DAC-56608 169 FEBRUARY 1969

SACRAMENTO
NARRATIVE END ITEM REPORT
SATURN S-IVB-506N

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY

MCDONNELL DOUGLAS
CORPORATION

SACRAMENTO NARRATIVE END ITEM REPORT SATURN S-IVB-506N

DAC-56608
FEBRUARY 1969

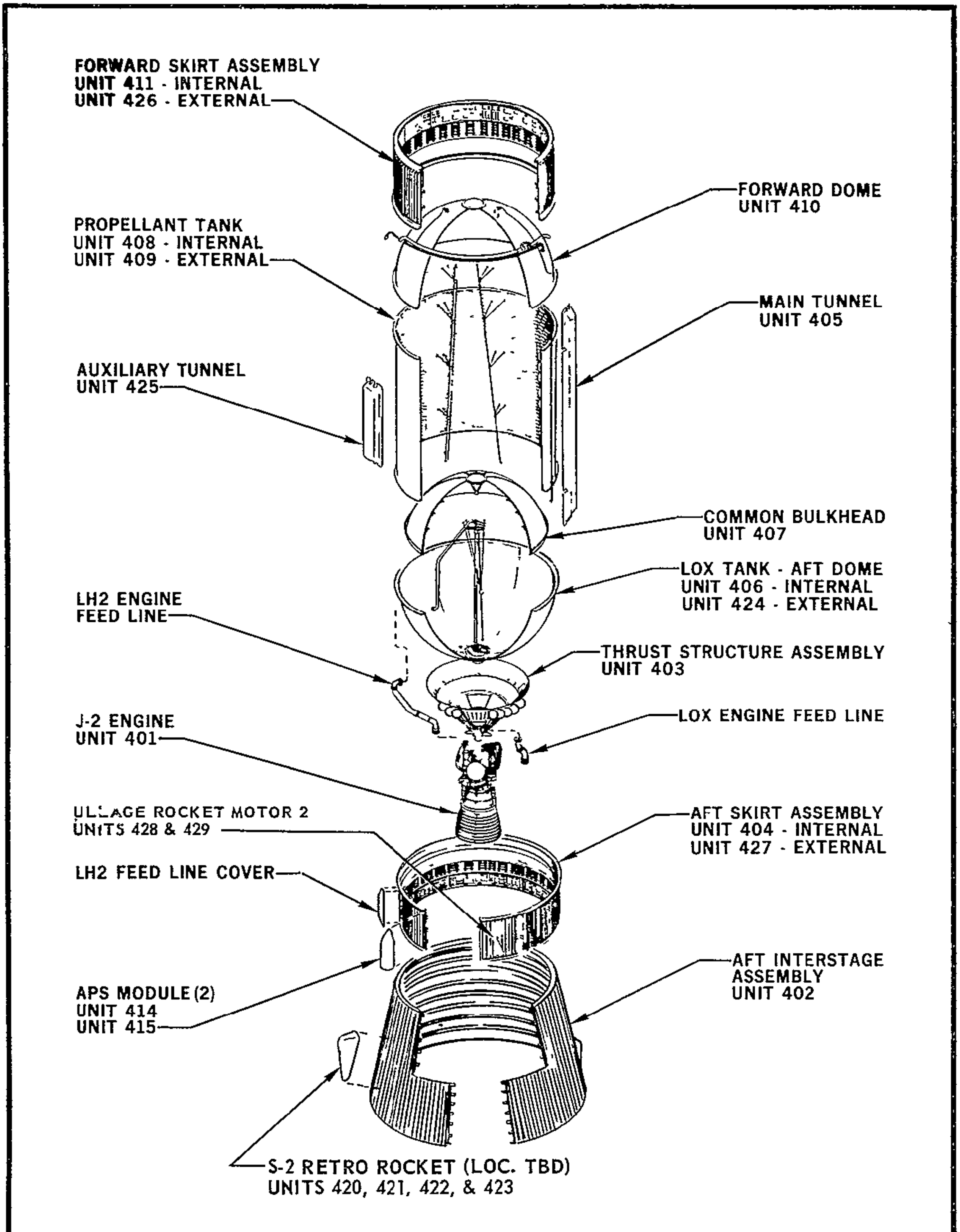
PREPARED BY W. M. REITZELL BRANCH CHIEF
QUALITY DATA AND REPORTING
RELIABILITY ASSURANCE DEPARTMENT

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

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

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-506N Flight Stage (P/N 1A39300-511, S/N 1011).

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 Reliability Assurance Directorate 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-506N, Douglas Report DAC-56622, dated February 1968.

CONTENTS

CONTENTS (Continued)

CONTENTS (Continued)

APPENDIX I

APPENDIX II

APPENDIX III

SECTION 1
INTRODUCTION

1.0 INTRODUCTION

1.1 Scope

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

a. Configuration at 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 Reliability Assurance Directorate Central Data Files. Vendor technical data is received on functional purchased parts and also retained in Central Data 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 16 January 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-327-9). Two letters: A3-131-5.4.3.18-L-121, dated 10 January 1969; and A45-870-L-002, dated 16 January 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, and were noted as shortage items on the stage DD250.

SECTION 2
NARRATIVE SUMMARY

2.0 NARRATIVE SUMMARY

The following paragraphs present a narrative summary of stage checkout of the S-IVB-506N 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 B, delineated the general philosophies of the STC test programs. Test request 1316 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 25 January 1968. The prefire checkouts began on 26 January 1968, and were concluded on 9 July 1968. Twenty-four

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 two FARR's. There were three 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 14 March 1968, with the initiation of the stage power setup procedure. Three issues were required. The first two issues, on 14 March and 19 March 1968, were not acceptable due to numerous malfunction printouts. These malfunction printouts were caused by the removal of several talkback connectors for stage modifications and errors in the paper tape. The third attempt, on 9 April 1968, was acceptable. No FARR's were written; however, fourteen revisions were written to the procedure. The stage power turnoff procedure was successfully demonstrated on 20 March 1968, with the second issue. The first issue was unsuccessful due to several malfunctions occurring during initial condition scan as the valves associated with the parameters checked were not installed. One FARR was initiated and twelve revisions were made to the procedure.

2.1 (Continued)

The power distribution system test was conducted twice during prefire operations on 19 March and 15 May 1968. The first attempt was unacceptable due to the LOX chilldown inverter phase voltage being out-of-tolerance. No FARR's were written, but a total of eighteen revisions were recorded in both issues of the procedure.

The level sensor and control unit calibration checkout was initally accomplished on 22 March 1968; however, due to the replacement of the LH_2 probe and rework of the LOX probe, reverification by a second and third issue was required on 14 May 1968, and 20 June 1968, respectively. No major problems were encountered during the tests, nor were any FARR's written. There were eighteen revisions made to the three issues.

The common bulkhead vacuum system checkout and the stage and GSE manual controls check were successfully demonstrated without generating any FARR's. Eight revisions were written against the common bulkhead vacuum checkout while the stage and GSE manual controls check required fourteen revisions.

The cryogenic temperature sensor verification was successfully accomplished on 26 March 1968, and accepted on 7 May 1968. A second issue was performed on 13 May 1968, after the fuel mass probe had been reworked in accordance with WRO 4183. Subsequent to the LOX tank feedthrough inspection per WRO 4373, a third issue was accomplished on 21 June 1968. Three revisions were made to the checkout.

The hydraulic system setup and operation checkout was initiated on 27 March 1968, and completed on 10 July 1968. One problem was encountered during the

2.1 (Continued)

procedure. FARR A261833 reported that hydraulic fluid was noted on the pitch actuator, and authorized its removal and replacement. The procedure required eighteen revisions.

Two issues of the digital data acquisition system calibration were required to satisfactorily complete prefire calibration of the digital data acquisition system. Issue one consisted of two test attempts with the first being initiated on 28 March 1968, after investigation of test malfunctions, attempt one was interrupted to rework the remote digital submultiplexer for connector and pin damage per FARR A261830. The malfunctions were attributed to incomplete electrical installation and improper adjustment of the fluke voltmeter. Problems documented by FARR's were limited to the remote digital submultiplexer rework on FARR A261830. Fourteen revisions were made to the procedure.

Preliminary propulsion leak and functional checks were successfully completed after the incorporation of ninety-seven revisions. Three FARR's were generated as a result of this checkout.

The EBW system checkout, the range safety system check, the telemetry and range safety antenna system checkout, and the APS check were successfully demonstrated without generating any FARR's. Fifteen revisions were written against the EBW system procedure, five revisions were made to the range safety system checkout, three revisions were written to the telemetry and range safety system procedure, and five revisions were written to the APS procedure.

The propellant utilization sytem calibration required two issues. The first issue was not acceptable as the propellant utilization electronics assembly

2.1 (Continued)

failed to pass the LH_2 linearity test and was removed and repaired on FARR A270685. The second issue was accomplished on 24 May 1968, and required fourteen revisions.

Three tests were required to satisfactorily complete the prefire automatic checkout of the propellant utilization system. The initial test was satisfactorily completed on 27 May 1968. Temporary removal of the LOX mass probe for feedthrough connector inspection necessitated a second test on 21 June 1968. An investigation of radio frequency interference during prefire operations resulted in a third and final test to reverify the system on 26 June 1968. One FARR was initiated and ten revisions were written in the procedure.

Three tests utilizing two issues of the automatic propulsion system test were conducted to verify prefire operational capability of the propulsion system. The first issue was used for two tests on 5 June and 7 June 1968. The initial test was terminated due to the inability of the program to perform the pressure set routine for the stage 6 helium regulator of the GSE console "A." Test attempt two was not entirely successful. The LOX tank ground fill pressure switch pickup pressure was out-of-tolerance due to an incorrect pressure transducer calibration entered into the program. In addition, an indication of failure to open for the O_2H_2 burner LOX propellant valve was attributed to incomplete wiring of the LOX propellant valve ground backup solenoid. These malfunctions, plus hardware changes after attempt two, necessitated repeating the propulsion systems test per issue two. This final test was successfully

2.1 (Continued)

accomplished on 22 June 1968. No FARR's were written as a result of this checkout; however, thirty-eight revisions were recorded in the second issue.

Three tests were conducted to successfully demonstrate the proper operational status of the digital data acquisition system. Test attempt one was conducted on 10 June 1968. Three channel malfunctions reported and corrected on two FARR's necessitated a second test attempt. The second test was successful with the exception of channel D231 malfunctions which were corrected per the disposition on FARR 500-225-530. The third test was conducted to check channel D231 only. No further problems were encountered. Fifteen revisions were made to the procedure.

The final prefire propulsion system leak check was successfully conducted without encountering any major problems that resulted in the generation of FARR's. It was necessary, however, to write sixty-eight revisions to the procedure.

The integrated system test was initiated on 22 June 1968. A second issue was required due to replacement of the O_2H_2 burner ignitors and was initiated on 2 July 1968. No FARR's were written and a total of sixty-nine revisions were made to the procedure.

The simulated cold flow test was accomplished on 28 and 29 June 1968. The test was conducted per test request 1316 and was designated as countdown 614106. Countdown for the simulated static firing test was initiated on 3 July 1968. A 24-hour hold was effected on 4 July 1968, and the test was resumed on 5 July 1968.

2.1 (Continued)

The cold flow test was accomplished on 11 July 1968. The two day test was initiated on 10 July 1968, and was conducted per test request 1316 and designated as countdown 614108.

The acceptance firing test designated countdown 614109 was initiated on 16 July 1968, and was terminated after 445.2 seconds of successful mainstage operation. A detailed narrative of the acceptance firing is delineated in Douglas Report DAC 61229, dated August 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 1316 on Test Stand Beta III.

The abbreviated postfire checkout, following completion of acceptance firing, was initiated on 9 July 1968, with the performance of the postfire structural inspection. FARR 500-372-109 reported that paint was peeling from the forward skirt exterior. No other problem areas were noted and six revisions were written to the procedure.

The propulsion system leak check was conducted from 18 July through 31 July 1968, to determine leakage which could have resulted from the stage acceptance firing. The cold helium dump module was removed and replaced on FARR 500-372-079 for excessive internal leakage. FARR 500-225-939 removed and

2.2 (Continued)

replaced a defective vacuum probe in the lower LH_2 low pressure duct. No unacceptable leakages were detected. Twenty-three revisions were recorded in the procedure.

The stage power setup and the stage power turnoff procedures were successfully completed with no problems that resulted in the initiation of FARR's; however, twenty-two revisions were recorded in the stage power setup procedure, while the stage power turnoff required two revisions.

The integrated systems test was initiated on 19 July 1968, and accepted on 26 July 1968. Two problems were encountered. FARR 500-372-176 removed and replaced a defective LH_2 feedthrough contact and sleeve assembly, and FARR 500-372-133 reported that the D209 transducer was shorted and operating out-of-tolerance. The transducer was removed and replaced. All other problem areas were resolved by the thirty-nine revisions recorded in the procedure.

The postfire operation and securing procedure for the hydraulics system was conducted on 24 July 1968, to secure the system and prepare it for shipment to the VCL. There were no problem areas resulting in FARR documentation; however, six revisions were made to the procedure.

The postfire propellant utilization system test was performed as a part of an evaluation to determine how radiated radio frequency (RF) energy was affecting PU system telemetry measurements. The test was conducted on 26 July 1968. No problems were noted and no FARR's were initiated as a result of this test; however, thirteen revisions were recorded in the procedure.

2.2 (Continued)

The final prestorage postfire procedure conducted was the forward skirt thermoconditioning system checkout. This prepared the thermoconditioning system for shipment to the VCL for storage preparations. No FARR's were initiated, but four revisions were recorded.

The stage was removed from the test stand on 1 August 1968, and transferred to the VCL for storage preparations.

2.3 Deferred Postfire Acceptance Tests

The stage was removed from the VCL and installed in Test Stand Beta III on 23 November 1968, for continued modifications and preparations for the deferred postfire checkouts. The first checkout of the stage system on Beta III started on 25 November 1968, and was completed on 3 January 1969. Twenty-eight 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 deferred postfire checkouts began with the checkout of the forward skirt thermoconditioning system (TCS) on 25 November 1968. This procedure functionally checked the TCS to prepare it for operation and to verify that the system was capable of supporting stage deferred postfire operations. There were no discrepancies recorded against the TCS. One revision was written to update the procedure.

PRECEDING PAGE BLANK NOT FILMED

2.3 (Continued)

The digital data acquisition system test required three attempts. The first and second attempts were unsatisfactory due to numerous malfunction indications. The third attempt was successfully accomplished on 19 December 1968. Nineteen revisions were required to complete the checkout.

The level sensor and control unit calibration was accomplished with the inclusion of one revision. FARR 500-607-599 reported that the LH_2 point level sensor number 4 amplifier would not adjust. The amplifier was removed and replaced.

Resistance and continuity checks of the internal fuel tank temperature transducers were conducted by two issues of the cryogenic temperature sensor verification procedure. The first issue, conducted between 6 December and 12 December 1968, was accepted on 16 December 1968. A second issue, accomplished and accepted on 10 January 1969, was required due to entry into the LH_2 tank for structural inspection. No FARR's were written during this checkout.

The digital data acquisition system calibration, the structural inspection, the exploding bridgewire system checkout, the auxiliary propulsion system (APS) checkout, and the APS automatic test were satisfactorily completed with no FARR's being written. The digital data acquisition system calibration required four revisions while the structural inspection required five, and the exploding bridgewire system check required one revision. The APS checkout and the APS automatic test required seven revisions, and six revisions, respectively.

The propellant utilization system calibration was accomplished twice during the deferred postfire checkouts. The first issue was accomplished on

2.3 (Continued)

12 December and 13 December 1968. The replacement of the propellant utilization electronics assembly required a second issue, which was performed on 19 December 1968. There were no FARR's and no revisions written during this checkout.

The propellant utilization system automatic test was issued twice. The initial test was satisfactorily conducted on 11 December 1968. Due to replacement of the propellant utilization electronics assembly, a second test was accomplished on 19 December 1968. There were no FARR's written as a result of this checkout. Three revisions were made to the procedure.

The range safety receiver checks were initiated on 12 December 1968, and after the second attempt, was accepted on 16 December 1968. The first attempt was terminated after it was noted that the test code plugs were not installed on the decoder assemblies. Seven revisions were documented against the checkout. The range safety system automatic test was successfully accomplished with no FARR's, and two revisions.

Signal conditioning setup was accomplished between 13 December and 18 December 1968, by the calibration of three 5 volt excitation modules, seven 20 volt excitation modules, and three temperature bridges. FARR 500-607-629 reported that the 20 volt excitation module, P/N 1A74036-1, S/N 0353, had an output below the minimum tolerance. The module was removed and replaced. Three revisions were written in the checkout.

The hydraulic system checkout was satisfactorily accomplished by the third attempt on 19 December 1968. The first attempt initiated on 14 December 1968,

2.3 (Continued)

was aborted due to a leak in the auxiliary hydraulic pump, which was removed and replaced on FARR 500-607-637. The second attempt was aborted when the coast mode thermal switch on the auxiliary hydraulic pump failed to operate when the dry ice pack was applied. Troubleshooting revealed that the dry ice pack had been applied to the wrong location; however, during the troubleshooting it was noted that the hydraulic pump was leaking fluid at the shaft seal drain port. The pump was removed and replaced on FARR 500-607-653. Ten revisions were recorded in the procedure.

The telemetry and range safety antenna system check was accomplished on 16 December 1968, with no FARR's; however, two revisions were required.

The propulsion system automatic test was performed twice during the deferred postfire checkouts. The first test was successfully accomplished on 16 December 1968. The second test performed only that portion of the procedure needed to verify the passivation circuitry and the J-2 orbital safing valve checks, which were not checked during the first issue due to incomplete stage wiring. FARR 500-607-696 reported that the LH_2 fill and drain valve did not transmit open talkback. The valve was acceptable for use at the STC, and final disposition is to be given at the FTC. Fourty-four revisions were required to complete the procedure.

The all systems test was performed two times, the first attempt was successfully accomplished on 18 December 1968. Due to replacement of the propellant utilization electronics assembly and the auxiliary hydraulic pump a second

2.3 (Continued)

issue was required on 20 December 1968. There were no FARR's written during this checkout; however, nineteen revisions were made to the procedure.

The hydraulic system checkout was accomplished on 27 December 1968, 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 shipment. No FARR's were written and the procedure required three revisions.

The final deferred postfire checkout was the forward skirt thermoconditioning system test, initiated on 31 December 1968, and accepted on 3 January 1969. No FARR's were initiated as a result of this test. One revision was made to the procedure.

2.4 Final Inspection

Following the final manufacturing operations and modifications, the final inspection of stage 506N was accomplished between 23 December 1968, and 16 January 1969, to locate and correct any remaining stage discrepancies. A total of three-hundred and twenty mechanical and electrical area discrepancies were recorded during the inspection, mostly of a minor nature. All except fourteen of these discrepancies were cleared to an acceptable condition without requiring failure and rejection report action. The remaining problems were noted on FARR's 500-607-785, 500-608-749, 500-608-935, 500-608-943, 500-608-960, and 500-609-001, and were acceptably corrected. FARR 500-703-113, dealing with a torn curtain 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 14 January 1969, the stage was weighed by means of a three point electronic weighing system. Three electronic load cells, one aft and two forward, measured the reaction forces of the otherwise unsupported stage. The reaction force measurements were then used to determine that the stage shipping and handling weight was 26,804.9 pounds, the stage weight corrected for Standard Gravity in a vacuum was 26,857.2 pounds, and the stage longitudinal center of gravity was located at station 329.4, paragraph 4.5, presents a more detailed narration on this operation.

2.6 Preshipment Purge

The final operation before the stage was shipped to FTC was the preshipment purge. Gaseous nitrogen was used to purge the stage systems to dewpoints of -30.0°F for the LH_2 system, and -47.0°F for the LOX system. The proper 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

2.7 (Continued)

at FTC. These modifications invalidated parts of the previously accomplished stage testing, including power distribution system, hydraulic system, range safety receiver checks, propellant utilization system, propulsion system leak and functional checks, propulsion system automatic, and the all systems test. MDAC report DAC 61237, dated 17 January 1969, extensively covered these modifications and the retesting that would be required at FTC to reverify the affected stage systems. This report was prepared in accordance with contract change order CO 2055.

2.8 Incomplete FARR's

Six FARR's were not closed at the time stage 506N was shipped to FTC, and these FARR's were transferred open with the stage. FARR 500-489-782 reported that a pressure of 475 psig was applied to the engine pneumatics and the LH_2 repressurization bottles. No pressure should have been applied. FARR 500-607-696 noted that the LH_2 fill and drain valve did not transmit open talkback. FARR 500-608-986 noted several data discrepancies during AST data review. One transducer, 409MT650, P/N 1B40242-595, was removed and replaced, all other items were acceptable for use. The FARR was transferred to the FTC for NASA review. FARR 500-703-113 reported several torn areas on the curtain assembly, P/N 1B69815. The curtain was classified as interim use material (IUM), with final disposition to be given at the FTC. FARR 500-703-121 reported that the ground strap assembly, P/N 1B55324-501, was damaged. The ground strap was classified as IUM, with final disposition to be given at the FTC. FARR 500-703-148 was concerned with discrepancies noted during AST data review.

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; paragraph 3.2 describes those flight critical items which deviate from the stage design; and paragraph 3.3 contains those variations in stage configuration which represent changes in the scope of the program.

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

Existing contractual configuration control papers are referenced wherever possible.

3.1 Design Intent Verification

This configuration of the stage is defined in the Engineering Configuration List (ECL), Space Vehicle, Model DSV-4B-1-1, Manufacturing Serial Number 1011, revision C, dated 19 August 1968. This ECL document includes a listing of all parts, non-hardware drawings, and manufacturing and process specifications required for the manufacture and test of the stage, as defined by engineering production drawings and EO releases. The ECL has been transmitted to NASA under a separate cover.

Verification of design intent was accomplished by comparing the ECL with the Planning Configuration List (PCL), and the Reliability Assurance Department

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

3.2.1 LOX and LH_2 Fill and Drain Valves

SEO 1A48240-007 authorized the removal of the existing bonded insert and O-ring from the electrical connectors, leak testing of the receptacles, and subsequent installation of an unbonded insert and O-ring for the LOX and LH_2 fill and drain valves, P/N 1A48240-505, S/N's 0114 and 0121, respectively. The unbonded inserts were installed to minimize cracking of the inserts and glass insulation at cryogenic temperatures, in accordance with NASA Change Order 1602.

3.2.2 Oxidizer Mass Probe

SEO 1A48430-012A authorized reworking the oxidizer mass probe, P/N 1A48430-511, S/N C2, to provide proper insulation resistance equivalent to the -513 configuration.

3.2.3 LH_2 Chilldown Pump

SEO 1A49421-010 provided instructions to rework the LH_2 chilldown pump, P/N 1A49421-507, S/N 158, equivalent to the -505 configuration.

3.2.4 LH_2 Chilldown Shutoff Valve

SEO 1A49965-012 authorized unbonded insert replacement for the bonded insert, as previously described in paragraph 3.2.1, for the LH_2 chilldown shutoff valve P/N 1A49965-523, S/N 0517.

3.2.5 LOX Chilldown Shutoff Valve

SEO 1A49965-013A 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 0601, which was assembled with an acceptable lubricant.

3.2.6 Pneumatic Power Control Module

SEO 1A58345-007 provided instructions to rework the pneumatic power control module, P/N 1A58345-523, S/N 1024, equivalent to the -523 configuration.

3.2.7 Chilldown Inverter Electronic Assembly

SEO 1A74039-014A provided for low and high temperature testing of the chilldown inverters, P/N 1A74039-517, S/N's 052 and 00036, to verify the compatibility of the current limiting circuits.

3.2.8 Cold Helium Fill Module

SEO 1B57781-005 provided for special tests of the cold helium fill module, P/N 1B57781-507, S/N 0029, to check for internal leakage after cold temperature operation.

3.2.9 O_2H_2 Burner Assembly

SEO 1B62600-012B authorized reworking the O_2H_2 burner assembly, P/N 1B62600 -529, S/N 013, to update it to provide restart capability.

3.2.10 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 74, 82, 83, 90, 92, 93, 94, 95, 96, and 174.

3.3 Scope Change/Engineering Change Proposal Verification

Scope Change (SC) and Engineering Change Proposals (ECP), with the applicable verification data, are listed in Form DD829-1, which is included in the Stage Log Book. The following SC/ECP's were incorporated subsequent to stage transfer from the SSC and were substantiated as being incorporated by MDAC and AFQA personnel "buy off" of the AO paper. The SC/ECP's are listed as previously complied with (PCW) on Form DD829-1.

a. ECP X021, authorized by CCO 363, provided for static test monitoring of the engine turbopump RPM.

b. ECP X056, authorized by CCO's 413 and 572, provided that consecutive reference designation numbers be assigned to stage relays.

3.3 (Continued)

c. ECP X082, authorized by CCO's 434 and 539, provided new engine transducer design requirements.

d. ECP X085, authorized by CCO 444, provided for the redesign of the engine cutoff circuitry.

e. ECP X092, authorized by CCO's 451 and 539, provided for additonal MSFC flight control wiring.

f. ECP X099, authorized by CCO 461, provided for additional hardwire measurements through the umbilical.

g. ECP X113, authorized by CCO's 472 and 539, provided a method for implementing the secure range safety command system.

h. ECP X114, authorized by CCO 482, provided for independent excitation of LOX and LH tank pressure transducer 5-volt power supplies.

i. ECP X119, authorized by CCO's 502 and 586, provided a revised venting system for the LH_2 tank.

j. ECP X124, authorized by CCO's 506, 539, 562, provided for changes in the stage for Rocketdyne ECP compatibility.

k. ECP X126, authorized by CCO's 511, 551, 578, and 607, and letter S-IVB-5-293, provided for modification of the cryogenic repressurization system.

l. ECP X132, authorized by CCO's 383, 422, 435, 508, and 516, and letter S-IVB-5-581, provided for an operational telemetry system.

m. ECP X134, authorized by CCO 537, provided for redesign of the engine/stage electrical interface.

n. ECP X136, authorized by CCO's 329, 538, and 631, provided for the release of a coolant system common to both the S-IB and S-V stages.

o. ECP X137, authorized by MSFC letter I-V-S-TD-65-53, defined the programmed mixture ratio.

p. ECP X147, authorized by letter D151, provided for the addition of a relay to the aft 28 vdc power distribution assembly.

q. ECP X154, authorized by SA 790, provided for design, procurement, and installation of the control relay package.

r. ECP X171, authorized by CCO's 79 and 582, provided for MC fittings and flared tubing.

3.3 (Continued)

s. ECP X176, authorized by CCO 587, modified the thrust structure.

t. ECP X178, authorized by CCO 597, provided for the release of a stage positive pressure system.

u. ECP X190, authorized by letter 762, provided for the forward skirt environmental control system.

v. ECP X198, authorized by CCO's 658 and 692, revised the engine thrust OK circuits.

w. ECP X199, authorized by CCO 630, provided redesign criteria for the APS modules.

x. ECP X204, authorized by CCO's 650, 661, 670, and 708, and letter S-IVB-65-246, provided for the deletion of the pad safety and minimum liftoff pressure switches.

y. ECP X209, authorized by CCO 847 and NASA letter L96, revised forward skirt paint requirements.

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

aa. ECP X218, authorized by CCO's 742, 772, and letter S-IVB-5-1425, provided for modifications of the LH_2 tank forward dome and the LOX tank aft dome.

ab. ECP X221, authorized by CCO 693, provided for the redesign of the APS gemini engine nozzle supports.

ac. ECP X222, authorized by letter SD-L-1470 and technical directive TD-66-1, provided for the modification of the LOX tank propellant utilization probe.

ad. ECP X224, authorized by CCO 739, provided for RPM measurements for the recirculation chilldown pump.

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

af. ECP X255, authorized by CCO 645 and letter S-IVB-6-518, provided for the thermal insulation of Model II switch selectors.

ag. ECP X262, authorized by CCO's 813 and 853, and letter S-IVB-6-198, provided for the modification of the emergency detection system cutoff circuits.

3.3 (Continued)

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

ai. ECP X267, authorized by letter L-131-66, provided for the identification of GFE test code plugs.

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

ak. ECP 0273, authorized by CCO 837, provided for deletion of the LH_2 tank translunar vent termination pressure switch.

al. ECP 0277, authorized by CCO 801, provided for the deletion of the interstage propellant dispersion system pyrotechnics.

am. ECP 0281, authorized by letters L-192-66 and L-380-66, provided for the relocation of stage coolant system plumbing to ensure proper mating with the NASA Instrumentation Unit (I.U.).

an. ECP 0302, authorized by CCO's 886 and 942, provided for the design of an LH_2 slosh filter for the propellant utilization system, and a guidance system computer M/F filter.

ao. ECP 0304, authorized by CCO 977 and letters S-IVB-6-886 and S-IVB-6-1050, provided for the deletion of S-IVB vent termination pressure switches.

ap. ECP 0314, authorized by MSFC lstter I-60-SD-L-329-66, provided for rework and installation of the Model II switch selector.

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

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

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

at. ECP 0355, authorized by letter L307, provided for the redesign of the LH_2 pressurization diffuser.

au. ECP 0364, authorized by letter L307, provided for the addition of a check valve to the APS helium supply line.

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

3.3 (Continued)

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

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

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

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

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

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

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

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

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

bf. ECP 0490, a compatibility ECP, provided for the redesign of check-out valve, P/N 1B53817.

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

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

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

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

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

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

3.3 (Continued)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

cb. ECP 0622R3, a compatibility ECP, provided for replacement of the 10 amp relay modules.

3.3 (Continued)

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

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

ce. ECP 0634, a compatibility ECP, provided for revision to the emergency detection system.

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

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

ch. ECP 0648, authorized by letter I-CO-S-IVB-6-1327, provided for the deletion of the relief valve function from the ambient helium fill module.

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

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

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

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

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

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

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

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

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

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

3.3 (Continued)

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

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

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

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

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

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

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

cz. ECP 0943R3, a compatibility ECP, provided for modification of the forward skirt signal conditioning panel.

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

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

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

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

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

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

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

dh. ECP 0984R1, a compatibility ECP, provided for the replacement of a battery ground strap.

3.3 (Continued)

di. ECP 0991R1, a compatibility ECP, provided for elimination of wire and ground strap interference with the -402 access kit.

dj. ECP 1008R3, authorized by CCO 1074, provided for modifications to the redundant EDS J-2 engine cutoff.

dk. ECP 1016R1, authorized by CCO 1207, provided for control of Navan seals.

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

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

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

do. ECP 2037, a compatibility ECP, provided for the main hydraulic pump compensator attachment.

dp. ECP 2040, authorized by letter I-CO-S-IVB-7-100, provided for additional measurements in the S-IVB stage operational measurement program.

dq. ECP 2046, a compatibility ECP, provided for the relocation of the pressure transducers for measurements D16, D183, and D184.

dr. ECP 2048R1, authorized by CCO 1198, provided for the modification of the continuous vent module bypass valve hardwire talkback.

ds. ECP 2049R2, a compatibility ECP, provided for procurement and installation of pneumatic actuation control module, P/N 1B66692-501.

dt. ECP 2051, a management directive ECP, provided for the reconfiguration of the cold helium dump module.

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

dv. ECP 2060R2, a compatibility ECP, provided for rework of the cold helium check valve.

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

dx. ECP 2073, a compatibility ECP, provided for painting the hydraulic actuators.

3.3 (Continued)

dy. ECP 2079, authorized by CCO's 1231 and 1318, provided for rain baffles for the environmental control system vents.

dz. ECP 2090, authorized by letter I-CO-S-DAC-L-403-67, provided for redesigning the directional control valve.

ea. ECP 2091, a compatibility ECP, provided for reworking the auxiliary hydraulic pump assembly.

eb. ECP 2092, a compatibility ECP, provided for the reconfiguration of the bus connectors.

ec. ECP 2096, authorized by CCO 1198, provided for modification of the continuous vent system hardwire talkback.

ed. ECP 2105, authorized by letter I-CO-S-IVB-7-158, provided for modification of the propellant utilization system to permit restart with the PU valve in the hardover position.

ee. ECP 2112, a compatibility ECP, provided for the reconfiguration of the pneumatic actuator.

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

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

eh. ECP 2128R1, authorized by CCO 1399 and CCO 1566, provided for the reconfiguration of the pneumatic power control module P/N 1A58345.

ei. ECP 2130, authorized by letters I-CO-S-IVB-7-346 and I-CO-S-IVB-7-1238, provided for eddy current testing of the ambient helium tanks.

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

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

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

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

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

3.3 (Continued)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3.3 (Continued)

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

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

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

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

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

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

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

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

fm. ECP 2270R1, a compatibility ECP, provided for testing of the chill-down inverters.

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

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

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

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

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

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

ft. ECP 2293, a management directed ECP, provided for the removal of the exterior coordinate system markings from the stage.

fu. ECP 2295, a compatiblity ECP, provided for the replacement of a hand valve.

3.3 (Continued)

fv. ECP 2296R2, authorized by CCO 1647, provided for modification of the relay control packages to incorporate an O-ring type seal in lieu of a welded assembly.

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

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

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

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

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

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

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

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

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

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

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

gh. ECP 2328R1, authorized by CCO 1791, provided for incorporation of redundant instrumentation for critical pressure measurements.

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

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

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

3.3 (Continued)

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

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

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

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

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

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

gr. ECP 2491R2, authorized by CCO 1900, provided for modification of the LH_2 vent and relief system.

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

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

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

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

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

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

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

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

ha. ECP 2640R1, authorized by CCO 1717, provided for a modified fuel vent directional control valve to minimize stress corrosion.

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

3.3 (Continued)

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

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

he. ECP 2649, authorized by CCO 1684, provided for incorporation of a redesigned repressurization control module.

hf. ECP 2652R1, authorized by CCO 1714, provided for the procurement of PU oven components.

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

hh. ECP 2658R1, authorized by CCO 1602, provided for rework of Deutsch electrical connectors.

hi. ECP 2691, authorized by CCO 1911, provided for an orbital and translunar safing system.

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

hk. ECP 2763R1, authorized by letter I-CO-S-IVB-8-229, provided for reducing electromagnetic interference levels for J-2 engine pressure measurements through excitation and ground wire relocation.

hl. ECP 2787R1, authorized by letter I-CO-S-IVB-8-287, provided for the addition of suppression diodes across the safe and arm device command lines.

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

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

ho. ECP 2799, a compatibility ECP, provided for the replacement of the 1/4-inch pneumatic check valves, P/N 1B51361-1 with P/N 1B67598-501.

hp. ECP 2802, authorized by CCO 1778, provided for the LH_2 probe rework.

hq. ECP 2862, a compatibility ECP, provided for modification of the LH_2 chilldown pump to eliminate bearing coolant flow.

3.3 (Continued)

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

hs. ECP 2900R1, authorized by CCO 1896, provided for replacement of pipe assemblies containing MC-125 sleeves.

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

hu. ECP 2941, authorized by CCO 1924, provided for the elimination of the switching function for measurement K0128.

hv. ECP 2991, a compatibility ECP, provided thermal control for the control relay modules.

hw. ECP 2993, a compatibility ECP, provided for reconfiguration of the repressurization control modules.

hx. ECP 3007, a compatibility ECP, provided for installation of an orifice, P/N 1B63023-1, at the inlet of the actuation control module.

hy. ECP 3011, a compatibility ECP, provided for correction of reference designation numbers on thermal switch and thermal switch fitting.

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

ia. SC 1045B, authorized by CCO 118, provided design specifications for the forward skirt thermoconditioning system.

ib. SC 1124, authorized by CCO 259, provided closed loop checkout ability for the stage range safety command RF system.

ic. SC 1187, authorized by CCO's 136, 172, and 330, installed the MSFC furnished control accelerometers and rate gyro.

id. SC 1189, authorized by CCO's 111 and 126, provided for the design, release, and manufacture of the necessary parts and documents for the two-hour and four-and-one-half hour translunar coasts.

ie. SC 1193, authorized by CCO 156, provided for the redesign of the LOX tank vent line and supporting hardwire.

if. SC 1203, authorized by CCO 168, provided for RPM measurement of the LOX and LH_2 turbopumps.

3.3 (Continued)

ig. SC 1205, authorized by CCO 173, provided for the installation of three additional interface connectors.

ih. SC 1207, authorized by CCO's 197, 213, 330, 343, and 414, provided for the modification of the propellant utilization system.

ii. SC 1218, authorized by CCO 202, provided for the chilldown system recirculation pump and motor.

ij. SC 1219, authorized by CCO 201, provided for the APS control relay package.

ik. SC 1221A, authorized by CCO 210, provided for the redesign of the APS modules for the ullage engine system.

il. SC 1241, authorized by CCO 222, provided for additional sensing elements in the engine cutoff system.

im. SC 1274, authorized by CCO's 264 and 330, provided for power supply short circuit protection.

in. SC 1277, authorized by CCO 265, provided for the installation of an emergency detection system.

io. SC 1297A, authorized by CCO's 284 and 330, provided for venting of the forward skirt.

ip. SC 1304, authorized by CCO 288, provided for redesigning the hydrogen fuel tank.

iq. SC 1312, authorized by I-V-S-IVB-TD-64-101, provided for reduced tolerance on dome segments.

ir. SC 1326, authorized by CCO's 279, 496, and 595, provided for recirculation chilldown pressure measurements.

is. SC 1376A, authorized by CCO's 395 and 467, provided for the reduction of trapped propellants at stage burnout.

it. SC 1383A, authorized by letters I-CO-SD-L-1037 and -1616, provided for the incorporation of dual diaphragm pressure switches with a calibration capability.

3.4 Time/Cycle Significant Items

Twenty-nine items installed on the stage are time/cycle significant as defined by design requirements drawings 1B55423, Government Furnished Property Time/Cycle Significant Items, and 1B55425, Reliability Time/Cycle Significant Items The following table lists these items, along with the time/cycles accrued on each at the time of stage transfer to FTC, and the maximum allowable limits prescribed by engineering.

Part Number and Part Name	Serial Number	Accumulated Measurement	Engineering Limit
Reliability Items (1B55425 R)			
1A48858-1 Helium Storage Sphere	1169	4 cycles	50 cycles
	1171	4 cycles	50 cycles
	1176	4 cycles	50 cycles
	1183	4 cycles	50 cycles
	1184	4 cycles	50 cycles
	1188	4 cycles	50 cycles
	1189	4 cycles	50 cycles
	1192	4 cycles	50 cycles
	1195	4 cycles	50 cycles
1A49421-507 LH_2 Chilldown Pump	158	0.6 hours*	100 hours cryogenic
		0 min*	40 minute dry
		0 cycles*	10 cycles (dry star
1A49423-509 LOX Chilldown Pump	1865	1.5 hours	20 hours
1A59563-509 PU Bridge Potentiometer	5033	404 cycles	5,000 cycles
	5038	370 cycles	5,000 cycles
1A66241-511 Auxiliary Hydraulic Pump	X458916	14.8 hours	120 hours
		44 cycles	300 cycles
1B57731-501 Control Relay Package	414	124 cycles	100,000 cycles
	419	70 cycles	100,000 cycles

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

3.4 (Continued)

Part Number and Part Name	Serial Number	Accumulated Measurement	Engineering Limit
G.F.P. Items (1B55423 H)			
40M39515-113 EBW Firing Unit	252	35 firings	1,000 firings
	253	36 firings	1,000 firings
	271	38 firings	1,000 firings
	284	42 firings	1,000 firings
40M39515-119 EBW Firing Unit	418	35 firings	1,000 firings
	419	34 firings	1,000 firings
50M10697 Command Receiver	187	100.8 hours	2,000 hours
	198	101.0 hours	2,000 hours
50M10698 Range Safety Decoder	0165	107.2 hours	2,000 hours
	0167	102.2 hours	2,000 hours
50M67864-5 Switch Selector	107	88,340 cycles	250,000 cycles
103826 J-2 Engine	J-2101		
a. Customer connect lines and inlet ducts		39.84%*	250-10,000 cycles
b. Gimbal bearing		45.60%*	250-10,000 cycles
c. Firing time		790.9 seconds	3,750 seconds
d. Helium Regulator (P/N 558100-111)	4088592	49 cycles	None Given

* This data includes all engine gimbal cycles at STC, plus cycles brought forward from Rocketdyne records. The cycle data is expressed as a per cent 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

NARRATIVE

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 A261829 and 500-225-599). The referenced FARR's are also presented numerically by serial number in Appendix II.

4.1 Stage Prefire Checkout

Stage prefire checkouts bagan on 26 January 1968, with initiation of the prefire structural inspection, paragraph 4.1.1. The stage prefire checkouts were completed on 16 July 1968, with completion of the final prefire propulsion system leak check, paragraph 4.1.23. 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 26 January 1968 and 24 June 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 LH_2 feed line fairing assembly, P/N 1B28109; the fill, drain, and chill system fairing assembly, P/N 1B28110; the LH_2 childown 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 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.

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

4.1.1 (Continued)

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), did not reveal any foreign material.

There were two FARR's generated during the operation of this procedure for the following:

a. FARR A261895 noted that there were B-nuts requiring torqueing; missing inspection seals; missing grounding studs; loose wire harness clamps; missing safety wires; foreign material on the J-2 engine throat area; wet receptacles; dings in the LOX helium heater bellows and the upper bellows section of the lower LH_2 engine feed duct, P/N 1A49320-515, S/N 32R; and walnut shell residue in the 403, 411, and 427 areas. It was also noted that the RF assembly, P/N 1B65788-1-002, S/N 15501, had to be resealed per 1B57447N.

b. FARR A270679 noted that the isolators, P/N 1B32258-1 and 1B32267-1, respective locations 404A61 and 404A64, were debonded in excess of 1/4 inch. The isolators were removed and replaced.

There were three revisions written to the procedure for the following:

a. One revision provided instructions for the isolator pull test.

b. One revision provided for Customer and Quality Engineering authorization and documentation.

c. One revision noted that the Disposition Column in Tables I, II, and III, of revision one were not required because the disposition had been provided for in the second revision.

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 on 29 February and 1 March 1968, and was verified as acceptable on 29 March 1968. Preliminary operations included setup and connection of the servicer to the TSC 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 $\pm$0.2 gpm. The differential pressure was recorded as 16.5 psid while inlet and outlet temperatures were recorded at 60°F, each.

The final step consisted of the TCS operation with the servicer at the require 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, nor 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 first issue of this procedure was accomplished on 12 March 1968, and was accepted on 14 March 1968, after a revision was written to retest the test points associated with the umbilical cables, Ref. Desig. 404W15J1 and 404W15J2, which were incorrectly installed. Issue two was performed and certified as acceptable on 14 March 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 shown in Test Data Table 4.1.3.1 are from the second issue.

Engineering comments indicated that the expected value for test point A2J30-W should have been shown as $\frac{\text{10-300}}{\text{500k min}}$, and should have been incorporated in the procedure when the fuel vent valve open command was changed to show this value.

4.1.3 (Continued)

No FARR's were generated as a result of the issue one and issue two checkouts. There were two revisions written to issue one, and one revision was written to issue two, as follows:

a. Two revisions changed terminal callout CB-11-12 to CB-11-2 to correct a procedural error for both issues.

b. One revision deleted the test point measurements associated with the umbilical cables, Ref. Desig. 404W15J1 and 404W15J2, which had been interchanged.

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	12	5-100
CB-10-2	Cmd., Engine Control Bus Pwr Off	Inf	Inf
CB-11-2	Cmd., Engine Control Bus Pwr On	50	5-100
A2J29-N	Cmd., Engine He Emerg Vent Control On	45	10-60
A2J29-P	Cmd., Fuel Tnk Repress He Dump Vlv Open	34	10-60
A2J29-Y	Cmd., Start Tnk Vent Pilot Vlv Open	24	10-60
CB-4-2	Cmd., LOX Tank Cold He Sphere Dump	28	10-60
A2J29-c	Cmd., LOX Tnk Repress He Sphere Dump	33	10-60
A2J29-h	Cmd., Fuel Tnk Vent Pilot Vlv Open	65	10-300
	(Same, reverse polarity)	Inf	500k min
A2J29-i	Cmd., Fuel Tnk Vent Vlv Boost Close	65	10-80
	(Same, reverse polarity)	Inf	500k min
A2J29-q	Cmd., Amb He Supply Shutoff Vlv Close	23	10-60
A2J30-H	Cmd., Cold He Supply Shutoff Vlv Close	1.2k	1.5k max
	(Same, reverse polarity)	Inf	Inf
A2J30-W	Cmd., LOX Vent Valve Open	64	10-80
	(Same, reverse polarity)	Inf	500k min
A2J30-X	Cmd., LOX Vent Valve Close	63	10-80
	(Same, reverse polarity)	Inf	500k min
A2J30-Y	Cmd., LOX & Fuel Prevlv Emerg Close	62	10-80
	(Same, reverse polarity)	Inf	Inf
A2J30-Z	Cmd., LOX & Fuel Chilldown Vlv Close	61	10-80
	(Same, reverse polarity)	Inf	500k min

4.1.3.1 (Continued)

Test Point	Function	Meas. Ohms	Limit Ohms
A2J30-b	Cmd., LOX F&D Valve Boost Close	30	10-40
A2J30-c̄	Cmd., LOX F&D Valve Open	30	10-40
A2J30-d̄	Cmd., Fuel F&D Valve Boost Close	30	10-40
A2J30-ē	Cmd., Fuel F&D Valve Open	30	10-40
A2J42-F̄	Meas. Bus +4D111 Regulation	120	100 min
A2J35-y	Meas. Bus +4D141 Regulation	1050	50 min
A2J6-AĀ	Sup. 28v Bus +4D119 Talkback Power	80	60-120

Reference Designation 463A1

A5J41-A	Meas. Bus +4D131 Regulation	400	20 min
A5J41-E	Meas. Bus +4D121 Regulation	2.2k	1.6k min
A5J53-AA	Sup. 28v +4D119 Fwd Talkback Pwr	62	60-100

4.1.4 APS Interface Compatibility Checkout (1B49558 B)

Initiated, accomplished, and accepted on 12 March 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/or other physical defects. Proper connection between the control relay package, the aft skirt components, and the APS simulators was verified by point-to-point resistance measurements as shown in Test Data Table 4.1.4.1.

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.

4.1.4.1 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	25 ± 5
404A51A4 J4 K	414A10L5 Eng. 3 Valve 1	26	25 ± 5
404A51A4 J4 L	414A10L2 Eng. 3 Valve C	26	25 ± 5
404A51A4 J4 M	414A10L6 Eng. 3 Valve 3	26	25 ± 5
404A51A4 J4 N	414A10L3 Eng. 3 Valve B	26	25 ± 5
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	25 ± 5
404A51A4 J4 U	414A9L5 Eng. 2 Valve 1	26	25 ± 5
404A51A4 J4 V	414A9L2 Eng. 2 Valve C	26	25 ± 5
404A51A4 J4 W	414A9L6 Eng. 2 Valve 3	26	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	25 ± 5
404A51A4 J4 a	414A9L8 Eng. 2 Valve 4	26	25 ± 5
404A71A19 J4 A	415A8L1 Eng. 1 Valve A	28	25 ± 5
404A71A19 J4 B	415A8L5 Eng. 1 Valve 1	28	25 ± 5
404A71A19 J4 C	415A8L2 Eng. 1 Valve C	28	25 ± 5
404A71A19 J4 D	415A8L6 Eng. 1 Valve 3	28	25 ± 5
404A71A19 J4 E	415A8L3 Eng. 1 Valve B	28	25 ± 5
404A71A19 J4 F	415A8L7 Eng. 1 Valve 2	28	25 ± 5
404A71A19 J4 G	415A8L4 Eng. 1 Valve D	28	25 ± 5
404A71A19 J4 H	415A8L8 Eng. 1 Valve 4	28	25 ± 5
404A71A19 J4 J	415A10L1 Eng. 3 Valve A	28	25 ± 5
404A71A19 J4 K	415A10L5 Eng. 3 Valve 1	28	25 ± 5
404A71A19 J4 L	415A10L2 Eng. 3 Valve C	28	25 ± 5
404A71A19 J4 M	415A10L6 Eng. 3 Valve 3	28	25 ± 5
404A71A19 J4 N	415A10L3 Eng. 3 Valve B	28	25 ± 5
404A71A19 J4 P	415A10L7 Eng. 3 Valve 2	28	25 ± 5
404A71A19 J4 R	415A10L4 Eng. 3 Valve D	28	25 ± 5
404A71A19 J4 S	415A10L8 Eng. 3 Valve 4	28	25 ± 5
404A71A19 J4 T	415A9L1 Eng. 2 Valve A	28	25 ± 5
404A71A19 J4 U	415A9L5 Eng. 2 Valve 1	28	25 ± 5

4.1.4.1 (Continued)

Test Point		Component Nomenclature	Meas. Ohms	Limit Ohms
404A71A19	J4 V	415A9L2 Eng. 2 Valve C	28	25 ± 5
404A71A19	J4 W	415A9L6 Eng. 2 Valve 3	28	25 ± 5
404A71A19	J4 X	415A9L3 Eng. 3 Valve B	28	25 ± 5
404A71A19	J4 Y	415A9L7 Eng. 2 Valve 2	28	25 ± 5
404A71A19	J4 Z	415A9L4 Eng. 2 Valve D	28	25 ± 5
404A71A19	J4 a	415A9L8 Eng. 2 Valve 4	28	25 ± 5
404A4	J7 r	414A5L1	555	550 - 650
404A4	J7 d	414A5L1	550	550 - 650
404A4	J7 p	414A6L1	555	550 - 650
404A4	J7 x	414A1L1	550	550 - 650
404A4	J7 f	414A1L1	555	550 - 650
404A4	J7 v	414A2L1	550	550 - 650
404A4	J7 m	414A6L2	550	550 - 650
404A4	J7 t	414AA2L2	550	550 - 650
404A4	J7 z	Spare	Inf	10 meg min
404A4	J7 q	415A5L1	550	550 - 650
404A4	J7 c	415A5L1	550	550 - 650
404A4	J7 n	415A6L1	550	550 - 650
404A4	J7 w	415A1L1	550	550 - 650
404A4	J7 e	415A1L1	550	550 - 650
404A4	J7 u	415A2L1	550	550 - 650
404A4	J7 k	415A6L2	550	550 - 650
404A4	J7 s	415A2L2	550	550 - 650
404A4	J7 y	Spare	Inf	10 meg min
404A2A16	J2 B	414A7L1 Eng. 4 Valve A	555	550 - 650
404A2A16	J2 C	414A7L2 Eng. 4 Valve 1	555	550 - 650
404A2A16	J2 A	415A7L1 Eng. 4 Valve A	570	550 - 650
404A2A16	J2 D	415A7L2 Eng. 4 Valve 1	570	550 - 650

4.1.5 Stage Power Setup (1B55813 F)

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 initial attempt, on 14 March 1968, to perform this checkout was successfully completed; however, the removal of several talkback connectors for stage modifications resulted in numerous malfunction printouts. Because of these malfunction printouts, this attempt was unacceptable. The second attempt, on 19 March 1968, was also successfully completed; but it was unacceptable becaus of numerous malfunction printouts. These malfunction printouts were caused by an error in the paper tape and an unconnected talkback connector. The third attempt, on 9 April 1968, to clear the malfunction printouts from the second attempt was successfully completed; and the procedure was signed off as acceptable on 19 April 1968. The following narration and the measurement valu shown in Test Data Table 4.1.5.1 are from this 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 LO and LH_2 inverters were disconnected. The bus 4D119 talkback power was turned on, and the prelaunch checkout group power was turned off. The forward power

4.1.5 (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 LH_2 prevalves and chilldown shutoff valves were verified to be open, and the LOX and LH_2 vent valves and fill and drain valves were verified to be closed; then, 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 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 LH_2 prevalves and chilldown shutoff valves were verified to be open. The LOX and LH_2 vent valves and fill and drain valves were verified to be closed.

4.1.5 (Continued)

and the 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 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 LH_2 continuous vent valve relay, the LH_2 and LOX repressurization mode relay, the LOX repressurization control valve relay, and the O_2H_2 burner propellant valve relay were reset. The LH_2 continu ous vent and relief overboard valve was verified to be closed.

The propellant utilization boiloff bias was turned off. The O_2H_2 burner spark system 1 and 2 voltages were measured and recorded. It was verified that the O_2H_2 burner LOX valve, LOX shutdown valve, LH_2 valve, and the LH_2 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.

4.1.5 (Continued)

The aft and forward 5 volt excitation 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 LH_2 boiloff bias on indication was verified to be off. The O_2H_2 burner spark system 1 and 2 monitor voltages were measured; then, the O_2H_2 burner LOX propellant and shutdown valve, the O_2H_2 burner LH_2 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 fourteen revisions written against the procedure for the following:

a. One revision added ALCO statements to set switch selector channel 108, LH_2 control vent relay orificed open, per ECP 2424 and WRO 4043.

b. One revision changed FILADD statements to increase the tolerance for the external stage bus power supply line from 28 $\pm$0.5 vdc to 28 $\pm$2.0 vdc, because it is not possible to stay within the 28 $\pm$0.5 vdc. ECP 7848 corrected this condition.

c. One revision noted that the malfunction printouts, "The O_2H_2 burner LOX sled valve not closed," occurred because the valve was not installed. This malfunction did not occur on the third attempt because the valve was installed at that time.

d. One revision noted that the malfunction printout, "LH_2 continuous vent orifice bypass valve not closed," resulted because the valve could not close until pneumatic pressure was applied to the stage.

e. One revision deleted the environmental control group power talkback steps from the procedure because the parameters had been deleted per ECP 2057.

4.1.5 (Continued)

f. One revision authorized the second attempt of the stage power setup and initial conditions scan to verify the proper talkback through the connectors that had been removed for stage modifications.

g. One revision authorized the rerun of the initial condition scan portion of the stage power setup, because instead of deleting steps 2153 and 2154 (see revision "e"), steps 2351 and 2352 were erroneously deleted. This did not effect the second attempt.

h. Four revisions corrected programming errors by making COAL statements.

i. One revision explained that the SIM interrupts on channels 83 and 84 resulted from troubleshooting on the test stand before the executive tape was loaded.

j. One revision explained that the SIM interrupt on channel 72 resulted because the LOX prevalve was not installed.

k. One revision authorized the running of a third attempt to clear all malfunctions encountered on previous runs.

4.1.5.1 <u>Test Data Table, Stage Power Setup</u>

Function	Measured Value	Limits
Forward Bus 1 Power Supply Current (amps)	4.10	20 max
Bus 4D31 Forward 1 Voltage (vdc)	28.08	28 ± 2
O_2H_2 Burner Spark System 1 Voltage (vdc)	-0.01	0 ± 0.5
O_2H_2 Burner Spark System 2 Voltage (vdc)	0.00	0 ± 0.5
Forward Bus 1 Quiescent Current (amps)	1.10	5 max
PCM System Group Current (amps)	2.90	5 ± 3
Aft 1 Power Supply Current (amps)	0.20	2 max
Bus 4D11 Aft 1 Voltage (vdc)	27.84	28 ± 2
Prelaunch Checkout Group Current (amps)	1.80	1 ± 3
Aft 1 Power Supply Curent (amps)	0.10	2 max
Aft 1 Power Supply Voltage (vdc)	28.08	28 ± 0.5
Sequencer Power (amps)	-0.20	3 max
Aft 5v Excitation Module Voltage (vdc)	4.98	5 ± 0.030
Fwd 1 5v Excitation Module Voltage (vdc)	5.01	5 ± 0.030
Fwd 2 5v Excitation Module Voltage (vdc)	5.00	5 ± 0.030
Range Safety 1 EBW Firing Unit Chg Voltage (vdc)	0.00	0 ± 1
Range Safety 2 EBW Firing Unit Chg Voltage (vdc)	0.00	0 ± 1

4.1.5.1 (Continued)

Function	Measured Value	Limits
Bus 4D41 Aft Bus 2 Voltage (vdc)	0.00	0 ± 1
Bus 4D30 Fwd Battery 1 Voltage (vdc)	0.00	0 ± 1
Bus 4D20 Fwd Battery 2 Voltage (vdc)	0.00	0 ± 1
Bus 4D10 Aft Battery 1 Voltage (vdc)	0.00	0 ± 1
Bus 4D40 Aft Battery 2 Voltage (vdc)	0.00	0 ± 1
Component Test Power Voltage (vdc)	0.56	0 ± 1

Initial Conditions Scan

Function	Measured Value	Limits
Forward Bus 1 Voltage (vdc)	28.00	28 ± 0.5
Forward Bus 2 Voltage (vdc)	27.88	28 ± 0.5
Aft Bus 1 Voltage (vdc)	28.00	28 ± 0.5
Aft 5v Excitation Module Voltage (vdc)	4.98	5 ± 0.030
Forward 1, 5v Excitation Module Voltage (vdc)	5.01	5 ± 0.030
Forward 2, 5v Excitation Module Voltage (vdc)	5.00	5 ± 0.030
Range Safety 1 EBW Firing Unit Chg Voltage (vdc)	0.00	0 ± 1
Range Safety 2 EBW Firing Unit Chg Voltage (vdc)	0.00	0 ± 1
Bus 4D41 Aft Bus 2 Voltage (vdc)	0.00	0 ± 1
Bus 4D30 Fwd Battery 1 Voltage (vdc)	0.00	0 ± 1
Bus 4D20 Fwd Battery 2 Voltage (vdc)	0.00	0 ± 1
Bus 4D10 Aft Battery 1 Voltage (vdc)	0.00	0 ± 1
Bus 4D40 Aft Battery 2 Voltage (vdc)	0.00	0 ± 1
Component Test Power Voltage (vdc)	0.56	0 ± 1
O_2H_2 Burner Spark System 1 Voltage (vdc)	0.00	0 ± 0.5
O_2H_2 Burner Spark System 2 Voltage (vdc)	0.01	0 ± 0.5

4.1.6 Stage Power Turnoff (1B55814 E)

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 14 March 1968; however, it was unacceptable because several malfunctions occurred during the initial conditions scan as the valves associated with the parameters checked were not installed. The second demonstration of this procedure was accomplished satisfactorily on 20 March 1968. Stage power turnoff measurement values for the second demonstration are tabulated in Test Data Table 4.1.6.1. Following this, the stage power turnoff 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

4.1.6 (Continued)

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.

There was one discrepancy recorded by FARR 500-026-341 against this test for damaged connector P53 on wire harness 404A3W1. The connector was replaced and the system verified (refer to revision item "i").

Twelve revisions were recorded to the procedure for the following:

a. One revision to attempt 1 and 2 added ALCO statements to set switch selector channel 108, LH_2 control vent relay orificed open, per ECP 2424 and WRO 4043.

b. One revision authorized the running of a second attempt to verify that the malfunctions obtained on run 1 had been corrected.

c. One revision to attempt 1 and 2 noted that the printout, "the O_2H_2 burner LOX shutdown valve not closed," occurred because the valve was not installed. This malfunction was corrected and subsequently verified on 9 April 1968, during stage power setup procedure 1B55813F.

d. One revision to attempt 2 deleted the TM environmental control group power talkback steps from the procedure because the parameters had been deleted per ECP 2057 and WRO 3748.

e. One revision to attempt 1 and 2 noted that the printout, "LH_2 continuous vent orificed bypass valve not closed," occurred because the valve could not close until pneumatic pressure was applied to the stage. This malfunction was also corrected when pressure was applied to the stage, and was verified on 9 April 1968, during stage power setup procedure 1B55813F.

4.1.6 (Continued)

f. Two revisions to attempt 2 corrected programming errors by making COAL statements.

g. One revision to attempt 2 authorized deletion of the period counter echo checks due to inability to comply with the executive program without additional wiring in the response conditioner.

h. One revision to attempt 2 authorized changing the 2-second flip-flop sense code in the computer interface unit to incorporate the manual control detection and ground instrumentation system interface control modifications.

i. One revision to attempt 1 noted that the printout, "LH_2 and LOX repress mode relay reset not on," occurred because connector P53 of wire harness 404A3W1 was damaged. The connector was repaired per FARR 500-026-341 and reverified during attempt 2.

j. One revision to attempt 1 noted that the printout, "O_2H_2 burner LH_2 prop valve not closed," occurred because the valve was not installed. This malfunction did not occur on attempt 2 because the valve was installed at that time.

k. One revision to attempt 2 noted that the malfunctions during initial conditions were corrected as noted in items "c" and "e" during stage power setup 1B55813F on 9 April 1968.

4.1.6.1 Test Data Table, Stage Power Turnoff

Function	Measurement	Limits
Forward Bus 1 Voltage, Power On (vdc)	27.96	28 $\pm$ 2
Aft Bus 1 Voltage, Power On (vdc)	28.00	28 $\pm$ 2
O_2H_2 Burner Spark System 1 Voltage (vdc)	0.03	0 $\pm$ 0.5
O_2H_2 Burner Spark System 2 Voltage (vdc)	0.01	0 $\pm$ 0.5
Forward Bus 1 Battery Simulator Voltage (vdc)	-0.04	0 $\pm$ 2
Forward Bus 2 Battery Simulator Voltage (vdc)	0.00	0 $\pm$ 2
Aft Bus 1 Battery Simulator Voltage (vdc)	0.04	0 $\pm$ 2
Aft Bus 2 Battery Simulator Voltage (vdc)	0.00	0 $\pm$ 2
Forward Bus 1 Voltage, Power Off (vdc)	0.08	0 $\pm$ 1
Forward Bus 2 Voltage, Power Off (vdc)	0.00	0 $\pm$ 1
Aft Bus 1 Voltage, Power Off (vdc)	0.04	0 $\pm$ 1
Aft Bus 2 Voltage, Power Off (vdc)	0.00	0 $\pm$ 1

4.1.7 Power Distribution System (1B55815 F)

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 conducted twice during prefire operations on 19 March 1968 and 15 May 1968. The first attempt was unacceptable due to the LOX chilldown inverter phase voltages being out-of-tolerance. The discussion that follows and the measurements listed in Test Data Table 4.1.7.1 are limited to the final test on 15 May 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 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.

4.1.7 (Continued)

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 measure 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 signal turned off 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 LH_2 tank and four LOX tank poin level sensors was verified to respond to simulated wet condition 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 commands, resulted in the required engine cutoff signal. For the dry condition of LOX tank point level sensors

4.1.7 (Continued)

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.

4.1.7 (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 LH_2 chilldown inverters; and for each inverter, measurements 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. The bus voltages were measured again with the buses transferre 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 measured. The range safety EBW firing units were verified to be on when they

4.1.7 (Continued)

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 eighteen revisions were recorded in both issues of the procedure as follows:

a. Five revisions corrected program errors.

b. Two revisions deleted portions of the procedure that were no longer required.

c. Two revisions explained that the out-of-tolerance condition of the LOX chilldown inverter phase voltages, during the first attempt, was due to an error in the inverter simulator signal voltage ratios. Adjustment of the simulator resulted in a successful recheck during the second attempt.

d. Two revisions established a delay between the turnon of the LOX chilldown inverter and measurement of the inverter output frequency to allow sufficient time for the relay set to pull in prior to frequency measurement.

e. One revision adjusted the bus voltage safety item monitor level to 30.5 vdc to allow for power transients that occur when the PU electronics and inverter power was turned on. After the turnon was accomplished, the level was returned to the nominal 28 vdc setting.

f. One revision added the statement, "This procedure is to be accomplished per the Vehicle Safety Brochure, Beta-STC," to the safety procedure paragraph.

g. One revision changed the performance of the stage power setup from before to after loading of the executive and DDT programs.

h. One procedure explained two malfunctions that occurred during the initial condition scan as follows:

    1. The O_2H_2 burner LOX shutdown valve talkback was not present, due to the valve not being connected electrically.

    2. The LH_2 continuous vent valve closed talkback was missing because the pneumatic lines were not connect to the valve.

4.1.7 (Continued)

These functions are checked only during the initial condition scan and are not required for successful accomplishment of this procedure.

i. One revision reran a section of the test to verify proper LOX chilldown inverter output frequency.

j. One revision explained that a SIM interrupt on channel 22 was due to an operator error.

k. Because of extensive stage modification, one revision authorized the second attempt of this procedure to verify the LOX chilldown inverter phase voltages after rework and recalibration of the inverter simulators.

4.1.7.1 Test Data Table, Power Distribution System

Function	Measurement	Limits
Engine Control Bus Current (amps)	0.300	2 ± 2
Engine Control Bus Voltage (vdc)	27.845 *	Bus 4D11 ± 1
APS Bus Current (amps)	0.700	1.5 ± 3
Engine Ignition Bus Current (amps)	0.699	0 ± 2
Engine Ignition Bus Voltage, On (vdc)	27.845 *	Bus 4D11 ± 1
Engine Ignition Bus Voltage, Off (vdc)	0.000	0 ± 0.45
Component Test Power Current (amps)	0.400	0 ± 2
Component Test Power Voltage, On (vdc)	27.958	28 ± 2
Component Test Power Voltage, Off (vdc)	0.560	0 ± 1
Engine Control Bus Voltage, EDS 2 On (vdc)	0.000	0 ± 0.450
Engine Control Bus Voltage, EDS 2 Off (vdc)	27.876 *	Bus 4D11 ± 1
Propellant Level Sensor Power Current (amps)	0.000	1 ± 2
LOX Depletion Engine Cutoff Timer (sec)	0.550	0.560 ± 0.025
PU Inverter & Electronics Power Current (amps)	3.700	3 ± 2
PCM RF Assembly Power Current (amps)	3.500	4.5 ± 3.0
PCM RF Transmitter Output Power, AO (watts)	22.366	10 min
PCM RF Transmitter Output Power, BO (watts)	22.366	10 min
PCM RF Transmitter Output Power, AO T/M RF Silence On (watts)	-0.118	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)	22.099	10 min
Aft Bus 2 Current (amps)	-0.199	5 max
Aft Bus 2 Voltage (vdc)	56.078	56 ± 1

* In Tolerance, Actual Voltage Limits Not Specified

4.1.7.1 (Continued)

Chilldown Inverter Tests

Function	LOX Inv.	LH2 Inv.	Limits
Inverter Current (amps)	19.399	22.399	20.0 ± 5.0
Phase AB Voltage, Hardwire (vac)	55.211 *	54.951 *	Bus 4D41 ∓ 3
Phase AC Voltage, Hardwire (vac)	55.691 *	55.082 *	Bus 4D41 ∓ 3
Phase A1B1 Voltage, Hardwire (vac)	55.082 *	54.821 *	Bus 4D41 ∓ 3
Phase A1C1 Voltage, Hardwire (vac)	54.691 *	54.951 *	Bus 4D41 ∓ 3
Frequency, Hardwire (Hz)	401.0	400.00	400.0 ∓ 4.0
Phase AB Voltage, Telemetry (vac)	55.132 *	54.932 *	Bus 4D41 ∓ 3
Phase AC Voltage, Telemetry (vac)	55.266 *	54.865 *	Bus 4D41 ∓ 3
Frequency, Telemetry (Hz)	400.2	400.00	400.0 ∓ 4.0

Function	Measurement	Limits
Forward Battery 1 Simulator Voltage (vdc)	28.24	28 ± 2
Forward Battery 2 Simulator Voltage (vdc)	28.04	28 ∓ 2
Aft Battery 1 Simulator Voltage (vdc)	28.00	28 ∓ 2
Aft Battery 2 Simulator Voltage (vdc)	55.92	56 ∓ 4
Bus 4D20 ESE Load Bank (vdc)	0.04	0 ∓ 1
Bus 4D40 ESE Load Bank (vdc)	0.00	0 ∓ 1
Bus 4D30 ESE Load Bank (vdc)	0.00	0 ∓ 1
Bus 4D10 ESE Load Bank (vdc)	0.00	0 ∓ 1
Forward Bus 1 Voltage-Internal (vdc)	28.00	28 ∓ 2
Forward Bus 2 Voltage-Internal (vdc)	28.08	28 ∓ 2
Aft Bus 1 Voltage-Internal (vdc)	28.00	28 ∓ 2
Aft Bus 1 Voltage-External (vdc)	27.84	28 ∓ 2
Aft Battery 1 Voltage (vdc)	0.00	0 ∓ 1
Aft Bus 2 Voltage-Internal (vdc)	55.84	56 ∓ 4
Aft Bus 2 Voltage-External (vdc)	55.84	56 ∓ 4
Aft Battery 2 Voltage (vdc)	0.08	0 ∓ 1
Forward Bus 1 Voltage-External (vdc)	28.08	28 ∓ 2
Forward Battery 1 Voltage (vdc)	-0.04	0 ∓ 1
Forward Bus 2 Voltage-External (vdc)	28.16	28 ∓ 2
Forward Battery 2 Voltage (vdc)	0.00	0 ∓ 1
Aft Bus 2 Voltage, Off (vdc)	0.00	0 ∓ 1
Range Safety Receiver 1 External Power Current (amps)	-0.750	0 ± 2
Range Safety Receiver 2 External Power Current (amps)	0.751	0 ± 2

* In Tolerance, Actual Voltage Limits Not Specified

4.1.8 Level Sensor and Control Unit Calibration (1B44473 D)

This manual procedure determined that the control units associated with the LOX and LH_2 liquid level, point level, fast fill, and overfill sensors were adjusted for operating points within the design calibration limits. The particular items involved in this test are noted in Test Data Table 4.1.8.1. The procedure was initially accomplished on 22 March 1968; and due to the replacement of the LH_2 probe and rework of the LOX probe, reverification by a second and third issue was required on 14 May 1968 and 20 June 1968, respectively.

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. These calibration capacitances were 0.7 ±0.01 picofarads for all LH_2 sensors, except the LH_2 overfill sensor, which required 1.1 ±0.02 picofarads; and 1.5 ±0.02 picofarads for all LOX sensors, except the LOX overfill sensor, which required 2.1 ±0.02 picofarads. With the control unit power turned on, the control unit control point adjustement R1 was adjusted until the control unit output signal changed from 0 ±1 vdc to 28 ±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 ±1 vdc, indicating deactivation of the output relay; then increased until the output signal changed back to 28 ±2 vdc, indicating reactivation of the output relay. The deactivation and reactivation capacitance values of issue two for the LH_2

4.1.8 (Continued)

sensors and of issue three for the LOX sensors were recorded in Test Data Table 4.1.8.1 with the appropriate minimum and maximum capacitance limits.

A series of checks then verified the operation of the output relay test function. With the associated sensor disconnected, the control unit output relay was verified to be deactivated under both normal and test conditions. 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 eighteen revisions made to the three issues for the following:

a. Eight revisions added the requirement to disconnect the calibration unit and reconnect the liquid level control unit, to ensure that the power connector was returned to flight configuration after sensor calibration.

b. Three revisions specified turning off stage power when disconnecting and reconnecting specific power connectors, as it was not necessary to have power off for the calibration of all sensors.

c. Three revisions required that the PCM RF assembly power be turned off during sensor calibration, as the sensor circuits in the forward interstage are susceptible to RF interference.

d. Two revisions deleted sections of the test that were not required for the second issue.

e. Two revisions deleted sections of the test that were not required for the third issue.

4.1.8.1 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
LH_2 Tank	408			411						
Liq Lev L17	MT732	-507	D46	A61A217	-509	C21	0.5995	0.5	0.6042	0.9
Liq Lev L18	MT733	-507	D50	A61A219	-509	C23	0.6059	0.5	0.6083	0.9
Liq Lev L19	MT734	-507	D79	A61A221	-509	C4	0.5028	0.5	0.5032	0.9
Pt Lev 1	A1C1	-507	D28	A92A25	-509	C36	0.5662	0.5	0.5674	0.9
Pt Lev 2	A2C2	-507	D34	A92A26	-509	C47	0.6243	0.5	0.6264	0.9
Pt Lev 3	A2C3	-507	D37	A92A27	-509	C7	0.6740	0.5	0.7040	0.9
Pt Lev 4	A2C4	-507	D40	A61A201	-509	C18	0.5990	0.5	0.6003	0.9
Fastfill	A2C5	-1	D112	A92A43	-509	C43	0.6708	0.5	0.6785	0.9
Overfill	*	*	*	A92A24	-509	C41	1.080	0.9	1.088	1.3

* Part of LH_2 Mass Probe, P/N 1A48431-509, S/N D4C2, Location 408A1

	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	D114	A63A223	-511	C3	1.442	1.3	1.444	1.7
Liq Lev L15	MT658	-1	D115	A63A206	-511	C1	1.383	1.3	1.3875	1.7
Liq Lev L16	MT659	-1	D121	A63A221	-511	C2	1.436	1.3	1.440	1.7
Pt Lev 1	A2C1	-1	E79	A72A1	-511	C7	1.328	1.3	1.331	1.7
Pt Lev 2	A2C2	-1	E131	A72A2	-511	C11	1.428	1.3	1.432	1.7
Pt Lev 3	A2C3	-1	E147	A72A3	-511	C6	1.443	1.3	1.445	1.7
Pt Lev 4	A2C4	-1	E163	A63A227	-511	C4	1.444	1.3	1.450	1.7
Fastfill	A2C5	-1	E101	A72A5	-511	C8	1.332	1.3	1.335	1.7
Overfill	**	-1	**	A72A4	-511	C9	1.93	1.9	1.934	2.3

** Part of LOX Mass Probe, P/N 1A48430-511, S/N C2, Location 406A1

4.1.9 Common Bulkhead Vacuum System (1B49286 J)

The purpose of this manual checkout, initiated on 22 March 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 number 1 was re-opened. After 1 minute, sample supply switch number 1

4.1.9 (Continued)

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 1.0 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 99.95 per cent pure argon was connected to the bulkhead GN_2 supply line. The bulkhead GN_2 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 24 hours. After 24 hours, 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 13.8 psia. The LOX tank was pressurized to 30 ±1 psia, and the LH_2 tank was pressurized to 25 ±1 psia. This pressure was maintained for 12

4.1.9 (Continued)

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 12 July 1968.

Engineering comments revealed that there were no part shortages and no interim use material items installed at the start of this test. No FARR's were written as a result of this checkout.

There were 8 revisions written to the procedure for the following:

a. One revision deleted the requirement to turn on the Model 791A circuit breakers at the power panel on the sixth deck, because the circuit breakers were not located there. This revision also deleted the reference to circuit breakers 21 and 22, which had been entered in error in the procedure, and added circuit breaker 19.

b. One revision closed purge supply hand valve 182, instead of opening it, in order to comply with vacuum pumping requirements.

c. One revision added the step to connect the hand system to the stage. This step was inadvertently omitted.

d. One revision corrected the procedure paragraph numbering for paragraphs 4.3.15, 4.3.17, 4.3.19, and 4.3.20.

e. One revision provided instructions for the removal of the argon regulator because it was needed on the Beta I Test Stand for coldflow evaluation tests.

f. One revision provided instructions for securing the argon purge because coverage was not available on the third shift.

g. One revision provided instructions to record the bulkhead pressures during the static firing 96-hour pumpdown to checkout the transducer for measurement D545.

h. One revision authorized securing the bulkhead pumpdown over a weekend to eliminate the need for a monitor.

4.1.10 Stage and GSE Manual Controls Check (1B70177 F)

This procedure defined the checkout required to certify manual mode control of the components in the propulsion GSE and stage systems. Pneumatic regulators and valves in consoles A and B, the LH_2 and LOX control skids, and the pneumatic regulators on the stage were manually functioned. Manual control verification consisted of supplying electrical and pneumatic signals to system components and checking for the proper response.

The checkout was initiated on 25 March 1968, and verified as complete on 28 June 1968. The first section of the test certified that all GSE valves were functioning properly. Verification of proper operation was made by talkback indication and audible means.

A check of the stage mounted components was accomplished next. All stage purge hand valves were closed, and it was verified that the LH_2 and LOX pressure spheres were isolated in accordance with H&CO 1B70422. From the stage supply panel, the control helium shutoff valve was closed and the control helium bottle fill valve was opened until the control helium sphere pressure reached 125 psig, within the tolerance of 100 $\pm$25 psig; then, the helium sphere valve was closed. The control helium bottle dump valve was opened until the sphere pressure decayed to ambient; then, the control helium bottle dump valve was closed. The control helium shutoff valve and the control helium bottle fill valve were opened, then it was verified that the control helium regulator discharge pressure was stabilized at 500 $\pm$50 psig.

4.1.10 (Continued)

On the mainstage panel, the LOX and LH_2 chilldown valves and the LOX and LH_2 prevalves were cycled. At the LH_2 control panel, the tank fill and drain valve and the tank vent valve were cycled. The LH_2 tank vent boost and the fill and drain boost were cycled, and the directional vent was placed in the flight position, then, returned to the ground position.

At the LOX control panel, the tank vent valve, the cold helium shutoff valve, and the LOX fill and drain valve were cycled. The tank vent boost and fill and drain valve boost were cycled.

The engine control bottle dump, the cold helium dump, the start tank dump, the LOX repressurization dump, the LH_2 repressurization dump, and the control helium bottle fill on the stage supply panel were cycled.

An LH_2 and LOX umbilical purge interlock check was accomplished next. At the LH_2 control panel, the LH_2 fill and drain valve and the LH_2 umbilical drain valve were verified to be closed. The LH_2 umbilical purge valve was then opened, and talkback indication was verified. The LH_2 fill and drain valve was cycled, and it was verified that the LH_2 umbilical purge valve opened and closed. Verification was made that operating the LH_2 umbilical drain valve also operated the LH_2 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 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 valves were

4.1.10 (Continued)

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

To begin the test shutdown, the helium supply hand valve in console "A" was closed, the stage 1 bleed valve was opened, and the stage 1 line pressure was verified to be ambient; then, all systems were bleed down to ambient.

The checkout of the engine valves began by ensuring that the start tank pressure the LOX and LH_2 tank pressures, and the engine control bottle pressure were ambient and that the chilldown shutoff valves and the prevalves were closed. It was then verified that the flight measurement enable indication was on. The engine control package power, the component test power, and the component test sub-bus power were turned on. The helium control solenoid was energized for 1 second after the J-2 engine sequence oscillograph was turned on; then, the solenoid was de-energized, the oscillograph was turned off, and the solenoid was re-energized. The LOX and LH_2 bleed valves were opened, the engine control helium bottle was pressurized to 750 $\pm$50 psig, the line regulator discharge pressure was verified to be 350 $\pm$25 psia; then, the LH_2 and LOX bleed valves were closed.

Next, the J-2 engine sequence oscillograph was turned on; the ignition phase solenoid, the mainstage solenoid, and the start tank discharge valve solenoid were cycled; then, the oscillograph was turned off. The engine control bottle pressure was bled to ambient, and the helium control solenoid was closed. The engine control package power, the component test power, and the component test sub-bus power were turned off. The chilldown shutoff valves and the prevalves were then opened.

4.1.10 (Continued)

During the operation of this procedure, two FARR's were generated to repair two GSE valves in console A. Since these were not stage valves, no further discussion of the FARR's is given in this report. There were fourteen revisions written against the procedure for the following; however, one revision was voided:

a. One revision added instructions to verify proper operation of the engine sled valves.

b. One revision changed the procedure callouts for the LH_2 and LOX repressurization valves enable switch position from closed to enable, to agree with the panel nomenclature.

c. One revision changed the procedural pressure units (psig and psia) to agree with the pressure units indicated by the test gauges.

d. One revision closed the GH_2 bleed valve to ensure that there would be enough supply pressure for the test. With the GH_2 bleed valve open, approximately 200 psig supply pressure was lost.

e. One revision deleted the requirement to check the helium shutoff valve backup switch and added a step to open and close the control helium bottle fill valve, as required, to maintain 500 to 550 psig in the control helium bottle.

f. One revision added steps to permit the prevalves and chilldown shutoff valves to cycle, pending reinstallation of the GSE backup solenoid.

g. One revision provided steps to adjust the LH_2 sled replenish valve.

h. One revision added instructions to obtain LH_2 and LOX prevalve and chilldown shutoff valve timing information per WRO 4155.

i. One revision deleted the step to close the O_2H_2 burner LOX propellant valve, because the valve had been deleted and the O_2H_2 LOX shutdown valve had been reidentified as the O_2H_2 burner LOX propellant valve.

j. One revision deleted the requirement to check the GH_2 lead ignitor hand valves because it had been accomplished per another procedure.

4.1.10 (Continued)

k. One revision deleted the requirement to vent the system to ambient in order to rerun the test as the normal pressures would be acceptable.

l. One revision deleted the requirement to check the LOX shutdown valve with the O_2H_2 LH_2 propellant valve, as it was no longer plumbed to the LH_2 propellant valve actuation module.

m. One revision deleted the requirement to check the GN_2 ejector, as the checkout had been accomplished per another procedure.

4.1.11 Cryogenic Temperature Sensor Verification (1B44471 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 Callender-Van Dusen equation.

There were three issues of this test procedure. The first issue was successfully accomplished on 26 March 1968, and accepted on 7 May 1968. A second issue was performed and accepted on 13 May 1968. This issue was necessary because the fuel mass probe had been reworked in accordance with WRO 4183, and three O_2H_2 burner voting circuit temperature sensor measurements were added in accordance with WRO's 2887 and 3431. After the LOX tank feedthrough inspection work was performed in accordance with WRO 4373, the third issue was satisfactorily accomplished on 21 June 1968, to reverify the LOX tank sensors.

4.1.11 (Continued)

Each sensor was tested at 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 required to be within 5 per cent of calculated resistance, except for eleven specified sensors which were allowed a 7 per cent 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 4.1.11.1 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. No problems were encountered during the test, no FARR's were written, and the checkout was accepted by Engineering.

Revisions were made to the three issues as follows:

Issue 1: Two revisions were written against issue 1. The second revision cancelled the first revision because it was accomplished in the second issue (reference issue 2,b.).

Issue 2: a. One revision added three measurements for the O_2H_2 burner voting circuit to verify sensor integrity.

b. One revision deleted all sensor measurements, except those for the O_2H_2 burner voting circuit sensor and the temperature sensors for the fuel tank, as shown in the Test Data Table.

Issue 3: One revision deleted all sensor measurements, except those for the LOX tank, as shown in the Test Data Table.

4.1.11.1 Test Data Table, Cryogenic Temperature Sensor Verification

Meas. Number	P/N	Sensor S/N	Ref. Desig.	Temp (°F)	Resistance (ohms) Meas.	Limits
CO 003	1B34473-1	1417	403MT686	61	4967	4947.0 to 5691.0
CO 004	1B34473-501	339	403MT687	60	1460	1411.7 to 1560.3
CO 005	1A67863-503	915	405MT612	61	520	505.3 to 558.5
CO 009	1A67863-535	705	403MT653	63	214	202.9 to 224.3
CO 015	1A67863-509	1087	410MT603	62	1513	1418.0 to 1577.0
CO 040	1A67862-505	580	406MT613 **	72	1542	1426.6 to 1576.6
CO 052	1A67862-513	309	408MT612 *	55	5230	4885.0 to 5621.0
CO 057	1A67862-501	51297	406MT606 **	72	555.5	517.0 to 571.0
CO 059	1A67862-517	582	406MT611 **	72	557.5	517.0 to 571.0
CO 133	NA5-27215T5	13533	401(3MTT17)	60	1280	1266.8 to 1400.0
CO 134	NA5-27215T5	13614	401(3MTT16)	60	1290	1266.8 to 1400.0
CO 159	1A67863-519	884	424MT610	63	215.6	202.9 to 224.3
CO 161	1A67863-537	1096	404MT733	63	4997	4968.0 to 5714.0
CO 208	1A67863-503	863	405MT605	61	520	505.3 to 558.5
CO 230	1A67863-509	1127	403MT706	61	1436	1413.3 to 1564.7
CO 231	1A67863-529	1067	403MT707	59	523	503.3 to 556.1
CO 256	1B37878-501	1426	409MT646	61	1475	1414.5 to 1564.5
CO 257	1B37878-501	1500	409MT647	61	1473	1414.5 to 1564.5
CO 368	1A67862-505	433	406MT660 **	72	1517	1426.6 to 1576.6
CO 369	1A67862-505	448	406MT661 **	72	1544	1426.6 to 1576.6
CO 370	1A67862-533	612	408MT735 *	55	5230	4885.0 to 5621.0
CO 371	1A67862-533	617	408MT736 *	55	5000	4885.0 to 5621.0
C 2030	1B37878-511	1479	404MT760	59	517.5	503.3 to 556.1
C 2031	1B37878-511	1481	404MT761	59	525.5	503.3 to 556.1
†	1B37878-507	1694	403A20 *	63	5040.0	4967.0 to 5715.0
†	1B37878-507	1700	403A21 *	63	5053	4967.0 to 5715.0
†	1B37878-507	1711	403A22 *	63	5055	4967.0 to 5715.0

* Issue 2

** Issue 3

† NASA Measurement No. Not Applicable to O_2H_2 Burner Voting Circuit

4.1.12 Hydraulic System Setup and Operation (1B41005 B)

The purpose of this manual procedure, initiated on 27 March 1968, and completed on 10 July 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 X454594; the hydraulic actuator assemblies, P/N's 1A66248-507-011, S/N's 84 and 71; the main hydraulic pump, P/N 1A66240-503, S/N X457811; and the accumulator/reservoir assembly, P/N 1B29319-519, S/N 00029, 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 bottles were 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.

4.1.12 (Continued)

On completion 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 in the Test Data Table. 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.

4.1.12 (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 per cent 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 supply was next. The stage air bottles were 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

4.1.12 (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 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 at T+500 seconds of terminal chilldown and firing, and the hydraulic system pressure was set at 3650 psig. After simulated engine cutoff, the HPU was turned off.

FARR A261833 reported that subsequent to system shutdown, hydraulic oil was noted on the pitch actuator, P/N 1A66248-507, S/N 74. The discrepant actuator was removed and replaced with S/N 84.

4.1.12 (Continued)

Eighteen revisions were made to the procedure for the following:

a. Four revisions authorized the taking of hydraulic fluid samples after the HPU had been connected to the hydraulic system for more than 48 hours.

b. Two revisions concerned trouble shooting to investigate a possible leak on the pitch actuator.

c. Two revisions specified the retest required to verify proper operation of the hydraulic system after replacement of the pitch actuator per FARR A261833.

d. Two revisions performed a special test to check for a suspected GN_2 leak in the hydraulic accumulator.

e. One revision added the requirement to remove the platform extension, P/N 1B70620, from the vicinity of the engine prior to removal of the midstroke locks.

f. One revision changed the temperature versus fluid volume chart to increase the volume of hydraulic fluid from the hydraulic reservoir during final air content checks, to allow for thermal expansion.

g. One revision set up the HPU to support the debugging run of the static firing program.

h. One revision changed the system high pressure from 3700 psig to 3650 psig, to keep the pressure well under the SIM interrupt value of 3900 psig.

i. One revision clarified procedure wording.

j. One revision corrected an error in the procedure.

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

4.1.12.1 Test Data Table, Hydraulic System Setup and Operation

Test Description	Instrumentation Name	Instrumentation Location	Actual (in)	Required (in)
Actuator	Pitch Vernier	Pitch Actuator	0	0
	Yaw Vernier	Yaw Actuator	0	0
			Position	Voltage
Instrumentation Support	Pitch Actuator Position (deg.)	TCC	0	2.506 vdc
			+1	2.1616 vdc
			+2	1.8146 vdc
			+1	2.1722 vdc
			0	2.5120 vdc
	Pitch Actuator Position (deg.)	TCC	0	2.5120 vdc
			-1	2.8511 vdc
			-2	3.1940 vdc
			-1	2.8444 vdc
			0	2.5057 vdc
	Yaw Actuator Position (deg.)	TCC	0	2.5057 vdc
			+1	2.8682 vdc
			+2	3.2130 vdc
			+1	2.8690 vdc
			0	2.5185 vdc
	Yaw Actuator Position (deg.)	TCC	0	2.5185 vdc
			-1	2.1756 vdc
			-2	1.8340 vdc
			-1	2.1837 vdc
			0	2.5167 vdc
Stage Air Bottle Decay Check	Air Bottle Pressure	Stage	Start 1300 4-2-68	450 psig *
			Stop 1300 4-3-68	450 psig *

* Limits Not Specified

4.1.13 Digital Data Acquisition System Calibration (1B55816 F)

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 6800054, which replaced P/N 1B65792-1, S/N 6700092; the CP1-B0 time division multiplexer, P/N 1B65897-1, S/N 07; the DP1-B0 time division multiplexer, P/N 1B65897-1, S/N 05; the remote digital submultiplexer (RDSM), P/N 1B66051-501, S/N 05; and the low level remote analog submultiplexer (RASM), P/N 1B66050-501.1, S/N 06.

Two issues of this procedure were required to satisfactorily complete prefire calibration of the DDAS. Issue one consisted of two test attempts with the first being initiated on 28 March 1968, and continued on 29 March 1968. Attempt one was interrupted to rework the RDSM for connector and pin damage per FARR A261830 after investigation of RDSM test malfunction indications. After the RDSM rework, attempt one was then resumed and completed on 1 April 1968; however, channel malfunctions during the RASM test made a repeat test for the submultiplexer necessary. The malfunctions were attributed to incomplete electrical installation and improper adjustment of the Fluke voltmeter. Attempt two was a successful RASM test on 3 April 1968, completing successful DDAS calibration testing.

A second issue of the procedure was necessary due to the replacement of the PCM/DDAS assembly, S/N 6700092. It was removed to test Stage 505N and was

4.1.13 (Continued)

replaced by S/N 6800054. The new PCM/DDAS assembly was successfully tested on 10 May 1968. All measurements quoted in this narrative are taken from the final prefire test, with the exception of the RASM portion which was not required to verify correct operation of the new PCM/DDAS. The following is a description of the individual tests conducted with reference to final measurements.

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 71,989 bits per second, within the limits of 71,975 to 72,025 bits per second. 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 629.8 kHz at 3.6 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 564.5 kHz at 3.6 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 65.3 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. All channels measured during the final tests were within the required tolerances.

4.1.13 (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 outputs 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, corresponding to the 0 to 30 millivolt range input. All measured outputs for the final RDSM and RASM tests were within the required tolerances.

A final test measured the PCM/FM transmitter current as 3.4 amperes, within the 4.5 $\pm$3.0 amperes limits.

Problems documented by FARR's in the procedure were limited to the RDSM rework per FARR A261830, as previously described.

Fourteen revisions were recorded in the procedure for issue one, and six revisions in issue two as follows:

<u>Issue 1</u>:

a. One revision substituted a battery and variable resistors for the specified power supply in a test setup to eliminate variations encountered during previous testing with the power supply.

b. One revision corrected an error in test cable connections specified by a test setup schematic.

c. One revision deleted the Model DSV-4B-232 telemetry console from the end item requirements list, as it no longer exists in the Beta test area.

d. One revision concerned stage power setup changes and malfunction indications which had no bearing on DDAS calibration testing and are identical to those described in paragraph 4.1.5, stage power setup.

4.1.13 (Continued)

e. Six revisions were changes to shutdown the automatic program and then restart at a later time due to the RDSM rework and test scheduling.

f. Two revisions explained SIM interrupts that were received due to concurrent testing.

g. One revision discussed an error message received due to a procedural error.

h. One revision authorized test attempt two to rerun the RASM test after correction of the causes for test malfunctions.

Issue 2:

a. One revision indicated that issue two was required only to test the new PCM/DDAS assembly; and therefore, deleted RASM setup and testing, which was not applicable.

b. One revision repeated revision "c" of issue one.

c. One revision corrected a procedure error.

d. One revision updated the procedure to incorporate the latest stage configuration requirements.

e. One revision explained an error message that was received because of concurrent repair work on the model DSV-4B-298 system status display.

f. One revision indicated that a DP1-BO multiplexer channel malfunction occurred due to an improper ground connection. After correction, the DP1-BO multiplexer test was repeated satisfactorily without malfunction.

4.1.14 (Continued)

Stage integrity checks performed pickup and dropout pressure tests on the control helium regulator discharge pressure switch and the cold helium regulator backup pressure switch. Audible leak checks were conducted on the cold and ambient helium systems, the engine spheres, and the stage tanks by pressurizing the engine control bottle to 350 $\pm$50 psig, the start tank to 250 $\pm$50 psig, the LOX tank to 5 psig, and the LH_2 tank to 3 psig. At the completion of the above audible leak checks, stage integrity checks were continued by pressurizing the control helium bottle to 3100 $\pm$100 psig, the start tank to 800 $\pm$25 psig, the cold helium spheres to 1500 $\pm$50 psig, and the engine control bottle to 3015 $\pm$100 psig. These pressures were maintained for 5 minutes; then, the LOX and LH_2 tanks were pressurized to relief pressure while the vent valves were allowed to perform three relief cycles.

One condition of leakage was noted at the cold helium fill line B-nut. The leak was repaired by retightening the B-nut to the proper torque value. IIS 363180 reported that the LH_2 start tank would not hold pressure. Investigation revealed that the LH_2 continuous vent valve had been left open during a previous checkout. The valve was closed, no further problems were encountered, and this section was satisfactorily completed.

The ambient helium system leak and flow check was accomplished next. This section began with an orifice flow verification of the purge system, a reverse leak check of the valves, and a leak check of the purge system. An internal leak check of the ambient helium fill module and the pneumatic power control module was performed next. Then, the ambient LOX and LH_2 repressurization

4.1.14 (Continued)

system was functioned and checked for internal leakage. The ambient LH_2 repressurization module backup check valve was checked for reverse leakage, then the ambient repressurization system was leak checked. The control helium system was functioned and checked for leakage. The pneumatic control system was locked up and checked for pressure decay over a 30 minute period. Twelve conditions of leakage were noted during this checkout. Seven were corrected by retightening the unions and B-nuts; three required new seals; one was acceptable as the leakage rate was below the maximum allowable; and one leak required replacement of the LOX fill and drain valve, P/N 1A48240-505, S/N 0009, per FARR A261835.

The engine start system leak and functional checks included a drying sequence for the start tank vent valve actuator, a seat leak check of the start tank control solenoid valve, and a reverse leak check of the start tank fill check valve. Leak checks were performed on the GH_2 start system, the start tank dump-control solenoid seal, and the vent and relief valves and valve bellows. Start bottle retention tests were conducted to measure the start bottle decay by calculating the pound-mass/hour-loss. One leak was noted, and repair was accomplished by retightening a B-nut.

The LH_2 pressurization and repressurization system leak and functional checkouts included a functional check of the O_2H_2 burner LH_2 repressurization control valves, a reverse leak test of the O_2H_2 burner LH_2 check valve, and leak checks of the repressurization system and the O_2H_2 burner LH_2 repressurization control valve seat and pilot bleed valve. This section also performed a reverse leak

4.1.14 (Continued)

test of the fuel pressure module check valve and the LH_2 prepressurization check valve. All tests were satisfactorily completed.

Thrust chamber leak checks included a leak check of the thrust chamber system, reverse leakage of the engine LOX dome purge check valve, and flow checks of the main fuel and oxidizer valve drive and idler shaft seals. This section also covered reverse leakage of the thrust chamber jacket purge check valves. Two conditions of leakage were noted during this section. One was repaired by replacement of a seal and retightening of the union. FARR 500-026-472 reported a small fuzz leak at weld 003A on the LOX dome purge inlet. This leak was repaired by rewelding the seam.

The LOX pressurization and repressurization system leak and functional checks performed a reverse leak check of the cold helium sphere fill check valve, an internal leak and functional check of the LOX pressurization module, a LOX pressurization system leak check, a leak and functional check of the O_2H_2 burner LOX repressurization system, a LOX repressurization system leak check, and a cold helium system leak check. One condition of leakage noted during these checks was corrected by replacing a seal.

Leak checks were then performed on the LOX tank, the O_2H_2 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 checked 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

4.1.14 (Continued)

torque and running torque and for primary seal leakage. The LOX chilldown pump purge flow checks included checks of the LOX chilldown pump purge flow and chilldown pump purge bypass flow, set leakage check of the chilldown pump purge module shutoff valve and the chilldown pump purge dump valve, seal leakage checks of the chilldown pump shaft (in the pump direction and in the tank direction), and a general leak check of the chilldown pump purge system.

Then the LOX prevalve shaft seal was leak checked with the prevalve opened and closed. The LOX fill and drain valve was checked for seat leakage. Next, leak checks of the LOX umbilical and the main fill and replenish valve seat were performed. Seat leakage checks of the O_2H_2 burner LOX propellant valve and the O_2H_2 burner LOX propulsion valve, and a leak check from the LOX tank to the O_2H_2 burner LOX propellant valve were performed. Four conditions of leakage noted during these tests were correct by replacement of seals and retightening.

Leak checks were then performed on the LH_2 tank, the O_2H_2 burner, and the engine LH_2 feed system. Internal leak checks of the engine feed system checked for seat leakage of the LH_2 prevalve and chilldown shutoff valve, the engine LH_2 bleed valve, the engine main fuel valve, and checked for reverse leakage of the LH_2 chilldown return valve. The LH_2 engine pump drain check valve, the LH_2 turbine seal cavity purge check valve, and the LOX turbine seal cavity check valve were checked for reverse leakage. The LH_2 engine pump intermediate seal was checked for leakage. The LH_2 engine pump drain check valve was also checked for forward flow. Then the LH_2 tank and the engine feed system were

4.1.14 (Continued)

leak checked. Next, the LH_2 turbopump was checked for breakaway and running torque and was checked for primary seal leakage.

The LH_2 prevalve shaft seal was leak checked with the valve opened and closed. The LH_2 fill and drain valve was checked for seat leakage. Leak checks of the LH_2 umbilical and the main fill and replenish valve seat were performed. Then leak checks of the O_2H_2 burner LH_2 propellant valve seat and the LOX shutdown valve seat were made, as well as a general leak check of the O_2H_2 propellant system. Six conditions of leakage were noted. Three required retightening and three required the installation of new seals.

Leak and flow checks of the engine gas generator (GG) and exhaust system were conducted next, and included reverse leak checks of the GG LH_2 purge check valve, the GG LOX purge check valve, and the GG LOX poppet. Leak checks of the start tank discharge valve gate seal and the hydraulic pump seal were conducted. A bleed flow check of the LH_2 and LOX turbine seal cavity was conducted. General leak checks of the GG and exhaust system and the pressure actuated purge system were also conducted. Two conditions of leakage were noted. One was corrected by the replacement of a seal, and the other was acceptable as the leak rate was below the maximum.

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 LH_2 turbine seal cavity bleed exits and the LH_2 pump drain test port, and verified the GG fuel purge flow of the LH_2 turbopump access. All engine pump purge leak checks were satisfactorily completed.

4.1.14 (Continued)

Leak and flow checks of the engine pneumatics 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 discharged valve solenoid energized leak checks, the mainstage 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 tests were conducted to determine the control bottle decay by calculating the pound-mass/hour-loss. Three conditions of leakage were noted during this section. One was corrected by retightening a B-nut, one required a new seal, and the third necessitated a rewelding operation by Rocketdyne personnel.

LOX and LH_2 vent system leak and flow checks included leak checks of the nonpropulsive vent ducting; the nonpropulsive vent and ground system vent; the LOX and LH_2 vent systems; the LOX vent and relief, and the relief valve internal leakage; the LH_2 vent and relief, relief, and the directional vent valve internal leakage; and an actuator piston leak check of the LH_2 directional vent. Seven conditions of leakage were noted during this section. One was repaired by retightening a B-nut, and six were repaired per FARR A270691.

As a result of this checkout, three FARR's were generated for the following:

a. FARR A261835 noted that the LOX fill and drain valve, P/N 1A48240-505, S/N 0009, leaked at the closing solenoid vent port. The leakage rate was 400 scims, as compared to the maximum allowable leakage of 2 scims. The valve was removed and replaced.

b. FARR A270691 reported six leaks on the LOX nonpropulsive vent ducts, P/N's 1B69220-1 and 1B69223-1. The ducts were removed, and the flange surfaces were reworked.

4.1.14 (Continued)

c. FARR 500-026-472 noted a small fuzz leak at weld C039A on the LOX dome purge inlet of the J-2 engine. The leak was repaired by rewelding the tube assembly.

There were ninety-seven revisions written against this test procedure for the following:

a. Forty revisions corrected and/or added requirements that were in error or missing.

b. Thirteen revisions added steps to acquire Engineering data or install temporary leak check installations.

c. Ten revisions were incorporated to leak check hardware which was replaced subsequent to its systems leak checks.

d. Ten revisions deleted or changed sections that were not required or were affected by stage configuration or were postfire requirements.

e. Eight revisions repeated leak checks and/or test requirements previously accomplished.

f. Five revisions added the steps required to support stage modifications or parallel procedures.

g. Three revisions were needed to return equipment and/or stage hardware, being utilized in support of parallel procedures, to leak check configuration.

h. Three revisions provided a helium purge during R/NAA welding on the J-2 engine.

i. Two revisions were required to clarify procedure wording.

j. One revision provided instructions for a bolt torque check.

k. One revision was written and subsequently voided.

l. One revision authorized transferring steps not accomplished and leaks not corrected to the final postfire leak check procedure.

4.1.14.1 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)	3225	3225	3225	*
Reseat Pressure (psig)	3175	3175	3175	*
Internal Leak Check at 3100 + psig				
Relief Valve Seat Leakage (scim)		0		5 max
Dump Solenoid Seat Leakage (scim) (Pilot Bleed & Seat - Combined)		0		5 max
Internal Leak Check at 500 +50 psig				
Relief Valve Seat Leakage (scim)		0		12.5 max
Dump Solenoid Seat Leakage (scim) (Pilot Bleed & Seat - Combined)		0		12.5 max

Calip Pressure Switch Leak Checks

Function	Measurement	Limits
Mnstg Press Sw C/O Circuit Decay (psi)	0	5.0 max/5 minutes
LOX Press Sw C/O Circuit Decay (psi)	0	0.5 max/5 minutes
LH_2 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)	401.0	
Final (psig)	398.0	
Decay (psi)	3.0	10.0 max/15 minutes

Stage Integrity Checks

Function	Measurement			Limits
	Run 1	Run 2	Run 3	
Control He Reg Disch P/S:				
Pickup Press (psia)	603.0	605.0	605.0	600 + 21
Dropout Press (psia)	479.0	478.0	479.0	490 ∓ 31
Cold He Reg Backup P/S:				
Pickup Press (psia)	462.7	462.7	462.7	444 to 491
Dropout Press (psia)	344.7	344.7	344.7	329 to 376
LOX Tank Relief Cycle (psia)	43.1	43.3	43.3	41 to 44
LH_2 Tank Relief Cycle (psia)	36.9	36.9	37.0	34 to 37

* Limits Not Specified

4.1.14.1 (Continued)

Ambient Helium System Flow Checks

Function	Measurement	Limits
LOX Tnk Ullage Sense Line Purge (scim)	330.0	432 ± 245
LOX F&D Vlv Microsw Housing Purge (scim)	1.5	3.5 ± 2
LH_2 F&D Vlv Microsw Housing Purge (scim)	1.7	3.5 ± 2
Nonpropulsive Vent Duct Purge (scim)	250.0	432 ± 245
Contin Vent Mod Purge (scim)	45.0	20 ± 30
Orifice Bypass Vlv Microsw Purge (scim)	1.6	3.5 ± 2
Contin Vent Duct Purge (scim)	200.0	432 ± 245

Purge System Check Valve Reverse Leak Checks (P/N 1B51361-1)

Check Valve Function	S/N	Measurement	Limits
LOX Vent Purge (scim)	323	0	10 max
LOX Fill & Drain Purge (scim)	325	0	10 max
LH_2 Fill & Drain Purge (scim)	345	0	10 max
LH_2 Vent Purge (scim)	314	0	10 max

Ambient He Fill Module Internal Leak Checks (P/N 1A57350-507, S/N 0233)

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

Ambient He Spheres Fill System Check Valves Reverse Leak Checks (P/N 1B51361-1)

Function	S/N	Measurement	Limits
LOX Repress Mod Check Vlv (scim)	-	0	10 max
LH_2 Repress Mod Backup Check Valve (scim)	338	0	10 max
LH_2 Repress Mod Check Vlv (scim)	-	0	10 max
He Fill Mod Backup Check Valve (scim)	342	0	10 max

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	*

* Limits Not Specified

4.1.14.1 (Continued)

Function	Measurement	Limits
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

LH_2 Repress System

Function	Measurement	Limits
Cont Vlv (L3) Seal 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 1B55200-505, S/N 1054)

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
O_2H_2 Burner LOX Vlv Control (scim)	83	0.2	0	0	6 max
O_2H_2 Burner LH_2 Vlv Control (scim)	95	0	0	0	6 max
Orificed Bypass Vlv Control (scim)	94	0	0	0	6 max
		Normal	Open	Boost	
LOX Vent Valve Control (scim)	82	0	0	0	6 max
LH_2 Fill & Drain Vlv Control (scim)	90	0	0	0	6 max
LOX Fill & Drain Vlv Control (scim)	92	0	0	0	6 max
LH_2 Vent Valve Control (scim)	96	0	0	0	6 max

* Limits Not Specified

4.1.14.1 (Continued)

Module Function	S/N	Open	Closed	Limits
LH_2 F&D Act Seal Lkg (scim)	83	0	0	2 max
LOX F&D Act Seal Lkg (scim)	92	400†	5.2†	2 max
LH_2 Cont Vent Act Piston & Shaft Seal Lkg (scim)		0	0	20 max
Cont Vent Bypass Shutoff Vlv Act Lkg (scim)	94	0	0	5 max
LOX Shutdown Act Piston & Shaft Seal Lkg (scim)	95	0	0.48	20 max

	S/N	Normal	Flight	Ground	Limits
Bi-Directional Vent Valve Control	93	0	0	0	6 max

	S/N	Normal	Closed	Limits
Prevalve/Childown Valve Control (scim)	74	0	-	6 max
Prevalve Control (scim)	74	-	0	6 max
Chilldown Valve Control (scim)	74	-	0	6 max

Pneumatic Control System Decay Checks

Function	Measurement Initial	Measurement Final	Limits
Reg Disch Press - Valve Pos, Normal (psig)	551.0	548.0	*
Reg Disch Press - Valve Pos, Activated (psig)	534.0	491.0	*

Engine Start Tank Leak Checks

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

LH_2 Repressurization System Leak Checks

Function	Measurement	Limits
O_2H_2 Burner Control Vlv Seat Leakage (scim)	0	*
O_2H_2 Burner Control Vlv Pilot Bleed Lkg (scim)	0	*

* Limits Not Specified

† Reference FARR-A261835

4.1.14.1 (Continued)

Function	Measurement	Limits
O_2H_2 Burner Module Cont Vlv Int Leakage (scim)	0	12 max
O_2H_2 Burner Cont Vlv & Check Vlv Rev Lkg (scim)	0	*
O_2H_2 Burner Check Vlv Reverse Leakage (scim)	0	5 max
O_2H_2 Burner Coil Leakage (scim)	0	0

LH_2 Pressurization System Leak Check

Function	Measurement	Limits
LH_2 Press Module Check Vlv Rev Lkg (scim)	0	10 max
LH_2 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)	26.0	20 min
Jacket Purge Check Vlv Rev Lkg (scim)	5.6	25 max

LOX Pressurization & Repressurization System Leak Checks

Function	Measurement	Limits
Cold Helium Sphere		
Fill Check Vlv Rev Lkg (scim)	0	0
Shutoff Vlv Seat & Pilot Bleed Lkg (scim)	0	12.5 max
LOX Press Module Internal		
Hot Gas Bypass Vlv Seat & Pilot Bleed Lkg (scim)	0	1000 max
O_2H_2 Burner LOX Repress System		
Burner Control Valve Seal Leakage (scim)	0	*
Burner Control Valve Pilot Bleed Lkg (scim)	0	*
Burner Module Control Vlv Internal Lkg (scim)	0	12 max
Combined Burner Check Vlv & Cont Vlv Seat Leakage (scim)	0	0

* Limits Not Specified

4.1.14.1 (Continued)

Function	Measurement	Limits
Burner Check Vlv Rev Leakage (scim)	0	0
Burner Coil Leakage (scim)	0	0
Cold Helium System		
LOX Tank Prepress Check Vlv Rev Leakage (scim)	0	0
LH_2 Tank Repress Press Sw Diaphragm Leakages (scim)	0	*

LOX Tank, O_2H_2 Burner & Engine Feed System Leak Checks

Function	Measurement	Limits
LOX Tank Helium Content		
Top (%)	99.1	99 min
Bottom (%)	99.1	99 min
Engine Feed Sys Internal Leak Checks		
LOX Prevlv & Childown Shutoff Vlv Seat & Chilldown Return Check Vlv Lkg (scim)	19.0	*
LOX Chilldown Ret Check Vlv Rev Lkg (scim)	4.5	350 max
LOX Prevlv & Chilldown Shutoff Vlv Combined Seat Leakage (scim)	9.5	150 max
LOX Bleed Vlv & Chilldown Return Check Vlv Rev Leakage (scim)	5.0	*
LOX Bleed Vlv Seat Leakage (scim)	0.5	300 max
Main Oxidizer Vlv Seat Leakage (scim)	0.0	10 max
LOX Tank & Engine Feed System Leak Checks		
LOX Low Pressure Duct Pressure (psig)	29.0	30 max
Oxidizer Pump Speed Pickup Seat Bleed (scim)	0	0
LOX Turbopump Torque Checks		
Pump Primary Seal Leakage:		
Max (scim)	61.0	350 max
Min (scim)	61.0	350 max
Turbine Torque:		
Breakaway (in/lbs)	35.0	1000 max
Running (in/lbs)	30.0	200 max
LOX Boiloff Valve Flow Check		
Valve Seat Leakage (scim)	0	10 max
LOX Turbopump Torque Checks		
Prevalve Shaft Seal Leakage:		
Open Position (scim)	0	10 max
Closed Position (scim)	0	10 max
Internal Closed Pos (scim)	2.0	75 max
Fill and Drain Valve Seat Leakage (scim)	0	18 max
Fill and Drain Vlv Primary Shaft Seal Lkg (scim)	0	6.1 max

* Limits Not Specified

4.1.14.1 (Continued)

Function	Measurement	Limits
LOX Umbilical & Main Fill & Replenish Vlv Seat Leak Checks		
LOX Main Fill, Replenish, & Fill & Drain Vlvs Seat Leakage (scim)	2600.0	*
LOX Main Fill & Replenish Vlvs Seat Lkg (scim)	2600.0	*
O_2H_2 Burner LOX System Leak Check		
Burner LOX Prop Valve Seat Leakage (scim)	0	50 max

LH_2 Tank, O_2H_2 Burner & Engine Feed System Leak Checks

Function	Measurement	Limits
LH_2 Tank Helium Content (%)	99.9	99 min
Engine Feed System Internal Leak Checks		
LH_2 Prevlv & Chilldown Shutoff Vlv & Chilldown Return Check Vlv Rev Leakage (scim)	0	*
LH_2 Chilldown Ret Check Vlv Rev Lkg (scim)	1.6	350 max
LH_2 Prevlv & Chilldown Shutoff Vlv Combined Seal Leakage (scim)	-1.6	150 max
LH_2 Bleed Vlv & Chilldown Return Check Vlv Rev Leakage (scim)	2.0	*
LH_2 Bleed Vlv Seat Leakage (scim)	0.4	300 max
MOV & MFV Combined Seat Leakage (scim)	0	*
Main Fuel Vlv Seat Leakage (scim)	0	10 max
Engine Purge System Leak Checks		
LH_2 Pump Drain Check Vlv Rev Leakage (scim)	0	25 max
LH_2 Pump Drain Check Vlv Fwd Flow 30 psi (scim)	0	30 max
LH_2 Pump Drain Check Vlv Fwd Flow 60 psi (scim)	8750.0	2420 min
LH_2 Pump Purge Check Vlv Rev Leakage (scim)	0	25 max
LH_2 Pump Intermediate Seal Leakage (scim)	4.0	500 max
LH_2 Turbine Seal Cavity Prg Check Vlv Rev Leakage (scim)	0.75	25 max
LOX Turbine Seal Cavity Prg Check Vlv Rev Leakage (scim)	0	25 max
LH_2 Tank & Engine Feed System Leak Checks		
LH_2 Low Pressure Duct Pressure (psig)	29.0	30 max
LH_2 Pump Speed Monitor Seal Bleed (scim)	0	0
LH_2 Turbopump Torque Checks		
LH_2 Pump Primary Seal Leakage:		
Max (scim)	16.0	350 max
Min (scim)	16.0	350 max

* Limits Not Specified

4.1.14.1 (Continued)

Function	Measurement	Limits
Turbine Torque:		
Breakaway (in/lbs)	25.0	1000 max
Running (in/lbs)	25.0	300 max
LH_2 Valves Leak Checks		
Prevalve Shaft Seal Leakage:		
Open Position (scim)	0	10 max
Closed Position (scim)	0	10 max
Fill & Drain Valve Seat Leakage (scim)	0	18 max
LH_2 Fill & Drain Vlv Primary Shaft Seal Leakage (scim)	0.8	6.1 max
LH_2 Umbilical & Main Fill & Replenish Valve Seat Leak Checks		
LH_2 Main Fill, Replenish, & Fill & Drain Valves Seat Leakage (scim)	0	*
LH_2 Main Fill & Replenish Valves Seat Leakage (scim)	0	*
O_2H_2 Burner LH_2 System Leak Check		
Combined Burner LH_2 Prop Vlv & LOX Shutdown Valve Seat Leakage (scim)	0	*
Burner LH_2 Prop Valve Seat Leakage (scim)	0	0.7 max
LOX Prop Line Relief Valve Seat Leakage (scim)	0	0

Engine GG & Exhaust System Leak Checks

Function	Measurement	Limits
Engine Seal Leak Checks		
GG Fuel Purge Check Vlv Rev Lkg (scim)	1.1	25 max
LH_2 Turbine Seal Leakage (scim)	900.0	3750 max
2nd E&M Value from J-2 Eng Log Book (scim)	750.0	*
LOX Turbine Seal Leakage (scim)	0	350 max
Start Tnk Disch Vlv Gate Seal Leakage (scim)	3.0	15 max
GG & Exhaust System Leak Checks		
Oxid Turb Bypass Vlv Shaft Seal Lkg (scim)	0.2	10 max
Oxid Manifold Carr Flng Bleed (scim)	0.2	20 max
GG LOX Poppet Rev Leakage (scim)	39.0	600 max
GG LOX Purge Check Vlv Rev Lkg (scim)	0	15 max
Hydraulic Pump Shaft Seal Lkg (scim)	4.4	228 max
GG LOX & LH_2 Propellant Valve Seat Leak Checks		
GG LOX Prop Vlv Seat & Oxid Pump Shaft Seal Leakage (scim)	0	20 max
Combined GG LOX & LH_2 Prop Vlv Seat Lkg (scim)	0	*
GG LH_2 Prop Vlv Seat & Fuel Pump Shaft Seal Leakage (scim)	0	15 max

* Limits Not Specified

4.1.14.1 (Continued)

Engine Pump Purge Leak Checks

Function	Measurement	Limits
Pump Purge Module Internal Leak Checks		
Purge Valve Seat Leakage (scim)	0	12 max
Purge Discharge Pressure (psig)	83.0	67 to 110
Pump Purge Flow Checks		
GG Fuel Purge Flow (scim)	4075.0	2400 min
LOX Turbine Seal Purge Flow (scim)	3050.0	2400 min
LH_2 Turbine Seal Purge Flow (scim)	3000.0	2400 min
Fuel Pump Seal Cavity Purge Flow (scim)	850.0	200 min

Engine Pneumatics Leak Checks

Function	Measurement	Limits
Helium Control Solenoid Energized Leak Checks		
Low Press Relief Vlv Seal Leakage (scim)	0	5 max
Low Press Relief Vlv Pilot Bleed Lkg (scim)	0.1	10 max
Fast Shutdown Vent Port Diaph Leakage (scim)	0	3 max
Press Act Purge Vlv Diaph Leakage (scim)	0	3 max
Int Pneu Sys Leakage (He Cont Sol On) (scim)	15.0	20 max
LOX Pump Intermediate Seal Purge Leak Checks		
Seal Leakage Pump Direction (scim)	8.25	*
Seal Leakage Turbine Direction (scim)	6.4	*
Seal Leakage Total (scim)	14.65	850 max
Seal Purge Check Vlv Overboard Flow (scim)	2625	*
Seal Purge Flow (scim)	2639.65	1300 to 3500
Ignition Phase Solenoid Energized Leak Checks		
Start Tnk Disch Vlv 4-Way Sol Seat Lkg (scim)	2.2	15 max
Start Tnk Disch Vlv Piston Seal Lkg (Closed Pos) (scim)	0	40 max
Internal Pneu Sys Lkg (Ign Phase Sol On) (scim)	10.0	20 max
Start Tank Discharge Valve Solenoid Energized Leak Checks		
STDV 4-Way Sol Seat Lkg (Energized) (scim)	1.9	15 max
STDV Piston Seal Lkg (Open Pos) (scim)	0	40 max
Mainstage Control Solenoid Energized Leak Check		
Press Act Fast Shutdown Vlv Seat Lkg (scim)	0	10 max
Int Pneu Sys Lkg (Mnstg Sol On) (scim)	0	20 max

* Limits Not Specified

4.1.14.1 (Continued)

Function	Measurement	Limits
Pressure Actuated Purge System Leak Check		
Press Act Purge Vlv Vent Seat Lkg (scim)	0	10 max
Press Act Purge Vlv Inlet Seat Lkg (scim)	0	10 max
Engine Control Bottle Fill System Leak Check		
Eng Cont Bot Fill Check Vlv Rev Lkg (scim)	0	3 max
Eng Cont Bot Decay Check (Delta M) (lb-mass/hr)	0.003	0.036 max

LOX & LH_2 Vent System Leak Checks

Function	Measurement	Limits
LOX Vent System Leak Checks		
Combined LOX Vent & Relief Vlv & Relief Vlv Seat & Pilot Bleed Lkg (scim)	40.0	100 max
Combined LOX V&R Vlv & Npv Vlv Seat, Pilot Bleed Lkg (scim)	135.0	*
LOX Vent Boost Piston Seal Lkg (scim)	95.0	2420 max
LOX Vent Valve Open Act Seal Lkg (scim)	0	75 max
Propulsive Vent System Leak Checks		
Continuous Vent & Orifice Bypass Vlv Seat Lkg (scim)	0	16 max
Nonpropulsive Vent System Leak Checks		
Bidirect Vent Vlv Act Seal & Blade Shaft Seal Lkg - Flight Pos (scim)	0	3.5 max
Bidirect Vent Vlv Seat Lkg (Flt Pos) (scim)	0	50 max
Bidirect Vent Vlv Act Seal & Blade Shaft Seal Leakage - Ground Pos (scim)	**	3.5 max
Ground Vent System Leak Checks		
Combined LH_2 V&R Vlv, Relief Vlv Seat, & Pilot Bleed Lkg (scim)	0	150 max
Combined LH_2 V&R Vlv & Relief Vlv Seat, Pilot Bleed, & Boost Piston Seal Lkg (scim)	120.0	*
LH_2 V&R Vlv Boost Piston Seal Lkg (scim)	120.0	1725 max
LH_2 Vent Valve Open Act Seal Lkg (scim)	0	75 max
Bidirect Vent Vlv Seat Lkg (Gnd Pos) (scim)	0	50 max
Bidirect Vent Vlv Act Piston Leakage (scim)	0	3 max

* Limits Not Specified
** Not Measurable - Too Small

4.1.15 Exploding Bridgewire System (1B55822 E)

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	252
	EBW Firing Unit	404A47A2	40M39515-113	253
	Pulse Sensor *	404A47A4A2	40M02852	-
	Pulse Sensor *	404A47A4A2	40M02852	-
*	On Pulse Sensor Bracket Assy	404A47A4	1B52640-1	8
Ullage Rocket Jettison System				
	EBW Firing Unit	404A75A1	40M39515-113	284
	EBW Firing Unit	404A75A2	40M39515-113	271
	Pulse Sensor **	404A75A10A1	40M02852	-
	Pulse Sensor **	404A75A10A2	40M02852	-
**	On Pulse Sensor Bracket Assy	404A75A10	1A97791-501	4

This procedure was conducted on 4 April 1968, and was accepted on 9 April 1968. A second issue was accomplished on 13 May 1968, to reverify the system after modifications. Throughout this procedure, the charged condition of each EBW firing unit was determined by verifying that the firing unit voltage indication measured 4.2 ±0.3 vdc; while the uncharged or discharged condition was determined by verifying that the voltage indication measured 0.0 ±0.3 vdc, or during the firing unit disable test, 0.2 ±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

4.1.15 (Continued)

that the self test command properly turned on the four EBW pulse sensors and that the reset command properly turned off the pulse sensors.

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

The ullage jettison EBW firing units were tested in the same way by verifying that the charge ullage jettison command charged the ullage jettison EBW firing units and that the fire ullage jettison command fired 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 command 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 and fire ullage ignition and jettison commands were turned on and that the pilot relay reset indication was on after each command was reset.

4.1.15 (Continued)

Engineering comments noted that all parts were installed at the start of this checkout. No problems were encountered that resulted in FARR's being written during this test.

A total of fifteen revisions were made to the two issues of this procedure for the following:

a. Five revisions were required to correct program errors.

b. Four revisions deleted steps no longer required.

c. One revision changed the performance of stage power setup and/or initial condition scan from before to after program loading, as stage power setup cannot be performed until after the executive and DDT programs are loaded.

d. One revision added the statement, "This procedure is to be accomplished per the Vehicle Safety Brochure, Beta-STC," to the safety section of the procedure.

e. One revision deleted a step to allow a check to assure that the "fire ullage ignition" and "fire ullage jettison" commands are not shorted together by having both ignition and jettison units charged when sending the "fire ullage jettison" command.

f. One revision changed the time delay for the firing unit to discharge before checking the voltage from 2 seconds to 5 seconds.

g. One revision authorized rerunning the procedure to verify proper operation after the time delay change from 2 seconds to 5 seconds.

h. One revision explained that the EBW ullage rocket ignition voltage out-of-tolerance condition was caused by the program change made by revision "e", which decreased the time allowed for the ignition firing unit to discharge before checking for 0 $\pm$0.3 vdc. The program time delay was then changed from 2 seconds to 5 seconds per revision "f", and the procedure was reran. The out-of-tolerance condition reoccurred. The time delay was established at 8 seconds per this revision. The procedure was completed with no further malfunctions.

4.1.16 Range Safety System (1B55821 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	Reference Location	P/N	S/N
Range Safety Receiver 1	411A97A14	50M10697	187
Range Safety Receiver 2	411A97A18	50M10697	198
Secure Command Decoder 1	411A99A1	50M10698	0165
Secure Command Decoder 2	411A99A2	50M10698	0167
Secure Command Controller 1	411A97A13	1B33084-503	016
Secure Command Controller 2	411A97A19	1B33084-503	015
RS System 1 EBW Firing Unit	411A99A12	40M39515-119	418
RS System 2 EBW Firing Unit	411A99A20	40M39515-119	419
RS System 1 EBW Pulse Sensor	411A99A31*	40M02852B	501
RS System 2 EBW Pulse Sensor	411A99A32*	40M02852B	500
Safe and Arm Device	411A99A22*	1A02446-503	00050
Directional Power Divider	411A97A56	1B38999-1	034
Hybrid Power Divider	411A97A34	1A74778-501	050
* Installed In Pulse Sensor Assembly	411A99A31/A32	1B29054-501	0016

This procedure was satisfactorily accomplished by the first attempt on 11 April 1968. Values measured during the test are shown in Test Data Table 4.1.16.1. Initial conditions were established for the test, and the GSE destruct system test set, P/N 1A59952-1, was set up for closed loop 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

4.1.16 (Continued)

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

The EBW firing unit arm and engine cutoff test was conducted next. The engine control bus power was turned on, the bus voltage was measured, and the low level signal strength indications were measured for both receivers. The EBW firing unit arm and engine cutoff command was turned on and verified to be received by range safety system 1. The system 1 firing unit charging voltage indication was measured. Verification was made that the engine cutoff indications were off at the umbilical and through the AO and BO telemetry multiplexers, that the 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

4.1.16 (Continued)

then off, that the engine cutoff indications were still off at the umbilical and through both multiplexers, that the nonprogrammed engine cutoff indications 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 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

4.1.16 (Continued)

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.

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

4.1.16 (Continued)

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

The safe and arm device was tested next. The safe-arm safe command was turned on, the safe indication was verified to be on, and the arm indication was verified to be off. The safe-arm arm command was turned on, the safe indication was verified to be off, and the arm indication was verified to be on. The safe-arm safe command was turned back on, and again the safe indication was verified to be on, and the arm indication was verified to be off. This completed the range safety system tests, and the shutdown operations were accomplished.

There were no part shortages affecting this test and no problems were encountered that resulted in initiation of FARR's. Five revisions were recorded in the procedure for the following:

a. Two revisions corrected program and procedure errors.

b. One revision provided stage power setup changes which are identical to those described in paragraph 4.1.5, stage power setup.

c. One revision provided a test plan to obtain the necessary data for open loop setup of the destruct test set, P/N 1A59952-1, in preparation for the integrated systems test. This data would normally be obtained during the range safety receiver test, which was not scheduled for prefire checkout.

d. One revision authorized the use of the cable attenuation value obtained during checkout of Stage 206 because the range safety receiver test was not conducted during prefire checkout.

4.1.16.1 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	27.999	28.0 ± 2.0
External/Internal Power Transfer Test		
External Power On		
System 1 Charging Voltage Indication	4.239	4.2 ± 0.3
System 1 Firing Unit Indication	4.220	4.2 ± 0.3
System 2 Charging Voltage Indication	4.220	4.2 ± 0.3
System 2 Firing Unit Indication	4.204	4.2 ± 0.3
Internal Power		
System 1 Charging Voltage Indication	4.234	4.2 ± 0.3
System 2 Charging Voltage Indication	4.220	4.2 ± 0.3
External Power Off		
System 1 Charging Voltage Indication	0.055	0.3 max
System 2 Charging Voltage Indication	0.045	0.3 max
Firing Unit Arm and Engine Cutoff Test		
Engine Control Bus Voltage	27.968	28.0 ± 2.0
Receiver 1 Signal Strength Indication	3.620	3.75 ± 1.25
Receiver 2 Signal Strength Indication	3.718	3.75 ± 1.25
System 1 Arm and Engine Cutoff Test		
Firing Unit Charging Voltage Indication	4.234	4.2 ± 0.3
Engine Control Bus Voltage	27.91	28.0 ± 2.0
External Power Off		
System 1 Charging Voltage Indication	0.045	0.3 max
System 2 Charging Voltage Indication	0.045	0.3 max
System 2 Arm and Engine Cutoff Test		
Firing Unit Charging Voltage Indication	4.209	4.2 ± 0.3

4.1.16.1 (Continued)

Function	Measured Value (vdc)	Limits (vdc)
Propellant Dispersion Test		
System 1 Propellant Dispersion Test		
Charging Voltage Indication (Pulse Sensor Off)	4.260	4.2 ± 0.3
Charging Voltage Indication (Pulse Sensor On)	1.675	3.0 max
System 2 Propellant Dispersion Test		
Charging Voltage Indication (Pulse Sensor Off)	4.249	4.2 ± 0.3
Charging Voltage Indication (Pulse Sensor On)	1.729	3.0 max

4.1.17 Telemetry and Range Safety Antenna System Check (1B44472 D)

Prefire modifications necessitated conducting the PCM RF power detector calibration, a portion of the telemetry and range safety antenna system checkout procedure. The test was successfully accomplished on 17 April 1968. System hardware installed at test time included:

Part Name	P/N	Reference Location	S/N
PCM RF Assembly	1B65788-1	411A64A200	15501
Bidirectional Coupler	1A69214-503	411A64A204	20009
Coaxial Switch	1A69213-1	411A64A202	0080
Power Divider	1A69215-501	411A64A201	043
Telemetry Antennas	1A69206-501	411E200 & E201	055 & 073
Reflected Power Det.	1A74776-501	411MT744	283
Forward Power Det.	1A74776-503	411MT728	303
Dummy Load	1A84057-1	411A64A203	659
Directional Power Divider	1B38999-1	411A97A56	034
Hybrid Power Detector	1A74778-501	411A97A34	050
Range Safety Antennas	1A69207-501.1	411E56 & E57	047 & 049
Range Safety Receivers	50M10697	411A97A14 & A18	187 & 198

4.1.17 (Continued)

Stage power was turned on for the test, and after allowing 3 minutes for transmitter warmup, the forward power detector output was measured and verified to be within ±3 per cent of the detector calibration requirements for the transmitter output power. For calibration of the reflected power detector, the forward power detector output was measured, and the equivalent forward power was determined from the detector calibration. The reflected power was measured and verified to be 11 ±1 per cent of the forward power. The output of the reflected power detector was then measured and verified to be within ±3 per cent of the detector calibration requirement for the measured reflected power.

After running a high and low RACS test on telemetry channels for PCM/FM transmitter output power and reflected power, the test was concluded by measuring the telemetry RF system reflected power and transmitter output power through AO and BO telemetry multiplexers.

There were no problem areas that resulted in FARR initiation. Three revisions were recorded in the procedure as follows:

a. One revision deleted all portions of the procedure that were not applicable to PCM RF power detector calibration.

b. One revision authorized the use of test equipment power meter and adapters other than those specified, based on availability.

c. One revision accepted discrepancies noted on IIS 336033 against GSE test equipment because performance of the procedure was not affected.

4.1.18 Auxiliary Propulsion System (1B55825 D)

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 355, at reference location 404A51A4 and S/N 357, at reference location 404A71A19. The procedure was initiated on 24 April 1968, and accepted on 24 May 1968.

After initial conditions were established, 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.

4.1.18 (Continued)

During the initial condition scan section of the test an "engine main LOX valve closed" talkback was not received. This malfunction was due to the engine main LOX valve not being installed at the start of this test. Valve talkback was verified by a rerun of initial condition scan on 24 May 1968.

No other problems were encountered, and no FARR's were written as a result of this procedure.

Five revisions were written for the following:

a. Four revisions concerned changes to update the procedure to the latest configurations.

b. One revision explained that the initial condition scan talkback malfunction of the engine main LOX valve was due to the valve not being installed.

4.1.18.1 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 or 1-3	3.75	3.77	3.8 ± 0.3
	Off	1-1 or 1-3	0.00	-0.00	0.0 ∓ 0.25
Nozzle I II	On	1-1 or 1-3	3.72	3.73	3.8 ± 0.3
	Off	1-1 or 1-3	0.00	0.00	0.0 ∓ 0.25
Nozzle I P	On	1-2	3.76	3.82	3.8 ± 0.3
	Off	1-2	0.00	0.00	0.0 ∓ 0.25
Nozzle III II	On	2-1 or 2-3	3.65	3.66	3.7 ± 0.3
	Off	2-1 or 2-3	0.00	0.00	0.0 ∓ 0.25
Nozzle III IV	On	2-1 or 2-3	3.62	3.65	3.7 ± 0.3
	Off	2-1 or 2-3	0.00	0.00	0.0 ∓ 0.25
Nozzle III P	On	2-2	3.68	3.71	3.7 ± 0.3
	Off	2-2	-0.00	--	0.0 ∓ 0.25

4.1.19 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 LH_2 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	031
Static Inverter-Converter	411A92A7	1A66212-507	00011
LOX Mass Probe	406A1	1A48430-511	C2
LH_2 Mass Probe	408A1	1A48431-513	D4C2
LOX Overfill Sensor	(Part of LOX Mass Probe)		
LOX Overfill Control Unit	404A72A4	1A68710-511.1	C9
LOX Fastfill Sensor	406A2C5	1A68710-1	D112
LOX Fastfill Control Unit	404A72A5	1A68710-511.1	C8
LH_2 Overfill Sensor	(Part of LH_2 Mass Probe)		
LH_2 Overfill Control Unit	411A92A24	1A68710-509	C41
LH_2 Fastfill Sensor	408A2C5	1A68710-1	E101
LH_2 Fastfill Control Unit	411A92A43	1A68710-509	C45

The first issue of the calibration procedure was accomplished on 7, 22, and 24 May 1968; however, it was necessary to perform a second issue because the PUEA, P/N 1A59358-529, S/N 031, failed to pass the LH_2 linearity test and was removed and repaired per FARR A270685. The second issue was accomplished on 24 May 1968, and accepted on 28 May 1968. Measurements and ratiometer settings made during the last test appear in Test Data Table 4.1.19.1.

Atmospheric conditions in the test area were measured before the calibration was started. Megohm resistance measurements were made on the LH_2 and LOX mass

4.1.19 (Continued)

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.

The PUEA bridge calibrations were conducted next. Simulated empty conditions were established with the PUT/S; the PUEA LH_2 and LOX bridge empty condition calibrations were accomplished by nulling the bridge tap voltages with the PUT/S ratiometer at settings of 0.01390 for the LH_2 bridge and 0.04078 for the LOX bridge; then, the bridge outputs were nulled by adjusting the PUEA R2 potentiometer for the LH_2 bridge and the PUEA R1 potentiometer for the LOX bridge. Simulated full conditions were then established with the PUT/S using a C1 capacitor (LH_2) setting of 182.52 picofarads and a C2 capacitor (LOX) setting of 122.83 picofarads, and the ratiometers were set to 0.82322 for the LH_2 bridge and 0.82337 for the LOX bridge. To accomplish the PUEA LH_2 and LOX bridge full calibrations, the bridge outputs were nulled by adjusting the PUEA R4 potentiometer for the LH_2 bridge and the PUEA R3 potentiometer for the LOX bridge.

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

4.1.19 (Continued)

For the reference mixture ratio (RMR) calibration, the difference between the previously determined LH_2 and LOX empty ratiometer settings, 0.02688, was multiplied by 98.4 vdc to give a V1 reference voltage of 2.644 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 potentiometer was adjusted to null the RMR bias voltage. For a fuel boiloff bias calibration, simulated boiloff conditions were established with the PUT/S using a C1 capacitor (LH_2) setting of 182.52 picofarads and a C2 capacitor (LOX) setting of 96.89 picofarads. The PUEA fuel bias R7 potentiometer was then adjusted to null the RMR bias voltage.

PUEA LH_2 and LOX bridge linearity checks were accomplished by individually setting the PUT/S C1 capacitor (LH_2) and C2 capacitor (LOX) to specific values and 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 2.6263 vdc under simulated empty conditions and as 14.633 vdc under bias internal test conditions. The fuel boiloff bias voltage was the difference between these measurements, -12.09 vdc.

The hardwire loading circuits were checked by establishing simulated full conditions with the PUT/S, setting the PUT/S ratiometer to 0.00000, and measuring the hardwire loading circuit PUEA LH_2 and LOX bridge output voltages. The LH_2 voltage was 22.8 vdc and the LOX voltage 22.8 vdc, meeting the 23.52 $\pm$2.0 vdc requirements.

4.1.19 (Continued)

FARR A270685 reported that the PUEA, P/N 1A59358-529, S/N 031, failed to pass the LH_2 and LOX linearity tests. The unit was removed, repaired, and reinstalled.

A total of fourteen revisions were made to the two issues of the procedure for the following:

a. Four revisions concerned isolating test equipment from the test stand ground system by using isolation transformers.

b. Three revisions were required to correct procedure errors.

c. Two revisions corrected typographical errors.

d. Two revisions deleted redundant operations.

e. Two revisions changed the procedure to reflect the PU oven monitor strip chart channel assignment changes.

f. One revision deleted sections of the test concerned with the PUEA due to failure of the unit to pass the LH_2 and LOX linearity tests.

4.1.19.1 Test Data Table, Propellant Utilization System Calibration

Pre-Test Atmospheric Conditions

Temperature:	64°F
Pressure:	30.08 inches of Hg
Relative Humidity	59 per cent

LH_2 Mass Probe Megohm Check - Plug 411W11P1

Function	Resistance (megohms)	Limits (megohms)
LH_2 Probe Elements, Pins G to E	Inf	1000 min
Pin G to Shield	Inf	1000 min
Pin G to Stage Ground	20k	1000 min
Pin G Shield to Stage Ground	20k	1000 min
Pin E to Stage Ground	20k	1000 min

4.1.19.1 (Continued)

LOX Mass Probe Megohm Check - Plug 411W11P1

Function	Resistance (megohms)	Limits (megohms)
LOX Probe Elements, Pin A to C	Inf	1000 min
Pin C to Shield	Inf	1000 min
Pin C to Stage Ground	20k	1000 min
Pin C Shield to Stage Ground	20k	1000 min
Pin A to Stage Ground	Inf	1000 min

Static Inverter-Converter Measurements

Function	Measurement	Limits
5.0 vdc Output Voltage (vdc)	4.945	4.75 to 5.05
21.0 vdc Output Voltage (vdc)	21.53	20.00 to 22.50
28.0 vdc Output Voltage (vdc)	27.51	26.00 to 30.00
117 vdc Output Voltage (vdc)	121.35	115.00 to 122.50
115 vrms Monitor Voltage (vdc)	2.773	2.23 to 3.18
Test Point 2 Voltage (vdc)	21.66	20.00 to 22.5
V/P Excitation Voltage (vdc)	50.75	49.025 to 52.18
Operating Frequency (Hz)	401.00	394.000 to 406.00

Data Acquisition

Function	PUT/S Ratiometer	Limits
LH_2 Empty	0.00016	*
LOX Empty	0.02115	*
LH_2 Full	0.82322	*
LOX Full	0.82337	*

Bridge Slew Checks

LH_2 1/3 Slew	0.30949	*
LH_2 2/3 Slew	0.63891	*
LOX 1/3 Slew	0.28265	*
LOX 2/3 Slew	0.56986	*

LH_2 Bridge Linearity Check

PUT/S C1 Value	PUT/S Ratiometer	Limits
36.5 pf	0.16001	0.15802 to 0.16131
73.01 pf	0.32565	0.32394 to 0.32723
109.51 pf	0.49087	0.48986 to 0.49715
146.01 pf	0.65647	0.65578 to 0.65907
182.52 pf	0.82300	0.82170 to 0.82499

* Limits Not Specified

4.1.19.1 (Continued)

LOX Bridge Linearity Check

PUT/S C2 Value	PUT/S Ratiometer	Limits
24.57 pf	0.18129	0.17977 to 0.18306
49.13 pf	0.34151	0.34025 to 0.34354
73.70 pf	0.50152	0.50073 to 0.50403
98.27 pf	0.66207	0.66121 to 0.66207
122.83 pf	0.82319	0.82170 to 0.82499

* Limits Not Specified

4.1.20 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 LH_2 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	031
Static Inverter-Converter	411A92A7	1A66212-507	00011
LOX Mass Probe	406A1	1A48430-511	C2
LH_2 Mass Probe	408A1	1A48431-513	D4C2
LOX Overfill Sensor		(Part of LOX Mass Probe)	
LOX Overfill Control Unit	404A72A4	1A68710-511	C9
LOX Fastfill Sensor	406A2C5	1A68710-1	D112
LOX Fastfill Control Unit	404A72A5	1A68710-511	C8
LH_2 Overfill Sensor		(Part of LH_2 Mass Probe)	
LH_2 Overfill Control Unit	411A92A24	1A68710-509	C41
LH_2 Fastfill Sensor	408A2C5	1A68710-1	E101
LH_2 Fastfill Control Unit	411A92A43	1A68710-509	C45

Three tests were required to satisfactorily complete prefire checkout of the PU system. The initial test was satisfactorily completed on 27 May 1968. Temporary removal of the LOX mass probe for feedthrough connector inspection per WRO S-IVB-4373 necessitated a second test conducted on 21 June 1968. An investigation of radio frequency interference during prefire operations resulted in a third and final test to reverify the system on 26 June 1968. Test results listed in Test Data Table 4.1.20.1 are taken from the final prefire test. The following is a narrative description of the PU system checkout.

4.1.20 (Continued)

Initial conditions for the test were established and 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 LH_2 coarse mass voltages, fine mass voltages, and loading voltages. After an evaluation of the computer printout, a test of 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 servo balance and ratio valve null test was conducted next. The ratio valve position was measured, and the LOX and LH_2 coarse and fine mass voltages were measured through the A0 and B0 instrumentation multiplexers.

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

4.1.20 (Continued)

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

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

The valve movement test 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 LH_2 bridge 1/3 checkout relay, then measuring the LH_2 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

4.1.20 (Continued)

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.

One FARR tag was initiated as a result of prefire testing. FARR 500-225-629 documented measurement M10, fuel boiloff bias signal, as out-of-tolerance during the first and second tests. Cause was attributed to radio frequency interference resulting in signal oscillation. The condition was dispositioned as acceptable and a tolerance change was put into the program based on ROD A3-250-KDLD-266.

Ten revisions were recorded in issue three of the procedure for the following:

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

b. Two revisions updated the procedure based on the existing stage configuration.

c. 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.

d. One revision provided instructions for a program change made to prevent the forward bus 2 power supply from over-regulating when the PU inverter-converter and PU electronics assembly were turned on.

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

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

4.1.20.1 Test Data Table, Propellant Utilization System

Loaded Ratio Values (from H&CO 1B64368)

LOX Empty Ratio	0.021	LH_2 Empty Ratio	0.000
LOX 1/3 Bridge Slew Ratio	0.283	LH_2 1/3 Bridge Slew Ratio	0.310
LOX 2/3 Bridge Slew Ratio	0.569	LH_2 2/3 Bridge Slew Ratio	0.639
LOX Wiper Ratio	0.040	LH_2 Wiper Ratio	0.014
LH_2 Boiloff Bias Voltage (vdc)		12.007	

4.1.20.1 (Continued)

Computed Coarse Mass Voltages (vdc)

LOX Empty	0.103	LH_2 Empty	0.000
LOX 1/3 Mass	1.416	LH_2 1/3 Mass	1.548
LOX 2/3 Mass	2.847	LH_2 2/3 Mass	3.193

Computed Fine Mass Voltages (vdc)

LOX Empty	4.009	LH_2 Empty	1.367
LOX 1/3 Mass	0.249	LH_2 1/3 Mass	2.339
LOX 2/3 Mass	2.207	LH_2 2/3 Mass	4.590

Computer Loading Voltages (vdc)

LOX Empty	0.574	LH_2 Empty	0.000
LOX 1/3 Coarse Mass	7.930	LH_2 1/3 Coarse Mass	8.668

PU System Power Test

Function	Measured Value	Limits
Inv-Conv 115 vrms Output (vac)	114.875	115.0 ± 3.4
Inv-Conv 21 vdc Output (vdc)	21.729	21.25 ± 1.25
Inv-Conv 5 vdc Output (vdc)	5.001	4.9 ± 0.2
Inv-Conv Frequency (Hz)	401.297	400.0 ± 6
PU Oven Monitor Voltage Z1 (vdc)	1.964	2.6 ± 2.35
PU Oven Monitor Voltage Z2 (vdc)	1.964	1.964 ± 0.075
PU Oven Monitor Voltage Z3 (vdc)	1.964	1.964 ± 0.075
PU Oven Monitor Voltage - Final (vdc)	1.964	1.964 ± 0.075
PU Oven Monitor Voltage - High RAC (vdc)	3.933	4.0 ± 0.075
PU Oven Monitor Voltage - RACS Run Mode On (vdc)	1.964	1.964 ± 0.075
PU Oven Monitor Voltage - Low RAC (vdc)	-0.021	0.0 ± 0.075
PU Oven Monitor Voltage - RACS Run Mode On (vdc)	1.953	1.964 ± 0.075

Bridge Balance and Ratio Valve Null Test

Function	Measured Value	AO Multi	BO Multi	Limits
Ratio Valve Position (deg)	-0.125			0.000 ± 1.5
LOX Coarse Mass Voltage (vdc)		0.107	0.107	0.103 ± 0.1
LOX Fine Mass Voltage (vdc)		4.063	4.067	4.009 ± 0.4
LH_2 Coarse Mass Voltage (vdc)		0.000	0.000	0.000 ± 0.1
LH_2 Fine Mass Voltage (vdc)		1.401	1.401	1.367 ± 0.4

4.1.20.1 (Continued)

PU Loading Test

Function	Measured Value	Limits
LH_2 Boiloff Bias Signal Volt. (vdc)	13.83	13.007 ± 1.0
GSE Power Supply Voltage (vdc)	28.919	28.0 ± 2.0

Loading Potentiometer Function	LOX Value	LH_2 Value	Limits
Sense Voltage, GSE Power On (vdc)	28.958	28.919	28.919 ± 0.4
Signal Voltage, Relay Commands	0.602		0.574 ± 0.5
Off (vdc)		0.000	0.0 ± 0.5
Signal Voltage, Relay Commands	7.766		7.930 ± 0.6
On (vdc)		8.477	8.668 ± 0.6
Signal Voltage, Relay Commands	0.602		0.574 ± 0.5
Off (vdc)		0.027	0.0 ± 0.5
Sense Voltage, GSE Power OFF (vdc)	0.000	0.039	0.0 ± 0.75

Servo Balance Bridge Gain Test

Function	Measured Value	AO Multi	BO Multi	Limits
Ratio Valve Position (deg)	-0.058			-0.125 ± 1.5
LOX Coarse Mass Voltage (vdc)		0.112	0.103	0.103 ± 0.1
LOX Fine Mass Voltage (vdc)		4.058	4.053	4.009 ± 0.4
LH_2 Coarse Mass Voltage (vdc)		0.000	0.010	0.000 ± 0.1
LH_2 Fine Mass Voltage (vdc)		1.392	1.396	1.367 ± 0.4
1/3 Checkout Relay Commands On				
Ratio Valve Position (deg)	0.419			-0.125 ± 1.5
LOX Coarse Mass Voltage (vdc)		1.411	1.421	1.416 ± 0.1
LOX Fine Mass Voltage (vdc)		0.195	0.195	0.249 ± 0.4
LH_2 Coarse Mass Voltage (vdc)		1.548	1.548	1.548 ± 0.1
LH_2 Fine Mass Voltage (vdc)		2.441	2.446	2.339 ± 0.4
2/3 Checkout Relay Commands On				
Ratio Valve Position (deg)	0.828			-0.125 ± 1.5
LOX Coarse Mass Voltage (vdc)		2.847	2.847	2.847 ± 0.1
LOX Fine Mass Voltage (vdc)		1.968	1.968	2.207 ± 0.4
LH_2 Coarse Mass Voltage (vdc)		3.198	3.203	3.193 ± 0.1
LH_2 Fine Mass Voltage (vdc)		4.883	4.873	4.590 ± 0.4
2/3 Checkout Relay Commands Off				
Ratio Valve Position (deg)	0.624			-0.125 ± 1.5
LOX Coarse Mass Voltage (vdc)		1.416	1.416	1.416 ± 0.1
LOX Fine Mass Voltage (vdc)		0.195	0.195	0.249 ± 0.4
LH_2 Coarse Mass Voltage (vdc)		1.553	1.558	1.548 ± 0.1
LH_2 Fine Mass Voltage (vdc)		2.441	2.446	2.339 ± 0.4

4.1.20.1 (Continued)

Function	Measured Value	AO Multi	BO Multi	Limits
1/3 Checkout Relay Commands Off				
Ratio Valve Position (deg)	0.010			-0.125 ± 1.5
LOX Coarse Mass Voltage (vdc)		0.103	0.103	0.103 ∓ 0.1
LOX Fine Mass Voltage (vdc)		4.048	4.058	4.009 ∓ 0.4
LH_2 Coarse Mass Voltage (vdc)		0.000	0.000	0.000 ∓ 0.1
LH_2 Fine Mass Voltage (vdc)		1.401	1.401	1.367 ∓ 0.4

PU Valve Movement Test

Function	Measured Value	Limits
Ratio Valve Position, AO (deg)	-0.058	-0.125 ± 1.50
Ratio Valve Position, BO (deg)	-0.125	-0.125 ∓ 1.50
50 Second Plus Valve Slew, AO Multiplexer		
+1 vdc System Test Valve Position Signal (vdc)	0.994	1.00 ± 0.02
V1, Position at T+3 Seconds (deg)	4.091	2.037 to 6.351
V2, Position at T+5 Seconds (deg)	5.181	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)	5.932	5.226 to 7.396
V5, Position at T+50 Seconds(deg)	5.932	5.226 to 7.396
50 Second Minus Valve Slew, AO Multiplexer		
Ratio Valve Position, AO (deg)	0.08	-0.125 ± 1.5
-1 vdc System Test Valve Error Signal (vdc)	-0.994	-1.000 ± 0.02
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)	-5.453	-5.226 to -7.396
V5, Position at T+50 Seconds (deg)	-5.521	-5.226 to -7.396

PU Activation Test

Function	AO Multi	BO Multi	Limits
Ratio Valve Position (deg)	-0.262	-0.330	-0.125 ± 1.50
LOX 1/3 Command Relay On			
LOX Coarse Mass Voltage (vdc)	1.416	1.421	1.416 ± 0.1
PU System On			
Ratio Valve Position (deg)	33.280	33.280	20.0 min

4.1.20.1 (Continued)

Function	AO Multi	BO Multi	Limits
PU System Off			
Ratio Valve Position (deg)	0.419	0.282	15.0 max
LOX 1/3 Command Relay Off			
LOX Coarse Mass Voltage (vdc)	0.103	0.107	0.103 ± 0.1
Ratio Valve Position (deg)	0.010	0.010	-0.125 ± 1.5
LH_2 1/3 Command Relay On			
LH_2 Coarse Mass Voltage (vdc)	1.548	1.548	1.548 ± 0.1
PU System On			
Ratio Valve Position (deg)	-27.260	-27.328	-20.0 max
PU System Off			
Ratio Valve Position (deg)	0.08	-	-15.0 min
LH_2 1/3 Command Relay Off			
LH_2 Coarse Mass Voltage (vdc)	0.000	-0.005	0.000 ± 0.1
Ratio Valve Position (deg)	-0.058	-0.058	-0.125 ± 1.5
PU Valve Hardover Test			
Ratio Valve Position (deg)	-27.532	-	-20.0 max

4.1.21 Propulsion System Test (1B62753 J)

This automatic procedure performed the integrated electromechanical functional tests required to verify the prefire 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.

Three tests utilizing two issues of the procedure were conducted to verify prefire operational capability of the system. The first issue was used for two tests conducted on 5 June, and 7 June 1968. The initial test was terminated due to inability of the program to perform the pressure set routine for the stage 6 helium regulator of GSE test console "A". The cause of this problem was attributed to an improper adjustment of the variable orifice bleed valve for the regulator. This bleed valve was adjusted prior to the second test attempt. Test attempt 2 was not entirely successful. The LOX tank ground fill pressure switch pickup pressure was out-of-tolerance due to incorrect pressure transducer calibration data entered into the program. A paper tape

4.1.21 (Continued)

change corrected the digital data tape (DDT) prior to issue 2 testing. In addition, an indication of failure to open for the O_2H_2 burner LOX propellant valve during test attempt 2 was attributed to incomplete wiring of the LOX propellant valve ground backup solenoid. The valve wiring was completed prior to issue 2 testing.

These malfunctions plus hardware changes after test attempt 2 necessitated repeating the propulsion system test per issue 2. This final prefire test was successfully accomplished on 22 June 1968. Measurements taken from this test are listed in Test Data Table 4.1.21.1.

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 $\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 LH_2 and LOX repressurization control module dump valves and control valves were verified to operate properly.

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 708.58 psia; and the control helium regulator discharge pressure was measured at 528.36 psia, both within acceptable limits. A series of checks verified the operation of the pneumatically controlled valves, including the LH_2 and LOX vent valves, fill

4.1.21 (Continued)

and drain valves, prevalves, chilldown shutoff valves, the LH_2 directional vent valve, the LH_2 continuous vent and relief override valve, the LH_2 continuous vent orificed bypass valve, the O_2H_2 burner propellant valves, and the LOX nonpropulsive vent (NPV) valve. The LH_2 tank pressurization and continuous vent valve blowdown check completed the ambient helium system test.

After establishing initial conditions, 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.

The LOX and LH_2 repressurization control valves were verified to operate properly, and the operation of the LOX and LH_2 tank repressurization backup pressure switch interlocks was verified by the three-cycle tests and by demonstrating that the switches properly controlled the LOX and LH_2 repressurization control valves.

The proper operation of the O_2H_2 burner spark ignition system was 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.

4.1.21 (Continued)

The LH_2 repressurization and ground fill overpressurization pressure switches were verified to operate properly. Control of the LH_2 main fill valve, the LH_2 replenish valve, the LH_2 auxiliary tank pressurization valve, the step pressure valve, and the LH_2 bypass control valve by the pressure switches was also demonstrated. After satisfactory completion of the LH_2 pressure switch checks, the cold helium system was pressurized to 896.45 psia, followed by blowdown of the cold helium spheres and a cold helium regulator high flow test. The system was then repressurized to 896.45 psia, and another sphere blowdown was conducted in conjunction with the cold helium regulator low flow test. After venting the cold helium spheres to ambient, a series of checks verified proper operation for the O_2H_2 burner voting circuit and burner malfunction temperature sensors. This completed testing of the propellant pressurization systems.

After performing stage power setup and establishing initial conditions, section three, the J-2 engine functional tests, was conducted next. The LH_2 and LOX tanks were vented to ambient, the O_2H_2 burner spark systems 1 and 2, the emergency detection systems 1 and 2 engine cutoffs, the repressurization control valves, and the O_2H_2 burner propellant valves were 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

4.1.21 (Continued)

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 LH_2 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 LH_2 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 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 1459.94 psia to conduct the engine valve sequence tests which demonstrated that actuation and deactuation of the helium control solenoid valve caused the LH_2 and LOX bleed valves to close and open, that opening and closing the ignition phase control solenoid valve caused the engine augmented spark igniter (ASI) LOX valve and engine main fuel valve to open and close, that the start tank discharge solenoid valve

4.1.21 (Continued)

opened and closed, 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, 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. Test Data Table 4.1.21.1 lists the computer printout measurements for the engine sequence check, and also the data recorded manually in the procedure that was taken from the J-2 engine oscillograph records.

There were no parts shortages affecting propulsion automatic testing and no test discrepancies resulting in the initiation of FARR's.

Thirty-eight revisions were recorded in issue 2 of the procedure for the acceptable test on 22 June 1968, as follows:

a. Seven revisions concerned updating and corrections for stage power setup and initial conditions scan that had no effect on the validity of the propulsion system test.

b. Ten revisions corrected program and test requirements drawing (TRD) errors.

c. One revision updated procedure tolerances to the latest requirements.

d. Twelve revisions were changes to the digital data tape (DDT), adding and/or correcting curve coefficients based on transducer calibration data.

4.1.21 (Continued)

e. Two revisions authorized switching to battery power instead of the external power supply for turn-on of the O_2H_2 burner sparks, augmented spark ignition system (ASI) sparks, and gas generator sparks. Noise due to sparks turn-on exceeded the external power supply voltage limitation for SIM channel 41 interrupt.

f. One revision indicated that SIM channel 85 interrupts occurred due to the interference of concurrent testing.

g. Three revisions concerned GSE malfunction indications that had no effect on the validity of the propulsion system test.

h. One revision attributed a malfunction indication of "LOX prepress flight P/S de-energize not on" to insufficient time allowed by the program.

i. One revision indicated that a valve opening malfunction indication for the LH_2 replenish valve was caused by low actuation pressure setting at the test stand. After correctly resetting the pressure, the valve opened properly and the test was continued.

4.1.21.1 Test Data Table, Propulsion Test

Section 1 - Ambient Helium Test

Function		Measured Values			
		Test 1	Test 2	Test 3	Limits
Engine Pump Purge Pressure Switch Checkout					
Pickup Pressure	(psia)	120.91	119.36	118.58	136.0 max
Dropout Pressure	(psia)	108.48	109.26	110.03	99.0 min
Deadband	(psia)	12.43	10.10	8.55	3.0 min
Control Helium Regulator Backup Pressure Switch Checkout					
Pressurization Time	(sec)	98.814	44.845	47.956	180.0 max
Pickup Pressure	(psia)	604.20	604.97	606.53	600 + 21
Depressurization Time	(sec)	14.513	15.525	15.736	180.0 max
Dropout Pressure	(psia)	491.54	486.88	486.10	490 ± 31

4.1.21.1 (Continued)

Pneumatically Controlled Valve Timing Checkout

Valve	Operating Times (sec) Open	Total Open	Close	Total Close	Boost Close	Total Boost Close
LH_2 Vent Valve	0.015	0.077	0.192	0.469	0.080	0.272
LOX Vent Valve	0.019	0.081	0.111	0.331	0.061	0.192
LOX F&D Valve	0.138	0.257	0.729	2.289	0.403	0.923
LH_2 F&D Valve	0.153	0.273	0.738	2.314	0.407	0.869
LOX Prevalve	1.185	1.775	0.177	0.309	*	*
LH_2 Prevalve	1.295	1.888	0.205	0.341	*	*
LOX C/D SOV	0.276	1.132	0.041	0.187	*	*
LH_2 C/D SOV	0.340	1.110	0.028	0.134	*	*
LH_2 Cont Vent Orif'd Bypass Valve	0.009	0.042	0.008	0.069	*	*
O_2H_2 Burner LH Prop	0.021	0.099	0.021	0.101	*	*
O_2H_2 Burner LOX Prop	0.007	0.085	0.008	0.083	*	*
LOX NPV Vlv	0.020	0.047	0.130	0.354	0.077	0.212

Valve	Flight Position	Total Flt. Position	Ground Position	Total Ground Position
LH_2 Directional Vent Valve	0.083	0.190	0.815	1.386

Section 2 - Propellant Tanks Pressurization System Test

Function		Measured Values Test 1	Test 2	Test 3	Limits
Cold Helium Regulator Backup Pressure Switch Checkout					
Pressurization Time	(sec)	92.245	22.942	22.443	180 max
Pickup Pressure	(psia)	474.45	473.66	472.11	467.5 ± 23.5
Depressurization Time	(sec)	19.588	19.563	19.461	180 max
Dropout Pressure	(psia)	382.76	382.76	382.76	362.5 ± 33.5
LOX Tank Repressurization Backup Pressure Switch Checkout					
Pressurization Time	(sec)	46.307	64.617	64.313	180 max
Pickup Pressure	(psia)	471.34	471.34	471.34	467.5 ± 23.5
Depressurization Time	(sec)	22.147	22.119	22.028	180 max
Dropout Pressure	(psia)	372.66	371.88	372.66	362.5 ± 33.5
LH_2 Tank Repressurization Backup Pressure Switch Checkout					
Pressurization Time	(sec)	61.487	61.838	62.565	180 max
Pickup Pressure	(psia)	465.90	467.45	466.68	467.5 ± 23.5
Depressurization Time	(sec)	20.513	20.262	20.035	180 max
Dropout Pressure	(psia)	376.54	376.54	378.09	362.5 ± 33.5

* Not applicable to these valves

4.1.21.1 (Continued)

Function		Measured Values Test 1	Test 2	Test 3	Limits
LOX Tank Ground Fill Overpressure Pressure Switch Checkout					
Pressurization Time	(sec)	72.721	34.628	24.677	180 max
Pickup Pressure	(psia)	40.45	40.40	40.45	41 max
Depressurization Time	(sec)	8.907	6.828	7.421	180 max
Dropout Pressure	(psia)	39.02	39.07	39.07	37.5 min
Deadband	(psid)	1.43	1.33	1.38	0.5 min
LH_2 Repressurization Control Pressure Switch Checkout					
Pressurization Time	(sec)	77.620	23.081	22.424	180 max
Pickup Pressure	(psia)	30.68	30.63	30.68	31 max
Depressurization Time	(sec)	50.328	48.860	46.980	180 max
Dropout Pressure	(psia)	28.34	28.29	28.29	28.0 min
Deadband	(psid)	2.34	2.34	2.39	0.5 min
LH_2 Tank Ground Fill Overpressure Pressure Switch Checkout					
Pressurization Time	(sec)	71.799	28.155	21.651	180 max
Grd. Fill Overpress Pickup Press	(psia)	30.58	30.47	30.42	31 max
Depressurization Time	(sec)	63.096	59.401	63.033	180 max
Grd. Fill Overpress Dropout Pressure	(psia)	28.19	28.29	28.29	28.0 min
Deadband	(psid)	2.39	2.18	2.13	0.5 min

Section 3 - J-2 Engine Functional Test (Engine S/N J-2101)

Function	Delay Time (sec)	Limits (sec)
Engine Delay Timer Checkout		
Ignition Phase Timer	0.438	0.450 ± 0.030
Helium Delay Timer	0.989	1.000 ± 0.110
Sparks De-energized Timer	3.301	3.300 ± 0.200
Start Tank Discharge Timer	1.002	1.000 ± 0.040

4.1.21.1 (Continued)

Function		Measured Values Test 1	Test 2	Test 3	Limits
Mainstage OK Pressure Switch 1 Checkout					
Pickup Pressure	(psia)	507.84	504.76	503.99	515 ± 36
Dropout Pressure	(psia)	431.60	434.68	436.99	*
Deadband	(psid)	76.24	70.08	67.00	62.5 ± 48.5
Mainstage OK Pressure Switch 2 Checkout					
Pickup Pressure	(psia)	519.40	512.50	513.30	515 ± 36
Dropout Pressure	(psia)	440.26	440.26	441.03	*
Deadband	(psid)	79.24	72.24	72.27	62.5 ± 48.5

Engine Sequence Check

Function	Start or Delay Time (sec)	Oper. or Travel Time (sec)	Total Time (sec)
Engine Start			
Cont He Solenoid Command Talkback	**	0.013	**
Ign Phase Cont Solenoid Command Talkback	**	0.006	**
ASI Valve Open	**	0.048	**
Engine LOX Bleed Valve Close	**	0.091	**
Engine LH_2 Bleed Valve Close	**	0.065	**
Main Fuel Valve Open	0.083	0.103	0.186
Start Tank Disch Timer	**	1.000	**
Start Tank Disch Valve Open	0.094	0.095	0.188
Mainstage Cont Solenoid Energized	**	1.452	**
Ignition Phase Timer	**	0.452	**
Start Tnk Disch Cont Solenoid De-energized	**	0.006	**
Main LOX Valve Open	0.499	1.571	2.070
Start Tnk Disch Valve Close	0.148	0.183	0.331
Gas Generator Valve Open	**	0.153	0.250
LOX Turbine Bypass Valve Close	0.028	0.465	0.493
Spark System Off Timer	**	3.312	**

* Limits Not Specified
** Not Applicable Or Not Available

4.1.21.1 (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	**	0.007	**
Mainstage Cont Solenoid De-energized from Cutoff	**	0.016	**
ASI Valve Close	0.040	**	**
Main LOX Valve Close	0.096	0.064	0.160
Main Fuel Valve Close	0.196	0.070	0.267
Gas Generator Valve Close	0.109	0.123	0.232
He Cont De-energized Timer	**	0.998	**
Engine LOX Bleed Valve Open	**	**	9.241
Engine LH Bleed Valve Open	**	**	9.976
LOX Turbine Bypass Valve Open	0.286	0.534	0.820

Engine Sequence Data (Oscillograph Records)

Function	Measurements		Limits	
	Delay	Valve Motion	Delay	Valve Motion
Ignition (sec)				
Main Fuel Valve Open	0.042	0.071	0.030-0.090	0.030-0.130
Start Tank Disch Vlv Open	0.83	0.094	0.080-0.120	0.085-0.125
Mainstage (sec)				
GG Valve Fuel Open	0.070	0.040	*	*
GG Valve LOX Open	0.132	0.062	0.130-0.150	0.020-0.080
Start Tank Disch Valve Close	0.121	0.227	0.130+0.020	0.215+0.040
MOV 1st Stage Open	0.043	0.045	0.030-0.070	0.025-0.075
MOV 2nd Stage Open	0.593	1.767	0.540-0.680	1.750-1.900
Oxidizer Turbine Bypass Vlv Close	0.183	0.276	*	5.0 max

* Limits Not Specified
** Not Applicable Or Not Available

4.1.21.1 (Continued)

Function	Measurements Delay	Measurements Valve Motion	Limits Delay	Limits Valve Motion
Cutoff (sec)				
Oxidizer Turbine Bypass Vlv Open	0.207	0.606	*	10.0 max
GG Valve LOX Close	0.065	0.030	0.040-0.100	0.010-0.055
Main Oxid Vlv Closed	0.063	0.121	0.045-0.075	0.105-0.135
Main Fuel Vlv Closed	0.083	0.230	0.065-0.115	0.200-0.250
GG Valve Fuel Close	0.104	0.085	*	*
Bleeds (sec)				
ASI Open	**	0.038	**	0.100 max
ASI Close	**	0.030	**	0.100 max
GG Valve LOX Open	**	9.250	**	30.0 max
GG Valve LOX Close	**	0.055	**	0.120 max
GG Valve Fuel Open	**	9.970	**	30.0 max
GG Valve Fuel Close	**	0.049	**	0.120 max
Timers (sec)				
Start Tnk Disch Vlv Delay	0.988	**	0.960-1.040	**
Ignition Phase	0.454	**	0.420-0.480	**
Sparks De-energize	3.283	**	3.10 -3.50	**
Helium Cont De-energize	0.998	**	0.890-1.110	**
Trace Deflections				
Oxid Turbine Bypass Valve @ 80% (sec)	0.409	**	0.350-0.550	**
Main Oxid Valve (deg)	14.1	**	12-16	**
GG Valve (%)	49	**	35-65	**

* Limits Not Specified
** Not Applicable Or Not Available

4.1.22 Digital Data Acquisition System (1B55817 J)

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

Components tested by this procedure consisted of the PCM/DDAS assembly, P/N 1B65792-1, S/N 6800054; the CP1-BO time division multiplexer, P/N 1B65897-1, S/N 07; the DP1-BO time division multiplexer, P/N 1B65897-501, S/N 05; the remote digital submultiplexer (RDSM), P/N 1B66051-501, S/N 05; the low level remote analog submultiplexer (RASM), P/N 1B66050-501.1, S/N 06; and the PCM RF assembly, P/N 1B65788-1, S/N 15501.

Three tests were conducted to successfully demonstrate proper operational status for all data channels checked. Test attempt one was conducted on 10 June 1968. Channel malfunctions for measurements D002, D016, and D043 necessitated a second test attempt after replacement of instrumentation hardware per FARR's 500-226-790 and 500-226-927 and other corrections. Test attempt two conducted on 21 June 1968, was a successful DDAS automatic checkout with the exception of channel malfunctions for measurement D231. After replacement of the transducer kit per FARR 500-225-530, a special test for D231 only was satisfactorily completed on 22 June 1968. Variable data quoted in this narrative is taken from the successful test of 21 June 1968.

4.1.22 (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.

4.1.22 (Continued)

After establishing initial conditions, a DDAS ground station calibration was performed to verify that the DDAS ground station and peripheral equipment were properly setup and ready for test.

During the PCM RF test, 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, 22.099 watts; reflected power, 1.160 watts; VSWR, 1.594. The DP1-BO multiplexer telemetry readings were: forward power, 22.068 watts; reflected power, 1.129 watts; VSWR, 1.584. The CP1-BO multiplexer ground monitor readings were: forward power, 22.009 watts; reflected power, 0.069 watts; VSWR, 1.118. The DP1-BO multiplexer ground monitor readings were: forward power, 22.009 watts; reflected power, 0.075 watts; VSWR, 1.124. 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 3.999 vdc and 4.005 vdc, respectively. Low RACS were 0.000 vdc and -0.005 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

4.1.22 (Continued)

indication, liquid level indication, and position indication, as applicable for the various channels. Output values for each of the CP1-BO multiplexer channels tested on 21 June 1968, were within the required limits with the exception of channels for pitch and yaw position measurements G001 and G002. These were manually verified to be within tolerance after correcting the improper centering of the J-2 engine.

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 on 21 June 1968, were within tolerance with the exception of measurement D231. Channels for D231 were tested satisfactorily on 22 June 1968, after replacement of the transducer kit.

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 LH_2 chilldown inverter frequencies, and the LOX and LH_2 circulation pump flow rates. The LOX and LH_2 flowmeter tests at 100 Hz followed the 400 Hz test, and the LOX and LH_2 pump speeds were checked using the 1500 Hz signal. Out-of-tolerance high and low RACS voltages for measurements M012, M028, and M029 resulted in repeating the special channel tests after correcting the test frequency entered into the program, which was responsible for the malfunction. 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

4.1.22 (Continued)

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 ^{O}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 LH_2 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 per cent and 80 per cent calibration checks of the common bulkhead pressure and the umbilical LOX and LH_2 ullage pressure measurements. Ambient pressure checks of the LOX and LH_2 emergency detection system transducers completed the umbilical measurements test. All measurements for the test were within tolerance, and the DDAS was accepted for use.

Fifteen revisions were recorded in the procedure for the following:

a. Two revisions corrected program and procedure errors.

b. Two revisions updated the program for initial conditions scan to the latest requirements. These had no bearing on DDAS testing.

c. One revision provided additional delay time to provide satisfactory warm-up of the 5-volt transducer GSE power supply.

4.1.22 (Continued)

d. One revision deleted O_2H_2 burner valve measurements that were not applicable to the restartable burner configuration for the stage.

e. One revision provided a test plan to investigate the channel malfunctions for measurement D002 which occurred during test attempt one.

f. One revision authorized the second DDAS test attempt which was successfully conducted on 21 June 1968, with the exception of channels for measurement D231.

g. One revision authorized the special test for measurement D231 on 22 June 1968, after replacement of the malfunctioning instrumentation.

h. One revision indicated that an out-of-tolerance indication, for aft battery 2 simulator voltage during test attempt 2, occurred because the aft 2 power supply was not turned on. After power turn on, the program was satisfactorily resumed.

i. One revision authorized a manual test of channels for measurements G001 and G002 after correcting J-2 engine position, which was responsible for malfunction of these channels during automatic test attempt two.

j. Three revisions concerned program changes to correct the 400 Hz test frequency entered into the program, which had resulted in channel malfunctions during the 400 Hz special channel test.

k. One revision provided program changes necessary to verify LOX and LH_2 chilldown pump differential pressure measurements that were returned to their respective telemetry channels after the umbilical checks were completed.

4.1.23 Final Prefire Propulsion System Leak Check (1B70175 G)

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 distrubance 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.

Due to an extended period of checkout inactivity on the Beta III Test stand, a special issue of the propulsion system leak check was performed between 19 June and 10 July 1968. This procedure was for a post refurbishment check of the test stand facilities and firing crew re-orientation. The final prefire leak checks were performed between 12 July and 16 July 1968. For the purpose of this narrative, only the final issue of the procedure will be discussed and all data listed in the text and the test data table are the result of the final issue, with the exception of the engine thrust chamber leak checks which were accomplished by the first issue. The listing of revisions in the later section of this narrative were taken from both issues.

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.

4.1.23 (Continued)

The stage ambient helium system leak checks were conducted next, with the pneumatic control sphere and the LOX and LH_2 ambient helium repressurization spheres pressurized with helium to 1450 ±50 psig, and the control regulator discharge pressure set at 515 ±50 psig. All portions of the system were checked for external helium leakage with a helium leak detector and LOX compatible bubble solution AMS3159. In addition, the pneumatic actuation control modules were checked for internal leakage by monitoring each module vent port for the 6.0 scim maximum allowable leakage.

After the satisfactory completion of the ambient helium systems leak check, the cold helium system was leak checked with helium by pressurizing the cold helium spheres to 950 ±50 psig, and using the helium leak detector to check all plumbing, including the O_2H_2 burner portion of the system, for external leakage. The cold helium system was then depressurized and all bolted conoseal flanges and tube fittings from the cold helium sphere manifolds to the LOX pressurization module were tightened to check the breakaway torque. Subsequent to the torque check all bolted flanges and tube fittings were safety wired and torque stripped. The system was re-pressurized and a second leak check was performed. Four conditions of leakage were noted and all were corrected by the retightening of B-nuts.

After completing the setup operations for pressurizing the LOX and LH_2 tank assembly, the O_2H_2 burner nozzle plug was installed in preparation for the burner propellant system leak checks. Pressurizing the LOX and LH_2 tank

4.1.23 (Continued)

assembly with helium to 5 + 0, -1 psig, the O_2H_2 burner propellant valves and LOX shutdown valve were individually checked for internal leakage at the burner nozzle plug monitoring ports. Next, the burner nozzle plug monitoring ports were capped, and the burner propellant valves were opened to lock up pressure between the tank assembly and the nozzle plug. The entire O_2H_2 burner propellant system was then checked externally for leakage from the tank assembly to the burner nozzle plug. One condition of leakage was noted at the O_2H_2 burner number two injector. The leak was corrected by retightening the injector cap.

The burner propellant valves were then closed, the downstream systems were vented, and the burner nozzle plug was removed in preparation for the LOX and LH_2 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 monitoring 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 LH_2 tank. Prior to the pressurization, gas samples were taken from both tanks and analyzed for helium content. The results of the helium concentration check and the pressure decay check for the LOX and LH_2 tank assembly are listed in the Test Data Table.

Next, the control helium bottle fill valve was closed and a 30 minute control sphere pressure decay check was made (refer to the Test Data Table).

While maintaining the LOX tank helium pressure at 15 + 0, -1 psig, the LOX propellant supply line (low pressure duct) to the J-2 engine was pressurized

4.1.23 (Continued)

with helium at 15 to 30 psig. The entire LOX propellant supply system, the recirculation system, and the LOX tank fill and drain line were checked 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, the main LOX shutoff valve (MOV), the ASI valve, and the gas generator oxidizer circuitry terminating at the gas generator oxidizer valve. No external leakage was recorded for the LOX system.

After venting the LOX low pressure duct, the LH_2 low pressure duct (propellant supply to the J-2 engine), was pressurized with helium at 10 to 30 psig while the LOX tank and LH_2 tank pressures were maintained at 10 to 15 psig and 10 +0, -1 psig, respectively. The LH_2 system for the LH_2 tank through the J-2 engine was then checked for external helium leakage, similarly to the LOX system previously described. A fuzz leak, too small to measure, was noted at the oxidizer pump outlet to the oxidizer high pressure duct leak check port. The leak was acceptable as it was below the maximum allowable leakage of 1 scim.

The J-2 engine start system was leak checked by pressurizing the tank with helium to 500 $\pm$10 psig and checking all connections for external leakage. No leakage was detected. 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. IIS 396658 reported that the engine start tank mass decay rate was 0.0394 pound-mass/hour, above the 0.0066 pound-mass/hour maximum. Investigation revealed a faulty pressure transducer, D-525.

4.1.23 (Continued)

After replacement of the transducer the mass decay rate check and leak check were satisfactorily completed. The calculated decay rate was 0.0038 pound-mass/hour, which was acceptable based on an allowable mass decay rate of 0.0066 pound-mass/hour.

The J-2 engine control sphere was then pressurized with helium to between 225 psig and 250 psig in preparation for the 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 as measured at the pneumatic control module common vent port were within the acceptable tolerances, as listed in the Test Data Table. The engine control sphere pressure was then increased to 300 $\pm$10 psig and the helium control solenoid was turned on to pressurize the pressure actuated purge system for external leak checks. No leaks were detected. The engine control sphere pressure was then increased to 1450 $\pm$50 psia 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 0.0007 pound-mass/hour, which was acceptable based on an allowable decay rate of 0.036 pound-mass/hour.

The LH_2 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

4.1.23 (Continued)

with helium, at 5 +0, -1 psig for the LOX tank and 3 +0, -1 psig for the LH_2 tank. All systems, except the LOX and LH_2 tanks, were vented to ambient and secured.

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 LH_2 tank pressurization modules. There were no areas of unacceptable leakage detected, no FARR's were initiated, and the stage was designated acceptable for static firing countdown operations.

Sixty-eight revisions were recorded in the two issues of the procedure as follows:

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

b. Nine revisions added or changed requirements that were missing or in error.

c. Three revisions concerned the leak check of a newly installed pneumatic power control module.

d. Two revisions authorized a decay and leak check to verify that the ASI block was sealed to the engine dome.

e. Two revisions deleted steps that had been previously accomplished in other procedures.

f. Two revisions added the note "do not continue procedure until the 30 minute purge is complete" to prevent spinning of the engine flowmeter.

g. Two revisions reran leak checks after seal replacement to correct leakage conditions.

4.1.23 (Continued)

h. Two revisions concerned items held over from the preliminary leak check procedure 1B71877.

i. Two revisions concerned a post cold flow leak and torque check of the cold helium system.

j. One revision deleted venting the LOX and LH_2 tanks as both tanks were at leak check pressure for bulkhead sampling.

k. One revision deleted the thrust chamber leak check in the final issue as the thrust chamber was not chilled during the cold flow.

l. One revision increased the flow rate for the LH_2 low pressure duct pressurization.

m. One revision changed the stage control sphere pressure from 750 $\pm$50 psia to 550 $\pm$50 psia, to maintain the control regulator discharge pressure below the maximum limit of 605 psig.

n. One revision authorized an additional decay check of the engine start tank as the first readings were not accurate.

o. One revision reran the engine start tank decay check after replacement of transducer D-525.

p. One revision deleted the leak check of the aft skirt tunnel purge line as the line had been checked prior to the cold flow and was not subjected to temperature cycling during the cold flow.

q. One revision deleted the requirement to purge the LOX and LH_2 tanks as the tanks were purged during the cold flow shutdown operations and were secured at 99.9 per cent helium concentration.

r. One revision authorized the removal and reinstallation of the LOX chilldown pump orifice, to determine its size.

s. Two revisions concerned a leak check and bolt torque check of the LOX pressurization module after replacement of the module per FARR 500-372-044 during the cold flow test.

t. One revision concerned changing the pressure level of the stage control sphere from ambient to 500 $\pm$50 psig so the sphere could be held at a safe level without dumping to ambient.

4.1.23 (Continued)

u. One revision specified a leak check of the LOX pressurization line at the test plate installation.

v. One revision authorized an additional checkout of the engine start tank integrity checks and leak checks subsequent to replacement of the TF1 transducer.

w. One revision specified the performance of a leak check of the LH_2 and LOX repressurization plenums.

x. One revision concerned the installation of a 0 to 600 psig test gauge at the closing pneumatic port of the LOX prevalve to perform preliminary leak checks of the prevalve.

y. One revision authorized a cycle purge of the LOX and the LH_2 tanks to attain a 99 per cent helium concentration in support of a PU system test.

z. One revision concerned a leak check of transducer D231 after removal and replacement.

aa. One revision authorized removal and preplacement of the seal between pipe assemblies, P/N 1B55285-1 and 1B68899-1 in support of TAN 11585R1.

ab. One revision authorized a leak check of the non-propulsive vent connection on the LH_2 tank.

ac. One revision gave instructions to rerun the leak check of the O_2H_2 burner injector after replacement of the igniters.

ad. One revision authorized reconnecting flex line No. T323 to umbilical No. 5 after completing a special test.

ae. One revision outlined a special integrity check of the LH_2 tank vent and relief valve relief pressure.

af. One revision repeated sections that were previously accomplished.

4.1.23.1 Test Data Table, Final Prefire Propulsion System Leak Check

Stage Vacuum Duct Readings

	Reading (Microns)	Limits (Microns)
LH_2 LPD Upper	175	Less than 250
LH_2 LPD Lower	15	Less than 250

4.1.23.1 (Continued)

	Reading (Microns)	Limits (Microns)
LH_2 Recirculation	20	Less than 250
O_2H_2 Burner Propellant Upper	72	Less than 250
O_2H_2 Burner Propellant Lower	12	Less than 250
O_2H_2 Burner Propellant	100	Less than 250

Ambient Helium System Decay Check

	Initial (psig)	Final (psig)	Limits
Cold Helium Sphere	1400	1400	*
LOX Repress Sphere	1400	1400	*
LH_2 Repress Sphere	1400	1400	*
Control Helium Reg. Discharge	530	530	*

LOX and LH_2 Tank Helium Concentration

		Reading (%)	Limits (%)
LOX Tank:	Top	100.0	75 min
	Bottom	100.0	75 min
LH_2 Tank:	Top	99.7	75 min
	Bottom	99.7	75 min

LOX and LH_2 Tank Pressure Decay Test

	Initial (psig)	Final (psig)	Limits
LOX Tank	14.5	14.8	*
LH_2 Tank	9.3	9.3	*

Thrust Chamber Valve Actuator Shaft Seal Leak Checks

	Measured (scim)	Limits (scim)
MOV Idler	0.0	3.3 max
MFV Idler	0.0	3.3 max
MOV 2nd Stage Actuator	0.0	3.3 max
MFV Actuator	2.9	3.3 max

* Limits Not Specified

4.1.23.1 (Continued)

Engine Pneumatic Control Package (Low Pressure Side) Leak Check

	Vent Port Flow (scim)	Limits (scim)
Helium Control Solenoid On	1.31	20 max
Ignition Phase Solenoid On	1.62	20 max
Mainstage Solenoid On	1.62	20 max

LOX Pressurization Module Leak Test

	Measured (scim)	Limits (scim)
Cold Helium Shutoff Vlv Seat Leakage and Pilot Leakage	0.0	12.5 max
Hot Gas Bypass Vlv Seat and Pilot Bleed Leakage	210	3000 max

Final Helium Concentration Check

		Reading (%)	Limits (%)
LOX Tank:	Top	99.8	99 min
	Bottom	99.8	99 min
LH_2 Tank:	Top	99.9	99 min
	Bottom	99.9	99 min

4.1.24 Integrated System Test (1B55831 G)

This automatic checkout verified the design integrity and operation capability of the S-IVB 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 22 June 1968. A second issue was required due to replacement of the O2H2 burner ignitors. Initial conditions for the second issue were established on 2 July 1968. The narration and the test data are taken from the second issue. 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. There were two malfunctions that indicated the helium console value did not open and that the stage 3 pressure was not reached in the allotted time. The helium console value was slow to open and the program saw a not open indication. An isolation hand valve for the stage 3 GH2 pressure was closed giving an indication of no pressure. The valve was opened and the pressure readings were normal.

The telemetry and digital data acquisition systems were checked next, with the PCM transmitter operated open loop during this section. The telemetry 5

4.1.24 (Continued)

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-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. Four malfunctions were recorded during this section; two were attributed to program errors, one was due to stage miswiring. The fourth malfunction occurred because the pressure in the LOX chilldown motor cannister was not up to the desired pressure of 50 psig. The pressure in the cannister is a function of the shaft seal leakage which varies with shaft position. The pressure of 40 psig was acceptable.

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.

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. Two malfunctions occurred during this section, both were concerned with the

4.1.24 (Continued)

forward bus 1 voltage indicating out-of-tolerance. The surface charge of the batteries was drained off and the test was concluded.

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 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.

Engineering status review indicated that all parts were installed at the start of this test, and the procedure was accepted on 9 July 1968.

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

a. Twenty-six revisions were required to update the procedure to the latest configuration.

b. Twenty-two revisions added or changed requirements that were missing or in error.

c. Four revisions attributed four malfunctions of pressure switches during the deflector water test, to a hand isolation valve being closed and to incompleted wiring modifications.

d. Two revisions changed the stage bus power tolerance from 28 $\pm$ 0.5 vdc to 28 $\pm$ 2.0 vdc, as the external power cannot be maintained within the $\pm$ 0.5 vdc tolerance before power is applied to the stage.

e. Two revisions concerned the failure of the LH2 tank GH2 purge supply valve to open in the 1 second allowed by the program. The valve opened 10 seconds later. A checkout indicated no problem with the valve as the valve was cycled manually with no slow action.

4.1.24 (Continued)

f. Two revisions stated that a SIM interrupt occurred due to a wiring change made by ECP 2798, which connected the shutdown bus to the EDS 1 cutoff.

g. One revision stated that due to incomplete wiring in J-box N69-3, an expected "deflection water pressure switch 2 not on" was received.

h. One revision concerned dual talkback of the 2000 psi helium crossover valve. The talkback was adjusted on GSE FARR 500-225 -548.

i. One revision stated that the GH2 igniter supply valve operated slow during the torch functional test. Investigation indicated no apparent cause.

j. One revision attributed a SIM interrupt to an operator's error.

k. One revision attributed the malfunction of the torch ignition detector to torch talkback switch maladjustments. The talkback switch was adjusted and the program continued.

l. One revision stated that the forward bus 2 voltage was out-of-tolerance during stage power setup. The bus voltage which was too low was subsequently adjusted and the program continued.

m. One revision stated that due to an instrumentation problem the main oxidizer valve did not appear to move. The instrumentation was corrected and OLSTOL was entered to repeat the engine sequence to verify proper operation of the valve.

n. One revision concerned the out-of-tolerance reading of measurement M 061. The channel indicated 1.008 vdc, the reading should have been 0 ± 1 vdc. The condition was accepted on FARR 500-225-572.

o. One revision stated that the emergency stop during engine gimbaling was initiated per a test stand operator's request. The flexible duct covers had not been removed. No damage resulted and the test was continued.

p. One revision attributed two malfunctions of the forward bus 1 voltage to a surface charge on the batteries. The surface charge was drained off and the program continued.

q. One revision explained that the O2H2 shutdown reset does not reset the engine cutoff, therefore when the program requests that engine cutoff be given, cutoff is already there and the program continues and requests for a cutoff reset. Depressing the reset button therefore, generates the SIM interrupt on channel 145.

4.1.24.1 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	2359.118 psia	2350.000 ± 125.000 psia
M025	Hi RACS Test	4.005 vdc	4.000 ± 0.500 vdc
M025	Lo RACS Test	-0.005 vdc	0.000 ± 0.050 vdc
M025	Amb Output	4.975 vdc	5.000 ± 0.030 vdc
D236	Hi RACS Test	3.989 vdc	4.000 ± 0.100 vdc
D236	Lo RACS Test	1.005 vdc	1.000 ± 0.100 vdc
D236	Amb Output	13.086 psia	14.700 ± 70.000 psia
D225	Hi RACS Test	3.994 vdc	4.000 ± 0.100 vdc
D225	Lo RACS Test	1.015 vdc	1.000 ± 0.100 vdc
D225	Amb Output	12.410 psia	14.700 ± 10.000 psia
D016	Hi RACS Test	4.015 vdc	4.000 ± 0.100 vdc
D016	Lo RACS Test	1.030 vdc	1.000 ± 0.100 vdc
D016	Amb Output	18.136 psia	14.700 ± 70.000 psia
D019	Hi RACS Test	4.035 vdc	4.015 ± 0.100 vdc
D019	Lo RACS Test	1.040 vdc	1.041 ± 0.050 vdc
D019	Amb Output	50.652 psia	14.700 ± 70.000 psia
D018	Hi RACS Test	4.066 vdc	4.071 ± 0.050 vdc
D018	Lo RACS Test	1.066 vdc	1.071 ± 0.050 vdc
D018	Amb Output	15.300 psia	14.700 ± 15.000 psia
M024	Hi RACS Test	4.020 vdc	4.000 ± 0.050 vdc
M024	Lo RACS Test	-0.005 vdc	0.000 ± 0.050 vdc
M024	Amb Output	5.006 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	5.001 vdc	5.000 ± 0.030 vdc
D017	Hi RACS Test	4.056 vdc	4.056 ± 0.050 vdc
D017	Lo RACS Test	1.062 vdc	1.056 ± 0.050 vdc
D017	Amb Output	14.884 psia	14.700 ± 30.000 psia
G001	Amb Output	-0.410°F	-0.300 ± 0.400°F
G002	Amb Output	0.377°F	0.300 ± 0.400°F
D020	Hi RACS Test	4.076 vdc	4.000 ± 0.100 vdc
D020	Lo RACS Test	1.015 vdc	1.000 ± 0.100 vdc
D020	Amb Output	1.869 psia	14.700 ± 70.000 psia
D177	Amb Output	14.764 psia	14.700 ± 1.000 psia
D178	Amb Output	14.959 psia	14.700 ± 1.000 psia
D088	Hi RACS Test	3.953 vdc	4.000 ± 0.100 vdc
D088	Lo RACS Test	1.046 vdc	1.000 ± 0.100 vdc
D088	Amb Output	35.521 psia	14.700 ± 70.000 psia
D179	Amb Output	14.644 psia	14.700 ± 1.000 psia
D180	Amb Output	14.538 psia	14.700 ± 1.000 psia
L007	Amb Output	47.810 pct	50.000 ± 10.000 pct

4.1.24.1 (Continued)

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

Meas. No.	Function	Measurement	Limits
D236	Hi RACS Test	3.989 vdc	4.000 ± 0.100 vdc
D236	Lo RACS Test	0.999 vdc	1.000 ± 0.100 vdc
D236	Amb Output	9.348 psia	14.700 ± 70.000 psia
D043	Amb Output	2356.438 psia	2350.000 ±120.000 psia
C138	Hi RACS Test	4.010 vdc	4.000 ± 0.075 vdc
C138	Lo RACS Test	0.010 vdc	0.000 ± 0.075 vdc
C138	Amb Output	68.617°F	70.000 ± 16.000°F
M025	Amb Output	4.994 vdc	5.000 ± 0.030 vdc
D209	Amb Output	13.289 psia	20.750 ± 11.950 psia
M074	Amb Output	-0.005 vdc	0.000 ± 0.075 vdc
M073	Amb Output	0.000 vdc	0.000 ± 0.075 vdc
D016	Hi RACS Test	3.999 vdc	4.000 ± 0.100 vdc
D016	Lo RACS Test	1.025 vdc	1.000 ± 0.100 vdc
D016	Amb Output	14.317 psia	14.700 ± 70.000 psia
D014	Amb Output	18.438 psia	14.700 ± 13.000 psia
D019	Hi RACS Test	4.030 vdc	4.041 ± 0.050 vdc
D019	Lo RACS Test	1.035 vdc	1.041 ± 0.050 vdc
D019	Amb Output	54.217 psia	14.700 ± 70.000 psia
M006	Amb Output	27.938 vdc	28.000 ± 2.000 vdc
M007	Amb Output	0.000 vdc	0.000 ± 1.000 vdc
D050	Amb Output	14.565 psia	14.700 ± 3.000 psia
D054	Hi RACS Test	3.994 vdc	4.000 ± 0.100 vdc
D054	Lo RACS Test	1.025 vdc	1.000 ± 0.100 vdc
D054	Amb Output	14.811 psia	14.700 ± 2.000 psia
M024	Hi RACS Test	4.020 vdc	4.000 ± 0.050 vdc
M024	Lo RACS Test	-0.005 vdc	0.000 ± 0.050 vdc
M024	Amb Output	5.006 vdc	5.000 ± 0.030 vdc
M068	Hi RACS Test	3.999 vdc	4.000 ± 0.050 vdc
M068	Lo RACS Test	-0.005 vdc	0.000 ± 0.050 vdc
M068	Amb Output	5.000 vdc	5.000 ± 0.030 vdc
D017	Hi RACS Test	4.056 vdc	4.051 ± 0.050 vdc
D017	Lo RACS Test	1.062 vdc	1.051 ± 0.050 vdc
D017	Amb Output	17.004 psia	14.700 ± 30.000 psia
C006	Hi RACS Test	4.061 vdc	4.000 ± 0.075 vdc
C006	Lo RACS Test	0.010 vdc	0.000 ± 0.075 vdc
C006	Amb Output	72.018°F	70.000 ± 18.000°F
D103	Amb Output	14.729 psia	14.700 ± 3.000 psia
G001	Amb Output	-0.410°F	-0.300 ± 0.400°F
G002	Amb Output	0.361°F	0.300 ± 0.400°F
M010	Hi RACS Test	4.010 vdc	4.000 ± 0.060 vdc
M010	Lo RACS Test	1.015 vdc	1.000 ± 0.060 vdc
M010	Amb Output	0.365 vdc	0.000 ± 1.000 vdc
D020	Hi RACS Test	4.076 vdc	4.000 ± 0.100 vdc
D020	Lo RACS Test	1.010 vdc	1.000 ± 0.100 vdc

4.1.24.1 (Continued)

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

Meas. No.	Function	Measurements	Limits
D020	Amb Output	1.869 psia	14.700 ± 70.000 psia
C231	Hi RACS Test	3.999 vdc	4.000 ± 0.075 vdc
C231	Lo oACS Test	0.000 vdc	0.000 ± 0.075 vdc
C231	Amb Output	-155.555°F	-155.000 ± 8.000°F
C001	Hi RACS Test	4.046 vdc	4.000 ± 0.075 vdc
C001	Lo RACS Test	0.035 vdc	0.000 ± 0.075 vdc
C001	Amb Output	90.908°F	70.000 ± 72.000°F
D177	Amb Output	14.944 psia	14.700 ± 1.000 psia
D178	Amb Output	14.959 psia	14.700 ± 1.000 psia
D105	Hi RACS Test	3.964 vdc	4.000 ± 0.100 vdc
D105	Lo RACS Test	1.020 vdc	1.000 ± 0.100 vdc
D105	Amb Output	14.047 psia	14.700 ± 10.000 psia
C230	Hi RACS Test	4.025 vdc	4.000 ± 0.075 vdc
C230	Lo RACS Test	-0.015 vdc	0.000 ± 0.075 vdc
C230	Amb Output	-378.438°F	-379.000 ± 4.000°F
D088	Hi RACS Test	3.948 vdc	4.000 ± 0.100 vdc
D088	Lo RACS Test	1.051 vdc	1.000 ± 0.100 vdc
D088	Amb Output	31.782 psia	14.700 ± 70.000 psia
C002	Hi RACS Test	4.010 vdc	4.000 ± 0.075 vdc
C002	Lo RACS Test	0.005 vdc	0.000 ± 0.075 vdc
C002	Amb Output	63.798°F	65.000 ± 48.000°F
D179	Amb Output	14.944 psia	14.700 ± 1.000 psia
D180	Amb Output	14.497 psia	14.700 ± 1.000 psia
M026	Amb Output	0.000 vac	0.000 ± 1.500 vac
M027	Amb Output	0.000 vac	0.000 ± 1.500 vac
M041	Amb Output	0.000 vac	0.000 ± 1.500 vac
M040	Amb Output	0.000 vac	0.000 ± 1.500 vac
M060	Hi RACS Test	4.035 vdc	4.000 ± 0.100 vdc
M060	Lo RACS Test	0.990 vdc	1.000 ± 0.100 vdc
M060	Amb Output	4.841 vac	6.000 ± 6.000 vac
M061	Hi RACS Test	3.958 vdc	4.000 ± 0.100 vdc
M061	Lo RACS Test	1.015 vdc	1.000 ± 0.100 vdc
M061	Amb Output	-0.308 vdc	0.000 ± 1.000 vdc
L007	Amb Output	47.560 pct	50.000 ± 10.000 pct
C199	Hi RACS Test	4.046 vdc	4.000 ± 0.075 vdc
C199	Lo RACS Test	-0.015 vdc	0.000 ± 0.075 vdc
C199	Amb Output	74.328°F	70.000 ± 21.000°F

4.1.24.1 (Continued)

LOX and LH2 Valve Functional Checks

Function	Measurement		Limits
LH2 & LOX Prevalves	Close Time (sec)	0.045	4.000 max
	Open Time (sec)	1.876	4.000 max
LH2 Vent Valve	Open Time (sec)	0.120	4.000 max
	Close Time (sec)	0.482	4.000 max
LOX Vent Valve	Open Time (sec)	0.123	4.000 max
	Close Time (sec)	0.371	4.000 max
LH2 & LOX C/D SOV	Close Time (sec)	0.261	4.000 max
	Open Time (sec)	1.196	4.000 max
LH2 Vent Valve	Open Time (sec)	0.085	4.000 max
	Close Time (sec)	0.460	4.000 max
	Open Time (sec)	0.085	4.000 max
	Close Time (sec)	0.292	4.000 max
LOX Vent Valve	Open Time (sec)	0.090	4.000 max
	Close Time (sec)	0.351	4.000 max
	Open Time (sec)	0.090	4.000 max
	Close Time (sec)	0.352	4.000 max
LH2 Fill & Drain Valve	Open Time (sec)	0.289	4.000 max
	Close Time (sec)	2.339	4.000 max
	Open Time (sec)	0.284	4.000 max
	Close Time (sec)	0.899	4.000 max
LOX Fill & Drain Valve	Open Time (sec)	0.272	4.000 max
	Close Time (sec)	2.324	4.000 max
	Open Time (sec)	0.256	4.000 max
	Close Time (sec)	0.945	4.000 max
LH2 & LOX Prevalves	Close Time (sec)	0.367	4.000 max
	Open Time (sec)	1.795	4.000 max
LH2 & LOX C/D Sov	Close Time (sec)	0.206	4.000 max
	Open Time (sec)	1.123	4.000 max
Dir Vent to Flt Pos	(sec)	0.217	4.000 max
Dir Vent to Grd Pos	(sec)	0.205	4.000 max

4.1.24.1 (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	0.05	-0.00	-0.01	0.01	0.04
1° pitch 0° yaw	6.70	0.10	0.84	-0.01	0.84	0.04
0° pitch 0° yaw	-0.05	0.10	-0.05	-0.01	-0.04	0.04
1° pitch 0° yaw	-6.70	0.00	-1.07	0.00	-1.08	0.04
0° pitch 0° yaw	0.00	0.10	0.01	-0.01	0.01	0.06
0° pitch 1° yaw	-0.20	-6.55	0.03	-0.81	0.03	-0.74
0° pitch 0° yaw	-0.05	0.05	0.01	-0.01	0.01	0.04
0° pitch 1° yaw	0.00	6.55	0.01	1.00	0.03	1.05
0° pitch 0° yaw	0.00	0.10	0.01	-0.01	0.01	0.06
0° pitch 0° yaw	0.00	-0.05	-0.02	-0.01	0.01	0.04
1° pitch 0° yaw	6.70	0.00	1.03	0.00	1.08	0.07
0° pitch 0° yaw	0.00	0.05	-0.05	-0.01	-0.04	0.04
1° pitch 0° yaw	-6.70	0.05	-1.07	-0.01	-1.05	0.04

4.1.24.1 (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	0.05	-0.00	-0.01	0.00	0.04
1° pitch 0° yaw	6.65	0.05	1.04	-0.01	1.05	0.04
0° pitch 0° yaw	-0.01	0.05	-0.07	-0.01	-0.03	0.06
1° pitch 0° yaw	-6.70	0.00	-1.05	-0.01	-1.03	0.06
0° pitch 0° yaw	-0.10	0.05	0.01	0.00	0.01	0.06
0° pitch 0° yaw	-0.10	-6.55	0.01	-1.01	0.01	-0.96
0° pitch 0° yaw	-0.05	0.00	0.01	0.02	0.03	0.07
0° pitch 1° yaw	-0.05	6.70	0.01	1.02	0.01	1.09
0° pitch 0° yaw	0.00	0.05	0.01	-0.01	0.03	0.04
0° pitch 0° yaw	-0.10	0.10	-0.00	0.00	0.01	0.04
1° pitch 0° yaw	6.60	0.05	1.03	0.00	1.06	0.07
0° pitch 0° yaw	-0.05	0.05	-0.05	0.00	-0.04	0.06
1° pitch 0° yaw	-6.75	0.05	-1.07	0.00	-1.05	0.06
0° pitch 0° yaw	-0.10	0.00	-0.00	-0.01	0.03	0.06
0° pitch 1° yaw	0.05	-6.55	0.01	-1.00	0.03	-0.95

4.1.24.1 (Continued)

Engine Gimbal Commands - Restrainer Links Disengaged (Continued)

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	0.01	0.02	0.04	0.07
0° pitch 1° yaw	0.00	6.70	-0.00	1.03	0.03	1.09
0° pitch 0° yaw	-0.10	0.05	0.03	0.00	0.03	0.07

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	0.53	0.056	10.539	4.10	2.028
	5.00	4.21	0.030	45.926	10.63	2.041
	7.00	6.13	0.028	62.515	14.64	2.037
0.25° Yaw	0.60	0.52	0.055	10.191	3.07	2.027
	5.00	4.05	0.021	31.304	10.71	2.034
	7.00	7.06	0.025	64.551	16.18	2.019
0.50° Ptch	0.60	0.05	0.056	10.029	3.04	2.001
	5.00	3.98	0.028	40.622	9.93	1.999
	7.00	5.36	0.038	73.508	13.01	2.027
0.50° Yaw	0.60	0.53	0.078	14.876	3.10	2.021
	5.00	4.27	0.027	42.000	10.67	2.035
	7.00	6.83	0.034	84.000	15.97	2.011

4.1.25 Hydraulic System (1B55824 F)

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 X457811; the auxiliary hydraulic pump, P/N 1A66241-511, S/N X454599; the accumulator/reservoir assembly, P/N 1B29319-519, S/N 29; the hydraulic pitch actuator, P/N 1A66248-507, S/N 71; and the hydraulic yaw actuator, P/N 1A66248-507, S/N 84.

The test was conducted on 20 May 1968, and accepted on 21 May 1968. Those function values measured during the test are presented in Test Data Table 4.1.25.1. 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, its voltage was measured, and the aft 5 volt excitation module voltage was measured. Measurements were made of various hydraulic system functions with the hydraulic system unpressurized. Measurements were also made to determine the accumulator/reservoir gaseous nitrogen mass and corrected oil level.

The methods of controlling the auxiliary hydraulic pump were checked next. After verifying that a power cable was connected to the auxiliary hydraulic pump motor, the aft bus 2 power supply was turned on, and the bus voltage was verified to be 56.0 $\pm$4.0 vdc. The coast mode operation was checked by applying dry ice to the coast mode thermal switch, and 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; then, 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 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 correct 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 ± 7 1/2 degrees, in a square pattern, conterclockwise as viewed from the engine bell. The engine was then returned to its 0 degree centered position. As the engine was sequenced through the square pattern, a clearance check verified that there was no interference to engine motion within the gimbal envelope. A comparison of the hydraulic servo engine positioning system command and response signals verified that the response movement was of the correct polarity and magnitude to agree with the command signal, and met the requirements for movement linearity. Checks of the hydraulic system pressure and reservoir oil pressure, when the actuators were at their extreme and when they were returned to neutral, verified that these pressures remained acceptable.

Transient response tests were conducted next. Step commands were separately applied to the pitch and yaw actuators, causing each actuator to individually move the engine from 0 degrees to -3 degrees, from -3 degrees to 0 degrees, from 0 degrees to +3 degrees, and from +3 degrees to 0 degrees. The engine response was observed visually and audibly for unwanted oscillations, and the actuator responses were recorded during the engine movement. The engine slew rates were computed for each of the step movements. The test data table shows the computed slew rates and representative actuator response values for the

4.1.25 (Continued)

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 the tests. No major problems were encountered during the test, and no FARRs were written.

Seven revisions were recorded in the procedure for the following:

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

b. One revision added a test to obtain measurements for parameters D209 and D223, prior to, during and after operation of the auxiliary pump.

c. One revision added a statement to the procedure to ensure the performance of stage power setup on intiial condition scan immediately prior to the test.

d. One revision corrected a program error.

4.1.25.1 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 ±0.05
Hydraulic System Unpressurized		
Reservoir Oil Pressure (psia)	80.74	*
Accumulator GN_2 Pressure (psia)	2337.38	*
Accumulator GN_2 Temperature (°F)	72.53	*
Reservoir Oil Level (%)	90.60	*
Pump Inlet Oil Temperature (°F)	70.97	*
Reservoir Oil Temperature (°F)	72.53	*
Aft Bus 2 Current (amp)	-0.60	*
Gaseous Nitrogen Mass (lb)	1.898	1.925 ±0.2
Corrected Reservoir Oil Level (%)	100.7	95.0 min
Engine Centering Test, Locks On, System Unpressurized		
T/M Pitch Actuator Position (deg)	-0.04	*
IU Pitch Actuator Position (deg)	-0.06	*
T/M Yaw Actuator Position (deg)	-0.01	*
IU Yaw Actuator Position (deg)	0.04	*
IU Substitute 5 Volt Power Supply (vdc)	5.00	*
Aft 5 Volt Excitation Module (vdc)	4.99	*
Pitch Actuator Signal (ma)	-0.15	*
Yaw Actuator Signal (ma)	0.10	*
Corrected T/M Pitch Actuator Position (deg)	-0.057	-0.236 to 0.236
Corrected IU Pitch Actuator Position (deg)	-0.051	-0.236 to 0.236
Corrected T/M Yaw Actuator Position (deg)	0.009	-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)	55.68	56.0 ±4.0
Aft Bus 2 Current (amp)	55.00	55.0 ±30.0
Hyd System 4 Second Press Change (psia)	278.20	200.0 min
T/M Pitch Actuator Position (deg)	-0.05	*
IU Pitch Actuator Position (deg)	-0.03	*
T/M Yaw Actuator Position (deg)	-0.04	*
IU Yaw Actuator Position (deg)	0.01	*
IU Substitute 5 Volt Power Supply (vdc)	5.00	*
Aft 5 Volt Excitation Module (vdc)	4.98	*
Pitch Actuator Signal (ma)	-0.20	*
Yaw Actuator Signal (ma)	0.20	*
Corrected T/M Pitch Actuator Position (deg)	-0.072	-0.517 to 0.517
Corrected IU Pitch Actuator Position (deg)	0.021	-0.517 to 0.517
Corrected T/M Yaw Actuator Position (deg)	-0.022	-0.517 to 0.517
Corrected IU Yaw Actuator Position (deg)	0.006	-0.517 to 0.517

*Limits Not Specified

4.1.25.1 (Continued)

Function	Measurement	Limits
Hydraulic System Pressurized, Locks Off, Zero Excitation Signal Applied to Actuators		
Hydraulic System Pressure (psia)	3558.81	*
Reservoir Oil Pressure (psia)	170.64	*
Accumulator GN_2 Pressure (psia)	3556.63	*
Accumulator GN_2 Temperature (°F)	90.57	*
Reservoir Oil Level (%)	41.55	*
Pump Inlet Oil Temperature (°F)	78.80	*
Reservoir Oil Temperature (°F)	80.76	*
Aft Bus 2 Current (amp)	41.40	*
T/M Pitch Actuator Position (deg)	-0.07	*
IU Pitch Actuator Position (deg)	-0.04	*
T/M Yaw Actuator Position (deg)	-0.03	*
IU Yaw Actuator Position (deg)	0.04	*
IU Substitute 5 Volt Power Supply (vdc)	5.01	*
After 5 Volt Excitation Module (vdc)	4.99	*
Pitch Actuator Signal (ma)	-0.10	*
Yaw Actuator Signal (ma)	0.10	*
Corrected T/M Pitch Actuator Position (deg)	-0.088	-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)	-0.007	-0.517 to 0.517
Corrected IU Yaw Actuator Position (deg)	0.029	-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: 13.6 deg/sec			
0.000	-0.100	-0.117	5.010
0.100	-19.971	-1.529	5.005
0.191	-19.971	-2.827	5.010
0.292	-20.068	-3.188	5.010
0.394	-20.020	-3.044	5.005
0.493	-20.068	-3.087	5.010
0.595	-20.068	-3.131	5.005
0.695	-20.117	-3.131	5.015
0.860	-19.971	-3.146	5.010
1.008	-20.068	-3.146	5.005
1.100	-20.068	-3.146	5.000

*Limits Not Specified

4.1.25.1 (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: 13.8 deg/sec			
0.000	-20.000	-3.177	4.999
0.100	-0.195	-1.803	5.010
0.191	-0.195	-0.447	5.005
0.293	-0.146	-0.028	5.010
0.394	-0.195	-0.144	5.005
0.495	-0.244	-0.115	5.010
0.595	-0.244	-0.071	5.005
0.697	-0.195	-0.043	5.010
0.880	-0.244	-0.086	5.005
1.009	-0.195	-0.058	5.005
1.100	-0.195	-0.058	5.010
Pitch 0 to +3 Degree Step Response - Engine Slew Rate: 13.3 deg/sec			
0.000	-0.100	-0.073	5.010
0.109	19.922	1.414	5.000
0.191	19.873	2.627	5.010
0.292	19.824	3.103	5.010
0.394	19.873	2.987	5.005
0.494	19.824	3.030	5.005
0.596	19.873	3.060	5.005
0.696	19.873	3.045	5.005
0.881	19.873	3.074	5.005
1.009	19.824	3.060	5.010
1.118	19.824	3.103	5.010
Pitch +3 to 0 Degree Step Response - Engine Slew Rate: 14.2 deg/sec			
0.000	19.850	3.028	5.010
0.100	-0.195	1.646	5.010
0.191	-0.195	0.260	5.010
0.292	-0.195	-0.173	5.010
0.394	-0.195	-0.043	5.010
0.494	-0.195	-0.058	5.010
0.596	-0.195	-0.115	5.010
0.696	-0.195	-0.101	5.005
0.879	-0.244	-0.115	5.005
1.081	-0.244	-0.115	5.000
1.118	-0.195	-0.101	5.005

4.1.25.1 (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	0.100	0.059	5.005
0.109	-19.678	-1.313	5.005
0.192	-19.678	-2.641	5.005
0.292	-19.678	-3.045	5.010
0.395	-19.727	-2.900	5.010
0.494	-19.727	-2.915	5.010
0.595	-19.775	-2.958	5.010
0.697	-19.775	-2.973	5.005
0.880	-19.727	-2.973	5.010
1.082	-19.775	-2.987	5.010
1.119	-19.727	-2.973	5.010
Yaw -3 to 0 Degree Step Response - Engine Slew Rate: 14.2 deg/sec			
0.000	-19.699	-2.970	5.010
0.109	0.049	-1.588	5.010
0.191	0.098	-0.188	5.020
0.292	0.049	0.144	5.005
0.394	0.049	-0.029	5.005
0.494	0.049	0.043	5.005
0.597	0.049	0.086	5.010
0.696	0.000	0.043	5.000
0.880	0.049	0.071	5.010
1.082	0.049	0.086	5.010
1.119	0.098	0.071	5.010
Yaw 0 to +3 Degree Step Response - Engine Slew Rate: 13.8 deg/sec			
0.000	0.050	0.103	4.999
0.108	19.922	1.472	5.005
0.190	19.922	2.842	5.010
0.293	19.873	3.188	5.010
0.393	19.922	3.029	5.005
0.494	19.873	3.059	5.005
0.596	19.873	3.131	5.005
0.696	19.922	3.116	5.010
0.880	19.873	3.116	5.005
1.082	19.922	3.116	5.010
1.1			

4.1.25.1 (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: 13.5 deg/sec			
0.000	19.899	3.161	4.999
0.101	0.049	1.904	5.005
0.192	0.098	0.519	5.000
0.293	0.098	-0.025	5.005
0.395	0.049	0.158	5.015
0.495	0.098	0.144	5.010
0.597	0.049	0.086	5.010
0.697	0.049	0.058	5.005
0.880	0.098	0.071	5.010
1.083	0.098	0.101	5.000
1.119	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)	3555.56	*
Reservoir Oil Pressure (psia)	173.26	*
Accumulator GN_2 Pressure (psia)	3556.63	*
Accumulator GN_2 Temperature (°F)	79.97	*
Reservoir Oil Level (%)	44.43	*
Pump Inlet Oil Temperature (°F)	138.27	*
Reservoir Oil Temperature (°F)	128.38	*
Aft Bus 2 Current (amps)	43.20	*
T/M Pitch Acutator Position (deg)	-0.13	*
IU Pitch Actuator Position (deg)	-0.12	*
T/M Yaw Actuator Position (deg)	0.05	*
IU Yaw Actuator Position (deg)	0.12	*
IU Substitute 5 Volt Power Supply (vdc)	5.00	*
Aft 5 Volt Excitation Module (vdc)	4.99	*
Pitch Actuator Signal (ma)	-0.15	*
Yaw Actuator Signal (ma)	0.05	*
Corrected T/M Pitch Actuator Position (deg)	-0.150	-0.517 to 0.517
Corrected IU Pitch Actuator Position (deg)	-0.109	-0.517 to 0.517
Corrected T/M Yaw Actuator Position (deg)	0.070	-0.517 to 0.517
Corrected IU Yaw Actuator Position (deg)	0.109	-0.517 to 0.517

*Limits Not Specified

4.2 Abbreviated Postfire Acceptance Testing

Stage abbreviated postfire acceptance testing began on 18 July 1968, with the initiation of the structural inspection, paragraph 4.2.1. The abbreviated postfire checkouts were completed on 31 July 1968, with the acceptance of the forward skirt thermoconditioning checkout, paragraph 4.2.8.

4.2.1 Postfire Structural Inspection (1B70756 B)

This manual procedure outlined the postfire inspection requirements for the stage. The purpose of the checkout was to verify that static firing was not detrimental to the stage structure, and provided a comparison with the prefire structural inspection results.

The procedure was initiated on 18 July 1968, and was completed on 6 August 1968. The checkout was started with an inspection of the LOX and LH_2 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. FARR 500-372-109 reported that paint was peeling from the forward skirt exterior near fin line 1. The area was repainted per DPS 42210.

All bonded supports were verified to be acceptable by performing a "coin tap" test by direction of MR&PM Engineering. The areas inspected included the forward and aft domes, and the main and auxiliary tunnels.

4.2.1 (Continued)

The environmental control plenum, P/N 1B64850, was then inspected for rips and debonded areas, and was found acceptable. This was followed by visual inspection of the stage air bottle, the control helium, the ambient helium, and cold helium spheres for dings, scratches, or other damage.

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 LH_2 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 removal of the stage from Test Stand Beta III.

Seven revisions were recorded in the procedure for the following; however, one revision was voided.

a. Four revisions updated the procedure with the latest part number and nomenclature changes.

b. One revision deleted the APS module fit check because installation of the APS modules was scheduled for poststorage operations.

c. One revision deleted the postfire LH_2 tank internal inspection as it was not required at this time.

d. One revision was written and subsequently voided.

4.2.2 Final Postfire Propulsion System Leak Check (1B70175 G)

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 18 July 1968, and completed and certified as acceptable on 31 July 1968. Measurements recorded are listed in Test Data Table 4.2.2.1.

After preliminary test equipment setup, a cold helium system ambient leak and torque check was performed per Test Request 1316. The cold helium spheres were pressurized with ambient helium at 950 $\pm$50 psig, and the system was checked for leakage before and after breakaway torque measurements per the detailed checklist. No external leakage was detected before or after the torque checks; however, internal leakage of 11,000 scims at 900 psig was detected through the cold helium dump module, P/N 1B57781, S/N 0040. The module was removed and replaced with, P/N 1B57781-507, S/N 0029, per FARR 500-372-079, and satisfactorily tested and leak checked.

Next, vacuum readings of the stage vacuum jacketed ducts were taken. All vacuum levels measured were within acceptable limits, as listed in Test Data Table 4.2.2.1, with the exception of the lower LH_2 low pressure duct. The vacuum probe for this duct failed to respond during the test. A special test setup authorized by procedure revision obtained an estimated reading of 200 microns. After completion of the abbreviated postfire checkout, the defective probe was replaced and the integrity of the duct was verified per FARR 500-225-939.

4.2.2 (Continued)

Stage ambient helium system leak checks were conducted next with the pneumatic control sphere and the LOX and LH_2 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 LH_2 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 6.0 scim allowable leakage at the vent ports. No unacceptable leakage was detected for any portion of the ambient helium systems.

After completing setup operations for pressurizing the LOX and LH_2 tank assembly, the O_2H_2 burner nozzle plug was installed in preparation for the burner propellant system leak checks. Pressurizing the LOX and LH_2 tank assembly with helium to 5 + 0, -1 psig, the O_2H_2 burner LH_2 propellant valve and LOX shutdown valve were checked for internal leakage at the burner nozzle plug monitoring ports; leakage was detected. Next, the burner nozzle plug monitoring ports were capped, and the burner propellant valves opened to lockup pressure between the tank assembly and nozzle plug to conduct external leak checks. The entire O_2H_2 burner propellant system was then checked externally for leakage from the tank assembly to the burner nozzle plug. No leaks were detected.

4.2.2 (Continued)

The burner propellant valves were then closed, the downstream systems vented, and the burner nozzle plug removed in preparation for the LOX and LH_2 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 LH_2 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 LH_2 tanks are listed in Test Data Table 4.2.2.1.

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 AMS 3159 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. No leaks were detected.

After venting the LOX low pressure duct, the LH_2 low pressure duct (propellant supply to the J-2 engine) was pressurized with helium at 10 to 30 psig while maintaining LOX tank and LH_2 tank pressures at 10 to 15 psig and 10 + 0, -1

4.2.2 (Continued)

psig, respectively. The LH_2 system for the LH_2 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 30 ±1 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 0.0017 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

4.2.2 (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 0.0012 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 other problem areas documented by FARR's other than those previously described. Twenty-three revisions were recorded in the procedure as follows:

a. Two revisions corrected errors in the procedure.

b. Two revisions corrected errors in other revisions.

c. Two revisions deleted the cold helium system leak check specified by the procedure and substituted the special cold helium system ambient leak check and torque check per Test Request 1316.

d. One revision updated the checklist used for the special cold helium system leak check and torque check based on the existing configuration.

4.2.2 (Continued)

e. One revision authorized procedure changes to increase the J-2 engine thrust chamber system leak check pressure from 9 + 1, -0 psig to 30 $\pm$1 psig.

f. One revision deleted procedure steps for taking fuel and LOX tank gas samples, indicating that gas samples for analysis of propellant tank helium concentration were taken during task 49.

g. One revision authorized a special test setup to determine the approximate vacuum level in the lower LH_2 low pressure duct because of no response from the vacuum probe installed.

h. One revision deleted the start tank vent valve actuation drying procedure which was not required for the new configuration pneumatic power control module.

i. Two revisions deleted all steps of the procedure dealing with the O_2H_2 burner LOX propellant valve because this valve had been eliminated from the configuration.

j. One revision repeated a test setup which had been removed for concurrent integrated systems testing (IST).

k. One revision provided for temporary copying of the cold helium dump outlet tee to permit pressurizing the cold helium bottles while using a cold helium dump valve with internal leakage during concurrent IST testing.

l. One revision provided requirements for testing and leak checking the new replacement cold helium dump module.

m. One revision provided a special test setup to leak check the LH_2 tank pressurization line. No leaks were detected.

n. One revision authorized a special leak test of the augmented spark ignitor (ASI) secondary seal by means of a pressure decay check of the primary and secondary seal cavity. Leakage was not detected.

o. Three revisions authorized special torque checks which were concerned with investigations of hydrogen leakage detected during stage static firing only.

p. One revision deleted procedure requirements for engine and stage purges because the purges were accomplished per H&CO IB73265.

4.2.2 (Continued)

q. One revision added a requirement to safety wire all leak check plugs after completion of leak checks in preparation for stage storage.

4.2.2.1 Test Data Table, Final Postfire Propulsion System Leak Checks

Stage Vacuum Duct Readings

	Reading (Microns)	Limits (Microns)
LH_2 LPD Upper	185	Less than 250
LH_2 LPD Lower	200†	Less than 250
LH_2 Recirculation	40	Less than 250
O_2H_2 Burner Propellant Upper	120	Less than 250
O_2H_2 Burner Propellant Lower	10	Less than 250
O_2H_2 Burner Propellant	100	Less than 250

Ambient Helium System Pressure Decay Checks

	Initial (psig)	Final (psig)	Limits
Control Helium Sphere Pressure	1380	1345	*
LOX Repressurization Sphere Pressure	1360	1325	*
LH_2 Repressurization Sphere Pressure	1325	1300	*
Control Helium Regulator Discharge Pressure	535	532	*

Control Pneumatics System Pressure Decay Test

	Initial (psig)	Final (psig)	Limits
Control Helium Regulator Discharge Pressure	537	533	*

LOX and LH_2 Tank Helium Concentration

		Reading (per cent)	Limits (per cent)
LOX Tank:	Top	100	75 min
	Bottom	98.7	75 min
LH_2 Tank:	Top	99.8	75 min
	Bottom	99.6	75 min

† Estimated. Refer to FARR 500-225-939
* Limits Not Specified

4.2.2.1 (Continued)

LOX and LH_2 Tank Pressure Decay Test

	Initial (psig)	Final (psig)	Limits
LOX Tank	14.5	14.6	*
LH_2 Tank	10.0	10.0	*

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	19.0	20 max
Ignition Phase Solenoid On	15.0	20 max
Mainstage Solenoid On	6.4	20 max

* Limits Not Specified

4.2.3 Stage Power Setup (1B55813 F)

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 intial setup sequences. After the procedure was successfully demonstrated, it was used to establish initial conditions during subsequent postfire automatic procedures.

This procedure was successfully demonstrated on 19 July 1968. The measurements recorded are shown in Test Data Table 4.2.3.1.

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 LH_2 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 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 were turned on.

4.2.3 (Continued)

The bus 4D131, 28 vdc power was turned on, and the forward bus 1 initial current and voltage were measured. The range safety safe and arm device was verified to be in the safe condition.

The 70 pound ullage engine relay, the LH_2 and LOX repressurization mode relay, the LH_2 and LOX repressurization control valve relay, and the O_2H_2 burner propellant valve relay were reset. The LH_2 continuous vent and relief overboard valve was verified to be closed.

The propellant utilization boiloff bias was turned off, and the O_2H_2 burner spark systems 1 and 2 voltages were measured and recorded. It was verified that the O_2H_2 burner LOX valve, LOX shutdown valve, LH_2 valve, and the LH_2 continuous vent orificed bypass valve were closed.

The forward bus 1 quiescent current was measured; then, the PCM system group was turned on and the amperage of the PCM system group was measured. The cold helium supply shutoff valve was closed. The aft 1 power supply current and voltage were measured, and it was verified that the aft 1 local sensor was off. Sequencer power was turned on, the forward bus 2 current and voltage were measured, and it was verified that the forward 2 local sensor was off.

The prelaunch checkout group power was turned on, and the current was measured. The forward and aft battery load test off commands were set; then, the DDAS ground station selector switch was manually set to position 1, and it was verified that the ground station was in synchronization. The EBW pulse sensor power was turned off.

4.2.3 (Continued)

A series of checks verified that stage functions were in the proper state. Forty functions were verified to be off, and twenty functions were verified to be on. The LOX and LH_2 prevalves and chilldown shutoff valves were verified to be open, and the LOX and LH_2 vent valves and fill and drain valves were verified to be closed.

The final operations measured the forward and aft 5 volt excitation module voltages, the range safety firing unit charging voltages, the aft bus 2 voltages, the forward and aft battery simulator voltages, and the component test power voltages.

No problems were encountered during the test, and no FARR's were initiated. There were twenty-two revisions made to the procedure for the following:

a. Sixteen revisions added or changed the program and/or requirements that were missing or in error.

b. Five revisions were required to update the procedure to the latest configuration.

c. One revision changed the tolerance of the external bus voltage from 28 ±0.5 vdc to 28 ±2.0 vdc. The bus voltage cannot be maintained within the original 28 ±0.5 vdc prior to applying power to the stage.

4.2.3.1 Test Data Table, Stage Power Setup

Function	Measured Value	Limits
Forward Bus 1 Power Supply Current (amps)	5.10	20 max
Bus 4D31 Forward 1 Voltage (vdc)	28.16	28 ± 2
O_2H_2 Burner Spark System 1 Voltage (vdc)	0.00	0 ∓ 0.5
O_2H_2 Burner Spark System 2 Voltage (vdc)	0.00	0 ∓ 0.5
Forward Bus 1 Quiescent Current (amps)	1.40	5 max
PCM System Group Current (amps)	3.80	5 ± 3
Aft 1 Power Supply Current (amps)	0.40	2 max

4.2.3.1 (Continued)

Function	Measured Value	Limits
Bus 4D11 Aft 1 Voltage (vdc)	28.00	28 ± 2
Sequencer Power (amps)	0.20	3 max
Forward Bus 2 Power Supply Current (amps)	0.30	2 max
Bus 4D21 Forward 2 Voltage (vdc)	27.50	28 ± 2
Prelaunch Checkout Group Current (amps)	1.30	4 ± 4
Aft 5v Excitation Module Voltage (vdc)	4.99	5.00 ± 0.030
Fwd 1, 5v Excitation Module Voltage (vdc)	5.01	5.00 ± 0.030
Fwd 2, 5v Excitation Module Voltage (vdc)	5.01	5.00 ± 0.030
Range Safety 1 EBW Firing Unit Chg Voltage (vdc)	0.01	0 ± 1
Range Safety 2 EBW Firing Unit Chg Voltage (vdc)	0.01	0 ± 1
Bus 4D41 Aft Bus 2 Voltage (vdc)	0.00	0 ± 1
Bus 4D30 Fwd Battery 1 Voltage (vdc)	0.08	0 ± 1
Bus 4D20 Fwd Battery 2 Voltage (vdc)	0.00	0 ± 1
Bus 4D10 Aft Battery 1 Voltage (vdc)	0.00	0 ± 1
Bus 4D40 Aft Battery 2 Voltage (vdc)	0.00	0 ± 1
Component Test Power Voltage (vdc)	0.68	0 ± 1

4.2.4 Stage Power Turnoff (1B55814 E)

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 19 July 1968. Stage power turnoff measurement values for this demonstration issue are tabulated in Test Data Table 4.2.4.1. 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

4.2.4 (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 turnoff.

There were no discrepancies recorded by FARR's against this test. Two revisions were recorded in the procedure for the following:

a. One revision deleted two steps pertaining to the LOX shutdown valve because it did not exist on the stage.

b. One revision added ALCO statements to set switch selector channel 108 for the LH_2 continuous vent relay orificed open per ECP 2424, WRO 4043.

4.2.4.1 Test Data Table, Stage Power Turnoff

	Measurement	Limit
Forward Bus 1 Voltage, Power On (vdc)	27.96	28 + 2
Aft Bus 1 Voltage, Power On (vdc)	28.00	28 ± 2
O_2H_2 Burner Spark System 1 Voltage (vdc)	0.00	0 ± 0.5
O_2H_2 Burner Spark System 2 Voltage (vdc)	0.01	0 ± 0.5
Forward Bus 1 Battery Simulator Voltage (vdc)	0.00	0 ± 2
Forward Bus 2 Battery Simulator Voltage (vdc)	-0.04	0 ± 2
Aft Bus 1 Battery Simulator Voltage (vdc)	0.00	0 ± 2
Aft Bus 2 Battery Simulator Voltage (vdc)	0.00	0 ± 2
Forward Bus 1 Voltage, Power Off (vdc)	0.08	0 ± 1
Forward Bus 2 Voltage, Power Off (vdc)	0.00	0 ± 1
Aft Bus 1 Voltage, Power Off (vdc)	0.00	0 ± 1
Aft Bus 2 Voltage, Power Off (vdc)	0.00	0 ± 1

4.2.5 <u>Integrated System Test (1B55831 G)</u>

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 19 July 1968, and were accepted on 26 July 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. At the conclusion of the DDAS test, the output was again received by the 600 Hz VCO. During the CP1-BO multiplexer test, thirty-seven functions were verified to be off, and twenty

4.2.5 (Continued)

functions were verified to be on. The DP1-BO multiplexer test verified that seven functions were off, and thirteen were on. Measurements recorded for the multiplexer tests are listed in Test Data Table 4.2.5.1.

The torch and water test was performed satisfactorily. Following setup of the console GH_2 supply, the GH_2 ignitors, the diffuser water, the deflection plate water, and the aspirator water were functioned in sequence. This series of events verified that the proper water pressures and torch ignition signals were received.

During the stage valves and O_2H_2 burner functional checkouts, the LH_2 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 LH_2 valves were opened and boosted closed while the boost close times were measured. The LOX and LH_2 prevalves and chilldown shutoff valves were closed and opened while the operating times were measured. The LH_2 directional vent valve was set to the flight and ground positions while the operating times were measured; then, a simulated O_2H_2 burner firing flight sequence was conducted. Valve operating times are listed in Test Data Table 4.2.5.1.

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

4.2.5 (Continued)

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.

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 LH_2 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.

4.2.5 (Continued)

FARR 500-372-176 reported that coaxial contact No. 11 of the LH_2 feed-through receptacle 410A1J6, P/N 4703-14-0024, had a piece of foreign material imbeded in the teflon sleeve and that the contact depth was 0.047 inches. The depth should have been 0.050 inch minimum per DPS 54002-10. The contact and sleeve assemblies were removed and replaced. FARR 500-372-133 reported that the D209 transducer, P/N 1B31356-505, was shorted causing out-of-tolerance readings. The transducer was removed and replaced. All problem areas were resolved by the thirty-nine revisions recorded in the procedure as follows:

a. Eleven revisions concerned additions or corrections of TRD, program, and procedure that were missing or in error.

b. Four revisions updated the program to conform to current design requirements.

c. Three revisions attributed the out-of-tolerance readings of measurement D209 to a defective transducer. Reference FARR 500-372-133.

d. Three revisions concerned the "LH_2 point level sensor 2 not off" malfunction which was caused by a faulty level sensor cable contact. Proper operation was verified after replacement per FARR 500-372-176.

e. Three revisions deleted steps and/or requirements that were for prefire conditions.

f. Two revisions entered the necessary PU constants into the program.

g. Two revisions were associated with GSE system malfunctions which had no effect on the stage hardware.

h. Two revisions stated that the ASI probe was burned out during static firing causing an "ASI ignition detect SIM not off" malfunction.

i. One revision attributed a SIM interrupt to a stage wiring change.

4.2.5 (Continued)

j. One revision explained that reception of a SIM channel 145 interrupt was caused by a program arrangement.

k. One revision changed the aft bus 2 voltage from 60.5 ±1.5 vdc to 60.5 + 3.5, -1.5 vdc as the secondary battery for the aft bus 2 had been moved from the 6th level of the test stand to the 10th level. The extra tolerance was required to compensate for the additional voltage drop.

l. One revision attributed the out-of-tolerance LH_2 sled supply pressure to the initial setup pressure being above the 25 ±5.0 psia tolerance. The pressure was lowered to the required tolerance.

m. One revision stated that the LH_2 replenish valve "not open" malfunction was due to the LH_2 sled pressure being excessively lowered to allow proper operation of the valve.

n. One revision attributed the "stage 3 helium not pressurized in time" malfunction to an improper initial setup.

o. One revision attributed the "LOX cold helium dump valve did not open" malfunction to a capped vent port which prevented the cold helium sphere pressure from decaying to less than 200 psia within 120 seconds.

p. One revision stated that due to a defective side load recorder, it was necessary to skip segment 7, hydraulic system setup temporarily.

q. One revision was written and subsequently voided.

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)	2438.250	2350.000 ± 125.000
M025	Hi RACS Test (vdc)	3.999	4.000 ± 0.050
M025	Lo RACS Test (vdc)	0.000	0.000 ± 0.050
M025	Amb Output (vdc)	4.984	5.000 ± 0.030
D236	Hi RACS Test (vdc)	3.984	4.000 ± 0.100
D236	Lo RACS Test (vdc)	1.005	1.000 ± 0.100
D236	Amb Output (psia)	20.565	14.700 ± 70.000
D225	Hi RACS Test (vdc)	3.994	4.000 ± 0.100

4.2.5.1 (Continued)

Meas No.	Function	Measurement	Limits
D225	Lo RACS Test (vdc)	1.015	1.000 ± 0.100
D225	Amb Output (psia)	11.865	14.700 ± 10.000
D016	Hi RACS Test (vdc)	3.989	4.000 ± 0.100
D016	Lo RACS Test (vdc)	0.999	1.000 ± 0.100
D016	Amb Output (psia)	6.680	14.700 ± 70.000
D019	Hi RACS Test (vdc)	4.061	4.062 ± 0.050
D019	Lo RACS Test (vdc)	1.066	1.062 ± 0.050
D019	Amb Output (psia)	68.471	14.700 ± 70.000
D018	Hi RACS Test (vdc)	4.066	4.066 ± 0.050
D018	Lo RACS Test (vdc)	1.066	1.066 ± 0.050
D018	Amb Output (psia)	15.300	14.700 ± 15.000
M024	Hi RACS Test (vdc)	4.015	4.000 ± 0.050
M024	Lo RACS Test (vdc)	0.000	0.000 ± 0.050
M024	Amb Output (vdc)	5.004	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)	4.999	5.000 ± 0.030
D017	Hi RACS Test (vdc)	4.061	4.066 ± 0.050
D017	Lo RACS Test (vdc)	1.066	1.066 ± 0.050
D017	Amb Output (psia)	17.004	14.700 ± 30.000
G001	Amb Output (°F.)	-0.426	-0.300 ± 0.400
G002	Amb Output (°F.)	0.361	0.300 ± 0.400
D020	Hi RACS Test (vdc)	4.081	4.000 ± 0.100
D020	Lo RACS Test (vdc)	1.015	1.000 ± 0.100
D020	Amb Output (psia)	5.607	14.700 ± 70.000
D177	Amb Output (psia)	14.644	14.700 ± 1.000
D178	Amb Output (psia)	14.839	14.700 ± 1.000
D088	Hi RACS Test (vdc)	3.938	4.000 ± 0.100
D088	Lo RACS Test (vdc)	1.046	1.000 ± 0.100
D088	Amb Output (psia)	9.348	14.700 ± 70.000
D179	Amb Output (psia)	14.824	14.700 ± 1.000
D180	Amb Output (psia)	14.418	14.700 ± 1.000
L007	Amb Output (%)	47.560	50.000 ± 10.000

DP1-B0 Multiplexer Ambient Measurements and High and Low RACS Voltages

D236	Hi RACS Test (vdc)	3.984	4.000 ± 0.100
D236	Lo RACS Test (vdc)	0.999	1.000 ± 0.100
D236	Amb Output (psia)	20.565	14.700 ± 70.000
D043	Amb Output (psia)	2438.250	2350.000 ± 125.000
C138	Hi RACS Test (vdc)	4.010	4.000 ± 0.075
C138	Lo RACS Test (vdc)	0.010	0.000 ± 0.075
C138	Amb Output (°F.)	94.105	95.000 ± 16.000
M025	Amb Output (vdc)	4.974	5.000 ± 0.030
D209	Amb Output (psia)	4.778†	20.750 ± 11.950

† See Revision C.

4.2.5.1 (Continued)

Meas No.	Function	Measurement	Limits
M074	Amb Output (vdc)	-0.005	0.000 ± 0.075
M073	Amb Output (vdc)	-0.005	0.000 ± 0.075
D016	Hi RACS Test (vdc)	3.994	4.000 ± 0.100
D016	Lo RACS Test (vdc)	0.984	1.000 ± 0.100
D016	Amb Output (psia)	2.862	14.700 ± 70.000
D014	Amb Output (psia)	23.402	14.700 ± 13.000
D019	Hi RACS Test (vdc)	4.061	4.062 ± 0.050
D019	Lo RACS Test (vdc)	1.062	1.062 ± 0.050
D019	Amb Output (psia)	64.908	14.700 ± 70.000
M006	Amb Output (vdc)	27.845	28.000 ± 2.000
M007	Amb Output (vdc)	0.000	0.000 ± 1.000
D050	Amb Output (psia)	14.565	14.700 ± 3.000
D019	Hi RACS Test (vdc)	4.061	4.062 ± 0.050
D019	Lo RACS Test (vdc)	1.062	1.062 ± 0.050
D019	Amb Output (psia)	64.908	14.700 ± 70.000
M024	Hi RACS Test (vdc)	4.015	4.000 ± 0.050
M024	Lo RACS Test (vdc)	0.000	0.000 ± 0.050
M024	Amb Output (vdc)	5.003	5.000 ± 0.030
M068	Hi RACS Test (vdc)	3.994	4.000 ± 0.050
M068	Lo RACS Test (vdc)	0.000	0.000 ± 0.050
M068	Amb Output (vdc)	4.999	5.000 ± 0.030
D017	Hi RACS Test (vdc)	4.056	4.056 ± 0.050
D017	Lo RACS Test (vdc)	1.056	1.056 ± 0.050
D017	Amb Output (psia)	17.009	14.700 ± 30.000
C006	Hi RACS Test (vdc)	4.046	4.000 ± 0.075
C006	Lo RACS Test (vdc)	0.010	0.000 ± 0.075
C006	Amb Output (°F.)	96.156	95.000 ± 18.000
D103	Amb Output (psia)	14.729	14.700 ± 3.000
G001	Amb Output (°F.)	-0.426	-0.300 ± 0.400
G003	Amb Output (°F.)	0.346	0.300 ± 0.400
M010	Hi RACS Test (vdc)	4.025	4.000 ± 0.060
M010	Lo RACS Test (vdc)	1.020	1.000 ± 0.060
M010	Amb Output (vdc)	0.387	0.000 ± 1.000
D020	Hi RACS Test (vdc)	4.081	4.000 ± 0.100
D020	Lo RACS Test (vdc)	1.015	1.000 ± 0.100
D020	Amb Output (psia)	5.607	14.700 ± 70.000
C231	Hi RACS Test (vdc)	3.999	4.000 ± 0.075
C231	Lo RACS Test (vdc)	-0.005	0.000 ± 0.075
C231	Amb Output (°F.)	-155.555	-155.000 ± 8.000
C001	Hi RACS Test (vdc)	4.035	4.000 ± 0.075
C001	Lo RACS Test (vdc)	0.035	0.000 ± 0.075
C001	Amb Output (°F.)	111.746	95.000 ± 72.000
D177	Amb Output (psia)	14.583	14.700 ± 1.000
D178	Amb Output (psia)	14.778	14.700 ± 1.000
D105	Hi RACS Test (vdc)	3.958	4.000 ± 0.100

4.2.5.1 (Continued)

Meas No.	Function	Measurement	Limits
D105	Lo RACS Test (vdc)	1.020	1.000 ± 0.100
D105	Amb Output (psia)	12.956	14.700 ± 10.000
C230	Hi RACS Test (vdc)	4.020	4.000 ± 0.075
C230	Lo RACS Test (vdc)	-0.015	0.000 ± 0.075
C230	Amb Output (°F.)	-378.438	-379.000 ± 4.000
D088	Hi RACS Test (vdc)	3.934	4.000 ± 0.100
D088	Lo RACS Test (vdc)	1.046	1.000 ± 0.100
D088	Amb Output (psia)	5.607	14.700 ± 70.000
C002	Hi RACS Test (vdc)	4.010	4.000 ± 0.075
C002	Lo RACS Test (vdc)	0.000	0.000 ± 0.075
C002	Amb Output (°F.)	89.395	95.000 ± 48.000
D179	Amb Output (psia)	14.944	14.700 ± 1.000
D180	Amb Output (psia)	14.358	14.700 ± 1.000
M026	Amb Output (vac)	0.000	0.000 ± 1.500
M027	Amb Output (vac)	0.000	0.000 ± 1.500
M041	Amb Output (vac)	-0.066	0.000 ± 1.500
M040	Amb Output (vac)	0.000	0.000 ± 1.500
M060	Hi RACS Test (vdc)	4.040	4.000 ± 0.100
M060	Lo RACS Test (vdc)	1.015	1.000 ± 0.100
M060	Amb Output (vac)	4.102	6.000 ± 6.000
M061	Hi RACS Test (vdc)	3.969	4.000 ± 0.100
M061	Lo RACS Test (vdc)	1.020	1.000 ± 0.100
M061	Amb Output (vdc)	-0.267	0.000 ± 1.000
L007	Amb Output (%)	47.685	50.000 ± 10.000
C199	Hi RACS Test (vdc)	4.035	4.000 ± 0.075
C199	Lo RACS Test (vdc)	-0.021	0.000 ± 0.075
C199	Amb Output (°F.)	96.436	77.000 ± 21.000
D054	Hi RACS Test (vdc)	3.989	4.000 ± 0.100
D054	Lo RACS Test (vdc)	1.025	1.000 ± 0.100
D054	Amb Output (psia)	14.702	14.700 ± 2.000

Valve Functional Check

Function	Measurement		Limits
LH_2 & LOX Prevalves	Close Time (sec)	0.390	4.000 max
	Open Time (sec)	1.839	4.000 max
LH_2 Vent Valve	Open Time (sec)	0.117	4.000 max
	Close Time (sec)	0.565	4.000 max
LOX Vent Valve	Open Time (sec)	0.126	4.000 max
	Close Time (sec)	0.394	4.000 max
LH_2 & LOX C/D SOV	Close Time (sec)	0.237	4.000 max
	Open Time (sec)	1.165	4.000 max

4.2.5.1 (Continued)

Function	Measurement		Limits
LH_2 Vent Valve	Open Time (sec)	0.089	4.000 max
	Close Time (sec)	0.540	4.000 max
	Open Time (sec)	0.090	4.000 max
	Close Time (sec)	0.314	4.000 max
LOX Vent Valve	Open Time (sec)	0.086	4.000 max
	Close Time (sec)	0.365	4.000 max
	Open Time (sec)	0.085	4.000 max
	Close Time (sec)	0.367	4.000 max
LH_2 Fill & Drain Valve	Open Time (sec)	0.279	4.000 max
	Close Time (sec)	2.342	4.000 max
	Open Time (sec)	0.282	4.000 max
	Close Time (sec)	0.884	4.000 max
LOX Fill & Drain Valve	Open Time (sec)	0.258	4.000 max
	Close Time (sec)	2.307	4.000 max
	Open Time (sec)	0.255	4.000 max
	Close Time (sec)	0.931	4.000 max
LH_2 & LOX Prevalves	Close Time (sec)	0.345	4.000 max
	Open Time (sec)	1.810	4.000 max
LH_2 & LOX C/D SOV	Close Time (sec)	0.197	4.000 max
	Open Time (sec)	1.124	4.000 max
LH_2 Dir Vent Valve	Dir Vent to Flt Pos (sec)	0.233	4.000 max
	Dir Vent to Grd Pos (sec)	0.213	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	-0.05	0.10	0.04	-0.03	0.03	0.03
1° pitch 0° yaw	6.60	0.05	0.87	-0.01	0.89	0.07
0° pitch 0° yaw	-0.10	0.10	-0.05	0.00	-0.03	0.04

4.2.5.1 (Continued)

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 0° yaw	-6.80	0.10	-1.07	0.00	-1.06	0.06
0° pitch 0° yaw	-0.05	0.05	0.04	0.00	0.03	0.04
0° pitch 1° yaw	-0.10	-6.55	0.04	-0.83	0.07	-0.77
0° pitch 0° yaw	-0.10	0.05	0.03	-0.03	0.07	0.07
0° pitch 1° yaw	-0.05	6.65	0.04	0.99	0.06	1.02
0° pitch 0° yaw	-0.10	0.05	0.04	0.00	0.06	0.06

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	0.10	-0.02	0.00	-0.03	0.06
1° pitch 0° yaw	6.60	0.00	1.03	0.00	1.03	0.04
0° pitch 0° yaw	-0.15	0.10	-0.05	0.00	-0.04	0.06
1° pitch 0° yaw	-6.70	0.00	-1.05	-0.01	-1.06	0.06
0° pitch 0° yaw	-0.10	0.05	-0.00	-0.01	0.00	0.04
0° pitch 1° yaw	-0.05	-6.50	0.01	-1.00	0.03	-0.93
0° pitch 0° yaw	-0.10	0.00	0.01	0.02	0.01	0.07

4.2.5.1 (Continued)

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 1° yaw	0.00	6.70	0.01	1.02	0.01	1.09
0° pitch 0° yaw	-0.05	0.05	0.01	-0.01	0.01	0.06

Engine Gimbal Frequency Response

Axis (deg)	Desired Freq(Hz)	Actual Freq-F(Hz)	Time Lag-T (sec)	Phase Lag (360xTxF)	Cycles Gimb'd	Sample Time(sec)
0.25°Ptch	0.60	0.52	0.063	11.993	3.10	2.019
	5.00	4.28	0.046	70.795	10.84	2.040
	7.00	6.65	0.040	95.844	15.81	2.035
0.25°Yaw	0.60	0.55	0.066	13.083	3.14	2.003
	5.00	5.04	0.030	54.975	13.40	2.024
	7.00	6.83	0.024	60.000	15.86	2.005
0.50°Ptch	0.60	0.51	0.068	12.500	3.04	1.999
	5.00	4.25	0.036	55.270	10.69	2.037
	7.00	6.83	0.037	91.199	16.16	2.029
0.50°Yaw	0.60	0.54	0.066	12.884	3.11	1.998
	5.00	5.02	0.029	52.940	12.22	2.002
	7.00	7.01	0.035	88.767	16.37	2.010

4.2.6 Hydraulic System Postfire Operating and Securing (1B41006 A)

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.

This procedure was initiated on 24 July 1968, and satisfactorily completed on 31 July 1968. Components of the stage hydraulic system installed during this checkout included the main engine driven hydraulic pump, P/N 1A66240-503, S/N X457811; the auxiliary hydraulic pump, P/N 1A66241-511, S/N X454594; the hydraulic pitch and yaw actuator assemblies, P/N 1A66248-507, S/N's 84 and 71; and the accumulator/reservoir assembly, P/N 1B29319-519, S/N 00029.

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.

The accumulator/reservoir was charged with gaseous nitrogen, and the stage auxiliary hydraulic pump air bottle was 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 torque striped or lockwired to indicate proper torque. All bleed valves were verified to be closed, and all external signs of hydraulic fluid were rinsed from the system.

With the midstroke locks installed on the hydraulic actuators, the auxiliary hydraulic pump was turned on and operated for 6 minutes, bringing the system

4.2.6 (Continued)

pressure to the required 3600 ±100 psig. After shutting down the auxiliary pump, closed loop system fluid samples were obtained, for cleanliness evaluation, from the hydraulic actuators and the reservoir inlet sampling valve. Particle counts for the various micron ranges were acceptable for all initial samples, with the exception of the pitch actuator sample which had a high particle count for the 10 to 25 micron range. The hydraulic system was then run through the flush and fill routine to obtain acceptable particle counts. All repeat samples were acceptable.

Following closed loop sampling, the hydraulic system was refilled to replace the sampling fluid loss. During the system refill, the HPU was turned on and operated for 3 minutes with system pressure at 3650 psig; then, the shutdown sequence of the procedure was begun.

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 ($0^{\circ}F$ to $160^{\circ}F$). The HPU was turned on, and the system pressure was increased to 3650 ±50 psig, the bypass valve was opened, and the HPU 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

4.2.6 (Continued)

return pressure was decreased to 80 ± 5 psig. The 9 milliliter volume of fluid bled off was less than 16 milliliter maximum, as specified per design requirements.

The reservoir oil temperature was measured at 107.5°F, and a total of 160 milliliters of hydraulic fluid was removed at the drain valve, based on the curve for temperature versus drained fluid volume.

The HPU was disconnected from the stage system and secured. Hydraulic system preparations for stage removal from the test stand included depressurization of the GN_2 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.

There were no FARR's initiated as a result of this checkout. However, six revisions were recorded in the procedure for the following:

a. One revision provided instructions to correct a minor leak noted at a tubing connection between the auxiliary hydraulic pump and the hydraulic accumulator/reservoir. The leak was corrected by tightening the connection to the required torque.

b. Three revisions authorized instructions for the additional hydraulic system fill and flush procedure.

c. One revision modified the slope of the curve depicting temperature versus drained hydraulic fluid volume to provide for greater fluid thermal expansion during operation.

d. One revision was written to verify proper operation of measurement D209, auxiliary hydraulic pump motor gas pressure, following replacement of the transducer.

4.2.7 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 LH_2 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	031
Static Inverter-Converter	411A92A7	1A66212-507	00011
LOX Mass Probe	406A1	1A48430-511	C2
LH_2 Mass Probe	408A1	1A48431-513	D4C2
LOX Overfill Sensor	(Part of LOX Mass Probe)		
LOX Overfill Control Unit	404A72A4	1A68710-511.1	C9
LOX Fastfill Sensor	406A2C5	1A68710-1	D112
LOX Fastfill Control Unit	404A72A5	1A68710-511.1	C8
LH_2 Overfill Sensor	(Part of LH_2 Mass Probe)		
LH_2 Overfill Control Unit	411A92A24	1A68710-509	C41
LH_2 Fastfill Sensor	408A2C5	1A68710-1	E101
LH_2 Fastfill Control Unit	411A92A43	1A68710-509	C45

This postfire test was conducted on 26 July 1968, as part of an evaluation to determine how radiated radio frequency (RF) energy was affecting PU system telemetry measurements. Initial conditions for the test were established and 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 LH_2 coarse mass voltages, fine mass voltages, and loading voltages. After an evaluation of the computer printout,

4.2.7 (Continued)

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

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

The servo balance bridge gain test was conducted next. The ratio valve position was measured, and the LOX and LH_2 coarse and fine mass voltages were

4.2.7 (Continued)

measured through the AO and BO telemetry multiplexers. The measurements were repeated with the LOX and LH_2 bridge 1/3 checkout relays on, with the bridge 2/3 checkout relays on, with the bridge 2/3 checkout relays off, and again with the bridge 1/3 checkout relays off.

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

The valve movement test 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 positions 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 LH_2 bridge 1/3 checkout relay, then measuring the LH_2 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 ratio 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.

4.2.7 (Continued)

Test results are listed in Test Data Table 4.2.7.1. There were no FARR's initiated as a result of this test. However, thirteen revisions were recorded in the procedure for the following:

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

b. Two revisions updated the procedure based on the existing stage configuration.

c. 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.

d. One revision provided instructions for a program change made to prevent the forward bus 2 power supply from over regulating when the PU inverter and electronics assembly were turned on.

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

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

g. One revision bypassed a computer command which did not affect the test. The engine pump seal purge heater was turned off because of engine purging requirements.

h. One revision changed the tolerance range from +1 vdc to +2 vdc for PU boiloff bias voltage based on ROD A3-250-KDLD-266.

i. One revision attributed a malfunction indication for measurement of LH_2 fine mass voltage during the servo balance bridge gain test to the use of air instead of helium as the environmental purge gas. Helium was used to calibrate the system and air increased the probe capacitance, resulting in increased bridge potentiometer slew.

4.2.7.1 Test Data Table, Propellant Utilization System

Loaded Ratio Values (from H&CO 1B64368)

LOX Empty Ratio	0.021	LH_2 Empty Ratio	0.000
LOX 1/3 Bridge Slew Ratio	0.283	LH_2 1/3 Bridge Slew Ratio	0.310
LOX 2/3 Bridge Slew Ratio	0.569	LH_2 2/3 Bridge Slew Ratio	0.639
LOX Wiper Ratio	0.040	LH_2 Wiper Ratio	0.014

LH_2 Boiloff Bias Voltage (vdc) 12.007

4.2.7.1 (Continued)

Computed Coarse Mass Voltages (vdc)

LOX Empty	0.103	LH_2 Empty	0.000
LOX 1/3 Mass	1.416	LH_2 1/3 Mass	1.548
LOX 2/3 Mass	2.847	LH_2 2/3 Mass	3.193

Computed Fine Mass Voltages (vdc)

LOX Empty	4.009	LH_2 Empty	1.367
LOX 1/3 Mass	0.249	LH_2 1/3 Mass	2.339
LOX 2/3 Mass	2.207	LH_2 2/3 Mass	4.590

Computer Loading Voltages (vdc)

LOX Empty	0.574	LH_2 Empty	0.000
LOX 1/3 Coarse Mass	7.930	LH_2 1/3 Coarse Mass	8.668

PU System Power Test

Function	Measured Value	Limits
Inv-Conv 115 vrms Output (vac)	114.736	115.0 ± 3.4
Inv-Conv 21 vdc Output (vdc)	21.439	21.25 ± 1.25
Inv-Conv 5 vdc Output (vdc)	4.927	4.9 ± 0.2
Inv-Conv Frequency (Hz)	399.266	400.0 ∓ 6
PU Oven Monitor Voltage Z1 (vdc)	1.969	2.6 ∓ 2.35
PU Oven Monitor Voltage Z2 (vdc)	1.969	1.969 ± 0.075
PU Oven Monitor Voltage Z3 (vdc)	1.974	1.969 ∓ 0.075
PU Oven Monitor Voltage - Final (vdc)	1.974	1.969 ± 0.075
PU Oven Monitor Voltage - High RAC (vdc)	3.933	4.0 ± 0.075
PU Oven Monitor Voltage - RACS Run Mode on (vdc)	1.969	1.974 ± 0.075
PU Oven Monitor Voltage - Low RAC (vdc)	-0.021	0.0 ± 0.075
PU Oven Monitor Voltage - RACS Run Mode on (vdc)	1.969	1.974 ± 0.075

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	0.122	0.103 ∓ 0.1
LOX Fine Mass Voltage (vdc)		4.194	4.180	4.009 ∓ 0.4
LH_2 Coarse Mass Voltage (vdc)		-0.005	0.005	0.000 ∓ 0.1
LH_2 Fine Mass Voltage (vdc)		1.641	1.646	1.367 ∓ 0.4

4.2.7.1 (Continued)

PU Loading Test

Function	Measured Value	Limits
LH_2 Boiloff Bias Signal Volt. (vdc)	13.350	12.007 $\pm$ 2.0
GSE Power Supply Voltage (vdc)	29.199	28.0 $\pm$ 2.0

Loading Potentiometer Function	LOX Value	LH_2 Value	Limits
Sense Voltage, GSE Power On (vdc)	29.158	29.158	29.199 $\pm$ 0.4
Signal Voltage, Relay Commands	0.574		0.574 $\pm$ 0.5
Off (vdc)		-0.027	0.0 $\pm$ 0.5
Signal Voltage, Relay Commands	7.793		7.930 $\pm$ 0.6
On (vdc)		8.449	8.668 $\pm$ 0.6
Signal Voltage, Relay Commands	0.574		0.574 $\pm$ 0.5
Off (vdc)		-0.027	0.0 $\pm$ 0.5
Sense Voltage, GSE Power OFF (vdc)	0.039	0.000	0.0 $\pm$ 0.75

Servo Balance Bridge Gain Test

Function	Measured Value	AO Multi	BO Multi	Limits
Ratio Valve Position (deg)	0.419			0.351 $\pm$ 1.5
LOX Coarse Mass Voltage (vdc)		0.112	0.122	0.103 $\pm$ 0.1
LOX Fine Mass Voltage (vdc)		4.185	4.185	4.009 $\pm$ 0.4
LH_2 Coarse Mass Voltage (vdc)		0.000	0.005	0.000 $\pm$ 0.1
LH_2 Fine Mass Voltage (vdc)		1.646	1.646	1.367 $\pm$ 0.4
1/3 Checkout Relay Commands On				
Ratio Valve Position (deg)	0.965			0.351 $\pm$ 1.5
LOX Coarse Mass Voltage (vdc)		1.426	1.426	1.416 $\pm$ 0.1
LOX Fine Mass Voltage (vdc)		0.088	0.088	0.249 $\pm$ 0.4
LH_2 Coarse Mass Voltage (vdc)		1.563	1.563	1.548 $\pm$ 0.1
LH_2 Fine Mass Voltage (vdc)		2.627	2.627	2.339 $\pm$ 0.4
2/3 Checkout Relay Commands On				
Ratio Valve Position (deg)	1.374			0.351 $\pm$ 1.5
LOX Coarse Mass Voltage (vdc)		2.856	2.866	2.847 $\pm$ 0.1
LOX Fine Mass Voltage (vdc)		1.890	1.890	2.207 $\pm$ 0.4
LH_2 Coarse Mass Voltage (vdc)		3.223	3.213	3.193 $\pm$ 0.1
LH_2 Fine Mass Voltage (vdc)		4.980	4.980	4.590 $\pm$ 0.4

4.2.7.1 (Continued)

Function	Measured Value	AO Multi	BO Multi	Limits
2/3 Checkout Relay Commands Off				
Ratio Valve Position (deg)	1.033			0.351 ± 1.5
LOX Coarse Mass Voltage (vdc)		1.421	1.426	1.416 ∓ 0.1
LOX Fine Mass Voltage (vdc)		0.088	0.088	0.249 ∓ 0.4
LH_2 Coarse Mass Voltage (vdc)		1.558	1.567	1.548 ∓ 0.1
LH_2 Fine Mass Voltage (vdc)		2.627	2.637	2.339 ± 0.4
1/3 Checkout Relay Commands Off				
Ratio Valve Position (deg)	0.419			0.351 ± 1.5
LOX Coarse Mass Voltage (vdc)		0.107	0.122	0.103 ∓ 0.1
LOX Fine Mass Voltage (vdc)		4.175	4.209	4.009 ∓ 0.4
LH_2 Coarse Mass Voltage (vdc)		0.000	0.000	0.000 ∓ 0.1
LH_2 Fine Mass Voltage (vdc)		1.641	1.646	1.367 ± 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)	0.994	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)	4.977	2.659 to 7.396
V3, Position at T+8 Seconds (deg)	5.591	2.977 to 7.396
V4, Position at T+20 Seconds (deg)	5.864	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)	0.42	0.351 ± 1.5
-1 vdc System Test Valve Error Signal (vdc)	-1.005	-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)	-4.498	-2.659 to -7.396
V3, Position at T+8 Seconds (deg)	-5.180	-2.977 to -7.396
V4, Position at T+20 Seconds (deg)	-5.317	-5.226 to -7.396
V5, Position at T+50 Seconds (deg)	-5.317	-5.226 to -7.396

4.2.7.1 (Continued)

PU Activation Test

Function	AO Multi	BO Multi	Limits
Ratio Valve Position (deg)	0.351	0.282	0.351 ± 1.50
LOX 1/3 Command Relay On			
LOX Coarse Mass Voltage (vdc)	1.426	1.431	1.416 ± 0.1
PU System On			
Ratio Valve Position (deg)	33.280	33.280	20.0 min
PU System Off			
Ratio Valve Position (deg)	0.965	0.692	15.0 max
LOX 1/3 Command Relay Off			
LOX Coarse Mass Voltage (vdc)	0.107	0.122	0.103 ± 0.1
Ratio Valve Position (deg)	0.487	0.487	0.351 ± 1.5
LH_2 1/3 Command Relay On			
LH_2 Coarse Mass Voltage (vdc)	1.558	1.563	1.548 ± 0.1
PU System On			
Ratio Valve Position (deg)	-26.851	-26.851	-20.0 max
PU System Off			
Ratio Valve Position (deg)	0.42	-	-15.0 min
LH_2 1/3 Command Relay Off			
LH_2 Coarse Mass Voltage (vdc)	-0.005	0.010	0.000 ± 0.1
Ratio Valve Position (deg)	0.419	0.351	0.351 ± 1.5

PU Valve Hardover Test

Ratio Valve Position (deg)	-27.123	-	-20.0 max

4.2.8 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 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 prior to and during shipment.

The postfire TCS checkout was initiated on 30 July 1968, and was successfully completed on 31 July 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.

4.2.8 (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 at 85°F and the return temperature at 84°F.

Next, the TCS was purged of water/methanol with GN_2 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 welds, and manifold bellows. No leakage was detected. The freon was then purged from the TCS using GN_2 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. Four revisions were recorded in the procedure for the following:

4.2.8 (Continued)

a. One revision corrected a procedure error.

b. One revision authorized an additional particle count as a cleanliness check for particles in the 100 to 175 micron range, a range not specified in the procedure for the cleanliness test.

c. One revision postponed final checking of water/methanol level in the TCS servicer reservoir, scheduling this to be accomplished per the procedure for the next stage tested.

d. One revision authorized a freon bottle substitution for the R12 freon bottle which was not installed in the TCS servicer.

4.3 Deferred Postfire Acceptance Testing

The deferred postfire acceptance operations were initiated on 25 November 1968, with the performance of the forward skirt thermoconditioning system checkout, paragraph 4.3.1. Acceptance of the forward skirt thermoconditioning system checkout and securing, paragraph 4.3.28, on 3 January 1969, completed the postfire retest requirements as delineated in the End Item Test Plan, 1B66684 K, dated 20 September 1968.

4.3.1 Forward Skirt Thermoconditioning System Checkout Procedure (1B41955 C)

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 poststorage 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.

Checkout of the TCS was accomplished between 25 November and 3 December 1968, and was certified as acceptable on 3 December 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. 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, and 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 system inlet sample had 5 particles in the 175-700 micron range (25 allowed), and one particle in the 700-2500 micron range and no particles above 2500 microns (none allowed). The system return sample had 0 particles in the 175-700 micron range, one particle in the 700-2500 range, and none in the 2500 micron range.

4.3.1 (Continued)

The specific gravity and temperature of the fluid were measured with a hydrometer and thermometer, respectively, determing that the water/methanol concentration was within the acceptable mixture range (delta P testing band).

A differential pressure test was conducted to verify correct system geometry and proper flow distribution. The test was conducted by measuring the differential pressure between the TCS inlet and outlet, plus the inlet and outlet temperatures, while maintaining a water/methanol flow rate of 7.8 $\pm$0.2 gpm. The differential pressure was recorded as 16.8 psi, while inlet and outlet temperatures were recorded at 56°F and 57°F, respectively. During this checkout, operation of the TCS was conducted with the servicer at the required temperatures, pressures, and flow rate while visually checking for water/methanol leakage at all water lines, internal piping, and supply and return lines to the TCS. No leakage was detected.

This procedure demonstrated that the system was prepared to support poststorage checkout activities on the test stand. There were no discrepancies recorded against the TCS as a result of this test. One revision was written to rerun the setup of the TCS servicer after replacement of the coolant and GN_2 supply hoses.

4.3.2 Propulsion Leak and Functional Check (1B71877 C)

This checkout procedure defined the operations required to perform the deferred postfire leak and functional checks for the stage propulsion system. Initiated on 26 November 1968, the checkout was completed and certified as acceptable on 30 December 1968. Leak check results for the individual propulsion system components are listed in Test Data Table 4.3.2.1.

After preliminary setup operations, the O_2H_2 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 O_2H_2 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

4.3.2 (Continued)

bottle supply, the engine control sphere supply, the LOX tank prepressurization supply, the LH_2 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 cirucits, plus the engine mainstage pressure switch diaphragm pressure decay test. The LOX and LH_2 pressure switch checkout circuits were pressurized with their individual supplies to 30 $\pm$ 5 psia and checked for external leakage. Similar leak checks were conducted for the low pressure switch checkout circuit at 600 $\pm$ 50 psia and the mainstage pressure switch checkout circuit at 500 $\pm$ 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 $\pm$ 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 LH_2 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 LH_2 repressurization systems were tested for reverse leakage. After a control valve functional check for the ambient LOX and LH_2 repressurization modules, internal leak checks of the modules and the pneumatic power control module were performed. The control helium system and the LOX and LH_2

4.3.2 (Continued)

ambient repressurization systems were checked for external leakage. The actuation control modules were checked for internal leakage under functionsl test conditions. Finally, a pressure decay check of the pneumatic control system was performed over a 30-minute pressure lockup period.

Two external leaks were reported during the ambient helium system leak checks. One was corrected by a seal replacement and the other by tightening a loose connection. Also, reverse leakage of 0.42 scim for the ambient helium fill module check valve was accepted in a revision to the procedure (refer to discussion for revision "y").

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 ± 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. No unacceptable leakage was detected for the engine start system.

The LH_2 pressurization and repressurization systems tests started with a functional check of the O_2H_2 burner LH_2 repressurization control valves, leak

4.3.2 (Continued)

checks of the burner LH_2 repressurization control valve seat and pilot bleed valve, and a reverse leak check of the burner LH_2 check valve. The LH_2 repressurization system was pressurized to 450 $\pm$ 50 psig and checked for external leakage. The LH_2 pressurization system was checked similarly for external leakage at 450 $\pm$ 25 psig. In addition, reverse leak checks were performed for the LH_2 pressurization module check valve and the LH_2 prepressurization check valve. Measurements of leakage rates for the main components of the LH_2 repressurization and pressurization systems are listed in the test data table. There were no unacceptable leakages for these systems.

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. No unacceptable leaks were detected.

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 O_2H_2 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. No unacceptable leaks were recorded.

4.3.2 (Continued)

Leak checks were then performed on the LOX tank, the O_2H_2 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 shutoff valve seat leak check, a pump shaft seal leak check, and an external leak check of the pump purge circuit. Two areas of unacceptable leakage were detected in this section. One leak was corrected by replacing a seal between the LOX bleed valve and the gas generator. In addition the LOX prevalve, P/N 1A49968-521, S/N 101, was rejected on FARR 500-607-611 for excessive seat leakage. The valve flapper and seat were wiped and dried, and the valve was cycled 10 times. The leak check was then repeated successfully, measuring 40 scim which was within the allowable 150 scim maximum.

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 O_2H_2 burner LOX shutdown valve and an external leak check from the LOX tank to the O_2H_2 burner LOX shutdown valve were performed.

Leak checks were then performed on the LH_2 tank, the O_2H_2 burner, and the engine feed system. Internal leak checks of the engine feed system checked for seat leakage of the LH_2 prevalve and chilldown shutoff valve, the engine

4.3.2 (Continued)

LH_2 bleed valve, the engine main fuel valve, and checked for reverse leakage of the LH_2 chilldown return check valve. The LH_2 engine pump drain and purge check valves, the LH_2 turbine seal cavity purge check valve, and the LOX turbine seal cavity check valve were checked for reverse leakage. The LH_2 engine pump intermediate seal was checked for leakage. The LH_2 engine pump drain check valve was also checked for forward flow. Then the LH_2 tank and the engine feed system were leak checked. One leak detected between the upper and lower low pressure duct was corrected by seal replacement.

The LH_2 turbopump was checked for breakaway and running torque and for primary seal leakage. The LH_2 prevalve shaft seal was leak checked with the valve opened and closed. The LH_2 fill and drain valve was checked for seat leakage. Leak checks of the O_2H_2 burner LH_2 propellant valve seat and the LOX shutdown valve seat were made, as well as an external leak check of the O_2H_2 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 LH_2 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 LH_2 and LOX turbine seal cavity was conducted. External leak checks of the GG and exhaust system were also performed. Several areas of unacceptable leakage were detected and corrected. FARR's 500-489-758 and 500-607-521 documented excessive reverse leakage for the GG fuel and LOX purge check valves. These

4.3.2 (Continued)

valves were replaced and the new valves were leak checked acceptably. The initial start tank discharge valve gate seal leak check was not acceptable and the valve was replaced per ECP J2-640. The leak check of the new valve was acceptable, as listed in the test data table. A leak at the GG chamber pressure port, GG1A, was corrected by seal replacement. Leakage was noted at the plugged end of the hardwire stub-out for GF4, the LH_2 GG injector pressure port. The welded sleeve was also detected to be leaking at the lower weld. The leaks were corrected by installing a new plug and rewelding the sleeve.

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 LH_2 turbine seal cavity bleeds and the fuel pump seal cavity, and verified the GG fuel purge flow the LH_2 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.

4.3.2 (Continued)

The LOX and LH_2 vent system leak and flow checks included external leak checks of the LOX vent system and the LH_2 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 LH_2 vent and relief valve, the LH_2 latching relief valve, the bidirectional vent valve, and the LH_2 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.

Problem areas recorded on FARR tags that resulted from this checkout were limited to those previously discussed. However, eighty revisions were recorded in the procedure for the following:

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

b. Eleven revisions were required to update the procedure to the latest stage configuration.

c. Six revisions were incorporated to leak check hardware which was replaced subsequent to system leak checks.

d. Four revisions changed or deleted previous revisions or portions thereof.

e. One revision deleted the cold helium system torque checks which were postponed until new seals were installed per WRO S-IVB-4592.

4.3.2 (Continued)

f. Four revisions were deletions and changes based on hardware that was not installed for the postfire checkout.

g. Two revisions provided instructions to return to the original configuration after disassembly for leak check purposes.

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

i. One revision added the steps required to support concurrent test procedures.

j. One revision was needed to return equipment and/or stage hardware, being utilized in support of parallel procedures, to the leak check configuration.

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

l. One revision modified the allowable leakage rates for the LOX and LH_2 fill and drain valves to comply with the latest revisions of the specification control drawing.

m. One revision added notes to prevent introducing bubble soap solution into the stage systems.

n. One revision changed the procedure to prevent damage to the LH_2 directional vent valve.

o. One revision provided for venting the tanks through the fill and drain valves, when needed during the leak checks.

p. One revision changed the maximum allowable leakage for the hot gas bypass valve and pilot valve leakage from 3000 scim to 1000 scim.

q. Three revisions provided instructions to permit out-of-sequence leak checks.

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

s. Five revisions deleted portions of the procedure that were prefire checks.

t. Two revisions were written and subsequently voided.

4.3.2 (Continued)

u. One revision clarified the intent of the "black light" injector inspection procedure.

v. One revision deleted a procedure which was checked out during the manual controls test per H&CO 1B70177.

w. One revision provided a test setup to sample the bottom of the LH_2 and LOX tanks for helium and moisture content.

x. One revision deleted the pressure checks on the engine electrical instrumentation packages and the igniter cable. These had been previously accomplished during Rocketdyne modification R-5436-633.

y. One revision accepted the 0.42 scim reverse leakage for the ambient helium fill module check valve with test pressure at 1450 $\pm$ 50 psia, because the combined dump valve and check valve leakage was within the allowable combined leakage of the specification control drawing.

z. One revision authorized use of a substitute O_2H_2 burner exit nozzle plug.

4.3.2.1 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
LH_2 Prepress Supply, High Press (scim)	0.0	0
LH_2 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)	395.0	*
Final (psig)	392.0	*
Decay (psi)	3.0	10.0 max/15 minutes

* Limits Not Specified

4.3.2.1 (Continued)

Ambient Helium System Flow Checks

Function	Measurement	Limits
O_2H_2 LOX S/D Vlv Bellow Purge (scim)	45.0	70 ± 30
O_2H_2 LOX S/D Vlv Microsw Housing Purge Flow (scim)	3.0	3.5 ± 2

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

Function	S/N	Measurement	Limits
LOX Vent Purge (scim)	30	0.0	10 max
LOX Fill & Drain Purge (scim)	35	0.0	10 max
LH_2 Fill & Drain Purge (scim)	37	0.0	10 max
LH_2 Vent Purge (scim)	34	0.0	10 max

Ambient Helium Fill Module Internal Leak Checks (P/N 1A57350-507, S/N 0233)

Function	Measurement	Limits
Amb He Fill Module C/V Rev Lkg (scim)	0.42†	0
Amb He Fill Module Dump Vlv Seat Lkg (scim)	0.0	0

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)	87	0.0	10 max
LH_2 Repress Mod Backup Check Valve (scim)	38	5.0	10 max
LH_2 Repress Mod Ck Vlv (scim)	40	5.0	10 max
He Fill Mod Backup Check Valve (scim)	36	8.0	10 max

Ambient LOX and LH_2 Repress Module Internal Leak Checks

LOX Repress Module (P/N 1B69550-501, S/N 029)

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	*

* Limits Not Specified

† Refer To Revision y

4.3.2.1 (Continued)

Function	Measurement	Limits
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

LH_2 Repress Module (P/N 1B69550-501, S/N 023)

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 1024)

Function	Measurement	Limits
Control He Shutoff Seat Leakage (scim)	0	10 max
Control Module Reg Lockup Press (psig)	538	550 max

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

Function	S/N	Normal	Open	Closed	Limits
O_2H_2 Burner LOX S/D Vlv Cont Mod (scim)	83	0.0	0.0	0.0	6 max
O_2H_2 Burner LH_2 Vlv Cont Mod (scim)	95	0.0	0.0	0.0	6 max
Orificed Bypass Vlv Cont Mod (scim)	94	0.0	0.0	0.0	6 max

Function	S/N	Normal	Open	Boost	Limits
LOX Vent Vlv Cont Mod (scim)	82	0.0	0.0	0.0	6 max
LH_2 Fill & Drain Vlv Cont Mod (scim)	90	0.0	0.0	0.0	6 max
LOX Fill & Drain Vlv Cont Mod (scim)	92	0.0	0.0	0.0	6 max
LH_2 Vent Vlv Cont Mod (scim)	96	0.0	0.0	0.0	6 max

* Limits Not Specified

4.3.2.1 (Continued)

Function	Open	Closed	Limits
LH_2 F&D Act Seal Leakage (scim)	1.6	0.0	350 max
LOX F&D Act Seal Leakage (scim)	0.8	0.0	350 max
LOX S/D Vlv Act Piston & Shaft Seal Leakage (scim)	0.0	0.0	70 max
LH_2 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)	174	0.0	0.0	0.0	6 max

Function	S/N	Normal	Closed	Limits
Prevlv-C/D Vlv Act Cont Mod (scim)	74	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)	-	-	0.0	20 max

Function	S/N	Normal	Flight	Ground	Limits
Bidirect Vent Vlv Act Cont Mod (scim)	93	0.0	0.0	0.0	6 max

Function	S/N	Normal	Open	Latching	Limits
LH_2 Latching Relief Vlv Cont Mod (scim)	15	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)	554	548	*
Reg Disch Press - Vlv Pos, Activated (psig)	524	318	*

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
Dump Valve Bellows Leakage (scim)	0.0	0
Bottle Decay (Delta M) (lb-mass/hr)	0.0013	0.0066 max

* Limits Not Specified

4.3.2.1 (Continued)

LH_2 Repressurization System Leak Checks

Function	Measurement	Limits
O_2H_2 Burner Control Vlv Seat Lkg (scim)	0.0	*
O_2H_2 Burner Control Vlv Pilot Bleed Lkg (scim)	0.0	*
O_2H_2 Burner Mod Cont Vlv Int Lkg (scim)	0.0	12 max
O_2H_2 Burner Cont Vlv & Check Vlv Rev Lkg (scim)	0.0	*
O_2H_2 Burner Check Vlv Reverse Lkg (scim)	0.0	1.0 max
O_2H_2 Burner Coil Leakage (scim)	0.0	0

LH_2 Pressurization System Leak Check

Function	Measurement	Limits
LH_2 Press Module Check Vlv Rev Lkg (scim)	0.0	10 max
LH_2 Prepress Check Vlv Rev Lkg (scim)	0.0	0

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)	2.2	10 max
Thrust Chamber		
Pressure (psig)	25.0	20 min
Jacket Purge Check Vlv Rev Lkg (scim)	3.0	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	11.3 max
Shutoff Vlv Seat & Pilot Vlv Lkg-Low Press (scim)	0.0	12.5 max
Dump Vlv, Relief Vlv Seat & Pilot Bleed Lkg (scim)	0.0	12.5 max

* Limits Not Specified

4.3.2.1 (Continued)

Function	Measurement	Limits
LOX Press Module Internal		
Hot Gas Bypass Vlv Seat & Pilot Bleed Lkg (scim)	0.0	1000 max
O_2H_2 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 O_2H_2 Burner & Engine Feed System Leak Checks

Function	Measurement	Limits
LOX Tank Helium Content		
Top (%)	99.6	75 min
Bottom (%)	99.6	75 min
Engine Feed Sys Internal Leak Checks		
LOX Prevlv & Chilldown Shutoff Vlv Seat & Chilldown Return Check Vlv Lkg (scim)	410.0	*
LOX Chilldown Ret Check Vlv Rev Lkg (scim)	2.5	350 max
LOX Prevlv & Chilldown Shutoff Vlv Combined Seat Leakage (scim)	407.5†	150 max
LOX Bleed Vlv & Chilldown Return Check Vlv Rev Leakage (scim)	4.0	*
LOX Bleed Vlv Seat Leakage (scim)	1.5	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 Torque Checks		
Pump Primary Seal Leakage:		
Max (scim)	5.2	350 max
Min (scim)	0.75	*
Turbine Torque:		
Breakaway (in/lbs)	10	1000 max
Running (in/lbs)	10	200 max
LOX Chilldown Pump Purge Flow Checks		
Pump Purge Shutoff Vlv Seat Leakage (scim)	0.0	0
Pump Shaft Seal Leakage Tank Pressurized & Purge On (scim)	4.3	50 max
Pump Shaft Seal Lkg - LOX Tank Side (scim)	0.3	*
Pump Shaft Seal Lkg - Motor Canister Side (scim)	4.0	*

* Limits Not Specified

† Refer to FARR 500-607-611

4.3.2.1 (Continued)

Function	Measurement	Limits
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)	2.0	75 max
F&D Vlv Seat Leakage (scim)	0.0	100 max
F&D Vlv Primary Shaft Seal Lkg (scim)	0.0	31 max
O_2H_2 Burner LOX Shutdown Valve Checks		
Valve Actuator Bellows Lkg (scim)	0.0	*
Valve Seat Leakage (scim)	0.0	*

LH_2 Tank, O_2H_2 Burner & Engine Feed System Leak Checks

Function	Measurement	Limits
LH_2 Tank Helium Content		
Top (%)	100	75 min
Bottom (%)	99.9	75 min
Engine Feed System Internal Leak Checks		
LH_2 Prevlv & Childown 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
LH_2 Prevlv & C/D Shutoff Vlv Combined Seat Leakage (scim)	0.0	150 max
LH_2 Bleed Vlv & C/D Return Check Vlv Rev Leakage (scim)	0.0	*
LH_2 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		
LH_2 Pump Drain Check Vlv Rev Lkg (scim)	0.0	25 max
LH_2 Pump Drain Check Vlv Fwd Flow 30 psi (scim)	0.0	30 max
LH_2 Pump Drain Check Vlv Fwd Flow 60 psi (scim)	8250	2420 min
LH_2 Pump Purge Check Vlv Rev Lkg (scim)	0.0	25 max
LH_2 Pump Intermediate Seal Lkg (scim)	9.0	500 max
LH_2 Turbine Seal Cavity Prg Check Vlv Rev Leakage (scim)	6.0	25 max
LOX Turbine Seal Cavity Prg Check Vlv Rev Leakage (scim)	0.0	25 max
LH_2 Tank & Engine Feed System Leak Checks		
LH_2 Pump Speed Monitor Seal Bleed (scim)	0.0	0

* Limits Not Specified

4.3.2.1 (Continued)

Function	Measurement	Limits
LH_2 Turbopump Torque Checks		
LH_2 Pump Primary Seal Leakage:		
Max (scim)	12.2	350 max
Min (scim)	4.6	*
Turbine Torque:		
Breakaway (in/lbs)	20.0	1000 max
Running (in/lbs)	10.0	300 max
LH_2 Valves Leak Checks		
Prevlave 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
LH_2 Fill & Drain Vlv Primary Shaft Seal Leakage (scim)	0.0	31 max
O_2H_2 Burner LH_2 System Leak Check		
Combined Burner LH_2 Prop Vlv & LOX S/D Vlv Seat Leakage (scim)	0.0	*
Burner LH_2 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)	0.0	25 max
LH_2 Turbine Seal Leakage (scim)	2600	3000 scim max Above 2nd E&M Lkg Value (1)
LOX Turbine Seal Leakage (scim)	2.5	350 max
STDV Gate Seal Leakage (scim)	2.2	20 max
OTBV Shaft Seal Leakage (scim)	0	15 max
Oxid Manifold Carrier Flange Bleed (scim)	0.35	20 max
Hydraulic Pump Shaft Seal Lkg (scim)	0.8	228 max
GG LOX Prop Vlv Seat & LOX Pump Shaft Seal Leakage (scim)	0.0	20 max
Combined GG LOX & LH_2 Prop Vlv Seat & Pump Shaft Seal Lkg (scim)	0.0	*
GG LH_2 Prop Vlv Seat Lkg & Fuel Pump Omni Seal Lkg (scim)	0.0	15 max

* Limits Not Specified

(1) 2nd E&M Leakage Valve = 750 scim

4.3.2.1 (Continued)

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)	95	67 to 110
Pump Purge Flow Checks		
GG Fuel Purge Flow (scim)	4000	2400 min
LOX Turbine Seal Purge Flow (scim)	4000	2400 min
LH_2 Turbine Seal Purge Flow (scim)	3750	2400 min
Fuel Pump Seal Cavity Purge Flow (scim)	280	200 min

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)	0.2	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)	15	20 max
LOX Pump Intermediate Seal Purge Leak Checks		
Seal Leakage Pump Direction (scim)	0.0	*
Seal Leakage Turbine Direction (scim)	6	*
Seal Leakage Total (scim)	6	850 max
Seal Purge Check Vlv Overboard Flow (scim)	2500	*
Seal Purge Flow (scim)	2506	1300 to 3500
Ignition Phase Solenoid Energized Leak Checks		
Start Tnk Disch Vlv 4-Way Sol Seat Lkg (scim)	0.8	15 max
Internal Pneu Sys Lkg (Ign Phase Sol On) (scim)	17	20 max
Start Tank Discharge Valve Solenoid Energized Leak Checks		
STDV 4-Way Sol Seat Lkg (Energized) (scim)	1.2	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 Sold On) (scim)	12	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

* Limits Not Specified

4.3.2.1 (Continued)

Function	Measurement	Limits
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)	0.001	0.036 max

LOX & LH_2 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)	14.5	*
Combined LOX V&R and NPV Boose Piston Seal Lkg (scim)	14.5	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
LH_2 Cont Vent Vlv Act Bellows Lkg (scim)	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)	0.0	50 max
Bidirect Vent Vlv Seal & Blade Shaft Seal Leakage - Ground Pos (scim)	0.0	3.5 max
Ground Vent System Leak Checks		
Combined LH_2 V&R & LH_2 Latching Vlv Combined Seat & Pilot Bleed Lkg (scim)	15	210 max
Combined LH_2 V&R Vlv & LH_2 Latching Relief Vlv Seat, Pilot Bleed, & Boost Piston Seal Lkg (scim)	265	*
LH_2 V&R Vlv & LH_2 Latching Vlv Boost Piston Seal Lkg (scim)	250	1728 max
LH_2 Vent Vlv Open Act Seal Lkg (scim)	0.0	75 max
Bidirect Vent Vlv Seat Lkg (Gnd Pos) (scim)	0.0	50 max
Bidirect Vent Vlv Act Piston Leakage:		
Ground Position (scim)	0.0	3 max
Flight Position (scim)	0.0	3 max
LH_2 Latching Relief Vlv Open Act Piston Seal Lkg (scim)	0.0	150 max

* Limits Not Specified

4.3.3 Hydraulic System Setup and Operation (1B41005 B)

The purpose of this manual procedure, initiated on 2 December 1968, and completed on 23 December 1968, was to ensure that the hydraulic system was correctly flushed, filled, bled, and maintained free of contamination during hydraulic system operation. The hydraulic system pressures and temperatures were checked for proper operational level, 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 X458916; the main hydraulic actuator assemblies, P/N 1A66248-507, S/N 84 and P/N 1A66248-507, S/N 71; the main hydraulic pump, P/N 1A66240-503, S/N X457811; and the accumulator/reservoir assembly, P/N 1B29319-519, S/N 00029, were verified during the course of this checkout.

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 via the pressure and return hoses. Hydraulic fluid was circulated through the stage system to ensure that the system was properly filled, and hydraulic fluid samples were taken and certified to be free of contamination.

The accumulator/reservoir was charged with gaseous nitrogen, and the stage air bottles were 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.

4.3.3 (Continued)

On completion 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. The midstroke locks were then 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 in the Test Data Table. 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.

4.3.3 (Continued)

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 determined to be a function of the fluid temperature measurement to provide space in the reservoir for fluid thermal expansion under ground operating conditions ($0^{o}F$ to $160^{o}F$). The HPU was turned on, and the system pressure was increased to 3650 $\pm$50 psig. The bypass valve was opened, and the HPU 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 $\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 as specified per design requirements.

A check to determine the pressure decay of the stage air bottles was conducted next. The air bottles were verified to be charged to 448.2 psia, well within 475 $\pm$50 psia limits, and the pressure and range time were recorded. After a lapse of 24 hours, the bottle pressure was remeasured and recorded as 444.0 psia, well within the allowable limits.

All data was reviewed, and this checkout was acceptable to Engineering. There were neither part shortages nor retest requirements pending that affected this test.

4.3.3 (Continued)

There were twelve revisions written to the procedure for the following:

a. Two revisions authorized taking additional hydraulic fluid samples after cycling the accumulator.

b. Two revisions concerned filling and flushing the hydraulic system after replacement of the auxiliary hydraulic pump, P/N 1A66241-511, S/N X454594, which was found to be leaking during hydraulic system automatic checkout, reference FARR 500-607-637.

c. One revision was required to update the procedure to the latest configuration.

d. One revision authorized flushing and refilling the hydraulic system subsequent to a high particle count noted during lab reports LR683440 and LR683449.

e. One revision authorized recharging the accumulator as the pressure and temperature readings were not available from the test control center during the initial charging.

f. One revision deleted steps that were static firing requirements.

g. One revision concerned trouble shooting instructions to isolate a possible leak on the auxiliary hydraulic pump. No leak was found.

h. One revision authorized an additional 70 ml of hydraulic fluid to be drained from the accumulator, during the final air content test, to allow for thermal expansion.

i. Two revisions were written and subsequently voided.

4.3.3.1 Test Data Table, Hydraulic System Setup and Operation

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

4.3.3.1 (Continued)

Instrumentation

Test Description	Name	Location	Actual	Requirement
Actuator	Pitch	Pitch	0 inches	Ref. Only
System Pressurized	Venier	Actuator		
	Yaw	Yaw	0 inches	Ref. Only
	Vernier	Actuator		
			Position	Voltage
Instrumentation Support	Pitch Actuator Position (deg.)	TCC	0	2.506 vdc
			+1	2.131 vdc
			+2	1.783 vdc
			+1	2.152 vdc
			0	2.500 vdc
	Pitch Actuator Position (deg.)	TCC	0	2.500 vdc
			-1	2.546 vdc
			-2	3.184 vdc
			-1	2.825 vdc
			0	2.500 vdc
	Yaw Actuator Position (deg.)	TCC	0	2.500 vdc
			+1	2.485 vdc
			+2	3.199 vdc
			+1	2.855 vdc
			0	2.507 vdc
	Yaw Actuator Position (deg.)	TCC	0	2.507 vdc
			-1	2.165 vdc
			-2	1.819 vdc
			-1	2.169 vdc
			0	2.509 vdc
Stage Air Bottle Decay Check	Air Bottle Pressure	Stage	Start 1443 12-12-68	448.2 psig*
			Stop 1445 12-13-68	444.0 psig*

*Limits Not Specified

4.3.4 Auxiliary Propulsion System Interface Compatibility Checkout (1B49558 B)

Contained in this manual checkout were the test sequences necessary to verify a suitable electrical interface between the stage and the auxiliary propulsion system (APS) modules, P/N 1A83918-519, S/N's 1011-1 and 1011-2, after installation of the modules on the stage.

This checkout was satisfactorily performed on 3 December 1968, and certified as acceptable on 10 December 1968. 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 4.3.4.1 for results of the point-to-point resistance measurements.

There were no discrepancies recorded by FARR's as a result of this checkout.

4.3.4.1 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	30	25 ± 5
404A51A4	J4 B	414A8L5 Eng. 1, Valve 1	30	25 ± 5
404A51A4	J4 C	414A8L2 Eng. 1, Valve C	30	25 ± 5
404A51A4	J4 D	414A8L6 Eng. 1, Valve 3	30	25 ± 5
404A51A4	J4 E	414A8L3 Eng. 1, Valve B	30	25 ± 5
404A51A4	J4 F	414A8L7 Eng. 1, Valve 2	30	25 ± 5
404A51A4	J4 G	414A8L4 Eng. 1, Valve D	30	25 ± 5
404A51A4	J4 H	414A8L8 Eng. 1, Valve 4	30	25 ± 5
404A51A4	J4 J	414A10L1 Eng. 3, Valve A	30	25 ± 5
404A51A4	J4 K	414A10L5 Eng. 3, Valve 1	30	25 ± 5
404A51A4	J4 L	414A10L2 Eng. 3, Valve C	30	25 ± 5
404A51A4	J4 M	414A10L6 Eng. 3, Valve 3	30	25 ± 5
404A51A4	J4 N	414A10L3 Eng. 3, Valve B	30	25 ± 5

4.3.4.1 (Continued)

Stage Comp.	Test Point	APS Component	Meas. Ohms	Limit Ohms
404A51A4	J4 P	414A10L7 Eng. 3, Valve 2	30	25 ± 5
404A51A4	J4 R	414A10L4 Eng. 3, Valve D	30	25 ± 5
404A51A4	J4 S	414A10L8 Eng. 3, Valve 4	30	25 ± 5
404A51A4	J4 T	414A9L1 Eng. 2, Valve A	30	25 ± 5
404A51A4	J4 U	414A9L5 Eng. 2, Valve 1	30	25 ± 5
404A51A4	J4 V	414A9L2 Eng. 2, Valve C	30	25 ± 5
404A51A4	J4 W	414A9L6 Eng. 2, Valve 3	30	25 ± 5
404A51A4	J4 X	414A9L3 Eng. 2, Valve B	30	25 ± 5
404A51A4	J4 Y	414A9L7 Eng. 2, Valve 2	30	25 ± 5
404A51A4	J4 Z	414A9L4 Eng. 2, Valve D	29	25 ± 5
404A51A4	J4 a	414A9L8 Eng. 2, Valve 4	30	25 ± 5
404A71A19	J4 A	415A8L1 Eng. 1, Valve A	30	25 ± 5
404A71A19	J4 B	415A8L5 Eng. 1, Valve 1	30	25 ± 5
404A71A19	J4 C	415A8L2 Eng. 1, Valve C	30	25 ± 5
404A71A19	J4 D	415A8L6 Eng. 1, Valve 3	30	25 ± 5
404A71A19	J4 E	415A8L3 Eng. 1, Valve D	30	25 ± 5
404A71A19	J4 F	415A8L7 Eng. 1, Valve 2	29	25 ± 5
404A71A19	J4 G	415A8L4 Eng. 1, Valve D	30	25 ± 5
404A71A19	J4 H	415A8L8 Eng. 1, Valve 4	30	25 ± 5
404A71A19	J4 J	414A10L1 Eng. 3, Valve A	30	25 ± 5
404A71A19	J4 K	414A10L5 Eng. 3, Valve 1	30	25 ± 5
404A71A19	J4 L	414A10L2 Eng. 3, Valve C	30	25 ± 5
404A71A19	J4 M	414A10L6 Eng. 3, Valve 3	29	25 ± 5
404A71A19	J4 N	414A10L3 Eng. 3, Valve B	29	25 ± 5
404A71A19	J4 P	414A10L7 Eng. 3, Valve 2	29	25 ± 5
404A71A19	J4 R	414A10L4 Eng. 3, Valve D	29	25 ± 5
404A71A19	J4 S	414A10L8 Eng. 3, Valve 4	29	25 ± 5
404A71A19	J4 T	415A9L1 Eng. 2, Valve A	29	25 ± 5
404A71A19	J4 U	415A9L5 Eng. 2, Valve 1	29	25 ± 5
404A71A19	J4 V	415A9L2 Eng. 2, Valve C	30	25 ± 5
404A71A19	J4 W	415A9L6 Eng. 2, Valve 3	30	25 ± 5
404A71A19	J4 X	415A9L3 Eng. 2, Valve B	30	25 ± 5
404A71A19	J4 Y	415A9L7 Eng. 2, Valve 2	29	25 ± 5
404A71A19	J4 Z	415A9L4 Eng. 2, Valve D	29	25 ± 5
404A71A19	J4 a	415A9L8 Eng. 2, Valve 4	30	25 ± 5
404A4	J7 r	414A5L1	18	15 to 25
404A4	J7 d	414A5L1	19	15 to 25
404A4	J7 p	414A6L1	16	15 to 25
404A4	J7 x	414A1L1	18	15 to 25
404A4	J7 f	414A1L1	19	15 to 25
404A4	J7 v	414A2L2	16	15 to 25
404A4	J7 m	414A6L2	17	15 to 25
404A4	J7 t	414A2L2	15	15 to 25
404A4	J7 z	SPARE	Inf.	Inf.

4.3.4.1 (Continued)

Stage Comp.	Test Point	APS Component	Meas. Ohms	Limit Ohms
404A4	J7 q	415A5L1	19.5	15 to 25
404A4	J7 c	415A5L1	19.5	15 to 25
404A4	J7 n	415A6L1	16	15 to 25
404A4	J7 w	415A1L1	15	15 to 25
404A4	J7 e	415A1L1	18	15 to 25
404A4	J7 u	415A2L1	17	15 to 25
404A4	J7 k	415A6L2	18	15 to 25
404A4	J7 s	415A2L2	16	15 to 25
404A4	J7 y	SPARE	Inf.	Inf.
404A2A16	J2 B	414A7L1 Eng. 4, Valve A	45	40 ± 5
404A2A16	J2 C	414A7L2 Eng. 4, Valve 1	44	40 ∓ 5
404A2A16	J2 A	414A7L1 Eng. 4, Valve A	45	40 ∓ 5
404A2A16	J2 D	414A7L2 Eng. 4, Valve 1	45	40 ∓ 5

4.3.5 Umbilical Interface Compatibility Check (1B64316 E)

Prior to connecting the forward and aft umbilical cables for automatic power on checks, 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 circuits for the propulsion valves and safety items on the stage were within prescribed tolerances.

This procedure was initially conducted between 4 December and 11 December 1968, prior to connection of the umbilicals for the deferred postfire test operations. Two additional issues of the procedure were required on 19 December and 23 December 1968, due to ejection of the umbilicals during the all systems test (AST) runs. The data presented in Test Data Table 4.3.5.1 represents resistance measurements taken during the last test on 23 December 1968.

A series of resistance measurements were made at specified test points on the GSE 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 in the umbilical cable and stage umbilical wiring were intact and of the proper material and wire gauge, and that all resistance values and loads were within the design requirement limits. A Simpson, Model 260, multimeter was used to make the resistance measurements.

No FARR's were written that resulted from the compatibility checks. Four revisions were written to the procedure for the following:

4.3.5 (Continued)

a. One revision performed a special test to obtain engineering data on the stage bus loading.

b. One revision changed the tolerance for the 4D111 bus magnetic relay K10 from minimum of 100 ohms to a minimum of 20 ohms as the relay was positioned to the open position during AST.

c. One revision concerned four out-of-tolerance conditions. The relays involved were left on by the performance of AST.

d. One revision changed the tolerance of the bus 4D121 magnetic relay from 1.6K ohms minimum to 230 ohms minimum. An additional relay had been added which resulted in lower resistance readings.

4.3.5.1 Test Data Table, Umbilical Interface Compatibility Check

Reference Designation 463A2

Test Point	Function	Meas. Ohms	Limit Ohms
A2J29-C	Cmd., Ambient Helium Sphere Dump	30	10-60
CB-8-2	Cmd., Engine Ignition Bus Power Off	6†	Inf.
CB-9-2	Cmd., Engine Ignition Bus Power On	Inf.†	5-100
CB-10-2	Cmd., Engine Control Bus Power Off	7†	Inf.
CB-11-12	Cmd., Engine Control Bus Power On	Inf.†	5-100
A2J29-N	Cmd., Engine He Emerg Vent Control On	45	10-60
A2J29-P	Cmd., Fuel Tank He Sphere Dump	34	10-60
A2J29-Y	Cmd., Stark Tk Vent Pilot Valve Open	45	10-60
CB-4-2	Cmd., LOX Tank Cold He Sphere Dump	30	10-60
A2J29-c	Cmd., LOX Tank Repress He Sphere Dump	35	10-60
A2J29-h	Cmd., Fuel Tank Vent Pilot Vlv Open	70	10-300
	(Same, reverse polarity)	Inf.	500k min
A2J29-i	Cmd., Fuel Tank Vent Vlv Boost Close	68	10-80
	(Same, reverse polarity)	Inf.	500k min
A2J29-q	Cmd., Ambient He Supply Shutoff Vlv Close	54	10-60
A2J30-H	Cmd., Cold He Shutoff Vlv Close	500	1.5k max
	(Same, reverse polarity)	Inf.	Inf.
A2J30-W	Cmd., LOX Vent Valve Open	70	10-80
	(Same, reverse polarity)	Inf.	500k min
A2J30-X	Cmd., LOX Vent Valve Close	68	10-80
	(Same, reverse polarity)	Inf.	500k min
A2J30-Y	Cmd., LOX and Fuel Prevlv Emergency Close	68	10-80
	(Same, reverse polarity)	Inf.	Inf.
A2J30-Z	Cmd., LOX and Fuel Chilldown Valve Close	66	10-80
	(Same, reverse polarity)	Inf.	500k min

† Reference Revision C.

4.3.5.1 (Continued)

Test Point	Function	Meas. Ohms	Limit Ohms
A2J30-b	Cmd., LOX Fill & Drain Vlv Boost Close	32	10-40
A2J30-c	Cmd., LOX Fill & Drain Valve Open	30	10-40
A2J30-d	Cmd., Fuel Fill & Drain Valve Boost Close	30	10-40
A2J30-e	Cmd., Fuel Fill & Drain Valve Open	30	10-40
A2J42-F	Meas., Bus +4D111 Regulation	Inf.	100 min
A2J35-y	Meas., Bus +4D141 Regulation	Inf.	50 min
A2J6-AA	Sup., 28v Bus +4D119 Talkback Power	95	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 Power	70	60-100

4.3.6 Stage Power Setup (1B55813 L)

Prior to the initiation of deferred postfire checkouts for the stage on Test Stand Beta III, 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 postfire automatic checkouts.

Initial test attempt one, conducted on 5 December 1968, was aborted due to the forward 1 power supply voltage being too low. After correction, test attempt two was conducted on 5 December 1968, and was a successful demonstration of stage power setup. Measurements listed in Test Data Table 4.3.6.1 are taken from the second 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 LH_2 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 power, and propellant 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.

4.3.6 (Continued)

The range safety system safe and arm device was verified to be in the SAFE condition. The 70 pound ullage engine relay, the LH_2 continuous vent valve relays, the LH_2 and LOX repressurization mode relay, the O_2H_2 burner propellant valve relay, and the engine passivation relays were all verified to be reset. The LH_2 continuous vent and relief overboard 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 O_2H_2 burner spark systems 1 and 2 voltages were measured and recorded. The O_2H_2 LOX and LH_2 valves 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 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-three functions were verified to be off and twenty-six were verified to be on. The LOX and LH_2 prevalves and chilldown shutoff valves were verified as open, and the LOX and LH_2 vent valves and fill and drain valves were verified as closed.

4.3.6 (Continued)

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 concerned program changes required to turnoff the RF assembly power, the PCM RF assembly power, the PCM support group assembly power and the auxiliary hydraulic pump power, to reset stage relays.

b. One revision attributed the out-of-tolerance condition of the forward bus 1 voltage to the output being adjusted too low. Readjustment of the voltage corrected the problem.

c. One revision authorized the second attempt after correction of the forward bus 1 out-of-tolerance condition.

d. One revision explained that a malfunction of the ambient helium supply shutoff valve was expected and was not detrimental to the stage operation.

4.3.6.1 Test Data Table, Stage Power Setup

Function	Measured Value	Limit
Forward Bus 1 Power Supply Current (amps)	2.000	39 max
Forward Bus 1 Voltage (vdc)	28.278	28 ± 0.5
O_2H_2 Burner Spark System 1 Voltage (vdc)	0.020	0 ∓ 0.5
O_2H_2 Burner Spark System 2 Voltage (vdc)	0.000	0 ∓ 0.5
Forward Bus 1 Quiescent Current (amps)	1.800	8 max
PCM System Group Current (amps)	5.200	7 ± 3
Forward Bus 2 Power Supply Current (amps)	0.000	2 max
Forward Bus 2 Voltage (vdc)	28.199	28 ± 0.5
Aft Bus 1 Power Supply Current (amps)	0.399	2 max
Aft Bus 1 Voltage (vdc)	28.199	28 ± 0.5
Sequencer Power (amps)	-0.101	0 ∓ 3
Aft 5v Excitation Module Voltage (vdc)	4.980	5 ∓ 0.030

4.3.6.1 (Continued)

Function	Measured Value	Limit
Fwd 1 5v Excitation Module Voltage (vdc)	5.008	5 ± 0.030
Fwd 2 5v Excitation Module Voltage (vdc)	4.999	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)	0.079	0 ± 1
Forward Battery 1 Simulator Voltage (vdc)	0.000	0 ± 1
Forward Battery 2 Simulator Voltage (vdc)	0.039	0 ± 1
Aft Battery 1 Simulator Voltage (vdc)	0.079	0 ± 1
Aft Battery 2 Simulator Voltage (vdc)	0.079	0 ± 1
Component Test Power Voltage (vdc)	0.680	0 ± 1

4.3.7 Stage Power Turnoff (1B55814 K)

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 on Test Stand Beta III. 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 5 December 1968, by a second attempt. The first attempt was aborted due to a malfunction caused by a stage cable being disconnected. Stage power turnoff measurement values for this demonstration issue are tabulated in Test Data Table 4.3.7.1. 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 postmodification 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 O_2H_2 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.

4.3.7 (Continued)

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 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, three revisions were recorded in the procedure as follows:

a. One revision concerned program changes required to update the procedure to the latest stage configuration.

b. One revision corrected a program error.

c. One revision authorized attempt two. The first attempt was aborted due to a disconnected stage cable.

4.3.7.1 Test Data Table, Stage Power Turnoff

Function	Measured Value	Limits
Forward Bus 1 Voltage, Power On (vdc)	28.318	28 + 2
Aft Bus 1 Voltage, Power On (vdc)	28.158	28 ∓ 2
O_2H_2 Burner Spark System 1 Voltage (vdc)	0.005	0 ∓ 0.5
O_2H_2 Burner Spark System 2 Voltage (vdc)	0.005	0 ∓ 0.5
Forward Bus 1 Battery Simulator Voltage (vdc)	0.000	0 ∓ 1.0
Forward Bus 2 Battery Simulator Voltage (vdc)	0.000	0 ∓ 1.0
Aft Bus 1 Battery Simulator Voltage (vdc)	0.000	0 ∓ 1.0
Aft Bus 2 Battery Simulator Voltage (vdc)	0.000	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)	0.000	0 ∓ 1.0

4.3.8 Power Distribution System (1B55815 K)

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 conducted three times, unsuccessfully on 5 December and 10 December 1968, and then satisfactorily on 13 December 1968. The initial test was aborted due to malfunctions of the GSE period counter and the LH_2 point level sensors 2 and 4.

The second test was performed after corrections were made for the level sensors and the period counter. The level sensors were checked out per the level sensor and control unit calibration test (reference paragraph 4.3.11), which resulted in replacement of the control unit for LH_2 point level sensor 4 per FARR 500-607-599, and adjustment of the control unit for LH_2 point level sensor 2. The period counter was set up and recertified.

The third and final test was required because of loss of data on the PCM tape recorder during the second test. All measurements listed in Test Data Table 4.3.8.1 are taken from the final test. The following narrative is a description of that test.

4.3.8 (Continued)

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 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

4.3.8 (Continued)

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 LH_2 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 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 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.

4.3.8 (Continued)

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 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.

Forward 1 power supply current was measured before and after turn on of the FM/FM system group switch, and the current differential was determined. Aft 1 power supply current was measured before and after turn on of preflight mode calibration command, and the current differential was determined.

The aft 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 LH_2 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.

4.3.8 (Continued)

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.

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 provided instructions for setup of the GSE period counter after its malfunction during the first power distribution system test.

4.3.8 (Continued)

b. One revision employed the DSV-4B-127 wideband recorder to provide tape data for evaluation of the effectiveness of the modified J-2 engine instrumentation grounding system to eliminate noise from the engine pressure parameters.

c. Two revisions concerned malfunction indications that resulted from program errors.

d. Two revisions authorized the second and third tests of the power distribution system.

4.3.8.1 Test Data Table, Power Distribution System

Function	Measurement	Limits
Engine Control Bus Current (amps)	0.000	2 ± 2
Engine Control Bus Voltage (vdc)	27.999	28.158 ± 1
APS Bus Current (amps)	0.399	1.5 ± 3
Engine Ignition Bus Current (amps)	0.200	0 ± 2
Engine Ignition Bus Voltage, On (vdc)	27.906	28.158 ± 1
Engine Ignition Bus Voltage, Off (vdc)	0.000	0 ± 0.45
Component Test Power Current (amps)	-0.101	0 ± 2
Component Test Power Voltage, On (vdc)	28.079	28 ± 2
Component Test Power Voltage, Off (vdc)	0.680	0 ± 1
Engine Control Bus Voltage, EDS 2 On (vdc)	-0.030	0 ± 0.45
Engine Control Bus Voltage, EDS 2 Off (vdc)	28.029	28.118 ± 1
Propellant Level Sensor Pwr Current (amps)	0.100	1 ± 2
LOX Depletion Engine Cutoff Timer (sec)	0.545	0.560 ± 0.025
PU Inverter & Electronics Pwr Current (amps)	3.700	3 ± 2
PCM RF Assembly Power Current (amps)	4.399	4.5 ± 3.0
PCM RF Transmitter Output Power, AO (watts)	12.908	10 min
PCM RF Transmitter Output Power, BO (watts)	13.265	10 min
PCM RF Transmitter Output Power, AO T/M RF Silence On (watts)	-0.118	0 ± 2
Switch Selector Output Monitor, K128 (vdc)	2.046	2 ± 0.425
PCM RF Transmitter Output Power, AO, T/M RF Silence Off (watts)	21.058	10 min
FM/FM System Group Current (amps)	0.100	0 ± 2
Calibration Preflight Mode Current (amps)	-0.199	0 ± 2
Aft Bus 2 Current (amps)	0.399	5 max
Aft Bus 2 Voltage (vdc)	55.838	56 ± 1

4.3.8.1 (Continued)

LOX Chilldown Inverter Tests

Function	Measurement	Limits
Inverter Current (amps)	20.755	20.0 ± 5.0
Phase AB Voltage, Hardwire (vac)	54.234	54.878 ± 3
Phase AC Voltage, Hardwire (vac)	53.715	54.878 ± 3
Phase A1B1 Voltage, Hardwire (vac)	54.170	54.878 ± 3
Phase A1C1 Voltage, Hardwire (vac)	53.648	54.878 ± 3
Frequency, Hardwire (Hz)	401.000	400.0 ± 4.0
Phase AB Voltage, Telemetry (vac)	54.932	55.038 ± 3
Phase AC Voltage, Telemetry (vac)	55.266	55.038 ± 3
Frequency, Telemetry (Hz)	400.789	400.0 ± 4.0

LH_2 Chilldown Inverter Tests

Function	Measurement	Limits
Inverter Current (amps)	19.994	20.0 ± 5.0
Phase AB Voltage, Hardwire (vac)	54.300	55.038 ± 3
Phase AC Voltage, Hardwire (vac)	53.648	55.038 ± 3
Phase A1B1 Voltage, Hardwire (vac)	54.170	55.038 ± 3
Phase A1C1 Voltage, Hardwire (vac)	53.584	55.038 ± 3
Frequency, Hardwire (Hz)	400.000	400.0 ± 4.0
Phase AB Voltage, Telemetry (vac)	55.064	54.878 ± 3
Phase AC Voltage, Telemetry (vac)	55.331	54.878 ± 3
Frequency, Telemetry (Hz)	400.023	400.0 ± 4.0

Function	Measurement	Limits
Forward Battery 1 Simulator Voltage (vdc)	28.278	28 ± 2
Forward Battery 2 Simulator Voltage (vdc)	28.158	28 ± 2
Aft Battery 1 Simulator Voltage (vdc)	28.118	28 ± 2
Aft Battery 2 Simulator Voltage (vdc)	55.758	56 ± 4
Bus 4D20 ESE Load Bank (vdc)	0.159	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
Prelaunch Checkout Group Current (amps)	1.899	1 ± 3
Forward Bus 1 Voltage - Internal (vdc)	27.999	28 ± 2
Forward Bus 2 Voltage - Internal (vdc)	28.039	28 ± 2
Aft Bus 1 Voltage - Internal (vdc)	27.999	28 ± 2
Aft Bus 1 Voltage - External (vdc)	28.118	28 ± 2
Aft Battery 1 Voltage (vdc)	0.039	0 ± 1
Aft Bus 2 Voltage - Internal (vdc)	55.599	56 ± 4
Aft Bus 2 Voltage - External (vdc)	55.599	56 ± 4
Aft Battery 2 Voltage (vdc)	0.079	0 ± 1
Forward Bus 1 Voltage - External (vdc)	28.118	28 ± 2

4.3.8.1 (Continued)

Function	Measurement	Limits
Forward Battery 1 Voltage (vdc)	0.000	0 ± 1
Forward Bus 2 Voltage - External (vdc)	28.199	28 ± 2
Forward Battery 2 Voltage (vdc)	0.079	0 ± 1
Aft Bus 2 Voltage, Off (vdc)	0.560	0 ± 1
Range Safety Receiver 1 External Power Current (amps)	0.250	0 ± 2
Range Safety Receiver 2 External Power Current (amps)	-0.249	0 ± 2

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

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 Beta III Test Control Center (TCC) panels.

The manual controls checkout was satisfactorily conducted on 5 December 1968, and was certified as acceptable on 31 December 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 spheres were pressurized to 100 ±25 psig and the control sphere dump valves were functioned; then, the spheres were pressurized to 500 ±50 psig for the stage valves control check.

4.3.9 (Continued)

The stage valves control check was accomplished by supplying signals manually from the Beta III 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 main-stage propulsion manual control panel, the LH_2 and LOX chilldown shutoff valves and the LH_2 and LOX prevalves were individually cycled and verified. At the TCC LH_2 control panel, the LH_2 tank vent and the fill and drain valves were cycled open and closed. The LH_2 tank vent boost close valve and the LH_2 fill and drain boost close valve were cycled. The LH_2 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 LH_2 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 O_2H_2 burner LOX and LH_2 propulsion valves and the LOX shutdown valve.

4.3.9 (Continued)

The final portion of the procedure consisted of the LH_2 and LOX umbilical purge interlock check using the TCC LH_2 and LOX control panels.

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

There were no stage FARR's resulting from this checkout.

Eight revisions were recorded in the procedure during checkout as follows:

a. Three revisions deleted portions of the procedure that were not required for this checkout.

b. One revision added the engine safety cutoff system (ESCS) initials to the procedure for reference.

c. Three revisions concerned slow operation and dual talkback conditions for GSE valves. These conditions did not affect stage operations.

d. One revision attributed to the inability of the GH_2 regulator to load to a low bleed valve pressure of 2000 psi.

4.3.10 Digital Data Acquisition System (1B55817 L)

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	6800054
CP1-B0 Time Division Multiplexer	404A61A200	1B65897-1	07
DP1-B0 Time Division Multiplexer	404A61A201	1B65897-501	05
Remote Digital Submultiplexer (RDSM)	404A60A200	1B66051-501	05
Remote Analog Submultiplexer (RASM)	404A60A201	1B66050-501.1	06
PCM RF Assembly	411A64A200	1B65788-1.-002	15501

This automatic procedure was initiated on 5 December 1968, and accepted on the third attempt on 19 December 1968. The first and second attempts were unsatisfactory due to numerous malfunction indications. For the purpose of this narrative only the third issue will be discussed.

All channels were checked at ambient conditions, and those channels having a calibration capability were also checked under a RACS high or low mode calibration command. Ambient conditions were defined as 70°F at 14.7 psia, or for bi-level parameters, the normal state of valves or switches during the performance of this test. All channel outputs were measured and printed out.

4.3.10 (Continued)

The PCM RF test was conducted first. The forward and reflected RF output powers of the PCM/DDAS assembly were measured through the CP1-BO and the DP1-BO multiplexer telemetry outputs, and the voltage standing wave ratios (VSWR's) 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, 25.489 watts; reflected power, 0.188 watts; VSWR, 1.188. The DP1-BO multiplexer telemetry readings were: forward power, 25.489 watts; reflected power, 0.170 watts; VSWR, 1.178. The CP1-BO multiplexer ground monitor readings were: forward power, 20.343 watts; reflected power, 0.088 watts: VSWR, 1.141. The DP1-BO multiplexer ground monitor readings were: forward power, 20.343 watts; reflected power, 0.088 watts; VSWR, 1.141.

All measurements were within the acceptable tolerances. High and low RACS tests were then conducted for the aft 5 volt excitation module voltage, while both the ground monitor and telemetry outputs were measured. High and low RACS for telemetry outputs were 3.999 vdc and 0.000 vdc, respectively, and 3.999 vdc (high) and -0.005 vdc (low) for the ground monitor.

The CP1-BO multiplexer was tested next, except for special channels. This test made measurements of 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.

4.3.10 (Continued)

The DP1-BO multiplexer was then tested, except for special channels, in the same manner as described for the CP1-BO multiplexer, with no malfunctions. All channel outputs were within tolerance.

Special channel tests were conducted next. 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 LH_2 chilldown inverter frequencies, and the LOX and LH_2 circulation pump flow rates. The LOX and LH_2 flowmeter tests at 100 Hz followed the 400 Hz test, and the LOX and LH_2 pump speeds were checked using the 1500 Hz signal. All of these special channels were within the required tolerance of the expected values.

An APS multiplexer test was then run to check the special channels on both multiplexers that measured the APS functions. Measurements were made of the high and low RACS voltages for each of the APS channels having calibration capabilities, and the ambient outputs were measured in $^{\circ}F$ or psia, as appropriate for the channel tested. All special channels were within the required tolerances.

The common bulkhead pressure and the LOX and LH_2 ullage pressures were verified to be within tolerances.

There were nineteen revisions made to this procedure for the following:

a. Six revisions added or corrected requirements that were missing or in error.

b. Three revisions attributed malfunction indications to program errors.

c. Two revisions deleted steps or requirements that were previously accomplished.

4.3.10 (Continued)

d. Two revisions concerned out-of-tolerance temperature measurements that were due to the actual temperature being different than the excepted value that was loaded into the program. Thermometer measurements indicated that all were within tolerance.

e. Two revisions attributed the SIM interrupts on channels 64, 67 and 141, and the malfunction indication on channel CP1-BO-09 to the umbilical bypass cables being installed.

f. One revision provided instructions for troubleshooting the GH_2 start bottle temperature transducer, C006.

g. One revision stated that a system status display card was not presented when requested by the program due to a malfunction in the logic power supply of the system status display console.

h. One revision attributed the malfunction on channel CP1/DP1-BO-13-10, measurement D38 to the blanket pressure established during the APS checkout.

i. One revision stated that the malfunction of the APS fuel and oxidizer ullage pressures was due to a pressure decay in the APS unit. These ullage pressures had been established during the APS checkout.

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

This manual procedure determined that the control units associated with the LOX and LH_2 liquid level, point level, fast fill, and overfill sensors, were adjusted for operating points within the design calibration limits. The particular items involved in this test are noted in Test Data Table 4.3.11.1

This procedure was initiated on 6 December 1968, and completed 16 December 1968.

The point level sensor manual checkout assembly, P/N 1B50928-1, and a variable precision capacitor, General Radio Type 1422 CD, were used during the test to provide capacitance changes to the control units as required to simulate wet conditions and to determine the control unit operation points.

The manual checkout assembly was connected between each control unit and its associated sensor, and the precision capacitor was connected to the checkout assembly to parallel the sensor capacitance. A voltmeter, connected to the appropriate checkout assembly test points, measured the control unit output signal. The precision capacitor, set to an appropriate capacitance for the sensor under test, simulated a wet condition for the appropriate level sensor. The required settings for the precision capacitor were: 0.7 ±0.01 picofarads for all LH_2 sensors with the exception of the LH_2 overfill sensor, which required 1.10 ±0.02 picofarads; and 1.50 ±0.02 picofarads for all LOX sensors except the LOX overfill sensor, which required 2.10 ±0.02 picofarads. The control unit power was turned on, and the control point adjustment, R1, on the unit under test was adjusted until the control unit output signal increased from 0.0 ±1.1 vdc to 28.0 ±2.0 vdc, indicating activation of the

4.3.11 (Continued)

control unit output relay. The capacitance value of the precision capacitor was reduced until the control unit output relay deactivated; then, the deactivation capacitance value was recorded. The capacitance value of the precision capacitor was increased until the control unit output relay reactivated. The reactivation capacitance was also recorded, as shown in Test Data Table 4.3.11.1.

The capacitance checks were followed by a series of tests to verify operation of the output relay. With the sensor reconnected, the output relay for each control unit was reverified to be deactivated under normal conditions and activated under test conditions.

There were no part shortages that affected this test. FARR 500-607-599 reported that the amplifier module, P/N 1A68710-509, S/N C18, for the LH_2 point level sensor number 4 would not adjust. The defective module was removed and replaced.

One revision was written to delete the requirement for checking the End Item models needed to support this procedure. The successful completion of stage power setup ensures proper operation of end item circuitry required.

4.3.11.1 Test Data Table, Level Sensor and Control Unit Calibration

	Sensor P/N 1A68710			Control Unit P/N 1A68710-509		Capacitance (pf)		
Function	Ref. Loc.	Dash No.	S/N	Ref. Loc.	S/N	Act. Meas.	Deact. Meas.	Tolerance
LH_2 Tank	408			411				
Liq. Lev. L17	MT732	-507	D46	A61A217	C21	0.6625	0.6340	0.7 ± 0.15
Liq. Lev. L18	MT733	-507	D50	A61A219	C23	0.5830	0.5783	0.7 ∓ 0.15

4.3.11.1 (Continued)

Function	Sensor P/N 1A68710 Ref. Loc.	Dash No.	S/N	Control Unit P/N 1A68710-509 Ref. Loc.	S/N	Capacitance (pf) Act. Meas.	Deact. Meas.	Tolerance
Liq. Lev. L19	MT734	-507	D79	A61A221	C24	0.7874	0.7830	0.7 ∓ 0.15
Pt. Lev. 1	A2C1	-507	D28	A92A25	C36	0.6732	0.6715	0.7 ∓ 0.15
Pt. Lev. 2	A2C2	-507	D34	A92A26	C47	0.6746	0.6725	0.7 ∓ 0.15
Pt. Lev. 3	A2C3	-507	D37	A92A27	C7	0.6466	0.6443	0.7 ∓ 0.15
Pt. Lev. 4	A2C4	-507	D40	A61A201	0-17	0.6918	0.6902	0.7 ∓ 0.15
Fastfill	A2C5	-1	E101	A92A43	C45	0.6708	0.6677	0.7 ∓ 0.15
Overfill	*	*	*	A92A24	C41	1.088	1.076	1.1 ∓ 0.15

Function	Sensor P/N 1A68710 Ref. Loc.	Dash No.	S/N	Control Unit P/N 1A68710-511 Ref. Loc.	S/N	Capacitance (pf) Act. Meas.	Deact. Meas.	Tolerance
LOX Tank	406			404				
Liq. Lev. L14	MT657	-1	D114	A63A221	C2	1.461	1.453	1.5 ∓ 0.15
Liq. Lev. L15	MT658	-1	D115	A63A206	C1	1.391	1.382	1.5 ∓ 0.15
Liq. Lev. L16	MT659	-1	D121	A63A223	C3	1.461	1.452	1.5 ∓ 0.15
Pt. Lev. 1	A2C1	-1	E79	A72A1	C7	1.364	1.360	1.5 ∓ 0.15
Pt. Lev. 2	A2C2	-1	E131	A72A2	C11	1.410	1.392	1.5 ∓ 0.15
Pt. Lev. 3	A2C3	-1	E147	A72A3	C6	1.443	1.440	1.5 ∓ 0.15
Pt. Lev. 4	A2C4	-1	E163	A63A227	C4	1.463	1.460	1.5 ∓ 0.15
Fastfill	A2C5	-1	D112	A72A5	C8	1.462	1.453	1.5 ∓ 0.15
Overfill	**	**	**	A72A4	C9	2.062	2.052	2.1 ∓ 0.15

* Part of LH_2 Mass Probe, P/N 1A48431-513, S/N D4C2, 408A1
** Part of LOX Mass Probe, P/N 1A48430-511, S/N C2, 406A1

4.3.12 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 between 6 December and 12 December 1968, was accepted on 16 December 1968. A second issue, accomplished and accepted on 10 January 1969, was required due to entry into the LH_2 tank for structural inspection. One revision was made to this issue to delete all sections except those concerned with LH_2 tank sensors; C-0370, C-0371 and C-0052.

The test sequences consisted of sensor element resistance checks and sensor wiring continuity checks. The sensor element resistance was measured for each of the transducers at the ambient room temperature with a General Radio, Model 1652A, resistance limit bridge. The ambient temperature was measured and recorded for each sensor. The checkout sensor parameter table specified the resistance value at $32^{o}F$ for each sensor and its change in resistance for each degree between $32^{o}F$ and $100^{o}F$. Using these values, the required resistance at the recorded ambient temperature was calculated and compared with the actual resistance measured to determine acceptability for each sensor. A tolerance of ± 5 to ± 7 per cent of the calculated resistance (depending on sensor part number) was allowed for acceptance of the actual resistance measurements.

4.3.12 (Continued)

A check for correct sensor wiring (continuity) was accomplished by connecting a jumper wire on the adapter cable, P/N 1B64095-1, and verifying that the sensor element for each transducer was shorted out to a resistance measurement of 5 ohms or less.

Three revisions to the three issues of the procedure were written for the following:

a. Two revisions concerned reverification of the LH_2 circulation return line tank inlet sensor (C161) as the ambient temperature during the initial calibration was too high.

b. One revision was required to correct a procedure error.

4.3.12.1 <u>Test Data Table, Cryogenic Temperature Sensor Verification</u>

Meas	Sensor			Temp	Resistance (ohms)			
No.	P/N	S/N	Ref Desig	(°F)	Meas	Calc	±Tol	Cont
C-0368	1A67862-505	433	406MT660	60	1461.0	1465.0	73.0	1.0
C-0369	1A67862-505	448	406MT661	60	1461.0	1465.0	73.0	1.0
C-0256	1B37878-501	1426	409MT646	60	1434.0	1486.2	74.3	0.08
C-0371	1A67862-533	617	409MT736	65	5170.0	5363.0	375.0	1.5*
C-0059	1A67862-517	582	406MT611	60	530.0	530.0	26.0	1.35
C-0057	1A67862-501	51297	406MT606	60	524.0	531.0	37.0	1.15
C-0230	1A67863-509	1127	403MT706	60	1498.0	1486.0	74.0	0.96
C-0257	1B37878-501	1500	409MT647	58	1460.0	1480.1	74.0	0.72
C-0161	1A67863-537	1096	404MT733	52	4970.0	5220.0	365.4	0.6
C-0159	1A67863-519	884	424MT610	60	215.0	212.3	10.6	0.78
C-0231	1A67863-529	1067	403MT707	60	532.0	530.0	26.0	1.1
C-0370	1A67862-533	612	408MT735	65	5180.0	5363.0	375.0	1.6*
C-2030	1B37878-511	1479	404MT760	60	526.0	531.0	26.5	0.9
C-2031	1B37878-511	1481	404MT761	60	528.0	531.0	26.5	0.65
C-0012	NA5-27215T5	13607	401(4MT72)	60	1351.0	1333.0	66.0	1.3
C-0015	1A67863-509	1426	410MT603	56	530.0	526.4	26.3	1.16
C-0040	1A67862-505	580	406MT613	60	1455.0	1465.1	73.3	1.13
C-0009	1A67863-535	705	403MT653	60	214.8	212.3	10.6	1.4
C-0052	1A67862-513	309	408MT612	65	5431.0	5363.0	375.0	1.6*
C-0208	1A67863-503	1178	405MT605	60	514.0	532.0	60.0	1.3
C-0005	1A67863-503	747	405MT612	60	513.0	532.0	26.0	2.0

* Second Issue Measurements

4.3.12.1 (Continued)

Meas No.	Sensor P/N	Sensor S/N	Sensor Ref Desig	Temp (°F)	Resistance (ohms) Meas	Resistance (ohms) Calc	Resistance (ohms) ± Tol	Resistance (ohms) Cont
C-0003	1B34473-1	337	403MT686	60	5120.0	5308.0	371.0	1.1
C-0004	1B34473-501	339	403MT687	60	1490.0	1486.2	74.3	1.08
C-0134	NA5-27215T5	13614	401(3MTT16)	60	1330.0	1333.3	66.7	0.86
C-0133	NA5-27215T5	13533	401(3MTT17)	60	1350.0	1333.3	66.7	0.66
O_2H_2 Voter 1	1B37878-507	1694	403A20	60	5078.0	5305.0	371.6	0.63
O_2H_2 Voter 2	1B37878-507	1700	403A21	60	5090.0	5308.0	371.6	0.67
O_2H_2 Voter 3	1B37878-507	1711	403A22	60	5095.0	5308.0	371.6	0.67

* Second Issue Measurements

4.3.13 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 6800054; CP1-BO time division multiplexer, P/N 1B65897-1, S/N 07; DP1-BO time division multiplexer, P/N 1B65897-501, S/N 05; remote digital submultiplexer (RDSM), P/N 1B66051-501, S/N 05; and low level remote analog submultiplexer (RASM), P/N 1B66050-501.1, S/N 06.

This test was conducted on 9 December 1968, and acceptance occurred on 11 December 1968.

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 71,989 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 635.3 kHz at 3.0 vrms, within the acceptable limits of 623.3 kHz to 642.2 kHz, at greater than 2.2 vrms. The lower band edge frequency was measured at 569.6 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 65.7 kHz, within the acceptable limits of 60 to 80 kHz.

4.3.13 (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. All measured channels were 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. All measured outputs for the RDSM and the RASM were within the required tolerances.

A final test measured the PCM/FM transmitter current as 4.399 amperes, within the 4.5 ±3.00 amperes limit.

There were no problem areas during the test that resulted in FARR documentation. Four revisions were recorded in the procedure as follows:

a. Three revisions were corrections of program errors.

b. One revision concerned "set" commands sent via OLSTOL in support of the leak check procedure, 1B71877, which was run concurrently with the DDAS calibration test.

4.3.14 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	252
EBW Firing Unit	404A47A2	40M39515-113	253
Pulse Sensor *	404A47A4A1	40M02852	-
Pulse Sensor *	404A47A4A2	40M02852	-
* On Pulse Sensor Bracket Assy	404A47A4	1B52640-1	00008
Ullage Rocket Jettison System			
EBW Firing Unit	404A75A1	40M39515-113	271
EBW Firing Unit	404A75A2	40M39515-113	284
Pulse Sensor **	404A75A10A1	40M02852	-
Pulse Sensor **	404A75A10A2	40M02852	-
** On Pulse Sensor Bracket Assy	404A75A10	1A97791-501	00004

This procedure was accomplished on 9 December 1968, and was accepted on 10 December 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 discharged 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.

4.3.14 (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.

4.3.14 (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 two malfunction indications were expected and were not hardware malfunctions.

4.3.15 <u>Auxiliary Propulsion System Checkout (1B70430 NC)</u>

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 10 December 1968, 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 hand loader 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.

4.3.15 (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. 4.3.15.1.

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 hand loader 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.

4.3.15 (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 31 December 1968.

Seven revisions were written to the procedure:

a. One revision repeated the fuel and oxidizer manifold circuit purges.

b. One revision corrected valve designation numbers that were incorrectly listed in the procedure.

c. One revision changed a connection point callout from port "P" to "the helium bottle fill line between the first two check valves." Port "P" was located in an unaccessible position.

d. One revision concerned establishing the blanket pressures to support DDAS automatic checkout.

e. One revision added the steps necessary to secure the APS modules after the performance of AST.

f. One revision provided instructions to connect the pressurization system to APS 1 and APS 2 control helium systems in support of AST.

g. One revision was written and subsequently voided.

4.3.15.1 Test Data Table, Auxiliary Propulsion System Checkout

Module Setup	APS 1	APS 2	Limits
Fuel Tank Pressure (psig)	5.0	4.0	0.5 min
Fuel Ullage Pressure (psia)	.0166	15.3	*
Fuel Manifold Pressure (psia)	.0170	9.6	*
Oxidizer Tank Pressure (psig)	4.5	3.5	0.5 min
Oxidizer Ullage Pressure (psia)	.0135	18.3	*
Oxidizer Manifold Pressure (psia)	.0161	31.0	*

* Limits Not Specified

4.3.15.1 (Continued)

Module Setup	APS 1	APS 2	Limits
Fuel Valve Functional Check			
Fuel Manifold Pressure			
Initial (psia)	32.7	32.3	35 ± 15
Final (psia)	32.7	32.3	35 ± 15
Oxidizer Valve Functional Check			
Oxidizer Manifold Pressure			
Initial (psia)	35.8	40.2	35 ± 15
Final (psia)	35.8	40.2	35 ± 15
Helium Valve Functional Check			
Fuel Ullage Pressure (psia)	43.2	40.2	50 ± 15
Oxidizer Ullage Pressure (psia)	41.9	41.0	50 ± 15
Engine Valve Functional Test			
Voltage Required for Valve Cycle			
Engine 1 (vdc)	4.076	4.030	*
Engine 2 (vdc)	4.076	4.092	*
Engine 3 (vdc)	4.076	4.010	*
Blanket Pressures (psia)			
Oxidizer Ullage	38.8	44.1	*
Fuel Ullage	42.3	41.9	*
Fuel Manifold	34.0	28.8	*
Oxidizer Manifold	35.8	37.5	*

* Limits Not Specified

4.3.16 Structural Inspection (1B70756 B)

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

The procedure was initiated on 10 December 1968, with the inspection of the "V-section," between the thrust structure and the aft dome, for foreign material which could result in damage to the LOX tank during pressurization. Next, a visual inspection was accomplished for rips, debonding, or other damage to the external insulation on the aft dome of the LOX tank and the environmental control plenum sphere. This was followed by an inspection of the control helium, helium storage, compressed gas, and cold helium spheres. These areas were documented as acceptable.

Inspection of the LOX and LH_2 tank assembly, thrust structure, tunnel areas, and the forward and aft skirt assemblies for cracked or debonded brackets, cracks or deformation of skin panels, and chipped or peeled paint. The external ducts, tubes, and spheres were checked for scratches, dings, and corrosion.

All bonded supports for the propellant tank forward and aft domes and the tunnel areas were checked for bond continuity by the coin tap test per DPS 32330.

The APS modules were installed on the stage at positions I and III for a fit check. The alignment of the APS support structural installation was checked

4.3.16 (Continued)

and designated as acceptable. After completion of the deferred postfire checkouts, the APS modules were removed from the stage per this procedure and returned to the Gamma area for storage.

The envelope clearance check of the forward skirt components was accomplished next. The hardware mounted on the forward dome was checked to verify that all components, with the exception of the temperature transducer, P/N 1B67863, were not extended more than 8 inches outward from the outer surface of the dome. Verification was also made that stage hardware was not extended inward more than 17-1/2 inches from the forward skirt.

This procedure was completed on 20 January 1969, with the reinstallation of all fairing covers and thrust structure access doors, after verifying the cleanliness of the thrust structure interior and tunnel areas.

There were no discrepancies recorded for the checkout and no problems were encountered.

Five revisions were made to the procedure for the following:

a. Three revisions concerned the deletion of steps that had been accomplished by the previous issue of this procedure, and one during stage removal subsequent to static firing.

b. One revision added the requirement to sweep out the "V-section" to remove all loose foreign material that could damage the LOX dome during pressurization.

c. One revision authorized taking photographs of the retro-rocket heat impingement curtains in the mounted position, immediately prior to the installation of the aft dust cover, to obtain a record of the condition of the curtain prior to stage shipment.

4.3.17 Auxiliary Propulsion System Test (1B66774 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 1B55813, on 11 December 1968. 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 transfer 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,

4.3.17 (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 preopellant 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 4.3.17.1. The checkout was completed and accepted on 12 December 1968.

There were six revisions written during the course of this procedure:

a. One revision provided a comparison of APS 1 and APS 2 helium tank pressure transducers.

b. One revision added a reference to the Sacramento Test Center.

c. One revision attributed the malfunction statements received to concurrent operations being carried out in the performance of propulsion leak checks.

d. One revision attributed the out-of-tolerance condition of the APS 1 oxidizer tank pressure to the initial setup pressure being on the low side of the tolerance and had settled back.

e. One revision deleted the removal of the throat plugs. This operation was performed during AST.

4.3.17 (Continued)

f. One revision explained that the SIM channel 64 interrupt was due to the performance of propulsion leak checks.

There were no FARR discrepancies, and the APS system was accepted for use.

4.3.17.1 Test Data Table, Auxiliary Propulsion System

APS 1 Test

Function	Meas.	AO Multi	BO Multi	Limit
IU Substitute Power (vdc)	-27.96			-28.5 ± 2.5
Helium Sphere Pressure (psia)		38.2	38.2	100.0 max
Helium Regulator Outlet (psia)		41.9	41.9	50.0 ± 10.0
Helium Sphere Temperature (°F)		62.5	-	*
Oxidizer Tank Temperature (°F)		56.8	56.9	*
Fuel Tank Temperature (°F)		60.1	60.3	*
Fuel Tank Ullage Pressure (psia)		41.9	-	50.0 ± 10.0
Oxidizer Tank Ullage Pressure (psia)		39.28+	-	50.0 ± 10.0
Fuel Manifold Pressure (psia)		36.2	-	40.0 ± 20.0
Oxidizer Manifold Pressure (psia)		38.8	-	40.0 ± 20.0
Engine 1-2 Valve Test				
Valve Open Ind (Closed) (vdc)	0.000			*
Aft Bus 1 Voltage (vdc)	28.118			*
Valve Open Ind (Open) (vdc)	4.076			*
Engine 1-3 Valve Test				
Valve Open Ind (Closed) (vdc)	0.000			*
Aft Bus 1 Voltage (vdc)	28.199			*
Valve Open Ind (Open) (vdc)	4.076			*
Engine 1-1 Valve Test				
Valve Open Ind (Closed) (vdc)	0.000			*
Aft Bus 1 Voltage (vdc)	28.118			*
Valve Open Ind (Open) (vdc)	4.076			*

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	15.891	38.406	35.787
	0.023	0.000	15.679	38.406	36.224
	0.060	4.040	26.918	35.787	36.224
	0.096	4.051	28.615	35.787	32.295
	0.130	4.061	28.190	32.731	32.295

* Limits Not Specified

\+ Refer to Revision d

4.3.17.1 (Continued)

Valve Movement	Time (sec)	Valve Open Ind (vdc)	Measured Pressures (psia) Thrust Chamb	Oxid Manif	Fuel Manif
Close	0.022	4.071	27.130	32.731	30.986
	0.055	0.000	22.465	30.986	30.986
	0.089	0.000	18.647	30.986	30.986
	0.125	-0.005	16.950	30.986	30.550
	0.161	0.005	15.891	30.986	30.550
Engine 1-3					
Open	0.000	0.000	15.446	34.042	32.295
	0.021	-0.005	15.660	34.042	32.295
	0.058	3.979	24.426	34.042	32.731
	0.095	4.051	27.205	31.858	32.731
	0.130	4.056	26.777	31.858	32.731
Close	0.022	4.051	26.563	30.986	30.550
	0.057	0.000	22.502	30.986	30.550
	0.091	0.000	19.081	30.550	30.113
	0.123	0.000	17.156	30.550	30.113
	0.158	-0.005	16.088	30.550	29.676
Engine 1-1					
Open	0.000	-0.005	16.060	34.042	32.295
	0.022	0.066	16.060	34.478	32.295
	0.057	4.030	23.882	34.478	32.295
	0.091	4.051	26.630	34.478	32.295
	0.124	4.066	26.842	31.423	32.295
Close	0.024	4.061	26.419	31.423	30.550
	0.061	0.000	22.824	30.550	30.550
	0.093	0.000	19.019	30.550	30.113
	0.127	-0.005	17.328	30.550	30.113
	0.162	-0.010	16.693	30.550	30.113

APS 2 Test

Function	Meas.	AO Multi	BO Multi	Limit
IU Substitute Power (vdc)	-28.08			-28.5 ± 2.5
Helium Sphere Pressure (psia)		42.0	42.0	100.0 max
Helium Regulator Outlet (psia)		46.3	46.3	50.0 ± 10.0
Helium Sphere Temperature (°F)		64.3	-	*
Oxidizer Tank Temperature (°F)		62.9	63.3	*
Fuel Tank Temperature (°F)		61.0	61.3	*
Fuel Tank Ullage Pressure (psia)		41.9	-	50.0 ± 10.00
Oxidizer Tank Ullage Pressure (psia)		44.1	-	50.0 ± 10.00
Fuel Manifold Pressure (psia)		32.3	-	40.0 ± 20.00
Oxidizer Manifold Pressure (psia)		39.3	-	40.0 ± 20.00

* Limits Not Specified

4.3.17.1 (Continued)

Function	Meas.	AO Multi	BO Multi	Limit
Engine 2-2 Valve Test				
Valve Open Ind (Closed) (vdc)	0.000			*
Aft Bus 1 Voltage (vdc)	28.199			*
Valve Open Ind (Open) (vdc)	4.092			*
Engine 2-3 Valve Test				
Valve Open Ind (Closed) (vdc)	0.000			*
Aft Bus 1 Voltage (vdc)	28.158			*
Valve Open Ind (Open) (vdc)	4.010			*
Engine 2-1 Valve Test				
Valve Open Ind (Closed) (vdc)	0.000			*
Aft Bus 1 Voltage (vdc)	28.158			*
Valve Open Ind (Open) (vdc)	4.030			*

APS 2 - Engine Propellant Transfer Valve Tests

Valve Movement	Time (sec)	Valve Open Ind (vdc)	Measured Pressures (psia) Thrust Chamb	Oxid Manif	Fuel Manif
Engine 2-2					
Open	0.000	-0.005	15.634	39.715	31.858
	0.023	-0.005	15.846	39.715	32.295
	0.060	4.035	25.817	36.224	32.295
	0.096	4.061	29.212	36.224	28.367
	0.131	4.061	29.000	36.224	28.367
Close	0.021	4.066	27.515	33.604	24.875
	0.056	0.000	23.060	33.604	24.875
	0.092	0.000	19.240	34.042	24.875
	0.123	0.000	17.188	34.042	24.875
	0.160	0.000	16.059	34.042	24.875
Engine 2-3					
Open	0.000	0.000	15.418	36.224	27.059
	0.022	-0.005	15.418	35.787	27.059
	0.060	3.958	24.540	35.787	27.059
	0.096	3.999	27.087	34.042	24.875
	0.130	4.005	26.874	34.042	24.875
Close	0.021	3.584	26.237	30.986	23.566
	0.056	0.000	22.419	30.986	23.566
	0.090	0.000	18.600	30.550	24.439
	0.124	0.000	16.267	30.550	24.439
	0.159	0.000	15.630	30.550	24.439

* Limits Not Specified

4.3.17.1 (Continued)

Valve Movement	Time (sec)	Valve Open Ind (vdc)	Measured Pressures (psia) Thrust Chamb	Oxid Manif	Fuel Manif
Engine 2-1					
Open	0.000	0.000	15.076	37.096	27.494
	0.021	0.000	15.076	37.096	27.494
	0.056	3.989	24.610	37.096	27.494
	0.091	4.015	26.518	37.096	27.494
	0.124	4.030	26.094	34.042	24.875
Close	0.022	4.030	25.458	34.042	24.875
	0.059	0.005	20.797	30.550	24.439
	0.096	-0.010	17.194	30.550	24.439
	0.129	0.000	15.550	31.423	24.003
	0.164	-0.005	14.652	31.423	24.003

Ullage Engine Tests

Function	Measurement	Limits
IU Substitute Power (vdc)	-27.92	-28.5 + 2.5
APS 1 Fuel Supply Manifold Pressure (psia)	34.5	40.0 ∓ 20.0
APS 1 Oxidizer Supply Manifold Pressure (psia)	36.2	40.0 ∓ 20.0
APS 2 Fuel Supply Manifold Pressure (psia)	28.8	40.0 ∓ 20.0
APS 2 Oxidizer Supply Manifold Pressure (psia)	37.5	40.0 ∓ 20.0

Ullage Engine Propellant Transfer Valve Test

Valve Movement	Time (sec)	Measured Pressures (psia) Thrust Chamb	Oxid Manif	Fuel Manif
APS 1 - Engine 1-4				
Open	0.000	16.104	36.224	34.478
	0.030	16.104	35.787	34.478
	0.078	23.996	35.787	34.478
	0.123	23.996	33.168	33.168
	0.167	20.797	33.168	33.168
	0.210	20.797	31.423	30.986
Close	0.032	19.304	30.113	28.367
	0.079	19.304	27.931	27.059
	0.124	16.104	27.931	27.059
	0.167	16.104	27.494	26.622
	0.210	16.104	27.494	26.186
APS 2 - Engine 2-4				
Open	0.000	15.669	38.406	28.804
	0.030	15.669	37.969	29.240
	0.078	15.456	37.532	29.240
	0.123	15.456	37.532	28.367
	0.167	15.881	37.532	28.367
	0.210	15.881	37.532	28.804

4.3.17.1 (Continued)

Valve Movement	Time (sec)	Measured Pressures (psia) Thrust Chamb	Oxid Manif	Fuel Manif
Close	0.030	15.456	37.532	28.804
	0.179	15.456	37.532	28.804
	0.124	15.881	37.532	28.804
	0.167	15.881	37.532	28.804
	0.210	15.881	37.532	28.804

4.3.18 Propellant Utilization Calibration (1B64367 K)

Calibration and operation instructions for the propellant utilization (PU) system were provided by this manual checkout. For calibration purposes, the propellant utilization test set (PUT/S), P/N 1A68014-1, was utilized to provide varying capacitance inputs to the propellant utilization electronics assembly (PUEA) to simulate the LOX and LH_2 mass probe outputs under varying propellant load conditions.

The items involved in this test included:

Part Name	Ref. Location	P/N	S/N
Propellant Utilization Electronics Assy	411A92A6	1A59358-529	034
Static Inverter-Converter	411A92A7	1A66212-507	00011
LOX Mass Probe	406A1	1A48430-511	C2
LH_2 Mass Probe	408A1	1A48431-513	D4C2
LOX Overfill Sensor	(Part of LOX Mass Probe)		
LOX Overfill Control Unit	404A72A4	1A68710-511	C9
LOX Fastfill Sensor	406A2C5	1A68710-1	D112
LOX Fastfill Control Unit	404A7A5	1A68710-511	C8
LH_2 Overfill Sensor	(Part of LH_2 Mass Probe)		
LH_2 Overfill Control Unit	411A92A24	1A68710-509	C41
LH_2 Fastfill Sensor	408A2C5	1A68710-1	E101
LH_2 Fastfill Control Unit	411A92A43	1A68710-509	C45

The PU calibration was accomplished twice during the deferred postfire checkout. The first issue was accomplished on 12 December and 13 December 1968. The replacement of the PU electronics assembly required a second issue, which was performed on 19 December 1968, and accepted on 20 December 1968. For this narrative only the second issue will be discussed. The data listed in the test data table is from the second issue.

Megohm resistance measurements of the LOX and LH_2 mass probes were verified to be greater than the 1000 megohm minimum requirement. The output voltage

4.3.18 (Continued)

and operating frequency of the static inverter-converter were measured, and the resulting values were within the specified limits. The PUEA LH_2 bridge was calibrated for the empty condition by nulling the PUT/S ratiometer at a reading of 0.0139 then nulling the PUEA R2 potentiometer. The PUEA LOX bridge was calibrated for the empty condition by nulling the PUT/S ratiometer to a reading of 0.0405, and then nulling the PUEA R1 potentiometer. The PUEA LH_2 and LOX bridges were calibrated for full conditions by setting the PUT/S ratiometer to 0.823 and nulling the LH_2 and LOX bridge potentiometers.

Data acquisition was verified by establishing simulated empty and full conditions and determining the PUT/S ratiometer settings required to null the PUEA LH_2 and LOX bridges. All values obtained were within the required limits. The bridge slew checks were conducted by simulating 1/3 and 2/3 slew conditions and determining the PUT/S ratiometer settings required to null the PUEA LH_2 and LOX bridges for each case.

The reference mixture ratio (RMR) calibration was then accomplished. The first step consisted of determining the difference between the LOX and LH_2 empty ratiometer readings and multiplying this difference by 98.4 vdc. The resultant product was designated as VI. Simulated empty conditions were setup and the PUEA residual empty bias potentiometer R6 was nulled. Simulated full conditions were then established with the PUT/S C1 (LH_2) capacitor set to 182.52 picofarads and the C2 (LOX) capacitor set to 122.83 picofarads. The residual full bias potentiometer R5 on the PUEA was set to the null position. The bridge linearity checks were then accomplished by adjusting the PUT/S

4.3.18 (Continued)

capacitors C1 (LH_2) and C2 (LOX) to specific values and determining the PUT/S ratiometer settings required to null the PUEA bridges. The hardwire loading voltages of the LH_2 and LOX bridges were checked and found to be within the specified tolerance of 23.6 $\pm$2.0 vdc.

All required parts were installed at the start of this checkout. No problems were encountered during the procedure, no FARR's were written as a result of this checkout, and no revisions were required.

4.3.18.1 Test Data Table, Propellant Utilization System Calibration

Function	Measured Value	Limits
Static Inverter Output		
5 vdc (vdc)	4.964	4.75 to 5.05
21 vdc (vdc)	21.49	20 to 22.5
28 vdc (vdc)	27.58	26 to 30
V/P Excitation (vdc)	50.99	49.21 to 52.37
115 VRMS Monitor (vdc)	2.78	2.28 to 3.18
117 vdc (vdc)	121.8	115 to 122.5
TP_2 Reading (vdc)	21.74	20 to 22.5
Frequency Output (Hz)	402.0	394 to 406
Data Acquisition (Ratios)		
LH_2 Empty	0.00012	*
LOX Empty	0.02090	*
LH_2 Full	0.82387	*
LOX Full	0.82327	*
Bridge Slew Checks (Ratios)		
LH_2 1/3 Slew	0.31063	*
LH_2 2/3 Slew	0.64100	*
LOX 1/3 Slew	0.28308	*
LOX 2/3 Slew	0.56977	*

* Limits Not Specified

4.3.18.1 (Continued)

Function	Measured Value	Limits
LH_2 Bridge Linearity Check (Ratios)		
36.50 pf	0.16022	0.15802 to 0.16131
73.01 pf	0.32589	0.32394 to 0.32723
109.51 pf	0.49151	0.48986 to 0.49715
146.01 pf	0.65744	0.65578 to 0.65907
182.52 pf	0.82378	0.82170 to 0.82499
LOX Bridge Linearity Check (Ratios)		
24.57 pf	0.18095	0.17977 to 0.18306
49.13 pf	0.34130	0.34025 to 0.34354
73.70 pf	0.50154	0.50073 to 0.50403
98.27 pf	0.66230	0.66121 to 0.66451
122.83 pf	0.82306	0.82170 to 0.82499

4.3.19 Propellant Utilization System (1B55823 K)

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 LH_2 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	034
Static Inverter-Converter	411A92A7	1A66212-507	00011
LOX Mass Probe	406A1	1A48430-511	C2
LH_2 Mass Probe	408A1	1A48431-513	D4C2
LOX Overfill Sensor		(Part of LOX Mass Probe)	
LOX Overfill Control Unit	404A72A4	1A68710-511	C9
LOX Fastfill Sensor	406A2C5	1A68710-1	D112
LOX Fastfill Control Unit	404A72A5	1A68710-511	C8
LH_2 Overfill Sensor		(Part of LH_2 Mass Probe)	
LH_2 Overfill Control Unit	411A92A24	1A68710-509	C41
LH_2 Fastfill Sensor	408A2C5	1A68710-1	E101
LH_2 Fastfill Control Unit	411A92A43	1A68710-509	C45

The procedure was issued twice to complete deferred postfire testing. The initial test was satisfactorily conducted on 11 December 1968. A second test was required due to replacement of the PUEA, P/N 1A59358-529, S/N 031, with S/N 034, during the all systems test, reference paragraph 4.3.24. This final test, conducted on 19 December 1968, is the source of the measurements listed in Test Data Table 4.3.19.1.

4.3.19 (Continued)

Initial conditions for the test were established and 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 LH_2 coarse mass voltages, fine mass voltages, and loading voltages. After an evaluation of the computer printout, a test of the PU system power was made. Power was applied to the PU inverter and PU 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 final PU oven monitor output voltage was within tolerance.

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

The PU loading test followed. The LH_2 boiloff bias signal voltage was measured with the boiloff bias cutoff turned on and 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 LH_2 loading potentiometer sense voltages and signal voltages. Measurements of the LOX and LH_2 loading potentiometer signal voltages were repeated after the LOX and LH_2

4.3.19 (Continued)

bridge 1/3 checkout relay commands were turned on, and again after these commands were turned off. The GSE power was turned off, and the LOX and LH_2 loading potentiometer sense voltages were again measured.

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

The next check verified that the LOX and LH_2 tank overfill and 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 swtich 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 LH_2 bridge 1/3 checkout relay, then measuring the LH_2 coarse mass voltage.

4.3.19 (Continued)

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 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, LH_2 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 switch 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, three revisions were recorded in the procedure for the following:

a. One revision indicated an initial conditions scan malfunction caused by a program error. The program looked for the wrong valve position.

b. One revision modified the program to obtain faster strip chart speed for PU valve movement during the valve slew check only. This was done to obtain a more accurate valve movement record.

4.3.19

c. One revision attributed an out-of-tolerance indication for PU oven monitor stability to a program error. All PU oven voltages were within tolerance, and additional delay time to obtain stability was not required and therefore bypassed.

4.3.19.1 Test Data Table, Propellant Utilization System

Loaded Ratio Values (from H&CO 1B64367)

LOX Empty Ratio	0.021	LH_2 Empty Ratio	0.000
LOX 1/3 Bridge Slew Ratio	0.283	LH_2 1/3 Bridge Slew Ratio	0.311
LOX 2/3 Bridge Slew Ratio	0.570	LH_2 2/3 Bridge Slew Ratio	0.641
LOX Wiper Ratio	0.041	LH_2 Wiper Ratio	0.014

LH_2 Boiloff Bias Voltage (vdc) 12.520

Computed Coarse Mass Voltages (vdc)

LOX Empty	0.103	LH_2 Empty	0.000
LOX 1/3 Mass	1.416	LH_2 1/3 Mass	1.553
LOX 2/3 Mass	2.852	LH_2 2/3 Mass	3.203

Computed Fine Mass Voltages (vdc)

LOX Empty	4.009	LH_2 Empty	1.367
LOX 1/3 Mass	0.249	LH_2 1/3 Mass	2.432
LOX 2/3 Mass	2.109	LH_2 2/3 Mass	4.780

Computer Loading Voltages (vdc)

LOX Empty	0.574	LH_2 Empty	0.000
LOX 1/3 Coarse Mass	7.930	LH_2 1/3 Coarse Mass	8.695

PU System Power Test

Function	Measured Value	Limits
Inv-Conv 115 vrms Output (vac)	114.922	115.0 $\pm$ 3.4
Inv-Conv 21 vdc Output (vdc)	21.712	21.25 $\pm$ 1.25
Inv-Conv 5 vdc Output (vdc)	5.001	4.9 $\pm$ 0.2
Inv-Conv Frequency (Hz)	401.219	400.0 $\pm$ 6
PU Oven Monitor Voltage Z1 (vdc)	2.205	2.6 $\pm$ 2.35
PU Oven Monitor Voltage Z2 (vdc)	2.199	2.205 $\pm$ 0.075
PU Oven Monitor Voltage Z3 (vdc)	2.205	2.205 $\pm$ 0.075
PU Oven Monitor Voltage - Final (vdc)	2.205	2.205 $\pm$ 0.075

4.3.19.1 (Continued)

Bridge Balance and Ratio Valve Null Test

Function	Measured Value	AO Multi	BO Multi	Limits
Ratio Valve Position (deg)	-0.058			0.000 ± 1.5
LOX Coarse Mass Voltage (vdc)		0.093	0.107	0.103 ± 0.1
LOX Fine Mass Voltage (vdc)		4.023	4.019	4.009 ± 0.4
LH_2 Coarse Mass Voltage (vdc)		-0.005	0.005	0.000 ± 0.1
LH_2 Fine Mass Voltage (vdc)		1.406	1.411	1.367 ± 0.4

PU Loading Test

Function	Measured Value	Limits
LH_2 Boiloff Bias Signal Volt. (vdc)	14.04	13.520 ± 2.0
GSE Power Supply Voltage (vdc)	29.079	28.0 ± 2.0

Loading Potentiometer Function	LOX Value	LH_2 Value	Limits
Sense Voltage, GSE Power On (vdc)	29.079	29.079	29.079 ± 0.4
Signal Voltage, Relay Commands Off (vdc)	0.574		0.574 ± 0.5
		0.000	0.0 ± 0.5
Signal Voltage, Relay Commands On (vdc)	7.793		7.930 ± 0.6
		8.447	8.695 ± 0.6
Signal Voltage, Relay Commands Off (vdc)	0.684		0.574 ± 0.5
		0.027	0.0 ± 0.5
Sense Voltage, GSE Power OFF (vdc)	0.000	0.000	0.0 ± 0.75

Servo Balance Bridge Gain Test

Function	Measured Value	AO Multi	BO Multi	Limits
Ratio Valve Position (deg)	0.010			-0.058 ± 1.5
LOX Coarse Mass Voltage (vdc)		0.093	0.103	0.103 ± 0.1
LOX Fine Mass Voltage (vdc)		4.019	4.019	4.009 ± 0.4
LH_2 Coarse Mass Voltage (vdc)		0.000	0.000	0.000 ± 0.1
LH_2 Fine Mass Voltage (vdc)		1.416	1.411	1.367 ± 0.4
1/3 Checkout Relay Commands On				
Ratio Valve Position (deg)	0.419			-0.058 ± 1.5
LOX Coarse Mass Voltage (vdc)		1.406	1.421	1.416 ± 0.1
LOX Fine Mass Voltage (vdc)		0.142	0.142	0.249 ± 0.4
LH_2 Coarse Mass Voltage (vdc)		1.553	1.558	1.553 ± 0.1
LH_2 Fine Mass Voltage (vdc)		2.554	2.554	2.432 ± 0.4

4.3.19.1 (Continued)

Function	Measured Value	AO Multi	BO Multi	Limits
2/3 Checkout Relay Commands On				
Ratio Valve Position (deg)	0.828			-0.058 ± 1.5
LOX Coarse Mass Voltage (vdc)		2.856	2.856	2.852 ∓ 0.1
LOX Fine Mass Voltage (vdc)		1.865	1.865	2.109 ∓ 0.4
LH_2 Coarse Mass Voltage (vdc)		3.208	3.203	3.203 ∓ 0.1
LH_2 Fine Mass Voltage (vdc)		4.917	4.897	4.780 ∓ 0.4
2/3 Checkout Relay Commands Off				
Ratio Valve Position (deg)	0.556			-0.058 ± 1.5
LOX Coarse Mass Voltage (vdc)		1.411	1.411	1.416 ∓ 0.1
LOX Fine Mass Voltage (vdc)		0.151	0.151	0.249 ∓ 0.4
LH_2 Coarse Mass Voltage (vdc)		1.553	1.553	1.553 ∓ 0.1
LH_2 Fine Mass Voltage (vdc)		2.544	2.544	2.432 ∓ 0.4
1/3 Checkout Relay Commands Off				
Ratio Valve Position (deg)	0.010			-0.058 ± 1.5
LOX Coarse Mass Voltage (vdc)		0.103	0.103	0.103 ∓ 0.1
LOX Fine Mass Voltage (vdc)		3.999	4.014	4.009 ∓ 0.4
LH_2 Coarse Mass Voltage (vdc)		-0.010	0.000	0.000 ∓ 0.1
LH_2 Fine Mass Voltage (vdc)		1.396	1.411	1.367 ∓ 0.4

PU Valve Movement Test

Function	Measured Value	Limits
Ratio Valve Position, AO (deg)	-0.058	-0.058 ± 1.50
Ratio Valve Position, BO (deg)	-0.058	-0.058 ∓ 1.50
50 Second Plus Valve Slew, AO Multiplexer		
+1 vdc System Test Valve Position Signal (vdc)	0.996	1.00 ± 0.02
V1, Position at T+3 Seconds (deg)	4.295	2.037 to 6.351
V2, Position at T+5 Seconds (deg)	5.181	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)	5.932	5.226 to 7.396
V5, Position at T+50 Seconds (deg)	5.862	5.226 to 7.396

4.3.19.1 (Continued)

Function	Measured Value	Limits
50 Second Minus Valve Slew, AO Multiplexer		
Ratio Valve Position, AO (deg)	0.01	-0.058 ± 1.5
-1 vdc System Test Valve Error Signal (vdc)	-0.996	-1.000 ± 0.02
V1, Position at T+3 Seconds (deg)	-3.816	-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)	-5.385	-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)	-0.398	-0.262	-0.058 ± 1.50
LOX 1/3 Command Relay On			
LOX Coarse Mass Voltage (vdc)	1.416	1.421	1.416 ± 0.1
PU System On			
Ratio Valve Position (deg)	33.485	33.417	20.0 min
PU System Off			
Ratio Valve Position (deg)	0.351	0.351	15.0 max
LOX 1/3 Command Relay Off			
LOX Coarse Mass Voltage (vdc)	0.103	0.103	0.103 ± 0.1
Ratio Valve Position (deg)	0.010	-0.058	-0.058 ∓ 1.5
LH_2 1/3 Command Relay On			
LH_2 Coarse Mass Voltage (vdc)	1.558	1.558	1.553 ± 0.1
PU System On			
Ratio Valve Position (deg)	-27.532	-27.532	-20.0 max
PU System Off			
Ratio Valve Position (deg)	0.01	-	-15.0 min
LH_2 1/3 Command Relay Off			
LH_2 Coarse Mass Voltage (vdc)	0.000	-0.005	0.000 ± 0.1
Ratio Valve Position (deg)	-0.058	-0.125	-0.058 ∓ 1.5

PU Valve Programmed Mixture Ratio Test

Function	Measured Value	Limits
4.5 MR Switch On		
Ratio Valve Position (deg)	-20.510	-20.0 max
LOX 1/3 Command Relay On and PU System On		
Ratio Valve Position (deg)	-27.941	-20.0 max
PU Programmed MR Switch Off		
Ratio Valve Position (deg)	0.487	-1.5 min

4.3.19.1 (Continued)

Function	Measured Value	Limits
5.5 MR Switch On		
Ratio Valve Position (deg)	22.509	20.0 min
LH_2 1/3 Command Relay On and PU System On		
Ratio Valve Position (deg)	33.826	20.0 min
PU Programmed MR Switch Off		
Ratio Valve Position (deg)	-0.603	1.5 min
4.5 MR Switch On		
Ratio Valve Position (deg)	-22.760	-20.0 max
5.5 MR Switch On		
Ratio Valve Position (deg)	-7.489	0 ± 10
PU Programmed MR Switch Off		
Ratio Valve Position (deg)	1.442	0.058 ± 1.5

4.3.20 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	187
Range Safety Receiver 2	411A97A18	50M10697	198
Secure Command Decoder 1	411A99A1	50M10698	0165
Secure Command Decoder 2	411A99A2	50M10698	0167

Initiated on 12 December 1968, this checkout was completed and accepted on 16 December 1968, after the second attempt. The first attempt was terminated after it was noted that the test code plugs were not installed on the decoder assemblies.

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 30.3 db for range safety system 1 and 30.3 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.

4.3.20 (Continued)

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

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 per cent 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 4.3.20.1, the AGC values were all acceptable; and the drift deviations were well below the 3 per cent of full scale maximum limit.

Manual -3 db and -60 db RF bandwidth checks were individually conducted on each reciever. 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

4.3.20 (Continued)

the receiver AGC voltage was again 2.0 ±0.1 vdc. The frequencies at which this occurred were measured as the upper and lower -3 db bandedge frequencies. The -3 db bandwidth was found as the difference between these frequencies, and the bandwidth centering was found as the difference between the midpoint of these frequencies and 450 MHz. For the -60 db bandwidth check, this 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 ±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 ±0.045 MHz with a fixed deviation of 60 ±0.5 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

4.3.20 (Continued)

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.

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 3.56 vdc while that of receiver 2 was 3.78 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

4.3.20 (Continued)

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.

Engineering comments noted that there were no part shortages affecting the test.

Seven revisions were documented against the checkout:

a. Two revisions concerned a NASA request to change the test set output from -63 dbm to -93 dbm.

b. Two revisions concerned attempt two. Run one was terminated after it was noted that the test code plugs were not installed on the decoder assembly.

c. One revision was required to update the procedure to the latest configuration.

d. One revision attributed the ambient helium supply shutoff valve closed relay reset not off malfunction indication to a program error.

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

4.3.20.1 Test Data Table, Range Safety Receiver Checks

AGC Calibration and Drift Checks (% = Per Cent 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
-97.0	-127.0	14.36	14.24	0.12	-127.3	23.07	22.46	0.61
-90.0	-120.0	14.55	14.36	0.20	-120.3	23.38	22.87	0.51
-85.0	-115.0	14.77	14.86	0.10	-115.3	23.79	23.38	0.41

4.3.20.1 (Continued)

Test Set Output (dbm)	Receiver 1 Input (dbm)	AGC 1 (%)			Receiver 2 Input (dbm)	AGC 2 (%)		
		Run 1	Run 2	Drift		Run 1	Run 2	Drift
-80.0	-110.0	16.50	16.82	0.31	-110.3	25.53	25.33	0.20
-75.0	-105.0	21.93	21.84	0.10	-105.3	29.94	30.55	0.61
-70.0	-100.0	34.45	33.73	0.72	-100.3	44.20	43.16	1.04
-65.0	-95.0	56.09	55.27	0.82	-95.3	64.08	63.38	0.70
-60.0	-90.0	71.17	71.27	0.10	-90.3	75.18	75.27	0.10
-55.0	-85.0	75.18	75.06	0.12	-85.3	77.42	77.32	0.10
-50.0	-80.0	76.41	76.41	0.00	-80.3	77.83	77.83	0.00
-45.0	-75.0	77.01	77.01	0.00	-75.3	78.14	78.05	0.10
-40.0	-70.0	77.23	77.23	0.00	-70.3	78.05	78.05	0.00

-3 db RF Bandwidth Check

Function	Receiver 1	Receiver 2	Limits
Reference Voltage (AGC) (vdc)	1.99	1.98	2.0 ± 0.1
Reference RF Power Level (dbm)	-88.8	-91.6	-
Upper Band Edge Freq. (MHz)	450.151	450.152	-
Lower Band Edge Freq. (MHz)	449.827	449.819	-
-3 db Bandwidth (kHz)	324.0	333.0	340.0 ± 30.0
Bandwidth Centering (MHz)	449.989	450.005	450 ± 0.0338

-60 db RF Bandwidth Check

Function	Receiver 1	Receiver 2	Limits
Reference Voltage (ABC) (vdc)	1.99	1.98	2.0 ± 0.1
Reference RF Power Level (dbm)	-88.8	-91.6	-
Upper Band Edge Freq. (MHz)	450.504	450.454	-
Lower Band Edge Freq. (MHz)	449.446	449.452	-
-60 db Bandwidth (MHz)	1.058	1.002	1.2 max

Deviation Sensitivity Check

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

RF Sensitivity Check

Range Safety Command	Minimum Input Level (dbm) Receiver 1	Receiver 2
Arm and Engine Cutoff	-105.0	-100.3
Propellant Dispersion	-105.3	-105.0
Range Safety System Off	-105.3	-105.0

4.3.21 Range Safety System (1B55821 J)

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	187
Range Safety Receiver 2	411A97A18	50M10697	198
Secure Command Decoder 1	411A99A1	50M10698	0165
Secure Command Decoder 2	411A99A2	50M10698	0167
Secure Command Controller 1	411A97A13	1B33084-503	016
Secure Command Controller 2	411A97A19	1B33084-503	015
RS System 1 EBW Firing Unit	411A99A12	40M39515-119	418
RS System 2 EBW Firing Unit	411A99A20	40M39515-119	419
RS System 1 EBW Pulse Sensor	411A99A31	40M02852	*
RS System 2 EBW Pulse Sensor	411A99A32	40M02852	*
Safe and Arm Device	411A99A22	1A02446-503	*
Directional Power Divider	411A97A56	1B38999-1	034
Hybrid Power Divider	411A97A34	1A74778-501	050
*Installed in Pulse Sensor Assembly	411A99A31/32	1B29054-501	0016

Initiated on 12 December 1968, the procedure was accepted as complete on 16 December 1968.

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

4.3.21 (Continued)

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

The EBW firing unit arm and engine cutoff command was turned on and verified to be received by range safety system 1. The system 1 firing unit charging voltage indication was measured. Verification was made that the engine cutoff indications were off at the umbilical and through the AO and BO telemetry multiplexers, that the 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

4.3.21 (Continued)

and through both multiplexers, that the nonprogrammed engine cutoff indication was still off, and the 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 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

4.3.21 (Continued)

indication was verified again to 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.

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

4.3.21 (Continued)

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 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, again the safe indication was verified to be on, and the arm indication was verified to be off.

Engineering comments noted that there were no part shortages affecting this test. There were a total of two revisions written to the procedure, both concerned changes required to correct program errors.

4.3.21.1 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	28.118	28.0 ± 2.0
External Internal Power Transfer Test		
External Power On		
System 1 Charging Voltage Indication	4.229	4.2 ± 0.3
System 1 Firing Unit Indication	4.220	4.2 ± 0.3
System 2 Firing Unit Indication	4.225	4.2 ± 0.3
System 2 Charging Voltage Indication	4.220	4.2 ± 0.3
Internal Power		
System 1 Charging Voltage Indication	4.239	4.2 ± 0.3
System 2 Charging Voltage Indication	4.225	4.2 ± 0.3

4.3.21.1 (Continued)

Function	Measured Value (vdc)	Limits (vdc)
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	27.999	28.0 ± 2.0
Receiver 1 Signal Strength Indication	3.748	3.75 ± 1.25
Receiver 2 Signal Strength Indication	3.871	3.75 ± 1.25
System 1 Arm and Engine Cutoff Test		
Firing Unit Charging Voltage Indication	4.229	4.2 ± 0.3
Engine Control Bus Voltage	28.000	28.0 ± 2.0
External Power Off		
System 1 Charging Voltage Indication	0.060	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	4.229	4.2 ± 0.3
Propellant Dispersion Test		
System 1 Propellant Dispersion Test		
Charging Voltage Indication (Pulse Sensor Off)	4.239	4.2 ± 0.3
Charging Voltage Indication (Pulse Sensor On)	1.800	3.0 max
System 2 Propellant Dispersion Test		
Charging Voltage Indication (Pulse Sensor Off)	4.234	4.2 ± 0.3
Charging Voltage Indication (Pulse Sensor On)	1.439	3.0 max

4.3.22 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 monitors. Only the particular items calibrated during this procedure are noted below and in Test Data Table 4.3.22.1.

The procedure was initiated on 13 December 1968, and was certified as completed on 18 December 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 $\pm$0.1 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$200Hz. 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.

4.3.22 (Continued)

Three temperature bridges required calibration for measurements C040, oxidizer tank temperature; C200, fuel injection temperature; and C012, G.G. fuel bleed valve temperature. With a low level calibration input, the temperature bridge was adjusted to obtain a bridge output of 0.000 vdc, within the 0.000 ± 0.005 vdc limits. With a high level calibration input, the bridge output was verified to be 4.000 vdc, within the 4.000 ±0.005 vdc limits.

No part shortages were recorded that affected this test; however, one failure and Rejection Report (FARR) was written as a result of this procedure. FARR 500-607-629 reported that the 20 volt excitation module, P/N 1A74036-1, S/N 0353, had an output of 16.5 vdc. The tolerance was expressed as 20.00 ± 0.005 vdc. The module was removed and replaced.

Three revisions were made to the procedure for the following:

a. One revision authorized calibrating parameters C040, C012 and C200. These parameters were found out-of-tolerance during DDAS.

b. One revision concerned checking the 20 volt excitation module installed on FARR 500-607-629.

c. One revision deleted all sections that were not required as the procedure was used only for those parameters that were found to be out-of-tolerance and were adjusted by this procedure.

4.3.22.1 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
404A52A7	0141	5.000	-20.000	9.8	2034
411A98A2	0193	5.003	-20.001	10.0	2055
411A99A33	D198	5.003	-20.000	9.9	2040

4.3.22.1 (Continued)

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

Reference Location	S/N	20 vdc Output (vdc)	Tolerance (vdc)
411A61A242	0295	20.001	20.0 ± 0.005
404A62A241	0292	20.002	20.0 ± 0.005
404A63A241	0261	19.999	20.0 ± 0.005
404A64A241	0298	20.002	20.0 ± 0.005
404A65A241	0297	20.000	20.0 ± 0.005
404A63A233	0266	20.000	20.0 ± 0.005
404A66A241	0367	20.000	20.0 ± 0.005

Temperature Bridge

			Output (mvdc)			
			Zero		Gain	
P/N	S/N	Reference Location	Reading	Tolerance	Reading	Tolerance
1A82274-517	02976	404A62A216	0.0	0.0 ± 0.05	24.0	24.0 ± 0.3
1A98088-1	069	404A64A210	0.0	0.0 ± 0.05	24.23	24.0 ± 0.3
1A82274-505	03497	404A66A204	0.0	0.0 ± 0.05	24.02	24.0 ± 0.3

4.3.23 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 X457811; the auxiliary hydraulic pump, P/N 1A66241-511, S/N X458916; the accumulator/reservoir assembly, P/N 1B29319-519, S/N 00029; the hydraulic pitch actuator, P/N 1A66248-505-011, S/N 71; and the hydraulic yaw actuator, P/N 1A66248-505-011, S/N 84.

This checkout required three attempts, the first, initiated on 14 December 1968, was aborted due to a fluid leak in the auxiliary pump, P/N 1A66241-511, S/N X454594. Replacement was made on FARR 500-607-637 with S/N X458923. The second attempt, on 19 December 1968, was aborted due to failure of the coast mode thermal switch on the auxiliary hydraulic pump to operate when a dry ice pack was applied. Trouble shooting revealed that the dry ice pack had been applied to the wrong location. After repositioning the ice pack, the auxiliary pump came on in the required time. During trouble shooting it was noted that the hydraulic pump was leaking fluid at the shaft seal drain port. The pump was removed and replaced with S/N X458916 on FARR 500-607-653.

The procedure was satisfactorily accomplished by the third attempt on 19 December 1968, and was accepted on 27 December 1968. Those function values measured during the test are presented in Test Data Table 4.3.23.1. All of

4.3.23 (Continued)

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 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

4.3.23 (Continued)

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 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

4.3.23 (Continued)

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 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

4.3.23 (Continued)

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. Two FARR's were initiated as a result of this checkout. FARR 500-607-637 reported that the auxiliary hydraulic pump, P/N 1A66241-511, S/N X454594, was leaking between the motor case and the pump assembly. The pump was removed and replaced with S/N X458923. FARR 500-607-653 documented a fluid leak on the auxiliary hydraulic pump, S/N X458923, at the shaft seal drain port. The pump was removed and replaced with S/N X458916. Ten revisions were made to 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 program.

c. One revision was required to update the procedure to the latest configuration.

d. One revision attributed a malfunction indication to a program error.

e. One revision stated that the "LOX repressurization control valve relay reset indication, not off" malfunction was caused by the panel switch being left in the reset position after the leak check procedure.

4.3.23 (Continued)

f. One revision authorized performance of the second attempt. The first attempt was aborted due to replacement of the auxiliary hydraulic pump.

g. One revision authorized performance of the third attempt. The second attempt was aborted due to a suspected malfunction of the coast mode thermal switch.

h. One revision attributed the malfunction of the PU inverter power to concurrent performance of the PU calibration procedure and the PU inverter power was on to support the checkout.

i. One revision attributed the failure of the auxiliary hydraulic pump coast mode thermal switch to close to improper positioning of the dry ice pack. After repositioning the ice, the switch operated properly.

j. One revision deleted a previous revision.

4.3.23.1 Test Data Table, Hydraulic System

Function	Measurement	Limits
IU Substitute 5 Volt Power Supply (vdc)	5.01	5.00 ± 0.05
Aft 5 Volt Excitation Module (vdc)	4.98	5.00 ± 0.05
Hydraulic System Unpressurized		
Reservoir Oil Pressure (psia)	72.12	*
Accumulator GN_2 Pressure (psia)	2285.56	*
Accumulator GN_2 Temperature (°F)	54.94	*
Reservoir Oil Level(%)	88.06	*
Pump Inlet Oil Temperature (°F)	42.08	*
Reservoir Oil Temperature (°F)	64.31	*
Aft Bus 2 Current (amp)	0.00	*
Gaseous Nitrogen Mass (lb)	1.920	1.925 ± 0.2
Corrected Reservoir Oil Level (%)	99.6	95.0 min
Engine Centering Test, Locks On, System Unpressurized		
T/M Pitch Actuator Position (deg)	-0.06	*
IU Pitch Actuator Position (deg)	-0.04	*
T/M Yaw Actuator Position (deg)	0.00	*
IU Yaw Actuator Position (deg)	0.06	*
IU Substitute 5 Volt Power Supply (vdc)	5.00	*

* Limits Not Specified

4.3.23.1 (Continued)

Function	Measurement	Limits
Aft 5 Volt Excitation Module (vdc)	4.98	*
Pitch Actuator Signal (ma)	0.05	*
Yaw Actuator Signal (ma)	0.05	*
Corrected T/M Pitch Actuator Position (deg)	-0.086	-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)	0.021	-0.236 to 0.236
Corrected IU Yaw Actuator Position (deg)	0.053	-0.236 to 0.236
Aft Bus 2 Voltage (vdc)	56.88	56.0 + 4.0
Aft Bus 2 Current (amp)	63.20	55.0 ∓ 30.0
Hyd System 4 Second Press Change (psia)	330.60	200.0 min
Engine Centering Test, Locks Off, Systems Pressurized No Excitation Signal		
T/M Pitch Actuator Position (deg)	-0.03	*
IU Pitch Actuator Position (deg)	0.00	*
T/M Yaw Actuator Position (deg)	-0.02	*
IU Yaw Actuator Position (deg)	0.02	*
IU Substitute 5 Volt Power Supply (vdc)	5.00	*
Aft 5 Volt Excitation Module (vdc)	4.98	*
Pitch Actuator Signal (ma)	0.05	*
Yaw Actuator Signal (ma)	0.05	*
Hydraulic System Pressurized, Locks Off, Zero Excitation Signal Applied to Actuators		
Hydraulic System Pressure (psia)	3581.75	*
Reservoir Oil Pressure (psia)	171.95	*
Accumulator GN_2 Pressure (psia)	3575.75	*
Accumulator GN_2 Temperature (^{o}F)	72.92	*
Reservoir Oil Level (%)	35.19	*
Pump Inlet Oil Temperature (^{o}F)	67.45	*
Reservoir Oil Temperature (^{o}F)	72.92	*
Aft Bus 2 Current (amp)	39.80	*
T/M Pitch Actuator Position (deg)	-0.03	*
IU Pitch Actuator Position (deg)	0.00	*
T/M Yaw Actuator Position (deg)	-0.03	*
IU Yaw Actuator Position (deg)	0.02	*
IU Substitute 5 Volt Power Supply (vdc)	5.00	*
Aft 5 Volt Excitation Module (vdc)	4.98	*
Pitch Actuator Signal (ma)	0.00	*
Yaw Actuator Signal (ma)	0.10	*
Corrected T/M Pitch Actuator Position (deg)	-0.062	-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)	-0.004	-0.517 to 0.517
Corrected IU Yaw Actuator Position (deg)	0.016	-0.517 to 0.517

* Limits Not Specified

4.3.23.1 (Continued)

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: 17.0 deg/sec			
0.000	0.000	-0.073	5.005
0.146	-19.775	-2.297	5.005
0.275	-19.824	-3.001	5.005
0.394	-19.873	-3.059	5.000
0.542	-19.775	-3.087	5.000
0.698	-19.824	-3.102	5.000
0.937	-19.775	-3.087	5.005
1.176	-19.775	-3.102	4.990
1.452	-19.824	-3.116	5.010
1.747	-19.824	-3.087	5.005
Pitch -3 to 0 Degree Step Response - Engine Slew Rate: 16.9 deg/sec			
0.000	-19.699	-3.117	5.010
0.137	0.000	-1.067	5.000
0.283	0.000	-0.101	5.010
0.413	0.000	-0.014	5.005
0.542	0.049	-0.000	5.005
0.688	0.000	-0.000	5.010
0.919	0.000	-0.000	5.005
1.176	0.049	-0.000	5.005
1.453	0.049	-0.029	5.000
1.729	0.049	-0.000	5.010
Pitch 0 to +3 Degree Step Response - Engine Slew Rate: 16.6 deg/sec			
0.000	0.100	-0.015	5.005
0.165	20.020	2.453	5.000
0.274	19.971	3.017	5.005
0.413	19.922	3.117	5.005
0.542	20.020	3.132	5.010
0.688	19.922	3.146	5.005
0.900	19.922	3.146	5.005
1.177	19.922	3.146	5.005
1.379	20.020	3.160	5.005
1.637	19.971	3.160	5.005
Pitch +3 to 0 Degree Step Response - Engine Slew Rate: 17.3 deg/sec			
0.000	20.000	3.117	4.999
0.137	0.049	0.866	5.005
0.274	0.049	0.072	5.000

4.3.23.1 (Continued)

Time From Start (sec)	Pitch Excitation Signal (ma)	IU Pitch Actuator Pot. Pos. (deg)	IU 5 Volt Power Supply (vdc)
0.413	0.049	-0.028	4.990
0.551	0.098	-0.043	5.005
0.688	0.049	-0.043	5.000
0.919	0.049	-0.058	5.005
1.176	0.098	-0.058	5.005
1.471	0.098	-0.071	5.005
1.747	0.049	-0.058	5.000
Yaw 0 to -3 Degree Step Response - Engine Slew Rate: 15.3 deg/sec			
0.000	0.000	0.016	5.005
0.146	-19.775	-2.208	5.000
0.411	-19.922	-3.017	5.010
0.540	-19.824	-3.030	5.005
0.688	-19.775	-3.017	5.010
0.918	-19.824	-3.030	5.005
1.175	-19.824	-3.030	5.005
1.413	-19.824	-3.030	5.005
1.727	-19.824	-3.030	5.005
Yaw -3 to 0 Degree Step Response - Engine Slew Rate: 16.1 deg/sec			
0.000	-19.800	-3.026	5.005
0.136	0.000	-0.909	5.005
0.274	0.049	-0.059	5.005
0.403	0.098	0.014	5.010
0.541	0.000	0.043	5.000
0.688	0.000	0.058	5.005
0.917	0.049	0.043	5.005
1.193	0.049	0.043	5.005
1.450	0.049	0.058	5.005
1.744	0.049	0.043	5.000
Yaw 0 to +3 Degree Step Response - Engine Slew Rate: 15.6 deg/sec			
0.000	0.050	0.061	5.005
0.138	20.020	2.164	5.000
0.274	19.971	3.029	5.000
0.412	20.020	3.059	5.005
0.550	20.020	3.102	5.005
0.688	19.971	3.131	5.005
0.937	19.971	3.131	5.005
1.175	20.020	3.116	5.010
1.414	19.971	3.131	5.005
1.745	19.971	3.116	5.005

4.3.23.1 (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: 14.9 deg/sec			
0.000	20.000	3.133	5.005
0.138	0.000	1.053	5.015
0.274	0.049	0.115	5.005
0.412	0.049	0.071	5.000
0.541	0.049	0.058	5.010
0.688	0.049	0.043	5.005
0.918	0.000	0.043	4.990
1.193	0.049	0.058	5.005
1.470	0.146	0.058	5.010
1.745	0.049	0.043	5.010

Final Hydraulic System and Engine Centering Test

System Pressurized, Locks Off, No Excitation Signal

Function	Measurement	Limits
Hydraulic System Pressure (psia)	3578.44	*
Reservoir Oil Pressure (psia)	178.82	*
Accumulator GN_2 Pressure (psia)	3575.75	*
Accumulator GN_2 Temperature (^{o}F)	63.14	*
Reservoir Oil Level (%)	36.32	*
Pump Inlet Oil Temperature (^{o}F)	112.21	*
Reservoir Oil Temperature (^{o}F)	102.36	*
Aft Bus 2 Current (amps)	43.00	*
T/M Pitch Actuator Position (deg)	-0.11	*
IU Pitch Actuator Position (deg)	-0.07	*
T/M Yaw Actuator Position (deg)	0.01	*
IU Yaw Actuator Position (deg)	0.06	*
IU Substitute 5 Volt Power Supply (vdc)	5.00	*
Aft 5 Volt Excitation Module (vdc)	4.98	*
Pitch Actuator Signal (ma)	0.05	*
Yaw Actuator Signal (ma)	0.10	*
Corrected T/M Pitch Actuator Position (deg)	-0.140	-0.517 to 0.517
Corrected IU Pitch Actuator Position (deg)	-0.065	-0.517 to 0.517
Corrected T/M Yaw Actuator Position (deg)	0.042	-0.517 to 0.517
Corrected IU Yaw Actuator Position (deg)	0.053	-0.517 to 0.517

* Limits Not Specified

4.3.24 Telemetry and Range Safety Antenna System Check (1B64679 F)

This test procedure performed the PCM transmitter center frequency and carrier deviation checks.

Initiated on 16 December 1968, the checkout was completed on 18 December 1968. The tests in this procedure were performed by applying a +5.0 vdc signal to the input of the PCM RF assembly and measuring the output (f_2) of the RF assembly. The signal was changed to a -5.0 vdc and the RF output (f_1) was measured. The center frequency (F_c) was calculated by using the formula $F_c = \frac{f_1 + f_2}{2}$ = MHz. The result was 258.506 MHz, within the 258.500 $\pm$0.026 MHz tolerance. Carrier deviation was calculated as 36 kHz (36.0 $\pm$3 kHz) by using the formula $F_d = \frac{f_2 - f_1}{2}$.

There were no FARR's written as a result of this procedure. Two revisions were written for the following:

a. One revision updated the procedure to the latest stage configuration.

b. One revision deleted all portions of the procedure with the exception of the PCM RF center frequency and carrier deviation checks.

4.3.25 Propulsion System Test (1B62753 M)

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 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.

Two tests were performed on 16 December 1968, to demonstrate proper operation of the propulsion system. The second test performed only that portion of section one of the procedure needed to verify the passivation circuitry. These checks had not been accomplished during the first test because of incomplete wiring for K213, the passivation buss enable indication.

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.

Subsequent to the performance of initial conditions scan, testing of the ambient helium system commenced by pressurizing the ambient helium pneumatic control

4.3.25 (Continued)

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 power control module shutoff valve. The proper functioning of the LOX and LH_2 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 682.406 psia; and the control helium regulator discharge pressure was measured at 532.61 psia, both within acceptable limits. A series of checks verified the operation of the pneumatically controlled valves, including the LH_2 and LOX vent valves, fill and drain valves, prevalves, chilldown shutoff valves, the LH_2 directional vent valve, the LH_2 continuous vent and relief override valve and orificed bypass valve, the O_2H_2 burner propellant valves, the LOX nonpropulsive vent valve and the LH_2 latch relief valve.

The J-2 orbital safing valve functional checks were accomplished. However, a second test was necessary to verify the passivation circuitry as previously described. The LH_2 tank pressurization and continuous vent valve blowdown check completed the ambient helium system test.

Section two, the propellant tanks pressurization systems test, was initiated with functional checks of the cold helium dump and shutoff valves. The

4.3.25 (Continued)

operation and the ability of the cold helium regulator backup pressure switch to properly control the cold helium shutoff valve was verified by the three-cycle pressure switch test.

The LOX and LH_2 repressurization control valves were verified to operate properly, and the operation of the LOX and LH_2 tank repressurization backup pressure switch interlocks was verified by the three-cycle test and by demonstrating that the switches properly controlled the LOX and LH_2 repressurization control valves.

The proper operation of the O_2H_2 burner spark ignition system was 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 LH_2 repressurization and ground fill overpressurization pressure switches were verified to operate properly. Control of the LH_2 main fill valve, the LH_2 replenish valve, the LH_2 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 LH_2 pressure switch checks, the cold helium system was pressurized to 888.813 psia; and the cold helium sphere blowdown and cold helium regulator high flow test were conducted. The cold helium system was then repressurized to 881.172 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 O_2H_2 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 LH_2 and LOX tanks were vented to ambient; the O_2H_2 burner spark systems 1 and 2, the emergency detection systems 1 and 2 engine cutoffs, the repressurization control valves, and the O_2H_2 burner propellant valves were 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 LH_2 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 LH_2 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 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 1452.781 psia to conduct the engine valve sequence tests which demonstrated that actuation and deactuation of the helium control solenoid valve caused the LH_2 and LOX bleed valves to close and open, that opening and closing the ignition phase control solenoid valve caused the engine augmented spark igniter (ASI) LOX valve and engine main 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 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.

All problem areas were handled by revisions to the procedure with one exception. FARR 500-607-696 recorded no open talkback for the LH_2 fill and drain

4.3.25 (Continued)

valve, P/N 1A48240-505, S/N 121. A slow closing indication was also noted by the computer, which resulted from not receiving the open indication. Investigation revealed proper actuation of the valve and satisfactory closed talkback. The FARR was dispositioned to maintain the valve installed on the stage until a replacement was available.

Forty-four revisions were recorded in the procedure as follows:

a. Nine revisions corrected program errors.

b. Three revisions modified the procedure to assure safety of the stage.

c. One revision reset SIM 47 and 48 in support of concurrent manual checkout of the auxiliary hydraulic pump.

d. One revision indicated a SIM interrupt occurred when talkback power was turned off to connect the LH_2 continuous vent valve.

e. One revision attributed a malfunction indication to improper setup of the LH_2 continuous vent valve. It was setup and the test was continued.

f. Three revisions concerned the missing wiring for K213, the installation and checkout of this wiring, and instructions for the second propulsion system test to verify the passivation circuitry after completion of the wiring.

g. Fourteen revisions noted that malfunction indications and SIM interrupts received resulted from program and TRD errors.

h. One revision indicated that a SIM interrupt was received because the engine yaw restrainer pin was disengaged. This had no effect on the test.

i. Two revisions recorded that malfunction indications for the LOX main fill valve occurred because the valve was partially disconnected for rework.

4.3.25 (Continued)

j. Five revisions attributed malfunction indications to improper setup and operator error. After setup corrections, testing was resumed without further malfunction.

k. One revision attributed a malfunction dropout for the LOX repress pressure switch to a leak in the GSE pressure supply circuit. The circuit was repressurized and the test was continued.

l. Three revisions concerned GSE valves and had no bearing on the propulsion system test.

4.3.25.1 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)	120.223	119.445	119.445	136.0 max
Dropout Pressure	(psia)	109.344	110.119	110.119	99.0 min
Deadband	(psid)	10.879	9.326	9.326	3.0 min

Control Helium Regulator Backup Pressure Switch Checkout

		Test 1	Test 2	Test 3	Limits
Pressurization Time	(sec)	89.386	41.459	42.185	180.0 max
Pickup Pressure	(psia)	605.094	605.859	605.859	600 + 21
Depressurization Time	(sec)	14.319	14.812	14.819	180.0 max
Dropout Pressure	(psia)	486.211	486.211	486.984	490 ± 31

Pneumatically Controlled Valve Timing Checkout

	Operating Times (sec)					
Valve	Open	Total Open	Close	Total Close	Boost Close	Total Boost Close
LH_2 Vent Valve	0.016	0.077	0.189	0.493	0.080	0.272
LOX Vent Valve	0.016	0.076	0.110	0.331	0.070	0.201
LOX F&D Valve	0.138	0.257	0.720	2.353	0.419	0.938
LH_2 F&D Valve	†	†	2.422†	2.428	0.425	0.886

† No open indication and slow to close indication, refer to FARR 500-607-696.

4.3.25.1 (Continued)

Section 1 - Ambient Helium Test (Continued)

Valve	Operating Times (sec) Open	Total Open	Close	Total Close	Boost Close	Total Boost Close
LOX Prevalve	1.272	1.877	0.159	0.291	*	*
LH_2 Prevalve	1.201	1.813	0.185	0.316	*	*
LOX C/D SOV	0.267	1.144	0.062	0.192	*	*
LH_2 C/D SOV	0.320	1.061	0.034	0.139	*	*
LH_2 Cont Vent Orif'd Bypass Valve	0.016	0.096	0.007	0.139	*	*
O_2H_2 Burner LH_2 Prop	0.007	0.013	0.031	0.096	*	*
O_2H_2 Burner LOX Prop	0.009	0.015	0.008	0.082	*	*
LH_2 Latch RLF Vlv	0.024	0.068	0.116	0.352	0.068	0.200
LOX NPV Vlv	0.030	0.054	0.137	0.353	0.077	0.208

Valve	Flight Position	Total Flt. Position	Ground Position	Total Ground Position
LH_2 Directional Vent Valve	0.063	0.160	0.810	1.427

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)	84.275	60.292	60.051	180 max
Pickup Pressure	(psia)	474.55	473.00	473.00	467.5 ± 23.5
Depressurization Time	(sec)	18.449	18.504	18.411	180 max
Dropout Pressure	(psia)	382.086	383.641	383.641	362.5 ± 33.5

LOX Tank Repressurization Backup Pressure Switch Checkout

		Test 1	Test 2	Test 3	Limits
Pressurization Time	(sec)	59.316	58.287	58.997	180 max
Pickup Pressure	(psia)	472.219	472.219	470.672	467.5 ± 23.5
Depressurization Time	(sec)	20.617	20.532	20.442	180 max
Dropout Pressure	(psia)	372.758	372.758	372.758	362.5 ± 33.5

LH_2 Tank Repressurization Backup Pressure Switch Checkout

		Test 1	Test 2	Test 3	Limits
Pressurization Time	(sec)	57.200	56.897	56.916	180 max
Pickup Pressure	(psia)	467.563	466.781	466.781	467.5 ± 23.5
Depressurization Time	(sec)	19.053	18.945	19.010	180 max
Dropout Pressure	(psia)	377.422	376.641	376.641	362.5 ± 33.5

* Not Applicable To These Valves

4.3.25.1 (Continued)

Section 2 - Propellant Tanks Pressurization System Test (Continued)

Function

LOX Tank Ground Fill Overpressure Pressure Switch Checkout

		Measured Values			
		Test 1	Test 2	Test 3	Limits
Pressurization Time	(sec)	74.755	41.289	33.900	180 max
Pickup Pressure	(psia)	40.172	40.021	40.021	41 max
Depressurization Time	(sec)	25.067	5.763	5.888	180 max
Dropout Pressure	(psia)	38.707	38.707	38.707	35.5 min
Deadband	(psid)	1.465	1.313	1.313	0.5 min

LH_2 Repressurization Control Pressure Switch Checkout

Pressurization Time	(sec)	74.564	22.766	21.459	180 max
Pickup Pressure	(psia)	30.409	30.359	30.257	31 max
Depressurization Time	(sec)	51.677	48.843	48.211	180 max
Dropout Pressure	(psia)	27.979	27.928	28.080	27.8 min
Deadband	(psid)	2.431	2.432	2.177	0.5 min

LH_2 Tank Ground Fill Overpressure Pressure Switch Checkout

Pressurization Time	(sec)	69.668	27.152	21.883	180 max
Grd. Fill Overpress Pickup Press	(psia)	30.409	30.155	30.054	31 max
Depressurization Time	(sec)	148.596	52.297	51.824	180 max
Grd. Fill Overpress Dropout Pressure	(psia)	27.827	27.979	27.979	27.8 min
Deadband	(psid)	2.582	2.177	2.075	0.5 min

Section 3 - J-2 Engine Functional Test (Engine S/N J-2101)

Engine Delay Timer Checkout

Function	Delay Time (sec)	Limits (sec)
Ignition Phase Timer	0.434	0.450 + 0.030
Helium Delay Timer	0.989	1.000 ∓ 0.110
Sparks De-energized Timer	3.299	3.300 ∓ 0.200
Start Tank Discharge Timer	1.005	1.000 ∓ 0.040

4.3.25.1 (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)	505.94	498.84	498.84	515 ± 36
Dropout Pressure	(psia)	429.63	432.77	432.77	*
Deadband	(psid)	76.31	66.07	66.07	62.5 ± 48.5

Mainstage OK Pressure Switch 2 Checkout

		Test 1	Test 2	Test 3	Limits
Pickup Pressure	(psia)	519.61	511.07	510.30	515 ± 36
Dropout Pressure	(psia)	438.03	438.80	438.80	*
Deadband	(psid)	81.58	72.27	71.49	62.5 ± 48.5

Engine Sequence Check

Function	Start or Delay Time (sec)	Oper. or Travel Time (sec)	Total Time (sec)
Cont He Solenoid Command Talkback	**	0.016	**
Ign Phase Cont Solenoid Command Talkback	**	0.010	**
ASI Valve Open	**	0.049	**
Engine LOX Bleed Valve Close	**	0.090	**
Engine LH_2 Bleed Valve Close	**	0.066	**
Main Fuel Valve Open	0.082	0.037	0.119
Start Tank Disch Timer	**	1.002	**
Start Tnk Disch Valve Open	0.097	0.095	0.191
Mainstage Cont Solenoid Energized	**	1.456	**
Ignition Phase Timer	**	0.454	**
Start Tnk Disch Cont Solenoid De-energized	**	0.007	**
Main LOX Valve Open	0.505	1.483	1.988
Start Tank Disch Valve Close	0.166	0.162	0.328
Gas Generator Valve Open	**	0.158	0.254
LOX Turbine Bypass Valve Close	0.031	0.468	0.499
Spark System Off Timer	**	3.296	**

* Limits Not Specified
** Not Applicable Or Not Available

4.3.25.1 (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	0.041	**	**
Main LOX Valve Close	0.124	0.042	0.166
Mail Fuel Valve Close	0.131	0.151	0.282
Gas Generator Valve Close	0.139	0.109	0.248
He Cont De-energized Timer	**	1.000	**
Engine LOX Bleed Valve Open	**	**	6.698
Engine LH_2 Bleed Valve Open	**	**	9.770
LOX Turbine Bypass Valve Open	0.302	0.520	0.821

Engine Sequence Data (Oscillograph Records)

Function	Measurements		Limits	
	Delay	Valve Motion	Delay	Valve Motion
Ignition (sec)				
Main Fuel Valve Open	0.043	0.074	0.030-0.090	0.030-0.130
Start Tank Disch Vlv Open	0.089	0.092	0.080-0.120	0.085-0.125
Mainstage (sec)				
GG Valve Fuel Open	0.068	0.044	*	*
GG Valve LOX Open	0.135	0.063	0.130-0.150	0.020-0.080
Start Tank Disch Valve Close	0.126	0.239	0.110-0.150	0.175-0.255
MOV 1st Stage Open	0.046	0.048	0.030-0.070	0.025-0.075
MOV 2nd Stage Open	0.569	1.689	0.490-0.630	1.650-1.700
Oxidizer Turbine Bypass Vlv Close	0.206	0.279	*	5.0 max

* Limits Not Specified
** Not Applicable Or Not Available

4.3.25.1 (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	0.214	0.654	*	10 max
GG Valve LOX Close	0.059	0.029	0.040-0.100	0.010-0.0551
Main Oxid Vlv Closed	0.059	0.127	0.045-0.075	0.105-0.135
Main Fuel Vlv Closed	0.079	0.244	0.065-0.115	0.200-0.250
Bleeds (sec)				
ASI Open	**	0.049	**	0.100 max
ASI Close	**	0.041	**	0.100 max
GG Valve LOX Open	**	6.698	**	30.0 max
GG Valve LOX Close	**	0.090	**	0.120 max
GG Valve Fuel Open	**	9.770	**	30.0 max
GG Valve Fuel Close	**	0.066	**	0.120 max
Timers (sec)				
Start Tnk Disch Vlv Delay	0.988	**	0.960-1.040	**
Ignition Phase	0.453	**	0.420-0.480	**
Sparks De-energize	3.296	**	3.10-3.50	**
Helium Cont De-energize	0.989	**	0.890-1.110	**
Trace Deflections				
Oxid Turbine Bypass Valve 80% (sec)	0.433	**	0.350-0.550	**
Main Oxid Valve (deg)	13	**	10-16	**
GG Valve (%)	47	**	35-65	**

* Limits Not Specified

** Not Applicable Or Not Available

4.3.26 All Systems Test (1B55833 H)

The all systems test (AST) was conducted to demonstrate the combined operation of the stage electrical, hydraulic, propulsion, instrumentation, and telemetry systems under simulated flight conditions. The test procedure followed, as closely as possible, the actual flight sequence of prelaunch operations, simulated liftoff, ullage firing, engine start, hydraulic gimballing, engine cutoff, coast period, engine restart and cutoff, attitude control, and stage shutdown.

The AST was conducted twice--first with the umbilicals in, then with the umbilicals out. During the umbilicals-in test, the umbilical cables were connected to permit monitoring of talkback during test and to provide complete stage control for troubleshooting and safing operations. During the umbilicals-out test, the umbilicals were ejected at simulated liftoff to verify the proper operation of all on-board systems with the umbilicals disconnected. After completion of the AST, the umbilicals were reconnected, and the stage power turnoff was executed to the pretest configuration.

The AST was performed two times during the deferred postfire operations. The first attempt was initiated on 18 December 1968, and accepted on 2 Jaunary 1969. Due to replacement of the PU electronics assembly and the auxiliary hydraulic pump a second issue was required. The second issue was initiated 20 December 1968, and the AST was accepted on 2 January 1969. For the purpose of this narrative only the second issue will be discussed.

After accomplishing the various manual electrical and propulsion system setups, automatic testing started with a performance of the stage power setup to

4.3.26 (Continued)

establish initial conditions. During the power setup, power was turned on to the propellant utilization (PU) inverter and electronics assembly, the EBW pulse sensors, the engine control and ignition buses, the APS buses, and aft bus 2. The various currents and voltages were measured as listed in the power setup portion of Test Data Table 4.3.26.1. The EBW ullage rocket firing unit disable command and the propellant dispersion cutoff command inhibit for the range safety receivers were turned on. The proper operation of the switch selector was verified during the umbilicals-in test. The power turnon to the PCM RF group and a transmitter warm-up completed the stage 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. The LOX chilldown pump purge and engine pump purge sequences were then accomplished.

The next series of prelaunch checks verified that the LOX and LH_2 tank vent valves and fill and drain valves opened properly on command, and that the LOX and LH_2 point level sensors, fastfill sensors, and overfill sensors responded properly to simulated wet conditions. The simulated wet conditions were left on for all, except the overfill sensors, to simulate loaded propellant tanks. The proper operation of the LOX and LH_2 chilldown shutoff valves, prevalves, and vent valves was verified, and the LOX and LH_2 tank prepressurization sequences were accomplished. The LH_2 pressure control module pressure (D104) was measured during the last sequence. The LOX and LH_2 fill and drain valves were then closed, the proper operation of the LH_2 directional vent valve was verified, and the valve was set to the ground position.

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

The hydraulic system prelaunch checks were conducted next. The pitch and yaw actuator locks were removed, the hydraulic reservoir gaseous nitrogen mass and corrected oil level were measured, and the hydraulic system functions were measured with the hydraulic system unpressurized. The auxiliary hydraulic pump was then turned on to pressurize the system. The system pressure increase over a 4-second period was measured, and the hydraulic system functions were remeasured with the system pressurized. During the umbilicals-in test only,

4.3.26 (Continued)

the 7.5 degree square gimbal pattern check was then satisfactorily accomplished, after which the hydraulic system was depressurized by the 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 then measured the reference indication voltages for the LOX and LH_2 circulation pump flow rates, the static inverter-converter frequency, the LH_2 and LOX chilldown inverter frequencies, the LOX and LH_2 flowmeter, and the LOX and LH_2 pump speeds. A 400 Hz GSE calibration frequency was used for the pump flow rates and the static inverter-converter and chilldown inverter frequencies, a 100 Hz GSE calibration frequency was used for the flowmeters, and a 1500 Hz calibration frequency was used for the pump speeds. The telemetry system forward and reflected RF powers were then measured, and the telemetry system open loop VSWR was determined. The LOX and LH_2 chilldown pumps were turned on, and the chilldown inverter frequencies and phase voltages were measured by hardwire and telemetry.

A series of measurements were then made of the common bulkhead pressure, the LH_2 ullage pressure, and their 20 and 80 per cent calibration voltages, the LOX ullage pressure, and the LH_2 and LOX emergency detection system pressures. After the 20 and 80 per cent calibration tests, the common bulkhead pressure and the ambient LH_2 ullage pressure were remeasured. Common bulkhead pressures reflected the vacuum drawn on the bulkhead. The rate gyro was then turned on, and the RACS and telemetry calibrations were performed.

4.3.26 (Continued)

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

The forward and aft power buses were transferred to internal, and the bus voltages were measured. Both range safety receivers were transferred to internal power, and their low level signal strength indications were measured.

The EBW ullage rocket firing unit disable command was turned off, the range safety system safe and arm device was set to the ARM condition, the DDAS antenna input was turned on, and the propellant dispersion cutoff command inhibit was turned off for both range safety receivers. It was verified that the open loop PCM RF signal was being received at the PCM and DDAS ground stations. The cold helium supply shutoff valve was opened. For the umbilicals-out test only, the external power was turned off for the talkback bus, the forward and aft power buses, and the range safety receivers and EBW firing units; the aft and forward umbilicals were ejected and visually verified to be disconnected; then, the local sense indications were verified to be on. For the umbilicals-in test only, the external powers were on; it was verified that the umbilicals remained connected; and the local sense indications were

4.3.26 (Continued)

verified to be off. The emergency detection system ullage pressures were then measured for both tests. The prelaunch checks were completed with simualted liftoff.

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

APS roll and engine start checks were conducted following the simulated stage separation. The instrument unit (IU) substitute -28 volt power was turned on and the voltage was measured. For the APS roll checks, attitude control nozzles I-IV and III-II were turned on and off; and the corresponding APS engine valves were measured for open and closed indication voltages, In addition, the APS engine thrust chamber pressures were measured with the engine valves in the open and closed positions, the thrust chamber throat plugs installed, and pressure upstream of the valves. This procedure was then repeated for attitude control nozzles I-II and III-IV and their corresponding APS engines, to satisfactorily complete the roll checks.

4.3.26 (Continued)

The LOX chilldown pump was then turned off, and the LH_2 and LOX chilldown shutoff valves were cycled open and closed. With the simulated ignition detected indication and the simulated mainstage OK indication turned on to simulate a satisfactory engine start, the engine start sequence was accomplished. The two ullage rocket jettison EBW firing units were charged, the fire ullage jettison command was turned on, and it was verified that both ullage jettison firing units responded properly and that the ullage jettison pulse sensors were on. During this part of the umbilicals-in test only, additional checks verified that the ullage rocket firing unit disable command prevented the jettison EBW firing units from charging, and discharged the previously charged firing units while preventing them from firing.

Following the engine start sequence, the hydraulic gimbal and propellant utilization valve slew checks were conducted, starting with the step response gimbal and LOX valve slew checks. The propellant utilization system ratio valve position and the hydraulic system pressure were both measured, and the LOX bridge 1/3 checkout relay was turned on. A series of step response gimbal checks were conducted at 0 to -3 degrees, -3 to 0 degrees, 0 to +3 degrees, and +3 to 0 degrees, in the pitch and yaw planes.

Following the gimbal sequence, the propellant utilization system ratio valve position was again measured, and the LOX bridge 1/3 checkout relay was turned off. The 0.6 Hz gimbal and LH_2 propellant utilization valve slew checks were conducted next. The propellant utilization system ratio valve position and the hydraulic pressure were measured, and the LH_2 bridge 1/3 checkout relay

4.3.26 (Continued)

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 instrument unit engine pitch and yaw positions were measured, and the hydraulic system functions were measured with the hydraulic system pressurized. The propellant utilization system ratio valve position was measured, and the LH_2 bridge 1/3 checkout relay was turned off.

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

The engine restart preparations were conducted next. The 70 pound ullage engine command 1 was turned on and off, the LH_2 continuous vent valves were

4.3.26 (Continued)

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

The O_2H_2 burner spark excitation systems were verified to operate properly. The proper operation of the LOX and LH_2 repressurization control valves was verified, and the LOX and LH_2 tank cryogenic repressurization sequences were accomplished. The pressures of the cold helium sphere and the LOX repressurization spheres were measured, and the LOX tank ambient repressurization sequence was accomplished. The LOX and LH_2 chilldown pumps were turned on, and the chilldown inverter voltages were measured. The LH_2 tank ambient repressurization sequence was then accomplished. With the propellant utilization valve hardover position command on, the ratio valve position was verified to be less than -20 degrees. The LH_2 and LOX chilldown pumps were turned off, and the inverter operating frequencies and voltages were measured. The cold helium supply shutoff valve was then opened, completing the restart preparations.

The engine restart sequence was accomplished with the simulated ignition detected indication and the simulated mainstage OK indication turned on to simulate a satisfactory engine restart. The cold helium supply shutoff valve was closed to complete the restart sequence. The LH_2 second burn repressurization sequence was accomplished, with the LH_2 pressurization control module helium

4.3.26 (Continued)

pressure measured with the prepressurization supply open, and again after the pressure switch supply was closed. The engine cutoff was then accomplished, the simulated ignition detected indication was turned off, and the coast period command was turned on.

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

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

4.3.26 (Continued)

A series of APS yaw and pitch attitude control checks were conducted next. The yaw attitude control nozzles I-IV and III-IV, plus pitch control nozzle I-P, were turned on and off, and the corresponding APS engine valves were measured for open and closed indication voltages. In addition, the APS engine thrust chamber pressures were measured with the valves open and closed, pressure upstream of the valves, and the thrust chamber throat plugs installed. This procedure was then repeated for yaw attitude control nozzles I-II and III-II and pitch control nozzle III-P, satisfactorily completing the yaw and pitch checks. After a final telemetry calibration, the stage shutdown was accomplished, completing the all systems test.

Forty-one revisions were made to the procedure as follows:

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

b. Four revisions were required to update the procedure to the latest configuration.

c. Three revisions attributed three malfunction indications to program errors.

d. Two revisions concerned malfunction indications that were attributed to the addition of transient suppression diodes.

e. Two revisions deleted portions of the test that were previously accomplished.

f. One revision attributed the out-of-tolerance malfunction of the T/M antenna forward power exceeding the procedure tolerance of 19.00 $\pm$7.25 watts to test stand environmental conditions.

g. One revision attributed a malfunction indication to an operators error.

h. One revision attributed the "STG 2 bleed valve not open" malfunction to a defective talkback circuit on the bleed valve, reference GSE FARR 500-607-688.

4.3.26 (Continued)

i. One revision attributed the aft 2 out-of-tolerance malfunction to a surface charge of 63 volts not being drained off the battery prior to the test.

j. One revision attributed the GH_2 sphere pressure not pressurizing in the alloted 2 minutes to a low STG 3 helium regulator pressure. The STG 3 regulator was reset and the program was continued.

k. One revision stated that the flow meter spin indication on the aural alarm was due to noise coupling in the ESCS.

l. One revision enabled the program to measure the PU oven temperature without the required delay as the oven had be on and no delay was required.

m. One revision turned on the PCM RF power to verify receipt of open loop data at the data laboratory.

n. One revision stated that the LOX main fill valve was pneumatically locked in the full open position causing a not closed malfunction.

o. One revision attributed the out-of-tolerance condition of the cold helium sphere pressure to insufficient time allowed for the pressure to stabilize after manual pressurization.

p. One revision enabled the program to perform stage power turnoff between umbilicals-in and umbilicals-out.

4.3.26.1 Test Data Table, All Systems Test

Function	Umbil.-In	Umbil.-Out	Limits
Power Setup			
PU Inv and Elect. Current (amps)	3.399	3.600	5.0 max
Aft Bus 1 Current with Eng Cont Bus Pwr On (amps)	2.00	2.10	2.7 ± 3.0
Aft Bus 1 Voltage with Eng Cont Bus Pwr on (X) (vdc)	28.12	28.12	28.0 ± 2.0
Engine Control Bus Voltage (vdc)	27.94	27.94	Meas.(X) ∓ 1.0
Component Test Pwr Voltage (vdc)	27.72	27.72	Meas.(X) ∓ 1.0
Aft Bus 1 Current with Eng Ign Bus Pwr On (amps)	2.40	2.30	2.7 ± 3.0
Aft Bus 1 Voltage with Eng Ign Bus Pwr On (Y) (vdc)	28.12	28.12	28.0 ± 2.0

4.3.26.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
Engine Ignition Bus Voltage (vdc)	27.91	27.84	Meas.(Y) ± 1.0
Aft Bus 1 Current with APS Bus Pwr On (amps)	2.90	2.90	2.7 ± 3.0
Aft Bus 2 Current (amps)	0.02	-0.20	5.0 max
Aft Bus 2 Voltage (vdc)	56.56	56.64	56.0 ± 4.0
Propulsion System Setup			
Amb He Pneu Sphere Press. D236 (psia)	686.10	708.60	700.0 ± 50.0
Cold Helium Sphere Press. D016 (psia)	862.10	888.80	900.0 ± 50.0
Eng Cont He Supply Press. D019 (psia)	1570.80	1570.80	1450.0 min
Cont He Reg Discharge Press. D014 (psia)	533.30	532.6	515.0 ± 50.0
LH_2 Repress. He Sphere Press. D020 (psia)	319.70	327.20	*
LOX Repress. He Sphere Press. D088 (psia)	719.80	742.20	*
APS 1 Fuel Sup Manf Press (psia)	40.15	40.59	38 ± 15
APS 1 Oxid Sup Manf Press (psia)	41.90	42.33	38 ± 15
APS 2 Fuel Sup Manf Press (psia)	34.48	34.04	38 ± 15
APS 2 Oxid Sup Manf Press (psia)	41.02	41.46	38 ± 15
APS 1 Fuel Ull Vol Press (psia)	59.80	58.90	50 ± 15
APS 1 Oxid Ull Vol Press (psia)	56.30	56.7	50 ± 15
APS 2 Fuel Ull Vol Press (psia)	52.80	52.8	50 ± 15
APS 2 Oxid Ull Vol Press (psia)	58.50	58.9	50 ± 15
LH_2 Prepressurization Sequence			
LH_2 Press. Control Module GH_2 Press. D104 (psia)	174.30	173.21	50.0 min
EBW and Telemetry Checks			
Prelaunch C/O Group Current (amps)	1.70	1.50	*
PCM/FM Transmitter Output with PCM RF Assy Off (watts)	-0.15	**	2.0 max
PCM/FM Transmitter Output with PCM RF Assy On (watts)	22.48	**	10.0 min
T/M Antenna 1 Forward Power (watts)	22.604	22.574	21.75 ± 6.75
T/M RF System Reflected Power (watts)	0.094	0.101	3.08 max

* Limits Not Specified

** Measurements Not Applicable

4.3.26.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
Telemetry System Closed Loop VSWR	1.138	1.143	2.0 max
Inv-Conv 115 vac Output (vac)	114.92	114.97	115 ± 3.45
Inv-Conv 5 vdc Output (vdc)	5.00	5.00	4.9 ± 0.2
Inv-Conv 21 vdc Output (vdc)	21.69	21.71	21.25 ± 1.25
Inv-Conv Operating Frequency (Hz)	401.13	401.22	400.0 ± 6.0
Hydraulic System Checks			
Reservoir GN_2 Mass (lbs)	1.893	1.938	1.925 ± 0.2
Corrected Reservoir Oil Level (%)	99.80	99.6	95.0 min
Hydraulic System Unpressurized			
Hydraulic System Pressure (psia)	1375.563	1372.313	*
Accumulator GN_2 Pressure (psia)	2266.438	2329.188	*
Accumulator GN_2 Temperature (°F)	57.281	61.580	*
Reservoir Oil Temperature (°F)	64.314	72.922	*
Reservoir Oil Level (%)	88.725	89.475	*
Reservoir Oil Pressure (psia)	77.684	79.430	*
Pump Inlet Oil Temperature (°F)	47.532	49.871	*
T/M Yaw Actuator Position (deg)	1.112	0.987	*
Corrected T/M Yaw Act. Pos (deg)	1.146	1.020	*
IU Yaw Actuator Position (deg)	1.168	1.035	*
Corrected IU Yaw Act. Pos (deg)	1.150	1.019	*
T/M Pitch Actuator Position (deg)	-0.378	-0.269	*
Corrected T/M Pitch Act. Pos (deg)	-0.408	-0.298	*
IU Pitch Actuator Position (deg)	-0.369	-0.222	*
Corrected IU Pitch Act. Pos (deg)	-0.350	-0.206	*
IU Substitute 5V Power Supply (vdc)	5.010	5.010	*
Aft 5V Excitation Module (vdc)	4.979	4.980	*
Aft Bus 2 Current (amps)	0.000	0.000	*
Hydraulic System Pressurized			
Hyd System 4 Second Press. Change (psia)	284.8	278.3	200.0 min
Hydraulic System Pressure (psia)	3578.438	3568.625	*
Accumulator GN_2 Pressure (psia)	3564.875	3567.563	*
Accumulator GN_2 Temperature (°F)	81.543	85.072	*
Reservoir Oil Temperature (°F)	64.314	72.529	*
Reservoir Oil Level (%)	35.441	37.688	*
Reservoir Oil Pressure (psia)	171.516	171.512	*
Pump Inlet Oil Temperature (°F)	58.849	64.711	*
T/M Yaw Actuator Position (deg)	-0.048	-0.032	*
Corrected T/M Yaw Act. Pos (deg)	-0.020	-0.004	*

⋮

* Limits Not Specified

4.3.26.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
IU Yaw Actuator Position (deg)	0.001	0.016	*
Corrected IU Yaw Act. Pos (deg)	-0.007	0.008	*
T/M Pitch Actuator Position (deg)	-0.033	-0.018	*
Corrected T/M Pitch Act. Pos (deg)	-0.062	-0.046	*
IU Pitch Actuator Position (deg)	0.000	-0.015	*
Corrected IU Pitch Act. Pos (deg)	0.008	-0.007	*
IU Substitute 5v Power Supply (vdc)	5.005	5.005	*
Aft 5v Excitation Module (vdc)	4.979	4.979	*
Aft Bus 2 Current (amps)	43.600	41.399	*
FRATS Calibration			
LOX Circ Pump Flowrate Ind (vdc)	3.928	3.887	3.866 ± 0.100
LH_2 Circ Pump Flowrate Ind (vdc)	3.876	3.871	3.866 ± 0.100
Static Inv-Conv Freq Ind (vdc)	3.056	3.051	2.989 ± 0.100
LH_2 C/D Inv Freq Ind (vdc)	2.969	2.989	2.989 ± 0.100
LOX C/D Inv Freq Ind (vdc)	2.984	2.989	2.989 ± 0.100
LOX Flowmeter Indication (vdc)	1.702	1.702	1.667 ± 0.100
LH_2 Flowmeter Indication (vdc)	1.702	1.691	1.667 ± 0.100
LOX Pump Speed Indication (vdc)	3.133	3.158	3.125 ± 0.100
LH_2 Pump Speed Indication (vdc)	1.281	1.271	1.250 ± 0.100
Telemetry RF Checks			
T/M Antenna 1 Forward Power (watts)	26.441+	25.667	19.00 ± 7.25
T/M RF System Reflected Power (watts)	1.567	0.265	3.08 max
Telemetry System Open Loop VSWR	1.646	1.226	3.0 max
Chilldown Inverter Telemetry Checks			
LH_2 C/D Inv Frequency (Hz)	399.80	399.80	400.0 ± 4.0
LH_2 C/D Inv Phase AB Volt. (vac)	55.50	54.10	*
LH_2 C/D Inv Phase AC Volt. (vac)	55.70	54.00	*
LOX C/D Inv Frequency (Hz)	400.30	400.30	400.0 ± 4.0
LOX C/D Inv Phase AB Volt. (vac)	55.30	54.00	*
LOX C/D Inv Phase AC Volt. (vac)	55.70	54.00	*
Pressure Measurements			
Common Bulkhead Internal Press. (psia)	2.499	2.394	2.529 ± 0.707
Common Bulkhead 20% Calib (vdc)	1.064	1.064	1.0 ± 0.1
Common Bulkhead Press. (psia)	2.394	2.420	2.529 ± 0.707
Common Bulkhead 80% Calib (vdc)	4.034	4.039	4.0 ± 0.1

* Limits Not Specified

\+ See Revision f

4.3.26.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
Common Bulkhead Press. (psia)	2.529	2.502	2.529 ± 0.707
LH_2 Ullage Pressure (psia)	14.641	14.692	14.7 ± 1.0
LH_2 Ullage 20% Calib (vdc)	0.999	0.994	1.0 ± 0.1
LH_2 Ullage Amb Press. (psia)	14.536	14.744	14.7 ± 1.0
LH_2 Ullage 80% Calib (vdc)	3.999	4.005	4.0 ± 0.1
LH_2 Ullage Amb Press. (psia)	14.744	14.744	14.7 ± 1.0
LOX Ullage Pressure (psia)	14.885	14.992	14.7 ± 1.0
LH_2 EDS Transducer 1 Press. (psia)	14.9	14.9	14.7 ± 1.0
LH_2 EDS Transducer 2 Press. (psia)	15.0	14.9	14.7 ± 1.0
LOX EDS Transducer 1 Press. (psia)	14.8	14.6	14.7 ± 1.0
LOX EDS Transducer 2 Press. (psia)	14.8	14.2	14.7 ± 1.0
LH_2 C/D Pump Diff. Press. (psid)	-0.376	-0.313	0 ± 1.2
LOX C/D Pump Diff. Press. (psid)	-0.253	-0.253	0 ± 1.2

Final Prelaunch Checks

Function	Umbil.-In	Umbil.-Out	Limits
Fwd Bus 1 Batt. Sim. (Bus 4D30) (vdc)	28.60	**	28.0 ± 2.0
Fwd Bus 2 Batt. Sim. (Bus 4D20) (vdc)	28.28	**	28.0 ± 2.0
Aft Bus 1 Batt. Sim. (Bus 4D10) (vdc)	28.24	**	29.5 ± 1.5
Aft Bus 2 Batt. Sim. (Bus 4D40) (vdc)	56.40	**	56.0 ± 4.0
Bus 4D20 ESE Load Bank (vdc)	0.16	**	0.0 ± 1.0
Bus 4D40 ESE Load Bank (vdc)	0.00	**	0.0 ± 1.0
Bus 4D30 ESE Load Bank (vdc)	0.00	**	0.0 ± 1.0
Bus 4D10 ESE Load Bank (vdc)	0.08	**	0.0 ± 1.0
Fwd Bus 1 C/O Batt. (Bus 4D30) (vdc)	**	30.56	29.5 ± 1.5
Fwd Bus 2 C/O Batt. (Bus 4D20) (vdc)	**	30.60	29.5 ± 1.5
Aft Bus 1 C/O Batt. (Bus 4D10) (vdc)	**	30.28	29.5 ± 1.5
Aft Bus 2 C/O Batt. (Bus 4D40) (vdc)	**	63.28+	60.5 ± 1.5
Common Bulkhead Press. Xducer (vdc)	0.005	0.015	0.0 ± 0.353
LH_2 Ullage Press. Xducer (vdc)	0.000	0.010	0.0 ± 0.353
LOX Ullage Press. Xducer (vdc)	0.109	0.140	0.0 ± 0.353
Fwd Bus 1 Internal (Bus 4D31) (vdc)	28.12	29.92	28.0 ± 2.0
Fwd Bus 2 Internal (Bus 4D21) (vdc)	27.72	29.20	28.0 ± 2.0
Aft Bus 1 Internal (Bus 4D11) (vdc)	28.08	29.96	28.0 ± 2.0
Aft Bus 2 Internal (Bus 4D41) (vdc)	55.44	**	56.0 ± 4.0
Receiver 1 Low Level Signal (vdc)	3.60	3.60	2.5 min
Receiver 2 Low Level Signal (vdc)	3.81	3.81	2.5 min
LH_2 EDS 1 Ullage Pressure (psia)	14.76	14.64	14.7 ± 1.0
LH_2 EDS 2 Ullage Pressure (psia)	14.90	14.78	14.7 ± 1.0
LOX EDS 1 Ullage Pressure (psia)	14.82	14.76	14.7 ± 1.0
LOX EDS 2 Ullage Pressure (psia)	14.54	14.48	14.7 ± 1.0

** Measurements Not Applicable
+ See Revision i

4.3.26.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
APS Roll Checks			
IU Substitute -28 Volt Power (vdc)	-27.559	-27.879	-28.5 ± 2.5
Attitude Control Nozzles I-IV and III-II On			
APS Engine 1-1 Valves Open Ind (vdc)	4.05	4.17	3.9 ± 0.4
APS Engine 2-1 Valves Open Ind (vdc)	3.96	4.12	3.9 ± 0.4
APS Engine 1-1 Chamber Pressure with Valves Open (psia)	31.07	29.59	*
APS Engine 2-1 Chamber Pressure with Valves Open (psia)	28.42	26.73	*
Attitude Control Nozzles I-IV and III-II Off			
APS Engine 1-1 Valves Open Ind (vdc)	0.00	0.00	0.00 ± 0.25
APS Engine 2-1 Valves Open Ind (vdc)	0.00	0.00	0.00 ± 0.25
APS Engine 1-1 Chamber Pressure with Valves Closed (psia)	17.75	17.12	*
APS Engine 2-1 Chamber Pressure with Valves Closed (psia)	15.29	15.08	*
Attitude Control Nozzles I-II and III-IV On			
APS Engine 1-3 Valves Open Ind (vdc)	4.04	4.16	3.9 ± 0.4
APS Engine 2-3 Valves Open Ind (vdc)	3.92	4.10	3.9 ± 0.4
APS Engine 1-3 Chamber Pressure with Valves Open (psia)	20.20	27.85	*
APS Engine 2-3 Chamber Pressure with Valves Open (psia)	29.42	26.45	*
Attitude Control Nozzles I-II and III-IV Off			
APS Engine 1-3 Valves Open Ind (vdc)	-0.00	-0.00	0.00 ± 0.25
APS Engine 203 Valves Open Ind (vdc)	-0.00	0.00	0.00 ± 0.25

* Limits Not Specified

4.3.26.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
APS Engine 1-3 Chamber Pressure with Valves Closed (psia)	15.66	15.66	*
APS Engine 2-3 Chamber Pressure with Valves Closed (psia)	15.63	15.84	*
Hydraulic Gimbal Step Response Check			
Ratio Valve Pos. (Relay Off)(P)(deg)	-0.19	-0.19	0.0 ± 1.5
Hydraulic System Pressure (psia)	3569.0	3585.0	3575 ± 75
Ratio Valve Pos. (Relay On) (deg)	33.49	33.42	20.0 min
Ratio Valve Pos. (Relay Off) (deg)	1.3	1.306	Meas.(P) ± 1.5
Hydraulic System Pressure (psia)	3582.0	3572.0	3575 ± 75
Pitch Act. Piston Pos., AO (deg)	-0.049	-0.080	0.0 ± 0.517
Pitch Act. Piston Pos., BO (deg)	-0.064	-0.096	0.0 ± 0.517
Yaw Act. Piston Position, AO (deg)	-0.001	0.014	0.0 ± 0.517
Yaw Act. Piston Position, BO (deg)	0.014	0.029	0.0 ± 0.517
Engine Pitch Position, IU (deg)	-0.015	-0.059	0.0 ± 0.517
Engine Yaw Position, IU (deg)	0.046	0.061	0.0 ± 0.517
Hydraulic System Pressurized			
Hydraulic System Pressure (psia)	3578.438	3471.875	*
Accumulator GN_2 Pressure (psia)	3567.563	3567.563	*
Accumulator GN_2 Temperature (°F)	66.660	68.225	*
Reservoir Oil Temperature (°F)	87.426	120.092	*
Reservoir Oil Level (%)	35.441	39.186	*
Reservoir Oil Pressure (psia)	172.824	172.824	*
Pump Inlet Oil Temperature (°F)	97.252	124.438	*
T/M Yaw Actuator Position (°F)	-0.001	0.014	*
Corrected T/M Yaw Act. Pos. (deg)	-0.027	0.042	*
IU Yaw Actuator Position (deg)	0.030	0.061	*
Corrected IU Yaw Act. Pos. (deg)	0.037	0.061	*
T/M Pitch Actuator Position (deg)	-0.033	-0.096	*
Corrected T/M Pitch Act. Pos. (deg)	-0.062	-0.124	*
IU Pitch Actuator Position (deg)	-0.044	-0.059	*
Corrected IU Pitch Act. Pos. (deg)	-0.051	-0.059	*
IU Substitute 5v Power Supply (vdc)	4.994	4.999	*
Aft 5v Excitation Module (vdc)	4.979	4.979	*
Aft Bus 2 Current (amp)	42.399	**	*
Aft Checkout Battery 2 Current (amp)	**	43.00	*
Ratio Valve Pos. (Relay On) (deg)	-20.237	-20.169	-20.0 max

* Limits Not Specified
** Measurements Not Applicable

4.3.26.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
First Burn and Coast Period			
LOX Press. Module Helium Pressure D105			
Cold Helium Supply Open (psia)	152.066	159.160	*
LOX Press. Sw. Supply Closed (psia)	138.977	143.340	*
LH_2 Press. Module Helium Pressure D104			
LH_2 Prepress. Supply Open (psia)	295.406	292.133	*
LH_2 Press. Sw. Supply Closed (pais)	231.040	224.490	*
LH_2 First Burn Relay Off (psia)	181.940	178.660	*
Engine Restart Preparations			
LH_2 Boiloff Bias Signal M010:			
Bias Cutoff Off (vdc)	0.387	0.409	0.0 + 2.5
Bias Cutoff On (vdc)	14.149	14.085	4.0 min
LOX Repress. Spheres, D088 (psia)	708.58	727.27	*
Cold Helium Spheres, D261 (psia)	556.56	583.31	*
Cold Helium Spheres, D261 (psia)	449.66	457.30	*
LOX Repress. Spheres, D088 (psia)	319.70	727.27	*
Chilldown Pumps On			
LOX C/D Inv Phase AB Volt. (vac)	55.67	59.18	50.0 min
LOX C/D Inv Phase AC Volt. (vac)	54.95	58.53	50.0 min
LOX C/D Inv Phase A1B1 Volt. (vac)	55.41	59.99	50.0 min
LOX C/D Inv Phase A1C1 Volt. (vac)	54.89	58.40	50.0 min
LH_2 C/D Inv Phase AB Volt. (vac)	55.08	57.62	50.0 min
LH_2 C/D Inv Phase AC Volt. (vac)	54.30	56.90	50.0 min
LH_2 C/D Inv Phase A1B1 Volt. (vac)	55.02	57.49	50.0 min
LH_2 C/D Inv Phase A1C1 Volt. (vac)	54.23	56.90	50.0 min
Chilldown Pumps Off			
LH_2 C/D Inv Frequency (Hz)	389.5	389.5	390.0 + 1.0
LH_2 C/D Inv Phase AB Volt. (vac)	0.00	0.00	0.0 ∓ 1.5
LH_2 C/D Inv Phase AC Volt. (vac)	0.00	0.00	0.0 ∓ 1.5
LOX C/D Inv Frequency (Hz)	389.5	389.5	390.0 ∓ 1.0
LOX C/D Inv Phase AB Volt. (vac)	0.00	0.13	0.0 ∓ 1.5
LOX C/D Inv Phase AC Volt. (vac)	0.07	0.00	0.0 ∓ 1.5

* Limits Not Specified

4.3.26.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
LH_2 Second Burn Repressurization			
LH_2 Press. Module Helium Pressure D104			
LH_2 Prepress. Supply Open (psia)	295.406	295.406	*
LH_2 Press. Sw. Supply Closed (psia)	231.040	216.852	*
LH_2 Second Burn Off	181.94	177.570	*
LOX Depletion Timer Check			
LOX Sensors 1 and 2 Dry (sec)	0.546	**	0.560 ± 0.025
LOX Sensors 1 and 3 Dry (sec)	0.538	**	0.560 ± 0.025
LOX Sensors 2 and 3 Dry (sec)	0.547	**	0.560 ± 0.025
APS Yaw Checks			
Attitude Control Nozzles I-IV and III-IV On			
APS Engine 1-1 Valves Open Ind (vdc)	4.02	4.11	3.9 ± 0.4
APS Engine 2-3 Valves Open Ind (vdc)	3.94	4.04	3.9 ± 0.4
APS Engine 1-1 Chamber Pressure with Valves Open (psia)	28.96	28.74	*
APS Engine 2-3 Chamber Pressure with Valves Open (psia)	27.93	27.51	*
Attitude Control Nozzles I-IV and III-IV Off			
APS Engine 1-1 Valves Open Ind (vdc)	0.00	0.00	0.0 ± 0.25
APS Engine 2-3 Valves Open Ind (vdc)	0.00	-0.00	0.0 ± 0.25
APS Engine 1-1 Chamber Pressure with Valves Closed (psia)	16.27	16.27	*
APS Engine 2-3 Chamber Pressure with Valves Closed (psia)	15.63	15.84	*
Attitude Control Nozzles I-II and III-II On			
APS Engine 1-3 Valves Open Ind (vdc)	4.02	4.12	3.9 ± 0.4
APS Engine 2-1 Valves Open Ind (vdc)	3.96	4.07	3.9 ± 0.4
APS Engine 1-3 Chamber Pressure with Valves Open (psia)	28.06	27.42	*
APS Engine 2-1 Chamber Pressure with Valves Open (psia)	25.67	25.46	*

* Limits Not Specified
** Measurement Not Applicable

4.3.26.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
Attitude Control Nozzles I-II and III-II Off			
APS Engine 1-3 Valves Open Ind (vdc)	0.00	0.00	0.0 ± 0.25
APS Engine 2-1 Valves Open Ind (vdc)	0.00	0.00	0.0 ± 0.25
APS Engine 1-3 Chamber Pressure with Valves Closed (psia)	15.87	15.87	*
APS Engine 2-1 Chamber Pressure with Valves Closed (psia)	15.08	15.29	*
Attitude Control Nozzle I-P On			
APS Engine 1-2 Valves Open Ind (vdc)	4.05	4.15	3.9 ± 0.4
APS Engine 1-2 Chamber Pressure with Valves Open (psia)	30.10	29.04	*
Attitude Control Nozzle I-P Off			
APS Engine 1-2 Valves Open Ind (vdc)	0.00	0.00	0.0 ± 0.25
APS Engine 1-2 Chamber Pressure with Valves Closed (psia)	17.16	16.31	*
Attitude Control Nozzle III-P On			
APS Engine 2-2 Valves Open Ind (vdc)	4.01	4.17	3.9 ± 0.4
APS Engine 2-2 Chamber Pressure with Valves Open (psia)	29.42	28.59	*
Attitude Control Nozzle III-P Off			
APS Engine 2-2 Valves Open Ind (vdc)	0.00	0.00	0.0 ± 0.25
APS Engine 2-2 Chamber Pressure with Valves Closed (psia)	16.69	16.06	*

* Limits Not Specified

4.3.27 Hydraulic System Poststorage Operating and Securing (1B41006 B)

The purpose of this procedure was to obtain poststorage 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 27 December 1968, and satisfactorily completed on 31 December 1968. Components of the stage hydraulic system installed during this checkout included the main engine driven hydraulic pump, P/N 1A66240-503, S/N X457811; the auxiliary hydraulic pump, P/N 1A66241-511, S/N X45494; the hydraulic pitch and yaw actuator assemblies, P/N 1A66248-505, S/N's 71 and 84; and the accumulator/reservoir assembly, P/N 1B29319-519, S/N 00029.

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.

The accumulator/reservoir was charged with gaseous nitrogen, and the stage auxiliary hydraulic pump air bottle was 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.

With the midstroke locks installed on the hydraulic actuators, the auxiliary hydraulic pump was turned on and operated for 6 minutes, bringing the system

4.3.27 (Continued)

pressure to the required 3600 ±100 psig. After shutting down the auxiliary pump, closed loop system fluid samples were obtained, for cleanliness evaluation, from the hydraulic actuators and the reservoir inlet sampling valve. Particle counts for the various micron ranges were acceptable for all samples.

Following closed loop sampling, the hydraulic system was refilled to replace the sampling fluid loss. During the system refill, the HPU was turned on and operated for 3 minutes with system pressure at 3650 psig; then, the shutdown sequence of the procedure was begun.

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 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 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 11.0 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 76.0°F, and based on the curve for temperature versus drained fluid volume, a total of 268 milliliters of hydraulic fluid was removed.

4.3.27 (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 GN_2 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.

There were no recorded discrepancies during this checkout, and no FARR's were initiated. Three revisions were recorded in the procedure for the following:

a. One revision gave instructions to retorque the pitch actuator return hose assembly, P/N 1B63071-1, at the actuator end to 550-650 inch pounds to stop a possible leak.

b. Two revisions provided instructions to flush and obtain hydraulic fluid samples from the accumulator to ensure system cleanliness.

4.3.28 Forward Skirt Thermoconditioning System Checkout (1B41883 C)

This procedure tested the forward skirt thermoconditioning system (TCS) in preparation for shipment at the completion of the stage 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 TCS, P/N 1B38426-513, during deferred postfire operations.

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 that could cause TCS system failure by such conditions as restriction of flow or pump abrasion.

A TCS differential pressure test was conducted to check for 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 GN_2 purge was conducted to dry the TCS after completion of the freon leak check of the TCS.

The final TCS checkout was initiated on 31 December 1968, and was successfully completed and accepted on 3 January 1969. The water/methanol cleanliness test was conducted first. Water/methanol fluid was circulated through the TCS, then water/methanol samples were obtained and taken to the laboratory for a particle count. The samples were found acceptable for each micron range.

4.3.28 (Continued)

The results for the supply and return samples were; 2 particles (supply circuit) and one particle (return circuit) in the 175-700 micron range (25 particles allowed; no particles in the 700-2500 micron range, (5 particles allowable); and no particles over 2500 microns (none allowable).

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. 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 ±0.1 gpm at a supply pressure of 42.0 ±0 psig. The differential pressure was recorded at 15.7 psi with fluid supply temperature indicating 82.0°F and the return temperature indicating 78°F.

Prior to leak checking the TCS, the system was purged of water/methanol with GN_2 until a system dryness of 25°F dewpoint was obtained, as verified by an Alnor dewpoint meter. Next, an inspection of the TCS panels for open equipment mounting bolt holes and properly torqued bolts was accomplished satisfactorily, indicating readiness for the system leak checks. The 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 GN_2 pressurized to 32 ±1 psig.

4.3.28 (Continued)

The final operation consisted of disconnecting and securing the servicer and preparing the TCS for the stage shipment.

There were no FARR's initiated as a result of this checkout, and no discrepancies were noted.

One revision was written to delete the specific gravity test. This test will be made prior to connecting the TCS servicer to the next stage.

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 23 December 1968, and was completed on 16 January 1969, to verify that the stage was in satisfactory condition for shipment to FTC.

A total of 320 defects were noted during this inspection, 200 by MDAC personnel and 120 by AFQC personnel. Of the 200 discrepancies noted by MDAC personnel, 63 were concerned with electrical components and 137 were concerned with mechanical components. Of the 120 discrepancies noted by AFQC personnel, 54 were concerned with electrical components and 66 were concerned with mechanical components.

Most of these discrepancies were corrected without requiring FARR action, but 14 items were transferred to FARR's for disposition:

a. FARR 500-607-785 reported that the 403 area had several conditions of micro-surface contamination and the L1 power control module in the 403 area had a broken safety wire. The micro-surface contamination was acceptable to the Material Review Board without rework, and the L1 power control module was safety wired.

b. FARR 500-608-749 reported that electrical connectors P105 through P109 and P153 through P155, at the engine disconnect panel, were not tightened and safety wired. The connectors were loosened, new O-rings were installed, tightened per DPS 54015, and tested per 1B66572.

c. FARR 500-608-935 reported that the 411MT649 cable assembly, P/N 1B40242-95, S/N 593-4, had damaged insulation 3/8 inch long by 1/4 inch wide at stringer 32 in the forward interstage. The cable assembly was removed and replaced.

4.4 (Continued)

c. FARR 500-608-943 reported that the mylar covering, at the LH_2 tank dome, had 32 burn holes exceeding the outline of the scrim thread pattern, also the mylar cover was debonded and scrim threads were exposed adjacent to the LH_2 vent port. The 32 burn holes in the mylar cover were acceptable without rework to the Material Review Board, and the debonded mylar was rebonded per DPS 22301.

d. FARR 500-608-960 reported that the 409MT651 cable assembly, P/N 1B40242-91, S/N 597-8, had torn insulation 1/2 inch long by 1/4 inch wide, also several shield strands were broken adjacent to stringer 46 in the forward interstage. The broken strands were removed, and the shield braid area was wrapped with three layers of DPM 2766 tape; then, the damaged area was repaired per DPS 54010.

e. FARR 500-609-001 reported that the LH_2 prevalve neoprene coated nylon boot, P/N 1B57698-1, had a 2 inch tear. The nylon boot was cleaned, and DPM 3230 tape was installed overlapping the torn area by 1 inch.

f. FARR 500-703-113 reported several areas of the curtain assembly in the aft interstage were torn or not properly secured. The curtain assembly was classified as interim use material, and the FARR was transferred to the FTC for final disposition.

4.5 Weight and Balance Procedure (1B55602 E)

This procedure measured the stage weight with an accuracy of ±0.1 per cent, using a three point electronic weighing system, and determined the longitudinal center of gravity of the stage. The measured stage weight was corrected for gravity and air buoyancy forces to determine the weight at Standard Gravity in a vacuum. The procedure was initiated on 14 January 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 15 January 1969.

4.5 (Continued)

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 554.702 and 286.147. The dry bulb temperature, barometric pressure, and relative humidity were measured in the weighing area for use in determining the air density. These measurements were repeated every half hour throughout the weighing operation.

Using the hand pumps on the aft jack, P/N 1A93232-1, and the two forward glide-air jacks, P/N 1A83320-1, the stage was raised to just clear the cradles and leveled to the previous limit. Regulator air pressure was applied to the forward glide-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

4.5 (Continued)

Test Data Table, the stage shipping and handling weight was 26,804.9 pounds, the weight at Standard Gravity in a vacuum was 26,857.2 pounds, and the longitudinal center of gravity was at station 329.4.

No parts were short during this procedure, no revisions were written, and no problems were encountered.

4.5.1 Test Data Table, Weight and Balance Procedure

Time	Barometric Press (in. Hg)	Relative Humidity (%)	Dry Bulb Temp (°F)
06:30	29.62	64.0	64.0
07:00	29.62	63.0	63.0
07:30	29.63	62.0	63.0
08:00	29.63	60.0	63.0
08:30	29.64	60.0	63.0

Calculated Air Density: 0.0762 pounds per cubic foot

Load Cell Collected Data

Reaction Load	Aft (R1)	Forward (R2)	Forward (R3)
Serial Number	36243	34251	34180
Capacity (pounds)	25,000	10,000	10,000
Run 1 Reading (%)	79.241	37.944	39.285
Run 2 Reading (%)	79.267	37.891	39.333
Run 3 Reading (%)	79.253	37.878	39.363
Average Reading (%)	79.254	37.904	39.327
Calibration Correction	0.953	0.225	0.214
Corrected Reading (%)	80.207	38.129	39.541
Reaction (pounds)	20,051.1	3,812.9	3,954.1

Weight Determination (pounds)

Aft Reaction R1	20,051.7
Forward Reaction R2	3,812.9
Forward Reaction R3	3,954.1
Total Reactions as Recorded	27,818.7
Minus Weighing Equipment "Tare"	-1,013.8
Shipping and Handling Weight	26,804.9
Plus Gravitational Correction	18.9
Plus Buoyancy Correction	33.4
Weight at Standard Gravity in a Vacuum	26,857.2

4.5 (Continued)

Longitudinal Center of Gravity

Reaction R1 Moment at Sta. 189.3	3,795,786.8
Reaction R2 Moment at Sta. 684.0	2,608,023.6
Reaction R3 Moment at Sta. 684.0	2,704,604.4
Moment Sum	9,108,414.8
Tare Moment	-278,870.75
Moment Sum Less Tare	8,829,544.05

As weighed Center of Gravity = 329.4
(Moment Sum Less Tare Divided by Total Reactions Less Tare)

4.6 GN_2 Electrical Air Carry Preshipment Purge (1B65454 H)

Just prior to stage shipment, this procedure purged the stage to a dewpoint of -30°F (235 ppm by volume) or less, using gaseous nitrogen and installed the necessary desiccants for stage air carry shipment. The desiccants maintained a clean, dry environment and a safe differential pressure during air transportation.

The procedure was satisfactorily performed between 14 January and 20 January 1969, and was accepted on 21 January 1969. The purge preparations started with the installation of the LOX and LH_2 desiccant support assemblies, P/N's 1B61272-1 and 1B61270-1. The LOX bellows, P/N 1A49971-501, and the LOX and LH_2 disconnects, P/N's 1A49970-503 and 1B66932-501, were removed for separate shipment with the stage. Covers and desiccators were installed at the LOX and LH_2 fill and drain vents, the LH_2 propulsive, nonpropulsive, and ground vents, the LOX propulsive and nonpropulsive vents, and the O_2H_2 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

4.6 (Continued)

unit and the stage. The engine LOX chilldown line and LH_2 feed duct; the LH_2 pressurization line; the LH_2 propulsive vent, nonpropulsive vent, and ground vent; the LOX propulsive vent and nonpropulsive vent; the O_2H_2 burner LOX and LH_2 ducts; and the LOX and LH_2 propellant tanks were all purged with gaseous nitrogen. The final dewpoints attained were -47.0°F for the LOX system and -30.0°F for the LH_2 system. The LOX tank desiccant breather, P/N 1A79691-1, and the four LH_2 tank desiccant breathers, P/N 1A79691-501, were prepared, filled with desiccant material, and installed.

After satisfactory completion of the purge operation, the purge unit was disconnected from the stage and secured. The aft skirt dust cover, P/N 1B61077-1, and the forward skirt dust cover, P/N 1B61099-1, were then installed to complete the procedure.

There were no parts shortages affecting this test. FARR 500-489-782 reported that a pressure of 475 psig was inadvertently applied to the engine pneumatics and to the LH_2 repressurization bottles. No pressure should have been applied. The FARR was transferred open to the FTC for final disposition. Fourteen revisions were made to the procedure for the following:

a. Two revisions deleted steps that were performed by other procedures.

b. One revision deleted two previous revisions and provided instructions for sampling the purge gas.

c. One revision reperformed steps necessitated by a hose assembly being erroneously plumbed into the wrong pneumatic system. Refer to FARR 500-489-782.

d. One revision gave instructions for venting the engine control bottles. Reference revision c.

4.6 (Continued)

e. Three revisions were required to update the procedure to the latest configuration.

f. One revision authorized the use of a portable GN_2 gas heater.

g. One revision authorized the adjustment of the purge gas flow rates to conserve GN_2.

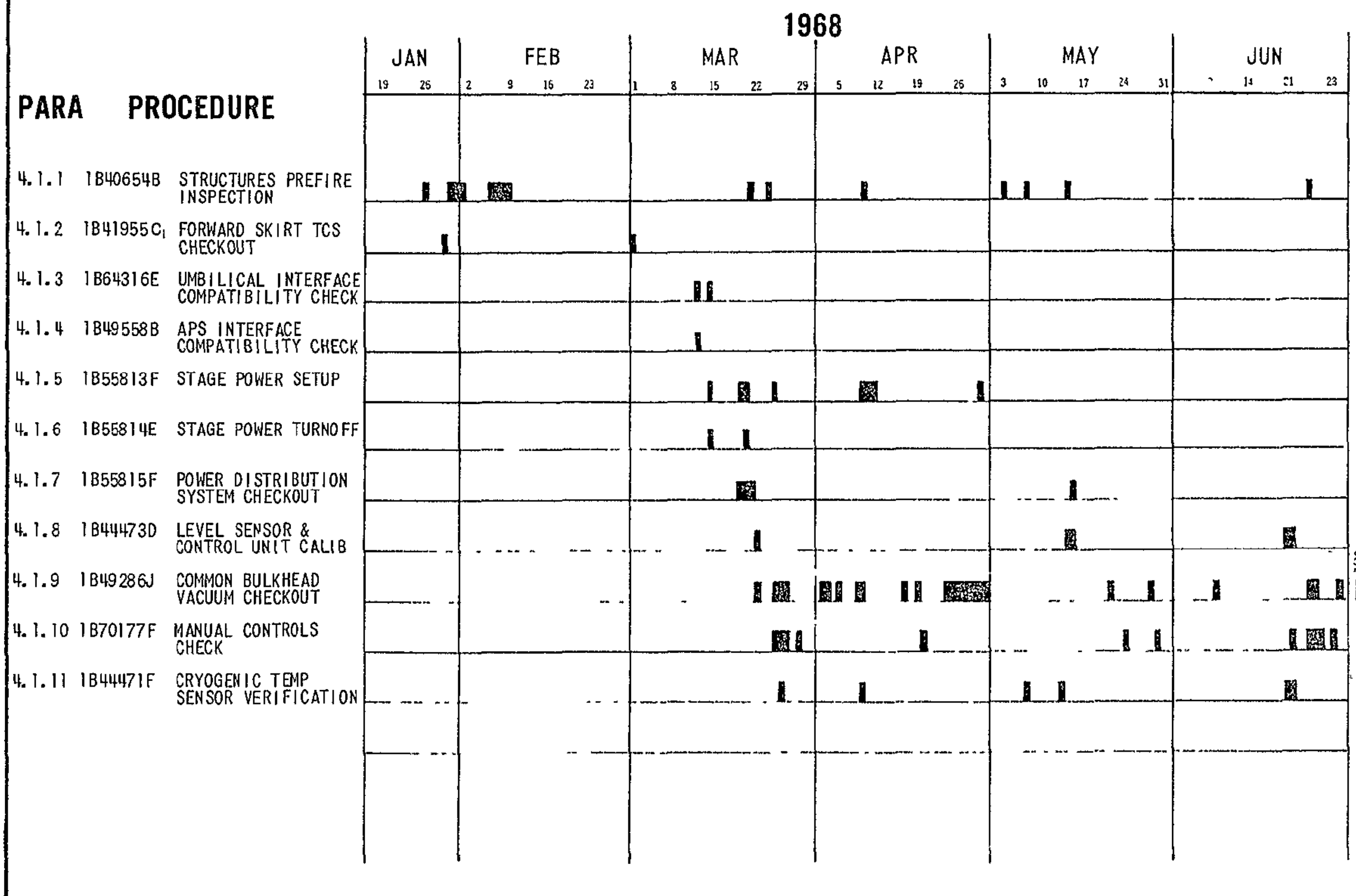
h. One revision provided the instructions for taping a split sleeve to the LOX duct as the cover was improperly clocked for this stage.

i. Three revisions were written and subsequently voided or deleted.

APPENDIX I

TESTING SEQUENCE

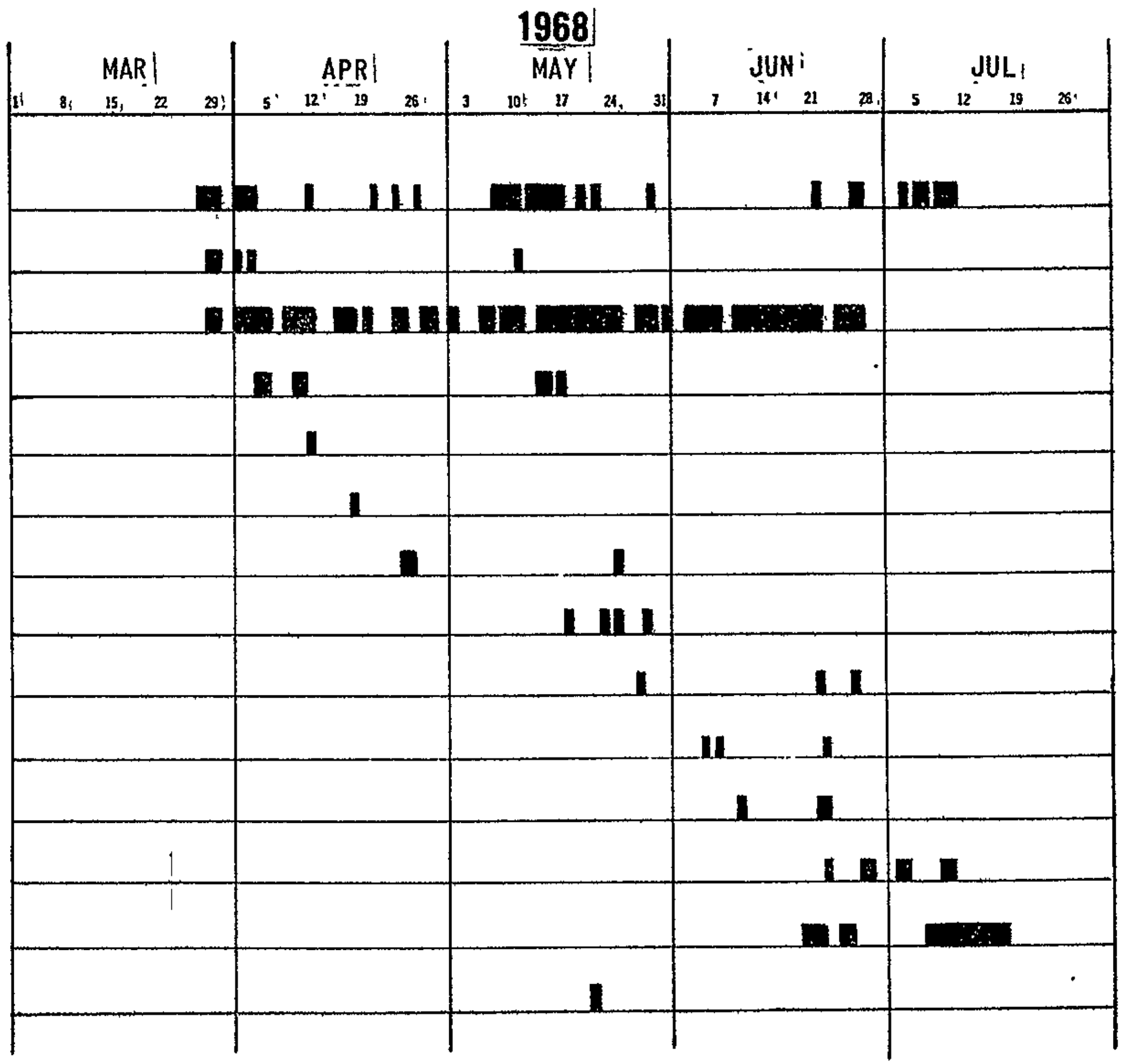
506N PREFIRE ACCEPTANCE TESTING



PRECEDING PAGE BLANK NOT FILMED

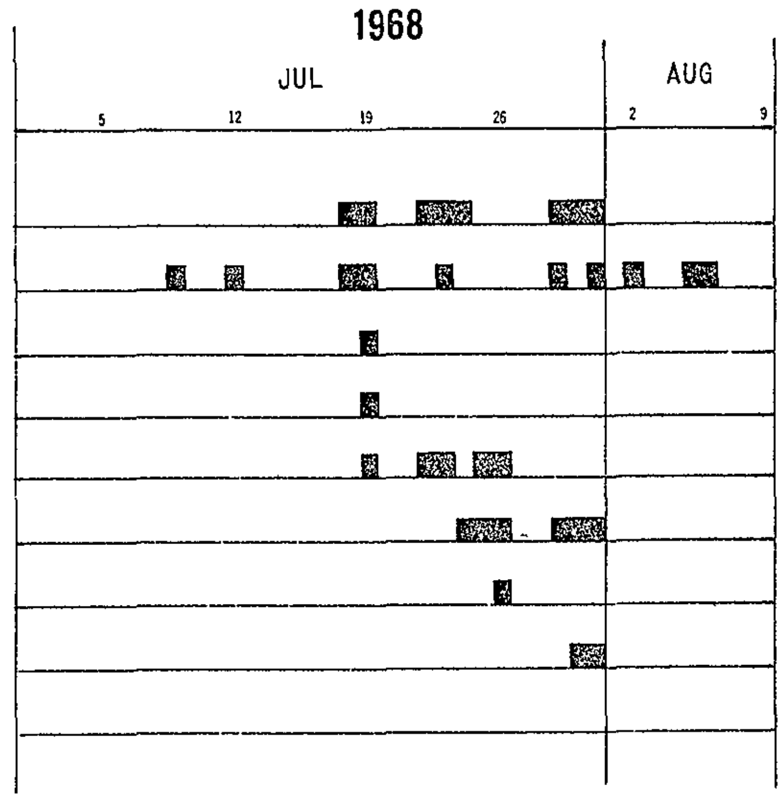
506N PREFIRE ACCEPTANCE TESTING (Cont'd)

PARA	PROCEDURE	
4.1.12	1B41005B	HYDRAULIC SYSTEM SETUP & OPERATION
4.1.13	1B55816F	DDAS CALIBRATION
4.1.14	1B71877B	PROPULSION SYSTEM LEAK CHECKS
4.1.15	1B55822E	EBW AUTO CHECKOUT
4.1.16	1B55821G	RANGE SAFETY SYSTEM AUTO
4.1.17	1B44472D	T/M & R/S ANTENNA SYSTEM CHECKOUT
4.1.18	1B55825D	APS AUTOMATIC CHECKOUT
4.1.19	1B64368F	PU SYSTEM CALIB
4.1.20	1B55823H	PU SYSTEM AUTO CHECKOUT
4.1.21	1B62753J	PROPULSION SYSTEM AUTO
4.1.22	1B55817J	DDAS AUTO CHECKOUT
4.1.23	1B70175G	FINAL PROPULSION SYSTEM LEAK CKS
4.1.24	1B55831G	IST
4.1.25	1B55824F	HYDRAULIC SYSTEM CHECKOUT



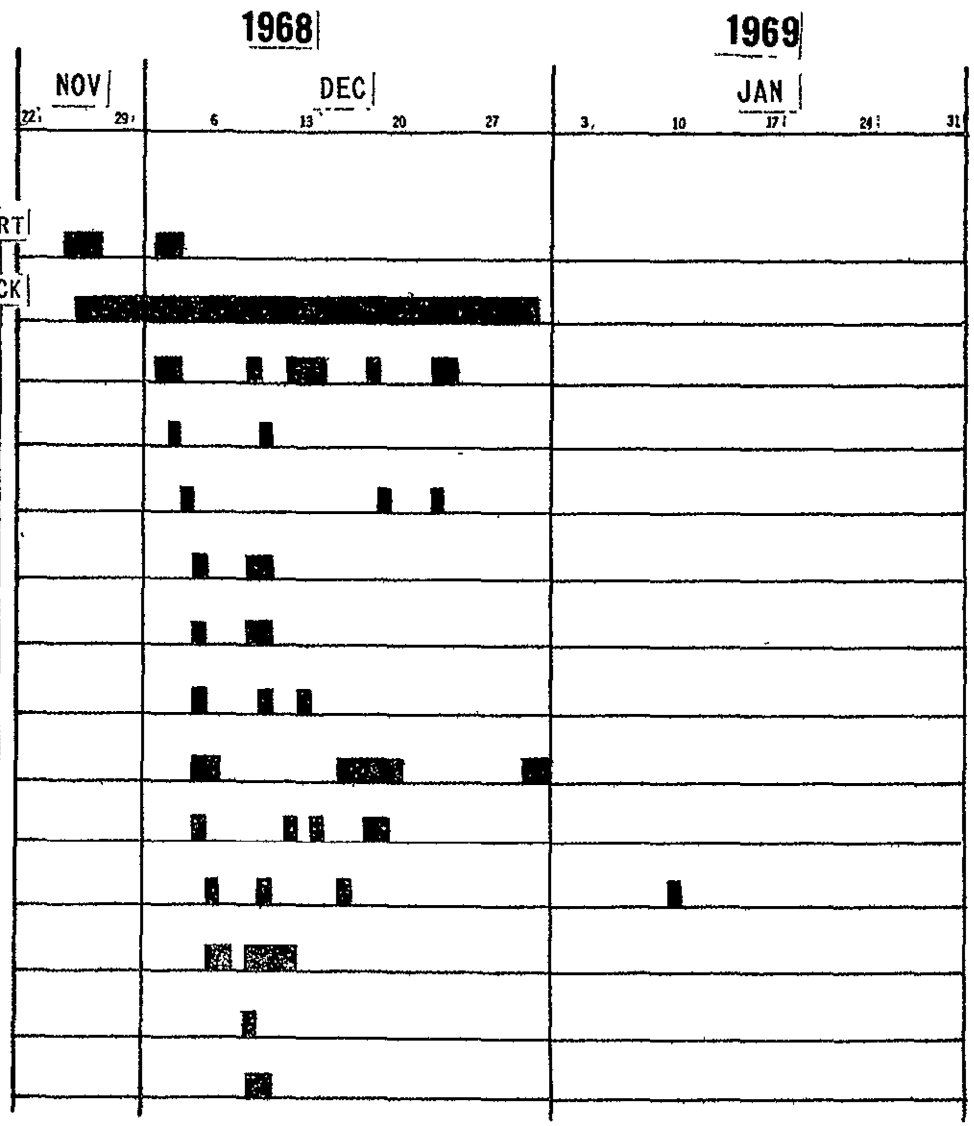
506N ABBREVIATED POSTFIRE ACCEPTANCE TESTING

PARA		PROCEDURE
4.2.1	1B70756B	STRUCTURES POSTFIRE INSPECTION
4.2.2	1B70175G	FINAL PROPULSION SYSTEM LEAK CHECKS
4.2.3	1B55813F	STAGE POWER TURNON
4.2.4	1B55814E	STAGE POWER TURNOFF
4.2.5	1B55831G	IST
4.2.6	1B41006A	HYDRAULIC SYSTEM OPERATION AND SECURING
4.2.7	1B55823H	PU SYSTEMS CHECKOUT
4.2.8	1B41883C	TCS POSTFIRE CHECKOUT



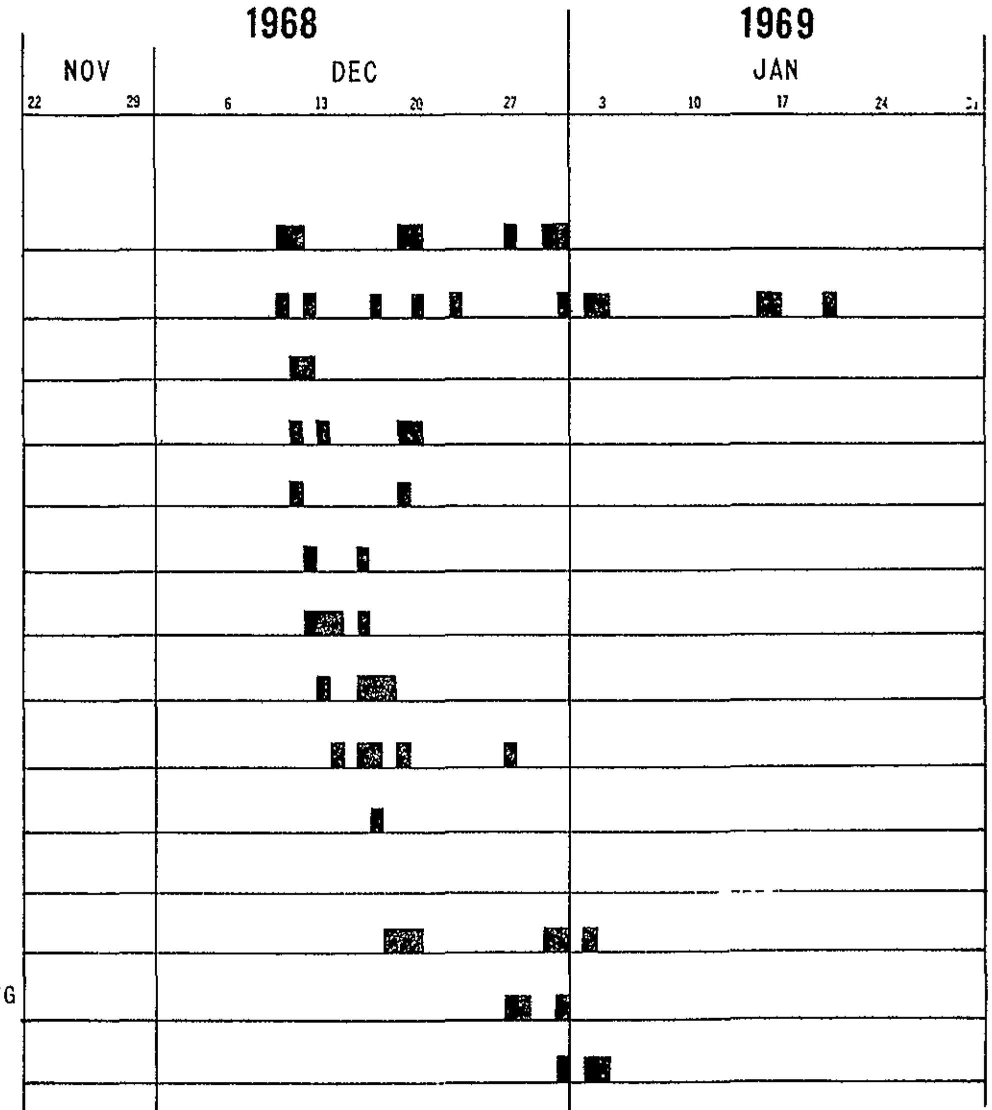
506N DEFERRED POSTFIRE ACCEPTANCE TESTING

PARA		PROCEDURE
4.3.1	1B41955C	CHECKOUT & OPERATION T/C SYS FWD SKIRT
4.3.2	1B71877C	PROPULSION SYS LEAK & FUNCTIONAL CHECK
4.3.3	1B41006B	HYDRAULIC SYS SETUP & OPERATION
4.3.4	1B49558B	APS INTERFACE COMPATIBILITY CHECKOUT
4.3.5	1B64316E	UMB INTERFACE COMPATIBILITY CHECKOUT (3 issues)
4.3.6	1B55813L	STAGE POWER SETUP
4.3.7	1B55814K	STAGE POWER TURNOFF
4.3.8	1B55815K	POWER DISTRIBUTION SYSTEM CHECKOUT
4.3.9	1B70177G	STAGE AND GSE MANUAL CONTROLS CHECK
4.3.10	1B55817L	DDAS AUTO
4.3.11	1B64680D	LEVEL SENSOR AND CONTROL UNIT CALIB
4.3.12	1B64678F	CRYOGENIC TEMP SENSOR VERIFICATION
4.3.13	1B55816G	DDAS CALIBRATION
4.3.14	1B55822F	EBW SYSTEM CHECKOUT



506N DEFERRED POSTFIRE ACCEPTANCE TESTING (Cont'd)

PARA	PROCEDURE	
4.3.15	1B70430NC	APS SYSTEM CHECKOUT
4.3.16	1B70756B	STRUCTURAL INSPECTION
4.3.17	1B66774A	APS SYSTEM AUTO
4.3.18	1B64367K	PU SYSTEM CALIBRATION (2 issues)
4.3.19	1B55823K	PU SYSTEM CHECKOUT (2 issues)
4.3.20	1B55819G	RANGE SAFETY RECEIVER CHECKOUT
4.3.21	1B55821J	RANGE SAFETY SYSTEM CHECKOUT
4.3.22	1B64681G	SIGNAL CONDITIONING SETUP
4.3.23	1B55824G	HYDRAULIC SYSTEM CHECKOUT (AUTO)
4.3.24	1B64679F	T/M & R/S ANTENNA CHECKOUT
4.3.25	1B62753M	PROPULSION SYSTEM AUTO
4.3.26	1B55833H	ALL SYSTEM TEST
4.3.27	1B41006B	HYDRAULIC SYSTEM OPERATING & SECURING
4.3.28	1B41883C	FORWARD SKIRT T/C CHECKOUT



APPENDIX II
TABLES

TABLE I. FAILURE AND REJECTION REPORTS
STAGE RECEIPT TO FORMAL COUNTDOWN INITIATION

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A255230 4-24-68	The check valve, P/N 1B67481-1, S/N 7060532, at 1 psid pressure had reverse leakage of 0.7 scim. At 15 psid pressure the reverse leakage was 16 scim; should have been 0 scim per 1B70422.	The check valve was retested at LOX service with no leakage. The maximum allowed was 10 scim. The part was acceptable to the Material Review Board.
A261711 3-22-68	The check valve, P/N 1B67481-1, S/N 70621193, had a slight bubble leak at 1 psid pressure. The reverse leakage should have been 0 scim per 1B70422.	The check valve was removed and replaced.
A261829 3-29-68	During the engineering run of DDAS 1B55817, the engine regulator outlet pressure transducer, P/N NA5-27412T7LT, S/N 4621A, indicated an ambient pressure of 30.30 psia; should have been 14.7 $\pm$15 psia.	The transducer was removed, replaced, and tested per 1B55817.
A261830 3-29-68	a. Pin R, of receptacle J3 on the submultiplexer remote digital assembly, P/N 1B66051-501, S/N 05, was bent.	a. The pin was straightened per DPS 54002.
	b. The 404W203 P3, P/N 1B67087-1, S/N 8359, connector insert was damaged with possible damage to socket R.	b. The connector was removed and replaced.
A261831 4-2-68	Radiographic inspection of the aft skirt per 1B40654 revealed that the filler, P/N 1A39295-5, at stringer 144 was improperly installed. The filler moved to a 45° angle after the aft rivet was installed, also the top two rivets did not pierce the filler assembly.	The filler void was filled with adhesive DPM 3485. The area was painted per finish specifications F289.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A261833 4-4-68	The pitch actuator, P/N 1A66248-507, S/N 74, was noted to have one drop of hydraulic fluid under the cylinder bypass valve after 15 minutes of operation per 1B41005. No leakage is allowed. The system was run for five additional times with the same results.	The actuator was removed and replaced..
A261834 4-8-68	During propulsion leak and functional check, two disc assemblies ruptured inward on the leak check adapter, P/N 1B59852-1, causing possible contamination of the fuel pressure line.	The adapter, P/N 1B59852-1, was removed and replaced. A particulate matter sample was taken which did not meet the DPS requirements. The system was purged at 100 psig for 10 minutes; a sample was taken and was acceptable to the Material Review Board.
A261835 4-11-68	During propulsion leak and functional check, the LOX fill and drain valve, P/N 1A48240-505-007, S/N 0009, had a 400 scim leakage at the closing solenoid vent port at the close position and 5.2 scim at the boost position. The maximum leakage allowed is 2 scims.	The valve was removed and replaced.
A261836 4-15-68	The temperature transducer, P/N 1B64968-503, S/N 990, had approximately a 5 degree bend 1/2 inch from the tip of the probe.	The transducer was removed and replaced.
A261839 4-17-68	The flex portion of the LOX tank pressurization line, P/N 1B68897-1, was within 0.020 inches from the LOX vent valve, P/N 1A48312; should have been 1/8 inch.	The pipe assembly was removed and replaced.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A261841 4-18-68	During the propulsion leak check per 1B71877, the J2 engine, P/N 103826, S/N J2101, had a small bubble leak at the inside edge of the weld at the LOX dome purge inlet boss, P/N C03A.	The thrust chamber injector, P/N 208021-11, S/N 4081787, was removed, sent to R/NAR, reworked, tested, reinstalled, leak checked, and accepted by the Material Review Board.
A261844 4-29-68	During installation of the J2 engine injector, the pitch and yaw actuator low pressure hoses, P/N 1B63071-1, SN's 07380H800022 and 07380H800032, were crimped.	The hoses were removed and replaced.
A261845 4-25-68	a. During installation of the J2 engine after R/NAA rework, it was noted that bolt, P/N 1B39037-501, S/N 66, on the second installation was stripped at the torque value of 125 ft. lbs. with a maximum of 144 ft. lbs. b. Five additional engine securing bolts S/N's 11, 12, 26, 42, and 92 were installed with no discrepancies.	The six bolts were removed and replaced.
A261846 4-29-68	During installation of the J2 engine injector, it was suspected that the pitch and yaw actuator high pressure hoses, P/N 1B63006-1, S/N's 07380H100057 and 07380H100063, were internally damaged due to a crimp in the low pressure hoses.	The hoses were removed and replaced.
A261847 3-7-68	During installation and leak check it was noted that leakage existed at the stage vent flange and tee assembly, P/N 1B69768-1. Inspection of the flange sealing surface revealed several scores and gouges approximately 4 inches x 1/16 inch in area.	The flange sealing surfaces were smoothed up, a new seal was installed, leak checked and accepted by the Material Review Board.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A261849 2-27-68	During removal of the flex duct, P/N FT167-4-96, from the environmental control flange duct, P/N 1A67978-515, the duct was torn two places 2 inches in length.	The duct was removed and replaced.
A261895 1-30-68	During receiving structure inspection, the following discrepancies were noted:	
	a. The LH_2 external tank vent duct, P/N 1A94469, was not wrapped with L-T-100 type tape around the flex bellows.	a. The tape was removed and replaced.
	b. The tube assembly, P/N 1B64607-1, had a loose B-nut under the LH_2 vent valve duct at stringer 14.	b. The B-nut was tightened to the required torque value.
	c. The following items had no inspection seals: 1. Connector P10 and P20 of the 410W-200 wire harness at stringers 23 and and 43. 2. On the control actuation modules forward of the 404A60 panel at stringer 55. 3. The connector at the 404A45A8 J2 module. 4. Connectors P10 and P11 of the 404W29 wire harness forward of the 404A43 panel. 5. The safing connector 40M37743-1 at the safety controller on stringer 37.	c. & d. The noted items were sealed with inspection seals.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A261895 (Cont.)	6. The Schrader valve caps on two digital command receivers, P/N 50M10697 at stringer 37, the PU electronic assembly at stringer 57, and the switch selector control assembly, P/N 1B65319-503, S/N 023, on the 404A70 panel.	
	7. The pressure valve caps on the chill-down inverters at the 404A74A1 and A2 modules.	
	8. Connector P2 of the 404W204 harness forward of the 404A70 panel.	
	d. Connector P1 of the 411W2 harness forward of the 411A9 panel had a broken inspection seal.	
	e. The following items had loose or missing safety wire:	e. The loose safety wire was removed and all connectors were safety wired.
	1. The central decoder assembly, P/N 1A74051-501, electrical connectors, not installed.	
	2. The connectors to the 411A99A31 and A32 pulse sensors, not installed.	
	3. Coaxial connector P1 of the 411W211 at the 411A64A204 module, loose.	
	4. The connectors to the 404A25 and 404A47 pulse sensors on stringers 3 and 13.	
	f. The 404A3 wire harness at stringer 53 had a loose clamp.	f. The loose clamp was tightened.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A261895 (cont.)	g. The first two convolutions of the bellows, P/N 1A49986-1, between the bi-directional vent valve and the LH_2 tank ground vent valve, were damaged.	g. The bellows was acceptable to the Material Review Board.
	h. The following areas required paint or finish rework: 1. The forward side of the customer connect panel in the 403 area. 2. The rib at "Vee" section and forward end of stringer 26 in the 404 area.	h. The noted areas were finished per finish specification F289.
	i. The upper convolution of the lower bellows section, of the LOX feed duct to the O_2H_2 burner in the 403 area had a ding.	i. The ding was acceptable to the Material Review Board.
	j. The lower LH_2 engine feed duct, P/N 1A49320-515, S/N 32R, in the 403 area, had a sharp ding in the sixth convolution from top of upper bellows.	j. The duct was removed and replaced.
	k. Unused holes, burnished to bare metal, for ground stud or strap installation were noted at the following areas: 1. Approximately 30-1/2 inches from the forward end of stringers 31 and 37 in the 411 area. 2. On stringers 49, 55, 61 and 67 in the 411 area.	k. The ground straps were installed per 1B38426, the unused holes were finished per finish specification F289 and were acceptable as open holes to the Material Review Board.

TABLE I (Continued)

FARR NO.		DESCRIPTION OF DEFECTS		DISPOSITION
A261895 (Cont.)	l.	The RF assembly, P/N 1B65788-1-002, S/N 15501, was not sealed around the mating surface per drawing 1B57447 N, Zone 10, General Note 10.	l.	The assembly was removed, the mating surface was resealed, and the assembly was reinstalled.
	m.	Residue from the walnut hull blasting was adhered to surfaces with a lubricant or sticky substance throughout the 403, 411, and 427 areas.	m.	The residue was acceptable to the Material Review Board.
	n.	Paint overspray was noted on the pipe assemblies forward of helium bottle between stiffeners 8 and 9 in the 403 area.	n.	The paint overspray was acceptable to the Material Review Board.
	o.	The lower rib, P/N 1B28112-11, of the O_2H_2 burner LH_2 propellant valve fairing was contacting pipe assembly, P/N 1B67796-1, in the 427 area, reference drawing 1B58004, Zone 44.	o.	A radius was cut in the rib, P/N 1B28112-11, to a maximum depth of 3/8 inch. The trim was blended over a distance of 1 inch from the center line of the maximum depth.
	p.	Two pipe assemblies, P/N 1B67796-1 and P/N 1B65055-1, were contacting each other inboard of the clamp in the 427 area.	p.	The two pipe assemblies were reformed for a minimum of 0.090 inch clearance.
	q.	The forward and aft electrical umbilical receptacles had moisture inside. The receptacles had plastic covers installed and should have been metal caps per DPS 54002.	q.	The receptacles were cleaned with isophropyl alcohol using a nylon brush, dried, inspected for corrosion, and metal caps were installed.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A261895 (Cont.)	r. The injector had two spots approximately 3/4 inch in diameter plus numerous small areas that was luminous under the ultra-violet light.	r. The spots were acceptable to the Material Review Board.
	s. The throat and area to the injector revealed foreign matter that was luminous under the ultra-violet light.	s. The area was cleaned with trichlor-ethylene using a nylon bristle brush.
A261896 2-15-68	The panel assembly, P/N 1B51291-503, had corrosion, metal damage, and the alodine was removed or not applied while accomplishing AO 1B51291 T.	The corrosion was cleaned per DPS 41004, the metal damage was smoothed up and all bare surfaces were brushed with alodined per DPS 41410.
A261897 2-15-68	The switch selector control assembly, P/N 1B65319-503, S/N 023, location 404A70, had corrosion on the mounting surface.	The corrosion was cleaned per DPS 41004 and finished per DPS 41480.
A261898 2-21-68	The aft dome LOX vent valve support, P/N 1B37762-1, was mislocated by 0.28 inch at the top hole and 0.19 inch at the bottom hole. The two holes were elongated to 3/4 inch long by 5/8 inch wide; should have been 1/2 inch diameter holes per 1B69608, Zone 7.	The LOX tank vent valve and pipe assemblies were installed. The support, P/N 1B37762-1, was trimmed, and a phenolic filler was fabricated and installed with Lefkoweld 109 per DPS 32300.
A261900 3-6-68	The breakout of wire harness 404W208 was on the right; should have been on the left of stringer 13A per 1B66505, Sheet 84.	The harness routing was accepted by the Material Review Board.
A270676 4-29-68	During modification rework the bonded electrical support standoffs were noted to be stripped as follows:	All noted standoffs were repaired per drawing 1B58312.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS			DISPOSITION
A270676 (Cont.)	Wire Harness	404 Area Stringer No.	Panel P/N	
	a. 404W208	116A	1B62907-43 NC	
	b. 404W208	111	1B62907-41 B	
	c. 404W208	108	1B62907-41 B	
	d. 404W208	124A	1B62907-45 B	
	e. 404W208	104	1B62907-39 S	
	f. 404W44	76	1B62907-31 U	
	g. 404W203	74	1B62907-31 U	
	h. 404W209	74	1B62907-31 U	
	i. 404W208	80	1B62907-31 U	
	j. 404W208	76	1B62907-31 U	
	k. 404W7	92	1B62907-35 NC	
	l. 404W203	26A	1B54086-1 A	

Wire Harness	403 Area Stiffener
m. 404W208	21
n. 404W208	21-1/4
o. 404W200	21 A
p. 404W209	22-1/4
q. 403W5	1
r. 404W6	1

Wire Harness	424 Area Above Stiffener
s. 403W7	13-1/4
t. 403W7	13-1/4

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A270678 5-1-68	During engine reassembling after the LOX dome rework, the LOX ASI line, P/N 410117-11, was misaligned with the mounting bracket by approximately 1/2 inch and 5/8 inch with the attach flange on the main oxidizer valve.	The line was removed and replaced.
A270679 5-2-68	a. Panel isolator, P/N 1B32258-1, S/N 323, at the 404A61 panel on stringer 68, was debonded 3/8 inch in length; maximum allowable is 1/4 inch per drawing 1B40654. b. Panel isolator, P/N 1B32267-1, S/N 475, at the 404A64 panel on stringer 114, was debonded 3/4 inch in length; maximum allowable is 1/4 inch per drawing 1B40654.	The isolators were removed and replaced.
A270680 5-3-68	During reinstallation of the 404A3 sequencer panel, P/N 1B39550-513, it was noted that the threaded sleeve of panel isolator, P/N 1B32258-1, S/N 316, was torn loose.	The isolator was removed and replaced.
A270681 5-3-68	During the DDAS automatic run H&CO 1B55817 J, the cold helium sphere pressure indicated a high calibration of 4.107 vdc; should have been 4.000 ±0.100 vdc. Ambient pressure was -16.231 psia; should have been 14.700 ± 70.000 psia. It was noted that the transducer cable, P/N 1B40242-99, at connector P2 pin G, had infinite resistance; should have been less than 1.0 ohm.	The cable, P/N 1B40242-99, was removed and replaced.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A270684 5-15-68	During line check A45-81, it was noted that the twenty-seven drain holes in the aft angle segment of the forward skirt, P/N 1A58608, between stringers 1 through 14 and 42 through 108, were approximately 0.188 inch; should have been 0.310 to 0.319 inch per drawing 1A58608, Zone 3.	The drain holes were acceptable to the Material Review Board.
A270685 5-17-68	a. During the PU subsystem calibration, the electronic PU assembly, P/N 1A59358-529, S/N 031, indicated that the linearity checks were out-of-tolerance. At full ratio the LH_2 data acquisition was 0.82308, and the linearity check was 0.82908. At full ratio the LOX data acquisition was 0.82308, and the linearity check was 0.82757. b. The oven temperature stability monitor voltage drifted from 4.395 to 3.728 vdc in 6 hrs. resulting in a decrease in the reference capacitance and unbalanced the bridges which caused the above noted changes.	The PU assembly was removed, reworked, and reinstalled.
A270691 5-22-68	During leak checks with the system pressurized to 10 psig, the LOX nonpropulsive vent ducts, P/N 1B69220-1 and 1B69223-1, had leaks as follows: a. The port near fin line 1 had a bubble leak between the skin and inner doubler, and a blowing leak between the skin and outer doubler.	The ducts were removed, sent to the LOX lab; and the flange surfaces reworked, reinstalled, and leak checked per drawing 1B71877.

TABLE I (Continued

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A270691 (Cont.)	b. The port near fin line 3 had a bubble leak between the skin and inner doubler, and an audible leak between the skin and outer doubler.	
A270692 5-23-68	The pipe assembly, P/N 1B62600-5, would not mate to the pneumatic latching actuator assembly, P/N 1B66639-515.	The pipe assembly was removed and a new pipe assembly was fabricated per P/N 1B62600-5, mockup.
A270693 5-23-68	The pipe assembly, P/N 1B62600-9, would not mate to the pneumatic latching actuator assembly, P/N 1B66639-515.	The pipe assembly was removed and a new pipe assembly was fabricated per P/N 1B62600-9, mockup.
A270694 5-24-68	During hydraulic setup and operation, the transducer receptacle P57 of wire harness 404W208, P/N 1B31358-513, S/N 137-1, at the aft end of the hydraulic accumulator reservoir assembly, showed evidence of hydraulic fluid.	The cable assembly, transducer and receptacle were cleaned with isopropyl alcohol, dried with dry GN_2, reassembled, and functional tested by the DDAS automatic procedure.
A270696 5-25-68	During the simulated static firing procedure, the following items were noted: a. The nonpropulsive vent duct, P/N 1A87234-2, had a ding approximately 4 inches long by 2-1/2 inches wide and a sharp crease 3/4 inch at the bottom of the ding. The damaged area was between stringer 34 and 35, and was 11 inches from duct assembly, P/N 1A87436-502, in the 411 area.	The duct and pipe assemblies were removed and replaced. The replacement parts were leak checked per drawing 1B71877.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A270696 (Cont.)	b. Suspected damaged to pipe assembly, P/N 1B43397-1, when it struck the 1A87436-2 duct while the system was pressurized. There were numerous scrapes on the tape wrapping near the center of the pipe assembly.	
A270697 5-28-68	During rework per AO 1B51354 AU the identification plate, P/N 1B51354-33, was not bonded to the 404A2 power distribution panel per DPS 33250, paragraph 7.2.	Additional adhesive was added to comply with DPS 33250, paragraph 7.2.
A271252 10-26-67	a. During the propellant tank leak checks, it was noted that the LH_2 fill and drain valve, P/N 1A48240-505, S/N 0050, had 28 scim leakage at the blade shaft seal. Maximum allowed leakage was 6.1 scim per drawing 1B59459 C.	The valve was removed and replaced.
	b. The valve was retested per A659-1A48240-1 with 55 psig applied to port No. 6 outlet. A leakage of 28 scim was recorded at ambient temperature. The gasket under the electrical plug on the micro-switch cavity was also leaking.	
A271254 11-8-67	During the all systems test, the gas generator chamber pressure transducer, P/N NA5-27412 T1OT, S/N 1322A, NASA measurement No. D010, was 2.1 per cent peak-to-peak during the time the hydraulic pump was running and should not have exceeded 2 to 5 per cent peak-to-peak in excess of 1 second per SM 47376, paragraph 3.1.	The condition was reworked per WRO SIVB-4188. The original discrepancy was verified not to exist during AST.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A271260 11-30-67	During the DER evaluation of the all system test, the LH_2 not overfill sensor control unit, P/N 1A68710-509, S/N C-41, ref. location 411A92A24, cycled from dry to wet and back to dry when 28 vdc command was applied to the safe and arm device. The depletion sensor, P/N 1A68710-509, S/N C-18, ref. location 411A61A201, also cycled from dry to wet then back to dry.	The condition was reworked per WRO SIVB-4266. The original discrepancy was verified not to exist during AST.
500-026-260 3-8-68	a. During rework per AO 1B57996 S, connector P99 of cable assembly, P/N 1B67209-1, 404W208, had a damaged insert adjacent to socket EE.	a. The connector was removed, replaced, and functionally checked per drawing 1B55816.
	b. Pins EE, t an u of receptacle J1 on the sub-multiplexer remote analog environmental control, P/N 1B66050-1, S/N 03, were bent.	b. The unit was removed and replaced.
500-026-286 3-13-68	During the performance of H&CO 1B64316, it was noted that the 404W15 wire harness, P/N 1B58311-1, had moisture inside of the J1 and J2 receptacle.	The receptacles were flushed with isoprophy alcohol, dried with dry GN_2 and baked with heat lamps for 6 hours.
500-026-294 2-21-68	The pipe assembly, P/N 1B69916, had excessive preload and could not be clamped or secured per drawing 1B58001.	The pipe assembly was removed and replaced.
500-026-308 3-18-68	The pipe assembly, P/N 1B69917, had excessive preload and could not be clamped or secured per drawing 1B58001.	The pipe assembly was removed and replaced.
500-026-316 3-18-68	The pipe assembly, P/N 1B74201, could not be installed and clamped per drawing 1B58004 without excessive preload.	The pipe assembly was removed and replaced.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-026-324 3-18-68	The pipe assembly, P/N 1B69992, could not be installed and clamped per drawing 1B58004 without excessive preload.	The pipe assembly was removed and replaced.
500-026-332 3-18-68	The pipe assembly, P/N 1B69994, could not be installed and clamped per drawing 1B58004 without excessive preload.	The pipe assembly was removed and replaced.
500-026-341 3-19-68	a. The P53 connector insert of the 404A3W1 wire harness, P/N 1B66966-1, S/N 01, was punctured adjacent to socket u.	a. Socket u was removed and replaced.
	b. Pin u of receptacle J1 of the potted bus connector, P/N 1B57771-557, 404A3A53 was bent approximately 20 degrees and pin W was bent approximately 5 degrees.	b. Pins u and W were straightened per DPS 54002, Section 6.2. The assembly reinstalled, and tested per stage power turnoff H&CO 1B55814.
	Note: Sockets u and D of connector P53 were touching each other.	
500-026-367 3-25-68	During rework per AO 1B69493 A, of the 404A74 panel, P/N 1B51297-507 K, the RF bond for the 404MT759 transducer per general note 2 of drawing 1B69493 was 0.0038 ohms; should have been 0.0025 ohms maximum.	Material was removed from the 404A74 panel inserts which allowed the transducer to mount flush against the panel. The reworked area was brush alodined per DPS 41410 and the transducer was reinstalled per drawing 1B69493.
500-026-383 3-28-68	During the DDAS checkout per H&CO 1B55817, the fuel pump inlet pressure transducer, P/N 1B40242-579, S/N 579-2, mounting 403MT670, the indicated output at ambient was 0 and should have been approximately 1.25 vdc, low calibration was 0 vdc; should have been 1.0 ±0.1 vdc, and high calibration was 0 vdc; should have been 4.0 ±0.1 vdc.	The transducer and amplifier were removed and replaced.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-026-391 3-29-68	During the DDAS checkout per H&CO 1B55817, the cold helium sphere pressure transducer, P/N 1B40242-583, S/N 583-20, 425MT601, indicated that once a calibration was sent, then removed, the output would not return to the original value until the input power was cycled. The low calibration value after being cycled once was 1.9 vdc; should have been 1.000 ±0.100 vdc.	The transducer and amplifier were removed and replaced.
500-026-405 4-1-68	During rework per drawing 1B41181 G, Zone 10, the 409MT649A transducer mounting hole spacing was 2.406 inches; should have been 2.037 inches.	The aft mounting hole was used as a starting point and a 0.190 to 0.195 inch hole was drilled at the forward end. The mislocated hole was left open and accepted by the Material Review Board.
500-026-430 4-3-68	a. Connector P21, of the 404A64W200 harness, P/N 1B66645-1, had a damaged insert, also socket G was damaged.	a. The connector and the socket were removed and replaced.
	b. Pin G of the 404A64A221 J2 module, P/N 1B63306-505, S/N 0180, was bent.	b. The pin was straightened per DPS 54002 and the unit was retested during H&CO 1B55817.
500-026-448 4-3-68	During installation of the nonpropulsive vent (NPV) per drawing 1B69606, view E, zone 26, two holes 0.191 to 0.194 inches were mislocated through stringer 19 and 19-1/4 and tee, P/N 1B69606-5. On resubmit, four 0.255 to 0.264 inch holes were mislocated through the duct, P/N 1B69219-1 and support P/N 1B69891-1, also the 5.56 ±0.03 dimension was 5.75 inches. Refer to drawing 1B69013, zone 15, view H and zone 10, view B-B respectively.	The fitting, P/N 1B69903-1, support, P/N 1B75097-1, tee assemblies (2), P/N 1B69606-5 and associated hardware were removed. Stringer 19-1/4 was trimmed, a doubler was fabbed and placed over the mislocated holes with the reworked fittings. The tees were replaced and the rework was clamped and submitted to engineering. On resubmit, the duct, P/N 1B69219-1 was removed, welded per

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-026-448 (Cont.)		DPS 14000 and passivated per DPS 41003. The duct was reinstalled using bracket, P/N 1B69891-1 as a guide. The doubler was attached with 4BJ5 rivets and the 5.75 inch holes were accepted by the Material Review Board.
500-026-456 4-9-68	During rework per AO 1B74873-1 B, the 403W5 harness, P/N 1B74873-1, had six damaged areas in the insulation of one wire and two areas of another from 1/2 to 1-1/2 inches in length between the customer disconnect panel and the LOX tank attaching point to the thrust structure.	The damaged insulation was repaired per DPS 54010 and proper size clamps were installed.
500-026-464 4-9-68	During installation, it was noted that the 403A72-A1 hydraulic actuator, P/N 1A66248-507, S/N 71, had two nicks (1/16 x 1/32 inches in length) at the aft end of the shaft; also, the lock assembly mating halves had burred edges.	The nicks and burred edges were smoothed up and the assembly was accepted for use by the Material Review Board.
500-026-481 4-15-68	During preliminary propulsion leak and functional checks, it was noted that the 403A74A3 LOX repressurization module check valve, P/N 1B51361-501, S/N 413, had a reverse seat leakage of 51 scims at 1450 psig; should have been 10 scim maximum per H&CO 1B71877, paragraph 4.7.6, item 6.	The check valve was removed and replaced with, P/N 1B67598-503, per WRO 3992.
500-026-855 6-18-68	During rework per WRO 4377 Job 1, the following conditions were noted:	

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-026-855 (Cont.)	a. Five clamps which supported three 1/4 inch pipe assemblies adjacent to the LOX vent line forward of the aft dome, were loose.	a. The mounting hardware was tightened per drawing requirements.
	b. Weld seams No. 5, 7, and 9 of the LOX tank forward dome had pitted circular areas 1/8 to 1/4 inch diameter by 1/16 inch in depth.	b. The pitted areas were accepted by the Material Review Board.
	c. The LOX tank sump flange inner surface had four areas with scratches approximately 5/8 inch by 3/4 inch by 0.005 inches in depth.	c. The scratches were blended in with 400 mesh cloth. The reworked surfaces were realodined and wiped clean with freon.
	d. The LOX tank probe support, P/N 1B31596-503, had a dent approximately 1/4 inch deep tapering to the original contour over a 2-1/2 inch area.	d. The dent was straightened and the support was accepted by the Material Review Board.
	e. On the lower flange of the LOX tank probe support, P/N 1B31596-503, a small amount of teflon shavings and alodine flakes were noted.	e. The area was cleaned per DPS 43110 and wiped down with freon.
	f. Small pieces of foreign material were found at the childown pump and the wire harness feedthrough openings.	f. The foreign material was removed from the noted openings.
	g. The ends of six huck bolts at the thrust structure attach ring were discolored.	g. & h. The discolored huck bolt ends and the LOX tank, without a positive purge, were accepted by the Material Review Board.
	h. The LOX tank was without a positive purge from 15 to 30 minutes.	

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-026-855 (Cont.)	i. A small piece of paper was found under the support bracket and a speck of green paint was noted adjacent to a nutplate of the diffuser screen assembly, P/N 1B55445-1.	i. The paper and speck of paint were removed.
	j. The diffuser screens, P/N 1B55445-1, S/N's 00023 and 00024, had discoloration on the inside half of the joining point and seven weld spots.	j. The discoloration was cleaned per DPS 43000.
	k. Fairing, P/N 1B63932-1, had deep gouges at the bolt holes.	k. The gouges were smoothed up with DPM 3296 cloth.
	l. Safety wire was improperly installed on the diffuser screen assembly, P/N 1B55445-1, S/N 00023, as follows: 1. Refer to zones 5 and 6, section EE, the safety wire was too tight between two nuts and nine nuts were not safety wired. 2. Reference zone 10, view HH, the safety wire was loose between two nuts on the outer edge of the assembly. 3. Reference zones 9-12, bolts over the maximum 6 inch spacing were safetied together. 4. The assembly had numerous nicks on the safety wire, excessive pigtail lengths and improper severed ends. 5. The screen and associated hardware was not maintained clean.	l. & m. The noted areas were safety wired per 1B55445 and DPS 13300, cleaned per DPS 43000 and the screen assemblies reinstalled on the stage.

TABLE I (Continued)

FARR NO.		DESCRIPTION OF DEFECTS		DISPOSITION
500-026-855 (Cont.)	m.	Safety wire was improperly installed on the diffuser screen assembly, P/N 1B55445-1, S/N 00024 as follows: 1. Refer to zones 5 and 6, section EE, safety wire was missing in three places, a 1-1/2 inch piece of safety wire was caught in the twists of the safety wire, and the safety wire was broken and loose in two places. 2. Refer to zones 9-12, bolts over the maximum 6 inch spacing were safetied together. 3. The assembly had numerous nicks on existing safety wire, excessive pigtail lengths, and improper severed ends were noted. 4. The screen and associated hardware was not maintained clean per DPS 43000.		
	n.	The internal non-sealing surface of the conoseal at the LOX tank sump, P/N 1B69037-1, S/N 7, was distorted.	n.	The conoseal was acceptable for use by the Material Review Board.
	o.	The LOX tank sump, P/N 1B69037-1, S/N 7, was gouged and scratched in five places. The deepest defect was approximately 0.004 inches. The sump was not maintained clean when removed from the stage.	o.	The raised portions were polished. The scratches and gouges were smoothed out with DPM 3296 cloth. The sump was alodined, cleaned per DPS 43000, and reinstalled on the stage.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-026-952 6-20-68	During VFR inspection, it was noted that the duct assembly, P/N 1A87755-501, had been dinged in two places approximately in the center of the 90 degree bend. The dings were 2 inches by 1 inch by 0.070 inch and 1 inch by 3/4 inch by 0.050 inch.	The noted dings were accepted by the Material Review Board.
500-026-961 6-20-68	a. During installation of the instrumentation probe, P/N 1A69275-509, S/N 05, scratches were noted approximately 12 inches from the forward end in a 2 inch area and extending from the aft end forward for approximately 24 inches by 2 inches in width.	a. The scratches were removed and the reworked area was alodined per DPS 41410. The probe was cleaned per DPS 43000-1 and the connectors were cleaned with cloths dampened with freon.
	b. The feedthrough flange and neck area had scratches and pieces of foreign material.	b. The scratches were removed and the reworked area was alodined per DPS 41410. The area was wiped clean with cloths dampened with freon PCA.
500-081-538 4-9-68	The oxidizer nonpropulsive vent duct (NPV), P/N 1B69236-1, had a small slag hole approximately 3/32 inch long by 1/16 inch wide by 0.30 inch deep. On resubmit the NPV was noted to have numerous scratches and gouges.	The NPV duct was removed from the stage sent to the machine shop, the hole was drilled out and welded per DPS 14120, routed to LOX service for cleaning, and proof and leak tested per 1A69236-1. The scratches and gouges were reworked and alodined per DPS 41410. The NPV was reinstalled on the stage per 1B69013.
500-223-880 2-7-68	During rework per AO 1A98308 the external tunnel cover, P/N 1A98308-509, had the following discrepancies: Refer to 1A98308, zone 4.	All noted discrepancies were accepted by the Material Review Board for use.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-223-880 (Cont.)	a. The 0.750 inch diameter slotted holes were 0.930 inch; should have been 0.098 inch. b. The rivet holes were plugged and redrilled without authorization. c. The -75 channel had deep set marks after being reworked and the radius at the ends of the slots were not per drawing. d. The flange of the -91 doublers did not nest against the side of the slotted holes and the radius at the end of the slots were not per drawing. NOTE: The above conditions were found when submitted to inspection for acceptance.	
500-225-513 6-20-68	While accomplishing AO 1A39300-511, the purge air conditioner was turned on with split vinyl tubing attached to the LOX tank dessicant connection. The air, which flowed through the LOX vent valve and out the instrumentation probe port, was not sampled.	The condition was referred to Material Methods Research Evaluation (MM-RE), for analysis and was acceptable per DPS 43110.
500-225-521 6-21-68	The bracket, P/N 1B33155-1, had a blind nut consisting of a sleeve, P/N BN330-428-1, an expander, P/N BB341-12, which was loose and rotated due to an oversize hole in the bracket assembly.	The bracket, P/N 1B33155-1, was removed and replaced. The rivet pattern was relocated 1/4 inch outboard to clear the radius of the box assembly, P/N 1B33155-1, and a new sleeve and expander was installed per 1B33777.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-225-530 6-21-68	The 403MT770 transducer kit, P/N 1B40242-609, S/N 609-11, measurement No. D0231 was out-of-tolerance per 1B66651-1 as follows: a. Low calibration was 1.481 vdc; should have been 1.000 ±0.100 vdc. b. High calibration was 5.122 vdc; should have been 4.000 ±0.100 vdc. c. Ambient was 69.693 psia; should have been 14.700 ±10 psia.	The transducer kit was removed and replaced.
500-225-572 6-27-68	During performance of the integrated systems test, channel M061 was found to exceed the specified tolerance of 0.0 +1.00 vdc. Output of the channel was 1.088 vdc. Conditions at the time of the malfunction were: the 309 kit, P/N 1A57871-1, was installed and the PCM transmitter was on and operating in the open loop mode. This parameter (M016) was within procedural specifications when the kit was removed and the fiberglass firing cover was installed.	The condition was acceptable for test run 1316. On resubmit after test run 1316, the condition was accepted for use by the Material Review Board.
500-225-599 6-27-68	During the flow check of the O_2H_2 burner LOX shutdown valve bellows per 1B70422, paragraph 4.22.3, the flow from restrictor, P/N 1B40622-509, S/N 1011, was 240 scims; should have been 300 ±25 scims per 1A94846-A45-31E.	The condition was acceptable for test run 1316. After test run 1316 the restrictor was cleaned per DPS 43100 PEOA45L and flow tested to 300 ±25 scims.
500-225-602 6-29-68	During performance of the integrated systems test, the 403A16 and 403A17 igniter spark	The igniters were removed and replaced.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-225-602 (Cont.)	exciters, P/N 1B59986-507 AF, S/N's 068 and 069, were energized for 8 minutes, 51 seconds per the digital event recorder tape. Should not have been more than 5 seconds on, then, cycled off for 5 minutes before re-energizing.	
500-225-629 7-3-68	During the performance of 1B55823 H, issues No. 1 and 2, the PU electronics assembly, P/N 1A59358-529 BN, S/N 031, boiloff bias signal M10 took four passes before the parameter passed. The readings were as follows: Issue 1; 14.129, 14.063, 14.149, and 13.610 vdc. Issue 2; 14.149, 14.021, 14.129, and 13.910 vdc. One attempt was made for issue 3 which was 13.8 vdc. The tolerance was 12 + 2 - 0 vdc.	The condition was acceptable for test run 1316 and resubmitted after test run. The measurement was acceptable to the Material Review Board for use.
500-225-718 7-12-68	During performance of cold flow TR1316 the 403A73A1 pneumatic power control module, P/N 1A58345-523, S/N 1047, failed to properly regulate. The pressure was locked up at 565 psia and gradually increased to 590 psia, then, to pressure switch pick up. The purge was reinitiated to maintain normal outlet pressure for the duration of the cold flow.	The module was removed and replaced.
500-225-726 7-12-68	During the performance of task 6 of the TR1316 cold flow, the hydraulic pump vent plug, P/N 1B27980-1, was noted to have the -5 filler broken off.	The vent plug was removed and replaced.
500-225-734 7-12-68	During performance of task 6 of the TR1316 cold flow, the hydraulic pump vent plug, P/N 1B27980-501, was noted to have the -5 filler broken off.	The vent plug was removed and replaced.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-225-742 7-12-68	Data from the TR1316 cold flow revealed that the 403MT750 LH_2 chilldown pump differential pressure transducer, P/N 1B53574-503, S/N 503-1, measurement No. D218, had a positive 2.5 psid shift while subjected to cryogenic temperatures with no pressure change present. Under ambient conditions the transducer indicated a proper reading.	The 1B53574-503 transducer kit was removed and replaced.
500-226-773 6-4-68	During installation per 1B62602 zone 11, view EE, it was noted that the 403MT792 temperature probe port was 120 degrees out of position on the dome of the O_2H_2 burner, P/N 1B62600-509-009, S/N 013.	The noted part was capped with cap, P/N MC224C6. This port was accepted by the Material Review Board. The port was relocated and a boss was installed per 1B62600 AB, 1B62602 V and W, 1B59968 AL and 1B62600-013.
500-226-790 6-4-68	During the engineering run of DDAS 1B55817, it was noted that the cold helium sphere pressure transducer, P/N 1B40242-583, S/N 583-18, measurement No. D016 had out-of-tolerance readings as follows: a. High calibration was 4.117 vdc; should have been 4.000 $\pm$0.100 vdc. b. Low calibration was 1.040 vdc; should have been 1.000 $\pm$0.100 vdc. c. Ambient was 720.780 psia; should have been 14.700 $\pm$ 70.000 psia.	The transducer kit, P/N 1B40242-583, S/N 583-16, was removed and replaced.
500-226-811 6-5-68	The pipe assembly, P/N 1B74502-1, was fabricated 3/8 inch too long on the O_2H_2 burner assembly.	The pipe assembly was cut, reflared, cleaned, and tested per 1B74502-1.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-226-854 6-6-68	During performance of leak checks per 1B71877, it was noted that inserts, P/N SPLD258, were missing as follows: a. Four inserts were missing between fin lines I and IV at the nonpropulsive vent adapter, P/N 1B59264. b. One insert was missing between fin line II and III at the nonpropulsive vent adapter, P/N 1B59264.	Inserts were installed per 1B59264 and 1A94845.
500-226-871 6-11-68	During the engineering run of 1B55817, it was noted that the cold helium sphere pressure transducer, P/N 1B40242-583, S/N 583-20, measurement No. D016, had out-of-tolerance readings as follows: a. Ambient was 720.781 psia; should have been 14.700 $\pm$70.000 psia. b. High calibration was 4.005 vdc; should have been 4.000 $\pm$0.100 vdc. c. Low calibration was 1.025 vdc; should have been 1.000 $\pm$0.100 vdc.	The transducer kit, P/N 1B40242-583, S/N 583-20, was removed and replaced.
500-226-897 6-12-68	During modification of the J2 engine, the wire harness 404W7-P41, P/N 1B74463 C, at the 401A11S2J1 and approximately 3 feet forward of connector P41, had a sharp bend; also, the harness was nicked two places on two 20 gauge teflon insulated wires.	The insulation on noted wires were repaired per DPS 54010, paragraph 6.2.5 with DPM 2766 tape.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-226-919 6-15-68	During normal checkout, it was noted that the 4013MTP5 GH_2 start tank bottle pressure transducer, P/N NA5-27412-T15T, S/N 5961A, measurement No. D017, had out-of-tolerance readings as follows: a. Ambient was 58.0 psia; should have been 14.700 ±30.0 psia. b. High calibration was 4.165 vdc; should have been 4.030 ±0.050 vdc. c. Low calibration was 1.187 vdc; should have been 1.030 ±0.050 vdc.	The transducer was removed and replaced.
500-226-927 6-17-68	During DDAS checkout, it was noted that the fuel pump inlet pressure transducer, P/N 1B40242-579, S/N 579-4, measurement No. D002, was out-of-tolerance. The high calibration was 3.814 vdc; should have been 4.000 ±0.100 vdc. On resubmit at the calibration lab. the high calibration was 4.609 vdc; should have been 4.85 ±0.10 vdc per 1B70338G, paragraph 7.6.1.	The transducer was removed and replaced.
500-226-943 6-17-68	During rework, per WRO 4377 Job 1, it was noted that the LOX duct, P/N 1A87740-1, had the following discrepancies: a. The duct was not identified with a part number. b. Rust colored residue on and around the welds and convolutions.	The duct assembly was identified per 1A87740. The residue was removed and the welds were passivated with DPM 1571. The residue on the center convolutions was acceptable to the Material Review Board.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-226-986 6-19-68	During rework per 1B58009, the LH_2 repressurization module, P/N 1B69550-1, S/N 023, had a check valve, P/N 1B67598-501, installed; should have been, P/N 1B67598-503.	The check valve, P/N 1B67598-501, was removed and P/N 1B67598-503 was installed, and leak tested per 1B70175.
500-226-994 6-18-68	During inspection per 1A49553, the propellant utilization probe, P/N 1A48430-511, S/N 02, had discrepancies as follows:	
	a. The coupling flange was scratched in three places on the external edge. b. A scratch approximately 1-1/2 inches long, 18 inches from forward end of probe and a scratch 9 inches from the forward end extending to 16 inches aft.	a. and b. The scratches were re-alodined per DPS 41410 and was accepted by the Material Review Board.
	c. The pins of the probe receptacle were slightly bent.	c. The receptacle was mated with a proper connector, continuity was checked and the receptacle was accepted by the Material Review Board
500-227-001 6-18-68	During inspection per 1B71971, the instrumentation probe, P/N 1A69275-509 P, S/N 05, had numerous scratches over the entire length of the probe cover. The scratches were deep enough to remove the alodine and sharp enough to catch a gloved hand. During rework of the scratches, it was noted the insulation on the wires terminating to connector, S/N 1260, pins 1, 4, 8, 10, 11, 16 and 18 and connector, S/N 1146, were cut through the insulation.	The scratches were polished out using DPM 3296 and re-alodined per DPS 41410. The cut insulation was repaired per DPS 54010 and tested per applicable portions of 1B363247A.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-372-010 7-15-68	During propellant loading exercise TR1316, the chilldown pump purge flow restrictor, P/N 1B40622-513, S/N 298, consisting of a -3 and -5 restrictor, would not maintain a minimum of 41.25 psia chilldown cannister pressure with a regulated pressure between 500 and 510 psia.	The restrictor was removed and replaced.
500-372-028 7-15-68	While submerged in LH_2, during cold flow TR 1316, it was noted that the LH_2 level control sensor, P/N 1A68710-509, S/N C29, measurement no. L019, cycled to a dry indication; should have remained in a wet indication. The unit was checked per 1B44473D and was noted to drift in an increasing direction.	The sensor was removed and replaced.
500-372-036 7-15-68	During the strip chart monitoring of measurement D0577, the 403MT724 LOX tank ullage pressure transducer, P/N 1B43324-601, S/N 48-6, had an indication of 19.5 to 21 psia with an applied pressure of 25 psia. This was an approximate 3 per cent noise level and when the self check relay was set for the parameter the noise did not exist.	The transducer was removed and replaced.
500-372-044 7-15-68	During the critical components section of TR 1316, the LOX pressurization module, P/N 1B42290-507, S/N 0024, had a pressure spike to 310 psia for 3 seconds then dropped to 230 psia and back to 320 psia in 10 seconds. It should have maintained a regulated pressure of 385 $\pm$ 25 psig.	The module was removed and replaced.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-372-052 7-15-68	During the performance of leak checks, it was noted that the 425MT601 cold helium sphere pressure transducer, P/N 1B40242-583, S/N 583-29, measurement No. D016, was out-of-tolerance. The high calibration was 4.194 vdc; should have been 4.000 ±0.100 vdc. The low calibration was 1.179 vdc; should have been 1.000 ±0.100 vdc. During leak checks the transducer was pressurized to 1041 psia and the panel meter was reading 890 psig while the vehicle monitor panel was reading 900 psig. At 106 psia the panel meter and vehicle monitor panel meters were 0 psig.	The transducer kit was removed and replaced.
500-026-472 4-10-68	During the preliminary propulsion leak and functional check, a small fuzz leak was noted at the LOX dome purge inlet of the J-2 engine.	The leak was acceptably repaired by rewelding the pipe assembly.

TABLE II. FAILURE AND REJECTION REPORTS
FORMAL COUNTDOWN INITIATION AND ABBREVIATED POSTFIRE CHECKS

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-372-079 7-18-68	During the postfire leak check, it was noted that the cold helium dump valve, P/N 1B57781-507, S/N 0040, had 11,000 scims leakage at 900 psig. No leakage was allowed per 1B70175.	The valve was removed and replaced.
500-372-087 7-18-68	During task 50 of countdown 1B71945, it was noted that the J2 engine, P/N 103826, S/N J201, had a braze void between tubes 309 and 311, 17 inches aft of the throat.	The engine was leak checked per Rocketdyne Manual R3825-3, Figure 2-Z, Volume II, which revealed there was sufficient braze between the subject tubes, also no voids existed.
500-372-109 7-18-68	The ablative coating (Korotherm) was blistered, peeled and cracked in numerous areas at the 426 and 427 areas.	The Korotherm, at the discrepant areas was removed per DPS 42105 and replaced per DPS 42210.
500-372-125 7-23-68	During the static firing, the continuous vent valve, P/N 1B66639-501, S/N 011, opening time was 0.069 seconds during the critical components section. Prior to the first burner firing it was commanded to open and took 2.234 seconds which is within the tolerance of 1B66639 but considered excessive by engineering.	The valve was removed and replaced.
500-372-150 7-26-68	During task 41, sequence 56 of countdown 1B71945, it was noted that the 403A73A1 pneumatic control module, P/N 1A58345-523, S/N 1071, would not maintain a regulator pressure of 540 psia.	The module was removed and replaced.

TABLE II (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-372-168 7-24-68	During TR 1316, it was noted that the main fuel valve position indicator, P/N NA5-27285, S/N 5K376, measurement G506, showed the close to open correctly but a 15 per cent downward noise for 3 seconds was noted.	The unit was removed and replaced.
500-372-176 7-26-68	During performance of 1B55831G, it was noted that the LH_2 feedthrough receptacle 410A1J6 coaxial contact No. 11, P/N 4703-14-0024, had a piece of foreign material imbedded in the adjacent teflon sleeve. The depth check of the contact was 0.047 inch; should have been 0.050 inch minimum per DPS 54002-10.	The contact and sleeve assemblies were removed and replaced per DPS 54002-10. The assembly was tested per 1B63248.
500-372-184 7-26-68	During static firing 1B71945, TR 1316, data review revealed the existence of a positive voltage spike on the switch selector output monitor signal measurement M539, when a non-programmed stage cutoff was turned off.	The condition was acceptable by the Material Review Board.
500-372-206 7-31-68	During postfire leak check per 1B70175, it was noted that the forward section of the LH_2 low pressure duct, P/N 1A49320, S/N 37, was 1000 + microns; should have been less than 250 microns. NOTE: Moisture was present inside the duct assembly.	The shutoff valve was inspected for seat damage and found to have minute scratches on the sealing face. The duct was pumped down and readings were verified and recorded. After the thirteenth resubmit, the duct read 100 microns and was accepted by the Material Review Board.

TABLE II (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-372-214 7-23-68	During performance per countdown 1B71945, TR 1316, it was noted that the 425MT601 cold helium pressure transducer, P/N 1B40242-583, S/N 583-42, measurement No. D0016, was sensitive to approximately -60°F. The actual temperature during TR 1316 was less than -200°F.	The transducer was removed and replaced with 403MT643, measurement no. D0263 per 1A81844-517 AB.
500-372-231 8-1-68	During the performance of 1B39612, it was noted that bolt, P/N 1B49496-1, aft of stringer 68 was sheared when raising the stage from the test stand. NOTE: No apparent damage was visible to the stage.	The area was radiograph inspected per DPS 15200 which revealed no discontinuities and was acceptable by the Material Review Board.
500-372-133 7-23-68	During the integrated system test, it was noted that pin C of transducer, P/N 1B31356-505, S/N 17-1, indicated 30 ohms to ground; should have been infinity.	The discrepant transducer, S/N 17-1, was removed. Replacement transducer, S/N 22-3, was installed and acceptable tested.

TABLE III. FAILURE AND REJECTION REPORTS DEFERRED POSTFIRE CHECKOUT

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A261722 11-13-68	During rework per 1B67418 J and K, the 404A71 APS control panel, P/N 1B67418-1, had a misdrilled hole. Hole M was drilled 0.38 inch from the edge; should have been 0.279 to 0.289 inch. The hole was also elongated diagonally from its centerline to 0.300 inch.	The hole was acceptable for use by the Material Review Board.
A270640 8-5-68	The pipe assembly, P/N 1B66772-1, attached to the 403A73A1 module, P/N 1A58345-523, did not meet the cleanliness requirements per DPS 43100. Also pipe assemblies, P/N's 1B67225-1, 1B65099-1, and 1B66773-1, did not meet the cleanliness requirements per DPS 43100.	The pipe assemblies were removed, sent to the LOX lab., flushed, sampled, cleaned reinstalled on the stage, and leak checked per 1B71877.
A270645 8-9-68	Per record of discussion ROD 661, it was suspected that the pneumatic check valve, P/N 1B67598-501, S/N 16, was made from 300 series stainless steel; should have been type 286.	The part was returned to the vendor for replacement.
500-081-520 10-28-68	The pipe assembly, P/N 1B74265-1, was approximately 1/2 inch too long between two 90 degree turns. Refer to 1B69013 N/C, zone 34, view V-V.	The pipe assembly was removed and replaced.
500-225-874 8-2-68	During line check 48, the plate assembly, P/N 1B59265-1, and adapter, P/N 1B59264-1, were not installed between stringers 101-102 and 47-48 in the forward skirt. Refer to 1A39322, zone 11, view AC-AC.	The plate and adapter orientation was not critical and was accepted by the Material Review Board.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSTION
500-225-939 10-24-68	During performance of 1B49196, it was noted that the LH_2 low pressure duct, P/N 1A49320 -515, S/N 13R, had no reading of vacuum. The duct should have had a reading of 250 microns or less.	The probe was removed and replaced. The duct was pumped down for 24 hours to a reading of 13 microns, then, locked up for 5 days. The duct was checked with a reading of 18 microns at the end of the fifth day.
500-372-222 8-2-68	During performance of H&CO 1B55831, it was noted that the 403MT749 transducer, P/N 1B31356-505, S/N 17-1, measurement D0209, read 300 ohms at pin C to ground; should have been an infinite resistance.	The transducer was removed and replaced.
500-372-451 10-17-68	During rework per 1A39295-026 B, it was noted that the hole pattern for locating doubler, P/N 1A39295-026-3, was approximately 7-1/2 inches from the lower edge of the frame at station 240.937; should have been 8.29 $\pm$0.12 inches from the edge of the frame.	The mislocated doubler was removed and replaced per Material Review Board instructions.
500-372-460 10-18-68	During the performance of 1B74873, it was noted that two helium heater support brackets, P/N 1B64183-1, had indications of rust like discoloration at stringers 10 and 11A. Refer to drawing 1B62679, zone 5, view A and B.	The condition is normal when welding stainless steel and was accpetable to the Material Review Board.
500-372-494 10-29-68	During inspection per WRO S4B4495, the following discrepancies were noted:	
	a. Pipe assembly, P/N 1B69999-1, was contacting pipe assembly, P/N 1B74201, in the 403 area at stiffener 17A.	a. The clamp was rotated to prevent the interference condition.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-372-494 10-29-68 (Cont.)	b. Pipe assembly, P/N 1B67696-1, revealed a preload condition in the 403 area between stiffeners 23A and 23-3/4.	b. The pipe assembly was removed and replaced.
	c. Fuel duct, P/N 1A49320-515, S/N 13R, had two indentations, one was 1.60 inches diameter by 0.12 inch in depth, and the second was 0.40 inch long by 0.90 inch wide by 0.27 inch deep at the thrust structure on stiffener 21A.	c. through h. The conditions were accept- by the Material Review Board.
	d. The bellows section of duct, P/N 1A49320-515, S/N 13R, had an indentation 0.110 inch long by 0.06 inch wide by 0.015 inch deep, and the face of the bellows had been distorted 0.20 x 0.30 x 0.015 inch from a previous indentation at the feedthrough of the thrust structure at stiffener 21A.	
	e. LOX return line, P/N 1A87736-1, had an indentation 0.32 inch long by 0.025 inch in width by 0.005 to 0.010 inch in depth at the thrust structure on stiffener 2, 9-3/4 inches aft of the forward thrust structure attach bracket.	
	f. The exterior cover of the flex hoses in pipe assemblies, P/N 1B64112-1 and 1B52566-1, revealed signs of distortion at the 404 umbilical area.	
	g. The weld joints of duct assembly, P/N 1B59005-501, revealed no indication of passivation at the O_2H_2 burner assembly.	

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-372-494 (Cont.)	h. Duct assembly, P/N 1B59009-503, had a ding 0.300 inch long by 0.200 inch wide by 0.010 inch deep in the 403 area at stiffener 10, 5-1/2 inches forward of the junction between the duct and the O_2H_2 burner.	
	i. The teflon tape wrapping of pipe assembly, P/N 1B67466-1, was damaged at the main tunnel two feet forward of station 556.	i. The teflon tape was removed and replaced.
	j. The teflon tape wrapping of pipe assemblies, P/N 1B74790-1, and 1B67609-1, was damaged at the auxiliary tunnel two feet forward of station 556.	j. The pipe assemblies were deleted by 1B58006 BK.
	k. Bellows assembly, P/N 1A49986-1, S/N 6362-007, had a series of dings in the first convolution ridge, approximately 0.020 inch deep behind and under the bellows in the forward interstage between the bi-directional control valve and the vent and relief valve.	k. The bellows assembly was removed and replaced.
500-372-508 10-25-68	The feedthrough assembly, P/N 1B42292-501, S/N D00006, had an illegible part number.	The part number was electro-chemical etched on the assembly opposite the vendor part number.
500-373-245 10-25-68	During rework per 1B39550 BL and BW, it was noted that the mounting assembly, P/N 1B39550-531, S/N 011, had dark brown discoloration under the potted modules; also, at the metal to metal installations.	The faying surfaces were inspected for pitting and pile up. The inspection revealed no such discrepancy and the assembly was accepted by the Material Review Board.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-372-253 10-27-68	During installation per 1B58009 F, it was noted that the electrical resistance checkout of the L1 module of the repressurization control module assembly, P/N 1B69550-501, S/N 029, was 0.0028 ohms, the L2 module was 0.0030 ohms, and L3 module was 0.0030 ohms. The reading should have been less than 0.0025 ohms per 1B69950, general note 8.	The shim between the modules was cleaned of all paint and primer. A recheck was made and the resistance value obtained was 0.0012 ohms for all modules.
500-373-521 12-2-68	During rework per 1B44389 AN, the panel assembly, P/N 1B39550-531 BK, S/N 011, had the 0.248 to 0.258 inch holes located 1.625 inches from the edge of the panel; should have been 1.625 inches from centerline of the two holes located 0.44 inch from the edge of the panel.	The mislocated holes were filled. New holes were drilled per 1B44389, zone 8, view M.
500-488-018 10-27-68	During installation per 1B58009 F, it was noted that the repressurization control module assembly, P/N 1B69550-501, S/N 023, electrical resistance checkout of the L1 module was 0.0030 ohms, the L2 module was 0.0032 ohms, and the L3 module was 0.0034 ohms. The reading should have been less than 0.0025 ohms per 1B69950, general note 8.	The shim between the modules was cleaned of all paint and primer. A recheck was made with the resistance value of 0.0014 ohms or less for all modules.
500-488-026 10-26-68	During performance of 1A39316 DW, zone 4, the forward most hole at the 50-1/4 inch dimension on stringer 23, was out-of-round and drilled off center. NOTE: The hole was used for a grounding strap attachment.	The hole was acceptable to the Material Review Board.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-488-042 11-8-68	During the performance of 1B67212, it was noted that the pipe assemblies, P/N 1B62600 -5 AC and P/N 1B62600-9 AC, were out of alignment with the ports in the manifold, P/N 1B65008-1. The manifold is a part of the pneumatic latching actuator, P/N 1B66639-515, on the O_2H_2 burner.	The pipe assemblies were removed and replaced.
500-488-051 11-8-68	During the performance of 1A39310 AG, it was noted that the aft tunnel equipment assembly, P/N 1B50984-1, had a 3/4 inch long crack at the panel radius 15 inches from the aft end of the main tunnel; also, the metal plate was debonded at the forward corner.	The panel assembly was removed and replaced.
500-488-093 11-18-68	During rework per 1B74943 NEW, it was noted that the mating surface between the LH_2 relief valve, P/N 1B74535-1, S/N 0009, and duct assembly, P/N 1B74940-1, had a leak rate decrease from 25 to 7.5 psig in 15 min. The leak rate should have been less than 1.0 psig in 15 minutes.	The valve was removed and replaced.
500-488-107 11-21-68	During performance of 1B69018 A45-5, it was noted that wire harness, P/N 1B69018-1, S/N 00004, at the 404A3 panel had discrepancies as follows:	
	a. Wire F113A20 had a cut through the insulation 3 inches from the P14 connector.	a. through e. The damaged wires were removed and replaced.
	b. Wire F604A20 had a cut through the insulation 1/2 inch from the P53 connector.	

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-488-107 (Cont.)	c. Wire K613H20 was pinched 3 inches from the P44 connector. d. Wire F4037C20 had a nick 6 inches from the P46 connector. e. Wire F639A20 had two nicks 3 inches from the P30 connector.	
500-488-301 11-18-68	During handling per 1B42499 R, it was noted that the LOX instrumentation probe, P/N 1A69275-509, S/N 05, had scratches and burrs through the alodine on the probe covers.	The loose burrs were removed and the scratched areas were treated with alodine 1200.
500-488-310 11-19-68	During rework per FO 6711506, it was noted that the LH_2 tank pressure module, P/N 1B66230-509, S/N 1054, had scratches on the inlet and outlet seating surfaces at the 403A73 panel.	The module was removed and replaced.
500-489-022 10-30-68	The fuel vent and relief valve, P/N 1A48257 -521-007, S/N 0070, an interum use part, was resubmitted to the Material Review Board after static firing.	The part was removed and sent to the LOX lab. for vendor rework and test per 1A48257 -007 A and DCRSED 1A48257 A45-2. The part was identified as 1A48257-525, leak checked per 1B71877 and tested per 1B62753.
500-489-031 11-1-68	During rework per 1B44389 AK, it was noted that the 404A3A37 module, P/N 1B39975-501, S/N 0284, had the forward right corner 1/2 inch by 1/8 inch by 1/16 inch deep ground away.	The damaged area was brush coated with fungicide varnish DPM 499.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-489-049 11-2-68	During surveillance inspection, it was noted that the support standoff, P/N 1B27889-529, which supported wire harnesses 404W6 and 404W208, had a portion broken off adjacent to the insert in the aft interstage at stringer 13.	The harnesses were supported on the remaining leg of the standoff.
500-489-065 11-7-68	During line check 88-45 per 1B62600, zone 42, view P, and DPS 13350, paragraph 6.9, it was noted that the O_2H_2 burner, P/N 1B62600-529 -009C-012B AK, S/N 013, had improper hardware installed at the nozzle installation.	One bolt was removed at a time and new hardware was installed as follows: Four NAS 1004-10A bolts, four MS 20500-428 nuts and eight 1041 washers.
500-489-073 11-6-68	During performance of 1B74633 C, it was noted that wire M243A22 of the 404W7 wire harness, P/N 1B74463-1, was cut through to the conductor and several strands were severed in the 404 area adjacent to stringer 34.	The wire was removed, replaced, and tested per 1B74463.
500-489-081 11-6-68	During surveillance inspection, it was noted that the isolators, P/N 1B32258-1, S/N's 257 and 302, were debonded in the aft interstage at stringers 42 and 50.	The isolators were removed and replaced.
500-489-103 11-8-68	During installation, it was noted that bracket, P/N 1B75295-6, would not properly fit the next assembly at stringer 12 in the 411 area per 1B75295 B, zone 2, view AA.	Shim spacers were added per 1B75295 A45-2.
500-489-111 11-8-68	During performance of 1A81844, it was noted that the 425MT602C cable assembly, P/N 1B40242-99, S/N 583-16, had 1/8 inch wide by 1/4 inch diameter insulation cut exposing shield strands at the second standoff forward of stiffener 13-1/4 on the aft LOX dome.	The cable was repaired per DPS 54010, section 6.2.5, and continuity and megger checked per 1B40242.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-489-120 11-9-68	During performance of 1B51379 BD, it was noted that pin t of the J1 receptacle on the power transfer 300 ampere switch, P/N 1A68085-505, S/N 0097, was recessed and bent, also pin y was bent at the 411A99A10 panel.	The unit was removed and replaced.
500-489-146 11-7-68	During rework per 1B67271 L, it was noted that connector, P/N S0286E22-55S, on the wire harness, P/N 1B67271-1, had a damaged insert adjacent to pin T at the 404A2A21 module.	The connector was removed and replaced.
500-489-171 11-11-68	a. During performance of 1A81845 P, it was noted that the 405MT605 transducer, P/N 1A67863-503, S/N 863, was dinged and scarred. b. The 405MT612 transducer, P/N 1A67863 -503, S/N 915, had two dings at the outer edge of the sealing surface.	a. and b. The transducers were removed and replaced.
500-489-189 11-11-68	During performance of 1A81845 P, it was noted that the 405MT607 transducer, P/N 1B34473 -505, S/N 332, had a damaged sealing surface.	The transducer was removed and replaced.
500-489-197 11-12-68	During performance of 1B67461 AK, it was noted that the 411W205 wire harness, P/N 1B58329-1, S/N 04, had a 1/2 inch long cut through the insulation and shielding 18 inches from the 411W205J1 receptacle on stringer 53.	The broken strands were withdrawn and overwrapped with four layers of DMP 2766 tape. The insulation was repaired per DPS 54010.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-489-227 11-16-68	During rework per FO 6686423, it was noted that pin z of the 411A99A10A1J1 receptacle, P/N 1A97062-539, was improperly crimped.	The pin was removed and replaced per DPS 54002-21.
500-489-235 11-19-68	During rework per FARR 500-372-176, a piece of polyethylene 0.062 inch wide by 0.375 inch long accidentally dropped through the LH_2 feedthrough into the LH_2 tank.	The LH_2 tank was opened, vacuum cleaned, and accepted by the Material Review Board.
500-489-740 11-26-68	Electrical standoff supports had stripped threads as follows: (Refer to 1B66505) a. One each, supporting wire harness 403W2 at stringer 42. b. Three each, supporting wire harness 404W6 at stringers 34, 35, and 43.	The standoffs had inserts installed per 1B53312.
500-489-758 12-2-68	During performance of 1B71877, sheet 187, it was noted that the GG fuel purge check valve, P/N 557755, S/N 3777910, had reverse seat leakage of 80 scims; should have been 25 scims or less.	The check valve was removed and replaced.
500-489-782 1-14-69	During performance of 1B65454, revision 6, a pressure of 475 psig GN_2 was applied to the engine pneumatics and the LH_2 repress bottles at the cross between pipe assemblies, P/N 1B64614-1, and 1B66803-1. No pressure should have been applied.	The FARR was transferred to the FTC for the final disposition.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-607-521 12-4-68	During performance of 1B71877, sheet 191, it was noted the GG oxidizer purge check valve, P/N 557755, S/N 3784840, had reverse seat leakage of 1180 scims; should have been 15 scims or less.	The check valve was removed and replaced.
500-607-530 12-5-68	During performance of line check 90, it was suspected that the RF assembly, P/N 1B65788-1 -002, S/N 15501, reference location 411A64A -200, had two power supplies, P/N 50M60040-7 and 13, S/N 042, that were of faulty workmanship.	The power supplies, P/N 50M60040-7 and 13, S/N 042, were removed. Installation will be accomplished at the FTC.
500-607-556 12-5-68	During surveillance inspection per 1B57505 N, zone 5, it was noted that electrical support standoff, P/N 1B57305-5, had stripped threads aft of the 411A9 panel, P/N 1B58181-505 G on stringer 16.	The standoff had an insert installed per 1B53312.
500-607-564 12-6-68	During inspection per WRO S-IVB-4495, it was noted that pipe assembly, P/N 1B43397-1, had damage to the teflon wrapping in the 411 area between stringers 31 and 32.	With the pipe assembly installed, the frayed edges were smoothed down and two layers of teflon tape were wrapped over the damaged area.
500-607-572 12-5-68	During performance of 1B71136, revision 17, it was noted that the 403W200 P24 connector would not correctly mate with the 403MT686J1 receptacle.	The P24 connector was removed, replaced, and tested per 1B67824.
500-607-599 12-10-68	During performance of 1B64680, it was noted that the 411A61A201 amplifier module, P/N 1A68710-509, S/N 218, malfunctioned. The sensor indicated wet when the test capacitor was set at 1.62 PF with limits of 0.7 $\pm$0.15 pf.	The module was removed and replaced.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-607-602 12-12-68	During the pressure check, it was noted that the PU assembly, P/N 1A59358-529, S/N 031, was pressurized to 12 psig, and 24 hours later it was verified to be 3.5 psig, should have been no less than 5 psig.	The unit was removed and replaced.
500-607-611 12-13-68	During performance of 1B71877, it was noted that the LOX prevalve, P/N 1A49968-521, S/N 101, had a leak through the seat of 407.5 scims. The valve was then cycled ten more times and leakage was 200 scims with 15 psig in the LOX tank. On resubmit, the leakage was 40 scims with 150 scims maximum allowed.	The prevalves was leak checked per 1B71877 with the results resubmitted. The valve was acceptable to the Material Review Board.
500-607-629 12-13-68	During performance of 1B64681 G, paragraph 4.2.2, it was noted that the 404A66A241 20 volt excitation module, P/N 1A74036-1 Y, S/N 0353, had an output of 16.5 vdc; should have been 20.000 $\pm$0.005 vdc.	The module was removed and replaced.
500-607-637 12-16-68	During performance of 1B55824, it was noted that the auxiliary hydraulic pump, P/N 1A66241-511, S/N X454594, had leakage at the flange between the pump and motor case, with no leakage allowed.	The pump was removed and replaced.
500-607-653 12-17-68	During operation and leak check, it was noted that the auxiliary hydraulic pump, P/N 1A66241-511, S/N X458923, after 10 minutes of operation, had two drops of fluid leakage at the shaft seal drain port. The allowable leakage is 0.5 cc per hour. Bubbles were noted after the pump was shut down. A second run was made for 10 minutes with eight drops of fluid leakage.	The unit was removed and replaced.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-607-670 12-19-68	During routine inspection, it was noted that the bracket assembly, P/N 1B57145-501, had two 0.221 to 0.224 holes drilled with NAS -1031N3 nutplates installed. NOTE: The bracket should have been installed after the thermoconditioner return line installation at the FTC. Refer to 1B57305 N.	The bracket was removed and replaced.
500-607-696 12-20-68	During performance of 1B71877 and 1B62753, it was noted that the LH_2 fill and drain valve, P/N 1A48240-505-007, S/N 0121, at ambient condition would not send open talkback with the valve functioning. The valve was then cycled several times with no results.	The FARR was transferred to the FTC for disposition.
500-607-700 1-2-69	The chilldown pump purge restrictors, P/N 1B40622-513, S/N 323, consisting of -3 and -5 components, was installed on 7-17-68, with a canister pressure of 60 psia and a regulated discharge pressure of 535 psia. On 12-19-68, the canister pressure had decayed to 48.1 psia with a discharge pressure of 524 psia. This amount of decay is marginal per A3-860-KCBA ROD-473. Projected to FTC checkout this would be out-of-tolerance.	The restrictors were removed and replaced.
500-607-734 12-26-68	During two runs of 1B55833 H, it was noted that the 411MT728 forward power detector, P/N 1A74776-503, S/N 303, measurement N018, N055, and M060 were 26.4 watts with a tolerance of 19 +7.25 watts. During both runs they exhibited RFI susceptibility.	The condition was acceptable to the Material Review Board.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-607-742 12-27-68	During the second attempt of 1B55833 H, it was noted that the 409MT650 LH_2 tank non-propellant vent 1 transducer, P/N 1B40242-595, S/N 595-3, measurement D0183, had out-of-tolerance readings as follows: a. Low RAC calibration was 1.297 vdc; should have been 1.00 $\pm$0.1 vdc. b. High RAC calibration was 5.122 vdc; should have been 4.00 $\pm$ 0.1 vdc.	The transducer was removed and replaced.
500-607-751 12-27-68	During the performance of AO 1B68375 H, the LOX prevalve, P/N 1A49968-521, S/N 101, opened and would not allow the marman clamp to go into position.	The chilldown duct was disconnected and 300 psig helium was applied to the prevalve butterfly. The resilient mount was loosened and the thrust cone bolts were removed to allow the prevalve to drop in place. New seals and marman clamps were installed, ducting replaced, actuation pressure removed, and leak checked per 1A39321, general note 24.
500-607-769 12-30-68	During the performance of 1B70422, revision 7, it was noted that a dark colored residue and a white substance existed on the flat surface of the LOX vent at fins I and III, adjacent to nozzle, P/N 1B69234-1.	The residue was removed with 400 grit carborundum paper and wiped with LOX clean cloths dampened with MEK, and the bare aluminum parts were brush alodined. The loose dynatherm was removed and replaced as required.
500-607-777 1-2-69	During installation per 1B58009 G, zone 16, view B, it was noted that the pipe assembly, P/N 1B76764-1, was 3/4 inch too long at the thrust structure between stiffeners 23-3/4 and 1-1/4.	The pipe assembly was shortened 3/4 inch at noted end, reflared, proof and leak checked per 1B76764, and cleaned per DPS 43000.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-607-785 1-2-69	a. During preshipment inspection, it was noted that several areas had micro-surface contamination as follows: 1. Pipe assembly, P/N 1A87736-1 at the welds in the 403 area. 2. Low pressure LH_2 duct, P/N 1A49320 -515, S/N 13R, forward of the engine connection. 3. Pipe assembly, P/N 1B66808-1, at the tee to the helium sphere in the 403 area on stringer 18. 4. Low pressure LH_2 duct, P/N 1A49320 -509, S/N 37. 5. Pipe assembly, P/N 1A77111-507 R, on bottle manifold four welds at stringer 24. 6. LOX feed line to the O_2H_2 burner in the 403 area. 7. Pipe assembly, P/N 1B67829-1, at the four-way cross forward of the O_2H_2 burner.	a. The micro-surface contamination, as a result of welding stainless steel, was accepted by the Material Review Board.
	b. The safety wire at the L1 power control module in the 403 area was broken.	b. The module was safety wired per drawing requirements.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-608-021 12-28-68	During installation per 1B58009 G, zone 10, it was noted that pipe assembly, P/N 1B75762-1, was 7/16 inch too short at the helium sphere 1, adjacent to stringer 6-1/4.	The pipe assembly was reformed within limits of DPS 10003 to fit, proof tested per 1B75762-1, and cleaned per DPS 43000.
500-608-269 11-21-68	During rework per 1B67271 M, it was noted that wire P11A16 of wire harness, P/N 1B67271-1, was nicked 2 inches from the J2 receptacle at the 404A2 panel.	The wire was removed, replaced, continuity checked, and tested per 1B73436 and 1B55815.
500-608-722 1-7-69	During the performance of 1B73265, revision 6, the following items were removed and were not leak checked after reinstallation. a. Start tank liquid refill line, P/N 307599-41, at the flange connection to the lower fuel ASI. b. Start tank gaseous refill line at the thrust chamber injector manifold. c. Start tank fill pipe assembly, P/N 1B52566-1, at the bulkhead elbow forward of the customer connect panel. d. Start tank vent and relief valve drain line at the customer connect panel. e. Start tank dump valve actuation line, P/N 1B67231-1, at the customer connect panel. f. Start tank discharge flex hose at the start tank dump valve.	The items will be leak checked at the FTC.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-608-722 (Cont.)	g. Pneumatic supply manifold flange to the GG control valve and to the fast shut down valve inlet.	
	h. LOX chilldown return line instrumentation port blank flange.	
	i. LH_2 chilldown return line instrumentation port blank flange.	
	j. Start tank vent and drain line, P/N 1B52556-1, at the bulkhead elbow forward of the customer connect panel.	
500-608-749 1-7-69	Prior to transferring the stage from the test stand to VCL, it was noted that electrical connectors P105 through P109, and P153 through P155, at the engine disconnect panel were not tightened or saftied.	The connectors were loosened, new O-rings installed, tightened per DPS 54015, and tested per 1B66572.
500-608-757 1-7-69	During rework per FARR 500-372-109, it was noted that the provisions of DPI 0127, paragraph 6.3.4.1, were not complied with during grit shell blasting. A positive pressure was not maintained in the forward skirt. On resubmit 1, the forward skirt was noted to have a large amount of walnut shell grit.	The surfaces inside the forward skirt within 6 feet of the auxiliary tunnel were inspected for the presence of walnut shells. On resubmit 1, the area was vacuum cleaned after rotation of the stage.
500-608-935 1-9-69	During preshipment inspection, it was noted that the 411MT649 cable assembly, P/N 1B40242-95, S/N 593-4, had insulation damage 3/8 inch long by 1/4 inch wide at stringer 32 in the forward interstage.	The cable assembly was removed and replaced.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-608-943 1-10-69	During pershipment inspection, the following discrepancies were noted:	
	a. The mylar covering at the LH_2 tank dome had 32 burn holes exceeding the outline of the rectangular scrim thread pattern.	a. The condition was acceptable to the Material Review Board.
	b. The mylar cover was debonded, also scrim threads were exposed adjacent to the LH_2 vent port.	b. The loose mylar was reinstalled per DPS 22301.
500-608-960 1-10-69	During preshipment inspection, it was noted that the 404MT651 cable assembly, P/N 1B40242-91, S/N 597-8, had torn insulation 1/2 inch long by 1/4 inch wide, also several shield strands were broken adjacent to stringer 46 in the forward interstage.	The broken strands were removed. The shield braid area was covered with three layers of DPM 2766 tape and the damaged area was then repaired per DPS 54010.
500-608-978 1-10-69	During final installation, it was noted that the fairing cover, P/N 1B28112-401 A, was contacting the adjacent pipe assembly, P/N 1B65055-1, approximately 4 inches aft of the pneumatic propellant control valve between stringers 54 and 57 at the 427 area.	The adjacent stiffener, P/N 1B28112-11, was trimmed for the pipe assembly to eliminate the interference; then, the reworked area was reprimed.
500-608-986 1-10-69	a. At the completion of the all system test, it was noted that the 404MT650 LH_2 tank nonpropellant vent system had invalid data.	a. The 409MT650 transducer, P/N 1B40242 -595, was removed and replaced.
	b. Measurements K0607, K0608, and K0676 had EMI noise which induced invalid cycles on the DER.	b., c., and d. The noted conditions were acceptable to the Material Review Board. NOTE: The FARR was transferred to the FTC for NASA review and concurrence.

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-608-986 (Cont.)	c. Measurements M0060 and N0018 had varying levels of output during open loop transmission from 3 to 4 per cent, and 2 to 80 per cent.	
	d. Measurement N0055 exhibited from 2 to 80 per cent variations during open loop transmission.	
500-608-994 1-10-69	Prior to final installation, it was noted that the tunnel covers, P/N 1B27716-517 AE, and 1A98308-503-2Y, had notches in the slotted holes due to misaligned bolts.	The condition was accepted by the Material Review Board.
500-609-001 1-10-69	During preshipment shakedown, it was noted that the LH_2 prevalve neoprene coated nylon boot, P/N 1B57698-1, had a 2 inch tear.	The boot surfaces were cleaned and DPM 3230 tape was installed overlapping the torn area by 1 inch.
500-703-113 1-15-69	During preshipment inspection, the following conditions were noted:	The noted discrepancies were classified as interum use material (IUM). The FARR was sent to the FTC for final disposition.
	a. Curtain assembly, P/N 1B69815-3-9, had a 1 inch delamination at the forward right corner adjacent to stringer 20.	
	b. Clamp, P/N AN737TW114, was missing from the curtain assembly, P/N 1B65611-511, adjacent to stringer 22-3/4. Refer to 1B69815, zone 4.	
	c. Curtain assembly, P/N 1B65607-1, had a 1 inch tear at the forward right corner adjacent to stringer 1A.	

TABLE III (Continued)

FARR NO.		DESCRIPTION OF DEFECTS	DISPOSITION
500-703-113 (Cont.)	d.	Curtain assembly, P/N 1B65608-1, had a 2 inch tear at stringer 4A, also delamination at the boot adjacent to the retainer at stringer 5 and the forward right flap adjacent to stringer 4-3/4.	
	e.	Curtain assembly, P/N 1B65609-503, had torn seams in 2 places at the forward left flap. Also, an area was debonded at the zipper adjacent to stringer 7.	
	f.	Curtain assemblies, P/N 1B65610-501 A, S/N 06, and P/N 1B69815 A45-3-9, had a 1/4 inch gap between them at stringer 13A.	
	g.	The installation of the curtain boot around the helium pipe assemblies was improperly secured, also pipe assembly, P/N 1B75770, contacted the adjacent curtain assembly.	
	h.	The boot of curtains, P/N 1B69815 A45-3-9, and P/N 1B69815 A45-3-8, were improperly installed around the nonpropulsive vent line.	
	i.	Curtain assembly, P/N 1B69815-9 was improperly installed between stringers 17A and 19; also, the assembly had a 3/8 inch tear at the Vee, provided for pipe assembly, P/N 1B69999, and a 1 inch hole was noted at the underside of the boot at stringers 16 and 16A.	

TABLE III (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-703-113 (Cont.)	j. Curtain assembly, P/N 1B69815-3-19, had a zipper flap which was pulled loose for 1-1/2 inches at stringer 20.	
	k. The boot of curtain, P/N 1B69815 A45-3-9, had a 1/2 inch tear at the nonpropulsive vent line.	
500-703-148 1-14-69	The ground strap assembly, P/N 1B55324-505 N/C was damaged at the 403A75 panel. Refer to 1A39324, zone 26.	The noted discrepancy was classified as interum use material (IUM). The FARR was sent to the FTC for final disposition.
500-703-148	Data review of AST revealed that the input voltage of the LH_2 and LOX chilldown inverter, P/N 1A74039-517-014 A, S/N 052 and 00036, exceeded the maximum of 60.0 volts.	The condition was transferred to the FTC for disposition.

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
1A48240-505-007	0144	404A7	Fill and drain valve
1A48240-505-007	0121	427A8	Fill and drain valve
1A48257-525	0070	411A1	LH_2 vent and relief valve
1A48312-517	0048	424A1	LOX vent and relief valve
1A48430-511.1-012A	C2	406A1	LOX mass probe
1A48431-513	D4C2	408A1	LH_2 mass probe
1A48857-503	51	403A73	Control helium tank
1A48858-1	1169	Bnk 2 Pos 9	Helium sphere, cold
1A48858-1	1189	Bnk 1 Pos 3	Helium sphere, cold
1A48858-1	1188	Bnk 2 Pos 8	Helium sphere, cold
1A48858-1	1195	Bnk 1 Pos 4	Helium sphere, cold
1A48858-1	1192	Bnk 2 Pos 7	Helium sphere, cold
1A48858-1	1176	Bnk 1 Pos 5	Helium sphere, cold
1A48858-1	1171	Bnk 1 Pos 2	Helium sphere, cold
1A48858-1	1183	Bnk 1 Pos 1	Helium sphere, cold
1A48858-1	1184	Bnk 2 Pos 10	Helium sphere, cold
1A49421-507-010	158	427A3	LH_2 aux chilldown pump
1A49423-509	1865	424A4	LOX aux chilldown pump
1A49964-501	280	424 (LOX)	Chill system check valve
1A49964-501	283	427 (LH_2)	Chill system check valve
1A49965-523-012	0517	424A41	Chill system shutoff valve
1A49965-525-013A	0601	424A4	Chill system shutoff valve
1A49968-519	118	404A44	Prop. tank shutoff valve
1A49968-521	101	424A6	Prop. tank shutoff valve
1A49991-1	72	403A7	Tank, comp. gas, cold helium
1A49991-1	49	403A74	Tank, comp. gas, cold helium
1A49991-1	67	403A6	Tank, comp. gas, cold helium
1A57350-507	0233	404A73A13	Helium fill module
1A58345-523-007	1024	403A73A1	Module, pneumatic pwr control
1A58347-513	2	403A75A2	Engine pump prg cont mod
1A59358-529	034	411A92A6	PU electronics assembly
1A66212-507	00011	411A92A7	Inv-conv elect. assy
1A66240-503	X457811	401A11S1, S2	Engine driven pump, hydraulic
1A66241-511	X458916	403B1	Aux hydraulic pump
1A66248-507	71	403A71L1	Hydraulic actuator assy
1A66248-507	84	403A72L1	Hydraulic actuator assy
1A68085-505	0085	411A99A10A1	300 amp pwr transfer switch

APPENDIX III

FLIGHT CRITICAL ITEMS

PRECEDING PAGE BLANK NOT FILMED.

Appendix III (Continued)

P/N	S/N	Ref. Location	Name
1A68085-505	0118	404A45A1	300 amp pwr transfer switch
1A68085-505	094	404A2A1	300 amp pwr transfer switch
1A74039-517-014E	052	404A74A2	Chilldown inv. elect. assy
1A74039-517-014E	00036	404A74A1	Chilldown inv. elect. assy
1A74211-515	0630	411A99A10A12	2 amp relay module
1A74211-515	0631	404A45A8	2 amp relay module
1A74211-515	0632	404A3A17	2 amp relay module
1A74211-515	0642	404A3A41	2 amp relay module
1A74211-515	0673	411A99A10A11	2 amp relay module
1A74211-515	0674	411A99A10A13	2 amp relay module
1A74211-515	0691	404A45A7	2 amp relay module
1A74211-515	0693	404A3A19	2 amp relay module
1A74211-515	0694	404A45A10	2 amp relay module
1A74211-515	0747	404A2A8	2 amp relay module
1A74211-515	0804	404A3A48	2 amp relay module
1A74211-515	0805	404A2A6	2 amp relay module
1A74211-515	0872	404A45A9	2 amp relay module
1A74216-503	0479	411A99A10A6	Mag latch relay module
1A74216-503	0506	404A45A5	Mag latch relay module
1A74216-503	0494	404A3A23	Mag latch relay module
1A74216-503	0505	404A3A13	Mag latch relay module
1A74216-503	0507	404A3A21	Mag latch relay module
1A74218-515	0579	404A45A11	10 amp relay module
1A74218-515	0591	404A3A14	10 amp relay module
1A74218-515	0621	411A99A10A10	10 amp relay module
1A74218-515	0685	404A3A20	10 amp relay module
1A74218-515	0688	404A3A49	10 amp relay module
1A74218-515	0693	404A3A44	10 amp relay module
1A74218-515	0694	404A2A2	10 amp relay module
1A74218-515	0695	404A3A12	10 amp relay module
1A74765-507	222	401A11S1	Hyd syst thermal switch
1A74890-501	0130	404A2A7	50 amp relay module
1A74890-501	0128	404A45A2	50 amp relay module
1A74890-501	0126	404A2A10	50 amp relay module
1A74890-501	00112	411A99A10A2	50 amp relay module
1A74890-501	0132	404A2A9	50 amp relay module
1A77310-503.1	0193	411A98A2	5 volt excitation module
1A77310-503.1	0198	411A99A33	5 volt excitation module
1A77310-503.1	0141	404A52A200	5 volt excitation module
1A86847-509	042	401A11S1, S2	Hyd pump thermal isol assy
1B29319-519	00029	403A46	Accum/reservoir assy
1B32647-505	069	404A45A3	Hyd pwr unit start switch
1B33084-503	015	411A97A19	RS controller assy
1B33084-503	016	411A97A13	RS controller assy
1B39037-501	19	401	Eng installation bolts
1B39037-501	59	401	Eng installation bolts

Appendix III (Continued)

P/N	S/N	Ref. Location	Name
1B39037-501	60	401	Eng installation bolts
1B39037-501	72	401	Eng installation bolts
1B39037-501	84	401	Eng installation bolts
1B39057-501	94	401	Eng installation bolts
1B39550-531	011	404A3	Sequencer mounting assy
1B39975-501	0271	404A2A17	Diode module
1B39975-501	0276	404A3A1	Diode module
1B39975-501	0277	404A2A16	Diode module
1B39975-501	0279	404A3A3	Diode module
1B39975-501	0282	404A3A5	Diode module
1B39975-501	0284	404A3A37	Diode module
1B39975-501	0285	404A3A39	Diode module
1B39975-501	0286	404A3A43	Diode module
1B40604-1.2	056	404A2A18	Diode assy module
1B40604-1.2	061	411A99A10A39	Diode assy module
1B40604-1.2	089	404A3A50	Diode assy module
1B40604-1.2	090	404A3A51	Diode assy module
1B40604-1.2	0117	404A3A7	Diode assy module
1B40604-1.2	0124	404A3A42	Diode assy module
1B40604-1.2	0144	404A3A34	Diode assy module
1B40824-507.1	113	403 Str 9-3/4	Check valve
1B40824-507.1	511	403 Str 5	Check valve
1B40824-507.1	114	403A74A2	Check valve
1B40824-507.1	507	403 Str 5A	Check valve
1B40824-507.1	115	403 Str 7	Check valve
1B40824-507.1	118	403 Str 9A	Check valve
1B40887-501	0266	404A2A15	10 amp mag latch relay mod
1B40887-501	0317	404A45A6	10 amp mag latch relay mod
1B40887-501	0209	411A99A10A4	10 amp mag latch relay mod
1B40887-501	0318	411A99A10A5	10 amp mag latch relay mod
1B40887-501	0278	404A3A16	10 amp mag latch relay mod
1B40887-501	0355	404A3A57	10 amp mag latch relay mod
1B40887-501	0420	404A3A58	10 amp mag latch relay mod
1B40887-501	0207	404A3A4	10 amp mag latch relay mod
1B40887-501	0208	404A3A2	10 amp mag latch relay mod
1B40887-501	0261	404A3A10	10 amp mag latch relay mod
1B40887-501	0262	404A3A8	10 amp mag latch relay mod
1B40887-501	0271	404A3A6	10 amp mag latch relay mod
1B40887-501	0279	404A318	10 amp mag latch relay mod
1B40887-501	0323	404A3A46	10 amp mag latch relay mod
1B51211-505	013	404A45	Aft 56 volt pwr dist assy
1B51354-507	012	404A2	Aft 28 volt pwr dist assy
1B51379-511	011	411A99A10	Fwd pwr dist mount assy
1B51753-511	030	411A32	LH_2 prop vent reg & S/D valve
1B52623-515	021	403S2	Pressure switch
1B52624-511	007	411S2	Pressure switch

Appendix III (Continued)

P/N	S/N	Ref. Location	Name
1B52624-511	026	411S4	Pressure switch
1B52624-515	48	403S8	Pressure switch
1B52624-519	49	403S1	Pressure switch
1B52624-519	53	403S5	Pressure switch
1B52624-519	57	403S6	Pressure switch
1B53920-501	045	403A73	Chill feed duct check valve
1B53920-503	053	LOX C/D duct	Chill feed duct check valve
1B53920-503	056	LH_2 C/D duct	Chill feed duct check valve
1B55408-503	0020	Str 13-14	Compressed air tank
1B57731-501	419	404A71A19	Control relay package
1B57731-501	414	404A51A4	Control relay package
1B57781-507-005	0029	403A74A2	Cold helium fill module
1B58006-401	49	403A74	1A49991, teflon wrapped
1B59010-509	136	427A7	Pneu prop. control valve
1B62600-529-012	013	403 Str 10-3/4	O_2H_2 welded burner assy
1B62778-503	34	403A7	Helium plenum & valve assy
1B62778-503	32	403A6	Helium plenum & valve assy
1B65319-503	023	404A70A1	Sw sel emissivity cont assy
1B66230-509	1043	403A73A3	Calibrated LH_2 press. cont mod
1B66639-515	029	403	Pneu latching actuator assy
1B66639-519	050	411A32	Pneu latching actuator assy
1B66692-501-004	90	404A44	Actuation control module
1B66692-501-004	74	404A43	Actuation control module
1B66692-501-004	83	403A15	Actuation control module
1B66692-501-004	93	411A30	Actuation control module
1B66692-501-004	95	404A17	Actuation control module
1B66692-501-004	82	403A75A1	Actuation control module
1B66692-501-004	92	404A9	Actuation control module
1B66692-501-004	96	411A2	Actuation control module
1B66692-501-004	94	411A3	Actuation control module
1B66692-501-004	174	403A8	Actuation control module
1B66692-501	15	411A14	Actuation control module
1B66868-501	20	Pos 8 Str 20	Ambient helium sphere
1B66868-501	25	Pos 9 Str 23	Ambient helium sphere
1B66868-501	29	Pos 10 Str 24A	Ambient helium sphere
1B66868-501	30	Pos 1 Str 6A	Ambient helium sphere
1B66868-501	22	Pos 2 Str 7A	Ambient helium sphere
1B66868-501	21	Pos 7 Str 18	Ambient helium sphere
1B66868-501	23	Pos 6 Str 17	Ambient helium sphere
1B66868-501	24	Pos 5 Str 12	Ambient helium sphere
1B66988-1	04	404A71A1	Sphere assy, helium storage
1B67193-511	019	411A32	Continuous vent control mod
1B67598-501	36	403 Str 6	Pneumatic check valve
1B67598-501	170	403 Str 18	Pneumatic check valve
1B67598-501	37	404 Str 28A	Pneumatic check valve
1B67598-501	38	403A73A4	Pneumatic check valve

Appendix III (Continued)

P/N	S/N	Ref. Location	Name
1B67598-501	171	403 Str 4	Pneumatic check valve
1B67598-503	185	403 Str 9	Pneumatic check valve
1B67598-501	30	403 Str 13A	Pneumatic check valve
1B67598-501	34	C/L Umb	Pneumatic check valve
1B67598-501	35	C/L Umb	Pneumatic check valve
1B67598-501	182	403 Str 9	Pneumatic check valve
1B67598-503	40	403A73A4	Pneumatic check valve
1B67598-503	87	403A74A3	Pneumatic check valve
1B69030-501	0022	424A9	LOX NPV control valve
1B69514-501	023	404A3A56	Isolation diode module
1B69514-501	022	411A99A8	Isolation diode module
1B69514-501	017	404A3A55	Isolation diode module
1B69550-501	023	403A73A4	Repress. control module
1B69550-501	029	403A74A3	Repress. control module
1B74535-1	0009	411A15	Valve, relief, LH_2 tnk latch.
1B76452-1	08	404A51A4	Control relay package
1B67452-1	09	404A71A19	Control relay package
7851823-503	1085	Pos 2 at umb	Helium control disconnect
7851823-503	1092	Pos 1 at umb	Helium control disconnect
7851844-501	36	10" from F&D	Cold helium disconnect
7851861-1	30	427	LH_2 tank press. disconnect
40M39515-113	252	404A75A1	EBW firing unit
40M39515-113	253	404A75A2	EBW firing unit
40M39515-113	271	404A47A2	EBW firing unit
40M39515-113	284	404A47A1	EBW firing unit
40M39515-119	418	411A99A12	EBW firing unit
40M39515-119	419	411A99A20	EBW firing unit
103826	J-2101	401	J-2 engine

NASA
FORMAL
REPORT