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JULY 1969

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SACRAMENTO NARRATIVE END ITEM REPORT SATURN S-IVB-508

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY

MCDONNELL DOUGLAS CORPORATION

SACRAMENTO

NARRATIVE END ITEM REPORT
SATURN S-IVB-508

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JULY 1969

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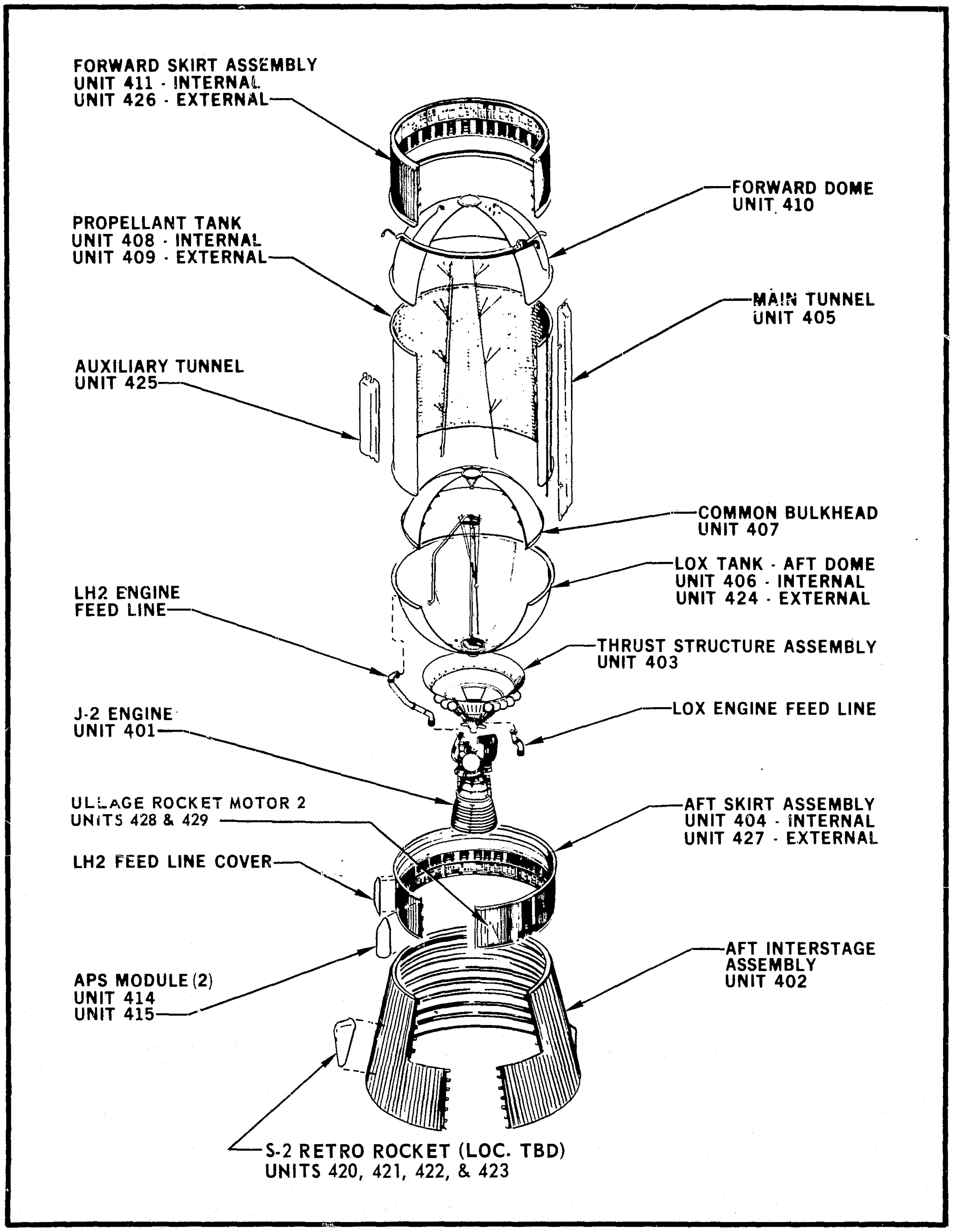

Exploded View of S-IVB Stage for Saturn V

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-508 Flight Stage (P/N 1A39300-523, S/N 508).

Narrations are included on those conditions related to permanent nonconformances which were generated during the manufacturing cycle and existed at the time of 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
Postfire

PREFACE

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

The previous period of stage acceptance testing at the MDAC-WD Space Systems Center, Huntington Beach, California, and transfer to the MDAC-WD Sacramento Test Center, was covered by Narrative End Item Report, Saturn S-IVB-508, Douglas Report DAC-56639, dated January 1969.

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APPENDIX III

1.0 INTRODUCTION

1.1 Scope

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

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

b. Replacements made during Sacramento Test Center (STC) test and acceptance checkout, including serial number of articles removed or substituted.

c. Nature of problems and malfunctions encountered.

d. Corrective action taken or pending.

e. Extent of retests or tests not completed.

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

1.2 Format

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

SECTION:

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

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

3. STAGE CONFIGURATION. Conformance to engineering design and data on time/cycle significant items.

1.2 (Continued)

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

APPENDICES:

I Testing Sequence

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

III Flight Critical Items

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

1.3 Stage Functional Description

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

1.4 Documentation

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

1.5 Turnover

Turnover of the stage was made on 12 June 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-19706-9). Two letters: A3-131-5.4-3.13-L-1913, dated 15 May 1969; and PM-CO-S-MDAC-L-230-69, dated 22 May 1969; from the MDAC-WD management to the NASA Resident Manager at STC, submitted the documentation necessary to effect turnover. Copies of these letters and the accompanying documentation is included in the stage log book.

2.0 NARRATIVE SUMMARY

The following paragraphs present a narrative summary of stage checkout of the S-IVB-508 stage. Stage prefire tests and postfire tests conducted at the Sacramento Test Center (STC) are summarized in paragraphs 2.1 and 2.2, respectively. The Final Inspection, Weight and Balance, and Preshipment Preparations are summarized in paragraphs 2.3, 2.4, and 2.5, respectively. More detailed narrations on these tests and operations are presented in section 4.

Paragraph 2.6 summarizes any tests that were invalidated or not completed prior to stage transfer, and any retesting that will be required. Paragraph 2.7 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 D, and SEO 008 delineated the general philosophies of the STC test programs. Test request 1319 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 30 December 1968. The prefire checkouts began on 2 January 1969, and were concluded on 17 February 1969. Twenty-nine

2.1 (Continued)

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

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

The cryogenic temperature sensor verification was successfully accomplished between 7 and 15 January 1969. Subsequent removal and rework of the LOX tank instrumentation probe necessitated a second issue which was successfully accomplished on 3 February 1969. One problem, reported on FARR 500-607-882 was encountered during issue one. Three revisions were made to issue one, while one revision was written during issue two.

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

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 seven revisions were written against these procedures. Six revisions were written during the umbilical interface compatibility checks, one was written during the APS interface compatibility check, while none were written during the forward skirt thermoconditioning system check.

The common bulkhead vacuum system checkout was successfully demonstrated without generating any FARR's. However, eleven revisions were made to the procedure.

2.1 (Continued)

The hydraulic system setup and operation checkout was initiated on 9 January 1969, and completed on 17 February 1969. The procedure required fourteen revisions for completion.

Power was applied to the stage for the first time on 10 January 1969, with the initiation of the stage power setup procedure. No FARR's were written; however, four revisions were written to the procedure. The stage power turnoff procedure was successfully demonstrated on 10 January 1969. No FARR's were initiated and three revisions were made to the procedure.

The power distribution system test was conducted three times during prefire operations on 11 January, on 16 January; then, satisfactorily on 24 January 1969. The initial test was aborted due to a recessed pin in a connector socket, which was reported on FARR 500-607-971. The second test was aborted by failure of the LH2 chilldown inverter, P/N 1A74039-517, S/N 075, and was reported on FARR 500-702-958. After replacement of the LH2 chilldown inverter the test was successfully completed. There were a total of fifteen revisions recorded in the three runs of the procedure.

The signal conditioning setup and the stage and GSE manual controls check were completed without the initiation of any FARR's. Two revisions were written to the signal conditioning setup, while seven revisions were made to the stage and GSE manual controls checkout.

Three tests were conducted to verify operation of the DDAS. Test attempts one and two, conducted on 13 January and 31 January 1969, respectively, were not

2.1 (Continued)

successful because of numerous channel malfunctions. The third and final test was a successful checkout performed on 4 February 1969. There were three FARR's initiated as a result of DDAS testing. FARR 500-703-369, 500-702-915, and 500-703-580 documented the channel malfunctions encountered in the first two attempts. Sixteen revisions were recorded in the procedure.

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

Seven tests were required to satisfactorily complete prefire DDAS calibration. The initial test was conducted on 15 January 1969, and the second attempt on 20 January 1969, were both aborted due to noise occurring during the DP1-BO multiplexer test, which resulted in channel malfunctions. FARR 500-702-915 removed and replaced the DP1-BO multiplexer, P/N 1B65897-501, S/N 06, with S/N 017. Additional tests conducted from 20 January through 23 January 1969, were investigation checkouts of electro-magnetic interference of test cable grounding. The investigation was documented on FARR 500-702-991. The seventh and final test was successfully conducted on 27 January 1969. A total of sixteen revisions were required during this checkout.

The propellant utilization (PU) system calibration, the propellant utilization system automatic were completed without the initiation of any FARR's. The PU system calibration required three revisions, while the PU automatic checkout required eleven revisions.

2.1 (Continued)

Two tests were conducted to verify the hydraulic system automatic checkout. The initial test was successfully performed on 20 January 1969; however, repeat testing became necessary due to subsequent replacement of the accumulator/reservoir assembly, P/N 1B29319-505, S/N 00026 with S/N 00040, per FARR 500-703-482. Two tests were conducted per issue two on 31 January 1969, with the first test attempt aborted due to malfunctioning of the analog to digital converter in the GSE response conditioner. The second test was successful. Six revisions were required during both issues.

The range safety receiver checkout and range safety system automatic checkout were completed without the initiation of any FARR's. The range safety receiver checkout required nine revisions, while the range safety system automatic checkout required three revisions.

The single sideband was accomplished between 27 January and 5 February 1969. Three FARR's documented discrepancies that were noted during SSB testing. FARR 500-703-377 reported that the R6 potentiometer would not adjust. FARR 500-703-491 reported that measurement N061 failed to RAC (low level) and FARR 500-703-458 reported an interference condition of a cable assembly connector. Seventy-six revisions were required for the checkout.

The hydraulic system servicing was satisfactorily accomplished on 31 January 1969. Replacement of the accumulator/reservoir assembly, P/N 1B29319-519, S/N 00026 with S/N 00040, per FARR 500-703-482 was due to GN2 leakage, and required issuance of this servicing procedure to ensure that the hydraulic system was properly filled, bled, and maintained free of contamination after the replacement. Two revisions were recorded in the procedure.

2.1 (Continued)

The propulsion system test was performed satisfactorily on 31 January 1969. A second issue of the procedure to repeat section three, the J-2 engine functional tests, became necessary when a J-2 engine electrical cable assembly was found defective and replaced per FARR 500-704-136 during the integrated systems testing. The second test was successfully conducted on 7 February 1969. There were forty-one revisions made to the initial test, while nineteen revisions were required for completion of the second issue.

The manual and automatic sequences for the performance of the integrated systems test were initiated on 5 February 1969. This initial test was aborted due to numerous malfunctions including test equipment, program, and stage hardware. The second test was performed satisfactorily on 7 February 1969. There were three FARR's resulting from testing during the initial aborted test, none were recorded for the second test. Thirty-five revisions were recorded in the procedure.

The final prefire propulsion system leak check was accomplished between 14 February and 17 February 1969. Twenty-two revisions were recorded in the procedure.

The acceptance firing test, designated countdown 614116, was initiated on 20 February 1969, and was terminated after 457 seconds of successful mainstage operation. A detailed narrative of the acceptance firing is delineated in Saturn S-IVB-508 Stage Acceptance Firing Report DAC 56757, dated April 1969.

2.2 Stage Postfire Checkout

The stage postfire checkout, following completion of acceptance firing, was initiated on 21 February 1969, and completed on 28 March 1969. Twenty-one H&CO's involving the stage systems were performed during this period. Detailed narrations on the postfire checkouts accomplished per test request 1322 are presented in paragraph 4.2.

Postfire checkouts began on 21 February 1969, with the initiation of stage power setup and the stage power turnoff procedures. No FARR's were written during either procedure; however, the stage power setup required three revisions and the stage power turnoff required one revision.

The structural inspection was initiated on 21 February 1969, and was satisfactorily completed on 28 March 1969. FARR 500-703-989 reported that the Korotherm coating on the forward and aft skirt areas was cracked and peeling. The coating was repaired per DPS 42210 with DPM 3486. There were no other discrepancies documented; however, three revisions were recorded in the procedure.

The postfire operation and securing procedure for the hydraulics system was initiated on 24 February 1969, and satisfactorily completed on 24 March 1969. There were no recorded discrepancies during this checkout; however, FARR 500-703-873 was initiated for the use of unfiltered, unsampled freon. This condition was accepted as the system was under positive pressure during the wash. Five revisions were recorded in the procedure.

The propulsion system leak checks were initiated on 24 February 1969, and certified as acceptable on 25 March 1969. A number of leaks were found and

2.2 (Continued)

those exceeding the allowable limits were corrected. FARR 500-703-865 reported an excessive reverse leakage through the LH2 ambient repressurization check valve, P/N 1B67598-501, S/N 202. The valve was replaced with S/N 249, which was satisfactorily leak checked. FARR 500-703-890 reported an excessive reverse leakage through the LH2 prepressurization check valve, P/N 1B65673-1, S/N 30. The valve was replaced with S/N 8, which was satisfactorily leak checked. FARR 500-704-004 reported an excessive internal leakage of the pressure actuated fast shutdown valve, P/N 558127-11, S/N 4092538. The valve was replaced with S/N 4090180, which was satisfactorily leak checked.

The digital data acquisition system automatic checkout required four attempts. Attempt one, conducted on 25 February 1969, resulted in numerous malfunctions including replacement of a faulty D002 fuel pump inlet pressure transducer, P/N 1B40242-579, S/N 579-2, per FARR 500-703-962. Test attempt two and three performed on 6 March 1969, experienced difficulty with measurement D002; however, only the high RACS malfunctioned during the DP1-B0 multiplexer test. The investigation was documented on FARR 500-704-047. The fourth and final test was successfully conducted on 12 March 1969. Nineteen revisions were required to complete this checkout.

The range safety system checkout, the level sensor and control unit calibration, the power distribution system test, and the APS simulator automatic test, were satisfactorily completed with no FARR's written. The range safety system checkout required six revisions, the level sensor and control unit calibration required three revisions, while the power distribution system test and the APS

2.2 (Continued)

simulator automatic test required five revisions each to complete their respective checkouts.

The single sideband system was accomplished between 26 February 1969, and 10 March 1969. FARR 500-704-276 reported that the SSB translator, P/N 1B55252, S/N 00006, had an intermittent output. The assembly was reworked by the vendor and reinstalled on the stage. Checkout is scheduled at the FTC. Fifty-nine revisions were required for the checkout.

The signal conditioning system setup was initiated on 27 February 1969, and successfully completed on 17 March 1969, after seven revisions were made to the procedure. FARR 500-704-055 reported that the propellant utilization (PU) oven on indication module, P/N 1B65331-1, S/N 068, failed to adjust during setup. The module was replaced with S/N 061, which was properly adjusted.

The radiated spectrum signature test, the digital data acquistion system calibration, and the propellant utilization system automatic checkout, were satisfactorily completed with no FARR's being written. The radiated spectrum signature test required eleven revisions, the digital data acquisition system calibration required nine revisions, and the propellant utilization system automatic checkout required eleven revisions.

The propulsion system automatic checkout was initiated on 10 March 1969, and completed on 14 March 1969, after fifty-six revisions were made to the procedure. Six tests were required to complete the checkout. The initial test was aborted due to a computer malfunction which terminated executive operation.

2.2 (Continued)

The second test successfully checked the three sections of the procedure on 10 March 1969. The third and fourth tests were necessary to verify proper operating times after re-orificing became necessary to correct the main engine oxidizer valve (MOV) opening time. FARR 500-704-055 reported that the propellant utilization (PU) oven on indicating module, P/N 1B65331-1, S/N 068, failed to adjust during signal conditioning setup per 1B64681. This resulted in a fifth test to retest the O2H2 burner voting circuit. The sixth and final test on 14 March 1969, was required to test the LOX pressurization control module, P/N 1B42290-507, S/N 0037, which was replaced per FARR 500-703-881.

The all system test required three attempts. The initial test, conducted on 12 March 1969, encountered malfunctions and additional testing was conducted on 13 March 1969, to troubleshoot the range safety problem. A final test was conducted on 14 March 1969, to verify the umbilicals-out portion of AST. Forty-one revisions were made to the procedure. FARR 500-816-384 was initiated after the AST when data review indicated RF interference for forward and reflected power transmission measurements N18, N55, N60, and N61. This discrepancy was submitted to the FTC for further evaluation.

The umbilical interface compatibility check required two issues for compatibility checks after reconnecting umbilicals which had been ejected by each of two all systems tests. The checkouts were performed on 12 March and 14 March 1969, after each all systems test.

The range safety system checkout was accomplished three times. The second test was required due to cutoff malfunctions occurring from lack of engine safety

2.2 (Continued)

cutoff system (ESCS) power, which had not been turned on when the umbilical bypass cables were installed. The third and final test, necessitated by AST test problems, was performed on 14 March 1969. Eleven revisions were recorded during the tests.

The forward skirt thermoconditioning system checkout was initiated on 18 March 1969, and successfully completed on 19 March 1969. Six revisions were required to complete the test.

The final postfire checkout was the cryogenic temperature sensor verification conducted on 28 March 1969. Resistance and continuity checks of the internal fuel tank temperature transducers for measurements C-0052, C-0370, and C-0371 were conducted because of entry into the LH2 tank for postfire structural inspection. All sections of the procedure were deleted except those concerned with the three LH2 tank measurements noted. Only one revision was recorded, deleting all portions of the procedure except those required for reverifying the required LH2 tank sensors.

2.3 Final Inspection

Following the final manufacturing and testing operations, the final inspection of the stage was accomplished between 17 March and 22 May 1969, to locate and correct any remaining stage discrepancies. A more detailed narration on the final inspection is presented in paragraph 4.3.

2.4 Weight and Balance

The stage was rotated to a horizontal position in preparation for the weight and balance operation. On 19 May 1969, the stage was weighed by means of a three point electronics weighing system. Three electronic load cells, one aft and two forward, measured the reaction forces of the otherwise unsupported stage. The reaction force measurements were then used to determine that the stage shipping and handling weight was 27,069.8 pounds, the stage weight corrected for standard gravity in a vacuum was 27,122.1 pounds, and the stage longitudinal center of gravity was located at station 330.7. Paragraph 4.4 presents a more detailed narration on this operation.

2.5 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 -32.0°F for the LH2 system, and -49.0°F for the LOX system. The proper desiccants were installed to maintain the proper stage environment during the air transport operations. Paragraph 4.5 presents a more detailed narration on this operation.

2.6 Incomplete Tests and Retesting Requirements

All required prefire and 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

2.6 (Continued)

at FTC. These modifications invalidated parts of the previously accomplished stage testing. MDAC report 61242B, revised 26 May 1969, extensively covered these modifications and the retesting that would be required at FTC to reverify the affected stage systems and was prepared in accordance with contract change order 2095.

2.7 Incomplete FARR's

Three FARR's were not closed at the time of stage shipment to the FTC, and were transferred open with the stage. FARR 500-373-598 reported that the APS system had not been verified as a complete system, that the APS modules had not been tested in conjunction with the flight APS relay module and associated stage wire harnesses and that the APS valves opening and closing times have not been determined in a flight configuration. FARR 500-704-675 reported that numerous scratches were noted on the sealing flange area for the LH2 tank door. FARR 500-816-384 reported that the data review initiated after AST noted that the forward and reflected power measurement N-18, N-55, N-60, and N-61 were RF susceptible.

3.0 STAGE CONFIGURATION

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

A listing, in tabular form, of all time/cycle significant items on the stage, with the accumulated time/cycles for each item, is included in paragraph 3.3.

Existing contractual configuration control papers are referenced wherever possible.

3.1 Design Intent Verification

This configuration of the stage is defined in the Engineering Configuration List (ECL), Space Vehicle, Model DSV-4B-1-1, Manufacturing Serial Number 508, revision A, dated 18 July 1968. This ECL document includes a listing of all parts, non-hardware drawings, and manufacturing and process specifications required for the manufacture and test of the stage, as defined by engineering production drawings and EO releases. The ECL has been transmitted to NASA under a separate cover.

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

3.2 Stage Variations - Flight Critical Items

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

3.2.1 Oxidizer Mass Probe

SEO 1A48430-012 A authorized reworking the oxidizer mass probe, P/N 1A48430 -511.1, S/N C4, to provide insulation resistance equivalent to the -513 configuration.

3.2.2 LH2 Chilldown Pump

SEO 1A49421-A45-2 provided for performing the product acceptance phase continuity test of the LH2 chilldown pump, P/N 1A49421-507, S/N 154, while installed on the stage.

3.2.3 LH2 Chilldown Shutoff Valve

SEO 1A49965-012 A authorized the removal of the existing bonded insert and O-ring from the electrical connector, leak testing of the receptacle, and subsequent installation of an unbonded insert and O-ring for the LH2 chilldown shutoff valve, P/N 1A49965-523, S/N 0301. The unbonded insert was installed to minimize cracking of the insert and glass insulation at cryogenic temperatures, in accordance with NASA Change Order 1602.

3.2.4 LOX Chilldown Shutoff Valve

SEO 1A49965-013B authorized the removal of the valve assembled with Drilube 822, which was not LOX compatible, and the installation of LOX chilldown shutoff valve, P/N 1A49965-525, S/N 0205, which was assembled with an acceptable lubricant.

3.2.5 Pneumatic Power Control Module

SEO 1A58345-007 provided instructions to rework the pneumatic power control module, P/N 1A58345-521, S/N 1017, equivalent to the -523 configuration.

3.2.6 Hydraulic Yaw Actuator Assembly

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

3.2.7 Chilldown Inverter Electronic Assembly

SEO 1A74039-016A modified the chilldown inverter electronics assembly, P/N 1A74039-517, S/N 074, to ensure that the installed zener diode, P/N 1B52278-1, would meet the environmental and operational requirements. The diode, CR13 in the assembly circuit, was checked by reverse current, forward voltage, zener voltage, and surge current tests.

3.2.8 Cold Helium Fill Module

SEO 1B57781-005C provided for special tests of the cold helium fill module, P/N 1B57781-507, S/N 0032, to check for internal leakage after cold temperature operation.

3.2.9 O2H2 Burner Assembly

SEO 1B62600-012 authorized reworking the O2H2 burner assembly, P/N 1B62600-529, S/N 010, 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 10, 20, 111, 118, 126, 127, 128, 132, and 134.

3.3 Time/Cycle Significant Items

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

Part Number and Part Name	Serial Number	Accumulated Measurement	Engineering Limits
Reliability Items (1B55425 S)			
1A48858-1 Helium Storage Sphere	1137	6 cycles	50 cycles
	1175	6 cycles	50 cycles

3.3 (Continued)

Part Number and Part Name	Serial Number	Accumulated Measurement	Engineering Limits
	1181	5 cycles	50 cycles
	1211	5 cycles	50 cycles
	1212	5 cycles	50 cycles
	1213	5 cycles	50 cycles
	1215	6 cycles	50 cycles
	1217	5 cycles	50 cycles
	1219	5 cycles	50 cycles
1A49421-507 LH2 Chilldown Pump	154	4.5 hours	100 hours total (cryogenic and dry)
		0 min	40 minutes dry
		0 cycles	10 cycles (dry starts)
1A49423-509 LOX Chilldown Pump	1871	1.6 hours	20 hours
1A59562-509 PU Bridge Potentiometer	5018	391 cycles	5,000 cycles
	5020	419 cycles	5,000 cycles
1A66241-511 Auxiliary Hydraulic Pump	X458912	23.2 hours	120 hours
		111 cycles	300 cycles
1B57731-503 Control Relay Package	423	195 cycles	100,000 cycles
	424	169 cycles	100,000 cycles
G.F.P. Items (1B55423 H)			
40M39515-113 EBW Firing Unit	292	35 firings	1,000 firings
	293	25 firings	1,000 firings
	298	59 firings	1,000 firings
	299	27 firings	1,000 firings
40M39515-119 EBW Firing Unit	554	230 firings	1,000 firings
	555	227 firings	1,000 firings
50M10697 Command Receiver	182	46.4 hours	2,000 hours
	189	45.7 hours	2,000 hours
50M10698 Range Safety Decoder	0039	139.8 hours	2,000 hours
	0178	20.3 hours	2,000 hours
50M67864-5 Switch Selector	178	73,794 cycles	250,000 cycles

3.3 (Continued)

Part Number and Part Name		Serial Number	Accumulated Measurement	Engineering Limits
103826	J-2 Engine	J-2122		
a.	Customer connect lines and inlet ducts		5.86%*	250-10,000 cycles
b.	Gimbal bearing		7.05%*	250-10,000 cycles
c.	Firing time		808.0 seconds	3,750 seconds
d.	Helium Regulator (P/N 558130-321)	4088592	48 cycles**	None Given

* This data includes all engine gimbal cycles at STC, plus cycles brought forward from SSC records. The cycle data are expressed as percent ages 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.

** From Rocketdyne Records. Not tested by MDC to date.

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 Postfire Checkout; 4.3, Final Inspection; 4.4, Weight and Balance; 4.5, Preshipment Preparations; 4.6, Incomplete Tests and Retest Requirements; and 4.7, Incomplete FARR's. Each major paragraph is subdivided to the degree required to present a complete historical record of stage checkout.

Nonconformance and functional failures affecting the stage are recorded on FARR's and are referred to by serial numbers throughout the section (e.g., FARR 500-373-598 and 500-488-352). The referenced FARR's are also presented numerically by serial number in Appendix II.

4.1 Stage Prefire Checkout

Stage prefire checkouts began on 2 January 1969, with initiation of the prefire structural inspection, paragraph 4.1.1. The stage prefire checkouts were completed on 17 February 1969, with completion of the final prefire propulsion system leak check, paragraph 4.1.29. All tests required per End Item Test Plan 1B66684, change K, dated 20 September 1968, were activated and completed.

4.1.1 Structural Prefire Inspection (1B40654 C)

Performed between 2 January 1969, and 14 January 1969, this inspection verified that transportation of the stage from the Space System Center to the Sacramento Test Center had no detrimental effect on the structure, and also established the condition of the stage prior to static acceptance firing for comparison with the stage condition subsequent to a full duration static firing program.

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

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

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

4.1.1 (Continued)

A visual inspection of the ambient helium storage spheres, control spheres, and auxiliary hydraulic pump air tank was accomplished to determine if any out-of-tolerance ding, scratch or finish discrepancy existed. The condition of the insulation on the cold helium plenums was checked for the plenum and valve assemblies.

A radiographic inspection of the forward and aft V-section (the junction of the forward skirt and the forward dome, and the junction of the thrust structure and the aft dome) revealed foreign material in both the forward and aft V-sections. Three NAS679-3 nuts were identified in the forward V-section and one nut in the aft V-section. The nuts were removed per FARR 500-702-885 and IIS 462649.

There were no other discrepancies documented by FARR. The one revision recorded in the procedure deleted the fit check for the APS modules, because it was a postfire requirement.

4.1.2 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 were initiated on 7 January 1969, and satisfactorily completed on 15 January 1969. Subsequent removal, rework, and reinstallation of the LOX tank instrumentation probe necessitated a second issue of the procedure to repeat checkout of the five measurements on the probe. Checkout per the second issue was successfully accomplished on 3 February 1969.

Each sensor was tested at the prevalent ambient temperature. Using the values for resistance at 32°F and sensitivity, which were given for each individual sensor, the expected resistance at room temperature was calculated. The actual resistance was measured, and compared with the calculated value. The measured resistance was required to be within ±5 percent of calculated resistance, except for specified sensors which were allowed a ±7 percent tolerance. The sensor wiring was verified to be correct by shorting out the sensor element, measuring the continuity resistance, and by verifying that this was 5.0 ohms or less. Test Data Table 4.1.2.1, shows the measured and calculated values for each sensor involved in this test.

The initial resistance measurement was out-of-tolerance for measurement C2031, LOX NPV nozzle 2 temperature. Temperature sensor, P/N 1B37878-511, S/N 1818,

4.1.2 (Continued)

was removed and replaced with S/N 1484 per FARR 500-607-882. The repeat test with the new sensor was satisfactory, as noted in Test Data Table 4.1.2.1.

There were no other discrepancies. There was only one revision recorded in the second issue of the procedure, deleting all portions of the second issue except those requirements concerned with the five measurements on the LOX tank instrumentation probe. Three revisions were recorded in the first issue of the procedure for the following:

a. Two revisions corrected typographical errors.

b. One revision provided for the retest of measurement C2031, after replacement of the transducer.

4.1.2.1 Test Data Table, Cryogenic Temperature Sensor Verification

Meas. Number	P/N	Sensor S/N	Ref. Desig.	Temp. (°F)	Resistance (ohms) Meas.	Calc.	± Tol.
CO 003	1B34473-1	320	403MT686	57	5052	5275	263.8
CO 004	1B34473-501	340	403MT687	57	1486	1477	73.9
CO 005	1A67863-503	852	405MT612	57	512.0	527.5	26.4
CO 009	1A67863-535	1187	403MT653	57	213	211	10.5
CO 012	NA5-27215T5	13375	401(4MTT72)	57	1320	1325	66.2
CO 015	1A67863-539	10343	410MT603	43	514.1	512.1	25.6
CO 040	1A67862-535	10638	406MT613	47	1418.0	1425.4	71.2*
CO 052	1A67862-513	563	408MT612	43	4900	5121	358.5
CO 057	1A67862-501	554	406MT606	47	516.0	516.5	25.8*
CO 059	1A67862-517	571	406MT611	47	516.5	516.5	25.8*
CO 133	NA5-27215T5	13433	401(3MTT17)	57	1330	1325	66.2
CO 134	NA5-27215T5	14179	401(3MTT16)	57	1328	1325	66.2
CO 159	1A67863-519	1212	424MT610	57	215	211	10.5
CO 161	1A67863-537	1254	404MT733	46	4910	5154	360.8
CO 208	1A67863-503	751	405MT605	57	511.0	527.5	26.4
CO 230	1A67863-509	1183	403MT706	55	1479	1471	73.4
CO 231	1A67863-529	1167	403MT707	55	535.3	525.3	26.3
CO 256	1B37878-501	1505	409MT646	47	1427.0	1446.2	72.3
CO 257	1B37878-501	1424	409MT647	47	1430.0	1446.2	72.3
CO 368	1A67862-505	605	406MT660	47	1425.0	1425.6	71.0*

* Second Issue Measurements

4.1.2.1 (Continued)

Meas. Number	P/N	Sensor S/N	Ref. Desig.	Temp. (°F)	Resistance (ohms) Meas.	Calc.	± Tol.
CO 369	1A67862-505	271	406MT661	62	1427.0	1471.0	73.5*
CO 370	1A67862-533	610	408MT735	47	4890	5165	361.6
CO 371	1A67862-533	635	408MT736	47	4920	5165	361.6
CO 2030	1B37878-511	1819	404MT760	57	528.0	527.5	26.4
CO 2031	1B37878-511	1484	404MT761	58	528.6	528.6	28.6
+	1B37878-507	1762	403A20	57	5070	5275	369.3
+	1B37878-507	1699	403A21	57	5090	5275	369.3
+	1B37878-507	1729	403A22	57	5090	5275	369.3

* Second Issue Measurements
\+ NASA Measurement No. Not Applicable to O2H2 Burner Voting Circuit

4.1.3 Preliminary Propulsion Leak and Functional Check (1B71877 D)

This checkout procedure defined the operations required to perform the leak and functional checks which certified the stage propulsion system preparatory to static firing. All portions pertaining to S-IB stages and postfire operations were deleted. The prefire test sequences performed during this checkout were initiated on 8 January 1969, and were completed on 10 February 1969. Leak check results for the individual propulsion system components are listed in Test Data Table 4.1.3.1.

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

A new cold helium fill module per E.O. 1B58006 BM was checked for internal leakage and relief valve cracking and reseat pressures. This checkout was made in the LOX service lab per procedure requirement, after which the module was installed on the stage.

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

4.1.3 (Continued)

check of the engine mainstage pressure switch diaphragm. The LOX and LH2 pressure switch checkout circuits were pressurized to 30 ±5 psia for these decay checks, the low pressure switch checkout circuit at 600 ±10 psia, the mainstage pressure switch checkout circuit at 550 ±10 psia, and the mainstage pressure switch diaphragm check at 400 ±10 psig. All decay rates were acceptable, as noted in the Test Data Table.

Stage integrity checks included high pressure proof tests of stage system spheres after verifying that no audible leakage existed for these systems. The ambient helium system and cold helium systems were checked for audible leakage with the spheres pressurized to 300 ±50 psig. The engine start system was checked audibly with the start tank at 250 ±50 psia. The engine control helium system was checked audibly at 300 + 0, -50 psig. Proof checks were then conducted with the ambient helium control and repressurization spheres pressurized to 3100 ±100 psig for 5 minutes, the engine start tank at 1300 ±25 psig for 2 minutes, the cold helium spheres at 1500 ±50 psia for 5 minutes, and the engine control bottle at 3000 ±50 psig for 2 minutes. Three-cycle checks were also made of the pickup and dropout pressures for the control helium regulator discharge pressure switch and the cold helium regulator backup pressure switch. The LOX and LH2 tank valves were cycled and verified audibly and by talkback. The tank systems were then checked for audible leakage, with the LOX tank pressurized to 5 psig and the LH2 tank at 3 psig. Finally, the LOX and LH2 tanks were pressurized to relief pressures for three-cycle checks of tank vent valve operation.

4.1.3 (Continued)

After completing stage integrity checks, vacuum readings for the stage vacuum jacketed ducts were taken per 1B49196.

The ambient helium system leak and flow checks were accomplished after a three-cycle relief pressure integrity test of the LOX chilldown pump purge system. A reverse leak check of the LOX and LH2 purge check valves, and an external leak check of the purge system were conducted after verifying purge system flow. The ambient helium fill module was checked for internal leakage. The check valves for the ambient helium fill system and the ambient LOX and LH2 repressurization systems were tested for reverse leakage. After a control valve functional check for the ambient LOX and LH2 repressurization modules, internal leak checks of the modules and the pneumatic power control module were performed. The control helium system and the LOX and LH2 ambient repressurization systems were checked for external leakage. The actuation control modules were checked for internal leakage under functional test conditions. A pressure decay check of the control system was then performed over a 30-minute pressure lockup period. Finally, the APS helium bottle fill manifold was checked for external leakage.

Thirteen external leaks were recorded during the ambient helium system leak checks. Five were corrected by gasket replacement, one by replacement of a cross, three by tightening B-nut connections, three were within the acceptable limits of specification control drawings, and one was corrected by replacing a check valve, P/N 1B40824-507, S/N 515, per FARR 500-703-563 because of external leakage at the inlet side of the valve. In addition to these external

4.1.3 (Continued)

leaks, the LH2 repressurization module backup check valve, P/N 1B67598-501, S/N 146, was rejected for excessive reverse flow leakage and replaced per FARR 500-703-407. The repeat leak check for reverse leakage with a new check valve installed was acceptable as listed in the Test Data Table.

The engine start system leak and functional checks were started with a drying procedure for the start tank vent valve actuator. This was followed by a leak check of the start tank vent control valve seat and a reverse leak check of the start tank initial fill check valve. After pressurizing the start tank to 500 ±10 psig with helium, the entire start system was checked for external leakage. The start bottle retention test obtained the necessary measurements for start tank temperature and pressure to calculate the helium pound-mass/hour loss. This decay rate for the start bottle was taken over a 60-minute period and was acceptable. The start system check was concluded with leak checks of the tank vent and relief valve, dump valve bellows, and an external leak check of the start tank vent system. FARR 500-702-974 documented inadvertent pressurizing of the start tank to 500 ±10 psig through the wrong quick-disconnect, the outlet port of the start tank vent and relief valve, P/N 557848, S/N 4092778. The vent and relief valve was removed and replaced for investigation of possible damage to the valve. After installation of the new valve, the start tank was pressurized through the proper fill system connection to complete the start system leak checks. No unacceptable leaks were detected.

The LH2 pressurization and repressurization systems tests started with a functional check of the O2H2 burner LH2 repressurization control valves, leak

4.1.3 (Continued)

checks of the burner LH2 repressurization control valve seat and pilot bleed valve, and a reverse leak check of the burner LH2 check valve. The LH2 repressurization system was pressurized to 450 $\pm$50 psig and checked for external leakage. The LH2 pressurization system was checked similarly for external leakage at 450 $\pm$25 psig. In addition, reverse leak checks were performed for the LH2 pressurization module check valve and the LH2 prepressurization check valve. Measurements of leakage rates for the main components of the LH2 repressurization and pressurization systems are listed in the test data table. Two external leaks were detected. One leak was corrected by tightening a B-nut connection and another by replacing a gasket.

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 recorded.

The LOX pressurization and repressurization systems were tested for reverse leakage of the cold helium bottle fill check valve, external leak checks of the LOX pressurization system, and the ambient and O2H2 burner LOX repressurization systems. Internal leakage rates were measured for the LOX pressurization module and the burner LOX repressurization module. In addition, reverse leak checks were performed for the LOX repressurization system check valve and the burner LOX repressurization check valve. Leakage rates for the major

4.1.3 (Continued)

system components are in the test data table. Five external leaks were detected. One leak was corrected by tightening a union and the others were corrected by replacement of a gasket, a union, an adapter, and a tube assembly. The tube assembly was replaced per FARR 500-703-474 to correct a leak at a B-nut connection.

After sampling the LOX tank to ensure 75% minimum helium concentration, leak checks were performed on the LOX tank and the O2H2 burner and engine LOX feed systems. Internal leak checks of the engine feed system checked for seat leakage of the LOX prevalve and chilldown shutoff valve, the engine LOX bleed valve, the engine main oxidizer valve, and for reverse leakage of the LOX chilldown return check valve. Then the LOX tank and the engine feed system were checked for external leakage. The LOX turbopump was checked for breakaway torque, running torque, and primary seal leakage. The LOX chilldown pump purge leak and pressure checks included a pump motor canister pressure check, a pump shaft seal leak check, and an external leak check of the pump purge circuit. Next, checks were made for seat leakage through the LOX boiloff valve, the LOX fill and drain valve, and the LOX main fill and replenish valve. The LOX fill and drain valve was also checked for primary shaft seal leakage. The LOX prevalve was checked for shaft seal leakage with the prevalve open and closed. The LOX primary seal drain lines were checked for external leakage. Leak checks of the O2H2 burner LOX shutdown valve and an external leak check from the LOX tank to the O2H2 burner LOX shutdown valve were performed, completing the LOX propellant system checks. Two external leaks were found during the LOX pressurization and repressurization systems leak checks. Both were corrected by tightening the connections.

4.1.3 (Continued)

After sampling the LH2 tank to ensure 75 percent minimum helium concentration, leak checks were performed on the LH2 tank and on the O2H2 burner and engine LH2 feed systems. Internal leak checks of the engine LH2 feed system checked for seat leakage of the LH2 prevalve and chilldown shutoff valve, the engine LH2 bleed valve, the engine main fuel valve, and checked for reverse leakage of the LH2 chilldown return check valve. The LH2 engine pump drain and purge check valves, the LH2 turbine seal cavity purge check valve, and the LOX turbine seal cavity check valve were checked for reverse leakage. The LH2 engine pump intermediate seal was checked for leakage. The LH2 engine pump drain check valve was also checked for forward flow. Then the LH2 tank and the engine feed system were checked for external leakage. The LH2 turbopump was checked for breakaway and running torque and for primary seal leakage. The LH2 prevalve shaft seal was leak checked with the valve opened and closed. The LH2 fill and drain valve was checked for shaft seal and seat leakage. The LH2 main fill and replenish valve was checked for seat leakage. Leak checks of the O2H2 burner LH2 propellant valve seat and the LOX shutdown valve seat were made, as well as an external leak check of the O2H2 burner propellant system. Four external leaks were found during the LH2 tank and feed systems checks, all of which were corrected by gasket replacement.

Leak and flow checks of the engine gas generator (GG) and exhaust system were conducted next, and included reverse leak checks of the GG LH2 purge check valve and the GG LOX purge check valve. Leak checks of the GG propellant valves, the start tank discharge valve gate seal, and the hydraulic pump shaft seal were also performed. A bleed flow check of the LH2 and LOX turbine seal

4.1.3 (Continued)

cavity was conducted. External leak checks of the GG and the exhaust system completed this portion of the test. Two external leaks were detected during this portion of the checkout. One was corrected by gasket replacement and the other was within the allowable leakage rate for engine copperplated Naflex seals.

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

Leak and flow checks of the engine pneumatics system included the helium control solenoid energized leak checks, the LOX intermediate seal purge flow checks, the ignition phase solenoid energized leak checks, the start tank discharge valve solenoid energized leak checks, the main stage control solenoid energized leak checks, the pressure actuated purge system leak checks, and the engine control bottle fill system leak checks. Also, the engine control bottle retention test was performed to determine the control bottle decay by calculating the helium pound-mass/hour-loss. Five external leaks were detected in the engine pneumatics system. One was corrected by replacement of a gasket and elbow. The four remaining leaks were within acceptable limits for the J-2 engine.

The LOX and LH2 vent system leak and flow checks included external leak checks of the LOX vent system and the LH2 ground and flight vent systems, plus internal

4.1.3 (Continued)

leak checks of the valves in the systems, including the LOX vent and relief valve, the LOX NPV valve, the LH2 vent and relief valve, the LH2 latching relief valve, the bidirectional vent valve, and the LH2 continuous vent valve. A summary of the internal leak checks is listed in the Test Data Table. Four areas of external leakage were recorded. One was corrected by gasket replacement and the others by tightening the connections.

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. Inspection results were acceptable.

Problem areas recorded on FARR tags that resulted from this checkout were limited to those previously discussed. However, seventy-eight revisions were recorded in the procedure for the following:

a. Thirty-two revisions concerned changes that were required to update or correct the procedure for errors, missing requirements, and tolerances.

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

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

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

e. One revision deleted or changed sections that were affected by stage configuration.

f. One revision deleted the purge system orifice flow measurements, scheduling same for postfire operations.

g. Three revisions authorized test gauge substitutions for system pressurization.

4.1.3 (Continued)

h. Two revisions authorized supply substitutions for system pressurization.

i. Eight revisions added steps required to support concurrent test procedures.

j. One revision authorized the setup procedure for the performance of Rocketdyne EFIR J2-38B, and the posttest return to original configuration.

k. One revision provided instructions to leak check newly installed ambient helium system check valves and plumbing per ECP 3006.

l. One revision specified modifications to pressurize systems during leak checks without the use of GSE power.

m. One revision concerned an investigation of an apparent out-of-tolerance leak check measurement which was later attributed to procedural error.

n. One revision approved the use of three television cameras instead of the required four during the stage integrity checks because video tape was available for only three cameras.

o. One revision provided instructions to close the LH2 continuous vent valve after connecting the override valve electrically.

p. One revision provided for B-nut torque checks after relocation of transducers.

q. One revision authorized a substitution for a facility LH2 vent system burst disc because the specified disc was not available.

r. Two revisions were written and subsequently voided prior to incorporation.

s. One revision corrected a portion of a previous revision.

4.1.3.1 Test Data Table, Propulsion Leak and Functional Check

Cold Helium Fill Module Relief and Internal Leakage Checks

Function	Measurement Cycle 1	Cycle 2	Cycle 3	Limits
Relief Valve				
Cracking Pressure (psig)	3200	3200	3200	3200-3500
Reseat Pressure (psig)	3100	3100	3100	3100-3500
Internal Leak Check at 3100 ±100 psig				
(a) Relief Valve Seat Leakage (scim)		0		5 max
(b) Dump Solenoid Seat Leakage (scim) (Pilot Bleed & Seat - Combined)		0.5		(a+b)
Internal Leak Check at 300 ±50 psig				
(c) Relief Valve Seat Leakage (scim)		0		18 max
(d) Dump Solenoid Seat Leakage (scim) (Pilot Bleed & Seat - Combined)		0		(c+d)

Calip Pressure Switch Leak Checks

Function	Measurement	Limits
LOX Press Sw C/O Circuit Decay (psi)	0.5	0.5 max/5 minutes
LH2 Press Sw C/O Circuit Decay (psi)	0	0.5 max/5 minutes
Low Press Sw C/O Circuit Decay (psi)	1.0	5.0 max/5 minutes
Eng Mnstg Press Sw Diaph Decay:		
Initial (psig)	400	*
Final (psig)	394	*
Decay (psi)	6	10.0 max/15 minutes
Mnstg #1 Press Sw C/O Circuit Decay (psi)	4.0	5.0 max/5 minutes
Mnstg #2 Press Sw C/O Circuit Decay (psi)	0	5.0 max/5 minutes

Stage Integrity Checks

Function	Measurement Run 1	Run 2	Run 3	Limits
Control He Reg Disch P/S:				
Pickup Press (psia)	605	605	605	600 ± 21
Dropout Press (psia)	500	495	490	490 ± 31
Cold He Reg Backup P/S:				
Pickup Press (psia)	475	475	475	444 to 491
Dropout Press (psia)	355	355	355	329 to 376
LOX Tank Relief Cycle (psia)	43.9	43.9	43.9	41 to 44
LH2 Tank Relief Cycle (psia)	32.7	32.7	32.7	31 to 34
LOX C/D Mtr Canister Press (psia)	80.7	80.2	80.2	100 max

* Limits Not Specified

4.1.3.1 (Continued)

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

Check Valve Function	S/N	Measurement	Limits
LOX Vent Purge (scim)	147	0	10 max
LOX Fill & Drain Purge (scim)	140	0	10 max
LH2 Fill & Drain Purge (scim)	143	0	10 max
LH2 Vent Purge (scim)	141	0	10 max

Ambient He Fill Module Internal Leak Checks (P/N 1A57350-507, S/N 0234)

Function	Measurement	Limits
Check Valve Reverse Leakage (scim)	0	0
Dump Valve Seat Leakage (scim)	0	5

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

Function	S/N	Measurement	Limits
LOX Repress Mod Check Vlv (scim)	82	0	10 max
LH2 Repress Mod Backup Check Valve (scim)	202	0	10 max
LH2 Repress Mod Check Vlv (scim)	-	0	10 max
He Fill Mod Backup Check Vlv (scim)	130	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	*
Module Dump Vlv Seat Leakage (scim)	0	*
Mod Dump Vlv Pilot Bleed (scim)	0	*
Mod Dump Vlv Seat & Pilot Bleed Leakage (scim)	0	9 max
Cont Vlv (L2) Pilot Bleed Leakage (scim)	0	*
Cont Vlv (L2) Seat & Pilot Bleed Leakage (scim)	0	9 max
Cont Vlv (L3) Pilot Bleed Leakage (scim)	0	*
Cont Vlv (L3) Seat & Pilot Bleed Leakage (scim)	0	9 max

LH2 Repress System

Function	Measurement	Limits
Cont Vlv (L3) Seat Leakage (scim)	0	*
Cont Vlv (L2) Seat Leakage (scim)	0	*

* Limits Not Specified

4.1.3.1 (Continued)

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

Pneumatic Power Control Module Internal Leak Check (P/N 1A58345-529, S/N 1057)

Function	Measurement	Limits
Control He Shutoff Seat Leakage (scim)	0.0	10 max
Control Module Reg Lockup Press (scim)	532.0	550 max

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

Function	S/N	Normal	Open	Closed	Boost	Limits
O2H2 Burner LOX S/D Vlv Act Cont Module Leakage (scim)	10	0.0	0.0	0.0	-	3 max
O2H2 Burner LOX S/D Vlv Act Leakage (scim)	-	-	0.0	-	-	*
O2H2 Burner LOX S/D Vlv Shaft Seal Leakage (scim)	-	-	0.0	-	-	*
O2H2 LOX S/D Vlv Act and Shaft Seal Leakage Total (scim)	-	-	0.0	0.0	-	20 max
LOX Vent Act Cont Module Leakage (scim)	126	0.0	0.0	-	0.0	3 max
LOX Vent Vlv Act Seal Leakage (scim)	-	-	0.0	-	-	75 max
LH2 F&D Act Cont Module Leakage (scim)	157	0.0	0.0	-	-	3 max
LH2 F&D Act Seal Lkg (scim)	-	-	0.0	0.0	-	350 max
LH2 F&D Act Module Lkg (scim)	-	-	0.0	-	-	3 max
LOX F&D Act Cont Module Leakage (scim)	111	0.0	0.0	-	0.0	3 max
LOX F&D Act Seal Lkg (scim)	-	-	0.0	0.0	-	350 max
O2H2 Burner LH2 Prop Vlv Act Cont Module Lkg (scim)	134	0.0	0.0	0.0	-	3 max
Orifice Bypass Vlv Act Cont Module Lkg (scim)	198	0.0	0.0	0.0	-	3 max
Orifice Bypass Vlv Actuator Lkg (scim)	-	-	0.0	-	-	*
Orifice Bypass Vlv Shaft Seal Lkg (scim)	-	-	0.0	-	-	*

* Limits Not Specified

4.1.3.1 (Continued)

Function	S/N	Normal	Open	Closed	Boost	Limits
Orifice Bypass Vlv Act & Shaft Seal Lkg Total (scim)	-	-	0.0	0.0	-	20 max
LH2 Vent Act Cont Module Lkg (scim)	152	0.0	0.0	-	0.0	3 max
LH2 Vent Vlv Open Act Seal Lkg (scim)	-	-	0.0	-	-	75 max

Function	S/N	Normal	Open	Open Latch	Limits
LOX NPV Act Cont Mod Lkg (scim)	175	0.0	0.0	0.0	3 max
LOX NPV Open Act Piston Seal Leakage (scim)	-	-	0.0	-	150 max

Function	S/N	Normal	Closed	Limits
Prevlv-C/D Vlv Act Cont Mod (scim)	118	0.0	-	3 max
Prevlv Act Control (scim)	-	-	0.0	3 max
C/D Act Control (scim)	-	-	0.0	3 max
LOX Prevlv Microsw Housing (scim)	-	-	0.0	1.2 max

Function	S/N	Normal	Flight	Ground	Limits
Bidirect Vent Vlv Act Cont Mod	50	0.0	0.0	0.0	3 max
Bidirect Vent Vlv Act Piston Lkg (scim)	-	-	0.0	0.0	3 max

Function	S/N	Normal	Open	Latching	Limits
LH2 Latching Relief Vlv Cont Mod (scim)	185	0.0	0.0	1.0	3 max
LH2 Latching Relief Vlv Open Act Piston Seal Lkg (scim)	-	-	0.0	-	150 max

Pneumatic Control System Decay Checks

Function	Measurement Initial	Measurement Final	Limits
Reg Disch Press - Vlv Pos, Normal (psig)	538	527	*
Reg Disch Press - Vlv Pos, Activated (psig)	516	365	*

* Limits Not Specified

4.1.3.1 (Continued)

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)	0.00236	0.0066 max

LH2 Repressurization System Leak Checks

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

LH2 Pressurization System Leak Check

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

Thrust Chamber Checks

Function	Measurement	Limits
LOX Dome		
Purge Check Valve Reverse Lkg (scim)	0.4	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)	25.0	20 min
Jacket Purge Check Vlv Rev Lkg (scim)	15	25 max

* Limits Not Specified

4.1.3.1 (Continued)

LOX Pressurization & Repressurization System Leak Checks

Function	Measurement	Limits
Cold Helium Sphere		
Fill Check Vlv Rev Lkg (scim)	0.0	0
Shutoff Vlv Seat & Pilot Vlv Lkg-High Press (scim)	0.0	11.3 max
Shutoff Vlv Seat & Pilot Vlv Lkg-Low Press (scim)	0.0	12.5 max
Dump Vlv Relief and Pilot Bleed Lkg (scim)	0.0	12.5 max
Dump Vlv Seat Lkg (scim)	0.0	0
LOX Press Module Internal		
Hot Gas Bypass Vlv Seat & Pilot Bleed Lkg (scim)	140	1000 max
O2H2 Burner LOX Repress System		
Burner Control Valve Seat Leakage (scim)	0.0	*
Burner Control Valve Pilot Bleed Lkg (scim)	0.0	*
Burner Module Control Vlv Internal Lkg (scim)	0.0	12 max
Combined Burner Check Vlv & Cont Vlv Seat Leakage (scim)	0.0	*
Burner Check Vlv Rev Leakage (scim)	0.0	0
Burner Coil Leakage (scim)	0.0	0
Cold Helium System		
LOX Tank Prepress Check Vlv Rev Lkg (scim)	0.0	0

LOX Tank, O2H2 Burner & Engine Feed System Leak Checks

Function	Measurement	Limits
LOX Tank Helium Content		
Top (%)	99.1	75 min
Bottom (%)	99.1	75 min
Engine Feed Sys Internal Leak Checks		
LOX Prevlv & Chilldown Shutoff Vlv Seat & Chilldown Return Check Vlv Lkg (scim)	68.0	*
LOX Chilldown Ret Check Vlv Rev Lkg (scim)	2.2	350 max
LOX Prevlv & Chilldown Shutoff Vlv Combined Seat Leakage (scim)	55.8	150 max
LOX Bleed Vlv & Chilldown Return Check Vlv Rev Leakage (scim)	2.2	*
LOX Bleed Vlv Seat Leakage (scim)	0.0	300 max
Main Oxidizer Vlv Seat Leakage (scim)	0.0	10 max
LOX Turbopump Checks		
Pump Primary Seal Leakage:		
Max (scim)	35	350 max
Min (scim)	35	*
Turbine Torque:		
Breakaway (in/lbs)	50	1000 max
Running (in/lbs)	40	200 max

* Limits Not Specified

4.1.3.1 (Continued)

Function	Measurement	Limits
LOX Chilldown Pump Purge Flow Checks		
Motor Canister Pressure (psia)	53	51-65
Pump Shaft Seal Flow Tank Pressurized & Purge On (scim)	0.0	50 max
Pump Shaft Seal Flow - LOX Tank Side (scim)	0.0	*
Pump Shaft Seal Flow - Motor Canister Side (scim)	0.0	*
LOX Boiloff Valve Flow Check		
Valve Seat Leakage (scim)	0	10 max
LOX Valves Checks		
Prevalve Shaft Seal Leakage:		
Open Position (scim)	0.0	5 max
Closed Position (scim)	0.0	*
Prevalve Actuator Internal Leakage (scim)	15	*
Prevalve Total Internal Leakage (scim)	15	300 max
F&D Vlv Seat Leakage (scim)	10	100 max
F&D Vlv Primary Shaft Seal Lkg (scim)	0.0	31 max
LOX Main Fill, Replenish, & Fill & Drain Valve Seat Leakage (scim)	21	*
LOX Main Fill & Replenish Vlv Seat Lkg (scim)	11	*
O2H2 Burner LOX Shutdown Valve Checks		
Valve Actuator Bellows Lkg (scim)	0.0	*
Valve Seat Leakage (scim)	0.0	50 max

LH2 Tank, O2H2 Burner & Engine Feed System Leak Checks

Function	Measurement	Limits
LH2 Tank Helium Content		
Top (%)	99.9	75 min
Bottom (%)	99.6	75 min
Engine Feed System Internal Leak Checks		
LH2 Prevlv & Chilldown Shutoff Vlv & C/D Return Check Vlv Rev Lkg (scim)	0.0	*
LH2 C/D Ret Check Vlv Rev Lkg (scim)	0.0	350 max
LH2 Prevlv & C/D Shutoff Vlv Combined Seat Leakage (scim)	0.0	150 max
LH2 Bleed Vlv & C/D Return Check Vlv Rev Leakage (scim)	2.0	*
LH2 Bleed Vlv Seat Leakage (scim)	2.0	300 max
MOV & MFV Combined Seat Leakage (scim)	0.0	*
Main Fuel Vlv Seat Leakage (scim)	0.0	10 max
Engine Purge System Leak Checks		
LH2 Pump Drain Check Vlv Rev Lkg (scim)	0.0	25 max

* Limits Not Specified

4.1.3.1 (Continued)

Function	Measurement	Limits
LH2 Pump Drain Check Vlv Fwd Flow 30 psi (scim)	0.0	30 max
LH2 Pump Drain Check Vlv Fwd Flow 60 psi (scim)	8,050.0	2420 min
LH2 Pump Purge Check Vlv Rev Lkg (scim)	0.0	25 max
LH2 Pump Intermediate Seal Lkg (scim)	120.0	500 max
LH2 Turbine Seal Cavity Prg Check Vlv Rev Leakage (scim)	0.0	25 max
LOX Turbine Seal Cavity Prg Check Vlv Rev Leakage (scim)	0.0	25 max
LH2 Turbopump Checks		
LH2 Pump Primary Seal Leakage:		
Max (scim)	2.1	350 max
Min (scim)	0.6	*
Turbine Torque:		
Breakaway (in/lbs)	25.0	1000 max
Running (in/lbs)	25.0	300 max
LH2 Valves Leak Checks		
Prevalve Shaft Seal Leakage:		
Open Position (scim)	0.0	5 max
Closed Position (scim)	0.0	10 max
Fill & Drain Valve Seat Leakage (scim)	0.0	100 max
Fill & Drain Vlv Primary Shaft Seal Leakage (scim)	0.3	31 max
LH2 Main Fill, Replenish, & Fill & Drain Valves Seat Leakage (scim)	0.0	*
LH2 Main Fill & Replenish Valve Seat Leakage (scim)	0.0	*
O2H2 Burner LH2 System Leak Check		
Combined Burner LH2 Prop Vlv & LOX S/D Vlv Seat Leakage (scim)	0.0	*
Burner LH2 Prop Valve Seat Leakage (scim)	0.0	0.7 max

Engine GG and Exhaust System Leak and Flow Tests

Function	Measurement	Limits
GG Fuel Purge Ck Vlv Rev Lkg (scim)	0.0	25 max
LH2 Turbine Seal Leakage (scim)	430	3000 scim max Above 2nd E&M Lkg Value (1)
LOX Turbine Seal Leakage (scim)	310	350 max
STDV Gate Seal Leakage (scim)	1.0	20 max
OTBV Shaft Seal Leakage (scim)	0.0	15 max
Oxid Manifold Carrier Flange Bleed (scim)	0.0	20 max

* Limits Not Specified
(1) 2nd E&M Leakage Valve = 390 scim

4.1.3.1 (Continued)

Function	Measurement	Limits
GG LOX Purge Check Vlv Rev Lkg (scim)	0	15 max
Hydraulic Pump Shaft Seal Lkg (scim)	2.7	228 max
GG LOX Prop Vlv Seat & LOX Pump Shaft Seal Leakage (scim)	0	20 max
Combined GG LOX & LH2 Prop Vlv Seat & Pump Shaft Seal Lkg (scim)	0	*
GG LH2 Prop Vlv Seat Lkg & Fuel Pump Omni Seal Lkg (scim)	0	15 max

Engine Pump Purge Leak Checks

Function	Measurement	Limits
Pump Purge Module Internal Leak Checks		
Purge Valve Seat Leakage (scim)	0.0	12 max
Purge Discharge Pressure (psig)	100	67 to 110
Pump Purge Flow Checks		
GG Fuel Purge Flow (scim)	3950	2400 min
LOX Turbine Seal Purge Flow (scim)	4000	2400 min
LH2 Turbine Seal Purge Flow (scim)	4000	2400 min
Fuel Pump Seal Cavity Purge Flow (scim)	340	200 min

Engine Pneumatics Leak Checks

Function	Measurement	Limits
Helium Control Solenoid Energized Leak Checks		
Low Press Relief Vlv Seat Lkg (scim)	0.0	5 max
Low Press Relief Vlv Pilot Bleed Lkg (scim)	0	10 max
Fast Shutdown Vent Port Diaph Lkg (scim)	0.0	3 max
Press Act Purge Vlv Diaph Lkg (scim)	0.0	3 max
Int Pneu Sys Lkg (He Cont Sol On) (scim)	0	20 max
LOX Pump Intermediate Seal Purge Leak Checks		
Seal Leakage Pump Direction (scim)	0	*
Seal Leakage Turbine Direction (scim)	14.5	*
Seal Leakage Total (scim)	14.5	850 max
Seal Purge Check Vlv Overboard Flow (scim)	2450	*
Seal Purge Flow (scim)	2464.5	1300 to 3500
Ignition Phase Solenoid Engergized Leak Checks		
Start Tnk Disch Vlv 4-Way Sol Seat Lkg (scim)	0	15 max
Internal Pneu Sys Lkg (Ign Phase Sol On) (scim)	14.5	20 max
Start Tank Discharge Valve Solenoid Energized Leak Checks		
STDV 4-Way Sol Seat Lkg (Energized) (scim)	1.8	15 max

* Limits Not Specified

4.1.3.1 (Continued)

Function	Measurement	Limits
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)	14	20 max
Pressure Actuated Purge System Leak Check		
Press Act Purge Vlv Vent Seat Lkg (scim)	0.0	10 max
Press Act Purge Vlv Inlet Seat Lkg (scim)	0.0	10 max
MOV Seq Valve Lip & Shaft Seal Lkg (scim)	0.0	*
MOV Seq Valve Lip & OTBV Piston Lkg (scim)	0.0	5 max
Engine Control Bottle Fill System Leak Check		
Eng Cont Bot Fill Check Vlv Rev Lkg (scim)	0.0	3 max
Eng Cont Bot Decay Check (Delta M) (lb-mass/hr)	0.030	0.036 max

LOX & LH2 Vent System Leak Checks

Function	Measurement	Limits
LOX Vent System Leak Checks		
Combined LOX Vent & Relief Vlv & NPV Seat & Pilot Bleed Lkg (scim)	0.0	60 max
Combined LOX V&R and NPV Seat, Pilot Bleed & Boost Piston Seal Lkg (scim)	265	*
Combined LOX V&R and NPV Boost Piston Seal Lkg (scim)	265	1728 max
Propulsive Vent System Leak Checks		
Cont Vent & Orifice Bypass Vlv Seat Lkg (scim)	0.0	16 max
Nonpropulsive Vent System Leak Checks		
Direct Vent Vlv Blade Shaft Seal Lkg - Flight Pos (scim)	0.0	3.5 max
Direct Vent Vlv Seat Lkg (Flt Pos) (scim)	0	50 max
Direct Vent Vlv Blade Shaft Seal Lkg - Ground Pos (scim)	0	3.5 max
Ground Vent System Leak Checks		
Combined LH2 V&R & LH2 Latching Vlv Combined Seat & Pilot Bleed Lkg (scim)	0	60 max
Combined LH2 V&R Vlv & LH2 Latching Relief Vlv Seat, Pilot Bleed, & Boost Piston Seal Lkg (scim)	795	*
LH2 V&R Vlv & LH2 Latching Vlv Boost Piston Seal Lkg (scim)	795	1728 max
LH2 Vent Vlv Open Act Seal Lkg (scim)	0	*
Direct Vent Vlv Seat Lkg (Gnd Pos) (scim)	0	*

* Limits Not Specified

4.1.4 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 8 January and 9 January 1969, and was verified as acceptable on 12 January 1969. Preliminary operations included setup and connection of the servicer to the TCS and inspection of the TCS panels for open equipment mounting bolt holes and properly torqued bolts. The TCS was pressurized to 32 ±1 psig with freon gas and leak checked with the gaseous leak detector, P/N 1B37134-1. The areas checked for leakage included all TCS B-nuts and fittings, manifold weld areas, panel inlet and outlet boss welds, and manifold bellows. No leakage was detected.

The TCS was purged with gaseous nitrogen, then water/methanol fluid was circulated through the system. Water/methanol samples were taken from the fluid sample pressure valve and the fluid sample return valve 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).

4.1.4 (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 supply and return temperatures, while maintaining a water/methanol flow rate of 7.8 $\pm$0.2 gpm. The differential pressure was recorded as 17.2 psid while supply and return temperatures were recorded at $54^{\circ}F$ and $52^{\circ}F$, respectively.

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

There were no revisions recorded against the procedure, nor were any FARR's generated as a result of the checkout.

4.1.5 Umbilical Interface Compatibility Check (1B64316 E)

After connecting the forward and aft umbilical cables, this manual checkout provided the test sequences which were used to check the design specifications and the continuity of the stage umbilical wiring prior to stage power turn on. 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 checkout was successfully performed on 8 January and 9 January 1969. A series of resistance checks were made at specified test points on the signal distribution unit, P/N 1A59949-1, using test point terminal 463A1A5-J43FF as the common test point for all measurements. These measurements verified that all wires and connections were intact and of the proper material and wire gauge, and that all resistance values and loads were within the design requirement limits. The test points, circuit functions, measured resistances, and resistance limits are shown in Test Data Table 4.1.5.1.

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

a. One revision corrected a typographical error.

b. One revision established a higher resistance limit for test point A2J30-W because of the installation of the LOX emergency vent cable which contained an additional diode.

c. One revision accepted the infinite resistance measurement at test point CB-11-2. The value was expected because the magnetic latch relay, K10, on the 28 volt aft power distribution assembly was in the set position preventing the correct reading from being obtained at the patch panel. The resistance reading was verified at the stage at 75 ohms.

4.1.5 (Continued)

d. Two revisions investigated out-of-tolerance resistance readings that resulted from magnetic latch relays being in the set position.

e. One revision established new limits for resistance measurements affected by magnetic latch relays being in the set position.

4.1.5.1 Test Data Table, Umbilical Interface Compatibility Check

Reference Designation 463A2

Test Point	Function	Meas. Ohms	Limit Ohms
A2J29-C	Cmd., Ambient Helium Sphere Dump	28	10-60
CB-8-2	Cmd., Engine Ignition Bus Pwr Off	Inf	Inf
CB-9-2	Cmd., Engine Ignition Bus Pwr On	28	5-100
CB-10-2	Cmd., Engine Control Bus Pwr Off	Inf	Inf
CB-11-2	Cmd., Engine Control Bus Pwr On	Inf†	5-100
A2J29-N	Cmd., Engine He Emerg Vent Control On	50	10-60
A2J29-P	Cmd., Fuel Tnk Repress He Dump Vlv Open	38	10-60
A2J29-Y	Cmd., Start Tnk Vent Pilot Vlv Open	49	10-60
CB-4-2	Cmd., LOX Tank Cold He Sphere Dump	30	10-60
A2J29-c	Cmd., LOX Tnk Repress He Sphere Dump	37	10-60
A2J29-h	Cmd., Fuel Tnk Vent Pilot Vlv Open	210	10-300
	(Same, reverse polarity)	Inf	500k min
A2J29-i	Cmd., Fuel Tnk Vent Vlv Boost Close	61	10-80
	(Same, reverse polarity)	Inf	500k min
A2J29-q	Cmd., Amb He Supply Shutoff Vlv Close	55	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	210	10-300
	(Same, reverse polarity)	Inf	500k min
A2J30-X	Cmd., LOX Vent Valve Close	64	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	64	10-80
	(Same, reverse polarity)	Inf	500k min
A2J30-b	Cmd., LOX F&D Valve Boost Close	31	10-40
A2J30-c	Cmd., LOX F&D Valve Open	31	10-40
A2J30-d	Cmd., Fuel F&D Valve Boost Close	31	10-40
A2J30-e	Cmd., Fuel F&D Valve Open	31	10-40
A2J42-F	Meas. Bus +4D111 Regulation	69	20 min
A2J35-y	Meas. Bus +4D141 Regulation	120	50 min
A2J6-AA	Sup. 28V Bus +4D119 Talkback Power	100	60-120

† See revision c

4.1.5.1 (Continued)

Reference Designation 463A1

Test Point	Function	Meas. Ohms	Limit Ohms
A5J41-A	Meas. Bus +4D131 Regulation	440	20 min
A5J41-E	Meas. Bus +4D121 Regulation	2.8k	1.6k min
A5J53-AA	Sup. 28V +4D119 Fwd Talkback Pwr	80	60-100

4.1.6 APS Interface Compatibility Checkout (1B49558 B)

Initiated, accomplished, and accepted on 8 January 1969, this manual checkout specified and provided instructions for compatibility and continuity test requirements that were performed subsequent to installation of the auxiliary propulsion system (APS) simulators, P/N 1B56715-1, and prior to the operational checkout of stage systems pertinent to APS circuitry.

The check was started with a visual inspection of all plugs and connectors involved in this test for bent or broken pins and other physical defects. Proper connection between the control relay packages, the aft skirt components, and the APS simulators was verified by point-to-point resistance measurements as shown in Test Data Table 4.1.6.1.

No FARR's were generated as a result of this test. One revision was written which deleted the requirement to measure the resistance levels from test point 404A4J7, pins y and z to stage ground, because these pins were no longer associated with the APS units since incorporation of WRO S-IVB-4513.

4.1.6.1 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

4.1.6.1 (Continued)

Test Point	Component Nomenclature	Meas. Ohms	Limit Ohms
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	29	25 ± 5
404A71A19 J4 D	415A8L6 Eng. 1 Valve 3	29	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	29	25 ± 5
404A71A19 J4 H	415A8L8 Eng. 1 Valve 4	29	25 ± 5
404A71A19 J4 J	415A10L1 Eng. 3 Valve A	29	25 ± 5
404A71A19 J4 K	415A10L5 Eng. 3 Valve 1	29	25 ± 5
404A71A19 J4 L	415A10L2 Eng. 3 Valve C	29	25 ± 5
404A71A19 J4 M	415A10L6 Eng. 3 Valve 3	29	25 ± 5
404A71A19 J4 N	415A10L3 Eng. 3 Valve B	29	25 ± 5
404A71A19 J4 P	415A10L7 Eng. 3 Valve 2	29	25 ± 5
404A71A19 J4 R	415A10L4 Eng. 3 Valve D	29	25 ± 5
404A71A19 J4 S	415A10L8 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	28	25 ± 5
404A71A19 J4 V	415A9L2 Eng. 2 Valve C	28	25 ± 5
404A71A19 J4 W	415A9L6 Eng. 2 Valve 3	29	25 ± 5
404A71A19 J4 X	415A9L3 Eng. 2 Valve B	28	25 ± 5
404A71A19 J4 Y	415A9L7 Eng. 2 Valve 2	28	25 ± 5
404A71A19 J4 Z	415A9L4 Eng. 2 Valve D	29	25 ± 5
404A71A19 J4 a	415A9L8 Eng. 2 Valve 4	29	25 ± 5
404A4 J7 r	414A5L1	570	550 - 650
404A4 J7 d	414A5L1	590	550 - 650
404A4 J7 p	414A6L1	550	550 - 650
404A4 J7 x	414A1L1	550	550 - 650
404A4 J7 f	414A1L1	600	550 - 650
404A4 J7 v	414A2L1	550	550 - 650

4.1.6.1 (Continued)

Test Point		Component Nomenclature	Meas. Ohms	Limit Ohms
404A4	J7 m	414A6L2	550	550 - 650
404A4	J7 t	414A2L2	560	550 - 650
404A4	J7 z	Spare	*	10 meg min
404A4	J7 q	415A5L1	550	550 - 650
404A4	J7 c	415A5L1	600	550 - 650
404A4	J7 n	415A6L1	550	550 - 650
404A4	J7 w	415A1L1	550	550 - 650
404A4	J7 e	415A1L1	590	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	*	10 meg min
404A2A16	J2 B	414A7L1 Eng. 4 Valve A	560	550 - 650
404A2A16	J2 C	414A7L2 Eng. 4 Valve 1	560	550 - 650
404A2A16	J2 A	415A7L1 Eng. 4 Valve A	560	550 - 650
404A2A16	J2 D	415A7L2 Eng. 4 Valve 1	550	550 - 650

* See Revision Discussion

4.1.7 Common Bulkhead Vacuum System (1B49286 K)

The purpose of this manual checkout, initiated on 9 January 1969, was to ensure that the common bulkhead, P/N 1A39309-501, was free of leakage conditions and acceptable for propellant loading and static acceptance firing of the J-2 engine.

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

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

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

4.1.7 (Continued)

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

After 96 hours of vacuum pumpdown, the vacuum supply switch was turned off; the evacuation supply switch was set to evacuate the bottles; then, the 48-hour bulkhead decay check was started. The indicated bulkhead pressure at the start was recorded as 0.25 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 percent pure argon was connected to the bulkhead GN2 supply line. The bulkhead GN2 purge hand valve was opened, the evacuation supply switch was set to evacuate the bulkhead, and the purge supply regulator was set to 2.5 psig. The argon purge was run for 96 hours. After the argon purge was completed, the argon bottle was removed, and the bulkhead vacuum system was secured.

The bulkhead leak check was accomplished next. Bulkhead pressure was determined to be 14.7 psia. The LOX tank was pressurized to 29 ± 1 psia, and the LH2 tank was pressurized to 25 ± 1 psia. This pressure was maintained for 12

4.1.7 (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 10 February 1969.

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

a. One revision provided instructions to checkout the test stand vacuum system prior to starting the test procedure.

b. One revision replaced the mercury manometer with an absolute pressure gauge to check the command bulkhead pressure transducers, as authorized by WRO S-IVB-4721.

c. One revision provided instructions to continue the 96-hour vacuum pumpdown during the weekend with GSE and stage power secured.

d. One revision provided instructions to resume the 96-hour bulkhead vacuum pumpdown using GSE power at the beginning of the week.

e. Two revisions modified portions of previous revisions.

f. One revision was used to document the gas analysis results of a second argon bottle, which was used to purge the common bulkhead.

g. Two revisions provided instructions to ensure that the bulkhead evacuation was not interrupted when GSE power was cycled on and off.

h. One revision provided required changes in the procedure because stage power was not available at the beginning of the vacuum pumpdown.

i. One revision added a requirement to close a hand valve to ensure that the bulkhead system did not lose vacuum during weekend securing. This revision also added the requirement, to enter the vacuum pump off time into the data table, when the system was secured.

4.1.8 Hydraulic System Setup and Operation (1B41005 C)

The purpose of this manual procedure, initiated on 9 January 1969, and completed on 17 February 1969, 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 X458912; the hydraulic pitch and yaw actuator assemblies, P/N's 1A66248-507, S/N's 77 and 66; the main hydraulic pump, P/N 1A66240-505, S/N X457813; and the accumulator/reservoir assembly, P/N 1B29319-519, S/N 00040, 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 to a pressure of 2355 psig, and the stage air bottle was charged to a pressure of 475 $\pm$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

4.1.8 (Continued)

in pressure, but was less than 4400 psig. The stage hydraulic system was then checked for leaks. 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 ±50 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.

An actuator center check was performed to determine the differential between the mechanical center and the hydraulic center for each actuator. With the midstroke locks installed on the hydraulic actuators, the vernier scales were adjusted to read zero, then the midstroke locks were removed. The HPU was turned on, and the hydraulic system pressure was brought up to 3650 ±50 psig. The pitch and yaw vernier scales were read, and the values were recorded. The HPU was turned off, and the midstroke locks were reinstalled.

The engine deflection clearance check was accomplished next. The gimbal control unit (GCU), P/N 1B50915, was installed and set up per H&CO 1B53382. The J-2 engine bellows protective covers were removed; and the platform extension, P/N 1B70620, was removed from the engine area. The J-2 engine restrainer and the hydraulic actuator midstroke locks were removed. 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 to obtain fully extended and retracted actuator positions for the engine while inspection for any possible interference was conducted. By returning the pitch and yaw controls to center, the actuators were positioned to center; and the HPU was

4.1.8 (Continued)

turned off. The midstroke locks and the J-2 engine bellows protective covers were reinstalled.

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 and accumulator GN2 pressure, D043. The reservoir oil level was checked at zero and one hundred percent by parameter L504.

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

A check to determine the pressure decay of the stage air bottle was next. The stage air bottle was charged to 460 psig. After a 24 hour period, the pressure was remeasured and found to be 458.1 psig. This was within the acceptable decay rate of 5 psi per hour.

4.1.8 (Continued)

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

The simulated static firing support test was then performed. This checkout was required to simulate the engine driven hydraulic pump flow capabilities during simulated static firing. The HPU was turned on approximately 20 seconds

4.1.8 (Continued)

prior to simulated engine start, and the hydraulic system pressure was set at 3700 psig. After simulated engine cutoff, the HPU was turned off.

The shutdown sequence of this checkout included a final air content test which provided the information necessary for system analysis by discharging a portion of the internal system fluid volume overboard. The volume discharged was determined to be a function of the fluid temperature measurement to provide space in the reservoir for fluid thermal expansion underground 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 10 milliliters of fluid bled was less than the 16 milliliters maximum allowable as specified per design requirements.

There were no FARR's generated as a result of this procedure. However, additional checkout was performed due to subsequent replacement of the accumulator/reservoir assembly, P/N 1B29319-519, S/N 00026; with P/N 1B29319-519, S/N 00040, per FARR 500-703-482. The repeat tests were performed per revisions recorded in the procedure. Fourteen revisions were recorded in the procedure for the following:

a. Three revisions clarified or corrected errors in the procedure.

b. One revision provided instructions for filling the hydraulic system reservoir with fluid because the fluid level indication was low.

4.1.8 (Continued)

c. One revision provided instructions for a special leak check of the GN2 accumulator vent relief valve.

d. One revision provided for recharging the GN2 accumulator.

e. Two revisions provided instructions for additional fill and flush routine after replacement of the accumulator/reservoir.

f. One revision provided for rechecking engine deflection clearance after completion of electrical cable wrapping in the engine area.

g. Two revisions investigated indications of a slowly decreasing reservoir oil level measurement noted during previous testing (IST). One source of leakage was detected, a reverse flow leak through the check valve located downstream from the HPU supply hose quick-disconnect; however, this leak was within the allowable reverse leakage rate. The cause of the problem during IST was attributed to probable leakage through the HPU shutoff valve in the reservoir cycling hose due to failure to completely close the valve.

h. One revision temporarily depressurized the stage air bottle and the GN2 accumulator to permit removal and replacement of the GN2 temperature transducer for measurement C138, which had given erratic indications during previous testing.

i. One revision provided for rechecking engine deflection clearance after completion of engine diffuser hose routing.

j. One revision deleted final hydraulic system fluid refill instructions because the system did not require refilling prior to shutdown.

4.1.8.1 Test Data Table, Hydraulic System Setup and Operation

Test Description	Name	Location	Actual	Requirement
Actuator Center Check (System Unpressurized)	Pitch Vernier	Pitch Actuator	0 inches	0 inches
	Yaw Vernier	Yaw Actuator	0 inches	0 inches
	Pitch Position	TCC	-0.04 degrees	Ref. Only

4.1.8.1 (Continued)

Test Description	Name	Location	Actual	Requirement
	Yaw Position	TCC	0.03 degrees	Ref. Only
Actuator Center Check (System Pressurized)	Pitch Vernier	Pitch Actuator	0 inches	Ref. Only
	Yaw Vernier	Yaw Actuator	0 inches	Ref. Only
	Pitch Position	TCC	0.06 degrees	Ref. Only
	Yaw Position	TCC	0.02 degrees	Ref. Only

Engine Gimbal Test

Name	Location	Command Position	Actuator Position	Output Voltage
Pitch Actuator Position (deg.)	TCC	0°	0.06°	2.485 vdc
		$+1^\circ$	1.00°	2.162 vdc
		$+2^\circ$	2.02°	1.815 vdc
		$+1^\circ$	1.05°	2.148 vdc
		0°	0.06°	2.483 vdc
Pitch Actuator Position (deg.)	TCC	0°	0.06°	2.483 vdc
		-1°	-0.90°	2.808 vdc
		-2°	-1.86°	3.133 vdc
		-1°	-0.93°	2.818 vdc
		0°	0.03°	2.491 vdc
Yaw Actuator Position (deg.)	TCC	0°	0.08°	2.526 vdc
		$+1^\circ$	1.15°	2.893 vdc
		$+2^\circ$	2.23°	3.250 vdc
		$+1^\circ$	1.11°	2.874 vdc
		0°	0.08°	2.522 vdc
Yaw Actuator Position (deg.)	TCC	0°	0.08°	2.522 vdc
		-1°	-0.99°	2.169 vdc
		-2°	-2.05°	1.805 vdc
		-1°	-0.96°	2.171 vdc
		0°	0.08°	2.527 vdc

4.1.9 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 4.1.9.1.

The checkout was performed on 10 January and 29 January 1969. The stage power setup, H&CO 1B55813, was performed prior to calibration activity to provide electrical power to the equipment.

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

4.1.9 (Continued)

Four hydraulic system pressure transducers were checked by measuring the ambient outputs of the transducers before the hydraulic system was pressurized. As shown in the Test Data Table, these measurements were all within the required limits.

One temperature bridge required calibration for measurement C040, position 1 oxidizer tank temperature. With a low level calibration input, the temperature bridge was adjusted to obtain a bridge output within the 0.00 ±0.05 vdc limits. With a high level calibration input, the bridge output was verified to be within the 24.0 ±0.3 vdc limits.

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

a. One revision deleted all portions of the procedure except those required for the items calibrated.

b. One revision authorized installing the connector on the reservoir oil pressure transducer in preparation for checkout. The connector had been disconnected from the transducer in preparation for hardwire connection.

4.1.9.1 Test Data Table, Signal Conditioning Setup

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

Reference Location	S/N	5 vdc Output (vdc)	-20 vdc Output (vdc)	ac Output vpp	ac Output Hz
411A99A33	0194	4.995	-20.001	9.5	2036
404A52A7	0163	5.000	-19.997	9.5	2059
411A98A2	0192	4.998	-20.000	10.0	2061

4.1.9.1 (Continued)

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

Reference Location	S/N	20 vdc Output (vdc)
411A61A242	0335	20.001
404A62A241	0322	19.999
404A63A241	0316	19.997
404A64A241	0327	20.000
404A65A241	0321	20.003
404A63A233	0323	19.998
404A66A241	0357	19.999

Hydraulic Pressure Transducer Ambient Condition Check

Function	Measurement	Limits
Reservoir Oil Pressure	13.1 psia	14.7 + 8 psia
GN2 Accumulator Pressure	1396 psia	1395 ± 50 psia
Aux Hyd Pump Motor Gas Press	1.11 psig	0 ± 1.2 psig
Aux Hyd Pump Air Tank Press	17.7 psia	14.7 ± 13 psia

Temperature Bridge - Temperature, Oxidizer Tank Position 1, C040

			Output (mvdc)			
			Zero		Gain	
P/N	S/N	Reference Location	Reading	Tolerance	Reading	Tolerance
1A82274-511	02979	404A62A216	0.0	0.0 ± 0.5	24.0	24.0 ± 0.3

4.1.10 Stage Power Setup (1B55813 L)

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 checkout was successfully demonstrated on 10 January 1969. Measurements from this test are listed in Test Data Table 4.1.10.1.

The test was started by resetting all matrix magnetic latching relays and verifying that the corresponding command relays were in the proper stage. The umbilical connectors were verified to be mated, and the LOX and LH2 inverters were verified to be disconnected. The bus 4D119 talkback power was turned on, and the prelaunch checkout group was turned off. The forward and aft power buses were transferred to external power. The sequencer power, engine control bus power, engine ignition bus power, APS bus 1 and bus 2 power, and propellant level sensor power were all verified to be off. The power to the range safety 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.

4.1.10 (Continued)

The range safety system safe and arm device was verified to be in the SAFE condition. The 70 pound ullage engine relay, the LH2 continuous vent valve relays, the LH2 and LOX repressurization mode relay, the O2H2 burner propellant valve relay, and the engine passivation relays were all verified to be reset. The LH2 continuous vent and relief override valve was verified to be closed, and the LOX repressurization control valve enable was verified to be on. Power was verified to be off for the propellant utilization boiloff bias. The O2H2 burner spark systems 1 and 2 voltages were measured and recorded. The O2H2 LOX and LH2 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 then verified that the stage functions were in the proper state. Forty-three functions were verified to be off and twenty-five were verified to be on. The LOX and LH2 prevalves and chilldown shutoff valves were verified as open, and the LOX and LH2 vent valves and fill and drain valves were verified as closed.

4.1.10 (Continued)

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

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

a. One revision updated the program to the requirements of ECP's 3006 and 3008.

b. One revision deleted the calibration preflight mode function per WRO S-IVB-3676R10.

c. One revision attributed a malfunction indication for the ambient helium supply shutoff valve to a program error. The program looked for the wrong state of the valve.

d. One revision indicated a malfunction indication for the LH2 continuous vent orificed bypass valve occurred because the valve was not installed electrically.

4.1.10.1 Test Data Table, Stage Power Setup

Function	Measured Value	Limit
Forward Bus 1 Power Supply Current (amps)	2.000	20 max
Forward Bus 1 Voltage (vdc)	28.118	28 ± 0.5
O2H2 Burner Spark System 1 Voltage (vdc)	0.010	0 ∓ 0.5
O2H2 Burner Spark System 2 Voltage (vdc)	0.000	0 ∓ 0.5
Forward Bus 1 Quiescent Current (amps)	2.000	5 max
PCM System Group Current (amps)	4.601	5 ± 3
Forward Bus 2 Power Supply Current (amps)	0.300	2 max
Forward Bus 2 Voltage (vdc)	28.239	28 ± 0.5
Aft Bus 1 Power Supply Current (amps)	0.500	2 max
Aft Bus 1 Voltage (vdc)	28.118	28 ± 0.5
Sequencer Power (amps)	0.100	0 ∓ 3
Aft 5V Excitation Module Voltage (vdc)	4.999	5 ∓ 0.030
Fwd 1 5V Excitation Module Voltage (vdc)	5.000	5 ∓ 0.030

4.1.10.1 (Continued)

Function	Measured Value	Limit
Fwd 2 5V Excitation Module Voltage (vdc)	4.995	5 ± 0.030
RS 1 EBW Firing Unit Chg Voltage (vdc)	0.015	0 ± 1
RS 2 EBW Firing Unit Chg Voltage (vdc)	0.005	0 ± 1
Aft Bus 2 Voltage (vdc)	0.000	0 ± 1
Forward Battery 1 Simulator Voltage (vdc)	0.119	0 ± 1
Forward Battery 2 Simulator Voltage (vdc)	0.039	0 ± 1
Aft Battery 1 Simulator Voltage (vdc)	0.000	0 ± 1
Aft Battery 2 Simulator Voltage (vdc)	0.000	0 ± 1
Component Test Power Voltage (vdc)	0.680	0 ± 1

4.1.11 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 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 demonstration test was successfully performed on 10 January 1969. Following this, the procedure was used to shutdown the stage at the conclusion of the various automatic checkouts during perfire operations. Measurement values for the demonstration test are listed in Test Data Table 4.1.11.1.

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

The switch selector functions were then turned off; the O2H2 burner spark systems 1 and 2 voltages were measured; and a series of checks verified that the stage electrical functions were in the proper stage of off, reset, or closed.

The forward and aft bus power supplies were verified to be off, and the forward and aft bus battery simulator voltages were measured. The stage buses 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

4.1.11 (Continued)

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 turn-off.

There were no FARR's written against this test. However, three revisions were recorded in the procedure as follows:

a. One revision updated the program to the requirement of ECP's 3006 and 3008.

b. One revision deleted the calibration preflight mode function per WRO S-IVB-3676R10.

c. One revision indicated that a malfunction indication for the LH2 continuous vent orificed bypass valve occurred because the valve was not connected electrically.

4.1.11.1 Test Data Table, Stage Power Turnoff

Function	Measured Value	Limits
Forward Bus 1 Voltage, Power On (vdc)	28.118	28 + 2
Aft Bus 1 Voltage, Power On (vdc)	28.158	28 ± 2
O2H2 Burner Spark System 1 Voltage (vdc)	0.000	0 ± 0.5
O2H2 Burner Spark System 2 Voltage (vdc)	0.010	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)	0.119	0 ± 1.0
Forward Bus 2 Voltage, Power Off (vdc)	0.039	0 ± 1.0
Aft Bus 1 Voltage, Power Off (vdc)	0.079	0 ± 1.0
Aft Bus 2 Voltage, Power Off (vdc)	0.079	0 ± 1.0

4.1.12 Power Distribution System (1B55815 K)

The automatic checkout of the stage power distribution system during prefire 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 11 January and 16 January 1969, and then satisfactorily on 24 January 1969. The initial test was aborted due to malfunctions which occurred because of a recessed pin in a connector socket. After correcting the connector problem per FARR 500-607-971, the second test proceeded until aborted by failure of the LH2 chilldown inverter, P/N 1A74039-517, S/N 075. The third and final test was successfully accomplished after replacement of the LH2 chilldown inverter per FARR 500-702-958. All measurements listed in Test Data Table 4.1.12.1 are taken from the final test. The following narrative is a description of that test.

The initial conditions scan was conducted per the stage power setup, H&CO 1B55813. 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

4.1.12 (Continued)

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 A0 and B0 multiplexer engine cutoff signal indication (K13). With the EDS 1 engine cutoff signal turned off, the engine ready bypass on turned off both the nonprogrammed engine cutoff signal and the A0 and B0 multiplexer engine cutoff signal indications.

The propellant point level sensor test was started by turning on the propellant level sensor power and measuring the resulting current differential for the forward 1 power supply. Next, each of the four LH2 tank and four LOX tank

4.1.12 (Continued)

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.

The propellant utilization (PU) inverter and electronics power supply current differentials were measured while power was momentarily turned on. The PCM RF assembly power was turned on, the RF group was verified to be on, the power supply differential current was measured, and the PCM RF transmitter output wattage was measured through the AO and BO multiplexers. With the telemetry RF silence command turned on, the RF group was verified to be off; the PCM RF transmitter output wattage was measured through the AO multiplexer; and the

4.1.12 (Continued)

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

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

A series of automatic checks verified the operation of the external/internal transfer system for forward buses 1 and 2 and aft buses 1 and 2. The battery simulator voltages and the electrical support equipment load bank voltages were measured initially; then, the power bus voltages were measured with the buses transferred to internal, and the bus local sense indications were verified to be off. Prior to transfer to internal power, the prelaunch checkout group was turned on and the current draw measured. The bus voltages were measured again with the buses transferred back to external, and the battery

4.1.12 (Continued)

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. There were no discrepancies resulting in FARR documentation with the exception of the two previously described. Fifteen revisions were recorded in the procedure for the following:

a. Two revisions were initiated and then voided as not required.

b. Two revisions corrected program errors.

c. One revision indicated that the LH2 continuous vent orificed bypass valve was not closed during initial conditions scan, because stage pneumatics were not applied.

d. One revision attributed a malfunction indication for the ambient helium supply shutoff valve to a program error. The program looked for the wrong state of the valve.

e. One revision deleted the calibration preflight mode indication per WRO S-IVB-3676R10.

f. Two revisions deleted functional checkouts of the FM/FM system group power because the FM/FM system was not installed on the stage.

g. Four revisions provided for investigation of the malfunctions attributed to the LH2 chilldown inverter.

4.1.12 (Continued)

h. Two revisions authorized the second and third tests of the power distribution system.

4.1.12.1 Test Data Table, Power Distribution System

Function	Measurement	Limits
Engine Control Bus Current (amps)	0.300	2 ± 2
Engine Control Bus Voltage (vdc)	27.906	28.118 ± 1
APS Bus Current (amps)	0.600	1.5 ± 3
Engine Ignition Bus Current (amps)	0.200	0 ± 2
Engine Ignition Bus Voltage, On (vdc)	27.968	28.079 ± 1
Engine Ignition Bus Voltage, Off (vdc)	0.000	0 ± 0.45
Component Test Power Current (amps)	0.100	0 ± 2
Component Test Power Voltage, On (vdc)	27.999	28 ± 2
Component Test Power Voltage, Off (vdc)	0.640	0 ± 1
Engine Control Bus Voltage, EDS 2 On (vdc)	-0.030	0 ± 0.45
Engine Control Bus Voltage, EDS 2 Off (vdc)	27.845	28.118 ± 1
Propellant Level Sensor Pwr Current (amps)	0.100	1 ± 2
LOX Depletion Engine Cutoff Timer (sec)	0.546	0.560 ± 0.025
PU Inverter & Electronics Pwr Current (amps)	4.200	3 ± 2
PCM RF Assembly Power Current (amps)	4.400	4.5 ± 3.0
PCM RF Transmitter Output Power, AO (watts)	17.459	10 min
PCM RF Transmitter Output Power, BO (watts)	17.667	10 min
PCM RF Transmitter Output Power, AO T/M RF Silence On (watts)	-0.059	0 ± 2
Switch Selector Output Monitor, K128 (vdc)	1.984	2 ± 0.425
PCM RF Transmitter Output Power, AO, T/M RF Silence Off (watts)	19.005	10 min
Calibration Preflight Mode Current (amps)	0.000	0 ± 2
Aft Bus 2 Current (amps)	0.000	5 max
Aft Bus 2 Voltage (vdc)	56.237	56 ± 1

LOX Chilldown Inverter Tests

Function	Measurement	Limits
Inverter Current (amps)	20.964	20.0 ± 5.0
Phase AB Voltage, Hardwire (vac)	54.756	55.438 ± 3
Phase AC Voltage, Hardwire (vac)	54.234	55.438 ± 3
Phase A1B1 Voltage, Hardwire (vac)	54.625	55.438 ± 3
Phase A1C1 Voltage, Hardwire (vac)	54.040	55.438 ± 3
Frequency, Hardwire (Hz)	400.000	400.0 ± 4.0
Phase AB Voltage, Telemetry (vac)	55.598	55.518 ± 3
Phase AC Voltage, Telemetry (vac)	55.598	55.518 ± 3
Frequency, Telemetry (Hz)	399.578	400.0 ± 4.0

4.1.12.1 (Continued)

LH2 Chilldown Inverter Tests

Function	Measurement	Limits
Inverter Current (amps)	20.704	20.0 ± 5.0
Phase AB Voltage, Hardwire (vac)	54.886	55.599 ± 3
Phase AC Voltage, Hardwire (vac)	54.170	55.599 ± 3
Phase A1B1 Voltage, Hardwire (vac)	54.821	55.599 ± 3
Phase A1C1 Voltage, Hardwire (vac)	54.234	55.599 ± 3
Frequency, Hardwire (Hz)	401.000	400.0 ± 4.0
Phase AB Voltage, Telemetry (vac)	55.731	55.599 ± 3
Phase AC Voltage, Telemetry (vac)	55.932	55.599 ± 3
Frequency, Telemetry (Hz)	400.500	400.0 ± 4.0

Function	Measurement	Limits
Forward Battery 1 Simulator Voltage (vdc)	28.199	28 ± 2
Forward Battery 2 Simulator Voltage (vdc)	28.118	28 ± 2
Aft Battery 1 Simulator Voltage (vdc)	28.039	28 ± 2
Aft Battery 2 Simulator Voltage (vdc)	56.317	56 ± 4
Bus 4D20 ESE Load Bank (vdc)	0.039	0 ± 1
Bus 4D40 ESE Load Bank (vdc)	0.079	0 ± 1
Bus 4D30 ESE Load Bank (vdc)	0.000	0 ± 1
Bus 4D10 ESE Load Bank (vdc)	0.079	0 ± 1
Prelaunch Checkout Group Current (amps)	1.500	1 ± 3
Forward Bus 1 Voltage - Internal (vdc)	27.839	28 ± 2
Forward Bus 2 Voltage - Internal (vdc)	27.999	28 ± 2
Aft Bus 1 Voltage - Internal (vdc)	27.999	28 ± 2
Aft Bus 1 Voltage - External (vdc)	28.079	28 ± 2
Aft Battery 1 Voltage (vdc)	0.000	0 ± 1
Aft Bus 2 Voltage - Internal (vdc)	56.237	56 ± 4
Aft Bus 2 Voltage - External (vdc)	56.158	56 ± 4
Aft Battery 2 Voltage (vdc)	0.079	0 ± 1
Forward Bus 1 Voltage - External (vdc)	28.118	28 ± 2
Forward Battery 1 Voltage (vdc)	0.039	0 ± 1
Forward Bus 2 Voltage - External (vdc)	28.118	28 ± 2
Forward Battery 2 Voltage (vdc)	0.000	0 ± 1
Aft Bus 2 Voltage, Off (vdc)	0.079	0 ± 1
Range Safety Receiver 1 External Power Current (amps)	0.500	0 ± 2
Range Safety Receiver 2 External Power Current (amps)	0.501	0 ± 2

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

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

The manual controls checkout was initiated on 11 January 1969, and completed satisfactorily on 29 January 1969. Preliminary GSE setup operations were initiated to verify that the switches and valves on the test consoles were positioned properly for the functional check. The GSE manual controls were then operated to ensure their functional capability.

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

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

4.1.13 (Continued)

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

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

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

Two tests were required to accomplish the LOX umbilical purge interlock check. The initial test was not completed due to malfunction of the GSE LOX umbilical purge valve. After replacement of this valve in the GSE console, testing was resumed satisfactorily. On the LOX control panel, the LOX emergency drain

4.1.13 (Continued)

valve was opened, and the LOX fill and drain and the LOX umbilical drain valves were verified to be closed. The LOX umbilical purge valve was positioned to open, and talkback indication was verified. The LOX fill and drain and the LOX umbilical drain valves were cycled to verify that the LOX umbilical purge valve opened and closed as the drain valves were functioned.

The J-2 engine oscillograph was then set up in preparation for Galvo trace verification during the engine valve functional check. Preliminary operations included ensuring that the LOX and LH2 tanks and the engine start tank were vented to ambient, closing the chilldown shutoff valves and prevalves, and verifying the engine throat plug and injector cover were removed. Power was turned on for engine valve actuation, and the engine control helium bottle was pressurized to 600 ±100 psig. At the mainstage panel, the helium control solenoid, ignition phase solenoid, and the start tank discharge valve (STDV) solenoid were energized. Verification of proper oscillograph traces was made, respectively, for the helium control solenoid voltage, the main fuel valve (MFV) position, the gas generator (GG) valve position, the STDV solenoid voltage, and the STDV position, after each was turned on. Next, the mainstage solenoid valve was energized and oscillograph traces were verified for the solenoid voltage, the main oxidizer valve (MOV) position, and the oxidizer turbine bypass valve (OTBV) position. The solenoid valves were then individually deenergized, the engine control bottle was vented to ambient, and the LOX and LH2 tank vent valves were closed.

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

4.1.13 (Continued)

There were no FARR's initiated against stage hardware as a result of this test.

Seven revisions were recorded in the procedure for the following:

a. Two revisions corrected errors in the procedure.

b. One revision added a requirement to verify the digital events recorder input during stage valve cycling.

c. One revision authorized deleting the requirement to perform the leak check procedure prior to conducting the manual controls check.

d. One revision modified the GSE supply to the engine control bottle and reduced bottle pressure from 1450 +50 psig to 600 +100 psig to permit continued testing with a flange leak in the GSE supply line.

e. Two revisions authorized repeating portions of the test. One repeated the engine manual controls check after bypassing the previously described flange leak in the GSE supply line. The other revision authorized repeating the entire galvo trace verification and engine valve functional check, because the automatic typewriter printout was not verified during the initial attempt.

4.1.14 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	6700083
CP1-BO Time Division Multiplexer	404A61A200	1B65897-1	08
DP1-BO Time Division Multiplexer	404A61A201	1B65897-501	017
Remote Digital Submultiplexer (RDSM)	404A60A200	1B66051-501	01
Remote Analog Submultiplexer (RASM)	404A60A201	1B66050-501	01
PCM RF Assembly	411A64A200	1B65788-1-004	18004

Three tests were conducted to verify the operation of all data channels checked. Test attempt one, conducted on 13 January 1969, was aborted due to numerous malfunctions. Corrections included the replacement of a pressure transducer and the DP1-BO multiplexer. FARR 500-703-369 documented malfunction of pressure transducer, P/N 1B40242-583, S/N 583-52, for measurement D263, which was replaced with S/N 583-56. FARR 500-702-915 recorded the malfunction of DP1-BO multiplexer, P/N 1B65897-501, S/N 06, which was replaced with multiplexer, S/N 017. Test attempt two, performed on 31 January 1969, was a satisfactory test. However, malfunction of measurement D002 during this test resulted in replacement of the pressure transducer, P/N 1B40242-579, S/N 579-1, with S/N 579-2

4.1.14 (Continued)

per FARR 500-703-580. A third test was then performed per revision to the procedure on 4 February 1969, to verify proper operation of those channels associated with measurement D002. Measurements quoted and the following narrative test descriptions are from the successful test conducted on 31 January 1969.

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 $70^{\circ}F$ 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 lineprinter.

4.1.14 (Continued)

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

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

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

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

The PCM RF test was performed next. The forward and reflected RF output powers of the PCM/DDAS assembly were measured through the CP1-BO and DP1-BO multiplexer telemetry outputs; and the voltage standing wave ratios (VSWR) were determined. The same measurements were also made through the ground monitor outputs for both multiplexers. The CP1-BO multiplexer telemetry readings were: forward power, 22.842 watts; reflected power, 2.353 watts; VSWR, 1.944. The DP1-BO multiplexer telemetry readings were: forward power, 22.813 watts; reflected power, 2.340 watts, VSWR, 1.941. The CP1-BO multiplexer ground monitor readings were: forward power, 19.748 watts; reflected

4.1.14 (Continued)

power, 0.504 watts; VSWR, 1.380. The DP1-BO multiplexer ground monitor readings were: forward power, 19.748 watts; reflected power, 0.504 watts; VSWR, 1.380. High and low RACS tests were then conducted on measurement channel CP1-BO-05-10 for the aft 5 volt exciation module voltage, while both the ground monitor and telemetry outputs were measured. High RACS for telemetry and ground monitor outputs measured 3.989 vdc. Low RACS were -0.015 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 indication, liquid level indication, and position indication, as applicable for the various channels. The DP1-BO multiplexer test was also performed, except for special channels, in the same manner as described for the CP1-BO multiplexer. With the following exceptions, all channel outputs for both multiplexers were within tolerance. Malfunctions for measurement D002 during both multiplexer tests resulted in transducer replacement per FARR 500-703-580, as previously described. The repeat test for D002 channels was successful. Malfunctions for measurements D020 and D227 occurred during both multiplexer tests because of programming errors. The measurements obtained were within the acceptable tolerances. Malfunctions for measurement G002, yaw actuator piston potentiometer position, occurred during both multiplexer tests because the actuator links were up and the locks were not installed due to concurrent testing. Ambient output malfunctions for two measurements during the DP1-BO

4.1.14 (Continued)

multiplexer test occurred because the transducers for these measurements were operating at ambient temperatures that were substantially higher than those expected by the program. Ambient output for a pressure measurement during the DP1-BO multiplexer test malfunctioned because system pressure had been locked up for concurrent testing. After venting to ambient, the ambient output measured within tolerance.

Special channel tests were also conducted. These special channels measured 400 Hz, 100 Hz, and 1500 Hz signals. The 400 Hz test checked the static inverter-converter frequency, the LOX and LH2 chilldown inverter frequencies, and the LOX and LH2 circulation pump flow rates. The LOX and LH2 flowmeter tests at 100 Hz followed the 400 Hz test, and the LOX and LH2 pump speeds were checked using the 1500 Hz signal. All of the special channels were within the required tolerances of the expected values for the final test.

An APS simulator multiplexer test and a J-2 engine pressures multiplexer test were run to check those channels on the CP1-BO and DP1-BO multiplexers that measured the APS simulator and special J-2 engine functions. Measurements were made of the high and low RACS voltages for each of the APS simulator and special J-2 engine channels having calibration capability; and the ambient outputs were measured in ^{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 LH2

4.1.14 (Continued)

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

Discrepancies documented by FARR were limited to those previously described. Sixteen revisions were recorded in the procedure for the following:

a. Two revisions corrected program errors.

b. Two revisions updated the program to the requirements of ECP 3006.

c. One revision authorized a test equipment substitution, which was more convenient to use.

d. Six revisions discussed the malfunction indications received during the DP1-B0 and CP1-B0 multiplexer tests, as previously described in this report.

e. One revision provided instructions to reverify proper operation of measurement D225 after it had been temporarily electrically disconnected to troubleshoot malfunctions for measurement D002.

f. One revision noted that the initial measurement of the GSE 5-volt power supply was out-of-tolerance because of failure to set the power supply to the required tolerance. After adjustment, the program was resumed and the power supply measurement was within tolerance.

4.1.14 (Continued)

g. One revision corrected a programming error which had inserted the wrong value for the 400 Hz period into the program.

h. Two revisions authorized the performance of the second and third tests, as previously described.

4.1.15 Auxiliary Propulsion System Simulator (1B55825 E)

The auxiliary propulsion system simulator 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 interfaces 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 1B57731-503, S/N 424, at reference location 404A51A4 and S/N 423, at reference location 404A71A19. The test was satisfactorily accomplished on 14 January 1969.

After performing initial conditions scan per H&CO 1B55813, 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 was 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 conculsion of these tests, the stage was returned to the pre-test configuration, thereby completing the test procedure.

4.1.15 (Continued)

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

4.1.15.1 Test Data Table, Auxiliary Propulsion System Simulator

Attitude Control Nozzle Command		APS Engine	Valve Open Indication Voltage (vdc) AO Multiplexer	BO Multiplexer	Limits
Nozzle I IV	On	1-1	3.759	3.769	3.8 ± 0.25
	Off	1-1	-0.005	-	0.0 ∓ 0.25
Nozzle I II	On	1-3	3.723	3.728	3.8 ± 0.25
	Off	1-3	-0.010	-	0.0 ∓ 0.25
Nozzle I P	On	1-2	3.743	3.753	3.8 ± 0.25
	Off	1-2	0.000	-	0.0 ∓ 0.25
Nozzle III II	On	2-1	3.691	3.712	3.7 ± 0.25
	Off	2-1	0.000	-	0.0 ∓ 0.25
Nozzle III IV	On	2-3	3.650	3.677	3.7 ± 0.25
	Off	2-3	-0.005	-	0.0 ∓ 0.25
Nozzle III P	On	2-2	3.732	3.732	3.7 ± 0.25
	Off	2-2	0.000	-	0.0 ∓ 0.25

4.1.16 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	292
EBW Firing Unit	404A47A2	40M39515-113	298
Pulse Sensor *	404A47A4A1	40M02852	551
Pulse Sensor *	404A47A4A2	40M02852	517
* On Pulse Sensor Bracket Assy	404A47A4	1B52640-1	00010
Ullage Rocket Jettison System			
EBW Firing Unit	404A75A1	40M39515-113	299
EBW Firing Unit	404A75A2	40M39515-113	293
Pulse Sensor **	404A75A10A1	40M02852	532
Pulse Sensor **	404A75A10A2	40M02852	583
** On Pulse Sensor Bracket Assy	404A75A10	1A97791-501	00005

Three tests were performed to satisfactorily demonstrate the system. The initial attempt, conducted on 14 January 1969, was aborted due to malfunctions of test equipment and improper electrical connections. Test attempt 2, performed on 15 January 1969, was aborted because of a malfunction that resulted from an operator error during executive loading. The third and final test was conducted successfully on 15 January 1969, and is the basis for this narrative report.

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 discharge condition was determined by

4.1.16 (Continued)

verifying that the voltage indication measured 0.0 ±0.3 vdc, or during the firing unit disable test, 0.2 ±0.3 vdc.

Testing was started by performing initial conditions scan per H&CO 1B55813. An EBW pulse sensor self test was conducted first by verifying that the self test command properly turned on the four EBW pulse sensors and that the reset command properly turned off the pulse sensors.

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

4.1.16 (Continued)

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

Engineering comments noted that all parts were installed at the start of the tests. No FARR's were written as a result of the tests. Six revisions were recorded in the procedure for the following:

a. Four revisions concerned initial conditions scan, but had no bearing on the EBW system tests.

b. Two revisions authorized the performance of the second and third test attempts.

4.1.17 Digital Data Acquisition System Calibration (1B55816 H)

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 6700083; CP1-BO time division multiplexer, P/N 1B65897-1, S/N 08; DP1-BO time division multiplexer, P/N 1B65897-501, S/N 017; remote digital submultiplexer (RDSM), P/N 1B66051-501, S/N 01; and low level remote analog submultiplexer (RASM), P/N 1B66050-501, S/N 01.

Seven tests were conducted from 15 January through 27 January 1969, to satisfactorily complete prefire DDAS calibration. The initial test resulted in the replacement of the malfunctioning DP1-BO multiplexer, P/N 1B65897-501, S/N 06, with S/N 017 per FARR 500-702-915. During the second test, performed on 20 January 1969, the new DP1-BO multiplexer was observed to have random noise on the full scale reference channel 29. Additional tests conducted from 20 January through 23 January 1969, were investigation checkouts of electro-magnetic interference of test cable grounding. Various grounding configurations were used, including flight configuration, substantiating that the noise occurred from a test cable grounding configuration. The noise was eliminated when the stage connectors were in flight configuration. The investigation was documented on FARR 500-702-991. The seventh and final test was successfully conducted on 27 January 1969.

The stage power was turned on, and the initial conditions scan was conducted for the stage and DDAS per H&CO 1B55813. The 72 kHz bit rate check was made

4.1.17 (Continued)

on the PCM data train to ensure that the frequency was within tolerance. The 72 kHz bit rate was measured as 72,004 bits per second, within the 71,975 to 72,025 bits per second limits. The 600 kHz VCO test was accomplished by measuring the band edge frequencies and voltages of the PCM/DDAS VCO output. The upper band edge frequency was measured at 634.42 kHz at 2.8 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 568.86 kHz at 2.8 vrms, within the acceptable limits of 556.8 kHz to 576.8 kHz, at greater than 2.2 vrms. The frequency differential was calculated as 65.56 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-B0 and DP1-B0 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 acceptable.

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 acceptable.

A final test measured the PCM/FM transmitter current as 4.4 amperes, within the 4.5 ±3.00 amperes limit.

4.1.17 (Continued)

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

a. Four revisions concerned initial conditions scan which had no effect on DDAS testing.

b. One revision updated the program to the requirements of ECP 3006 and ECP 3008.

c. One revision repeated the RDSM test due to malfunctions resulting from incorrect power supply polarity.

d. One revision noted the malfunctions during the initial test that resulted in replacing the DP1-BO multiplexer per FARR 500-702-915.

e. One revision authorized repeat testing after replacement of the DP1-BO multiplexer.

f. Seven revisions provided instructions for investigating the malfunctions occurring from electro-magnetic interference caused by test cable grounding.

g. Two revisions provided program changes to support concurrent testing.

h. One revision was processed to complete the RASM test after completion of investigation of the electro-magnetic interference problem.

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

This manual procedure determined that the control units associated with the LOX and LH2 liquid level, point level, fastfill, and overfill sensors were adjusted for operating points within the design calibration limits. The particular items involved in this test are noted in Test Data Table 4.1.18.1. The checkout was accomplished between 15 January and 30 January 1969.

A point level sensor manual checkout assembly, P/N 1B50928-1, and a variable precision capacitor, General Radio Type 1422CD, were connected in parallel with the sensor to provide capacitance changes to each control unit simulating sensor wet conditions for calibrations and to establish the control unit operating point. With the control unit power turned on, the control unit control point adjustment R1 was adjusted until the control unit output signal changed from 0 ±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 for the LH2 sensors and for the LOX sensors were recorded in Test Data Table 4.1.18.1 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.

4.1.18 (Continued)

There were no FARR's initiated as a result of this checkout. However, nine revisions were recorded in the procedure for the following:

a. Four revisions updated the procedure to the latest design requirements for allowable tolerances and calibration capacitances.

b. Two revisions repeated checkout of the LH2 fastfill and overfill sensors after correcting improper calibration capacitances specified in error.

c. Two revisions corrected errors in previous revisions.

d. One revision deleted obsolete portions of the procedure.

4.1.18.1 Test Data Table, Level Sensor and Control Unit Calibration

	Sensor P/N 1A68710			Control Unit P/N 1A68710			Deactivate Cap (pf)		Reactivate Cap (pf)	
Function	Ref. Loc.	Dash P/N	S/N	Ref. Loc.	Dash P/N	S/N	Meas	Min	Meas	Max
LH2 Tank	408			411						
Liq Lev L17	MT732	-507	D73	A61A217	-509	C42	1.335	1.250	1.336	1.450
Liq Lev L18	MT733	-507	D84	A61A219	-509	C43	1.345	1.250	1.346	1.450
Liq Lev L19	MT734	-507	D90	A61A221	-509	C46	1.337	1.250	1.339	1.450
Pt Lev 1	A1C1	-507	01	A92A25	-509	C27	0.789	0.600	0.794	0.800
Pt Lev 2	A2C2	-507	04	A92A26	-509	C38	0.650	0.600	0.651	0.800
Pt Lev 3	A2C3	-507	05	A92A27	-509	C39	0.758	0.600	0.762	0.800
Pt Lev 4	A2C4	-507	09	A61A201	-509	C40	0.768	0.600	0.771	0.800
Fastfill	A2C5	-1	D136	A92A43	-509	D71	1.350	1.250	1.356	1.450
Overfill	*	*	*	A92A24	-509	C100	1.351	1.250	1.357	1.450

* Part of LH2 Mass Probe, P/N 1A48431-513, S/N C7/C6, Location 408A1

4.1.18.1 (Continued)

Function	Sensor P/N 1A68710 Ref. Loc.	Dash P/N	S/N	Control Unit P/N 1A68710 Ref. Loc.	Dash P/N	S/N	Deactivate Cap (pf) Meas	Min	Reactivate Cap (pf) Meas	Max
LOX Tank	406			404						
Liq Lev L14	MT657	-1	C33	A63A223	-511	C20	2.631	2.500	2.640	2.700
Liq Lev L15	MT658	-1	C32	A63A206	-511	C17	2.654	2.500	2.664	2.700
Liq Lev L16	MT659	-1	C36	A63A221	-511	C18	2.658	2.500	2.666	2.700
Pt Lev 1	A2C1	-1	C5	A72A1	-511	C40	1.422	1.400	1.425	1.600
Pt Lev 2	A2C2	-1	D120	A72A2	-511	C33	1.458	1.400	1.464	1.600
Pt Lev 3	A2C3	-1	D132	A72A3	-511	C42	1.415	1.400	1.427	1.600
Pt Lev 4	A2C4	-1	D135	A63A227	-511	C22	1.552	1.400	1.557	1.600
Fastfill	A2C5	-1	C18	A72A5	-511	C45	2.567	2.500	2.576	2.700
Overfill	**	**	**	A72A4	-511	C24	2.040	2.000	2.047	2.200

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

4.1.19 Propellant Utilization System Calibration (1B64367 K)

This manual calibration procedure verified the operation of the propellant utilization system and provided the necessary calibration prior to the automatic checkout of the system. For calibration purposes, the propellant utilization test se. (PUT/S), P/N 1A68014-1, was used to provide varying capacitance inputs to the propellant utilization electronic assembly (PUEA) to simulate the LOX and LH2 mass probe outputs under varying propellant load conditions. The items involved in this test included the following:

Part Name	Ref. Location	P/N	S/N
Propellant Utilization Electronic Assembly (PUEA)	411A92A6	1A59358-529	036
Static Inverter-Converter	411A92A7	1A66212-507	018
LOX Mass Probe	406A1	1A48430-511.1	C4
LH2 Mass Probe	408A1	1A48431-513	C7/C6
LOX Overfill Sensor	(Part of LOX Mass Probe)		
LOX Overfill Control Unit	404A72A4	1A68710-511	C24
LOX Fastfill Sensor	406A2C5	1A68710-1	C18
LOX Fastfill Control Unit	404A72A5	1A68710-511	C45
LH2 Overfill Sensor	(Part of LH2 Mass Probe)		
LH2 Overfill Control Unit	411A92A24	1A68710-509	C100
LH2 Fastfill Sensor	408A2C5	1A68710-1	D136
LH2 Fastfill Control Unit	411A92A43	1A68710-509	D71

The test was performed on 17 and 22 January 1969. Measurements and ratiometer settings made during the 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 LH2 and LOX mass probe elements through connector 411W11P1 at the PUEA, using a 50 vdc megohmeter. The PUT/S was connected to the PUEA, then the static inverter-converter and the stage power for these units was manually turned on. The static inverter-converter voltages and operating frequency were then measured.

4.1.19 (Continued)

The PUEA bridge calibrations were conducted next. Simulated empty conditions were established with the PUT/S; the PUEA LH2 and LOX bridge empty condition calibrations were accomplished by nulling the bridge tap voltages with the PUT/S ratiometer at settings of 0.01424 for the LH2 bridge and 0.04021 for the LOX bridge; then, the bridge outputs were nulled by adjusting the PUEA R2 potentiometer for the LH2 bridge and the PUEA R1 potentiometer for the LOX bridge. Simulated full conditions were then established with the PUT/S using a C1 capacitor (LH2) setting of 182.25 picofarads and a C2 capacitor (LOX) setting of 123.00 picofarads, and the ratiometers were set to 0.82297 for the LH2 bridge and the LOX bridge. To accomplish the PUEA LH2 and LOX bridge full calibrations, the bridge outputs were nulled by adjusting PUEA R4 potentiometer for the LH2 bridge and the PUEA R3 potentiometer for the LOX bridge.

Data acquisition was verified by establishing simulated empty and full conditions with the PUT/S and by adjusting the PUT/S ratiometer to null the PUEA LH2 and LOX bridge outputs. Bridge slew checks were conducted by establishing simulated 1/3 and 2/3 slew conditions with the PUT/S and by adjusting the PUT/S ratiometer to null the PUEA LH2 and LOX bridge outputs for each condition. For the reference mixture ratio (RMR) calibration, the difference between the previously determined LH2 and LOX empty ratiometer settings, 0.02597, was multiplied by 98.4 vdc to give a V1 reference voltage of 2.558 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

4.1.19 (Continued)

bias calibration, simulated boiloff conditions were established with the PUT/S using a C1 capacitor (LH2) setting of 182.25 picofarads and a C2 capacitor (LOX) setting of 88.78 picofarads. The PUEA fuel bias R7 potentiometer was then adjusted to null the RMR bias voltage.

PUEA LH2 and LOX bridge linearity checks were accomplished by individually setting the PUT/S C1 capacitor (LH2) and C2 capacitor (LOX) to specific values and by adjusting the PUT/S ratiometer to null the appropriate PUEA bridge output.

For a fuel boiloff bias data acquisition check, the RMR bias voltage was measured as 20.955 vdc under simulated empty conditions and as 2.538 vdc under bias internal test conditions. The fuel boiloff bias voltage was the difference between these measurements, 18.417 vdc.

The hardwire loading circuits were checked by establishing simulated full conditions with the PUT/S, setting the PUT/S ratiometer to 0.00000, and measuring the hardwire loading circuit PUEA LH2 and LOX bridge output voltages. The LH2 voltage was 22.39 vdc, within the 22.43 ±2.0 vdc limits, and the LOX voltage 22.38 vdc, meeting the 22.43 ±2.0 vdc requirements.

Post test securing and shutdown operations, plus observation of the PU oven stability monitor voltage trace for voltage variation completed the checkout.

There were no discrepancies that resulted in FARR documentation. However, three revisions were recorded in the procedure for the following:

a. Two revisions corrected and clarified the procedure.

4.1.19 (Continued)

b. One revision repeated portions of the test that were invalid as a result of out-of-tolerance voltage readings that occurred because of incomplete electrical wiring between the inverter-converter and the PUEA. After completing the wiring, the test was completed satisfactorily.

4.1.19.1 Test Data Table, Propellant Utilization System Calibration

Pre-Test Atmospheric Conditions

Temperature: 41°F
Pressure: 29.95 inches of Hg
Relative Humidity: 70 percent

LH2 and LOX Mass Probe Insulation Resistance Checks

Function	Resistance (megohms)	Limits (megohms)
LH2 Probe Elements, Pins G to E	20k	1000 min
Pin G to Shield	20k	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
LOX Probe Elements, Pins A to C	20k	1000 min
Pin C to Shield	20k	1000 min
Pin C to Stage Ground	20k	1000 min
Pin C Shield to Stage Ground	20k	1000 min
Pin A to Stage Ground	20k	1000 min

Static Inverter-Converter Measurements

Function	Measurement	Limits
5.0 vdc Output Voltage (vdc)	4.95	4.75 to 5.05
21.0 vdc Output Voltage (vdc)	21.71	20.00 to 22.50
28.0 vdc Output Voltage (vdc)	27.26	26.00 to 30.00
117 vdc Output Voltage (vdc)	122.30	115.00 to 122.50
115 vrms Monitor Voltage (vdc)	2.71	2.23 to 3.18
Test Point 2 Voltage (vdc)	21.87	20.00 to 22.50
V/P Excitation Voltage (vdc)	50.76	49.41 to 52.59
Operating Frequency (Hz)	401.6	394.0 to 406.0

4.1.19 (Continued)

Data Acquisition

Function	PUT/S Ratiometer	Limits
LH2 Empty	0.00017	*
LOX Empty	0.02086	*
LH2 Full	0.82305	*
LOX Full	0.82288	*

Bridge Slew Checks

LH2 1/3 Slew	0.30989	*
LH2 2/3 Slew	0.63922	*
LOX 1/3 Slew	0.28347	*
LOX 2/3 Slew	0.57141	*

LH2 Bridge Linearity Check

PUT/S C1 Value	PUT/S Ratiometer	Limits
36.45 pf	0.15986	0.15794 to 0.16124
72.90 pf	0.32564	0.32379 to 0.32708
109.35 pf	0.49118	0.48963 to 0.49293
145.80 pf	0.65681	0.65548 to 0.65877
182.25 pg	0.82319	0.82132 to 0.82461

LOX Bridge Linearity Check

PUT/S C2 Value	PUT/S Ratiometer	Limits
24.60 pf	0.18080	0.17944 to 0.18273
49.20 pf	0.34110	0.33991 to 0.34320
73.80 pf	0.50097	0.50038 to 0.50367
98.40 pf	0.66185	0.66085 to 0.66414
123.00 pf	0.82291	0.82132 to 0.82461

* Limits Not Specified

4.1.20 Hydraulic System (1B55824 H)

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 1A66240-505, S/N X457813; the auxiliary hydraulic pump, P/N 1A66241-511, S/N X458912; the accumulator/reservoir assembly, P/N 1B29319-519, S/N 00040; the hydraulic pitch actuator, P/N 1A66248-507, S/N 77; and the hydraulic yaw actuator, P/N 1A66248-507, S/N 66.

The procedure was issued twice to complete prefire verification of the system. The initial test per issue one was successfully performed on 20 January 1969. However, repeat testing became necessary due to subsequent replacement of the accumulator/reservoir assembly, P/N 1B29319-505, S/N 00026 with S/N 00040, per FARR 500-703-482 on 30 January 1969. Two tests were then conducted per issue two on 31 January 1969. The first test attempt was aborted due to malfunction of the analog to digital converter in the GSE response conditioner. After correcting the malfunction, the final test was accomplished satisfactorily. Those function values measured during the final test are presented in Test Data Table 4.1.20.1. All of these values were acceptable and were within general design requirements, although specific limit requirements were not defined in the procedure for most of the measurements.

The stage power setup, H&CO 1B55813, was accomplished; and initial conditions were established for the test. The instrument unit (IU) substitute 5 volt power supply was turned on and its voltage measured; then, the aft 5 volt

4.1.20 (Continued)

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 ±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 ±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.

4.1.20 (Continued)

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 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

4.1.20 (Continued)

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 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. There were no discrepancies during the tests that resulted in FARR documentation. Six revisions were recorded in issue two of the procedure for the following:

4.1.20 (Continued)

a. One revision explained the malfunctions of the analog to digital converter in the GSE response conditioner that resulted in aborting the first test attempt of issue two. A defective printed circuit card was replaced in the converter to correct the malfunction and resume testing.

b. One revision authorized the second and final test of issue two.

c. One revision authorized steps to troubleshoot program malfunctions.

d. One revision updated the program to the requirements of ECP 3006 and ECP 3008.

e. Two revisions concerned stage power setup and had no bearing on the hydraulic system test.

4.1.20.1 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)	5.00	5.00 ± 0.03
Hydraulic System Unpressurized		
Reservoir Oil Pressure (psia)	70.27	*
Accumulator GN2 Pressure (psia)	2334.63	*
Accumulator GN2 Temperature (°F)	54.94	*
Reservoir Oil Level (%)	87.23	*
Pump Inlet Oil Temperature (°F)	47.92	*
Reservoir Oil Temperature (°F)	56.11	*
Aft Bus 2 Current (amp)	0.00	*
Aux Hyd Pump Air Tank Pressure (psia)	447.50	282.5 + 217.5
Aux Hyd Pump Motor Gas Pressure (psig)	13.09	21 + 12
Gaseous Nitrogen Mass (lb)	1.961	1.925 + 0.2
Corrected Reservoir Oil Level (%)	99.2	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)	0.04	*
IU Yaw Actuator Position (deg)	0.05	*
IU Substitute 5 Volt Power Supply (vdc)	5.00	*

* Limits Not Specified

4.1.20.1 (Continued)

Function	Measurement	Limits
Aft 5 Volt Excitation Module (vdc)	5.00	*
Pitch Actuator Signal (ma)	0.10	*
Yaw Actuator Signal (ma)	0.00	*
Corrected T/M Pitch Actuator Position (deg)	-0.064	-0.236 to 0.236
Corrected IU Pitch Actuator Position (deg)	-0.036	-0.236 to 0.236
Corrected T/M Yaw Actuator Position (deg)	0.045	-0.236 to 0.236
Corrected IU Yaw Actuator Position (deg)	0.038	-0.236 to 0.236

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

Function	Measurement	Limits
Aft Bus 2 Voltage (vdc)	56.08	56.0 + 4.0
Aft Bus 2 Current (amp)	60.60	55.0 ∓ 30.0
Hyd System 4 Second Press Change (psia)	271.7	200.0 min
T/M Pitch Actuator Position (deg)	-0.02	*
IU Pitch Actuator Position (deg)	-0.01	*
T/M Yaw Actuator Position (deg)	-0.00	*
IU Yaw Actuator Position (deg)	0.02	*
IU Substitute 5 Volt Power Supply (vdc)	5.01	*
Aft 5 Volt Excitation Module (vdc)	5.00	*
Pitch Actuator Signal (ma)	0.05	*
Yaw Actuator Signal (ma)	0.10	*
Corrected T/M Pitch Actuator Position (deg)	-0.018	-0.517 to 0.517
Corrected IU Pitch Actuator Position (deg)	0.000	-0.517 to 0.517
Corrected T/M Yaw Actuator Position (deg)	-0.001	-0.517 to 0.517
Corrected IU Yaw Actuator Position (deg)	0.001	-0.517 to 0.517

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

Function	Measurement	Limits
Hydraulic System Pressure (psia)	3578.44	*
Reservoir Oil Pressure (psia)	164.09	*
Accumulator GN2 Pressure (psia)	3583.94	*
Accumulator GN2 Temperature (°F)	69.40	*
Reservoir Oil Level (%)	36.19	*
Pump Inlet Oil Temperature (°F)	71.75	*
Reservoir Oil Temperature (°F)	68.22	*
Aft Bus 2 Current (amp)	44.80	*
T/M Pitch Actuator Position (deg)	-0.02	*
IU Pitch Actuator Position (deg)	0.01	*
T/M Yaw Actuator Position (deg)	-0.00	*
IU Yaw Actuator Position (deg)	0.02	*
IU Substitute 5 Volt Power Supply (vdc)	5.00	*
Aft 5 Volt Excitation Module (vdc)	5.00	*
Pitch Actuator Signal (ma)	0.05	*
Yaw Actuator Signal (ma)	0.05	*

* Limits Not Specified

4.1.20.1 (Continued)

Function	Measurement	Limits
Corrected T/M Pitch Actuator Position (deg)	-0.018	-0.517 to 0.517
Corrected IU Pitch Actuator Position (deg)	0.022	-0.517 to 0.517
Corrected T/M Yaw Actuator Position (deg)	-0.001	-0.517 to 0.517
Corrected IU Yaw Actuator Position (deg)	0.008	-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: 13.8 deg/sec			
0.000	0.050	-0.029	5.010
0.026	-19.775	-0.403	5.010
0.054	-19.824	-0.750	5.010
0.082	-19.775	-1.082	5.005
0.109	-19.824	-1.515	5.005
0.137	-19.775	-1.947	5.005
0.165	-19.824	-2.309	5.005
0.191	-19.873	-2.611	5.010
0.220	-19.775	-2.770	5.010
0.248	-19.824	-2.827	5.005
0.274	-19.824	-2.856	5.005
0.303	-19.824	-2.842	5.005
Pitch -3 to 0 Degree Step Response - Engine Slew Rate: 12.8 deg/sec			
0.000	-19.800	-2.896	5.005
0.027	0.000	-2.554	5.005
0.055	0.000	-2.236	5.000
0.082	0.098	-1.904	5.010
0.109	0.049	-1.515	5.010
0.138	0.049	-1.096	5.005
0.165	0.000	-0.721	5.005
0.192	0.098	-0.375	5.000
0.221	0.049	-0.115	5.005
0.248	0.049	0.044	5.005
0.275	0.000	0.072	5.005
0.304	0.049	0.044	5.010
Pitch 0 to +3 Degree Step Response - Engine Slew Rate: 12.8 deg/sec			
0.000	0.000	0.015	4.999
0.025	19.971	0.318	5.000
0.054	19.971	0.664	5.005
0.082	19.922	0.996	5.000

4.1.20.1 (Continued)

Time From Start (sec)	Pitch Excitation Signal (ma)	IU Pitch Actuator Pot. Pos. (deg)	IU 5 Volt Power Supply (vdc)
0.108	19.922	1.371	5.000
0.137	19.971	1.761	5.010
0.164	19.922	2.180	5.005
0.191	19.971	2.555	5.010
0.220	19.922	2.800	5.010
0.248	19.971	2.944	5.000
0.274	19.971	3.030	5.005
0.303	19.971	3.030	5.005

Pitch +3 to 0 Degree Step Response - Engine Slew Rate: 13.6 deg/sec

0.000	20.000	3.088	4.999
0.026	0.000	2.670	5.010
0.054	0.000	2.338	5.005
0.082	0.000	1.978	5.005
0.108	0.049	1.573	5.005
0.137	0.000	1.126	5.005
0.165	0.000	0.736	5.010
0.191	0.049	0.419	5.010
0.220	0.049	0.202	5.010
0.247	0.049	0.102	5.010
0.274	0.000	0.087	5.010
0.303	0.049	0.087	5.005

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: 14.3 deg/sec

0.000	0.000	0.016	4.999
0.026	-19.824	-0.448	5.005
0.054	-19.824	-0.794	5.000
0.082	-19.824	-1.169	5.005
0.109	-19.824	-1.603	5.005
0.137	-19.824	-2.093	5.010
0.165	-19.873	-2.525	5.005
0.192	-19.873	-2.857	5.005
0.220	-19.824	-3.060	5.010
0.248	-19.873	-3.175	5.010
0.275	-19.824	-3.175	5.010
0.303	-19.824	-3.160	5.010

4.1.20.1 (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: 14.2 deg/sec			
0.000	-19.800	-3.159	5.005
0.026	0.000	-2.742	5.000
0.055	0.000	-2.367	5.005
0.082	0.000	-1.992	5.010
0.109	0.000	-1.544	5.000
0.138	0.049	-1.083	5.005
0.165	0.049	-0.606	5.005
0.192	0.000	-0.274	5.005
0.221	0.049	-0.072	5.010
0.248	0.000	0.043	5.005
0.275	0.000	0.058	5.005
0.304	0.000	0.043	5.005
Yaw 0 to +3 Degree Step Response - Engine Slew Rate: 14.4 deg/sec			
0.000	0.050	0.061	5.005
0.026	19.922	0.490	5.005
0.055	19.971	0.836	5.010
0.082	19.971	1.212	5.005
0.109	19.971	1.630	5.010
0.138	19.971	2.120	5.005
0.165	19.922	2.554	5.005
0.192	19.971	2.871	5.000
0.221	19.922	3.102	5.005
0.247	19.971	3.217	5.010
0.275	19.922	3.246	5.010
0.304	19.971	3.246	5.010
Yaw +3 to 0 Degree Step Response - Engine Slew Rate: 14.7 deg/sec			
0.000	20.000	3.280	5.005
0.027	0.000	2.799	5.005
0.055	0.000	2.409	5.005
0.082	0.000	2.049	5.005
0.109	0.049	1.615	5.005
0.138	0.000	1.154	5.005
0.165	0.000	0.721	5.005
0.192	0.000	0.331	5.005
0.221	0.098	0.086	5.010
0.248	0.049	-0.029	5.010
0.276	0.049	-0.044	5.005
0.304	0.049	-0.028	5.000

4.1.20.1 (Continued)

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

Function	Measurement	Limits
Hydraulic System Pressure (psia)	3588.31	*
Reservoir Oil Pressure (psia)	171.52	*
Accumulator GN2 Pressure (psia)	3581.19	*
Accumulator GN2 Temperature (°F)	60.02	*
Reservoir Oil Level (%)	37.94	*
Pump Inlet Oil Temperature (°F)	123.25	*
Reservoir Oil Temperature (°F)	104.33	*
Aft Bus 2 Current (amps)	50.20	*
Aux Hyd Pump Air Tank Pressure (psia)	445.38	282.5 + 217.5
Aux Hyd Pump Motor Gas Pressure (psig)	20.69	21 ± 12
T/M Pitch Actuator Position (deg)	-0.00	*
IU Pitch Actuator Position (deg)	0.01	*
T/M Yaw Actuator Position (deg)	0.03	*
IU Yaw Actuator Position (deg)	0.03	*
IU Substitute 5 Volt Power Supply (vdc)	5.00	*
Aft 5 Volt Excitation Module (vdc)	5.00	*
Pitch Actuator Signal (ma)	0.00	*
Yaw Actuator Signal (ma)	0.05	*
Corrected T/M Pitch Actuator Position (deg)	-0.002	-0.517 to 0.517
Corrected IU Pitch Actuator Position (deg)	0.022	-0.517 to 0.517
Corrected T/M Yaw Actuator Position (deg)	0.029	-0.517 to 0.517
Corrected IU Yaw Actuator Position (deg)	0.022	-0.517 to 0.517

* Limits Not Specified

4.1.21 Telemetry and Range Safety Antenna System Checks (1B64679 F)

Installation of a new PCM RF assembly, P/N 1B65788-1-004, S/N 18004, at the STC, required checkout per applicable portions of this procedure. The stage had been shipped "short" the PCM RF assembly to the STC. Testing was initiated on 21 January 1969, and successfully completed on 3 February 1969. The tests performed were the PCM transmitter center frequency and carrier deviation checks, and the PCM RF power detector calibration. All other portions of the procedure were deleted as not applicable to checkout of the PCM RF assembly. System hardware installed during checkout included:

Part Name	Ref. Location	P/N	S/N
PCM RF Assembly	411A64A200	1B65788-1-004	18004
Bi-Directional Coupler	411A64A204	1A69214-503	20010
Coaxial Switch	411A64A202	1A69213-1	077
Power Divider	411A64A201	1A69215-501	052
Telemetry Antennas	411E200 & E201	1A69206-501	075 & 076
Reflected Power Detector	411MT744	1A74776-501	290
Forward Power Detector	411MT728	1A74776-503	301
Dummy Load	411A64A203	1A84057-1	817
Directional Power Divider	411A97A56	1B38999-1	036
Hybrid Power Divider	411A97A34	1A74778-501	042
Range Safety Antennas	411E56 & E57	1A69207-501.1	060 & 061

Stage power was turned on for the PCM transmitter test. A dummy load, P/N 1A84057-1, S/N 817, was connected to the output of the transmitter, and power was turned on to the PCM RF assembly. After allowing 3 minutes for transmitter warmup, a 5 vdc input signal was applied, and the output frequency was measured at 258.539 MHz. The frequency measurement was then repeated after reversing the polarity of the 5 vdc input. This repeat measurement was recorded as 258.465 MHz. The PCM transmitter center frequency was calculated by averaging the two measured frequencies, and the carrier deviation was

4.1.21 (Continued)

calculated as one-half of the differential between the two measured frequencies. The resultant center frequency of 258.502 MHz and carrier deviation of 37.0 kHz were within the allowable limits of 258.500 ±0.026 MHz and 36.0 ±3.0 kHz, respectively.

After the DC amplifier gains were verified and with the transmitter reconnected to the system, the forward power detector output was measured and verified to be within ±3 percent of the detector calibration 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 VSWR characteristic of the power detector was adjusted to obtain the desired reflected power. The output of the reflected power detector was then measured and verified to be within ±3 percent of the detector calibration requirement for the measured reflected power.

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.

No other checks were required to verify proper operation of the system, and it was accepted for use.

Setup and adjustment discrepancies resulted in replacement of the forward power detector, P/N 1A74776-503, twice during the checkout. S/N 302 was replaced with

4.1.21 (Continued)

S/N 300 per FARR 500-703-016, and S/N 300 was then replaced with S/N 301 per FARR 500-703-041. S/N 301 performed satisfactorily to complete detector calibration.

Five revisions were recorded in the procedure for the following:

a. One revision deleted all portions of the procedure except those required for PCM transmitter checkout and PCM RF power detector calibration.

b. One revision corrected typographical errors in the procedure.

c. Three revisions modified the procedure for power detector adjustment based on the VSWR characteristics of the antenna system.

4.1.22 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 LH2 loading operations. The automatic checkout system (ACS) was utilized during testing to function PU system components and to monitor responses. This test involved all components of the stage PU system including:

Part Name	Ref. Location	P/N	S/N
Propellant Utilization Electronics Assy (PUEA)	411A92A6	1A59358-529	036
Static Inverter-Converter	411A92A7	1A66212-507	018
LOX Mass Probe	406A1	1A48430-511.1	C4
LH2 Mass Probe	408A1	1A48431-513	C7/C6
LOX Overfill Sensor		(Part of LOX Mass Probe)	
LOX Overfill Control Unit	404A72A4	1A68710-511	C24
LOX Fastfill Sensor	406A2C5	1A68710-1	C18
LOX Fastfill Control Unit	404A72A5	1A68710-511	C45
LH2 Overfill Sensor		(Part of LH2 Mass Probe)	
LH2 Overfill Control Unit	411A92A24	1A68710-509	C100
LH2 Fastfill Sensor	408A2C5	1A68710-1	D136
LH2 Fastfill Control Unit	411A92A43	1A68710-509	D71

The test was satisfactorily performed on 22 January 1969. Measurements recorded during the test are listed in Test Data Table 4.1.22.1.

Initial conditions scan was performed per H&CO 1B55813, 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 LH2 coarse mass voltages, fine mass voltages, and loading voltages. After an evaluation of the computer printout, a test of the

4.1.22 (Continued)

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 LH2 coarse and fine mass voltages were measured through the AO and BO instrumentation multiplexers.

The PU loading test followed. The LH2 boiloff bias signal voltage was measured with the boiloff bias cutoff turned on and was verified to be 0.0 $\pm$2.5 vdc with the cutoff turned off. The GSE loading potentiometer power was turned on, and the voltage measured. Measurements were then made of the LOX and LH2 loading potentiometer sense voltages and signal voltages. Measurements of the LOX and LH2 loading potentiometer signal voltages were repeated after the LOX and LH2 bridge 1/3 checkout relay commands were turned on, and again after these commands were turned off. The GSE power was turned off, and the LOX and LH2 loading potentiometer sense voltages were again measured.

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

4.1.22 (Continued)

repeated with the LOX and LH2 bridge 1/3 checkout relays on, with the bridge 2/3 checkout relays on, with the bridge 2/3 checkout relays off, and again with the bridge 1/3 checkout relays off.

The next check verified that the LOX and LH2 tank overfill and fastfill sensors and their associated control units responded properly under ambient (dry) conditions and under simulated wet conditions of the sensors.

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

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

The PU valve 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 then -20 degrees. Next,

4.1.22 (Continued)

the PU activate switch, the LOX bridge 1/3 checkout relay command, and the PU programmed mixture ratio switch were turned off; then, the ratio valve position was verified to be greater than -1.5 degrees. This procedure was then repeated with the PU mixture ratio 5.5 switch, LH2 bridge 1/3 checkout relay command, and the PU activate switch. The ratio valve position was verified to be greater than +20 degrees with the switches and commands on, and less than +1.5 degrees with switches and commands off. After turning on the PU mixture ratio 4.5 switch and verifying ratio valve position to be less than -20 degrees, the PU mixture ratio 5.5 switch selector was turned on; then, the ratio valve position was verified to be 0 $\pm$10 degrees. The test was completed by turning off the PU programmed mixture ratio switch and verifying that the ratio valve had returned to the null position.

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

a. One revision corrected a program error.

b. One revision provided program changes to support concurrent testing which did not affect the PU system test.

c. Two revisions concerned the malfunction and the elimination of the system status display from the list of GSE required for checkout.

d. Two revisions noted that malfunction indications during the initial conditions scan occurred due to concurrent testing. These had no affect on the PU system test.

e. One revision noted that a malfunction indication for the LH2 tank fastfill sensor occurred because of a fuse contact problem in the GSE signal distribution unit. After correction, the checkout was performed satisfactorily.

4.1.22 (Continued)

f. Two revisions concerned a malfunction indication for the LH2 tank overfill sensor. Prior reduction of the control unit sensitivity to minimize the effects of sloshing, bubbling, and high-density gas on the sensor would not permit the automatic checkout to be operational. The control unit was reset to permit checkout of the sensor.

g. One revision corrected a printout error by the automatic line-printer.

h. One revision modified strip chart speed to obtain a more accurate recording of PU valve movement during the valve slew check.

4.1.22.1 Test Data Table, Propellant Utilization System

Loaded Ratio Values (from H&CO 1B64367)

LOX Empty Ratio	0.021	LH2 Empty Ratio	0.000
LOX 1/3 Bridge Slew Ratio	0.283	LH2 1/3 Bridge Slew Ratio	0.310
LOX 2/3 Bridge Slew Ratio	0.571	LH2 2/3 Bridge Slew Ratio	0.639
LOX Wiper Ratio	0.039	LH2 Wiper Ratio	0.014

LH2 Boiloff Bias Voltage (vdc) 18.417

Computed Coarse Mass Voltages (vdc)

LOX Empty	0.103	LH2 Empty	0.000
LOX 1/3 Mass	1.416	LH2 1/3 Mass	1.548
LOX 2/3 Mass	2.856	LH2 2/3 Mass	3.193

Computed Fine Mass Voltages (vdc)

LOX Empty	4.009	LH2 Empty	1.367
LOX 1/3 Mass	0.249	LH2 1/3 Mass	2.339
LOX 2/3 Mass	2.017	LH2 2/3 Mass	4.590

Computer Loading Voltages (vdc)

LOX Empty	0.574	LH2 Empty	0.000
LOX 1/3 Coarse Mass	7.930	LH2 1/3 Coarse Mass	8.668

PU System Power Test

Function	Measured Value	Limits
Inv-Conv 115 vrms Output (vac)	114.461	115.0 ± 3.4
Inv-Conv 21 vdc Output (vdc)	22.078	21.25 ± 1.25

4.1.22.1 (Continued)

Function	Measured Value	Limits
Inv-Conv 5 vdc Output (vdc)	5.039	4.9 ± 0.2
Inv-Conv Frequency (Hz)	402.875	400.0 ± 6
PU Oven Monitor Voltage Z1 (vdc)	2.384	2.65 ± 2.35
PU Oven Monitor Voltage Z2 (vdc)	2.379	2.384 ± 0.075
PU Oven Monitor Voltage Z3 (vdc)	2.384	2.384 ± 0.075
PU Oven Monitor Voltage - Final (vdc)	2.384	2.384 ± 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)		0.098	0.098	0.103 ± 0.1
LOX Fine Mass Voltage (vdc)		3.989	3.984	4.009 ± 0.4
LH2 Coarse Mass Voltage (vdc)		0.000	0.000	0.000 ± 0.1
LH2 Fine Mass Voltage (vdc)		1.401	1.392	1.367 ± 0.4

PU Loading Test

Function	Measured Value	Limits
LH2 Boiloff Bias Signal Volt. (vdc)	21.370	18.417 ± 2.0
GSE Power Supply Voltage (vdc)	29.118	28.0 ± 2.0

Loading Potentiometer Function	LOX Value	LH2 Value	Limits
Sense Voltage, GSE Power On (vdc)	29.039	29.079	29.118 ± 0.4
Signal Voltage, Relay Commands	0.656		0.574 ± 0.5
Off (vdc)		0.027	0.0 ± 0.5
Signal Voltage, Relay Commands	7.793		7.930 ± 0.6
On (vdc)		8.504	8.668 ± 0.6
Signal Voltage, Relay Commands	0.574		0.574 ± 0.5
Off (vdc)		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)	0.282			0.351 ± 1.5
LOX Coarse Mass Voltage (vdc)		0.103	0.088	0.103 ± 0.1
LOX Fine Mass Voltage (vdc)		4.004	3.994	4.009 ± 0.4
LH2 Coarse Mass Voltage (vdc)		0.000	-0.005	0.000 ± 0.1
LH2 Fine Mass Voltage (vdc)		1.396	1.392	1.367 ± 0.4

4.1.22.1 (Continued)

Function	Measured Value	AO Multi	BO Multi	Limits
1/3 Checkout Relay Commands On				
Ratio Valve Position (deg)	1.033			0.351 ± 1.5
LOX Coarse Mass Voltage (vdc)		1.421	1.411	1.416 ± 0.1
LOX Fine Mass Voltage (vdc)		0.137	0.137	0.249 ± 0.4
LH2 Coarse Mass Voltage (vdc)		1.553	1.538	1.548 ± 0.1
LH2 Fine Mass Voltage (vdc)		2.485	2.485	2.339 ± 0.4
2/3 Checkout Relay Commands On				
Ratio Valve Position (deg)	1.374			0.351 ± 1.5
LOX Coarse Mass Voltage (vdc)		2.861	2.856	2.856 ± 0.1
LOX Fine Mass Voltage (vdc)		1.753	1.743	2.017 ± 0.4
LH2 Coarse Mass Voltage (vdc)		3.193	3.193	3.193 ± 0.1
LH2 Fine Mass Voltage (vdc)		4.927	4.971	4.590 ± 0.4
2/3 Checkout Relay Commands Off				
Ratio Valve Position (deg)	0.896			0.351 ± 1.5
LOX Coarse Mass Voltage (vdc)		1.416	1.411	1.416 ± 0.1
LOX Fine Mass Voltage (vdc)		0.132	0.132	0.249 ± 0.4
LH2 Coarse Mass Voltage (vdc)		1.543	1.538	1.548 ± 0.1
LH2 Fine Mass Voltage (vdc)		2.495	2.480	2.339 ± 0.4
1/3 Checkout Relay Commands Off				
Ratio Valve Position (deg)	0.282			0.351 ± 1.5
LOX Coarse Mass Voltage (vdc)		0.103	0.098	0.103 ± 0.1
LOX Fine Mass Voltage (vdc)		3.999	3.994	4.009 ± 0.4
LH2 Coarse Mass Voltage (vdc)		0.000	-0.005	0.000 ± 0.1
LH2 Fine Mass Voltage (vdc)		1.396	1.392	1.367 ± 0.4

PU Valve Movement Test

Function	Measured Value	Limits
Ratio Valve Position, AO (deg)	0.282	0.351 ± 1.50
Ratio Valve Position, BO (deg)	0.351	0.351 ± 1.50
50 Second Plus Valve Slew, AO Multiplexer		
+1 vdc System Test Valve Position Signal (vdc)	0.997	1.00 ± 0.02
V1, Position at T+3 Seconds (deg)	4.296	2.037 to 6.351
V2, Position at T+5 Seconds (deg)	5.182	2.659 to 7.396

4.1.22.1 (Continued)

Function	Measured Value	Limits
V3, Position at T+8 Seconds (deg)	5.796	2.977 to 7.396
V4, Position at T+20 Seconds (deg)	5.933	5.226 to 7.396
V5, Position at T+50 Seconds (deg)	5.864	5.226 to 7.396
50 Second Minus Valve Slew, AO Multiplexer		
Ratio Valve Position, AO (deg)	0.350	0.351 ± 1.5
-1 vdc System Test Valve Error Signal (vdc)	-0.994	-1.000 ± 0.02
V1, Position at T+3 Seconds (deg)	-3.885	-2.037 to -6.351
V2, Position at T+5 Seconds (deg)	-4.566	-2.659 to -7.396
V3, Position at T+8 Seconds (deg)	-5.111	-2.977 to -7.396
V4, Position at T+20 Seconds (deg)	-5.316	-5.226 to -7.396
V5, Position at T+50 Seconds (deg)	-5.316	-5.226 to -7.396

PU Activation Test

Function	AO Multi	BO Multi	Limits
Ratio Valve Position (deg)	0.146	0.282	0.351 ± 1.50
LOX 1/3 Command Relay On			
LOX Coarse Mass Voltage (vdc)	1.411	1.411	1.416 ± 0.1
PU System On			
Ratio Valve Position (deg)	31.713	31.713	20.0 min
PU System Off			
Ratio Valve Position (deg)	0.624	0.692	15.0 max
LOX 1/3 Command Relay Off			
LOX Coarse Mass Voltage (vdc)	0.098	0.093	0.103 ± 0.1
Ratio Valve Position (deg)	0.419	0.487	0.351 ± 1.5
LH2 1/3 Command Relay On			
LH2 Coarse Mass Voltage (vdc)	1.543	1.543	1.548 ± 0.1
PU System On			
Ratio Valve Position (deg)	-28.077	-27.941	-20.0 max
PU System Off			
Ratio Valve Position (deg)	0.62	-	-15.0 min
LH2 1/3 Command Relay Off			
LH2 Coarse Mass Voltage (vdc)	0.000	-0.015	0.000 ± 0.1
Ratio Valve Position (deg)	0.419	0.419	0.351 ± 1.5

PU Valve Programmed Mixture Ratio Test

Function	Measured Value	Limits
4.5 MR Switch On		
Ratio Valve Position (deg)	-23.168	-20.0 max

4.1.22.1 (Continued)

Function	Measured Value	Limits
LOX 1/3 Command Relay On and PU System On		
Ratio Valve Position (deg)	-28.350	-20.0 max
PU Programmed MR Switch Off		
Ratio Valve Position (deg)	0.692	-1.5 min
5.5 MR Switch On		
Ratio Valve Position (deg)	23.327	20.0 min
LH2 1/3 Command Relay On and PU System On		
Ratio Valve Position (deg)	31.849	20.0 min
PU Programmed MR Switch Off		
Ratio Valve Position (deg)	-1.012	1.5 max
4.5 MR Switch On		
Ratio Valve Position (deg)	-20.578	-20.0 max
5.5 MR Switch On		
Ratio Valve Position (deg)	-6.875	0 ± 10
PU Programmed MR Switch Off		
Ratio Valve Position (deg)	1.851	0.351 ± 1.5

4.1.23 Range Safety Receiver Checks (1B55819 H)

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	182
Range Safety Receiver 2	411A97A18	50M10697	189
Secure Command Decoder 1	411A99A1	50M10698	0181
Secure Command Decoder 2	411A99A2	50M10698	0039

The test was performed satisfactorily on 24 January 1969.

Several manual operations were accomplished before the automatic phase of the checkout was started. The total cable insertion loss values at the 450 MHz range safety frequency were determined to be 30.4 db for range safety system 1 and 30.8 db for range safety system 2. The destruct system test set, P/N 1A59952-1, was set up at 450 $\pm$0.045 MHz with a -17 dbm output level and a 60 $\pm$0.60 kHz deviation. The stage range safety antennas were disconnected from the directional power divider; and until the open loop RF checks, the 50 ohm loads were connected to the power divider for testing.

The cable insertion loss values were loaded into the computer, initial conditions scan was performed, the range safety receivers were transferred to external power and turned on, and the propellant dispersion cutoff command inhibit was turned on.

4.1.23 (Continued)

The receiver AGC calibration checks were then conducted. For each input signal level used in the calibration check, the computer determined the GSE test set output levels required to compensate for the cable insertion loss. Per the computer typeout, the GSE test set was manually adjusted to the appropriate output levels. The computer determined the input signal levels and measured the low level signal strength (AGC telemetry) of each receiver. These AGC measurements, in the 0.0 to 5.0 vdc range, were multiplied by a conversion factor of 20 and presented as percent of full scale values. The difference in AGC values at each step was determined and utilized for the AGC drift check. As shown in Test Data Table 4.1.23.1, the AGC values were all acceptable; and the drift deviations were well below the 3 percent of full scale maximum limit.

Manual -3 db and -60 db RF bandwidth checks were individually conducted on each receiver. With a GSE test set output frequency of 450.000 ±0.005 MHz, the output level was adjusted to obtain a 2.0 ±0.1 vdc AGC voltage from the receiver under test. The corresponding receiver RF output level was determined, and +20 dbm was added to obtain the RF reference level. The GSE test set output level was increased by 3 dbm, and the test set frequency was increased to greater than 450 MHz and decreased to less than 450 MHz until the receiver AGC voltage was again 2.0 ±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.

4.1.23 (Continued)

For the deviation threshold checks, the GSE test set was adjusted to an output of 450 ±0.045 MHz at a level that provided receiver input levels of -63 dbm for receivers 1 and 2. A series of checks determined the minimum input deviation frequency at which each receiver responded to the respective range safety command. For each command, the GSE test set was manually adjusted to a sequence of deviation frequencies increasing from 5 kHz per the computer typeout. At each deviation frequency, the range safety secure command decoders were checked for the presence of the command signal from the appropriate receiver. As shown in the Test Data Table, the receivers responded to all commands at minimum deviation frequencies less than the 50 kHz maximum limit.

For the radio frequency sensitivity checks, the GSE test set was adjusted for an output of 450 ±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 -84.6 dbm, as requested by the computer. This gave input levels increasing from -115.4 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

4.1.23 (Continued)

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 -81 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 -87 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 3.55 vdc while that of receiver 2 was 3.74 vdc. The range safety commands were transmitted from the GSE test set, and checks of the secure command decoders indicated the receivers responded properly to the open loop transmission. The PCM RF assembly power was turned on, the open loop PCM signal was verified to be received at the DDAS ground station, and the range safety commands were again transmitted. Checks of the decoders indicated that the receivers responded and were not adversely affected by the PCM RF transmission. The PCM RF assembly power was turned off, and the range safety EBW firing units were transferred to external power. The propellant dispersion cutoff command inhibits were turned off for each receiver, and the range safety receivers were turned off, thus completing the range safety receiver checks.

No FARR's were initiated as a result of this checkout. Nine revisions were recorded in the procedure for the following:

4.1.23 (Continued)

a. One revision corrected a procedure error.

b. One revision deleted the initial conditions scan check for calibration preflight mode, as authorized by WRO S-IVB-3676R10.

c. One revision noted that a malfunction indication during initial conditions scan was attributed to program error and did not affect the range safety receiver checks.

d. One revision added program changes to turn on the single sideband system transmitter during the range safety commands.

e. One revision deleted the range safety decoder leakage tests because the required GSE decoder test set was not available at test time. The decoder leakage tests were rescheduled for postfire checkout.

f. Two revisions authorized backup routines to restart the deviation threshold checks, after correction of operator errors.

g. One revision noted that a channel 6 lockout required resetting the PAM ground station to continue the test.

h. One revision indicated that the receipt of SIM channel 141 interrupt at the end of the test was expected because the program turned off range safety receiver 2 propellant dispersion cutoff command inhibit.

4.1.23.1 Test Data Table, Range Safety Receiver Checks

AGC Calibration and Drift Checks (% = Percent of Full Scale)

Test Set Output (dbm)	Receiver 1 Input (dbm)	AGC 1 (%)			Receiver 2 Input (dbm)	AGC 2 (%)		
		Run 1	Run 2	Drift		Run 1	Run 2	Drift
-96.6	-127.0	11.68	11.37	0.31	-127.4	15.47	15.59	0.12
-89.6	-120.0	11.68	11.48	0.20	-120.4	15.68	15.68	0.00
-84.6	-115.0	11.99	11.89	0.10	-115.4	16.41	16.29	0.12
-79.6	-110.0	12.81	12.91	0.10	-110.4	18.14	17.73	0.41
-74.6	-105.0	15.37	15.59	0.22	-105.4	22.87	22.97	0.10
-69.6	-100.0	23.57	22.75	0.82	-100.4	36.00	35.47	0.53
-64.6	-95.0	40.51	40.20	0.31	-95.4	56.70	57.11	0.41
-59.6	-90.0	64.08	64.30	0.22	-90.4	72.40	72.40	0.00
-54.6	-85.0	72.50	72.50	0.00	-85.4	75.27	75.18	0.09
-49.6	-80.0	74.14	74.24	0.10	-80.4	76.29	76.19	0.10
-44.6	-75.0	74.77	74.77	0.00	-75.4	76.60	76.41	0.19
-39.6	-70.0	74.96	74.96	0.00	-70.4	76.70	76.60	0.10

4.1.23.1 (Continued)

-3 db RF Bandwidth Check

Function	Receiver 1	Receiver 2	Limits
Reference Voltage (AGC) (vdc)	1.98	1.98	2.0 ± 0.1
Reference RF Power Level (dbm)	-64.8	-68.1	-
Upper Bandedge Freq. (MHz)	450.168	450.154	-
Lower Bandedge Freq. (MHz)	449.850	449.829	-
-3 db Bandwidth (kHz)	318.0	325.0	340.0 + 30.0
Bandwidth Centering (MHz)	450.009	449.991	450 ± 0.0338

-60 db RF Bandwidth Check

Function	Receiver 1	Receiver 2	Limits
Reference Voltage (ABC) (vdc)	1.98	1.99	2.0 ± 0.1
Reference RF Power Level (dbm)	-64.8	-68.1	-
Upper Bandedge Freq. (MHz)	450.539	450.557	-
Lower Bandedge Freq. (MHz)	449.546	449.536	-
-60 db Bandwidth (MHz)	0.993	1.021	1.2 max

Deviation Sensitivity Check

Range Safety Command	Minimum Deviation (kHz) Receiver 1	Minimum Deviation (kHz) Receiver 2
Arm and Engine Cutoff	15.0	12.5
Propellant Dispersion	15.0	12.5
Range Safety System Off	17.5	12.5

RF Sensitivity Check

Range Safety Command	Minimum Input Level (dbm) Receiver 1	Minimum Input Level (dbm) Receiver 2
Arm and Engine Cutoff	-100.0	-105.4
Propellant Dispersion	-105.0	-105.4
Range Safety System Off	-100.0	-105.4

4.1.24 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	Ref. Location	P/N	S/N
Range Safety Reveiver 1	411A97A14	50M10697	182
Range Safety Receiver 2	411A97A18	50M10697	189
Secure Command Decoder 1	411A99A1	50M10698	0181
Secure Command Decoder 2	411A99A2	50M10698	0039
Secure Command Controller 1	411A97A13	1B33084-503	019
Secure Command Controller 2	411A97A19	1B33084-503	020
RS System 1 EBW Firing Unit	411A99A12	40M39515-119	555
RS System 2 EBW Firing Unit	411A99A20	40M39515-119	554
RS System 1 EBW Pulse Sensor	411A99A31	40M02852	382
RS System 2 EBW Pulse Sensor	411A99A32	40M02852	0164
Safe and Arm Device	411A99A22	1A02446-503	*
Directional Power Divider	411A97A56	1B38999-1	036
Hybrid Power Divider	411A97A34	1A74778-501	042
*Installed in Pulse Sensor Assembly	411A99A31/32	1B29054-501	00008

The test was satisfactorily performed on 24 January 1969.

Initial conditions scan was performed per H&CO 1B55813, and the GSE destruct 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

4.1.24 (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 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 and through both multiplexers, that the nonprogrammed engine cutoff indication was still off, and that the instrument unit receiver 1 arm and engine cutoff

4.1.24 (Continued)

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 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.

4.1.24 (Continued)

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 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.

4.1.24 (Continued)

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, and again the safe indication was verified to be on, and the arm indication was verified to be off. This completed the range safety system tests, and the shutdown operation was accomplished.

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

a. One revision provided program changes to comply with hardwire modifications per ECP 3006R1 and WRO S-IVB-4612R2.

b. One revision deleted the initial conditions scan check for the calibration preflight mode, as authorized by WRO S-IVB-3676R10.

c. One revision noted that a malfunction indication during initial conditions scan was attributed to a program error and did not affect the range safety system test.

4.1.24.1 Test Data Table, Range Safety System

Function	Measured Value (vdc)	Limits (vdc)
Forward Bus 1 Battery Simulator	28.158	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	4.270	4.2 ± 0.3
System 1 Firing Unit Indication	4.261	4.2 ± 0.3
System 2 Charging Voltage Indication	4.265	4.2 ± 0.3
System 2 Firing Unit Indication	4.266	4.2 ± 0.3

4.1.24.1 (Continued)

Function	Measured Value (vdc)	Limits (vdc)
Internal Power		
System 1 Charging Voltage Indication	4.279	4.2 ± 0.3
System 2 Charging Voltage Indication	4.265	4.2 ± 0.3
External Power Off		
System 1 Charging Voltage Indication	0.034	0.3 max
System 2 Charging Voltage Indication	0.045	0.3 max
Firing Unit Arm and Engine Cutoff Test		
Engine Control Bus Voltage	27.876	28.0 ± 2.0
Receiver 1 Signal Strength Indication	3.584	3.75 ± 1.25
Receiver 2 Signal Strength Indication	3.748	3.75 ± 1.25
System 1 Arm and Engine Cutoff Test		
Firing Unit Charging Voltage Indication	4.274	4.2 ± 0.3
Engine Control Bus Voltage	27.91	28.0 ± 2.0
External Power Off		
System 1 Charging Voltage Indication	0.050	0.3 max
System 2 Charging Voltage Indication	0.050	0.3 max
System 2 Arm and Engine Cutoff Test		
Firing Unit Charging Voltage Indication	4.270	4.2 ± 0.3
Propellant Dispersion Test		
System 1 Propellant Dispersion Test		
Charging Voltage Indication (Pulse Sensor Off)	4.284	4.2 ± 0.3
Charging Voltage Indication (Pulse Sensor On)	1.524	3.0 max
System 2 Propellant Dispersion Test		
Charging Voltage Indication (Pulse Sensor Off)	4.274	4.2 ± 0.3
Charging Voltage Indication (Pulse Sensor On)	1.694	3.0 max

4.1.25 Single Sideband System Checkout (1B75537 A)

The purpose of this combined manual and automatic procedure was to verify the capability of the single sideband (SSB) telemetry system to properly measure, frequency multiplex, and transmit vibration and acoustical data. Stage hardware involved in the checkout included the vibration and acoustical instrumentation, the subcarrier, oscillator (SCO) assembly, the model 245 multiplexer, the telemetry (T/M) calibrator, the SSB translator, the SSB wideband amplifier, and the SSB transmitter.

The manual test sequences were initiated on 27 January 1969, and completed on 5 February 1969. Automatic test sequences were initiated on 27 January 1969, and completed on 4 February 1969.

The checkout consisted of twelve tests, the SSB antenna system insertion loss, voltage standing wave ratio (VSWR) with dummy load, VSWR with antenna, the SSB RF power detector calibration, the transmitter center frequency and deviation checks, the SSB ground station frequency response, the SSB translator frequency response, the preflight/inflight calibration of the T/M calibrator, pilot tone, the channel identification and remote automatic calibration (RAC) response test, and the open and closed loop transmitter information test.

Three FARR's documented discrepancies that were noted during SSB testing. Power detector, P/N 1A74776-501, S/N 286, was removed and replaced per FARR 500-703-377 because the R6 potentiometer would not adjust. This had resulted in no output voltage during the test. Failure to RAC (low level) for measurement N061 resulted in replacement of channel calibration decoder, P/N 1A74053-503, S/N 355,

4.1.25 (Continued)

per FARR 500-703-491. Cable assembly, P/N 1A68321-569, would not connect to the bulkhead connector at location 411A95A203, due to interference of the screws securing the stage connector to bracket, P/N 1B32295-501 E. As a temporary measure to complete SSB testing, the bulkhead was disconnected from the bracket and the plug was then connected to the jack. After the test, the screw holes in the bracket were countersunk to eliminate the screw head interference per FARR 500-703-458.

Seventy-six revisions were required to complete the test and were recorded in the procedure for the following:

a. Fifty-two revisions corrected errors and omissions in the procedure and the program.

b. Three revisions were written to clarify the procedure.

c. One revision deleted steps that were previously accomplished.

d. One revision deleted another which was not required.

e. Two revisions were not required and were deleted before being incorporated.

f. One revision authorized the use of an HP420A crystal detector in place of an HP420B, which was not available.

g. One revision authorized the use of the 5253B Hewlett-Packard frequency converter in place of the 5253A, which was not available.

h. One revision was an ICS change which was identical to one incorporated for stage power setup, H&CO 1B55813.

i. One revision attributed a malfunction indication during initial conditions scan (ICS) to a program error. The SSB test was not affected.

j. Two revisions attributed ICS malfunction indications to concurrent testing (leak checks).

4.1.25 (Continued)

k. One revision attributed an ICS malfunction indication to previous manual SSB testing, which had turned on the telemetry RF silence.

l. One revision provided instructions to troubleshoot the low RACS command malfunction for channel 19, measurement N061. This resulted in replacement of the channel calibration decoder per FARR 500-703-491.

m. Two revisions provided instructions to obtain preflight calibration data through the transmitter and repeat the inflight calibration test in open and closed loop modes, and to verify the parameters that utilize the channel calibration decoder after replacement of the decoder per FARR 500-703-491.

n. One revision attributed a tape unit turn-on malfunction to a program error. The tape unit turned on satisfactorily, after correcting the program.

o. One revision provided for resuming the program after a malfunction indication had been dispositioned.

p. One revision noted that two malfunction indications occurred because the SSB transmitter had not been turned off as required due to operator error.

q. One revision corrected procedure errors and also provided for a temporary connection of the cable assembly and connector which had been rejected on FARR 500-703-458 for inability to connect due to bracket screw interference.

r. One revision modified the procedure for reflected power detector adjustment based on the VSWR characteristics of the antenna system.

s. One revision repeated the forward power calibration after replacement of the reflected power detector per FARR 500-703-377.

4.1.26 <u>Hydraulic System Servicing (1B41004 C)</u>

Replacement of the accumulator/reservoir assembly, P/N 1B29319-519, S/N 00026 with S/N 00040, per FARR 500-703-482 was due to GN2 leakage, and required issuance of this servicing procedure to ensure that the hydraulic system was properly filled, bled, and maintained free of contamination after the replacement.

The servicing procedure was issued and satisfactorily completed on 31 January 1969. After charging the new accumulator/reservoir with GN2 per H&CO 1B41005, the GSE hydraulic pumping unit (HPU), P/N 1A67443-1, was used to gradually increase system pressure in 500 psi increments to 4400 psig maximum, while a continuous check of the hydraulic system was made for leakage. No unacceptable external leakage was detected in the stage hydraulic system.

The HPU was then used to circulate hydraulic fluid through the stage hydraulic system at 1800 ± 50 psig, to flush the accumulator/reservoir. After 30 minutes of circulation at this pressure, the system was bled free of excessive air by draining hydraulic fluid from the bleed valves at the accumulator inlet and outlet, the reservoir inlet, the engine driven hydraulic pump outlet, and the auxiliary hydraulic pump outlet.

The HPU was turned off and the system pressure was allowed to decay to 180 ± 5 psig. Sufficient hydraulic fluid was then drained from the system to reduce the system pressure to 80 ± 5 psig. The amount of fluid drained was verified to be less than 50 milliliters, indicating that the hydraulic system was satisfactorily filled and bled. Checks were then made of the accumulator/reservoir

4.1.26 (Continued)

low pressure and high pressure relief valve functions, as shown in Test Data Table 4.1.26.1.

After charging the GN2 accumulator to 1800 ±50 psig, the HPU was used to circulate hydraulic fluid through the stage hydraulic system at 1000 ±50 psig. Next, the stage auxiliary hydraulic pump was turned on, verified for correct operation and then secured after operating for 1 minute. The system fluid was then circulated at 3650 ±50 psig for 30 seconds with the HPU. The HPU was then secured. This procedure utilizing the auxiliary pump and the HPU was repeated four times. Next, after running the HPU for 10 minutes with system pressure at 3650 ±50 psig, fluid samples were obtained from the HPU pressure and return oil sample ports for the cleanliness checks. The cleanliness samples met the particle count requirements.

This completed the hydraulic servicing procedure. There were no discrepancies documented by FARR, and only two revisions were recorded in the procedure. One revision corrected typographical errors in numbering paragraphs of the procedure. The other revision deleted all portions of the procedure except those required to be performed due to the accumulator/reservoir change.

4.1.26.1 Test Data Table, Hydraulic System Servicing

Function	Measurement	Limits
Accumulator/Reservoir Relief Valve Checks		
Low Pressure Relief Valve		
Relief Pressure, Ground Return (psig)	260.0	275.0 ± 25.0
Reseat Pressure, Ground Return (psig)	255.0	220.0 min
Relief Pressure, Overboard (psig)	265.0	275.0 ± 25.0
Reseat Pressure, Overboard (psig)	255.0	220.0 min

4.1.26.1 (Continued)

Function	Measurement	Limits
High Pressure Relief Valve		
System Hydraulic Pressure (psig)	4400.0	4400.0 max
Return Pressure (psig)	275.0	*
Differential Pressure (psid)	4125.0	*

* Limits Not Specified

4.1.27 Propulsion System Test (1B62753 M)

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

The test was performed satisfactorily on 31 January 1969. However, a second issue of the procedure to repeat section three, the J-2 engine functional tests, became necessary when a J-2 engine electrical cable assembly was found defective and replaced per FARR 500-704-136 during integrated systems testing. A second test for section three of the procedure was conducted successfully on 7 February 1969, completing prefire propulsion system testing.

Significant measurements recorded during propulsion system testing are listed in Test Data Table 4.1.27.1 Measurements for section three are from the second test. The following narrative is a description of the tests performed.

4.1.27 (Continued)

Subsequent to the performance of stage power setup per H&CO 1B55813, testing of the ambient helium system commenced by pressurizing the ambient helium pneumatic control sphere and repressurization spheres to 700 $\pm$50 psia and setting the stage control helium regulator discharge pressure at 515 $\pm$50 psia. A series of checks verified the proper operation of the control helium dump valve and the pneumatic power control module shutoff valve. The proper functioning of the LOX and LH2 repressurization system was verified, including operation of the control valves, dump valves, and pressure switch system control.

A three-cycle test of the engine pump purge pressure switch preceded the functional checkout of the engine pump purge valve. The control helium regulator backup pressure switch and the control helium shutoff valve were similarly tested. The control helium sphere was pressurized to 697.359 psia; and the control helium regulator discharge pressure was measured at 550.33 psia, both within acceptable limits. A series of checks verified the operation of the pneumatically controlled valves, including the LH2 and LOX vent valves, fill and drain valves, prevalves, chilldown shutoff valves, the LH2 directional vent valve, the LH2 continuous vent and relief override valve, the LH2 continuous vent orificed bypass valve, the O2H2 burner propellant valves, the LOX nonpropulsive vent valve and the LH2 latch relief valve.

The passivation circuitry checkout and the J-2 orbital safing valve functional checks were accomplished satisfactorily. The LH2 tank pressurization and continuous vent valve blowdown check completed the ambient helium system test.

Section two, the propellant tanks pressurization systems test, was initiated with functional checks of the cold helium dump and shutoff valves. The

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

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

The LH2 repressurization and ground fill overpressurization pressure switches were verified to operate properly. Control of the LH2 main fill valve, the LH2 replenish valve, the LH2 auxiliary tank pressurization valve, the step pressure valve, the LH2 bypass control valve, and the repressurization control valve by the pressure switches was also demonstrated. After satisfactory completion of the LH2 pressure switch checks, the cold helium system was pressurized to 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 888.813 psia, and the cold helium sphere blowdown and cold helium regulator

4.1.27 (Continued)

low flow test were conducted. The cold helium spheres were vented, and a series of checks verified proper operation for the O2H2 burner voting circuit and burner malfunction temperature sensors. This completed testing of the propellant tanks pressurization systems.

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

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

The next series of tests verified that the simulated aft separation signals, 1 and 2, individually inhibited engine start and demonstrated proper operation of the LH2 injector temperature detector bypass and start tank discharge control.

4.1.27 (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 1460.781 psia to conduct the engine valve sequence tests which demonstrated that actuation and deactuation of the helium control solenoid valve caused the LH2 and LOX bleed valves to close and open, that opening and closing the ignition phase control solenoid valve caused the engine augmented spark igniter (ASI) LOX valve and engine main fuel valve to open and close, that the start tank discharge solenoid valve 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.

No FARR's were initiated as a result of propulsion system testing. All problem areas were resolved by revisions recorded in the two issues of the procedure. The first issue had forty-one revisions for the following:

4.1.27 (Continued)

a. Twenty-one revisions corrected errors in the program or procedure.

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

c. Two revisions modified the procedure to assure safety of the stage.

d. One revision changed stage power setup to comply with changes made during the demonstration test of H&CO 1B55813.

e. One revision turned on transducer power supplies to permit numeric readout of propellant tank ullage pressures.

f. One revision indicated that malfunctions for event indication K102 occurred because of an improper connection. The mislocated connector was relocated and testing was satisfactorily resumed.

g. One revision provided instructions to reverify function K102 after correcting mislocation of the connector.

h. One revision attributed the failure of the O2H2 burner propellant valves to be closed by shutdown backup to low helium supply pressure. After bringing helium pressure up to requirements, the program was resumed successfully.

i. Four revisions explained the causes of SIM interrupts received during testing. These included concurrent testing, program changes in the course of the test, and the program itself.

j. One revision noted that the initial testing of the control helium regulator backup pressure switch resulted in out-of-tolerance dropout pressures. The Calips pressure switch line was orificed to obtain subsequent satisfactory dropout pressures.

k. Five revisions attributed malfunction indications to insufficient time allowed by the program. After program changes to increase delay times, repeat tests were satisfactory.

Nineteen revisions were recorded in the second issue of the procedure for the following:

a. Two revisions deleted all portions of the procedure except those required for J-2 engine functional testing per section three of the procedure.

b. One revision provided instructions to verify operation of the pneumatic power control module.

4.1.27 (Continued)

c. One revision provided the prefire timing limits for the J-2 engine main oxidizer valve second stage opening. The procedure had listed the postfire limits which are based on retiming the valve.

d. Fifteen revisions were identical with those previously described for issue one of the procedure.

4.1.27.1 Test Data Table, Propulsion Test

Section 1 - Ambient Helium Test

Function

Engine Pump Purge Pressure Switch Checkout

		Measured Values			
		Test 1	Test 2	Test 3	Limits
Pickup Pressure	(psia)	121.758	120.207	120.207	136.0 max
Dropout Pressure	(psia)	108.551	107.773	108.551	99.0 min
Deadband	(psid)	13.207	12.434	11.656	3.0 min

Control Helium Regulator Backup Pressure Switch Checkout

Pressurization Time	(sec)	41.304	27.767	27.810	180.0 max
Pickup Pressure	(psia)	601.188	600.422	601.969	600 ± 21
Depressurization Time	(sec)	11.439	11.433	11.395	180.0 max
Dropout Pressure	(psia)	494.742	494.742	494.742	490 ± 31

Pneumatically Controlled Valve Timing Checkout

	Operating Times (sec)					
Valve	Open	Total Open	Close	Total Close	Boost Close	Total Boost Close
LH2 Vent Valve	0.023	0.072	0.175	0.429	0.082	0.235
LOX Vent Valve	0.016	0.078	0.101	0.354	0.065	0.228
LOX F&D Valve	0.145	0.251	0.725	2.335	0.434	0.983
LH2 F&D Valve	0.106	0.203	0.622	1.925	0.345	0.847
LOX Prevalve	1.111	1.703	0.153	0.274	*	*
LH2 Prevalve	1.134	1.742	0.172	0.298	*	*
LOX C/D SOV	0.210	0.976	0.015	0.135	*	*
LH2 C/D SOV	0.227	1.056	0.021	0.128	*	*
LH2 Cont Vent Orif'd Bypass Valve	0.009	0.104	0.008	0.146	*	*
O2H2 Burner LH2 Prop	0.007	0.538	0.007	0.507	*	*

* Not Applicable To These Valves

4.1.27.1 (Continued)

Section 1 - Ambient Helium Test (Continued)

Valve	Operating Times (sec) Open	Total Open	Close	Total Close	Boost Close	Total Boost Close
02H2 Burner LOX Prop	0.007	0.088	0.008	0.085	*	*
LH2 Latch Rlf Vlv	0.021	0.063	0.121	0.345	0.070	0.200
LOX NPV Vlv	0.028	0.051	0.152	0.387	0.088	0.220

Valve	Flight Position	Total Flt. Position	Ground Position	Total Ground Position
LH2 Directional Vent Valve	0.067	0.173	0.877	1.469

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)	67.920	48.041	48.929	180 max
Pickup Pressure	(psia)	475.32	473.77	473.77	467.5 ± 23.5
Depressurization Time	(sec)	15.000	14.974	14.944	180 max
Dropout Pressure	(psia)	381.297	381.297	380.516	362.5 ± 33.5

LOX Tank Repressurization Backup Pressure Switch Checkout

		Test 1	Test 2	Test 3	Limits
Pressurization Time	(sec)	48.641	48.812	48.814	180 max
Pickup Pressure	(psia)	474.547	473.766	473.766	467.5 ± 23.5
Depressurization Time	(sec)	14.648	14.595	14.589	180 max
Dropout Pressure	(psia)	385.180	383.625	384.398	362.5 ± 33.5

LH2 Tank Repressurization Backup Pressure Switch Checkout

		Test 1	Test 2	Test 3	Limits
Pressurization Time	(sec)	48.447	48.059	47.252	180 max
Pickup Pressure	(psia)	471.438	472.211	471.438	467.5 ± 23.5
Depressurization Time	(sec)	15.889	15.988	15.998	180 max
Dropout Pressure	(psia)	375.859	375.859	375.859	362.5 ± 33.5

LOX Tank Ground Fill Overpressure Pressure Switch Checkout

		Test 1	Test 2	Test 3	Limits
Pressurization Time	(sec)	84.299	55.197	43.729	180 max
Pickup Pressure	(psia)	40.477	40.424	40.371	41 max

* Not Applicable To These Valves

4.1.27.1 (Continued)

Section 2 - Propellant Tanks Pressurization System Test (Continued)

Function		Measured Values Test 1	Test 2	Test 3	Limits
Depressurization Time	(sec)	9.965	4.508	5.208	180 max
Dropout Pressure	(psia)	38.962	38.962	39.065	37.5 min
Deadband	(psid)	1.515	1.462	1.306	0.5 min

LH2 Repressurization Control Pressure Switch Checkout

Pressurization Time	(sec)	74.815	20.311	19.552	180 max
Pickup Pressure	(psia)	30.761	30.658	30.607	31 max
Depressurization Time	(sec)	47.043	43.939	42.992	180 max
Dropout Pressure	(psia)	28.620	28.569	28.569	27.8 min
Deadband (psid)	(psid)	2.141	2.089	2.038	0.5 min

LH2 Tank Ground Fill Overpressure Pressure Switch Checkout

Pressurization Time	(sec)	70.701	31.671	19.400	180 max
Grd. Fill Overpress Pickup Pressure	(psia)	30.148	30.148	30.098	31 max
Depressurization Time	(sec)	74.675	49.821	47.960	180 max
Grd. Fill Overpress Dropout Pressure	(psia)	28.314	28.416	28.314	27.8 min
Deadband	(psid)	1.834	1.732	1.783	0.5 min

Section 3 - J-2 Engine Functional Test (Engine S/N J-2122)

Engine Delay Timer Checkout

Function	Delay Time (sec)	Limits (sec)
Ignition Phase Timer	0.436	0.450 ± 0.030
Helium Delay Timer	0.996	1.000 ± 0.110
Sparks De-energized Timer	3.304	3.300 ± 0.200
Start Tank Discharge Timer	1.004	1.000 ± 0.040

Function

Mainstage OK Pressure Switch 1 Checkout

		Measured Values Test 1	Test 2	Test 3	Limits
Pickup Pressure	(psia)	512.31	507.65	505.33	515 ± 36
Dropout Pressure	(psia)	450.24	451.79	451.79	*
Deadband	(psid)	62.07	55.86	53.54	62.5 ± 48.5

* Limits Not Specified

4.1.27.1 (Continued)

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

Function

Mainstage OK Pressure Switch 2 Checkout

		Measured Values			
		Test 1	Test 2	Test 3	Limits
Pickup Pressure	(psia)	521.94	517.28	517.28	515 ± 36
Dropout Pressure	(psia)	448.13	448.13	448.13	*
Deadband	(psid)	73.81	69.16	69.16	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	**	0.018	**
Ign Phase Cont Solenoid Command Talkback	**	0.012	**
ASI Valve Open	**	0.066	**
Engine LOX Bleed Valve Close	**	0.128	**
Engine LH2 Bleed Valve Close	**	0.110	**
Main Fuel Valve Open	0.075	0.140	0.215
Start Tank Disch Timer	**	1.004	**
Start Tank Disch Valve Open	0.090	0.114	0.204
Mainstage Cont Solenoid Energized	**	1.453	**
Ignition Phase Timer	**	0.449	**
Start Tnk Disch Cont Solenoid De-energized	**	0.007	**
Main LOX Valve Open	0.518	1.652	2.170
Start Tank Disch Valve Close	0.186	0.157	0.343
Gas Generator Valve Open	**	0.159	0.258
LOX Turbine Bypass Valve Close	0.269	0.241	0.510
Spark System Off Timer	**	3.304	**

Engine Cutoff

Ign Phase Cont Solenoid De-energized from Cutoff	**	0.008	**
Mainstage Cont Solenoid De-energized from Cutoff	**	0.017	**
ASI Valve Close	0.025	**	**
Main LOX Valve Close	0.123	0.043	0.166

* Limits Not Specified

** Not Applicable Or Not Available

4.1.27.1 (Continued)

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

Function	Start or Delay Time (sec)	Oper. or Travel Time (sec)	Total Time (sec)
Main Fuel Valve Close	0.132	0.156	0.288
Gas Generator Valve Close	0.139	0.094	0.232
He Cont De-energized Timer	**	0.998	**
Engine LOX Bleed Valve Open	**	**	7.279
Engine LH2 Bleed Valve Open	**	**	8.166
LOX Turbine Bypass Valve Open	0.308	0.510	0.817

Engine Sequence Data (Oscillograph Records)

Function	Measurements		Limits	
	Delay	Valve Motion	Delay	Valve Motion
Ignition (sec)				
Main Fuel Valve Open	0.045	0.100	0.030-0.090	0.030-0.130
Start Tank Disch Vlv Open	0.083	0.091	0.080-0.120	0.085-0.125
Mainstage (sec)				
GG Valve Fuel Open	***	***	*	*
GG Valve LOX Open	0.135	0.060	0.130-0.150	0.020-0.080
Start Tank Disch Valve Close	0.126	0.243	0.110-0.150	0.175-0.255
MOV 1st Stage Open	0.042	0.050	0.030-0.070	0.025-0.075
MOV 2nd Stage Open	0.618	1.828	0.540-0.680	1.750-1.900
Oxidizer Turbine Bypass Vlv Close	0.194	0.299	*	5.0 max
Cutoff (sec)				
Oxidizer Turbine Bypass Vlv Open	0.224	0.661	*	10 max
GG Valve LOX Close	0.051	0.021	0.040-0.100	0.010-0.055
Main Oxid Vlv Closed	0.059	0.124	0.045-0.075	0.105-0.135
Main Fuel Vlv Closed	0.075	0.234	0.065-0.115	0.200-0.250

* Limits Not Specified
** Not Applicable Or Not Available
*** Not Recorded By Engineering

4.1.27.1 (Continued)

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

Function	Measurements Delay	Measurements Valve Motion	Limits Delay	Limits Valve Motion
Bleeds (sec)				
ASI Open	**	***	**	0.100 max
ASI Close	**	***	**	0.100 max
GG Valve LOX Open	**	***	**	30.0 max
GG Valve LOX Close	**	***	**	0.120 max
GG Valve Fuel Open	**	***	**	30.0 max
GG Valve Fuel Close	**	***	**	0.120 max
Timers (sec)				
Start Tnk Disch Vlv Delay	0.992	**	0.960-1.040	**
Ignition Phase	0.452	**	0.420-0.480	**
Sparks De-energize	3.295	**	3.10-3.50	**
Helium Cont De-energize	1.009	**	0.890-1.110	**
Trace Deflections				
Oxid Turbine Bypass Valve 80% (sec)	0.440	**	0.350-0.550	**
Main Oxid Valve (deg)	14.9	**	10-16	**
GG Valve (%)	50	**	35-65	**

* Limits Not Specified
** Not Applicable Or Not Available
*** Not Recorded By Engineering

4.1.28 Integrated System Test (1B55831 J)

The automatic and manual test sequences performed during this checkout verified the design integrity and operational capability of the stage and facility systems which were functional during propellant loading and static acceptance firing.

Two test attempts were conducted during prefire test operations. The initial attempt, performed on 5 February 1969, was aborted due to numerous malfunctions, including test equipment, program, and stage hardware. During this test, engine ready could not be obtained due to malfunction of GH2 ignition detection. This was attributed to a broken wire in the leg of the J-2 engine electrical cable assembly that services the ignition detector probe. The cable assembly, P/N 503157, S/N 3793212, was removed and replaced per FARR 500-704-136. Failure to properly regulate the helium supply for pneumatic control resulted in rejection and replacement of pneumatic power control module, P/N 1A58345-523, S/N 1057, per FARR 500-704-110. In addition, the pressure transducer for measurement D054, LH2 tank inlet pressure, failed during the initial test. Pressure transducer, P/N 1B40242-585, S/N 585-14, was removed and replaced per FARR 500-608-056.

The second test was performed satisfactorily on 7 February 1969. The narration and the test data in Test Data Table 4.1.28.1 are taken from this test.

The stage power setup H&CO 1B55813 established initial conditions and systematically applied power to the stage buses and systems required for operation of the test.

4.1.28 (Continued)

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

The telemetry and digital data acquisition systems were checked next, with the PCM transmitter operated open loop. The telemetry 5-step calibration high and low RACS, and special calibrations of flows, speed, and frequencies were commanded to provide verification of all calibration techniques. The parameters on the CP1-BO and DP1-BO multiplexers and remote analog and digital submultiplexers, which were required for loading or firing, were verified by receipt of the proper response through open loop PCM transmissions. During the CP1-BO multiplexer test, thirty-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 fourteen functions to be on. A separate CP1-BO and DP1-BO multiplexer test was conducted for those channels that measure J-2 engine pressures.

The torch and water test was performed satisfactorily. Following setup of the console GH2 supply, the GH2 igniters, diffuser water, deflection plate water, and aspiration 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. The LOX and LH2 prevalves and chilldown

4.1.28 (Continued)

shutoff valves were closed and opened while the operating times were measured. The LH2 directional vent valve was set to the flight and ground positions while the operating times were measured; then, the simulated O2H2 burner firing flight sequence was conducted.

Engine gimbal testing followed the stage valve functional test. The auxiliary hydraulic 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.

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 igntion and jettison EBW units were functionally certified by charging and firing into the pulse sensors.

Proper control of engine cutoff with the LOX and LH2 point level sensors was verified. 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 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.

4.1.28 (Continued)

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, voltage, and frequency tests; then, aft bus 2 was switched from internal to external. This completed stage testing for the integrated system test.

FARR documentation resulting from testing was limited to those previously described for the initial aborted test, none being recorded for the second test.

Thirty-five revisions were recorded in the procedure for the following:

a. Thirteen revisions corrected errors in the program.

b. One revision added changes to stage power setup which were identical to those incorporated during the demonstration test per H&CO 1B55813.

c. Ten revisions updated the program to the latest requirements.

d. Two revisions entered the required PU system constants into the program.

e. One revision indicated that the out-of-tolerance high RACS value for measurement D020 was acceptable because it was within the allowable 2% tolerance of the calibration curve for the transducer.

f. One revision indicated that error messages and a channel 6 lockout occurred due to operator error. The PAM/FM/FM ground station transfer switch had been inadvertently left in disable position.

g. One revision noted that the malfunction indication due to low LOX chilldown pump motor canister pressure was expected. This had been documented prior to integrated system testing on FARR 500-703-415. The low pressure condition was accepted for simulated static firing. After static firing, the low pressure condition was corrected by changing orificing.

4.1.28 (Continued)

h. Five revisions attributed malfunctions to program errors.

i. One revision investigated the cause of high ambient output for measurement D014, control helium regulator discharge pressure. The regulator discharge pressure was found to be above ambient due to a check valve in the bleed line which had prevented complete venting to ambient.

4.1.28.1 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)	2411.000	2350.000 ± 100.000
M025	Hi RACS Test (vdc)	3.994	4.000 ± 0.050
M025	Lo RACS Test (vdc)	-0.010	0.000 ± 0.050
M025	Amb Output (vdc)	4.995	5.000 ± 0.030
D236	Hi RACS Test (vdc)	3.958	4.000 ± 0.100
D236	Lo RACS Test (vdc)	0.974	1.000 ± 0.100
D236	Amb Output (psia)	-1.870	14.700 ± 70.000
D225	Hi RACS Test (vdc)	3.989	4.000 ± 0.100
D225	Lo RACS Test (vdc)	0.999	1.000 ± 0.100
D225	Amb Output (psia)	9.683	14.700 ± 10.000
D261	Hi RACS Test (vdc)	4.015	4.000 ± 0.100
D261	Lo RACS Test (vdc)	0.999	1.000 ± 0.100
D261	Amb Output (psia)	56.326	14.700 ± 70.000
M024	Hi RACS Test (vdc)	3.999	4.000 ± 0.050
M024	Lo RACS Test (vdc)	-0.021	0.000 ± 0.050
M024	Amb Output (vdc)	4.999	5.000 ± 0.030
M068	Hi RACS Test (vdc)	3.964	4.000 ± 0.050
M068	Lo RACS Test (vdc)	-0.030	0.000 ± 0.050
M068	Amb Output (vdc)	4.990	5.000 ± 0.030
G001	Amb Output (°F)	-0.395	-0.300 ± 0.400
G002	Amb Output (°F)	0.453	0.300 ± 0.400
D020	Hi RACS Test (vdc)	3.892†	4.000 ± 0.100
D020	Lo RACS Test (vdc)	0.984	1.000 ± 0.100
D020	Amb Output (psia)	31.782	14.700 ± 70.000
D177	Amb Output (psia)	14.463	14.700 ± 1.000
D178	Amb Output (psia)	14.959	14.700 ± 1.000
D088	High RACS Test (vdc)	3.984	4.000 ± 0.100
D088	Lo RACS Test (vdc)	1.025	1.000 ± 0.100
D088	Amb Output (psia)	20.565	14.700 ± 70.000
D179	Amb Output (psia)	14.223	14.700 ± 1.000
D180	Amb Output (psia)	15.019	14.700 ± 1.000
L007	Amb Output (%)	47.422	50.000 ± 10.000

† See Revision e

4.1.28.1 (Continued)

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

Meas. No.	Function	Measurement	Limits
D236	Hi RACS Test (vdc)	3.964	4.000 + 0.100
D236	Lo RACS Test (vdc)	0.979	1.000 ± 0.100
D236	Amb Output (psia)	5.607	14.700 ± 70.000
D043	Amb Output (psia)	2413.750	2350.000 ± 100.000
C138	Hi RACS Test (vdc)	3.969	4.000 ± 0.075
C138	Lo RACS Test (vdc)	-0.005	0.000 ± 0.075
C138	Amb Output (°F)	75.666	70.000 ± 16.000
M025	Amb Output (vdc)	5.005	5.000 ± 0.030
D209	Amb Output (psia)	12.962	20.750 ± 11.950
M074	Amb Output (vdc)	0.000	0.000 ± 0.075
M073	Amb Output (vdc)	0.000	0.000 ± 0.075
D261	Hi RACS Test (vdc)	4.020	4.000 ± 0.100
D261	Lo RACS Test (vdc)	1.010	1.000 ± 0.100
D261	Amb Output (psia)	63.962	14.700 ± 70.000
D014	Amb Output (psia)	29.077††	14.700 ± 13.000
M006	Amb Output (vdc)	28.029	28.000 ± 2.000
M007	Amb Output (vdc)	0.000	0.000 ± 0.450
D050	Amb Output (psia)	15.384	14.700 ± 3.000
M024	Hi RACS Test (vdc)	4.010	4.000 ± 0.050
M024	Lo RACS Test (vdc)	-0.025	0.000 ± 0.050
M024	Amb Output (vdc)	4.999	5.000 ± 0.030
M068	Hi RACS Test (vdc)	3.969	4.000 ± 0.050
M068	Lo RACS Test (vdc)	-0.015	0.000 ± 0.050
M068	Amb Output (vdc)	4.990	5.000 ± 0.030
C006	Hi RACS Test (vdc)	4.020	4.000 ± 0.075
C006	Lo RACS Test (vdc)	-0.010	0.000 ± 0.075
C006	Amb Output (°F)	75.592	70.000 ± 18.000
D103	Amb Output (psia)	17.184	14.700 ± 3.000
G001	Amb Output (°F)	-0.395	-0.300 ± 0.400
G002	Amb Output (°F)	0.469	0.300 ± 0.400
M010	Hi RACS Test (vdc)	3.994	4.000 ± 0.100
M010	Lo RACS Test (vdc)	1.040	1.000 ± 0.100
M010	Amb Output (vdc)	0.688	0.000 ± 1.000
D020	Hi RACS Test (vdc)	3.896†	4.000 ± 0.100
D020	Lo RACS Test (vdc)	0.984	1.000 ± 0.100
D020	Amb Output (psia)	31.782	14.700 ± 70.000
D054	Hi RACS Test (vdc)	3.994	4.000 ± 0.100
D054	Lo RACS Test (vdc)	1.025	1.000 ± 0.100
D054	Amb Output (psia)	15.575	14.700 ± 2.000
C231	Hi RACS Test (vdc)	3.964	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

† See Revision e
†† See Revision i

4.1.28.1 (Continued)

Meas. No.	Function	Measurement	Limits
C001	Hi RACS Test (vdc)	3.984	4.000 ± 0.075
C001	Lo RACS Test (vdc)	0.000	0.000 ± 0.075
C001	Amb Output (°F)	70.156	70.000 ± 72.000
D177	Amb Output (psia)	14.463	14.700 ± 1.000
D178	Amb Output (psia)	15.079	14.700 ± 1.000
D105	Hi RACS Test (vdc)	3.979	4.000 ± 0.100
D105	Lo RACS Test (vdc)	1.015	1.000 ± 0.100
D105	Amb Output (psia)	14.593	14.700 ± 10.000
C230	Hi RACS Test (vdc)	3.979	4.000 ± 0.075
C230	Lo RACS Test (vdc)	0.010	0.000 ± 0.075
C230	Amb Output (°F)	-378.438	-379.000 ± 4.000
D088	Hi RACS Test (vdc)	3.989	4.000 ± 0.100
D088	Lo RACS Test (vdc)	1.025	1.000 ± 0.100
D088	Amb Output (psia)	20.565	14.700 ± 70.000
C002	Hi RACS Test (vdc)	3.989	4.000 ± 0.075
C002	Lo RACS Test (vdc)	0.005	0.000 ± 0.075
C002	Amb Output (°F)	71.576	70.000 ± 48.000
D179	Amb Output (psia)	14.463	14.700 ± 1.000
D180	Amb Output (psia)	15.139	14.700 ± 1.000
M026	Amb Output (vac)	0.000	0.000 ± 0.980
M027	Amb Output (vac)	-0.066	0.000 ± 0.980
M041	Amb Output (vac)	0.000	0.000 ± 0.980
M040	Amb Output (vac)	0.000	0.000 ± 0.980
M060	Hi RACS Test (vdc)	4.030	4.000 ± 0.100
M060	Lo RACS Test (vdc)	1.020	1.000 ± 0.100
M060	Amb Output (vac)	1.518	6.000 ± 6.000
M061	Hi RACS Test (vdc)	3.953	4.000 ± 0.100
M061	Lo RACS Test (vdc)	1.020	1.000 ± 0.100
M061	Amb Output (vdc)	-0.472	0.000 ± 1.200
L007	Amb Output (%)	47.547	50.000 ± 10.000
C199	Hi RACS Test (vdc)	4.005	4.000 ± 0.075
C199	Lo RACS Test (vdc)	-0.025	0.000 ± 0.075
C199	Amb Output (°F)	73.807	70.000 ± 21.000

CP1-BO Multiplexer - J-2 Engine Pressures Test

Meas. No.	Function	Measurement	Limits
D019	Hi RACS Test (vdc)	4.066	4.066 ± 0.050
D019	Lo RACS Test (vdc)	1.071	1.076 ± 0.050
D019	Amb Output (psia)	51.810	14.700 ± 70.000
D018	Hi RACS Test (vdc)	4.117	4.117 ± 0.050
D018	Lo RACS Test (vdc)	1.123	1.117 ± 0.050
D018	Amb Output (psia)	15.520	14.700 ± 15.000
D017	Hi RACS Test (vdc)	4.087	4.092 ± 0.050
D017	Lo RACS Test (vdc)	1.097	1.092 ± 0.050
D017	Amb Output (psia)	16.515	14.700 ± 30.000

4.1.28.1 (Continued)

DP1-B0 Multiplexer - J-2 Engine Pressures Test

Meas. No.	Function	Measurement	Limits
D017	Hi RACS Test (vdc)	4.092	4.092 ± 0.050
D017	Lo RACS Test (vdc)	1.107	1.092 ± 0.050
D017	Amb Output (psia)	19.561	14.700 ± 30.000
D019	Hi RACS Test (vdc)	4.066	4.066 ± 0.050
D019	Lo RACS Test (vdc)	1.087	1.066 ± 0.050
D019	Amb Output (psia)	51.810	14.700 ± 70.000

Valve Functional Check

Function	Measurement		Limits
LH2 & LOX Prevalves	Close Time (sec)	0.357	4.000 max
	Open Time (sec)	1.746	4.000 max
LH2 Vent Valve	Open Time (sec)	0.118	4.000 max
	Close Time (sec)	0.402	4.000 max
LOX Vent Valve	Open Time (sec)	0.120	4.000 max
	Close Time (sec)	0.378	4.000 max
LH2 & LOX C/D SOV	Close Time (sec)	0.184	4.000 max
	Open Time (sec)	1.032	4.000 max
LH2 Vent Valve	Open Time (sec)	0.086	4.000 max
	Close Time (sec)	0.377	4.000 max
	Open Time (sec)	0.085	4.000 max
	Close Time (sec)	0.229	4.000 max
LOX Vent Valve	Open Time (sec)	0.082	4.000 max
	Close Time (sec)	0.351	4.000 max
	Open Time (sec)	0.085	4.000 max
	Close Time (sec)	0.348	4.000 max
LH2 Fill & Drain Valve	Open Time (sec)	0.212	4.000 max
	Close Time (sec)	1.905	4.000 max
	Open Time (sec)	0.204	4.000 max
	Close Time (sec)	0.855	4.000 max
LOX Fill & Drain Valve	Open Time (sec)	0.262	4.000 max
	Close Time (sec)	2.284	4.000 max
	Open Time (sec)	0.253	4.000 max
	Close Time (sec)	0.979	4.000 max

4.1.28.1 (Continued)

Function	Measurement		Limits
LH2 & LOX Prevalves	Close Time (sec)	0.318	4.000 max
	Open Time (sec)	1.724	4.000 max
LH2 & LOX C/D SOV	Close Time (sec)	0.152	4.000 max
	Open Time (sec)	1.010	4.000 max
LH2 Dir Vent Valve	Dir Vent to Flt Pos (sec)	0.197	4.000 max
	Dir Vent to Grd Pos (sec)	0.190	4.000 max

Engine Gimbal Step Commands - Restrainer Links Engaged

Position (deg)	Pitch Exc (ma)	Yaw Exc (ma)	TM Pitch Pos(deg)	TM Yaw Pos(deg)	IU Pitch Pos(deg)	IU Yaw Pos(deg)
0^o pitch 0^o yaw	0.00	0.05	0.01	-0.00	0.03	0.00
1^o pitch 1^o yaw	6.75	0.05	0.86	0.01	0.84	0.02
0^o pitch 0^o yaw	0.05	0.00	0.03	-0.00	0.04	0.02
-1^o pitch -1^o yaw	-6.55	0.00	-0.90	0.01	-0.90	0.02
0^o pitch 0^o yaw	0.00	0.00	0.01	-0.00	0.01	0.02
0^o pitch 0^o yaw	0.00	-6.55	-0.02	-0.72	0.03	-0.72
0^o pitch 0^o yaw	0.00	0.05	-0.02	0.08	0.03	0.06
0^o pitch 0^o yaw	0.00	6.70	0.01	1.11	0.01	1.12
0^o pitch 0^o yaw	0.05	0.05	-0.00	-0.00	0.01	0.02

4.1.28.1 (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	0.00	0.00	0.01	0.03	0.03	0.03
1° pitch 1° yaw	6.70	0.00	0.99	0.03	1.00	0.03
0° pitch 0° yaw	0.00	0.05	0.03	0.03	0.03	0.02
-1° pitch -1° yaw	-6.55	0.05	-0.88	0.03	-0.93	0.03
0° pitch 0° yaw	0.00	0.00	0.03	0.03	0.03	0.05
0° pitch 0° yaw	0.00	-6.55	0.01	-1.02	0.04	-1.02
0° pitch 0° yaw	0.00	0.05	0.01	0.06	0.04	0.05
0° pitch 0° yaw	0.05	6.70	0.01	1.11	0.03	1.11
0° pitch 0° yaw	0.00	0.05	0.01	0.03	0.01	0.02

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	0.57	0.086	17.590	3.20	2.018
	5.00	5.02	0.031	56.470	12.21	1.996
	7.00	7.06	0.034	86.896	16.47	2.007
0.25° Yaw	0.60	0.56	0.077	15.473	3.15	1.995
	5.00	5.02	0.030	54.705	12.19	1.994
	7.00	7.11	0.030	77.500	16.53	2.004
0.50° Ptch	0.60	0.55	0.078	15.533	3.16	2.028
	5.00	5.02	0.024	44.117	12.28	2.015
	7.00	7.01	0.033	83.835	16.46	2.021
0.50° Yaw	0.60	0.56	0.072	14.501	3.16	2.002
	5.00	5.04	0.029	53.201	12.25	1.994
	7.00	7.06	0.032	81.931	16.47	2.010

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

Final leak checks for the stage propulsion system were conducted prior to acceptance firing after all other stage checkouts had been completed. The primary purpose of the final prefire leak checks was to test for any external leakage that could occur as a result of system disturbance during checkouts conducted after the prefire propulsion system leak check procedure, H&CO 1B71877, had been completed. Examples of system disturbances that required a repeat of the external leak checks included removal and replacement of instrumentation, replacement of malfunctioning components, and plumbing connections required to facilitate prefire checkouts.

Checkout was initiated on 14 February 1969, and satisfactorily completed on 17 February 1969. Significant measurements recorded during the leak checks are listed in Test Data Table 4.1.29.1.

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

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

4.1.29 (Continued)

helium regulator discharge pressure was monitored for decay during a 15-minute actuation lockup. Results of the ambient helium system decay checks are listed in the test data table. In addition to the decay checks, the pneumatic actuation control modules were checked for internal leakage by monitoring each module for the 3.0 scim allowable leakage at the vent ports. Checks for external helium leakage with a helium leak detector and bubble solution AMS 3159 were conducted for the purge line from the aft skirt tunnel interface to the NPV purge port, and from the tee upstream of the NPV purge port to the continuous vent valve and duct ports. No unacceptable leakage was detected for the ambient helium system.

After the satisfactory completion of the ambient helium systems leak check, the cold helium system was leak checked by pressurizing the cold helium spheres with helium to 950 ±50 psig, and using AMS 3159 bubble solution to check all plumbing, including the O2H2 burner portion of the system, for external leakage. No leaks were detected.

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

4.1.29 (Continued)

O2H2 burner propellant system was then checked externally for leakage from the tank assembly to the burner nozzle plug. No leaks were detected.

The burner propellant valves were then closed and the downstream systems vented in preparation for the LOX and LH2 tank assembly pressure decay checks. These were accomplished by closing all engine and burner propellant supply valves to maintain static helium pressure in the tank assembly and monitor any loss in tank pressures over a 30-minute period. The pressure requirements were 15 + 0, -1 psig for the LOX tank and 9 + 1, -0 psig for the LH2 tank. Prior to the decay checks, gas samples were taken from both tanks and analyzed for helium content. Results of the helium concentration check and the pressure decay checks for the LOX and LH2 tanks are listed in Test Data Table 4.1.29.1.

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. One external leak at the LOX PU probe flange was corrected by tightening to the required torque.

After venting the LOX low pressure duct, the LH2 low pressure duct (propellant supply to the J-2 engine) was pressurized with helium at 10 to 30 psig while

4.1.29 (Continued)

maintaining LOX tank and LH2 tank pressures at 10 to 15 psig and 10 + 0, -1 psig, respectively. The LH2 system for the LH2 tank through the J-2 engine was then checked for external helium leakage, similarly to the LOX system previously described. No leaks were detected.

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

The J-2 engine start tank was pressurized with helium to 500 ±10 psig to perform the tank decay rate test. After allowing the start tank pressure to stabilize for 2 hours, the start tank temperature and pressure were measured and recorded. After 1 hour, these measurements were repeated to calculate the helium mass decay rate for the start tanks. The calculated decay rate was 0.0000 pounds-mass/hour, which was acceptable based on an allowable mass decay rate of 0.0066 pounds-mass/hour. During the pressure lockup for the decay rate test, the start tank system was checked for external helium leakage. No leaks were detected.

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

4.1.29 (Continued)

side leak check was then conducted to determine internal leakage within the engine pneumatic control package. Leakage rates were measured at the control package common vent port as listed in the test data table. Initial leak measurements with mainstage solenoid on were out-of-tolerance. Repeated cycles of the ignition phase and mainstage solenoids at 400 psig helium pressure corrected the initial out-of-tolerance measurement.

Engine control sphere pressure was then increased to 300 $\pm$10 psia, and the helium control solenoid was turned on to pressurize the pressure actuated purge system for external leak checks. No leaks were detected with the helium leak detector or the bubble solution. The engine control sphere pressure was then increased to 1450 $\pm$50 psig for the pneumatic control high pressure side retention test. After allowing the control sphere pressure to stabilize for 1 hour, the control sphere temperature and pressure were measured and recorded to calculate sphere helium mass. This was repeated 1 hour later to obtain a calculated engine control sphere helium mass decay rate of 0.000 pounds-mass/hour, which was acceptable based on an allowable decay rate of 0.036 pounds-mass/hour.

Tank blanket pressures were then maintained with helium, at 5 + 0, -1 psig for the LOX tank and 3 + 0, -1 psig for the LH2 tank. All systems, except the LOX and LH2 tanks, were vented to ambient and secured.

Final checks were then made to verify that the umbilical hoses required for static firing were installed, and that those stage umbilical ports not required were capped off. The stage checkout was completed by verifying that the required

4.1.29 (Continued)

electrical cables were connected to the proper solenoid valves in the LOX and LH2 tank pressurization modules.

There were no stage hardware test discrepancies resulting in FARR documentation. However, two FARR's were generated against a hardwire transducer failure and a ding in a thrust chamber tube. The FARR against the tube ding was voided because research revealed previous acceptance on another FARR prior to stage arrival at the STC. The hardwire transducer failure was for the start tank pressure measurement D525, noted during pressurization of the start tank system for leak checks. The hardwire transducer was replaced and the start tank system was then leak checked satisfactorily.

Twenty-two revisions were recorded in the procedure for the following:

a. Seven revisions corrected or updated the procedure.

b. Two revisions provided for the removal of the LOX and LH2 repressurization isolation hand valves, returning the LOX and LH2 repressurization systems to flight configuration, and then leak checking the connections for external leakage.

c. One revision provided a constant trickle purge by maintaining the LOX chilldown pump motor canister purge hand valve open at all times.

d. One revision deleted the cold helium system torque checks because these had been previously performed during the propulsion system leak check procedure, H&CO 1B71877.

e. Six revisions provided for leak checks required because of previous replacements of stage hardware, hardwire instrumentation, and rework of GSE test equipment.

f. One revision deleted the use of the 1B73519-1 desiccant cover for the O2H2 burner nozzle plug monitoring port because the cover was not available. A cap was used.

4.1.29 (Continued)

g. One revision deleted the use of the helium leak detector, requiring the soap solution only for external leak detection on 15 February 1969. The wind velocity made the use of the detector impractical that day.

h. Two revisions provided for recycling of the ignition and main-stage solenoids during the J-2 engine low pressure side pneumatic leak checks to investigate the initial out-of-tolerance internal leakage within the pneumatic control package. After repeat cycles at slightly higher pressures (400 psig), internal leakage rates at the specified pressure became acceptable.

i. One revision deleted the final purges for the LOX and LH2 tank and engine systems because the required 99 percent helium concentration for the tanks had been obtained.

4.1.29.1 Test Data Table, Final Prefire Propulsion System Leak Checks

Stage Vacuum Duct Readings

	Reading (Microns)	Limits (Microns)
LH2 LPD Upper	55	Less than 250
LH2 LPD Lower	49	Less than 250
LH2 Recirculation	67	Less than 250
O2H2 Burner LH2 Propellant Upper	15	Less than 250
O2H2 Burner LH2 Propellant Lower	85	Less than 250
O2H2 Burner LOX Propellant	16	Less than 250

Ambient Helium System Pressure Decay Checks

	Initial (psig)	Final (psig)	Limits
Control Helium Sphere Pressure	1400	1400	*
LOX Repressurization Sphere Pressure	1350	1340	*
LH2 Repressurization Sphere Pressure	1325	1310	*
Control Helium Regulator Disch Pressure	535	540	*

Control Pneumatics System Pressure Decay Test

	Initial (psig)	Final (psig)	Limits
Control Helium Regulator Disch Pressure	527	535	*

* Limits Not Specified

4.1.29.1 (Continued)

LOX and LH2 Tank Helium Concentration

		Reading (percent)	Limits (percent)
LOX Tank:	Top	99	75 min
	Bottom	99	75 min
LH2 Tank:	Top	99	75 min
	Bottom	99	75 min

LOX and LH2 Tank Pressure Decay Test

	Initial (psig)	Final (psig)	Limits
LOX Tank	14.4	14.4	*
LH2 Tank	9.2	9.2	*

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	10.2	20 max
Ignition Phase Solenoid On	18.0	20 max
Mainstage Solenoid On	1.5	20 max

* Limits Not Specified

4.2 Postfire Acceptance Testing

Stage postfire acceptance testing began on 21 February 1969, with the initiation of the stage power setup, paragraph 4.2.1. The postfire checkouts were completed on 28 March 1969, with the acceptance of the cryogenic temperature sensor verification, paragraph 4.2.21.

4.2.1 Stage Power Setup (1B55813 L)

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 postfire testing.

The checkout was successfully demonstrated on 21 February 1969, with the initial condition scan portion demonstrated on 24 February 1969. Measurements from this test are listed in Test Data Table 4.2.1.1.

The test was started by resetting all matrix magnetic latching relays and verifying that the corresponding command relays were in the proper stage. The umbilical connectors were verified to be mated, and the LOX and LH2 inverters were verified to be disconnected. The bus 4D119 talkback power was turned on, and the prelaunch checkout group was turned off. The forward and aft power buses were transferred to external power. The sequencer power, engine control bus power, engine ignition bus power, APS bus 1 and bus 2 power, and propellant level sensor power were all verified to be off. The power to the range safety 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.

4.2.1 (Continued)

The range safety system safe and arm device was verified to be in the safe condition. The 70 pound ullage engine relay, the LH2 continuous vent valve relays, the LH2 and LOX repressurization mode relay, the O2H2 burner propellant valve relay, and the engine passivation relays were all verified to be reset. The LH2 continuous vent and relief override valve was verified to be closed, and the LOX repressurization control valve enable was verified to be on. Power was verified to be off for the propellant utilization boiloff bias. The O2H2 burner spark systems 1 and 2 voltages were measured and recorded. The O2H2 LOX and LH2 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 then verified that the stage functions were in the proper state. Forty-three functions were verified to be off and twenty-five were verified to be on. The LOX and LH2 prevalves and chilldown shutoff valves were verified as open, and the LOX and LH2 vent valves and fill and drain valves were verified as closed.

4.2.1 (Continued)

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

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

a. One revision updated the program to the requirements of ECP's 3006 and 3008.

b. One revision deleted the calibration preflight mode function per WRO S-IVB-3676R10.

c. One revision attributed a malfunction indication for the ambient helium supply shutoff valve to program error. The program looked for the wrong state of the valve.

4.2.1.1 Test Data Table, Stage Power Setup

Function	Measured Value	Limit
Forward Bus 1 Power Supply Current (amps)	2.000	20 max
Forward Bus 1 Voltage (vdc)	28.118	28 ± 0.5
O2H2 Burner Spark System 1 Voltage (vdc)	0.010	0 ± 0.5
O2H2 Burner Spark System 2 Voltage (vdc)	0.029	0 ± 0.5
Forward Bus 1 Quiescent Current (amps)	2.100	5 max
PCM System Group Current (amps)	5.101	5 ± 3
Forward Bus 2 Power Supply Current (amps)	0.500	2 max
Forward Bus 2 Voltage (vdc)	28.118	28 ± 0.5
Aft Bus 1 Power Supply Current (amps)	0.699	2 max
Aft Bus 1 Voltage (vdc)	28.199	28 ± 0.5
Sequencer Power (amps)	0.300	0 ± 3
Aft 5V Excitation Module Voltage (vdc)	4.981	5 ± 0.030
Fwd 1 5V Excitation Module Voltage (vdc)	4.996	5 ± 0.030
Fwd 2 5V Excitation Module Voltage (vdc)	4.999	5 ± 0.030
RS 1 EBW Firing Unit Chg Voltage (vdc)	0.005	0 ± 1
RS 2 EBW Firing Unit Chg Voltage (vdc)	0.005	0 ± 1
Aft Bus 2 Voltage (vdc)	0.159	0 ± 1
Forward Battery 1 Simulator Voltage (vdc)	0.039	0 ± 1
Forward Battery 2 Simulator Voltage (vdc)	0.000	0 ± 1
Aft Battery 1 Simulator Voltage (vdc)	0.000	0 ± 1
Aft Battery 2 Simulator Voltage (vdc)	0.000	0 ± 1
Component Test Power Voltage (vdc)	0.720	0 ± 1

4.2.2 Stage Power Turnoff (1B55814 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 postfire 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 demonstration test was successfully performed on 21 February 1969. Following this, the procedure was used to shutdown the stage at the conclusion of the various automatic checkouts during postfire operations. Measurement values for the demonstration test are listed in Test Data Table 4.2.2.1.

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

The switch selector functions were then turned off; the O2H2 burner spark systems 1 and 2 voltages were measured; and a series of checks verified that the stage electrical functions were in the proper stage of off, reset, or closed.

The forward and aft bus power supplies were verified to be off, and the forward and aft bus battery simulator voltages were measured. The stage buses 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

4.2.2 (Continued)

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 turn-off.

There were no FARR's written against this test. However, one revision was required to update the program to the requirements of ECP's 3006 and 3008.

4.2.2.1 Test Data Table, Stage Power Turnoff

Function	Measured Value	Limits
Forward Bus 1 Voltage, Power On (vdc)	28.118	28 ± 2
Aft Bus 1 Voltage, Power On (vdc)	28.158	28 ± 2
O2H2 Burner Spark System 1 Voltage (vdc)	0.024	0 ± 0.5
O2H2 Burner Spark System 2 Voltage (vdc)	0.000	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)	0.079	0 ± 1.0
Forward Bus 2 Voltage, Power Off (vdc)	0.000	0 ± 1.0
Aft Bus 1 Voltage, Power Off (vdc)	0.000	0 ± 1.0
Aft Bus 2 Voltage, Power Off (vdc)	0.079	0 ± 1.0

4.2.3 Structural Inspection (1B70756 C)

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

The checkout was initiated on 21 February 1969, and completed satisfactorily on 28 March 1969.

The checkout was started with an inspection of the LOX and LH2 tank assemblies, the thrust structure, the tunnel areas, and the forward and aft skirt assemblies for cracked or debonded brackets, for cracks or deformations in the skin panels, and for chipped or peeled paint. The external ducts, tubes, and spheres were checked for scratches, dings, and corrosion. Cracked and peeling Korotherm coating in forward and aft skirt areas was documented on FARR 500-703-989. The damaged coating was repaired per DPS 42210 and DPM 3486.

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

The environmental control plenum, P/N 1B64850, was then inspected for rips and debonded areas, and was found acceptable. This was followed by visual inspection of the stage air bottle, the control helium, the ambient helium, and cold helium spheres for dings, scratches, or other damage. The cold helium plenums, P/N 1A49991, were inspected for insulation condition. Internal inspection of the LH2 tank was accomplished per H&CO 1B71972.

4.2.3 (Continued)

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

This completed the postfire structural inspection of the stage prior to shipment to FTC.

There were no other discrepancies documented by FARR; however, three revisions were recorded in the procedure for the following:

a. One revision deleted the removal and reinstallation of the access door, P/N 1A68531-3, as a convenience because inspection could be accomplished without the removal of this door.

b. One revision deleted the APS module fit check because the modules are no longer shipped to the STC for test and fit.

c. One revision provided instructions to remove eight covers, P/N 1A89016-501, and eight fillers, P/N 1B33685-1, from the grooves in the frame assembly, P/N 1B29827, inspect the grooves for residual walnut shell grit from the blasting operation, and reinstallation of the covers and fillers after completion.

4.2.4 Hydraulic System Poststorage Operating and Securing (1B41006 B)

The purpose of this procedure was to obtain postfire closed loop hydraulic fluid samples and to secure the hydraulic system prior to removal of the stage from the test stand for transfer to the VCL.

Checkout was initiated on 24 February 1969, and satisfactorily completed on 24 March 1969. Components of the stage hydraulic system installed during this checkout included the main engine driven hydraulic pump, P/N 1A66240-505, S/N X457813; the auxiliary hydraulic pump, P/N 1A66241-511, S/N X458912; the hydraulic pitch and yaw actuator assemblies, P/N 1A66248-507, S/N's 66 and 77; and the accumulator/reservoir assembly, P/N 1B29319-519, S/N 00040.

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 ±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

4.2.4 (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 ($0^{\circ}F$ 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 return pressure was decreased to 80 ±5 psig. The 10.0 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 $83.1^{\circ}F$, and based on the curve for temperature versus drained fluid volume, a total of 240 milliliters of hydraulic fluid was removed.

4.2.4 (Continued)

The HPU was disconnected from the stage system and secured. Hydraulic system preparations for stage removal from the test stand included depressurization of the GN2 accumulator, the stage auxiliary hydraulic pump case, and the air supply bottle. All auxiliary equipment was removed from the hydraulic system, and all sample ports were capped. The accumulator/reservoir drain hose was removed, and a plastic dust cover was installed on the port of the reservoir low pressure relief valve. This completed the securing of the system for stage transfer to the VCL.

There were no recorded discrepancies during this checkout; however, FARR 500-703-873 was initiated for the use of unfiltered, unsampled freon to wash down port "P" on the auxiliary hydraulic pump. This condition was accepted by the Material Review Board as the system was under positive pressure during the wash. Five revisions were recorded in the procedure for the following:

a. Two revisions provided instructions to setup the system to check proper operation of hydraulic parameters after disconnection of hardwire cables and to reverify the proper operation of D209 pressure transducer for the IST procedure 1B55831.

b. One revision gave instructions to drain any hydraulic fluid from the accumulator vent relief valve and remeasure after a 48-hour period to monitor possible accumulator vent relief valve leakage. No leakage was indicated.

c. One revision required the depressurization of the stage air supply bottle to support the repair of an air regulator.

d. One revision provided instruction to verify the proper operation of the coast mode switch and talkback due to disconnect-connect of the thermal switch connector.

4.2.5 Propulsion Leak and Functional Check (1B71877 D)

This checkout procedure defined the operations required to perform the postfire leak and functional checks for the stage propulsion system. Initiated on 24 February 1969, the checkout was completed and certified as acceptable on 25 March 1969. Leak check results for the individual propulsion system components are listed in Test Data Table 4.2.5.1.

After preliminary setup operations, the O2H2 burner postfire checks were accomplished. The burner was inspected for external signs of damage or loose equipment. The injectors were removed from the burner, and the injector faces and igniter tips were inspected for cracks and excessive erosion. After cleaning the injectors per MSFC-164, the igniter tips were reinstalled in the injector igniter ports and the injectors attached to the burner using safety wire, such that the injector faces and igniter tips were visible for the O2H2 burner sparks check. In addition to obtaining oscillograph record spark traces for both igniters, visual observation of the spark gap verified constant arcing in or around the bore for each igniter tip 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 bottle supply, the engine control sphere supply, the LOX tank pressurization

4.2.5 (Continued)

supply, the LH2 tank prepressurization supply, the ambient helium fill, and the APS helium bottle supply. No unacceptable leakage was detected.

The postfire Calip pressure switch system leak checks included 5-minute pressure decay and external leak checks of the pressure switch checkout circuits. The LOX and LH2 pressure switch checkout circuits were pressurized with their individual supplies to 30 ±5 psia and checked for external leakage. Similar leak checks were conducted for the low pressure switch checkout circuit at 600 ±50 psia and the mainstage pressure switch checkout circuit at 500 ±50 psia. No external leaks were detected for the pressure switch checkout circuits. In addition, pressure decay for each checkout circuit was monitored over a 5-minute lockup period at the previously noted pressures. All decay checks were acceptable, as noted in the Test Data Table.

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

4.2.5 (Continued)

a pressure decay check of the pneumatic control system was performed over a 30-minute pressure lockup period.

One external leak was detected at the LOX fill and drain valve, P/N 1A48240-505, S/N 0132, which was subsequently replaced by P/N 1A48240-511, S/N 0103, per A.O. 1B68375 E. The replacement valve was leak checked satisfactorily. Excessive reverse leakage through the LH2 ambient repressurization check valve, P/N 1B67598-501, S/N 202, resulted in replacement of the valve per FARR 500-703-865. The replacement valve checkout out satisfactorily, as noted in the Test Data Table.

The engine start system leak and functional checks were started with a leak check of the start tank vent control valve seat and a reverse leak check of the start tank initial fill check valve. After pressurizing the start tank to 500 $\pm$10 psig with helium, the entire start system was checked for external leakage. The start bottle retention test obtained the necessary measurements for start tank temperature and pressure to calculate the helium pound-mass/hour loss. This decay rate for the start bottle was taken over a 60-minute period and was acceptable. The start system check was concluded with leak checks of the tank vent and relief valve, dump valve bellows, and an external leak check of the start tank vent system. No leaks were detected.

The LH2 pressurization and repressurization systems tests started with a functional check of the O2H2 burner LH2 repressurization control valves, leak checks of the burner LH2 repressurization control valve seat and pilot bleed valve, and a reverse leak check of the burner LH2 check valve. The LH2

4.2.5 (Continued)

repressurization system was pressurized to 450 ±50 psig and checked for external leakage. The LH2 pressurization system was checked similarly for external leakage at 450 ±25 psia. In addition, reverse leak checks were performed for the LH2 pressurization module check valve and the LH2 prepressurization check valve. Measurements of leakage rates for the main components of the LH2 repressurization and pressurization systems are listed in the test data table. One external leak was noted and corrected by tightening the connection. Also, excessive reverse leakage was measured through the LH2 prepressurization check valve, P/N 1B65673-1, S/N 30. The valve was removed and replaced per FARR 500-703-890, and leak checked satisfactorily as noted in the Test Data Table.

The thrust chamber system was checked for external leakage with the thrust chamber throat plug installed and the system pressurized to 30 ±2 psig. In addition, the LOX dome purge check valve and the thrust chamber jacket purge check valve were tested for reverse leakage. The thrust chamber main oxidizer and fuel valves were tested for drive and idler shaft seal leakage. 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 O2H2 burner LOX repressurization systems. Internal leakage rates were measured for the LOX pressurization module, cold helium fill module, and the burner LOX repressurization module. In addition, reverse leak checks were performed for the LOX repressurization system check valve and the burner LOX repressurization check valve. Leakage

4.2.5 (Continued)

rates for the major system components are in the Test Data Table. No rejectable leaks were recorded.

Leak checks were then performed on the LOX tank and the O2H2 burner and 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 LOX feed system were checked for external leakage. The LOX turbopump was checked for breakaway torque, running torque, and primary seal leakage. The LOX chilldown pump purge leak and pressure checks included a pump canister pressure check, a pump shaft seal leak check, and an external leak check of the pump purge circuit. No unacceptable leaks were recorded.

The LOX prevalve shaft seal was leak checked with the prevalve open and closed, and the LOX fill and drain valve was checked for seat leakage. Next, leak checks of the O2H2 burner LOX shutdown valve and an external leak check from the LOX tank to the O2H2 burner LOX shutdown valve were performed. An external leak check of the LOX pump primary seal drain lines completed this portion of the checkout.

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

4.2.5 (Continued)

valves, the LH2 turbine seal cavity purge check valve, and the LOX turbine seal cavity purge check valve were checked for reverse leakage. The engine LH2 pump intermediate seal was checked for leakage. The engine LH2 pump drain check valve was also checked for forward flow. Then the LH2 tank and the engine feed system were checked for external leakage. There were no unacceptable leaks.

The LH2 turbopump was checked for breakaway and running torque and for primary seal leakage. The LH2 prevalve shaft seal was leak checked with the valve opened and closed. The LH2 fill and drain valve was checked for seat leakage and primary shaft seal leakage. Leak checks of the O2H2 burner LH2 propellant valve seat and the LOX shutdown valve seat were made, as well as an external leak check of the O2H2 propellant system. Two external leaks detected at the O2H2 burner igniters were corrected by replacing the igniter gaskets.

Leak and flow checks of the engine gas generator (GG) and exhaust system were conducted next, and included reverse leak checks of the GG LH2 purge check valve, and the GG LOX purge check valve. Leak checks of the GG propellant valves, the start tank discharge valve gate seal, and the hydraulic pump shaft seal were also performed. Bleed flow checks of the LH2 and LOX turbine seal cavities were conducted. External leak checks of the GG and exhaust system were also performed. One external leak, recorded at the heat exchanger hot gas discharge pressure port, was corrected by replacement of the fitting and gasket.

Engine pump purge leak and flow checks performed a regulation check of the engine pump purge module discharge pressure, measured the seat leakage of the

4.2.5 (Continued)

engine pump purge valve, checked the purge flows of the LOX and LH2 turbine seal cavity bleeds and the fuel pump seal cavity, and verified the GG fuel purge flow at the LH2 turbopump access. An external leak check of the engine pump purge system was also conducted. No unacceptable leakage was recorded.

Leak and flow checks of the engine pneumatics system included the helium control solenoid energized leak checks, the LOX intermediate seal purge flow checks, the ignition phase solenoid energized leak checks, the start tank discharge valve solenoid energized leak checks, the 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 test was performed to determine the control bottle decay by calculating the helium pound-mass/hour-loss. An out-of-tolerance inertial pneumatic system leakage, with mainstage control solenoid energized, was measured at the engine pneumatic control package common vent port. This leakage was isolated to the pressure actuated fast shutdown valve, P/N 558127-11, S/N 4092538, which was removed and replaced per FARR 500-704-004. Repeat leak checks were acceptable.

The LOX and LH2 vent system leak and flow checks included external leak checks of the LOX vent system and the LH2 ground and flight vent systems, plus internal leak checks of the valves in the system, including the LOX vent and relief valve, the LOX NPV valve, the LH2 vent and relief valve, the LH2 latching relief valve, the bidirectional vent valve, and the LH2 continuous vent valve. A summary of the internal leak checks is listed in the test data table. There were no areas of unacceptable leakage recorded during the vent system checks.

4.2.5 (Continued)

Pressure checks were then conducted on the engine electrical instrumentation packages and the igniter cabling. 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. Some evidence of fluorescent particles were detected, but designated acceptable by a revision to the procedure.

Problem areas recorded on FARR tags that resulted from this checkout were limited to those previously discussed. However, eighty-five revisions were recorded in the procedure for the following:

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

b. Four revisions were written and subsequently voided.

c. Six revisions corrected or deleted previous revisions or portions thereof.

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

e. Six revisions were required to update the procedure to the stage configuration.

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

g. One revision added provisions for a temporary leak check installation.

h. Two revisions authorized test gauge substitutions for system pressurization.

i. Three revisions added steps required to support concurrent test procedures.

j. Two revisons provided instructions to leak check newly installed ambient helium system check valves and plumbing per ECP 3006.

4.2.5 (Continued)

k. One revision specified modifications to pressurize systems during leak checks without the use of GSE power.

l. One revision provided for B-nut torque checks after relocation of transducers.

m. One revision authorized a substitution for a facility LH2 vent system burst disc because the specified disc was not available.

n. Two revisions provided instructions for the postfire engine purging and drying required by Rocketdyne Manual Data Supplement, R-3825-1B-20, and authorized by CCO 2053.

o. One revision provided for removal of the 1/4-inch vent port check valves to accomplish internal leak checks of the actuation control modules. The procedure which normally removes these valves prior to leak checks had not been issued.

p. Two revisions to the procedure were made for convenience of operation.

q. Four revisions deleted leak checks designated as prefire requirements only.

r. Three revisions provided instructions to support Rocketdyne welding of propellant utilization (PU) valve instrumentation lines, proof tests of the welds, and a subsequent leak check of the new PU valve.

s. One revision provided for removal and reinstallation instructions prior to leak checks to verify installation of proper part numbers for plugs and seals.

t. One revision authorized investigation of the previously described engine pneumatics system internal leakage, which resulted in replacement of the pressure actuated fast shutdown valve per FARR 500-704-004.

u. Two revisions provided procedure changes to obtain measurements through telemetry rather than hardwire, because the hardwire transducers had been removed.

v. One revision indicated that fluorescent particles detected during the black light inspection of the injector were not detrimental, and were acceptable.

4.2.5.1 Test Data Table, Propulsion Leak and Functional Check

Umbilical Quick Disconnect Check Valve Leak Check

Function	Measurement	Limits
Thrust Chamber Purge (scim)	0	0
Engine Start Bottle Supply (scim)	0.5	10
Engine Control Supply (scim)	0	0
LOX Prepress Supply (scim)	0.5	10
LH2 Prepress Supply, High Press (scim)	0	0
LH2 Prepress Supply, Low Press (scim)	0	0
Repress Bottle Supply (scim)	0	0
APS Helium Bottle Supply (scim)	0	0

Calip Pressure Switch Leak Checks

Function	Measurement	Limits
LOX Press Sw C/O Circuit Decay (psi)	0.14	0.5 max/5 minutes
LH2 Press Sw C/O Circuit Decay (psi)	0	0.5 max/5 minutes
Low Press Sw C/O Circuit Decay (psi)	0	5.0 max/5 minutes
Mnstg #1 Press Sw C/O Circuit Decay (psi)	0.7	5.0 max/5 minutes
Mnstg #2 Press Sw C/O Circuit Decay (psi)	1.5	5.0 max/5 minutes

Purge System Flow Checks

Function	Measurement	Limits
LH2 Chilldown Shutoff Microswitch Purge Orifice (scim)	4750	6500 ± 2450
LOX Tank Ullage Sense Line Purge Orifice (scim)	220	432 ± 245
LOX NPV Duct Purge Orifice (scim)	200	432 ± 245
LH2 NPV Duct Purge Orifice (scim)	380	432 ± 245
Continuous Vent Duct Purge Orifice (scim)	195	432 ± 245
Cont Vent Module Bellows Purge Orifice (scim)	64	75 ± 30
O2H2 Burner LOX S/D Vlv Bellows Purge (scim)	47	70 ± 30
O2H2 Burner LOX S/D Vlv Microswitch Housing Purge (scim)	2.0	3.5 ± 2
LH2 F&D Vlv Microswitch Purge Orifice (scim)	3.75	3.5 ± 2
LOX F&D Vlv Microswitch Purge Orifice (scim)	2.7	3.5 ± 2
LH2 Prop Vlv Microswitch Purge Orifice (scim)	2.5	3.5 ± 2
Orificed Bypass Vlv Microswitch Purge Orifice (scim)	2.7	3.5 ± 2

4.2.5.1 (Continued)

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

Function	S/N	Measurement	Limits
LOX Vent Purge (scim)	147	0	10 max
LOX Fill & Drain Purge (scim)	140	7.5	10 max
LH2 Fill & Drain Purge (scim)	143	6.7	10 max
LH2 Vent Purge (scim)	141	0	10 max

Ambient Helium Fill Module Internal Leak Checks (P/N 1A57350-507, S/N 0234)

Function	Measurement	Limits
Amb He Fill Module C/V Rev Lkg (scim)	0	0
Amb He Fill Module Dump Vlv Seat Lkg (scim)	0	0

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

Function	S/N	Measurement	Limits
LOX Repress Mod Ck Vlv (scim)	182	0	10 max
LH2 Repress Mod Backup Check Valve (scim)	249	0	10 max
LH2 Repress Mod Ck Vlv (scim)	102	0.43	10 max
He Fill Mod Backup Check Valve (scim)	130	2.2	10 max

Ambient LOX and LH2 Repress Module Internal Leak Checks

LOX Repress Module (P/N 1B69550-501, S/N 016)

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

* Limits Not Specified

4.2.5.1 (Continued)

LH2 Repress Module (P/N 1B69550-501, S/N 046)

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

Pneumatic Power Control Module Internal Leak Check (P/N 1A58345-523, S/N 1006)

Function	Measurement	Limits
Control He Shutoff Vlv Seat Leakage (scim)	0	10 max
Control Module Reg Lockup Press (psig)	532	550 max

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

Function	S/N	Normal	Open	Closed	Boost	Limits
O2H2 Burner LOX S/D Vlv Act Cont Module Leakage (scim)	10	0	0	0	-	3 max
O2H2 Burner LOX S/D Vlv Act Leakage (scim)	-	-	0	-	-	*
O2H2 Burner LOX S/D Vlv Shaft Seal Leakage (scim)	-	-	0.8	-	-	*
O2H2 LOX S/D Vlv Act and Shaft Seal Leakage Total (scim)	-	-	0.8	0.8	-	20 max
LOX Vent Act Cont Module Leakage (scim)	126	0	0	-	0	3 max
LOX Vent Vlv Act Seal Leakage (scim)	-	-	0	-	-	75 max
LH2 F&D Act Cont Module Leakage (scim)	127	0	0	-	-	3 max
LH2 F&D Act Seal Lkg (scim)	-	-	0	0	-	350 max
LH2 F&D Act Module Lkg (scim)	-	-	0	-	-	3 max
LOX F&D Act Cont Module Leakage (scim)	111	0	0	-	0	3 max
LOX F&D Act Seal Lkg (scim)	-	-	0	0	-	350 max
O2H2 Burner LH2 Prop Vlv Act Cont Module Lkg (scim)	134	0	0	0	-	3 max
Orifice Bypass Vlv Act Cont Module Lkg (scim)	128	0	0	0	-	3 max

* Limits Not Specified

4.2.5.1 (Continued)

Function	S/N	Normal	Open	Closed	Boost	Limits
Orifice Bypass Vlv Actuator Lkg (scim)	-	-	0	-	-	*
Orifice Bypass Vlv Shaft Seal Lkg (scim)	-	-	2.5	-	-	*
Orifice Bypass Vlv Act & Shaft Seal Lkg Total (scim)	-	-	2.5	0	-	20 max
LH2 Vent Act Cont Module Lkg (scim)	145	0	0	-	0	3 max
LH2 Vent Vlv Open Act Seal Lkg (scim)	-	-	0	-	-	75 max

Function	S/N	Normal	Open	Open Latch	Limits
LOX NPV Act Cont Mod Lkg (scim)	175	0	0	0	3 max
LOX NPV Open Act Piston Seal Leakage (scim)	-	-	0	-	150 max

Function	S/N	Normal	Closed	Limits
Prevlv-C/D Vlv Act Cont Mod (scim)	118	0	-	3 max
Prevlv Act Control (scim)	-	-	0	3 max
C/D Act Control (scim)	-	-	0	3 max
LOX Prevlv Microsw Housing (scim)	-	-	0	1.2 max

Function	S/N	Normal	Flight	Ground	Limits
Bidirect Vent Vlv Act Cont Mod	20	0	0	0	3 max
Bidirect Vent Vlv Act Piston Lkg (scim)	-	-	0	0	3 max

Function	S/N	Normal	Open	Latching	Limits
LH2 Latching Relief Vlv Cont Mod (scim)	186	0	0	0	3 max
LH2 Latching Relief Vlv Open Act Piston Seal Lkg (scim)	-	-	0	-	150 max

Pneumatic Control System Decay Checks

Function	Measurement Initial	Measurement Final	Limits
Reg Disch Press - Vlv Pos, Normal (psig)	545	550	*
Reg Disch Press - Vlv Pos, Activated (psig)	535	360	*

* Limits Not Specified

4.2.5.1 (Continued)

Engine Start Tank Leak Checks

Function	Measurement	Limits
Vent Control Solenoid Seat Leakage (scim)	0	10 max
Initial Fill, Check Vlv 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

LH2 Repressurization System Leak Checks

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

LH2 Pressurization System Leak Check

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

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)	27	20 min
Jacket Purge Check Vlv Rev Lkg (scim)	14.5	25 max
Cold Helium Sphere		
Fill Check Vlv Rev Lkg (scim)	0	0
Shutoff Vlv Seat & Pilot Vlv Lkg-High Press (scim)	0	11.3 max

* Limits Not Specified

4.2.5.1 (Continued)

Function	Measurement	Limits
Shutoff Vlv Seat & Pilot Vlv Lkg-Low Press (scim)	0	12.5 max
Dump Vlv Relief and Pilot Bleed Lkg (scim)	0	12.5 max
LOX Press Module Internal		
Hot Gas Bypass Vlv Seat & Pilot Bleed Lkg (scim)	250	1000 max
O2H2 Burner LOX Repress System		
Burner Control Valve Seat 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	*
Burner Check Vlv Rev Leakage (scim)	0	0
Burner Coil Leakage (scim)	0	0
Cold Helium System		
LOX Tank Prepress Check Vlv Rev Lkg (scim)	0	0

LOX Tank, O2H2 Burner & Engine Feed System Leak Checks

Function	Measurement	Limits
LOX Tank Helium Content		
Top (%)	99.0	75 min
Bottom (%)	98.9	75 min
Engine Feed Sys Internal Leak Checks		
LOX Prevlv & Chilldown Shutoff Vlv Seat & Chilldown Return Check Vlv Lkg (scim)	130	*
LOX Chilldown Ret Check Vlv Rev Lkg (scim)	2.0	350 max
LOX Prevlv & Chilldown Shutoff Vlv Combined Seat Leakage (scim)	128	150 max
LOX Bleed Vlv & Chilldown Return Check Vlv Rev Leakage (scim)	3.0	*
LOX Bleed Vlv Seat Leakage (scim)	1.0	300 max
Main Oxidizer Vlv Seat Leakage (scim)	0	10 max
LOX Turbopump Checks		
Pump Primary Seal Leakage:		
Max (scim)	42	350 max
Min (scim)	33	*
Turbine Torque:		
Breakaway (in/lbs)	100	1000 max
Running (in/lbs)	60	200 max
LOX Chilldown Pump Purge Flow Checks		
Motor Canister Pressure (psia)	46.3	40-70
Pump Shaft Seal Flow Tank Pressurized & Purge On (scim)	3.2	50 max

* Limits Not Specified

4.2.5.1 (Continued)

Function	Measurement	Limits
Pump Shaft Seal Flow - LOX Tank Side (scim)	0.4	*
Pump Shaft Seal Flow - Motor Canister Side (scim)	2.8	*
LOX Valves Checks		
Prevalve Shaft Seal Leakage:		
Open Position (scim)	0	5 max
Closed Position (scim)	0	*
Prevalve Actuator Internal Leakage (scim)	0	*
Prevalve Total Internal Leakage (scim)	0	300 max
F&D Vlv Seat Leakage (scim)	0	100 max
F&D Vlv Primary Shaft Seal Lkg (scim)	0	31 max
O2H2 Burner LOX Shutdown Valve Checks		
Valve Actuator Bellows Lkg (scim)	0	0
Valve Seat Leakage (scim)	0	50 max

LH2 Tank, O2H2 Burner & Engine Feed System Leak Checks

Function	Measurement	Limits
LH2 Tank Helium Content		
Top (%)	99.8	75 min
Bottom (%)	99.7	75 min
Engine Feed System Internal Leak Checks		
LH2 Prevlv & Chilldown Shutoff Vlv & C/D Return Check Vlv Rev Lkg (scim)	9.5	*
LH2 C/D Ret Check Vlv Rev Lkg (scim)	0	350 max
LH2 Prevlv & C/D Shutoff Vlv Combined Seat Leakage (scim)	9.5	150 max
LH2 Bleed Vlv & C/D Return Check Vlv Rev Leakage (scim)	0	*
LH2 Bleed Vlv Seat Leakage (scim)	0	300 max
MOV & MFV Combined Seat Leakage (scim)	0	*
Main Fuel Vlv Seat Leakage (scim)	0	10 max
Engine Purge System Leak Checks		
LH2 Pump Drain Check Vlv Rev Lkg (scim)	0.76	25 max
LH2 Pump Drain Check Vlv Fwd Flow 30 psi (scim)	0	30 max
LH2 Pump Drain Check Vlv Fwd Flow 60 psi (scim)	3,500	2420 min
LH2 Pump Purge Check Vlv Rev Lkg (scim)	0	25 max
LH2 Pump Intermediate Seal Lkg (scim)	25	500 max
LH2 Turbine Seal Cavity Prg Check Vlv Rev Leakage (scim)	0	25 max
LOX Turbine Seal Cavity Prg Check Vlv Rev Leakage (scim)	0	25 max

* Limits Not Specified

4.2.5.1 (Continued)

Function	Measurement	Limits
LH2 Turbopump Checks		
LH2 Pump Primary Seal Leakage:		
Max (scim)	2.6	350 max
Min (scim)	2.6	*
Turbine Torque:		
Breakaway (in/lbs)	25.0	1000 max
Running (in/lbs)	25.0	300 max
LH2 Valves Leak Checks		
Prevalve Shaft Seal Leakage:		
Open Position (scim)	0	5 max
Closed Position (scim)	0	10 max
Fill & Drain Valve Seat Leakage (scim)	0	100 max
Fill & Drain Vlv Primary Shaft Seal Leakage (scim)	0	31 max
O2H2 Burner LH2 System Leak Check		
Combined Burner LH2 Prop Vlv & LOX S/D Vlv Seat Leakage (scim)	0	*
Burner LH2 Prop Valve Seat Leakage (scim)	0	0.7 max

Engine GG and Exhaust System Leak and Flow Tests

Function	Measurement	Limits
GG Fuel Purge Ck Vlv Rev Lkg (scim)	0	25 max
LH2 Turbine Seal Leakage (scim)	2600	3000 scim max Above 2nd E&M Lkg Value (1)
LOX Turbine Seal Leakage (scim)	4.5	350 max
STDV Gate Seal Leakage (scim)	13	20 max
OTBV Shaft Seal Leakage (scim)	0	15 max
Oxid Manifold Carrier Flange Bleed (scim)	0.5	20 max
GG LOX Purge Check Vlv Rev Lkg (scim)	0	15 max
Hydraulic Pump Shaft Seal Lkg (scim)	2	228 max
GG LOX Prop Vlv Seat & LOX Pump Shaft Seal Leakage (scim)	0	20 max
Combined GG LOX & LH2 Prop Vlv Seat & Pump Shaft Seal Lkg (scim)	0	*
GG LH2 Prop Vlv Seat Lkg & Fuel Pump Omni Seal Lkg (scim)	0	15 max

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 (psia)	96	67 to 110

* Limits Not Specified

(1) 2nd E&M Leakage Valve = 390 scim

4.2.5.1 (Continued)

Function	Measurement	Limits
Pump Purge Flow Checks		
GG Fuel Purge Flow (scim)	3900	2400 min
LOX Turbine Seal Purge Flow (scim)	3900	2400 min
LH2 Turbine Seal Purge Flow (scim)	3900	2400 min
Fuel Pump Seal Cavity Purge Flow (scim)	880	200 min
Engine Pneumatics Leak Checks		
Helium Control Solenoid Energized Leak Checks		
Low Press Relief Vlv Seat Lkg (scim)	0	5 max
Low Press Relief Vlv Pilot Bleed Lkg (scim)	0	10 max
Fast Shutdown Vent Port Diaph Lkg (scim)	0	3 max
Press Act Purge Vlv Diaph Lkg (scim)	0	3 max
Int Pneu Sys Lkg (He Cont Sol On) (scim)	6.8	20 max
LOX Pump Intermediate Seal Purge Leak Checks		
Seal Leakage Pump Direction (scim)	4.1	*
Seal Leakage Turbine Direction (scim)	12.1	*
Seal Leakage Total (scim)	16.2	850 max
Seal Purge Check Vlv Overboard Flow (scim)	1370	*
Seal Purge Flow (scim)	1386.2	1300 to 3500
Ignition Phase Solenoid Energized Leak Checks		
Start Tnk Disch Vlv 4-Way Sol Seat Lkg (scim)	1.7	15 max
Internal Pneu Sys Lkg (Ign Phase Sol On) (scim)	12	20 max
Start Tank Discharge Valve Solenoid Energized Leak Checks		
STDV 4-Way Sol Seat Lkg (Energized) (scim)	1.8	15 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)	12	20 max
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
MOV Seq Valve Lip & Shaft Seal Lkg (scim)	0	*
MOV Seq Valve Lip & OTBV Piston Lkg (scim)	0	5 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/hour)	0.005	0.036 max

* Limits Not Specified

4.2.5.1 (Continued)

LOX & LH2 Vent System Leak Checks

Function	Measurement	Limits
LOX Vent System Leak Checks		
Combined LOX Vent & Relief Vlv & NPV Seat & Pilot Bleed Lkg (scim)	10	60 max
Combined LOX V&R and NPV Seat, Pilot Bleed & Boost Piston Seal Lkg (scim)	290	*
Combined LOX V&R and NPV Boost Piston Seal Lkg (scim)	280	1728 max
Propulsive Vent System Leak Checks		
Cont Vent & Orifice Bypass Vlv Seat Lkg (scim)	9	16 max
Nonpropulsive Vent System Leak Checks		
Direct Vent Vlv Blade Shaft Seal Lkg - Flight Pos (scim)	0	3.5 max
Direct Vent Vlv Seat Lkg (Flt Pos) (scim)	2.5	50 max
Direct Vent Vlv Blade Shaft Seal Lkg - Ground Pos (scim)	0	3.5 max
Ground Vent System Leak Checks		
Combined LH2 V&R & LH2 Latching Vlv Combined Seat & Pilot Bleed Lkg (scim)	0.9	60 max
Combined LH2 V&R Vlv & LH2 Latching Relief Vlv Seat, Pilot Bleed, & Boost Piston Seal Lkg (scim)	450	*
LH2 V&R Vlv & LH2 Latching Vlv Boost Piston Seal Lkg (scim)	449	1728 max
LH2 Vent Vlv Open Act Seal Lkg (scim)	0	*
Direct Vent Vlv Seat Lkg (Gnd Pos) (scim)	10	*

* Limits Not Specified

4.2.6 Digital Data Acquisiton 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	1A74049-519	094
CP1-BO Time Division Multiplexer	404A61A200	1B65897-1	08
DP1-BO Time Division Multiplexer	404A61A200	1B65897-501	017
Remote Digital Submultiplexer (RDSM)	404A60A200	1B66051-501	01
Remote Analog Submultiplexer (RASM)	404A60A201	1B66050-501	01
PCM RF Assembly	411A64A200	1B65788-1-004	18004

Four tests were conducted to verify the operation of all data channels checked. Test attempt one, conducted on 25 February 1969, resulted in numerous malfunctions including replacement of a faulty D002 fuel pump inlet pressure transducer, P/N 1B40242-579, S/N 579-2, per FARR 500-703-962. Test attempt two, performed on 6 March 1969, also experienced difficulty with measurement D002. However, in this case the high RACS malfunctioned only during the DP1-BO multiplexer test. The high RACS measured value was within tolerance during the CP1-BO multiplexer test. Troubleshooting during test attempt three on 6 March 1969, did not expose the cause of the DP1-BO channel malfunction. Repeated cycles would not repeat the out-of-tolerance high RACS measurement. The investigation

4.2.6 (Continued)

was documented on FARR 500-704-047. The fourth and final test was successfully conducted on 12 March 1969. Measurements quoted and the following narrative descriptions are from this final test.

All channels having a calibration capability were compared one at a time, by the computer, to the tolerance limits. Transducer analog outputs were signal 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 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 lineprinter.

4.2.6 (Continued)

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

After performing initial conditions scan per 1B55813, the DDAS test started with automatic setup, including turn on of the 5-volt and 28-volt transducer power supplies and reset of the control matrix 8 switch. Turn on of DDAS input No. 1, common bulkhead pressure transducer 28-volt power, and LOX and LH2 ullage pressure transducer power completed the automatic setup.

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

The PCM RF test was performed next. The forward and reflected RF output powers of the PCM/DDAS assembly were measured through the CP1-BO and DP1-BO multiplexer telemetry outputs; and the voltage standing wave ratios (VSWR) were determined. The same measurements were also made through the ground monitor outputs for both multiplexers. The CP1-BO multiplexer telemetry readings were: forward power, 19.986 watts; reflected power, 2.938 watts; VSWR, 2.243. The DP1-BO multiplexer telemetry readings were: forward power, 19.897 watts; reflected power, 2.926 watts, VSWR, 2.243. The CP1-BO multiplexer ground monitor readings were: forward power 19.570 watts; reflected power, 0.504 watts; VSWR, 1.382. The DP1-BO multiplexer ground monitor readings were: forward power, 19.540

4.2.6 (Continued)

watts; reflected power, 0.511 watts; VSWR, 1.386. 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 measured 3.989 vdc. Low RACS were -0.010 vdc and 0.000 vdc, respectively, for telemetry and ground monitor outputs. All measurements were within the acceptable tolerances.

The CP1-BO multiplexer test made measurements of the high and low RACS voltages of each channel having calibration capability, and measurements of the ambient outputs in units of temperature, pressure, voltage, current, frequency, event indication, liquid level indication, and position indication, as applicable for the various channels. The DP1-BO multiplexer test was also performed, except for special channels, in the same manner as described for the CP1-BO multiplexer. With the following exceptions, all channel outputs for both multiplexers were within tolerance.

High RACS channel malfunctions for measurement D020 during the CP1-BO and DP1-BO multiplexer tests were acceptable because the value obtained was determined to be within 2 percent of the calibration curve for the transducer, although out-of-tolerance per the automatic program. This method to determine acceptability is specified in the procedure.

Channel malfunctions during both multiplexer tests occurred because temperature readings for measurements C050, C006, C007, C197, and C200 were higher than the values expected by the automatic program. This was attributed to a much higher

4.2.6 (Continued)

ambient temperature in the aft thrust structure area than that provided in the program. Based on the actual ambient temperature in that area, the measured values were within tolerance.

The ambient output for measurement D227 malfunctioned during both multiplexer tests because atmospheric pressure was higher than provided for by the automatic program. Based on the actual ambient pressure the measured value received was within tolerance.

One event indication malfunctioned during the CP1-BO multiplexer test because a new ignition detection probe had been installed after static firing, which gave an off indication instead of the on indication required by the program.

Ambient output for measurement D014 malfunctioned during the DP1-BO multiplexer test because the control helium regulator discharge line was not vented to ambient due to a check valve in the bleed line.

Special channel tests were also conducted. These special channels measured 400 Hz, 100 Hz, and 1500 Hz signals. The 400 Hz test checked the static inverter-converter frequency, the LOX and LH2 chilldown inverter frequences, and the LOX and LH2 circulation pump flow rates. The LOX and LH2 flowmeter tests at 100 Hz followed the 400 Hz test, and the LOX and LH2 pump speeds were checked using the 1500 Hz signal. All of the special channels were within the required tolerances of the expected values for the final test with the exception of the following.

4.2.6 (Continued)

High RACS channel malfunctions for measurements M012 and M029 were attributed to insufficient accuracy of the 400 kHz oscillator frequency computed from the period measurement. As a result, the program tolerance was not met. Manual calculation indicated the measured values obtained were within the required tolerances.

An APS simulator multiplexer test and a J-2 engine pressures multiplexer test were run to check those channels on the CP1-BO and DP1-BO multiplexers that measured the APS simulator and special J-2 engine pressure 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 °F or psia, as appropriate for the channel tested. All APS simulator and J-2 engine special channels were within the required tolerances with the exception of ambient output for J-2 measurement D005. This malfunction occurred because the program had not been changed to reflect the allowable 5 percent tolerance for the Rocketdyne pressure transducers per ECP 647. The measurement was acceptable because it was within the 5 percent tolerance, although out of the 2 percent tolerance range of the automatic program.

The last check conducted was the umbilical measurements test. Umbilical measurements were made for ambient pressure and voltage checks of the LOX and LH2 chilldown pump differential pressure transducers. After the umbilical checks, these measurements were returned to their respective telemetry channels and verified. Next, a CP1-BO multiplexer test was run for the common bulkhead internal pressure channel including high and low RACS voltages and ambient

4.2.6 (Continued)

output pressure. Then, additional umbilical measurements included the 20 percent and 80 percent calibration checks of the common bulkhead pressure and the umbilical LOX and LH2 ullage pressure measurements. Ambient pressure checks of the LOX and LH2 emergency detection system transducers completed the umbilical measurements test. All measurements for the test were within tolerance, and the DDAS was accepted for use.

Discrepancies documented by FARR were limited to those previously described. Nineteen revisions were recorded in the procedure for the following:

a. Two revisions corrected errors and omissions in the program.

b. Two revisions concerned initial conditions scan and had no bearing on the DDAS test.

c. Two revisions updated the program to the requirements of ECP 3006.

d. One revision authorized a test equipment substitution which was more convenient to use.

e. One revision concerned changes required to correct programming errors made during test attempt three troubleshooting.

f. One revision described SIM interrupts received due to the interference of concurrent testing.

g. One revision deleted requirements that were applicable to the use of APS modules because APS simulators were used for testing.

h. Nine revisions discussed the malfunction indications received during the tests, as previously described in this report.

4.2.7 Range Safety Receiver Checks (1B55819 H)

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	182
Range Safety Receiver 2	411A97A18	50M10697	189
Secure Command Decoder 1	411A99A1	50M10698	0181
Secure Command Decoder 2	411A99A2	50M10698	0039

The test was performed satisfactorily on 25 February 1969.

Several manual operations were accomplished before the automatic phase of the checkout was started. The total cable insertion loss values at the 450 MHz range safety frequency were determined to be 30.4 db for range safety system 1, and 31.0 db for range safety system 2. The destruct system test set, P/N 1A59952-1, was set up to 450 ±0.045 MHz with a -17 dbm output level and a 60 ±0.60 kHz deviation. The stage range safety antennas were disconnected from the directional power divider; and until the open loop RF checks, the 50 ohm loads were connected to the power divider for testing.

The cable insertion loss values were loaded into the computer, the initial conditions scan was performed, the range safety receivers were transferred to external power and turned on, and the propellant dispersion cutoff command inhibit was turned on.

4.2.7 (Continued)

The receiver AGC calibration checks were then conducted. For each input signal level used in the calibration check, the computer determined the GSE test set output levels required to compensate for the cable insertion loss. Per the computer typeout, the GSE test set was manually adjusted to the appropriate output levels. The computer determined the input signal levels and measured the low level signal strength (AGC telemetry) of each receiver. These AGC measurements, in the 0.0 to 5.0 vdc range, were multiplied by a conversion factor of 20 and presented as percent of full scale values. The difference in AGC values at each step was determined and utilized for the AGC drift check. As shown in Test Data Table 4.2.7.1, the AGC values were all acceptable; and the drift deviations were well below the 3 percent of full scale maximum limit.

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

4.2.7 (Continued)

For the deviation threshold checks, the GSE test set was adjusted to an output of 450 ±0.045 MHz at a level that provided receiver input levels of -63 dbm for receivers 1 and 2. A series of checks determined the minimum input deviation frequency at which each receiver responded to the respective range safety command. For each command, the GSE test set was manually adjusted to a sequence of deviation frequencies increasing from 5 kHz per the computer typeout. At each deviation frequency, the range safety secure command decoders were checked for the presence of the command signal from the appropriate receiver. As shown in the Test Data Table, the receivers responded to all commands at minimum deviation frequencies less than the 50 kHz maximum limit.

For the radio frequency sensitivity checks, the GSE test set was adjusted for an output of 450 ±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 -84.6 dbm, as requested by the computer. This gave input levels increasing from -115.0 dbm for receivers 1 and 2. At each input level, the range safety secure command decoders were checked for receipt of the command signal from the appropriate receiver. Both receivers responded to minimum input levels less than the -93 dbm maximum limit.

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

4.2.7 (Continued)

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 -81 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 -87 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 3.08 vdc while that of receiver 2 was 3.58 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. Leakage measurements for range safety decoders 1 and 2 were both 7 mvdc, within the 100 mvdc allowable. 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 had responded, and were not adversely affected by the PCM RF transmission. The PCM RF assembly power was turned off, and the range safety EBW firing units were transferred to external power. The propellant dispersion cutoff command inhibits were turned off for each receiver, and the range safety receivers were turned off, thus completing the range safety receiver checks.

4.2.7 (Continued)

No FARR's were initiated as a result of this checkout. Six revisions were recorded in the procedure for the following:

a. One revision deleted the initial conditions scan check for the calibration preflight mode, as authorized by WRO S-IVB-3676R10.

b. One revision noted that a malfunction indication during initial conditions scan was attributed to program error and did not affect the range safety receiver checks.

c. One revision added program changes to turn on the single sideband system transmitter during the range safety commands.

d. One revision noted that as a result of concurrent testing, during the initial condition scan, improper valve opening and closing states were indicated.

e. One revision noted that SIM interrupts occurred when the prevalves were cycled to bleed down the control helium regulator pressure to permit a delay because of inclement weather.

f. One revision entered program changes to support concurrent testing per the leak check procedure.

4.2.7.1 Test Data Table, Range Safety Receiver Checks

AGC Calibration and Drift Checks (% = Percent of Full Scale)

Test Set Output (dbm)	Receiver 1 Input (dbm)	AGC 1 (%)			Receiver 2 Input (dbm)	AGC 2 (%)		
		Run 1	Run 2	Drift		Run 1	Run 2	Drift
-96.6	-127.0	9.73	9.53	0.20	-127.6	14.04	14.36	0.31
-89.6	-120.0	9.84	9.84	0.00	-120.6	14.77	14.36	0.41
-84.6	-115.0	10.14	9.94	0.20	-115.6	15.06	14.86	0.20
-79.6	-110.0	10.86	11.07	0.21	-110.6	16.70	16.60	0.10
-74.6	-105.0	13.83	13.63	0.20	-105.6	21.62	21.43	0.20
-69.6	-100.0	21.62	21.74	0.12	-100.6	33.63	33.63	0.00
-64.6	-95.0	37.73	37.93	0.20	-95.6	54.65	55.06	0.41
-59.6	-90.0	62.56	62.03	0.53	-90.6	71.17	70.76	0.41
-54.6	-85.0	71.37	71.37	0.00	-85.6	73.95	73.83	0.12
-49.6	-80.0	73.01	72.91	0.10	-80.6	74.65	74.65	0.00
-44.6	-75.0	73.63	73.42	0.21	-75.6	75.27	75.06	0.21
-39.6	-70.0	73.73	73.73	0.00	-70.6	75.37	75.37	0.00

4.2.7.1 (Continued)

-3 db RF Bandwidth Check

Function	Receiver 1	Receiver 2	Limits
Reference Voltage (AGC) (vdc)	2.0	1.99	2.0 ± 0.1
Reference RF Power Level (dbm)	-64.3	-67.9	-
Upper Bandedge Freq. (MHz)	450.165	450.153	-
Lower Bandedge Freq. (MHz)	449.855	449.828	-
-3 db Bandwidth (kHz)	310.0	325.0	340.0 ± 30.0
Bandwidth Centering (MHz)	450.010	449.990	450 ± 0.0338

-60 db RF Bandwidth Check

Function	Receiver 1	Receiver 2	Limits
Reference Voltage (ABC) (vdc)	2.0	1.99	2.0 ± 0.1
Reference RF Power Level (dbm)	-64.3	-67.9	-
Upper Bandedge Freq. (MHz)	450.536	450.547	-
Lower Bandedge Freq. (MHz)	449.548	449.536	-
-60 db Bandwidth (MHz)	0.988	1.011	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	-105.6
Propellant Dispersion	-105.0	-105.6
Range Safety System Off	-105.0	-105.6

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

This manual procedure determined that the control units associated with the LOX and LH2 liquid level, point level, fastfill, and overfill sensors were adjusted for operating points within the design calibration limits. The particular items involved in this test are noted in Test Data Table 4.2.8.1. The checkout was accomplished between 25 and 26 February 1969.

A point level sensor manual checkout assembly, P/N 1B50928-1, and a variable precision capacitor, General Radio Type 1422CD, were connected in parallel with the sensor to provide capacitance changes to each control unit simulating sensor wet conditions for calibrations and to establish the control unit operating point. With the control unit power turned on, the control unit control point adjustment R1 was adjusted until the control unit output signal changed from 0 ±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 for the LH2 sensors and for the LOX sensors were recorded in Test Data Table 4.2.8.1, with the appropriate minimum and maximum capacitance limits.

There were no FARR's initiated as a result of this checkout. However, three revisions were recorded in the procedure for the following:

a. One revision deleted obsolete instructions for providing protection against improper buss voltages and currents, because SIM protection was available with buss power turn on.

4.2.8 (Continued)

b. One revision deleted adjustment of the LOX point level sensor control units because the prefire values were correct.

c. One revision recorded energized and de-energized capacitance values for the LH2 point level sensors prior to adjustments of the control units to evaluate LH2 depletion cutoff during the static firing.

4.2.8.1 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
LH2 Tank	408			411						
Liq Lev L17	MT732	-507	D73	A61A217	-509	C42	0.811	0.550	0.812	0.850
Liq Lev L18	MT733	-507	D84	A61A219	-509	C43	0.792	0.550	0.794	0.850
Liq Lev L19	MT734	-507	D90	A61A221	-509	C46	0.810	0.550	0.815	0.850
Pt Lev 1	A1C1	-507	01	A92A25	-509	C27	0.804	0.550	0.810	0.850
Pt Lev 2	A2C2	-507	04	A92A26	-509	C38	0.789	0.550	0.791	0.850
Pt Lev 3	A2C3	-507	05	A92A27	-509	C39	0.761	0.550	0.765	0.850
Pt Lev 4	A2C4	-507	09	A61A201	-509	C40	0.791	0.550	0.794	0.850
Fastfill	A2C5	-1	D136	A92A43	-509	D71	0.785	0.550	0.788	0.850
Overfill	*	*	*	A92A24	-509	C100	1.169	0.950	1.173	1.250
LOX Tank	406			404						
Liq Lev L14	MT647	-1	C33	A63A223	-511	C20	1.474	1.350	1.480	1.650
Liq Lev L15	MT658	-1	C32	A63A206	-511	C17	1.468	1.350	1.470	1.650
Liq Lev L16	MT659	-1	C36	A63A221	-511	C18	1.464	1.350	1.473	1.650
Fastfill	A2C5	-1	C18	A72A5	-511	C45	1.474	1.350	1.480	1.650
Overfill	**	**	**	A72A4	-511	C24	2.024	1.950	2.054	2.250

* Part of LH2 Mass Probe, P/N 1A48431-513, S/N C7/C6, Location 408A1

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

4.2.9 Power Distribution System (1B55815 K)

The automatic checkout of the stage power distribution system was successfully conducted on 26 February 1969. The test 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. Measured values are listed in Test Data Table 4.2.9.1.

Stage power setup was conducted per the stage power setup, H&CO 1B55813. 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.

4.2.9 (Continued)

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 A0 and B0 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 A0 and B0 multiplexer engine cutoff signal indications.

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

4.2.9 (Continued)

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 to be off while K13 and the engine cutoff remained on, until turned off by the engine ready bypass.

The propellant utilization (PU) inverter and electronics power supply current differentials were measured while power was momentarily turned on. The PCM RF assembly power was turned on, the RF group was verified to be on, the power supply differential current was measured, and the PCM RF transmitter output wattage was measured through the AO and BO multiplexers. With the telemetry RF silence command turned on, the RF group was verified to be off; the PCM RF transmitter output wattage was measured through the AO multiplexer; and the 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.

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 2 power supply was verified to be within the 56 ± 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

4.2.9 (Continued)

indication was verified to be off. The chilldown pump simulator was connected to the LOX and LH2 chilldown inverters; and measurements for each inverter were made of the current, the phase voltages, and the operating frequency. The inverter voltages and frequencies were monitored and measured through hardwire and telemetry.

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

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.

V

4.2.9 (Continued)

There were no part shortages affecting the test. There were no discrepancies resulting in FARR documentation. Five revisions were recorded in the procedure for the following:

a. Two revisions corrected program errors.

b. Two revisions deleted the calibration preflight mode indication per WRO S-IVB-3676R10.

c. One revision deleted functional checkouts of the FM/FM system group power because the FM/FM system was not installed on the stage.

4.2.9.1 Test Data Table, Power Distribution System

Function	Measurement	Limits
Engine Control Bus Current (amps)	0.400	2 + 2
Engine Control Bus Voltage (vdc)	28.029	28.158 ± 1
APS Bus Current (amps)	0.500	1.5 + 3
Engine Ignition Bus Current (amps)	0.200	0 + 2
Engine Ignition Bus Voltage, On (vdc)	28.091	28.199 + 1
Engine Ignition Bus Voltage, Off (vdc)	0.000	0 + 0.45
Component Test Power Current (amps)	0.301	0 ± 2
Component Test Power Voltage, On (vdc)	28.118	28 ± 2
Component Test Power Voltage, Off (vdc)	0.640	0 ± 1
Engine Control Bus Voltage, EDS 2 On (vdc)	-0.030	0 ± 0.45
Engine Control Bus Voltage, EDS 2 Off (vdc)	27.968	28.239 ± 1
Propellant Level Sensor Pwr Current (amps)	-0.100	1 + 2
LOX Depletion Engine Cutoff Timer (sec)	0.548	0.560 ± 0.025
PU Inverter & Electronics Pwr Current (amps)	2.500	3 + 2
PCM RF Assembly Power Current (amps)	4.399	4.5 ± 3.0
PCM RF Transmitter Output Power, AO (watts)	18.262	10 min
PCM RF Transmitter Output Power, BO (watts)	18.291	10 min
PCM RF Transmitter Output Power, AO T/M RF Silence On (watts)	-0.148	0 + 2
Switch Selector Output Monitor, K128 (vdc)	2.051	2 ± 0.425
PCM RF Transmitter Output Power, AO, T/M RF Silence Off (watts)	18.083	10 min
Calibration Preflight Mode Current (amps)	0.100	0 ± 2
Aft Bus 2 Current (amps)	0.199	5 max
Aft Bus 2 Voltage (vdc)	55.438	56 ± 1

4.2.9.1 (Continued)

LOX Chilldown Inverter Tests

Function	Measurement	Limits
Inverter Current (amps)	20.474	20.0 ± 5.0
Phase AB Voltage, Hardwire (vac)	55.017	55.838 ± 3
Phase AC Voltage, Hardwire (vac)	54.495	55.838 ± 3
Phase A1B1 Voltage, Hardwire (vac)	54.951	55.838 ± 3
Phase A1C1 Voltage, Hardwire (vac)	54.495	55.838 ± 3
Frequency, Hardwire (Hz)	400.000	400.0 ± 4.0
Phase AB Voltage, Telemetry (vac)	55.932	55.758 ± 3
Phase AC Voltage, Telemetry (vac)	56.265	55.758 ± 3
Frequency, Telemetry (Hz)	399.805	400.0 ± 4.0

LH2 Chilldown Inverter Tests

Function	Measurement	Limits
Inverter Current (amps)	21.324	20.0 ± 5.0
Phase AB Voltage, Hardwire (vac)	55.082	55.679 ± 3
Phase AC Voltage, Hardwire (vac)	54.366	55.679 ± 3
Phase A1B1 Voltage, Hardwire (vac)	54.951	55.679 ± 3
Phase A1C1 Voltage, Hardwire (vac)	54.300	55.679 ± 3
Frequency, Hardwire (Hz)	401.000	400.0 ± 4.0
Phase AB Voltage, Telemetry (vac)	55.932	55.679 ± 3
Phase AC Voltage, Telemetry (vac)	55.998	55.679 ± 3
Frequency, Telemetry (Hz)	400.398	400.0 ± 4.0

Function	Measurement	Limits
Forward Battery 1 Simulator Voltage (vdc)	28.318	28 ± 2
Forward Battery 2 Simulator Voltage (vdc)	28.079	28 ± 2
Aft Battery 1 Simulator Voltage (vdc)	28.158	28 ± 2
Aft Battery 2 Simulator Voltage (vdc)	56.558	56 ± 4
Bus 4D20 ESE Load Bank (vdc)	0 000	0 ± 1
Bus 4D40 ESE Load Bank (vdc)	0.079	0 ± 1
Bus 4D30 ESE Load Bank (vdc)	0.000	0 ± 1
Bus 4D10 ESE Load Bank (vdc)	0.079	0 ± 1
Prelaunch Checkout Group Current (amps)	2.600	1 ± 3
Forward Bus 1 Voltage - Internal (vdc)	28.039	28 ± 2
Forward Bus 2 Voltage - Internal (vdc)	28.158	28 ± 2
Aft Bus 1 Voltage - Internal (vdc)	28.039	28 ± 2
Aft Bus 1 Voltage - External (vdc)	28.158	28 ± 2
Aft Battery 1 Voltage (vdc)	0.000	0 ± 1
Aft Bus 2 Voltage - Internal (vdc)	56.479	56 ± 4
Aft Bus 2 Voltage - External (vdc)	56.479	56 ± 4
Aft Battery 2 Voltage (vdc)	0.159	0 ± 1
Forward Bus 1 Voltage - External (vdc)	28.158	28 ± 2

4.2.9.1 (Continued)

Function	Measurement	Limits
Forward Battery 1 Voltage (vdc)	0.039	0 ± 1
Forward Bus 2 Voltage - External (vdc)	28.199	28 ± 2
Forward Battery 2 Voltage (vdc)	0.000	0 ± 1
Aft Bus 2 Voltage, Off (vdc)	0.000	0 ± 1
Range Safety Receiver 1 External Power Current (amps)	1.250	0 ± 2
Range Safety Receiver 2 External Power Current (amps)	0.500	0 ± 2

4.2.10 Single Sideband System Checkout (1B75537 A)

The purpose of this combined manual and automatic procedure was to verify the capability of the single sideband (SSB) telemetry system to properly measure, frequency multiplex, and transmit vibration and acoustical data. Stage hardware involved in the checkout included the vibration and acoustical instrumentation, the subcarrier oscillator (SCO) assembly, the model 245 multiplexer, the telemetry (T/M) calibrator, the SSB translator, the SSB wideband amplifier, and the SSB transmitter.

The manual test sequences were initiated on 26 February 1969, and completed on 10 March 1969. Automatic test sequences were performed on 27 February 1969.

The checkout consisted of eight tests, the transmitter center frequency and deviation checks, the SSB ground station frequency response, the SSB translator frequency response, the preflight/inflight calibration of the T/M calibrator, pilot tone, the channel identification and remote automatic calibration (RAC) response test, and the open and closed loop transmitter information test. Four tests were deleted because they were performed during prefire checkout and do not require recheck unless failure or replacement occurs in the antenna system.

FARR 500-704-276 documented malfunction of the SSB translator, P/N 1B55252-1, S/N 00006, during SSB system checkout. Channel 4 was not operative and channel 10 had a low drop-in level. Testing was continued with the condition that the discrepant translator was removed and replaced, after completing the checkout of the SSB system.

4.2.10 (Continued)

There were no other FARR's generated as a result of SSB system testing; however, fifty-nine revisions were required to complete the checkout and were recorded in the procedure for the following:

a. Twenty-nine revisions corrected errors and omissions in the procedure and the program.

b. One revision was written to clarify the procedure.

c. One revision was an ICS change which was identical to one incorporated for stage power setup, H&CO 1B55813.

d. One revision attributed a malfunction indication during the initial conditions scan (ICS) to a program error. The SSB test was not affected.

e. One revision attributed ICS malfunction indications to concurrent testing (leak checks).

f. One revision deleted portions of previous revisions.

g. Three revisions deleted those tests performed during the prefire checkout, which did not require repeating.

h. Three revisions provided changes to combine the ripple test and response test, obtain additional frequency points for the tests, and perform these tests in closed loop.

i. One revision provided instructions to obtain the relative intermediate frequency with a calibrated center frequency standard during the transmitter center frequency checks.

j. One revision was a convenience change during test setups.

k. Five revisions provided data tables to record results of manual test sequences.

l. Two revisions changed the program to verify that transmitter power does not exceed open and closed loop wattage limits.

m. One revision added a 90-second program delay for filament cool-down prior to reapplying power to the transmitter.

n. Four revisions provided instructions for manual checkouts to be accomplished at halts in the automatic program.

4.2.10 (Continued)

o. One revision repeated a portion of the checkout to obtain oscillograph data. The oscillograph paper take-up reel had jammed, resulting in data loss.

p. One revision was a program change to correct a previous operator error.

q. One revision deleted further testing requirements for channel 4 of the SSB translator. This channel was inoperative, although the translator was used to complete SSB system testing as previously described per FARR 500-704-276.

r. One revision deleted further testing requirements for measurement B38 because the transducer to amplifier cable had been broken prior to SSB checkout as documented on FARR 500-704-314.

s. One revision deleted further testing of SSB translator channels which exceeded the 30 percent limit during the translator response test, because the translator had been rejected per FARR 500-704-276.

4.2.11 Auxiliary Propulsion System Simulator (1B55825 E)

The auxiliary propulsion system simulator 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 interfaces 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 1B57731-503, S/N 424, at reference location 404A51A4 and S/N 423, at reference location 404A71A19. The test was satisfactorily accomplished on 27 February 1969.

After performing initial conditions scan per H&CO 1B55813, 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.

4.2.11 (Continued)

No problems were encountered during the APS simulator test and no FARR's were written. Five revisions were recorded in the procedure for the following:

a. One revision indicated that error messages received were caused by procedure error.

b. Two revisions explained that malfunctions during initial conditions scan occurred because of the interference of concurrent leak check procedure.

c. One revision incorporated the requirements of WRO S-IVB-3676R10.

d. One revision attributed a malfunction during the initial conditions scan to a program error. This had no bearing on the APS simulator test.

4.2.11.1 Test Data Table, Auxiliary Propulsion System Simulator

Attitude Control Nozzle Command		APS Engine	Valve Open Indication Voltage (vdc) AO Multiplexer	BO Multiplexer	Limits
Nozzle I IV	On	1-1	3.779	3.779	3.8 ± 0.25
	Off	1-1	0.000	-	0.0 ∓ 0.25
Nozzle I II	On	1-3	3.732	3.738	3.8 ± 0.25
	Off	1-3	0.000	-	0.0 ∓ 0.25
Nozzle I P	On	1-2	3.759	3.773	3.8 ± 0.25
	Off	1-2	0.000	-	0.0 ∓ 0.25
Nozzle III II	On	2-1	3.691	3.712	3.7 ± 0.25
	Off	2-1	0.000	-	0.0 ∓ 0.25
Nozzle III IV	On	2-3	3.677	3.691	3.7 ± 0.25
	Off	2-3	0.000	-	0.0 ∓ 0.25
Nozzle III P	On	2-2	3.748	3.743	3.7 ± 0.25
	Off	2-2	0.000	-	0.0 ∓ 0.25

4.2.12 Signal Conditioning Setup (1B64681 H)

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 4.2.12.1.

The checkout was initiated on 27 February 1969, and successfully completed on 17 March 1969. The stage power setup, H&CO 1B55813, was performed prior to calibration activity to provide electrical power to the equipment.

Three 5 volt excitation modules were calibrated. The input voltage to each module was verified to be 28 ±0.5 vdc; and each module was adjusted to obtain a 5 vdc output of 5.0 ±0.005 vdc, a -20 vdc output of -20.00 ±0.005 vdc, and an ac output of 10 ±1 volts peak-to-peak at 2000 ±200 Hz. The final values measured, as shown in the Test Data Table, were all within the above limits. The ac output measurements were made with 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 ±0.005 vdc. The final measured value for each module was within the above limits.

4.2.12 (Continued)

Four hydraulic system pressure transducers were checked by measuring the ambient outputs of the transducers before the hydraulic system was pressurized. As shown in the Test Data Table, these measurements were all within the required limits.

The propellant utilization (PU) oven on indication module, P/N 1B65331-1, S/N 068, was suspected to have lost adjustment during propulsion system testing per 1B62753. The module failed to adjust during signal conditioning setup and was removed and replaced per FARR 500-704-055. As noted in the test data table, the replacement module was adjusted properly, obtaining low level and high level outputs within the required tolerances.

The final checkout was the environmental control temperature sensor verification. Resistance checks for both thermistor groups were within the required tolerances.

There were no FARR's generated other than previously described. Seven revisions were recorded in the procedure for the following:

a. One revision deleted all portions of the procedure except those required for the items calibrated.

b. One revision deleted GSE test equipment which was not available and not required for this checkout.

c. Four revisions corrected errors in the procedure.

d. One revision authorized obtaining two of the hydraulic system ambient outputs from the DDAS automatic test procedure data, as recorded previously in H&CO 1B55817.

4.2.12.1 Test Data Table, Signal Conditioning Setup

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

Reference Location	S/N	5 vdc Output (vdc)	-20 vdc Output (vdc)	ac Output vpp	Hz
411A99A33	0194	4.998	-20.000	9.8	2039
404A52A7	0163	5.002	-20.001	9.9	2056
411A98A2	0192	4.999	-20.000	10.2	2068

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

Reference Location	S/N	20 vdc Output (vdc)
411A61A242	0335	20.000
404A62A241	0322	20.000
404A63A241	0316	20.000
404A64A241	0327	20.000
404A65A241	0321	20.000
404A63A233	0323	20.000
404A66A241	0357	20.000

Hydraulic Pressure Transducer Ambient Condition Check

Function	Measurement	Limits
Reservoir Oil Pressure (psia)	13.965	14.7 ± 8
GN2 Accumulator Pressure (psia)	1396.3	1395 ± 50
Aux Hyd Pump Motor Gas Press (psig)	0	0 ± 1.2
Aux Hyd Pump Air Tank Press (psia)	21.275	14.7 ± 13

P. U. Oven On Monitor Module - P/N 1B65331-1, S/N 061

Function	Measurement		Limits
Temp-transducer No. 1	Low	0.1999	0.1 ± 0.1 vdc
	High	19.542	19.0 ± 1.0 vdc

Environmental Control Temperature Sensor Verification - P/N 75M08342

Function	Temp (^{o}F)	Resistance (ohms) Measured	Expected
Supply APS Thermistor Group RT1 Environmental Temperature	64	2340	2278 ± 91
Supply APS Thermistor Group RT2 Environmental Temperature	64	2346	2279 ± 91

4.2.13 EMC Radiated Spectrum Signature Test (1B76059 NC)

The radiated spectrum signature test checked the Apollo/Saturn receiver frequencies for possible RF interference caused by operation of the SSB/FM and the PCM/FM transmitters on the stage.

The test was initiated on 4 March 1969, and completed on 5 March 1969. Test equipment setup included the Empire Models NF-105 and NF-112 radio interference and field intensity (RIFI) meters, the RIFI meter antenna, and the required calibration equipment. The RIFI test antenna was placed 6 feet from the Saturn S-IVB telemetry antenna for the test.

After performing initial conditions scan per H&CO 1B55813, power was turned on to the PCM RF assembly and the SSB system and the resultant current draws and transmitter output powers were measured and determined to be within acceptable limits. Using the appropriate RIFI meter, antenna, and calibration equipment for specific frequency bands, the frequency range from 150 kHz to 10 GHz was scanned to detect any RF signals more than 3 db above the ambient signal level. Field strength measurements were taken with stage transmitters on. Ambient measurements were taken immediately after with the transmitters off. At only three of the frequencies monitored were the signals found to be above ambient levels. These were the SSB/FM and PCM/FM transmitter operating frequencies (253.74 MHz and 258.48 MHz, respectively) and the fundamental frequency (259.70 MHz) of the VHF backup receiver for the Command and Service Module (CSM) and the Lunar Excursion Module (LEM).

The probability of adverse affect on the VHF backup receiver frequency was indicated. Signal strength at this frequency due to radiation from the PCM/FM

4.2.13 (Continued)

transmitter was -102 dbm, while the nominal VHF receiver sensitivity was -115 dbm, a 13 db differential. This was attributed to the closeness of the PCM/FM operating frequency and the VHF backup receiver fundamental frequency plus the high VHF receiver sensitivity.

A detailed analysis of the test is presented in report DAC-56709, in which it is recommended that due to the probability of RF interference, the VHF backup receiver should be operated after S-IVB separation.

No FARR's were initiated as a result of this test. However, eleven revisions were recorded in the procedure to complete the test as follows:

a. Four revisions corrected errors and omissions in the procedure.

b. One revision updated the procedure to the latest requirements and configuration.

c. Five revisions authorized substitutions for specified test equipment not available at STC, and corrected the non-end item list to reflect procedure requirements at STC.

d. One revision indicated that the certification sticker on the VA-105 antenna was not applicable because certification of the antenna was no longer a requirement.

4.2.14 Digital Data Acquisition System Calibration (1B55816 H)

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 1A74049-519, S/N 094; CP1-BO time division multiplexer, P/N 1B65897-1, S/N 08; DP1-BO time division multiplexer, P/N 1B65897-501, S/N 017; remote digital submultiplexer (RDSM), P/N 1B66051-501, S/N 01; and low level remote analog submultiplexer (RASM), P/N 1B66050-501, S/N 01. Postfire checkout was required because the PCM/DDAS assembly had been replaced. A narrative of the tests which were conducted on 5 March 1969, follows.

The stage power was turned on, and the initial conditions scan was conducted for the stage and DDAS per H&CO 1B55813. The 72 kHz bit rate check was made on the PCM data train to ensure that the frequency was within tolerance. The 72 kHz bit rate was measured as 72,002 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 2.8 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 568.03 kHz at 2.8 vrms, within the acceptable limits of 556.8 kHz to 576.8 kHz, at greater than 2.2 vrms. The frequency differential was calculated as 67.3 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

4.2.14 (Continued)

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. Final channel measurements were acceptable. However, it was necessary to repeat the CP1-B0 checks twice for the 0.000 vdc input level and once for the 1.250 vdc input level, because of test setup errors that resulted in numerous malfunctions. The power supply had not been properly connected per the procedure schematic for the initial checks.

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 final measured outputs for the RDSM and the RASM were acceptable. However, the RASM test was backed up and rerun twice because of malfunctions that occurred due to operator error. The initial RASM test attempt had been made with 0.001 vdc applied erroneously for the 0.010 vdc signal level check. A second attempt with input signal corrected to 0.010 vdc also malfunctioned because the voltmeter required reference calibration setup for proper input adjustment. After the voltmeter setup was adjusted, the third RASM test was conducted satisfactorily.

A final test measured the PCM/FM transmitter current as 4.3 amperes, within the 4.5 $\pm$3.00 amperes limit.

There were no discrepancies during the test that resulted in FARR documentation. Nine revisions were recorded in the procedure for the following:

4.2.14 (Continued)

a. Four revisions authorized the repeat tests necessitated by the malfunctions previously described for the initial CP1-BO multiplexer and RASM checkouts.

b. One revision accepted random channel malfunctions for the CP1-BO and DP1-BO multiplexers caused by noise resulting from electromagnetic interference of test cable grounding. The noise was investigated during the prefire DDAS calibration and was eliminated when flight configuration was used for grounding.

c. Three revisions concerned the initial conditions scan and the stage power turn-off, which had no effect on DDAS testing.

d. One revision updated the program to the requirements of ECP 3006 and ECP 3008.

4.2.15 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 LH2 loading operations. The automatic checkout system (ACS) was utilized during testing to function PU system components and to monitor responses. This test involved all components of the stage PU system including:

Part Name	Ref. Location	P/N	S/N
Propellant Utilization Electronics Assy (PUEA)	411A92A6	1A59358-529	036
Static Inverter-Converter	411A92A7	1A66212-507	018
LOX Mass Probe	406A1	1A48430-511.1	C4
LH2 Mass Probe	408A1	1A48431-513	C7/C6
LOX Overfill Sensor		(Part of LOX Mass Probe)	
LOX Overfill Control Unit	404A72A4	1A68710-511	C24
LOX Fastfill Sensor	406A2C5	1A68710-1	C18
LOX Fastfill Control Unit	404A72A5	1A68710-511	C45
LH2 Overfill Sensor		(Part of LH2 Mass Probe)	
LH2 Overfill Control Unit	411A92A24	1A68710-509	C100
LH2 Fastfill Sensor	408A2C5	1A68710-1	D136
LH2 Fastfill Control Unit	411A92A43	1A68710-509	D71

The test was satisfactorily performed on 5 March 1969. Measurements recorded during the test are listed in Test Data Table 4.2.15.1.

Initial conditions scan was performed per H&CO 1B55813, and the ratio values, obtained from the prefire manual PU system calibration procedure, H&CO 1B64367, were loaded into the computer. From these ratio values, nominal test values were computed for the LOX and LH2 coarse mass voltages, fine mass voltages, and loading voltages. After an evaluation of the computer printout, a test of the

4.2.15 (Continued)

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 LH2 coarse and fine mass voltages were measured through the AO and BO instrumentation multiplexers.

The PU loading test followed. The LH2 boiloff bias signal voltage was measured with the boiloff bias cutoff turned on and was verified to be 0.0 $\pm$2.5 vdc with the cutoff turned off. The GSE loading potentiometer power was turned on, and the voltage measured. Measurements were then made of the LOX and LH2 loading potentiometer sense voltages and signal voltages. Measurements of the LOX and LH2 loading potentiometer signal voltages were repeated after the LOX and LH2 bridge 1/3 checkout relay commands were turned on, and again after these commands were turned off. The GSE power was turned off, and the LOX and LH2 loading potentiometer sense voltages were again measured.

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

4.2.15 (Continued)

repeated with the LOX and LH2 bridge 1/3 checkout relays on, with the bridge 2/3 checkout relays on, with the bridge 2/3 checkout relays off, and again with the bridge 1/3 checkout relays off.

The next check verified that the LOX and LH2 tank overfill and 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 A0 and B0 multiplexers. The ratio valve position was measured; then, the LOX bridge 1/3 checkout relay command was turned on, and the LOX coarse mass voltage was measured. The ratio valve position was remeasured with the PU activate switch turned on and again with it turned off. The LOX bridge 1/3 checkout relay command was turned off, then the LOX coarse mass voltage and the ratio valve position were measured. These steps were repeated using the LH2 bridge 1/3 checkout relay, then measuring the LH2 coarse mass voltage.

The PU valve programmed mixture ratio test was the final checkout of the procedure. The PU mixture ratio 4.5 switch selector was turned on and the ratio 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,

4.2.15 (Continued)

the PU activate switch, the LOX bridge 1/3 checkout relay command, and the PU programmed mixture ratio switch were turned off; then, the ratio valve position was verified to be greater than -1.5 degrees. This procedure was then repeated with the PU mixture ratio 5.5 switch, LH2 bridge 1/3 checkout relay command, and the PU activate switch. The ratio valve position was verified to be greater than +20 degrees with the switches and commands on, and less than +1.5 degrees with switches and commands off. After turning on the PU mixture ratio 4.5 switch and verifying ratio valve position to be less than -20 degrees, the PU mixture ratio 5.5 switch selector was turned on; then, the ratio valve position was verified to be 0 $\pm$10 degrees. The test was completed by turning off the PU programmed mixture ratio switch and verifying that the ratio valve had returned to the null position.

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

a. Two revisions corrected a program error.

b. One revision specified the propellant tank conditions to be maintained during the PU system test. Tank moisture content, gas concentrations, and pressures were required to be identical with those recorded during the prefire PU manual calibration procedure, 1B64367.

c. One revision vented tank pressures to maintain the limits previously specified for tank pressures.

d. One revision entered the ratio values obtained from the PU calibration procedure into the program.

e. One revision was a program change for initial conditions scan per WRO S-IVB-3676-R10.

f. One revision indicated that an expected malfunction during initial conditions scan was attributable to a program error which was not feasible to correct.

4.2.15 (Continued)

g. Two revisions noted that malfunction indications during initial conditions scan occurred due to concurrent testing. These had no affect on the PU system test.

h. One revision modified the strip chart speed to obtain a more accurate recording of PU valve movement during the valve slew check.

i. One revision attributed an initial out-of-tolerance measurement for the LH2 fine mass voltage to an improper expected value entered into the program.

4.2.15.1 Test Data Table, Propellant Utilization System

Loaded Ratio Values (from H&CO 1B64367)

LOX Empty Ratio	0.021	LH2 Empty Ratio	0.000
LOX 1/3 Bridge Slew Ratio	0.283	LH2 1/3 Bridge Slew Ratio	0.310
LOX 2/3 Bridge Slew Ratio	0.571	LH2 2/3 Bridge Slew Ratio	0.639
LOX Wiper Ratio	0.039	LH2 Wiper Ratio	0.014

LH2 Boiloff Bias Voltage (vdc) 18.417

Computed Coarse Mass Voltages (vdc)

LOX Empty	0.103	LH2 Empty	0.000
LOX 1/3 Mass	1.416	LH2 1/3 Mass	1.548
LOX 2/3 Mass	2.856	LH2 2/3 Mass	3.193

Computed Fine Mass Voltages (vdc)

LOX Empty	4.009	LH2 Empty	1.367
LOX 1/3 Mass	0.249	LH2 1/3 Mass	2.339
LOX 2/3 Mass	2.017	LH2 2/3 Mass	4.590

Computer Loading Voltages (vdc)

LOX Empty	0.574	LH2 Empty	0.000
LOX 1/3 Coarse Mass	7.930	LH2 1/3 Coarse Mass	8.668

PU System Power Test

Function	Measured Value	Limits
Inv-Conv 115 vrms Output (vac)	114.367	115.0 ± 3.4
Inv-Conv 21 vdc Output (vdc)	22.078	21.25 ± 1.25
Inv-Conv 5 vdc Output (vdc)	5.040	4.9 ± 0.2
Inv-Conv Frequency (Hz)	403.203	400.0 ± 6

4.2.15.1 (Continued)

Function	Measured Value	Limits
PU Oven Monitor Voltage Z1 (vdc)	2.374	2.65 ± 2.35
PU Oven Monitor Voltage Z2 (vdc)	2.374	2.374 ± 0.075
PU Oven Monitor Voltage Z3 (vdc)	2.374	2.374 ± 0.075
PU Oven Monitor Voltage - Final (vdc)	2.374	2.374 ± 0.075

Bridge Balance and Ratio Valve Null Test

Function	Measured Value	AO Multi	BO Multi	Limits
Ratio Valve Position (deg)	0.624			0.000 ± 1.5
LOX Coarse Mass Voltage (vdc)		0.103	0.098	0.103 ± 0.1
LOX Fine Mass Voltage (vdc)		4.033	4.019	4.009 ± 0.4
LH2 Coarse Mass Voltage (vdc)		0.000	-0.010	0.000 ± 0.1
LH2 Fine Mass Voltage (vdc)		1.470	1.470	1.367 ± 0.4

PU Loading Test

Function	Measured Value	Limits
LH2 Boiloff Bias Signal Volt. (vdc)	21.240	18.417 ± 2.0
GSE Power Supply Voltage (vdc)	28.999	28.0 ± 2.0

Loading Potentiometer Function	LOX Value	LH2 Value	Limits
Sense Voltage, GSE Power On (vdc)	28.999	28.999	28.999 ± 0.4
Signal Voltage, Relay Commands	0.574		0.574 ± 0.5
Off (vdc)		0.000	0.0 ± 0.5
Signal Voltage, Relay Commands	7.711		7.930 ± 0.6
On (vdc)		8.531	8.668 ± 0.6
Signal Voltage, Relay Commands	0.602		0.574 ± 0.5
Off (vdc)		0.000	0.0 ± 0.5
Sense Voltage, GSE Power Off (vdc)	0.000	0.000	0.0 ± 0.75

Servo Balance Bridge Gain Test

Function	Measured Value	AO Multi	BO Multi	Limits
Ratio Valve Position (deg)	0.692			0.624 ± 1.5
LOX Coarse Mass Voltage (vdc)		0.103	0.098	0.103 ± 0.1
LOX Fine Mass Voltage (vdc)		4.019	4.019	4.009 ± 0.4
LH2 Coarse Mass Voltage (vdc)		0.000	-0.010	0.000 ± 0.1
LH2 Fine Mass Voltage (vdc)		1.484	1.479	1.367 ± 0.4

4.2.15.1 (Continued)

Function	Measured Value	AO Multi	BO Multi	Limits
1/3 Checkout Relay Commands On				
Ratio Valve Position (deg)	1.237			0.624 + 1.5
LOX Coarse Mass Voltage (vdc)		1.411	1.411	1.416 ± 0.1
LOX Fine Mass Voltage (vdc)		0.122	0.107	0.249 ± 0.4
LH2 Coarse Mass Voltage (vdc)		1.553	1.553	1.548 ± 0.1
LH2 Fine Mass Voltage (vdc)		2.549	2.554	2.339 ± 0.4
2/3 Checkout Relay Commands On				
Ratio Valve Position (deg)	1.578			0.624 + 1.5
LOX Coarse Mass Voltage (vdc)		2.861	2.852	2.856 ± 0.1
LOX Fine Mass Voltage (vdc)		1.738	1.729	2.017 ± 0.4
LH2 Coarse Mass Voltage (vdc)		3.193	3.193	3.193 ± 0.1
LH2 Fine Mass Voltage (vdc)		4.980	4.990	4.590 ± 0.4
2/3 Checkout Relay Commands Off				
Ratio Valve Position (deg)	1.169			0.624 + 1.5
LOX Coarse Mass Voltage (vdc)		1.411	1.411	1.416 ± 0.1
LOX Fine Mass Voltage (vdc)		0.122	0.122	0.249 ± 0.4
LH2 Coarse Mass Voltage (vdc)		1.553	1.548	1.548 ± 0.1
LH2 Fine Mass Voltage (vdc)		2.539	2.529	2.339 ± 0.4
1/3 Checkout Relay Commands Off				
Ratio Valve Position (deg)	0.692			0.624 + 1.5
LOX Coarse Mass Voltage (vdc)		0.103	0.098	0.103 ± 0.1
LOX Fine Mass Voltage (vdc)		4.019	3.999	4.009 ± 0.4
LH2 Coarse Mass Voltage (vdc)		0.000	-0.005	0.000 ± 0.1
LH2 Fine Mass Voltage (vdc)		1.470	1.460	1.367 ± 0.4

PU Valve Movement Test

Function	Measured Value	Limits
Ratio Valve Position, AO (deg)	0.692	0.624 + 1.50
Ratio Valve Position, BO (deg)	0.761	0.624 ± 1.50
50 Second Plus Valve Slew, AO Multiplexer		
+1 vdc System Test Valve Position Signal	0.997	1.00 + 0.02
V1, Position at T+3 Seconds (deg)	4.227	2.037 to 6.351
V2, Position at T+5 Seconds (deg)	5.317	2.659 to 7.396

4.2.15.1 (Continued)

Function	Measured Value	Limits
V3, Position at T+8 Seconds (deg)	5.727	2.977 to 7.396
V4, Position at T+20 Seconds (deg)	5.999	5.226 to 7.396
V5, Position at T+50 Seconds (deg)	5.999	5.226 to 7.396
50 Second Minus Valve Slew, AO Multiplexer		
Ratio Valve Position, AO (deg)	0.830	0.624 ± 1.5
-1 vdc System Test Valve Error Signal (vdc)	-0.995	-1.000 ± 0.02
V1, Position at T+3 Seconds (deg)	-3.817	-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)	-5.316	-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)	0.487	0.692	0.624 ± 1.50
LOX 1/3 Command Relay On			
LOX Coarse Mass Voltage (vdc)	1.421	1.411	1.416 ± 0.1
PU System On			
Ratio Valve Position (deg)	33.758	33.826	20.0 min
PU System Off			
Ratio Valve Position (deg)	1.102	1.033	15.0 max
LOX 1/3 Command Relay Off			
LOX Coarse Mass Voltage (vdc)	0.103	0.093	0.103 ± 0.1
Ratio Valve Position (deg)	0.692	0.828	0.624 ± 1.5
LH2 1/3 Command Relay On			
LH2 Coarse Mass Voltage (vdc)	1.553	1.543	1.548 ± 0.1
PU System On			
Ratio Valve Position (deg)	-27.805	-27.805	-20.0 max
PU System Off			
Ratio Valve Position (deg)	0.90	-	-15.0 min
LH2 1/3 Command Relay Off			
LH2 Coarse Mass Voltage (vdc)	0.000	-0.005	0.000 ± 0.1
Ratio Valve Position (deg)	0.761	0.896	0.624 ± 1.5

PU Valve Programmed Mixture Ratio Test

Function	Measured Value	Limits
4.5 MR Switch On		
Ratio Valve Position (deg)	-22.011	-20.0 max

4.2.15.1 (Continued)

Function	Measured Value	Limits
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)	-0.398	-1.5 min
5.5 MR Switch On		
Ratio Valve Position (deg)	21.213	20.0 min
LH2 1/3 Command Relay On and PU System On		
Ratio Valve Position (deg)	33.962	20.0 min
PU Programmed MR Switch Off		
Ratio Valve Position (deg)	-1.693	1.5 max
4.5 MR Switch On		
Ratio Valve Position (deg)	-21.874	-20.0 max
5.5 MR Switch On		
Ratio Valve Position (deg)	-6.602	0 ± 10
PU Programmed MR Switch Off		
Ratio Valve Position (deg)	2.124	0.624 ± 1.5

4.2.16 Propulsion System Test (1B62753 M)

This automatic procedure performed the postfire integrated electro-mechanical 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.

Testing was initiated on 10 March 1969, and completed on 14 March 1969. The initial test was aborted during section one of the procedure due to a computer malfunction which terminated executive operation. A second test successfully checked the three sections of the procedure on 10 March 1969. A third test was performed on 10 March 1969, after reorificing to obtain the postfire timing requirements for the main engine oxidizer valve (MOV) per ECP-J2-599. This test performed only the engine sequence check portion of section three. Reorificing again became necessary to correct MOV second stage opening time and the engine sequence test was repeated three times to verify proper operating times on 11 March 1969.

4.2.16 (Continued)

A fifth test was conducted to retest the O2H2 burner voting circuit per section two of the procedure on 11 March 1969. Malfunction during initial testing had resulted in isolating the problem to the propellant utilization (PU) oven on indication module, P/N 1B65331-1-002, S/N 068, which was retested per the signal conditioning setup procedure, 1B64681, and removed and replaced per FARR 500-704-055.

The sixth and final test on 14 March 1969, performed that portion of section two of the procedure required to test the newly installed LOX pressurization control module. Module, P/N 1B42290-507, S/N 0037, had been regulating low since the stage static firing, and was removed and replaced per FARR 500-703-881.

Significant measurements recorded during propulsion system testing are listed in Test Data Table 4.2.16.1. Measurements listed in all cases are final test results. The following narrative is a description of the tests performed.

Subsequent to the performance of stage power setup per H&CO 1B55813, testing of the ambient helium system commenced by pressurizing the ambient helium pneumatic control sphere and repressurization spheres to 700 ±50 psia and setting the stage control helium regulator discharge pressure at 515 ±50 psia. A series of checks verified the proper operation of the control helium dump valve and the pneumatic power control module shutoff valve. The proper functioning of the LOX and LH2 repressurization system was verified, including operation of the control valves, dump valves, and pressure switch system control.

A three-cycle test of the engine pump purge pressure switch preceded the functional checkout of the engine pump purge valve. The control helium regulator

4.2.16 (Continued)

backup pressure switch and the control helium shutoff valve were similarly tested. The control helium sphere was pressurized to 674.922 psia; and the control helium regulator discharge pressure was measured at 534.73 psia, both within acceptable limits. A series of checks verified the operation of the pneumatically controlled valves, including the LH2 and LOX vent valves, fill and drain valves, prevalves, chilldown shutoff valves, the LH2 directional vent valve, the LH2 continuous vent and relief override valve, the LH2 continuous vent orificed bypass valve, the O2H2 burner propellant valves, the LOX non-propulsive vent valve and the LH2 latch relief valve.

The passivation circuitry checkout and the J-2 orbital safing valve functional checks were accomplished satisfactorily. The LH2 tank pressurization and continuous vent valve blowdown check completed the ambient helium system test.

Section two, the propellant tanks pressurization systems test, was initiated with functional checks of the cold helium dump and shutoff valves. The operation and the ability of the cold helium regulator backup pressure switch to properly control the cold helium shutoff valve was verified by the three-cycle pressure switch test.

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

4.2.16 (Continued)

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

The LH2 repressurization and ground fill overpressurization pressure switches were verified to operate properly. Control of the LH2 main fill valve, the LH2 replenish valve, the LH2 auxiliary tank pressurization valve, the step pressure valve, the LH2 bypass control valve, and the repressurization control valve by the pressure switches was also demonstrated. After satisfactory completion of the LH2 pressure switch checks, the cold helium system was pressurized to 873.547 psia; and the cold helium sphere blowdown and cold helium regulator high flow test were conducted. The cold helium system was then repressurized to 892.625 psia, and the cold helium sphere blowdown and cold helium regulator low flow test were conducted. The cold helium spheres were vented, and a series of checks verified proper operation for the O2H2 burner voting circuit and burner malfunction temperature sensors after replacement of the PU oven on indication module, as previously described. This completed testing of the propellant tanks pressurization systems.

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

4.2.16 (Continued)

control valves, and the O2H2 burner propellant valves were verified to operate properly.

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

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

Three-cycle tests of mainstage OK pressure switches 1 and 2 were conducted. It was verified that the pickup of either switch turned off the engine thrust OK 1 and 2 indications and that after a dry engine start sequence, pickup of 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.

4.2.16 (Continued)

The engine helium control sphere was pressurized to 1460.781 psia to conduct the engine valve sequence tests which demonstrated that actuation and deactuation of the helium control solenoid valve caused the LH2 and LOX bleed valves to close and open, that opening and closing the ignition phase control solenoid valve caused the engine augmented spark igniter (ASI) LOX valve and engine main fuel valve to open and close, that the start tank discharge solenoid valve 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.

FARR's initiated were limited to those previously described. Other problem areas were resolved by the fifty-six revisions recorded in the procedure as follows:

a. Twenty-four revisions corrected errors or omissions in the program or procedure.

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

c. Two revisions modified the procedure to assure safety of the stage.

d. One revision modified previous revisions.

e. Two revisions concerned initial conditions scan and were identical with the demonstration test of stage power setup, 1B55813.

4.2.16 (Continued)

f. Three revisions provided instructions to investigate an 02H2 burner voting circuit malfunction, which resulted in replacement of the PU oven on indication module per FARR 500-704-055.

g. Five revisions authorized the repeat tests performed as previously described in this narrative.

h. Two revisions concerned program changes to obtain proper initial conditions prior to the repeat tests.

i. One revision indicated that SIM interrupts received were caused by manual setups for the repeat engine sequence tests.

j. Two malfunction indications were attributed to setup error.

k. One revision indicated an error message was received because of an improper paper tape program change.

4.2.16.1 Test Data Table, Propulsion Test

Section 1 - Ambient Helium Test

Function

Engine Pump Purge Pressure Switch Checkout

		Measured Values			
		Test 1	Test 2	Test 3	Limits
Pickup Pressure	(psia)	121.758	119.428	119.428	136.0 max
Dropout Pressure	(psia)	107.773	108.551	107.773	99.0 min
Deadband	(psid)	13.984	10.877	11.654	3.0 min

Control Helium Regulator Backup Pressure Switch Checkout

		Test 1	Test 2	Test 3	Limits
Pressurization Time	(sec)	76.470	30.426	30.417	180.0 max
Pickup Pressure	(psia)	600.422	600.422	600.422	600 + 21
Depressurization Time	(sec)	18.018	12.975	12.965	180.0 max
Dropout Pressure	(psia)	493.180	493.180	493.180	490 ± 31

Pneumatically Controlled Valve Timing Checkout

	Operating Times (sec)					
Valve	Open	Total Open	Close	Total Close	Boost Close	Total Boost Close
LH2 Vent Valve	0.015	0.077	0.124	0.378	0.061	0.215
LOX Vent Valve	0.021	0.087	0.123	0.391	0.060	0.238
LOX F&D Valve	0.120	0.211	0.743	1.811	0.373	0.729

4.2.16.1 (Continued)

Section 1 - Ambient Helium Test (Continued)

Valve	Operating Times (sec) Open	Total Open	Close	Total Close	Boost Close	Total Boost Close
LH2 F&D Valve	0.189	0.310	1.131	2.624	0.579	1.081
LOX Prevalve	1.143	1.688	0.160	0.281	*	*
LH2 Prevalve	1.136	1.738	0.177	0.301	*	*
LOX C/D SOV	0.213	0.964	0.031	0.144	*	*
LH2 C/D SOV	0.223	1.031	0.024	0.129	*	*
LH2 Cont Vent Orif'd Bypass Valve	0.025	0.119	0.009	0.162	*	*
O2H2 Burner LH2 Prop	0.067	0.162	0.016	0.093	*	*
O2H2 Burner LOX Prop	0.007	0.086	0.008	0.085	*	*
LH2 Latch Rlf Vlv	0.023	0.063	0.128	0.339	0.069	0.202
LOX NPV Vlv	0.023	0.051	0.149	0.373	0.087	0.219

Valve	Flight Position	Total Flt. Position	Ground Position	Total Ground Position
LH2 Directional Vent Valve	0.064	0.154	0.834	1.420

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)	78.909	55.336	55.103	180 max
Pickup Pressure	(psia)	473.77	473.77	472.99	467.5 ± 23.5
Depressurization Time	(sec)	17.271	17.280	17.277	180 max
Dropout Pressure	(psia)	381.297	380.516	380.516	362.5 ± 33.5

LOX Tank Repressurization Backup Pressure Switch Checkout

		Test 1	Test 2	Test 3	Limits
Pressurization Time	(sec)	54.807	55.296	54.853	180 max
Pickup Pressure	(psia)	474.547	474.547	473.766	467.5 ± 23.5
Depressurization Time	(sec)	17.069	16.883	16.863	180 max
Dropout Pressure	(psia)	383.625	383.625	382.844	362.5 ± 33.5

* Not Applicable To These Valves

4.2.16.1 (Continued)

Section 2 - Propellant Tanks Pressurization System Test (Continued)

Function

LH2 Tank Repressurization Backup Pressure Switch Checkout

		Measured Values			
		Test 1	Test 2	Test 3	Limits
Pressurization Time	(sec)	54.287	54.811	54.623	180 max
Pickup Pressure	(psia)	471.438	469.875	469.875	467.5 ± 23.5
Depressurization Time	(sec)	18.401	18.211	18.186	180 max
Dropout Pressure	(psia)	376.633	374.297	375.859	362.5 ± 33.5

LOX Tank Ground Fill Overpressure Pressure Switch Checkout

		Test 1	Test 2	Test 3	Limits
Pressurization Time	(sec)	80.417	37.756	27.734	180 max
Pickup Pressure	(psia)	40.737	40.477	40.424	41 max
Depressurization Time	(sec)	9.173	7.479	7.375	180 max
Dropout Pressure	(psia)	39.065	39.065	39.119	37.5 min
Deadband	(psid)	1.672	1.411	1.305	0.5 min

LH2 Repressurization Control Pressure Switch Checkout

		Test 1	Test 2	Test 3	Limits
Pressurization Time	(sec)	74.058	33.938	19.823	180 max
Pickup Pressure	(psia)	30.812	30.607	30.658	31 max
Depressurization Time	(sec)	66.264	46.128	43.882	180 max
Dropout Pressure	(psia)	28.518	28.569	28.569	27.8 min
Deadband	(psid)	2.294	2.038	2.089	0.5 min

LH2 Tank Ground Fill Overpressure Pressure Switch Checkout

		Test 1	Test 2	Test 3	Limits
Pressurization Time	(sec)	73.207	46.357	23.808	180 max
Grd. Fill Overpress Pickup Pressure	(psia)	30.199	30.199	30.148	31 max
Depressurization Time	(sec)	72.802	49.791	48.394	180 max
Grd. Fill Overpress Dropout Pressure	(psia)	28.314	28.314	28.314	27.8 min
Deadband	(psid)	1.885	1.885	1.834	0.5 min

Section 3 - J-2 Engine Functional Test (Engine S/N J-2122)

Engine Delay Timer Checkout

Function	Delay Time (sec)	Limits (sec)
Ignition Phase Timer	0.437	0.450 ± 0.030
Helium Delay Timer	1.000	1.000 ∓ 0.110

4.2.16.1 (Continued)

Section 3 - J-2 Engine Functional Test (Engine S/N J-2122) (Continued)

Function	Delay Time (sec)	Limits (sec)
Sparks De-energized Timer	3.294	3.300 ± 0.200
Start Tank Discharge Timer	1.006	1.000 ∓ 0.040

Function

Mainstage OK Pressure Switch 1 Checkout

		Measured Values			
		Test 1	Test 2	Test 3	Limits
Pickup Pressure	(psia)	510.76	508.44	506.88	515 ± 36
Dropout Pressure	(psia)	449.46	450.24	450.24	*
Deadband	(psid)	61.30	58.20	56.63	62.5 ± 48.5

Mainstage OK Pressure Switch 2 Checkout

		Test 1	Test 2	Test 3	Limits
Pickup Pressure	(psia)	519.61	517.28	516.48	515 ± 36
Dropout Pressure	(psia)	448.13	448.13	447.35	*
Deadband	(psid)	71.48	69.16	69.13	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	**	0.018	**
Ign Phase Cont Solenoid Command Talkback	**	0.011	**
ASI Valve Open	**	0.075	**
Engine LOX Bleed Valve Close	**	0.136	**
Engine LH2 Bleed Valve Close	**	0.118	**
Main Fuel Valve Open	0.084	0.139	0.223
Start Tank Disch Timer	**	1.002	**
Start Tank Disch Valve Open	0.089	0.123	0.212
Mainstage Cont Solenoid Energized	**	1.455	**
Ignition Phase Timer	**	0.453	**
Start Tank Disch Cont Solenoid De-energized	**	0.007	**
Main LOX Valve Open	0.521	1.490	2.012
Start Tank Disch Valve Close	0.187	0.146	0.332

* Limits Not Specified
** Not Applicable Or Not Available

4.2.16.1 (Continued)

Section 3 - J-2 Engine Functional Test (Engine S/N J-2122) (Continued)

Function	Start or Delay Time (sec)	Oper. or Travel Time (sec)	Total Time (sec)
Gas Generator Valve Open	**	0.087	0.186
LOX Turbine Bypass Valve Close	0.278	0.237	0.516
Spark System Off Timer	**	3.312	**
Engine Cutoff			
Ign Phase Cont Solenoid De-energized from Cutoff	**	0.007	**
Mainstage Cont Solenoid De-energized from Cutoff	**	0.015	**
ASI Valve Close	0.038	**	**
Main LOX Valve Close	0.120	0.047	0.167
Main Fuel Valve Close	0.129	0.139	0.268
Gas Generator Valve Close	0.137	0.099	0.235
He Cont De-energized Timer	**	1.001	**
Engine LOX Bleed Valve Open	**	**	6.650
Engine LH2 Bleed Valve Open	**	**	7.524
LOX Turbine Bypass Valve Open	0.303	0.497	0.800

Engine Sequence Data (Oscillograph Records)

Function	Measurements		Limits	
	Delay	Valve Motion	Delay	Valve Motion
Ignition (sec)				
Main Fuel Valve Open	0.051	0.101	0.030-0.090	0.030-0.130
Start Tank Disch Vlv Open	0.081	0.089	0.080-0.120	0.085-0.125
Mainstage (sec)				
GG Valve Fuel Open	***	***	*	*
GG Valve LOX Open	0.133	0.064	0.130-0.150	0.020-0.080
Start Tank Disch Valve Close	0.121	0.240	0.110-0.150	0.175-0.255
MOV 1st Stage Open	0.045	0.040	0.030-0.070	0.025-0.075
MOV 2nd Stage Open	0.563	1.669	0.490-0.630	1.650-1.700
Oxidizer Turbine Bypass Vlv Close	0.415	0.479	*	5.0 max

* Limits Not Specified
** Not Applicable Or Not Available
*** Not Recorded By Engineering

4.2.16.1 (Continued)

Section 3 - J-2 Engine Functional Test (Engine S/N J-2122) (Continued)

Function	Measurements Delay	Measurements Valve Motion	Limits Delay	Limits Valve Motion
Cutoff (sec)				
Oxidizer Turbine Bypass Vlv Open	***	0.825	*	10 max
GG Valve LOX Close	0.052	0.020	0.040-0.100	0.010-0.055
Main Oxid Vlv Closed	0.058	0.121	0.045-0.075	0.105-0.135
Main Fuel Vlv Closed	0.075	0.221	0.065-0.115	0.200-0.250
Bleeds (sec)				
ASI Open	**	0.066	**	*
ASI Close	**	0.037	**	*
GG Valve LOX Open	**	8.532	**	30.0 max
GG Valve LOX Close	**	0.113	**	*
GG Valve Fuel Open	**	7.645	**	30.0 max
GG Valve Fuel Close	**	0.093	**	0.120 max
Timers (sec)				
Start Tnk Disch Vlv Delay	0.989	**	0.960-1.040	**
Ignition Phase	0.451	**	0.420-0.480	**
Sparks De-energize	3.300	**	3.10-3.50	**
Helium Cont De-energize	0.991	**	0.890-1.110	**
Trace Deflections				
Oxid Turbine Bypass Valve 80% (sec)	0.479	**	0.350-0.550	**
Main Oxid Valve (deg)	13	**	10-16	**
GG Valve (%)	50	**	35-65	**

* Limits Not Specified
** Not Applicable Or Not Available
*** Not Recorded By Engineering

4.2.17 All Systems Test (1B55833 J)

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

AST was initiated on 12 March 1969, but encountered malfunctions resulting from the range safety system during the umbilicals-out portion of the test. Additional testing was conducted on 13 March 1969, to troubleshoot the range safety problem. This resulted in increasing the delay time between tone 5 and the arm and engine cutoff (ECO) command to make the range safety system operate properly during the umbilicals-out test. A final test was conducted on 14 March 1969, to verify the umbilicals-out portion of AST using the new range safety delay time.

After accomplishing the various manual electrical and propulsion system setups, automatic testing started with stage power setup to establish initial conditions.

4.2.17 (Continued)

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 4.2.17.1. 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 only. Power turnon to the PCM RF group and the single sideband (SSB) plus transmitter warm-up sequences completed power setup for the AST.

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

The next series of prelaunch checks verified that the LOX and LH2 tank vent valves and fill and drain valves opened properly on command, and that the LOX and LH2 point level sensors, fastfill sensors, and overfill sensors 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 LH2 chilldown shutoff valves, prevalves, and vent valves was verified, and the LOX and LH2 tank prepressurization sequences were accomplished. The LH2 pressure control module pressure (D104) was measured during the last sequence. The LOX and LH2 fill and drain valves were then closed, the proper operation of the LH2 directional vent valve was verified, and the valve was set to the ground position.

4.2.17 (Continued)

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. Antenna forward and reflected powers were measured for the PCM and SSB telemetry systems, and closed loop VSWR was determined for each telemetry system. 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 verified to be over 200 psia, and the hydraulic system functions were remeasured with the system pressurized. During the umbilicals-in test only, the 7.5 degree square gimbal pattern check was satisfactorily accomplished, after which the hydraulic system was depressurized by the auxiliary hydraulic pump shutdown.

4.2.17 (Continued)

The stage and GSE were then set for open loop telemetry operation by turning on the RF distribution system 2 and setting the PCM ground station for open loop reception. A flow rate and turbine speed (FRATS) calibration measured the reference indication voltages for the LOX and LH2 circulation pump flowrates, the static inverter-converter frequency, and the LH2 and LOX chilldown inverter frequencies, using a 400 Hz GSE calibration frequency. The reference voltages were also measured for the LOX and LH2 flowmeters using a 100 Hz GSE calibration frequency, and for the LOX and LH2 pump speeds using a 1500 Hz GSE calibration frequency. The PCM/FM telemetry system forward and reflected RF powers were then measured, and the telemetry system open loop VSWR was determined. Similar measurements were made for the SSB telemetry system. The propellant utilization system oven stability monitor voltage was measured, to verify that the oven temperature had increased since the propellant utilization system power was originally turned on. The LOX and LH2 chilldown pumps were turned on, and the chilldown inverter currents were measured. The inverter frequencies and phase voltages were measured by hardwire and telemetry. A series of measurements were then made of the common bulkhead pressure and the LH2 ullage pressure, their 20 and 80 percent calibration voltages, and the ambient pressures after each calibration; the LOX ullage pressure; the LH2 and LOX emergency detection system pressures; and the LH2 and LOX chilldown pump differential pressures. Common bulkhead pressures reflected the vacuum drawn on the bulkhead. A telemetry and RACS calibration was then performed.

The final prelaunch checks were then started. During the umbilicals-in test, the battery simulators were turned on, and measurements were made of the battery

4.2.17 (Continued)

simulator voltages and the electrical support equipment load bank voltages. During the umbilicals-out test, the checkout batteries were turned on, and the checkout battery voltages were measured. The transducers for the common bulkhead pressure and the LH2 and LOX ullage pressures were all turned off, and the transducer output voltages were measured. The LH2 and LOX fastfill sensor simulated wet conditions were then turned off.

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

4.2.17 (Continued)

Following the simulated liftoff, a telemetry calibration was accomplished, and the preseparation checks were conducted. The two ullage rocket ignition EBW firing units were charged. The LH2 and LOX prevalves were cycled, and the LH2 chilldown inverter was turned off. The fire ullage ignition command was turned on, and it was verified that the two ullage ignition EBW firing units responded properly and that the ullage ignition pulse sensors were on. The aft separate simulation 1 and 2 signals were then turned on to simulate stage separation. During the above part of the umbilicals-in test only, additional checks verified that the ullage rocket firing unit disable command prevented the ignition EBW firing units from charging, and discharged the previously charged firing units while preventing them from firing.

APS roll checks using the APS simulators and engine start checks were conducted following the simulated stage separation. The instrument unit (IU) substitute -28 volt power was turned on and measured. For the APS roll checks, attitude control nozzles I-IV and III-II were turned on and off while the corresponding APS engine valve open indications were measured for open and close voltages. This procedure was then repeated for attitude control nozzles I-II and III-IV and their corresponding APS engine valves to complete the roll checks. The LOX chilldown inverter was then turned off, and the LH2 and LOX chilldown shutoff valves were cycled. The engine start sequence was accomplished with the simulated mainstage OK indication turned on to simulate a satisfactory engine start. The LH2 first burn relay was also turned on. The two ullage rocket jettison EBW firing units were charged, the fire ullage jettison command was turned on, and it was verified that both ullage jettison

4.2.17 (Continued)

firing units responded properly and that the ullage jettison pulse sensors were on. During this part of the umbilicals-in test, additional checks verified that the ullage rocket firing unit disable command prevented the jettison EBW firing units from charging, and discharged the previously charged firing units while preventing them from firing.

Following the engine start sequence, the hydraulic gimbal and propellant utilization valve slew checks were conducted, starting with the step response gimbal and PU LOX valve slew checks. The propellant utilization system ratio valve position and the hydraulic system pressure were both measured, and the LOX bridge 1/3 checkout relay was turned on. A series of step response gimbal checks were conducted for 0 to -3 degrees, -3 to 0 degrees, 0 to +3 degrees, and +3 to 0 degrees, in the pitch and yaw planes. Following the gimbal sequence, the propellant utilization system ratio valve position was again measured, and the LOX bridge 1/3 checkout relay was turned off. A 0.6 Hz gimbal and LH2 propellant utilization valve slew check was conducted next. The propellant utilization system ratio valve position and the hydraulic pressure were measured, and the LH2 bridge 1/3 checkout relay was turned on. A 0.5 degree gimbal signal, at 0.6 Hz, was applied in the pitch and yaw planes. The engine position command currents and resulting instrument unit actuator piston positions were found to be within the required limits throughout the cycling in both planes, for the umbilicals-in and umbilicals-out tests. At the completion of the gimbal sequences, the hydraulic actuator piston positions and the instrument unit engine pitch and yaw positions were measured, and the hydraulic system functions were measured with the hydraulic system pressurized.

4.2.17 (Continued)

The propellant utilization system ratio valve position was measured, and the LH2 bridge 1/3 checkout relay was turned off.

The first burn and coast period sequences were conducted next. During the first burn pressurization, the helium pressures of the LOX and LH2 pressurization control modules, and the cold helium control valve inlet, were measured while the helium supply valves were temporarily open, and again after the pressure switch supplies were closed and the flight control pressure switches were verified to be off. The engine cutoff was then accomplished, the engine control helium sphere pressure was measured, the auxiliary hydraulic pump was set for coast mode operation, the LH2 first burn relay was turned off, and the LH2 pressurization control module helium pressure was again measured. The coast period command was turned on, the LOX flight pressurization system was turned off, and the engine pump was started. The simulated mainstage OK indication was turned off to complete the first burn sequence. During the coast period, the 70 pound ullage engine command 1 was turned on and off, the LH2 continuous vent valves were opened, and the ullage engine command 2 was turned on and off. The engine pump purge was then completed. The LH2 boiloff bias signal voltage was measured with the propellant utilization boiloff bias cutoff turned on and off.

The engine restart preparations were conducted next. The LH2 continuous vent valves were closed, and the LOX repressurization spheres and cold helium spheres pressures were measured. The O2H2 burner spark excitation systems were verified to operate properly. The proper operation of the LOX and LH2

4.2.17 (Continued)

repressurization control valves was verified, and the LOX and LH2 tank cryogenic repressurization sequences were accomplished. During the LH2 sequence, it was verified that pick up of the LH2 pressurization switch turned on the ullage engine commands when the O2H2 burner voting circuit was enabled. The cold helium sphere pressure and the LOX repressurization spheres pressure were measured after these sequences were completed. The LOX tank ambient repressurization sequence was then accomplished, with the cold helium sphere pressure measured before the sequence, and the LOX repressurization spheres pressure measured during the sequence. The LOX and LH2 chilldown pumps were turned on, and the chilldown inverter voltages were measured. The LH2 tank ambient repressurization sequence was then accomplished, with the LH2 tank repressurization helium sphere pressure measured during the sequence. The PU system ratio valve position was verified to respond properly to the programmed mixture ratio switches and bridge commands. The LH2 and LOX chilldown pumps were turned off, and the inverter operating frequencies and voltages were measured. The cold helium supply shutoff valve was then opened, completing the restart preparations.

The engine restart sequence was accomplished, with the engine control helium sphere pressure measured. The simulated mainstage OK indication was turned on to simulate a satisfactory engine restart, and the LH2 second burn relay was turned on. The cold helium supply shutoff valve was closed to complete the restart sequence. An LH2 second burn repressurization sequence was accomplished, with the LH2 pressurization control module helium pressure measured with the prepressurization supply open, and again after the pressure switch supply was

4.2.17 (Continued)

closed. The engine cutoff was then accomplished with the engine control helium sphere pressure measured, the simulated ignition detected indication and the LH2 second burn relay were turned off and the coast period command was turned on.

After performing the propellant dump and orbital safing sequence, the depletion level sensor and engine cutoff timer test was performed. A series of checks verified that a dry condition of any one LOX or LH2 point level sensor would not cause engine cutoff, but that a dry condition of any two LOX sensors or any two LH2 sensors would cause engine cutoff. The sensors were checked by turning off the simulated wet conditions for the combinations of LOX and LH2 sensors. During the umbilicals-in test, the operating time of the LOX depletion engine cutoff timer was measured for each combination of LOX sensors.

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

4.2.17 (Continued)

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

FARR 500-816-384 was initiated after the AST, when data review indicated RF interference for forward and reflected power transmission measurements N18, N55, N60, and N61. This discrepancy was submitted to the FTC for further evaluation.

Forty-one revisions were made to the procedure as follows:

a. Eight revisions corrected errors or omissions in the program.

b. Four revisions were required to update the procedure to the latest requirements.

c. Seven revisions attributed malfunction indications to program errors.

d. One revision deleted portions of the test that were previously accomplished.

e. Two revisions attributed malfunction indications to operator error.

f. Two revisions provided stage power setup and turnoff program changes identical to those for the demonstration tests per H&CO's 1B55813 and 1B55814.

4.2.17 (Continued)

g. One revision corrected operator programming errors that resulted in malfunctions.

h. One revision indicated that low GN2 supply pressure from the gas farm was acceptable because it was sufficiently high to properly set the GN2 regulators.

i. One revision attributed one malfunction indication to a marginal cold helium sphere pressurization setting near the low limit plus instrumentation accuracy.

j. Three revisions attributed malfunction indications to GSE, which after correction performed properly to complete the AST.

k. One revision traced a malfunction to interference caused by simultaneous work on the J-2 engine. The malfunction did not effect the AST.

l. One revision authorized lineprinter sheets to be reproduced from the test results tape due to damage of several lineprinter sheets.

m. One revision provided instructions for investigation of the range safety system malfunction during the initial umbilicals-out test.

n. Two revisions attributed the range safety system malfunction during initial umbilicals-out testing to insufficient delay between tone 5 and the arm and ECO command.

o. One revision authorized repeating the umbilicals-out portion of AST after resolving the range safety system problem.

p. One revision increased the AST program delay time for the range safety system between tone 5 and the arm and ECO command based on the investigation of the range safety system prior to repeating the umbilicals-out portion of the test.

q. One revision accepted an out-of-tolerance measurement for the aft bus 2 checkout battery voltage. The voltage was slightly high due to excess surface charge.

r. One revision explained the need to correct a parity error in order to properly load the magnetic tape to accomplish the AST shutdown routine.

s. Two revisions concerned expected SIM interrupts and malfunction indications which occurred during stage power turnoff following AST. These had no bearing on AST.

4.2.17.1 Test Data Table, All Systems Test

Power Setup Check

Function	Umbil.-In	Umbil.-Out	Limits
PU Power On			
PU Inv and Elect Current (amps)	3.800	3.700	5.0 max
PU Oven Stab Monitor Voltage (vdc)	-0.120	-0.120	-0.023 ± 0.1
Engine Control Bus On			
Aft Bus 1 Current (amps)	2.30	2.20	2.7 ± 3.0
Aft Bus 1 Voltage (vdc)	28.24	28.28	28.0 ± 2.0
Engine Control Bus Voltage (vdc)	28.03	28.03	Bus 1 ± 1.0
Component Test Power On			
Component Test Power Voltage (vdc)	27.84	27.92	Bus 1 ± 1.0
Engine Ignition Bus On			
Aft Bus 1 Current (amps)	2.60	2.30	2.7 ± 3.0
Aft Bus 1 Voltage (vdc)	28.24	28.24	28.0 ± 2.0
Engine Ignition Bus Voltage (vdc)	28.12	28.15	Bus 1 ± 1.0
APS Bus On			
Aft Bus 1 Current (amps)	3.00	2.70	2.7 ± 3.0
Aft Bus 2 On			
Aft Bus 2 Current (amps)	-0.20	0.00	5.0 max
Aft Bus 2 Voltage (vdc)	56.96	56.72	56.0 ± 4.0

Propulsion System Setup Check

Function	Umbil.-In	Umbil.-Out	Limits
Amb He Pneu Sphere Pressure D236 (psia)	693.6	704.8	700.0 ± 50.0
Cold Helium Sphere Pressure D261 (psia)	865.9	919.4	900 ± 50
Control Helium Supply Pressure D019 (psia)	1575.4	1614.8	1450.0 min
Cont He Reg Discharge Pressure D014 (psia)	525.5	524.8	515.0 ± 50.0
LH2 Repress He Sphere Pressure D020 (psia)	588.9	581.4	*

* Limits Not Specified

4.2.17.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
LOX Repress He Sphere Pressure D088 (psia)	603.9	596.4	*
LH2 Prepressurization Sequence			
LH2 Press Control Module GH2 Press D104 (psia)	176.48	180.85	50.0 min
EBW and Telemetry Checks			
PCM/FM Transmitter Output Power:			
RF Silence On (watts)	-0.12	**	2.0 max
RF Silence Off (watts)	19.45	**	10.0 min
Prelaunch C/O Group Current (amps)	2.300	2.300	1 ± 3
T/M Antenna 1 Forward Power (watts)	19.540	19.480	19.0 ± 7.25
T/M RF Sys Reflected Power (watts)	1.047	1.060	3.08 max
PCM Closed Loop VSWR	1.602	1.607	2.0 max
Operational T/M Kit RF Transmitter Power (watts)	20.046	20.076	19.00 ± 7.25
Operational T/M Kit Reflected RF Power (watts)	0.208	0.214	3.08 max
SSB Closed Loop VSWR	1.227	1.229	2.0 max
Inv-Conv 115 vac Output (vac)	114.41	114.41	115.0 ± 3.40
Inv-Conv 5 vdc Output (vdc)	5.04	5.04	4.9 ∓ 0.2
Inv-Conv 21 vdc Output (vdc)	22.04	22.04	21.25 ± 1.25
Inv-Conv Operating Frequency (Hz)	402.98	402.88	400.0 ± 6.0
Hydraulic System Checks			
Reservoir GN2 Mass (lbs)	1.932	1.922	1.925 ± 0.2
Corrected Reservoir Oil Level (%)	96.9	96.8	95.0 min
Hydraulic System Unpressurized			
Hydraulic System Pressure (psia)	1372.313	1382.125	*
Accumulator GN2 Pressure (psia)	2394.625	2383.750	*
Accumulator GN2 Temperature (°F)	74.486	76.840	*
Reservoir Oil Temperature (°F)	76.057	76.840	*
Reservoir Oil Level (%)	87.229	87.229	*
Reservoir Oil Pressure (psia)	73.756	77.248	*
Pump Inlet Oil Temperature (°F)	79.195	90.570	*
T/M Yaw Actuator Position (deg)	2.131	1.990	*
Corrected T/M Yaw Act. Pos (deg)	2.121	1.999	*
IU Yaw Actuator Position (deg)	2.128	1.980	*
Corrected IU Yaw Act. Pos (deg)	2.118	1.962	*

* Limits Not Specified
** Measurement Not Applicable

4.2.17.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
T/M Pitch Actuator Position (deg)	-1.084	-0.990	*
Corrected T/M Pitch Act. Pos (deg)	-1.075	-0.998	*
IU Pitch Actuator Position (deg)	-1.034	-0.989	*
Corrected IU Pitch Act. Pos (deg)	-1.025	-0.973	*
IU Substitute 5V Power Supply (vdc)	5.005	5.010	*
Aft 5V Excitation Module (vdc)	5.003	4.994	*
Aft Bus 2 Current (amps)	0.000	0.000	*
Hydraulic System Pressurized			
Hydraulic System Pressure (psia)	3591.500	3594.813	*
Accumulator GN2 Pressure (psia)	3583.938	3581.188	*
Accumulator GN2 Temperature (°F)	93.318	94.891	*
Reservoir Oil Temperature (°F)	76.057	76.840	*
Reservoir Oil Level (%)	37.189	36.940	*
Reservoir Oil Pressure (psia)	165.402	165.402	*
Pump Inlet Oil Temperature (°F)	76.453	79.195	*
T/M Yaw Actuator Position (deg)	0.045	-0.001	*
Corrected T/M Yaw Act. Pos (deg)	0.037	0.006	*
IU Yaw Actuator Position (deg)	0.046	0.016	*
Corrected IU Yaw Act. Pos (deg)	0.038	0.001	*
T/M Pitch Actuator Position (deg)	0.061	0.028	*
Corrected T/M Pitch Act. Pos (deg)	0.068	0.021	*
IU Pitch Actuator Position (deg)	0.044	0.029	*
Corrected IU Pitch Act. Pos (deg)	0.052	0.044	*
IU Substitute 5V Power Supply (vdc)	5.005	5.010	*
Aft 5V Excitation Module (vdc)	5.002	4.993	*
Aft Bus 2 Current (amps)	48.800	47.800	*
FRATS Calibration			
LOX Circ Pump Flowrate Ind (vdc)	3.855	3.866	3.882 ± 0.100
LH2 Circ Pump Flowrate Ind (vdc)	3.882	3.871	3.882 ± 0.100
Static Inv-Conv Freq Ind (vdc)	3.030	3.066	3.037 ± 0.100
LH2 C/D Inv Freq Ind (vdc)	3.000	2.989	3.037 ± 0.100
LOX C/D Inv Freq Ind (vdc)	3.000	2.984	3.037 ± 0.100
LOX Flowmeter Indication (vdc)	1.697	1.691	1.667 ± 0.100
LH2 Flowmeter Indication (vdc)	1.718	1.712	1.667 ± 0.100
LOX Pump Speed Indication (vdc)	3.194	3.194	3.125 ± 0.100
LH2 Pump Speed Indication (vdc)	1.276	1.297	1.250 ± 0.100
Telemetry RF and PU Oven Checks			
T/M Antenna 1 Forward Power (watts)	20.552	21.027	20.75 ± 9.00
T/M RF Sys Reflected Power (watts)	6.525	6.235	*
PCM Open Loop VSWR	3.580	3.390	*

* Limits Not Specified

4.2.17.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
T/M Kit RF Transmitter Power (watts)	20.671	21.146	20.75 ± 9.00
T/M Kit Reflected RF Power (watts)	3.065	2.996	*
SSB Open Loop VSWR	2.251	2.207	*
PU Oven Stability Monitor Z1 (vdc)	2.374	2.369	2.65 ± 2.35
PU Oven Stability Monitor Z2 (vdc)	2.369	2.363	Z1 ± 0.075
PU Oven Stability Monitor Z3 (vdc)	2.374	2.374	Z1 ± 0.075
LOX Chilldown Inverter Checks			
Inverter Current (amps)	20.210	20.744	20.0 ± 5.0
Aft Bus 2 Voltage (vdc)	56.317	54.398	*
Phase AB Voltage, Hardwire (vac)	55.343	53.519	Bus 2 ± 3.0
Phase AC Voltage, Hardwire (vac)	54.756	52.803	Bus 2 ± 3.0
Phase A1B1 Voltage, Hardwire (vac)	55.343	53.454	Bus 2 ± 3.0
Phase A1C1 Voltage, Hardwire (vac)	54.821	52.868	Bus 2 ± 3.0
Inverter Frequency, Hardwire (Hz)	401.0	400.0	400.0 ± 4.0
Inverter Frequency, Telemetry (Hz)	399.5	399.6	400.0 ± 4.0
Phase AB Voltage, Telemetry (vac)	55.5	53.6	Bus 2 ± 3.0
Phase AC Voltage, Telemetry (vac)	55.6	53.7	Bus 2 ± 3.0
LH2 Chilldown Inverter Checks			
Inverter Current (amps)	20.778	20.598	20.0 ± 5.0
Aft Bus 2 Voltage (vdc)	55.358	53.438	*
Phase AB Voltage, Hardwire (vac)	54.431	52.868	Bus 2 ± 3.0
Phase AC Voltage, Hardwire (vac)	53.779	52.021	Bus 2 ± 3.0
Phase A1B1 Voltage, Hardwire (vac)	54.495	52.738	Bus 2 ± 3.0
Phase A1C1 Voltage, Hardwire (vac)	53.715	52.217	Bus 2 ± 3.0
Inverter Frequency, Hardwire (Hz)	401.0	400.0	400.0 ± 4.0
Phase AB Voltage, Telemetry (vac)	55.3	53.5	Bus 2 ± 3.0
Phase AC Voltage, Telemetry (vac)	55.5	53.7	Bus 2 ± 3.0
Inverter Frequency, Telemetry (Hz)	400.0	399.7	400.0 ± 4.0
Pressure Measurements			
Common Bulkhead Pressure (psia)	3.757	3.921	CBP ± 0.707
Common Bulkhead 20% Calib (vdc)	1.034	1.045	1.0 ± 0.1
Common Bulkhead Press (psia)	4.148	4.308	CBP ± 0.5
Common Bulkhead 80% Calib (vdc)	4.020	4.020	4.0 ± 0.1
Common Bulkhead Press (psia)	4.175	4.361	CBP ± 0.5
LH2 Ullage Pressure (psia)	14.634	14.687	14.7 ± 1.0
LH2 Ullage 20% Calib (vdc)	1.034	1.045	1.0 ± 0.1
LH2 Ullage Amb Press (psia)	14.476	14.739	14.7 ± 1.0
LH2 Ullage 80% Calib (vdc)	4.079	4.079	4.0 ± 0.1
LH2 Ullage Amb Press (psia)	14.845	14.687	14.7 ± 1.0
LOX Ullage Pressure (psia)	14.810	14.595	14.7 ± 1.0

* Limits Not Specified

4.2.17.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
LH2 EDS Transducer 1 Press (psia)	14.6	14.2	14.7 ∓ 1.0
LH2 EDS Transducer 2 Press (psia)	14.9	14.9	14.7 ∓ 1.0
LOX EDS Transducer 1 Press (psia)	14.2	13.9	14.7 ∓ 1.0
LOX EDS Transducer 2 Press (psia)	14.9	15.0	14.7 ∓ 1.0
LH2 C/D Pump Diff Press (psid)	0.061	0.186	0.0 ∓ 1.2
LOX C/D Pump Diff Press (psid)	-0.506	-0.506	0.0 ∓ 1.2

Final Prelaunch Checks

Fwd Bus 1 Batt Sim (Bus 4D30) (vdc)	28.48	**	28.0 ∓ 2.0
Fwd Bus 2 Batt Sim (Bus 4D20) (vdc)	28.40	**	28.0 ∓ 2.0
Aft Bus 1 Batt Sim (Bus 4D10) (vdc)	28.36	**	28.0 ∓ 2.0
Aft Bus 2 Batt Sim (Bus 4D40) (vdc)	56.56	**	56.0 ∓ 4.0
Bus 4D20 ESE Load Bank (vdc)	0.08	**	0.0 ∓ 1.0
Bus 4D40 ESE Load Bank (vdc)	0.24	**	0.0 ∓ 1.0
Bus 4D30 ESE Load Bank (vdc)	0.00	**	0.0 ∓ 1.0
Bus 4D10 ESE Load Bank (vdc)	0.16	**	0.0 ∓ 1.0
Fwd Bus 1 C/O Batt (Bus 4D30) (vdc)	**	29.84	30.0 ∓ 1.5
Fwd Bus 2 C/O Batt (Bus 4D20) (vdc)	**	30.08	30.0 ∓ 1.5
Aft Bus 1 C/O Batt (Bus 4D10) (vdc)	**	30.48	30.0 ∓ 1.5
Aft Bus 2 C/O Batt (Bus 4D40) (vdc)	**	63.68+	61.0 ∓ 2.0
Com Bulkhead Press Transducer (vdc)	0.010	0.005	0.0 ∓ 0.353
LH2 Ullage Press Transducer (vdc)	0.000	0.005	0.0 ∓ 0.353
LOX Ullage Press Transducer (vdc)	0.114	0.039	0.0 ∓ 0.353
Fwd Bus 1 Internal (Bus 4D31)(vdc)	27.92		28.0 ∓ 2.0
Fwd Bus 1 Internal (Bus 4D31)(vdc)		28.92	29.5 ∓ 1.5
Fwd Bus 2 Internal (Bus 4D21)(vdc)	27.72		28.0 ∓ 2.0
Fwd Bus 2 Internal (Bus 4D21)(vdc)		28.48	29.5 ∓ 1.5
Aft Bus 1 Internal (Bus 4D11)(vdc)	27.96		28.0 ∓ 2.0
Aft Bus 1 Internal (Bus 4D11)(vdc)		29.96	29.5 ∓ 1.5
Aft Bus 2 Internal (Bus 4D41)(vdc)	55.76		56.0 ∓ 4.0
Aft Bus 2 Internal (Bus 4D41)(vdc)		57.92	56.5 ∓ 4.5
Receiver 1 Low Level Signal (vdc)	3.19	3.17	2.5 min
Receiver 2 Low Level Signal (vdc)	3.68	3.67	2.5 min
Receiver 1 Current (amps)	0.20	-0.20	0.0 ∓ 2.0
Receiver 2 Current (amps)	0.00	-0.20	0.0 ∓ 2.0
LH2 EDS 1 Ullage Pressure (psia)	14.46	14.22	14.7 ∓ 1.0
LH2 EDS 2 Ullage Pressure (psia)	14.84	14.84	14.7 ∓ 1.0
LOX EDS 1 Ullage Pressure (psia)	14.04	13.98	14.7 ∓ 1.0
LOX EDS 2 Ullage Pressure (psia)	14.78	14.72	14.7 ∓ 1.0
LH2 EDS 1 Transducer Press (psia)	14.33	14.16	14.7 ∓ 1.0
LH2 EDS 2 Transducer Press (psia)	14.93	14.93	14.7 ∓ 1.0
LOX EDS 1 Transducer Press (psia)	13.92	14.10	14.7 ∓ 1.0
LOX EDS 2 Transducer Press (psia)	14.88	14.93	14.7 ∓ 1.0

** Measurements Not Applicable
\+ See Revision q

4.2.17.1 (Continued)

APS Simulator Roll Checks

Function	Umbil.-In	Umbil.-Out	Limits
IU Substitute -28 Volt Power (vdc)	-27.839	-27.799	-28.5 ± 2.5
Attitude Control Nozzles I-IV and III-II On			
APS Engine 1-1 Valves Open Ind (vdc)	3.759	3.876	3.9 ± 0.3
APS Engine 2-1 Valves Open Ind (vdc)	3.702	3.805	3.8 ± 0.3
Attitude Control Nozzles I-IV and III-II Off			
APS Engine 1-1 Valves Open Ind (vdc)	0.000	0.000	0.00 ± 0.25
APS Engine 2-1 Valves Open Ind (vdc)	0.000	0.000	0.00 ± 0.25
Attitude Control Nozzles I-II and III-IV On			
APS Engine 1-3 Valve Open Ind (vdc)	3.707	3.825	3.9 ± 0.3
APS Engine 2-3 Valves Open Ind (vdc)	3.671	3.773	3.8 ± 0.3
Attitude Control Nozzles I-II and III-IV Off			
APS Engine 1-3 Valves Open Ind (vdc)	0.000	0.005	0.00 ± 0.25
APS Engine 2-3 Valves Open Ind (vdc)	0.000	0.000	0.00 ± 0.25
Hydraulic Gimbal Step Response Check			
Ratio Valve Pos. (Relay Off)(P)(deg)	0.21	-0.40	0.0 + 1.5
Hydraulic System Pressure (psia)	3598	3601	3575 ∓ 75
Ratio Valve Pos. (Relay On)(deg)	33.69	33.69	20.0 min
Ratio Valve Pos. (Relay Off)(deg)	1.7	1.1	Meas.(P) + 1.5
Hydraulic System Pressure (psia)	3598	3592	3575 ∓ 75
Pitch Act. Piston Pos., AO (deg)	-0.002	0.013	0.0 ∓ 0.517
Pitch Act. Piston Pos., BO (deg)	-0.013	0.044	0.0 ∓ 0.517
Yaw Act. Piston Position, AO (deg)	0.045	0.061	0.0 ∓ 0.517
Yaw Act. Piston Position, BO (deg)	0.029	0.045	0.0 ∓ 0.517
Engine Pitch Position, IU (deg)	0.000	0.029	0.0 ∓ 0.517
Engine Yaw Position, IU (deg)	0.030	0.075	0.0 ∓ 0.517

4.2.17.1 (Continued)

Hydraulic System Pressurized

Function	Umbil.-In	Umbil.-Out	Limits
Hydraulic System Pressure (psia)	3594.813	3594.813	*
Accumulator GN2 Pressure (psia)	3597.563	3581.188	*
Accumulator GN2 Temperature (°F)	81.936	81.543	*
Reservoir Oil Temperature (°F)	104.326	133.129	*
Reservoir Oil Level (%)	38.188	40.558	*
Reservoir Oil Pressure (psia)	170.207	168.457	*
Pump Inlet Oil Temperature (°F)	121.676	144.609	*
T/M Yaw Actuator Position (°F)	0.045	0.076	*
Corrected T/M Yaw Act. Pos. (deg)	0.037	0.083	*
IU Yaw Actuator Position (deg)	0.046	0.061	*
Corrected IU Yaw Act. Pos. (deg)	0.038	0.046	*
T/M Pitch Actuator Position (deg)	0.013	0.013	*
Corrected T/M Pitch Act. Pos. (deg)	0.021	0.006	*
IU Pitch Actuator Position (deg)	0.029	0.044	*
Corrected IU Pitch Act. Pos. (deg)	0.037	0.059	*
IU Substitute 5V Power Supply (vdc)	5.005	5.010	*
Aft 5V Excitation Module (vdc)	5.001	4.993	*
Aft Bus 2 Current (amp)	47.800	**	*
Aft Checkout Battery 2 Current (amp)	**	49.000	*

First Burn and Coast Period

LOX Press Module He Press D105:			
Cold He Supply Open (psia)	172.250	182.617	*
LOX Press Sw Supply Closed (psia)	157.523	165.160	*
Cold He Control Valve Inlet Press D225:			
Cold He Supply Open (psia)	111.699	118.244	*
LOX Press Sw Supply Closed (psia)	102.426	107.879	*
LH2 Press Module He Press D104:			
LH2 Prepress Supply Open (psia)	304.133	306.320	*
LH2 Press Sw Supply Closed (psia)	229.95	229.95	*
LH2 First Burn Relay Off (psia)	180.85	180.85	*
Eng Cont He Sphere Press D019 (psia)	1518.06	1536.00	*
Aux Hyd Pump Air Tank Press (psia)	446.078	387.227	282.5 ± 217.5
Aux Hyd Pump Motor Gas Press (psig)	16.365	18.396	21 ± 12
LH2 Boiloff Bias Signal M10:			
Bias Cutoff Off (vdc)	0.560	0.538	0.0 ± 2.5
Bias Cutoff On (vdc)	21.517	21.517	10.0 min
Bias Cutoff Off (vdc)	0.495	0.667	0.0 ± 2.5

* Limits Not Specified
** Measurements Not Applicable

4.2.17.1 (Continued)

Engine Restart Preparations

Function	Umbil.-In	Umbil.-Out	Limits
LOX Repress Sphere Press D088 (psia)	585.19	585.19	*
LH2 Repress Sphere Press D022 (psia)	573.95	570.22	*
Cold He Sphere Press D261 (psia)	667.31	694.05	*
Cryogenic Repressurization			
Cold He Sphere Press D261 (psia)	548.92	575.67	*
LOX Repress Sphere Press D088 (psia)	581.44	573.95	*
LH2 Repress Sphere Press D022 (psia)	570.22	562.73	*
LOX Tank Ambient Repressurization			
LOX Repress Sphere Press D088 (psia)	431.875	450.578	*
Same, after 30 second delay (psia)	458.050	476.760	Previous ± 75
Chilldown Pumps On			
LOX C/D Inv Phase AB Voltage (vac)	54.17	54.95	50.0 min
LOX C/D Inv Phase AC Voltage (vac)	53.39	54.17	50.0 min
LOX C/D Inv Phase A1B1 Voltage (vac)	54.17	54.95	50.0 min
LOX C/D Inv Phase A1C1 Voltage (vac)	53.52	54.30	50.0 min
LH2 C/D Inv Phase AB Voltage (vac)	53.39	53.52	50.0 min
LH2 C/D Inv Phase AC Voltage (vac)	52.80	52.80	50.0 min
LH2 C/D Inv Phase A1B1 Voltage (vac)	53.32	53.32	50.0 min
LH2 C/D Inv Phase A1C1 Voltage (vac)	52.61	52.87	50.0 min
LH2 Tank Ambient Repressurization			
LH2 Tank Repress He Sphere Press D20 (psia)	282.3	330.9	*
Same, after 30 second delay (psia)	308.5	360.8	Previous ± 75
Chilldown Pumps Off			
LH2 C/D Inv Frequency (Hz)	389.5	389.5	390.0 ± 1.0
LH2 C/D Inv Phase AB Voltage (vac)	0.00	0.00	0.0 ∓ 1.5
LH2 C/D Inv Phase AC Voltage (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 Voltage (vac)	0.00	0.00	0.0 ∓ 1.5
LOX C/D Inv Phase AC Voltage (vac)	0.00	0.00	0.0 ∓ 1.5
Engine Restart			
Eng Cont He Sphere Press D019 (psia)	1632.69	1647.03	1450 min

* Limits Not Specified

4.2.17.1 (Continued)

LH2 Second Burn Repressurization

Function	Umbil.-In	Umbil.-Out	Limits
LH2 Press Module He Press D104:			
LH2 Prepress Supply Open (psia)	310.688	312.867	*
LH2 Press Sw Supply Closed (psia)	227.762	228.855	*
LH2 Second Burn Off	184.121	186.301	*
Engine Cutoff			
Eng Cont He Sphere Press D019 (psia)	1496.56	1500.16	*
LOX Depletion Timer Check			
LOX Sensors 1 and 2 Dry (sec)	0.547	**	0.560 ± 0.025
LOX Sensors 1 and 3 Dry (sec)	0.540	**	0.560 ± 0.025
LOX Sensors 2 and 3 Dry (sec)	0.540	**	0.560 ± 0.025
APS Simulator Yaw and Pitch Checks			
Control Nozzles I-IV and III-IV On			
Engine 1-1 Valve Open Ind (vdc)	3.76	3.83	3.9 ± 0.30
Engine 2-3 Valve Open Ind (vdc)	3.68	3.72	3.8 ± 0.30
Control Nozzles I-IV and III-IV Off			
Engine 1-1 Valve Open Ind (vdc)	0.00	0.00	0.0 ± 0.25
Engine 2-3 Valve Open Ind (vdc)	0.00	0.00	0.0 ± 0.25
Control Nozzle I-II and III-II On			
Engine 1-3 Valve Open Ind (vdc)	3.73	3.78	3.9 ± 0.30
Engine 2-1 Valve Open Ind (vdc)	3.71	3.75	3.8 ± 0.30
Control Nozzles I-II and III-II Off			
Engine 1-3 Valve Open Ind (vdc)	0.00	0.00	0.0 ± 0.25
Engine 2-1 Valve Open Ind (vdc)	0.00	0.00	0.0 ± 0.25
Control Nozzle I-P On			
Engine 1-2 Valve Open Ind (vdc)	3.75	3.85	3.9 ± 0.30
Control Nozzle I-P Off			
Engine 1-2 Valve Open Ind (vdc)	-0.00	0.00	0.0 ± 0.25

* Limits Not Specified
** Measurements Not Applicable

4.2.17.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
Control Nozzle III-P On			
Engine 2-2 Valve Open Ind (vdc)	3.74	3.83	3.8 ± 0.30
Control Nozzle III-P Off			
Engine 2-2 Valve Open Ind (vdc)	0.00	0.00	0.0 ± 0.25

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4.2.18 Umbilical Interface Compatibility Check (1B64316 E)

After connecting the forward and aft umbilical cables, this manual checkout provided the test sequences which were used to check the design specifications and the continuity of the stage umbilical wiring prior to stage power turn on. 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.

Two issues of the procedure were required for compatibility checks after reconnecting umbilicals which had been ejected by each of two all systems tests. The checkouts were performed on 12 March and 14 March 1969, after each all systems test.

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 4.2.18.1 are from the final checkout.

No FARR's were generated as a result of this checkout. There were four revisions recorded in each issue of the procedure for the following:

a. One revision corrected a typographical error.

4.2.18 (Continued)

b. Three revisions noted that apparent out-of-tolerance resistance measurements were actually acceptable because the procedure tolerances are for the external power condition of the stage. The subject buses were in the internal condition when the umbilicals were ejected during AST and were not switched back to external power prior to the resistance checks. The measured values were as expected for buses in the internal condition.

4.2.18.1 Test Data Table, Umbilical Interface Compatibility Check

Reference Designation 463A2

Test Point	Function	Meas. Ohms	Limit Ohms
A2J29-C	Cmd., Ambient Helium Sphere Dump	27	10-60
CB-8-2	Cmd., Engine Ignition Bus Pwr Off	7†	Inf
CB-9-2	Cmd., Engine Ignition Bus Pwr On	Inf†	5-100
CB-10-2	Cmd., Engine Control Bus Pwr Off	8†	Inf
CB-11-2	Cmd., Engine Control Bus Pwr On	Inf†	5-100
A2J29-N	Cmd., Engine He Emerg Vent Control On	40	10-60
A2J29-P	Cmd., Fuel Tnk Repress He Dump Vlv Open	40	10-60
A2J29-Y	Cmd., Start Tnk Vent Pilot Vlv Open	35	10-60
CB-4-2	Cmd., LOX Tank Cold He Sphere Dump	30	10-60
A2J29-c	Cmd., LOX Tnk Repress He Sphere Dump	40	10-60
A2J29-h	Cmd., Fuel Tnk Vent Pilot Vlv Open	50	10-300
	(Same, reverse polarity)	Inf	500k min
A2J29-i	Cmd., Fuel Tnk Vent Vlv Boost Close	50	10-80
	(Same, reverse polarity)	Inf	500k min
A2J29-q	Cmd., Amb He Supply Shutoff Vlv Close	45	10-60
A2J30-H	Cmd., Cold He Supply Shutoff Vlv Close	2.5k	1.5k max
	(Same, reverse polarity)	Inf	Inf
A2J30-W	Cmd., LOX Vent Valve Open	50	10-80
	(Same, reverse polarity)	Inf	500k min
A2J30-X	Cmd., LOX Vent Valve Close	50	10-80
	(Same, reverse polarity)	Inf	500k min
A2J30-Y	Cmd., LOX & Fuel Prevlv Emerg Close	50	10-80
	(Same, reverse polarity)	Inf	Inf
A2J30-Z	Cmd., LOX & Fuel Chilldown Vlv Close	50	10-80
	(Same, reverse polarity)	Inf	500k min
A2J30-b	Cmd., LOX F&D Valve Boost Close	30	10-40
A2J30-c	Cmd., LOX F&D Valve Open	28	10-40
A2J30-d	Cmd., Fuel F&D Valve Boost Close	28	10-40
A2J30-e	Cmd., Fuel F&D Valve Open	28	10-40
A2J42-F	Meas. Bus +4D111 Regulation	Inf	100 min
A2J35-y	Meas. Bus +4D141 Regulation	100	50 min
A2J6-AA	Sup. 28V Bus +4D119 Talkback Power	100	60-120

† See Revision b

4.2.18.1 (Continued)

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	1.0k†	1.6k min
A5J53-AA	Sup. 28V +4D119 Fwd Talkback Pwr	30†	60-100

† See Revision b

4.2.19 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	Ref. Location	P/N	S/N
Range Safety Receiver 1	411A97A14	50M10697	182
Range Safety Receiver 2	411A97A18	50M10697	189
Secure Command Decoder 1	411A99A1	50M10698	0181
Secure Command Decoder 2	411A99A2	50M10698	0039
Secure Command Controller 1	411A97A13	1B33084-503	019
Secure Command Controller 2	411A97A19	1B33084-503	020
RS System 1 EBW Firing Unit	411A99A12	40M39515-119	555
RS System 2 EBW Firing Unit	411A99A20	40M39515-119	554
RS System 1 EBW Pulse Sensor	411A99A31	40M02852	382
RS System 2 EBW Pulse Sensor	411A99A32	40M02852	0164
Safe and Arm Device	411A99A22	1A02446-503	*
Directional Power Divider	411A97A56	1B38999-1	036
Hybrid Power Divider	411A97A34	1A74778-501	042
*Installed in Pulse Sensor Assembly	411A99A31/32	1B29054-501	00008

The procedure was issued postfire to reverify the range safety system after all systems test (AST) malfunctions associated with the range safety system. The initial test attempt for the range safety system was conducted on 13 March 1969, but was aborted due to cutoff malfunctions occurring from lack of engine safety cutoff system (ESCS) power. ESCS power had not been turned on as required when umbilical bypass cables are installed.

The second test attempt was completed on 13 March 1969, but a special setup to measure and record range safety decoder interval timer data for correction of the AST test problems necessitated another test to verify the range safety system.

4.2.19 (Continued)

The third and final test was performed on 14 March 1969. Measurements from this test are listed in Test Data Table 4.2.19.1. A description of the test follows.

Initial conditions scan was performed per H&CO 1B55813, and the GSE destruct test set, P/N 1A59952-1, was set up for closed loop operation at 450 MHz with a -56.6 dbm output level and a 60 kHz deviation. The forward bus 1 and bus 2 battery simulators were turned on, both receivers were verified to be off, and the battery simulator voltages were measured.

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

The EBW firing unit arm and engine cutoff command was turned on and verified to be received by range safety system 1. The system 1 firing unit charging

4.2.19 (Continued)

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

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

4.2.19 (Continued)

and the instrument unit receiver 1 arm and engine cutoff indication was verified to be off. Verification was made that the engine control bus power was still on, that the engine cutoff indication was then on at the umbilical and through both multiplexers, that the nonprogrammed engine cutoff indication was then on, and that the instrument unit receiver 2 arm and engine cutoff indication was on. The receiver 2 propellant dispersion cutoff command inhibit was turned back on, and the instrument unit receiver 2 arm and engine cutoff indication was verified 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

4.2.19 (Continued)

2, the propellant dispersion cutoff command inhibit was turned off for both receivers; and the engine control bus power was verified to be off.

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

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

No FARR's were initiated as a result of this test. Eleven revisions were made to the procedure for the following:

a. One revision provided program changes to comply with hardwire modifications per ECP 3006R1 and WRO S-IVB-4612R2.

b. One revision deleted the initial conditions scan check for the calibration preflight mode, as authorized by WRO S-IVB-3676R10.

c. One revision noted that a malfunction indication during initial conditions scan was attributed to a program error and did not affect the range safety system test.

4.2.19 (Continued)

d. One revision authorized setup of the GSE destruct test set for open loop operation during the aborted initial test attempt.

e. Two revisions authorized the additional test attempts as previously described.

f. One revision provided instructions for the special measurement of range safety decoder interval timer data.

g. One revision authorized manual turn on of ESCS power which was required because umbilical bypass cables were installed.

h. One revision attributed a malfunction indication to operator error. Personnel were adjusting the GSE destruct test set during the beginning of the test. After adjustment of the test set, the program was resumed.

i. One revision indicated that an out-of-tolerance measurement for engine control bus voltage with power off during the firing unit arm and engine cutoff test was acceptable. The program tolerance did not allow for the installation of umbilical cables, which resulted in additional potential from the GSE power return bus in the signal distribution unit being reflected into the engine control bus via the component test bus power.

j. One revision was a program change to permit resuming the test, after the above noted out-of-tolerance measurement for engine control bus turn off.

4.2.19.1 Test Data Table, Range Safety System

Function	Measured Value (vdc)	Limits (vdc)
Forward Bus 1 Battery Simulator	28.438	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	4.274	4.2 + 0.3
System 1 Firing Unit Indication	4.261	4.2 ± 0.3
System 2 Charging Voltage Indication	4.260	4.2 ± 0.3
System 2 Firing Unit Indication	4.251	4.2 ± 0.3

4.2.19.1 (Continued)

Function	Measured Value (vdc)	Limits (vdc)
Internal Power		
System 1 Charging Voltage Indication	4.284	4.2 ± 0.3
System 2 Charging Voltage Indication	4.270	4.2 ± 0.3
External Power Off		
System 1 Charging Voltage Indication	0.034	0.3 max
System 2 Charging Voltage Indication	0.055	0.3 max
Firing Unit Arm and Engine Cutoff Test		
Engine Control Bus Voltage	28.029	28.0 ± 2.0
Receiver 1 Signal Strength Indication	3.691	3.75 ± 1.25
Receiver 2 Signal Strength Indication	3.773	3.75 ± 1.25
System 1 Arm and Engine Cutoff Test		
Firing Unit Charging Voltage Indication	4.300	4.2 ± 0.3
Engine Control Bus Voltage, Power Off	0.461†	0 ± 0.45
Engine Control Bus Voltage, Power On	28.030	28.0 ± 2.0
External Power Off		
System 1 Charging Voltage Indication	0.050	0.3 max
System 2 Charging Voltage Indication	0.055	0.3 max
System 2 Arm and Engine Cutoff Test		
Firing Unit Charging Voltage Indication	4.244	4.2 ± 0.3
Engine Control Bus Voltage	28.029	28.0 ± 2.0
Propellant Dispersion Test		
System 1 Propellant Dispersion Test		
Charging Voltage Indication (Pulse Sensor Off)	4.294	4.2 ± 0.3
Charging Voltage Indication (Pulse Sensor On)	1.569	3.0 max

† See Revision i

4.2.19.1 (Continued)

Function	Measured Value (vdc)	Limits (vdc)
System 2 Propellant Dispersion Test		
Charging Voltage Indication (Pulse Sensor Off)	4.274	4.2 ± 0.3
Charging Voltage Indication (Pulse Sensor On)	1.715	3.0 max

4.2.20 Forward Skirt Thermoconditioning System Postfire Checkout (1B41883 C)

The forward skirt thermoconditioning system was tested in preparation for transfer to the FTC 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.

The postfire TCS checkout was initiated on 18 March 1969, and was successfully completed on 19 March 1969. 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.

4.2.20 (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 solution specific gravity was recorded as 0.9 with temperature at 58°F. 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 16.8 psi with the fluid supply temperature and the return temperature both at 60°F.

Next, the TCS was purged of water/methanol with GN2 until a system dryness of 25°F dewpoint was obtained, as verified by the Alnor dewpoint meter. Prior to leak checking the TCS, all bolts in the TCS panels were checked for proper torque, after ensuring that there were no open equipment-mounting bolt holes in the panels. The TCS was pressurized to 32 ±1 psig with freon gas and checked for external leakage with the gaseous leak detector, P/N 1B37134-1. Areas checked for leakage included TCS B-nuts and fittings, manifold welded areas, boss welds, and manifold bellows. No leakage was detected. The freon was then purged from the TCS using GN2 for a minimum period of 5 minutes.

The final operation consisted of disconnecting and securing the servicer and preparing the TCS for stage transfer to the FTC.

There were no FARR's initiated as a result of this checkout, and no discrepancies for the TCS were noted. Six revisions were recorded in the procedure for the following:

4.2.20 (Continued)

a. Three revisions corrected errors or omissions in the procedure.

b. One revision deleted steps for servicer setup prior to system drying and leak checking due to stage removal.

c. One revision authorized a substitution for the specified fiber washers used with the bolts for open equipment mounting bolt holes found prior to the leak check.

d. One revision authorized the use of aluminum foil to cover stage quick disconnects during securing operations. The specified dust caps were not available.

4.2.21 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 for measurements C-0052, C-0370, and C-0371 were conducted on 28 March 1969, because of entry into the LH2 tank for postfire structural inspection. All sections of the procedure were deleted except those concerned with the three LH2 tank measurements noted.

Each sensor was tested at the prevalent ambient temperature. Using the values for resistance at 32°F and sensitivity, which were given for each individual sensor, the expected resistance at room temperature was calculated. The actual resistance was measured, and compared with the calculated value. The measured resistance was required to be within ±7 percent of calculated resistance for the three LH2 tank sensors checked. 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 4.2.21.1, shows the measured and calculated values for each sensor involved in this test.

There were no discrepancies resulting in FARR documentation during the checkout. Only one revision was recorded, deleting all portions of the procedure except those required for reverifying the required LH2 tank sensors.

4.2.21.1 Test Data Table, Cryogenic Temperature Sensor Verification

Meas. Number	P/N	Sensor S/N	Ref. Desig.	Temp. (°F)	Resistance (ohms		
					Meas.	Calc.	± Tol.
CO 052	1A67862-513	563	408MT612	72	5230	5440	380
CO 370	1A67862-533	610	408MT735	72	5230	5440	380
CO 371	1A67862-533	635	408MT736	72	5250	5440	380

4.3 Final Inspection

A final inspection was accomplished by MDAC and AFQC personnel on all stage mechanical and electrical areas, to locate and correct any remaining discrepancies. The inspection was initiated on 17 March 1969, and was completed on 22 May 1969, to verify that the stage was in satisfactory condition for shipment to FTC.

A total of 531 defects were noted during this inspection, 425 by MDAC personnel and 106 by AFQC personnel. Of the 531 discrepancies noted by MDAC personnel, 116 were concerned with electrical components and 415 were concerned with mechanical components. Of the 106 discrepancies noted by AFQC personnel, 14 were concerned with electrical components and 92 were concerned with mechanical components.

Most of these discrepancies were corrected without requiring FARR action, but 18 items were transferred to FARR's for disposition.

a. FARR 500-489-952 reported a hole in the inner and outer seal of rubber seal, P/N 1A87429-503; that excessive sealant was noted on several doublers in the tunnel areas; that loose debris could be heard during stage rotation. These items were acceptable to the Material Review Board. Also, the mylar on the forward dome was damaged at stringers 27 and 37 and was repaired with aluminized polyester film patches per DPS 22301.

b. FARR 500-816-368 reported discolorations on the ends of the convolutions of tube assemblies, P/N 1B67299-503, P/N 1B67094-1, and P/N 1B67299-505. The discoloration was removed by a stainless steel wire brush, solvent wiped with MEK; then, a heavy coat of clear acrylic lacquer was applied over the cleaned areas.

c. FARR 500-816-376 reported that the teflon jacket on the 405W203 wire harness, P/N 1B65304-1, was found to have a small pin hole exposing the shield. The insulation was repaired per DPS 54010.

4.3 (Continued)

d. FARR 500-816-392 reported several discrepancies which are presented in more detailed narration within Table II of Appendix II.

e. FARR 500-816-422 reported a brown discoloration on the flex section, P/N 1A48712-501 and P/N 1B48712-1, of the auxiliary tunnel manifold, P/N 1B67299-1. The discoloration was removed by brushing the area with a stiff bristle brush.

4.4 Weight and Balance Procedure (1B55602 E)

This procedure measured the stage weight with an accuracy of ±0.1 percent, using a three point electronic weighing system, and determined the longitudinal center of gravity of the stage. The measured stage weight was corrected for gravity and air buoyancy forces to determine the weight at standard gravity in a vacuum. The procedure was initiated on 19 May 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 20 May 1969.

Before starting the weighing operation, the electronic weighing system, P/N 1A57907-1, was setup and calibrated. Three load cell assemblies, P/N CMU-1204 or 1B38965-1 and -501, were connected to the load cell readout indicator, P/N CMU-1204, checked for linearity and stability by the use of the indicator standardizer, and adjusted for a zero setting. The stage was verified to be level within 0.250 inches over the axial distance between stations 544.702 and 286.147. The dry bulb temperature, barometric pressure, and relative humidity were measured in the weighing area for use in determining the air density. These measurements were repeated every half hour throughout the weighing operation.

4.4 (Continued)

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 4.4.1. The stage was then lowered back onto the cradles; the load cells were allowed to creep stabilize again; and the load cell zero was rechecked and adjusted, if necessary. The weighing procedure was repeated three times, and the average reading for each load cell was determined and corrected for calibration. From the capacity of each load cell and the load cell reading, the reaction force on each load cell was determined. These reaction forces were then used to determine the stage shipping and handling weight, the stage weight at standard gravity in a vacuum, and the longitudinal center of gravity. As shown in the Test Data Table, the stage shipping and handling weight was 27,069.8 pounds, the weight at standard gravity in a vacuum was 27,122.1 pounds, and the longitudinal center of gravity was at station 330.7.

No parts were short during this procedure, no revisions were written, and no problems were encountered.

4.4.1 Test Data Table, Weight and Balance Procedure

Time	Barometric Press (in. Hg)	Relative Humidity (%)	Dry Bulb Temp (°F)
09:30	29.72	54.2	66.0
09:30	29.72	52.8	66.5
10:00	29.72	52.0	66.8
10:30	29.72	52.0	68.0

Calculated Air Density: 0.0745 pounds per cubic foot

4.4.1 (Continued)

Load Cell Collected Data

Reaction Load	Aft (R1)	Forward (R2)	Forward (R3)
Serial Number	36234	34459	34251
Capacity (pounds)	25,000	10,000	10,000
Run 1 Reading (%)	79.647	39.226	39.354
Run 2 Reading (%)	79.603	39.135	39.401
Run 3 Reading (%)	79.620	39.137	39.394
Average Reading (%)	79.623	39.166	39.383
Calibration Correction	1.063	0.290	0.282
Corrected Reading (%)	80.686	39.456	39.665
Reaction (pounds)	20,171.5	3,945.6	3,966.5

Weight Determination (pounds)

Aft Reaction R1	20,171.5
Forward Reaction R2	3,945.6
Forward Reaction R3	3,966.5
Total Reactions as Recorded	28,083.6
Minus Weighing Equipment "Tare"	-1,013.8
Shipping and Handling Weight	27,069.8
Plus Gravitational Correction	19.0
Plus Buoyancy Correction	33.3
Weight at Standard Gravity in a Vacuum	27,122.1

Longitudinal Center of Gravity

Reaction R1 Moment at Sta. 189.3	3,818,464.95
Reaction R2 Moment at Sta. 684.0	2,698,790.40
Reaction R3 Moment at Sta. 684.0	2,713,086.00
Moment Sum	9,230,341.35
Tare Moment	-278,870.75
Moment Sum Less Tare	8,951,470.60

As weighed Center of Gravity = 330.7
(Moment Sum Less Tare Divided by Total Reactions Less Tare)

4.5 Environmental System Installation, Air Carry (1B65454 J)

Just prior to stage shipment, this procedure purged the stage to a dewpoint of -30°F (235 ppm by volume) or less, using gaseous nitrogen and installed the necessary desiccants for stage air carry shipment. The desiccants maintained a clean, dry environment and a safe differential pressure during air transportation.

4.5 (Continued)

The procedure was satisfactorily performed initially from 20 May through 22 May 1969. A second issue of the procedure was released to repeat the purges to meet the dewpoint requirement when the stage shipment date was postponed. The repeat purges were conducted on 9 June 1969.

The purge preparations started with the installation of the LOX and LH2 desiccant support assemblies, P/N's 1B61272-1 and 1B61270-1. The LOX bellows, P/N 1A49971-501, and the LOX and LH2 disconnects, P/N's 1A49970-503 and 1B66932-501, were removed for separate shipment with the stage. Covers and desiccators were installed at the LOX and LH2 fill and drain vents, the LH2 propulsive, nonpropulsive, and ground vents, the LOX propulsive and nonpropulsive vents, and the O2H2 burner nozzle.

The purge units, P/N 1B51117-1, were prepared for operation, and the electrical and pneumatic purge connections were made on the stage and between the purge unit and the stage. The engine LOX chilldown line and LH2 feed duct; the LH2 pressurization line; the LH2 propulsive vent, nonpropulsive vent, and ground vent; the LOX propulsive vent and nonpropulsive vent; the O2H2 burner LOX and LH2 ducts; and the LOX and LH2 propellant tanks were all purged with gaseous nitrogen. The final dewpoints attained were -49.0°F for the LOX system and -32.0°F for the LH2 system. The LOX tank desiccant breather, P/N 1A79691-1, and the four LH2 tank desiccant breathers, P/N 1A79691-501, were prepared, filled with desiccant material, and installed.

After satisfactory completion of the purge operation, the purge unit was disconnected from the stage and secured. The aft skirt dust cover, P/N 1B61077-1,

4.5 (Continued)

and the forward skirt dust cover, P/N 1B61099-1, were then installed to complete the procedure.

No FARR's were initiated as a result of this procedure. Nine revisions were recorded in the first issue of the procedure for the following:

a. Three revisions concerned the installation and operation of a heater in the purge system, and the postfire removal of the heater.

b. One revision authorized taking samples of the purge gas to determine the non-volatile hydrocarbon content.

c. One revision deleted steps that had been previously accomplished.

d. One revision provided instructions to remove the LH2 tank door and install the air carry manifold prior to an in-storage purge.

e. One revision requested initiation of a removal card item to revalidate the stage at FTC after removal and installation of electrical connectors.

f. One revision authorized sampling of the GN2 supply trailer to determine the non-volatile hydrocarbon content.

g. One revision postponed the removal of the protective coverings from the relief valves, which were scheduled for the stage loading air carrier procedure, 1B57044.

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

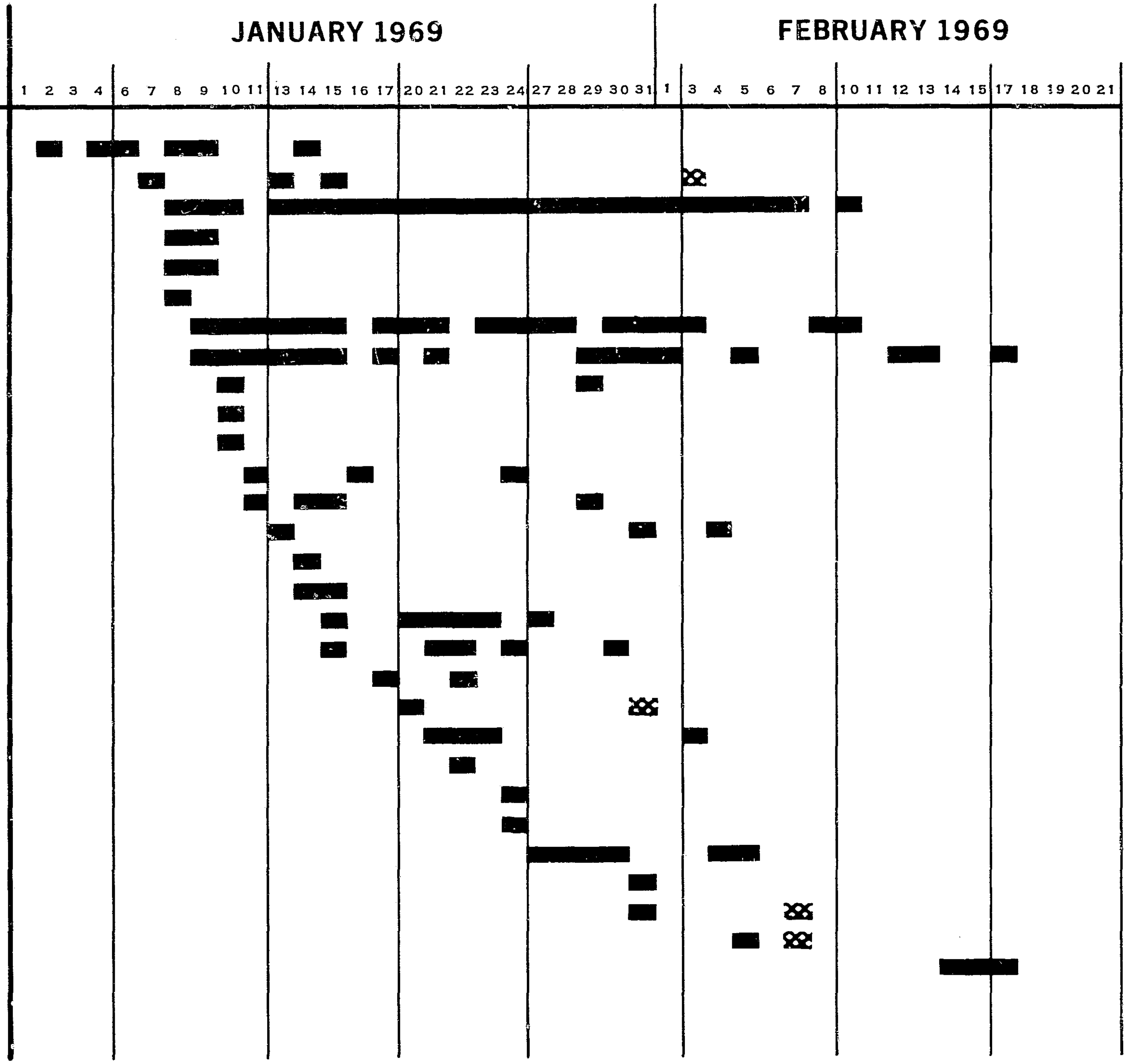
a. One revision deleted portions of the procedure that had been performed during the first issue and did not require repeating.

b. Six revisions were identical with revisions a, b, e, and g of the first issue.

c. Three revisions provided instructions for temporary removal of items to facilitate the repeat purging per issue two of the procedure.

508 STC PREFIRE SEQUENCE

PARA		PROCEDURE
4.1.1	1B40654	STRUCTURAL INSPECTION
4.1.2	1B64678	CRYO TEMP SENSOR VERIF
4.1.3	1B71877	PROP SYSTEM L/C
4.1.4	1B41955	FWD SKIRT TCS C/O
4.1.5	1B64316	UMBILICAL I/F COMPAT
4.1.6	1B49558	APS I/F COMPAT
4.1.7	1B49286	COMM BULKHEAD VAC SYS
4.1.8	1B41005	HYD SYS SETUP & OPER
4.1.9	1B64681	SIGNAL COND SETUP
4.1.10	1B55813	STAGE POWER SETUP
4.1.11	1B55814	STAGE POWER TURNOFF
4.1.12	1B55815	POWER DISTRIBUTION SYS
4.1.13	1B70177	MANUAL CONTROLS C/O
4.1.14	1B55817	DDAS AUTO C/O
4.1.15	1B55825	APS AUTO C/O
4.1.16	1B55822	EBW SYSTEM C/O
4.1.17	1B55816	DDAS CALIBRATION
4.1.18	1B64680	LEV SENS CONT UNIT CALIB
4.1.19	1B64367	PU SYSTEM CALIB
4.1.20	1B55824	HYDRAULIC SYS AUTO
4.1.21	1B64679	T/M & RS ANTENNA SYS
4.1.22	1B55823	PU SYSTEM AUTO
4.1.23	1B55819	RANGE SAFETY RCVR C/O
4.1.24	1B55821	RANGE SAFETY SYS AUTO
4.1.25	1B75537	SSB SYSTEM C/O
4.1.26	1B41004	HYD SYS SERVICING
4.1.27	1B62753	PROPULSION SYS AUTO
4.1.28	1B55831	INTEGRATED SYSTEMS TEST
4.1.29	1B70175	FINAL LEAK CHECKS



▩ INDICATES SECOND ISSUE

508 POSTFIRE ACCEPTANCE TESTING

PARA		PROCEDURE
4.2.1	1B55813	STAGE POWER SETUP
4.2.2	1B55814	STAGE POWER TURNOFF
4.2.3	1B70756	STRUCTURAL INSPECTION
4.2.4	1B41006	HYD. SYS. OPER & SECURING
4.2.5	1B71877	PROP. SYS. LEAK CHECK
4.2.6	1B55817	DDAS AUTOMATIC
4.2.7	1B55819	RANGE SAFETY RCVR C/O
4.2.8	1B64680	LVL SENSOR & CONT UNIT CALIB
4.2.9	1B55815	PWR DISTRIB SYS C/O
4.2.10	1B75537	SSB SYSTEM C/O
4.2.11	1B55825	APS SIMULATOR AUTO
4.2.12	1B64681	SIGNAL CONDIT SETUP
4.2.13	1B76059	EMC, RAD SPECT SIG TEST
4.2.14	1B55816	DDAS CALIBRATION
4.2.15	1B55823	PU SYS AUTO
4.2.16	1B62753	PROPULSION SYS AUTO
4.2.17	1B55833	ALL SYSTEMS TEST
4.2.18	1B64316	UMB INTERFACE COMPAT C/O
4.2.19	1B55821	RANGE SAFETY SYS AUTO
4.2.20	1B41883	T/C SYS POSTFIRE C/O
4.2.21	1B64678	CRYOGENIC TEMP SENSOR VERF

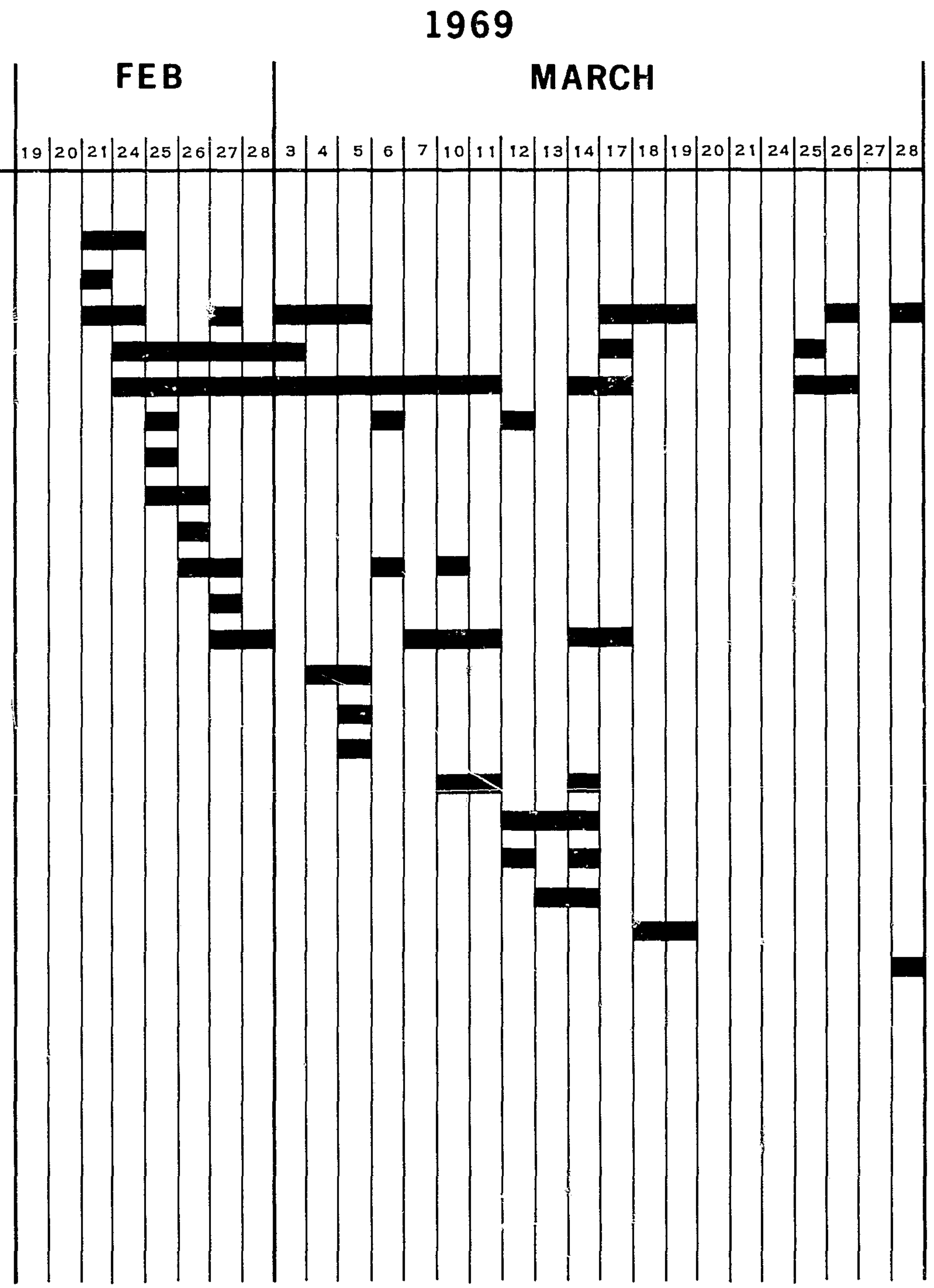


TABLE I. FAILURE AND REJECTION REPORTS
STAGE RECEIPT TO FORMAL COUNTDOWN INITIATION

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-373-547 1-9-69	During rework per FARR 500-607-921, the pipe assembly, P/N 1B75965, was cut downstream of boss, P/N 1B64251-1, which should have been cut upstream.	Since the initial rework was unacceptable, the pipe assembly was replaced.
500-373-555 1-27-69	The connector of the 401W453 cable assembly, P/N 1B49398-509, was broken off.	The connector was replaced with a new part, which was checked per drawing requirements.
500-607-807 1-3-69	The identity of the plenum, P/N 1A49991, was not recorded on the inventory log sheets for the plenum valve assemblies, P/N 1B62278-501, S/N 00009, and S/N 00010. Physical identification was not possible due to mylar wrapping. Subsequent investigation after removal of the plenums revealed the following identification: a. Plenum, P/N 1A49991-1, S/N 55, was installed on assembly, P/N 1B62778-501, S/N 00009, at location 403A6. b. Plenum, P/N 1A49991-1, S/N 52, was installed on assembly, P/N 1B62778-501, S/N 00010, at location 403A7.	The plenums were removed and checked for identification. Subsequent to the identification verification, new seals were installed on the plenums.
500-607-858 1-6-69	During performance of 1A57882, it was noted that the 411W17J2 receptacle of cable harness, P/N 1B38005-509, had approximately 1/8 inch of keyway broken off.	The cable assembly was removed and replaced.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-607-874 1-7-69	Receiving inspection revealed that the mylar was torn aft of the fuel tank vent.	The mylar was patched per DPS 22301.
500-607-882 1-7-69	During checkout per 1B64678, temperature sensor, P/N 1B37878-511, S/N 1818, had an out-of-tolerance reading of 396 ohms. The reading should have been 500 ohms $\pm$ 5 percent.	The sensor was removed and replaced with, S/N 1484 and tested per 1B55817.
500-607-891 1-8-69	Tube assembly, P/N 1B76427-1, was approximately 1/2 inch short and was misaligned 7/8 inch.	The tube assembly was removed and replaced.
500-607-904 1-8-69	Tube assembly, P/N 1B76429-1, was approximately 5/8 inch too long.	The tube assembly was removed and replaced.
500-607-912 1-8-69	Tube assembly, P/N 1B76430-1, was misaligned 3/8 inch at the adapter end.	The tube assembly was removed and replaced.
500-607-921 1-9-69	During the installation of pipe assembly, P/N 1B75965-1, it was noted to be approximately 1/4 inch too long at the upstream end. Reference 1B58006 BH, zone 52.	The pipe assembly was removed, reworked, and subsequently rejected on FARR 500-373-547.
500-607-939 1-10-69	During hydraulic system setup, it was noted that the identification label of the 403MT605 hydraulic reservoir pressure transducer, P/N 1B31356-517, was illegible. NOTE: Per serialization records the S/N is 332-5.	The transducer was reidentified as S/N 332-5 and functionally checked during hydraulic system setup.
500-607-971 1-11-69	Troubleshooting per IIS 462774 revealed that socket A of the 411W200P4 connector was recessed approximately 1/2 inch at the aft end of the 411A64 panel.	The socket was extracted, checked, reinserted, and tested per 1B55815.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-608-056 2-6-69	During performance of 1B55831, it was noted that the D054 pressure transducer, P/N 1B40242-585, S/N 585-14, had out-of-tolerance data. The high calibration was 0.123 vdc, but should have been 4 ±0.1 vdc. The low calibration was also 0.123 vdc, but should have been 1 ±0.1 vdc.	The transducer kit was removed and replaced with S/N 585-6, which was tested per 1B62753.
500-608-064 2-5-69	During performance of 1B71877, revision 69, it was noted that the LOX flowmeter, P/N 251216, S/N 4093227, had spun for approximately 120 seconds in a dry condition.	The condition was acceptable by the Material Review Board.
500-639-105 12-18-68	Inspection of the LOX turbine bypass valve, P/N 409940, S/N 4093594, revealed that the gate end of the link to the piston pin was corroded.	The condition was acceptable to the Material Review Board.
500-702-851 1-14-69	Tube assembly, P/N 1B75965-1, was 1/4 inch too long at the upstream end.	The tube assembly was reworked per 1B75965 to fit the next assembly.
500-702-869 1-14-69	During the repair of leaks per IIS 441480, it was noted that the engine control bottle fill flange at the pipe assembly, P/N NA5-260058-1, S/N 103, had a recessed and damaged seal.	The damaged seal was removed, replaced, and leak checked per 1B71877.
500-702-885 1-15-69	X-ray inspection during receiving inspection, per 1B40654, revealed three NAS679C3 nuts, at stringer 30, wedged between the stringer and the wire bundle support tray.	All nuts were removed.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-702-915 1-15-69	During the performance of 1B55816, the DP1-BO multiplexer, P/N 1B65897-501, S/N 06, indicated the following malfunctions on channel DP1-BO-07-03: RUN — EXPECTED — RECEIVED 1 — 1.250 ± 0.025 vdc — 0.395 vdc 2 — 2.500 ± 0.025 vdc — 0.989 vdc 3 — 3.750 ± 0.025 vdc — 1.589 vdc 4 — 5.000 ± 0.025 vdc — 2.226 vdc	The multiplexer was removed and replaced with S/N 017, which was tested per 1B55817.
500-702-931 1-17-69	During rework per 1A69275-A45-1A, it was suspected that the receptacle, P/N 1B37873-547, a part of the LOX instrumentation probe, was assembled with unauthorized parts.	The connector was inspected and reworked per 1A69275-A45-1A.
500-702-940 1-17-69	During the performance of the 1B55815, it was noted that the LOX chilldown inverter, P/N 1A74039-521, S/N 079, had a frequency output of 2.5 vrms at pin M to b of the J2 receptacle, which should have been 1.2 ±0.2 vrms.	The unit was removed from the stand and sent to the A503 test area for checkout. The unit was returned, reinstalled, and tested per 1B55815.
500-702-958 1-17-69	During the performance of 1B55815, the frequency output signal on pin M at the J2 receptacle of the LH2 chilldown inverter, P/N 1A74039-517, S/N 075, had a measurement of 1.9 volts, which should have been 1.2 ± 0.2 volts.	The LH2 chilldown inverter was removed and replaced.
500-702-966 1-20-69	During preliminary stage inspection, it was noted that wire Q9787A22 of the 404W30P7 wire harness had damaged insulation.	The damaged wire was removed, replaced, and tested per 1B64680.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-702-974 1-21-69	A pressure of 500 psig helium was applied to the outlet port of the vent and relief valve, P/N 557848, S/N 4092778. This condition was noted during the performance of revision 30 of 1B71877.	The vent and relief valve was removed and replaced.
500-702-982 1-21-69	During wire repair per FARR 500-703-966, wire Q9054A22 of the 404W30 wire harness, P/N 1B67152-1, was broken through to the shield.	The wire was repaired using teflon tape per DPS 54010.
500-702-991 1-23-69	During performance of 1B55816, the DP1-B0 multiplexer was observed to have random noise on channel 29. The level was 5.046 vdc, but should have been 5.000 $\pm$0.030 vdc.	The condition was acceptable to the Material Review Board.
500-703-008 1-22-69	Records revealed that the 411A61A259 command channel decoder, P/N 1A74053-503, S/N 244, was previously installed in the environmental stage, S/N 902.	The unit was removed and identified as a not for production use part. A production part, P/N 1A74053-503, S/N 394, was installed.
500-703-016 1-22-69	During the performance of 1B64679, the R6 potentiometer of the forward power detector, P/N 1A74776-503, S/N 302, would not adjust higher than 82 millivolts. I+ should have been set at 97 millivolts.	The detector was removed and replaced with S/N 300, which was tested per 1B55817.
500-703-041 1-23-69	A 97 millivolt output could not be maintained on power detector, P/N 1A74776-503, S/N 300. An intermittent output of 80 to 97 millivolts was detected during checkout per 1B64679.	The power detector was removed and replaced with S/N 301, which was tested per 1B55817.
500-703-059 1-24-69	During performance of 1B70422, two orifices, P/N 1B63023-1, S/N 97 and S/N 976, were not identified with the size number.	The orifices were checked, indentified per 1B63023, and cleaned per DPS 43000.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-703-075 1-27-69	During verification per WRO SIVB-4068 Job 1, it was noted that the module relay, P/N 1B39550-533, S/N 013, per serialization records, had a missing identification plate.	The module was removed and replaced.
500-703-091 1-28-69	During the performance of 1B64367, the relay module, P/N 1B40887-501, S/N 0273, had caused the forward bus 2 to short momentarily to stage ground. This caused a current spike of 54 amps for 200 msec which in turn caused an interrupt on channel 45. The channel was adjusted to trigger above 30 amperes.	The module was removed and replaced with S/N 0415, which was tested per 1B55831.
500-703-369 1-28-69	During performance of 1B55817, the 403MT643 cold helium sphere pressure transducer, P/N 1B40242-583, S/N 583-52, had a low calibration reading of 2.185 vdc which should have been 1.000 ±0.100 vdc. The ambient pressure was 1171 psia, but should have been 14.7 ±70 psia.	The transducer was removed and replaced with S/N 583-56, which was tested per 1B70175 and 1B55817.
500-703-377 1-28-69	During the performance of 1B75537, the adjustment of potentiometer R6 of power detector, P/N 1A74776-501, S/N 286, would not give an output voltage indication.	The power detector was removed and replaced with, P/N 1A74776-503, S/N 297, per 1B57997-507 A45-10, which was tested per 1B55817.
500-703-385 1-24-69	During rust removal on the LOX low pressure duct, P/N 1A49969-503, S/N 41, the passivation was removed.	The area was spot passivated per DPS 41003 with pasa-gel.
500-703-407 1-29-69	During the performance of 1B71877, the LH2 repress module backup check valve, P/N 1B67598-501, S/N 146, had a reverse leakage of 21 scims, which should have been less than 10 scims.	The check valve was removed and replaced with S/N 202, which was tested per 1B71877.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-703-415 2-4-69	During stage checkout between 1-21-69 and 1-27-69, the matched restrictors, P/N 1B40622-513, S/N 312, were causing the chilldown pump motor canister pressure to drop from 53 psia to 43 psia with a regulator discharge pressure drop from 532 psia to 517 psia. Per A3-860-KCBA-ROD-473, a 43 psia canister pressure with a regulator discharge pressure of 517 psia is marginal. Projected to the static firing date, it would have been out-of-tolerance.	The condition was acceptable for use during simulated static firing. The matched restrictors were replaced at the conclusion of simulated static firing with S/N 315, and tested per revision 6 of 1B70175.
500-703-440 1-29-69	During the performance of 1B75537, it was noted that wire P1-447C-C20 of wire harness 411W200 was installed in pin Y of the J1 receptacle, but should have been installed in pin g.	The noted wire was installed in the correct pin and tested per 1B75537.
500-703-458 1-30-69	During the performance of 1B75537, the GSE cable assembly, P/N 1A68321-569, would not mate with stage receptacle 411W290J1 at the 411A95A203 bracket due to interference with the NAS600-6P mounting screws.	The screw holes were countersunk in the bracket for NAS514P440-6P screws and the connector installed with NAS514P440-6P screws.
500-703-474 1-30-69	During the performance of 1B71877, tube assembly, P/N 1B67464-1, was found to be preloaded and improperly seated to the fitting of the cold helium bottle, No. 9.	The tube assembly was replaced.
500-703-482 1-30-69	The GN2 vent and relief valve, of the hydraulic accumulator, P/N 1B29319-519, S/N 26, leaked at a rate of 30 psig in 24 hours. No leakage allowable.	The accumulator was replaced with S/N 00040, which was tested per revision 6 of 1B41005.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-703-491 1-31-69	During the performance of 1B75537, no output was received on pin q at the J2 receptacle of the channel calibration decoder, P/N 1A74053-503, S/N 355. When the command was sent for rack 01, channel 19 low mode, an output of 28 vdc should have been detected.	The decoder was removed and replaced with S/N 341, which was tested per 1B55817 and 1B75537.
500-703-521 2-3-69	The check valve, P/N 1B40824-507.1, S/N 131, was reworked from a, P/N 1B40824-503, S/N 187, which was rejected on FARR A240275 dated 1-18-67, due to oversize threads. The disposition was to, "return to vendor for replacement."	The valve was replaced with S/N 506, which was tested per revision 70 of 1B71877.
500-703-539 2-3-69	The ablative coating was removed during the installation of an acoustic transducer per 1B69661.	The area was repaired per DPS 42210.
500-703-563 2-3-69	During the performance of 1B71877, check valve, P/N 1B40824-507.1, S/N 515, was noted to have a galled flare at the inlet port.	The valve was replaced with S/N 141, which was tested per 1B71877.
500-703-571 2-3-69	During the performance of 1B71877, tube assembly, P/N 1B75772-1, was found to have a galled flare at the short run end.	The flare was polished to the requirements of DPS 10001, and proof and leak checked per 1B75772.
500-703-580 2-3-69	During the performance of 1B55817, the D002 fuel pump inlet pressure transducer, P/N 1B40242-579, S/N 579-1 was reading the following: RECEIVED / EXPECTED Hi RACS 5.122 vdc / 4.000 ± 0.100 vdc Lo RACS 1.533 vdc / 1.000 ± 0.100 vdc Ambient 63.484 psia / 14.7 ± 1.2 psia	The transducer system was replaced with S/N 579-2, which was tested per revision 15 of 1B55817.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-703-598 2-3-69	The part number on the body of check valve, P/N 1B40824-507.1, S/N 506, was incomplete. The body was identified as a P/N 1B40824-50, and should have been a P/N 1B40824-507.1 P per part identification form 60-1295-1.	The valve body was identified with P/N 1B40824-507.1 per DPS 02303.
500-704-110 2-6-69	During the performance of 1B55831, it was noted that the 403A73A1 pneumatic power control module, P/N 1A58345-523-007, S/N 1057, had a recovery pressure in excess of 550 psig.	The module was replaced with S/N 1017, which was tested per 1B70175.
500-704-136 2-6-69	During the performance of FORR-J2-SAC-69-14, it was suspected that cable assembly, P/N 503157, S/N 3793212, had a broken wire in the ignition detector probe leg of the armored harness.	The cable assembly was replaced.
500-704-179 2-7-69	During records review, it was determined that the LH2 chilldown pump, P/N 1A49421-507, S/N 154, had no evidence that the pretest inspection, the insulation resistance check, the phase continuity check, and the receptacle leakage test were accomplished as required per PAPT 1A49431.	The pump was considered acceptable since the post cryogenic inspection was accepted, the insulation resistance was accomplished per 1A49421 AS, the phase continuity was complied with during S.E.O. 1A49421-A45-2 and the leak test of the connectors was accomplished per 1A49421 AS.
500-704-233 2-14-69	During simulated static firing, no strength data or data transmission was noticed at the ground station from the 411A64A210 FM transmitter, P/N 1B52721-511, S/N 020.	The transmitter was removed and replaced with S/N 025, which was tested per revision 10 and 11 of 1B70705.

TABLE I (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-704-241 2-18-69	During the performance of 1B55831, it was noted that the GN2 accumulator temperature transducer C138, P/N 1B34472-1, S/N 69418, had indicated an ambient reading of 100.393°F, but should have read 43 ± 16°F.	The transducer was removed and replaced with S/N 63212, which was tested per revision 12 of 1B41005.
500-704-250 2-15-69	The following discrepancies of the fuel tank inlet pressure transducer D054, P/N 1B40242 -585, S/N 585-6, were noted during data review of simulated static firing TR 1319: a. The fuel tank inlet was reading -4 psia, but should have been 14.7 ±2 psia, at ambient tank pressure. b. The transducer did not respond to the 20 percent and 80 percent RACS calibration.	The transducer was replaced with S/N 585-7, which was tested per revision 9 of 1B70705.
500-704-608 2-5-69	The LH2 vent and relief valve, P/N 1A48257 -525, S/N 36, was noted to have a past history of unexplained failures.	The valve was replaced with S/N 0051, which was tested per 1B71877.
500-706-171 1-13-69	The reverse leakage was in excess of the requirements for check valve, P/N 1B67481, S/N 706, as called for per 1B70422. The leak rate was 8 sccm, but should have been 0 sccm.	The checkout procedure was revised to allow a 10 sccm leak rate and the condition was accepted by the Material Review Board.

TABLE II. FAILURE AND REJECTION REPORTS
POSTFIRE CHECKOUT

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-373-598 5-22-69	The customer had requested that the following anomalies be documented: a. The APS system had not been verified as a complete system. b. The APS modules have not been tested in conjunction with the flight APS relay module and associated stage wire harnesses. c. The APS valves opening and closure times have not been determined in a flight configuration.	This report was transferred to the FTC for evaluation by NASA/MDAC.
500-488-352 2-24-69	During checkout in the LOX Lab, the O2H2 burner injector, P/N 1B68491-003-1, had damaged flares as follows: a. The 3/8 inch flare was scored and deformed, also two 1/4 inch flares were scored 0.005 inch in depth. Reference S/N 026. b. The 3/8 inch flare was scored and deformed, also two 1/4 inch flares were scored 0.004 inch in depth. Reference S/N 027.	a. and b. The conditions were acceptable to the Material Review Board.
500-488-361 3-6-69	During performance of 1B70422, it was noted that the check valve, P/N 1B67481-1, S/N 70621305, had a small amount of reverse leakage which was not measurable. No leakage was allowed.	The check valve was sent to the LOX Lab for checkout per 1B71877, and reinstalled on the stage.

TABLE II

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-488-379 3-6-69	During performance of 1B70422, it was noted that the check valve, P/N 1B67481-1, S/N 70621167, had a small amount of reverse leakage which was not measurable. No leakage was allowed.	The check valve was sent to the LOX Lab for checkout per 1B71877, and reinstalled on the stage.
500-488-387 3-6-69	During performance of 1B70422, it was noted that the check valve, P/N 1B67481-1, S/N 70621142, had a small amount of leakage which was not measurable. No leakage was allowed.	The check valve was sent to the LOX Lab for checkout per 1B71877, and reinstalled on the stage.
500-488-395 3-6-69	During performance of 1B70422, it was noted that the check valve, P/N 1B67481-1, S/N 70621105, did not reset at a pressure greater than 0.1 psig. The reset value was 0 psig.	The check valve was sent to the LOX Lab for checkout per 1B71877, and reinstalled on the stage.
500-488-409 3-12-69	A. During performance of 1B71877, it was noted that the check valve, P/N 1B67481-1, S/N 70621133, had the following discrepancies. 1. The reverse leakage rate was 32.8 sccm and should not have exceeded 10 sccm at 1 $\pm$0.5 psig. 2. The check valve failed to reseat. Reference 1B71877, paragraph 4.3.2.c.	A. The check valve was routed to LOX service to inspect for O-ring damage, to flush with freon and to retest per 1B71877, with results resubmitted.
	B. Re-inspection of the O-ring revealed no damage; however, dust and dirt particles were visible on the seating surface. After flushing with freon, the retest revealed a reverse leakage of 0 scim with 1.5 psig applied, a cracking pressure of 3.2 psig and a reseat pressure of 1.7 psig.	B. The retest was acceptable for use by the Material Review Board.

TABLE II (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-488-417 3-12-69	A. During performance of 1B71874, it was noted that the check valve, P/N 1B67481 -1, S/N 70621152, had reverse leakage of 14.8 sccm and should not have exceeded 10 sccm at 1 $\pm$0.5 psig.	A. The check valve was routed to LOX service to inspect for O-ring damage, to flush with freon and to retest per 1B71877, with results resubmitted.
	B. Re-inspection of the O-ring revealed no damage; however, dust and dirt particles were visible on the seating surface. After flushing with freon, the retest revealed a reverse leakage of 0 scim with 1.5 psig applied, a cracking pressure of 3.0 psig, and a reseat pressure of 1.9 psig.	B. The retest was acceptable for use by the Material Review Board.
500-489-936 4-24-69	Static firing data review indicated that the pressure on the Rocketdyne fuel turbopump inlet duct, P/N 409900-11, S/N 6733062, was 141 psia and should be no more than 132 psia per R/NAA Manual R3825-1.	The duct was replaced with S/N 6733065, and tested per 1B71877.
500-489-952 4-25-69	The following discrepancies were noted during final inspection: a. Rubber seal, P/N 1A87429-503, had a hole in the outer seal at stringer 143 and a hole in the forward inner seal at the APS connection. b. The mylar was damaged on the forward dome at stringer 27 and 37. c. Excessive sealant material was noted on several doublers in the auxiliary and main tunnel area.	Items a., c., and d., were acceptable to the Material Review Board and item b. was corrected by repairing the damaged areas with aluminized polyester film patches per DPS 22301.

TABLE II (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-489-952 4-25-69 (Cont'd)	d. Loose debris could be heard moving within the stage during rotation.	
500-489-961 5-1-69	The following discrepancies were noted during installation of the environmental curtain, P/N 1B68756-1: a. Several holes in the curtain were noted near the ground straps. b. Numerous spots of paint were noted on both sides of the curtain. c. The silver coating was wearing off of the curtain.	The conditions were not acceptable and the curtain was replaced.
500-489-979 5-1-69	Both teflon seals, P/N VD261-0040-0008, had scratches in the teflon coating exposing the base metal. This condition was noted during R/NAA removal of the LH2 low pressure duct.	The seals were returned to the vendor for rework or replacement.
500-490-004 5-1-69	During the removal of the R/NAA helium regulator assembly, the main stage solenoid flange, P/N 556127, S/N 3797019, was noted to have numerous surface finish scratches.	The flange was removed and replaced and the system retested per 1B71877.
500-607-955 3-24-69	The head of bolt, P/N 1B69496-1, was sheared leaving the threaded portion in expander, P/N BB341-1032-2, and sleeve, P/N BN330-1032-2, of the standoff, P/N 1B27678-1.	The threaded portion of the bolt was removed and a new bolt was installed.

TABLE II (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-608-081 2-20-69	A. During the performance of 1B55831, revision 31 for TR1319 Run 1A, the gas pressure regulator of the auxiliary hydraulic pump motor, P/N 1A66241-511, S/N X-458912, was indicating an outlet pressure of 33.976 psig and should have been 15 $\pm$ 5 psig.	A. The pressure regulator was replaced and satisfactorily tested per 1B41006, paragraph 4.1.8.
	B. During the retest of the replacement regulator, a fuzz leak too small to measure was noted at the pump case and the check valve, P/N 612889.	B. The leak was acceptable to the Material Review Board as the decay check was within acceptable limits.
500-703-351 3-4-69	During surveillance inspection, the following discrepancies were noted on the hydrogen tank vent system. a. The parallelism of the two bellows sections between stringers 40 and 41 was 0.500 inch, but should have been 0.280 inch maximum. b. The parallelism of the two bellows sections between stringers 102 and 102 was 0.400 inch, but should have been 0.280 inch maximum. c. The parallelism of the two bellows sections at stringer 16 was 0.500 inch, but should have been 0.280 inch.	a., b., and c. The conoseals and clamps were loosened to relieve the preload condition, then retightened and secured per drawing requirements.
500-703-865 2-24-69	During the performance of 1B71877, check valve, P/N 1B67598-501, S/N 202, had a reverse flow leakage of 28 scim, but should have been no more than 10 scim.	The valve was removed and replaced with S/N 249, which was tested per 1B71877.

TABLE II (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-703-873 2-24-69	During the performance of 1B41006, unfiltered freon that was missing cleanliness verification was used to flush port "P" on the auxiliary hydraulic pump, P/N 1A66241-511, S/N X-458912.	The condition was accepted by the Material Review Board since the pump was under a positive pressure of 30 psi during the flush.
500-703-881 2-25-69	During static firing, it was noted that the LOX tank pressurization control module, P/N 1B42290-507-007, S/N 0037, was regulating low at a pressure of 115 psia, but should have maintained a pressure minimum of 290 psia.	The module was removed and replaced with, P/N 1B42290-511, S/N 0027, which was tested per 1B71877 and 1B62753.
500-703-890 2-26-69	During the performance of 1B71877, the LH2 repress check valve, P/N 1B63573-1, S/N 30, had a reverse leakage of 40 scims. The maximum allowable leakage is 10 scims.	The check valve was removed and replaced with S/N 8, which was tested per 1B71877.
500-703-903 2-28-69	During checkout, transducer, P/N 1B43324-601, S/N 48-18, had an excitation voltage of 4-9905 vdc and a signal output of 1.2344 vdc with an ambient pressure of 14.22 psia. The calibration curve shows that the ambient value should indicate 10.50 psia which would indicate that the curve had shifted or was in error.	The transducer was removed and replaced with S/N 9-40, which was tested per 1B71877 and 1B55817.
500-703-911 2-28-69	The curtain assembly, P/N 1B66487-1, had a 3 inch tear at the support bracket cutout.	The curtain was repaired by the application of a layer of silver tape, DPM 895-1, over the tear. The edge binding tape was replaced with DPM 871-5 tape.
500-703-920 3-3-69	Pipe assembly, P/N 1B74202-1, would not route through the cutout provided in the impingement curtain retainer, P/N 1B65110-513.	A new tube assembly was fabricated to route through the retainer.

TABLE II (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-703-938 3-3-69	Pipe assembly, P/N 1B69963-1, would not route through the cutout provided in the impingement curtain retainer, P/N 1B65110 -513.	A new tube assembly was fabricated to route through the retainer.
500-703-946 3-3-69	Pipe assembly, P/N 1B74201-1, was routed through the impingement curtains, P/N 1B65746-501 and 1B65611-501. The pipe assembly should have been routed through the existing cutout at the curtain retainer.	A new tube assembly was fabricated to route through the retainer.
500-703-954 3-3-69	Pipe assembly, P/N 1B69573-1, was incorrectly developed. The pipe assembly would not route to the clamp point nearest the transducer as required per 1B58006.	A new tube assembly was fabricated to route to the transducer per drawing requirements.
500-703-962 3-4-69	During the performance of 1B55817, the D002 fuel pump inlet pressure transducer, P/N 1B40242-579, S/N 579-1, was reading 63.484 psia under ambient conditions, but should have read 14.7 $\pm$1.2 psia.	The transducer was removed and replaced with S/N 574-4, which was tested per 1B55817.
500-703-971 3-4-69	During the static firing LOX relief exercise, the LOX non-propulsive vent valve, P/N 1B69030-505, S/N 0024, indicated a pressure relief of 43.6 psia on the strip chart recorder. The valve should not relieve above 43.5 psia.	The condition was acceptable to the Material Review Board since analog data from three different sources indicated the valve relieved at or below the 43.5 psia value.
500-703-989 3-4-69	The following discrepancies were noted during postfire inspection:	
	a. The ablative coating is cracked and peeling loose between stringer 13 and 18.	a. The silicone dispersion coating was reapplied per MM-RE instructions.

TABLE II (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-703-989 3-4-69 (Cont'd)	b. The ablative coating is peeling where the LH2 fill and drain fairing attaches to the stage.	b. The loose edges of dispersion coating and paint were trimmed off with a plastic scraper.
	c. The ablative coating on the aft skirt at stringer 130 is missing with bare metal exposed.	c. Six brush coats of silicone dispersion coating was applied over the damaged area with a 1/2 inch overlap.
500-703-997 3-5-69	The 50M01952-1 cover was missing from the PCM/DDAS assembly, P/N 1A74049-519, S/N 094.	The cover was replaced per drawing requirements.
500-704-004 3-6-69	The leakage through the pneumatic port of the P/A fast shutdown valve, P/N 558127-11 S/N 4092538, was 17 scim, but should not have exceeded 2 scim.	The valve was removed and replaced with S/N 4090180, which was tested per revision 62, 67, and 68 of 1B71877.
500-704-012 3-7-69	A rust colored residue was noted at the weld upstream of the bellows on duct assembly, P/N 1B44575-502.	The residue was removed with a stainless steel wire brush and the area wiped with a MEK dampened cloth to remove the loosened residue.
500-704-021 3-7-69	Wire P11N16 of wire harness, P/N 1B67271-1, S/N 03, had a 1/8 inch cut in the insulation 8 inches from connector P31.	The insulation was repaired with teflon tape per DPS 54010.
500-704-039 3-7-69	The outer cable insulation of cable assembly, P/N 1B50036-1, was cut through to the conductor. No visible wire strand damage was noted.	The insulation was repaired with teflon tape per DPS 54010.

TABLE II (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-704-047 3-10-69	During the performance of 1B55817, the D002 fuel pump inlet pressure transducer, P/N 1B40242-579, S/N 579-4, malfunctioned on the high RACS value on the DP1-BO multiplexer during calibration Run 2. The high RACS was 3.384 vdc, but should have been 4.000 ±0.100 vdc. The CP1-BO multiplexer read 3.958 vdc.	The condition was accepted by the Material Review Board since subsequent checkout failed to repeat this condition and the transducer is not a flight critical item.
500-704-055 3-11-69	During the performance of 1B62753, an expected O2H2 burner malfunction failed to occur. Subsequent investigation revealed that the R10 potentiometer of the PU oven on monitor module, P/N 1B65331-1-002, S/N 068, would not set-up the module trigger point. The output remained at 0 vdc, but should drop to zero vdc from 19.0 vdc.	The module was removed and replaced with S/N 061, which was tested per revision 42 of 1B62753.
500-704-063 3-11-69	The cable harness support, P/N 1B62907-129, had stripped threads.	The support was repaired per 1B53312.
500-704-071 3-12-69	The following discrepancies were noted during impingement curtain installation per 1B65109:	
	a. An interference existed between the lap splice, cable and tube assembly, P/N 1B69999-1, which made the cinch fasteners hard to fasten.	a. The cable attachment clamp was moved to allow the impingement curtain to be fastened without undue strain.
	b. An interference existed between the lap splice and tube assemblies, P/N 1B66528-1, 1B64141-1, 1B52455-1, and 1B65189-1, which made the cinch fasteners hard to fasten.	b. A NAS 4300-32 spacer was installed under T/A 1B65189-1 and the clamp positioned to remove the noted strain. After rework T/A 1B65189-1 and 1B52455-1 were riding a cinch fastener. This problem was corrected upon installation.

TABLE II (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-704-080 3-17-69	During the performance of TR1319, the thrust chamber chilldown required 4 minutes longer than normal.	An investigation of the thrust chamber temperature patches and X-ray of the thrust chamber chilldown check valve failed to reveal any discrepancies in the chilldown system. The condition was accepted by the Material Review Board since no discrepancies could be found and the thrust chamber chilldown was within the proper envelop for both static firing and launch.
500-704-098 3-17-69	The dynatherm was damaged on plate, P/N 1B29825-625, during installation of nozzle, P/N 1B69234-1.	The loose material was removed and five brush coats of LOX compatible coating (DPM 3456) was applied.
500-704-217 2-25-69	During TR1319, transducer C0382, P/N 1B64968-503, S/N 998, went to fullscale (DDAS readout of 2047 counts), but should have remained ambient (80 counts).	The transducer was removed and replaced with S/N 1008, which was tested per 1B55817.
500-704-225 2-26-69	The safety wire holes were stripped on connector P1 of wire harness, P/N 1B39046-505, S/N 9517-6. These holes were pulled during safety wiring of the wire harness as required during procedure 1B55819.	The damaged safety wire holes were acceptable to the Material Review Board. The connector was safety wired utilizing a cable clamp per DPS 52060.
500-704-276 2-26-69	During the performance of SSB procedure 1B75537, the output from channel 4 of telemetry assembly, P/N 1B55252-1, S/N 00006, was intermittent.	The telemetry assembly was removed and sent to the vendor for rework. The assembly was installed after rework by the vendor and will be tested at the FTC.

TABLE II (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-704-659 3-26-69	During tank entry per 1B70900, the following discrepancies were noted:	
	a. A black discoloration was noted on the door jamb sealing surfaces and the inner side at the bolt flange.	a. All possible black discoloration was removed by wiping with a clean cloth dampened with freon. Any remaining discoloration was acceptable to the Material Review Board.
	b. The mylar was damaged in several areas adjacent to the door jamb.	b. The aluminized mylar film was removed and replaced.
500-704-675 3-28-69	During tank entry per 1B70900, numerous scratches were noted on the sealing flange area for the LH2 tank door. The maximum depth was approximately 0.002 inches.	The condition was acceptable per the Material Review Board pending leak check of the door seal at the FTC.
500-704-772 5-9-69	The following discrepancies were noted during line check 69-6:	
	a. Loading connector, P/N 1B39513-1, was not installed on the J2 recepticle of wire harness 403W200.	a. The loading connector was installed per drawing requirements.
	b. Dummy connector, P/N 10-150921-123, was installed on the wrong side of the attach bracket.	b. The dummy connector was installed per drawing requirements.
500-816-368 3-19-69	During final vehicle shakedown, the following discrepancies were noted:	

TABLE II (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-704-314 2-20-69	During the performance of task 34 of TR1319, the acoustical transducer assembly, P/N 1A68708-513, S/N 5279, was noted to have a severed cable at the pickup connector end.	The transducer kit was removed for vendor rework. The kit was returned, reinstalled on the stage and will be tested at the FTC.
500-704-322 2-20-69	During static firing, the LH2 low pressure duct, P/N 1A49320-515, S/N 18R, was noted to have a frost buildup. Subsequent investigation revealed that the annulus hand valve was 1/8 turn in the open position and that a gas sample of the annulus revealed a content of 72.49% hydrogen and 27.21% helium.	The duct was removed and replaced with S/N 00032R, which was tested per 1B71877.
500-704-331 2-24-69	The vacuum reading on the LH2 low pressure duct, P/N 1A49320-513, S/N 35, was over 1000 microns, but should have been 250 microns or less.	The low pressure duct was replaced with S/N 47, which was tested per 1B71877.
500-704-349 2-24-69	During the performance of TR1319, the D577 LOX tank ullage pressure transducer, P/N 1B43324-601, S/N 61-1, was observed to drop to zero output. Further investigation revealed a low resistance reading between pins A and B.	The transducer was removed and replaced with S/N 48-18, which was tested per 1B71877 and 1B55817.
500-704-641 3-26-69	Static firing data indicated that the 408421C2 LH2 depletion sensor, P/N 1A68710-507, did not cycle dry prior to engine cutoff.	All four sensors were inspected for the same level, cracks in the teflon coating, and for concentricity and tilt. No discrepancies were noted and the sensors were accepted by the Material Review Board. Test or operation was transferred to the FTC on stage turnover.

TABLE II (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-816-368 3-19-69 (Cont'd)	a. Tube assembly, P/N 1B67299-503, had discoloration on ends of each external convolution. b. Tube assembly, P/N 1B67094-1, had discoloration on ends of each external convolution. c. Tube assembly, P/N 1B67299-505, had discoloration on ends of each external convolution and on the welded flange at bottle 9.	a., b., and c. The corrosion was removed by a stainless steel wire brush, solvent wiped with MEK and a heavy coat of clear acrylic lacquer applied over the cleaned areas.
500-816-376 3-19-69	During final stage shakedown, the teflon jacket on the 405W203 wire harness, P/N 1B65304-1, was found to have a small pin hole exposing the shield.	The insulation was repaired per DPS 54010.
500-816-384 3-24-69	During the data evaluation of all system test per 1B55830, it was noted that the forward and reflected power measurement N-18, N-55, N-60, and N-61 were RF susceptible. The following data was obtained during RF transmission:	This condition has been submitted to Saturn Electronics Engineering at the FTC for evaluation.

Measurement	Closed Loop	Open Loop
N18	98MV	99-105MV
N55	3MV	13-45MV
N60	100MV	103MV
N61	1MV	10-20MV

TABLE II (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-816-392 3-24-69	The following discrepancies were noted during final inspection:	
	a. Pipe assembly, P/N 1B66773-1, appeared to have a crimp condition at the sleeve.	a. The tube assembly was replaced with a new pipe assembly and leak checked per 1B71877.
	b. The P38 connector of wire harness 404W7, P/N 1B74463-1, was scratched.	b. and c. The scratched areas were protected with alodine per DPS 41410.
	c. The P48 connector of wire harness 403W8, P/N 1B74669-1, was scratched.	
	d. The leak check port was open and the threads were stripped at the MEC 68100 flange on the LH2 vent valve.	d. The threads were chased to remove all burns and a plug installed on the port.
	e. The upper body of the LH2 vent valve had a deep scratch.	e. All sharp edges were deburred and alodined per DPS 41410.
	f. Pipe assembly, P/N 1B52476-1, had a dent at stringer 32 on the 404 aft skirt.	f. The pipe assembly was replaced and the new T/A leak checked per 1B71877.
	g. Corrosion was noted on the attach angle and hardware located above stringer 13 of the thrust structure.	g. The extraneous material was removed from the noted areas and the areas finished with FR primer.
	h. A continuous bond was noted on the edge of the mylar above stringer 13A. The mylar should have been spot bonded.	h. and i. The bond and wrinkles were acceptable to the Material Review Board.
	i. Excessive wrinkles were noted in the mylar above stringer 15 through 17.	

TABLE II (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-816-392 3-24-69 (Cont'd)	j. A scratch was noted on the forward skirt between stringers 16 and 17.	j. No scratch was noted after removal of the paint. The area was repainted with matching paint.
	k. A rust colored residue was noted at the welded tee of manifold, P/N 1B66808-1.	k. The noted residue was removed with a stiff bristle brush.
500-816-414 3-21-69	During the performance of all system tests per 1B55883, the range safety decoder, P/N 50M10698, S/N 0181, was suspected of malfunctioning since the system would not respond to arm and engine cutoff commands.	The decoder was replaced with S/N 0178, which will be tested at the FTC.
500-816-422 3-21-69	A brown discoloration was noted on the flex sections, P/N 1A48712-501 and P/N 1B48712-1, of the auxiliary tunnel manifold, P/N 1B67299-1.	The discoloration was removed by brushing the area with a stiff bristle brush.
500-816-431 3-24-69	Data review of IST and static firing indicated that various LH2 level sensors cycled when the PU ratio 4.5:1 command was sent.	A special test was accomplished on the 509 stage using 1B55823 K to investigate the transient levels. A 28 volt 10 microsecond pulse was seen on the engine cutoff bus depletion sensor arm command. Requirements per Rocketdyne for cutoff at 28 volts are for 1 millisecond minimum. The condition was accepted by the Material Review Board based on the above test.

APPENDIX III

FLIGHT CRITICAL ITEMS INSTALLED AT TURNOVER

The flight critical items (FCI), as designated by DRD 1B53279 P, that were installed on the stage at the time of turnover to NASA/STC for shipment to KSC are listed in the following tabulation:

P/N	S/N	Ref. Location	Name
1A48240-511	0103	404A7	Fill and drain valve
1A48240-511	0109	427A8	Fill and drain valve
1A48257-525	0051	411A1	LH2 vent and relief valve
1A48312-517	0049	424A1	LOX vent and relief valve
1A48430-511.1-012A	C4	406A1	LOX mass probe
1A48431-513	C7/C6	408A1	LH2 mass probe
1A48857-503	39	403A73	Control helium tank
1A48858-1	1137	Bnk 2 Pos 7	Helium sphere, cold
1A48858-1	1175	Bnk 1 Pos 5	Helium sphere, cold
1A48858-1	1181	Bnk 2 Pos 10	Helium sphere, cold
1A48858-1	1211	Bnk 1 Pos 2	Helium sphere, cold
1A48858-1	1212	Bnk 2 Pos 8	Helium sphere, cold
1A48858-1	1213	Bnk 2 Pos 9	Helium sphere, cold
1A48858-1	1215	Bnk 1 Pos 4	Helium sphere, cold
1A48858-1	1217	Bnk 1 Pos 3	Helium sphere, cold
1A48858-1	1219	Bnk 1 Pos 1	Helium sphere, cold
1A49421-507-A45-2	154	427A41	LH2 aux chilldown pump
1A49423-509	1871	424A2	LOX aux chilldown pump
1A49964-501	261	424 (LOX)	Chill system check valve
1A49964-501	289	427 (LH2)	Chill system check valve
1A49965-523-012A	0301	424A41	Chill system shutoff valve
1A49965-525-013B	0205	424A4	Chill system shutoff valve
1A49968-519	154	426A6	Prop. tank shutoff valve
1A49968-521	111	424A6	Prop. tank shutoff valve
1A49991-1	52	403A7	Tank, comp. gas, cold helium
1A49991-1	55	403A6	Tank, comp. gas, cold helium
1A49991-1	63	403A74	Tank, comp. gas, cold helium
1A57350-507	0234	403A73A5	Helium fill module
1A58345-523-007	1017	403A73A1	Module, pneumatic pwr control
1A58347-513	26	403A73A2	Engine pump prg. cont. mod.
1A59358-529	036	411A92A6	PU electronics assembly
1A66212-507	018	411A92A7	Inv-conv elect. assy.
1A66240-505	X457813	401A11S1, S2	Engine driven pump, hydraulic
1A66241-511	X458912	403B1	Aux hydraulic pump
1A66248-507-012A	66	403A72L1	Hydraulic actuator assy.
1A66248-507	77	403A71A1	Hydraulic actuator assy.
1A68085-505	0117	404A2A1	300 amp pwr transfer switch
1A68085-505	0136	404A45A1	300 amp pwr transfer switch

Appendix III (Continued)

P/N	S/N	Ref. Location	Name
1A68085-505	0146	411A99A10A1	300 amp pwr transfer switch
1A74039-517-016A	074	404A74A2	Chilldown inv. elect. assy
1A74039-521	079	404A74A1	Chilldown inv. elect. assy
1A74211-515	0628	404A45A9	2 amp relay module
1A74211-515	0721	404A3A41	2 amp relay module
1A74211-515	0724	404A3A19	2 amp relay module
1A74211-515	0725	404A3A17	2 amp relay module
1A74211-515	0726	411A99A10A11	2 amp relay module
1A74211-515	0727	411A99A10A13	2 amp relay module
1A74211-515	0728	404A45A10	2 amp relay module
1A74211-515	0729	404A3A48	2 amp relay module
1A74211-515	0730	411A99A10A12	2 amp relay module
1A74211-515	0731	404A45A8	2 amp relay module
1A74211-515	0742	404A45A7	2 amp relay module
1A74211-515	0743	404A2A8	2 amp relay module
1A74211-515	0744	404A2A6	2 amp relay module
1A74216-503	0376	411A99A10A6	Mag latch relay module
1A74216-503	0487	404A3A13	Mag latch relay module
1A74216-503	0510	404A3A23	Mag latch relay module
1A74216-503	0511	404A3A21	Mag latch relay module
1A74216-503	0520	404A45A5	Mag latch relay module
1A74218-515	0585	404A3A12	10 amp relay module
1A74218-515	0586	404A3A49	10 amp relay module
1A74218-515	0587	404A2A2	10 amp relay module
1A74218-515	0608	404A3A44	10 amp relay module
1A74218-515	0609	411A99A10A10	10 amp relay module
1A74218-515	0610	404A3A14	10 amp relay module
1A74218-515	0611	404A45A11	10 amp relay module
1A74218-515	0683	404A3A20	10 amp relay module
1A74890-501	00113	404A2A7	50 amp relay module
1A74890-501	0138	404A2A10	50 amp relay module
1A74890-501	0140	404A2A9	50 amp relay module
1A74890-501	0141	404A2A7	50 amp relay module
1A74890-501	0145	404A45A2	50 amp relay module
1A77310-503.1	0163	404A52A7	5 volt excitation module
1A77310-503.1	0192	411A98A2	5 volt excitation module
1A77310-503.1	0194	411A99A33	5 volt excitation module
1A86847-513	051	401A11S1, S2	Hyd pump thermal isol assy
1B29319-519	00040	403A46	Accum/reservoir assy
1B32647-505	070	404A45A3	Hyd pwr unit start switch
1B33084-503	019	411A97A13	RS controller assy
1B33084-503	020	411A97A19	RS controller assy
1B39037-501	130	401	Eng installation bolts
1B39037-501	147	401	Eng installation bolts
1B39037-501	152	401	Eng installation bolts
1B39037-501	181	401	Eng installation bolts
1B39037-501	193	401	Eng installation bolts
1B39037-501	196	401	Eng installation bolts

Appendix III (Continued)

P/N	S/N	Ref. Location	Name
1B39550-539	013	403A3	Sequencer mounting assy
1B39975-501	0171	403A3A1	Diode module
1B39975-501	0288	404A3A1	Diode module
1B39975-501	0295	404A2A17	Diode module
1B39975-501	0336	404A3A5	Diode module
1B39975-501	0346	404A2A16	Diode module
1B39975-501	0347	404A3A37	Diode module
1B39975-501	0349	404A3A3	Diode module
1B39975-501	0350	404A3A43	Diode module
1B39975-501	0383	404A3A3	Diode module
1B39975-501	0384	404A3A5	Diode module
1B39975-501	0385	404A3A39	Diode module
1B39975-501	0386	404A3A37	Diode module
1B39975-501	0388	404A3A43	Diode module
1B39975-501	0389	404A3A39	Diode module
1B40604-1.2	088	404A2A34	Diode assy module
1B40604-1.2	0156	404A3A7	Diode assy module
1B40604-1.2	0158	404A3A42	Diode assy module
1B40604-1.2	0159	404A3A42	Diode assy module
1B40604-1.2	0160	404A3A51	Diode assy module
1B40604-1.2	0161	404A3A50	Diode assy module
1B40604-1.2	0162	404A3A50	Diode assy module
1B40604-1.2	0163	404A3A7	Diode assy module
1B40604-1.2	0164	404A3A51	Diode assy module
1B40824-507.1	125	403A7A3	Check valve
1B40825-507.1	128	403 Str 9 3/4	Check valve
1B40824-507.1	129	403 Str 9	Check valve
1B40824-507.1	141	403 Str 5A	Check valve
1B40824-507.1	506	403 Str 5A	Check valve
1B40824-507.1	513	403 Str 5	Check valve
1B40887-501	0269	404A3A16	10 amp mag latch relay mod
1B40887-501	0272	404A2A15	10 amp mag latch relay mod
1B40887-501	0274	404A3A2	10 amp mag latch relay mod
1B40887-501	0275	404A3A46	10 amp mag latch relay mod
1B40887-501	0276	404A3A6	10 amp mag latch relay mod
1B40887-501	0284	404A3A16	10 amp mag latch relay mod
1B40887-501	0285	404A3A18	10 amp mag latch relay mod
1B40887-501	0326	404A45A6	10 amp mag latch relay mod
1B40887-501	0328	404A3A46	10 amp mag latch relay mod
1B40887-501	0330	404A3A4	10 amp mag latch relay mod
1B40887-501	0331	404A3A8	10 amp mag latch relay mod
1B40887-501	0340	404A3A18	10 amp mag latch relay mod
1B40887-501	0341	404A3A4	10 amp mag latch relay mod
1B40887-501	0342	411A99A10A5	10 amp mag latch relay mod
1B40887-501	0343	404A3A6	10 amp mag latch relay mod
1B40887-501	0344	404A3A8	10 amp mag latch relay mod

Appendix III (Continued)

P/N	S/N	Ref. Location	Name
1B40887-501	0349	404A3A58	10 amp mag latch relay mod
1B40887-501	0384	404A3A5	10 amp mag latch relay mod
1B40887-501	0415	411A99A10A4	10 amp mag latch relay mod
1B40887-501	0492	404A3A2	10 amp mag latch relay mod
1B40887-501	0501	404A3A57	10 amp mag latch relay mod
1B40887-501	0561	404A3A10	10 amp mag latch relay mod
1B40887-501	0277	404A3A10	10 amp mag latch relay mod
1B42290-511	0027	403A74A1	LOX tank press control module
1B51211-505	015	404A45	Aft 56 volt pwr dist assy
1B51354-523	014	404A2	Aft 28 volt pwr dist assy
1B51379-521	013	411A99	Fwd pwr dist mount assy
1B51753-511	034	411A32L1	LH2 prop vent reg & S/D valve
1B52623-515	020	403S2	Pressure switch
1B52624-511	030	411S2	Pressure switch
1B52624-511	031	411S4	Pressure switch
1B52624-515	45	403S8	Pressure switch
1B52624-519	47	403S5	Pressure switch
1B52624-519	48	503S1	Pressure switch
1B52624-519	55	403S6	Pressure switch
1B53920-501	047	403A73	Chill feed duct check valve
1B53920-503	059	LOX C/D duct	Chill feed duct check valve
1B53920-503	068	LH2 C/D duct	Chill feed duct check valve
1B55200-505	1019	403A73A3	Fuel Tank press control mod
1B57731-503	423	404A71A19	Control relay package
1B57731-503	424	404A51A4	Control relay package
1B57781-507-005C	0032	403A74A2	Cold helium fill module
1B58006-7	63	403A74	1A49991, teflon wrapped
1B59010-509	126	427A7	Pneu prop. control valve
1B62600-529-012	010	403 Str 10-3/4	O2H2 welded burner assy
1B62778-503.1	00009	403A6	Helium plenum & valve assy
1B62778-503.1	00010	403A7	Helium plenum & valve assy
1B65319-503	015	404A70A1	Sw sel emissivity cont assy
1B66230-509	1019	403A73A3	Calibrated LH2 press cont mod
1B66639-515	040	403 Str 10-3/4	Pneu latching actuator assy
1B66639-519	02	411A32L1	Pneu latching actuator assy
1B66692-501-004	10	403A15	Actuation control module
1B66692-501-004	20	411A30-17	Actuation control module
1B66692-501-004	111	403A9	Actuation control module
1B66692-501-004	118	404A43	Actuation control module
1B66692-501-004	126	403A75A1	Actuation control module
1B66692-501-004	127	404A44	Actuation control module
1B66692-501-004	128	411A3-17	Actuation control module
1B66692-501-004	132	411A2-13	Actuation control module
1B66692-501-004	134	404A17	Actuation control module
1B66692-501	175	403A8	Actuation control module
1B66692-501	186	411A14	Actuation control module

Appendix III (Continued)

P/N	S/N	Ref. Location	Name
1B66868-501	28	Tank Pos 10	Ambient helium sphere
1B66868-501	36	Tank Pos 9	Ambient helium sphere
1B66868-501	38	Tank Pos 1	Ambient helium sphere
1B66868-501	39	Tank Pos 8	Ambient helium sphere
1B66868-501	40	Tank Pos 2	Ambient helium sphere
1B66868-501	41	Tank Pos 7	Ambient helium sphere
1B66868-501	42	Tank Pos 5	Ambient helium sphere
1B66868-501	037	Tank Pos 6	Ambient helium sphere
1B66988-1	015	404A71A1	Sphere assy, helium storage
1B67193-511	052	411A32	Continuous vent control mod
1B67598-501	109	403 Str 9	Pneumatic check valve
1B67598-501	130	403 Str 7	Pneumatic check valve
1B67598-501	140	404 Str 22	Pneumatic check valve
1B67598-501	141	404 Str 22	Pneumatic check valve
1B67598-501	143	404 Str 22	Pneumatic check valve
1B67598-501	147	404 Str 9A	Pneumatic check valve
1B67598-501	156	403 Str 9	Pneumatic check valve
1B67598-501	163	403 C/L Umb	Pneumatic check valve
1B67598-501	165	403 Str 5	Pneumatic check valve
1B67598-501	249	403 Str 7	Pneumatic check valve
1B67598-503	82	403A74A3	Pneumatic check valve
1B67598-503	102	403A73A4	Pneumatic check valve
1B69030-505	0024	424A9	LOX NPV control valve
1B69514-501	012	404A3A9	Isolation diode module
1B69514-501	030	404A3A55	Isolation diode module
1B69514-501	042	411A99A8	Isolation diode module
1B69514-501	030	404A3A55	Isolation diode module
1B69550-501	00016	403A74A3	Repress. control module
1B69550-501	00046	403A73A4	Repress. control module
1B74535-1	0008	411A15	Valve, relief, LH2 tnk latch
1B76452-501	17	404A51A4	Control relay package
1B76452-501	20	404A19A71	Control relay package
7851823-503	1094	Amb Hel Inlt	Helium control disconnect
7851823-503	1096	APS Hel Inlt	Helium control disconnect
7851844-501	66	10 in. fm F&D	Cold helium disconnect
7851861-1	60	427	LH2 tank press. disconnect
40M39515-113	292	404A47A1	EBW firing unit
40M39515-113	293	404A75A2	EBW firing unit
40M39515-113	298	404A47A2	EBW firing unit
40M39515-113	299	404A75A1	EBW firing unit
40M39515-119	554	411A99A20	EBW firing unit
40M39515-119	555	411A99A12	EBW firing unit
103826	J-2122	401	J-2 engine