less than the 16 milliliter maximum, as specified per design requirements. The reservoir oil temperature was measured at 81°F, and based on the curve for temperature versus drained fluid volume, a total of 250 milliliters of hydraulic fluid was removed.

4.2.6 (Continued)

The HPU was disconnected from the stage system and secured. Hydraulic system preparations for stage removal from the test stand included depressurization of the GN2 accumulator, the stage auxiliary hydraulic pump case, and the air supply bottle. All auxiliary equipment was removed from the hydraulic system, and all sample ports were capped. The accumulator/reservoir drain hose was removed, and a plastic dust cover was installed on the port of the reservoir low pressure relief valve. This completed the securing of the system for stage transfer to the VCL.

FARR 500-488-743 recorded hydraulic fluid leakage at the filter differential pressure indicator mounting flange on the auxiliary hydraulic pump. The leak was corrected by replacing the O-rings and back-up ring prior to the final system flush and sample routine.

Seven revisions were recorded in the procedure for the following:

a. Three revisions provided instructions to obtain engineering information for evaluation of engine side loads and to check for external leakage at the auxiliary hydraulic pump filter differential pressure indicator after correction of leakage, as noted per FARR 500-488-743.

b. One revision deleted an obsolete setup requirement in the procedure.

c. One revision authorized flushing the hydraulic system and taking additional fluid cleanliness samples after the initial accumulator outlet sample was rejected for a high particle count.

d. One revision deleted the requirements for charging the hydraulic accumulator and the auxiliary hydraulic pump air supply bottle, as charging had been accomplished prior to this procedure.

4.2.6 (Continued)

e. One revision noted that ambient temperature in the area of the accumulator must be used in lieu of numerical readout for reservoir oil temperature as provided in the procedure. This revision also deleted the numerical readout for reservoir oil level. Instrumentation readouts were not available because the umbilical cables had been disconnected.

4.2.7 Forward Skirt Thermoconditioning System Postfire Checkout (1B41883 C)

The forward skirt thermoconditioning system was tested in preparation for transfer to the VCL at completion of the stage abbreviated postfire checkout operations. The procedure utilized the thermoconditioning servicer, P/N 1A78829-1, which had conditioned and supplied the water/methanol heat transfer fluid to the forward skirt thermoconditioning system (TCS), P/N 1B38426, during checkout operations.

Checkout included the water/methanol cleanliness test, the specific gravity test, the TCS differential pressure test, the TCS drying procedure, the TCS leak check, and preparation for shipment. The purpose of the cleanliness test was to ensure against contamination of the water/methanol solution by material that could cause TCS failure by restriction of the flow or cause pump abrasion. The specific gravity test checked for proper water/methanol concentration to obtain valid differential pressure measurements during the TCS "delta P test," which was conducted to check for correct TCS geometry and flow distribution. A drying procedure utilized gaseous nitrogen to purge the TCS of water/methanol vapor. The initial drying procedure prepared the TCS for the leak check, and a final drying of the system was accomplished to preclude the possibility of corrosion in the TCS cold plates.

The postfire TCS checkout was initiated on 25 October 1968, and was successfully completed on 28 October 1968. The water/methanol cleanliness test was conducted by circulating water/methanol fluid through the TCS; then, obtaining water/methanol samples which were taken to the laboratory for a particle count. The samples were found to be acceptable for each micron range.

4.2.7 (Continued)

Next, the specific gravity and temperature of the water/methanol solution was measured with a hydrometer and thermometer, respectively, to determine that the solution was within the acceptable mixture range for the required delta P testing band. The delta P test was then conducted by measuring the differential pressure between the TCS supply and return lines from the servicer and by measuring the supply and return temperatures with a water/methanol flow rate of 7.8 ±0.2 gpm at a supply pressure of 42.0 +0, -1 psig. The differential pressure was recorded at 14.5 psi with the fluid supply temperature and the return temperature both at 88°F.

Next, the TCS was purged of water/methanol with GN2 until a system dryness of 25°F dewpoint was obtained, as verified by the Alnor dewpoint meter. Prior to leak checking the TCS, all bolts in the TCS panels were checked for proper torque, after ensuring that there were no open equipment-mounting bolt holes in the panels. The TCS was pressurized to 32 ±1 psig with freon gas and checked for external leakage with the gaseous leak detector, P/N 1B37134-1. Areas checked for leakage included TCS B-nuts and fittings, manifold welded areas, boss weld, and manifold bellows. No leakage was detected. The freon was then purged from the TCS using GN2 for a minimum period of 5 minutes.

The final operation consisted of disconnecting and securing the servicer and preparing the TCS for stage transfer to the VCL.

There were no FARR's initiated as a result of this checkout, and no discrepancies for the TCS were noted. No revisions were recorded in the procedure.

4.3 Deferred Postfire Acceptance Testing

The deferred postfire acceptance operations were initiated on 6 January 1969, with the performance of the stage and GSE manual controls checkout, paragraph 4.3.1. Acceptance of the all systems test, paragraph 4.3.26, on 10 March 1969, completed the postfire retest requirements as delineated in the End Item Test Plan, 1B66684 K, dated 20 September 1968.

4.3.1 Stage and GSE Manual Controls Check, VCL (1B70767 B)

This deferred postfire procedure verified manual control capability for the pneumatic regulators and valves in the propulsion GSE and stage systems. The test consisted of supplying electrical and pneumatic signals to the system components and checking for the proper response utilizing the VCL test control center (TCC) panels. Stage pneumatic control and pressurization sphere moisture levels were also verified.

The manual controls checkout was satisfactorily conducted on 6 January 1969, and was certified as acceptable on 18 February 1969. Preliminary GSE setup operations were initiated to verify that the switches and valves on the test consoles were positioned properly for the functional check. The GSE manual controls were then operated to ensure their functional capability.

The stage control helium system check began by verifying that the LOX and LH2 repressurization spheres were isolated and that the stage purge hand valves were closed. The control helium sphere and the LH2 repressurization sphere were pressurized to 700 psig, while the LOX repressurization sphere pressure was recorded as 710 psig. Moisture levels in the control helium sphere, and the LOX and LH2 repressurization spheres were verified as 94 ppm, 62 ppm and 23 ppm, respectively. The spheres were then pressurized to 520 psig for the stage valves control check.

The stage valves controls check was accomplished by supplying signals manually from the VCL TCC control panels to the stage in a specified sequence and then verifying correct talkback. In addition, test stand personnel verified stage

4.3.1 (Continued)

valve actuation audibly or by touch. Starting at the TCC mainstage propulsion manual control panel, the LH2 and LOX prevalves were individually cycled and verified. The LH2 tank vent and the fill and drain valves were cycled open and closed. The LH2 tank vent boost close valve and the LH2 fill and drain boost close valve were cycled. The LH2 directional vent valve was cycled from the flight to the ground position. The LOX tank vent and the fill and drain valves were cycled open and closed. The LOX tank vent boost close valve and the LOX fill and drain boost close valve were cycled. The cold helium shutoff valve was cycled open and closed. The moisture level of the cold helium sphere was recorded as 50 ppm. The cold helium bottle fill valve was then closed.

The stage valves control check was completed at the TCC repressurization control panel by cycling the O2H2 burner LOX and LH2 propulsion valves and the LOX shutdown valve.

The test was terminated by securing the test stand pneumatics systems using the VCL TCC control panels.

There were no stage FARR's resulting from this checkout. Six revisions were recorded in the procedure for the following:

a. Three revisions deleted portions of the procedure that were not required for this checkout.

b. One revision corrected a procedure error.

c. One revision gave instructions to read and record the helium supply pressure and the console supply line pressure and verify that the readings were within 100 psi of each other, as the console pressure transducer was missing from the console.

d. One revision concerned a numerical readout for the engine control bottle pressure, as the vehicle monitor panel was not connected to the engine control bottle for this test.

4.3.2 Umbilical Interface Compatibility Check (1B59782 G)

Prior to connecting the forward and aft umbilical cables for stage power set-up, this manual checkout provided the test sequences which were used to check the design specifications and the continuity of the stage umbilical wiring. Accomplished by point-to-point resistance checks of all umbilical circuits, this test ensured that the proper loads were present on all power buses, and that the control circuit resistances for the propulsion valves and safety items on the stage were within the prescribed tolerances.

The procedure was initiated on 8 January 1969, and was accepted on 9 January 1969. However, a second issue was accomplished and accepted on 11 February 1969. This second issue was required to reverify the umbilicals after ejection during the performance of AST. The test points, circuit functions, measured resistances, and resistance limits shown in the Test Data Table 4.3.2.1, are from the final issue. A series of resistance checks were made at specified test points on the signal distribution unit, P/N 1A59949-1, using test terminal 463A1A5-J43FF as the common test point for all resistance measurements. These measurements verified 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.

No FARR's were generated as a result of this checkout. There were two revisions written to this procedure as follows:

a. One revision gave instructions to reinstall the patch panels 463A1A1, 463A2A2, and 463A1A5 on the signal distirubtion unit after the test. The reinstallation of these patch panels had been omitted from the procedure.

4.3.2 (Continued)

b. One revision changed the procedure to correspond to the "internal" configuration of the stage following the umbilicals-out portion of AST. The procedure is normally used on the "external" configuration.

4.3.2.1 Test Data Table, Umbilical Interface Compatibility Check

Reference Designation 463A2

Test Point	Function	Meas. Ohms	Limit Ohms
A2J29-C	Cmd., Ambient Helium Sphere Dump	28	10-60
CB-8-2	Cmd., Engine Ignition Bus Pwr Off	5.5	5-100
CB-9-2	Cmd., Engine Ignition Bus Pwr On	Inf	Inf
CB-10-2	Cmd., Engine Control Bus Pwr Off	5.2	5-100
CB-11-2	Cmd., Engine Control Bus Pwr On	Inf	Inf
A2J29-N	Cmd., Engine He Emerg Vent Control On	50	10-60
A2J29-P	Cmd., Fuel Tnk Repress He Dump Vlv Open	36	10-60
A2J29-Y	Cmd., Start Tnk Vent Pilot Vlv Open	48	10-60
CB-4-2	Cmd., LOX Tank Cold He Sphere Dump	30	10-60
A2J29-c	Cmd., LOX Tnk Repress He Sphere Dump	36	10-60
A2J29-h̲	Cmd., Fuel Tnk Vent Pilot Vlv Open	62	40-100
	(Same, reverse polarity)	Inf	500k min
A2J29-i̲	Cmd., Fuel Tnk Vent Vlv Boost Close	60	40-100
	(Same, reverse polarity)	Inf	500k min
A2J29-q	Cmd., Amb He Supply Shutoff Vlv Close	52	10-60
A2J30-H̄	Cmd., Cold He Supply Shutoff Vlv Close	1.2k	1.5k max
	(Same, reverse polarity)	Inf	Inf
A2J30-W	Cmd., LOX Vent Valve Open	60	40-100
	(Same, reverse polarity)	Inf	500k min
A2J30-X	Cmd., LOX Vent Valve Close	60	40-100
	(Same, reverse polarity)	Inf	500k min
A2J30-Y	Cmd., LOX & Fuel Prevlv Emerg Close	65	40-100
	(Same, reverse polarity)	Inf	Inf
A2J30-Z	Cmd., LOX & Fuel Chilldown Vlv Close	62	40-100
	(Same, reverse polarity)	Inf	500k min
A2J30-b	Cmd., LOX F&D Valve Boost Close	31	10-40
A2J30-c̄	Cmd., LOX F&D Valve Open	30	10-40
A2J30-d̄	Cmd. Fuel F&D Valve Boost Close	31	10-40
A2J30-ē	Cmd., Fuel F&D Valve Open	32	10-40
A2J42-F̄	Meas. Bus +4D111 Regulation	Inf	100 min
A2J35-y	Meas. Bus +4D141 Regulation	Inf	Inf
A2J6-AĀ	Sup. 28V Bus +4D119 Talkback Power	90	60-120

Reference Designation 463A1

Test Point	Function	Meas. Ohms	Limit Ohms
A5J41-A	Meas. Bus +4D131 Regulation	Inf	20 min
A5J41-E	Meas. Bus +4D121 Regulation	Inf	1.6k min
A5J53-AA	Sup. 28V 4D119 Fwd Talkback Pwr	70	60-100

4.3.3 Forward Skirt Thermoconditioning System Checkout Procedure (1B57599 D)

The forward skirt thermoconditioning system (TCS), P/N 1B38426-513, was functionally checked per this manual procedure to prepare it for operation and to verify that the system was capable of supporting stage deferred postfire checkout operations. The checkout utilized the TCS servicer, P/N 1A78829-1, which conditioned and supplied the water/methanol heat transfer fluid to the TCS. After completion of postfire checkout, the procedure was used to prepare the TCS for stage shipment to FTC.

Checkout included the water/methanol cleanliness test and specific gravity test, the TCS differential pressure test, the TCS drying and leak check procedure, and preparation for shipment. The purpose of the cleanliness test was to ensure against contamination of the water/methanol solution by elements that could cause TCS system failure by restriction of flow, or pump abrasion.

A TCS differential pressure test was conducted to check for the correct TCS system geometry and flow distribution. A drying procedure utilized gaseous nitrogen to purge the TCS system of water/methanol vapor prior to the system leak check. A final GN2 purge was conducted to dry the TCS after completion of the freon leak check of the TCS.

The TCS checkout was initiated on 8 January 1969. TCS preparations for the stage deferred postfire operations were completed on 9 January 1969. TCS preparations for stage shipment were started on 17 February and completed on 18 February 1969.

4.3.3 (Continued)

A water/methanol cleanliness test for the TCS servicer was conducted first. After circulating the fluid through the TCS for 30 minutes, water/methanol samples were taken from the servicer sample supply and return valves and checked in the laboratory for particle counts. The samples were found acceptable for each micron range checked.

Next, the specific gravity and temperature of the water/methanol solution was measured with a hydrometer and thermometer, respectively, determining that the solution was within the acceptable mixture range for the required differential pressure testing band. Prior to conducting the differential pressure test, the TCS servicer was used to circulate the fluid for another 30 minutes, after which additional supply and return samples were taken to ensure the TCS cleanliness level. These samples were also acceptable.

The differential pressure test was then conducted by measuring the differential pressure between the TCS supply and return lines from the servicer, plus the supply and return temperatures, with a water/methanol flow rate of 7.8 $\pm$0.3 gpm at a supply pressure of 42.0 +0, -1 psig. The differential pressure was recorded at 14.6 psi with fluid supply temperature indicating 59°F and the return temperature indicating 60°F.

Prior to leak checking the TCS, the system was purged of water/methanol with GN2 until a system dewpoint of 25°F was obtained, as verified by an Alnor dewpoint meter. Next, an inspection of the TCS panels for open equipment mounting bolt holes and bolts tightened to the proper torque value was accomplished satisfactorily, indicating readiness for the system leak checks. The

4.3.3 (Continued)

thermoconditioning system was then pressurized to 32 ±1 psig with freon gas and leak checked with the gaseous leak detector, P/N 1B37134-1. The areas checked for leakage included all TCS B-nuts, fittings, manifold weld areas, panel inlet and outlet boss welds, and manifold bellows. No leakage was detected, and the TCS was then purged of freon with GN2 pressurized to 32 ±1 psig until a system dewpoint of 25°F was again obtained.

The final operation consisted of disconnecting and securing the servicer and preparing the TCS for the stage shipment.

No FARR's were initiated as a result of this checkout. However, six revisions were recorded in the procedure for the following:

a. Three revisions corrected errors in the procedure.

b. One revision substituted a flex line for a specified GSE hose assembly, which was not available.

c. One revision provided for additional GN2 purging to obtain the required system dewpoint.

d. One revision provided instructions to maintain the TCS dewpoint level during shutdown operations.

4.3.4 Stage Power Setup (1B66560 G)

Prior to the initiation of deferred postfire automatic checkouts, the automatic 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 power distribution system was not subjected to excessive static loads during initial setup sequences. After successful demonstration, this procedure was used to establish initial conditions during the subsequent deferred automatic checkouts.

Testing was initiated on 9 January and completed on 10 January 1969. Six tests were conducted, of which the first five were aborted due to (1) computer holds generated by the GSE system status display and (2) a grounded wire within the forward bus 1 GSE power supply. The system status display was not used for further testing, having been previously deleted from the required GSE. The forward bus 1 GSE was repaired by reterminating the grounded wire and replacing the condenser from which the wire had been pulled loose. All measurements listed in Test Data Table 4.3.4.1 are from the acceptable sixth and final test. The following narrative is a description of that test.

The test was started by resetting all matrix magnetic latching relays and verifying that the corresponding command relays were in the proper state. The umbilical connectors were verified to be mated, and the LOX and LH2 inverters were verified to be disconnected. 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, engine control bus power, engine ignition bus power, APS bus 1 and bus 2 power, and propellant

4.3.4 (Continued)

level sensor power were all verified to be off. The power to the range safety receivers and EBW firing units was transferred to external and verified to be off. The switch selector checkout indication enable and the flight measurement indication enable were both turned on. The bus 4D131, 28 vdc power supply was turned on, and the forward bus 1 initial current and voltage were measured.

The range safety system safe and arm device was verified to be in the SAFE condition. The 70 pound ullage engine relay, the LH2 continuous vent valve relays, the LH2 and LOX repressurization mode relay, the O2H2 burner propellant valve relay, and the engine passivation relays were all verified to be reset. The LH2 continuous vent and relief override valve was verified to be closed, and the LOX repressurization control valve enable was verified to be on. Power was verified to be off for the propellant utilization boiloff bias. The O2H2 burner spark systems 1 and 2 voltages were measured and recorded. The O2H2 burner LOX and LH2 valves and the LH2 continuous vent orificed bypass valve were verified to be closed.

The forward bus 1 quiescent current was measured. The PCM system group power was turned on, and the current was measured and recorded. The forward bus 2, 28 vdc power supply was turned on, and the forward bus 2 current and voltage were measured.

The DDAS ground station source select switch was manually set to position 1, and the ground station was verified to be in synchronization. The cold helium supply shutoff valve was closed. The aft bus 1, 28 vdc power supply was turned

4.3.4 (Continued)

on, and the aft bus 1 power supply current and voltage were measured. The sequencer power was turned on and the current was measured. The forward and aft battery load test off commands were set.

A series of checks during initial conditions scan verified that the stage functions were in the proper state. Forty-four functions were verified to be off and twenty-six were verified to be on. The LOX and LH2 prevalves and chilldown shutoff valves were verified as open, and the LOX and LH2 vent valves and fill and drain valves were verified as closed.

The final operations of this automatic procedure measured the forward and aft 5 volt excitation module voltages, the range safety EBW firing unit charging voltages, the aft bus 2 voltage, the forward and aft battery simulator voltages, and the component test power voltage.

No FARR's were initiated against the stage as a result of stage power setup testing. However, ten revisions were recorded in the procedure for the following:

a. One revision clarified and corrected the setup procedure.

b. One revision added program changes to ensure that the single sideband transmitter was off during the test.

c. One revision deleted the calibration preflight mode check due to the addition of the single sideband system.

d. One revision authorized troubleshooting malfunctions caused by the previously described problem with the forward bus 1 GSE power supply.

e. One revision noted that the malfunction indication for the LH2 continuous vent orificed bypass valve was expected during initial conditions scan because the valve had been previously removed and not replaced.

4.3.4 (Continued)

f. Five revisions authorized each of the five additional test attempts conducted.

4.3.4.1 Test Data Table, Stage Power Setup

Function	Measured Value	Limit
Forward Bus 1 Power Supply Current (amps)	0.699	5 max
Forward Bus 1 Voltage (vdc)	28.438	28 ± 0.5
O2H2 Burner Spark System 1 Voltage (vdc)	0.015	0 ± 0.5
O2H2 Burner Spark System 2 Voltage (vdc)	0.060	0 ± 0.5
Forward Bus 1 Quiescent Current (amps)	0.699	5 max
PCM System Group Current (amps)	4.300	5 ± 3
Forward Bus 2 Power Supply Current (amps)	0.899	2 max
Forward Bus 2 Voltage (vdc)	28.358	28 ± 0.5
Aft Bus 1 Power Supply Current (amps)	0.699	2 max
Aft Bus 1 Voltage (vdc)	28.278	28 ± 0.5
Sequencer Power (amps)	0.000	0 ± 3
Aft 5V Excitation Module Voltage (vdc)	5.000	5 ± 0.030
Fwd 1 5V Excitation Module Voltage (vdc)	4.999	5 ± 0.030
Fwd 2 5V Excitation Module Voltage (vdc)	4.996	5 ± 0.030
RS 1 EBW Firing Unit Chg Voltage (vdc)	0.000	0 ± 1
RS 2 EBW Firing Unit Chg Voltage (vdc)	0.005	0 ± 1
Aft Bus 2 Voltage (vdc)	0.000	0 ± 1
Forward Battery 1 Simulator Voltage (vdc)	0.000	0 ± 1
Forward Battery 2 Simulator Voltage (vdc)	0.000	0 ± 1
Aft Battery 1 Simulator Voltage (vdc)	0.039	0 ± 1
Aft Battery 2 Simulator Voltage (vdc)	0.079	0 ± 1
Component Test Power Voltage (vdc)	0.039	0 ± 1

4.3.5 Stage Power Turnoff (1B66561 G)

The stage power turnoff procedure was used for automatic shutdown of the stage power distribution system, returning the stage to the de-energized condition after completion of the various system checkout procedures during the deferred postfire testing of the stage. The procedure deactivated the stage relays so that no current flowed from the battery simulators through the stage wiring. All internal/external transfer relays were set to the external condition.

Satisfactory demonstration of this procedure was accomplished on 10 January 1969. Measurements recorded during the test are listed in Test Data Table 4.3.5.1.

Following this acceptance, the stage power turnoff procedure was used to shut down the stage at the conclusion of the various automatic checkouts conducted during deferred postfire operations.

The automatic stage power turnoff was started by verifying that the umbilical connectors were mated and that the flight measurement indication enable was turned on. The bus 4D119 talkback power, the forward bus 1 and aft bus 1, 28 vdc power supplies, and the sequencer power were all verified to be on. The forward bus 1 and aft bus 1 voltages were then measured.

The switch selector functions were then turned off; the O2H2 burner spark systems 1 and 2 voltages were measured; and a series of checks verified that the stage electrical functions were in the proper stage of off, reset, or closed. The forward and aft bus power supplies were verified to be off, and the forward and aft bus battery simulator voltages were measured. The stage buses

5

4.3.5 (Continued)

were then transferred to external power, and the forward and aft stage bus voltages were measured. The EBW pulse sensor power was turned off, and the range safety receivers and the EBW firing units were transferred to external power. The range safety system safe and arm device was verified to be on, safe, and the bus 4D119 talkback power was turned off. The matrix magnetic latching relays were then reset, thus completing this demonstration run for stage power turnoff.

There were no FARR's written against this test. However, two revisions were recorded in the procedure as follows:

a. One revision clarified and corrected setup procedure.

b. One revision noted that a malfunction indication of, calibration preflight mode not on, occurred because this check had been deleted due to the addition of the single sideband system.

4.3.5.1 Test Data Table, Stage Power Turnoff

Function	Measured Value	Limits
Forward Bus 1 Voltage, Power On (vdc)	28.479	28 + 2
Aft Bus 1 Voltage, Power On (vdc)	28.318	28 ∓ 2
O2H2 Burner Spark System 1 Voltage (vdc)	0.034	0 ∓ 0.5
O2H2 Burner Spark System 2 Voltage (vdc)	0.039	0 ∓ 0.5
Forward Bus 1 Battery Simulator Voltage (vdc)	0.039	0 ∓ 1.0
Forward Bus 2 Battery Simulator Voltage (vdc)	0.000	0 ∓ 1.0
Aft Bus 1 Battery Simulator Voltage (vdc)	0.039	0 ∓ 1.0
Aft Bus 2 Battery Simulator Voltage (vdc)	0.079	0 ∓ 1.0
Forward Bus 1 Voltage, Power Off (vdc)	0.039	0 ∓ 1.0
Forward Bus 2 Voltage, Power Off (vdc)	0.039	0 ∓ 1.0
Aft Bus 1 Voltage, Power Off (vdc)	0.039	0 ∓ 1.0
Aft Bus 2 Voltage, Power Off (vdc)	-0.079	0 ∓ 1.0

4.3.6 Power Distribution System (1B66562 H)

The automatic checkout of the stage power distribution system during deferred postfire operations verified the capability of the GSE to control power switching to and within the stage and determined that initial static loads within the stage were not excessive. The procedure verified that particular stage relays were energized or de-energized, as required, and that bi-level talkback indications were received at the GSE. Static loading of the various stage systems was determined by measuring the GSE supply current before and after turn-on of each system.

The power distribution system test was performed three times. The initial test on 13 January 1969, was aborted due to malfunctions caused by incomplete GSE electrical patching. The second test was successfully conducted on 15 January 1969. However, this test was subsequently invalidated by the disconnection of electrical cabling to accommodate rework of the range safety systems. The third and final test was required because of this invalidation and was satisfactorily performed on 7 February 1969. All measurements listed in Test Data Table 4.3.6.1 are taken from the final test. The following narrative is a description of that test.

The initial conditions scan was conducted per the stage power setup, H&CO 1B55813, and initial conditions were established for the test. Starting with engine control bus power turn-on, the current differential for the aft 1 power supply was measured. The engine control bus voltage M6 was measured and determined to be within tolerance. The APS bus power was turned on, and again the current differential for the aft 1 power supply was measured. This operation

4.3.6 (Continued)

was repeated for the engine ignition bus by measuring aft 1 power supply current differential and engine ignition bus voltage M7. The engine ignition bus power and APS bus power were then turned off and verified.

The engine safety cutoff system (ESCS) power was turned on, and the aft 1 power supply current measured. The component test power was turned on, and the aft 1 power supply current differential and component test power voltage were measured. The component test power was turned off and verified to be off by measurement of the voltage. ESCS power was then turned off.

To check the emergency detection system (EDS), verification was made that the EDS 2 engine cutoff signal turned off the engine control bus power, prevented it from being turned back on, and also turned on the instrument unit (IU) 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 made that the EDS 1 engine cutoff signal turned on the nonprogrammed engine cutoff signal and the AO and BO multiplexer engine cutoff signal indication (K13). With the EDS 1 engine cutoff signal turned off, the engine ready bypass on turned off both the nonprogrammed engine cutoff signal and the AO and BO multiplexer engine cutoff signal indications.

The propellant point level sensor test was started by turning on the propellant level sensor power and measuring the resulting current differential for the forward 1 power supply. Next, each of the four LH2 tank and four LOX tank point level sensors was verified to respond to simulated wet condition

4.3.6 (Continued)

on commands within the allowable 300 milliseconds tolerance. A series of checks verified that a dry condition indication from any two point level sensors in either tank, obtained by simulated wet condition off command, resulted in the required engine cutoff signal. For the dry condition of LOX tank point level sensors 1 and 2, the LOX depletion engine cutoff timer value was measured to determine engine cutoff signal delay time. Each of the point level sensors was verified to respond to simulated wet condition off commands within the allowable 300 milliseconds tolerance. This completed the point level sensor testing.

Verification was 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, and that the nonprogrammed engine cutoff indication was not turned on as a result of the engine cutoff on command. With the engine cutoff command turned off, K140 was verified as off while K13 and the engine cutoff remained on until turned off by the engine ready bypass.

The propellant utilization (PU) inverter and electronics power supply current differentials were measured while power was momentarily turned on. The PCM RF assembly power was turned on, the RF group was verified to be on, the power supply differential current was measured, and the PCM RF transmitter output wattage 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 RF transmitter output wattage was measured through the AO multiplexer; and the

4.3.6 (Continued)

switch selector output monitor voltage (K128) was measured with the PCM RF assembly power and the switch selector 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 RF transmitter output wattage was again measured through the AO multiplexer. Power was then turned off to the PCM and RF assemblies.

The aft 2 power supply was verified to be within the 56.0 $\pm$1.0 vdc tolerance. The bus 4D141, 56 volt supply was turned on, the voltage was measured, and the aft 2 power supply current was measured. The aft 2 power supply local sense indication was verified to be off. The chilldown pump simulator was connected to the LOX and LH2 chilldown inverters; and measurements for each inverter were made of the current draw, the phase voltages, and the operating frequency. The inverter voltages and frequencies were monitored and measured through hardwire and telemetry.

A series of automatic checks verified the operation of the external/internal transfer system for forward buses 1 and 2 and aft buses 1 and 2. The battery simulator voltages and the electrical support equipment load bank voltages were measured initially; then, the power bus voltages were measured with the buses transferred to internal, and the bus local sense indications were verified to be off. Prior to transfer to internal power, the prelaunch checkout group was turned on and the current draw measured. 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.

4.3.6 (Continued)

A series of checks verified that the switch selector register was operating properly and that the instrument unit 28 vdc power supplies were on. Power was turned on to the range safety receivers after they were transferred to external power, and the resulting GSE power supply current differentials were measured. The range safety EBW firing units were verified to be on when they were transferred to external power and momentarily turned on. This completed the power distribution test.

There were no part shortages affecting the test and no problems resulting in the initiation of FARR's. Six revisions were recorded in the procedure as follows:

a. One revision corrected a program error.

b. One revision deleted the requirement for the systems status display, Model DSV-4B-298, from the GSE equipment list because it was not operable at test time and was not required for the power distribution system test.

c. One revision changed the program to comply with ECP 3006-R1, which removed the capability to energize the O2H2 burner shutdown bus from all nonprogrammed J-2 engine cutoff commands. The program was changed to verify that burner shutdown had not been energized.

d. One revision deleted power distribution checks for the FM/FM system and the preflight mode calibration circuitry because these were modified by the addition of the single sideband system which was incomplete. Checkout of these circuits was scheduled to be accomplished during the single sideband system test.

e. One revision added a 90-second delay in the program prior to turn-off of the telemetry RF silence command. This was done to ensure that the transmitter filaments would be cool before power was applied to the transmitter.

4.3.6 (Continued)

f. One revision indicated that the initial out-of-tolerance current measurement for the LOX chilldown pump simulator occurred because of failure to connect electrical cabling during setup operations.

4.3.6.1 Test Data Table, Power Distribution System

Function	Measurement	Limits
Engine Control Bus Current (amps)	0.400	2 ± 2
Engine Control Bus Voltage (vdc)	27.814	28.079 ± 1
APS Bus Current (amps)	0.600	1.5 ± 3
Engine Ignition Bus Current (amps)	-0.100	0 ± 2
Engine Ignition Bus Voltage, On (vdc)	27.691	28.118 ± 1
Engine Ignition Bus Voltage, Off (vdc)	0.000	0 ± 0.45
Component Test Power Current (amps)	0.300	0 ∓ 2
Component Test Power Voltage, On (vdc)	28.079	28 ∓ 2
Component Test Power Voltage, Off (vdc)	0.039	0 ∓ 1
Engine Control Bus Voltage, EDS 2 On (vdc)	-0.062	0 ∓ 0.45
Engine Control Bus Voltage, EDS 2 Off (vdc)	27.783	28.118 ± 1
Propellant Level Sensors Pwr Current (amps)	0.301	1 ± 2
LOX Depletion Engine Cutoff Timer (sec)	0.541	0.560 ± 0.025
PU Inverter & Electronics Pwr Current (amps)	4.200	3 ± 2
PCM RF Assembly Power Current (amps)	5.500	4.5 ± 3.0
PCM RF Transmitter Output Power, AO (watts)	14.662	10 min
PCM RF Transmitter Output Power, BO (watts)	14.841	10 min
PCM RF Transmitter Output Power, AO, T/M RF Silence On (watts)	-0.118	0 ± 2
Switch Selector Output Monitor, K128 (vdc)	1.928	2 ∓ 0.425
PCM RF Transmitter Output Power, AO, T/M RF Silence Off (watts)	10.112	10 min
Aft Bus 2 Current (amps)	0.000	5 max
Aft Bus 2 Voltage (vdc)	56.317	56 ± 1

LOX Chilldown Inverter Tests

Function	Measurement	Limits
Inverter Current (amps)	21.489	20.0 ± 5.0
Phase AB Voltage, Hardwire (vac)	53.363	55.438 ± 3
Phase AC Voltage, Hardwire (vac)	53.104	55.438 ∓ 3
Phase A1B1 Voltage, Hardwire (vac)	53.168	55.438 ∓ 3
Phase A1C1 Voltage, Hardwire (vac)	52.974	55.438 ∓ 3
Frequency, Hardwire (Hz)	401.000	400.0 ± 4.0
Phase AB Voltage, Telemetry (vac)	55.398	55.438 ± 3
Phase AC Voltage, Telemetry (vac)	55.398	55.438 ∓ 3
Frequency, Telemetry (Hz)	400.188	400.0 ± 4.0

4.3.6.1 (Continued)

LH2 Chilldown Inverter Tests

Function	Measurement	Limits
Inverter Current (amps)	21.975	20.0 ± 5.0
Phase AB Voltage, Hardwire (vac)	55.183	55.358 ± 3
Phase AC Voltage, Hardwire (vac)	53.363	55.358 ± 3
Phase A1B1 Voltage, Hardwire (vac)	55.313	55.358 ± 3
Phase A1C1 Voltage, Hardwire (vac)	53.168	55.358 ± 3
Frequency, Hardwire (Hz)	401.000	400.0 ± 4.0
Phase AB Voltage, Telemetry (vac)	55.266	55.438 ± 3
Phase AC Voltage, Telemetry (vac)	55.398	55.438 ± 3
Frequency, Telemetry (Hz)	400.789	400.0 ± 4.0

Function	Measurement	Limits
Forward Battery 1 Simulator Voltage (vdc)	28.278	28 ± 2
Forward Battery 2 Simulator Voltage (vdc)	28.039	28 ± 2
Aft Battery 1 Simulator Voltage (vdc)	28.039	28 ± 2
Aft Battery 2 Simulator Voltage (vdc)	55.758	56 ± 4
Bus 4D20 ESE Load Bank (vdc)	0.039	0 ± 1
Bus 4D40 ESE Load Bank (vdc)	0.000	0 ± 1
Bus 4D30 ESE Load Bank (vdc)	0.000	0 ± 1
Bus 4D10 ESE Load Bank (vdc)	0.000	0 ± 1
Prelaunch Checkout Group Current (amps)	1.800	1 ± 3
Forward Bus 1 Voltage - Internal (vdc)	27.958	28 ± 2
Forward Bus 2 Voltage - Internal (vdc)	27.958	28 ± 2
Aft Bus 1 Voltage - Internal (vdc)	28.000	28 ± 2
Aft Bus 1 Voltage - External (vdc)	28.039	28 ± 2
Aft Battery 1 Voltage (vdc)	0.079	0 ± 1
Aft Bus 2 Voltage - Internal (vdc)	55.917	56 ± 4
Aft Bus 2 Voltage - External (vdc)	55.838	56 ± 4
Aft Battery 2 Voltage (vdc)	0.000	0 ± 1
Forward Bus 1 Voltage - External (vdc)	28.158	28 ± 2
Forward Battery 1 Voltage (vdc)	0.000	0 ± 1
Forward Bus 2 Voltage - External (vdc)	28.118	28 ± 2
Forward Battery 2 Voltage (vdc)	0.039	0 ± 1
Aft Bus 2 Voltage, Off (vdc)	0.159	0 ± 1
Range Safety Receiver 1 External Power Current (amps)	0.000	0 ± 2
Range Safety Receiver 2 External Power Current (amps)	-0.500	0 ± 2

4.3.7 Level Sensor and Control Unit Calibration (1B64680 D)

This manual procedure determined that the control units associated with the LOX and LH2 liquid level, point level, fastfill, and overfill sensors were adjusted for operating points within the design calibration limits. The particular items involved in this test are noted in Test Data Table 4.3.7.1. The checkout was accomplished on 13 January and 23 January 1969.

A point level sensor manual checkout assembly, P/N 1B50928-1, and a variable precision capacitor, General Radio Type 1422CD, were connected in parallel with the sensor to provide capacitance changes to each control unit simulating sensor wet conditions for calibrations and to establish the control unit operating point. The calibration capacitances were 0.7 $\pm$0.01 picofarads for all LH2 sensors, except the LH2 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 deactivation of the output relay; 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 for the LH2 sensors and for the LOX sensors were recorded in Test Data Table 4.3.7.1 with the appropriate minimum and maximum capacitance limits.

4.3.7 (Continued)

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. With the sensor connected, the relay was verified to be deactivated under normal conditions and activated under test conditions.

There were no parts shortages that affected this test. No problems were encountered during the test, nor were any FARR's written. There were no revisions recorded in the procedure.

4.3.7.1 Test Data Table, Level Sensor and Control Unit Calibration

	Sensor P/N 1A68710			Control Unit P/N 1A68710			Deactivate Cap (pf)		Reactivate Cap (pf)	
Function	Ref. Loc.	Dash P/N	S/N	Ref. Loc.	Dash P/N	S/N	Meas	Min	Meas	Max
LH2 Tank	408			411						
Liq Lev L17	MT732	-507	D91	A61A217	-509	C22	0.617	0.55	0.624	0.85
Liq Lev L18	MT733	-507	D92	A61A219	-509	C28	0.670	0.55	0.760	0.85
Liq Lev L19	MT734	-507	D93	A61A221	-509	C29	0.672	0.55	0.770	0.85
Pt Lev 1	A1C1	-507	D75	A92A25	-509	C30	0.660	0.55	0.667	0.85
Pt Lev 2	A2C2	-507	D85	A92A26	-509	C33	0.708	0.55	0.717	0.85
Pt Lev 3	A2C3	-507	D87	A92A27	-509	C35	0.682	0.55	0.685	0.85
Pt Lev 4	A2C4	-507	D88	A61A201	-509	C20	0.680	0.55	0.720	0.85
Fastfill	A2C5	-1	D123	A92A43	-509	C66	0.713	0.55	0.720	0.85
Overfill	*	*	*	A92A24	-509	C19	1.081	0.95	1.084	1.25

* Part of LH2 Mass Probe, P/N 1A48431-513, S/N C2, Location 408A1

4.3.7.1 (Continued)

	Sensor P/N 1A68710			Control Unit P/N 1A68710			Deactivate Cap (pf)		Reactivate Cap (pf)	
Function	Ref. Loc.	Dash P/N	S/N	Ref. Loc.	Dash P/N	S/N	Meas	Min	Meas	Max
LOX Tank	406			404						
Liq Lev L14	MT657	-1	D140	A63A223	-511	C21	1.474	1.35	1.480	1.65
Liq Lev L15	MT658	-1	D134	A63A206	-511	C5	1.488	1.35	1.498	1.65
Liq Lev L16	MT659	-1	D133	A63A221	-511	C19	1.430	1.35	1.440	1.65
Pt Lev 1	A2C1	-1	C1	A72A1	-511	C12	1.480	1.35	1.489	1.65
Pt Lev 2	A2C2	-1	D107	A72A2	-511	C14	1.446	1.35	1.455	1.65
Pt Lev 3	A2C3	-1	C3	A72A3	-511	C25	1.480	1.35	1.487	1.65
Pt Lev 4	A2C4	-1	D126	A63A227	-511	D134	1.476	1.35	1.485	1.65
Fastfill	A2C5	-1	D81	A72A5	-511	C53	1.444	1.35	1.458	1.65
Overfill	**	**	**	A72A4	-511	C43	2.028	1.95	2.040	2.25

** Part of LOX Mass Probe, P/N 1A48430-511-012, S/N C3, Location 406A1

4.3.8 Propulsion Leak and Functional Check (1B71907 C)

This checkout procedure defined the operations required to perform the deferred postfire leak and functional checks for the stage propulsion system. Initiated on 13 January 1969, the checkout was completed and certifed as acceptable on 25 February 1969. Leak check results for the individual propulsion system components are listed in Test Data Table 4.3.8.1.

After preliminary setup operations, the O2H2 burner postfire checks were accomplished. The burner was inspected for external signs of damage or loose equipment. The injectors were removed from the burner, and the injector faces and igniter tips were inspected for cracks and excessive erosion. After cleaning the injectors per MSFC-164, the igniter tips were reinstalled in the injector igniter ports and the injectors attached to the burner using safety wire, such that the injector faces and igniter tips were visible for the O2H2 burner sparks check. In addition to obtaining oscillograph record spark traces for both igniters, visual observation of the spark gap verified constant arcing in or around the bore for each igniter during the 5-second application of exciter power. The injectors and feed lines were then reinstalled for the leak checks.

The umbilical quick-disconnect check valve leak test was accomplished by disconnecting the tube assembly on the stage side of the umbilical, applying regulated helium to the stage side of the quick-disconnect, and measuring the leakage with a flow tester, P/N G-3104. The quick-disconnect check valves involved in this check were for the thrust chamber purge, the engine start

4.3.8 (Continued)

bottle supply, the engine control sphere supply, the LOX tank prepressurization supply, the LH2 tank prepressurization supply, the ambient helium fill, and the APS helium bottle supply. No unacceptable leakage was detected.

The postfire Calip pressure switch system leak checks included leak checks of the pressure switch checkout circuits, plus the engine mainstage pressure switch diaphragm pressure decay test. The LOX and LH2 pressure switch checkout circuits were pressurized with their individual supplies to 30 ±5 psia and checked for external leakage. Similar leak checks were conducted for the low pressure switch checkout circuit at 600 ±50 psia and the mainstage pressure switch checkout circuit at 500 ±50 psia. No leaks were detected for the pressure switch checkout circuits. The mainstage pressure switch diaphragm decay check was conducted by monitoring system pressure decay over a 15-minute period with a system pressure lockup at 400 ±10 psig. All pressure switch system leak checks were acceptable.

The ambient helium system leak and flow checks were accomplished next. After an orifice flow verification of the new LOX vent purge system, a reverse leak check of the LOX and LH2 purge check valves, and an external leak check of the purge system were conducted. The ambient helium fill module was checked for internal leakage. The check valves for the ambient helium fill system and the ambient LOX and LH2 repressurization systems were tested for reverse leakage. After a control valve functional check for the ambient LOX and LH2 repressurization modules, internal leak checks of the modules and the pneumatic power control module were performed. The control helium system and the LOX and LH2

4.3.8 (Continued)

ambient repressurization systems were checked for external leakage. The actuation control modules were checked for internal leakage under functional test conditions. Finally, a pressure decay check of the pneumatic control system was performed over a 30-minute pressure lockup period.

Five external leaks were reported during the ambient helium system leak checks. Three were corrected by seal replacement and the other two were acceptable as the leakage was below the maximum allowable leakage.

The engine start system leak and functional checks were started with a leak check of the start tank vent control valve seat and a reverse leak check of the start tank initial fill check valve. After pressurizing the start tank to 500 $\pm$10 psig with helium, the entire start system was checked for external leakage. The start bottle retention test obtained the necessary measurements for start tank temperature and pressure to calculate the helium pound-mass/hour loss. This decay rate for the start bottle was taken over a 60-minute period and was acceptable. The start system check was concluded with leak checks of the tank vent and relief valve, dump valve bellows, and an external leak check of the start tank vent system. One leakage condition was noted at the start tank dump valve, however the leak stopped after stabilization of the start tank.

The LH2 pressurization and repressurization systems tests started with a functional check of the O2H2 burner LH2 repressurization control valves, leak checks of the burner LH2 repressurization control valve seat and pilot bleed valve, and a reverse leak check of the burner LH2 check valve. The LH2

4.3.8 (Continued)

repressurization system was pressurized to 450 ± 50 psig and checked for external leakage. The LH2 pressurization system was checked similarly for external leakage at 450 ± 25 psig. In addition, reverse leak checks were performed for the LH2 pressurization module check valve and the LH2 prepressurization check valve. Measurements of leakage rates for the main components of the LH2 repressurization and pressurization systems are listed in the test data table. One leakage condition was noted and repaired by replacement of a seal.

The thrust chamber system was checked for external leakage with the thrust chamber throat plug installed and the system pressurized to 30 ± 2 psig. In addition, the LOX dome purge check valve and the thrust chamber jacket purge check valve were tested for reverse leakage. The thrust chamber main oxidizer and fuel valves were tested for drive and idler shaft seal leakage. Replacement of a seal repaired the one leak noted during this section.

The LOX pressurization and repressurization systems were tested for reverse leakage of the cold helium bottle check valve, external leak checks of the LOX pressurization system, and the ambient and O2H2 burner LOX repressurization systems. Internal leakage rates were measured for the LOX pressurization module, cold helium fill module, and the burner LOX repressurization module. In addition, reverse leak checks were performed for the LOX repressurization system check valve and the burner LOX repressurization check valve. Leakage rates for the major system components are in the test data table. Two leakage conditions were noted, one required replacement of an adapter, P/N MC237 -C8W, the other leak was repaired by retightening a union to the proper torque value.

4.3.8 (Continued)

Leak checks were then performed on the LOX tank, the O2H2 burner, and the engine LOX feed system. Internal leak checks of the engine feed system checked for seat leakage of the LOX prevalve and chilldown shutoff valve, the engine LOX bleed valve, the engine main oxidizer valve, and for reverse leakage of the LOX chilldown return check valve. Then the LOX tank and the engine feed system were leak checked. The LOX turbopump was checked for breakaway torque, running torque, and primary seal leakage. The LOX chilldown pump purge leak and pressure checks included a pump canister pressure check, a pump purge shut-off valve seat leak check, a pump shaft seal leak check, and an external leak check of the pump purge circuit. One area of unacceptable leakage was detected in this section, which was corrected by replacing a seal. One other leak was acceptable as the leakage rate was below the maximum allowable leakage.

The LOX prevalve shaft seal was leak checked with the prevalve open and closed, and the LOX fill and drain valve was checked for seat leakage. Next, leak checks of the O2H2 burner LOX shutdown valve and an external leak check from the LOX tank to the O2H2 burner LOX shutdown valve were performed.

Leak checks were then performed on the LH2 tank, the O2H2 burner, and the engine feed system. Internal leak checks of the engine feed system checked for seat leakage of the LH2 prevalve and chilldown shutoff valve, the engine LH2 bleed valve, the engine main fuel valve, and checked for reverse leakage of the LH2 chilldown return check valve. The LH2 engine pump drain and purge check valves, the LH2 turbine seal cavity purge check valve, and the LOX turbine seal cavity check valve were checked for reverse leakage. The LH2 engine pump intermediate

4.3.8 (Continued)

seal was checked for leakage. The LH2 engine pump drain check valve was also checked for forward flow. Then the LH2 tank and the engine feed system were leak checked. Four conditions of leakage were noted during this section. Two were repaired by replacement of seals. The cold helium spheres, P/N 1A48858-1, at positions 7 and 8, bank number 2, exhibited bubble leaks, as documented on FARR 500-703-296. Entry into the LH2 tank was required to repair the two leaks by tightening the flange clamp bolts to the proper torque value.

The LH2 turbopump was checked for breakaway and running torque and for primary seal leakage. The LH2 prevalve shaft seal was leak checked with the valve opened and closed. The LH2 fill and drain valve was checked for seat leakage. Leak checks of the O2H2 burner LH2 propellant valve seat and the LOX shutdown valve seat were made, as well as an external leak check of the O2H2 propellant system.

Leak and flow checks of the engine gas generator (GG) and exhaust system were conducted next, and included reverse leak checks of the GG LH2 purge check valve, the GG LOX purge check valve, and the GG LOX poppet. Leak checks of the GG propellant valves, the start tank discharge valve gate seal, and the hydraulic pump seal were also performed. A bleed flow check of the LH2 and LOX turbine seal cavity was conducted. External leak checks of the GG and exhaust system were also performed. One leakage condition was noted and corrected by replacement of a seal.

Engine pump purge leak and flow checks performed a regulation check of the engine pump purge module discharge pressure, measured the seat leakage of the

4.3.8 (Continued)

engine pump purge valve, checked the purge flows of the LOX and LH2 turbine seal cavity bleeds and the fuel pump seal cavity, and verified the GG fuel purge flow at the LH2 turbopump access. An external leak check of the engine pump purge system was also conducted. No unacceptable leakage was recorded.

Leak and flow checks of the engine pneumatics system included the helium control solenoid energized leak checks, the LOX intermediate seal purge flow checks, the ignition phase solenoid energized leak checks, the start tank discharge valve solenoid energized leak checks, the main stage control solenoid energized leak checks, the pressure actuated purge system leak checks, and the engine control bottle fill system leak checks. Also, the engine control bottle retention test was performed to determine the control bottle decay by calculating the helium pound-mass/hour-loss. Two external leaks for the system were detected at welds and were corrected by weld repair.

The LOX and LH2 vent system leak and flow checks included external leak checks of the LOX vent system and the LH2 ground and flight vent systems, plus internal leak checks of the valves in the systems, including the LOX vent and relief valve, the LOX NPV valve, the LH2 vent and relief valve, the LH2 latching relief valve, the bidirectional vent valve, and the LH2 continuous vent valve. A summary of the internal leak checks is listed in the Test Data Table. There were no areas of unacceptable leakage recorded during the vent system checks.

The final operation was a "black light" inspection of the thrust chamber injector to detect any hydrocarbon contamination that would tend to restrict injector flow.

4.3.8 (Continued)

FARR 500-703-300 reported that the reducer, P/N MC169C19W, was leaking. Investigation revealed that the sealing surfaces were scratched. The reducer was removed and replaced. FARR 500-703-750 reported that nine orifices exhibited leakage above the maximum allowable leakage. Three orifices were removed and replaced, six were scheduled for replacement at the FTC. FARR 500-703-776 documented a leak at the pipe assembly, P/N 1B75772-1, adjacent to stiffener band 6 1/4. The pipe assembly flare was polished and retightened.

Seventy-five revisions were recorded in the procedure for the following:

a. Twenty-three revisions concerned changes that were required to update or correct the procedure for errors and missing requirements.

b. Twelve revisions were required to update the procedure to the latest stage configuration.

c. Eight revisions were incorporated to leak and functionally check hardware which was replaced subsequent to system leak checks.

d. Four revisions changed or deleted previous revisions or portions thereof.

e. Four revisions provided instructions to return to the original configuration after disassembly for leak check purposes.

f. Three revisions deleted steps that had been previously accomplished.

g. Two revisions were written and subsequently voided.

h. One revision added the steps required to support concurrent testing.

i. One revision modified the allowable leakage rate for the LH2 orifice bypass valve to comply with the latest revisions of the source control drawing.

4.3.8 (Continued)

j. One revision added a completed checkout of the cold helium system.

k. One revision authorized and outlined the postfire engine drying procedure for the start tank and the associated fill and drain lines, the GG control valve and the GG propellant lines.

l. One revision incorporated the postfire purge system flow checks and corrected the purge system leak check procedure.

m. One revision added engineering comment sheets for the use of the cognizant propulsion engineer, to allow logging the use of the USON helium detector and/or bubble soap during leak checks.

n. One revision added the steps required to preclude entry of the leak check gas past the LOX intermediate seal and into the engine pneumatic package.

o. One revision reduced the stage 4 helium pressure to 750 $\pm$25 psig during leak check of the LH2 chilldown shutoff microswitch purge orifice and reduced the allowable flow from 9200-14,200 scim to 3350-8350 scim, as the flowmeter was not available to measure flow rates exceeding 10,000 scim.

p. One revision reran the leak check of the ambient helium fill line, as the first check was voided during the quick disconnect leak check.

q. One revision authorized the setup procedure for the performance of Rocketdyne EFIR J2-38B, and the posttest return to original configuration.

r. One revision authorized and outlined the setup instructions for supplying filtered air to the LH2 tank during removal of the LH2 prevalve.

s. One revision deleted the requirement for a breakout box, as the box was not available.

t. One revision deleted the reference to the start tank hardwire transducer data, as this data is not required when the mass is calculated.

u. One revision provided instructions to leak check the start tank vent bellows with the vent closed.

4.3.8 (Continued)

v. One revision changed the stage 4 helium pressure from 265 $\pm$10 psia to 1500 $\pm$50 psia, and the engine control sphere pressure from less than 115 psia to 1500 $\pm$50 psia, as the pressure actuated purge valve would not activate at 250 psia.

w. One revision provided the steps required to isolate the LOX and LH2 ambient helium systems for the continuation of leak checks.

x. One revision outlined the procedure for control of the LOX tank vent valve while the opening actuation line was being reworked.

y. One revision provided the instructions and the setup required to close the continuous vent module relief override valve. The module was installed on the stage with the override valve open and should have been closed for checkout.

z. One revision provided the steps required to vent the repressurization system.

4.3.8.1 Test Data Table, Propulsion Leak and Functional Check

Umbilical Quick Disconnect Check Valve Leak Check

Function	Measurement	Limits
Thrust Chamber Purge (scim)	0.0	0
Engine Start Bottle Supply (scim)	0.0	0
Engine Control Supply (scim)	0.0	0
LOX Prepress Supply (scim)	0.0	0
LH2 Prepress Supply, High Press (scim)	0.0	0
LH2 Prepress Supply, Low Press (scim)	0.0	0
Repress Bottle Supply (scim)	0.0	0
APS Helium Bottle Supply (scim)	0.0	0

Calip Pressure Switch Leak Checks

Function	Measurement	Limits
Eng Mnstg Press Sw Diaph Decay:		
Initial (psig)	402.0	*
Final (psig)	393.0	*
Decay (psi)	9.0	10.0 max/15 minutes

* Limits Not Specified

4.3.8.1 (Continued)

Purge System Flow Checks

Function	Measurement	Limits
LH2 Chilldown Shutoff Microswitch Purge Orifice (scim)	4600	3350-8350
LOX Tank Sense Line Purge Orifice (scim)	510+	540-1030
LOX NPV Duct Purge Orifice (scim)	260+	540-1030
LH2 NPV Duct Purge Orifice (scim)	400+	540-1030
LH2 PV Duct Purge Orifice (scim)	330+	540-1030
Cont Vent Bypass Vlv Bellows Purge Orifice (scim)	83+	05-165
O2H2 Burner LOX S/D Vlv Bellows Purge (scim)	71+	05-165
O2H2 Burner LOX S/D Vlv Microswitch Housing Purge (scim)	8.0	4.5-8.5
LH2 F&D Vlv Microswitch Purge Orifice (scim)	2.7	4.5-8.5
LOX F&D Vlv Microswitch Purge Orifice (scim)	7.4	4.5-8.5
LH2 Prop Vlv Microswitch Purge Orifice (scim)	3.0+	4.5-8.5
Cont Vent Bypass Vlv Microswitch Purge Orifice (scim)	3.1+	4.5-8.5

Purge System Check Valve Reverse Leak Checks (P/N 1B67598-501)

Function	S/N	Measurement	Limits
LOX Vent Purge (scim)	79	0.0	10 max
LOX Fill & Drain Purge (scim)	81	0.0	10 max
LH2 Fill & Drain Purge (scim)	84	0.0	10 max
LH2 Vent Purge (scim)	80	0.0	10 max

Ambient Helium Fill Module Internal Leak Checks (P/N 1A57350-507, S/N 0239)

Function	Measurement	Limits
Amb He Fill Module C/V Rev Lkg (scim)	0.0	1 max
Amb He Fill Module Dump Vlv Seat Lkg (scim)	0.0	1 max

Ambient Helium Spheres Fill System Check Valves Reverse Leak Checks (P/N 1B67598-501)

Function	S/N	Measurement	Limits
LOX Repress Mod Ck Vlv (scim)	186	0.0	10 max
LH2 Repress Mod Backup Check Valve (scim)	46	3.7	10 max

\+ Refer to FARR 500-703-750

4.3.8.1 (Continued)

Function	S/N	Measurement	Limits
LH2 Repress Mod Ck Vlv (scim)	167	0.8	10 max
He Fill Mod Backup Check Valve (scim)	78	0.0	10 max
Engine Control Bottle Fill Backup	91	0.0	10 max

Ambient LOX and LH2 Repress Module Internal Leak Checks

LOX Repress Module (P/N 1B69550-501, S/N 026)

Function	Measurement	Limits
Cont Vlv (L3) Seat Leakage (scim)	0.0	*
Cont Vlv (L2) Seat Leakage (scim)	0.0	*
Module Dump Vlv Seat Lkg (scim)	0.0	*
Mod Dump Vlv Pilot Bleed (scim)	0.0	*
Mod Dump Vlv Seat & Pilot Bleed Lkg (scim)	0.0	9 max
Cont Vlv (L2) Pilot Bleed Lkg (scim)	0.0	*
Cont Vlv (L2) Seat & Pilot Bleed Lkg (scim)	0.0	9 max
Cont Vlv (L3) Pilot Bleed Lkg (scim)	0.0	*
Cont Vlv (L3) Seat & Pilot Bleed Lkg (scim)	0.0	9 max

LH2 Repress Module (P/N 1B69550-501, S/N 027)

Function	Measurement	Limits
Cont Vlv (L3) Seat Leakage (scim)	0.0	*
Cont Vlv (L2) Seat Leakage (scim)	0.0	*
Module Dump Vlv Seat Leakage (scim)	0.0	*
Mod Dump Vlv Pilot Bleed Lkg (scim)	0.0	*
Mod Dump Vlv Seat & Pilot Bleed Lkg (scim)	0.0	9 max
Mod Cont Vlv (L2) Pilot Bleed Lkg (scim)	0.0	*
Cont Vlv (L2) Seat & Pilot Bleed Lkg (scim)	0.0	9 max
Cont Vlv (L3) Pilot Bleed Leakage (scim)	0.0	*
Cont Vlv (L3) Seat & Pilot Bleed Lkg (scim)	0.0	9 max

Pneumatic Power Control Module Internal Leak Check (P/N 1A58345-523, S/N 1006)

Function	Measurement	Limits
Control He Shutoff Seat Leakage (scim)	0	10 max
Control Module Reg Lockup Press (psig)	544	550 max

* Limits Not Specified

4.3.8.1 (Continued)

Actuation Control Module Leak Checks (P/N 1B66692-501)

Function	S/N	Normal	Open	Closed	Boost	Limits
O2H2 Burner LOX S/D Vlv Act Cont Module Leakage (scim)	103	0.0	0.0	0.0	-	6 max
O2H2 Burner LOX S/D Vlv Act Leakage (scim)	-	-	0.0	-	-	*
O2H2 Burner LOX S/D Vlv Shaft Seal Leakage (scim)	-	-	0.2	-	-	*
O2H2 LOX S/D Vlv Act and Shaft Seal Leakage Total (scim)	-	-	0.2	1.9	-	20 max
LOX Vent Act Cont Module Leakage (scim)	109	0.0	0.0	-	0.0	6 max
LH2 F&D Act Cont Module Leakage (scim)	100	0.0	0.0	-	-	6 max
LH2 F&D Act Seal Lkg (scim)	-	-	0.0	0.0	-	350 max
LH2 F&D Act. Module Lkg (scim)	-	-	0.0	-	-	6 max
LOX F&D Act Cont Module Leakage (scim)	108	0.0	0.0	-	0.0	6 max
LOX F&D Act Seal Lkg (scim)	-	-	0.0	0.0	-	350 max
O2H2 Burner LH2 Prop Vlv Act Cont Module Lkg (scim)	110	-	0.0	0.0	-	6 max
Orifice Bypass Vlv Act Cont Module Lkg (scim)	97	0.0	0.3	2.0	-	6 max
Orifice Bypass Vlv Actuator Lkg (scim)	-	-	2.5	-	-	*
Orifice Bypass Vlv Shaft Seal Lkg (scim)	-	-	1.6	-	-	*
Orifice Bypass Vlv Act & Shaft Seal Lkg Total (scim)	-	-	5.6	17.5	-	20 max
LH2 Vent Act Cont Module Lkg (scim)	102	0.0	0.0	-	0.0	6 max
LH2 Vent Vlv Open Act Seal Lkg (scim)	-	-	0.0	-	-	75 max

Function	S/N	Normal	Open	Open Latch	Limits
LOX NPV Act Cont Mod (scim)	-	0.0	0.0	0.0	6 max
LOX NPV Act Open Act Piston Seal Leakage (scim)	-	**	-	-	150 max

Function	S/N	Normal	Closed	Limits
Prevlv-C/D Vlv Act Cont Mod (scim)	107	0.0	-	6 max
Prevlv Act Control (scim)	-	-	0.0	6 max
C/D Act Control (scim)	-	-	0.0	6 max
LOX Prevlv Microsw Housing (scim)	-	-	0.6	1.2 max

* Limits Not Specified

** Not Measurable

4.3.8.1 (Continued)

Function	S/N	Normal	Flight	Ground	Limits
Bidirect Vent Vlv Act Cont Mod (P/N 1A49988-513)	0035	0.0	0.0	0.0	6 max
Bidirect Vent Vlv Act Piston Lkg (scim)	-	-	0.0	0.0	3 max

Function	S/N	Normal	Open	Latching	Limits
LH2 Latching Relief Vlv Cont Mod (scim)	173	0.0	0.0	0.0	6 max
LH2 Latching Relief Vlv Open Act Piston Seal Lkg (scim)	-	-	0.0	-	150 max

Pneumatic Control System Decay Checks

Function	Measurement Initial	Measurement Final	Limits
Reg Disch Press - Vlv Pos, Normal (psig)	545.5	541.0	*
Reg Disch Press - Vlv Pos, Activated (psig)	560.0	354.5	*

Engine Start Tank Leak Checks

Function	Measurement	Limits
Vent Control Solenoid Seat Leakage (scim)	0.0	10 max
Initial Fill, Check Vlv Reverse Lkg (scim)	0.0	2 max
Vent & Relief Valve Seat Leakage (scim)	0.0	2 max
Bottle Decay (Delta M) (lb-mass/hr)	0.0018	0.0066 max

LH2 Repressurization System Leak Checks

Function	Measurement	Limits
O2H2 Burner Control Vlv Seat Lkg (scim)	0.0	*
O2H2 Burner Control Vlv Pilot Bleed Lkg(scim)	0.0	*
O2H2 Burner Mod Cont Vlv Int Lkg (scim)	0.0	12 max
O2H2 Burner Cont Vlv & Check Vlv Rev Lkg (scim)	0.0	*
O2H2 Burner Check Vlv Reverse Lkg (scim)	0.0	5 max
O2H2 Burner Coil Leakage (scim)	0.0	0

LH2 Pressurization System Leak Checks

Function	Measurement	Limits
LH2 Press Module Check Vlv Rev Lkg (scim)	0.0	150 max
LH2 Prepress Check Vlv Rev Lkg (scim)	0.0	2.5 max

* Limits Not Specified

4.3.8.1 (Continued)

Thrust Chamber Checks

Function	Measurement	Limits
LOX Dome		
Purge Check Valve Reverse Lkg (scim)	0.0	4 max
Main Oxidizer Valve		
Idler Shaft Seal Leakage (scim)	0.0	10 max
Drive Shaft Seal Leakage (scim)	0.0	10 max
Main Fuel Valve		
Idler Shaft Seal Leakage (scim)	0.0	10 max
Drive Shaft Seal Leakage (scim)	0.0	10 max
Thrust Chamber		
Pressure (psig)	24.0	20 min
Jacket Purge Check Vlv Rev Lkg (scim)	1.05	25 max

LOX Pressurization & Repressurization System Leak Checks

Function	Measurement	Limits
Cold Helium Sphere		
Fill Check Vlv Rev Lkg (scim)	0.0	0
Shutoff Vlv Seat & Pilot Vlv Lkg-High Press (scim)	0.0	*
Shutoff Vlv Seat & Pilot Vlv Lkg-Low Press (scim)	0.0	12.5 max

Cold Helium System Checks

Function	Measurements @ 50 ±5 psia	Measurements @ 300 ±15 psia	Measurements @ 400 ±20 psia	Limits
Cold Helium Dump Module Seat Lkg (scim)	0.0	0.0	0.0	*
Cold Helium Shutoff Seat Lkg (scim)	29.0	0.0	0.0	*
O2H2 Burner LOX Repress Vlv Seat Lkg (scim)	0.0	0.0	0.0	*
O2H2 Burner LOX Repress Vlv Pilot Lkg (scim)	0.0	0.5	0.5	*
O2H2 Burner LOX Repress Mod Int Lkg (scim)	0.0	0.5	0.5	*
O2H2 Burner LH2 Repress Vlv Seat Lkg (scim)	2.1	0.0	0.0	*
O2H2 Burner LH2 Repress Vlv Pilot Lkg (scim)	0.0	0.0	0.0	*
O2H2 Burner LH2 Repress Mod Int Lkg (scim)	2.1	0.0	0.0	*

* Limits Not Specified

4.3.8.1 (Continued)

Function	Measurement	Limits
LOX Press Module Internal		
Hot Gas Bypass Vlv Seat & Pilot Bleed Lkg (scim)	18.0	1000 max
O2H2 Burner LOX Repress System		
Burner Control Valve Seat Leakage (scim)	0.0	*
Burner Control Valve Pilot Bleed Lkg (scim)	0.0	*
Burner Module Control Vlv Internal Lkg (scim)	0.0	12 max
Combined Burner Check Vlv & Cont Vlv Seat Leakage (scim)	0.0	*
Burner Check Vlv Rev Leakage (scim)	0.0	0
Burner Coil Leakage (scim)	0.0	0

LOX Tank O2H2 Burner & Engine Feed System Leak Checks

Function	Measurement	Limits
LOX Tank Helium Content		
Top (%)	99.0	75 min
Bottom (%)	99.0	75 min
Engine Feed Sys Internal Leak Checks		
LOX Prevlv & Chilldown Shutoff Vlv Seat & Chilldown Return Check Vlv Lkg (scim)	10.0	*
LOX Chilldown Ret Check Vlv Rev Lkg (scim)	2.9	350 max
LOX Prevlv & Chilldown Shutoff Vlv Combined Seat Leakage (scim)	7.1	150 max
LOX Bleed Vlv & Chilldown Return Check Vlv Rev Leakage (scim)	2.9	*
LOX Bleed Vlv Seat Leakage (scim)	0.0	300 max
Main Oxidizer Vlv Seat Leakage (scim)	0.0	10 max
LOX Turbopump Torque Checks		
Pump Primary Seal Leakage:		
Max (scim)	35.0	350 max
Min (scim)	28.0	*
Turbine Torque:		
Breakaway (in/lbs)	80.0	1000 max
Running (in/lbs)	60.0	200 max
LOX Chilldown Pump Purge Flow Checks		
Pump Shaft Seal Leakage Tank Pressurized & Purge On (scim)	0.0	50 max
Pump Shaft Seal Lkg - LOX Tank Side (scim)	0.0	*
Pump Shaft Seal Lkg - Motor Canister Side (scim)	0.0	*
LOX Valves Checks		
Prevalve Shaft Seal Leakage:		
Open Position (scim)	0.0	5 max
Closed Position (scim)	0.0	*

* Limits Not Specified

4.3.8.1 (Continued)

Function	Measurement	Limits
Prevalve Actuator Internal Leakage (scim)	0.0	75 max
F&D Vlv Seat Leakage (scim)	0.0	18 max
F&D Vlv Primary Shaft Seal Lkg (scim)	0.0	31 max
O2H2 Burner LOX Shutdown Valve Checks		
Valve Seat Leakage (scim)	0.0	50 max

LH2 Tank, O2H2 Burner & Engine Feed System Leak Checks

Function	Measurement	Limits
LH2 Tank Helium Content		
Top (%)	99.89	75 min
Bottom (%)	99.64	75 min
Engine Feed System Internal Leak Checks		
LH2 Prevlv & Chilldown Shutoff Vlv & C/D Return Check Vlv Rev Lkg (scim)	18.5	*
LH2 C/D Ret Check Vlv Rev Lkg (scim)	0.5	350 max
LH2 Prevlv & C/D Shutoff Vlv Combined Seat Leakage (scim)	18.0	150 max
LH2 Bleed Vlv & C/D Return Check Vlv Rev Leakage (scim)	0.5	*
LH2 Bleed Vlv Seat Leakage (scim)	0.0	300 max
MOV & MFV Combined Seat Leakage (scim)	0.0	*
Main Fuel Vlv Seat Leakage (scim)	0.0	10 max
Engine Purge System Leak Checks		
LH2 Pump Drain Check Vlv Rev Lkg (scim)	1.3	25 max
LH2 Pump Drain Check Vlv Fwd Flow 30 psi (scim)	0.0	30 max
LH2 Pump Drain Check Vlv Fwd Flow 60 psi (scim)	10,000	2420 min
LH2 Pump Purge Check Vlv Rev Lkg (scim)	0.2	25 max
LH2 Pump Intermediate Seal Lkg (scim)	26.0	500 max
LH2 Turbine Seal Cavity Prg Check Vlv Rev Leakage (scim)	3.8	25 max
LOX Turbine Seal Cavity Prg Check Vlv Rev Leakage (scim)	0.5	25 max
LH2 Turbopump Torque Checks		
LH2 Pump Primary Seal Leakage:		
Max (scim)	3.6	350 max
Min (scim)	3.3	350 max
Turbine Torque:		
Breakaway (in/lbs)	19.0	1000 max
Running (in/lbs)	15.0	300 max

* Limits Not Specified

4.3.8.1 (Continued)

Function	Measurement	Limits
LH2 Valves Leak Checks		
Prevalve Shaft Seal Leakage:		
Open Position (scim)	0.0	5 max
Closed Position (scim)	0.0	10 max
Fill & Drain Valve Seat Leakage (scim)	0.0	100 max
LH2 Fill & Drain Vlv Primary Shaft Seal Leakage (scim)	0.0	31 max
O2H2 Burner LH2 System Leak Check		
Combined Burner LH2 Prop Vlv & LOX S/D Vlv Seat Leakage (scim)	0.0	*
Burner LH2 Prop Valve Seat Leakage (scim)	0.0	0.7 max

Engine GG and Exhaust System Leak and Flow Test

Function	Measurement	Limits
GG Fuel Purge Ck Vlv Rev Lkg (scim)	2.0	25 max
LH2 Turbine Seal Leakage (scim)	3600.0	3000 scim max Above 2nd E&M Lkg Value (1)
LOX Turbine Seal Leakage (scim)	3.0	350 max
STDV Gate Seal Leakage (scim)	7.0	20 max
OTBV Shaft Seal Leakage (scim)	0.0	15 max
Oxid Manifold Carrier Flange Bleed (scim)	0.0	20 max
Hydraulic Pump Shaft Seal Lkg (scim)	0.5	228 max
GG LOX Prop Vlv Seat & LOX Pump Shaft Seal Leakage (scim)	0.0	20 max
Combined GG LOX & LH2 Prop Vlv Seat & Pump Shaft Seal Lkg (scim)	0.0	*
GG LH2 Prop Vlv Seat Lkg & Fuel Pump Omni Seal Lkg (scim)	0.0	15 max

Engine Pump Purge Leak Checks

Function	Measurement	Limits
Pump Purge Module Internal Leak Checks		
Purge Valve Seat Leakage (scim)	0.0	12 max
Purge Discharge Pressure (psig)	88.0	67 to 110
Pump Purge Flow Checks		
GG Fuel Purge Flow (scim)	3250.0	2400 min
LOX Turbine Seal Purge Flow (scim)	3400.0	2400 min
LH2 Turbine Seal Purge Flow (scim)	3400.0	2400 min
Fuel Pump Seal Cavity Purge Flow (scim)	900.0	200 min

* Limits Not Specified
(1) 2nd E&M Leakage Valve = 1220 scim

4.3.8.1 (Continued)

Engine Pneumatics Leak Checks

Function	Measurement	Limits
Helium Control Solenoid Energized Leak Checks		
Low Press Relief Vlv Seal Lkg (scim)	0.0	5 max
Low Press Relief Vlv Pilot Bleed Lkg (scim)	0.0	10 max
Fast Shutdown Vent Port Diaph Lkg (scim)	0.0	3 max
Press Act Purge Vlv Diaph Lkg (scim)	0.0	3 max
Int Pneu Sys Lkg (He Cont Sol On) (scim)	0.0	20 max
LOX Pump Intermediate Seal Purge Leak Checks		
Seal Leakage Pump Direction (scim)	31.0	*
Seal Leakage Turbine Direction (scim)	15.0	*
Seal Leakage Total (scim)	46.0	850 max
Seal Purge Check Vlv Overboard Flow (scim)	2560.0	*
Seal Purge Flow (scim)	2606.0	1300 to 3500
Ignition Phase Solenoid Energized Leak Checks		
Start Tnk Disch Vlv 4-Way Sol Seat Lkg (scim)	2.6	15 max
Internal Pneu Sys Lkg (Ign Phase Sol On) (scim)	0.0	20 max
Start Tank Discharge Valve Solenoid Energized Leak Checks		
STDV 4-Way Sol Seat Lkg (Energized) (scim)	5.2	15 max
Mainstage Control Solenoid Energized Leak Check		
Press Act Fast Shutdown Vlv Seat Lkg (scim)	0.0	10 max
Int Pneu Sys Lkg (Mnstg Sol On) (scim)	5.8	20 max
Pressure Actuated Purge System Leak Check		
Press Act Purge Vlv Vent Seat Lkg (scim)	0.0	10 max
Press Act Purge Vlv Inlet Seat Lkg (scim)	0.0	10 max
MOV Seq Valve Lip & Shaft Seal Lkg (scim)	0.0	*
MOV Seq Valve Lip & OTBV Piston Lkg (scim)	0.0	5 max
Engine Control Bottle Fill System Leak Check		
Eng Cont Bot Fill Check Vlv Rev Lkg (scim)	0.0	3 max
Eng Cont Bot Decay Check (Delta M) (lb-mass/hr)	0.00965	0.036 max

LOX & LH2 Vent System Leak Checks

Function	Measurement	Limits
LOX Vent System Leak Checks		
Combined LOX Vent & Relief Vlv Seat & Pilot Bleed Lkg (scim)	0.0	100 max
Combined LOX V&R Pilot Bleed & Boost Piston Seal Lkg (scim)	55.0	*

* Limits Not Specified

4.3.8.1 (Continued)

Function	Measurement	Limits
Combined LOX V&R Boost Piston Seal Lkg (scim)	54.7	2420 max
LOX NPV Vlv Seat & Pilot Bleed Lkg (scim)	14.5	60 max
LOX NPV Vlv Seat, Pilot Bleed and Boost Piston Seal Lkg (scim)	72.0	*
LOX NPV Vlv Boost Piston Seal Lkg (scim)	57.5	1728 max
Propulsive Vent System Leak Checks		
Cont Vent & Orifice Bypass Vlv Seat Lkg (scim)	0.0	16 max
Nonpropulsive Vent System Leak Checks		
Directional Vent Vlv Act Seal & Blade Shaft Seal Lkg - Flight Pos (scim)	0.0	3.5 max
Bidirect Vent Vlv Seat Lkg (Flt Pos) (scim)	0.0	50 max
Directional Vent Vlv Seal & Blade Shaft Seal Leakage - Ground Pos (scim)	0.0	3.5 max
Ground Vent System Leak Checks		
Combined LH2 V&R & LH2 Latching Vlv Combined Seat & Pilot Bleed Lkg (scim)	2.0	60 max
Combined LH2 V&R Vlv & LH2 Latching Relief Vlv Seat, Pilot Bleed, & Boost Piston Seal Lkg (scim)	150.0	*
LH2 V&R Vlv & LH2 Latching Vlv Boost Piston Seal Lkg (scim)	148.0	1728 max
LH2 Vent Vlv Open Act Seal Lkg (scim)	0.0	75 max
Bidirect Vent Vlv Seat Lkg (Gnd Pos) (scim)	1.3	50 max

* Limits Not Specified

4.3.9 Digital Data Acquisition System Calibration (1B66563 G)

This procedure provided the manual and automatic operations for the checkout and calibration of the digital data acquisition system (DDAS) and prepared the system for use. The integrity of the DDAS was verified from data inputs through the various multiplexers and the PCM/DDAS assembly to the DDAS ground station. The items involved in this test were the PCM/DDAS assembly, P/N 1B65792-1, S/N 6700089; CP1-BO time division multiplexer, P/N 1B65897-1, S/N 013; DP1-BO time division multiplexer, P/N 1B65897-501, S/N 04; remote digital submultiplexer (RDSM), P/N 1B66051-501, S/N 04; low level remote analog submultiplexer (RASM), P/N 1B66050-501.1, S/N 05; and PCM/RF assembly, P/N 1B65788-1-004, S/N 15505.

The test was satisfactorily performed on 14 January 1969.

The stage power was turned on per H&CO 1B55813, and initial conditions were established for the stage and DDAS. The 72 kHz bit rate check was made on the PCM data train to ensure that the frequency was within tolerance. The 72 kHz bit rate was measured as 71,005 bits per second, within the 71,975 to 72,025 bits per second limits. The 600 kHz VCO test was accomplished by measuring the band edge frequencies and voltages of the PCM/DDAS VCO output. The upper band edge frequency was measured at 634.0 kHz at 3.1 vrms, within the acceptable limits of 623.2 kHz to 643.2 kHz, at greater than 2.2 vrms. The lower band edge frequency was measured at 568.4 kHz at 3.0 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 65.6 kHz, within the acceptable limits of 60 to 80 kHz.

4.3.9 (Continued)

The next tests performed were the automatic flight calibration checks and the individual multiplexer 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. Improper test setups resulted in numerous channel malfunctions for the 0.000 vdc input level during the initial CP1-BO and DP1-BO multiplexer tests. After correcting the errors, the tests were repeated satisfactorily with all measured channels within the required tolerances.

The RDSM was verified by inserting signal levels equivalent to ones (20 vdc) and zeros (0 vdc) into the RDSM input circuits and by checking the output at the computer for a digital word of corresponding ones and zeros. The RASM was verified by inserting signal voltages, 0 to 30 millivolts, which were amplified to an output range of 0 to 5 volts dc corresponding to the 0 to 30 millivolt range input. It was necessary to repeat portions of the RASM test for the input signal levels of 0, 10, and 30 millivolts because of setup errors that resulted in channel malfunctions. All measured outputs for the RDSM test and all final measurements for the RASM test were within the required tolerances.

A final test measured the PCM/FM transmitter current as 6.500 amperes, within the 4.5 $\pm$3.00 amperes limit.

There were no problem areas during the test that resulted in FARR documentation. Five revisions were recorded in the procedure. All were explanations of the test setup errors which made repeat tests necessary for the RASM and the CP1-BO and DP1-BO multiplexers, as previously described.

4.3.10 Digital Data Acquisition System (1B66564 H)

The digital data acquisition system (DDAS) test verified the operation of all data channels on the stage except certain data channels that were tested during specific system tests. The GSE D924A computer verified that the output of each channel tested was within the required tolerances. Proper operation was verified for the DDAS signal conditioning equipment and associated amplifiers, the remote automatic calibration system (RACS) and the associated command calibration channel decoder assemblies, and the telemetry transmitter and antenna system. The specific items involved in this test were:

Part Name	Ref. Location	P/N	S/N
PCM/DDAS Assembly	411A97A200	1B65792-1	6700089
CP1-BO Time Division Multiplexer	404A61A200	1B65897-1	013
DP1-BO Time Division Multiplexer	404A61A201	1B65897-501	04
Remote Digital Submultiplexer (RDSM)	404A60A200	1B66051-501	04
Remote Analog Submultiplexer (RASM)	404A60A201	1B66050-501.1	05
PCM RF Assembly	411A64A200	1B65788-1-004	15505

Three tests were conducted to verify the operation of all data channels checked. The first two tests were calibration tests performed on 15 January and 4 February 1969, to verify that the stage and ground instrumentation were operating satisfactorily. Both tests resulted in numerous channel malfunctions, the chief causes of which were stage hardware that was not installed and interference from concurrent testing (propulsion system leak checks). The third and final test was a successful checkout performed on 8 February 1969. Measurements quoted and the following narrative descriptions are from the final test.

All channels having a calibration capability were compared one at a time, by the computer, to the tolerance limits. Transducer analog outputs were signal

4.3.10 (Continued)

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

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

Channels without RACS capability and spare channels were tested by comparing the end item outputs at ambient conditions to tolerance limits. Ambient conditions were defined as $70^{o}F$ at 14.7 psia, and for bilevel parameters, the normal state of valves or switches during the performance of this test. All channel outputs were measured, and the results were recorded on the line-printer.

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

After performing initial conditions scan, the DDAS test started with automatic setup, including turn on of the 5-volt and 28-volt transducer power supplies

4.3.10 (Continued)

and reset of the control matrix 8 switch. Turn off of DDAS input No. 1, common bulkhead pressure transducer 28-volt power, and LOX and LH2 ullage pressure transducer power completed the automatic setup.

The first test performed was the CP1-BO and DP1-BO multiplexer flight calibration checks. 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 for both multiplexers.

The PCM RF test was performed next. The forward and reflected RF output powers of the PCM/DDAS assembly were measured through the CP1-BO and DP1-BO multiplexer telemetry outputs; and the voltage standing wave ratios (VSWR) were determined. The same measurements were also made through the ground monitor outputs for both multiplexers. The CP1-BO multiplexer telemetry readings were: forward power, 25.072 watts; reflected power, 1.526 watts; VSWR, 1.654. The DP1-BO multiplexer telemetry readings were: forward power, 25.161 watts; reflected power, 1.538 watts, VSWR; 1.656. The CP1-BO multiplexer ground monitor readings were: forward power, 25.221 watts; reflected power, 0.832 watts; VSWR, 1.443. The DP1-BO multiplexer ground monitor readings were: forward power, 25.221 watts; reflected power, 0.839 watts; VSWR, 1.445. High and low RACS tests were then conducted on measurement channel CP1-BO-05-10 for the aft 5 volt excitation module voltage, while both the ground monitor and telemetry outputs were measured. High RACS for telemetry and ground monitor outputs were 3.994 vdc and 3.999 vdc, respectively. Low RACS were -0.005 vdc and

4.3.10 (Continued)

-0.010 vdc, respectively, for telemetry and ground monitor outputs. All measurements were within the acceptable tolerances.

The CP1-BO multiplexer test made measurements of the high and low RACS voltages of each channel having calibration capability, and measurements of the ambient outputs in units of temperature, pressure, voltage, current, frequency, event indication, liquid level indication, and position indication, as applicable for the various channels. Output values for each of the CP1-BO multiplexer channels tested were within the required limits. One event indication, K155, malfunctioned as expected because the LH2 continuous vent orificed bypass valve was not installed during the test.

The DP1-BO multiplexer test was also run, except for special channels, in the same manner as described for the CP1-BO multiplexer. All channel outputs for the test were within tolerance with the exception of channels for measurement C382, O2H2 burner chamber dome temperature, and event indication K155, noted above. Malfunctions for both were expected because the transducer for C382 had been removed and a replacement was not available at test time. As noted above for K155, the valve was not installed.

Special channel tests were also conducted. These special channels measured 400 Hz, 100 Hz, and 1500 Hz signals. The 400 Hz test checked the static inverter-converter frequency, the LOX and LH2 chilldown inverter frequencies, and the LOX and LH2 circulation pump flow rates. The LOX and LH2 flowmeter tests at 100 Hz followed the 400 Hz test, and the LOX and LH2 pump speeds were

4.3.10 (Continued)

checked using the 1500 Hz signal. All of the special channels were within the required tolerances of the expected values for the final test.

An APS multiplexer test and a J-2 engine pressures multiplexer test were run to check those channels on both multiplexers that measured the APS and special J-2 engine functions. Measurements were made of the high and low RACS voltages for each of the APS and special J-2 engine channels having calibration capability; and the ambient outputs were measured in °F or psia, as appropriate for the channel tested. All APS and J-2 engine special channels were within the required tolerances. The APS multiplexer test was repeated because the initial test recorded channel malfunctions for measurements D37 and D38 due to programming errors. The program errors were corrected and the repeat test was satisfactory.

The last check conducted was the umbilical measurements test. Umbilical measurements were made for ambient pressure and voltage checks of the LOX and LH2 chilldown pump differential pressure transducers. After the umbilical checks, these measurements were returned to their respective telemetry channels and verified. Next, a multiplexer test was run for the common bulkhead internal pressure channel including high and low RACS voltages and ambient output pressure. Then, additional umbilical measurements included the 20 percent and 80 percent calibration checks of the common bulkhead pressure and the umbilical LOX and LH2 ullage pressure measurements. Ambient pressure checks of the LOX and LH2 emergency detection system transducers completed the umbilical measurements test. All measurements for the test were within tolerance, and the DDAS was accepted for use.

4.3.10 (Continued)

There were no FARR tags initiated as a result of DDAS testing. Fifteen revisions were recorded in the procedure for the following:

a. Four revisions corrected program and TRD errors.

b. Three revisions updated the program to the latest requirements.

c. Two revisions noted malfunction indications which were expected because the hardware was not installed during the test.

d. One revision attributed initial APS multiplexer test malfunctions for measurements D37 and D38 to programming errors during paper tape changes. These were corrected and the test repeated satisfactorily.

e. One revision noted that measurement D99 was within tolerance during the APS multiplexer test. An out-of-tolerance indication occurred because the program tolerance had not been updated prior to the test due to oversight.

f. One revision noted that a channel 6 lockout occurred due to operator error.

g. One revision attributed an out-of-tolerance measurement for engine control bus current to system noise. A repeat measurement was within tolerance.

h. One revision indicated an error message E10 was received due to operator error during OLSTOL changes.

i. One revision provided instructions for a special verification of LH2 and LOX tank ullage pressure transducers which determined that EDS 1 and EDS 2 were not cross-wired.

4.3.11 Exploding Bridgewire System (1B66566 F)

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

Part Name	Ref. Location	P/N	S/N
Ullage Rocket Ignition System			
EBW Firing Unit	404A47A1	40M39515-113	290
EBW Firing Unit	404A47A2	40M39515-113	291
Pulse Sensor *	404A47A4A1	40M02852	461
Pulse Sensor *	404A47A4A2	40M02852	456
* On Pulse Sensor Bracket Assy	404A47A4	1B52640-1	00011
Ullage Rocket Jettison System			
EBW Firing Unit	404A75A1	40M39515-113	259
EBW Firing Unit	404A75A2	40M39515-113	260
Pulse Sensor **	404A75A10A1	40M02852	479
Pulse Sensor **	404A75A10A2	40M02852	498
** On Pulse Sensor Bracket Assy	404A75A10	1A97791-501	00006

This procedure was accomplished on 20 January 1969, and was accepted on 21 January 1969. Throughout this procedure the charged condition of each EBW firing unit was determined by verifying that the firing unit voltage indication measured 4.2 $\pm$0.3 vdc, while the uncharged or discharge condition was determined by verifying that the voltage indication measured 0.0 $\pm$0.3 vdc, or during the firing unit disable test, 0.2 $\pm$0.3 vdc.

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

4.3.11 (Continued)

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

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

A final series of checks verified the operation of the EBW pilot relay by determining that the pilot relay reset indication was off after each of the charge ullage ignition and jettison, and fire ullage ignition and jettison commands were turned on, and that the pilot relay reset indication was on after each command was reset.

Engineering comments noted that all parts were installed at the start of this checkout. No problems were encountered during this test, and no FARR's were written. There were no revisions recorded in the procedure.

4.3.12 Propellant Utilization System Calibration (1B64367 K)

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) to simulate the LOX and LH2 mass probe outputs under varying propellant load conditions. The items involved in this test included the following:

Part Name	Ref. Location	P/N	S/N
Propellant Utilization Electronic Assembly (PUEA)	411A92A6	1A59358-529	032
Static Inverter-Converter	411A92A7	1A66212-507	023
LOX Mass Probe	406A1	1A48430-511	C3
LH2 Mass Probe	408A1	1A48431-513	C2
LOX Overfill Sensor	Part of LOX Mass Probe)		
LOX Overfill Control Unit	404A72A4	1A68710-511	C43
LOX Fastfill Sensor	406A2C5	1A68710-1	D81
LOX Fastfill Control Unit	404A72A5	1A68710-511	C53
LH2 Overfill Sensor	(Part of LH2 Mass Probe)		
LH2 Overfill Control Unit	411A92A24	1A68710-509	C19
LH2 Fastfill Sensor	408A2C5	1A68710-1	D123
LH2 Fastfill Control Unit	411A92A43	1A68710-509	C66

The test was performed on 21 January 1969. Measurements and ratiometer settings made during the test appear in Test Data Table 4.3.12.1

Atmospheric conditions in the test area were measured before the calibration was started. Megohm resistance measurements were made on the LH2 and LOX mass probe elements through connector 411W11P1 at the PUEA, using a 50 vdc megohmeter. The PUT/S was connected to the PUEA, then 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.

4.3.12 (Continued)

The PUEA bridge calibrations were conducted next. Simulated empty conditions were established with the PUT/S; the PUEA LH2 and LOX bridge empty condition calibrations were accomplished by nulling the bridge tap voltages with the PUT/S ratiometer at settings of 0.01619 for the LH2 bridge and 0.04116 for the LOX bridge; then, the bridge outputs were nulled by adjusting the PUEA R2 potentiometer for the LH2 bridge and the PUEA R1 potentiometer for the LOX bridge. Simulated full conditions were then established with the PUT/S using a C1 capacitor (LH2) setting of 181.49 picofarads and a C2 capacitor (LOX) setting of 123.20 picofarads, and the ratiometers were set to 0.82193 for the LH2 bridge and 0.82193 for the LOX bridge. To accomplish the PUEA LH2 and LOX bridge full calibrations, the bridge outputs were nulled by adjusting PUEA R4 potentiometer for the LH2 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 by adjusting the PUT/S ratiometer to null the PUEA LH2 and LOX bridge outputs. Bridge slew checks were conducted by establishing simulated 1/3 and 2/3 slew conditions with the PUT/S and by adjusting the PUT/S ratiometer to null the PUEA LH2 and LOX bridge outputs for each condition. For the reference mixture ratio (RMR) calibration, the difference between the previously determined LH2 and LOX empty ratiometer settings, 0.02497, was multiplied by 98.4 vdc to give a V1 reference voltage of 2.457 vdc. Simulated empty conditions were established with the PUT/S, and the PUEA residual empty bias R6 potentiometer was adjusted to null the RMR bias voltage. Simulated full conditions were then established with the PUT/S, and the PUEA residual full bias R5

4.3.12 (Continued)

potentiometer was adjusted to null the RMR bias voltage. For a fuel boiloff bias calibration, simulated boiloff conditions were established with the PUT/S using a C1 capacitor (LH2) setting of 181.49 picofarads and a C2 capacitor (LOX) setting of 123.20 picofarads. The PUEA fuel bias R7 potentiometer was then adjusted to null the RMR bias voltage.

PUEA LH2 and LOX bridge linearity checks were accomplished by individually setting the PUT/S C1 capacitor (LH2) and C2 capacitor (LOX) to specific values and by 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 2.4304 vdc under simulated empty conditions and as 2.4535 vdc under bias internal test conditions. The fuel boiloff bias voltage was the difference between these measurements, 0.0231 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 LH2 and LOX bridge output voltages. The LH2 voltage was 22.761 vdc, within the 22.489 $\pm$2.0 vdc limits, and the LOX voltage 22.764 vdc, meeting the 22.487 $\pm$2.0 vdc requirements.

Post test securing and shutdown operations, plus observation of the PU oven stability monitor voltage trace for voltage variation completed the checkout.

There were no discrepancies that resulted in FARR documentation. However, two revisions were recorded in the procedure for the following:

4.3.12 (Continued)

a. One revision deleted the 99% helium or nitrogen concentration requirement for the propellant tanks during the post-fire calibration test.

b. One revision authorized repeating the post test stabilization check for parameter N63, PU oven stability monitor voltage. The initial post test check was invalid due to insufficient strip chart paper.

4.3.12.1 Test Data Table, Propellant Utilization System Calibration

Pre-Test Atmospheric Conditions

Temperature:	62°F
Pressure:	29.47 inches of Hg
Relative Humidity:	72 percent

LH2 and LOX Mass Probe Insulation Resistance Checks

Function	Resistance (megohms)	Limits (megohms)
LH2 Probe Elements, Pins G to E	100k	1000 min
Pin G to Shield	4k	1000 min
Pin G to Stage Ground	100k	1000 min
Pin G Shield to Stage Ground	100k	1000 min
Pin E to Stage Ground	100k	1000 min
LOX Probe Elements, Pins A to C	100k	1000 min
Pin C to Shield	100k	1000 min
Pin C to Stage Ground	100k	1000 min
Pin C Shield to Stage Ground	40k	1000 min
Pin A to Stage Ground	100k	1000 min

Static Inverter-Converter Measurements

Function	Measurement	Limits
5.0 vdc Output Voltage (vdc)	4.954	4.75 to 5.05
21.0 vdc Output Voltage (vdc)	21.73	20.00 to 22.50
28.0 vdc Output Voltage (vdc)	27.36	26.00 to 30.00
117 vdc Output Voltage (vdc)	122.2	115.00 to 122.50
115 vrms Monitor Voltage (vdc)	2.765	2.23 to 3.18
Test Point 2 Voltage (vdc)	21.86	20.00 to 22.50
V/P Excitation Voltage (vdc)	50.725	49.368 to 52.546
Operating Frequency (Hz)	401.2	394.0 to 406.0

4.3.12.1 (Continued)

Data Acquisition

Function	PUT/S Ratiometer	Limits
LH2 Emtpy	0.00020	*
LOX Empty	0.02168	*
LH2 Full	0.82200	*
LOX Full	0.82191	*

Bridge Slew Checks

LH2 1/3 Slew	0.31231	*
LH2 2/3 Slew	0.64215	*
LOX 1/3 Slew	0.28282	*
LOX 2/3 Slew	0.56904	*

LH2 Bridge Linearity Check

PUT/S C1 Value	PUT/S Ratiometer	Limits
36.3 pf	0.16122	0.15957 to 0.16286
72.59 pf	0.32640	0.32475 to 0.32804
108.89 pf	0.49115	0.48993 to 0.49322
145.19 pf	0.65606	0.65511 to 0.65840
181.49 pg	0.82210	0.82029 to 0.82358

LOX Bridge Linearity Check

PUT/S C2 Value	PUT/S Ratiometer	Limits
24.64 pf	0.18087	0.17989 to 0.18317
49.28 pf	0.34120	0.33999 to 0.34327
73.92 pf	0.50131	0.50009 to 0.50338
98.56 pf	0.66099	0.66019 to 0.66348
123.20 pf	0.82190	0.82029 to 0.82358

* Limits Not Specified

4.3.13 Propellant Utilization System (1B66567 H)

This automatic checkout verified the capability of the propellant utilization (PU) system to determine and control the engine propellant flow mixture ratio in a manner that ensured simultaneous propellant depletion. The test also verified the capability of the PU system to provide propellant level information for controlling the fill and topping valves during LOX and LH2 loading operations. The automatic checkout system (ACS) was utilized during testing to function PU system components and to monitor responses. This test involved all components of the stage PU system including:

Part Name	Ref. Location	P/N	S/N
Propellant Utilization Electronics Assy (PUEA)	411A92A6	1A59358-529	032
Static Inverter-Converter	411A92A7	1A66212-507	023
LOX Mass Probe	406A1	1A48430-511	C3
LH2 Mass Probe	408A1	1A48431-513	C2
LOX Overfill Sensor		(Part of LOX Mass Probe)	
LOX Overfill Control Unit	404A72A4	1A68710-511	C43
LOX Fastfill Sensor	406A2C5	1A68710-1	D81
LOX Fastfill Control Unit	404A72A5	1A68710-511	C53
LH2 Overfill Sensor		(Part of LH2 Mass Probe)	
LH2 Overfill Control Unit	411A92A24	1A68710-509	C19
LH2 Fastfill Sensor	408A2C5	1A68710-1	D123
LH2 Fastfill Control Unit	411A92A43	1A68710-509	C66

The test was successfully conducted on 21 January 1969. Measurements taken during this test are shown in Test Data Table 4.3.13.1.

After conducting initial conditions scan per H&CO 1B66560, the ratio values, obtained from the manual PU system calibration procedure, H&CO 1B64367, were loaded into the computer. From these ratio values, nominal test values were computed for the LOX and LH2 coarse mass voltages, fine mass voltages, and loading voltages. After an evaluation of the computer printout, a test of

4.3.13 (Continued)

the PU system power was made. Power was applied to the PU inverter and electronics assemblies, and after a programmed delay to allow the inverter-converter to stabilize, the output voltages and frequency were measured and determined to be within specified limits. After an additional programmed delay for the PU oven temperature to stabilize, as indicated by the PU oven stability monitor output voltage, it was verified that the PUEA amplifier was properly calibrated by measuring the PU oven output voltages through the remote automatic calibration system (RACS).

The bridge balance and ratio valve null test was conducted next. The ratio valve position was measured, and the LOX and LH2 coarse and fine mass voltages were measured through the AO and BO instrumentation multiplexers.

The PU loading test followed. The LH2 boiloff bias signal voltage was measured with the boiloff bias cutoff turned on and was verified to be 0.0 ± 2.5 vdc with the cutoff turned off. The GSE loading potentiometer power was turned on, and the voltage measured. Measurements were then made of the LOX and LH2 loading potentiometer sense voltages and signal voltages. Measurements of the LOX and LH2 loading potentiometer signal voltages were repeated after the LOX and LH2 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 LH2 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 LH2 coarse and fine mass voltages were measured through the AO and BO telemetry multiplexers. The measurements were

4.3.13 (Continued)

repeated with the LOX and LH2 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 LH2 tank overfill and the LH2 fastfill sensor and their associated control units responded properly under ambient (dry) conditions and under simulated wet conditions of the sensors. Post test verification of the LOX fastfill sensor was accomplished on 24 January 1969, because the LOX instrumentation probe was not installed during the PU automatic test.

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

The next section of this procedure was the PU activate test. All measurements for this test were made through the AO and BO multiplexers. The ratio valve position was measured; then, the LOX bridge 1/3 checkout relay command was turned on, and the LOX coarse mass voltage was measured. The ratio valve position was remeasured with the PU activate switch turned on and again with it turned off. The LOX bridge 1/3 checkout relay command was turned off, then the LOX coarse mass voltage and the ratio valve position were measured. These steps were repeated using the LH2 bridge 1/3 checkout relay, then measuring the LH2 coarse mass voltage.

The PU valve programmed mixture ratio test was the final checkout of the procedure. The PU mixture ratio 4.5 switch selector was turned on and the ratio

4.3.13 (Continued)

valve position was verified to be less than -20 degrees. Then with the LOX bridge 1/3 checkout relay command and the PU activate switch both on, the ratio valve position was again verified to be less than -20 degrees. Next, the PU activate switch, the LOX bridge 1/3 checkout relay command, and the PU programmed mixture ratio switch were turned off; then, the ratio valve position was verified to be greater than -1.5 degrees. This procedure was then repeated with the PU mixture ratio 5.5 switch, LH2 bridge 1/3 checkout relay command, and the PU activate switch. The ratio valve position was verified to be greater than +20 degrees with the switches and commands on, and less than +1.5 degrees with switches and commands off. After turning on the PU mixture ratio 4.5 switch and verifying ratio valve position to be less than -20 degrees, the PU mixture ratio 5.5 switch selector was turned on; then, the ratio valve position was verified to be 0 $\pm$10 degrees. The test was completed by turning off the PU programmed mixture ratio switch and verifying that the ratio valve had returned to the null position.

There were no FARR's initiated as a result of this test; however, seven revisions were recorded in the procedure for the following:

a. One revision changed the ratio valve null checks to comply with customer requirements.

b. One revision authorized the post test verification of the LOX fastfill sensor as described previously.

c. One revision authorized a program change to permit completing the program without verification of the LOX fastfill sensor during the PU automatic test.

d. One revision attributed a malfunction indication for the PU inverter and the DC oven power to insufficient program time allowed by the test requirements drawing.

4.3.13 (Continued)

e. Three revisions concerned malfunction indications during initial conditions scan which had no affect on the PU automatic test. The malfunctions occurred because of two valves which had been removed and a parameter that no longer existed on the stage.

4.3.13.1 Test Data Table, Propellant Utilization System

Loaded Ratio Values (from H&CO 1B64367)

LOX Empty Ratio	0.021	LH2 Empty Ratio	0.000
LOX 1/3 Bridge Slew Ratio	0.283	LH2 1/3 Bridge Slew Ratio	0.312
LOX 2/3 Bridge Slew Ratio	0.568	LH2 2/3 Bridge Slew Ratio	0.642
LOX Wiper Ratio	0.041	LH2 Wiper Ratio	0.016

LH2 Boiloff Bias Voltage (vdc) 0.023

Computed Coarse Mass Voltages (vdc)

LOX Empty	0.107	LH2 Empty	0.000
LOX 1/3 Mass	1.416	LH2 1/3 Mass	1.558
LOX 2/3 Mass	2.842	LH2 2/3 Mass	3.208

Computed Fine Mass Voltages (vdc)

LOX Empty	4.106	LH2 Empty	1.563
LOX 1/3 Mass	0.249	LH2 1/3 Mass	2.529
LOX 2/3 Mass	2.305	LH2 2/3 Mass	4.873

Computer Loading Voltages (vdc)

LOX Empty	0.602	LH2 Empty	0.000
LOX 1/3 Coarse Mass	7.930	LH2 1/3 Coarse Mass	8.723

PU System Power Test

Function	Measured Value	Limits
Inv-Conv 115 vrms Output (vac)	114.830	115.0 ± 3.4
Inv-Conv 21 vdc Output (vdc)	21.877	21.25 ± 1.25
Inv-Conv 5 vdc Output (vdc)	4.999	4.9 ± 0.2
Inv-Conv Frequency (Hz)	401.172	400.0 ± 6.0
PU Oven Monitor Voltage Z1 (vdc)	2.276	2.65 ± 2.35
PU Oven Monitor Voltage Z2 (vdc)	2.276	2.276 ± 0.075
PU Oven Monitor Voltage Z3 (vdc)	2.281	2.276 ± 0.075
PU Oven Monitor Voltage - Final (vdc)	2.281	2.276 ± 0.075

4.3.13.1 (Continued)

Bridge Balance and Ratio Valve Null Test

Function	Measured Value	AO Multi	BO Multi	Limits
Ratio Valve Position (deg)	0.351			0.000 ± 1.5
LOX Coarse Mass Voltage (vdc)		0.107	0.088	0.107 ± 0.1
LOX Fine Mass Voltage (vdc)		4.097	4.082	4.106 ± 0.4
LH2 Coarse Mass Voltage (vdc)		-0.005	-0.015	0.000 ± 0.1
LH2 Fine Mass Voltage (vdc)		1.597	1.597	1.563 ± 0.4

PU Loading Test

Function	Measured Value	Limits
LH2 Boiloff Bias Signal Volt. (vdc)	0.279	1.023 ± 2.0
GSE Power Supply Voltage (vdc)	28.958	28.0 ± 2.0

Loading Potentiometer Function	LOX Value	LH2 Value	Limits
Sense Voltage, GSE Power On (vdc)	28.919	28.958	28.958 ± 0.4
Signal Voltage, Relay Commands	0.602		0.602 ± 0.5
Off (vdc)		0.000	0.0 ± 0.5
Signal Voltage, Relay Commands	7.820		7.930 ± 0.6
On (vdc)		8.531	8.723 ± 0.6
Signal Voltage, Relay Commands	0.574		0.602 ± 0.5
Off (vdc)		0.000	0.0 ± 0.5
Sense Voltage, GSE Power OFF (vdc)	-0.439	-0.359	0.0 ± 0.75

Servo Balance Bridge Gain Test

Function	Measured Value	AO Multi	BO Multi	Limits
Ratio Valve Position (deg)	0.351			0.351 ± 1.5
LOX Coarse Mass Voltage (vdc)		0.093	0.088	0.107 ± 0.1
LOX Fine Mass Voltage (vdc)		4.082	4.072	4.106 ± 0.4
LH2 Coarse Mass Voltage (vdc)		0.000	-0.005	0.000 ± 0.1
LH2 Fine Mass Voltage (vdc)		1.592	1.587	1.563 ± 0.4

1/3 Checkout Relay Commands On

Function	Measured Value	AO Multi	BO Multi	Limits
Ratio Valve Position (deg)	0.761			0.351 ± 1.5
LOX Coarse Mass Voltage (vdc)		1.401	1.396	1.416 ± 0.1
LOX Fine Mass Voltage (vdc)		0.176	0.166	0.249 ± 0.4
LH2 Coarse Mass Voltage (vdc)		1.558	1.548	1.558 ± 0.1
LH2 Fine Mass Voltage (vdc)		2.710	2.690	2.529 ± 0.4

4.3.13.1 (Continued)

Function	Measured Value	AO Multi	BO Multi	Limits
2/3 Checkout Relay Commands On				
Ratio Valve Position (deg)	1.237			0.351 ± 1.5
LOX Coarse Mass Voltage (vdc)		2.842	2.832	2.842 ± 0.1
LOX Fine Mass Voltage (vdc)		1.963	1.953	2.305 ± 0.4
LH2 Coarse Mass Voltage (vdc)		3.203	3.198	3.208 ± 0.1
LH2 Fine Mass Voltage (vdc)		4.751	4.751	4.873 ± 0.4
2/3 Checkout Relay Commands Off				
Ratio Valve Position (deg)	0.896			0.351 ± 1.5
LOX Coarse Mass Voltage (vdc)		1.406	1.396	1.416 ± 0.1
LOX Fine Mass Voltage (vdc)		0.181	0.176	0.249 ± 0.4
LH2 Coarse Mass Voltage (vdc)		1.553	1.548	1.558 ± 0.1
LH2 Fine Mass Voltage (vdc)		2.705	2.695	2.529 ± 0.4
1/3 Checkout Relay Commands Off				
Ratio Valve Position (deg)	0.351			0.351 ± 1.5
LOX Coarse Mass Voltage (vdc)		0.103	0.093	0.107 ± 0.1
LOX Fine Mass Voltage (vdc)		4.087	4.072	4.106 ± 0.4
LH2 Coarse Mass Voltage (vdc)		-0.005	-0.005	0.000 ± 0.1
LH2 Fine Mass Voltage (vdc)		1.592	1.587	1.563 ± 0.4

PU Valve Movement Test

Function	Measured Value	Limits
Ratio Valve Position, AO (deg)	0.419	0.351 ± 1.50
Ratio Valve Position, BO (deg)	0.487	0.351 ± 1.50
50 Second Plus Valve Slew, AO Multiplexer		
+1 vdc System Test Valve Position Signal (vdc)	0.997	1.00 ± 0.02
V1, Position at T+3 Seconds (deg)	4.022	2.037 to 6.351
V2, Position at T+5 Seconds (deg)	5.113	2.659 to 7.396
V3, Position at T+8 Seconds (deg)	5.728	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)	6.000	5.226 to 7.396
50 Second Minus Valve Slew, AO Multiplexer		
Ratio Valve Position, AO (deg)	0.419	0.351 ± 1.5
-1 vdc System Test Valve Error Signal (vdc)	-0.996	-1.000 ± 0.02

4.3.13.1 (Continued)

Function	Measured Value	Limits
V1, Position at T+3 Seconds (deg)	-3.749	-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)	-5.249	-2.977 to -7.396
V4, Position at T+20 Seconds (deg)	-5.590	-5.226 to -7.396
V5, Position at T+50 Seconds (deg)	-5.453	-5.226 to -7.396

PU Activation Test

Function	AO Multi	BO Multi	Limits
Ratio Valve Position (deg)	0.146	0.419	0.351 ± 1.50
LOX 1/3 Command Relay On			
LOX Coarse Mass Voltage (vdc)	1.411	1.396	1.416 ± 0.1
PU System On			
Ratio Valve Position (deg)	33.008	33.076	20.0 min
PU System Off			
Ratio Valve Position (deg)	0.692	0.761	15.0 max
LOX 1/3 Command Relay Off			
LOX Coarse Mass Voltage (vdc)	0.103	0.093	0.107 ± 0.1
Ratio Valve Position (deg)	0.282	0.419	0.351 ± 1.5
LH2 1/3 Command Relay On			
LH2 Coarse Mass Voltage (vdc)	1.558	1.548	1.558 ± 0.1
PU System On			
Ratio Valve Position (deg)	-27.805	-27.668	-20.0 max
PU System Off			
Ratio Valve Position (deg)	0.487		-15.0 min
LH2 1/3 Command Relay Off			
LH2 Coarse Mass Voltage (vdc)	0.000	-0.010	0.000 ± 0.1
Ratio Valve Position (deg)	0.215	0.419	0.351 ± 1.5

PU Valve Programmed Mixture Ratio Test

Function	Measured Value	Limits
4.5 MR Switch On		
Ratio Valve Position (deg)	-22.487	-20.0 max
LOX 1/3 Command Relay On and PU System On		
Ratio Valve Position	-28.010	-20.0 max
PU Programmed MR Switch Off		
Ratio Valve Position (deg)	0.556	-1.5 min
5.5 MR Switch On		
Ratio Valve Position (deg)	22.031	20.0 min
LH2 1/3 Command Relay On and PU System On		
Ratio Valve Position (deg)	33.213	20.0 min

4.3.13.1 (Continued)

Function	Measured Value	Limits
PU Programmed MR Switch Off		
Ratio Valve Position (deg)	-0.058	1.5 min
4.5 MR Switch On		
Ratio Valve Position (deg)	-21.056	-20.0 max
5.5 MR Switch On		
Ratio Valve Position (deg)	-7.011	0 ± 10
PU Programmed MR Switch Off		
Ratio Valve Position (deg)	1.851	0.351 ± 1.5

4.3.14 Hydraulic System Setup, Operation, and Securing (1B41007C)

The purpose of this manual procedure was to set up the stage hydraulic system in preparation for the deferred postfire checkout and then to shut down and secure the system after completion of the checkout activities. The procedure was initiated on 22 January 1969, and successfully completed on 14 February 1969.

Components of the stage hydraulic system installed during this checkout included the engine driven hydraulic pump, P/N 1A66240-503, S/N X123108; the auxiliary hydraulic pump, P/N 1A66241-511, S/N X458911; the accumulator/reservoir assembly, P/N 1B29319-519, S/N 33; and the hydraulic actuators, P/N 1A66248-507, S/N's 30 and 81.

Prior to operation of the stage hydraulic system, the Model DSV-4B-358 hydraulic pumping unit (HPU), P/N 1A67443-1, was checked to ensure that the hydraulic fluid met the cleanliness requirements. The HPU was connected to the stage via the pressure and return hoses, and hydraulic fluid was circulated through the stage system to ensure that the system was properly filled. Hydraulic fluid samples were taken and certified to be free of contamination.

The GSE Model DSV-4B-699 gimbal control unit was then setup and connected electrically to provide the electrical signals for cycling the hydraulic system gimbal actuators. After removal of the actuator midstroke locks, the GN2 accumulator in the hydraulic system and the stage auxiliary hydraulic pump air supply bottle were charged in preparation for the engine gimbal clearance check.

4.3.14 (Continued)

The J-2 engine restrainer and bellows protective covers were removed, and the hydraulic system pressure was brought up to 1000 psig with the HPU. While observing the engine area for possible interference points, the hydraulic pitch and yaw actuators were fully extended and retracted by electrical signals from the gimbal control unit. No engine deflection clearance problem existed, and the engine was positioned to center. The actuator midstroke locks and the engine bellows protective covers were reinstalled, and the gimbal control unit was disconnected from the hydraulic actuators.

The shutdown procedure prepared the hydraulic system for automatic testing. The shutdown sequence of this checkout included a final air content test which provided information necessary for system analysis by discharging a portion of the internal system fluid volume overboard. The volume discharged was determined to be a function of the fluid temperature measurement, to provide space in the reservoir for fluid thermal expansion under ground operating conditions (0° to $160^{\circ}F$). The HPU was turned on and the system pressure was increased to 3650 $\pm$50 psig. The bypass valve was then opened and the HPU was turned off. Verification was made that the return pressure gauge indicated a minimum of 200 psig. The shutoff valve was cycled open and closed until the return pressure was reduced to 180 $\pm$5 psig. An empty 100 ml graduate was placed under the drain port, and by cycling the reservoir drain valve open and closed, the return pressure was decreased to 80 $\pm$5 psig. The volume of fluid bled was less than the 16 milliliters maximum specified by design requirements.

4.3.14 (Continued)

After completion of deferred postfire checkout, the hydraulic system was secured. This included depressurizing the GN2 accumulator and stage auxiliary pump air supply bottle. The hydraulic pitch and yaw actuator rods and housings were inspected for nicks, gouges, or scratches. After completion of this inspection, the midstroke locks were reinstalled on the actuators; the drain hose was removed from the reservoir low pressure relief valve; and a plastic dust cover was installed on the relief valve port. Finally, all auxiliary equipment on the hydraulic system was removed and all sample ports were capped.

There were no discrepancies documented by FARR's as a result of this checkout. Three revisions were recorded in the procedure for the following:

a. One revision provided for system checkout including additional cleanliness samples subsequent to the seal replacement to correct hydraulic fluid leakage at the auxiliary hydraulic pump filter differential pressure indicator. The leak had been corrected per FARR 500-488-743 during the abbreviated postfire checkout (reference H&CO 1B41006B).

One revision authorized taking additional cleanliness samples from the HPU because the HPU cannot be connected to the stage for more than 48 hours without resampling.

One revision authorized recharging the GN2 accumulator prior to performance of the automatic test of the digital data acquisition system.

4.3.15 Single Sideband System Checkout (1B76771 NC)

The purpose of this combined manual and automatic procedure was to verify the capability of the single sideband (SSB) telemetry system to properly measure, frequency multiplex, and transmit vibration and acoustical data. Stage hardware involved in the checkout included the vibration and acoustical instrumentation, the subcarrier, oscillator (SCO) assembly, the model 245 multiplexer, the telemetry (T/M) calibrator, the SSB translator, the SSB wideband amplifier, and the SSB transmitter.

The manual test sequences were initiated on 22 January 1969, and continued on 23 January and 25 January 1969. Automatic test sequences were initiated on 28 January 1969, and completed on 8 February 1969. The procedure was accepted as complete on 10 February 1969; however, an out-of-tolerance condition of the SSB translator, P/N 1B55252-501, was suspected. FARR 500-489-880 documented the condition and specified a retest of the system to be accomplished at the FTC.

The checkout consisted of twelve tests, the SSB antenna system insertion loss, voltage standing wave ratio (VSWR) with dummy load, VSWR with antenna, the SSB RF power detector calibration, the transmitter center frequency and deviation checks, the SSB ground station frequency response, the SSB translator frequency response, the preflight/inflight calibration of the T/M calibrator, pilot tone, the channel identification and remote automatic calibration (RAC) response test, and the open and closed loop transmitter information test.

4.3.15 (Continued)

No further discrepancies were documented on FARR's. However, fifty-seven revisions were required to complete the procedure as follows:

a. Twenty-four revisions were required to correct program errors and omissions.

b. Four revisions were written to clarify the procedure.

c. Three revisions added the test data tables and called for the recording of data for the preflight calibration, the inflight calibration, the SSB/FM channel verification and the translator response test.

d. Two revisions deleted steps that were previously accomplish

e. Two revisions concerned the deletion of the requirement for the oscillator installation and the transducer for measurement B39. The transducer failed and a replacement was not available, reference FARR 500-703-181.

f. One revision reinstated the paragraphs concerned with the measurement B39 transducer. A previous revision deleted these paragraphs due to a transducer failure. A replacemen part was installed.

g. One revision verified that the SSB transmitter current was 4.5 ± 3 amps prior to the 30 second delay for transmitter warmup. Excessive current for 30 seconds could cause damag to the unit.

h. One revision changed the program to verify that the transmitter power did not exceed 29.75 watts during open loop operation.

i. One revision changed the program to verify that the transmitter power did not exceed 19.0 +7.25 watts during closed loop operation.

j. One revision added a 90 second delay after a halt so that the power to the SSB transmitter could not be turned on prior to cooldown of the transmitter filaments.

k. One revision authorized the use of an HP420A crystal detector in place of an HP420B, which was not available.

4.3.15 (Continued)

l. One revision changed the 50 ohm load from a Sierra 160-50D to a Micro-Lab TA-5FT, as the Sierra load was too heavy for the coax cable and could cause damage.

m. One revision gave instructions to turn on the TM tape recorder as the drift characteristics could not be assessed unless the data was recorded.

n. One revision changed the tolerance of the Harrison power supply output voltage from ± 0.5 vdc to ± 0.25 vdc to make the tolerance consistent with those listed in other procedures.

o. One revision added the tolerance of ± 5 Hz to the 1700 Hz output frequency of the SSB/FM, unit 126 oscillator, and changed the output voltage from 5 volt RMS to 0.442V RMS.

p. One revision deleted the callout for an obsolete part number.

q. One revision provided a program change to turn on the prelaunch checkout group power for the RAC run mode.

r. One revision gave instructions to turn off the prelaunch checkout group power after the RAC run as the channel decoders are susceptible to voltage transients and should remain off when not required.

s. One revision changed the amplitude of the input to the model 240 amplifier from 5 VRMS to 4 VRMS to prevent amplifier saturation.

t. One revision gave instructions to install a 40 micro-farad capacitor in series with the oscillator output and the SSB dummy transducer as coupling between the oscillator and simulator must be AC coupled.

u. One revision gave instructions to adjust the fine tuning and frequency controls of the SSB transmitter as necessary to obtain the desired value of transmitter, as the ground station receiver signal strength sensitivity was not sufficient to peak the receiver to the tolerance required.

v. One revision provided a program change to turn on the TM RF ground monitor, as the monitor must be on to receive closed loop data.

4.3.15 (Continued)

w. One revision concerned the malfunction printouts received and the FILADD changes during the IC scan. These malfunctions do not affect the procedure test results.

x. One revision concerned the receipt of two error codes. The first was due to an incorrect cell code. The second was caused by a step being changed while the program was halted at that step. OLSTOL was entered to go to the previous step and the program was resumed.

y. One revision repeated a step as the recording oscillograph was turned off too soon, and the test was repeated to ensure that all data was acquired.

z. One revision stated that the out-of-tolerance condition of the SSB translator data was acceptable for AST.

aa. One revision concerned the cal sweeping -296 not off malfunction. The cal sweep has a duration of 15 $\pm$0.5 seconds, the computer interrogated the -296 sweep at approximately 15.3 seconds. Oscillograph traces indicated an actual sweep of 15.4 seconds.

4.3.16 Cryogenic Temperature Sensor Verification (1B64678 F)

The calibration and functional capabilities of the cryogenic temperature sensors, for which the normal operating range did not include ambient temperatures, were verified by this manual procedure. The cryogenic temperature sensors, basically platinum resistance elements, changed resistance according to the Callendar-Van Dusen equation.

Resistance and continuity checks of the internal fuel tank temperature transducers were conducted by two issues of the procedure. The first issue, conducted on 23 January and 27 January 1969, was accepted on 28 January 1969. A second issue, accomplished and accepted on 21 February 1969, was required due to entry into the LH2 tank for structural inspection. One revision was made to this issue to delete all sections except those concerned with LH2 tank sensors; C-0370, C-0371 and C-0052.

Each sensor was tested at the prevalent ambient temperature. Using the values for resistance at 32°F and sensitivity, which were given for each individual sensor, the expected resistance at room temperature was calculated. The actual resistance was measured, and compared with the calculated value. The measured resistance was required to be within ±5 percent of calculated resistance, except for specified sensors which were allowed a ±7 percent tolerance. The sensor wiring was verified to be correct by shorting out the sensor element, measuring the continuity resistance, and by verifying that this was 5.0 ohms or less. Test Data Table 4.3.16.1, shows the measured and calculated values for each sensor involved in this test.

4.3.16 (Continued)

There were no discrepancies resulting in FARR documentation during the checkouts. Only one revision was recorded, deleting all portions of the second issue of the procedure except those requirements concerned with reverifying the LH2 tank sensors.

4.3.16.1 Test Data Table, Cryogenic Temperature Sensor Verification

Meas. Number	P/N	Sensor S/N	Ref. Desig.	Temp. (°F)	Resistance (ohms) Meas.	Calc.	± Tol.
CO 003	1B34473-1	331	403MT686	70	5150	5418	379.3
CO 004	1B34473-501	351	403MT687	70	1520.0	1516.9	75.8
CO 005	1A67863-503	849	405MT612	70	540.0	541.8	27.1
CO 009	1A67863-535	1105	403MT653	70	217.0	216.7	15.8
CO 012	NA5-27215T5	14220	401(4MTT72)	70	1364	1361	68
CO 015	1A67863-539	10657	410MT603	68	539	542	27
CO 040	1A67862-535	10644	406MT613	70	1501.0	1495.5	74.8
CO 052	1A67862-513	567	408MT612	62	5157	5330	373.1*
CO 057	1A67862-501	599	406MT606	70	540	542	27
CO 059	1A67862-517	51445	406MT611	70	540	542	27
CO 133	NA5-27215T5	13376	401(3MTT17)	70	1356.0	1361.0	68.0
CO 134	NA5-27215T5	14196	401(3MTT16)	70	1360.0	1361.0	68.0
CO 159	1A67863-519	1214	424MT610	70	217.5	216.7	15.8
CO 161	1A67863-537	1197	424MT733	70	5138.0	5418.0	379.3
CO 208	1A67863-503	907	405MT605	70	542.0	541.8	27.1
CO 230	1A67863-509	749	403MT706	70	1512	1516.9	75.8
CO 231	1A67863-529	1170	403MT707	70	543.0	541.8	27
CO 256	1B37878-501	1627	409MT646	68	1514	1511	76
CO 257	1B37878-501	1419	409MT647	68	1510	1511	76
CO 368	1A67862-505	601	406MT660	70	1500	1496	75
CO 369	1A67862-505	600	406MT661	70	1493	1496	75
CO 370	1A67862-533	631	408MT735	62	5150	5330	373.1*
CO 371	1A67862-533	634	408MT736	62	5123	5330	373.1*
CO 2030	1B37878-511	1825	404MT760	70	547.5	541.8	27
CO 2031	1B37878-511	1822	404MT761	70	547.0	541.8	27
†	1B37878-507	1718	403A20	70	5187	5418	379.3
†	1B37878-507	1708	403A21	70	5190	5418	379.3
†	1B37878-507	1709	403A22	70	5170	5418	379.3

† NASA Measurement No. Not Applicable To O2H2 Burner Voting Circuit
* Second Issue Measurements

4.3.17 Hydraulic System (1B66570 G)

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 main hydraulic pump, P/N 1A66240-503, S/N X123108; the auxiliary hydraulic pump, P/N 1A66241-511, S/N X458911; the accumulator/reservoir assembly, P/N 1B29319-519, S/N 00033; the hydraulic pitch actuator, P/N 1A66248-507, S/N 81; and the hydraulic yaw actuator, P/N 1A66248 -507, S/N 30.

The test was satisfactorily accomplished on 29 January 1969. Those function values measured during the test are presented in Test Data Table 4.3.17.1. 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 G, was accomplished; and initial conditions were established for the test. The instrument unit (IU) substitute 5 volt power supply was turned on and its voltage measured; then, the aft 5 volt excitation module voltage was measured. Measurements were made of various hydraulic system functions with the hydraulic system unpressurized. Measurements were also made to determine the accumulator/reservoir gaseous nitrogen mass and corrected oil level.

The methods of controlling the auxiliary hydraulic pump were checked next. After verifying that a power cable was connected to the auxiliary hydraulic

4.3.17 (Continued)

pump motor, the aft bus 2 power supply was turned on, and the bus voltage was verified to be 56.0 $\pm$4.0 vdc. The coast mode operation was checked by applying dry ice to the coast mode thermal switch and by 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 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 acutator position locks on and with the hydraulic system unpressurized. The actuator positions and the voltage of the IU substitute 5 volt power supply and the aft 5 volt excitation module were measured; and the corrected actuator positions were determined. The pitch and yaw actuator locks were removed, 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 determined to be within tolerance. With the hydraulic system

4.3.17 (Continued)

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

A clearance, linearity, and polarity check was accomplished next. The actuators were individually extended to their stops, then retracted causing the engine to move out to its extremes of travel, 0 degrees to $\pm 7\frac{1}{2}$ 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. When the actuators were at their extremes and when they were returned to neutral, checks of the hydraulic system pressure and reservoir oil pressure 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

4.3.17 (Continued)

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 exciation signals applied to the actuators.

The procedure was completed by turning off the auxiliary hydraulic pump, aft bus 2, and the IU substitute 5 volt power supply. The pitch and yaw actuator locks were then replaced.

Engineering comments noted that all parts were installed during this test. There were no discrepancies during the test that resulted in FARR documentation. Three revisions were recorded in the procedure for the following:

a. One revision concerned ALCO changes to turn on and zero set the analog recorder after turning on the auxiliary hydraulic pump.

b. One revision added the VCL setup, operation and securing procedure, hydraulic system, 1B41007, to the text as the VCL procedure had been omitted from the drawing list.

c. One revision deleted steps that were accomplished per 1B41007.

4.3.17.1 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)	71.57	*
Accumulator GN2 Pressure (psia)	2211.88	*
Accumulator GN2 Temperature (°F)	65.88	*
Reservoir Oil Level (%)	89.10	*
Pump Inlet Oil Temperature (°F)	65.10	*
Reservoir Oil Temperature (°F)	68.22	*
Aft Bus 2 Current (amp)	0.00	*
Aux Hyd Pump Air Tank Pressure (psia)	468.77	282.5 ± 217.5
Aux Hyd Pump Motor Gas Pressure (psig)	14.22	21 ± 12
Gaseous Nitrogen Mass (lb)	1.819	1.925 ± 0.2
Corrected Reservoir Oil Level (%)	99.7	95.0 min
Engine Centering Test, Locks On, System Unpressurized		
T/M Pitch Actuator Position (deg)	-0.00	*
IU Pitch Actuator Position (deg)	-0.06	*
T/M Yaw Actuator Position (deg)	0.01	*
IU Yaw Actuator Position (deg)	0.03	*
IU Substitute 5 Volt Power Supply (vdc)	4.99	*
Aft 5 Volt Excitation Module (vdc)	4.99	*
Pitch Actuator Signal (ma)	-0.10	*
Yaw Actuator Signal (ma)	0.05	*
Corrected T/M Pitch Actuator Position (deg)	-0.016	-0.236 to 0.236
Corrected IU Pitch Actuator Position (deg)	-0.066	-0.236 to 0.236
Corrected T/M Yaw Actuator Position (deg)	0.027	-0.236 to 0.236
Corrected IU Yaw Actuator Position (deg)	0.036	-0.236 to 0.236
Engine Centering Test, Locks Off, System Pressurized No Excitation Signal		
Aft Bus 2 Voltage (vdc)	56.00	56.0 ± 4.0
Aft Bus 2 Current (amp)	62.40	55.0 ± 30.0
Hyd System 4 Second Press Change (psia)	307.7	200.0 min
T/M Pitch Actuator Position (deg)	0.01	*
IU Pitch Actuator Position (deg)	-0.06	*
T/M Yaw Actuator Position (deg)	0.03	*
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)	-0.10	*
Yaw Actuator Signal (ma)	0.10	*

* Limits Not Specified

4.3.17.1 (Continued)

Function	Measurement	Limits
Corrected T/M Pitch Actuator Position (deg)	-0.001	-0.517 to 0.517
Corrected IU Pitch Actuator Position (deg)	-0.073	-0.517 to 0.517
Corrected T/M Yaw Actuator Position (deg)	0.043	-0.517 to 0.517
Corrected IU Yaw Actuator Position (deg)	0.028	-0.517 to 0.517
Hydraulic System Pressurized, Locks Off, Zero Excitation Signal Applied to Actuators		
Hydraulic System Pressure (psia)	3598.06	*
Reservoir Oil Pressure (psia)	163.66	*
Accumulator GN2 Pressure (psia)	3575.75	*
Accumulator GN2 Temperature (°F)	81.94	*
Reservoir Oil Level (%)	34.44	*
Pump Inlet Oil Temperature (°F)	82.33	*
Reservoir Oil Temperature (°F)	81.94	*
Aft Bus 2 Current (amp)	42.60	*
T/M Pitch Actuator Position (deg)	-0.02	*
IU Pitch Actuator Position (deg)	-0.03	*
T/M Yaw Actuator Position (deg)	0.04	*
IU Yaw Actuator Position (deg)	0.03	*
IU Substitute 5 Volt Power Supply (vdc)	4.99	*
Aft 5 Volt Excitation Module (vdc)	4.99	*
Pitch Actuator Signal (ma)	-0.10	*
Yaw Actuator Signal (ma)	0.15	*
Corrected T/M Pitch Actuator Position (deg)	-0.031	-0.517 to 0.517
Corrected IU Pitch Actuator Position (deg)	-0.036	-0.517 to 0.517
Corrected T/M Yaw Actuator Position (deg)	0.059	-0.517 to 0.517
Corrected IU Yaw Actuator Position (deg)	0.036	-0.517 to 0.517

Transient Response Tests, Pitch Axis

Time From Start (sec)	Pitch Excitation Signal (ma)	IU Pitch Actuator Pot. Pos. (deg)	IU 5 Volt Power Supply (vdc)
Pitch 0 to -3 Degree Step Response - Engine Slew Rate: 16.5 deg/sec			
0.000	-0.100	-0.074	4.999
0.101	-19.971	-1.745	4.990
0.204	-20.020	-2.842	5.005
0.298	-20.020	-2.986	5.000
0.400	-20.020	-3.016	4.985
0.495	-20.020	-3.029	5.000
0.598	-20.020	-3.044	5.000
0.701	-20.020	-3.087	4.990
0.804	-20.117	-3.044	5.000
0.896	-19.971	-3.044	4.980
1.010	-20.020	-3.044	4.985
1.215	-19.971	-3.059	4.990

* Limits Not Specified

4.3.17.1 (Continued)

Time From Start (sec)	Pitch Excitation Signal (ma)	IU Pitch Actuator Pot. Pos. (deg)	IU 5 Volt Power Supply (vdc)
Pitch -3 to 0 Degree Step Response - Engine Slew Rate: 15.5 deg /sec			
0.000	-20.000	-3.119	5.005
0.102	-0.146	-1.500	4.985
0.194	-0.244	-0.216	4.985
0.299	-0.146	-0.101	4.990
0.400	-0.146	-0.086	5.005
0.504	-0.195	-0.058	5.005
0.606	-0.146	-0.058	5.005
0.700	0.000	-0.086	5.000
0.804	-0.095	-0.028	5.005
0.897	0.000	-0.058	4.990
0.990	-0.195	-0.028	5.000
1.104	-0.146	-0.014	4.990
Pitch 0 to +3 Degree Step Response - Engine Slew Rate: 14.3 deg/sec			
0.000	-0.149	-0.015	4.999
0.103	19.873	1.559	4.990
0.205	19.775	2.814	5.000
0.299	19.775	2.973	5.000
0.402	19.824	2.987	4.985
0.505	19.629	2.973	5.000
0.600	19.824	2.987	5.000
0.701	19.775	2.987	4.990
0.804	19.775	3.017	5.000
0.898	19.824	3.017	5.005
1.010	19.824	3.017	5.000
1.104	19.775	3.017	5.000
Pitch +3 to 0 Degree Step Response - Engine Slew Rate: 17.1 deg/sec			
0.000	19.800	3.074	4.999
0.103	-0.195	1.371	5.000
0.196	-0.195	-0.014	5.000
0.299	-0.195	0.029	4.985
0.402	-0.244	-0.043	4.985
0.505	-0.195	-0.058	5.000
0.599	-0.146	-0.071	5.000
0.701	0.146	-0.071	5.000
0.804	0.000	-0.071	5.000
0.917	-0.146	-0.058	4.990
1.011	-0.146	-0.058	4.990
1.104	-0.146	-0.058	4.990

4.3.17.1 (Continued)

Transient Response Tests, Yaw Axis

Time From Start (sec)	Yaw Excitation Signal (ma)	IU Yaw Actuator Pot. Pos. (deg)	IU 5 Volt Power Supply (vdc)
Yaw 0 to -3 Degree Step Response - Engine Slew Rate: 15.5 deg/sec			
0.000	0.100	0.060	4.984
0.102	-19.775	-1.429	5.000
0.204	-19.824	-2.670	5.000
0.298	-19.922	-2.828	4.990
0.401	-19.824	-2.843	4.990
0.504	-19.971	-2.887	4.990
0.598	-19.873	-2.887	4.976
0.701	-19.824	-2.857	5.000
0.804	-19.824	-2.843	5.000
0.898	-19.775	-2.887	4.990
1.010	-19.775	-2.887	4.980
1.104	-19.873	-2.872	4.985
Yaw -3 to 0 Degree Step Response - Engine Slew Rate: 14.9 deg/sec			
0.000	-19.750	-2.925	4.999
0.103	0.195	-1.343	5.000
0.195	0.146	-0.087	5.000
0.298	0.049	0.058	4.990
0.401	0.146	0.058	4.990
0.504	0.195	0.115	5.000
0.599	0.098	0.101	5.000
0.701	0.049	0.071	5.010
0.804	0.195	0.144	5.000
0.898	0.098	0.129	4.990
1.010	0.146	0.129	4.990
1.104	0.049	0.129	4.990
Yaw 0 to +3 Degree Step Response - Engine Slew Rate: 15.8 deg/sec			
0.000	0.100	0.110	4.994
0.093	19.971	1.543	4.990
0.205	20.020	2.943	5.000
0.299	19.971	3.131	5.000
0.401	19.922	3.116	5.000
0.505	19.922	3.188	4.990
0.599	19.922	3.131	5.000
0.701	20.020	3.159	4.985
0.804	19.922	3.203	4.985
0.897	19.922	3.174	4.990
0.991	19.922	3.188	4.990
1.104	19.922	3.188	5.000

4.3.17.1 (Continued)

Time From Start (sec)	Yaw Excitation Signal(ma)	IU Yaw Actuator Pot. Pos. (deg)	IU 5 Volt Power Supply (vdc)
Yaw +3 to 0 Degree Step Response - Engine Slew Rate: 14.9 deg/sec			
0.000	19.949	3.239	4.999
0.102	-0.049	1.803	5.000
0.194	0.049	0.433	4.990
0.298	0.098	0.188	5.000
0.400	0.098	0.201	5.000
0.505	0.146	0.158	4.990
0.606	0.049	0.129	5.000
0.701	0.146	0.173	5.000
0.804	0.391	0.158	5.000
0.897	0.146	0.158	4.980
1.010	0.049	0.158	4.990
1.104	0.244	0.158	5.000

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

Function	Measurement	Limits
Hydraulic System Pressure (psia)	3591.50	*
Reservoir Oil Pressure (psia)	167.59	*
Accumulator GN2 Pressure (psia)	3583.94	*
Accumulator GN2 Temperature (^{o}F)	73.70	*
Reservoir Oil Level (%)	39.31	*
Pump Inlet Oil Temperature (^{o}F)	153.33	*
Reservoir Oil Temperature (^{o}F)	141.84	*
Aft Bus 2 Current (amps)	44.00	*
Aux Hyd Pump Air Tank Pressure (psia)	468.77	282.5 + 217.5
Aux Hyd Pump Motor Gas Pressure (psig)	24.22	21 $\pm$ 12
T/M Pitch Actuator Position (deg)	-0.03	*
IU Pitch Actuator Position (deg)	-0.07	*
T/M Yaw Actuator Position (deg)	0.14	*
IU Yaw Actuator Position (deg)	0.18	*
IU Substitute 5 Volt Power Supply (vdc)	5.00	*
Aft 5 Volt Excitation Module (vdc)	5.99	*
Pitch Actuator Signal (ma)	-0.10	*
Yaw Actuator Signal (ma)	0.10	*
Corrected T/M Pitch Actuator Position (deg)	-0.047	-0.517 to 0.517
Corrected IU Pitch Actuator Position (deg)	-0.074	-0.517 to 0.517
Corrected T/M Yaw Actuator Position (deg)	0.154	-0.517 to 0.517
Corrected IU Yaw Actuator Position (deg)	0.180	-0.517 to 0.517

* Limits Not Specified

4.3.18 APS Interface Compatibility Checkout (1B49558 B)

This manual checkout specified and provided instructions for compatibility and continuity test requirements that were performed subsequent to installation of the auxiliary propulsion system (APS) modules, P/N 1A83918-535, S/N's 507-3 and 507-4, and prior to the operational checkout of stage systems pertinent to APS circuitry.

This checkout was satisfactorily performed on 29 January 1969. Preliminary inspection of plugs and sockets was accomplished prior to mating to ensure against damaged electrical connectors. Resistance checks verified proper connections between the stage control relay packages and the APS engine valves, and also between the stage aft skirt and the APS control system components. Refer to Test Data Table 4.3.18.1 for results of the point-to-point resistance measurements.

There were no discrepancies recorded by FARR's as a result of this checkout. Three revisions were recorded in the procedure for the following:

a. One revision updated the procedure to the latest stage configuration.

b. One revision corrected a typographical error.

c. One revision accepted an out-of-tolerance resistance measurement for test point J7u, indicating that the reading obtained verifies proper connection.

4.3.18.1 Test Data Table, APS Interface Compatibility

Common Test Point: Stage Ground

Stage Comp.	Test Point	APS Component	Meas. Ohms	Limit Ohms
404A51A4	J4 A	414A8L1 Eng. 1, Valve A	22	25 ± 5
404A51A4	J4 B	414A8L5 Eng. 1, Valve 1	22	25 ± 5
404A51A4	J4 C	414A8L2 Eng. 1, Valve C	22	25 ± 5

4.3.18.1 (Continued)

Stage Comp.	Test Point	APS Component	Meas. Ohms	Limit Ohms
404A51A4	J4 D	414A8L6 Eng. 1, Valve 3	21	25 ± 5
404A51A4	J4 E	414A8L3 Eng. 1, Valve B	22	25 ± 5
404A51A4	J4 F	414A8L7 Eng. 1, Valve 2	22	25 ± 5
404A51A4	J4 G	414A8L4 Eng. 1, Valve D	21	25 ± 5
404A51A4	J4 H	414A8L8 Eng. 1, Valve 4	22	25 ± 5
404A51A4	J4 J	414A10L1 Eng. 3, Valve A	22	25 ± 5
404A51A4	J4 K	414A10L5 Eng. 3, Valve 1	22	25 ± 5
404A51A4	J4 L	414A10L2 Eng. 3, Valve C	22	25 ± 5
404A51A4	J4 M	414A10L6 Eng. 3, Valve 3	22	25 ± 5
404A51A4	J4 N	414A10L3 Eng. 3, Valve B	21	25 ± 5
404A51A4	J4 P	414A10L7 Eng. 3, Valve 2	22	25 ± 5
404A51A4	J4 R	414A10L4 Eng. 3, Valve D	22	25 ± 5
404A51A4	J4 S	414A10L8 Eng. 3, Valve 4	22	25 ± 5
404A51A4	J4 T	414A9L1 Eng. 2, Valve A	22	25 ± 5
404A51A4	J4 U	414A9L5 Eng. 2, Valve 1	22	25 ± 5
404A51A4	J4 V	414A9L2 Eng. 2, Valve C	21	25 ± 5
404A51A4	J4 W	414A9L6 Eng. 2, Valve 3	22	25 ± 5
404A51A4	J4 X	414A9L3 Eng. 2, Valve B	22	25 ± 5
404A51A4	J4 Y	414A9L7 Eng. 2, Valve 2	21	25 ± 5
404A51A4	J4 Z	414A9L4 Eng. 2, Valve D	22	25 ± 5
404A51A4	J4 a	414A9L8 Eng. 2, Valve 4	22	25 ± 5
404A71A19	J4 A	415A8L1 Eng. 1, Valve A	22	25 ± 5
404A71A19	J4 B	415A8L5 Eng. 1, Valve 1	22	25 ± 5
404A71A19	J4 C	415A8L2 Eng. 1, Valve C	22	25 ± 5
404A71A19	J4 D	415A8L6 Eng. 1, Valve 3	22	25 ± 5
404A71A19	J4 E	415A8L3 Eng. 1, Valve B	22	25 ± 5
404A71A19	J4 F	415A8L7 Eng. 1, Valve 2	22	25 ± 5
404A71A19	J4 G	415A8L4 Eng. 1, Valve D	22	25 ± 5
404A71A19	J4 H	415A8L8 Eng. 1, Valve 4	22	25 ± 5
404A71A19	J4 J	415A10L1 Eng. 3, Valve A	22	25 ± 5
404A71A19	J4 K	415A10L5 Eng. 3, Valve 1	21	25 ± 5
404A71A19	J4 L	415A10L2 Eng. 3, Valve C	22	25 ± 5
404A71A19	J4 M	415A10L6 Eng. 3, Valve 3	22	25 ± 5
404A71A19	J4 N	415A10L3 Eng. 3, Valve B	22	25 ± 5
404A71A19	J4 P	415A10L7 Eng. 3, Valve 2	22	25 ± 5
404A71A19	J4 R	415A10L4 Eng. 3, Valve D	22	25 ± 5
404A71A19	J4 S	415A10L8 Eng. 3, Valve 4	22	25 ± 5
404A71A19	J4 T	415A9L1 Eng. 2, Valve A	22	25 ± 5
404A71A19	J4 U	415A9L5 Eng. 2, Valve 1	22	25 ± 5
404A71A19	J4 V	415A9L2 Eng. 2, Valve C	21	25 ± 5
404A71A19	J4 W	415A9L6 Eng. 2, Valve 3	22	25 ± 5
404A71A19	J4 X	415A9L3 Eng. 2, Valve B	22	25 ± 5
404A71A19	J4 Y	415A9L7 Eng. 2, Valve 2	22	25 ± 5
404A71A19	J4 Z	415A9L4 Eng. 2, Valve D	22	25 ± 5
404A71A19	J4 a	415A9L8 Eng. 2, Valve 4	21	25 ± 5

4.3.18.1 (Continued)

Stage Comp.	Test Point	APS Component	Meas. Ohms	Limit Ohms
404A4	J7 r	414A5L1	16	15 to 25
404A4	J7 d	414A5L1	20	15 to 25
404A4	J7 p	414A6L1	16	15 to 25
404A4	J7 x	414A1L1	17	15 to 25
404A4	J7 f	414A1L1	21	15 to 25
404A4	J7 v	414A2L1	15	15 to 25
404A4	J7 m	414A6L2	17	15 to 25
404A4	J7 t	414A2L2	18	15 to 25
404A4	J7 q	415A5L1	16	15 to 25
404A4	J7 c	415A5L1	19	15 to 25
404A4	J7 n	415A6L1	16	15 to 25
404A4	J7 w	415A1L1	17	15 to 25
404A4	J7 e	415A1L1	20	15 to 25
404A4	J7 u	415A2L1	14†	15 to 25
404A4	J7 k	415A6L2	18	15 to 25
404A4	J7 s	415A2L2	17	15 to 25
404A2A16	J2 B	414A7L1 Eng. 4, Valve A	38	40 ± 5
404A2A16	J2 C	414A7L2 Eng. 4, Valve 1	38	40 ± 5
404A2A16	J2 A	414A7L1 Eng. 4, Valve A	38	40 ± 5
404A2A16	J2 D	414A7L2 Eng. 4, Valve 1	38	40 ± 5

† See revision c

4.3.19 Range Safety Receiver Checks (1B66565 F)

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

Item	Ref. Location	P/N	S/N
Range Safety Receiver 1	411A97A14	50M10697	188
Range Safety Receiver 2	411A97A18	50M10697	185
Secure Command Decoder 1	411A99A1	50M10698	0046
Secure Command Decoder 2	411A99A2	50M10698	0126

Initiated on 29 January 1969, this checkout was completed and accepted on 8 February 1969.

Several manual operations were accomplished before the automatic phase of the checkout was started. The total cable insertion loss values at the 450 MHz range safety frequency were determined to be 28.2 db for range safety system 1 and 28.3 db for range safety system 2. The destruct system test set, P/N 1A59952-1, was set up at 450 $\pm$0.045 MHz with a -17 dbm output level and a 60 $\pm$0.60 kHz deviation. The stage range safety antennas were disconnected from the directional power divider; and until the open loop RF checks, the 50 ohm loads were connected to the power divider for testing.

The cable insertion loss values were loaded into the computer, initial conditions scan was conducted, the range safety receivers were transferred to

4.3.19 (Continued)

external power and turned on, and the propellant dispersion cutoff command inhibit was turned on.

The receiver AGC calibration checks were conducted next. For each input signal level used in the calibration check, the computer determined the GSE test set output levels required to compensate for the cable insertion loss. Per the computer typeout, the GSE test set was manually adjusted to the appropriate output levels. The computer determined the input signal levels and measured the low level signal strength (AGC telemetry) of each receiver. These AGC measurements, in the 0.0 to 5.0 vdc range, were multiplied by a conversion factor of 20 and presented as percent of full scale values. The difference in AGC values at each step was determined and utilized for the AGC drift check. As shown in Test Data Table 4.3.19.1, 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 $\pm$0.005 MHz, the output level was adjusted to obtain a 2.0 $\pm$0.1 vdc AGC voltage from the receiver under test. The corresponding receiver RF output level was determined, and +20 dbm was added to obtain the RF reference level. The GSE test set output level was increased by 3 db, and the test set frequency was increased to greater than 450 MHz and decreased to less than 450 MHz until the receiver AGC voltage was again 2.0 $\pm$0.1 vdc. The frequencies at which this occurred were measured as the upper and lower-3 db bandedge frequencies. The -3 db bandwidth was found as the difference between these frequencies, and the bandwidth centering

4.3.19 (Continued)

was found as the difference between the midpoint of these frequencies and 450 MHz. For the -60 db bandwidth check, this checkout was repeated, except that the test set output level was increased by 60 db in lieu of 3 db.

For the deviation threshold check, the GSE test set was adjusted to an output of 450 $\pm$0.045 MHz at a level that provided receiver input levels of -63 dbm for receivers 1 and 2. A series of checks determined the minimum input deviation frequency at which each receiver responded to the respective range safety command. For each command, the GSE test set was manually adjusted to a sequence of deviation frequencies increasing from 5 kHz per the computer typeout. At each deviation frequency, the range safety secure command decoders were checked for the presence of the command signal from the appropriate receiver. As shown in the Test Data Table, the receivers responded to all commands at minimum deviation frequencies less than the 50 kHz maximum limit.

For the radio frequency sensitivity checks, the GSE test set was adjusted for an output of 450 $\pm$0.045 MHz with a fixed deviation of 60 $\pm$0.5 kHz. A series of checks determined the minumum input signal level at which each receiver responded to the respective range safety commands. For each command, the GSE test set output was manually adjusted to a sequence of levels increasing from -86.8 dbm, as requested by the computer. This gave input levels increasing from -115.0 dbm for receivers 1 and 2. At each input level, the range safety secure command decoders were checked for receipt of the command signal from the appropriate receiver. Both receivers responded to minimum input levels less than the -93 dbm maximum limit.

4.3.19 (Continued)

The 50 ohm loads were disconnected from the stage power divider, and the range safety antennas were reconnected. For the manual open loop check, the GSE test set was adjusted for open loop operation, and the test set antenna coaxial switch was set to test position 1. The test set output level was set at -100 dbm and increased in 1 dbm increments until the AGC voltage of the least sensitive receiver no longer increased. This occurred at an output level of -69 dbm. The AGC voltage of the other receiver was verified to be within 3 vdc of this level. The check was repeated with the test set antenna coaxial switch set to test position 2 with the output level measured as -70 dbm. The test set antenna coaxial switch was returned to the first test position, and the test set output level was set at -84.25 dbm for the automatic open loop RF checks.

Under open loop conditions, the low level signal strength (AGC telemetry voltage) of receiver 1 was 3.604 vdc while that of receiver 2 was 2.732 vdc. The range safety commands were transmitted from the GSE test set, and checks of the secure command decoders indicated the 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 indicated that the receivers responded and were not adversely affected by the PCM RF transmission. An out-of-tolerance leakage voltage measurement during the decoder leakage test resulted in replacement of the range safety 2 decoder, P/N 50M10698, S/N 0026, with S/N 0126 per FARR 500-489-821. The PCM RF assembly power was turned off, and the range safety EBW firing units were

4.3.19 (Continued)

transferred to external power. The propellant dispersion cutoff command inhibits were turned off for each receiver, and the range safety receivers were turned off, thus completing the range safety receiver checks.

There were no other discrepancies during the test that were documented by FARR, other than that previously described. However, ten revisions were recorded in the procedure for the following:

a. One revision corrected a program error.

b. One revision corrected a typographical error.

c. One revision changed the program to operate the single sideband transmitter during open loop checks to verify that the single sideband system did not affect range safety system operation.

d. Three revisions repeated the open loop radio frequency checks, the radio frequency sensitivity checks, and the range safety decoders leakage test for reverification purposes.

e. One revision authorized repeating the decoder leakage test after replacement of the range safety 2 decoder per FARR 500-489-821. Results were acceptable.

f. One revision authorized changing the acceptable limits for range safety receiver 1 signal strength from 2.0 $\pm$0.1 vdc to 2.2 $\pm$0.1 vdc, based on individual characteristics indicating high signal strength output at maximum test set signal attenuation.

g. One revision indicated a malfunction resulting from single sideband output power failing to reach 5 watts within the allowed program time could be attributed to insufficient time allowed by the program.

h. One revision explained malfunction indications that occurred during initial conditions scan which did not affect the range safety receiver test.

4.3.19.1 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
-98.8	-127.0	43.887	43.887	0.000	-127.1	20.801	20.508	0.293
-91.8	-120.0	43.984	44.297	0.313	-120.1	20.703	20.605	0.098
-86.8	-115.0	44.609	43.984	0.625	-115.1	20.801	20.605	0.195
-81.8	-110.0	44.922	45.625	0.703	-110.1	21.426	20.918	0.508
-76.8	-105.0	47.266	48.203	0.938	-105.1	22.148	22.754	0.605
-71.8	-100.0	53.828	54.766	0.938	-100.1	25.840	25.840	0.000
-66.8	-95.0	65.215	65.313	0.098	-95.1	34.863	35.176	0.313
-61.8	-90.0	72.305	72.188	0.117	-90.1	53.828	53.945	0.117
-56.8	-85.0	74.043	74.141	0.098	-85.1	71.484	71.270	0.215
-51.8	-80.0	74.648	74.648	0.000	-80.1	75.371	75.176	0.195
-46.8	-75.0	74.863	76.766	0.098	-75.1	76.191	76.191	0.000
-41.8	-70.0	74.863	74.863	0.000	-70.1	76.699	76.816	0.117

-3 db RF Bandwidth Check

Function	Receiver 1	Receiver 2	Limits
Reference Voltage (AGC) (vdc)	2.24†	2.03	2.0 ± 0.1
Reference RF Power Level (dbm)	-100.0	-84.0	-
Upper Bandedge Freq. (MHz)	450.169	450.179	-
Lower Bandedge Freq. (MHz)	449.840	449.835	-
-3 db Bandwidth (kHz)	329.0	344.0	340.0 + 30.0
Bandwidth Centering (MHz)	450.004	450.007	450 ± 0.0338

-60 db RF Bandwidth Check

Function	Receiver 1	Receiver 2	Limits
Reference Voltage (AGC) (vdc)	2.24†	2.03	2.0 ± 0.1
Reference RF Power Level (dbm)	-100.0	-84.0	-
Upper Bandedge Freq. (MHz)	450.493	450.559	-
Lower Bandedge Freq. (MHz)	449.570	449.534	-
-60 db Bandwidth (MHz)	0.923	1.025	1.2 max

Deviation Sensitivity Check

Range Safety Command	Minimum Deviation (kHz) Receiver 1	Minimum Deviation (kHz) Receiver 2
Arm and Engine Cutoff	12.500	12.500
Propellant Dispersion	12.500	12.500
Range Safety System Off	12.500	12.500

† Refer to Revision f

4.3.19.1 (Continued)

RF Sensitivity Check

Range Safety Command	Minimum Input Level (dbm) Receiver 1	Minimum Input Level (dbm) Receiver 2
Arm and Engine Cutoff	-105.000	-105.100
Propellant Dispersion	-105.000	-105.100
Range Safety System Off	-110.000	-100.100

4.3.20 Range Safety System (1B66568 G)

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

Part Name	Ref. Location	P/N	S/N
Range Safety Receiver 1	411A97A14	50M10697	188
Range Safety Receiver 2	411A97A18	50M10697	185
Secure Command Decoder 1	411A99A1	50M10698	0046
Secure Command Decoder 2	411A99A2	50M10698	0126
Secure Command Controller 1	411A97A13	1B33084-503	036
Secure Command Controller 2	411A97A19	1B33084-503	035
RS System 1 EBW Firing Unit	411A99A12	40M39515-119	452
RS System 2 EBW Firing Unit	411A99A20	40M39515-119	550
RS System 1 EBW Pulse Sensor	411A99A31*	40M02852	547
RS System 2 EBW Pulse Sensor	411A99A32*	40M02852	597
Safe and Arm Device	411A99A22*	1A02446-503	00100
Directional Power Divider	411A97A56	1B38999-1	043
Hybrid Power Divider	411A97A34	1A74778-501	031
* Installed In Pulse Sensor Assembly	411A99A31/A32	1B29054-501	00007

Three tests were conducted to complete system verification. The initial test was performed on 30 January 1969. During the test, the range safety system 1 pulse sensor, P/N 40M02852, S/N 0158, did not respond properly to the EBW self test command. The pulse sensor was replaced with P/N 40M02852, S/N 547, per FARR 500-489-812. The second test was satisfactorily accomplished on 4 February 1969. However, a third test was required after replacement of the range safety system 2 decoder, P/N 50M10698, S/N 0026, with S/N 0126 per FARR 500-489-821 (refer to range safety receiver checks, H&CO 1B66565). The third and final test was performed on 8 February 1969. The measurements listed in Test Data Table 4.3.20.1 are taken from this final test and the following narrative is a description of that test.

4.3.20 (Continued)

After conducting initial conditions scan per 1B66560, the GSE destruct system test set, P/N 1A59952-1, was set 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.

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

4.3.20 (Continued)

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 nonprogrammed engine cutoff indication was off, and that the instrument unit receiver 1 arm and engine cutoff indication was off. The receiver 1 propellant dispersion cutoff command inhibit was then turned off, and the instrument unit receiver 2 arm and engine cutoff indication was verified to be off. Verification was made that the engine control bus power was then off, that the engine cutoff indications were still off at the umbilical and through both multiplexers, that the nonprogrammed 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 engine cutoff command was turned off. The engine control bus power was turned back on, and the bus voltage was measured. Both firing units were transferred to external power and verified to be off, and the charging voltage indications were measured.

The EBW firing unit arm and engine cutoff command was turned back on and verified to be received by range safety system 2. The system 2 firing unit charging voltage indication was measured. Verification was made that the engine cutoff indications were off at the umbilical and through the AO and BO telemetry multiplexers, that the nonprogrammed engine cutoff indication was off, and that the instrument unit receiver 2 arm and engine cutoff indication was off. The

4.3.20 (Continued)

receiver 2 propellant dispersion cutoff command inhibit was turned off, and the instrument unit receiver 1 arm and engine cutoff indication was verified to be off. Verification was made that the engine control bus power was still on, that the engine cutoff indication was then on at the umbilical and through both multiplexers, that the nonprogrammed 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 the system under test, the firing unit charging voltage indication was measured; and the pulse sensor was verified to be on. The propellant dispersion cutoff command inhibit was then turned back on, and the propellant dispersion command was turned off.

4.3.20 (Continued)

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 test, and the shutdown operations were accomplished.

Engineering comments noted that there were no part shortages affecting this test. FARR's initiated as a result of this test were limited to those previously described. Four revisions were made to the procedure for the following:

a. One revision changed the program to comply with ECP 3006-R1, which removed the capability to energize the O2H2 burner shutdown bus from all nonprogrammed J-2 engine cutoff commands. The program was changed to verify that burner shutdown had not been energized.

4.3.20 (Continued)

b. One revision deleted the requirement for the systems status display, Model DSV-4B-298, from the GSE equipment list because it was not operable at test time and was not required for the test.

c. Two revisions concerned malfunction indications during initial conditions scan which had no effect on the system test. The malfunctions occurred because one valve had been removed and because the program looked for a parameter that no longer existed on the stage.

4.3.20.1 Test Data Table, Range Safety System

Function	Measured Value (vdc)	Limits (vdc)
Forward Bus 1 Battery Simulator	28.199	28.0 ± 2.0
Forward Bus 2 Battery Simulator	28.079	29.0 ± 2.0
External/Internal Power Transfer Test		
External Power On		
System 1 Charging Voltage Indication	4.215	4.2 ± 0.3
System 1 Firing Unit Indication	4.199	4.2 ± 0.3
System 2 Charging Voltage Indication	4.270	4.2 ± 0.3
System 2 Firing Unit Indication	4.266	4.2 ± 0.3
Internal Power		
System 1 Charging Voltage Indication	4.229	4.2 ± 0.3
System 2 Charging Voltage Indication	4.279	4.2 ± 0.3
External Power Off		
System 1 Charging Voltage Indication	0.045	0.3 max
System 2 Charging Voltage Indication	0.050	0.3 max
Firing Unit Arm and Engine Cutoff Test		
Engine Control Bus Voltage	27.783	28.0 ± 2.0
Receiver 1 Signal Strength Indication	3.732	3.75 ± 1.25
Receiver 2 Signal Strength Indication	3.784	3.75 ± 1.25
System 1 Arm and Engine Cutoff Test		
Firing Unit Charging Voltage Indication	4.225	4.2 ± 0.3
Engine Control Bus Voltage (Power Off)	-0.062	0 ± 0.45
Engine Control Bus Voltage (Power On)	27.783	28.0 ± 2.0

4.3.20.1 (Continued)

Function	Measured Value (vdc)	Limits (vdc)
External Power Off		
System 1 Charging Voltage Indication	0.060	0.3 max
System 2 Charging Voltage Indication	0.039	0.3 max
System 2 Arm and Engine Cutoff Test		
Firing Unit Charging Voltage Indication	4.284	4.2 ± 0.3
Engine Control Bus Voltage	27.783	28.0 ± 2.0
Propellant Dispersion Test		
System 1 Propellant Dispersion Tes		
Charging Voltage Indication (Pulse Sensor Off)	4.229	4.2 ± 0.3
Charging Voltage Indication (Pulse Sensor On)	1.454	3.0 max
System 2 Propellant Dispersion Test		
Charging Voltage Indication (Pulse Sensor Off)	4.284	4.2 ± 0.3
Charging Voltage Indication (Pulse Sensor On)	1.609	3.0 max

4.3.21 Auxiliary Propulsion System Checkout (1B70742 D)

Contained in this manual and automatic checkout were the procedures required to verify the functional capabilities of the auxiliary propulsion system (APS) when mated to the stage. This procedure defined the preliminary preparation, safety requirements, and detailed manual operations necessary for checkout.

The checkout was initiated on 30 January 1969, after the satisfactory completion of the APS and stage interface compatibility checkout, H&CO 1B49558.

After the initial setup, which included measuring and recording fuel and oxidizer tank and manifold pressures on APS module 1, a fuel valve functional and system leak check was performed. The blanket pressure line was connected to port "J" on APS 1, and the fuel tank transfer valve open command was executed. The APS panel blanket pressure supply valve was opened, and the handloader regulator was set at 20 ±5 psig. The APS blanket pressure valve was opened; then, the fuel manifold pressure was measured and recorded. Cycling of the fuel tank recirculation valve was accomplished, and it was verified that helium flowed from port "L" as the recirculation valve was opened and ceased when the valve was closed. The recirculation valve was again commanded open, and helium flow was again noted at port "L". The flow ceased when the fuel tank transfer valve was closed. The fuel tank recirculation valve and the fuel tank transfer valve were opened. After verification that the fuel manifold pressure had stabilized, both valves were closed. The APS blanket pressure panel was secured. The APS fuel manifold pressure was recorded; and after 5 minutes, a final pressure reading was taken. The same test procedure was repeated for the oxidizer section of APS 1.

4.3.21 (Continued)

A helium valve functional test was accomplished next. The APS blanket pressure line was connected to the helium bottle fill line between the first two check valves of APS 1. The blanket pressure handloader regulator was set to 40 ±5 psig, and bleed valve V-3315 was closed. The APS 1 fuel and oxidizer ullage pressures were reported and entered in Test Data Table 4.3.21.1.

The APS fuel and oxidizer tank ullage and emergency ullage vent valves were opened for 1 second, then closed. The APS blanket pressure panel was again secured, and the fuel and oxidizer ullage pressures were monitored for 5 minutes. The initial and final pressures were noted and recorded.

The pressure scan and engine valve function test for APS 1 was the next section completed. The blanket pressure regulator was set to 25 ±5 psig, and the bleed valve was closed. The APS 1 blanket pressure valve was opened, and the fuel tank and oxidizer tank transfer valves were opened. The APS automatic checkout was called up on the automatic checkout system, and the manual automatic control switch was placed in the automatic mode. During this section of the test, the computer verified several APS functions. Upon completion of the automatic test, manual control was resumed. The magnetic amplifier output voltage required to cycle the engine valves was noted and recorded.

The APS 1 blanket pressures were re-established and recorded; then, the fuel and oxidizer tank transfer valves were closed. The blanket pressure panel bleed valve was opened, and the handloader regulator was secured; then, the bleed valve was closed. Final securing from the APS 1 test was accomplished by closing the APS 1 blanket pressure valve and the blanket pressure supply valve.

4.3.21 (Continued)

The test, as performed on APS 1, was repeated for APS 2. All data for APS 1 and APS 2 are found in the Test Data Table.

No FARR's were written as a result of this test, and the procedure was accepted on 18 February 1969.

Four revisions were written to the procedure:

a. One revision corrected an error in the procedure listing.

b. One revision changed the throat plug part number from P/N 1B35115-1 to P/N 1B56419, as the P/N 1B35115-1 was not available.

c. One revision was required to update the procedure to the latest stage configuration.

d. One revision added a step to remove the flex lines from ports J and W, and to cap the ports.

4.3.21.1 Test Data Table, Auxiliary Propulsion System Checkout

Module Setup	APS 1	APS 2	Limits
Fuel Tank Pressure (psig)	5.0	4.90	0.5 min
Fuel Ullage Pressure (psia)	43.60	14.80	*
Fuel Manifold Pressure (psia)	23.10	10.90	*
Oxidizer Tank Pressure (psig)	5.0	4.0	0.5 min
Oxidizer Ullage Pressure (psia)	45.80	37.10	*
Oxidizer Manifold Pressure (psia)	13.10	14.00	*
Fuel Valve Functional Check			
Fuel Manifold Pressure			
Initial (psia)	32.70	28.40	35 ± 15
Final (psia)	32.70	28.40	35 ± 15

* Limits Not Specified

4.3.21.1 (Continued)

Module Setup	APS 1	APS 2	Limits
Oxidizer Valve Functional Che			
Oxidizer Manifold Pressure			
Initial (psia)	31.90	32.70	35 ± 15
Final (psia)	31.90	32.70	35 ± 15
Helium Valve Functional Check			
Fuel Ullage Pressure (psia)	43.60	44.50	50 ± 15
Oxidizer Ullage Pressure	46.30	41.90	50 ± [illegible]
Engine Valve Functional Test			
Voltage Required for Valve Cy			
Engine 1 (vdc)	3.938	3.830	*
Engine 2 (vdc)	3.979	3.882	*
Engine 3 (vdc)	3.912	3.820	*
Blanket Pressures (psia)			
Oxidizer Ullage	46.70	43.60	*
Fuel Ullage	44.10	39.70	*
Fuel Manifold	37.10	31.40	*
Oxidizer Manifold	34.50	37.50	*

* Limits Not Specified

4.3.22 Auxiliary Propulsion System Test (1B67673 A)

Contained in this automatic checkout were the procedures which verified the design integrity and operational capability of the auxiliary propulsion system (APS) electrical system for the flight stage.

Initial conditions for the test were established with the performance of the stage power setup procedure, H&CO 1B66560, on 31 January 1969. The instrument unit (IU) substitute power supply was turned on and measured. The APS 1 test was started by measuring the helium sphere and helium regulator outlet pressure through the AO and BO multiplexers. The helium sphere, oxidizer tank, and fuel tank temperatures were measured. The fuel and oxidizer ullage pressure were then measured.

The APS 1 engine propellant transfér valve test was accomplished next. The APS firing command was turned on, and the 1-2 engine valve open indication was verified to be 0.00 vdc (closed position). The aft bus 1 voltage was then measured. With the APS firing command turned off, the 1-2 engine valve was commanded open, then closed. During valve movement, the following functions were monitored and recorded: time, valve voltage, thrust chamber pressure, and oxidizer and fuel manifold pressures. The 1-2 engine propellant transfer valve full open indication was measured by the BO multiplexer. The APS firing enable command was turned off, the aft bus 1 voltage was measured, and the 1-3 engine propellant transfer valve open indication was verified to be -0.0005 vdc (closed position).

With the APS 1 firing command turned off, the propellant transfer valve for the 1-3 engine was operated; and the operating elapsed time, valve voltage,

4.3.22 (Continued)

thrust chamber pressure, and oxidizer and fuel manifold pressures were recorded The propellant transfer valve full open indication was measured, and the firing command was turned on. The transfer valve was closed, the open indication was recorded at 0.000 vdc, and the aft bus 1 voltage was measured.

The APS 1 firing command was again turned off, and the test repeated for the 1-1 engine propellant transfer valve.

Upon completion of the APS 1 engine propellant transfer valve test, the entire test was repeated for APS 2.

The APS 1 and 2 ullage engine propellant transfer valves, engine 1-4 and 2-4, were then tested using the same method as that used for the attitude control engines.

All measured values are listed in Test Data Table 4.3.22.1. The checkout was completed and accepted on 6 February 1969.

There were no FARR discrepancies, and the APS system was accepted for use.

There were six revisions written during the course of this procedure:

a. One revision deleted the requirement for recording the APS chamber pressure on an oscillograph as the parameters are measured and printed out by the computer.

b. One revision corrected a program error.

c. One revision concerned a change to the initial condition scan.

d. One revision attributed a malfunction indication received during the initial condition scan to concurrent running of the leak check procedure.

4.3.22 (Continued)

e. One revision concerned the LH2 continuous vent orifice by-pass valve not closed malfunction, and stated that the valve had been removed per FARR 500-608-846.

f. One revision authorized switching temporarily to manual control, during a hold point, to allow for manual operation required by concurrent running of the leak check procedure.

4.3.22.1 Test Data Table, Auxiliary Propulsion System

APS 1 Test

Function	Meas.	AO Multi	BO Multi	Limit
IU Substitute Power (vdc)	-30.48			-28.5 ± 2.5
Helium Sphere Pressure (psia)		45.8	42.0	100 max
Helium Regulator Outlet (psia)		48.4	47.6	50.0 ± 10.0
Helium Sphere Temperature (°F)		95.0	-	*
Oxidizer Tank Temperature (°F)		75.1	75.0	*
Fuel Tank Temperature (°F)		75.9	75.5	*
Fuel Tank Ullage Pressure (psia)		43.6	-	50.0 + 10.0
Oxidizer Tank Ullage Pressure (psia)		46.7	-	50.0 ± 10.0
Fuel Manifold Pressure (psia)		37.1	-	40.0 ± 20.0
Oxidizer Manifold Pressure (psia)		34.9	-	40.0 ± 20.0
Engine 1-2 Valve Test				
Valve Open Ind (Closed) (vdc)	-0.010			*
Aft Bus 1 Voltage (vdc)	28.118			*
Valve Open Ind (Open) (vdc)	3.979			*
Engine 1-3 Valve Test				
Valve Open Ind (Closed) (vdc)	-0.005			*
Aft Bus 1 Voltage (vdc)	28.039			*
Valve Open Ind (Open) (vdc)	3.912			*
Engine 1-1 Valve Test				
Valve Open Ind (Closed) (vdc)	-0.005			*
Aft Bus 1 Voltage (vdc)	28.239			*
Valve Open Ind (Open) (vdc)	3.938			*

* Limits Not Specified

4.3.22.1 (Continued)

APS 1 - Engine Propellant Transfer Valve Tests

Valve Movement	Time (sec)	Valve Open Ind (vdc)	Measured Pressures (psia) Thrust Chamb	Oxid Manif	Fuel Manif
Engine 1-2					
Open	0.000	0.000	18.051	35.351	37.096
	0.024	-0.005	18.051	35.787	37.096
	0.063	3.979	29.333	34.478	37.096
	0.100	3.984	31.794	34.478	37.096
Close	0.023	3.989	31.179	32.731	35.787
	0.059	0.005	26.051	32.731	35.787
	0.094	0.000	21.743	31.858	34.914
	0.129	0.000	19.076	31.858	34.914
	0.164	0.005	18.256	31.858	35.351
Engine 1-3					
Open	0.000	0.005	19.281	35.787	37.096
	0.021	0.138	19.076	35.351	37.096
	0.057	3.892	29.128	35.351	37.096
	0.093	3.907	32.410	35.351	37.096
	0.128	3.912	33.436	33.604	37.096
Close	0.021	3.938	33.230	33.604	35.351
	0.059	0.030	28.103	31.423	35.351
	0.097	0.005	22.769	31.423	34.914
	0.135	0.000	20.718	32.731	34.914
	0.170	0.000	19.281	32.731	34.914
Engine 1-1					
Open	0.000	0.005	18.666	35.787	37.969
	0.022	0.000	18.871	35.351	37.532
	0.059	3.892	24.000	35.351	37.096
	0.096	3.938	24.820	32.731	37.096
	0.134	3.943	23.794	32.731	37.096
Close	0.022	3.800	21.948	30.113	34.478
	0.059	0.051	18.666	30.113	33.604
	0.094	0.005	18.666	28.804	33.604
	0.129	0.005	18.666	28.804	33.604
	0.164	0.000	18.871	29.240	33.168

APS 2 Test

Function	Meas.	AO Multi	BO Multi	Limit
IU Substitute Power (vdc)	-30.36			-28.5 ± 2.5
Helium Sphere Pressure (psia)		42.0	42.0	100.0 max

4.3.22.1 (Continued)

Function	Meas.	AO Multi	BO Multi	Limit
Helium Regulator Outlet (psia)		41.9	41.9	50.0 ± 10.0
Helium Sphere Temperature (^{o}F)		95.0	-	*
Oxidizer Tank Temperature (^{o}F)		75.4	75.4	*
Fuel Tank Temperature (^{o}F)		74.7	74.4	*
Fuel Tank Ullage Pressure (psia)		40.2	-	50.0 + 10.00
Oxidizer Tank Ullage Pressure (psia)		43.6	-	50.0 ∓ 10.00
Fuel Manifold Pressure (psia)		31.4	-	40.0 ∓ 20.00
Oxidizer Manifold Pressure (psia)		35.8	-	40.0 ∓ 20.00
Engine 2-2 Valve Test				
Valve Open Ind (Closed) (vdc)	-0.005			*
Aft Bus 1 Voltage (vdc)	28.118			*
Valve Open Ind (Open) (vdc)	3.882			*
Engine 2-3 Valve Test				
Valve Open Ind (Closed) (vdc)	-0.005			*
Aft Bus 1 Voltage (vdc)	28.118			*
Valve Open Ind (Open) (vdc)	3.820			*
Engine 2-1 Valve Test				
Valve Open Ind (Closed) (vdc)	-0.005			*
Aft Bus 1 Voltage (vdc)	28.039			*
Valve Open Ind (Open) (vdc)	3.830			*

APS 2 - Engine Propellant Transfer Valve Tests

			Measured Pressures (psia)		
Valve Movement	Time (sec)	Valve Open Ind (vdc)	Thrust Chamb	Oxid Manif	Fuel Manif
Engine 2-2					
Open	0.000	0.000	19.486	35.787	31.858
	0.024	0.000	19.486	35.787	31.423
	0.061	3.866	31.179	35.787	31.423
	0.097	3.882	34.051	34.478	31.423
	0.132	3.896	34.461	34.478	31.423
Close	0.022	2.810	33.846	34.914	30.550
	0.058	0.005	27.896	34.914	30.550
	0.093	0.000	23.589	34.914	29.676
	0.130	0.005	21.128	34.914	29.676
	0.169	0.000	19.691	34.914	29.676

* Limits Not Specified

4.3.22.1 (Continued)

Valve Movement	Time (sec)	Valve Open Ind (vdc)	Measured Pressures (psia) Thrust Chamb	Oxid Manif	Fuel Manif
Engine 2-3					
Open	0.000	0.005	18.666	36.224	31.423
	0.022	0.000	18.871	36.224	31.858
	0.058	3.738	27.896	36.224	31.858
	0.092	3.810	30.153	34.914	31.423
	0.128	3.830	29.743	34.914	31.423
Close	0.022	3.841	28.718	32.295	29.676
	0.062	0.005	21.948	32.295	29.676
	0.099	0.005	18.871	31.858	29.240
	0.134	0.000	18.871	31.858	29.240
	0.169	0.000	18.666	32.731	29.240
Engine 2-1					
Open	0.000	0.000	18.256	35.787	31.423
	0.022	0.000	18.666	35.787	31.423
	0.059	3.773	29.743	34.914	31.423
	0.098	3.835	33.846	34.914	31.423
	0.134	3.825	34.666	34.914	31.423
Close	0.023	3.855	33.846	34.914	31.423
	0.059	0.000	29.333	34.914	31.423
	0.093	0.000	23.794	34.914	30.113
	0.128	0.010	20.718	34.914	30.113
	0.163	0.000	19.691	34.914	29.676

Ullage Engine Tests

Function	Measurement	Limits
IU Substitute Power (vdc)	-30.36	-28.5 ± 2.5
APS 1 Fuel Supply Manifold Pressure (psia)	35.8	40.0 ∓ 20.0
APS 1 Oxidizer Supply Manifold Pressure (psia)	34.9	40.0 ∓ 20.0
APS 2 Fuel Supply Manifold Pressure (psia)	31.4	40.0 ∓ 20.0
APS 2 Oxidizer Supply Manifold Pressure (psia)	35.8	40.0 ∓ 20.0

Ullage Engine Propellant Transfer Valve Test

Valve Movement	Time (sec)	Measured Pressures (psia) Fuel Chamb	Oxid Manif	Thrust Manif
APS 1 - Engine 1-4				
Open	0.000	36.224	34.917	19.691
	0.032	37.096	34.042	22.974
	.077	35.787	34.914	22.974

4.3.22.1 (Continued)

Valve Movement	Time (sec)	Measured Pressures (psia) Fuel Chamb	Oxid Manif	Thrust Manif
	0.123	35.351	34.914	25.436
	0.171	35.351	32.295	25.436
	0.218	33.604	30.113	24.615
Close	0.032	32.731	29.240	24.000
	0.077	30.986	28.367	23.384
	0.124	30.986	28.367	23.384
	0.174	30.986	28.367	19.486
	0.219	30.986	28.367	19.691
APS 2 - Engine 2-4				
Open	0.000	32.295	35.787	19.076
	0.032	31.858	35.787	19.076
	0.077	31.858	35.787	19.076
	0.123	31.858	35.351	19.076
	0.171	31.423	35.351	19.076
	0.218	31.423	36.659	19.076
Close	0.032	31.858	36.224	19.076
	0.077	31.423	35.351	18.871
	0.124	31.423	35.351	19.691
	0.174	30.550	34.914	19.691
	0.219	30.550	34.914	19.281

4.3.23 Telemetry and Range Safety Antenna System Checks (1B64679 F)

The PCM RF assembly, P/N 1B65788-1, S/N 15502, was replaced during a line check with P/N 1B65788-1, S/N 15505 per FARR 500-608-382. The replacement required issuance of this procedure to perform the required checkout of the new PCM RF assembly. This was satisfactorily accomplished on 1 February 1969.

Stage power was turned on for the PCM transmitter test. A dummy load, P/N 1A84057-1, S/N 658, was connected to the output of the transmitter, and power was turned on to the PCM RF assembly. After allowing 3 minutes for transmitter warmup, a 5 vdc input signal was applied, and the output frequency was measured at 258.548 MHz. The frequency measurement was then repeated after reversing the polarity of the 5 vdc input. This repeat measurement was recorded as 258.475 MHz. The PCM transmitter center frequency was calculated by averaging the two measured frequencies, and the carrier deviation was calculated as one-half of the differential between the two measured frequencies. The resultant center frequency of 258.511 MHz and carrier deviation of 36.5 kHz were within the allowable limits of 258.500 $\pm$0.026 MHz and 36.0 $\pm$3.0 kHz, respectively. No other checks were required to verify proper operation of the new PCM RF assembly, and it was accepted for use.

There were no discrepancies documented by FARR during this checkout. One revision was recorded in the procedure which deleted all portions of the procedure except those required to checkout the new PCM RF assembly.

4.3.24 Signal Conditioning Setup (1B64681 G)

This procedure calibrated the stage 5 volt and 20 volt excitation modules 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 monitor. Only the particular items calibrated during this procedure are noted below and in Test Data Table 4.3.24.1.

The test was satisfactorily performed on 3 February 1969. 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 $\pm$0.5 vdc; and each module was adjusted to obtain a 5 vdc output of 5.0 $\pm$0.005 vdc, a -20 vdc output of -20.00 $\pm$0.005 vdc, and an ac output of 10 $\pm$1 volt peak-to-peak at 2000 $\pm$200 Hz. The final values measured, as shown in the test data table, were all within the above limits. The ac output measurements were made with the test switch set to four different positions, sequentially, and were found to be the same for each position.

Seven 20 volt excitation modules were calibrated by adjusting the coarse control and fine control on each module to obtain an output of 20.000 $\pm$0.005 vdc. As shown in the test data table, the final measured value for each module was within the above limits.

4.3.24 (Continued)

One temperature bridge required calibration due to replacement of the transducer for measurement C0040, temperature-oxid tank position 1. The pressure readings, at ambient conditions, for the hydraulic reservoir oil pressure, the accumulator GN2 pressure, the auxiliary hydraulic pump motor gas pressure, and the auxiliary hydraulic pump air tank pressure were obtained from the DDAS automatic checkout, H&CO 1B66564.

No FARR's were generated as a result of this test. Four revisions were made to the procedure for the following:

a. One revision corrected a procedure error.

b. One revision deleted the Model DSV-4B-298 system status display from the required GSE test equipment list because it was not required for this test.

c. One revision concerned the deletion of the sections of the procedure that were not required. This procedure is used to calibrate only those measurements found to be out-of-tolerance during stage checkout.

d. One revision gave instructions to obtain the pressure readings for the hydraulic pressure transducers from the DDAS automatic checkout, H&CO 1B66564.

4.3.24.1 Test Data Table, Signal Conditioning Setup

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

Reference Location	S/N	5 vdc Output (vdc)	-20 vdc Output (vdc)	ac Output vpp	ac Output Hz
411A99A33	0144	4.999	-19.998	10.0	2008
404A52A7	0174	4.999	-20.004	10.0	2003
411A98A2	0191	4.997	-20.000	10.0	1992

4.3.24.1 (Continued)

20 Volt Excitation Module - P/N 1A74036

Reference Location	S/N	20 vdc Output (vdc)
411A61A242	0293	19.999
404A62A241	0296	19.996
404A63A241	0294	19.999
404A64A241	0370	20.001
404A65A241	*	20.001
404A63A233	0265	19.999
404A66A241	0355	19.999

Temperature Bridges

Function	Reference Location	S/N	Measurement		Limits
C0040 Temperature-Oxid Tank Pos #1 (P/N 1A67862-535)	406MT613	10644	Low	0.000 mvdc	0 + 0.05 mvdc
			High	24.000 mvdc	24.0 ± 0.3 mvdc

Hydraulic Pressure Transducer Ambient Condition Check

Function	Measurement	Limits
Reservoir Oil Pressure	13.965 psia	14.7 + 8 psia
GN2 Accumulator Pressure	1385.406 psia	1395 + 50 psia
Aux Hyd Pump Motor Gas Press	0.196 psig	0 ∓ 1.2 psig
Aux Hyd Pump Air Tank	14.893 psia	14.7 ± 13 psia

* S/N Not Available

4.3.25 Propulsion System Test (1B66572 H)

This automatic procedure performed the deferred postfire integrated electromechanical functional tests required to verify the operational capability of the stage propulsion system. For convenience of performance, the test sequence were divided into three sections: The first section checked the ambient helium system and included functional checks of the pneumatic control system and the propellant tanks repressurization system; the second test section checked the propellant tanks pressurization system; and the third section was a four part functional check of the J-2 engine system. The first segment of the J-2 engine checkout tested the spark ignition systems for the J-2 engine thrust chamber and gas generator, the second segment functionally checked the engine cutoff logic and delay timers, the third segment checked the J-2 engine valve sequencing with control helium pressurization, and the final segment was a combined automatic check of the J-2 engine system operation.

Two tests were performed to demonstrate proper operation of the propulsion system. The J-2 engine section of the first attempt on 4 February 1969, was not acceptable due to an out-of-tolerance condition of the main LOX valve 2nd stage travel time. The engine sequence was repeated to verify the discrepancy. After installation of a new control orifice by Rocketdyne, the J-2 engine sequence was successfully accomplished on 7 February 1969. The procedure was accepted on 11 February 1969.

Significant measurements recorded during propulsion system testing are listed in Test Data Table 4.3.25.1 The following narrative is a description of the tests performed.

4.3.25 (Continued)

Subsequent to the performance of initial conditions scan, testing of the ambient helium system commenced by pressurizing the ambient helium pneumatic control sphere and repressurization spheres to 700 $\pm$50 psia and setting the stage control helium regulator discharge pressure at 515 $\pm$50 psia. A series of checks verified the proper operation of the control helium dump valve and the pneumatic power control module shutoff valve. The proper functioning of the LOX and LH2 repressurization system was verified, including operation of the control valves, dump valves, and pressure switch system control.

A three-cycle test of the engine pump purge pressure switch preceded the functional checkout of the engine pump purge valve. The control helium regulator backup pressure switch and the control helium shutoff valve were similarly tested. The control helium sphere was pressurized to 670.20 psia; and the control helium regulator discharge pressure was measured at 536.86 psia, both within acceptable limits. A series of checks verified the operation of the pneumatically controlled valves, including the LH2 and LOX vent valves, fill and drain valves, prevalves, chilldown shutoff valves, the LH2 directional vent valve, the O2H2 burner propellant valves, the LOX nonpropulsive vent valve and the LH2 latch relief valve. The functional check of the LH2 continuous orificed bypass valve was deleted by revision e as the valve control module had been removed per FARR 500-608-846.

Section two, the propellant tanks pressurization systems test, was initiated with functional checks of the cold helium dump and shutoff valves. The operation and the ability of the cold helium regulator backup pressure switch to

4.3.25 (Continued)

properly control the cold helium shutoff valve was verified by the three-cycle pressure switch test.

The LOX and LH2 repressurization control valves were verified to operate properly, and the operation of the LOX and LH2 tank repressurization backup pressure switch interlocks was verified by the three-cycle test and by demonstrating that the switches properly controlled the LOX and LH2 repressurization control valves.

The proper operation of the O2H2 burner spark ignition system was verified. The LOX tank pressure switches, the cold helium shutoff valve, and the cold helium heat exchanger bypass valve were verified to operate properly. Proper control of the LOX main fill valve, the LOX auxiliary tank pressurization valve, the LOX replenish valve, and the LOX repressurization valve by the pressure switches was demonstrated.

The LH2 repressurization and ground fill overpressurization pressure switches were verified to operate properly. Control of the LH2 main fill valve, the LH2 replenish valve, the LH2 auxiliary tank pressure valve, the step pressure valve, and the repressurization control valve by the pressure switches was also demonstrated. After satisfactory completion of the LH2 pressure switch checks, the cold helium system was pressurized to 590.94 psia; and the cold helium sphere blowdown and cold helium regulator high flow test were conducted. The cold helium system was then repressurized to 655.86 psia, and the cold helium sphere blowdown and cold helium regulator low flow test were conducted.

4.3.25 (Continued)

The cold helium spheres were vented, and a series of checks verified proper operation for the O2H2 burner voting circuit and burner malfunction temperature sensors. This completed testing of the propellant tanks pressurization systems.

Section three, the J-2 engine functional tests, was conducted next. The LH2 and LOX tanks were vented to ambient; the O2H2 burner spark systems 1 and 2, the emergency detection systems 1 and 2 engine cutoffs, the repressurization control valves, and the O2H2 burner propellant valves were verified to operate properly.

The engine spark test verified proper operation of the thrust chamber augmented spark igniter (ASI) and gas generator spark systems. The engine start tank was pressurized, the proper operation of the start tank vent valve was verified, and the start tank was vented to ambient pressure prior to the engine cutoff test. The engine ready signal was verified to be on, and the simulated mainstage OK signal opened the prevalves. Verification of proper prevalve response to the switch selector engine cutoff signals was made with the prevalves closing to the cutoff signal and opening at signal removal. The engine ignition cutoff test and the LH2 injector temperature detector bypass test were satisfactorily conducted.

The next series of tests verified that the simulated aft separation signals, 1 and 2, individually inhibited engine start and demonstrated proper operation of the LH2 injector temperature detector bypass and start tank discharge control.

4.3.25 (Continued)

During these tests, measurements were made of the helium delay timer, the sparks de-energized timer, and the start tank discharge timer

Three-cycle tests of mainstage OK pressure switches 1 and 2 were conducted. It was 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, pickup of either switch would maintain the engine in mainstage. It was also demonstrate that dropout of both pressure switches was required to turn on engine thrust OK indications and cause engine cutoff.

The engine helium control sphere was pressurized to 1445.84 psia to conduct the engine valve sequence tests which demonstrated that actuation and deactuation of the helium control solenoid valve caused the LH2 and LOX bleed valves to close and open, that opening and closing the ignition phase control solenoi valve caused the engine augmented spark igniter (ASI) LOX valve and engine mai fuel 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.

The final test was the combined automatic functional demonstration of the enti J-2 engine system. The necessary commands were given to initiate engine start and cutoff; and throughout the automatic sequence, the engine system responses were verified to be within the predetermined limits.

One shortage existed at the start of this test. The LH2 continuous vent orificed bypass valve module, P/N 1B67193-511, S/N 54, had been removed per FARR

4.3.25 (Continued)

500-608-846. The section of the test concerning the valve module was deleted by a revision.

One item of interim-use material (IUM) was installed at the time of this test. The LOX pressurization control module, P/N 1B42290-505, was installed in place of a P/N 1B42290-511. The IUM part was scheduled for removal when the P/N 1B42290-511 is available.

FARR 500-703-636 reported that the ground fill overpressure pressure switch, P/N 1B52624-511, S/N 024, had an average dropout value of 28 psia. The minimu average dropout value should have been 27.6 psia. The defective switch was removed and replaced.

Twenty revisions were recorded in the procedure as follows:

a. Five revisions concerned program changes required to adapt the SCC checkout for use at the STC.

b. Three revisions were required to correct TRD and program errors.

c. One revision stated that the preflight calibration mode malfunction was due to a program error. This function does not exist on this stage.

d. One revision concerned the malfunction of the LH2 continuous vent orificed bypass valve, which was caused by the removal of the valve control module from the stage on FARR 500-608-846.

e. One revision authorized the deletion of the LH2 tank continuous vent test as the LH2 continuous vent orificed bypass valve control module was not installed at the time of the test. This section of the system will be checked subsequent to installation of the control module.

f. One revision attributed an E27 channel 6 lockout to a momentary malfunction of the time code generator.

4.3.25 (Continued)

g. One revision gave instructions to switch the time code generator from the translate mode to the generate mode position as the generator was erratic in the translate mode position.

h. One revision authorized rerunning the manual check of the LH2 overpressure pressure switch after replacement of the switch on FARR 500-703-636.

i. One revision concerned the out-of-tolerance condition of the main LOX valve 2nd stage travel time, and authorized rerunning the J-2 engine sequence after replacement of an orifice.

j. One revision stated that during the pressurization of stage 8, the computer measured a pressure spike and terminated pressurization before the stage 8 was fully pressurized.

k. One revision deleted the requirement for the monochrome system status display, as the display unit was inoperative at the time.

l. One revision attributed the malfunction of the repressurization control valve ground closed command relay reset, to the LH2 and LOX repressurization control valves closed switch on the repressurization console being left in the closed position.

m. One revision authorized the temporary removal and reinstallation of the control helium regulator backup calip switch orifice, P/N 1B04622-571, for a special test.

n. One revision documented the use of a Heise gauge to verify readings for the backup pressure switch supply, the LOX pressure actuation sequence valve supply, the LH2 and LOX systems checkout supply transducers.

4.3.25.1 Test Data Table, Propulsion System Test

Section 1, Ambient Helium Test

Pressure Switch Checks

Function	Measurement Test 1	Test 2	Test 3	Limits
Engine Pump Purge Pressure Switch				
Pickup Pressure (psia)	123.47	121.93	121.93	136.0 max
Dropout Pressure (psia)	109.54	109.54	108.77	99.0 min
Deadband (psi)	13.93	12.38	13.16	3.0 min
Control Helium Regulator Backup Pressure Switch				
Pressurization Time (sec)	17.623	16.913	16.256	180.0 max
Pickup Pressure (psia)	609.313	605.453	603.906	600.0 ± 21.
Depressurization Time (sec)	2.475	2.873	2.938	180.0 max
Dropout Pressure (psia)	499.150	503.000	502.230	490.0 ± 31.

Pneumatically Controlled Valve Checks

Valve	Operating Times (sec) Open	Total Open	Close	Total Close	Boost Close	Total Boo Closed
LH2 Vent Valve	0.021	0.081	0.229	0.465	0.083	0.226
LOX Vent Valve	0.020	0.075	0.113	0.410	0.064	0.287
LOX Fill & Drain Valve	0.140	0.245	0.612	2.098	0.371	0.834
LH2 Fill & Drain Valve	0.066	0.151	0.504	1.396	0.238	0.560
LOX Prevalve	0.943	1.533	0.157	0.274	*	*
LH2 Prevalve	0.997	1.549	0.164	0.287	*	*
LOX C/D Shutoff Valve	0.181	0.926	0.018	0.126	*	*
LH2 C/D Shutoff Valve	0.198	0.866	0.028	0.134	*	*
Burner LH2 Propellant Valve	0.027	0.096	0.030	0.098	*	*
Burner LOX Propellant Valve	0.008	0.090	0.008	0.088	*	*
LH2 Latch Relief Valve	0.025	0.067	0.145	0.344	0.080	0.201
LOX Nonpropulsive Vent Valve	0.029	0.053	0.137	0.360	0.075	0.216

* Not Applicable To These Valves

4.3.25.1 (Continued)

Section 1, Valve Checks (Continued)

Valve	Operating Times (sec) Flight Position	Total Flight Position	Ground Position	Total Ground Position
LH2 Directional Vent Valve	0.081	0.177	0.267	0.434

Section 2, Pressurization System Check

Pressure Switch Checks

Function	Measurement Test 1	Test 2	Test 3	Limits
Cold Helium Regulator Backup Pressure Switch				
Pressurization Time (sec)	12.866	12.350	12.174	180.0 max
Pickup Pressure (psia)	474.508	477.586	476.039	467.5 ± 23.5
Depressurization Time (sec)	4.364	4.474	4.487	180.0 max
Dropout Pressure (psia)	374.000	374.000	374.000	362.5 ± 33.5
LOX Tank Repressurization Backup Pressure Switch				
Pressurization Time (sec)	12.645	11.800	11.719	180.0 max
Pickup Pressure (psia)	470.700	469.900	472.200	467.5 ± 23.5
Depressurization Time (sec)	4.271	4.306	4.370	180.0 max
Dropout Pressure (psia)	375.100	376.700	372.800	362.5 ± 33.5
LH2 Tank Repressurization Backup Pressure Switch				
Pressurization Time (sec)	13.243	11.722	12.128	180.0 max
Pickup Pressure (psia)	476.000	476.000	475.300	467.5 ± 23.5
Depressurization Time (sec)	4.412	4.725	4.707	180.0 max
Dropout Pressure (psia)	369.700	370.500	366.600	362.5 ± 33.5
LOX Tank Ground Fill Pressure Switch				
Manifold Press Time (sec)	95.656	97.127	101.184	180.0 max
Pickup Pressure (psia)	39.940	39.990	39.890	41.0 max
Depressurization Time (sec)	17.976	9.258	11.647	180.0 max
Dropout Pressure (psia)	38.080	38.080	38.080	37.5 min
Deadband (psi)	1.860	1.920	1.810	0.5 min

4.3.25.1 (Continued)

Section 2, Pressurization System Checks (Continued)

Function	Measurement Test 1	Test 2	Test 3	Limits
LH2 Repressurization Control Pressure Switch				
Pressurization Time (sec)	99.967	101.474	103.876	180.0 max
Pickup Pressure (psia)	30.600	30.600	30.550	31.5 max
Depressurization Time (sec)	59.942	48.171	46.273	180.0 max
Dropout Pressure (psia)	28.270	28.160	28.320	27.8 min
Deadband (psi)	2.330	2.440	2.230	0.5 min
LH2 Ground Fill Pressure Switch				
Pressurization Time (sec)	96.495	102.518	104.324	180.0 max
Pickup Pressure (psia)	30.275	30.175	30.175	31.5 max
Depressurization Time (sec)	77.061	48.944	56.890	180.0 max
Dropout Pressure (psia)	27.90	27.90	27.85	27.8 min
Deadband (psi)	2.23	2.27	2.23	0.5 min

Burner Spark System Checks

Function	Measurement	Limits
Exciter 1 on (umb) (vdc)	3.46	2.7 min
Exciter 2 on (umb) (vdc)	3.27	2.7 min
System 1 on Ind (T/M M74) (vdc)	3.48	2.7 min
System 2 on Ind (T/M M73) (vdc)	3.24	2.7 min
Exciter 1 Off (umb) (vdc)	1.37	On-2.0 max
Exciter 2 Off (umb) (vdc)	1.15	On-2.0 max
System 1 Off Ind (T/M M74) (vdc)	0.00	0.0 + 0.2
System 2 Off Ind (T/M M73) (vdc)	0.01	0.0 ∓ 0.2

Section 3, J-2 Engine Checks

Engine Timer Checks

Function	Delay Time (sec)	Limits (sec)
Engine Ignition Timer	0.456	0.450 + 0.030
Helium Delay Timer	0.994	1.000 ∓ 0.110
Sparks De-Energized Timer	3.299	3.300 ∓ 0.200
Start Tank Discharge Timer	1.016	1.000 ∓ 0.040

4.3.25.1 (Continued)

Section 3, J-2 Engine Checks (Continued)

Pressure Switch Checks

Function	Measurement Test 1	Test 2	Test 3	Limits
Mainstage OK Pressure Switch 1				
Pickup Pressure (psia)	519.810	511.680	508.550	515.0 ± 36.0
Dropout Pressure (psia)	429.200	429.830	429.830	PU-62.5 ± 43.5
Mainstage OK Pressure Switch 2				
Pickup Pressure (psia)	531.480	524.560	525.340	515.0 ± 36.0
Dropout Pressure (psia)	468.340	469.110	467.570	PU-62.5 ± 43.5

Valve Position Measurements

Function	Position (%)	Limit (%)
Main LH2 Valve Closed	9.70	10 ± 10
Main LH2 Valve Open	90.90	90 ± 10
Main LH2 Valve Reclosed	9.80	Closed ± 1
Start Tank Discharge Valve Closed	11.50	10 ± 10
Start Tank Discharge Valve Open	89.10	90 ± 10
Start Tank Discharge Valve Reclosed	11.70	Closed ± 1
Gas Generator Valve Closed	12.50	10 ± 10
Gas Generator Valve Open	89.30	*
Gas Generator Valve Plateau	51.09	65 max
Gas Generator Valve Reclosed	12.20	Closed ± 1
Main LOX Valve Closed	8.50	10 ± 10
Main LOX Valve 1st Ramp	22.20	*
Main LOX Valve T/M Open Indication	89.70	*
Main LOX Valve Open	89.70	90 ± 10
Main LOX Valve Final Open	89.70	*
Main LOX Valve Open Difference, T/M to Final	9.00	*
Main LOX Valve Reclosed	8.90	Closed ± 1
LOX Turbine Bypass Valve Open	89.70	90 ± 10
LOX Turbine Bypass Valve Closed	9.70	10 ± 10
LOX Turbine Bypass Valve Reopened	89.60	Open ± 1

* Limits Not Specified

4.3.25.i (Continued)

Section 3, J-2 Engine Checks (Continued)

Engine Sequence Check

Function	Start Time (sec)	Oper. Time (sec)	Total Time (sec)
Engine Start			
Ignition Phase Solenoid Command Talkback	-	0.014	-
Control Helium Solenoid Command Talkback	-	0.021	-
ASI LOX Valve Open	-	0.050	-
Main LH2 Valve Open	0.047	0.083	0.130
LOX Bleed Valve Closed	-	0.069	-
LH2 Bleed Valve Closed	-	0.078	-
Start Tank Discharge Timer	-	1.012	-
Start Tank Discharge Valve Open	0.090	0.092	0.182
Mainstage Control Solenoid Energize	-	1.464	-
Ignition Phase Timer	-	0.452	-
Start Tank Discharge Control Solenoid Off	-	0.008	-
Main LOX Valve 1st Stage (Ramp) Open	0.059	0.035	0.094
Gas Generator Valve LOX Poppet Open	0.143	0.043	0.186
Start Tank Discharge Valve Closed	0.133	0.244	0.377
LOX Turbine Bypass Valve Closed	0.202	0.261	0.463
LOX Turbine Bypass Valve 80% Travel	-	0.431	-
Main LOX Valve 2nd Stage Open	0.598	1.614	2.204
Spark System Off Timer	-	3.300	-
Engine Cutoff			
Ignition Phase Control Solenoid Off	-	0.007	-
Mainstage Control Solenoid Off	-	0.035	-
ASI LOX Valve Closed	0.028	-	-
Main LOX Valve Closed	0.067	0.122	0.189
Main LH2 Valve Closed	0.085	0.235	0.320
Gas Generator Valve Closed	0.076	0.253	0.329
Gas Generator Valve LOX Poppet Closed	-	0.018	-
LOX Turbine Bypass Valve Open	0.260	0.594	0.854
Helium Control Solenoid De-Energize Timer	-	0.995	-
LOX Bleed Valve Open	10.161	-	-
LH2 Bleed Valve Open	10.550	-	-

4.3.25.1 (Continued)

Section 3, J-2 Engine Checks (Continued)

Engine Sequence Data (Oscillograph Records)

Function	Measurements Delay	Measurements Valve Motion	Limits Delay	Limits Valve Motion
Ignition (msec)				
Main Fuel Valve Open	46	72	30-90	30-130
Start Tank Disch Vlv Open	88	93	80-120	85-125
Mainstage (msec)				
GG Valve Fuel Open	70	43	*	*
GG Valve LOX Open	139	53	130-150	20-80
STDV Close	130	242	110-150	175-255
MOV 1st Stage Open	48	47	30-70	25-75
MOV 2nd Stage Open	601	1675	490-630	1650-1700
OTBV Close	**	489	**	5000 max
Cutoff (msec)				
OTBV Open	**	850	**	10,000 max
GG LOX Close	57	21	40-100	10-55
GG Fuel Close	**	193	**	*
MOV Close	61	121	45-75	105-135
MFV Close	80	227	65-115	200-250
Bleeds (msec)				
ASI Open	**	33	**	100 max
ASI Close	**	18	**	100 max
GG LOX Open	**	9180	**	30,000 max
GG LOX Close	**	49	**	200 max
GG Fuel Open	**	9740	**	30,000 max
GG Fuel Close	**	41	**	200 max
Timers (msec)				
STDV Delay	999	**	960-1040	**
Ignition Phase	451	**	420-480	**
Sparks De-Energize	3302	**	3100-3500	**
Helium Control De-Energize	993	**	890-1110	**

* Limits Not Specified

** Not Applicable To These Measurements

4.3.26 <u>All Systems Test (1B66571 J)</u>

After all individual system checkouts were completed, the all systems test (AST) demonstrated the combined operation of the stage electrical, hydraulic propulsion, instrumentation, and telemetry systems under simulated flight conditions. Where practical, the checkout followed the actual flight sequence of prelaunch operations, simulated liftoff, ullage firing, engine start, hydraulic gimbaling, engine cutoff, coast period, engine restart and cutoff, attitude control, and stage shutdown. The procedure was conducted twice, once for the umbilicals-in test, and again for the umbilicals-out test. During the umbilicals-in test, the umbilical cables were left connected during the entire procedure, to permit monitoring of the umbilical talkbacks, and to provide complete stage control for 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 pretest condition.

The test was successfully performed on 10 February 1969. The various measurements made during the umbilicals-in and umbilicals-out tests are presented in Test Data Table 4.3.26.1.

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

4.3.26 (Continued)

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 proper operation of the switch selector was verified during the umbilicals-in test only. Power turnon to the PCM RF group and the single sideband system (SSB) plus transmitter warm-up sequences completed power setup for the AST.

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 the APS fuel and oxidizer supply manifold pressures and the APS fuel and oxidizer ullage volume pressures. The LOX chilldown pump purge and engine pump purge sequence was then accomplished.

The next series of prelaunch checks verified that the LOX and LH2 vent valves and fill and drain valves opened properly on command, and that the LOX and LH2 point level sensors, fastfill 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 LH2 chilldown shutoff valves, pre-valves, and vent valves was verified, and the LOX and LH2 tank prepressurization sequences were accomplished. The LH2 pressure control module pressure

4.3.26 (Continued)

was measured during the last sequence. The LOX and LH2 fill and drain valves were then closed, the proper operation of the LH2 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. Similar measurements were made for the SSB system. 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.

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

4.3.26 (Continued)

measured with the hydraulic system unpressurized. The auxiliary 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 measured with the system pressurized. During the umbilicals-in test only, the 7.5 degree square gimbal pattern check was performed, after which the hydraulic system was depressurized by auxiliary hydraulic pump shutdown.

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 LH2 circulation pump flowrates, the static inverter-converter frequency, and the LH2 and LOX chilldown inverter frequences, using a 400 Hz GSE calibration frequency. The reference voltages were also measured for the LOX and LH2 flowmeters using a 100 Hz GSE calibration frequency, and for the LOX and LH2 pump speeds using a 1500 Hz GSE calibration frequency. The PCM/FM telemetry system forward and reflected RF powers were then measured, and the telemetry system open loop VSWR was determined. Similar measurements were made for the SSB telemetry system. 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 LH2 chilldown pumps were turned on, and the chilldown inverter currents were measured. The inverter frequencies and phase voltages were measured by hardwire and telemetry. A series of measurements were then made of the common bulkhead pressure and the LH2 ullage

4.3.26 (Continued)

pressure, their 20 and 80 percent calibration voltages, and the ambient pressures after each calibration; the LOX ullage pressure; the LH2 and LOX emergency detection system pressure; and the LH2 and LOX chilldown pump differential pressures. A telemetry and RACS calibration was then performed.

The final prelaunch checks were then started. During the umbilicals-in test, the battery simulators were turned on, and measurements were made of the battery simulator voltages and the electrical support equipment load bank voltages. During the umbilicals-out test, the checkout batteries were turned on, and the checkout battery voltages were measured. The transducers for the common bulkhead pressure and the LH2 and LOX ullage pressures were all turned off, and the transducer output voltages were measured. The LH2 and LOX fastfill 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 DDAS ground station. 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

4.3.26 (Continued)

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 LH2 and LOX prevalves were opened and reclosed, and the LH2 chilldown pump was turned off. The fire ullage ignition command was turned on, and it was verified that the two ullage ignition EBW firing units responded properly and that the ullage ignition pulse sensors were on. The aft separate simulation 1 and 2 signals were then turned on to simulate stage separation. During the above part of the umbilicals-in test only, additional checks verified that the ullage rocket firing unit disable command prevented the ignition EBW firing units from charging, and discharged the previously charged firing units while preventing them from firing.

APS roll 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

4.3.26 (Continued)

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 childown pump was then turned off, and the LH2 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 LH2 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 PU 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 4.3.17), the measured data are not repeated. Following the gimbal sequence, the propellant

4.3.26 (Continued)

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 LH2 propellant utilization valve slew check was conducted next. The propellant utilization system ratio valve position and the hydraulic pressure were measured, and the LH2 bridge 1/3 checkout relay was turned on. A 0.5 degree gimbal signal, at 0.6 Hz, was applied in the pitch and yaw planes. The engine position command currents and resulting instrument unit actuator piston positions were found to be within the required limits throughout the cycling in both planes, for the umbilicals-in and umbilicals-out tests. At the completion of the gimbal sequences, the hydraulic actuator piston positions and the engine pitch and yaw positions were measured, and the hydraulic system functions were measured with the hydraulic system pressurized. The propellant utilization system ratio valve position was measured, and the LH2 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 LH2 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 LH2 first burn relay was turned off, and the LH2 pressurization control module helium pressure was again measured. The LOX chilldown pump purge was started, the coast period command was turned on, the

4.3.26 (Continued)

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 LH2 continuous vent valves were opened, and the ullage engine command 2 was turned on and off. The engine pump purge was then completed. The LH2 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 LH2 continuous vent valves were closed, and the LOX repressurization spheres and cold helium spheres pressures were measured. The O2H2 burner spark excitation systems were verified to operate properly. The proper operation of the LOX and LH2 repressurization control valves was verified, and the LOX and LH2 tank cryogenic repressurization sequences were accomplished. During the LH2 sequence, it was verified that pick up of the LH2 pressurization switch turned on the ullage engine commands when the O2H2 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 LH2 chilldown pumps were turned on, and the chilldown inverter voltages were measured. The LH2 tank ambient repressurization sequence was then accomplished, with the LH2 tank repressurization helium sphere pressure measured during the sequence. The PU system ratio

4.3.26 (Continued)

valve position was verified to respond properly to the programmed mixture ratio switches and bridge commands. The LH2 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 LH2 second burn relay was turned on. The cold helium supply shutoff valves were closed to complete the restart sequence. An LH2 second burn repressurization sequence was accomplished, with the LH2 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 LH2 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 LH2 point level sensor would not cause engine cutoff, but that a dry condition of any two LOX sensors or any two LH2 sensors would cause engine cutoff. The sensors were checked by turning off the simulated wet conditions for the combinations of LOX and LH2 sensors. During the umbilicals-in test, the operating time of the LOX depletion engine cutoff timer was measured for each combination of LOX sensors.

4.3.26 (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 cut-off, 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. 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.

Engineering comments noted that interim use LOX pressurization module, P/N 1B42290-505, S/N 0012, was installed at reference location 403A74A1, in place of the required P/N 1B42290-511, which was not available at the time of the

4.3.26 (Continued)

test. Also, the LH2 continuous vent module, P/N 1B67193-511, and temperature transducer, P/N 1B64968-503, for measurement C382 were not installed during the test.

There were no test discrepancies documented by FARR. All problems areas were resolved by revisions to the procedure. Fifty-two revisions were recorded in the procedure for the following:

a. Twelve revisions added or changed requirements that were missing or in error.

b. Three revisions were required to update the procedure to the latest configuration.

c. Nine revisions attributed SIM interrupts malfunction indications to programming errors.

d. Two revisions deleted portions of the test that were previously accomplished.

e. One revision adjusted the program PU boiloff bias voltage based on the PU calibration boiloff bias voltage of 0.023 vdc.

f. Four revisions were explanations for clarification and information only.

g. One revision noted an error signal occurred because of a typing error.

h. Eight revisions stopped the automatic program to perform manual setups.

i. One revision indicated that slow opening for the LH2 prevalve occurred because the actuation vent was not in the required flight configuration. Added restriction of the plumbing slowed opening time.

j. One revision authorized cycling the prevalves with the actuation module vents in flight configuration to verify program requirements for valve cycling.

4.3.26 (Continued)

k. One revision attributed an out-of-tolerance measurement for APS 2 fuel ullage volume pressure to an APS module 2 system leak. The condition was documented on IIS 467350 for correction at the APS test area Gamma.

l. One revision was written to facilitate troubleshooting during the test.

m. One revision attributed out-of-tolerance SSB closed loop VSWR to breakpoint amplifier characteristics that were not taken into account by the digital data tape. Data reduction from telemetry data indicated the actual VSWR was within acceptable limits.

n. Two revisions indicated that out-of-tolerance measurements for common bulkhead ambient pressures occurred because the vacuum drawn on the common bulkhead had been locked up and maintained after the static firing.

o. One revision attributed a malfunction indication to operator error.

p. One revision indicated an out-of-tolerance stage 1 helium pressure occurred because of a burst disc failure in the test stand helium supply system.

q. One revision authorized evaluation of RF power interactio[n] between the SSB transmitter and the PCM transmitter.

r. One revision deleted securing of the APS modules, which was scheduled to be accomplished per H&CO 1B70742.

s. One revision indicated that out-of-tolerance PU oven voltage measurements occurred because of program changes made for early power turn on for the PU inverter and electronics to avoid delay. The program voltage tolerance allows for warm-up time which had been bypassed.

4.3.26.1 Test Data Table, All Systems Test

Power Setup Check

Function	Umbil.-In	Umbil.-Out	Limits
PU Power On			
PU Inv and Elect Current (amps)	0.300	0.199	5.0 max
PU Oven Voltage (vdc)	2.276†	2.251†	-0.023 ± 0.1

† Refer to revision s

4.3.26.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
Engine Control Bus On			
Aft Bus 1 Current (amps)	2.800	2.300	2.7 ± 3.0
Aft Bus 1 Voltage (vdc)	28.28	28.28	28.0 ± 2.0
Engine Control Bus Voltage (vdc)	28.091	28.091	Bus 1 ± 1.0
Component Test Power On			
Component Test Power Voltage (vdc)	28.399	28.118	Bus 1 ± 1.0
Engine Ignition Bus On			
Aft Bus 1 Current (amps)	2.399	2.500	2.7 ± 3.0
Aft Bus 1 Voltage (vdc)	28.278	28.358	28.0 ± 2.0
Engine Ignition Bus Voltage (vdc)	27.999	27.999	Bus 1 ± 1.0
APS Bus On			
Aft Bus 1 Current (amps)	3.100	2.899	2.7 ± 3.0
Aft Bus 2 On			
Aft Bus 2 Current (amps)	0.000	0.000	5.0 max
Aft Bus 2 Voltage (vdc)	55.917	55.999	56.0 ± 1.0

Propulsion System Setup Check

Function	Umbil.-In	Umbil.-Out	Limits
Amb He Pneu Sphere Pressure D236 (psia)	682.41	701.09	700.0 ± 50.0
Cold Helium Sphere Pressure D263 (psia)	808.625	804.797	825.0 ± 25.0
Control Helium Supply Pressure D019 (psia)	1485.19	1488.78	1450.0 min
Cont He Reg Discharge Pressure D014 (psia)	517.00	509.20	515.0 ± 50.0
LH2 Repress He Sphere Pressure D020 (psia)	615.09	671.19	*
LOX Repress He Sphere Pressure D088 (psia)	630.05	682.41	
LH2 Prepressurization Sequence			
LH2 Press. Control Module GH2 Press D104 (psia)	60.83	58.64	50.0 min

* Limits Not Specified

4.3.26.1 (Continued)

EBW and Telemetry Checks

Function	Umbil.-In	Umbil.-Out	Limits
PCM/FM Transmitter Output Power:			
RF Silence On (watts)	-0.15	**	2.0 max
RF Silence Off (watts)	25.22	**	10.0 min
Prelaunch C/O Group Current (amps)	1.700	1.601	1 + 3
T/M Antenna 1 Forward Power (watts)	25.607	25.936	19.0 ± 7.25
T/M RF Sys Reflected Power (watts)	0.788	0.719	3.08 max
T/M System Closed Loop VSWR	1.425	1.399	2.0 max
Operational T/M Kit RF Transmitter Power (watts)	24.478	24.626	19.00 ± 7.2
Operational T/M Kit Reflected RF Power (watts)	3.053	3.021	3.08 max
SSB Closed Loop VSWR	2.092†	2.077†	2.0 max
Inv-Conv 115 vac Output (vac)	114.83	114.83	115.0 ± 3.4C
Inv-Conv 5 vdc Output (vdc)	4.98	4.99	4.9 ∓ 0.2
Inv-Conv 21 vdc Output (vdc)	21.83	21.84	21.25 ± 1.2
Inv-Conv Operating Frequency (Hz)	400.99	401.09	400.0 ± 6.0

Hydraulic System Checks

Function	Umbil.-In	Umbil.-Out	Limits
Reservoir GN2 Mass (lbs)	1.940	1.915	1.925 ± 0.2
Corrected Reservoir Oil Level (%)	98.7	100.5	95.0 min

Hydraulic System Unpressurized

Function	Umbil.-In	Umbil.-Out	Limits
Hydraulic System Pressure (psia)	1369.031	1369.031	*
Accumulator GN2 Pressure (psia)	2378.250	2266.438	*
Accumulator GN2 Temperature (°F)	71.355	52.596	*
Reservoir Oil Temperature (°F)	80.367	38.955	*
Reservoir Oil Level (%)	89.475	86.855	*
Reservoir Oil Pressure (psia)	72.883	69.828	*
Pump Inlet Oil Temperature (°F)	75.670	72.533	*
T/M Yaw Actuator Position (deg)	1.223	1.207	*
Corrected T/M Yaw Act. Pos (deg)	1.239	1.224	*
IU Yaw Actuator Position (deg)	1.289	1.274	*
Corrected IU Yaw Act. Pos (deg)	1.289	1.266	*
T/M Pitch Actuator Position (deg)	-0.064	-0.159	*
Corrected T/M Pitch Act. Pos (deg)	-0.078	-0.174	*
IU Pitch Actuator Position (deg)	-0.060	-0.180	*
Corrected IU Pitch Act. Pos (deg)	-0.060	-0.172	*
IU Substitute 5V Power Supply (vdc)	4.999	5.005	*
Aft 5V Excitation Module (vdc)	4.988	4.988	*
Aft Bus 2 Current (amps)	0.199	0.399	*

* Limits Not Specified

** Measurement Not Applicable

† Refer to Revision m

4.3.26.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
Hydraulic System Pressurized			
Hydraulic System Pressure (psia)	3594.813	3491.500	*
Accumulator GN2 Pressure (psia)	3575.750	3556.625	*
Accumulator GN2 Temperature (°F)	89.389	72.529	*
Reservoir Oil Temperature (°F)	79.584	40.123	*
Reservoir Oil Level (%)	40.808	32.821	*
Reservoir Oil Pressure (psia)	164.531	161.039	*
Pump Inlet Oil Temperature (°F)	78.803	45.973	*
T/M Yaw Actuator Position (deg)	0.029	0.014	*
Corrected T/M Yaw Act. Pos (deg)	0.043	0.027	*
IU Yaw Actuator Position (deg)	0.044	0.074	*
Corrected IU Yaw Act. Pos (deg)	0.051	0.066	*
T/M Pitch Actuator Position (deg)	-0.018	-0.049	*
Corrected T/M Pitch Act. Pos (deg)	-0.031	-0.063	*
IU Pitch Actuator Position (deg)	-0.074	-0.074	*
Corrected IU Pitch Act. Pos (deg)	-0.081	-0.066	*
IU Substitute 5V Power Supply (vdc)	4.994	5.005	*
Aft 5V Excitation Module (vdc)	4.988	4.988	*
Aft Bus 2 Current (amps)	41.399	43.600	*
FRATS Calibration			
LOX Circ Pump Flowrate Ind (vdc)	3.861	-	3.866 ± 0.100
	-	3.861	3.866 ± 0.100
LH2 Circ Pump Flowrate Ind (vdc)	3.855	-	3.866 ± 0.100
	-	3.855	3.866 ± 0.100
Static Inv-Conv Freq Ind (vdc)	2.671	-	2.625 ± 0.100
	-	2.661	2.625 ± 0.100
LH2 C/D Inv Freq Ind (vdc)	2.595	-	2.625 ± 0.100
	-	2.595	2.625 ± 0.100
LOX C/D Inv Freq Ind (vdc)	2.636	-	2.625 ± 0.100
	-	2.641	2.625 ± 0.100
LOX Flowmeter Indication (vdc)	1.697	1.691	1.667 ± 0.100
LH2 Flowmeter Indication (vdc)	1.697	1.697	1.667 ± 0.100
LOX Pump Speed Indication (vdc)	3.128	3.128	3.125 ± 0.100
LH2 Pump Speed Indication (vdc)	1.281	1.281	1.250 ± 0.100
Telemetry RF and PU Oven Checks			
T/M Antenna 1 Forward Power (watts)	25.578	25.786	19.0 ± 7.25
T/M RF Sys Reflected Power (watts)	0.794	0.712	3.08 max
T/M System Open Loop VSWR	1.427	1.398	3.0 max
T/M Kit RF Transmitter Power (watts)	24.508	24.508	19.00 ± 7.25
T/M Kit Reflected RF Power (watts)	3.046	3.002	3.08 max
SSB Open Loop VSWR	2.089	2.076	3.0 max
PU Oven Stability Monitor Z1 (vdc)	2.281	2.281	2.65 ± 2.35
PU Oven Stability Monitor Z2 (vdc)	2.281	2.276	2.281 ± 0.075
PU Oven Stability Monitor Z3 (vdc)	2.276	2.281	2.281 ± 0.075

* Limits Not Specified

4.3.26.1 (Continued)

LOX Chilldown Inverter Checks

Function	Umbil.-In	Umbil.-Out	Limits
Inverter Current (amps)	20.37	21.51	20.0 ± 5.0
Aft Bus 2 Voltage (vdc)	55.28	54.48	*
Phase AB Voltage, Hardwire (vac)	53.1	52.3	Bus 2 ± 3.0
Phase AC Voltage, Hardwire (vac)	53.0	52.1	Bus 2 ± 3.0
Phase A1B1 Voltage, Hardwire (vac)	53.1	52.3	Bus 2 ± 3.0
Phase A1C1 Voltage, Hardwire (vac)	52.8	52.1	Bus 2 ± 3.0
Inverter Frequency, Hardwire (Hz)	400.0	401.0	400.0 ± 4.0
Inverter Frequency, Telemetry (Hz)	399.7	399.8	400.0 ± 4.0
Aft Bus 2 Voltage (vdc)	54.958	54.158	*
Phase AB Voltage, Telemetry (vac)	54.7	53.8	Bus 2 ± 3.0
Phase AC Voltage, Telemetry (vac)	54.6	53.7	Bus 2 ± 3.0

LH2 Chilldown Inverter Checks

Function	Umbil.-In	Umbil.-Out	Limits
Inverter Current (amps)	21.10	20.46	20.0 ± 5.0
Aft Bus 2 Voltage (vdc)	54.88	54.08	*
Phase AB Voltage, Hardwire (vac)	54.53	53.69	Bus 2 ± 3.0
Phase AC Voltage, Hardwire (vac)	52.71	51.80	Bus 2 ± 3.0
Phase A1B1 Voltage, Hardwire (vac)	54.86	53.62	Bus 2 ± 3.0
Phase A1C1 Voltage, Hardwire (vac)	52.78	51.61	Bus 2 ± 3.0
Inverter Frequency, Hardwire (Hz)	401.0	401.0	400.0 ± 4.0
Aft Bus 2 Voltage (vdc)	54.958	53.838	*
Phase AB Voltage, Telemetry (vac)	54.8	53.7	Bus 2 ± 3.0
Phase AC Voltage, Telemetry (vac)	54.9	53.9	Bus 2 ± 3.0
Inverter Frequency, Telemetry (Hz)	400.3	400.3	400.0 ± 4.0

Pressure Measurements

Function	Umbil.-In	Umbil.-Out	Limits
Common Bulkhead Pressure (psia)	6.839†	6.812†	14.7 ± 0.5
Common Bulkhead 20% Calib (vdc)	1.005	1.010	1.0 ± 0.1
Common Bulkhead Amb Press (psia)	6.888†	6.861†	14.7 ± 0.5
Common Bulkhead 80% Calib (vdc)	4.010	4.005	4.0 ± 0.1
Common Bulkhead Amb Press (psia)	6.834†	6.861†	14.7 ± 0.5
LH2 Ullage Pressure (psia)	14.686	14.686	14.7 ± 1.0
LH2 Ullage 20% Calib (vdc)	1.024	1.039	1.0 ± 0.1
LH2 Ullage Amb Press (psia)	14.527	14.633	14.7 ± 1.0
LH2 Ullage 80% Calib (vdc)	4.029	4.024	4.0 ± 0.1
LH2 Ullage Amb Press (psia)	14.738	14.580	14.7 ± 1.0
LOX Ullage Pressure (psia)	14.332	14.386	14.7 ± 1.0
LH2 EDS Transducer 1 Press (psia)	14.6	14.5	14.7 ± 1.0
LH2 EDS Transducer 2 Press (psia)	14.5	14.3	14.7 ± 1.0
LOX EDS Transducer 1 Press (psia)	14.2	14.3	14.7 ± 1.0

* Limits Not Specified

† See Revision n

4.3.26.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
LOX EDS Transducer 2 Press (psia)	15.0	15.0	14.7 ± 1.0
LH2 C/D Pump Diff Press, On (psid)	0.748	0.186	0.0 ± 1.2
LOX C/D Pump Diff Press, On (psid)	-0.190	-0.253	0.0 ± 1.2
LH2 C/D Pump Diff Press, Off (psid)	0.09	0.09	0.0 ± 1.2
LOX C/D Pump Diff Press, Off (psid)	-0.23	-0.23	0.0 ± 1.2
Final Prelaunch Checks			
Fwd Bus 1 Batt Sim (Bus 4D30)(vdc)	28.318	**	28.0 ± 2.0
Fwd Bus 2 Batt Sim (Bus 4D20)(vdc)	28.079	**	28.0 ± 2.0
Aft Bus 1 Batt Sim (Bus 4D10)(vdc)	28.358	**	28.0 ± 2.0
Aft Bus 2 Batt Sim (Bus 4D40)(vdc)	55.679	**	56.0 ± 4.0
Bus 4D20 ESE Load Bank (vdc)	0.000	**	0.0 ± 1.0
Bus 4D40 ESE Load Bank (vdc)	-0.079	**	0.0 ± 1.0
Bus 4D30 ESE Load Bank (vdc)	0.039	**	0.0 ± 1.0
Bus 4D10 ESE Load Bank (vdc)	0.079	**	0.0 ± 1.0
Fwd Bus 1 C/O Batt (Bus 4D30)(vdc)	**	30.278	30.0 ± 1.5
Fwd Bus 2 C/O Batt (Bus 4D20)(vdc)	**	30.118	30.0 ± 1.5
Aft Bus 1 C/O Batt (Bus 4D10)(vdc)	**	30.158	30.0 ± 1.5
Aft Bus 2 C/O Batt (Bus 4D40)(vdc)	**	60.479	61.0 ± 2.0
Com Bulkhead Press Transducer (vdc)	0.000	0.010	0.0 ± 0.353
LH2 Ullage Press Transducer (vdc)	0.005	0.010	0.0 ± 0.353
LOX Ullage Press Transducer (vdc)	0.095	0.095	0.0 ± 0.353
Fwd Bus 1 Internal (Bus 4D31)(vdc)	27.999	29.318	28.0 ± 2.0
Fwd Bus 2 Internal (Bus 4D21)(vdc)	27.679	28.438	28.0 ± 2.0
Aft Bus 1 Internal (Bus 4D11)(vdc)	28.278	29.679	28.0 ± 2.0
Aft Bus 2 Internal (Bus 4D41)(vdc)	54.958	55.679	56.0 ± 4.0
Receiver 1 Low Level Signal (vdc)	3.707	3.718	2.5 min
Receiver 2 Low Level Signal (vdc)	3.732	3.738	2.5 min
Receiver 1 Current (amps)	0.300	0.300	0.0 + 2.0
Receiver 2 Current (amps)	0.200	0.200	0.0 ± 2.0
LH2 EDS 1 Ullage Pressure (psia)	14.287	14.348	14.7 ± 1.0
LH2 EDS 2 Ullage Pressure (psia)	14.298	14.298	14.7 ± 1.0
LOX EDS 1 Ullage Pressure (psia)	14.106	14.046	14.7 ± 1.0
LOX EDS 2 Ullage Pressure (psia)	14.719	14.839	14.7 ± 1.0
LH2 EDS 1 Transducer Press (psia)	14.573	14.396	14.7 ± 1.0
LH2 EDS 2 Transducer Press (psia)	14.524	14.583	14.7 ± 1.0
LOX EDS 1 Transducer Press (psia)	14.455	13.928	14.7 ± 1.0
LOX EDS 2 Transducer Press (psia)	14.993	14.876	14.7 ± 1.0
APS Roll Checks			
IU Substitute -28 Volt Power (vdc)	-30.079	-30.118	-28 ± 2.8

** Measurements Not Applicable

4.3.26.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
Control Nozzles I IV and III II On			
Engine 1-1 Valve Open End (vdc)	3.923	3.907	*
Engine 2-1 Valve Open Ind (vdc)	3.825	3.800	*
Engine 2-1 Chamber Press (open) (psia)	32.205	27.458	*
Engine 2-1 Chamber Press (open) (psia)	34.051	28.953	*
Control Nozzles I IV and III II Off			
Engine 1-1 Valve Open Ind (vdc)	0.000	-0.005	0.0 ± 0.25
Engine 2-1 Valve Open Ind (vdc)	0.000	0.010	0.0 ± 0.25
Engine 1-1 Chamber Press (closed) (psia)	20.308	15.491	*
Engine 2-1 Chamber Press (closed) (psia)	21.948	16.133	*
Control Nozzles I II and III IV On			
Engine 1-3 Valve Open Ind (vdc)	3.902	3.871	*
Engine 2-3 Valve Open Ind (vdc)	3.830	3.794	*
Engine 1-3 Chamber Press (open) (psia)	33.230	28.313	*
Engine 2-3 Chamber Press (open) (psia)	27.486	23.185	*
Control Nozzles I II and III IV Off			
Engine 1-3 Valve Open Ind (vdc)	0.000	0.000	0.0 ± 0.25
Engine 2-3 Valve Open Ind (vdc)	0.000	0.005	0.0 ± 0.25
Engine 1-3 Chamber Press (closed) (psia)	20.513	15.705	*
Engine 2-3 Chamber Press (closed) (psia)	18.666	15.064	*
Hydraulic Gimbal Step Response Check			
Ratio Valve Pos (Relay Off)(deg)	0.42	0.42	0.0 ± 1.5
Hydraulic System Pressure (psia)	3595.0	3605.0	3575.0 ± 75.0
Ratio Valve Pos (Relay On)(deg)	32.939	33.008	20.0 min
Hydraulic Gimbal 0.6 Hz Check			
Ratio Valve Pos (Relay Off)(deg)	1.919	1.919	Previous + 1.
Hydraulic System Pressure (psia)	3595.0	3595.0	3575.0 ± 75.0

* Limits Not Specified

4.3.26.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
Pitch Act Piston Pos, AO (deg)	-0.002	-0.002	0.0 ± 0.517
Yaw Act Piston Position, AO (deg)	0.107	0.092	0.0 ∓ 0.517
Engine Pitch Position, IU (deg)	-0.060	-0.015	0.0 ∓ 0.517
Engine Yaw Position, IU (deg)	0.135	0.104	0.0 ∓ 0.517
Hydraulic System Pressurized			
Hydraulic System Pressure (psia)	3598.063	3601.375	*
Accumulator GN2 Pressure (psia)	3583.938	3575.750	*
Accumulator GN2 Temperature (°F)	80.760	58.844	*
Reservoir Oil Temperature (°F)	109.055	67.443	*
Reservoir Oil Level (%)	42.680	31.948	*
Reservoir Oil Pressure (psia)	168.457	168.457	*
Pump Inlet Oil Temperature (°F)	121.676	100.396	*
T/M Yaw Actuator Position (deg)	0.107	0.061	*
Corrected T/M Yaw Act Pos (deg)	0.121	0.074	*
IU Yaw Actuator Position (deg)	0.119	0.089	*
Corrected IU Yaw Act Pos (deg)	0.111	0.089	*
T/M Pitch Actuator Position (deg)	-0.018	-0.002	*
Corrected T/M Pitch Act. Pos (deg)	-0.031	-0.016	*
IU Pitch Actuator Position (deg)	-0.060	-0.044	*
Corrected IU Pitch Act. Pos (deg)	-0.052	-0.044	*
IU Substitute 5V Power Supply (vdc)	5.005	4.999	*
Aft 5V Excitation Module (vdc)	4.988	4.988	*
Aft Bus 2 Current (amps)	43.399	**	*
Aft Checkout Battery 2 Current (amp)	**	43.000	*
Ratio Valve Pos (Relay On) (deg)	-27.668	-27.668	-20.0 max
First Burn and Coast Period			
LOX Press Module He Press D105:			
Cold He Supply Open (psia)	228.445	245.902	*
LOX Press Sw Supply Closed (psia)	128.609	137.883	*
Cold He Control Valve Inlet Press D225:			
Cold He Supply Open (psia)	215.895	232.809	*
LOX Press Sw Supply Closed (psia)	87.148	93.150	*
LH2 Press Module He Press D104:			
LH2 Prepress Supply Open (psia)	105.56	96.83	*
LH2 Press Sw Supply Closed (psia)	84.83	73.92	*
LH2 First Burn Relay Off (psia)	63.01	57.55	*
Eng Cont He Sphere Press D019 (psia)	1331.313	1367.094	*
Aux Hyd Pump Air Tank Press (psia)	468.773	457.430	282.5 ± 217.5
Aux Hyd Pump Motor Gas Press (psig)	18.526	20.228	21 ± 12
LH2 Boiloff Bias Signal M10:			
Bias Cutoff Off (vdc)	0.30	0.47	0.0 + 2.5
Bias Cutoff On (vdc)	12.729	13.504	10.0 min

* Limits Not Specified

** Measurements Not Applicable

4.3.26.1 (Continued)

Engine Restart Preparations

Function	Umbil.-In	Umbil.-Out	Limits
LOX Repress Sphere Press D088 (psia)	615.09	674.92	*
LH2 Repress Sphere Press D020 (psia)	603.875	663.719	*
Cold He Sphere Press D261 (psia)	560.41	602.39	*
LOX Tank Cryogenic Repressurization			
Burner LOX Press Coil Press (psia)	130.793	141.156	75.0 min
LOX Tank Ambient Repressurization			
LOX Repress Sphere Press D088 (psia)	641.27	469.27	
Same, after 30 second delay (psia)	656.23	502.92	Previous ± 7
Chilldown Pumps On			
LOX C/D Inv Phase AB Voltage (vac)	53.104	55.639	50.0 min
LOX C/D Inv Phase AC Voltage (vac)	53.039	55.443	50.0 min
LOX C/D Inv Phase A1B1 Voltage (vac)	53.104	55.639	50.0 min
LOX C/D Inv Phase A1C1 Voltage (vac)	52.778	55.183	50.0 min
LH2 C/D Inv Phase AB Voltage (vac)	54.468	55.833	50.0 min
LH2 C/D Inv Phase AC Voltage (vac)	52.843	54.144	50.0 min
LH2 C/D Inv Phase A1B1 Voltage (vac)	54.664	56.093	50.0 min
LH2 C/D Inv Phase A1C1 Voltage (vac)	52.714	54.014	50.0 min
During LH2 Ambient Repressurization			
LH2 Tank Repress He Sphere Press D20 D20 (psia)	469.3	461.8	*
Same, after 30 second delay (psia)	488.0	491.0	Previous ± 7
Chilldown Pumps Off			
LH2 C/D Inv Frequency (Hz)	389.5	389.5	390.0 ± 1.0
LH2 C/D Inv Phase AB Voltage (vac)	0.07	0.00	0.0 ± 1.5
LH2 C/D Inv Phase AC Voltage (vac)	0.07	0.07	0.0 ± 1.5
LOX C/D Inv Frequency (Hz)	389.5	389.5	390.0 ± 1.0
LOX C/D Inv Phase AB Voltage (vac)	0.00	0.00	0.0 ± 1.5
LOX C/D Inv Phase AC Voltage (vac)	0.00	0.00	0.0 ± 1.5
Engine Restart			
Eng Cont He Sphere Press D019 (psia)	1116.84	1188.31	

* Limits Not Specified

4.3.26.1 (Continued)

LH2 Second Burn Repressurization

Function	Umbil.-In	Umbil.-Out	Limits
LH2 Press Module He Press D104:			
LH2 Prepress Supply Open (psia)	104.469	97.924	*
LH2 Press Sw, Supply Closed (psia)	77.193	71.736	*
Engine Cutoff			
Eng Cont He Sphere Press D019 (psia)	1288.41	1317.03	*
LOX Depletion Timer Check			
LOX Sensors 1 and 2 Dry (sec)	0.545	**	0.560 ∓ 0.025
LOX Sensors 1 and 3 Dry (sec)	0.544	**	0.560 ∓ 0.025
LOX Sensors 2 and 3 Dry (sec)	0.543	**	0.560 ∓ 0.025
APS Yaw and Pitch Checks			
Control Nozzles I IV and III IV On			
Engine 1-1 Valve Open Ind (vdc)	3.933	3.851	*
Engine 2-3 Valve Open Ind (vdc)	3.820	3.753	*
Engine 1-1 Chamber Press (open) (psia)	30.563	27.030	*
Engine 2-3 Chamber Press (open) (psia)	26.051	22.757	*
Control Nozzles I IV and III IV Off			
Engine 1-1 Valve Open Ind (vdc)	0.010	0.010	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)	19.076	15.491	*
Engine 2-3 Chamber Press (closed) (psia)	18.461	15.064	*
Control Nozzle I II and III II On			
Engine 1-3 Valve Open Ind (vdc)	3.896	3.830	*
Engine 2-1 Valve Open Ind (vdc)	3.820	3.743	*
Engine 1-3 Chamber Press (open) (psia)	31.384	27.030	*
Engine 2-1 Chamber Press (open) (psia)	32.205	28.313	*

* Limits Not Specified
** Limits Not Applicable

4.3.26.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
Control Nozzles I II and III II Off			
Engine 1-3 Valve Open Ind (vdc)	0.005	0.000	0.0 ± 0.25
Engine 2-1 Valve Open Ind (vdc)	0.005	0.005	0.0 ∓ 0.25
Engine 1-3 Chamber Press (closed) (psia)	19.281	15.705	*
Engine 2-1 Chamber Press (closed) (psia)	19.691	15.705	*
Control Nozzle I P On			
Engine 1-2 Valve Open Ind (vdc)	3.984	3.943	*
Engine 1-2 Chamber Press (open) (psia)	31.794	27.671	*
Control Nozzle I P Off			
Engine 1-2 Valve Open Ind (vdc)	0.010	0.000	0.0 ± 0.25
Engine 1-2 Chamber Press (closed) (psia)	18.666	14.851	*
Control Nozzle III P On			
Engine 2-2 Valve Open Ind (vdc)	3.876	3.820	*
Engine 2-2 Chamber Press (open) (psia)	34.256	29.808	*
Control Nozzle III P Off			
Engine 2-2 Valve Open Ind (vdc)	0.000	0.005	0.0 ± 0.25
Engine 2-2 Chamber Press (closed) (psia)	20.923	16.346	*

* Limits Not Specified

4.4 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 initiated on 20 January 1969, and was completed on 28 January 1969, to verify that the stage was in satisfactory condition for shipment to FTC.

A total of 504 defects were noted during this inspection, 439 by MDAC personnel and 65 by AFQC personnel. Of the 439 discrepancies noted by MDAC personnel, 139 were concerned with electrical components and 300 were concerned with mechanical components. Of the 65 discrepancies noted by AFQC personnel, 17 were concerned with electrical components and 48 were concerned with mechanical components.

Most of these discrepancies were corrected without requiring FARR action, but 29 items were transferred to FARR's for disposition.

a. FARR 500-815-965 reported a black residue was noted on weld boss of pipe assembly, P/N 1B38419-503, attached to the A92 cold plate between stringers 55 and 56 in the forward skirt. The FARR was transferred open to the FTC for final disposition.

b. FARR 500-815-973 reported a wire to the J4 receptacle of the 405W203 wire harness at the forward skirt LH2 attach point, was nicked. The wire was repaired using DPM 2766 tape per DPS 54010, paragraph 6.2.5.

c. FARR 500-816-015 reported twenty-six items against the mylar covering in the 424 area, for improper installation, unauthorized holes, and debonded areas. Six of the noted discrepancies were reworked to the drawing requirements and DPS 22301. Twenty of the noted items were accepted by the Material Review Board.

4.4 (Continued)

d. FARR 500-816-023 reported that the clamp installation on the pipe assembly, P/N 1B38423-1, in the forward interstage, was not possible due to a mislocated sleeve and expander at stringer 12. The clamp installation should have been located at stringer 13. The noted discrepancy was accepted by the Material Review Board.

4.5 Weight and Balance Procedure (1B55602 E)

This procedure measured the stage weight with an accuracy of ± 0.1 percent, using a three point electronic weighing system, and determined the longitudinal center of gravity of the stage. The measured stage weight was corrected for gravity and air buoyancy forces to determine the seight at Standard Gravity in a vacuum. The procedure was initiated on 25 February 1969, after the stage was rotated to a horizontal position and placed on the weighing cradles, P/N 1A68719-1. The procedure was accepted on 26 February 1969.

Before starting the weighing operation, the electronic weighing system, P/N 1A57907-1, was setup 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 544.702 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-air jacks, P/N 1A83320-1, the stage was raised to just clear the cradles and

4.5 (Continued)

leveled to the previous limit. Regulator air pressure was applied to the forward glide-air 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 4.5.1. 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 27,044.3 pounds, the weight at Standard Gravity in a vacuum was 27,097.0 pounds, and the longitudinal center of gravity was at station 330.5.

No parts were short during this procedure, no revisions were written, and no problems were encountered.

4.5.1 Test Data Table, Weight and Balance Procedure

Time	Barometric Press (in. Hg)	Relative Humidity (%)	Dry Bulb Temp (°F)
09:30	29.52	56.0	59.0
10:00	29.52	56.3	58.0
10:30	29.52	56.0	58.0
11:00	29.52	56.0	58.0
11:30	29.52	56.0	58.0

Calculated Air Density: 0.0754 pounds per cubic foot

4.5.1 (Continued)

Load Cell Collected Data

Reaction Load	Aft (R1)	Forward (R2)	Forward (R3)
Serial Number	36234	34251	34459
Capacity (pounds)	25,000	.0,000	10,000
Run 1 Reading (%)	79.89	38.772	39.682
Run 2 Reading (%)	79.882	38.782	39.678
Run 3 Reading (%)	79.888	38.782	39.652
Average Reading (%)	79.889	38.779	39.671
Calibration Correction	0.766	0.231	0.263
Corrected Reading (%)	80.655	39.010	39.934
Reaction (pounds)	20,163.7	3,901.0	3.993.4

Weight Determination (pounds)

Aft Reaction R1	20,163.7
Forward Reaction R2	3,901.0
Forward Reaction R3	3,993.4
Total Reactions as Recorded	28,058.1
Minus Weighing Equipment "Tare"	-1,013.8
Shipping and Handling Weight	27,044.3
Plus Gravitational Correction	19.0
Plus Buoyancy Correction	33.7
Weight at Standard Gravity in a Vacuum	27,097.0

Longitudinal Center of Gravity

Reaction R1 Moment at Sta. 189.3	3,816,988.41
Reaction R2 Moment at Sta. 684.0	2,668,284.00
Reaction Re Moment at Sta. 684.0	2,731,485.60
Moment Sum	9,216,758.01
Tare Moment	-278,870.75
Moment Sum Less Tare	8,937,887.26

As weighed Center of Gravity = 330.5
(Moment Sum Less Tare Divided by Total Reactions Less Tare)

4.6 GN2 Electrical Air Carry Preshipment Purge (1B65454 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.

4.6 (Continued)

The procedure was satisfactorily performed between 25 February and 3 March 1969, and was accepted on 6 March 1969. The purge preparations started with the installation of the LOX and LH2 desiccant support assemblies, P/N's 1B61272-1 and 1B61270-1. The LOX bellows, P/N 1A49971-501, and the LOX and LH2 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 LH2 fill and drain vents, the LH2 propulsive, nonpropulsive, and ground vents, the LOX propulsive and nonpropulsive vents, and the O2H2 burner nozzle.

The purge units, P/N 1B51117-1, were prepared for operation, and the electrical and pneumatic purge connections were made on the stage and between the purge unit and the stage. The engine LOX chilldown line and LH2 feed duct; the LH2 pressurization line; the LH2 propulsive vent, nonpropulsive vent, and ground vent; the LOX propulsive vent and nonpropulsive vent; the O2H2 burner LOX and LH2 ducts; and the LOX and LH2 propellant tanks were all purged with gaseous nitrogen. The final dewpoints attained were -49.0°F for the LOX system and -30.0°F for the LH2 system. The LOX tank desiccant breather, P/N 1A79691-1, and the four LH2 tank desiccant breathers, P/N 1A79691-501, were prepared, filled with desiccant material, and installed.

After 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 dover, P/N 1B61099-1, were then installed to complete the procedure.

4.6 (Continued)

There were no parts shortages affecting this test. Thirteen revisions were made to the procedure for the following:

a. Three revisions concerned the installation of a heater in the purge system, and the postfire removal of the heater.

b. Two revisions gave instructions to install an adapter, P/N 1B61096-1, on the LOX fill and drain valve and to set the LOX fill and drain switch on the purge control panel to open, to permit purging of the LOX tank.

c. One revision authorized taking samples of the purge gas to determine the non-volatile hydrocarbon content.

d. One revision authorized the use of the purge cart with a fuzz leak in the GN2 supply filter. Replacement parts were not available.

e. One revision deleted steps that had been previously accomplished.

f. One revision concerned a Customer request for a GN2 sample from each GN2 trailer prior to connecting the trailers to the VCL GN2 system.

g. One revision corrected an error made in the initial release of the procedure.

h. One revision authorized performing several steps out-of-sequence.

i. One revision concerned the deletion of several instrumentation channels on the Stage and Pallet Installation Kit, Model DSV -4B-207.

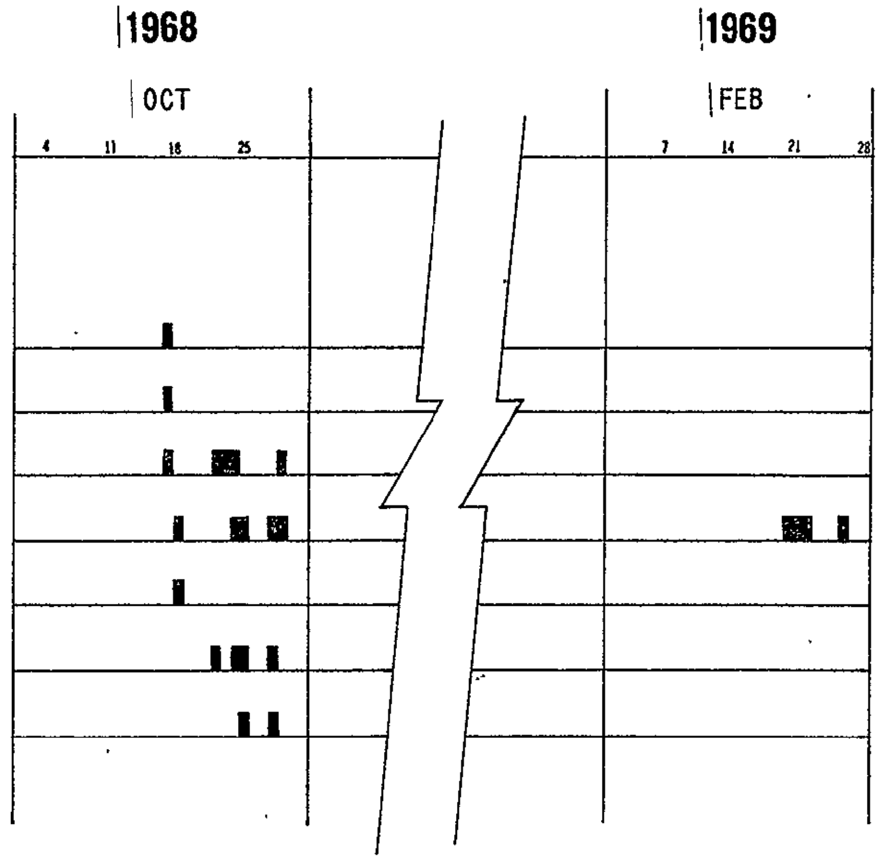
j. One revision authorized the use of 5/32 inch nylon rope in place of 3/16 inch nylon rope as the later was not available.

APPENDIX I

CHARTS

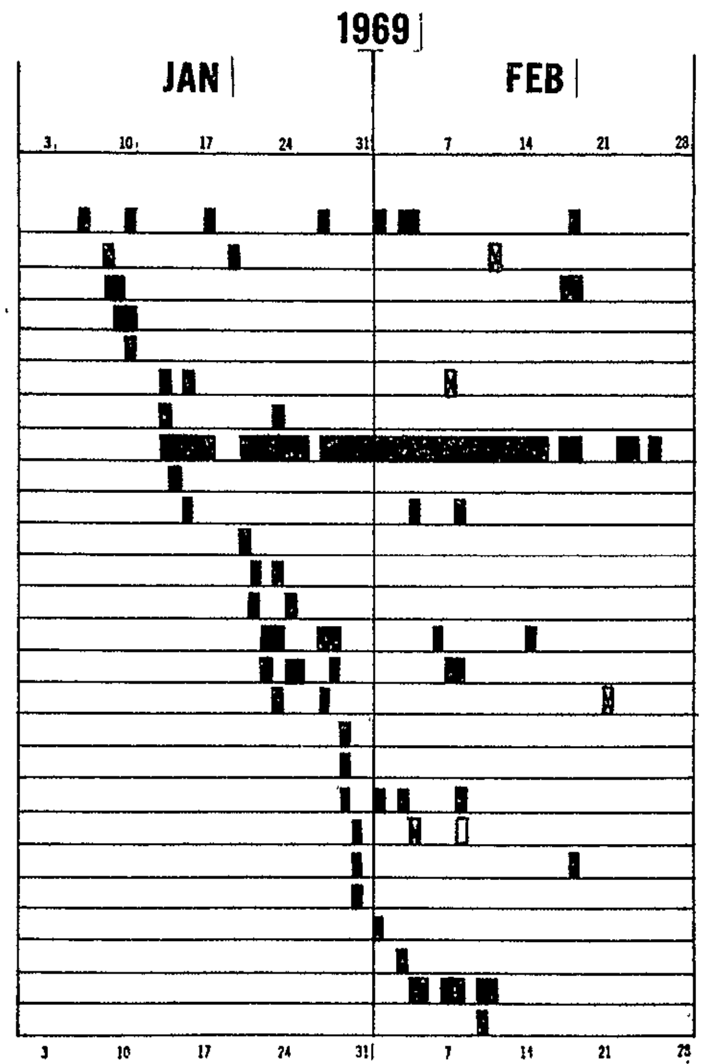
507 ABBREVIATED POSTFIRE CHECKOUT

PARA	PROCEDURE	
4.2.1	1B55813H	STAGE POWER SETUP
4.2.2	1B55814G	STAGE POWER TURNOFF
4.2.3	1B70175H	FINAL PROP. SYS. LK CK
4.2.4	1B70756B	STRUCTURAL INSPECTION
4.2.5	1B55831H	IST
4.2.6	1B41006B	HYD. SYSTEM OPERATION AND SECURING
4.2.7	1B41883C	T/C SYSTEM POSTFIRE C/O



507 DEFERRED POSTFIRE

PARA		PROCEDURE
4.3.1	1B70767B	STAGE AND GSE MANUAL CONTROLS CHECK
4.3.2	1B59782G	UMBILICAL INTERFACE COMPATIBILITY CHECK
4.3.3	1B57599D	C/O & OPERATION, FWD SKIRT THERMOCONDITIONING SYST.
4.3.4	1B66560G	STAGE POWER SETUP
4.3.5	1B66561G	STAGE POWER TURNOFF
4.3.6	1B66562H	POWER DISTRIBUTION SYSTEM CHECKOUT
4.3.7	1B64680D	LEVEL SENSOR AND CONTROL UNIT CALIBRATION
4.3.8	1B71909C	PROPULSION SYSTEM LEAK AND FUNCTIONAL CHECK
4.3.9	1B66563G	DDAS CALIBRATION
4.3.10	1B66564H	DDAS AUTOMATIC CHECKOUT
4.3.11	1B66566F	EBW SYSTEM CHECKOUT
4.3.12	1B64367K	PU SYSTEM CALIBRATION
4.3.13	1B66567H	PU SYSTEM AUTOMATIC CHECKOUT
4.3.14	1B41007C	HYDRAULIC SYST SETUP, OPERATION AND SECURRING
4.3.15	1B76771NC	SINGLE SIDEBAND SYSTEM CHECKOUT
4.3.16	1B64678F	CRYOGENIC TEMPERATURE SENSOR VERIF.
4.3.17	1B66570G	HYDRAULIC SYSTEM AUTOMATIC CHECKOUT
4.3.18	1B49558B	APS INTERFACE COMPATIBILITY CHECKOUT, VCL
4.3.19	1B66565F	RANGE SAFETY RECEIVER CHECKOUT
4.3.20	1B66568G	RANGE SAFETY SYSTEM CHECKOUT
4.3.21	1B70742D	APS MANUAL CHECKOUT
4.3.22	1B67673A	APS AUTOMATIC CHECKOUT
4.3.23	1B64679F	TM AND RS ANTENNA SYSTEM CHECKOUT
4.3.24	1B64681G	SIGNAL CONDITIONING SETUP
4.3.25	1B66572H	PROPULSION SYSTEM AUTOMATIC CHECKOUT
4.3.26	1B66571J	ALL SYSTEMS TEST

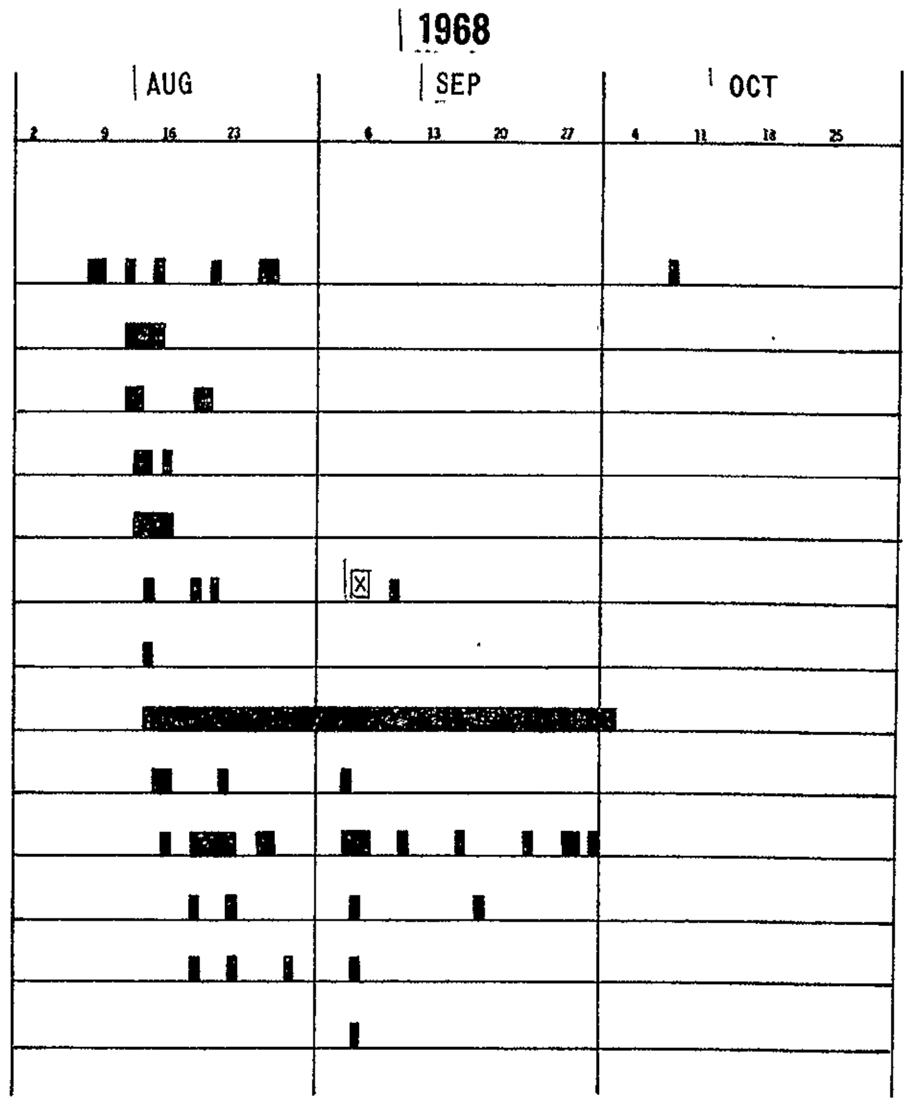


INDICATES SECOND ISSUE

INDICATES [illegible] ISSUE

507 PREFIRE ACCEPTANCE TESTING

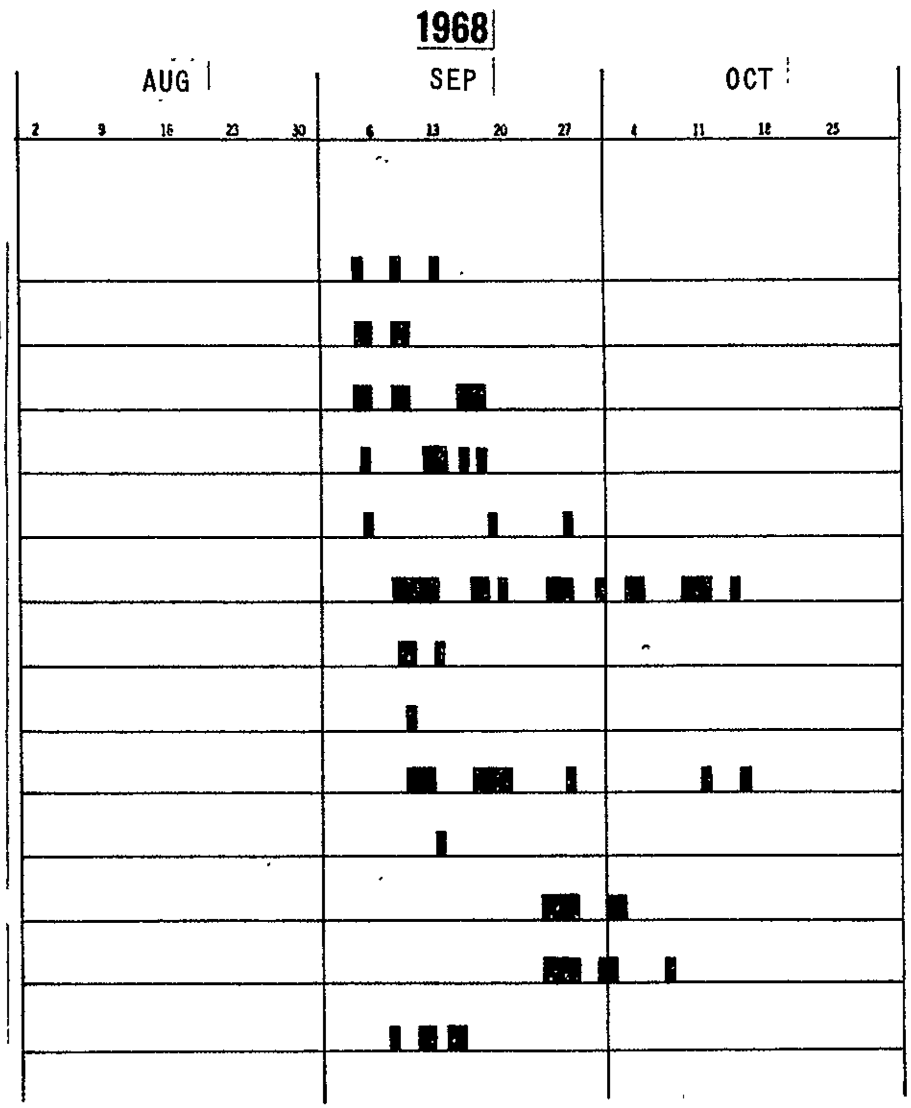
PARA	PROCEDURE	
4.1.1	1B40654B	STRUCTURAL INSPECTION
4.1.2	1B41955C	FORWARD SKIRT THERMOCONDITIONING SETUP
4.1.3	1B64316E	UMBILICAL INTERFACE COMPATIBILITY C/O
4.1.4	1B55813H	STAGE POWER SETUP
4.1.5	1B55814G	STAGE POWER TURNOFF
4.1.6	1B55815H	POWER DISTRIBUTION SYSTEM CHECKOUT
4.1.7	1B49558B	APS INTERFACE COMPATIBILITY CHECKOUT
4.1.8	1B71877C	PROPULSION SYSTEM LEAK CHECKS
4.1.9	1B55816G	DDAS CALIBRATION
4.1.10	1B49286J	COMMON BULKHEAD VACUUM SYSTEM
4.1.11	1B70177G	MANUAL CONTROLS CHECK
4.1.12	1B64678E	CRYOGENIC TEMP SENSOR VERIFICATION
4.1.13	1B55825E	APS SYSTEM AUTO



X DENOTES SECOND ISSUE

507 PREFIRE ACCEPTANCE TESTING (CONT'D)

PARA	PROCEDURE
4.1.14 1B55822F	EBW SYSTEM CHECKOUT
4.1.15 1B64680D	LEVEL SENSOR & CONTROL UNIT CALIBRATION
4.1.16 1B55819G	RANGE SAFETY RECEIVER CHECKOUT
4.1.17 1B55821H	RANGE SAFETY SYSTEM AUTO
4.1.18 1B55817K	DDAS AUTO
4.1.19 1B41005B	HYDRAULIC SYSTEM SETUP & OPERATION
4.1.20 1B64368F	PU SYSTEM CALIBRATION
4.1.21 1B55823H	PU SYSTEM AUTO
4.1.22 1B44474D	SIGNAL CONDITIONING SETUP
4.1.23 1B55824G	HYDRAULIC SYSTEM AUTO
4.1.24 1B62753K	PROPULSION SYSTEM AUTO
4.1.25 1B55831H	IST
4.1.26 1B70175H	FINAL LEAK CHECK



APPENDIX II

TABLES

TABLE I. FAILURE AND REJECTION REPORTS
STAGE RECEIPT TO FORMAL COUNTDOWN INITIATION

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A270614 8-15-68	During the performance of 1B70422 E, paragraph 4.24-2C, the check valve, P/N 1B67481-1, S/N 8010562, had a cracking pressure of 4.2 psig, which should have been less than 4.0 psig.	The check valve was removed and replaced.
A270615 8-15-68	During the performance of 1B70422 E, paragraph 4.24-2C, the check valve, P/N 1B67481-1, S/N 70621219, had a reseat pressure less than 1 psig, which should have been greater than 1 psig.	The check valve was removed and replaced.
A271292 2-8-68	During the umbilicals-in run of the AST, as observed on the DER, the start tank discharge solenoid, measurement K96, and the simulated ignition detected, measurement K8, cycled abnormally several times. NOTE: Troubleshooting revealed that the engine control assembly (ECA), P/N 502670-51, S/N 4091614, caused the noted malfunctions.	The ECA was removed, replaced, and tested per 1B62753.
A271296 2-19-68	a. Data evaluation of the all system test (AST) at A3 revealed the following measurements to be out-of-tolerance. The value should have been 2 to 5 percent peak-to-peak, not to exceed 1 second duration. .. Affected by the chilldown inverter: (a) Measurement D1 was 2.2 percent. (b) Measurement D18 was 2.4 percent.	WRO 4188 and 4266 generated nineteen assembly outlines to rework the affected systems. The rework was verified during the all systems test with no discrepancies.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A271296 2-19-68 (Cont.)	(c) Measurement M25 was 2.4 percent. 2. Affected by radio frequency interferer (RFI): (a) Measurement M60 was 2.8 percent. (b) Measurement N55 was 6.2 percent. (c) Measurement N18 was 3.8 percent. 3. The 404A72A5 LOX tank fastfill sensor, P/N 1A68710-511, S/N C-53, cycled unexpectedly when the LOX vent valve was actuated. 4. The 411A92A43 LH2 fastfill sensor, P/N 1A68710-509, S/N C-66, cycled unexpectedly. b. During static firing the following out-of-tolerance conditions existed: 1. Measurement M25 was -3 percent. 2. Measurement M60 was -3 percent bias during open loop transmission. 3. Measurement N55 was 17 percent bias during open loop transmission and 4 percent during engine burn. 4. Measurement N18 was 5 percent bias during open loop transmission.	

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-225-351 8-9-68	The following item was rejected per ROD 661, dated 8-5-68. The 403A74A3 check valve, P/N 1B67598-503, S/N 24, was suspected of being made from the incorrect materials.	The check valve was removed and replaced.
500-225-360 8-13-68	During installation of the test stand vent system, it was suspected that contamination, specifically walnut shell grit, was inside and around the oxidizer tank vent and relief port between stringers 102 and 103. NOTE: Grit and dust was found at the LOX vent poppet duct, P/N 1A68611-501-B -001, the elbow, P/N 1A77116-1, and the adjacent marmon clamps.	The LOX tank vent and relief elbow, P/N 1A77116-1, the adjacent marmon clamps, the duct, P/N 1A68611-501, and the LOX vent valve poppet were vacuumed, and maintained clean per DPS 43000 and 43150. After re-assembly, a leak check was performed per 1B71877.
500-225-394 8-17-68	During performance of 1B55816 G, it was noted that the multiplexer, P/N 1B65897-1, S/N 02, channel CP1-BO-23-09 had out-of-tolerance readings as follows:	The unit was removed and replaced.

Value Was	Expected Value
0 vdc	-0.062 vdc
1.25 vdc	0.281 vdc
2.50 vdc	0.841 vdc
3.75 vdc	1.426 vdc
5.00 vdc	2.025 vdc

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A271296 2-19-68 (Cont.)	5. Measurement K676, the LH2 fastfill sensor wet command on, talkback cycled to on for 5 milliseconds when the PU hard-over off command was sent. NOTE: Per QE Memo A45-721-QE/ROD 69019; the above discrepancies listed on this FARR were duplicated during AST.	
500-026-871 9-17-68	During range safety receiver checks, per 1B55819, Seq. 00542, the arm and engine cut-off command was not present at controller unit No. 1.	The condition was determined to be caused by random RFI noise and was acceptable to the Material Review Board.
500-026-928 10-12-68	During review of 1B60422, orifice, P/N 1B63047-521, S/N GA-45, was identified as 0.645, but should have been 0.00890.	The orifice was reidentified per 1B63437 B.
500-026-936 10-12-68	During review of 1B60422, orifice, P/N 1B63437-507, S/N GA-39, was identified as 0.00890, but should have been 0.645.	The orifice was reidentified per 1B63437 B.
500-071-125 2-27-68	It was noted that the pipe assembly, P/N 703098, had a 16-degree bend causing a pre-load on the weld joint and a flat area 1-1/2 inch by 1/4 inch 3 inches below the noted weld joint.	The pipe assembly was removed, replaced, and leak checked per Rocketdyne requirements.
500-225-343 8-9-68	The following item was rejected per ROD 661, dated 8-5-68. The 403A73A4 check valve, P/N 1B67598-501, S/N 11, was suspected of being made from the incorrect materials.	The check valve was removed and replaced.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-225-459 8-19-68	During performance of 1B70422, paragraph 4.3.6, while removing desiccant plates, P/N 1B61136-1 and P/N 1B61136-501, from the LH2 nonpropulsive vent ducts between stringers 47 and 48 and 101 and 102, granulated walnut hulls were noted around and on the inside surfaces of the vent duct.	The desiccant plates were removed, cleaned at the LOX lab. per DPS 43000. The walnut hulls were removed with lint free cloths dampened with methylene chloride and the plates were installed per 1B70422.
500-225-467 8-19-68	a. During performance of 1B55397 AS, it was noted that the environmental seal of connector P28 on the 404A3W1 wire harness, P/N 1B68987-1, S/N 02, had a puncture adjacent to socket FF. b. Pin FF in the 404A28 module, P/N 1B57771-557, was bent approximately 30 degrees. c. Wire F163B20 in the 404A3W1 harness, P/N 1B68987-1, S/N 02, was cut approximately 1/8 inch long 3 inches from connector P28.	a., b., and c. The noted defective items were removed and replaced.
500-225-491 8-22-68	The following discrepancies were noted during receiving inspection: a. Radiographic inspection per 1B40654, paragraph 4.4.2, revealed that two nuts, P/N NAS 679-3, were imbedded in potting compound at stringer 30, three inches forward of the forward skirt and the forward dome intersection.	a. and b. Noted items were accepted by the Material Review Board.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-225-491 8-22-68 (Cont.)	b. The fuel vent duct at stringer 18 in the forward interstage was dinged in two places.	
	c. Radiographic inspection per 1B40654, paragraph 4.4.4, revealed two pieces of aluminum rivets at stringers 138 and 104, 3 and 4 inches aft of the aft vee section.	c. The rivet pieces were removed from the stage.
	d. The flex duct, P/N NA5260113, S/N 033, at the GG control valve forward of the engine turbine had one frayed strand of metal braid.	d. The sharp edge of the cut braid was trimmed.
	e. A pipe assembly and an adjacent bracket at the heat exchanger LOX pump turbine flange were contacting each other.	e. The pipe assembly was relocated in the bracket and a clamp was installed.
	f. Pipe assemblies, P/N 458140-47, and P/N 458140-49, were contacting each other at the interface adjacent to the J-2 engine LOX pump.	f. and g. The noted conditions were acceptable per R/NAA report Q02688.
	g. The volute to carrier seal bleed port pipe assembly at the LOX pump was contacting an adjacent pipe assembly.	
	h. The black light detected a grease substance in several small areas in the engine throat.	h. The areas were acceptable to the Material Review Board.
	i. The O2H2 burner 2 inch ducts had the appearance of corrosion at the weld seams adjacent to stiffener 10-3/4.	i. and j. The areas were cleaned using pasajell, DPM 1571. The areas were then flushed with demineralized water and cleaned with freon PCA, DPM 2482-1.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-225-491 8-22-68 (Cont.)	j. The adapter, P/N 1B52432-503-001, at the cold helium plenum outlet adjacent to stringer 10, had a rust colored residue at weld joints.	
	k. The mylar covering installed over the aft dome had numerous areas which were de-bonded.	k. The mylar covering was bonded per DPS 22301 using adhesive DPM 2091.
	l. The J1 and J2 electrical cable rubber boots at the electrical control assembly (ECA) were torn.	l. The boots were stop punched per R/NAA manual R3825-3.
	m. The pipe assembly, P/N 1B66803-1, at stiffener 13 was not supported per 1B65024, zone 27.	m. The pipe assembly was clamped per 1B65024, zone 27.
500-373-270 8-23-68	a. During the performance of 1B64678, it was noted that the insulation of wires D9476-A22 and D9475A22 of the 404W208 wire harness were cut 1/4 inch long by 1/8 inch wide 12 inches from the P77 connector.	a. The damaged insulation was repaired per DPS 54010, paragraph 6.2.5.
	b. The insulation of wire D1303A22 of the 404W208 wire harness was cut, also two strands of the shield were broken 12 inches from the P77 connector.	b. The damaged shield strands were removed and the damaged insulation was repaired per DPS 54010, paragraph 6.2.5.
500-373-296 8-27-68	Pipe assembly, P/N 1B64136-1 A, had a dent and damaged teflon covering. NOTE: This condition occurred when pressure was applied to the pipe assembly during the performance of 1B71877 while one end of the assembly was disconnected.	The damage to the pipe assembly was acceptable to the Material Review Board. The damaged teflon wrapping was removed and replaced per 1B64136 and DPS 30220.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-373-300 8-27-68	It was noted during the reidentification of the 404W201 wire harness, P/N 1B76263-1, that the P3 connector was distorted and had a damaged rubber grommet.	The connector was removed, replaced, and tested per 1B55813.
500-373-318 8-27-68	During rework per 1B76263 NEW, it was noted that pin Z of the 404A52A200 module, P/N 1A96707-501, S/N 0579, was bent approximately 20 degrees.	The pin was straightened per DPS 54002 and tested per 1B55813.
500-373-326 8-28-68	While removing the rod end, P/N AREM-8SP11, from one of the strut assemblies, P/N 9024534, approximately 3/4 cup of iron oxide (rust) fell out from the inside of the strut assembly. NOTE: The rod end of the second unit was not removable.	The two strut assemblies were removed and replaced.
500-373-334 8-28-68	During the performance of 1B63247, the LOX instrumentation probe, P/N 1A69275-509, S/N 06, had out-of-tolerance resistance readings between pins 14 to 15 and 14 to 16 on receptacle J6. These readings were 8000 ohms. The tolerance was expressed as 1540 $\pm$ 75 ohms. Additional resistance measurements were made to receptacle J6. Using the stage ground as the common point, the resistance from pins 14, 15, and 16 to ground should have been infinity, but were 1.8k ohms, 100 ohms, and 95 ohms, respectively. These checks indicated a faulty temperature sensor, P/N 1A67862-505, S/N 601.	The procedure was rerun to verify the discrepancy. The instrumentation probe was removed from the stage, the faulty temperature sensor was removed and replaced with S/N 630. The probe was then reinstalled in the stage.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-373-342 8-28-68	Per inspection change request A45-721-0727 and AO 1B67212 R, the injector assembly, P/N 1B67723-1, S/N 08, was rejected as being identified as interim use material (IUM).	The IUM part was removed and scrapped. A production injector, P/N 1B68491-003, S/N 033, was installed.
500-373-369 9-4-68	During the performance of 1B49196, it was noted that the O2H2 burner LH2 upper propellant duct, P/N 1B65206-503, indicated a vacuum reading of 1000 + microns. Vacuum pumping had no effect on the reading. On resubmit 1, pins 3 and 5 of the vacuum probe were open, but should have been shorted.	The duct was removed and replaced.
500-373-385 9-5-68	During rework per 1B66222 AK, it was noted that support, P/N 1B37286-503, was installed on stringer 15 1/4, 11 1/2 inches from the top of the stringer. The support interferred with clip, P/N 1B66222-67. Reference 1B66222, zone 78, view CL.	The two side rivets were removed and the support was cut leaving the bottom portion installed. The condition was accepted by the Material Review Board.
500-373-393 9-10-68	During rework per 1B66505 BY, it was noted that the 404W201 wire harness, P/N 1B76263-1, had two wires with cut insulation, also one of the wires had the insulation crushed approximately 30 inches from the P3 connector installed at the 404A52A200 J2 module.	All four conductors of the wire harness were removed, replaced, and tested per 1B55817 K.
500-373-407 9-10-68	During performance of 1B41005, paragraph 4.1.7.2.e, it was noted that the GN2 accumulator fill valve, P/N 1B31295-1, S/N 117, leaked through in the closed position.	The valve was removed and replaced.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-373-415 9-11-68	During rework per 1B66505 BY, it was noted that the insert of the standoff, P/N 1B31245 -513, on the panel assembly, P/N 1B62907-119, at stringer 69 was missing. Reference 1B62907, zone 22.	The insert was installed per 1B53312.
500-373-423 9-11-68	During the performance of 1B71877, a test of the LH2 continuous vent module microswitch housing purge port, P/N 1B66639-501, S/N 018, revealed that the restrictor, P/N 1B40622 -505, was not installed.	The restrictor was installed per 1B75000. A leak and functional test was accomplished per 1B71877.
500-373-431 9-12-68	During the performance of 1B64268-1, it was noted that the 403W10 wire harness, P/N 1B63421-1, had two wires with cut insulation and four wires with cut strands approximately 18 inches from the 02H2 burner LOX propellant valve at stiffener 10 3/4.	The cable assembly was removed and replaced
500-373-440 9-12-68	During checkout of the 02H2 burner per 1B70422, it was noted that an orifice, P/N 1B63025-501, was erroneously installed, in place of a P/N 1B64352-503, in the secondary helium inlet port. In the process of the part number investigation, a rust colored residue was noted on the orifice and the threaded boss.	The residue was determined to be a LOX compatible lubricant. The correct orifice was installed.
500-373-458 9-12-68	During the performance of 1B64678, it was noted that transducer, P/N NA5-27215T5, S/N 13376, had an unstable continuity reading.	The transducer was removed and replaced.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-373-466 9-13-68	During the performance of 1B71877, it was noted that bi-directional vent valve, P/N 1A49988-513, had a seat leakage of 300 scim in both the ground and flight positions. The maximum allowable leakage was 50 scim.	The valve was removed and replaced.
500-373-504 9-18-68	During surveillance inspection, it was noted that the following isolators in the aft skirt were debonded. a. P/N 1B32258-1, S/N 325, at panel position 17 on stringer 140. b. P/N 1B32267-1, S/N 564, at panel position 16 on stringer 133. c. P/N 1B32255-1, S/N 382, at panel position 16 on stringer 25.	a. through c. The isolators were removed replaced.
500-373-768 9-24-68	During the performance of 1B71877, it was noted that the quick disconnect, P/N 1A49958 -517, S/N 106, leaked when coupled to its mating part. Also, it was not clean per DPS 43000 or identified per 1A49958.	The quick disconnect was removed and replaced.
500-373-784 9-20-68	During installation of the engine pump seal cavity drain line, P/N 1B75823-1, it was noted that two rivets were installed in reverse at stringers 12 and 13, causing interference between the flange and the skirt.	The rivets were removed, the holes were countersunk, and MS20426AD5 rivets were installed with the bucked ends shaved flush.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-373-806 9-20-68	During the performance of 1B71877, it was noted that the start tank vent and relief valve, P/N 557848, S/N 4094128, had leakage of 1 scim with no leakage allowed.	The valve was removed and replaced.
500-373-822 9-20-68	During the performance of 1A48312-007 A, it was noted that the flange of the tee assembly, P/N 1B69768, had numerous scratches.	The scratches were wiped clean with freon and brush alodined per DPS 41410. The assembly was leak checked per 1B71877.
500-373-831 9-20-68	During installation of the LH2 vent valve, it was noted that the pipe assembly, P/N 1B75268 -1, had an approximate 20 degree bend. Reference 1B75000, zone 63.	The pipe assembly was removed and replaced.
500-373-857 9-23-68	During the performance of 1B71877, revision 82, it was noted that LH2 secondary inlet orifice, P/N 1B64352-503, at the O2H2 burner had a cut on the sealing surface and the wrench flats were badly scarred.	The damaged orifice was removed and replaced.
500-373-890 9-26-68	While performing WRO-SIVB-4068-R1, it was noted that the 427A41 LH2 auxiliary motor driven chilldown pump, P/N 1A49421-507, S/N 190, was not worked to the "AS" configuration. The mandatory rework was removed, in error on FO 6681027 prior to static test.	The chilldown pump was reworked to the "AS" configuration.
500-373-903 9-27-68	During the performance of 1B55831, it was noted that two matched restrictors, P/N 1B40622-513, S/N 313, maintained a pump canister pressure of 38 psi, which should have been 43 psi with 510 psig upstream pressure.	The matched restrictors were removed and replaced.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-373-962 10-1-68	During the performance of 1B64268, it was noted that a wire of the cable assembly, P/N 1B74463-1, had cut insulation and scraped wire strands approximately 10 inches from the connector at the engine driven hydraulic pump.	The damaged insulation was repaired per DPS 54010.
500-373-971 10-1-68	a. During surveillance inspection, it was noted that the pipe assembly, P/N 1B66150 -1, was bent, forward of the nonpropulsive vent system between stringers 7 and 11 in the forward skirt. b. Pipe assembly, P/N 1B66151-1, was bent, forward of the nonpropulsive vent system between stringer 1 and 4 in the forward skirt.	a. and b. The noted pipe assemblies were acceptable for use per the Material Review Board.
500-445-661 8-2-68	During final inspection at the A3 location, the 404A75A1 EBW firing unit, P/N 40M39515-113, S/N 259, test record sheets 18, 19, and 20, form X60-999, was not available or could not be located at the QDR files. On resubmit, dated 8-19-68, the test records were retrieved.	The unit was acceptable for use upon the retrieval of the test data.
500-486-619 9-11-68	During installation per 1B58004, it was noted that the pipe assembly, P/N 1B65054-1, would not mate with the next assembly.	The pipe assembly was removed and replaced.
500-486-627 9-11-68	During installation per 1B58004, it was noted that the pipe assembly, P/N 1B65056-1, would not mate with the next assembly.	The pipe assembly was removed and replaced.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-488-565 10-11-68	During task 44 of the simulated countdown, TR 1051, it was noted that the pneumatic power control module, P/N 1A58345-523, S/N 1036, exceeded the pressure switch pickup of approximately 600 psia. The pneumatic power control module regulator should not have exceeded 565 psia.	The valve was removed and replaced.
500-488-590 10-15-68	It was noted over a two week period that two matched restrictors, P/N 1B40622-513, S/N 311, at the LOX chilldown canister pressure had a decrease from 58.5 psia down to 46 psia. This was considered marginal per memo A3-860-KCBA.	The matched restrictors were removed and replaced.
500-488-603 10-14-68	During repair of leaks per 1B70175, it was noted that the LOX fill and drain valve, P/N 1A48240-505, S/N 0128, had numerous scratches on the body of the valve near the sealing surfaces at LOX tank side of the valve.	The valve was removed, inspected, and reinstalled using a new conoseal gasket. The valve was leak checked with no further leaks.
500-488-620 10-14-68	During the performance of 1B70175, it was noted that the main fuel valve, P/N 409920, S/N 4090663, had 54 scim leakage with 250 psig applied through the actuator and out the closing port. The maximum allowable leakage was 20 scim.	The valve was removed and replaced.

TABLE II. FAILURE AND REJECTION REPORTS
FORMAL COUNTDOWN INITIATION AND ABBREVIATED POSTFIRE CHECKS

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-488-689 10-22-68	During the abbreviated postfire checkout of the 02H2 burner, it was noted that the 403MT777 thermocouple sensor, P/N 1B64968-503, S/N 992, measurement C0382, was noisy and drifted at ambient to 55 percent of full-scale, but should have been 4 percent of full-scale. Checkout at the Metrology Lab. per 1B49715 Z at 212 degrees F., the resistance was 14.995 ohms, but should have been 13.86 $\pm$0.28 ohms. The reading at 32°F was very erratic.	The thermocouple was removed and replaced.
500-488-697 10-24-68	During the static firing acceptance test, it was noted that the 425MT601 pressure transducer, P/N 1B40242-583, S/N 583-14, drifted to 3703 psia, but should have remained at 1360 psia.	The transducer was removed and replaced.
500-488-701 10-24-68	During the performance of 1B55831, it was noted that 403MT754 pressure transducer, P/N 1B40242-615, S/N 615-5, measurement D225, had the following out-of-tolerance readings: a. Ambient was -20.050 psia, but should have been 14.7 $\pm$10 psia. b. Low calibration was -0.123 vdc, but should have been 1.000 $\pm$0.100 vdc. c. High calibration was -0.123 vdc, but should have been 4.000 $\pm$0.100 vdc.	The transducer was removed and replaced.

TABLE II (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-488-719 10-24-68	During the installation of the forward lifting fixture per 1B71408, it was noted that the nutplates, P/N NAS686A6, in the forward skirt at stations 676 and 702, between stringers 43 and 44, also stringers 67 and 68, were bent. Reference 1A39264, zone 75, view AC.	The bent nutplates were acceptable to the Material Review Board.
500-488-727 10-25-68	During the static firing data review, it was noted that the operational T/M reflected R/F power kit, P/N 1A74776-503, S/N 2-0281, exceeded the 2 percent peak-to-peak for 1 second tolerance per the EMC test plan SM-47376.	The condition was acceptable to the Material Review Board.
500-488-743 10-28-68	During the abbreviated postfire checkout per 1B41006, it was noted that the auxiliary hydraulic pump, P/N 1A66241-511, S/N X458911, had hydraulic leakage at the differential pressure indicator gasket, which exceeded the 1 drop per 15 minutes at a working pressure of 3300 psi.	The differential pressure indicator gasket and O-Rings were removed and replaced. Th indicator assembly was tightened to a torque value of 10 to 14 inch-pounds. The assembly was leak checked with no further leaks.
500-488-751 10-28-68	During removal per 1B70425, it was noted that the fuel tank pressure pipe assembly, P/N 1A97404-1, had a ding approximately 3/8 inch deep by 3/4 inch long, 1 1/2 inches from the flex end of the assembly.	The teflon tape was removed and the pipe assembly was inspected and was acceptable to the Material Review Board. The pipe assembly was then rewrapped with teflon tape per 1A97404-1.

TABLE III. FAILURE AND REJECTION REPORTS DEFERRED POSTFIRE CHECKOUT

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-226-005 12-5-68	The Kototherm coating, at the forward skirt, between stringers 13 and 18, had a 6 by 8 inch area that was cracked and peeling.	The Korotherm coating was scheduled to be removed per DPI 0127 and replaced per DPS 42210 at the FTC.
500-488-166 12-4-68	During inspection per WRO-SIVB-4649, it was noted that the coaxial pins of receptacle 411A92A6J2 of the PU assembly, P/N 1A59358 -529, S/N 032, had nicked gold plating exposing copper base metal.	The J2 receptacle was removed, replaced, and retested per 1A74597, excluding general note 1.
500-488-247 12-10-68	a. During the performance of 1B51379 BP, it was noted that the grommet in the P21 connector, P/N SO286E22-55S, had punctures adjacent to pins A and U.	a. The connector was acceptable to the Material Review Board.
	b. The following wires of harness, P/N 1B68988-1, had cut insulation. Wire — Connector P31Y16 between P20 and P31 P211D16 between P32 and J2 P121P16 between P32 and J1	b. The noted discrepant wires were removed and replaced.
500-489-251 11-20-68	During surveillance inspection, it was noted that the Korotherm finish, at the forward skirt attach flange station 500.702, on stringer 29 and between stringers 28 and 29, had hairline cracks.	The area was cleaned with toluene. Six brush coats of unthinned DPM 3486-5 were applied allowing 15 minutes between coats to dry.
500-489-389 2-3-69	Prior to installation, it was noted that the environmental curtain, P/N 1B68756-7, had a tear five places near the two jumpers. Reference 1B68756, zone 3.	The areas adjacent to the tears were cleaned with toluene. The damaged areas were repaired using silver mylar aluminized tape extending 1 inch beyond the tears in all directions.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-489-766 11-29-68	During installation per 1B66488, zone 2, it was noted that the curtain assembly, P/N 1B66488-1, had a 6 inch tear at the lower right hand corner.	The surface of the curtain was wiped clean with isopropyl alcohol. The tear was repaired using a 2 inch wide sliver mylar aluminized tape.
500-489-791 1-23-69	The presence of foreign material in the stage hydraulic oil was suspected due to the possible use of the hydraulic servicers which may have contained Bray Oil Company hydraulic oil, MIL-H-5606, Batch B7RF2, rejected on FARR 500-597-054.	The hydraulic oil was acceptable to the Material Review Board upon review of Lab. report 690264.
500-489-804 1-23-69	During the performance of 1B64678 F, it was noted that wire D9845A22 of the 403W200 wire harness, P/N 1B67208-1, was installed in pin A, but should have been installed in pin B. Reference 1B67208 C, sheet 56.	The wire was reterminated in Pin B per 1B67208-1 and tested per 1B64678.
500-489-812 1-31-69	During the performance of 1B66568 G, it was noted that the 411A99A16A31 range safety EBW No. 1 pulse sensor, P/N 40M02852 B, S/N 0158, performed erratically.	The unit was removed and replaced.
500-489-821 2-1-69	During the performance of 1B66565, paragraph 4.2.6, it was noted that the range safety No. 2 decoder, P/N 50M10698, S/N 26, had voltage leakage of -0.1538 vdc. The maximum leakage allowed was 0.100 vdc.	The unit was removed and replaced.
500-489-871 2-6-69	a. During installation per 1B65109 AG, it was noted that the velcro zipper flap of impingement curtain, P/N 1B65610-501, had approximately 21 inches debonded at stringer 16A and approximately 2 1/4 inches debonded at stringer 13A.	a. through e. The curtain was sent to the vendor for rework. All items were not acceptable and the noted discrepancies were transferred to FARR 500-819-413.

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-489-871 2-6-69 (Cont.)	b. The stitches on seven flap interfolds were loose. c. The stich edge margin was not maintained on the zipper, P/N 1B65731-1. Reference zone 9, view B. d. The cloth, P/N 1B65610-3, was not stitched. Reference zones 8 and 11, views FF and G. e. The stud, P/N XX78332K1105, on the curtain assembly, P/N 1B65610-501, was mismatched with the eyelet, P/N BS78403K1105. Reference 1B65610, zone 15.	
500-489-880 2-12-69	During the performance of 1B76771, it was noted that the single sideband telemetry assembly, P/N 1B55252-501, S/N 9, had out-of-tolerance data during the preflight sweep calibration test.	The FARR was dispositioned to be resubmitted at the FTC after the single sideband test.
500-489-898 2-13-69	During rework per 1B69013-501 Job 1, it was noted that the LOX NPV nozzles had interference due to the openings having a buildup of dynatherm from 0.030 to 0.040 inch between stringers 62 and 63 and stringers 134 and 135. The buildup should have been less than 0.015 inch.	The buildup of dynatherm was removed down to bare metal using plastic scrapers. Four brush coats of LOX compatible dynatherm was then applied over the edges of the openings.
500-489-901 2-13-69	During pull test per 1A95641-004 B, it was noted that the isolators were debonded in the aft skirt as follows: a. P/N 1B54123-1, S/N 060, on stringer 143.	The debonded isolators were removed and replaced.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-489-901 2-13-69 (Cont.)	b. P/N 1B54125-1, S/N 036, batch No. 185, on stringer 14.	
	c. P/N 1B32267-1, S/N 316, batch No. 165, on stringer 24.	
	d. P/N 1B32267-1, S/N 564, batch No. 4453, on stringer 133.	
500-608-382 12-3-68	During performance of line check 90, the RF assemblies, P/N 1B65788-1, S/N 15502, and P/N 1B52721-511, S/N 025, were suspected of faulty workmanship.	The noted RF assemblies were removed and replaced.
500-608-439 12-10-68	a. During performance of 1B67461 AR, it was noted that wires Q29A22, Q30A22, and the shield approximately 12 inches from the 411W6P25 connector, had a hole exposing the shield.	a. and b. The damaged insulation was repaired using teflon tape, DPM 2766, per DPS 54010, paragraph 6.2.5.
	b. Wires Q21A22 c and d and shield approximately 9 inches from the 411W6P25 connector, had a hole exposing the shield.	
500-608-447 12-12-68	a. During inspection line check 88, it was noted that four bolts NAS 1004-9A installed in the nozzle of the O2H2 burner, P/N 1B62600-529-009C-012, did not meet the requirements of DPS 13350, paragraphs 6.9 through 6.9.2.1.	a. and b. The bolts and washers are scheduled to be removed and replaced per the drawing requirements at the FTC.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-608-447 12-12-68 (Cont.)	b. Eight 10491 spherical washers installed were rusted. The washers should have been 347 corrosion resistance steel per 1B63780, paragraph 3.3.	
500-608-455 12-10-68	The acceptance firing data review revealed that the outlet pressure of the pneumatic power control module, P/N 1B58345-523 AU, S/N 1006, went to pressure switch pickup of 600 psia. The maximum allowed is 550 psia at 70 degrees F.	The module was removed and replaced with a module reworked to 1B58004 AU. The module was leak checked per 1B71909 and tested per 1B66572.
500-608-498 12-12-68	During the performance of 1B74873 G, it was noted that wire P36A20, and wire jumper of the 403W5 wire harness, P/N 1B74873-1 was pulled from its termination point at the P15 connector.	The wires were reterminated per the drawing requirements.
500-608-811 12-19-68	Routine inspection revealed that the bracket assembly, P/N 1B57145-501, had two 0.221 to 0.224 holes with nutplates, NAS 1031N3, installed. NOTE: The bracket should have been drilled after the thermoconditioner was installed at the FTC.	The bracket assembly was removed and a new bracket was installed less the holes and nutplates.
500-608-846 12-20-68	It was suspected that the 411A32 control vent module, P/N 1B67193-511, S/N 54, had an improper spring installed.	The module was removed and replaced.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-608-854 12-26-68	During rework per 1B39550 CE, it was noted that wire F506A20 of the 404A3W1 wire harness, P/N 1B74668-1, S/N 02, approximately 2 inches from the P43 connector, was cut and exposing the conductor.	The wire was removed, replaced and tested per 1B67824, paragraphs 4.1, 4.2 B and C, 1B66572, 1B66567, and 1B66562.
500-608-927 1-6-69	During the performance of 1B76687 A, it was noted that the standoff, P/N 1B31249-1, at stringer 53 in the forward interstage, had stripped threads. Reference 1B62906, zone 29.	The standoff was repaired per 1B53312.
500-608-951 1-9-69	During the performance of 1A96570, it was noted that the aft umbilical quick disconnect, P/N 7851823-503, S/N 1083, energized with difficulty, and was noted to have a black substance on the sealing surface.	The quick disconnect was sent to LOX service, cleaned per DPS 43000, and reinstalled on the stage. The rework was acceptable to Engineering.
500-703-130 1-16-69	During surveillance inspection, it was noted that the Koratherm finish on the forward skirt had hairline cracks at the following areas: a. A 7-inch hairline crack to the right of stringer 28 at station 568. b. A 7-inch hairline crack between stringers 28 and 29 at station 556. c. A 6-inch L shape hairline crack between stringers 33 and 34 at station 550.	a. through e. The cracks and the adjacent areas were wiped clean with toluene, DPM 540, moistened cotton cloths. Six brush coats of unthinned silicone dispersion coating, DPM 3486-5, were applied allowing 15 minutes between coats to dry.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-703-130 1-16-69 (Cont.)	d. A 2-inch hairline crack on the attach flange adjacent to stringer 33 at station 554.702.	
	e. A 1-inch hairline crack on the attach flange on stringer 33 at station 554.702.	
500-703-164 1-22-69	During removal per 1B68375 F, the prevalve, P/N 1A49968-509-010A, S/N 146, was scratched three places 0.005 inch deep by 2 inches in length, adjacent to the seal, P/N FC-6511002 and spring, P/N 1B58882. Reference 1B68375, zone 14, view GG.	The prevalve was removed and replaced.
500-703-181 1-23-69	During rework per 1B69961 NEW, it was noted that the 404MT627 acoustic transducer, P/N 1A68708-513, S/N 5276, had a damaged diaphragm.	The transducer was removed and replaced.
500-703-199 1-23-69	Installation of clip, P/N 1B66222-147, was impossible due to a mislocated size 40 hole in stringer 1A, adjacent to the nylafil standoff 20 inches from the heel line. Reference 1B66222 AM, zones 13 and 14, view BB.	The nylafil standoff was back spot faced to clear the clip assembly.
500-703-202 1-23-69	It was noted at the LOX prevalve that the clamp assemblies, P/N MVC 68541-1000 W and MVC 68541-1150 W, were tightened to a torque value of 290 in-lb, but should have been between 145 and 165 in-lb per 1B68375 F and H. NOTE: The torque value was subsequently adjusted to 165 in-lb and leak checked.	The rework was accepted by the Material Review Board.

A

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-703-229 1-24-69	During performance of 1B71909, a foreign substance was noted on the LOX chilldown temperature transducer, P/N 1A67863-519, at the leak check seal area.	The transducer was removed, cleaned with demineralized water and freon. The transducer was then reinstalled on the stage.
500-703-245 1-28-69	The 404MT625 and 404MT626 acoustic transducer assemblies, P/N 1A68708-513, had the finish removed from their mounting brackets.	The mounting brackets were realodined per DPS 41410.
500-703-288 1-29-69	During performance of 1B69661 NEW, it was noted that the ablative coating adjacent to the 0.828 diameter hole for the 404MT627 transducer was chipped.	The adjacent area was cleaned with methyl ethyl keytone and reworked per DPS 42210, paragraph 6.9.
500-703-296 1-29-69	During the performance of 1B71909, it was noted that the cold helium spheres, P/N 1A48858-1, positions 7 and 8, bank No. 2, had bubble leaks.	The LH2 tank was pressure decay checked at 25 ±5 psig for 15 minutes; then, at 9-10 psig the leakage was measured.
	Resubmit 1: The decay rate for position 7 and 8 was 1.6 and 4.9 psig, respectively, in 15 minutes. The leakage rate for positions 7 and 8 was 0.045 and 0.55 scim, respectively.	Resubmit 1: The LH2 tank was entered and the torque values of the flange clamps were measured.
	Resubmit 2: The torque values for positions 7 and 8 was 46 in-lb and between 20 and 55 in-lb on the four mounting bolts, respectively, but should have been 65 ±5 in-lb.	Resubmit 2: The bolts were tightened to the torque values per the drawing requirements. The leaking connections were checked with 25 ±5 psig helium applied and locked up for 15 minutes.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-703-296 1-29-69 (Cont.)	Resubmit 3: No decay was noted.	Resubmit 3: The decay was acceptable to the Material Review Board and the FARR was transferred to the FTC for leak check and final disposition.
500-703-300 1-30-69	During performance of 1B71909, it was noted that the reducer, P/N MC169C19 W, had scratches 0.0005 inch deep on both seating surfaces.	The reducer was removed and replaced.
500-703-334 2-1-69	During the performance of 1B71909, it was noted that the helium heater exciter, P/N 1B59986-507, S/N 075, had no talkback indication.	The exciter was removed and replaced.
500-703-628 2-8-69	During the performance of 1B65109, it was noted that the mounting holes of bracket assembly, P/N 1B65109-37, interferred with pipe assembly, P/N 1B63271-1 and retainer, P/N 1B65778-541, on stiffener 9 3/4.	The pipe assembly was hand formed to clear by 1/32 inch per DPS 10002. The retainer was removed and replaced and the panel edg was trimmed to clear the curtain by 1/16 inch. The stud and clinch plate assembly were installed per 1B65608.
500-703-636 2-8-69	During the performance of 1B66572 H, it was noted that the ground fill overpressure switch, P/N 1B52624-511, S/N 024, dropout value average was 28 psia. The minimum dropout value should have been 27.6 psia.	The overpressure switch was removed and replaced.
500-703-644 2-11-69	During the performance of 1B70766, it was noted that the set of two LOX chilldown pump purge orifices, P/N 1B40622-513, S/N 318, would not maintain motor case pressure per the requirements of ROD A3-860-KCBA-473.	The FARR was transferred open to the FTC for final disposition.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-703-661 2-12-69	The impingement curtain, P/N 1B65608-1, was noted to have the following discrepancies: a. Three areas had improper or omitted stitches, also one area was debonded. Reference 1B65608, zone 9, views AA and BB. b. One area was torn 1 1/2 inch adjacent to the stub tab on stringer 7. Reference 1B65608, zones 3 and 12, view L. c. One clinch plate and fastener was omitted. Reference 1B65608, zone 11, view MM.	a., b., and c. The curtain was sent to tl vendor for rework. All items were not acceptable and the noted discrepancies were transferred to FARR 500-819-421.
500-703-679 2-12-69	a. The -3 cloth of the impingement curtain, P/N 1B65611-501, was noted to have the stitching omitted and was also debonded. Reference 1B65611-501, zones 3, 6, and 8 main view, and zone 7, view AA. b. The stitching was loose on the flap interfold areas of thirteen flaps.	a. and b. The curtain was sent to the vendor for rework. All items were not acceptable and the noted discrepancies were transferred to FARR 500-819-359.
500-703-687 2-12-69	a. The -3 cloth of the impingement curtain, P/N 1B65606-1, had omitted stitching and was also debonded. Reference 1B65606, zone 7, view EE. b. The stitching was loose on the flap interfold area of five flaps.	a., b., and c. The curtain was sent to th vendor for rework. All items were not acceptable and the noted discrepancies were transferred to FARR 500-819-367.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-703-687 2-12-69 (Cont.)	c. The stud assembly was mislocated by 0.400 inch on the aft skirt side. Reference 1B65611-501, zone 6.	
500-703-695 2-12-69	The -3 cloth of the impingement curtain, P/N 1B65609-503, had two areas of improper stitching and two areas with loose stitching. Reference 1B65609-503, zones 2, 8, and 12, views BB, RR, and FF, respectively.	The curtain was sent to the vendor for rework. All items were not acceptable and noted discrepancies were transferred to FARR 500-819-383.
500-703-709 2-12-69	a. The -3 cloth of the impingement curtain, P/N 1B65607-1, had omitted stitching and was also debonded. Reference 1B65607-1, zone 8, views L and AA.	a. and b. The curtain was sent to the vendor for rework. All items were not acceptable and the noted discrepancies were transferred to FARR 500-819-375.
	b. The stitching was loose on the flap interfold area of five flaps.	
500-703-717 2-12-69	a. The impingement curtain, P/N 1B65746-501, had three areas of loose or improper stitching and three areas which were debonded. Reference 1B65746-501, zones 3 through 7 and 10.	a., b., and c. The curtain was sent to the vendor for rework. All items were not acceptable and the noted discrepancies were transferred to FARR 500-819-405.
	b. The curtain had two 1 inch tears, one each forward of stiffener 17 1/4 and 18A.	
	c. The curtain cutout for pipe assembly, P/N 1B69917-1, adjacent to stringer 18 was improperly cut.	

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-703-725 2-12-69	The -3 cloth of the impingement curtain, P/N 1B65607-503, was improperly stitched and the flap interfold stitching was loose on seven flaps. Reference 1B65607, zones 8 and 9, views L, MM, and AA, respectively.	The curtain was sent to the vendor for rework. All items were not acceptable and the noted items were transferred to FARR 500-819-391.
500-703-750 2-13-69	During the performance of 1B71909, the following orifices were noted to be leaking in excess of the drawing tolerances. a. The LOX shutdown valve bellows purge orifice, P/N 1B40622-509, S/N 241, was 71 scim, but should have been 105 to 165 scim. b. The LOX tank sense line purge orifice, P/N 1B40622-501, S/N 203, was 510 scim, but should have been 540 to 1030 scim. c. The LOX NPV duct purge orifice, P/N 1B40622-501, S/N 152, was 260 scim, but should have been 540 to 1030 scim. d. The continuous vent bypass valve bellows purge orifice, P/N 1B40622-509, was 83 scim, but should have been 105 to 165 scim. e. The LH2 propellant valve purge orifice, P/N 1B40622-505, S/N 220, was 3 scim, but should have been 4.5 to 8.5 scim.	Items a through f are scheduled to be removed and replaced at the FTC. Items g through i were removed and replaced. All orifices are scheduled for leak and functional check at the FTC.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-703-750 2-13-69 (Cont.)	f. The continuous vent bypass vent microswitch purge orifice, P/N 1B40622-505, S/N 230, was 3.1 scim, but should have been 4.5 to 8.5 scim. g. The LH2 fill and drain purge orifice, P/N 1B40622-505, S/N 235, was 2.7 scim, but should have been 4.57 to 8.5 scim. h. The LH2 NPV duct purge orifice, P/N 1B04622 -501, S/N 204, was 400 scim, but should have been 540 to 1030 scim. i. The LH2 PU duct purge orifice, P/N 1B40622 -501, S/N 177, was 330 scim, but should have been 540 to 1030 scim.	
500-703-776 2-13-69	During the performance of 1B71909, it was noted that the pipe assembly, P/N 1B75772-1, adjacent to stiffeners 6 and 6 1/4, had bubble leakage.	The pipe assembly flare was polished, tested per 1B75772, cleaned per DPS 43000, reinstalled and leak checked per 1B71909.
500-703-822 2-14-69	During performance of ECP 666, it was noted that the PU valve, P/N 251351-51, S/N 4078043, required 18 volts to slew the valve, but should have required 15 volts or less.	The PU valve was removed and replaced.
500-703-831 2-15-69	During routine surveillance inspection, it was noted that pipe assembly, P/N 1B52479-1, adjacent to stiffener 5, was dinged 1/4 inch in length by 3/16 inch in width by 1/16 inch in depth.	The tube assembly was scheduled for removal, replacement, and compliance with general notes on page 3 of 1B52479 at the FTC.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITIO
500-703-849 2-15-69	The doubler, P/N 1B65109-37, and segment, P/N 1B65110-535 were mislocated. The 2.50 +0.03 inch dimension was 2.93 inches at stiffener 10. Reference 1B65109, zone 45, view T.	The condition was acceptable to the Material Review Board.
500-704-616 2-28-69	During preshipment inspection, it was noted that the 404W201 cable assembly, P/N 1B76263-1 NEW, was not secured to the three clamps between stringers 1 and 135. NOTE: The above discrepancy was located behind the interim dessicant assembly.	The cable clamps were scheduled to be secured after the interim dessicant assembly was removed at the FTC.
500-815-868 2-17-69	The boot was improperly fastened which caused excessive strain adjacent to the pipe assemblies on stiffener 5 1/4. Reference 1B65109, zone 14, view G.	The clamp fastener bolt was removed. spacer, P/N NAS 43DD-32, and bolt, P/ NAS 1003-10A, was installed.
500-815-876 2-18-69	Data review of the all systems test revealed that the pump purge regulator, P/N 1B43320 -511, S/N 43-8, and the pressure control helium regulator, P/N 1A72913-557, S/N 482-8, sent invalid data.	The transducers were scheduled to be removed and replaced at the FTC.
500-815-906 2-18-69	During preshipment inspection the helium tank, P/N 1B66868-501, S/N 35, was noted to have two dings 1/2 inch apart at the bottle rotation 270 degrees and 2 1/4 inches from plane A.	The noted areas were blended with No. wet cloth.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-815-914 2-19-69	During the performance of 1B70900, fourteen areas were noted to have surface corrosion at the outer flange of door assembly, P/N 1B63184-1, and the mating surface of tank, P/N 1B63182-1.	The corrosion was removed with No. 400 grit paper. The noted surfaces were brush alodined and reworked per DPS 40160.
500-815-957 2-19-69	The outer jacket of the 408W200 coaxial wire was exposing shielding approximately 1/8 inch above the P3 connector.	The condition was acceptable to the Material Review Board.
500-815-965 2-20-69	During preshipment inspection a black residue was noted at the weld of the boss on pipe assembly, P/N 1B38419-503, attached to the A92 cold plate in the forward skirt. Reference 1B38426, zone 5 and 6.	The pipe assembly was scheduled to be removed and replaced at the FTC.
500-815-973 2-20-69	During preshipment inspection, it was noted that a wire to the J4 receptacle of the 405W203 wire harness was nicked.	The nicked wire was repaired using DPM 2766 tape per DPS 54010.
500-815-981 2-20-69	During performance of 1B70900, it was noted that the epoxy coating and the Korotherm coating was chipped adjacent to the LH2 fill and drain port.	The noted area was cleaned with methyl ethyl keytone and reworked per DPS 42210.
500-815-990 2-20-69	Data review of the all systems test revealed that the LH2 fastfill sensor cycled during the PU mixture ratio 45 to 1 on command.	The FARR was transferred to the FTC for evaluation and final disposition.
500-816-007 2-21-69	During preshipment inspection, it was noted that the pipe assembly, P/N 1B75268-1, in the forward interstage, had a bend radius extending into the sleeve area of the B-nut.	The condition was acceptable to the Material Review Board.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-816-015 2-21-69	During preshipment inspection, it was noted that twenty-six areas of the mylar covering had improper holes, were loose or debonded and improperly installed.	Six of the noted discrepancies were reworked to the drawing requirements and DPS 22301. Twenty of the noted items were accepted by the Material Review Board.
500-816-023 2-21-69	During preshipment inspection, it was noted that the clamp installation on pipe assembly, P/N 1B38423-1, was not possible due to a mislocated sleeve and expander at stringer 12. The clamp should have been located at stringer 13. Reference 1A39264, zone 86 and 1B38426, zone 24.	The condition was accepted by the Material Review Board.
500-816-058 2-24-69	During rework, per FARR 500-815-914 on door assembly, P/N 1B63184-1, the mylar covering was torn and had several holes.	The mylar cover was removed using a plastic scraper and methyl ethyl keytone. The scratches were smoothed up and treated with sulfuric acid. A new mylar cover was replaced per DPS 22301.
500-816-066 2-25-69	During rework, the curtain assembly, P/N 1B66487-1, in the aft interstage at stringer 54, had a tear approximately 1/2 inch long.	The loose ends were trimmed, and the area was cleaned with isopropyl alcohol. One layer of 2 inch aluminized tape was applied over the torn area.
500-819-359 2-26-69	During receiving inspection and after rework of the impingement curtain, P/N 1B65611-501, per FARR 500-703-679, the following discrepancies were noted: a. The stitches were loose on the flap interfold.	The curtain was returned to the vendor for rework of noted discrepancies.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-819-359 2-26-69 (Cont.)	b. The -3 cloth 0.062 $\pm$0.06 inch stitch location was not maintained. c. The boot had a tear 0.3 inch above the center eyelet. d. The stenciled change letter had partiall flaked off.	
500-819-367 2-26-69	During receiving inspection and after rework of impingement curtain, P/N 1B65606-1, per FARR 500-703-687, the following discrepancies were noted: a. The -3 cloth 0.062 $\pm$0.06 inch stitch location was not maintained. b. The stud, P/N XX78332K1105, was mislocated. c. The stenciled change letter was flaking off.	The curtain was returned to the vendor for rework of noted discrepancies.
500-819-375 2-26-69	During receiving inspection and after rework of impingement curtain, P/N 1B65607-1, per FARR 500-703-709, the following discrepancies were noted: a. The -3 cloth 0.062 $\pm$0.06 inch stitch location was not maintained. b. The -3 cloth had two tears, one above the zipper tab in the closed position and one in the eyelet tab adjacent to the velcro fastener.	The curtain was returned to the vendor for rework of the noted discrepancies.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-819-375 2-26-69 (Cont.)	c. The stenciled change letter had partially flaked off.	
500-819-383 2-26-69	During receiving inspection and after rework of the impingement curtain, P/N 1B65609-503, per FARR 500-703-695, the following discrepancies were noted: a. The -3 cloth 0.062 $\pm$0.06 inch stitch location was not maintained. b. The 0.12 inch dimension was not maintained at the zipper edge. c. The boot section and the silver reinforcement strip were debonded from the thrust structure side.	The curtain was returned to the vendor for rework of the noted discrepancies.
500-819-391 2-26-69	During receiving inspection and after rework of the impingement curtain, P/N 1B65607-503, per FARR 500-703-725, the following discrepancies were noted: a. The stitches were loose and not per the drawing requirements in three areas. b. The curtain had two areas that were torn c. The stenciled change letter had partially flaked off.	The curtain was returned to the vendor for rework of the noted discrepancies.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-819-405 2-26-69	During receiving inspection and after rework of the impingement curtain, P/N 1B65746-501, per FARR 500-703-717, the following discrepancies were noted: a. The stitching was loose at the interfold area of the flap. b. The -3 cloth 0.062 ±0.06 inch stitch location was not maintained. c. The curtain had two 1 inch tears. d. The cutout for pipe assemblies were improper. e. The curtain had areas that had peeled and had exposed the inner fabric. f. The stenciled change letter had partially flaked off.	The curtain was returned to the vendor for rework of the noted discrepancies.
500-819-413 2-26-69	During receiving inspection and after rework of the impingement curtain, P/N 1B65610-501, per FARR 500-489-871, the following discrepancies were noted: a. The -3 cloth 0.062 ±0.06 inch stitch location was not maintained. b. The stud, P/N XX78332K1105, was relocated in error.	The curtain was returned to the vendor for rework of the noted discrepancies.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-819-413 2-26-69 (Cont.)	c. The stitching on the velcro fastener was loose at the zipper radius. d. The curtain had areas that had peeled and had exposed the inner fabric. e. The stenciled change letter had partially flaked off.	
500-819-421 2-26-69	During receiving inspection and after rework of the impingement curtain, P/N 1B65608-1, per FARR 500-703-661, the following discrepancies were noted: a. The patch was improperly installed adjacent to the stud tab. b. The -3 cloth 0.062 +0.06 inch stitch location was not maintained. c. The pull string for the zipper was improperly stitched. d. The curtain had areas that had peeled and had exposed the inner fabric. e. The stenciled change letter had partially flaked off.	The curtain was returned to the vendor for rework of the noted discrepancies.
500-819-448 3-3-69	After vendor rework of the impingement curtain, P/N 1B65610-501, per FARR 500-819-413, the following discrepancies were noted:	

TABLE III (Continued)

500-819-448 3-3-69 (Cont.)	a. The curtain had excessive bonding material at the four valve flaps.	a. The excess bonding material was removed and a bead of RTV 731 adhesive was applied to the frayed surfaces.
	b. The curtain had excessive soap residue, dirt, and black marks.	b. The dirt and residue was removed with isopropyl alcohol.
	c. The curtain valve flap corners had silicone sealistic (DPM 3201) applied which was not a drawing requirement.	c. The condition was acceptable to the Material Review Board.
500-819-456 3-3-69	After vendor rework of the impingement curtain, P/N 1B65611-501, per FARR 500-819-359, the following discrepancies were noted:	
	a. The curtain had excessive soap residue, dirt, and black marks.	a. The dirt and residue was removed with isopropyl alcohol.
	b. The curtain had excessive bonding material at all valve flaps.	b. and c. The noted conditions were acceptable to the Material Review Board.
	c. The curtain valve flap corners had silicone sealistic (DPM 3201) applied which was not a drawing requirement.	
500-819-464 3-3-69	After vendor rework of the impingement curtain, P/N 1B65606-1, per FARR 500-819-367, the following discrepancies were noted: The curtain had bonding material overlapping the valve flaps onto the curtain assembly, also silicone sealistic (DPM 3201) was applied which was not per the drawing requirements.	The noted conditions were acceptable to the Material Review Board.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-819-472 3-3-69	After rework of the impingement curtain, P/N 1B65607-503, per FARR 500-819-391, the following discrepancies were noted:	
	a. The curtain had excessive residue and black marks.	a. The dirt and residue was removed with isopropyl alcohol.
	b. The curtain had bonding material overlapping valve flaps onto the curtain assembly, also silicone sealistic (DPM 3201) was applied which was not a drawing requirement.	b. The noted conditions were acceptable to the Material Review Board.
500-819-481 3-3-69	After vendor rework of the impingement curtain, P/N 1B65608-1, per FARR 500-819-421, the following discrepancies were noted:	
	a. The curtain had excessive bonding material at the five valve flaps.	a. The excess bonding material was removed and a bead of RTV 731 adhesive was applied to the frayed surfaces.
	b. The curtain valve flap corners had silicone sealistic (DPM 3201) applied which was not a drawing requirement.	b. The condition was acceptable to the Material Review Board.
500-819-499 3-3-69	After vendor rework of the impingement curtain, P/N 1B65746-501, per FARR 500-819-405, the following discrepancies were noted:	
	a. The curtain had residue deposits, dirt, and black marks.	a. The dirt and residue was removed with isopropyl alcohol.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-819-499 3-3-69 (Cont.)	b. The curtain had bonding material overlapping the valve flaps onto the curtain assembly, also silicone sealistic (DPM 3201) was applied and not per the drawing requirements.	b. The noted conditions were acceptable to the Material Review Board.
500-819-502 3-3-69	After vendor rework of the impingement curtain, P/N 1B65609-503, per FARR 500-819-383, the following discrepancies were noted:	
	a. The curtain had residue deposits, dirt, and black marks.	a. The dirt and residue were removed with isopropyl alcohol.
	b. The curtain had bonding material overlapping the valve flaps onto the curtain assembly, also silicone sealistic (DPM 3201) was applied and not per the drawing requirements.	b. The noted conditions were acceptable to the Material Review Board.
500-819-511 3-3-69	After vendor rework of the impingement curtain, P/N 1B65607-1, per FARR 500-819-511, the following discrepancies were noted: The curtain had bonding material overlapping the valve flaps onto the curtain assembly, also silicone sealistic (DPM 3201) was applied and not per the drawing requirements.	The noted conditions were acceptable to the Material Review Board.

[redacted] APPENDIX III [redacted]

FLIGHT CRITICAL ITEMS

APPENDIX III

FLIGHT CRITICAL ITEMS INSTALLED AT TURNOVER

The flight critical items (FCI), as designated by DRD 1B53279 K, that were installed on the stage at the time of turnover to NASA/STC for shipment to KSC are listed in the following tabulation:

P/N	S/N	Ref. Location	Name
1A48240-511	0044	404A7	Fill and drain valve
1A48240-511	0001	427A8	Fill and drain valve
1A48257-525	0056	411A1	LH2 vent and relief valve
1A48312-517	0051	424A1	LOX vent and relief valve
1A48430-511-012	C3	406A1	LOX mass probe
1A48431-513	C2	408A1	LH2 mass probe
1A48857-503	49	403A73	Control helium tank
1A48858-1	1168	Bnk 2 Pos 7	Helium sphere, cold
1A48858-1	1173	Bnk 2 Pos 9	Helium sphere, cold
1A48858-1	1180	Bnk 1 Pos 5	Helium sphere, cold
1A48858-1	1185	Bnk 1 Pos 2	Helium sphere, cold
1A48858-1	1187	Bnk 1 Pos 1	Helium sphere, cold
1A48858-1	1191	Bnk 1 Pos 3	Helium sphere, cold
1A48858-1	1194	Bnk 1 Pos 4	Helium sphere, cold
1A48858-1	1216	Bnk 2 Pos 10	Helium sphere, cold
1A48858-1	1218	Bnk 2 Pos 8	Helium sphere, cold
1A49421-507	190	427A41	LH2 aux chilldown pump
1A49423-509	1868	424A2	LOX aux chilldown pump
1A49964-501	275	424 (LOX)	Chill system check valve
1A49964-501	291	427 (LH2)	Chill system check valve
1A49965-523-012	0106	424A41	Chill system shutoff valve
1A49965-529-013B	0502	424A4	Chill system shutoff valve
1A49968-519	133	426A6	Prop. tank shutoff valve
1A49968-521	145	404A44	Prop. tank shutoff valve
1A49991-1	51	403A6	Tank, comp. gas, cold helium
1A49991-1	53	403A74	Tank, comp. gas, cold helium
1A49991-1	86	403A7	Tank, comp. gas, cold helium
1A57350-507	0239	403A73A5	Helium fill module
1A58345-523	1006	403A73A1	Module, pneumatic pwr control
1A58347-513	7	403A73A2	Engine pump prg cont mod
1A59358-529	032	411A92A6	PU electronics assembly
1A66212-507	023	411A92A7	Inv-conv elect. assy
1A66240-503	X123108	401A11S1, S2	Engine driven pump, hydraulic
1A66241-511	X458911	403B1	Aux hydraulic pump
1A66248-507	30	403A72L1	Hydraulic actuator assy
1A66248-507	81	403A71L1	Hydraulic actuator assy
1A68085-505	0087	404A45A1	300 amp pwr transfer switch

Appendix III (Continued)

P/N	S/N	Ref. Location	Name
1A68085-505	0115	404A2A1	300 amp pwr transfer switch
1A74039-517-016A	071	404A74A2	Chilldown inv. elect. assy
1A74039-517-016A	072	404A74A1	Chilldown inv. elect. assy
1A74211-515	0625	411A99A10A11	2 amp relay module
1A74211-515	0626	411A99A10A12	2 amp relay module
1A74211-515	0627	411A99A10A13	2 amp relay module
1A74211-515	0647	404A3A17	2 amp relay module
1A74211-515	0648	404A45A9	2 amp relay module
1A74211-515	0649	404A3A19	2 amp relay module
1A74211-515	0650	404A45A7	2 amp relay module
1A74211-515	0661	404A45A8	2 amp relay module
1A74211-515	0662	404A3A41	2 amp relay module
1A74211-515	0664	404A3A48	2 amp relay module
1A74211-515	0773	404A2A6	2 amp relay module
1A74211-515	0779	404A45A10	2 amp relay module
1A74211-515	0780	404A2A8	2 amp relay module
1A74216-503	0480	404A3A13	Mag Latch relay module
1A74216-503	0499	404A3A21	Mag latch relay module
1A74216-503	0504	404A45A5	Mag latch relay module
1A74216-503	0375	404A3A23	Mag latch relay module
1A74218-515	0596	404A45A11	10 amp relay module
1A74218-515	0739	411A99A10A10	10 amp relay module
1A74218-515	0801	404A3A12	10 amp relay module
1A74218-515	0802	404A3A14	10 amp relay module
1A74218-515	0803	404A3A20	10 amp relay module
1A74218-515	0805	404A3A44	10 amp relay module
1A74218-515	0806	404A3A49	10 amp relay module
1A74218-515	0807	404A2A2	10 amp relay module
1A74765-507	231	401A11S1	Hyd syst thermal switch
1A74890-501	0127	404A2A10	50 amp relay module
1A74890-501	0131	404A2A9	50 amp relay module
1A74890-501	0133	404A2A7	50 amp relay module
1A74890-501	0137	404A45A2	50 amp relay module
1A77310-503.1	0144	411A99A33	5 volt excitation module
1A77310-503.1	0174	404A52A7	5 volt excitation module
1A77310-503.1	0191	411A98A2	5 volt excitation module
1A86847-509.	062	401A11S1, S2	Hyd pump thermal isol assy
1B29319-519	00033	403A46	Accum/reservoir assy
1B32647-505	071	404A45A3	Hyd pwr unit start switch
1B33084-503	035	411A97A19	RS controller assy
1B33084-503	036	411A97A13	RS controller assy
1B39037-501	115	401-III	Eng installation bolts
1B39037-501	117	401-IV	Eng installation bolts
1B39037-501	121	401-II	Eng installation bolts
1B39037-501	124	401-II-III	Eng installation bolts
1B39037-501	125	401-IV-I	Eng installation bolts

Appendix III (Continued)

P/N	S/N	Ref. Location	Name
1B39037-501	126	401-I	Eng installation bolts
1B39550-533	012	404A3	Sequencer mounting assy
1B39975-501	0274	404A3A1	Diode module
1B39975-501	0275	404A3A37	Diode module
1B39975-501	0278	404A3A39	Diode module
1B39975-501	0289	404A2A16	Diode module
1B39975-501	0290	404A3A3	Diode module
1B39975-501	0291	404A2A17	Diode module
1B39975-501	0292	404A3A5	Diode module
1B39975-501	0294	404A3A43	Diode module
1B40604-1.2	0123	404A2A34	Diode assy module
1B40604-1.2	0153	404A3A7	Diode assy module
1B4060401.2	0154	404A3A50	Diode assy module
1B40604-1.2	0155	404A3A42	Diode assy module
1B40604-1.2	0157	404A3A51	Diode assy module
1B40824-507.1	120	403 Str 5A	Check valve
1B40824-507.1	121	403 Str 9A	Check valve
1B40824-507.1	123	403 Str 9 3/4	Check valve
1B40824-507.1	124	403A74	Check valve
1B40824-507.1	509	403 Str 5	Check valve
1B40824-507.1	514	403 Str 5A	Check valve
1B40887-501	0253	404A3A16	10 amp mag latch relay mod
1B40887-501	0255	404A3A10	10 amp mag latch relay mod
1B40887-501	0267	404A3A2	10 amp mag latch relay mod
1B40887-501	0268	404A3A6	10 amp mag latch relay mod
1B40887-501	0319	404A2A15	10 amp mag latch relay mod
1B40887-501	0320	404A45A6	10 amp mag latch relay mod
1B40887-501	0321	404A3A18	10 amp mag latch relay mod
1B40887-501	0324	404A3A46	10 amp mag latch relay mod
1B40887-501	0337	404A3A8	10 amp mag latch relay mod
1B40887-501	0338	404A3A4	10 amp mag latch relay mod
1B40887-501	0356	404A3A57	10 amp mag latch relay mod
1B40887-501	0560	404A3A58	10 amp mag latch relay mod
1B42290-511	0033	403A74A1	LOX tank press control module
1B51211-505	014	404A45	Aft 56 volt pwr dist assy
1B51354-523	013	404A2	Aft 28 volt pwr dist assy
1B51361-501	319	403A74A3	Fuel vent purge check valve
1B51361-501	408	403A73A4	Fuel vent purge check valve
1B51379-521	012	411A99A10	Fwd pwr dist mount assy
1B51753-511	032	411A32	LH2 prop vent reg & S/D valve
1B52623-515	026	403S2	Pressure switch
1B52624-511	021	411S2	Pressure switch
1B52624-511	033	411S4	Pressure switch
1B52624-515	55	403S8	Pressure switch
1B52624-519	20	403S5	Pressure switch
1B52624-519	34	503S1	Pressure switch

Appendix III (Continued)

P/N	S/N	Ref. Location	Name
1B52624-519	36	403S6	Pressure switch
1B53920-501	041	403 Str 4	Chill feed duct check valve
1B53920-503	062	LH2 C/D duct	Chill feed duct check valve
1B53920-503	063	LOX C/D duct	Chill feed duct check valve
1B55200-505	1018	403A73A3	Fuel Tank press control mod
1B55408-503	2012	Str 13A	Compressed air tank
1B57731-503	429	404A51A4	Control relay package
1B57731-503	430	404A71A19	Control relay package
1B57781-507-005	0007	403A74A2	Cold helium fill module
1B58006-7	53	403A74	1A49991, teflon wrapped
1B59010-509	121	427A7	Pneu prop. control valve
1B62600-529-012	014	403 Str 10-3/4	O2H2 welded burner assy
1B62778-503	00014	403A6	Helium plenum & valve assy
1B62778-503	00038	403A7	Helium plenum & valve assy
1B65319-503	014	404A70A1	Sw sel emissivity cont assy
1B66320-509	1018	403A73A3	Calibrated LH2 press. cont mod
1B66639-515	054	403 Str 10A	Pneu latching actuator assy
1B66639-519	043	411A32	Pneu latching actuator assy
1B66692-501-004	97	404A44	Actuation control module
1B66692-501-004	99	404A43	Actuation control module
1B66692-501-004	100	403A15	Actuation control module
1B66692-501	102	411A30	Actuation control module
1B66692-501-004	103	404A17	Actuation control module
1B66692-501-004	107	403A75A1	Actuation control module
1B66692-501-004	108	404A9	Actuation control module
1B66692-501-004	109	403A75A1	Actuation control module
1B66692-501-004	110	404A17	Actuation control module
1B66692-501	173	411A14	Actuation control module
1B66692-501-004	177	403A8	Actuation control module
1B66868-501	15	Tank Pos 9	Ambient helium sphere
1B66868-501	18	Tank Pos 10	Ambient helium sphere
1B66868-501	26	Tank Pos 7	Ambient helium sphere
1B66868-501	31	Tank Pos 1	Ambient helium sphere
1B66868-501	32	Tank Pos 5	Ambient helium sphere
1B66868-501	33	Tank Pos 8	Ambient helium sphere
1B66868-501	34	Tank Pos 6	Ambient helium sphere
1B66868-501	35	Tank Pos 2	Ambient helium sphere
1B66988-1	017	404A71A1	Sphere assy, helium storage
1B67193-511	050	411A32	Continuous vent control mod
1B67598-501	46	403 Str 7	Pneumatic check valve
1B67598-501	78	403 Str 6	Pneumatic check valve
1B67598-501	79	404 Str 13A	Pneumatic check valve
1B67598-501	80	404 Str 29	Penumatic check valve
1B67598-501	81	404 Str 30	Pneumatic check valve
1B67598-501	84	404 Str 26	Pneumatic check valve
1B67598-501	91	403 Str 5	Pneumatic check valve
1B67598-501	167	403 Str 4	Pneumatic check valve

Appendix III (Continued)

P/N	S/N	Ref. Location	Name
1B67598-501	173	403 Str 9	Pneumatic check valve
1B67598-501	186	403 Str 9A	Pneumatic check valve
1B67598-503	68	403A74A3	Pneumatic check valve
1B67598-503	69	403A73A4	Pneumatic check valve
1B69030-505	0027	424A9	LOX NPV control valve
1B69514-501	010	404A3A56	Isolation diode module
1B69514-501	032	404A3A9	Isolation diode module
1B69514-501	033	404A3A55	Isolation diode module
1B69514-501	047	411A99A10A8	Isolation diode module
1B69550-501	026	403A74A3	Repress. control module
1B69550-501	027	403A73A4	Repress. control module
1B74535-1	0005	411A1	Valve, relief, LH2 tnk latch
1B76452-501	25	404A71A19	Control relay package
1B76452-501	33	404A51A4	Control relay package
7851823-503	1083	APS Hel Inlt	Helium control disconnect
7851823-503	1088	Amb Hel Inlt	Helium control disconnect
7851844-501	13	427 Cl O/Umb	Cold helium disconnect
7851861-1	55	427	LH2 tank press. disconnect
40M39515-113	259	404A75A1	EBW firing unit
40M39515-113	260	404A75A2	EBW firing unit
40M39515-113	290	404A47A1	EBW firing unit
40M39515-113	291	404A47A2	EBW firing unit
40M39515-119	452	411A99A12	EBW firing unit
40M39515-119	550	411A99A20	EBW firing unit
103826	J-2119	401	J-2 engine

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY

MCDONNELL DOUGLAS

CORPORATION

5301 Bolsa Avenue, Huntington Beach, CA 92647