NARRATIVE END ITEM REPORT
SATURN S-IVB-509

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MCDONNELL DOUGLAS ASTRONAUTICS COMPANY

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MCDONNELL DOUGLAS
CORPORATION

HUNTINGTON BEACH
NARRATIVE END-ITEM REPORT
SATURN S-IVB-509

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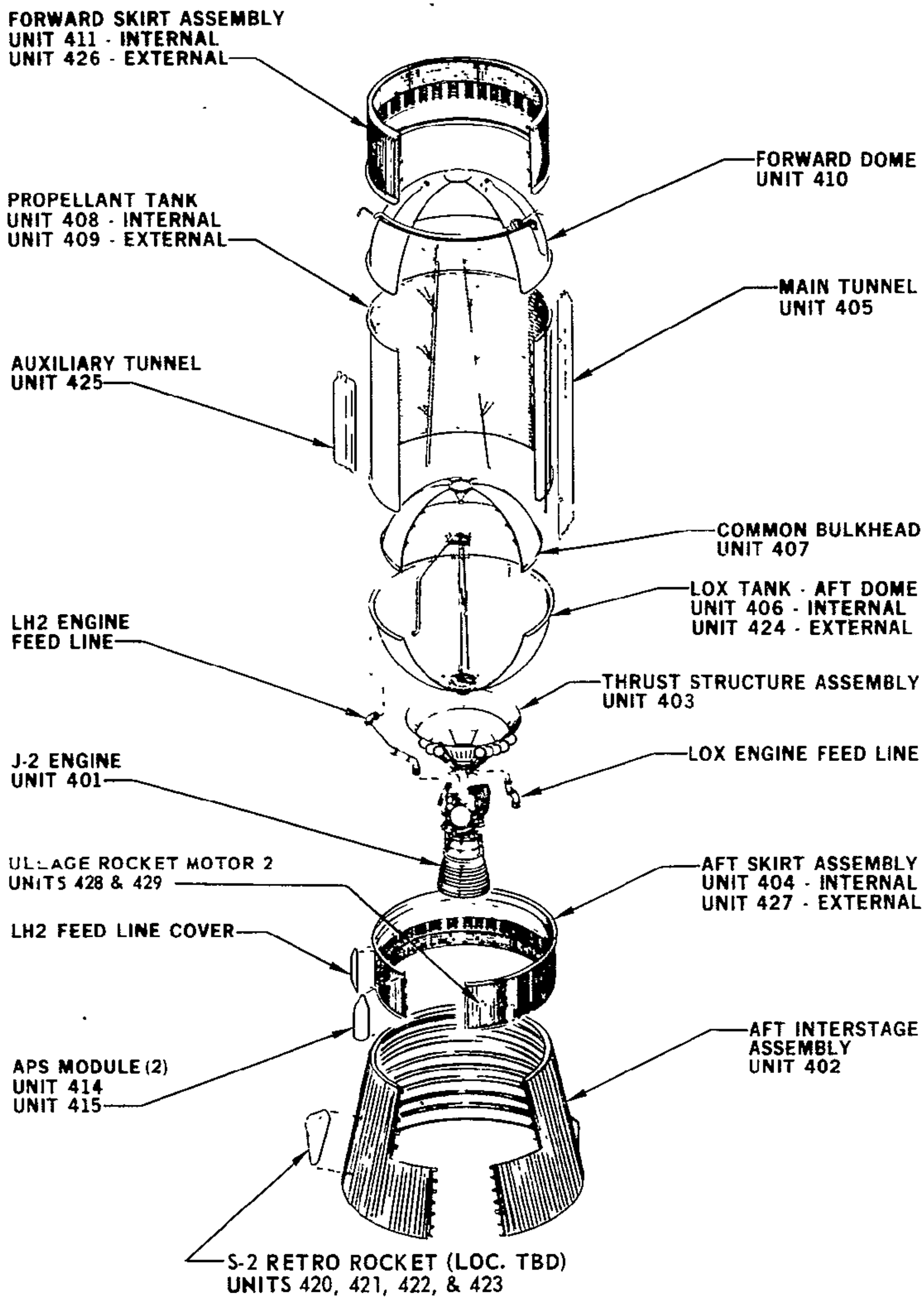
TO: All holders of NARRATIVE END ITEM REPORT, SATURN S-IVB-509, Douglas Report DAC-56662, November 1968.

Enclosed are the Supplementary pages required to provide the Section 5.0 Postretention information for the Narrative End Item Report (NEIR) as required by Contract Data Requirements, MSFC DRL 021. These pages are identified with the date line "April 1969". Update your copy of the NEIR by removing the obsolete pages and replacing them with new pages as indicated below:

Remove Existing Pages	Insert Pages (Identified Changed August 1968)
New	Title Page following existing title page
vi	vi and vi.i
155/156	155 through 156.11



Exploded View of S-IVB Stage for Saturn V

ABSTRACT

The Narrative End Item Report contained herein is a narrative summary of the McDonnell Douglas Astronautics Company (MDAC), Western Division manufacturing and Space Systems Center test records relative to the Saturn S-IVB-509 Flight Stage (Douglas P/N 1A39300-525, S/N 509).

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

Descriptors

NEIR	Significant Items
Documentation	Stage Checkout
Configuration	Manufacture and Test

PREFACE

This Narrative End Item Report is preapred by the Reliability Assurance Directorate of McDonnell Douglas Astronautics Company (MDAC) Western Division, Aeronautics and Space Administration under contract NAS7-101. This report is presented in response to requirements of NPC 200-2, paragraph 14.2.4, and is issued in accordance with MSFC-DRL-021, Contract Data Requirements, which details contract data required from MDAC. The report summarizes the period of initial stage acceptance testing at the MDAC Space Systems Center, Huntington Beach, California, and transfer to the MDAC Sacramento Test Center (STC), Sacramento, California.

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1.0 INTRODUCTION

1.1 Scope

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

a. Configuration at transfer to Sacramento Test Center.

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

c. Nature or problems and malfunctions encountered.

d. Corrective action taken or pending.

e. Extent of retests or tests not completed.

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

1.2 Format

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

SECTION:

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

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

3. STAGE CONFIGURATION. Conformance to engineering design and time/cycle significant items are covered in this section.

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

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

APPENDICES:

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

1.2 (Continued)

II. NONCONFORMANCE TABLES.

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

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

1.3 Stage Functional Description

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

1.4 Documentation

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

2.0 NARRATIVE SUMMARY

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

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

2.1 Stage Manufacturing Tests

Two major manufacturing tests conducted on the stage during the manufacturing sequence verified the structural integrity of the stage propellant tank assembly. A hydrostatic proof test, successfully conducted on 30 September and 1 November 1967, verified that the tank assembly could withstand the required test pressures without leakage or damage.

The propellant tanks leak check, conducted on 5 and 6 October 1967, ensured that there were no leaks in the weld areas or where the tank assembly wall was penetrated by lockbolts or other types of fasteners used to attach structural items to the tank assembly.

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

2.2 Stage Checkout SSC

The stage was installed in SSC VCL tower 6 on 15 April 1968. Checkout of the stage systems started on 23 April 1968, and was completed on 18 September 1968, after 93 working days of activity. A total of 38 checkout procedures involving the stage systems were accomplished during this period. The stage was removed from the VCL on 8 October 1968. Narrations on the checkout procedures are presented in paragraph 4.2, in the order in which the tests were started. Appendix I shows the chronological sequence of the tests, giving the narrative paragraph number, the H&CO drawing number and test title, and the dates each test was active.

Several procedures were initiated before the stage power was turned on. The stage wiring continuity compatibility check was accomplished after five revisions were made to the procedure, and after two FARR's were written to correct bent connector pins and damaged connectors. These FARR's, and other FARR's noted below are summarized in the applicable narration, and in Table II of Appendix II.

The engine alignment procedure was accomplished with no problems, but had to be partially repeated by a second issue after the yaw hydraulic actuator was subsequently replaced. Two revisions were applicable to the second issue only, but no FARR's were written against either issue. The cryogenic temperature sensor verification was accomplished with no problems and no FARR's,

2.2 (Continued)

although one procedure revision was made. Most of the hydraulic system fill, flush, bleed, and fluid samples procedure was accomplished after one FARR replaced the yaw hydraulic actuator because of excessive fluid leakage, and after one procedure revision was made. The procedure was satisfactorily completed after the all systems test was finished.

The manual propellant tanks system leak check was initiated, and was eventually completed after several leaks were corrected, two FARR's were written, and twenty-one revisions were made to the procedure. The forward skirt thermoconditioning system checkout procedure was accomplished with no problems, revisions, or FARR's, and the operating procedure was initiated. The forward skirt thermoconditioning system operating procedure was used as required throughout VCL testing until the all systems test was finished. No problems were encountered during this procedure, and no revisions or FARR's were required.

The telemetry and range safety antenna system procedure was initiated, and was completed after one FARR replaced a power detector. A second issue of this procedure was subsequently required to check the PCM RF transmitter after this unit was replaced during an early all systems test attempt. Five revisions were made to the first issue of this procedure, and four revisions were made to the second issue. The aft skirt and interstage thermoconditioning and purge system was checked with no problems, and no revisions or FARR's were required.

The propulsion components internal leak check was accomplished with no problems or FARR's, although five revisions were required to correct the procedure. The unbilical interface compatibility check was accomplished with no problems and no FARR's, although four procedure revisions were required.

Power was first applied to the stage on 6 June 1968, with the initiation of the stage power setup and turnoff procedures. No major problems were encountered, although several minor malfunctions were encounted and corrected. No FARR's were written, but four revisions were made to the power setup procedure and three revisions were made to the power turnoff procedure.

The signal conditioning setup procedure was accomplished after one FARR replaced a 5 volt excitation module. One revision was made to this procedure. The level sensor and control unit calibration was completed with no procedure revisions, but three FARR's were required to replace four defective control units. The digital data acquisition system (DDAS) calibration and the power distribution system check were both completed with no particular problems and no FARR's, although two revisions were required for each procedure.

The DDAS automatic procedure was completed after several problems were corrected. Twelve revisions were made to the procedure, and three FARR's replaced a channel decoder, a transducer kit, and another transducer. The auxiliary propulsion system (APS) simulator check was accomplished before the APS modules were installed on the stage. No problems were encountered during this test, no revisions were made, and no FARR's were written. The

2.2 (Continued)

exploding bridgewire system was checked with no particular problems and no FARR's, although one revision was made to the procedure.

The fuel tank pressurization system leak check was completed after one leak was corrected and two procedure revisions were made. No FARR's were written during this check. The propulsion system control console check was accomplished, although three procedure revisions were required and two FARR's were written to replace a broken bolt and two helium heater igniters. The cold helium system leak check was completed after the correction of several leaks, including the replacement of a pipe assembly by one FARR. Eight revisions were made to this procedure.

The propellant utilization (PU) system calibration was initially completed after two FARR's corrected problems with a bent connector pin, a damaged connector, and two mission wires. A second issue of this procedure was subsequently accomplished following the replacement of a conoseal in the PU probe to correct a leak. No problems were encountered during this second issue, and no other FARR's were written. Twelve revisions were made to the procedure, affecting both issues. The J-2 engine system leak check required the correction of two leaks, including the replacement of a quick-disconnect by one FARR. Twelve revisions were made to this procedure.

After the APS modules were installed on the stage, a manual auxiliary propulsion system checkout was accomplished with no stage problems. No FARR's were required, although twenty-five procedure revisions were necessary. The propellant utilization system automatic checkout was accomplished with no significant problems. Because of the previously noted PU probe conoseal replacement, this procedure was also repeated by a second issue, again with no problems and with no FARR's required. Seven revisions were made, affecting both issues of the procedure.

The hydraulic system automatic procedure was satisfactorily completed with no particular problems, no FARR's, and no revisions. The APS module automatic checkout procedure was completed after several GSE and program problems were corrected, and after nine revisions were made to the procedure. Two FARR's were written to cover problems with APS engine valve and an interim use control relay module. The EMC radio frequency signature and transient detection test was accomplished with no major stage problems and no FARR's, but sixty-six revisions were necessary to allow completion of the procedure. The range safety receiver check was accomplished with no problems and no FARR's, and only two revisions were made to this procedure.

The pneumatic control system leak check was intially completed after twenty-one revisions were made to the procedure. Subsequently, the replacement of the LOX fill and drain valve required a second issue of the procedure to check only this new valve. One revision was made to the second issue. No particular problems were encountered during either issue, and no FARR's were written. The repressurization system leak check was satisfactorily completed after six leaks were corrected and one procedure revision was made. No FARR's were required during this test.

2.2 (Continued)

The propulsion system automatic test was accomplished after a number of GSE and other minor problems were resolved, and after one FARR replaced the defective LOX fill and drain valve. Twenty revisions were made to this procedure. The range safety system automatic test was accomplished with no problems and no FARR's, although two procedure revisions were required. The propellant tank differential pressure scan procedure was accomplished in conjunction with parts of the propellant tanks leak check. Several minor problems were corrected without requiring FARR action, and six revisions were made to the procedure.

The all systems test (umbilicals-in only) was initially accomplished as part of the EMC radio frequency signature and transient detection test, to provide stage equipment operation for the EMC transient detection measurements. Several problems were resolved during this use of the procedure, and two FARR's were written to replace the PCM/FM telemetry transmitter and a transducer. The individual system tests were generally completed by the end of August, 1968, and the final all systems umbilicals-in and umbilicals-out tests were accomplished on 4 and 5 September 1968. Four more FARR's were written against this use of the procedure, to replace two transducers, and to note measurements and noise problems during the test. Forty-two revisions were made to the all systems test procedure. After the completion of the all systems test and the remaining work on other tests, the forward skirt thermoconditioning system postcheckout procedure was accomplished with no problems, FARR's, or revisions. This completed the VCL checkouts and prepared the stage for removal from the tower.

2.3 Stage Retention

After the conclusion of the stage testing period, the stage was removed from the VCL for further manufacturing activities. On 6 November 1968, the stage was placed into tower 8 at Huntington Beach for preshipment retention. Those activities occurring during stage retention, and during the subsequent preparations for stage shipment to STC, are covered in section 5.

3.0 STAGE CONFIGURATION

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

3.1 Design Intent Verification

This configuration of the stage is defined in the Engineering Configuration List (ECL), Space Vehicle, Model DSV-4B-1-1, Manufacturing Serial Number 509, revision A, dated 19 August 1968. This ECL document includes a listing of all parts, non-hardware drawings, and manufacturing and process specifications required for the manufacture and test of the stage, as defined by Engineering production drawings and EO releases. The ECL has been transmitted to NASA under a separate cover.

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

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

Part Number and Part Name	Serial Number	Accumulated Measurement	Engineering Limit
Reliability Items (1B55425 P)			
1A48858-1	1182	2 cycles	50 cycles
Helium Storage Sphere	1190	2 cycles	50 cycles
	1197	2 cycles	50 cycles
	1200	2 cycles	50 cycles
	1240	2 cycles	50 cycles
	1205	2 cycles	50 cycles
	1208	2 cycles	50 cycles
	1210	2 cycles	50 cycles
	1220	2 cycles	50 cycles
1A49421-507 LH2 Childown Pump	143	No Data Available**	100 hours
1A49423-507-011 LOX Childown Pump	1755	1.66 hours	20 hours

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

3.2 (Continued)

Part Number and Part Name	Serial Number	Accumulated Measurement	Engineering Limit
1A59562-505	0039	828 cycles	5,000 cycles
PU Bridge Potentiometer	1007	538 cycles	5,000 cycles
1A6624-511	X458915	14.9 hours	120 hours
Auxiliary Hydraulic Pump		45 cycles	300 cycles
1B57731-501	322	22,208 cycles	100,000 cycles
Control Relay Package	332	10,189 cycles	100,000 cycles
G.F.P. Items (1B55423 G)			
40M39515-113	305	29 firings	1,000 firings
EBW Firing Unit	307	22 firings	1,000 firings
	308	27 firings	1,000 firings
	309	20 firings	1,000 firings
40M39515-119	570	15 firings	1,000 firings
EBW Firing Unit	571	17 firings	1,000 firings
50M10697	204	24.2 hours	2,000 hours
Command Receiver	205	20.1 hours	2,000 hours
50M10698	0022	50.5 hours	2,000 hours
Range Safety Decoder	0182	23.9 hours	2,000 hours
50M67864-5	174	92,001 cycles	250,000 cycles
Switch Selector			
103826	J-2124		
J-2 Engine (for gimbal cycles)*			
a. Customer connect lines and inlet ducts	0.51 percent		250-10,000 cycles
b. Gimbal bearing	0.49 percent		250-10,000 cycles
c. Firing time	349.8 seconds		3,750 seconds
d. Helium Regulator (P/N 558.00-111)	65 cycles		Not established

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

4.0 NARRATIVE - STAGE CHECKOUT

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

Permanent nonconformances and functional failures affecting the stage have been recorded on FARR's, and are referred to by serial number throughout this section (e.g., FARR A261512 or 500-070-471). The referenced FARR's are presented in numerical order in Table I and Table II of Appendix II.

4.1 Stage Manufacturing Tests

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

4.1.1 Hydrostatic Proof Test (1B38414 J)

The hydrostatic proof test was conducted on the tank assembly for the stage to ensure the structural integrity of the LOX and LH2 tanks and to verify that the tank assembly could withstand the required test pressures without leakage or damage. The item subjected to this test was the tank assembly, P/N 1A39303 -545, S/N 509, without the thrust structure installation, P/N 1A39316-517, the LOX sump installation, P/N 1A39154, or the LH2 door installation, P/N 1B64441.

The hydrostatic proof test was accomplished on 30 September and 1 November 1967, using acceptance test procedure (ATP) A659-1B38414-1-PATP16. The test involved varying the water head pressure inside and outside the LOX and LH2 tanks, while varying the water in the test tank to equalize the hydrostatic head pressure across the skin of the tank assembly, as required to accomplish the following:

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

b. Proof the common bulkhead to a negative (external) pressure differential of -20.6 +0.0, -0.5 psi, and the LH2 tank at the common bulkhead joint to 22.5 +0.5, -0.0 psi.

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

d. Proof the LH2 tank aft dome to 38.0 +0.5, -0.0 psi, and the common bulkhead at the common bulkhead to aft dome joint to a positive (internal) pressure differential of 5.2 +0.0, -0.5 psi.

4.1.1 (Continued)

The water head pressures were varied by adjusting the water levels in the hydrostatic test tower outer tank, LOX tank standpipe, and LH2 tank standpipe. There was no direct correlation between the standpipe water levels used during the test and the specified pressure requirements, but the levels used were those established by Engineering to provide the required pressures.

The following water levels were achieved during the appropriate steps of the procedure. For the LOX tank pressure check the outer tank was empty, the LOX standpipe level was 81.0 feet, and the LH2 standpipe level was 36.7 feet. For the common bulkhead positive pressure check the outer tank was full to the top of the LH2 tank, the LOX standpipe level was 66.2 feet, and the LH2 standpipe level was 2.8 feet. For the common bulkhead negative pressure check the outer tank was full, the LOX standpipe level was 3.9 feet, and the LH2 standpipe level was 51.7 feet. For the LH2 tank pressure check the outer tank was full, the LOX standpipe level was 99.6 feet, and the LH2 standpipe level was 87.6 feet.

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

Leaks were detected in the cold helium bottle ports during the LH2 tank fill test. The LH2 tank was drained to the necessary level to repair the leaks, then the LH2 tank was refilled per the test conductor's instructions and the test was continued.

A low storage level warning, indicating that the water level in the LH2 tank had not reached the 36.7 foot mark, was noted during the LOX tank pressurization test. Three thousand gallons of demineralized water was added to the LH2 tank, allowing water to flow from the 36.7 foot level port.

During the LOX tank pressurization test, the R2 recorder was out of service and not used to record the overflow at the 36.7 foot level of the LH2 standpipe.

A revised step in the tanks drain test was written to "Verify that outer tank water level is below the LOX, LH2 6 inch PTE fill lines before continuation of test." The old step was "Verify that outer tank is empty before continuation of test."

During the tanks drain test, the BP1 sump pump was out of service and the BP2 sump pump and the B2 tank to sump valve were operated manually during the outer tank drain.

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

4.1.2 Propellant Tanks Leak Check (1B38414 J)

The propellant tanks leak check verified the integrity of the stage tank assembly, and ensured that no leaks existed in the tank assembly welds, or in areas where the tank wall was penetrated by lockbolts or other fasteners attaching structural items to the tank assembly. The item tested by this procedure was tank assembly, P/N 1A39303-545, S/N 509.

4.1.2 (Continued)

The leak check was initiated on 5 October 1967, using test procedure A659-1B38414-1-PATP30, and was completed on 6 October 1967. There were no part shortages at the start of the test, and no parts were changed as a result of the test.

The first part of the test was a preliminary leak check of the production test equipment (PTE). The LOX tank was pressurized to 3.2 psig with gaseous nitrogen. A bubble solution was used to check the LOX tank PTE adapters and connectors for leakage. Upon completion of the LOX tank check, the LH2 tank was pressurized to 3.1 psig with gaseous nitrogen, and the LH2 tank PTE adapters and connections were similarly checked with bubble solution.

A tank assembly integrity test was then started by pressurizing both the LOX tank and the LH2 tank to 12.0 psig with gaseous nitrogen. The nitrogen supply valves were then closed and the tank pressures were noted. After 10 minutes, the tank pressures were measured as 12.0 psig for the LOX tank, and 12.0 psig for the LH2 tank, indicating that there was no tank leakage. The tanks were then vented to atmosphere until the pressures in the LOX and LH2 tanks reached 8.3 psig each.

The last phase of the test was a freon injection test. The freon gas was flowed into the tanks at 20 cubic feet per minute until the tank pressures reached 10.3 psig for the LH2 tank and 10.2 for the LOX tank. The freon system downstream of the evaporator, and from the evaporator to the freon bottles, was then bled to atmosphere. After allowing 1 hour for freon gas diffusion, a bubble solution and a halogen detector were used to leak check the tanks at all weld areas and at all lockbolts or other structural fasteners that penetrated the tank wall. No leakage was detected during this check. At the conclusion of the freon leak check, the tanks were exhausted to atmosphere, then purged with dry air and recapped to ensure cleanliness.

No discrepancies were noted during the operation of this procedure, and no FARR's were written. No revisions were made to the procedure.

4.2 Stage Checkout - SSC/VCL

This paragraph details the tests performed on the stage in the Vehicle Checkout Laboratory (VCL) at the McDonnell Douglas Astronautics Company, Western Division Space System Center, prior to transfer of the stage for shipment to the Sacramento Test Center. The stage was placed in tower 6 of the VCL on 15 April 1968. System checkouts were initiated on 23 April 1968 and continued until 18 September 1968. Checkout was active on ninety-two working days during this period. All tests required by the End Item Test Plan, 1B66684-513B, dated 13 April 1967, were activated and completed.

At the time of the all system test there were three interim use parts installed on the stage. These were two attitude control relay modules, P/N 50M35076, locations 404A51A4 and 404A71A19, installed in accordance with 1B55397-001B and ECP 2296. One APS pitch control module, P/N 1A39597-509, installed in accordance with FARR 500-238-488. The flight use parts will be installed prior to the static firing at STC.

4.2 (Continued)

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

4.2.1 Continuity Compatibility Check (1B59780 F)

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

Initiated on 23 April 1968, the procedure was sufficiently completed by 1 May 1968 to allow stage testing to continue. Because of some part shortages the procedure was held open at that time and was completed on 22 May 1968, after a total of 8 days of activity. The procedure was certified and accepted on 22 May 1968. Stage wiring continuity was verified by a total of 2108 individual point-to-point resistance measurements, specified in the test procedure by reference item numbers, "from" component, cable, plug, and pin designations, and "to" component, cable, plug, and pin designations. 2019 of the measurements were within the original resistance requirement of 1.0 ohm or less. For an additional 56 measurements, indications between 1.0 and 3.0 ohms were acceptable because of the length and type of wire involved. Another 33 measurements were accepted with indications of 50 ±5 ohms, as these measurements were made through modules containing 49.9 ohm resistors.

Engineering comments noted that two items were not installed at the start of this test. These were transducer kit 403MT750A, P/N 1B53574-503, for measurement D218 and the LH2 chilldown shutoff valve 427A41, P/N 1A49965-523. The transducer kit and the LH2 shutoff valve were installed on 21 May 1968 and satisfactorily tested on 22 May 1968.

Several problems encountered during the test were corrected by the following FARR's:

a. FARR 500-238-267 noted that pin M in connector J9 on the remote digital multiplexer, P/N 1B66051-501, S/N 07, was bent approximately 30 degrees and connector P9 on wire harness 404W203, P/N 1B67089-1, had a punctured grommet adjacent to pin M. The bent pin was straightened per DPS 540002 and the damaged connector P9 was removed and a new connector was installed.

b. FARR 500-238-275 noted that pin AA in connector J2 on module, P/N 1A96707-501, S/N 606, was bent approximately 30 degrees and connector P89 on wire harness 404W208, P/N 1B67209-1, had a punctured grommet adjacent to pin AA. The bent pin was straightened per DPS 540002 and the damaged connector, P89, was removed and a new connector was installed. The rework was acceptable for use.

4.2.1 (Continued)

Five revisions were made to the procedure for the following:

a. One revision noted that 56 measurements were acceptable at 1.0 ohm to 3.0 ohms because of wire types and lengths.

b. One revision noted that 33 measurements were acceptable at 50 $\pm$5 ohms because the measurements were made through modules containing 49.9 ohm resistors.

c. Three revisions changed five measurement end point designations that were incorrect because of procedure and schematic errors.

4.2.2 Engine Alignment Procedure (1B39095 B)

The engine alignment procedure was conducted to verify that the exit plane of the J-2 engine thrust chamber was properly aligned with respect to the S-IVB stage structure. The items involved in this test were the J-2 engine, P/N 103826, S/N J2124; the hydraulic pitch actuator, P/N 1A66248-507, S/N 83; the hydraulic yaw actuator, P/N 1A66248-507, S/N 85; and the stage, P/N 1A39300 -525, S/N 509.

The first issue of the engine alignment verification was satisfactorily accomplished on 29 April 1968, and was accepted on the same date. However, a second issue was accomplished after the hydraulic yaw actuator was replaced because of leakage at the overboard relief valve port. FARR 500-238-330 removed S/N 82 and installed S/N 85. The second issue was satisfactorily completed on 19 June 1968, and was accepted on 20 June 1968. No problems were encountered during the second issue.

A Wild N-3 alignment scope was first used to determine the difference in elevation of datum plane "G" at four locations around the stage periphery. Datum plane "G" was defined as the mating surface between the aft skirt and the handling ring. The elevations at the four locations were determined to be 2.000 inches, 1.990 inches, 1.960 inches, and 1.965 inches. The maximum deviation between any two locations was 0.040 inch, well within the 0.062 inch maximum deviation limit.

The engine exit plane alignment fixture, P/N 1B54581-1, was positioned and attached to the J-2 engine exit flange, and two clinometers, P/N 1B29613-1, were positioned on the machined surface block of the fixture. From the clinometer readings, the pitch plane adjusted angle was found to be 8.5 minutes low toward stage position I, and the yaw plane adjusted angle was found to be 2.4 minutes low toward stage position IV. From these measurements, the adjusted exit plane inclination angle was determined to be 8.8 minutes, with the low quadrant between stage positions I and IV. This exit plane inclination was well within the maximum inclination limit of 21 minutes.

As the inclination angle was acceptable, no adjustment of either hydraulic actuator was required. For each of the actuators, the engine log book length, the adjusted actuator length, and the final actuator length, were obtained from the data tags provided by the pre-installation actuator adjustment

4.2.2 (Continued)

procedure, drawing 1B66209, and recorded. For the pitch hydraulic actuator, S/N 83, these lengths were 23.006 inches, 22.976 inches, and 22.975 inches, respectively. For the yaw hydraulic actuator, S/N 85, these lengths were 22.967 inches, 22.937 inches, and 22.945 inches, respectively.

Engineering comments noted that all parts were installed at start of the test. No discrepancies were noted during the test. No revisions were written against the first issue; however, two revisions were written against the second issue procedure as follows:

a. One revision provided instructions to set the actuator to the J-2 engine log book length per bench adjustment procedure 1B66209 B.

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

4.2.3 <u>Cryogenic Temperature Sensor Verification (1B64678 D)</u>

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

Initiated on 1 May 1968, this procedure was nearly completed on 2 May 1968, except for two sensors which were not installed at that time. After these sensors were installed, the procedure was completed and accepted on 4 June 1968.

For each sensor tested, the procedure specified a resistance value at 32°F, and a sensitivity value giving the resistance change per degree of temperature between 32°F and 100°F. Using these values and the measured ambient temperature, the expected ambient temperature resistance was calculated for each sensor. The applicable resistance tolerance was also calculated for each sensor. This tolerance was 5 percent of the expected resistance, except for seven specified sensors which were allowed a 7 percent tolerance. The actual ambient resistance of each sensor was then measured and verified to be within the applicable tolerance of the expected resistance. The sensor wiring was verified to be correct by shorting out the sensor element, measuring the continuity resistance, and verifying that this was 5.0 ohms or less. Test Data Table 4.2.3.1 shows the measured and calculated values for each sensor involved in this test.

As noted, two sensors were not installed at the start of this test. These temperature sensors, P/N 1B37878-511, were for the LOX nonpropulsive vent nozzle 1 and 2 temperatures, at reference locations 404MT760 and 404MT761, respectively. Both sensors were installed and tested during this procedure. No problems were encountered during the test, and no FARR's were written. One revision was made to the procedure, as adapter cable, P/N 1B64095-501, was not available for use in checking the O2H2 burner voter circuit sensors 1, 2, and 3. Test leads were used in two test setups, one to measure the sensor resistances and another to short the sensors for the wiring continuity checks.

4.2.3.1 Test Data Table, Cryogenic Temperature Sensor Verification

Meas Number	Sensor P/N	Sensor S/N	Sensor Ref Desig	Temp (°F)	Resistance (ohms) Meas	Resistance (ohms) Calc	Resistance (ohms) ±Tol	Cont
CO 003	1B34473-1	346	403MT686	70	5190.0	5418.0	369.0	1.1
CO 004	1B34473-501	343	403MT687	70	1521.0	1517.0	75.8	1.2
CO 005	1A67863-503	1177	405MT612	70	546.5	541.8	27.0	1.6
CO 009	1A67863-535	1200	403MT653	70	220.4	216.7	10.8	1.5
CO 015	1A67863-509	1189	410MT603	68	1514.0	1510.8	75.5	1.2
CO 040	1A67862-505	638	406MT613	70	1509.0	1495.5	74.7	1.2
CO 052	1A67862-513	562	408MT612	68	5160.0	5396.0	377.2	1.6
CO 057	1A67862-501	583	406MT606	70	544.6	541.8	27.0	1.2
CO 059	1A67862-517	574	406MT611	70	547.0	541.8	27.0	1.4
CO 133	NA5-27215T5	-	401(3MTT17)	69	1360.0	1358.1	67.9	0.8
CO 134	NA5-27215T5	-	401(3MTT16)	69	1358.0	1358.1	67.9	0.8
CO 159	1A67863-519	1267	424MT610	70	220.0	216.7	10.8	0.8
CO 161	1A67863-537	1188	404MT733	70	5200.0	5418.0	359.	0.6
CO 208	1A67863-503	1202	405MT605	70	546.5	541.8	27.0	1.0
CO 230	1A67863-509	1249	403MT706	70	1513.0	1517.0	75.8	1.0
CO 231	1A67863-529	611	403MT707	70	541.8	541.8	27.0	1.4
CO 256	1B37878-501	1462	409MT646	68	1511.0	1510.8	75.5	0.9
CO 257	1B37878-501	1460	409MT647	68	1514.0	1510.8	75.5	0.7
CO 368	1A67862-505	603	406MT660	70	1493.0	1495.7	74.8	1.0
CO 369	1A67862-505	648	406MT661	70	1505.0	1495.9	74.8	1.1
CO 370	1A67862-533	608	408MT735	68	5160.0	5396.0	377.2	1.6
CO 371	1A67862-533	609	408MT736	68	5148.0	5396.0	377.7	1.6
C2 030	1B37878-511	1832	404MT760	66.5	545.0	537.9	27.0	1.2
C2 031	1B37878-511	1820	404MT761	66.5	543.0	537.9	27.0	0.7
*Temp 1	1B37878-507	1721	403A20	67	5160.0	5385.0	375.3	1.1
*Temp 2	1B37878-507	1725	403A21	67	5148.0	5385.0	375.3	0.9
*Temp 3	1B37878-507	1732	403A22	67	5186.0	5386.0	375.3	0.9

*02H2 burner voter circuit sensors

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

This manual procedure ensured that the hydraulic system was correctly filled, flushed, bled, and maintained free of contaminants during hydraulic system operation. The hydraulic pressure and temperature were checked for proper operational levels, the hydraulic system transducers were tested for proper operation, and engine clearance in the aft skirt was verified. The hydraulic system components involved in this test were the auxiliary hydraulic pump, P/N 1A66241-511, S/N X458915; the engine driven hydraulic pump, P/N 1A66240-503, S/N X457805; the accumulator/reservoir assembly, P/N 1B29319-519, S/N 35; the pitch hydraulic actuator, P/N 1A66248-507, S/N 83; and the yaw hydraulic actuator, P/N 1A66248-507, S/N 85.

4.2.4 (Continued)

This procedure was initiated on 6 May 1968, and was completed, except for the preshipment preparations, by 8 July 1968. The procedure was then held open for use during automatic testing. On 13 June 1968, the yaw hydraulic actuator, P/N 1A66248-507, S/N 82, was rejected for leakage by FARR 500-238-330, and another actuator, S/N 85 was installed. Those parts of the test that involved the yaw actuator were repeated on 15 June 1968 to check the new actuator. At the completion of stage testing, the preshipment preparations were accomplished on 17 September 1968, and the procedure was accepted on the same date. The procedure was active on 16 days during this period.

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

The hydraulic system air tank was pressurized to 450 $\pm$50 psig, and a leak check of the auxiliary pump purge system verified that there was no leakage. An air tank decay check was then started, to run concurrent with other checks in the procedure. The air tank pressure was measured as 466 psia at the start of the test. After 24 $\pm$1 hours, the tank pressure was measured at 453 psia, giving a pressure decay of 13 psi, well within the 120 psi decay limit for the 24 hour period.

After the air tank was initially pressurized, the accumulator/reservoir was pressurized to 1800 $\pm$50 psig with nitrogen gas. The HPU was used to circulate hydraulic fluid through the stage hydraulic system at 1000 $\pm$100 psig to flush the accumulator/reservoir. After 30 minutes of circulation, hydraulic fluid was drained from the bleed valves on the reservoir, the accumulator inlet and outlet, the engine driven pump outlet, and the auxiliary pump inlet, and the fluid air content was verified not to be excessive. The auxiliary hydraulic pump was turned on for 5 minutes to circulate hydraulic fluid while the hydraulic system components and fluid connections were checked to verify that there was no external leakage. The engine driven hydraulic pump was flushed during this period by manually rotating the pump quill shaft. Checks were then made of the accumulator/reservoir low pressure and high pressure relief valve functions, as shown in Test Data Table 4.2.4.1.

Following these checks, the hydraulic system pressure was adjusted to 3650 $\pm$50 psig and the reservoir piston was cycled twenty times by reducing and increasing the hydraulic system pressure. During the last cycle, the maximum full reservoir oil level was measured as 100.2 percent, and the maximum empty reservoir oil level was measured as -003 percent, both within the acceptable limits of 100 $\pm$2 percent and 0 $\pm$2 percent, respectively. Hydraulic fluid samples were obtained from the HPU return and pressure sample points. The cleanliness samples met the particle count requirements.

Following the rejection of the yaw hydraulic actuator, P/N 1A66248-507, S/N 82, parts of the procedure were repeated to check the new actuator, S/N 85. The HPU and the accumulator/reservoir were flushed as before, the system air content was reverified to be acceptable, and a fluid sample from the HPU return sample point was verified to meet the cleanliness requirements. The accumulator was

4.2.4 (Continued)

pressurized with nitrogen gas to the 2375 psig required for the 80°F ambient temperature. The hydraulic system leak checks at system pressures of 1500 $\pm$100 psig and 4400 psig maximum were repeated to verify that there was no leakage.

The accumulator precharge and high pressure relief valve checks were started by pressurizing the accumulator with nitrogen gas to the pressure required for the ambient air temperature. The HPU was then used to pressurize the hydraulic system to 1500 $\pm$100 psig and then to 4400 psig maximum, while it was verified that the system had no leaks at either pressure. The system pressure was adjusted to 3650 $\pm$50 psig and the high pressure relief valve functions were checked, as shown in the Test Data Table. The hydraulic system pressure was then reduced to 1000 $\pm$100 psig, the air tank pressure was verified to be 450 $\pm$50 psig, and the auxiliary hydraulic pump was turned on for 5 minutes while the reservoir nitrogen gas pressure was verified to be about 3600 psig.

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

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

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

To compensate for hydraulic fluid thermal expansion, the accumulator nitrogen gas pressure was verified to be correct for the ambient temperature, and the hydraulic system was pressurized to 3650 $\pm$100 psig for 3 minutes. The oil temperature was measured, and the required amount of fluid for this temperature was drained from the reservoir bleed valve.

4.2.4 (Continued)

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

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

Engineering comments noted that there were no parts shortages affecting this test. Several problems were encountered during the test. Some of these were leakage problems, which were corrected by retightening the B-nuts involved to the proper torque value. One was corrected by replacing the defective part involved. One was explained by a revision.

One FARR, 500-238-330, was written to cover the excessive leakage of the overboard relief valve port of the yaw actuator, P/N 1A66284-507, S/N 82, as noted on IIS 399045. The defective actuator was replaced with S/N 85.

One revision was written to explain that the delta P accumulator differential reseating pressure of 3735.0 psid was acceptable because the reseating pressure was above the system operating pressure and was considered satisfactory. The exact seating pressure could not be determined because the 1 gallon flowmeter was pegged at that time.

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

Function	Measurement	Limits
Accumulator/Reservoir Relief Valve Checks		
Low Pressure Relief Valve		
Relief Pressure, Ground Return (psig)	290.0	275.0 ±25.0
Reseat Pressure, Ground Return (psig)	280.0	240.0 min
Relief Pressure, Overboard (psig)	285.0	275.0 ±25.0
Reseat Pressure, Overboard (psig)	275.0	240.0 min
High Pressure Relief Valve		
System Hydraulic Pressure (psig)	4250.0	4400.0 Max
Return Pressure (psig)	300.0	*
Differential Pressure (psid)	3950.0	3900.0 min
Accumulator High Pressure Relief Valve Checks		
System Internal Leakage (gpm)	0.7	0.8 max
Relief Valve Cracking Pressure (psig)	4100.0	*
Reservoir Pressure (psig)	285.0	*

*Limits not specified

4.2.4.1 (Continued)

Function	Measurement	Limits
Accumulator High Pressure Relief Valve Checks (Continued)		
Differential Cracking Pressure (psid)	3815.0	4100.0 max
Relief Valve Reseating Pressure (psig)	4000.0	*
Reservoir Pressure (psig)	265.0	*
Differential Reseating Pressure (psid)	3735.0†	3760.0 min
Hydraulic System Unpressurized (**)		
Aft 5v Excitation Module (vdc)	5.00	5.00 ±0.03
Hydraulic System Pressure (psia)	1372.0	1400.0 approx
Hydraulic Pump Inlet Oil Temperature (°F)	73.7	approx ambient
Reservoir Oil Pressure (psia)	70.7	55.0 min
Accumulator GN2 Pressure (psia)	2373.0	2350.0 approx
Accumulator GN2 Temperature (°F)	65.9	approx ambient
Reservoir Oil Level (%)	90.0	85.0 min
Reservoir Oil Temperature (°F)	78.0	approx ambient
Hydraulic System Pressurized (**)		
Aft 5v Excitation Module (vdc)	5.00	5.00 ±0.03
Hydraulic System Pressure (psia)	3595.0	3650.0 ±150.0
Hydraulic Pump Inlet Oil Temperature (°F)	80.0	approx ambient
Reservoir Oil Pressure (psia)	165.0	180.1 ±20.0
Accumulator GN2 Pressure (psia)	3603.0	sys press. ±100
Accumulator GN2 Temperature (°F)	76.0	approx ambient
Reservoir Oil Level (%)	36.5	25.0 min
Reservoir Oil Temperature (°F)	80.0	approx ambient
T/M Pitch Actuator Position (deg)	0.011	0.0 ±0.236
T/M Yaw Actuator Position (deg)	-0.003	0.0 ±0.236

*Limits Not Specified
**Measurements Made After Pitch Actuator Replacement
†See the Revision Discussion

4.2.5 Propellant Tanks System Leak Check (1B59459 D)

This manual leak check procedure verified the integrity of the stage propellant tanks and associated plumbing, the common bulkhead vacuum monitoring system, and the vacuum jacketed ducts. The propellant tank differential pressure scan, H&CO 1B74681 (reference paragraph 4.2.36), was run in conjunction with the propellant tanks pressurization parts of this procedure to verify that the tank pressures and the common bulkhead differential pressure remained within acceptable limits. The particular items checked by this procedure included the LOX and LH2 tank assembly, P/N 1A39303-549, S/N 509, and those items shown in Test Data Table 4.2.5.1.

Initiated on 7 May 1968, the procedure was completed on 16 August 1968, after 8 days of activity, and was accepted on 20 August 1968. In general, the leak check was accomplished by pressurizing the system with gaseous helium and using a USON leak detector and leak detection bubble solution to locate leakage.

The common bulkhead vacuum monitoring system was leak checked first. The test setup was made and the common bulkhead was pressurized to 2.5 $\pm$0.5 psig. To verify that there were no obstructions in the bulkhead fittings, the B-nut at the transducer for measurement D237 was temporarily loosened while a gas flow was verified. The common bulkhead system was then leak checked from the aft umbilical disconnect to the bulkhead, and to the transducers for measurements D545 and D237. No leaks were detected during this check. The common bulkhead was vented to ambient pressure after the completion of the leak check.

A vacuum check of the jacketed ducts was accomplished next. A thermocouple vacuum gauge meter, P/N 1A94433-501, S/N 4, was connected to the vacuum sensing thermocouple probe built into each duct, and the vacuum reading was verified to be 250 microns of mercury or less. The particular ducts checked, and the measured vacuums, are shown in the Test Data Table.

The O2H2 burner was leak checked next. The test setup was made, the pneumatic control sphere was pressurized to between 500 and 750 psig, and the proper operation of the burner LOX and LH2 propellant valves and LOX shutdown valve was verified. The burner system was pressurized to 5.0 $\pm$0.5 psig, and leak checks were accomplished on the connections of the burner propellant lines, the burner inlet and outlet, the injectors, and all burner fittings. No leaks were found during this check. The burner and the pneumatic control spheres were vented to ambient after these leak checks were completed.

The test setup was then made for the propellant tanks tests. The pneumatic control sphere was pressurized to 700 $\pm$50 psia, and the proper operation of the LH2 propellant valve and the LOX shutdown valve was verified. The LOX and LH2 tanks were purged with helium for a 1-1/2 hour period, and then pressurized to 12.0 psig in the LOX tank and 11.5 psig in the LH2 tank.

4.2.5 (Continued)

These pressures were maintained for 3 minutes for an integrity check. The tanks were then vented to 10.0 +0.0, -0.5 psig in the LOX tank and 9.5 +0.0 -0.5 psig in the LH2 tank, and gas samples were taken to determine if the helium content of the tanks was sufficient for subsequent leak checks. Additional tank venting, purging, pressurizing, and sampling was accomplished as required until the gas samples showed greater than 75 percent helium by volume.

When the helium content was acceptable, the tanks were pressurized to the nominal 10.0 psig in the LOX tank and 9.5 psig in the LH2 tank for the leak and flow checks. A flowmeter was used to measure the leakage at various valves, as shown in the Test Data Table, and leak checks were accomplished on the various connections of the LOX and LH2 tank systems. The propulsive and nonpropulsive vent pressures were measured with the vent valves both closed and open, as shown in the Test Data Table, to obtain sample transducer readings in a closed system. The tanks were vented to ambient pressure after the leak checks were completed. After the leaks noted below were corrected and satisfactorily rechecked, the stage was returned to the pre-test condition to complete the procedure.

Engineering comments noted that there were no parts shortages affecting this test. Several leaks were noted and corrected during this check:

a. During initial pressurizing of the LOX and LH2 tanks, blowing leaks were noted at the engine side of both the LOX and LH2 chilldown duct connections to the customer connect panel. Both leaks were corrected by replacing the Naflex seals. The new seals were tested and accepted. The removed defective seals were subsequently rejected by FARR 500-238-500, below.

b. During the LOX tank leak check, duct assembly, P/N 1A49969-503, leaked at the upstream seal to the LOX prevalve; the propellant utilization probe, P/N 1A48430-511, leaked at the seal in the bottom of the tank; a tee, P/N 1A59434-501, leaked at the inlet seal to the LOX vent valve; and pipe assembly, P/N 1B68897-1, leaked at the downstream seal to the vent valve tee. All of these leaks were corrected by replacing the seals. The new seals were rechecked and accepted for use.

c. Both ends of the LOX nonpropulsive vent ducts leaked at the stage skin, but these leaks were not corrected at this time. SEO 1A39295-025, to be accomplished after the completion of stage checkout, would correct these problems.

Two FARR's were written during the procedure:

a. FARR 500-238-500 rejected two seals, P/N VD261-0046-0004, S/N's 15695 and 15700, as they were damaged several places on the

4.2.5 (Continued)

sealing surfaces and would not hold pressure. The defective seals were removed and returned to the vendor, and new seals were installed, tested, and accepted for use.

b. FARR 500-353-015 noted that a plate, P/N 1B69608-5, holding a nutplate, fell inside a blind area of the thrust structure when pipe assemblies, P/N's 1B69992-1 and 1B69994-1, were removed to repair leaks at the LOX vent valve coupling. The plate and nutplate were left where they fell. A new plate and nutplate were installed 1-7/8 $\pm$1/8 inch forward of the original location to provide mounting for the reinstalled pipe assemblies.

Twenty-one revisions were made to the procedure:

a. Three revisions modified the propellant tanks test setup. Hoses were attached to the hand valves on the LH2 and LOX feed duct adapters, and the hand valves were opened, to carry exhaust vent gases away from the engine area. The setup of the LH2 and LOX venting systems was accomplished by changed and added individual setup steps, rather than by combined setup steps. The hand valves at the LH2 and LOX desicant ports were closed, rather than opened, for efficient tank purging.

b. One revision increased the initial purging time for the LH2 and LOX tanks to be 1 hour 30 minutes, as past experience indicated that the specified 45 minutes purging time did not give the required 75 percent helium content in the tanks.

c. Four revisions changed the procedure to include testing of the LOX tank nonpropulsive vent valve. The valve was added to those that were closed during the integrity check; steps were added to accomplish the required leak checks, flowrate checks, and nozzle pressure checks on the nonpropulsive vent valve and the associated plumbing; and one step involving the LOX tank relief valve was deleted, as the relief valve had been replaced by the nonpropulsive vent valve.

d. One revision changed a step to disconnect the electrical connectors from both the LOX and LH2 tank vent actuation control module opening solenoids, rather than from only the LOX solenoid, to ensure that both tanks were in the same venting mode at the same time. A caution note was also changed to note that for both the LOX and LH2 tanks, the fill and drain valves would be used for emergency venting while the solenoids were disconnected.

e. One revision changed a step to measure the LOX vent and relief valve seat leakage only, rather than the combined relief valve and vent and relief valve seat leakage, as the mechanical relief valve had been removed, eliminating the combined measurement.

4.2.5 (Continued)

f. One revision added steps to measure the LH2 continuous vent and nonpropulsive vent pressures, to obtain transducer readings in a closed system.

g. One revision provided special instructions to maintain tank pressures of 5 $\pm$1 psig in the LOX tank and 2 $\pm$1.5 psig in the LH2 tank during an overnight hold, to maintain the helium content of the tanks.

h. Two revisions changed allowable leakage limits. The 6.1 scim maximum limits on the LH2 and LOX fill and drain valve blade shaft seal leakages were deleted, as the specification control drawing for these valves did not specify an allowable leakage limit under ambient conditions. The 350 scim maximum limit on the LH2 continuous vent valve combined internal leakage was increased to 480 scim maximum, to reflect an increase in allowable leakage from the bypass actuator, as provided by a revision to the continuous vent module specification control drawing, 1B67193.

i. Two revisions changed part number references to reflect changes in the stage piping configuration. Pipe assemblies, P/N's 1B66878-1, 1B66913-1, and 1B66914-1, were changed to be P/N's 1B67796-1, 1B69996-1, and 1B69995-1, respectively.

j. One revision waived the requirement for a 75 percent helium gas concentration in the LOX tank when replacement seals were being leak checked, as the new seals were checked using leak test bubble solution. The helium gas was only required when the USON leak detector was used to locate gross leakages.

k. Three revisions added steps and repeated previous steps to recheck connections that were disconnected during the replacement of leaking seals. These included the pneumatic control line connections at the LOX prevalve, vent and relief valve, and nonpropulsive vent valve; the connections at the transducer for measurement D55; and the conoseal connections at the LOX nonpropulsive vent valve.

l. One revision corrected a procedure omission by adding a step to the post-test shutdown operations to remove the LOX nonpropulsive vent blanking adapters at the aft skirt, and to secure the blanking flanges.

4.2.5.1 Test Data Table, Propellant Tanks System Leak Check

Vacuum Duct Leak Checks

Part	P/N	S/N	Vacuum (microns of Hg)
LH2 Engine Feed Duct	1A49320-513	40	22
LH2 Engine Feed Duct	1A49320-515	41R	59
LH2 Chilldown Supply Duct	1A49966-503-003	22	84
LH2 Burner Feed Duct	1B65206-503	5	8
LH2 Burner Feed Duct	1B59005-501	55	6
LOX Burner Feed Duct	1B59009-501.1	22	6

Flowmeter Leakage Measurements

Part	Leakage Area	Measurement	Limits
LH2 Fill and Drain Valve	Blade Shaft Seal (scim)	27.0	*
	Main Seal (scim)	6.5	100.0 max
LOX Fill and Drain Valve	Blade Shaft Seal (scim)	0.0	*
	Main Seal (scim)	0.0	100.0 max
LOX Chilldown Pump	Seal (scim)	0.0	75.0 max
LOX Prevalve	Shaft Seal (scim)	0.0	100.0 max
LOX Vent and Relief Valve	Seat (scim)	1.9	100.0 max
	Piston Seal (scim)	481.0	4146.0 max
O2H2 Burner Prop Valves	Combined Main Seals (scim)	0.0	300.0 max
LOX Nonpropulsive Vent Valve	Main Poppet Seal (scim)	3.5	100.0 max
	Piston Seal (scim)	98.0	4146.0 max
LH2 Prevalve	Shaft Seal (scim)	0.0	100.0 max
LH2 Vent and Relief Valve	Combined Main Seal (scim)	0.0	480.0 max
	Piston Seal (scim)	23.0	6912.0 max
LH2 Directional Control Valve	Flight Position Seal (scim)	21.0	300.0 max
	Ground Position Seal (scim)	0.0	300.0 max
LH2 Continuous Vent Valve	Combined Internal (scim)	76.0	480.0 max

LOX and LH2 Tank Vent Pressures

Meas No.	Function	Vent Closed	Vent Open
D243	LOX Nonprop Vent Nozzle 1 Press. (psia)	14.40	24.39
D244	LOX Nonprop Vent Nozzle 2 Press. (psia)	14.77	24.81
-	LOX Tank Gauge Pressure (psig)	-	10.0
D181	LH2 Continuous Vent 1 Press. (psia)	24.54	24.43
D182	LH2 Continuous Vent 2 Press. (psia)	24.26	24.15
D183	LH2 Nonprop Vent 1 Press. (psia)	14.7	24.15
D184	LH2 Nonprop Vent 2 Press. (psia)	14.7	23.80
-	LH2 Tank Gauge Pressure (psig)	-	9.1

*See revision h.

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

Before automatic checkout activities were started on the stage, the forward skirt thermoconditioning system was functionally checked by this procedure to prepare it for operation and to verify that the system was capable of supporting stage checkout operations. The items involved in this test were the forward skirt thermoconditioning system, P/N 1B38426-515, and the GSE thermoconditioning servicer, P/N 1A78829-1.

The checkout of the forward skirt thermoconditioning system was started on 10 May 1968, and completed on 13 May 1968. The procedure was certified as acceptable on 13 May 1968.

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

The thermoconditioning system was purged with GN2, then water/methanol coolant was circulated through the system. Coolant samples were taken from both the fluid sample pressure valve (system inlet), and the fluid sample return valve (system outlet), and checked for cleanliness, specific gravity, and temperature. The cleanliness analysis showed that 2 contaminant particles existed within the 175 to 700 micron size; however, these were well within the maximum allowable of 25 particles. The specific gravity was 0.899 at a temperature of 60°F.

A differential pressure test was conducted by measuring the pressure difference between the thermoconditioning system inlet and outlet while a coolant flow rate of 7.8 ± 0.2 gpm was maintained. The coolant temperature was also measured at the system inlet and outlet. Ten measurements, taken at 2 minute intervals, showed that the differential pressure varied from 14.9 psid to 15.1 psid. The supply (inlet) temperature varied from 59°F to 62°F, and the return (outlet) temperature varied from 59°F to 62°F.

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

All parts were installed at the start of the test. No discrepancies or problems were noted during the test and no FARR's or revisions were written.

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

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

Initiated on 13 May 1968, the procedure was used as required until 18 September 1968, and was certified and accepted on the same date. The GSE servicer was set up for operation, and the coolant supply and return hoses, P/N's 1B37641-1 and -501, were verified to be connected between the servicer and the stage thermoconditioning system. The servicer fluid level was verified to be within the proper limits. The panels of the forward skirt thermoconditioning system were inspected to verify that there were no open equipment mounting bolt holes. The servicer was purged with gaseous nitrogen, and the servicer power was applied.

For normal operation during VCL testing, the servicer was continuously purged with gaseous nitrogen to prevent any possible ignition of the methanol vapors within the servicer. When required for use, the servicer was turned on, the fluid temperature control was adjusted to stabilize the supply temperature gauge reading between 80°F and 90°F, and the servicer flowmeter indication was verified to be 7.8 $\pm$0.3 gpm. The water lines, the servicer internal piping, the pressure and return hoses to the stage, and the stage system were visually checked for leakage. At 30 minute intervals during automatic checkout operations, a check was made to verify that the supply temperature, the coolant flowrate, the coolant supply and return pressures, the gaseous nitrogen source pressure, and the servicer fluid level were within the proper limits, and that there was no leakage. At the end of each use, the servicer was shut down, and it was verified that the servicer filter differential pressure indicator buttons were down, and that the coolant pump was stopped with a flowrate of approximately zero gpm. At the conclusion of VCL testing, the servicer and thermoconditioning system were secured by the Forward Skirt Thermoconditioning System Post-Checkout Procedure, H&CO 1B62965, (reference paragraph 4.2.38).

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

4.2.8 Telemetry and Range Safety Antenna System (1B64679 E)

This test procedure was used to verify the integrity of the telemetry and range safety antenna systems by verifying that the continuities, VSWR's, insertion losses, phasing, and power levels of the system were all within the required limits. In addition, the center frequency and carrier deviation of the PCM transmitter were determined to be correct, and the operation of the PCM RF

4.2.8 (Continued)

assembly and FM/FM group power functions were checked. The items involved in this test included:

Part Name	Reference Location	P/N	S/N
PCM RF Assembly	411A64A200	1B65788-1	15505
Bi-Directional Coupler	411A64A204	1A69214-503	184
Coaxial Switch	411A64A202	1A69213-1	66
Power Divider	411A64A201	1A69215-501	53
Telemetry Antennas	411E200 & E201	1A69206-501	81 & 85
Reflected Power Detector	411MT744	1A74776-501	288
Forward Power Detector	411MT728	1A74776-503	319
Dummy Load	411A64A203	1A84057-1	380
Directional Power Divider	411A97A56	1B38999-1	42
Hybrid Power Divider	411A97A34	1A74778-501	36
Range Safety Antennas	411E56 & E57	1A69207-501.1	64 & 65

The first issue of the procedure was initiated on 15 May 1968, completed on 14 June 1968, after 6 days of activity, and was accepted on 21 June 1968. However, a second issue, applicable to the PCM transmitter center frequency and carrier deviation checks and the PCM RF power detector calibration, was run because the RF transmitter assembly, P/N 1B65788-1, malfunctioned during the all systems test. FARR 500-353-040 removed the defective transmitter, S/N 15503, and installed a new unit, S/N 15505. The second issue was satisfactorily run on 23 August 1968 and was certified as acceptable on 6 September 1968.

The tests in this procedure were generally performed by disconnecting various transmission lines in the telemetry and range safety RF systems, and determining insertion losses and VSWR's for various segments of the systems. Measurements of the telemetry system components were made at 258.5 $\pm$0.1 MHz, and the range safety system components were measured at 450.0 $\pm$0.1 MHz. A test cable, P/N 1B50922-1, was calibrated for use in the procedure, with the VSWR measured at both operating frequencies. These VSWR's are shown in Test Data Table 4.2.8.1 along with other measurements made during the test.

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

On the range safety system transmission lines, the center conductor continuity resistances were measured from the input of each receiver to the output of each antenna, and the insulation resistances were measured between the center conductor and the shield at both receiver inputs and both antenna outputs.

4.2.8 (Continued)

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

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

Engineering comments noted that there were no parts shortages affecting this test. One problem encountered during the first system run was corrected by removing the power detector, P/N 1A74776-503, S/N 0142, because the potentiometer R6 could not be adjusted to produce the desired output. A FARR, 500-238-348, was written to document the detector rejection. A new detector, S/N 0319, was installed and accepted for use.

Five revisions were made to the first issue procedure and four revisions to the second issue procedure as follows:

a. One revision was made to the first issue to correct a typographical error.

b. One variation revision to the second issue deleted procedure paragraphs 4.1, 4.2.1, 4.2.2, and 4.2.3, also tables 1 through 8 and 10 through 12, because this portion of the procedure had been satisfactorily completed during the first issue run.

c. Two revisions to the second issue run were made to the PCM transmitter center frequency and carrier deviation checks to prevent the reduction of voltage to zero and avoid flip flop change of state. These two revisions were also written against the first issue, but were superceded by the second issue run.

4.2.8 (Continued)

d. One revision was made to the second issue to provide for a more accurate method of obtaining the cold plate temperature during PCM RF detector calibration. This revision was also written against the first issue, but was superceded by the second issue run.

e. One revision to the first issue was deleted by another revision that provided a better method of obtaining cold plate temperature.

4.2.8.1 Test Data Table, Telemetry and Range Safety Antenna System

Function	Measurement	Limits
Test Cable Calibration		
VSWR at 258.5 MHz	14.0	-
VSWR at 450.0 MHz	11.0	-
Telemetry System Tests		
Insertion Loss to Antenna 1 (db)	4.5	6.7 max
Insertion Loss to Antenna 2 (db)	4.7	6.7 max
Antenna Line Phase Difference (deg)	0.0	30.0 max
VSWR to Antenna 1	1.66	1.7 max
VSWR to Antenna 2	1.35	1.7 max
System Closed Loop VSWR	1.47	1.5 max
System Open Loop VSWR	1.47	1.7 max
Range Safety System Tests		
Transmission Line Continuity Resistance		
Receiver 1 to Antenna 1 (ohms)	0.2	0.5 max
Receiver 1 to Antenna 2 (ohms)	0.2	0.5 max
Receiver 2 to Antenna 1 (ohms)	0.2	0.5 max
Receiver 2 to Antenna 2 (ohms)	0.2	0.5 max
Transmission Line Insulation Resistance		
Receiver 1 (megohms)	Inf	100.0 min
Receiver 2 (megohms)	Inf	100.0 min
Antenna 1 (megohms)	Inf	100.0 min
Antenna 2 (megohms)	Inf	100.0 min
Insertion Loss Checks		
Receiver 1 to Receiver 2 Isolation (db)	31.3	25.0 min
Receiver 1 to Antenna 1 Loss (db)	3.9	6.0 max
Receiver 1 to Antenna 2 Loss (db)	5.5	6.0 max
Receiver 2 to Antenna 1 Loss (db)	5.4	6.0 max
Receiver 2 to Antenna 2 Loss (db)	5.0	6.0 max
Receiver 1 to Checkout Connector Loss (db)	23.9	24.0, +1.9, -1.5
Receiver 2 to Checkout Connector Loss (db)	23.4	24.0, +1.9, -1.5
Closed Circuit Checkout Cable Loss (db)	1.0	1.5 max

4.2.8.1 (Continued)

Function	Measurement	Limits
VSWR Checks		
Power Divider to Antenna 1 Line VSWR	1.23	1.7 max
Power Divider to Antenna 2 Line VSWR	1.23	1.7 max
Receiver 1 System VSWR	1.23	1.7 max
Receiver 2 System VSWR	1.23	1.7 max
PCM Transmitter RF Tests		
Center Frequency (MHz)	258.523	258.500 ±0.026
Carrier Deviation (kHz)	36.0	36.0 ±3.0
PCM FM Transmitter Output - High RACS (volts)	3.969	4.000 ±0.060
TM RF System Reflected Power - High RACS (volts)	3.994	4.000 ±0.060
PCM FM Transmitter Output - Low RACS (volts)	0.979	1.000 ±0.060
TM RF System Reflected Power - Low RACS (volts)	1.010	1.000 ±0.060
Output Power (watts)	22.5	12.75 to 25.25
Forward Power Detector Output (millivolts)	103.5	103.19 ±3.10
Forward Power Detector Output (millivolts)	92.1	-
Equivalent Forward Power (watts)	20.0	-
Reflected Power (watts)	2.10	2.20 ±0.20
Reflected Power Detector Output (millivolts)	6.7	6.82 ±0.20
Reflected Power, AO (watts)	2.012	2.10 ±0.21
Reflected Power, BO (watts)	2.012	2.10 ±0.21
Transmitter Output Power, AO (watts)	22.604	22.5 ±1.00
Transmitter Output Power, BO (watts)	22.544	22.5 ±1.00

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

The checkout of the aft skirt and interstage thermoconditioning and purge system was accomplished by this test procedure to verify that the airflow characteristics of the system were correct, and to show that the system could provide the inert environment required in the aft skirt and interstage area during all prelaunch and test firing operations involving the use of LH2. The items involved in this test were the aft skirt and interstage thermoconditioning and purge system installation, P/N 1A67979-515, and the GSE Model DSV-4B-651 aft skirt ventilation system kit, P/N 1B38121-1.

This checkout procedure was initiated on 22 May 1968 and completed on 23 May 1968, after 2 days of activity. The procedure was certified as acceptable on 24 May 1968. Preoperation setup steps were accomplished to prepare the Model 651 ventilation system for use, to connect it to the stage, and to cover and seal open holes in the stage system airflow areas. The stage system tests were conducted by installing various size orifices in the metering duct of the Model 651 aft skirt ventilation system, opening and closing various purge and ventilation holes on the stage, and measuring the Model 651 metering duct pressure difference and the main manifold pressure, while air was blown through the stage system.

For the main manifold leakage and fairing purge test, a 1.4 inch diameter orifice, P/N 1B38983-503, was installed, and the main manifold orifices in the station 241 frame, the hydraulic system accumulator reservoir shroud ventilation holes, the thrust structure supply duct, and the helium bottle shroud supply duct were sealed. From the measured metering duct orifice pressure difference of 20.2 inches of water, and the main manifold pressure of 3.7 inches of water, it was determined that the leakage and fairing purge area was 3.55 square inches.

In the thrust structure flow test, a 2.1 inch diameter orifice, P/N 1B38983-507, was installed, the main manifold orifices in the station 241 frame, the hydraulic system accumulator reservoir shroud ventilation holes, and the helium bottle shroud supply duct were sealed, and the thrust structure supply duct was opened. From the metering duct pressure difference of 20.0 inches of water and the main manifold pressure of 4.3 inches of water, it was determined that the gross thrust structure purge area was 7.3 square inches. Subtracting the previously determined leakage and fairing purge area, the net thrust structure purge area was 3.8 square inches, well within the 4.1 ±1.0 square inches requirement.

For the helium bottle shroud flow test, a 2.1 inch diameter orifice, P/N 1B38983-507, was installed, the main manifold orifices in the station 241 frame and the thrust structure supply duct were sealed, and the hydraulic system accumulator reservoir shroud ventilation holes and helium bottle shroud supply duct were opened. From the metering duct pressure difference of 21.5 inches of water and the main manifold pressure of 2.7 inches of water, the gross helium bottle shroud purge area was found to be 9.6 square inches. Subtracting the leakage and fairing purge area, the net helium bottle shroud purge area was 6.05 square inches, well within the 6.8 ±1.2 square inches requirement.

For the main manifold orifice flow test, a 5.2 inch diameter orifice, P/N 1B38983-511, was installed, all main manifold orifices were opened, the main manifold orifices in the station 241 frame and the hydraulic system accumulator

4.2.9 (Continued)

reservoir shroud ventilation holes were opened, and the thrust structure supply duct and the helium bottle shroud supply duct were sealed. From the metering duct pressure difference of 4.5 inches of water and the main manifold pressure of 1.6 inches of water, the gross main manifold purge area was found to be 48.5 square inches. Subtracting the leakage and fairing purge area, the net main manifold purge area was 45.0 square inches, well within the 44.2 $\pm$6.0 square inches requirement.

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

4.2.10 <u>Propulsion Components Internal Leak Check (1B59455 A)</u>

The propulsion components internal leak check was performed to determine reverse seat leakage (if any) of the pneumatic pressurization system check valves. The test was initiated on 23 May 1968 and was completed and accepted on 27 May 1968.

All components tested were removed from the stage, tested individually, and then re-installed on the stage, except one check valve which is an integral part of the ambient helium fill module, P/N 1A57350-507, S/N 0006. A flowtester and three Heisse gauges (ranges 0-60 psig, 0-600 psig, and 0-5000 psig) were used to test the check valves. All check valves were subjected to the desired pressure for approximately 1 minute.

The check valves tested and the test results are given in Test Data Table 4.2.10.1. The sequence of testing follows the listing in the Test Data Table.

Engineering comments indicated that there were no part shortages affecting this test. No particular problems were encountered during the test and no FARR's were written. Five revisions were made to the procedure for the following:

a. Two revisions corrected typographical errors. One to correct a valve part number configuration and the other to correct a pressure gauge range callout.

b. Two revisions deleted check valves that were no longer used on the stage.

c. One revision deleted an outdated document reference and added a new document reference.

4.2.10.1 Test Data Table, Propulsion Components Internal Leak Check

Name	P/N	S/N	Test Pressure	Actual Leakage (Scim)	Maximum Leakage Limits (Scim)
LOX V&R Vlv Purge	1B51361-1	397	1500 ±100 psig	0	10
LOX F&D Vlv Purge	1B51361-1	433	1500 ±100 psig	0	10
LH2 F&D Vlv Purge	1B51361-1	434	1500 ±100 psig	0	10
LH2 Repress Line	1B51361-1	439	1500 ±100 psig	0	10
Dir Cont Vlv Purge	1B51361-1	438	1500 ±100 psig	0	10
Amb He Fill Mod	1B51361-1	403	1500 ±100 psig	0	10
LH2 Repress Mod	1B51361-501	409	1500 ±100 psig	0	10
			28 ±3 psig	0	10
LOX Repress Mod	1B51361-501	421	1500 ±100 psig	0	10
			28 ±3 psig	0	10
LOX Press Sys	1B40824-507	133	1500 ±100 psig	0	1
LOX Press Sys	1B40824-507	127	1500 ±100 psig	0	1
LOX Burner Line	1B40824-507	140	1500 ±100 psig	0	1
LH2 Burner Line	1B40824-507	141	1500 ±100 psig	0	1
LH2 Press Sys	1B65673-1	24	300 psig	0	10
			28 ±3 psig	0	10
Amb He Fill Mod Check Valve	1A57350-507	0006	1500 ±100 psig	0	10

4.2.11 Umbilical Interface Compatibility Check (1B59782 G)

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

This procedure was initiated on 31 May 1968, and was completed and accepted on 5 June 1968. A series of resistance checks were made at specified test points on the signal distribution unit, P/N 1A59949-1, to verify that all wires and connections were intact and of the proper material and wire gauge, and that all resistance values and loads were within the design requirement limits. The test points, circuit functions, measured resistances, and resistance limits are shown in Test Data Table 4.2.11.1. Test point 463A1A5J43-FF was used as the common test point for all measurements.

Engineering comments indicated that all parts were installed at the start of this procedure. No malfunctions were encountered during the test, and no FARR's were written. Four revisions were made to the procedure for the following:

a. One revision corrected the callout and location of eight test points.

b. One revision added additional information to clarify the method of cycling the motor driven switches in case excessive resistance is measured at specified test points.

c. Two revisions corrected the resistance range limit values at three test points.

4.2.11.1 Test Data Table, Umbilical Interface Compatibility Check

Test Point	Function	Meas Ohms	Limit Ohms
Reference Designation 463A2			
A2J29-C	Cmd, Ambient Helium Sphere Dump	26	10-60
CB-8-2	Cmd, Engine Ignition Bus Power Off	Inf	Inf
CB-9-2	Cmd, Engine Ignition Bus Power On	14	5-15
CB-10-2	Cmd, Engine Control Bus Power Off	Inf	Inf
CB-11-2	Cmd, Engine Control Bus Power On	8	5-15
A2J29-N	Cmd, Engine Helium Emergency Vent Control On	50	10-60
A2J29-P	Cmd, Fuel Tank Repress Hel Dump Vlv Open	35	10-60
A2J29-Y	Cmd, Start Tank Vent Pilot Valve Open	22	10-60
CB-4-2	Cmd, LOX Tank Cold Helium Sphere Dump	30	10-60
A2J29-c	Cmd, LOX Tank Repress. Helium Sphere Dump	36	10-60
A2J29-h	Cmd, Fuel Tank Vent Pilot Valve Open	60	40-100
	(Same, reverse polarity)	10 meg	500K min
A2J29-i	Cmd, Fuel Tank Vent Valve Boost Close	56	40-100
	(Same, reverse polarity)	10 meg	500K min
A2J29-q	Cmd, Ambient He Supply Shutoff Valve Close	22	10-60
A2J30-H	Cmd, Cold He Supply Shutoff Valve Close	1.1K	1.5K max
	(Same, reverse polarity)	Inf	Inf
CB-7-2	Cmd, Sequencer Power On	13	5-15
A2J30-W	Cmd, LOX Vent Valve Open	60	40-100
	(Same, reverse polarity)	10 meg	500K min
A2J30-X	Cmd, LOX Vent Valve Close	60	40-100
	(Same, reverse polarity)	10 meg	500K min
A2J30-Y	Cmd, LOX and Fuel Prevalve Emergency Close	60	40-100
	(Same, reverse polarity)	10 meg	500K min
A2J30-Z	Cmd, LOX and Fuel Chilldown Pilot Valve	60	40-100
	Open (Same, reverse polarity)	10 meg	500K min
A2J30-b	Cmd, LOX Fill & Drain Valve Boost Close	32	10-40
A2J30-c	Cmd, LOX Fill & Drain Valve Open	32	10-40
A2J30-d	Cmd, Fuel Fill & Drain Valve Boost Close	31	10-40
A2J30-e	Cmd, Fuel Fill & Drain Valve Open	31	10-40
A2J42-F	Meas, Bus +4D111 Regulation	180	100 min
CB-23-2	Cmd, Bus +4D11 Power Transfer Internal	80	5-100
CB-26-2	Cmd, Bus +4D41 Power Transfer Internal	22	5-25
A2J35-y	Meas, Bus +4D141 Regulation	200	50-200
A2J6-AA	Sup, 28v Bus +4D119 Talkback Power	90	60-120
CB-44-2	Cmd, APS Power On	20	5-50
CB-46-2	Cmd, Aft Batteries Load Test On	8	5-15
Reference Designation 463A1			
A5J41-A	Meas, Bus +4D131 Regulation	140	20 min
CB-32-2	Cmd, Forward Power Transfer Kit	21	5-25
CB-4-2	Cmd, Pre-launch Checkout Group Power On	6.5	5-15
A5J41-E	Meas, Bus +4D121 Regulation	2.2K	1.6K min
A5J53-AA	Sup, 28v +4D119 Forward Talkback Power	70	60-100
CB-27-2	Cmd, Forward Battery Load Test On	7.5	5-15

4.2.12 Stage Power Setup (1B66560 D)

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

This procedure was initially conducted on 6 June 1968, with several minor malfunctions, which were corrected to enable the procedure to be used to establish initial conditions for subsequent automatic procedures. The "sell run" was conducted successfully on 5 July 1968 and accepted on 9 July 1968. The following narration and the measurement values shown in Test Data Table 4.2.12.1 are from this last run.

The test started by resetting all of the matrix magnetic latching relays, and verifying that the corresponding command relays were in the proper state. Verification was made that the umbilical connectors were mated, and that plugs 404W26P1 and 404W27P1 were disconnected from the LOX and LH2 inverters. The bus 4D119 talkback power was turned on, and the prelaunch checkout group was turned off. The forward power, bus 4D11 power, and bus 4D41 power, were transferred to external power. The sequencer power, engine control bus power, engine ignition bus power, APS bus 1 and bus 2 power, and propulsion level sensor power, were all verified to be off. The range safety system 1 and 2 receiver powers and EBW firing unit powers were all transferred to external and verified to be off. The switch selector checkout indication enable and the flight measurement indication enable were both turned on.

The bus 4D131 28 vdc power was turned on, and the forward bus 1 initial current and voltage were measured. The range safety safe and arm device was verified to be in the safe condition.

The 70 pound ullage engine reset relay, the LH2 continuous vent overboard valve closed indication, the LH2 and LOX repressurization mode reset relay, the LH2 and LOX repressurization control valve reset relay, and the O2H2 burner propellant valve reset relay were turned on.

The propellant utilization boiloff bias was turned off. The O2H2 burner spark systems 1 and 2 were measured and it was verified that the O2H2 burner LOX valve, LOX shutdown valve, LH2 valve, and the LH2 control vent orifice bypass valve were closed.

The forward bus 1 quiescent current was measured. The PCM system group was turned on and the amperage of the PCM system group was measured. The forward bus 2 current and voltage were measured and it was verified that the local sensor was off.

The prelaunch checkout group was turned on and the current was measured. The DDAS ground station selector switch was manually set to position 1 and it was verified that the ground station was in sync.

4.2.12 (Continued)

The cold helium supply shutoff valve command was set. The aft power supply current and voltage were measured and it was verified that the local sensor was off. The EBW pulse sensor power was verified to be off. The sequencer power was turned on and the current was measured.

A series of checks verified that stage functions were in the proper state. Forty functions were verified to be off, and twenty-two functions were verified to be on. The LOX and LH2 tank valves were verified to be in the proper open or closed positions.

The voltages of the aft 5 volt excitation module and both forward 5 volt excitation modules were measured through the AO multiplexer. The range safety 1 and 2 EBW firing unit charging voltages were measured. The aft bus 2, forward battery 1, forward battery 2, aft battery 1, and aft battery 2 voltages were measured. The component test power voltage was the last voltage measured, thus completing the power setup procedure and establishing the initial conditions for automatic procedures.

Engineering comments noted that there were no part shortages at the start of this test. There were no failure and rejection reports written. There were four revisions made to the procedure for the following:

a. One revision was made to change the initial power supply voltage to allow for GSE power supply local/remote sensing instructions.

b. One revision deleted the requirement for the use of a piece of ground support equipment and another revision noted that the previous revision was not valid because there was no initial requirement for using this piece of ground support equipment in performing this procedure.

c. One revision changed the digital signal synchronizer XCO-XTAL control from XTAL mode to XCO mode because of a design problem in the DDA ground station, which caused the computer to be intermittently out of sync with the ground station in the XTAL mode.

4.2.12.1 Test Data Table, Stage Power Setup

Function	Measured Value	Limits
Forward Bus 1 Initial Current	1.600 amp	20 amp max
Forward Bus 1 Voltage	28.039 vdc	28 ±0.5 vdc
O2H2 Burner Spark Sys 1	0.005 vdc	0 ±0.5 vdc
O2H2 Burner Spark Sys 2	0.000 vdc	0 ±0.5 vdc
Forward Bus 1 Quiescent Current	1.399 amp	5 amp max
PCM System Group Current	4.801 amp	5 ±3 amp
Forward Bus 2 Current	0.199 amp	2 amp max
Forward Bus 2 Voltage	28.039 vdc	28 ±0.5 vdc

4.2.12.1 (Continued)

Function	Measured Value	Limits
Prelaunch Checkout Group Current	1.301 amp	1 ±3 amp
Aft 1 Power Supply Current	0.300 amp	2 amp max
Aft 1 Power Supply Voltage	28.118 vdc	28 ±0.5 vdc
Sequencer Power Current	0.200 amp	3 amp max
Aft 5v Excit Module Voltage, AO	4.982 vdc	5 ±0.030 vdc
Forward 1 5v Excit Module Voltage, AO	5.008 vdc	5 ±0.030 vdc
Forward 2 5v Excit Module Voltage, AO	5.007 vdc	5 ±0.030 vdc
RS 1 EBW Firing Unit Charging Voltage	0.000 vdc	0 ±1 vdc
RS 2 EBW Firing Unit Charging Voltage	0.000 vdc	0 ±1 vdc
Aft Bus 2, Bus 4D41	0.000 vdc	0 ±1 vdc
Forward Battery 1, Bus 4D30	-0.079 vdc	0 ±1 vdc
Forward Battery 2, Bus 4D20	0.000 vdc	0 ±1 vdc
Aft Battery 1, Bus 4D10	-0.030 vdc	0 ±1 vdc
Aft Battery 2, Bus 4D40	-0.153 vdc	0 ±1 vdc
Component Test Power Voltage	0.000 vdc	0 ±1 vdc

4.2.13 Stage Power Turnoff (1B66561 D)

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

This procedure was initially conducted on 6 June 1968, with some minor malfunctions, which were corrected to enable the procedure to be used to establish initial conditions for subsequent automatic procedures. The "sell run" was conducted on 5 July 1968, and accepted on 7 July 1968.

It was verified that the umbilical connectors were mated, and that the flight measurement indication enable was turned on. Verification was made that the bus 4D119 talkback power, the buses 4D131 and 4D111 28 volt power, and the sequencer power were all on. The buses 4D31 and 4D11 voltages were verified to be 28 ±2.0 vdc. The flight measurements indication enable command was verified to be set, and the LH2 continuous vent valve relay reset was verified to be on. The switch selector functions were turned off, and a series of checks verified that the stage functions were in the proper state of off or reset, that the O2H2 burner spark systems 1 and 2 voltages were 0 ±0.5 vdc, that the stage bus powers were off, and that the bus voltages were 0 ±1.0 vdc. The EBW pulse sensor power was turned off, and the range safety receiver 1 and 2 power and EBW firing unit 1 and 2 power were transferred to external. The range safety safe and arm device was verified to be in the safe condition, and the bus 4D119 talkback power was turned off. The matrix magnetic latching relays were then reset, completing the stage power turnoff.

Engineering comments noted that there were no parts shortages affecting the test and no FARR's were written.

4.2.13 (Continued)

There were three revisions to the procedure for the following:

a. One revision deleted the requirement for the use of a piece of ground support equipment and another revision noted that the previous revision was not valid.

b. One revision, applicable to the pre-test setup of the digital signal synchronizer, changed the XVO-XTAL selector switch setting from XTAL to VCO and added a new callout to set the SERVO OPEN-CLOSE selector switch to CLOSE. A design problem caused an intermittent computer out of sync condition with the ground station in the XTAL mode.

4.2.14 Signal Conditioning Setup (1B64681 E)

This procedure calibrated the stage 5 volt and 20 volt excitation modules prior to the use of the stage instrumentation system, checked certain hydraulic system pressure transducers under ambient conditions prior to pressurizing the hydraulic system, and calibrated any items of the stage signal conditioning equipment that were found to be out of tolerance during testing. The signal conditioning equipment consisted of those items required to convert transducer low level or ac signals to the 0 to 5 vdc form used by the telemetry system, and included dc amplifiers, temperature bridges, frequency to dc converters, and expanded scale voltage monitors. Only the particular items checked and calibrated during this procedure are noted below and in Test Data Table 4.2.14.1. During computer holds, this procedure was also used as required to troubleshoot instrumentation problems.

The procedure was initiated on 7 June 1968, and most of the necessary calibrations were completed by 15 June 1968, after 6 days of activity. The procedure was then held open for use as required during subsequent VCL activity. One additional calibration was accomplished on 11 July 1968, and the procedure was closed out and accepted on 25 September 1968. The stage power setup, H&CO 1B66560, was performed prior to any calibration activity, to provide electrical power to the equipment.

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

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

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

4.2.14 (Continued)

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

One temperature measurement was calibrated by adjusting the temperature bridge and the associated dc amplifier. This was the propellant utilization oven stability monitor, measurement N63, temperature bridge 411A61A214, P/N 1B68861-1, S/N 172, and dc amplifier 411A61A226, P/N 1A82395-1, S/N 2594. The dc amplifier zero control and the temperature bridge potentiometer were initially adjusted for a 0.000 ±0.005 vdc amplifier output with a low level calibration signal applied. With a high level calibration signal applied, the dc amplifier gain control was adjusted to obtain a gain output of 4.004 vdc, meeting the 4.000 ±0.005 vdc limits. With a low level calibration signal again applied, the dc amplifier zero control was adjusted to obtain a zero output of 0.003 vdc, meeting the 0.000 ±0.005 vdc limits.

One expanded scale voltage monitor module was calibrated by calibrating the associated dc amplifier. This was the static inverter-converter 5 vdc monitor, measurement M4, expanded scale voltage module 411A61A255, P/N LA95181-1, S/N 156, and dc amplifier 411A61A254, P/N 1A82395-1, S/N 2602. With a low level calibration signal applied, the dc amplifier zero control was adjusted to obtain a zero output of 0.001 vdc, within the 0.000 ±0.005 vdc limits. With a high level calibration signal applied, the amplifier gain control was adjusted to obtain a gain output of 4.001 vdc, within the 4.000 ±0.005 vdc limits.

One breakpoint amplifier was calibrated, for measurement N55, the telemetry RF system reflected power, breakpoint amplifier 411A61A213, P/N 1B54875-501, S/N 61. With no calibration signal applied, the amplifier was initially adjusted for an output of 0.000 ±0.005 vdc. With a low level calibration signal applied, the amplifier was adjusted to obtain a low output of 1.002 vdc, within the 1.000 ±0.005 vdc limits. With a high level calibration signal applied, the amplifier was adjusted to obtain a high output of 3.996 vdc, within the 4.000 ±0.005 vdc limits. With no calibration signal applied, the amplifier bias output was then measured as 0.003 vdc, within the 0.000 ±0.005 vdc limits.

Engineering comments noted that all parts affected by this test were installed at the start of the test. Only one problem was encountered during the test. FARR 500-238-283 rejected the forward No. 2 5 volt excitation module 411A98A2, P/N 1A77310-503.1, S/N 143, as the unit had no 5 vdc or -20 vdc outputs. A new module, S/N 180, was installed, tested, and accepted for use.

One revision was made to the procedure, to delete the GSE Model DSV-4B-298 monochrome system status display, P/N1 1B37968-1, from the End Item Equipment list, as it was undergoing modification.

4.2.14.1 Test Data Table, Signal Conditioning Setup

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

Reference Location	S/N	5 vdc Out. (vdc)	-20 vdc Out. (vdc)	ac Output (vpp)	(Hz)
411A99A33	195	5.000	-19.998	10.0	2058
411A98A2	180	5.002	-19.999	10.0	2054
404A52A7	175	4.999	-20.001	10.0	2050

20 Volt Excitation Module, P/N 1A74036-1,2

Reference Location	S/N	20 vdc Output (vdc)
411A61A242	333	19.999
404A62A241	326	20.001
404A63A241	320	20.001
404A64A241	319	19.999
404A65A241	342	20.000
404A63A233	324	20.001

Hydraulic System Ambient Pressures

Meas No. and Function	Measurement	Limits
D42 - Reservoir Oil Pressure (psia)	14.401	14.7 ±8.0
D43 - Accumulator GN2 Pressure (psia)	1390.844	1395.0 ±50.0
D209 - Aux Hyd Pump Motor Gas Press. (psig)	1.047	0.0 ±1.2
D223 - Aux Hyd Pump Air Tank Press. (psia)	14.893	14.7 ±13.0

Temperature Bridge Calibration

Meas No. and Function	P/N	S/N	Reference Location	Output (mvdc) Low	High
C6 - GH2 Start Bottle Temperature	1A98088-501	89	404A64A207	-0.01	24.2
C7 - Engine Control Helium Temp.	1A98088-501	90	404A64A208	-0.03	24.2
C199 - Thrust Chamber Jacket Temp.	1A98088-1	71	404A64A209	0.04	24.27
C200 - Fuel Injection Temperature	1A98088-1	72	404A64A210	-0.03	24.2

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

This manual procedure verified that the control units associated with the LOX and LH2 liquid level, point level, fast fill, and overfill sensors were adjusted for operating points within the calibration limits, and responded properly to simulated sensor wet and dry conditions. Any control unit that was not properly adjusted was calibrated by the procedure. The particular items involved in this test are noted in Test Data Table 4.2.15.1.

4.2.15 (Continued)

Initiated on 7 June 1968, the procedure was completed and accepted on 11 June 1968, after 4 days of activity. A point level sensor manual checkout assembly, P/N 1B50928-1, was connected between each control unit and the stage power and sensor wiring, and a General Radio type 1422CD variable precision capacitor was connected in parallel with the sensor to provide the capacitance values required to simulate the wet and dry conditions of the sensor.

With the control unit power turned on, and with the variable capacitor set for 0.5 picofarads, the control unit output was verified to be 0 ±1 vdc, indicating that the control unit output relay was de-energized. The variable capacitance was then increased until the control unit output changed to 28 ±2 vdc, indicating that the output relay was energized. The capacitance value at this point was recorded as the "energized capacitance". The variable capacitance was then decreased until the control unit output changed back to 0 ±1 vdc, indicating that the output relay was again de-energized. The capacitance value at this point was recorded as the "de-energized capacitance". The energized and de-energized capacitance values appear in the Test Data Table with the appropriate calibration limits.

If the energized or de-energized capacitance values were not within the required limits for any control unit and sensor combination, the control unit was calibrated to establish the correct operating point. The precision capacitor was set to the appropriate calibration capacitance to simulate the wet condition of the associated sensor, and the control unit operating point adjustment, R1, was adjusted until the control unit output just changed from 0 ±1 vdc to 28 ±2 vdc, indicating that the control relay was energized. The appropriate calibration capacitances were 0.7 ±0.01 picofarads for all LH2 sensors except the LH2 overfill sensor, which required 1.1 ±0.02 picofarads, and were 1.5 ±0.02 picofarads for all LOX sensors except the LOX overfill sensor, which required 2.1 ±0.02 picofarads. After the operating point was established, the control unit was rechecked as before to verify that the energized and de-energized capacitance values were then within the required limits.

A final check of each control unit verified the proper operation of the test calibration capacitance built into the unit. The variable precision capacitor was not connected during this check. With the associated sensor disconnected from the control unit, it was verified that the built-in calibration capacitance did not energize the output relay under normal conditions, or when a test signal was applied to the control unit. With the sensor connected to the control unit, it was verified that the calibration capacitance did not energize the output relay under normal conditions, but did energize the relay when a test signal was applied. At the completion of this check, the manual checkout assembly was removed, and the control unit was reconnected to the stage wiring.

Engineering comments noted that there were no parts shortages affecting this test. No revisions were made to the procedure, but three FARR's were written to replace defective control units.

a. FARR 500-238-291 rejected the LOX fast fill control unit, P/N 1A68710-511, S/N C31, at location 404A72A5. The unit failed to function and could not be adjusted. A new control unit, S/N C91, was installed and accepted for use.

4.2.15 (Continued)

b. FARR 500-238-305 rejected the LOX liquid level control unit, P/N 1A68710-511, S/N C34, at location 404A63A206. The de-energized capacitance value was 1.165 picofarads, but should have been 1.5 ±0.15 picofarads. A new control unit, S/N C86, was installed and accepted for use.

c. FARR 500-238-313 rejected two LH2 liquid level control units, P/N 1A68710-509, S/N's C63 and C67, at locations 411A61A219 and 411A61A221, respectively. Both units failed to function and could not be adjusted. Two new units were installed and accepted, S/N C97 at 411A61A219, and S/N C101 at 411A61A221.

4.2.15.1 Test Data Table, Level Sensor and Control Unit Calibration

	Sensor, P/N 1A68710			Control Unit, P/N 1A68710			Capacitance (pf)		
Function	Ref Loc	Dash P/N	S/N	Ref Loc	Dash P/N	S/N	Energ	De-en	Limit
LH2 Tank	408			411					
Liq Lev L17	MT732	-507	C11	A61A217	-509	C61	0.678	0.674	0.7 ±0.15
Liq Lev L18	MT733	-507	C14	A61A219	-509	C97	0.654	0.644	0.7 ±0.15
Liq Lev L19	MT734	-507	C17	A61A221	-509	C101	0.662	0.654	0.7 ±0.15
Pt Lev 1	A2C1	-507	C2	A92A25	-509	C74	0.692	0.688	0.7 ±0.15
Pt Lev 2	A2C2	-507	C6	A92A26	-509	D114	0.629	0.618	0.7 ±0.15
Pt Lev 3	A2C3	-507	C7	A92A27	-509	C37	0.670	0.662	0.7 ±0.15
Pt Lev 4	A2C4	-507	C8	A61A201	-509	C44	0.690	0.675	0.7 ±0.15
Fastfill	A2C5	-1	C2	A92A43	-509	C60	0.675	0.668	0.7 ±0.15
Overfill	*	*	*	A92A24	-509	C68	0.996	0.980	1.1 ±0.15

*Part of LH2 Mass Probe, P/N 1A48431-509, S/N C4, Location 408A1

Function	Ref Loc	Dash P/N	S/N	Ref Loc	Dash P/N	S/N	Energ	De-en	Limit
LOX Tank	406			404					
Liq Lev L14	MT657	-1	C31	A63A221	-511	C35	1.498	1.486	1.5 ±0.15
Liq Lev L15	MT658	-1	E138	A63A206	-511	C86	1.432	1.408	1.5 ±0.15
Liq Lev L16	MT659	-1	E141	A63A223	-511	C37	1.470	1.460	1.5 ±0.15
Pt Lev 1	A2C1	-1	C38	A72A1	-511	C23	1.500	1.497	1.5 ±0.15
Pt Lev 2	A2C2	-1	D109	A72A2	-511	C41	1.475	1.472	1.5 ±0.15
Pt Lev 3	A2C3	-1	D118	A72A3	-511	C36	1.499	1.495	1.5 ±0.15
Pt Lev 4	A2C4	-1	C4	A63A227	-511	C38	1.544	1.363	1.5 ±0.15
Fastfill	A2C5	-1	D79	A72A5	-511	C91	1.437	1.420	1.5 ±0.15
Overfill	**	**	**	A72A4	-511	D109	2.101	2.088	2.1 ±0.15

**Part of LOX Mass Probe, P/N 1A48430-511, S/N C2/C5, Location 406A1

4.2.16 Digital Data Acquisition System Calibration, Automatic (1B66563 E)

The automatic calibration of the digital data acquisition system (DDAS) was accomplished by this procedure through the insertion of analog signals to the multiplexer inputs and discrete signals to the DDAS bilevel inputs. This test verified that the DDAS was ready to proceed with stage checkout operations.

4.2.16 (Continued)

The following items were involved in this test:

Part	Part Number	Serial Number	Ref. Designation
DCM/DDAS Assembly	1B65792-1	6700101	411A97A200
CP1-BO Time Division Multiplexer	1B65897-1	9	404A61A200
DP1-BO Time Division Multiplexer	1B65897-501	10	404A61A201
Remote Digital Multiplexer (RDSM)	1B66051-501	7	404A60A200
Low Level Remote Analog Multiplexer (RASM)	1B66050-501	7	404A60A200

This test was started on 10 June 1968, successfully completed on the third attempt on 11 June 1968, and accepted on 25 June 1968. The first two attempts were not successful due to synchronization problems with the DDAS ground station, which were caused by operator setup errors.

The stage power was turned on per H&CO 1B66560, then initial conditions were established for the stage and DDAS. The 72 kHz bit rate check was made of the PCM data train to ensure it was within tolerance. The 72 kHz bit rate was measured at 72,006 bits per second, well within the 71,975 to 72,025 bits per second limits. Then the 600 kHz VCO test was accomplished by measuring the bandedge frequencies and voltages of the PCM/DDAS VCO output. The upper bandedge frequency was measured at 633.2 kHz at 3.6 vrms, within the acceptable limits of 623.2 kHz to 643.2 kHz at greater than 2.2 vrms. The lower bandedge frequency was measured at 566.1 kHz at 3.6 vrms, within the acceptable limits of 556.8 kHz to 576.8 kHz at greater than 2.2 vrms. The frequency differential was calculated at 67.1 kHz, within the acceptable limits of 70 $\pm$10 kHz.

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

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

A final test measured the PCM/FM transmitter current as 3.8 amperes, within the 4.5 $\pm$3.0 amperes limits.

Engineering comments noted that all parts were installed for the test, and no FARR's were written as a result of this test.

4.2.16 (Continued)

Two revisions were made to the procedure for the following:

a. One revision was made to switch the DDAS ground station source selector to the simulator position at the beginning of the 600 kHz VCO test in order to re-establish synchronization with the DDAS ground station. After the 600 kHz VCO test, the DDAS ground station source selector was switched back to the stage position.

b. The other revision was made to the pre-test instructions, which deleted the requirement for the continuous vent relay indication to be on. This indication was off due to a wiring error, but had no effect on the test. SEO, 1B66966-002, was written to correct this condition.

4.2.17 Power Distribution System (1B66562 E)

The automatic checkout of the stage power distribution system verified the capability of the GSE to control power switching to and within the stage, and determined that static loads within the stage were not excessive. The procedure verified that particular stage relays were energized or de-energized as required, and that bilevel talkback indications were received at the GSE. Static loading of the various stage systems or assemblies was determined by measuring the GSE supply current before and after turn-on of the system. All electrical components on the stage were involved in this test, including the point level sensors, the propellant utilization system, the auxiliary propulsion system, the J-2 engine ignition bus, the stage telemetry system, the stage power buses, the LOX and LH2 chilldown inverters, and the external to internal power transfer system.

Initiated on 12 June 1968, the procedure was accomplished by the second attempt on 3 July 1968, after 2 days of activity. The first attempt was terminated due to an out of tolerance problem with the PCM RF transmitter power and some ground support equipment problems, which caused the LOX and LH2 chilldown inverter frequency hardwire to print out as out-of-tolerance. The problems were corrected prior to the second attempt. The procedure was certified as acceptable on 5 July 1968. The following narration and Test Data Table 4.2.17.1 cover the second attempt.

The stage power setup, H&CO 1B66560, was accomplished, and initial conditions were established for the test. To verify power supply and stage bus operation, measurements were made of the engine control bus current and voltage; the APS bus current; the engine ignition bus current and voltage with the bus on, and voltage with the bus off; and the component test power current and voltage with the power on and the component test power voltage with the power off. For a check of the emergency detection systems (EDS), it was verified that the EDS 2 engine cutoff signal turned off the engine control bus power and prevented it from being turned back on, and also turned on the instrument unit range safety 1 EBW firing unit arm and engine cutoff signal. The engine control bus voltage was measured during this check, and again after the check with the bus turned back on. Verification was then made that the EDS 1 engine cutoff signal turned on the non-programmed engine cutoff signal and the AO multiplexer engine cutoff signal indication (K13); and that with the EDS 1 signal turned off, the engine ready bypass turned off both cutoff indications.

4.2.17 (Continued)

For the point level sensor test, the propellant level sensor power current was measured, and each of the four LH2 tank and four LOX tank point level sensors were verified to respond properly within 300 milliseconds to simulated wet condition on commands. A series of checks then verified that a dry condition indication from any two point level sensors in either tank, obtained by simulated wet condition off commands, resulted in the required engine cutoff signal. For the dry condition of LOX tank sensors 1 and 2, the engine cutoff LOX depletion timer value was measured to determine the cutoff signal delay time. Each of the point level sensors was then verified to response properly within 300 milliseconds to simulated wet condition off commands.

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

The propellant utilization inverter and electrical power current was measured while the power was momentarily turned on. The PCM RF assembly power current was then measured, and the PCM/FM transmitter output power was measured through the AO and BO multiplexers. With the telemetry RF silence command turned on, the RF group was verified to be off, the PCM/FM transmitter output power was measured through the AO multiplexer, and the switch selector output monitor voltage (K128) was measured with the PCM RF assembly power and read commands 1 and 2 turned on. With the telemetry RF silence command turned off, the RF group was verified to be on, and the PCM/FM transmitter power was again measured through the AO multiplexer.

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

For the chilldown inverter tests, the chilldown pump simulator was connected to the LOX and LH2 chilldown inverters, and, for each inverter, measurements were made of the input current, the output voltages through both hardwire and telemetry, and the operating frequency through telemetry.

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

A series of checks then verified that the switch selector register was operating properly, and that the instrument unit 28 vdc power supplies were all on. The range safety receiver currents were measured with the receivers transferred to

4.2.17 (Continued)

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

Engineering comments noted that the LOX vent valve, P/N 1A48312-505 and the LOX nonpropulsive vent valve, P/N 1B69030-1, located at 424A1 and 424A9 respectively, were not installed at the start of testing. These parts shortages affected a change in the stage power setup portion of the pre-test instructions, but had no affect on the outcome of this test. Both of these valves were installed subsequent to the completion of this test. No other problems were encountered during the test and no FARR's were written against the procedure.

Two revisions were made to the procedure for the following:

a. One revision provided instructions to checkout spare circuits.

b. One revision deleted two steps in the stage power setup portion of the pre-test instructions, because the LOX vent valve and the LOX non-propulsive vent valve were not installed at the start of testing.

4.2.17.1 Test Data Table, Power Distribution System

Function	Measurement	Limits	
Engine Control Bus Current (amps)	0.200	2.0	±2.0
Engine Control Bus Voltage (vdc)	27.906	28.079	±1.0
APS Bus Current (amps)	0.899	1.5	±3.0
Engine Ignition Bus Current (amps)	0.300	0.0	±2.0
Engine Ignition Bus Voltage, Bus On (vdc)	28.876	28.079	±1.0
Engine Ignition Bus Voltage, Bus Off (vdc)	-0.062	0.0	±0.45
Component Test Power Current (amps)	0.200	0.0	±2.0
Component Test Power Voltage, Bus On (vdc)	28.039	28.0	±2.0
Component Test Power Voltage, Bus Off (vdc)	-0.039	0.0	±0.1
Engine Control Bus Voltage, EDS 2 On (vdc)	-0.092	0.0	±0.45
Engine Control Bus Voltage, EDS 2 Off (vdc)	27.906	28.039	±1.0
Propellant Level Sensor Power Current (amps)	0.500	1.0	±2.0
Engine Cutoff LOX Depletion Timer (seconds)	0.559	0.560	±0.025
PU Inverter and Electrical Power Current (amps)	2.900	3.0	±2.0
PCM RF Assembly Power Current (amps)	2.300	4.5	±3.0
PCM/FM Transmitter Output Power, AO (watts)	18.737	10.0	min
PCM/FM Transmitter Output Power, BO (watts)	18.737	10.0	min
PCM/FM Transmitter Output Power (RF Silence On) (watts)	-0.118	0.0	±2.0
Switch Selector Output Monitor (K128) (vdc)	2.128	2.0	±0.425
PCM/FM Transmitter Output Power (RF Silence Off) (watts)	18.737	10.0	min
Aft Bus 2 Current (amps)	0.000	5.0	max
Aft Bus 2 Voltage (vdc)	56.317	56.0	±1.0

4.2.17.1 (Continued)

LOX Childown Inverter Tests	Measurement	Limits
Inverter Current (amps)	22.004	20.000 ±5.0
Phase AB Voltage, Hardwire (vac)	55.833	55.838 ±3.0
Phase AC Voltage, Hardwire (vac)	55.443	55.838 ±3.0
Phase A1B1 Voltage, Hardwire (vac)	55.833	55.838 ±3.0
Phase A1C1 Voltage, Hardwire (vac)	55.964	55.838 ±3.0
Frequency, Hardwire (Hz)	401.000	400.000 ±4.0
Phase AB Voltage, Telemetry (vac)	55.864	55.838 ±3.0
Phase AC Voltage, Telemetry (vac)	55.998	55.838 ±3.0
Frequency, Telemetry (Hz)	400.438	400.000 ±4.0

LH2 Childown Inverter Tests		
Inverter Current (amps)	21.983	20.000 ±5.0
Phase AB Voltage, Hardwire (vac)	55.703	55.758 ±3.0
Phase AC Voltage, Hardwire (vac)	55.769	55.758 ±3.0
Phase A1B1 Voltage, Hardwire (vac)	55.574	55.758 ±3.0
Phase A1C1 Voltage, Hardwire (vac)	55.769	55.758 ±3.0
Frequency, Hardwire (Hz)	402.00	400.000 ±4.0
Phase AB Voltage, Telemetry (vac)	55.864	55.599 ±3.0
Phase AC Voltage, Telemetry (vac)	55.998	55.599 ±3.0

Forward Bus 1 Battery Simulator Voltage (vdc)	28.118	28.0 ±2.0
Forward Bus 2 Battery Simulator Voltage (vdc)	28.118	28.0 ±2.0
Aft Bus 1 Battery Simulator Voltage (vdc)	28.039	28.0 ±2.0
Aft Bus 2 Battery Simulator Voltage (vdc)	56.158	56.0 ±4.0
Bus 4D20 ESE Load Bank Voltage (vdc)	-0.199	0.0 ±1.0
Bus 4D40 ESE Load Bank Voltage (vdc)	0.000	0.0 ±1.0
Bus 4D30 ESE Load Bank Voltage (vdc)	0.000	0.0 ±1.0
Bus 4D10 ESE Load Bank Voltage (vdc)	0.000	0.0 ±1.0
Forward Bus 1 Internal Voltage (vdc)	27.958	28.0 ±2.0
Forward Bus 2 Internal Voltage (vdc)	27.999	28.0 ±2.0
Aft Bus 1 Internal Voltage (vdc)	28.080	28.0 ±2.0
Aft Bus 2 Internal Voltage (vdc)	56.317	56.0 ±4.0
Forward Bus 1 External Voltage (vdc)	27.958	28.0 ±2.0
Forward Bus 2 External Voltage (vdc)	27.919	28.0 ±2.0
Aft Bus 1 External Voltage (vdc)	28.079	28.0 ±2.0
Aft Bus 2 External Voltage (vdc)	56.317	56.0 ±4.0
Forward Bus 1 Battery Simulator Voltage (vdc)	0.159	0.0 ±1.0
Forward Bus 2 Battery Simulator Voltage (vdc)	-0.039	0.0 ±1.0
Aft Bus 1 Battery Simulator Voltage (vdc)	0.039	0.0 ±1.0
Aft Bus 2 Battery Simulator Voltage (vdc)	0.000	0.0 ±1.0
Aft Bus 2 Voltage (vdc)	0.000	0.0 ±1.0
Range Safety Receiver 1 Current (amps)	1.250	0.0 ±2.0
Range Safety Receiver 2 Current (amps)	0.500	0.0 ±2.0

4.2.18 Digital Data Acquisition System (1B66564 E)

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

Items tested by this procedure consisted of the PCM/DDAS assembly, P/N 1B65792-1, S/N 6700101; the CP1-BO time division multiplexer, P/N 1B65897-1, S/N 09; the DP1-BO time division multiplexer, P/N 1B65897-501, S/N 010; the remote digital submultiplexer (RASM), P/N 1B66051-501, S/N 07; the low level remote analog submultiplexer (RASM), P/N 1B66050-501, S/N 07; and the PCM RF assembly, P/N 1B65788-1-002, S/N 15503.

The first attempt to run the test procedure was on 12 June 1968. Four attempts were required before the test was successfully completed on 9 August 1968. The procedure was active for 9 days, which included troubleshooting of the malfunctions encountered. The procedure was accepted on 13 August 1968.

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

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

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

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

Special channel tests at 400 Hz, 100 Hz, and 1500 Hz were performed, in the order given, following completion of the DP1-BO multiplexer tests. 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. LOX and LH2 flowmeter test at 100 Hz followed by 400 Hz test. The LOX and LH2 pump speeds were checked using the 1500 Hz test input. The indications displayed during the special channel tests were as expected.

4.2.18 (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.

The first attempt to run the test was unsuccessful. Numerous channel malfunctions occurred and troubleshooting revealed that the channel decoder, P/N 1A74053-503, would not output the proper RACS commands. Refer to FARR 500-238-321. The amplifier on the transducer kit, P/N 1B40242-583, would not accept low RACS reset after the low RACS command had been set. Refer to FARR 500-238-399. The antenna system VSWR was also out of tolerance.

The second attempt was run through to completion; however, it was also unsuccessful. Onechannel indicated that the high RACS, low RACS, and ambient readings were too low. Troubleshooting revealed that the transducer, P/N 1B39293-519, located at 404A74 was defective. Refer to FARR 500-238-402.

The third attempt was run through to completion; however, it was also rejected. One channel malfunctioned because the forward power of the telemetry transmitter was out of tolerance. Two channels malfunctioned because the LOX nonpropulsive vent valve and the LOX vent valve were not installed. Five channels malfunctioned because of trapped gas in the auxiliary propulsion system. The APS was vented and these measurements were found to be within tolerance.

Run 4 was satisfactorily completed, although there was one channel malfunction due to a lack of pressure in the auxiliary hydraulic pump air tank. The tank was pressurized and this measurement was found to be within tolerance.

Engineering comments noted that there were no shortages affecting the procedure at the start of the test. It was also noted in the Engineering comments that an executive initiated E01 error message was printed out when the program tried to interrogate the PAM ground station at step 4102102. Since no other E01 messages were printed out and no computer hold was entered, the test was able to obtain the necessary data upon reattempt; therefore, the results of this test were in no way invalidated by the occurrence.

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

a. FARR 500-238-321 rejected the channel decoder, P/N 1A74053-503, S/N 365, because it would not output the proper RACS commands. The defective unit, S/N 365, was removed and returned to vendor for rework or replacement. A new unit, S/N 171, was installed.

b. FARR 500-238-399 rejected the transducer kit, P/N 1B40242-583, S/N 583-22. The amplifier would not accept the low RACS reset command after the low RACS set command had been set. The defective unit, S/N 583-22, was removed and a new unit, S/N 583-44, was installed.

c. FARR 500-238-402 rejected transducer, P/N 1B39293-519, S/N 169, because the high RACS, low RACS, and ambient readings were too low. The defective unit, S/N 169, was removed and a new unit, S/N 299, was installed.

4.2.18 (Continued)

Twelve revisions were made to the procedure as follows:

a. One revision added a step to the test instructions for re-evaluating all pressure transducers that failed to meet the high RACS, low RACS, and ambient calibration requirements by comparing actual test values with original calibration curves.

b. One revision to the pre-test instructions added additional instructions for obtaining a more accurate indication of the stage cold plate temperatures.

c. One revision changed the propulsion utilization oven voltage tolerance from -0.023, +1 to -0.023, +0.1.

d. One revision made seven corrections to the umbilical measurement test.

e. One revision added a procedural step to the pre-test instructions to ensure that the telemetry signal distribution unit, DSV-4B-296, was in the proper mode.

f. One revision changed four steps to correct the time callouts from TC1 to TC50. TC1 could not be used because it contained time read in at step 4101621 which was used to time the pneumatic 5 volt transducer power supply on period.

g. One revision made a deviation in the multiplex table program at step 4100350 to read, "If APS flag NE 0, go to MX11." When the APS flag was set, index N should have been incremented by 5 instead of 2, because of the way the multiplex table was programmed.

h. One revision accepted the printout data for steps 4103 07 and 4103410. The special channel low RACS printout for M028 and the high RACS printout for M029 gave the correct data for the CP1 channels, although DP1 was printed out. This was caused by AD being output instead of AC.

i. One revision made tolerance corrections at steps 4101430, 4101550, 4103720, and 4103930.

j. One revision corrected the bit patterns for the RACS commands at steps 4108052 and 4108054.

k. One revision changed the value of TC3 at step 4104614 to change the equipment warmup time from 36 to 30 minutes.

l. One variation revision directed that the auxiliary hydraulic pump air tank be fully pressurized for a recheck of measurement D233, which was successfully accomplished. During the test measurement D223 malfunctioned because the air tank had not been fully pressurized.

4.2.19 Auxiliary Propulsion System (1B66569 E)

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

All stage mounted components of the APS were tested, in particular the interim use attitude control relay packages, P/N 50M35076-1, S/N 332, at reference location 404A51A4, and S/N 322, at reference location 404A71A19.

The procedure was satisfactorily accomplished by the first attempt on 17 June 1968, and was accepted on 18 June 1968. The data in this narration and in Test Data Table 4.2.19.1 are from this attempt.

After initial conditions were established, the GSE IU substitute -28 vdc power supply was turned on and measured at -30.559 vdc, within the -28.5 ±2.5 vdc limit. The APS firing enable command and the APS bus power were turned on. A series of tests were then conducted to verify the proper operation of the APS engine valve solenoids. The attitude control nozzle commands were turned on and the appropriate APS engine valve open indication voltage was measured through the AO and BO instrumentation multiplexers.

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

Engineering comments noted that the continuous vent relay on indication was off during the initial conditions scan due to a wiring error, but that this had no effect on the test. SEO 1B66566-002 was written to correct this condition. There were no part shortages and no problems were encountered during the test. No FARR's were written and no revisions were made to the procedure.

4.2.19.1 Test Data Table, Auxiliary Propulsion System

Attitude Control Nozzle Command			APS Engine	Valve Open Indication Voltage (vdc) AO Multi.	BO Multi.	Limits
Nozzle I	IV	On	1-1 or 1-3	4.261	4.271	4.3 ±0.250
		Off	1-1 or 1-3	0.000	-	0.0 ±0.25
Nozzle I	II	On	1-1 or 1-3	4.251	4.261	4.3 ±0.250
		Off	1-1 or 1-3	0.005	-	0.0 ±0.25
Nozzle I	P	On	1-2	4.292	4.302	4.3 ±0.250
		Off	1-2	0.000	-	0.0 ±0.25

4.2.19.1 (Continued)

Attitude Control Nozzle Command			APS Engine	Valve Open Indication Voltage (vdc) AO Multi.	BO Multi.	Limits
Nozzle III	II	On	2-1 or 2-3	4.163	4.158	4.1 ±0.250
		Off	2-1 or 2-3	0.000	-	0.0 ±0.25
Nozzle III	IV	On	2-1 or 2-3	4.107	4.122	4.1 ±0.250
		Off	2-1 or 2-3	0.000	-	0.0 ±0.25
Nozzle III	P	On	2-2	4.220	4.230	4.1 ±0.250
		Off	2-2	-0.005	-	0.0 ±0.25

4.2.20 Exploding Bridgewire System (1B66566 E)

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

Part Name	Ref Location	P/N	S/N
Ullage Rocket Ignition System			
EBW Firing Unit	404A47A1	40M39515-113	305
EBW Firing Unit	404A47A2	40M39515-113	307
Pulse Sensor*	404A47A4A1	40M02852	538
Pulse Sensor*	404A47A4A2	40M02852	491
*On Pulse Sensor Bracket Assembly	404A47A4	1B52640-1	9
Ullage Rocket Jettison System			
EBW Firing Unit	404A75A1	40M39515-113	308
EBW Firing Unit	404A75A2	40M39515-113	309
Pulse Sensor**	404A75A10A1	40M02852	-
Pulse Sensor**	404A75A10A2	40M02852	-
**On Pulse Sensor Bracket Assembly	404A75A10	1A97791-501	7

This procedure was accomplished on 17 June 1968, and was accepted on 25 June 1968. Throughout this procedure, the charged condition of each EBW firing unit was determined by verifying that the firing unit voltage indication measured 4.2 ±0.3 vdc, while the uncharged or discharged condition was determined by verifying that the voltage indication measured 0.0 ±0.3 vdc or, during the firing unit disable test only, 0.2 ±0.3 vdc.

4.2.20 (Continued)

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

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

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

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

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

Engineering comments noted that there were no parts shortages affecting this test. No stage problems were encountered during this test and no FARR's were written. One revision was made to the pre-test instructions which deleted the requirement for the continuous vent relay indication to be on during the initial conditions scan. This indication was off due to a wiring error, but had no effect on the test. SEO 1B66966-002 was written to cure this condition.

4.2.21 <u>Fuel Tank Pressurization System Leak Check (1B59456 C)</u>

This manual procedure leak checked the LH2 tank pressurization system prior to its use during automatic procedures. The pressurization system consisted of the ground pressurization line from the aft umbilical and the flight pressurization line from the J-2 engine, both to the pressurization control module; the pressurization line from the control module to the LH2 tank forward dome; and the tank ullage pressure sensing lines leading to pressure switches and

4.2.21 (Continued)

transducers. The repressurization line from the O2H2 burner to the LH2 tank was also leak checked during this test. The flight pressurization line was checked during the J-2 engine system leak check, and not as part of this procedure. Leaks were detected by the use of a USON leak detector or leak detection bubble fluid.

The procedure was initiated on 17 June 1968 and completed and accepted on 19 June 1968, after 3 days of activity. The facilities pneumatic lines were connected to the stage aft umbilical plate and the LH2 tank pressurization system was set up for the test. The LH2 tank repressurization helium coil of the O2H2 burner was pressurized to 400 $\pm$10 psig with helium, and the connections were leak checked. For a helium coil pressure decay check, the pressure was measured as 403 psig both before and after a 30 minute delay, meeting the requirement of no pressure decay during this period. The helium coil was vented at the end of this test.

The GSE Model 321 pneumatic console was then set up and pressurized. The LH2 prepressurization supply valve was momentarily opened while it was audibly verified that there was no gross leakage in the stage LH2 tank pressurization system. The supply valve was reopened and the stage system was pressurized to 400 $\pm$50 psig with helium. Leak checks were then conducted on all connections and lines of the system. The LH2 tank pressurization module check valve reverse seat leakage was measured as zero scim, meeting the 10 scim maximum leakage limit.

The LH2 tank pressure switch checkout supply lines were pressurized to between 40 and 45 psig with helium, and leak checked. The LH2 pressure switch diaphragms were leak checked and no leakage was found.

Engineering comments noted that there were no parts shortages affecting this test and no FARR's were written. One leak was found during the test at the connection between the LH2 tank pressure intermediate pipe assembly, P/N 1A98355, and the LH2 tank pressurization pipe assembly, P/N 1B64168. The leak was corrected by replacing the defective conoseal at the pipe connection.

There were two revisions made to the procedure for the following:

a. One revision added a step to the procedure to disconnect and cap pipe assemblies, P/N 1B62874-1 and 1B66843-1, to prevent the passage of gases through the burner solenoid valves via the pilot bleed line, P/N 1B62874-1, into the cold helium spheres.

b. One revision deleted a step so the LH2 supply and bleed lines would be left disconnected, until the repressurization systems test, to prevent unseating of the shutoff valves during other tests.

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

The propulsion system control console, P/N 1A65728-1, remotely controlled and monitored the stage propulsion system during automatic and manual checkout operations in the VCL. Prior to using the console, this procedure ensured that the stage-mounted solenoid valves responded properly when the various electrical command switches on the console were operated. The checkout consisted of separate tests on valves in the forward skirt area, the aft skirt area, and the thrust structure area. A test of the O2H2 burner spark igniter system was also accomplished.

Initiated on 17 June 1968, the procedure was completed and accepted on 24 June 1968, after 5 days of activity. The proper actuation and deactuation of the solenoid valves was verified by listening for valve actuation at the appropriate modules, and it was verified that the correct indicator lights came on, on the Mainstage Propulsion Manual Control Panel of the control console.

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

In the aft skirt area, the valves checked were the main fuel tank fill and drain valve open/close solenoid valve 404A44L1 and boost close solenoid valve 404A44L2; the main oxidizer tank fill and drain valve open/close solenoid valve 404A9L1 and boost close solenoid valve 404A9L2; the LH2 and LOX chill-down shutoff valve close/open solenoid valve 404A43L1; the LH2 and LOX prevalve close/open solenoid valve 404A43L2; the O2H2 burner LH2 propellant valve open solenoid valve 404A17L1, and close solenoid valve 404A17L2; and the O2H2 burner LOX propellant valve open solenoid valve 403A15L1, and close solenoid valve 403A15L2. The LH2 and LOX repressurization valves were checked by indicator light response only.

In the thrust structure area, the valves checked were the main oxidizer vent valve open/close solenoid valve 403A75A1L1 and boost close solenoid valve 403A75A1L2; the control helium shutoff valve close/open solenoid valve 403A73A1L2 and the start tank vent valve open/close solenoid valve 403A73A1L1, both in the pneumatic control module; the ambient helium sphere dump valve open/close solenoid valve 403A73A5L1 in the ambient helium fill module; the cold helium dump valve open/close solenoid valve 403A74A2L1 in the cold helium fill module; the cold helium shutoff valve open/close solenoid valves 403A74A1L1 and 403A74A1L3 in the LOX tank pressurization control module; the engine control bottle vent valve open/close solenoid valve in the engine pneumatic power package; the LH2 tank repressurization dump valve open/close solenoid valve 403A73A4L1 in the LH2 repressurization module; and the LOX tank repressurization dump valve open/close solenoid valve 403A74A3L1 in the LOX repressurization module. All of the valves responded properly to the signals from the propulsion system control console.

4.2.22 (Continued)

This procedure was also used for spark igniter tests of the O2H2 burner, in conjunction with the O2H2 burner igniter tip alignment and manual spark check installation procedure, drawing 1B67337. Spark tests were initiated at the propulsion system control console, and proper operation of the tests were verified by the illumination of the spark test on lights at the console, and the presence of electric arcs at the stage spark igniter assembly.

Engineering comments noted that all parts were installed at the start of testing. One problem was encountered at the beginning of the test when it was found that there was no manual control for the LOX vent boost close and nonpropulsive vent valve boost close command. SEO 1B44773-006 was issued to rework the wiring on the stage program board assembly to correct this problem.

There were two FARR's written during the test as follows:

a. FARR 500-238-364 noted that the bolt, securing line, P/N 1B67829-1, to the O2H2 burner, was broken off. The broken bolt was removed from the blind nut and a new bolt was properly lubed and installed. The rework was acceptable for use.

b. FARR 500-238-381 rejected two helium heater igniter system igniters, P/N 1B59986-503, S/N's 48 and 60, because the center electrodes were bent approximately 30 degrees. The defective igniters S/N's 48 and 60 were removed and two new units, S/N's 58 and 59, were installed.

Three revisions were written against the procedure for the following:

a. One revision deleted a note in the procedure which stated that the igniter tips and exciters were cycle significant items. This revision was written to comply with EO 1B55424 "G".

b. One revision corrected a typing error.

c. One revision deleted the S-IB stage structures assembly, P/N 1A74634-1, from the end item requirements list, because this item was not required in this test.

4.2.23 Cold Helium System Leak Check (1B59458 C)

This manual leak and functional check verified the integrity of the cold helium system, and demonstrated the capability of the system to supply and regulate the helium gas used to pressurize the LOX tank. The particular items involved in this test included the cold helium spheres, P/N 1A48858-1, S/N's 1182, 1190, 1197, 1200, 1204, 1205, 1208, 1210, and 1220; the teflon wrapped plenum sphere,

4.2.23 (Continued)

P/N 1B58006-7, S/N 71; the cold helium dump module, P/N 1B57781-505, S/N 7; the LOX tank pressurization control module, P/N 1B42290-505, S/N 35; the LOX chilldown pump purge pressure switch S4, P/N 1B52624-515, S/N 49; the LOX prepressurization flight control pressure switch S8, P/N 1B52624-515, S/N 53; and the associated plumbing and manifold assemblies. The procedure also checked the dual repressurization system, including the O2H2 burner assembly, P/N 1B62600-509-009, S/N 15.

Initiated on 24 June 1968, the procedure was completed on 18 July 1968, after 5 days of activity, and was accepted on the same date. In general the leak checks were conducted by pressurizing the system with helium gas and using a helium leak detector or LOX compatible leak detection bubble solution to locate any leakage. Gross leakage was located by listening for audible escaping gas.

The GSE and stage test setups were accomplished, and the cold helium and dual repressurization systems were isolated from other systems. The LOX tank repressurization helium coil of the O2H2 burner was pressurized to 400 $\pm$10 psig and the connections were leak checked. For a helium coil pressure decay check the pressure was measured as 401.5 psig, before and after a 30 minute delay, showing that there was no pressure decay over this period. The helium coil was vented to ambient at the end of this test.

The LOX tank pressure switch checkout line was pressurized and leak checked from the aft umbilical disconnect to the LOX chilldown pump purge and prepressurization flight control pressure switches. It was verified that there was no leakage through the diaphragm of either calips pressure switch. At the end of this check, the checkout line was vented to ambient pressure.

The cold helium spheres were pressurized to 50 psig, the system was verified to have no gross leakage upstream or downstream of the control module, and the proper operation of the cold helium dump valve was verified. The LOX pressurization system downstream of the control module was then vented to ambient. The cold helium spheres were pressurized to 500 psia and it was verified that the cold helium regulator discharge pressure did not increase as the spheres were pressurized. The cold helium spheres were then pressurized to 950, +0, -25 psia and held at this pressure for 3 minutes for an integrity test. Following the integrity test the spheres were vented to 825 $\pm$25 psia and leak checks were conducted on the cold helium and dual repressurization systems upstream of the pressurization control module, and from the cold helium dump module to the helium spheres manifold. During these checks the combined valve leakage of the cold helium shutoff valves and the LOX burner solenoid valves was measured as zero scim, meeting the 25 scim combined leakage limit. The helium spheres were then vented to 500 psig while the cold helium dump line was checked for audible leakage. The seat leakage of the

4.2.23 (Continued)

cold helium dump and relief valve was verified to be less than the 12.5 scim maximum leakage limit.

The cold helium shutoff valves were verified to operate properly, leak checks were conducted on the cold helium and dual repressurization systems downstream of the pressurization control module, and the LH2 and LOX repressurization valves were verified to operate properly. A special check was made to determine the flowrate decay when the cold helium shutoff valves were closed while gas was flowing. The shutoff valves were opened and the cold helium spheres were vented to 450 +0, -50 psia. The cold helium shutoff valves were then closed, and measurements were made of the vented gas flowrate through the LOX pressurization line. The decay could not be established, as three measurements taken a few seconds apart all indicated 10,000 scim while a fourth measurement indicated 0 scim. After the completion of these checks the cold helium and dual repressurization systems were vented to ambient and the stage was returned to the pre-test configuration.

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

a. The cold helium dump module 403A74A2, P/N 1B57781-505, S/N 39, had a dump and relief valve seat leakage of 37.5 scim, exceeding the 12.5 scim maximum limit. By AO paper action, the module was removed and a new cold helium dump module, P/N 1B57781-507, S/N 7, was installed. The new unit was tested and accepted for use.

b. Leaks at the upstream B-nut of pipe assembly, P/N 1B67464-1, at the upstream B-nut of pipe assembly, P/N 1B67466-1, and at the inlet B-nut of pipe assembly, P/N 1B52441-1, were all corrected by retightening the B-nuts to the proper torque value.

c. A leak at adapter, P/N MFC 62339-075-12, on the LOX tank pressurization control module 403A74A1, was corrected by replacing the conoseal and gasket in the adapter flange.

One additional leak was corrected by FARR action. FARR 500-238-429 rejected pipe weld assembly, P/N 1B62801-1, for leakage due to scratches in the tapered face of the threaded cross fitting. The damaged pipe assembly was removed, and a new assembly was installed and accepted for use.

4.2.23 (Continued)

Eight revisions were made to the procedure:

a. Three revisions changed or corrected referenced part numbers. A pipe assembly, listed as P/N 1B67049-1, was changed to be P/N 1B68899-1, to reflect a plumbing change for the LOX nonpropulsive vent valve. A pipe assembly, listed as P/N 1B66839-1, was changed to be P/N 1B69840-1, to reflect the removal of a check valve and the replacement of a burner supply line. An adapter, listed as P/N 1B2432-501 by a typing error, was corrected to be P/N 1B52432-501.

b. Two revisions deleted the steps that disconnected the LH2 pressurization line, and added a step to vent this line after the completion of the test. The LH2 pressurization line was not readily accessible for disconnection and capping, so it was left connected and allowed to pressurize during the O2H2 burner check. It was then necessary to vent the line to ambient pressure.

c. One revision specified additional lines that were to be leak checked, to correct a procedure omission.

d. One revision added the steps to accomplish the final flowrate decay test when the cold helium shutoff valves were closed while gas was flowing.

e. One revision added a step to check the torque value of the four bolts, P/N NAS 1006-9H, securing gasket, P/N 51134-150 A1, to the LOX pressurization control module. The torque was checked because the connection had been subjected to expansion and contraction at ambient temperatures for 3 months following the initial tightening. All four bolts had a torque value of 80 inch-pounds, meeting the 70 to 80 inch-pounds requirement of DPS 10040.

4.2.24 <u>Propellant Utilization System Calibration (1B64367 H</u>)

Calibration and operation instructions for the propellant utilization (PU) system were provided by this manual checkout. For calibration purposes, the propellant utilization test set (PUT/S), P/N 1A68014-2, was utilized to provide varying capacitance inputs to the propellant utilization electronics assembly (PUEA) to simulate the LOX and LH2 mass probe outputs under varying propellant load conditions.

4.2.24 (Continued)

The items involved in this test included:

Part Name	Ref Location	P/N	S/N
Propellant Utilization Electronics Assy	411A92A6	1A59358-529	034
Static Inverter-Converter	411A92A7	1A66212-507	030
LOX Mass Probe	406A1	1A48430-511	D2/C5
LH2 Mass Probe	408A1	1A48431-505	121
LOX Overfill Sensor	(Part of LOX Mass Probe)		
LOX Overfill Control Unit	404A72A4	1A68710-511	D109
LOX Fastfill Sensor	406A2C5	1A68710-1	D79
LOX Fastfill Control Unit	404A72A5	1A68710-511	C91
LH2 Overfill Sensor	(Part of LH2 Mass Probe)		
LH2 Overfill Control Unit	411A92A24	1A68710-509	C68
LH2 Fastfill Sensor	408A2C5	1A68710-1	C2
LH2 Fastfill Control Unit	411A92A43	1A68710-509	C60

Initiated on 25 June 1968, the first issue of this procedure was completed on 29 June 1968, with acceptance occurring on 18 July 1968. A portion of the procedure was rerun on 8 July 1968, to verify that the PU boiloff bias voltage indication, given during the PU automatic procedure, was correct. The second issue was initiated and completed on 19 August 1968, with acceptance occurring on 22 August 1968. The second issue was required because the LOX PU probe conoseal was removed and replaced to correct a leak, during the propellant tank leak checks. The values obtained agreed with the data from the first issue; therefore, the narration and Test Data Table 4.2.24.1 that follow cover the second issue of the procedure.

Megohm resistance measurements were made on both 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 and the static inverter-converter, and the stage power for these units was manually turned on. The static inverter-converter voltages and the operating frequency, were then measured.

The PUEA bridge calibrations were conducted next. Simulated empty conditions were established with the PUT/S, and the PUEA LH2 and LOX bridge empty calibrations were accomplished by nulling the bridge tap voltages with the PUT/S ratiometer, at settings of 0.02017 for the LH2 bridge and 0.02026 for the LOX bridge, and then nulling the bridge outputs 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 210 picofarads and a C2 capacitor (LOX) setting of 128 picofarads, and the ratiometer was set to 0.84108. To accomplish the PUEA LH2 and LOX bridge full calibrations, the bridge outputs were nulled by adjusting the PUEA R4 potentiometer for the LH2 bridge and the PUEA R3 potentiometer for the LOX bridge.

4.2.24 (Continued)

Data acquisition was verified by establishing simulated empty and full conditions with the PUT/S, and adjusting the PUT/S ratiometer to null the PUEA 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 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, 0.00004, was multiplied by 98.4 vdc to give a reference voltage of 0.003936 vdc. Simulated empty conditions were established with the PUT/S, and the PUEA residual empty bias R6 potentiometer was adjusted to give the reference voltage output. Simulated full conditions were then established with the PUT/S, and the PUEA residual full bias R5 potentiometer was adjusted to null the RMR bias voltage. For a fuel boiloff bias calibration, simulated boiloff conditions were established with the PUT/S, using a C1 capacitor (LH2) setting of 244 picofarads and a C2 capacitor (LOX) setting of 128 picofarads. The PUEA fuel bias R7 potentiometer was then adjusted to null the RMR bias voltage.

PUEA 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 adjusting the PUT/S ratiometer to null the appropriate PUEA bridge output.

For a fuel boiloff bias data acquisition check, the RMR bias voltage was measured as -2.8 mvdc under simulated empty conditions, and as 10.36 vdc under bias internal test conditions. The fuel boiloff bias voltage was the difference between these measurements, 10.36 vdc. A fuel boiloff bias limitation check was accomplished by adjusting the PUEA fuel bias R7 potentiometer fully counterclockwise, setting the PUT/S C2 capacitor (LOX) to zero picofarads, and adjusting the C1 capacitor (LH2) to null the RMR bias voltage. The capacitor null setting was 67.2 picofarads, meeting the 48 picofarads minimum requirement. The PUT/S C1 capacitor was then set to zero picofarads and the LH2 boiloff bias voltage was measured as 19.93 vdc. The fuel boiloff bias calibration was repeated as before to re-establish the PUEA fuel bias R7 potentiometer setting.

The hardwire loading circuits were checked by establishing simulated full conditions with the PUT/S, setting the PUT/S ratiometer to 0.00000, and measuring the hardwire loading circuit PUEA LH2 and LOX bridge output voltages. Both voltages were 23.32 vdc, meeting the 23.52 $\pm$2.0 vdc requirements. This completed the propellant utilization system calibration.

There were no parts shortages affecting this test. No problems were encountered during the second issue of this procedure; however, two FARR's were generated during operation of the first issue. The FARR's were for the following:

a. FARR 500-238-411 documented that pin u of the J1 connector of bus module, P/N 1B57771-559, was bent approximately 30 degrees. The bent pin was straightened per DPS 54002. It was also noted that the grommet of connector P21 of wire harness, P/N 1B66969, was punctured between pins DD and EE. The defective connector was removed and a new one was installed. The rework was acceptable.

4.2.24 (Continued)

b. FARR 500-238-437 documented that two wires were missing from the wire harness, P/N 1B66969. The wire harness was reworked per advance EO "G". The rework was acceptable.

Twelve revisions were written against the first issue. The same revisions were recorded in the second issue, and are as follows:

a. One revision added instructions to monitor the PU oven and to verify that it rose to some stable value after turn on.

b. One revision added a note to verify that the counter chassis was grounded to the stage ground when checking the static inverter-converter frequency.

c. One revision changed the adjustment direction of R7 from clockwise to counterclockwise, because a design change to the boiloff bias circuitry changed the wiring to R7.

d. Four revisions corrected minor errors in the procedure.

e. Two revisions corrected typographical errors.

f. One revision raised the capacitance for potentiometer R7 to comply with the current design requirements of the boiloff bias circuit.

g. One revision added a step to disconnect the stage connector, reference designation 411W6P37, from J-2 of the static inverter-converter to permit connection of the PUT/S voltage breakout box to the static inverter-converter.

h. One revision added instructions to readjust R7 voltage to tolerance after it had been set to zero.

4.2.24.1 Test Data Table, Propellant Utilization System Calibration

LH2 Mass Probe Megohm Check, Plug 411W11P1

Function	Resistance (megohms)	Limits (megohms)
LH2 Probe Elements, Pins G to E	75k	1000 min
Pin G to Shield	3k	1000 min
Pin G to Stage Ground	16k	1000 min
Pin G Shield to Stage Ground	8k	1000 min
Pin E to Stage Ground	7k	1000 min

4.2.24.1 (Continued)

LOX Mass Probe Megohm Check, Plug 411W11P1

Function	Resistance (megohms)	Limits (megohms)
LOX Probe Elements, Pins A to C	40k	1000 min
Pin C to Shield	15k	1000 min
Pin C to Stage Ground	4k	1000 min
Pin C Shield to Stage Ground	2.1k	1000 min
Pin A to Stage Ground	2.1k	1000 min

Static Inverter-Converter Measurements

Function	Measurement	Limits
5.0 vdc Output Voltage (vdc)	4.948	4.50 to 5.10
21.1 vdc Output Voltage (vdc)	21.54	20.00 to 23.50
28.0 vdc Output Voltage (vdc)	27.60	26.00 to 30.00
117 vdc Output Voltage (vdc)	121.00	115.0 to 122.5
115 vrms Monitor Voltage (vdc)	2.728	2.23 to 3.18
Test Point 2 Voltage (vdc)	21.67	20.0 to 22.5
V/P Excitation Voltage (vdc)	50.27	48.884 to 52.030
Operating Frequence (Hz) (*)	399.2	394.0 to 406.0

Data Acquisition

Function	PUT/S Ratiometer	Limits
LH2 Empty	0.00026	0.00000 to 0.00168
LOX Empty	0.00030	0.00000 to 0.00168
LH2 Full	0.84107	0.83940 to 0.84276
LOX Full	0.84118	0.83940 to 0.84276

Bridge Slew Checks

Function	PUT/S Ratiometer	Limits
LH2 1/3 Slew	0.27627	*
LH2 2/3 Slew	0.56410	*
LOX 1/3 Slew	0.27060	*
LOX 2/3 Slew	0.56561	*

LH2 Bridge Linearity Check

PUT/S C1 Value	PUT/S Ratiometer	Limits
42 pf	0.16813	0.16653 to 0.16990
84 pf	0.33568	0.33475 to 0.33811
126 pf	0.50410	0.50297 to 0.50633
168 pf	0.67218	0.67118 to 0.67455
210 pf	0.84117	0.83940 to 0.84276

* Limits not Specified

4.2.24.1 (Continued)

LOX Bridge Linearity Check

PUT/S C2 Value	PUT/S Ratiometer	Limits
25.60 pf	0.16749	0.16653 to 0.16990
51.20 pf	0.33593	0.33475 to 0.33811
76.80 pf	0.50410	0.50297 to 0.50633
102.40 pf	0.67192	0.67118 to 0.67455
128.00 pf	0.84118	0.83940 to 0.84276

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

The manual leak check of the J-2 engine system was subdivided into two separate procedures. The J-2 engine leak check began with the pressurization, leak check, and depressurization of the start sphere. This was followed by a pressurization and leak check of the control sphere, and leak checks of the pneumatic lines with the mainstage control, helium control, ignition phase control, and start tank discharge control solenoids energized and de-energized. The thrust chamber leak check involved pressurization of the chamber, and leak checks of the system, under pressure, downstream of the main fuel and oxidizer valves, and the engine portion of the LH2 tank pressurization system.

Initiated on 28 June 1968, the procedure was completed 24 July 1968, after 4 days of activity, and was accepted on 26 July 1968. Helium gas was used for pressurization during this procedure, and leakage was detected by the use of a USON leak detector, leak detection fluid, or, for engine connections having leak detection ports, a Rocketdyne G3104 flow tester.

The thrust chamber leak check was accomplished first. After the test configuration was established, the thrust chamber was pressurized to 30 $\pm$5 psig. Leak checks were then conducted on the thrust chamber purge and chilldown line, and on those system lines and connections that were pressurized. The flapper valve, P/N 1B53920-501, on the LH2 pressurization line, was verified to be in the proper orientation. The engine start tank and the thrust chamber were then vented to ambient to complete this part of the test.

The J-2 engine leak check was accomplished next. After the test configuration was established, the checkout line for the mainstage OK pressure switches was pressurized to 500 $\pm$10 psig and leak checked. For a pressure switch pressure decay check, the checkout line pressure was measured as 502.5 psig, and remeasured as 502.5 psig after a 30 minute period. This was within the 2 psi pressure change allowed for temperature change effects. The checkout line was then vented to ambient, and the pneumatic control sphere was pressurized to 245, +10, -20, psia.

The engine start tank was then pressurized to 100 psia, the proper operation of the start tank vent valve was verified, and the start tank vent line was leak checked. The start tank was then pressurized to 550 $\pm$25 psia for an

4.2.25 (Continued)

integrity check, with checks made at 200 and 400 psia to verify that there was no gross leakage. The integrity pressure was held for 3 minutes, then the tank was vented to 485 $\pm$25 psia, the start tank fill line was leak checked, and the tank was vented to ambient.

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

Engineering comments noted that there were no parts shortages affecting this test. Two leaks found during this procedure were corrected as follows:

a. One leak was repaired by retightening the B-nut.

b. One leak was repaired by removing and replacing the quick-disconnect, P/N 1A49958-517, S/N 85, at the aft umbilical carrier location 27.

An IIS, 402825, was written to document a dirty injector face and possible thrust chamber bell interior contamination. The injector face and thrust chamber were reworked by Rocketdyne personnel. The IIS also documented the excessive leakage of the quick-disconnect mentioned previously. The quick-disconnect discrepancy was recapped to FARR 500-238-461, which was dispositioned to remove and replace S/N 85. Quick-disconnect S/N 40 was installed as a replacement part. The rework was acceptable.

Twelve revisions were written against the procedure for the following:

a. One revision was written to correct a typing error.

b. One revision deleted the 9026182 Rocketdyne injector shield because the G3120HD2 throat plugs had been modified to G3120HD3 and the injector shield was no longer required.

c. One revision changed two steps to "Verify/Connect..." instead of "Connect..." umbilicals as the umbilicals were normally installed per the aft umbilical kit procedure, H&CO 1B57918.

4.2.25 (Continued)

d. One revision clarified the type of throat plug, eliminated the use of the injector shield, and specified the instructions to be used for seating the dry throat plug.

e. One revision was written to permit verification of isolation, or isolation of the LH2 tank pressurization line and the LH2 repressurization system, although both connections were normally isolated per H&CO 1B59456; however, in the event the test was to be run out of sequence, this revision provided the necessary instructions to accomplish the setup.

f. One revision increased the allowable pressure of the pneumatic control sphere from 245 +10, -20 psig to 500 ±50 psig, per NASA letter I-V-5-IVB-L-68-108, dated 27 March 1968.

g. One revision provided instructions to permit a leak check of the repressurization line at the operating pressures normally associated with flight.

h. One revision corrected a minor procedural error.

i. One revision deleted two steps requiring the removal of the hand valve and adapter from the LH2 tank pressurization line and the reconnection of the LH2 tank pressurization line, the LH2 repressurization supply line, and the pilot bleed line. The hand valve was required for further testing and the supply and bleed lines would be reconnected in later procedures as required.

j. One variation revision was written to provide instructions for the thrust chamber leak check and shutdown because the Rocketdyne dry throat plug, P/N G3120MD3, could not be utilized as the procedure was originally written.

k. One revision was written to delete another revision.

4.2.26 Auxiliary Propulsion System Checkout (1B69403 NC)

After the installation of the auxiliary propulsion system (APS) modules onto the stage, this manual procedure ensured that the modules operated properly, and that there was no excessive leakage in the system. The ability of the GSE propulsion control console to control the solenoid valves in the APS modules was also verified. Both APS modules, P/N 1A83918-535, S/N's 509-1 and 509-2, were tested by this procedure.

Initiated on 29 June 1968, after the APS module installation was accomplished, this procedure was completed on 17 September 1968 and was accepted on 18 September 1968. The procedure was active 6 days during this period. After the completion of this procedure, the APS modules were removed from the stage for separate shipment to STC.

4.2.26 (Continued)

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

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

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

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

The APS modules were then prepared for use in the APS automatic checkout procedure, H&CO 1B69571 (paragraph 4.2.29), and the all systems test procedure, H&CO 1B66571 (paragraph 4.2.37). The test setups were made and verified, and the required gas pressures were supplied from the GSE. For the all systems test, the APS engine throat plugs were installed prior to the test, and were removed after the test. After these tests were completed, the module desiccants were replaced, and the blanket pressures were re-established as before.

4.2.26 (Continued)

Low pressure decay checks were then conducted on the fuel and oxidizer propellant systems of each APS module. The systems were vented to ambient pressure and repressurized to 23 ± 3 psig with helium. The pressure loss over a 1-hour period was then measured, as shown in Test Data Table 4.2.26.1. At the end of this check, the fuel and oxidizer systems were vented to ambient, and the blanket pressures were re-established.

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

Engineering comments noted that the 70 pound thrust ullage engine, P/N 15-210005, was not installed in either APS module during this test. The attitude control relay modules, 404A71A19, P/N 50M35076-1, S/N 322, and 404A51A4, P/N 50M35076-1, S/N 332, were both interim use parts. Two GSE problems required the retightening of a union on a pressure line, and the replacement of a ground half quick disconnect, P/N 7851823-505. A broken nutplate was replaced on APS module 2. No other problems were encountered during the test, and no stage FARR's were written.

Twenty-seven revisions were made to the procedure, with two of these subsequently deleted. The remaining revisions were:

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

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

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

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

e. Two revisions changed the preparations for the all systems test. An instruction was added to install the throat plugs from the Model 770 kit into the engines of APS modules 1 and 2, to provide the proper setup. A note was also added to remove the throat plugs and reinstall

4.2.26 (Continued)

the desiccant covers if the all systems test was to be inactive for a period of 72 hours or longer, and to reinstall the throat plugs before restarting the test. This was to ensure minimum exposure of the APS engines to possible corrosion and contamination.

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

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

h. One revision added steps to properly secure from the APS automatic procedure by removing the APS engine throat plugs, replacing the desiccants, and re-establishing blanket pressures in the APS modules.

i. Two revisions deleted two previous revisions that had been made in error.

4.2.26.1 Test Data Table, Auxiliary Propulsion System Checkout

Low Pressure Decay Check

Function	Pressure Meas. (psig) Start	End	Pressure Loss (psi) Meas.	Limit
APS 1 Fuel System	25.0	24.2	0.8	5.0
APS 1 Oxidizer System	23.0	22.2	0.8	5.0
APS 2 Fuel System	24.0	23.3	0.7	5.0
APS 2 Oxidizer System	24.0	23.2	0.8	5.0

4.2.26.1 (Continued)

Diode Integrity Check, APS 1, Wire Harness 414W1

Connector and Pin		Resistance (ohms)	
From (-)	To (+)	Measured	Limits
P6-c	P6-L	4.8	4.5 ±2.0
P6-d	P6-L	4.5	4.5 ±2.0
P6-e	P6-L	4.8	4.5 ±2.0
P6-f	P6-L	4.6	4.5 ±2.0
P6-b	P6-M	4.8	4.5 ±2.0
P6-a	P6-L	4.0	4.5 ±2.0
P6-T	P6-J	4.0	4.5 ±2.0
P6-U	P6-J	4.0	4.5 ±2.0
P6-P	P7-H	21.0	17.0 ±7.0
P6-N	P6-K	20.0	17.0 ±7.0

Diode Integrity Check, APS 2, Wire Harness 415W1

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

4.2.27 Propellant Utilization System (1B66567 E)

This automatic checkout procedure verified the ability of the propellant utilization system to determine and control the engine propellant flow mixture ratio to ensure simultaneous propellant depletion, and to provide propellant level information to control the fill and topping valves during LOX and LH2 loading. This test involved all components of the stage propulsion utilization system, including the propellant utilization valve in the J-2 engine, and the following:

Part	Ref. Location	P/N	S/N
Propellant Utilization Electronics Assembly (PUEA)	411A92A6	1A59358-529	034
Static Inverter-Converter	411A92A7	1A66212-507	030

4.2.27 (Continued)

Part	Ref. Location	P/N	S/N
LOX Mass Probe	406A1	1A48430-511	D2/C5
LH2 Mass Probe	408A1	1A48431-505	121
LOX Overfill Sensor	(Part of LOX Mass Probe)		
LOX Overfill Control Unit	404A72A4	1A68710-511	D109
LOX Fast Fill Sensor	406A2C5	1A68710-1	D79
LOX Fast Fill Control Unit	404A72A5	1A68710-511	C91
LH2 Overfill Sensor	(Part of LH2 Mass Probe)		
LH2 Overfill Control Unit	411A92A24	1A68710-509	C68
LH2 Fast Fill Sensor	408A2C5	1A68710-1	C2
LH2 Fast Fill Control Unit	411A92A43	1A68710-509	C60

The first issue of the procedure was initiated on 5 July 1968, and was successfully completed on 8 July 1968. A second run was required due to several program errors and an out-of-tolerance indication for the boiloff bias voltage. It was verified that the boiloff bias voltage was acceptable. The program errors were corrected and the second run of the first issue was successfully completed. The first issue was signed acceptable to Engineering on 16 July 1968.

The second issue of the procedure was initiated on 20 August 1968, and was successfully completed on 21 August 1968. A second run was required due to an out-of-tolerance indication for the 1 vdc system test valve position signal. After several retries were successfully passed without a malfunction type out, the tape was dumped and evaluated. The evaluation revealed that the computer had momentarily malfunctioned, causing the malfunction typeout. The second run of the second issue was successfully completed without malfunctions. The second issue was signed acceptable to Engineering on 23 August 1968. The operation and test results described in this paragraph and Test Data Table 4.2.27.1 are from the second issue procedure. The test data received during the first issue procedure were compatible with the second issue data.

After initial conditions were established, ratio values were obtained from the manual Propellant Utilization System Calibration procedure, H&CO 1B64367, and loaded into the computer. From these ratio values, nominal test values were computed for LOX and LH2 coarse mass voltages, fine mass voltage, and loading voltages. The propellant utilization (PU) system power test was conducted first. Power was applied to the PU inverter and electronics, then the static inverter-converter output voltages and operating frequency were measured.

The PU oven temperature was monitored for an output voltage of 2.65 $\pm$2.35 vdc to verify that the static inverter-converter had stabilized. Then, after the oven had stabilized, it was verified that the PUEA amplifier was properly

4.2.27 (Continued)

calibrated by measuring the PU oven output voltage with the high RAC set, the RACS system run mode turned on, and the low RAC set. The RACS system run mode was then set and a final measurement was taken to complete the PU system power test.

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

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

The servo balance bridge gain test was conducted next. The ratio valve position was measured, and the LOX and LH2 coarse and fine mass voltages were measured through both the AO and BO telemetry multiplexers. The measurements were 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 fast fill sensors and their associated control units responded properly under ambient (dry) conditions and under simulated wet conditions of the sensors.

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

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

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

4.2.27 (Continued)

Engineering comments noted that two program delay statements for the inverter-converter stabilization were typed out with delays in excess of 10 hours. The delays should have been typed out as 15 minutes and 30 minutes, respectively. The program had been changed and the time delays were executed correctly, but the corrections necessary to type out the correct delay time had not been implemented. There were no parts shortages at the start of this test. No FARR's were written as a result of this test.

There were eight revisions written against the first issue procedure; however, one revision was subsequently deleted. The revisions incorporated in the first issue were also incorporated in the second issue. The revision incorporated in both issues were for the following:

a. One revision changed the PU oven monitor voltage from ±0.03 to ±0.075 vdc.

b. Three revisions corrected minor program errors.

c. One revision correctly computed the remaining delay time for the inverter-converter stabilization type statements.

d. One revision deleted the instructions to adjust the Honeywell strip chart recorder blue pin for the midscale reading because the recorder had been set up per the system setup.

e. One revision corrected a channel number and added the name of the measurement applicable to that channel.

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

<u>Loaded Ratio Values (from H&CO 1B64367)</u>

LOX Empty Ratio	0.000	LOX 1/3 Bridge Slew Ratio	0.270
LH2 Empty Ratio	0.000	LOX 2/3 Bridge Slew Ratio	0.565
LH2 Boiloff Bias Voltage	10.360	LH2 1/3 Bridge Slew Ratio	0.276
		LH2 2/3 Bridge Slew Ratio	0.564
LOX Wiper Ratio	0.020		
LH2 Wiper Ratio	0.020		

<u>Computed Coarse Mass Voltages</u>

LOX Empty	0.000	LH2 Empty	0.000
LOX 1/3 Mass	1.348	LH2 1/3 Mass	1.382
LOX 2/3 Mass	2.827	LH2 2/3 Mass	2.822

4.2.27.1 (Continued)

Computed Fine Mass Voltages

LOX Empty	1.953	LH2 Empty	1.953
LOX 1/3 Mass	1.587	LH2 1/3 Mass	0.918
LOX 2/3 Mass	2.588	LH2 2/3 Mass	2.686

Computed Loading Voltages

LOX Empty	0.000	LH2 Empty	0.000
LOX 1/3 Coarse Mass	7.547	LH2 1/3 Coarse Mass	7.738

PU System Power Test

Function	Measured Value	Acceptable Limits
Inverter-Converter 115 vrms (vac)	114.553	115 ±3.4
Inverter-Converter 21 vdc (vdc)	21.805	21.25 ±1.25
Inverter-Converter 5 vdc (vdc)	5.009	4.9 ±0.2
Inverter-Converter Frequency (Hz)	399.695	400 ±6
	2.030	2.65 ±2.35
PU Oven Monitor Voltage Z1 (vdc)	2.030	2.65 ±2.35
PU Oven Monitor Voltage Z2 (vdc)	2.030	2.030 ±0.075
PU Oven Monitor Voltage Z3 (vdc)	2.030	2.030 ±0.075
PU Oven Monitor Voltage - Final (vdc)	2.030	*
PU Oven Monitor Voltage - High RAC (vdc)	3.994	4.0 ±0.075
PU Oven Monitor Voltage - RACS Run Mode On (vdc)	2.025	2.030 ±0.075
PU Oven Monitor Voltage - Low RAC (vdc)	0.000	0.000 ±0.75
PU Oven Monitor Voltage - RACS Run Mode Set (vdc)	2.025	2.030 ±0.075

Bridge Balance and Ratio Valve Null Test

Function	Measured Value	AO Multi-plexer	BO Multi-plexer	Limits
Ratio Valve Position	0.282 deg			0.0 ±1.5
LOX Coarse Mass Voltage		-0.015 vdc	-0.010 vdc	0.0 ±0.1
LOX Fine Mass Voltage		1.973 vdc	1.973 vdc	1.953 ±0.4
LH2 Coarse Mass Voltage		-0.005 vdc	-0.015 vdc	0.0 ±0.1
LH2 Fine Mass Voltage		1.953 vdc	1.953 vdc	1.953 ±0.4

PU Loading Test

Function	Measured Value	Acceptable Limits
LH2 Boiloff Bias Signal Voltage (vdc)	11.437 vdc	10.36 to 12.36
GSE Power Supply Voltage (vdc)	28.839	28 ±2

*Limits Not Specified

4.2.27.1 (Continued)

Loading Potentiometer Function	LOX Value	LH2 Value	Limits
Sense Voltage, GSE Power On (vdc)	28.839	28.759	GSE Pwr ±0.4
Signal Voltage, 1/3 Relay Commands Off (vdc)	0.000	-0.027	0.0 ±0.5
Signal Voltage, 1/3 Relay	7.410	-	7.547 ±0.6
Commands On (vdc)	-	7.656	7.738 ±0.6
Signal Voltage, 1/3 Relay Commands Off (vdc)	0.000	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 Multiplexer	BO Multiplexer	Limits
Ratio Valve Position	0.351 deg			0.282 ±1.5
LOX Coarse Mass Voltage (vdc)		-0.010	-0.015	0.0 ±0.1
LOX Fine Mass Voltage (vdc)		1.968	1.968	1.953 ±0.4
LH2 Coarse Mass Voltage (vdc)		-0.010	-0.015	0.0 ±0.1
LH2 Fine Mass Voltage (vdc)		1.943	1.943	1.953 ±0.4
1/3 Checkout Relay Commands On				
Ratio Valve Position	0.556 deg			0.282 ±1.5
LOX Coarse Mass Voltage (vdc)		1.343	1.343	1.348 ±0.1
LOX Fine Mass Voltage (vdc)		1.387	1.387	1.587 ±0.4
LH2 Coarse Mass Voltage (vdc)		1.367	1.367	1.382 ±0.1
LH2 Fine Mass Voltage (vdc)		0.835	0.835	0.918 ±0.4
2/3 Checkout Relay Commands On				
Ratio Valve Position	0.965 deg			0.282 ±1.5
LOX Coarse Mass Voltage (vdc)		2.822	2.817	2.827 ±0.1
LOX Fine Mass Voltage (vdc)		2.271	2.275	2.588 ±0.4
LH2 Coarse Mass Voltage (vdc)		2.813	2.813	2.822 ±0.1
LH2 Fine Mass Voltage (vdc)		2.432	2.437	2.686 ±0.4
2/3 Checkout Relay Commands Off				
Ratio Valve Position	0.761 deg			0.282 ±1.5
LOX Coarse Mass Voltage (vdc)		1.338	1.338	1.348 ±0.1
LOX Fine Mass Voltage (vdc)		1.387	1.387	1.587 ±0.4
LH2 Coarse Mass Voltage (vdc)		1.367	1.367	1.382 ±0.1
LH2 Fine Mass Voltage (vdc)		0.845	0.850	0.918 ±0.4
1/3 Checkout Relay Commands Off				
Ratio Valve Position	0.351 deg			0.282 ±1.5
LOX Coarse Mass Voltage (vdc)		-0.010	-0.005	0.0 ±0.1
LOX Fine Mass Voltage (vdc)		1.958	1.968	1.953 ±0.4
LH2 Coarse Mass Voltage (vdc)		-0.010	-0.010	0.0 ±0.1
LH2 Fine Mass Voltage (vdc)		1.943	1.948	1.953 ±0.4

4.2.27.1 (Continued)

PU Valve Movement Test

Function	Measured Value	Acceptable Limits
Ratio Valve Position, AO (deg)	0.419	0.282 ±1.50
Ratio Valve Position, BO (deg)	0.351	0.282 ±1.50

50 Second Plus Valve Slew, AO Multiplexer

+1 vdc System Test Valve Position Signal (vdc)	0.994	1.0 ±0.020
V1, Position at T+3 Seconds (deg)	3.955	2.037 to 6.351
V2, Position at T+5 Seconds (deg)	4.909	2.659 to 7.396
V3, Position at T+8 Seconds (deg)	5.386	2.977 to 7.396
V4, Position at T+20 Seconds (deg)	5.796	5.226 to 7.396
V5, Position at T+50 Seconds (deg)	5.728	5.226 to 7.296

50 Second Minus Valve Slew, AO Multiplexer

Ratio Valve Position, AO (deg)	0.419	0.282 ±1.50
-1 vdc System Test Valve Error Signal (vdc)	-0.999	-1.0 ±0.020
V1, Position at T+3 Seconds	-3.885	-2.037 to -6.351
V2, Position at T+5 Seconds	-4.976	-2.659 to -7.396
V3, Position at T+8 Seconds	-5.453	-2.977 to -7.396
V4, Position at T+20 Seconds	-5.590	-5.226 to -7.396
V5, Position at T+50 Seconds	-5.794	-5.226 to -7.296

PU Activation Test

Function	AO Multiplexer	BO Multiplexer	Limits
Ratio Valve Postion (deg)	0.078	0.010	0.282 ±1.50
LOX 1/3 Command Relay On			
LOX Coarse Mass Voltage (vdc)	1.338	1.338	1.348 ±0.1
PU System On			
Ratio Valve Postion (deg)	33.145	33.145	20.0 min
PU System Off			
Ratio Valve Position (deg)	0.692	0.624	15.0 max
LOX 1/3 Command Relay Off			
LOX Coarse Mass Voltage (vdc)	-0.010	-0.005	0.0 ±0.1
Ration Valve Position (deg)	0.351	0.351	0.282 ±1.50
LH2 1/3 Command Relay On			
LH2 Coarse Mass Voltage (vdc)	1.367	1.367	1.382 ±0.1
PU System On			
Ratio Valve Postion (deg)	-27.328	-27.328	-20.0 max
PU System Off			
Ratio Valve Position (deg)	0.282	-	-15.0 min
LH2 1/3 Command Relay Off			
LH2 Coarse Mass Voltage (vdc)	-0.010	-0.010	0.0 ±0.1
Ratio Valve Position (deg)	0.282	0.282	0.282 ±1.50
PU Valve Hardover Test			
Ratio Valve Position (deg)	-27.465	-	-20 max

4.2.28 Hydraulic System (1B66570 D)

This automatic procedure verified the integrity of the stage hydraulic system, and demonstrated the capability of the system to provide engine centering and control during powered flight. The test involved all components of the stage hydraulic system, including the hydraulic pump, P/N 1A66240-503, S/N X457805; the auxiliary hydraulic pump, P/N 1A66241-511, S/N X458915; the accumulator/reservoir assembly, P/N 1B29319-519, S/N 35; the hydraulic pitch actuator, P/N 1A66248-507, S/N 83; and the hydraulic yaw actuator, P/N 1A66248-507, S/N 85.

The procedure was satisfactorily accomplished by the second attempt on 9 July 1968, and was accepted on 17 July 1968. The first attempt was terminated after the DDAS dropped out of synchronization, causing data to be incorrectly stored, and resulting in out-of-tolerance indications for the pitch and yaw positions. Those function values measured during the acceptable attempt are presented in Test Data Table 4.2.28.1. All of these values were acceptable and were within general design requirements, although specific limit requirements were not discernible from the procedure for most of the measurements.

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

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

The engine centering tests were then conducted. The first test was conducted with the actuator position locks on and with the hydraulic system unpressurized. The actuator positions and the voltage of the IU substitute 5 volt power supply

4.2.28 (Continued)

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

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

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

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, the auxiliary hydraulic pump air tank and motor container air pressures, and the engine centering functions, with the hydraulic system pressurized, the actuator locks off, and no excitation signals applied to the actuators.

4.2.28 (Continued)

The procedure was completed by turning off the auxiliary hydraulic pump, aft bus 2, and the IU substitute 5 volt power supply. The pitch and yaw actuator locks were then replaced.

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

4.2.28.1 Test Data Table, Hydraulic System

Function	Measurement	Limits
IU Substitute 5 volt Power Supply (vdc)	5.03	5.00 ±0.05
Aft 5 volt Excitation Module (vdc)	4.98	5.00 ±0.03
Hydraulic System Unpressurized		
Reservoir Oil Pressure (psia)	72.45	*
Accumulator GN2 Pressure (psia)	2413.75	*
Accumulator GN2 Temperature (°F)	80.76	*
Reservoir Oil Level (%)	91.20	*
Pump Inlet Oil Temperature (°F)	83.12	*
Reservoir Oil Temperature (°F)	82.33	*
Aft Bus 2 Current (amp)	-0.40	*
Aux Hyd Pump Air Tank Press. (psia)	443.24	282.5 ±217.5
Aux Hyd Pump Motor Container Press. (psig)	23.11	21.0 ±12.0
Gaseous Nitrogen Mass (lb)	1.931	1.925 ±0.2
Corrected Reservoir Oil Level (%)	100.1	95.0 min.
Engine Centering Test, Locks On, System Unpressurized		
T/M Pitch Actuator Position (deg)	0.04	*
IU Pitch Actuator Position (deg)	-0.09	*
T/M Yaw Actuator Position (deg)	0.00	*
IU Yaw Actuator Position (deg)	0.07	*
IU Substitute 5 volt Power Supply (vdc)	5.03	*
Aft 5 volt Excitation Module (vdc)	4.98	*
Pitch Actuator Signal (ma)	0.00	*
Yaw Actuator Signal (ma)	-0.20	*
Corrected T/M Pitch Actuator Position (deg)	0.016	-0.236 to 0.236
Corrected IU Pitch Actuator Position (deg)	-0.045	-0.236 to 0.236
Corrected T/M Yaw Actuator Position (deg)	0.030	-0.236 to 0.236
Corrected IU Yaw Actuator Position (deg)	0.030	-0.236 to 0.236

* Limits Not Specified

4.2.28.1 (Continued)

Function	Measurement	Limits
Aft Bus 2 Voltage (vdc)	55.68	56.0 ±4.0
Aft Bus 2 Current (amp)	63.60	55.0 ±30.0
Hyd System 4 Second Press. Change (psia)	304.4	200.0 min.
<u>Engine Centering Test, Locks Off, System Pressurized, No Excitation Signal</u>		
T/M Pitch Actuator Position (deg)	0.06	*
IU Pitch Actuator Position (deg)	-0.04	*
T/M Yaw Actuator Position (deg)	-0.06	*
IU Yaw Actuator Position (deg)	0.09	*
IU Substitute 5 volt Power Supply (vdc)	5.03	*
Aft 5 volt Excitation Module (vdc)	4.98	*
Pitch Actuator Signal (ma)	0.00	*
Yaw Actuator Signal (ma)	-0.20	*
Corrected T/M Pitch Actuator Position (deg)	0.032	-0.517 to 0.517
Corrected IU Pitch Actuator Position (deg)	0.008	-0.517 to 0.517
Corrected T/M Yaw Actuator Position (deg)	-0.032	-0.517 to 0.517
Corrected IU Yaw Actuator Position (deg)	0.037	-0.517 to 0.517
<u>Hydraulic System Pressurized, Locks Off, Zero Excitation Signal Applied to Actuators</u>		
Hydraulic System Pressure (psia)	3601.38	*
Reservoir Oil Pressure (psia)	164.09	*
Accumulator GN2 Pressure (psia)	3603.06	*
Accumulator GN2 Temperature (°F)	96.86	*
Reservoir Oil Level (%)	41.89	*
Pump Inlet Oil Temperature (°F)	87.43	*
Reservoir Oil Temperature (°F)	87.82	*
Aft Bus 2 Current (amp)	48.00	*
T/M Pitch Actuator Position (deg)	0.06	*
IU Pitch Actuator Position (deg)	-0.04	*
T/M Yaw Actuator Position (deg)	-0.06	*
IU Yaw Actuator Position (deg)	0.01	*
IU Substitute 5 volt Power Supply (vdc)	5.02	*
Aft 5 volt Excitation Module (vdc)	4.98	*
Pitch Actuator Signal (ma)	0.00	*
Yaw Actuator Signal (ma)	-0.10	*
Corrected T/M Pitch Actuator Position (deg)	0.032	-0.517 to 0.517
Corrected IU Pitch Actuator Position (deg)	-0.007	-0.517 to 0.517
Corrected T/M Yaw Actuator Position (deg)	-0.032	-0.517 to 0.517
Corrected IU Yaw Actuator Position (deg)	-0.022	-0.517 to 0.517

* Limits Not Specified

4.2.28.1 (Continued)

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

Time from Start (sec)	Pitch Excitation Signal (ma)	IU Pitch Actuator Pot. Pos. (deg)	IU 5 volt Power Supply (vdc)
0.000	0.000	-0.180	5.034
0.027	-20.020	-0.563	5.034
0.055	-20.020	-0.980	5.024
0.084	-19.971	-1.413	5.034
0.112	-20.020	-1.890	5.034
0.141	-19.971	-2.309	5.029
0.169	-20.020	-2.684	5.034
0.197	-20.020	-2.914	5.029
0.227	-19.971	-3.016	5.034
0.254	-19.971	-3.116	5.024
0.282	-20.020	-3.174	5.034
0.312	-19.971	-3.246	5.029

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

Time from Start (sec)	Pitch Excitation Signal (ma)	IU Pitch Actuator Pot. Pos. (deg)	IU 5 volt Power Supply (vdc)
0.000	-19.949	-3.300	5.029
0.027	-0.049	-2.827	5.034
0.055	0.000	-2.481	5.029
0.084	0.000	-2.077	5.034
0.112	0.000	-1.659	5.024
0.141	0.000	-1.183	5.029
0.169	0.000	-0.793	5.034
0.198	0.049	-0.505	5.034
0.226	0.049	-0.346	5.029
0.254	0.000	-0.245	5.029
0.283	0.000	-0.201	5.034
0.311	0.000	-0.158	5.034

Pitch 0 to +3 Degree Step Response - Engine Slew Rate: 14.2 deg/sec

Time from Start (sec)	Pitch Excitation Signal (ma)	IU Pitch Actuator Pot. Pos. (deg)	IU 5 volt Power Supply (vdc)
0.000	0.000	-0.074	5.034
0.030	19.824	0.361	5.034
0.061	19.824	0.751	5.029
0.081	19.873	1.039	5.029
0.109	19.922	1.501	5.034
0.139	19.824	1.891	5.039
0.166	19.824	2.323	5.024
0.194	19.873	2.598	5.034
0.224	19.873	2.785	5.034
0.251	19.873	2.887	5.029
0.279	19.873	2.915	5.034
0.309	19.824	2.987	5.039

4.2.28.1 (Continued)

Pitch +3 to 0 Degree Step Response - Engine Slew Rate: 15.6 deg/sec

Time from Start (sec)	Pitch Excitation Signal (ma)	IU Pitch Actuator Pot. Pos. (deg)	IU 5 volt Power Supply (vdc)
0.000	19.949	3.074	5.039
0.026	0.049	2.641	5.029
0.056	0.049	2.237	5.034
0.084	0.000	1.804	5.034
0.111	0.000	1.356	5.034
0.141	0.000	0.896	5.029
0.169	0.000	0.506	5.029
0.197	0.000	0.231	5.029
0.226	0.049	0.116	5.024
0.255	0.000	0.072	5.034
0.283	0.000	-0.000	5.034
0.311	0.000	-0.043	5.039

Yaw 0 to -3 Degree Step Response - Engine Slew Rate: 15.7 deg/sec

Time from Start (sec)	Yaw Excitation Signal (ma)	IU Yaw Actuator Pot. Pos. (deg)	IU 5 volt Power Supply (vdc)
0.000	-0.149	0.060	5.039
0.027	-20.020	-0.361	5.029
0.056	-19.922	-0.751	5.034
0.084	-19.971	-1.141	5.029
0.112	-20.020	-1.631	5.034
0.142	-19.971	-2.121	5.034
0.169	-19.971	-2.540	5.034
0.197	-20.020	-2.800	5.034
0.227	-19.971	-2.915	5.034
0.254	-20.020	-2.987	5.034
0.282	-19.971	-2.930	5.024
0.312	-19.922	-2.930	5.034

Yaw -3 to 0 Degree Step Response - Engine Slew Rate: 16.8 deg/sec

Time from Start (sec)	Yaw Excitation Signal (ma)	IU Yaw Actuator Pot. Pos. (deg)	IU 5 volt Power Supply (vdc)
0.000	-20.000	-3.000	5.039
0.026	-0.146	-2.627	5.029
0.056	-0.195	-2.208	5.034
0.084	-0.146	-1.775	5.034
0.111	-0.244	-1.256	5.029
0.141	-0.244	-0.794	5.034
0.169	-0.195	-0.404	5.034
0.197	-0.146	-0.174	5.029
0.226	-0.244	0.014	5.034
0.254	-0.146	0.014	5.034
0.282	-0.244	0.043	5.034
0.311	-0.195	0.086	5.029

4.2.28.1 (Continued)

Yaw 0 to +3 Degree Step Response - Engine Slew Rate: 16.2 deg/sec

Time from Start (sec)	Yaw Excitation Signal (ma)	IU Yaw Actuator Pot. Pos. (deg)	IU 5 volt Power Supply (vdc)
0.000	-0.100	0.074	5.034
0.027	19.727	0.447	5.029
0.056	19.727	0.865	5.024
0.084	19.727	1.270	5.029
0.112	19.824	1.774	5.029
0.142	19.727	2.222	5.034
0.169	19.727	2.582	5.034
0.197	19.824	2.842	5.029
0.227	19.727	2.943	5.039
0.254	19.727	2.871	5.029
0.282	19.727	2.957	5.029
0.312	19.727	2.986	5.034

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

Time from Start (sec)	Yaw Excitation Signal (ma)	IU Yaw Actuator Pot. Pos. (deg)	IU 5 volt Power Supply (vdc)
0.000	19.800	3.119	5.034
0.027	-0.195	2.654	5.034
0.055	-0.244	2.222	5.039
0.084	-0.146	1.774	5.034
0.112	-0.244	1.428	5.044
0.141	-0.146	0.836	5.034
0.169	-0.146	0.433	5.049
0.197	-0.244	0.188	5.034
0.226	-0.244	0.071	5.029
0.254	-0.146	0.071	5.029
0.282	-0.244	0.086	5.034
0.312	-0.244	0.043	5.029

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

Function	Measurement	Limits
Hydraulic System Pressure (psia)	3601.38	*
Reservoir Oil Pressure (psia)	168.02	*
Accumulator GN2 Pressure (psia)	3619.38	*
Accumulator GN2 Temperature (°F)	87.43	*
Reservoir Oil Level (%)	44.63	*
Pump Inlet Oil Temperature (°F)	142.23	*

* Limits Not Specified

4.2.28.1 (Continued)

Function	Measurement	Limits
Reservoir Oil Temperature (°F)	123.38	*
Aft Bus 2 Current (amps)	51.00	*
Aux Hyd Pump Air Tank Press. (psia)	443.24	282.5 $\pm$217.5
Aux Hyd pump Motor Container Press. (psig)	32.14	21.0 $\pm$12.5
T/M Pitch Actuator Position (deg)	-0.00	*
IU Pitch Actuator Position (deg)	-0.10	*
T/M Yaw Actuator Position (deg)	-0.01	*
IU Yaw Actuator Position (deg)	0.09	*
IU Substitute 5 volt Power Supply (vdc)	5.03	*
Aft 5 volt Excitation Module (vdc)	4.98	*
Pitch Actuator Signal (ma)	0.05	*
Yaw Actuator Signal (ma)	-0.20	*
Corrected T/M Pitch Actuator Position (deg)	-0.030	-0.517 to 0.517
Corrected IU Pitch Actuator Position (deg)	-0.061	-0.517 to 0.517
Corrected T/M Yaw Actuator Position (deg)	0.016	-0.517 to 0.517
Corrected IU Yaw Actuator Position (deg)	0.045	-0.517 to 0.517

4.2.29 Auxiliary Propulsion System Module (1B69571 NC)

This automatic procedure verified that the telemetry outputs from each auxiliary propulsion system (APS) module were correct, and that the fuel and oxidizer solenoid valves for each engine in the module were operating properly. Oscillograph records were made of the current and voltage of each of the four series-parallel fuel valves and four series-parallel oxidizer valves for each engine. From these records the valve opening current signature and valve closing voltage signature were determined for each valve for comparison with previous post-manufacturing data. A stage wiring verification check was also accomplished. The items involved in this test were the APS modules, P/N 1A83918-535, S/N's 509-1 and 509-2.

Initiated on 10 July 1968, the procedure was completed by the sixth attempt on 25 July 1968, after 7 days of activity, and was accepted on 23 August 1968. The first five attempts were not accepteable because of several GSE and procedure problems. Malfunctions of the GSE computer, the digital events recorder, and the oscillograph recorders in the Model DSV-4B-240 telemetry system display console were corrected. Numerous out-of-tolerance current and voltage signature values were corrected by calibrating the oscillograph recorders and by revising the measurements to be made. One fuel valve in APS module 1 appeared to be operating slowly, but FARR 500-238-488 accepted the valve for use during VCL checkout. This narration and Test Data Table 4.2.29.1 cover the acceptable sixth attempt. The valve signature data resulting from the oscillograph records is also presented in the Test Data Table.

* Limits Not Specified

4.2.29 (Continued)

The stage power setup, H&CO 1B66560, was accomplished to establish initial conditions for the test. The APS checkout procedure, H&CO 1B69403 (paragraph 4.2.26), prepared the APS modules for the test, and supplied the 195 $\pm$10 psig pressure for the module fuel and oxidizer propellant systems. Verification was made that the engine covers and desiccants were removed, and that the engine throat plugs were not installed. Each APS module was tested separately, starting with APS module 1.

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

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

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

After all three attitude control engines in the APS module were tested, the APS bus power was turned off, and the manual set up was accomplished to prepare for the stage wiring configuration check. The pressure in the module fuel and oxidizer propellant systems was reduced to 23 $\pm$3 psig, the stage wiring was returned to the flight configuration, the upstream valves of all three engines were loaded with the differential pressure, and throat plugs were installed

4.2.29 (Continued)

in all three attitude control engines. The APS bus power was turned back on, and the fuel and oxidizer supply manifold pressures were measured. Each of the attitude control engines in the module was then checked by repeating the automatic engine valve test. After these checks were completed, the APS bus power and the IU substitute -28 vdc power were turned off. The APS module was then secured from the test by H&CO 1B69403. After the test of APS module 1 was completed, the same tests were conducted on APS module 2.

Engineering comments noted that several parts were not installed at the time of this test. The 70 pound thrust ullage engines, P/N 15-21005, were not installed in either APS module. These engines were to be installed after VCL checkout. Two interim use control relay modules, P/N 50M35076-1, S/N's 322 and 332, were installed in place of the flight use control relay modules, P/N 1B57731-501. The flight use modules were to be installed prior to STC prefiring operations. The LH2 chilldown shutoff valve, P/N 1A49965-523-012, had been removed for rework, but this affected only the power setup initial conditions scan and not the actual test.

The earlier GSE and procedure problems were corrected, as noted, and only one particular problem was encountered during the sixth attempt. The waveform signature analysis showed that several commands for engine 2 of APS module 2 were out-of-tolerance during this attempt, resulting in out-of-tolerance valve operation measurements. A procedure revision accepted the measurements, as the valve itself was not at fault (reference revision g), and the problem was covered by FARR 500-353-023, below.

Two FARR's were written during this test:

a. FARR 500-238-488 noted that a voltage signature analysis indicated that valve L3 on engine 2, P/N 1A39597-509, S/N 812, of APS module 1, P/N 1A83918-535, S/N 509-1, was not closing properly. The valve was accepted by Engineering for continued use during VCL checkout.

b. FARR 500-353-023 noted that a voltage signature analysis showed that the commands to engine 2, P/N 1A39597-509, S/N 816, of APS module 2, P/N 1A83918-535, S/N 509-2, were out-of-tolerance due to an open diode in interim use control relay module 404A71A19, P/N 50M35076, S/N 322. This caused engine valve dropout times to be out-of-tolerance. The interim use control relay module was accepted for continued use during VCL checkout, as it was scheduled for replacement prior to STC checkout operations.

Eleven revisions were made to the procedure, with two of these deleted by subsequent revisions. The nine revisions incorporated were:

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

4.2.29 (Continued)

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

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

d. One revision deleted a previous revision and restored the Model DSV-4B-298 monochrome system status display to the required End Item Equipment list. This item had originally been deleted from the list because it was not operational, but was subsequently returned to operation.

e. One revision deleted a previous revision that would have modified a reference voltage used in the voltage waveform signature analysis, and instead provided that the oscillograph recorders be calibrated just prior to the APS valve tests. The calibration data provided reference voltages to increase the accuracy of the voltage measurements obtained during the analysis.

f. Two revisions modified the voltage waveform signature analysis operation. New measurements were added to determine functions associated with the electrical operation of the APS and the control relay modules; and existing data tables were deleted from the procedure, as new tables were added to include the new measurements.

g. One revision accepted out-of-tolerance voltage waveform signature analysis measurements from engine 2 in APS module 2 only, as a transient suppression zener diode was open in the control relay module for APS module 2. This condition was acceptable for checkout as the control relay module was an interim use part and was scheduled for replacement. The open diode did not affect the operation of the APS module.

4.2.29.1 <u>Test Data Table, Auxiliary Propulsion System Module</u>

<u>APS Module 1</u>

Function	Meas.	AO Mult.	BO Mult.	Limits
IU Sub -28 vdc Power (vdc)	-29.68			-28.5 ±2.5
APS 1 Scan				
Helium Bottle Press (D35)(psia)		34.4	34.4	100.0 max
He Reg Outlet Press (D37)(psia)		47.6	47.6	50.0 ±15.0
He Bottle Gas Temp (C23)(°F)	78.0			*

* Limits Not Specified

4.2.29.1 (Continued)

APS Module 1

Function	Meas.	AO Mult.	BO Mult.	Limits
Oxid Temperature (C132)(°F)		78.9	79.1	*
Fuel Temperature (C136)(°F)		78.8	78.7	*
Fuel Ullage Press (PD97)(psia)	43.2			50.0 $\pm$15.0
Oxid Ullage Press (D98)(psia	47.1			50.0 $\pm$15.0
Fuel Manifold Press (D70)(psia)	211.7			210.0 $\pm$15.0
Oxid Manifold Press (D71)(psia)	211.2			210.0 $\pm$15.0
Wiring Verification				
Fuel Manifold Press (D70)(psia)	43.64			38.0 $\pm$15.0
Oxid Manifold Press (D71)(psia)	42.77			38.0 $\pm$15.0

APS 1 Valve Movement

	Test Condition 1		Test Condition 2		
Function	Test 1	Test 2	Test 1	Test 2	Wiring Verif.
Engine 1-1					
Aft Bus 1 Voltage (vdc)	28.118	28.239	28.318	28.039	28.158
Valve Open Ind (Closed)(vdc)	0.000	0.000	0.000	0.000	0.000
Valve Open Ind (Open)(vdc)	3.723	3.723	3.743	3.718	3.887
Engine 1-2					
Aft Bus 1 Voltage (vdc)	28.158	28.118	28.158	28.239	28.118
Valve Open Ind (Closed)(vdc)	-0.005	0.000	0.000	-0.010	0.000
Valve Open Ind (Open)(vdc)	3.753	3.728	3.728	3.732	3.917
Engine 1-3					
Aft Bus 1 Voltage (vdc)	27.958	28.118	28.199	28.118	28.079
Valve Open Ind (Closed)(vdc)	0.000	0.000	0.000	0.000	0.000
Valve Open Ind (Open)(vdc)	3.728	3.723	3.712	3.712	3.892

APS Module 2

Function	Meas.	AO Mult.	BO Mult.	Limits
IU Sub -28 vdc Power (vdc)	-29.76			-28.5 $\pm$2.5
APS 2 Scan				
Helium Bottle Press (D36)(psia)		49.6	49.6	100.0 max
He Reg Outlet Press (D38)(psia)		50.6	50.2	50.0 $\pm$15.0
He Bottle Gas Temp (C187)(°F)	80.6			*
Oxid Temperature (C22)(°F)		81.5	81.6	*
Fuel Temperature (C21)(°F)		80.5	80.5	*
Fuel Ullage Press (D100)(psia)	49.3			50.0 $\pm$15.0

* Limits Not Specified

4.2.29.1 (Continued)

APS Module 2

Function	Meas.	AO Mult.	BO Mult.	Limits
Oxid Ullage Press (D99)(psia	47.1			50.0 ±15.0
Fuel Manifold Press (D72)(psia)	206.9			210.0 ±15.0
Oxid Manifold Press (D73)(psia)	205.1			210.0 ±15.0
Wiring Verification				
Fuel Manifold Press (D72) (psia)	41.9			38.0 ±15.0
Oxid Manifold Press (D73)(psia)	42.8			38.0 ±15.0

APS 2 Valve Movement

	Test Condition 1		Test Condition 2		
Function	Test 1	Test 2	Test 1	Test 2	Wiring Verif.
Engine 2-1					
Aft Bus 1 Voltage (vdc)	28.239	28.039	28.278	28.199	28.239
Valve Open Ind (Closed)(vdc)	0.000	0.000	0.000	0.000	-0.005
Valve Open Ind (Open)(vdc)	3.620	3.615	3.615	3.620	3.769
Engine 2-2					
Aft Bus 1 Voltage (vdc)	28.118	28.278	28.199	27.958	28.239
Valve Open Ind (Closed)(vdc)	-0.005	-0.005	-0.005	0.000	-0.005
Valve Open Ind (Open)(vdc)	3.656	3.661	3.650	3.646	3.805
Engine 2-3					
Aft Bus 1 Voltage (vdc)	28.239	27.958	28.199	28.199	28.118
Valve Open Ind (Closed)(vdc)	0.000	0.000	-0.005	0.000	0.000
Valve Open Ind (Open)(vdc)	3.630	3.630	3.609	3.595	3.764

Valve Current and Voltage Signatures

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

Opening Current Signature

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

4.2.29.1 (Continued)

<u>Closing Voltage Signature</u>

M - Closing time (11 msec max)
P - Negative voltage to suppression (-60 ±10 vdc)
T - Control relay arcing time (not specified msec)
U - Control relay closing delay (1 to 5 msec)
V - Control relay opening delay time (1 to 5 msec)
W - Positive voltage to suppression of control relay coils, (all eight valves) (7 ±3 vdc)
X - Time from IU command off to valve closed (25 msec max)

<u>APS 1 Engine 1-1 Valve Signatures</u>

Function	L1	L2	L3	L4	L5	L6	L7	L8
Condition 1								
A (msec)	(0.5)		(0.0)		(0.0)		(0.5)	
B (msec)	2.0	2.5	2.0	2.5	2.5	2.0	2.0	2.5
C (msec)	N/A	N/A	9.5	9.5	N/A	N/A	10.5	10.0
D (msec)	19.5	19.0	N/A	N/A	18.5	18.5	N/A	N/A
E (amp)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
F (amp)	0.75	0.70	0.38	0.38	0.70	0.68	0.40	0.40
M (msec)	6.6	6.5	7.1	6.0	6.0	6.8	6.5	6.0
P (vdc)	60.0	57.0	55.0	69.0	57.0	57.0	58.0	60.0
T (msec)	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0
U (msec)	2.0	2.0	1.8	1.9	2.0	2.3	2.0	2.0
V (msec)	3.2	3.1	3.1	3.2	2.9	2.7	2.9	3.0
W (vdc)	(6.0)							
X (msec)	10.0	10.0	10.5	9.5	9.5	11.1	10.0	9.0
Condition 2								
A (msec)	(1.0)		(0.0)		(0.0)		(0.5)	
B (msec)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.5
C (msec)	10.0	9.0	N/A	N/A	9.0	9.0	N/A	N/A
D (msec)	N/A	N/A	19.0	19.0	N/A	N/A	19.5	19.0
E (amp)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
F (amp)	0.42	0.35	0.70	0.70	0.38	0.35	0.70	0.70
M (msec)	7.0	6.9	7.1	6.1	6.5	6.8	6.9	6.7
P (vdc)	60.0	60.0	66.0	69.0	56.0	55.0	58.0	58.0
T (msec)	0.0	0.0	0.0	0.0	0.0	1.2	0.0	1.2
U (msec)	2.0	2.0	1.8	1.8	2.1	2.3	2.0	1.9
V (msec)	3.0	3.0	3.1	3.0	2.5	2.5	2.8	2.8
W (vdc)	(8.0)							
X (msec)	10.0	9.8	10.0	9.0	9.0	10.9	9.5	10.5
Wiring Verification								
M (msec)	7.0	7.2	6.0	6.5	6.0	6.7	7.5	6.0
P (vdc)	60.0	60.0	56.0	69.0	56.0	56.0	58.0	57.0
T (msec)	0.0	0.0	6.0	0.0	0.0	2.0	0.0	3.5
U (msec)	2.0	2.0	1.8	1.9	2.1	2.5	2.0	2.0
V (msec)	3.7	3.5	3.8	3.0	3.0	3.0	2.7	3.0
W (vdc)	(6.0)							
X (msec)	10.5	10.5	15.5	9.5	10.0	11.5	10.0	11.5

4.2.29.1 (Continued)

APS 1 Engine 1-2 Valve Signatures

Function	L1	L2	L3	L4	L5	L6	L7	L8
Condition 1								
A (msec)	(1.0)		(0.5)		(1.0)		(1.0)	
B (msec)	2.5	2.5	2.5	2.0	3.0	2.0	2.5	2.5
C (msec)	N/A	N/A	9.5	9.5	N/A	N/A	10.0	9.0
D (msec)	18.5	19.5	N/A	N/A	18.0	19.0	N/A	N/A
E (amp)	1.1	1.0	1.1	1.0	1.0	1.1	1.0	1.2
F (amp)	0.70	0.72	0.38	0.38	0.69	0.72	0.40	0.36
M (msec)	7.2	6.0	6.5	7.2	6.5	7.5	7.5	7.0
P (vdc)	57.0	60.0	54.0	61.0	66.0	67.0	56.0	64.0
T (msec)	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
U (msec)	2.2	2.2	2.2	2.1	2.0	2.1	2.1	2.0
V (msec)	2.1	2.1	2.5	2.5	2.3	2.7	2.8	3.0
W (vdc)	(6.5)							
X (msec)	9.5	9.3	9.0	9.9	9.0	10.0	10.0	9.9
Condition 2								
A (msec)	(0.5)		(0.0)		(2.5)		(0.5)	
B (msec)	2.5	2.0	2.0	1.5	2.0	2.5	2.0	2.0
C (msec)	9.5	10.0	N/A	N/A	9.0	11.5	N/A	N/A
D (msec)	N/A	N/A	18.0	18.0	N/A	N/A	19.5	19.0
E (amp)	1.1	1.1	1.2	1.0	1.1	1.2	1.1	1.2
F (amp)	0.38	0.41	0.72	0.68	0.38	0.48	0.75	0.71
M (msec)	7.2	6.2	6.7	6.7	6.7	7.5	7.8	7.5
P (vdc)	57.0	62.0	55.0	60.0	65.0	61.0	56.0	64.0
T (msec)	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
U (msec)	2.5	2.2	2.2	2.1	2.1	2.1	2.1	2.1
V (msec)	2.2	2.2	2.2	2.3	2.2	2.3	2.3	2.9
W (vdc)	(7.0)							
X (msec)	9.5	8.5	9.0	10.0	9.0	9.8	10.0	9.8
Wiring Verification								
M (msec)	7.3	6.2	7.0	7.5	7.0	7.0	7.5	6.5
P (vdc)	57.0	62.0	55.0	60.0	66.0	66.0	57.0	63.0
T (msec)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0
U (msec)	2.5	2.5	2.5	2.5	2.2	2.3	2.4	2.3
V (msec)	2.1	2.1	2.5	2.5	2.7	2.5	2.7	3.0
W (vdc)	(7.0)							
X (msec)	9.5	8.5	9.0	9.6	9.8	10.0	10.1	10.8

4.2.29.1 (Continued)

APS 1 Engine 1-3 Valve Signatures

Function	L1	L2	L3	L4	L5	L6	L7	L8
Condition 1								
A (msec)	(0.0)		(1.0)		(0.0)		(0.0)	
B (msec)	3.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
C (msec)	N/A	N/A	9.0	10.0	N/A	N/A	9.0	9.0
D (msec)	20.0	20.0	N/A	N/A	20.0	20.0	N/A	N/A
E (amp)	1.1	1.0	1.0	1.0	1.1	1.1	1.0	1.1
F (amp)	0.72	0.78	0.38	0.40	0.75	0.75	0.38	0.38
M (msec)	7.5	6.8	7.5	8.0	6.8	8.0	8.0	8.0
P (vdc)	56.0	68.0	57.0	60.0	58.0	63.0	60.0	60.0
T (msec)	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
U (msec)	3.0	2.3	2.5	2.7	3.0	2.5	2.2	2.3
V (msec)	2.2	2.5	3.0	2.5	2.2	2.5	3.0	3.0
W (vdc)	(7.0)							
X (msec	11.0	9.0	10.0	10.0	9.0	10.5	10.0	10.5
Condition 2								
A (msec)	(1.0)		(1.0)		(0.0)		(0.0)	
B (msec)	2.0	3.0	2.0	2.0	2.0	2.5	2.0	2.0
C (msec)	9.0	10.0	N/A	N/A	10.0	10.0	N/A	N/A
D (msec)	N/A	N/A	18.0	19.0	N/A	N/A	19.0	19.0
E (amp)	1.0	1.0	1.0	1.0	1.0	1.1	1.0	1.1
F (amp)	0.38	0.40	0.72	0.75	0.41	0.40	0.74	0.76
M (msec)	8.5	6.9	7.9	7.5	6.8	6.9	7.8	6.2
P (vdc)	57.0	67.0	55.0	60.0	58.0	61.0	59.0	57.0
T (msec)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5
U (msec)	2.8	2.5	2.5	2.8	3.0	2.6	2.2	2.5
V (msec)	2.9	2.7	2.9	2.5	2.5	2.5	3.0	3.1
W (vdc)	(8.0)							
X (msec)	10.8	9.1	10.0	10.0	9.1	9.2	10.0	12.0
Wiring Verification								
M (msec)	7.5	6.0	7.2	6.8	6.5	7.8	7.0	7.5
P (vdc)	55.0	65.0	55.0	58.0	58.0	60.0	60.0	60.0
T (msec)	3.0	0.9	0.0	2.5	0.0	0.0	0.0	0.0
U (msec)	2.8	2.3	2.5	2.7	3.0	2.6	2.3	2.5
V (msec)	2.9	2.8	2.7	2.7	2.5	2.2	3.0	3.1
W (vdc)	(7.0)							
X (msec)	13.2	9.6	10.0	11.8	9.0	10.7	9.8	10.0

4.2.29.1 (Continued)

APS 2 Engine 2-1 Valve Signatures

Function	L1	L2	L3	L4	L5	L6	L7	L8
Condition 1								
A (msec)	(	0.0)	(	0.2)	(	1.0)	(	1.0)
B (msec)	3.0	2.0	2.2	2.5	2.5	2.5	2.5	2.0
C (msec)	N/A	N/A	9.2	9.0	N/A	N/A	9.5	8.5
D (msec)	18.0	18.0	N/A	N/A	18.5	17.5	N/A	N/A
E (amp)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
F (amp)	0.65	0.70	0.39	0.39	0.70	0.72	0.38	0.36
M (msec)	5.2	6.8	7.4	5.0	6.8	5.0	6.0	7.0
P (vdc)	56.0	58.0	58.0	65.0	56.0	57.0	56.0	58.0
T (msec)	6.6	0.0	0.0	6.2	2.9	4.0	1.9	0.7
U (msec)	2.2	2.2	2.3	2.3	2.5	2.5	2.7	2.8
V (msec)	2.4	2.3	2.7	2.3	2.5	2.0	2.0	2.0
W (vdc)	(			7.0				)
X (msec)	14.1	9.0	9.6	13.5	11.3	11.0	10.0	9.7
Condition 2								
A (msec)	(	0.5)	(	0.5)	(	1.0)	(	1.0)
B (msec)	2.0	2.5	2.0	2.0	2.5	2.0	2.0	2.0
C (msec)	8.5	9.0	N/A	N/A	9.5	8.5	N/A	N/A
D (msec)	N/A	N/A	20.0	20.5	N/A	N/A	20.0	19.0
E (amp)	1.0	1.0	1.0	0.98	1.0	1.0	1.0	1.0
F (amp)	0.35	0.38	0.72	0.75	0.40	0.32	0.72	0.72
M (msec)	5.8	6.2	6.3	6.8	7.5	6.3	5.2	6.0
P (vdc)	56.0	58.0	56.0	68.0	58.0	58.0	56.0	57.0
T (msec)	4.3	0.6	2.0	0.0	0.0	1.2	4.0	4.0
U (msec)	2.5	2.0	2.3	2.2	2.6	2.5	2.7	2.7
V (msec)	2.6	2.5	3.0	2.7	2.7	2.0	2.1	2.3
W (vdc)	(			7.5				)
X (msec)	12.3	9.5	11.2	8.8	9.5	9.5	10.9	11.5
Wiring Verification								
M (msec)	6.2	5.8	6.3	5.1	7.1	5.8	5.6	6.2
P (vdc)	57.0	57.0	56.0	64.0	57.0	57.0	57.0	58.0
T (msec)	1.1	4.0	4.2	5.1	1.4	3.5	3.5	3.2
U (msec)	2.7	2.7	2.7	2.8	2.9	2.7	2.8	2.9
V (msec)	3.0	2.4	2.7	2.5	2.3	2.0	2.0	2.0
W (vdc)	(			7.0				)
X (msec)	10.0	12.0	13.0	12.3	10.7	11.3	10.9	11.5

4.2.29.1 (Continued)

APS 2 Engine 2-2 Valve Signatures

Function	L1	L2	L3	L4	L5	L6	L7	L8
Condition 1								
A (msec)	(1.0)		(1.0)		(0.5)		(0.0)	
B (msec)	2.5	2.5	2.5	2.5	3.0	1.5	3.0	2.0
C (msec)	N/A	N/A	9.0	10.0	N/A	N/A	9.5	9.5
D (msec)	19.0	20.0	N/A	N/A	19.0	19.5	N/A	N/A
E (amp)	1.0	1.0	1.0	1.0	1.0	1.0	0.98	1.0
F (amp)	0.70	0.71	0.35	0.38	0.71	0.76	0.38	0.40
M (msec)	6.0	6.5	6.6	6.3	6.3	6.9	6.8	6.5
P (vdc)	56.0	61.0	58.0	58.0	60.0	61.0	57.0	64.0
T (msec)	3.1	1.0	1.3	1.0	1.0	0.0	0.0	5.6
U (msec)	2.4	2.6	2.4	2.2	2.1	2.3	2.1	2.0
V (msec)	1.0	1.0	1.0	1.0	1.2	1.2	1.2	1.0
W (vdc)	(155.0*)							
X (msec)	10.0	8.3	8.7	8.2	8.1	7.9	7.9	13.1
Condition 2								
A (msec)	(0.0)		(0.0)		(1.0)		(0.0)	
B (msec)	2.5	2.5	2.5	2.5	2.5	2.5	2.0	2.0
C (msec)	9.5	9.5	N/A	N/A	9.0	10.0	N/A	N/A
D (msec)	N/A	N/A	19.5	19.5	N/A	N/A	20.0	20.0
E (amp)	1.0	0.98	1.0	0.98	1.0	1.0	0.98	1.0
F (amp)	0.38	0.38	0.72	0.72	0.38	0.40	0.72	0.73
M (msec)	7.0	6.5	6.5	6.5	7.1	6.8	6.8	6.0
P (vdc)	57.0	60.0	57.0	61.0	60.0	60.0	58.0	63.0
T (msec)	0.0	0.0	1.8	0.0	0.0	2.0	0.0	6.6
U (msec)	2.9	3.0	2.9	2.8	2.5	2.9	2.6	2.5
V (msec)	0.5*	0.7*	0.9*	0.7*	1.0	1.2	1.0	1.0
W (vdc)	(164.0*)							
X (msec)	7.5	7.2	8.8	7.3	8.0	9.8	7.8	8.4
Wiring Verification								
M (msec)	6.6	5.8	6.2	5.5	7.0	6.2	7.0	6.3
P (vdc)	58.0	60.0	58.0	59.0	60.0	60.0	58.0	67.0
T (msec)	2.0	3.3	2.1	3.0	0.0	5.8	0.0	3.5
U (msec)	3.0	3.1	3.0	2.9	2.8	2.8	2.8	2.4
V (msec)	0.3*	0.3*	0.7*	0.7*	1.5	1.2	1.1	1.2
W (vdc)	(154.0*)							
X (msec)	9.0	9.6	8.9	9.1	7.9	12.8	7.8	10.7

* Out-of-tolerance condition acceptable, ref. revision g.

4.2.29.1 (Continued)

APS 2 Engine 2-3 Valve Signatures

Function	L1	L2	L3	L4	L5	L6	L7	L8
Condition 1								
A (msec)	(0.5)		(0.0)		(0.5)		(0.5)	
B (msec)	2.5	3.0	2.5	2.5	2.5	2.0	2.0	2.5
C (msec)	N/A	N/A	9.5	9.5	N/A	N/A	10.0	9.5
D (msec)	19.5	20.0	N/A	N/A	20.5	21.0	N/A	N/A
E (amp)	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.1
F (amp)	0.71	0.72	0.38	0.38	0.75	0.77	0.40	0.40
M (msec)	6.5	5.9	5.1	5.1	6.5	6.8	6.2	7.0
P (vdc)	64.0	65.0	56.0	60.0	56.0	56.0	58.0	60.0
T (msec)	3.0	4.5	3.0	3.5	0.0	2.5	2.4	0.0
U (msec)	2.2	2.2	2.7	2.2	2.2	2.1	2.0	2.0
V (msec)	2.6	2.5	2.5	2.5	2.2	2.2	2.3	2.3
W (vdc)	(7.0)							
X (msec)	11.8	12.5	10.3	11.1	9.1	11.8	11.1	9.9
Condition 2								
A (msec)	(0.0)		(0.0)		(0.5)		(0.0)	
B (msec)	2.5	2.5	2.0	2.0	2.0	2.5	1.5	2.5
C (msec)	9.5	9.5	N/A	N/A	10.0	10.5	N/A	N/A
D (msec)	N/A	N/A	20.0	20.0	N/A	N/A	20.0	20.3
E (amp)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
F (amp)	0.38	0.38	0.75	0.75	0.40	0.38	0.72	0.75
M (msec)	6.8	6.8	5.2	6.8	5.9	7.5	5.8	7.0
P (vdc)	64.0	67.0	56.0	65.0	55.0	57.0	54.0	61.0
T (msec)	1.0	2.8	2.8	0.0	3.5	1.8	4.5	0.0
U (msec)	2.5	2.7	3.0	2.7	2.8	2.7	2.5	2.3
V (msec)	3.0	3.0	2.5	2.5	2.5	2.5	2.5	2.5
W (vdc)	(8.0)							
X (msec)	10.5	12.0	10.8	9.2	11.8	11.5	12.7	9.6
Wiring Verification								
M (msec)	7.0	5.7	5.9	5.5	5.7	6.3	7.2	6.3
P (vdc)	65.0	65.0	55.0	60.0	55.0	54.0	58.0	60.0
T (msec)	0.0	3.8	2.0	2.6	3.2	3.3	0.0	0.0
U (msec)	2.5	2.5	3.0	2.5	3.0	2.7	2.5	2.3
V (msec)	2.7	2.5	2.2	2.1	2.0	2.0	3.0	2.8
W (vdc)	(9.0)							
X (msec)	9.6	12.0	10.2	11.0	11.2	12.7	10.2	9.3

4.2.30 EMC Radio Frequency Signature and Transient Detection (1B64709 NC)

This procedure verified the electromagnetic compatibility (EMC) of the stage by means of a radiated spectrum signature test and a conducted interference test. The radiated spectrum signature test verified that the operation of the stage telemetry transmitter did not cause any RF interference at frequencies that would adversely affect the various Apollo and Saturn vehicle receivers. The conducted interference test verified that the operation of the stage systems and equipment did not cause excessive transient signals on the stage electrical wiring, that a six decibel safety margin level was maintained at various critical points in the stage equipment, and that there were no RF interference signals within 0.5 MHz of the stage range safety receiver fundamental frequency. The umbilicals-in part of the all systems test, H&CO 1B66571 (reference paragraph 4.2.37), was performed in conjunction with this procedure to control the operation of the stage systems during the conducted interference test.

Initiated on 16 July 1968, the procedure was completed on 10 September 1968, after 16 days of stage testing activity, and was accepted on 18 September 1968. The radiated spectrum signature test was accomplished first, followed by the conducted interference test. After the completion of the final all systems test, it was necessary to repeat the radiated spectrum signature test, as the originally tested PCM RF assembly, P/N 1B65788-1, S/N 15503, had been subsequently replaced by another assembly, S/N 15505, during a preliminary attempt of the all systems test. (Reference FARR 500-353-040, paragraph 4.2.37).

The radiated spectrum signature test was started by performing the stage power setup, H&CO 1B66560, to establish initial conditions. The radio frequency test equipment was then set up, including the Empire Model NF-105 and Model NF-112 radio interference and field intensity (RIFI) meters, the appropriate GSE test antennas, and the required calibration equipment. The test antennas were placed approximately 6 feet from the stage antenna for this test.

The stage PCM RF assembly was turned on, the assembly current was verified to be 4.5 $\pm$ 3.0 amperes, and the PCM/FM transmitter output power was verified to be 19.00 $\pm$ 7.25 watts. Using the appropriate RIFI meter, antennas, and calibration equipment for specific frequency bands, the RF spectrum was scanned between 150 kHz and 10.0 GHz to detect any RF signals more than 3db above the ambient signal level. Any detected signals that were obviously not generated by the stage were ignored, and the spectrum scan was continued. For other detected signals, the telemetry RF group ground monitor was momentarily turned on, transferring the PCM/FM transmitter output to closed loop transmission and reducing the RF output. If the detected signal level did not change, the signal was not generated by the stage, and the spectrum scan was continued. If the detected signal level did change, indicating that the signal was generated by the stage, the signal frequency and level were measured, and the PCM RF assembly was turned off while the background level was measured at the detected signal frequency. The PCM RF assembly was then turned back on, the PCM/FM transmitter output power was verified to be 19.00 $\pm$ 7.25 watts, and the spectrum scan was continued.

4.2.30 (Continued)

In addition to those signals detected during the RF spectrum scan, signal level measurements were made at those specific frequencies used by Apollo and Saturn receivers. The PCM RF assembly was turned off after the completion of the measurement activities. The various measured signal levels, and the antenna and cable loss factors applicable to the particular frequency and test equipment, were used to determine the calculated signal levels as referenced to a 1 microvolt standard level. Test Data Table 4.2.30.1 shows the particular detected or specified signal frequencies, the measured signal and background levels, and the calculated signal levels that were recorded during the repeat performance of the test. The signal levels were all acceptable, although specific limits were not defined by the procedure.

To start the conducted interference test, an Empire Model NF-105 RIFI meter and a Stoddard Model NM-52A RIFI meter were connected at the inputs of range safety receivers 1 and 2, respectively, and were adjusted to measure RF interference at the 450 MHz range safety frequency. The cables, J-boxes, and EMC 6db and transient detectors from the Model DSV-4B-723 EMC cable accessory kit, P/N 1B57890-1, were installed. Breakout adapter cables were connected between the stage wiring and some 29 items of stage electrical equipment, and some 38 EMC detectors were connected to the breakout cables, with the detector outputs connected to the digital events recorder (DER) through the J-boxes. Each detector was individually checked to verify that it was operating properly and that the DER was responding properly to the detector output signals. This check was accomplished on the 6db detectors with the stage power off, while various stage powers were temporarily turned on while the transient detectors were checked.

After the EMC detectors were installed and accepted for use, the umbilicals-in all systems test was accomplished. During this performance, the RIFI meters were manually monitored for any indication of RF signals more than 3db above ambient at the range safety frequency, and the EMC detectors automatically monitored the stage electrical system for conducted interference transients and noise exceeding the 6db safety margin. After completion of the all systems test performance, the EMC detectors were again individually checked as before, to verify that they were still operating properly and that the DER was still responding properly to the detector output signals. The test equipment and cables were removed after all testing was completed, and the stage wiring was reconnected to the original configuration. No unacceptable conducted interference, noise, or RF interference was noted during this test.

All stage items affected by this procedure were installed at the time of the test. Several problems were encountered during the procedure, but there were no major stage problems, and no FARR's were written. The radiated spectrum signature test was complicated by excessive background RF noise, and it was necessary to complete this test during the second shift when the background noise was less. Those problems encountered during the all systems test performance are covered in paragraph 4.2.37.

4.2.30 (Continued)

A total of sixty-seven revisions were made to the procedure, with one subsequently voided:

a. Three revisions changed the Non-End Item Equipment list. One Empire Devices tripod, P/N TP-105-A, and one Empire Devices tripod, P/N TP-112, were added to the list as required items; the Empire Devices broadband antenna was changed to be P/N AC-112, rather than P/N AT-112, to agree with the part number on the antenna; and the Stoddard broadband antenna, P/N 91597-2, was deleted, as it was not used.

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

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

d. One revision changed the RF transmission line connections to the RIFI meters, to correct erroneous callouts. Line CB-105, rather than line 90933-8, connected to the NF-105 meter, while line 90933-1, rather than line CB-105, connected to the NM-52A meter.

e. Six revisions added the requirement for installing the EMC equipment for the conducted interference test; provided for the adapter brackets and grounding strap modifications required to mount the EMC detectors on the GSE handling ring rather than the tooling ring; and relocated a ground cable for better accessibility.

f. Two revisions changed the EMC detector individual checkout operations. Steps were added to check the 6db detectors with the stage power off; to turn particular stage systems on, check the transient detectors with the stage power on, and then turn the stage systems back off; to repeat the checks after the all systems test was completed; and to verify that the DER printed out only the function numbers of the detectors checked, in the proper order.

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

h. One revision changed a step at the start of the radiated spectrum signature test to obtain a reference measurement of the forward 1 power supply current, and to refer to the computer typewriter rather than the Model DSV-4B-161 typewriter, as there was no Model DSV-4B-161.

i. Two revisons deleted steps to turn on and verify the telemetry RF group transfer ground monitor at the start of the radiated spectrum signature test, and to turn it off at the end of the test, as the ground monitor had to remain off during the test to permit open loop transmission from the telemetry PCM/FM transmitter.

4.2.30 (Continued)

j. Three revisions added a note to clarify what scales to read on the NF-105 RIFI meter; changed a step to clarify what cables and connectors to use when calibrating this meter; and deleted a setup step for this meter, as the step was accomplished during the pre-test operations.

k. One revision changed two of the specific frequencies checked during the radiated spectrum signature test to be 4.994 MHz and 4939.806 MHz, rather than 4.944 MHz and 4940.806 MHz as listed, to agree with test plan SM-47376.

l. One revision specified the methods used to make specific frequency measurements at one point in the radiated spectrum signature test.

m. One revision added a step to the radiated spectrum signature test, to verify that the PCM/FM transmitter output power was 19.00 $\pm$ 7.25 watts after a 3 minute warmup, to ensure proper transmitter operation before continuing the test.

n. One revision deleted from the radiated spectrum signature test those calculations involving data on the range safety receivers, and added identical calculations to the conducted interference test, as the required data was collected as part of the latter test.

o. One revision added a step to the EMC detector setup to connect the ac power cables to the EMC J-boxes.

p. One revision added a step to reconnect the range safety receiver RF cables after the completion of the conducted interference test.

q. Three revisions modified the field strength measurement routine during the radiated spectrum signature test, to specify the minimum signal level to be measured; to eliminate measurements of non-vehicle RFI; to reduce unnecessary on-off cycling of the transmitter power; to delete reference to a non-existing Model DSV-4B-161; and to improve and correct the measurements.

r. Four revisions corrected the known frequency signal substitution routine used during the radiated spectrum signature test, to show the correct adapter cable connection; to provide an output of 300 millivolts from the signal generator, rather than 100,000 microvolts; and to delete two steps that were accomplished in the standard gain routine instead of in this routine.

s. Two revisions changed the standard gain routine for the NF-112 RIFI meter, used during the radiated spectrum signature test. The calibration example was made consistant with the procedure, and the meter function switch was set to the CW average position to make the CW average measurements.

4.2.30 (Continued)

t. Two revisions modified the standard gain routine for the NF-105 RIFI meter, used during the radiated spectrum signature test. A step was added to properly adjust the impulse generator fine contact setting; and a note was added to use only the 18 inch adapter cable supplied with the meter, to prevent calibration errors due to cable loss at high frequencies.

u. One revision added requirements to make field strength measurements in the frequency ranges of 47.5 to 60 MHz and 225 to 300 MHz during the radiated spectrum signature test, as these bands were inadvertently left out of the procedure.

v. Two revisions changed a requirement to verify that the EMC detectors had been certified within 15 days prior to use, rather than 7 days prior to use, and then deleted the requirement completely, as an H&CO should not determine the period of equipment certification.

w. One revision modified the unknown frequency signal substitution routine and the known frequency signal substitution routine, both used during the radiated spectrum signature test, to record the frequency and the tuning head band for each measurement made.

x. One revision corrected the plug designations on a hookup figure to agree with wiring harness drawing 1B69204.

y. Eleven revisions modified procedure Table A, the stage cable connections table; Table B, the EMC breakout and drag-in cable connections table; and Table C, the EMC detector calibration table. Incorrect reference locations, cable and connector designations, and function numbers were corrected; several omitted functions were added; and adapter cables were added as required to compensate for the changes in detector mounting. Also, all functions concerning the range safety EBW firing units 1 and 2, and the associated EMC detectors A16 and A19, were deleted. These detectors were not installed, as they put an excessive load on the firing unit voltage indication circuits.

z. One revision changed an instruction for using the NM-52A RIFI meter to reference the "Field Intensity" and "Peak" positions, rather than the "CW Average" and "CW Peak" positions as listed, to use the same nomenclature used on the meter.

aa. One revision changed requirements that the DER tapes become part of the EMC test data to require that the tapes be evaluated and retained by TP&E Engineering, as the DER data tape was for engineering evaluation and should be retained by Engineering.

ab. One revision modified the test description paragraph, and deleted two other steps, to delete all reference to a baseline all systems test during the conducted interference test.

4.2.30 (Continued)

ac. Two revisions changed the setup procedures for the NF-105 and NF-112 RIFI meters during the radiated spectrum signature test, to provide for the proper setup of the various tuning heads used with these meters.

ad. One revision added a note to the unknown frequency signal substitution routine, during the radiated spectrum signature test, to provide for setting up the electronic frequency counter for frequencies below 50 MHz.

ae. One revision changed the radiated spectrum signature test at one point to adjust the DM-105-T1 dipole antenna for a frequency of 140 MHz, rather than 150 MHz, as 140 MHz was the highest frequency for this antenna.

af. One revision deleted the data recording steps when the standard gain routine was used to calibrate the NF-112 RIFI meter during the radiated spectrum signature test, as no data was required during calibration.

ag. One revision interchanged two steps during the radiated spectrum signature test, so that field strength measurements would be made in the 450 to 480 MHz frequency range before the antenna was adjusted to 600 MHz.

ah. One revision added a note to the conducted interference test to record data on the range safety receiver checks only during the final umbilicals-in all system test run, as the data from this EMC all systems test was invalid because of an incorrect setup.

ai. One revision changed a step to turn off the 608C signal generator during the conducted interference test, to eliminate any possible RF radiation from the unit during the all systems test attempt.

aj. One revision changed the calculations involving the radiated spectrum signature test data obtained from the NF-105-RIFI meter using a T-A head, to use the cable loss factor rather than the antenna factor, and to clarify the procedure.

4.2.30.1 Test Data Table, EMC RF Signature and Transient Detection

Radiated Spectrum Signature, Empire NF-105 RIFI, S/N 3098

Measured	Meas Signal Level (db)			Calc Signal Level (db above 1 microv)	
Freq (MHz)	Carrier	Peak	Background	Carrier	Peak
0.455	1.0	14.0	*	7.5	21.0
3.599	14.0	19.0	25.0	14.5	18.0
3.993	11.5	15.5	13.5	18.0	22.0

*Specified Apollo or Saturn receiver frequency, background level not measured.

4.2.30.1 (Continued)

Measured Freq (MHz)	Meas Signal Level (db) Carrier	Peak	Background	Calc Signal Level (db above 1 microv) Carrier	Peak
4.197	8.0	11.5	18.0	20.5	25.5
4.994	18.0	24.0	*	28.5	30.5
10.000	-3.0	-3.0	*	2.5	0.5
10.006	9.0	13.0	*	15.5	19.5
30.000	7.0	16.0	*	13.5	22.5
47.500	5.0	7.0	*	7.5	9.5
47.650	5.0	7.0	*	7.5	9.5
50.000	5.0	7.0	*	8.0	10.0
55.200	53.0	57.0	*	57.0	61.0
60.000	14.0	26.0	*	19.0	31.0
60.194	7.0	8.0	*	12.0	13.0
104.475	37.5	39.5	*	47.5	49.5
123.850	13.0	15.0	2.0	25.0	27.0
213.380	24.0	27.0	13.5	41.0	44.0
226.200	14.5	18.0	*	32.0	35.5
239.960	32.0	35.0	18.0	49.5	51.5
241.050	15.0	19.0	*	32.5	36.5
243.000	14.5	22.0	*	32.0	39.5
243.490	22.0	25.0	21.0	39.5	42.5
252.400	31.0	35.0	22.0	49.0	53.0
258.320	Saturation		-	-	-
259.700	45.0	50.0	*	63.0	68.0
264.700	35.0	38.5	24.0	53.5	57.0
277.050	30.0	44.0	24.0	49.0	63.0
296.800	16.0	24.0	*	35.5	43.5
450.000	15.0	18.0	*	39.0	42.0
790.000	21.0	26.0	*	51.5	56.5
890.000	15.0	22.0	*	47.0	54.0

Radiated Spectrum Signature, Empire NF-112, S/N 117

Measured Freq (MHz)	Meas Signal Level (db) CW Average	CW Peak	Background	Calc Signal Level (db above 1 microv) CW Average	CW Peak
2101.800	20.0	20.0	*	38.3	38.3
2106.400	20.0	20.0	*	38.3	38.3
4939.806	29.0	30.0	*	52.5	53.5
5060.194	29.0	30.0	*	52.6	53.6
5590.000	29.0	30.0	*	53.2	54.2
5690.000	29.0	30.0	*	53.2	54.2

*Specified Apollo or Saturn receiver frequency, background level not measured.

4.2.31 Range Safety Receiver Checks (1B66565 D)

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

Item	Ref. Location	P/N	S/N
Range Safety Receiver 1	411A97A14	50M10697	200
Range Safety Receiver 2	411A97A18	50M10697	089
Secure Command Decoder 1	411A99A1	50M10698	041
Secure Command Decoder 2	411A99A2	50M10698	023

Initiated on 17 July 1968, the procedure was completed by the third attempt on 7 August 1968 after 3 days of activity, and was accepted on 13 August 1968.

The first attempt to perform the test was terminated during the setup when the destruct system test set, DSV-4B-136, could not be adjusted for the proper output. The defective test set was removed and replaced with a new unit. The second attempt was run to completion and the test set cable attenuation check and the RF bandwidth check were acceptable, however the remaining part of the test was not acceptable because the 20 db attenuator was not replaced in the destruct system test set after the RF bandwidth check was run. The 20 db attenuator was replaced in the test set and the remaining part of the test was run and accepted on the third attempt. The following narration and Test Data Table 4.2.31.1 cover the final run and the acceptable part of the second attempt.

Several manual operations were accomplished before the automatic procedure was started. The total cable insertion loss values at the 450 MHz range safety frequency were found to be 28.9 db for range safety system 1, and 29.3 db for range safety system 2. The Model DSV-4B-136 destruct system test set, P/N 1A59952-1, was set up at 450.000 $\pm$ 0.045 MHz with a -17 dbm output level and a 60.00 $\pm$ 0.60 kHz deviation. The stage range safety antennas were disconnected from the directional power divider, and 50 ohm loads were connected to the power divider in their place for test use until the open loop RF checks. Initial test conditions were established, the range safety receivers were transferred to external power and turned on, and the propellant dispersion cutoff command inhibit was turned on for both receivers. The cable insertion loss values were loaded into the computer for use in the program.

The receiver AGC calibration checks were conducted next. For each input signal level used in the calibration check, the computer determined the GSE test set output level required to compensate for the cable insertion loss, and, when requested by the computer typeout, the GSE test set was manually adjusted to these output levels. The computer then determined the input signal levels and measured the low level signal strength (AGC telemetry voltage) of each receiver. These AGC measurements, in the 0 to 5 vdc range, were multiplied by a conversion factor of twenty and presented as percent of full scale values. The AGC calibration check was conducted twice, and

4.2.31 (Continued)

the difference in AGC values at each step was determined for the AGC drift check. As shown in the Test Data Table, the AGC values were all acceptable, and the drift deviations were well below the 3 percent of full scale maximum limit.

Manual -3db and -60db RF bandwidth checks were individually conducted on each receiver. With a GSE test set output frequency of 450.000 $\pm$ 0.005 MHz, the output level was adjusted to obtain a 2.0 $\pm$ 0.1 vdc AGC voltage from the receiver under test. The corresponding receiver RF output level was determined, and +20 dbm was added to obtain the RF reference level. The GSE test set output level was increased by 3db, and the test set frequency was increased above 450 MHz, and then decreased below 450 MHz, until the receiver AGC voltage was again 2.0 $\pm$ 0.1 vdc. The frequencies at which this occurred were measured as the upper and lower -3db bandedge frequencies. The -3db 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 -60db bandwidth check, this procedure was repeated, except that the test set output level was increased by 60db rather than 3db. The results of these checks are shown in the Test Data Table.

For the deviation threshold check, the GSE test set was adjusted for an output of 450.000 $\pm$ 0.045 MHz at a level that provided receiver input levels of -63 dbm for receiver 1, and -63.399dbm for receiver 2. A series of checks determined the minimum input deviation frequency at which each receiver would respond to the range safety commands. For each command, the GSE test set was manually adjusted to a sequence of deviation frequencies increasing from 5 kHz, as requsted by the computer typeout. At each deviation frequency, the range safety secure command decoders were checked for the presence of the command signal from the appropriate receiver. As shown in the Test Data Table, both receivers responded to all commands at minimum deviation frequencies well below the 50 kHz maximum limit.

For the radio frequency sensitivity checks, the GSE test set was adjusted for an output of 450.000 $\pm$ 0.045 MHz with a fixed deviation of 60.0 $\pm$ 0.5 kHz. A series of checks determined the minimum input signal level at which each of the receivers would respond to the range safety commands. For each command, the GSE test set output was manually adjusted to a sequence of levels increasing from -85.5 dbm, as requested by the computer typeout. This gave input levels increasing from -115.0 dbm for receiver 1, and increasing from -115.399 dbm for receiver 2. At each input level, the range safety secure command decoders were checked for the presence of the command signal from the appropriate receiver. Both receivers responded to minimum input levels below the -93 dbm maximum limit, as shown in the Test Data Table.

The 50 ohm loads were disconnected from the stage power divider, and the range safety antennas were reconnected for the open loop RF checks. For a manual open loop check, the GSE test set was adjusted for open loop operation, and the test set antenna coaxial switch was set to the first test position. The test set output level was set at -100 dbm and increased in 1 dbm increments

4.2.31 (Continued)

until the AGC voltage of the least sensitive receivers no longer increased. This occurred at an output level of -76.0 dbm. The AGC voltage of the other receiver was verified to be at least 3 vdc at this level. The check was repeated with the test set antenna coaxial switch set to the second test position, with the output level measured as -77.0 dbm. The test set antenna coaxial switch was returned to the first test position, and the test set output level was set at -91.0 dbm for the automatic open loop RF checks.

Under open loop conditions, the low level signal strength (AGC telemetry voltage) of receiver 1 was 3.697 vdc, while that of receiver 2 was 3.348 vdc. The range safety commands were transmitted from the GSE test set, and checks of the secure command decoders showed that both receivers responded properly to the open loop transmission. The PCM RF assembly power was turned on, the open loop PCM signal was verified to be received at the DDAS ground station, and the range safety commands were again transmitted. Checks of the decoders showed that both receivers responded properly and were not adversely affected by the PCM RF transmission. The PCM RF assembly power was turned off, the range safety EBW firing units were transferred to external power, the propellant dispersion cutoff command inhibits were turned off for both receivers, and the range safety receivers were both turned off, completing the range safety receiver checks.

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

a. One revision corrected three paragraphs in the RF bandwidth check to specify less than 450 MHz or more than 450 MHz as applicable.

b. One revision added page 3.9, which contained figure 1, Setup for Cable Attenuation Test Procedure, which had been omitted from the procedure.

4.2.31.1 <u>Test Data Table, Range Safety Receiver Checks</u>

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

Test Set Output (dbm)	Receiver 1 Input (dbm)	AGC 1 (%) Run 1	AGC 1 (%) Run 2	Drift	Receiver 2 Input (dbm)	AGC 2 (%) Run 1	AGC 2 (%) Run 2	Drift
-98.100	-127.000	23.477	21.328	2.148	-127.399	16.289	15.176	1.11
-91.100	-120.000	22.344	22.051	0.293	-120.399	15.996	15.586	0.41
-86.100	-115.000	24.395	23.984	0.410	-115.399	17.324	17.012	0.31
-81.100	-110.000	30.449	29.941	0.508	-110.399	21.738	21.621	0.12
-76.100	-105.000	43.477	43.164	0.313	-105.399	32.305	31.484	0.82
-71.100	-100.000	62.656	63.066	0.410	-100.399	51.777	51.484	0.29
-66.100	-95.000	73.125	73.008	0.117	-95.399	65.020	65.020	0.00
-61.100	-90.000	74.238	74.141	0.098	-90.399	67.168	67.070	0.10

4.2.31.1 (Continued)

Test Set Output (dbm)	Receiver 1 Input (dbm)	AGC 1 (%) Run 1	AGC 1 (%) Run 2	AGC 1 (%) Drift	Receiver 2 Input (dbm)	AGC 2 (%) Run 1	AGC 2 (%) Run 2	AGC 2 (%) Drift
-56.100	-85.000	74.453	74.355	0.098	-85.399	67.988	67.891	0.10
-51.100	-80.000	74.551	74.453	0.098	-80.399	68.398	68.398	0.00
-46.100	-75.000	74.453	74.551	0.098	-75.399	68.496	68.613	0.12
-41.100	-70.000	74.238	74.238	0.000	-70.399	68.496	68.398	0.10

-3 db RF Bandwidth Check

Function	Receiver 1	Receiver 2	Limits
Reference Voltage (AGC) (vdc)	1.99	1.99	2.0 ± 0.1
Reference RF Power Level (dbm)	-98.0	-94.0	*
Upper Bandedge Frequency (Mhz)	450.138	450.131	*
Lower Bandedge Frequency (MHz)	449.813	449.797	*
-3 db Bandwidth (kHz)	325.0	354.0	340.0 ± 30.0
Bandwidth Centering (MHz)	449.975	449.974	450.000 ± 0.0338

-60 db RF Bandwidth Check

Function	Receiver 1	Receiver 2	Limits
Reference Voltage (AGC) (vdc)	1.99	1.99	2.0 ± 0.1
Reference RF Power Level (dbm)	-98.0	-94.0	*
Upper Bandedge Frequency (MHz)	450.466	450.453	*
Lower Bandedge Frequency (MHz)	449.453	449.415	*
-60 db Bandwidth (MHz)	1.013	1.038	1.2 max

Deviation Sensitivity Check

Range Safety Command	Minimum Deviation (kHz) Receiver 1	Minimum Deviation (kHz) Receiver 2
Arm and Engine Cutoff	7.500	10.000
Propellant Dispersion	7.500	10.000
Range Safety System Off	10.000	10.000

RF Sensitivity Check

Range Safety Command	Minimum Input Level (dbm) Receiver 1	Minimum Input Level (dbm) Receiver 2
Arm and Engine Cutoff	-110.000	-110.399
Propellant Dispersion	-110.000	-110.400
Range Safety System Off	-110.000	-110.399

*Limits Not Specified

4.2.32 Pneumatic Control System Leak Check (1B59457 C)

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

Initiated on 10 July 1968, the first issue of the procedure was completed on 25 July 1968, after 6 days of activity, and was accepted on 26 July 1968. The second issue procedure was initiated on 30 July 1968, to leak check the LOX fill and drain valve which had been replaced. The procedure was completed on 30 July 1968, with acceptance occurring on 2 August 1968. The discussion which follows does not differentiate between first and second issue procedures, instead the test is treated as though there had been only one procedure issued. This has been done to avoid confusion. In general, the test was accomplished by pressurizing the pneumatic control system with gaseous helium, and using a USON leak detector as the primary method of detecting leakage. Leak test bubble fluid was used when required as a secondary detection method, and gross leakage was located by listening for audible escaping gas.

The stage test configuration was established by capping various supply and purge lines to isolate the pneumatic control system. The APS helium supply lines were pressurized to 1500 ± 50 psia, with checks made at each 500 psi increment to verify that there was no gross leakage, and leak checked.

The pneumatic control sphere was pressurized to 1700 ± 50 psia for an integrity check, with checks made at several pressures to verify that there was no gross leakage. The integrity pressure was held for 3 minutes, then the pneumatic control sphere was vented to 1500 ± 100 psia and the control sphere supply lines and purge lines were leak checked. The pneumatic control shutoff valve seat leakage was measured, as shown in Test Data Table 4.2.32.1.

The pneumatic control sphere was then vented to 550 ± 50 psia to provide pressure for subsequent leak checks. Leak checks were conducted on the pneumatic control supply and purge lines, and on the following components of the system: The pneumatic control module; the engine pump purge control module; the LOX chilldown pump and the pump purge control module; the LOX and LH2 prevalves and chilldown shutoff valves, and the actuation control module for these valves; the LOX and LH2 vent and relief valves and their actuation control module; the LOX and LH2 fill and drain valves and their actuation control modules; the O2H2 burner LOX and LH2 propellant valves and their actuation control modules; the LOX shutoff valve; the directional control valve and its actuation control module; the LH2 continuous vent valve and its actuation control module; and the system pressure switches and transducers.

The measured valves and the design limits are shown in the Test Data Table. One condition of leakage was noted. A pipe assembly, P/N 1B65190-1, B-nut was

4.2.32 (Continued)

leaking at the hand valve at thrust structure stringer 5 3/4. The B-nut was retightened to the proper torque valve. These results were acceptable, and the system was returned to the pre-test configuration completing the procedure.

Engineering comments noted that all parts were installed at the start of these tests. No FARR's were generated as a result of these tests. The first issue procedure had twenty-one revisions written against it for the following:

a. One revision added the nonpropulsive vent valve module to the system description paragraph.

b. One revision was written to reflect the change in a disconnection point, a different pipe assembly number, and an additional purge line due to installation of the LOX nonpropulsive vent duct.

c. Two revisions corrected typing errors.

d. One revision was written to reflect the plumbing changes due to installation of the LOX nonpropulsive vent valve.

e. One revision was written to change the instructions for leak checking the LOX tank vent valve due to installation of the LOX nonpropulsive vent valve.

f. One revision was written to reflect the in-series line connections between the LOX propellant valve and the actuation control module.

g. One revision deleted the instructions to leak check the LOX propellant valve shaft seal vent port because it was inaccessible.

h. One revision changed the maximum allowable leakage rate of the directional control valve flight actuator seal leakage from 50 sccm to 100 scim to conform with the 1A49988 AC requirements.

i. One revision added the instructions to obtain the directional control valve ground actuator seal leakage to correct a procedural omission.

j. One revision added instructions to leak check the mating flanges of the continuous vent module and the bypass valve pneumatic actuator to comply with new leak check requirements.

k. One revision added provisions for leak checking the LOX tank nonpropulsive valve and lines, which had been installed on the stage.

l. One revision deleted four individual revisions and combined the instructions in one step by step revision to clarify to changes made.

m. One revision deleted the requirements to vent the pneumatic control sphere to between 225 and 250 psig and then subsequently repressurize it to 550 $\pm$ 50 psia in accordance with NASA letter I-V-S-IVB-L-68-168, dated 27 March 1968.

4.2.32 (Continued)

n. One revision deleted a revision which combined the instructions for the purge lines orifice flowrates and leak check, because there was insufficient information to perform a good flowrate test. The leak check provisions were retained in the new revision.

o. A variation revision was written to establish a flowrate curve for the restrictors, P/N 1B40622-501, to provide data for an analytical study.

There was one revision written against the second issue procedure to delete all portions of the procedure, except those provisions necessary to leak check the LOX fill and drain valve, which had been installed subsequent to completion of the first issue.

4.2.32.1 Test Data Table, Pneumatic Control System Leak Check

Function	Measured Value	Limits
Pneu Cont Shutoff Valve Seat Lkg (scim)	0	5 max
Eng Pump Purge Valve Flow (scfm)	6.25	6 ± 0.5
Pneu Cont Module Vent Port (scim) (Start Tank Vent Vlv Open)	0	1 max
Pneu Cont Module Vent Port (scim) (Start Tank Vent Vlv Closed)	0	1 max
LOX Chilldown Pump		
Pump Seal Overboard Drain Vent Lkg (scim)	0.5	8 max
Pump Relief Valve Seat Leakage (scim)	0	16 max
Pump Dump Valve Seat Leakage (scim)	0	25 max
Pump Purge Module Flow (scim)	43	33.0 to 48.8
Pump Purge Module Bypass Line Flow (scim)	10.75	10 ± 3
LOX and LH2 Prevalve and Chilldown Shutoff Valve Actuation Control Module		
Module Vent Port L2 Leakage (sccm) (Prevalves and Chilldown Shutoff Vlv Open)	0	100 max
Module Vent Port L1 Leakage (sccm) (Prevalves and Chilldown Shutoff Vlv Open)	0	100 max
Module Vent Port L2 Leakage (sccm) (Prevalves and Chilldown Shutoff Vlv Closed)	0	100 max
Module Vent Port L1 Leakage (sccm) (Prevalves and Chilldown Shutoff Vlv Closed)	0	100 max
LOX and LH2 Prevalve		
LOX Prevalve Piston Seal Lkg (scim)	1.3	300 max
LOX Prevalve Shaft Seal Lkg (scim)	0	100 max
LOX Prevalve Pos Ind Sw Housing Lkg (scim)	0	100 max
LH2 Prevalve Shaft Seal Lkg (scim)	0	100 max
Actuation Cont Mod Vent Port L1		1 psia/min
Decay Check-Start (psig)	510	*
After 30 min (psig)	510	*

* Limits Not Specified

4.2.32.1 (Continued)

Function	Measured Valve	Limits
LOX Vent and Relief Valve Actuation Control Module		
Module Vent Port Leakage L1 (sccm)	0	100 max
Module Vent Port Leakage L2 (sccm)	0	100 max
Solenoid Valve Leakage L1 (sccm) (LOX Tank Vent Vlv Open)	0	100 max
Combined Piston Seal and Static Seal Lkg (scim)	0	150 max
Solenoid Valve Leakage L2 (sccm) (LOX Tank Vent Vlv Closed)	0	100 max
LOX Tank Nonpropulsive Valve Actuation Control Module		
Module Vent Port Leakage L1 (sccm)	0	100 max
Module Vent Port Leakage L2 (sccm)	0	100 max
Solenoid Valve Leakage L2 (sccm) (LOX Nonprop Valve Open)	0	100 max
Opening Piston Seal Leakage (scim)	0	150 max
Solenoid Valve Leakage L1 (sccm) (LOX Nonprop Valve Closed)	0	100 max
Latching Plunger Leakage (scims)	1250	10,368 max
LOX Fill and Drain Valve Actuation Control Module		
Module Vent Port Leakage L1 (sccm)	0	100 max
Module Vent Port Leakage L2 (sccm)	0.1	100 max
Solenoid Valve Leakage L1 (sccm) (LOX F&D Valve Open)	0	100 max
Solenoid Valve Leakage L2 (sccm) (LOX F&D Valve Closed)	0	100 max
LH2 Fill and Drain Valve Actuation Control Module		
Module Vent Port Leakage L1 (sccm)	0	100 max
Module Vent Port Leakage L2 (sccm)	0	100 max
Solenoid Valve Leakage L1 (sccm) (LH2 F&D Valve Open)	0	100 max
O2H2 Burner LOX Prop Valve Actuation Control Module		
Module Vent Port Leakage L2 (sccm)	0	100 max
Module Vent Port Leakage L1 (sccm)	0	100 max
Solenoid Valve Leakage L1 (sccm) (LOX Prop Valve Open)	0	100 max

4.2.32.1 (Continued)

Function	Measured Value	Limits
LOX Prop Valve Act Leakage L2 (scim)	0	150 max
Solenoid Valve Leakage L2 (sccm) (LOX Prop Valve Closed)	0	100 max
LOX Prop Valve Act Leakage L1 (scim)	0	150 max
<u>O2H2 Burner LH2 Prop Valve & LOX Shutoff Valve Actuation Control Module</u>		
Module Vent Port Leakage L2 (sccm)	0	100 max
Module Vent Port Leakage L1 (sccm)	0	100 max
Solenoid Valve Leakage L1 (sccm) (LH2 Prop Vlv & LOX SOV Open)	0	100 max
Combined LH2 Prop Vlv & LOX SOV Lkg (scim)	0	22 max
Solenoid Valve Leakage L2 (sccm) (LH2 Prop Vlv & LOX SOV Closed)	0	100 max
Combined LH2 Prop Vlv & LOX SOV Lkg (scim)	0	22 max
<u>LH2 Vent and Relief Valve Actuation Control Module</u>		
Module Vent Port Leakage L2 (sccm)	0	100 max
Module Vent Port Leakage L1 (sccm)	20	100 max
Solenoid Valve Leakage L1 (sccm) (LH2 Tank Vent Valve Open)	0	100 max
Opening Piston Seal Leakage (scim)	0	150 max
Solenoid Valve Leakage L2 (sccm) (LH2 Tank Vent Valve Closed)	0	100 max
<u>Directional Control Valve Actuation Control Module</u>		
Module Vent Port Leakage L2 (sccm)	0	100 max
Module Vent Port Leakage L1 (sccm)	0	100 max
Solenoid Valve Leakage L1 (sccm) (Direct Cont Vlv Flt Pos)	0	100 max
Flight Act Seal Leakage (scim)	0	100 max
Solenoid Valve Leakage L2 (sccm) (Direct Cont Vlv Gnd Pos)	0	100 max
Ground Act Seal Leakage (sccm)	0	100 max
<u>LH2 Continuous Vent Actuation Module</u>		
Module Vent Port Leakage L2 (sccm)	0	100 max
Module Vent Port Leakage L1 (sccm)	0	100 max
Module & Bypass Vlv Pneu Act Lkg (sccm)	0	6.1 max
Module Vent Port Leakage L1 (sccm) (LH2 Continuous Vent Valve Open)	0	100 max

4.2.32.1 (Continued)

Function	Measured Value	Limits
Module Vent Port Leakage L2 (sccm) (LH2 Continuous Vent Valve Open)	0	330 max
Module Vent Port Leakage L1 (sccm) (LH2 Continuous Vent Valve Closed)	0	100 max
Module Vent Port Leakage L2 (sccm) (LH2 Continuous Vent Valve Closed)	0	330 max

Pneumatic Control Sphere Pressure Decay Test

Valves Not Actuated	Initial	30 Min Delay	Limits
Sphere Temperature (°F)	109	104	*
Sphere Pressure (psia)	1479	1468	*
Valves Actuated			
Sphere Temperature (°F)	102	98	*
Sphere Pressure (psia)	1443	1434	*

* Limits Not Specified

4.2.33 Repressurization System Leak Check (1B59460 B)

This manual procedure leak checked the repressurization system prior to automatic checkout activities, and is used to repressurize the LOX and LH2 tanks for the J-2 engine restart. The repressurization system included the LOX tank repressurization control module 403A74A3, P/N 1B56653-513, S/N 32; the LH2 tank repressurization control module 403A73A4, P/N 1B56653-513, S/N 37; seven ambient helium storage spheres, P/N 1B66868-501, two for LOX tank repressurization, S/N's 59 and 47, and five for LH2 tank repressurization, S/N's 43, 44, 46, 56, and 58; and the associated plumbing. The system also included an O2H2 burner and additional cold helium spheres for dual repressurization, but these were checked during the cold helium system leak check, H&CO 1B59458.

The procedure was initiated 24 July 1968 and completed on 25 July 1968, and was accepted on 26 July 1968. In general, the test was accomplished by pressurizing the system with helium gas and using a USON leak detector or leak detection bubble solution to locate any leakage. Gross leakage was located by listening for audible escaping gas.

After the GSE and stage test configuration was established, the repressurization ambient helium spheres were pressurized between 50 and 100 psia, and the proper operation of the LOX and LH2 repressurization dump valves was verified. The helium spheres were then pressurized to 1750 psig for an integrity check, with a check made at 500 psig to verify that there was no audible leakage. The integrity pressure was held for 3 minutes, then the spheres were vented to about 1500 psig.

4.2.33 (Continued)

Seat leakage measurements were then made on the valves, P/N 1B43660-509, within the LOX and LH2 repressurization control modules. The LOX helium spheres dump valve 403A74A3L1, S/N 2045, and the LH2 helium spheres dump valve 403A73A4L1, S/N 2131, both had zero scim seal leakages, meeting the 12 and 25 scim, allowable leakage limits respectively, for these valves. The LOX control shutoff valves 403A74A3L2 and L3, S/N's 2089 and 2095 had a 1.5 scim combined seat leakage, while the LH2 control shutoff valves 403A73A4L2 and L3, S/N's 2212 and 2142, had a 2.0 scim combined seat leakage, both within the 25 scim allowable combined leakage limit.

Leak checks were then conducted on the components, fittings, and connections of the repressurization system from the helium spheres to the repressurization control modules. The helium spheres were vented to 400 $\pm$ 50 psig, and the proper operation of the repressurization control shutoff valves was verified. Leak checks were then conducted on the system from the repressurization control modules to the connections to the LOX and LH2 pressurization lines. After the completion of these checks the repressurization system was vented to ambient and the stage was returned to the pre-test configuration.

Engineering comments noted that all parts were installed at the start of the test. The following six leaks were found and corrected:

a. A leak at the B-nut of pipe assembly, P/N 1B66835-1, was corrected by loosening and retightening the B-nut to the proper torque value.

b. A leak at the 3/4 inch cap on the manifold assembly, P/N 1B56657-501, was corrected by tightening the B-nut to the proper torque value.

c. A leak at the union between pipe assemblies, P/N 1B66803 and P/N 1B66808, was corrected by replacing the union.

d. A leak at the helium sphere leak port on the flange at stringer 24 3/4 was corrected by replacing the seal.

e. A leak at the union between pipe assemblies, P/N 1B67386 and P/N 1B58853, was corrected by replacing the union.

f. A leak at the helium sphere leak port on the flange at stringer 7 3/4 was corrected by replacing the seal.

No FARR's were written during this checkout; however, one revision was written against the procedure to delete the instructions to remove the test adapter and hand valve on the LOX pressurization line, because the hand valve was to be removed and an orifice adapter was to be installed during the propellant system automatic checkout.

4.2.34 Propulsion System Test (1B66572 E)

This automatic procedure performed the integrated electromechanical functional tests of the stage propulsion system. The procedure was divided into three sections, each of which was performed separately. The first section of the test checked the ambient helium system, and included functional checks of the pneumatic control system, the LOX and LH2 tank repressurization systems, and various pressure switches. The second section of the test performed functional checks on the LOX and LH2 tank pressurization systems. The third section of the test was a four part check of the J-2 engine system, including individual testing of the engine functions and a combined automatic check of engine operation.

Initiated on 26 July 1968, the procedure was completed on 8 August 1968, after 8 days of activity, and was accepted on 13 August 1968. The sections of the procedure are presented in order. Measurements made during the procedure are shown in Test Data Table 4.2.34.1.

Section 1, the ambient helium system test, was completed by the third attempt on 1 August 1968. The first two attempts were not acceptable because of a malfunction of the LOX fill and drain valve, and GSE problems with the digital events recorder and the A1 recorder in the Model DSV-4B-240 telemetry systems display console. The LOX fill and drain valve was replaced per FARR 500-238-496, and the GSE A1 recorder was also replaced. During the acceptable third attempt, the DDAS ground station was out of synchronization on five occasions, but this did not invalidate the test data. It was subsequently determined that the loss of synchronization was caused by a bad coaxial connector at the DDAS ground station, and this connector was replaced.

Measurements through the AO and BO telemetry multiplexers verified that the ambient helium pneumatic control sphere and the LH2 and LOX tank repressurization spheres were all pressurized to 700 ± 50 psia, and the control helium regulator discharge pressure was verified to be 515 ± 50 psia. A series of checks then verified the proper operation of the ambient helium sphere dump valve, the control helium supply shutoff valve, and the engine pump purge control valve. The LOX chilldown pump purge control module, dump valve, and control valve were verified to operate properly, and the operation of the LOX chilldown pump purge pressure switch was verified by measurements made three times, as shown in the Test Data Table. The LH2 and LOX repressurization control modules, dump valves, and control valves were then verified to operate properly.

A series of checks then verified the proper operation of the flight control pressure switches, the repressurization interlock functions, the O2H2 burner propellant valves, spark system, and voting circuits, and the repressurization control valves. The operation of the engine pump purge pressure switch and control valve was verified, as was the operation of the control helium regulator backup pressure switch and the control helium shutoff valve. Measurements were made three times on each of the pressure switches, as shown in the Test Data Table.

4.2.34 (Continued)

The ambient helium spheres were then repressurized, the control helium sphere pressure was measured as 708.58 psia, and the control helium regulator discharge pressure was measured as 531.89 psia, within the 515.0 ± 50.0 psia limits. A series of checks then verified the operation of the pneumatically controlled LH2 and LOX vent valves, fill and drain valves, prevalves, and chilldown shutoff valves; the LH2 directional vent valve; the LH2 continuous vent and relief override valve and orifice bypass valve; the O2H2 burner LH2 and LOX propellant valves and LOX shutdown valve; and the LOX nonpropulsive vent valve. Operating times for the various valves were measured as shown in the Test Data Table. Switch selector control of the valves was also verified. This completed the first section of the procedure.

Section 2, the pressurization systems check, was completed by the second attempt on 5 August 1968. The first attempt was not acceptable because of numerous problems involving the LOX repressurization control valve, the cold helium regulator, and the LH2 flight control and ground fill pressure switches. After these problems were corrected, a manual check was accomplished to verify the proper operation of the LH2 pressure switches (reference revision g).

During the second attempt, several GSE problems were encountered involving the DDAS ground station, the computer, a pressure switch, and a transducer power supply. These problems were satisfactorily corrected. An out-of-tolerance indication for the cold helium regulator was accepted, as the regulator was operating properly. The indication was due to the method used to monitor the pressure. Out-of-tolerance indications for the LH2 pressure switches were also accepted, as the manual check had verified that the switches were operating properly. The switch problems were attributed to difficulties with the 48 feet of 1/8 inch line used to supply gas pressure during the test.

The cold helium sphere pressure was verified to be 825 ± 25 psia and the cold helium dump valve and shutoff valve were verified to operate properly. The operation of the cold helium regulator backup pressure switch was verified by making measurements three times, as shown in the Test Data Table, and by verifying that the switch properly controlled the cold helium shutoff valve. The LOX and 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 making measurements three times, as shown in the Test Data Table, and by verifying that the switches properly controlled the LOX and LH2 repressurization control valves.

The proper operation of the O2H2 burner spark ignition system was then verified with the ignition voltages measured as shown in the Test Data Table. The LOX tank pressure switches, the cold helium shutoff valve, and the cold helium heat exchanger bypass valve were all verified to operate properly, with measurements made three times on the LOX tank ground fill pressure switch, as shown in the Test Data Table. The proper operation of the cold helium regulator was then verified. With a test orifice, P/N SO772C12-240, installed in the test adapter, the regulator outlet pressure dropped from 386.65 psia to 361.55 psia, above the 358 psia minimum limit, while the cold helium spheres pressure dropped from 793.34 psia to 739.88 psia. The outlet pressure then continued to drop to 252.99 psia while the spheres pressure dropped to 499.30 psia. With

4.2.34 (Continued)

a test orifice, P/N S0772C12-204, installed in the test adapter, the regulator outlet pressure dropped from 394.84 psia to 357.73 psia, just below the 358 psia minimum limit, while the cold helium spheres pressure dropped from 793.34 psia to 610.03 psia. As previously noted, this slight out-of-tolerance condition of the outlet pressure was attributed to the method used to measure the pressures, and not to any malfunction of the regulator. The outlet pressure then continued to drop to 321.73 psia while the spheres pressure dropped to 495.48 psia.

A series of checks then verified the proper operation of the LH2 repressurization control pressure switch, the LH2 step pressure valve and bypass control valve, the LH2 ground fill overpressure pressure switch, and the flight control indications from the latter switch. The pressure switches were both checked by measurements made three times, as shown in the Test Data Table. It was also verified that the bypass control valve and the step pressure valve were properly controlled by the LH2 pressure switches.

The cold helium and repressurization spheres were then vented to ambient pressure, and a final series of checks verified the proper operation of the O2H2 burner voting circuits, propellant valves, and temperature sensors, and the LH2 and LOX repressurization control valves.

Section 3, the J-2 engine check, was completed by the fourth attempt on 8 August 1968. The first three attempts were not acceptable because of several GSE problems with the DDAS ground station, the Model DSV-4B-321 pneumatic console, the recorders in the Model DSV-4B-240 telemetry system display console, and a 5 volt transducer power supply. One out-of-tolerance problem with the mainstage 1 pressure switch on the J-2 engine was traced to a malfunctioning pressure transducer in the Model DSV-4B-321 pneumatic console. This transducer was replaced, while tests conducted by Rocketdyne verified that the mainstage 1 pressure switch was operating satisfactorily. The other GSE problems, and some minor program problems, were corrected for the acceptable fourth attempt.

During the fourth attempt, a malfunction indication noted that the start tank discharge valve travel time was out-of-tolerance. As data from the recorder in the Model DSV-4B-240 display console showed that the travel time was within tolerance, the condition and the measured valves were considered acceptable

The LH2 and LOX vent valves were opened to vent the propellant tanks to ambient pressure. 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 all verified to operate properly. The LH2 and LOX prevalves and chilldown shutoff valves were then closed. A series of checks then verified that the engine spark ignition systems 1 and 2 properly caused thrust chamber and gas generator sparks.

The engine start tank was pressurized, the proper operation of the start tank vent valve was verified, and the start tank was vented back to ambient pressure. For an engine cutoff test the engine ready signal was verified to be on, it was verified that the simulated mainstage OK signal opened the LH2 and LOX prevalves, that the switch selector engine cutoff signal operated properly and

4.2.34 (Continued)

closed the prevalves, and that removing the cutoff signal reopened the prevalves. The proper operation of the switch selector engine start and LH2 injector temperature detector bypass commands was verified, and the engine ignition timer was measured as shown in the Test Data Table.

The next series of checks verified that the aft separation simulation 1 and 2 signals inhibited engine start when one or the other was off, and then verified the proper operation of the LH2 injector temperature detector bypass, the start tank discharge control indication, the ignition detected indication, and the helium control solenoid valve. During these checks, measurements were made of the helium delay timer, the sparks de-energized timer, and the start tank discharge timer, as shown in the Test Data Table.

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

The helium control sphere was pressurized to 1450.41 psia, meeting the 1450 psia minimum limit, for the engine solenoid valve component checks. A series of checks then verified that opening and closing the helium control solenoid valve caused the LH2 and LOX bleed valves to close and open; that opening and closing the ignition phase control solenoid valve caused the engine augmented spark ignitor (ASI) LOX valve and the engine main LH2 valve to open and close; that the start tank discharge solenoid valve opened and closed properly; and that opening and closing the mainstage control solenoid valve caused the gas generator valve and main LOX valve to open and close, and the LOX turbine bypass valve to close and open. During these checks, valve position measurements were made as shown in the Test Data Table, and the engine regulator outlet pressure was measured as 416.56 psia through the A0 multiplexer and 417.33 psia through the B0 multiplexer, when the helium control solenoid valve was opened.

For the final engine sequence check, the entire engine system was verified to be ready for the check, and a completely automatic repetition of the previous engine system checks was accomplished by giving the necessary commands to cause engine start and cutoff. Throughout the automatic sequence, the system responses were verified to be within predetermined limits. Various operating times were measured during the sequence, as shown in the Test Data Table, to verify the proper operation of the system component items. Also, the engine regulator outlet pressure was measured as 415.80 psia at the time of engine start.

4.2.34 (Continued)

Engineering comments noted that there were no parts shortages affecting this test. As noted in the individual section narrations, a number of GSE and other minor problems were encountered and corrected during the test, and one stage FARR was written. FARR 500-238-496 noted that the LOX fill and drain valve, P/N 1A48240-505-001, S/N 131, had a closing time of 2.293 seconds, exceeding the 2 second maximum limit. The defective valve was removed and a new valve, S/N 125, was installed, tested, and accepted for use.

Twenty revisions were made to the procedure:

a. One revision deleted the exciter-igniter tips, P/N's 71980 and 71983, and the accompanying referenced note, from the Time/Cycle Significant Items paragraph, as the tips were no longer considered cycle significant.

b. Three revisions changed the preliminary setup instructions for Section 2, the pressurization systems test. One step was changed to remove a hand valve from pipe assembly, P/N 1B55285-1, rather than to disconnect pipe assembly, P/N 1B67049, in order to install test adapter, P/N 1B59324. The hand valve had been previously installed for use during manual leak checks and Section 1 of this test. One step was changed to close the LOX repressurization supply valve rather than the cold helium bottle fill valve, to correct the valve nomenclature. A step was added to install a breakout box at the forward skirt prior to turning on stage power. This was to prevent damage to pins of wire harnesses or switches during the pressure switch tests.

c. Six revisions corrected various program errors. One typeout statement was changed to be a printout statement; a breakpoint was added to provide the minimum of 83 milliseconds required to allow the burner propellant valve relay to reset; three breakpoints were added to provide the required time delay between switch selector commands; a "Go To" command was changed to prevent resetting a counter to zero when the program cycled for the second and third pressure switch checks; and at two places, a time cell loading was changed so that the range time would be stored, rather than zero.

d. One revision added a step to vent the repressurization spheres at the time the cold helium spheres were vented during Section 2, to relieve any pressure caused by leakage under the repressurization control valve seats. The spheres were to be unpressurized during subsequent tests.

e. One revision disabled SIM channel 41 during the O2H2 burner spark tests, to avoid getting unnecessary SIM interrupts caused by the test. SIM channel 41 was re-enabled after the spark test was finished.

f. Two revisions modified the O2H2 burner spark system tests during Section 3. Prior to the spark system tests, one revision turned on the EBW pulse sensor power, turned off the aft bus 1 power supply, and verified that the aft bus 1 voltage was 28.0 +2.5, -2.0 vdc from

4.2.34 (Continued)

the backup power supply. The same revision turned the pulse sensor power back off after the spark system tests were finished. The second revision deleted additional steps to turn the aft bus 1 power supply back on and to turn the backup power off after these tests, as the remainder of the test could be accomplished using the backup power, making it unnecessary to return to the aft bus 1 power supply.

g. One revision performed pickup and dropout pressure checks to verify the operation of the LH2 pressure switches. The repressurization control switch, S-2, P/N 1B52624-513, S/N 24, had pickup pressures of 33.5, 33.5, and 33.5 psia, and dropout pressures of 31.1, 31.45, and 31.1 psia. The ground fill pressure switch, S-4, P/N 1B52624-513, S/N 28, had pickup pressures of 33.8, 33.8, and 33.8 psia, and dropout pressures of 31.4, 31.5, and 31.45 psia. Both switches met the limits of 34 psia maximum pickup pressure and 31 psia minimum dropout pressure, and both were accepted for use.

h. One revision add steps at four places in Section 2, to turn off the sequencer power during the removal and installation of wire harness during the pressure switch checks, to prevent arcing.

i. One revision changed three wait times during Section 2 fault routines, to be 25 seconds rather than 15 seconds, as more time was needed to allow the cold helium sphere pressure to drop the required 50 psia.

j. One revision changed the limits on the cold helium sphere pressure during the Section 2 regulator flow test, to be 610 psia rather than 600 psia at one place and to be 740 psia rather than 690 psia at another place. This was to allow for variations between a 0 to 3500 psia transducer and a 0 to 600 psia transducer.

k. One revision changed the tolerance on the gas generator valve position to be ± 0.050 percent rather than ± 0.040 percent during Section 3, to allow for the tolerance on the gas generator valve plateau measurement.

l. One revision deleted the telemetry measurements of the start tank discharge valve closing time during Section 3. Because of the computer capability, the typed out measurement was 263 milliseconds, exceeding the 215 $\pm$ 40 milliseconds limit. Oscillograph data indicated that the actual closing time was 245 milliseconds, well within the tolerance limit.

4.2.34.1 Test Data Table, Propulsion System Test

Section 1, Ambient Helium Test

Pressure Switch Checks

Function	Measurement Test 1	Test 2	Test 3	Limits
LOX Chilldown Pump Purge Pressure Switch				
Pressurization Time (sec)	35.243	23.722	23.467	300.0 max
Pickup Pressure (psia)	40.22	40.01	39.96	41.5 max
Depressurization Time (sec)	18.407	11.422	11.711	180.0 max
Dropout Pressure (psia)	38.65	38.75	38.80	37.5 min
Deadband (psi)	1.58	1.26	1.16	0.3 min
Engine Pump Purge Pressure Switch				
Pickup Pressure (psia)	123.05	121.49	121.49	136.0 max
Dropout Pressure (psia)	105.91	109.03	109.03	99.0 min
Deadband (psi)	17.14	12.46	12.46	3.0 min
Control Helium Regulator Backup Pressure Switch				
Pressurization Time (sec)	16.548	16.539	16.642	180.0 max
Pickup Pressure (psia)	598.219	598.984	598.984	600.0 ± 21.0
Depressurization Time (sec)	4.085	4.137	4.131	180.0 max
Dropout Pressure (psia)	493.84	493.84	493.84	490.0 ± 31.0

Pneumatically Controlled Valve Checks

Valve	Operating Times (sec) Open	Total Open	Close	Total Close	Boost Close	Total Bst Cls
LH2 Vent Valve	0.021	0.077	0.220	0.454	0.096	0.230
LOX Vent Valve	0.024	0.081	0.128	0.370	0.066	0.200
LOX Fill & Drain Valve	0.094	0.190	0.620	1.695	0.259	0.541
LH2 Fill & Drain Valve	0.096	0.199	0.701	1.841	0.356	0.805
LOX Prevalve	1.299	1.962	0.229	0.374		
LH2 Prevalve	1.323	1.994	0.251	0.396		
LOX C/D Shutoff Valve	0.087	0.813	0.007	0.123		
LH2 C/D Shutoff Valve	0.222	0.843	0.028	0.133		
LH2 Cont. Vent Orifice Bypass Valve	0.008	0.039	0.007	0.062		
Burner LH2 Propellant Valve	0.041	0.132	0.062	0.153		
Burner LOX Propellant Valve	0.076	0.157	0.049	0.146		
Burner LOX Shutdown Valve	0.007	0.074	0.007	0.087		
LOX Nonpropulsive Vent Valve	0.032	0.057	0.164	0.394	0.089	0.210

4.2.34.1 (Continued)

Section 1, Valve Checks (Continued)

Valve	Operating Times (sec) Flight Pos.	Total Flight Pos.	Gnd Pos.	Total Gnd Pos.
LH2 Directional Vent Valve	0.067	0.176	0.220	0.368

Section 2, Pressurization System Check

Pressure Switch Checks

Function	Measurement Test 1	Test 2	Test 3	Limits
Cold Helium Regulator Backup Pressure Switch				
Pressurization Time (sec)	12.627	11.979	12.286	180.0 max
Pickup Pressure (psia)	465.789	467.352	465.789	467.5 ±23.5
Depressurization Time (sec)	5.914	5.999	5.884	180.0 max
Dropout Pressure (psia)	366.0	365.0	367.0	362.5 ±33.5
LOX Tank Repressurization Backup Pressure Switch				
Pressurization Time (sec)	12.848	12.446	12.532	180.0 max
Pickup Pressure (psia)	472.0	472.0	472.8	467.5 ±23.5
Depressurization Time (sec)	6.037	6.089	5.977	180.0 max
Dropout Pressure (psia)	366.1	364.5	367.6	362.5 ±33.5
LH2 Tank Repressurization Backup Pressure Switch				
Pressurization Time (sec)	11.961	11.964	11.794	180.0 max
Pickup Pressure (psia)	468.1	467.4	467.4	467.5 ±23.5
Depressurization Time (sec)	5.583	5.625	5.710	180.0 max
Dropout Pressure (psia)	373.9	373.9	372.3	362.5 ±33.5
LOX Tank Ground Fill Pressure Switch				
Manifold Press Time (sec)	30.515	24.865	21.938	180.0 max
Pickup Pressure (psia)	39.96	39.80	39.80	41.0 max
Depressurization Time (sec)	12.661	11.188	11.096	180.0 max
Dropout Pressure (psia)	38.96	38.96	38.96	37.5 min
Deadband (psi)	1.00	0.84	0.84	0.5 min

4.2.34.1 (Continued)

Section 1, Valve Checks (continued)

Function	Measurement Test 1	Test 2	Test 3	Limits
LH2 Repressurization Control Pressure Switch				
Pressurization Time (sec)	41.858	17.685	25.304	180.0 max
Pickup Pressure (psia)	32.67	32.62	32.52	34.0 max
Depressurization Time (sec)	22.297	26.726	21.432	180.0 max
Dropout Pressure (psia)	30.56†	30.51†	30.46†	30.8 min
Deadband (psi)	**	**	**	0.5 min
LH2 Ground Fill Pressure Switch				
Pressurization Time (sec)	27.455	24.704	24.696	180.0 max
Pickup Pressure (psia)	32.88	32.88	32.83	34.0 max
Depressurization Time (sec)	23.162	20.922	21.096	180.0 max
Dropout Pressure (psia)	30.77†	30.82	30.77†	30.8 min
Deadband (psi)	**	2.06	**	0.5 min

Burner Spark System Checks

Function	Measurement	Limits
Exciter 1 on (umb) (vdc)	2.93	2.7 min
Exciter 2 on (umb) (vdc)	2.99	2.7 min
System 1 on Ind (T/M M74) (vdc)	3.18	2.7 min
System 2 on Ind (T/M M73) (vdc)	3.46	2.7 min
Exciter 1 Off (umb) (vdc)	0.95††	On-2.0 max
Exciter 2 Off (umb) (vdc)	0.75	On-2.0 max
System 1 Off Ind (T/M M74) (vdc)	0.01	0.0 ± 0.2
System 2 Off Ind (T/M M74) (vdc)	0.00	0.0 ± 0.2

Section 3, J-2 Engine Checks

Engine Timer Checks

Function	Delay Time (sec)	Limits (sec)
Engine Ignition Timer	0.454	0.450 ±0.030
Helium Delay Timer	0.984	1.000 ±0.110
Sparks De-Energized Timer	3.262	3.300 ±0.200
Start Tank Discharge Timer	1.015	1.000 ±0.040

**Measurement not made.
†Out-of-tolerance readings acceptable. Switches satisfactorily passed manual test (ref revision g).
††Out-of-tolerance due to voltage variation prior to measurement.

4.2.34.1 (Continued)

Section 3, J-2 Engine Checks (Continued)

Pressure Switch Checks

Function	Measurement Test 1	Test 2	Test 3	Limits
Mainstage OK Pressure Switch 1				
Pickup Pressure (psia)	509.35	507.80	507.02	515.0 ± 36.0
Dropout Pressure (psia)	432.02	430.45	428.89	PU-62.5 ± 43.5
Mainstage OK Pressure Switch 2				
Pickup Pressure (psia)	514.88	514.08	514.08	515.0 ± 36.0
Dropout Pressure (psia)	447.10	447.10	449.44	PU-62.5 ± 43.5

Valve Position Measurements

Function	Position (%)	Limit (%)
Main LH2 Valve Closed	9.70	10 ± 10
Main LH2 Valve Open	89.90	90 ± 10
Main LH2 Valve Reclosed	9.90	Closed ± 1
Start Tank Discharge Valve Closed	11.30	10 ± 10
Start Tank Discharge Valve Open	91.70	90 ± 10
Start Tank Discharge Valve Reclosed	11.70	Closed ± 1
Gas Generator Valve Closed	12.70	10 ± 10
Gas Generator Valve Open	87.70	*
Gas Generator Valve Plateau	48.50	65 max
Gas Generator Valve Reclosed	13.00	Closed ± 1
Main LOX Valve Closed	11.70	10 ± 10
Main LOX Valve 1st Ramp	24.30	*
Main LOX Valve T/M Open Indication	80.30	*
Main LOX Valve Open	89.90	90 ± 10
Main LOX Valve Final Open	89.50	*
Main LOX Valve Open Difference, T/M to Final	9.20	*
Main LOX Valve Reclosed	11.70	Closed ± 1
LOX Turbine Bypass Valve Open	89.40	90 ± 10
LOX Turbine Bypass Valve Closed	10.10	10 ± 10
LOX Turbine Bypass Valve Reopened	89.40	Open ± 1

* Limits not specified.

4.2.34.1 (Continued)

Section 3 (Continued)

Engine Sequence Check

Function	Start Time (sec)	Oper. Time (sec)	Total Time (sec)
Engine Start			
Ignition Phase Solenoid Command Talkback	-	0.015	-
Control Helium Solenoid Command Talkback	-	0.022	-
ASI LOX Valve Open	-	0.048	-
Main LH2 Valve Open	0.045	0.092	0.137
LOX Bleed Valve Closed	-	0.069	-
LH2 Bleed Valve Closed	-	0.077	-
Start Tank Discharge Timer	-	1.013	-
Start Tank Discharge Valve Open	0.085	0.095	0.180
Mainstage Control Solenoid Energize	-	1.456	-
Ignition Phase Timer	-	0.443	-
Start Tank Discharge Control Solenoid Off	-	0.007	-
Main LOX Valve 1st Stage (Ramp) Open	0.060	0.039	0.099
Gas Generator Valve LOX Poppet Open	0.138	0.059	0.196
Start Tank Discharge Valve Closed	0.129	0.263***	0.392
LOX Turbine Bypass Valve Closed	0.212	0.254	0.466
LOX Turbine Bypass Valve 80% Travel	-	0.436	-
Main LOX Valve 2nd Stage Open	0.609	1.851	2.460
Spark System Off Timer	-	3.298	-
Engine Cutoff			
Ignition Phase Control Solenoid Off	-	0.006	-
Mainstage Control Solenoid Off	-	0.032	-
ASI LOX Valve Closed	0.024	-	-
Main LOX Valve Closed	0.062	0.124	0.186
Main LH2 Valve Closed	0.080	0.237	0.317
Gas Generator Valve Closed	0.070	0.257	0.327
Gas Generator Valve LOX Poppet Closed	-	0.025	-
LOX Turbine Bypass Valve Open	0.261	0.742	1.003
Helium Control Solenoid De-energize Timer	-	0.992	-
LOX Bleed Valve Open	8.769	-	-
LH2 Bleed Valve Open	8.284	-	-

***Out-of-tolerance but acceptable, see revision 1.

4.2.35 Range Safety System (1B66568 E)

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

Part Name	Reference Location	P/N	S/N
Range Safety Receiver 1	411A97A14	50M10697	204
Range Safety Receiver 2	411A97A18	50M10697	205
Secure Command Decoder 1	411A99A1	50M10698	0022
Secure Command Decoder 2	411A99A2	50M10698	0182
Secure Command Controller 1	411A97A13	1B33084-503	024
Secure Command Controller 2	411A97A19	1B33084-503	021
RS System 1 EBW Firing Unit	411A99A12	40M39515-119	570
RS System 2 EBW Firing Unit	411A99A20	40M39515-119	571
RS System 1 EBW Pulse Sensor	411A99A31*	40M02852	0178
RS System 2 EBW Pulse Sensor	411A99A32*	40M02852	0132
Safe and Arm Device	411A99A22*	1A02446-503	0101
Directional Power Divider	411A97A56	1B38999-1	042
Hybrid Power Divider	411A97A34	1A74778-501	036
*Installed in Pulse Sensor Assembly	411A99A31/A32	1B29054-501	0019

This procedure was satisfactorily accomplished by the first attempt on 8 August 1968, and was accepted on 14 August 1968. Values measured during the test are shown in Test Data Table 4.2.35.1. Initial conditions were established for the test, and the GSE destruct system test set, P/N 1A59952-1, was set up for closed loop operation at 450 MHz with a -50 dbm output level and a 60 kHz deviation. The forward bus 1 and bus 2 battery simulators were turned on, both receivers were verified to be off, and the battery simulator voltages were measured.

The external/internal power transfer test was then started. Both EBW firing units were verified to be off, and the 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 again measured. The external power for both receivers was turned off, and the receivers were verified to be off. The receivers were transferred to internal power and verified to be on, then transferred back to external power and verified to be off. Finally, both receivers were transferred back to internal power and again verified to be on.

The EBW firing unit arm and engine cutoff test was conducted next. The engine control bus power was turned on, the bus voltage was measured, and the low level signal strength indications were measured for both receivers. The EBW

4.2.35 (Continued)

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 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 be again 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 indications was verified to again be off. The EBW firing unit arm and engine cutoff command was turned off. The engine ready bypass was turned on, and the engine cutoff indication was verified to be off at the umbilical.

The EBW pulse sense 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

4.2.35 (Continued)

the pulse sensor was verified to be on. The propellant dispersion cutoff command inhibit was then turned back on and the propellant dispersion command was turned off. The above steps were then repeated to test system 2. After the test of system 2, the propellant dispersion cutoff command inhibit was turned off for both receivers, and the engine control bus power was verified to be off.

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

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

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

Two revisions were made to the procedure for the following:

a. One revision added several manual operations to verify that range safety system 1 and range safety system 2 actually turned off the O2H2 burner system.

b. One revision was made to correct two type statements because telemetry measurements were called out and hardwire measurements were actually made.

4.2.35.1 Test Data Table, Range Safety System

Function	Measured Value (vdc)	Limits (vdc)
Forward Bus 1 Battery Simulator	28.158	28.0 $\pm$ 2.0
Forward Bus 2 Battery Simmulator	28.039	28.0 $\pm$ 2.0
External/Internal Power Transfer Test		
External Power On		
System 1 Charging Voltage Indication	4.265	4.2 $\pm$ 0.3
System 1 Firing Unit Indication	4.256	4.2 $\pm$ 0.3

4.2.35.1 (Continued)

Function	Measured Value (vdc)	Limits (vdc)
External Power On (Continued)		
System 2 Charging Voltage Indication	4.310	4.2 ±0.3
System 2 Firing Unit Indication	4.286	4.2 ±0.3
Internal Power		
System 1 Charging Voltage Indication	4.270	4.2 ±0.3
System 2 Charging Voltage Indication	4.324	4.2 ±0.3
External Power Off		
System 1 Charging Voltage Indication	0.050	0.3 max
System 2 Charging Voltage Indication	0.034	0.3 max
Firing Unit Arm and Engine Cutoff Test		
Engine Control Bus Voltage	27.906	28.0 ±2.0
Receiver 1 Signal Strength Indication	3.784	3.75 ±1.25
Receiver 2 Signal Strength Indication	3.466	3.75 ±1.25
System 1 Arm and Engine Cutoff Test		
Firing Unit Charging Voltage Indication	4.270	4.2 ±0.3
Engine Control Bus Voltage (Power Off)	-0.092	0.0 ±0.45
Engine Control Bus Voltage (Power On)	27.876	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	4.310	4.2 ±0.3
Propellant Dispersion Test		
System 1 Propellant Dispersion Test		
Charging Voltage Indication (Pulse Sensor Off)	4.289	4.2 ±0.3
Charging Voltage Indication (Pulse Sensor On)	1.779	3.0 max

4.2.35.1 (Continued

Function	Measured Value (vdc)	Limits (vdc)
System 2 Propellant Dispersion Test		
Charging Voltage Indication (Pulse Sensor Off)	4.329	4.2 ± 0.3
Charging Voltage Indication (Pulse Sensor On)	1.345	3.0 max

4.2.36 Propellant Tank Differential Pressure Scan (1B74681 NC)

This automatic procedure, accomplished in conjunction with the manual propellant tanks leak check, H&CO 1B59459, (reference paragraph 4.2.5), continuously verified that the LOX and LH2 tank pressures, the common bulkhead pressure, and the differential pressure across the common bulkhead remained within the required limits during the entire period the propellant tanks were pressurized for the integrity check and the manual leak checks.

The procedure was initiated on 13 August 1968, and was completed on 16 August 1968, after 3 days of activity. Acceptance of the test occurred on 27 August 1968. Three runs were required before the procedure was completed. The first run was terminated when stage power was turned off after a blanket pressure of 5 psig for the LOX tank and 2 psig for the LH2 tank had been established. The blanket pressure was established to maintain the helium content of the tanks during an overnight hold. The second run was terminated when the tanks were depressurized to correct several leaks. The third run was terminated with successfully completion of the propellant tanks leak check.

The stage power setup, H&CO 1B66560, was accomplished to establish the initial conditions for the test. The ambient condition of the LH2 tank, measurement D576, the LOX tank, measurement D577, and the common bulkhead, measurement D545, were made. Ambient conditions were recorded at 14.532 psia for LH2 tank, 14.611 psia for the LOX tank, and 15.025 psia for the common bulkhead. Initial measurements were made of the pump inlet pressure, the EDS transducer and ullage pressures, and the tank inlet pressure for the LH2 and LOX tanks, and of the common bulkhead internal pressure.

The differential scan was then activated for use while the tanks were pressurized by the manual leak check procedure. During this scan, repetitive measurements were made of the LH2 and LOX tank ullage pressures and the common bulkhead pressure. As long as both ullage pressures remained less than 15.7 psia, the tanks were considered to be at ambient pressure, and the common bulkhead pressure was verified to be less than 15.2 psia. After every one thousand measurement cycles, a printout was made of the measured LH2 and LOX tank ullage pressures and the common bulkhead pressure.

Once either ullage pressure exceeded 15.7 psia, the differential pressure across the common bulkhead was determined as the difference between the LOX ullage pressure and the LH2 ullage pressure. Verification was then made that the LH2 ullage pressure did not exceed the LOX ullage pressure; that the differential pressure did not exceed 10.0 psi if the LOX ullage pressure was less than 25.0

4.2.36 (Continued)

psia or 2.0 psi if the LOX ullage pressure was greater than 25.0 psia; that the LOX and LH2 ullage pressures did not exceed the maximum integrity pressure limits of 27.3 psia and 27.1 psia, respectively; and that the common bulkhead pressure did not exceed 16.2 psia. After every one thousand measurement cycles, a printout was made of the measured LH2 and LOX tank ullage pressures, the common bulkhead pressure, and the differential pressure; and measurements were made of the pump inlet pressures, EDS transducer and ullage pressures, and tank inlet pressures for both the LH2 and LOX tanks, and of the common bulkhead internal pressure. The differential scan was terminated after the LH2 and LOX tanks were vented to ambient pressure at the completion of the manual leak check procedure.

No parts shortages were noted that would affect this test. However, some minor problems were encountered during the first and second runs of the procedure. Several malfunctions were printed out; but, these were expected because some valves were opened per the manual leak check. Several "go to" statements were typed out because the tanks were pressurized previously, to terminate the scan at the end of the shift (blanket pressure established for overnight hold), tanks were pressurized from previous days testing and transducer power was already on therefore transducer power turn on was not required. Error statements were typed out due to GSE problems with the response conditioner and with the monochrome system status display. It was also noted in Engineering comments that repeated dropout of the 6.3 vdc inidcator light power supply in the Test Operators Console resulted in a continuous printout of E22 and E27 error messages. In order to surpress the output of these messages and return the system to the proper operational status the computer was master cleared and the executive tape and the propellant tank differential scan tape were reloaded.

No FARR's were generated as a result of this procedure. Six revisions were written against this procedure for the following:

a. One revisions reduced the amount printouts required during the scan from one in every hundred to one in every thousand.

b. One revision changed the tolerance for the common bulkhead pressure from "If C GT 0, go to M250" to "If C GT -1.5, go to M250."

c. One revision changed the 28 vdc power supply tolerance from $\pm$0.8 vdc to $\pm$0.5 vdc to comply with the electrical requirements at A3.

d. One revision added the telemetry signal distribution unit, P/N 1B41812-1, to the End Item Equipment list, because it was needed to transmit the 600 Hz VCO signal to the DDAS ground station.

e. One revision doubled the space from the top of the computer printout form to the first printout.

f. One revision was written to permit bypassing the initial pressure scan if the system was already pressurized. This was done to facilitate resumption of the test, after an overnight hold. The tanks had been pressurized to maintain a 75 percent helium concentrate.

4.2.37 All Systems Test (1B66571 F)

Prior to initiation of the all systems automatic test the umbilicals-in portion of the all systems test was run as an EMC baseline test procedure. Four attempts were made before the baseline test was successfully completed. The first run made on 21 August 1968 was not completed because of several malfunctions. The malfunctions were caused by out-of-tolerance voltages and pressures. One malfunction, in particular, was caused by a defective RF transmitter assembly, P/N 1B65788-1, S/N 15503, which was removed and replaced (reference FARR 500-353-040). All malfunctions were corrected or accounted for as the test progressed; however, when an illegal function number was encountered the test was terminated. A revision was written to correct the illegal function number problem.

The second run on 23 August 1968 was terminated because of a computer malfunction. Prior to the computer malfunction several chilldown inverter malfunctions occurred. These were bypassed and the test was continued. The common bulkhead ambient pressure was out-of-tolerance and the LOX tank prepressurization flight switch failed to pick up. Revisions were written to correct these problems. When the computer "NO EXIT" light came on testing was terminated.

The third run on 26 August 1968, also was not completed because of several problems. Some problems resulted from GSE malfunction and some occurred as a result of out-of-tolerance voltages, wattages, and pressures. The LOX and LH2 chilldown inverter frequencies still continued to pose problems.

The fourth run of 27 August 1968 was completed, although there were still problems with the LOX and LH2 chilldown inverter frequencies, the LOX tank prepressurization flight switch, and another computer "NO EXIT" indication. These problems were corrected.

The final EMC all systems test (umbilicals-in only) was successfully completed on 29 August 1968. The several minor problems which occurred as follows were not serious enough to require a rerun of the test:

a. Random noise pulses were received by the range safety receivers. The source was unknown, although it was known that it did not originate from the stage or GSE.

b. The LH2 point level sensor wet commands, 2 and 3, did not go off. Post-test troubleshooting revealed that the input cables were cross-connected at the associated control units. After correctly connecting the control units to the sensors, they were successfully retested.

   In addition the level sensors cycled erratically, after the propellant level sensor power was turned on. It was demonstrated that this condition was due to external RFI sensitivity. The problem was eliminated by holding a metal shield in front of the stage hardware. Nor did the problem exist when the EMC cables were removed from the stage. It appears the stage circuits were made more sensitive to interference from the additional wire lengths included in the EMC connections.

4.2.37 (Continued)

c. The LOX and LH2 prevalve switch selector on command EMC detectors cycled on and off each time an off command was sent. The detector should cycle only when an on command is sent. This problem is under investigation.

d. The LOX chilldown inverter detector and the LH2 chilldown inverter detector both cycled when the respective inverter was turned on, thereby indicating that the voltage momentarily exceeded 56 $\pm$28 vdc. The problem was a drop in voltage for less than 1 millisecond. This anomaly was still under investigation by the EMC engineering section.

e. When the level sensor arm command was sent, the A26 detector (EDS engine cutoff) and A27 detector (sequencer engine cutoff) cycled on and off. The anomalies appeared to be caused when the LOX depletion sensors were initially powered (level sensor arm command).

   The resulting current surge in the transistor voting circuit of these depletion sensors created a 1-millisecond output pulse to the engine cutoff circuitry. The pulse was not wide enough during this test to cause an actual engine cutoff. This problem is under investigation.

f. The APS module 1 and 2 bus power detectors cycled on and off when the engine control bus was turned on. Since the APS bus and engine control bus were both powered from aft bus 1, turning the engine control bus on produced a negative and positive transient of about 100 microseconds long and approximately 14 volts peak on aft bus 1, thereby causing these anomalies.

   In addition, these two detectors came on normally when the aft bus 1 battery simulator was turned off, but they abnormally went off three milliseconds later and stayed off for 16 milliseconds. This was caused by an anomaly in the GSE switching (relay chatter) that allows power to return to the bus within three milliseconds, after being turned off. The power decreases to 5 vdc and stays at that value for about 16 milliseconds before finally going off. This is not a stage hardware problem.

g. During test, the LOX and LH2 chilldown inverter frequency measurements were out of tolerance. The period counter in the GSE 131 response conditioner was again readjusted and the measurements were satisfactorily tested. The design and function of the trigger level sensitivity circuits are being studied for corrective action as required.

h. Also during test, the APS 1 fuel manifold pressure measurement, D70, exhibited erratic pressure indications when any fuel valve was opened. An investigation revealed that a transducer, P/N 1B31377-1L, S/N 1177, was faulty. It was replaced per FARR 500-353-066 and was satisfactorily tested.

4.2.37 (Continued)

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

The all systems test - automatic was initiated on 4 September 1968, and was active for 2 days. The umbilicals-in part of the test was completed on the first attempt on 4 September 1968, the umbilicals-out part of the test was completed by the second attempt on 5 September 1968. The procedure was accepted following the test data review meetings held on 13 and 16 September 1968.

The first attempt, made with the umbilicals in, was acceptable, although there were some minor malfunctions caused by program errors, GSE and computer problems, and operator errors. The second attempt was satisfactorily accomplished with the umbilicals out, although there were some out-of-tolerance measurements as discussed later.

The various measurements made during the acceptable umbilicals-in and umbilicals -out tests are presented in Test Data Table 4.2.37.1. All of these measurements were acceptable and within design requirements, unless otherwise noted, although specific test limits were not defined by the procedure for some of the measurements.

Prior to starting the all systems automatic procedure, the GSE electrical systems and the stage propulsion system were manually set up, and the stage power setup procedure, H&CO 1B66560, was accomplished. Initial conditions were then established, and the stage power setup test was conducted. During this test, power was applied to the propellant utilization inverter and electronics, the EBW pulse sensors, the engine control and ignition buses, the APS buses, and aft bus 2, while various currents and voltages were measured. The EBW ullage rocket firing unit disable command, and the propellant dispersion cutoff command inhibit for both range safety receivers, were also turned on, and the common bulkhead pressure, LH2 ullage pressure, and LOX ullage pressure were all verified to be greater than 5 psia. The proper operation of the switch selector was verified during the umbilicals-in test only.

4.2.37 (Continued)

The manual setup of the propulsion system was verified, the propulsion system initial conditions were established, and the various helium supply pressures were measured. Measurements were also made of the auxiliary hydraulic pump air tank pressure and of the auxiliary hydraulic pump motor conta ner pressure. The LOX chilldown pump purge and engine pump purge sequences were then accomplished.

The next series of prelaunch checks verified that the LOX and LH2 vent valves and fill and drain valves opened properly on command, and that the LOX and LH2 point level sensors, fast fill sensors, and overfill sensors all responded properly to simulated wet conditions. The simulated wet conditions were left on for all except the overfill sensors, to simulate loaded propellant tanks. The proper operation of the LOX and 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 and the GH2 start bottle pressure were measured during the last sequence. The LOX and LH2 fill and drain valves were then closed, the proper operation of the LH2 directional vent valve was verified, and the valve was set to the ground position.

The EBW and telemetry prelaunch checks were conducted next. A pulse sensor self test verified the proper operation of the ullage rocket and range safety EBW firing unit pulse sensors. The PCM RF assembly was then turned on and the current was measured. During the umbilicals-in test, a check verified that the telemetry RF silence command properly turned off the PCM RF assembly. During both tests, a telemetry calibration and a RACS calibration were then accomplished. The PCM/FM transmitter RF power was measured as the telemetry antenna 1 forward power, the telemetry RF system reflected power was measured, and the telemetry system closed loop VSWR was determined. Measurements were also made of the static inverter-converter output voltages and operating frequency. During the umbilicals-in test, the engine cutoff and the non-programmed engine cutoff indications were both verified to be off, while during the umbilicals-out test, 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 auxiliary hydraulic pump coast mode reset relay was turned on, and the aft bus 2 current was measured at 54.199 amps, within the 55.0 $\pm$30.0 amps limit. Then the system pressure increase over a 4 second period was determined to be greater than 200.0 psia, and the hydraulic system functions were remeasured with the system pressurized.

The stage and GSE were then set for open loop telemetry operation by turning on the RF distribution system 2 and setting the PCM ground station for open loop reception. A flowrate and turbine speed (FRATS) calibration measured the reference indication voltages for the LOX and LH2 circulation pump

4.2.37 (Continued)

flowrates; the static inverter-converter frequency, and the LH2 and LOX chilldown inverter frequencies, using a 400 Hz GSE calibration frequency during the umbilicals-in test; and during the umbilicals-out test for the LOX and 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 telemetry system forward and reflected RF powers were then measured, and the telemetry system open loop VSWR was determined. The LOX and LH2 chilldown pumps were turned on, and the chilldown inverter currents were both verified to be 23 $\pm$5.0 amperes. Verification was made that the chilldown inverter voltages were acceptable, as measured by the hardwire monitoring circuits, and the inverter operating frequencies were manually measured as 400 Hz each, meeting the 400 $\pm$4 Hz limits. The LH2 and LOX chilldown inverter operating frequencies and output voltages were then measured by telemetry.

A series of measurements were then made of the common bulkhead pressure and the LH2 ullage pressure, their 20 and 80 percent calibration voltages and the ambient pressures after each calibration, the LOX ullage pressure, and the LH2 and LOX emergency detection system pressures. The rate gyro was then turned on, and a RACS and telemetry calibration was performed.

The final prelaunch checks were then started. During the umbilicals-in test, the battery simulators were turned on, and measurements were made of the battery simulator voltages and the electrical support equipment load bank voltages. During the umbilicals-out test, the checkout batteries were turned on, and the checkout battery voltages were measured. The transducers for the common bulkhead pressure and the LH2 and LOX ullage pressures were all turned off, and the transducer output voltages were measured. The LH2 and LOX fast fill sensor simulated wet conditions were then turned off.

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

4.2.37 (Continued)

Following the simulated liftoff, a telemetry calibration was accomplished, and the pre-separation checks were conducted. The two ullage rocket ignition EBW firing units were charged. The LH2 and LOX prevalves were opened and reclosed, and the LH2 chilldown pump was turned off. The fire ullage ignition command was turned on, and it was verified that the two ullage ignition EBW firing units responded properly and that the ullage ignition pulse sensors were on. The aft separate simulation 1 and 2 signals were then turned on to simulate stage separation. During the above part of the umbilicals-in test only, additional checks verified that the ullage rocket firing unit disable command prevented the ignition EBW firing units from charging, and discharged the previously charged firing units while preventing them from firing.

APS roll and engine start checks were conducted following the simulated stage separation. The instrument unit (IU) substitute -28 volt power was turned on and measured. For the APS roll checks, attitude control nozzles I IV and III II were turned on and off, and attitude control nozzles I II and III IV were turned on and off, while the APS engine 1-1 1-3 and 2-1 2-3 valve open indications were measured for each condition. The LOX chilldown pump was then turned off, and the LH2 and LOX chilldown shutoff valves were opened and reclosed. The engine start sequence was then accomplished, with the simulated ignition detected indication and the simulated mainstage OK indication turned on to simulate a satisfactory engine start. The two ullage rocket jettison EBW firing units were charged, the fire ullage jettison command was turned on, and it was verified that both ullage jettison firing units responded properly and that the ullage jettison pulse sensors were on. During this part of the umbilicals-in test, additional checks verified that the ullage rocket firing unit disable command prevented the jettison EBW firing units from charging, and discharged the previously charged firing units while preventing them from firing.

Following the engine start sequence, the hydraulic gimbal and propellant utilization valve slew checks were conducted, starting with the step response gimbal and LOX valve slew checks. The propellant utilization system ratio valve position and the hydraulic system pressure were both measured, and the LOX bridge 1/3 checkout relay was turned on. A series of step response gimbal checks were conducted for 0 to -3 degrees, -3 to 0 degrees, 0 to +3 degrees, and +3 to 0 degrees, in the pitch and yaw planes. As the results of these checks were compatible with the results of the same checks during the hydraulic system automatic checkout, H&CO 1B66570, (reference paragraph 4.2.28), the measured data is not repeated. Following the gimbal sequence, the propellant utilization system ratio valve position was again measured, and the LOX bridge 1/3 checkout relay was turned off. A 0.6 Hz gimbal and 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

4.2.37 (Continued)

the umbilicals-in and umbilicals-out tests. At the completion of the gimbal sequences, the hydraulic actuator piston positions and the engine pitch and yaw positions were measured, and the hydraulic system functions were measured with the hydraulic system pressurized. The propellant utilization system ratio valve position was measured, and the LH2 bridge 1/3 checkout relay was turned off.

The first burn and coast period sequences were conducted next. During the first burn pressurization, the LOX tank pressure sequence check and the LH2 tank pressure control module check were performed. For the LOX tank pressure sequence check, measurements were made of the heat exchanger outlet pressure, the LOX pressure module helium pressure, and the cold helium control valve inlet pressure with the cold helium supply shutoff valve open. The measurements were repeated after the LOX system pressure switch was closed. The helium pressure of the LH2 pressurization control module was measured while the helium supply valve was temporarily opened, and again after the pressure switch supply was closed and the flight control pressure switch was verified to be off. The engine cut-off was then accomplished, the auxiliary hydraulic pump was set for coast mode operation, the LH2 first burn relay was turned off, and the LH2 pressurization control module helium pressure was again measured. The LOX chilldown pump purge was started, and the LOX pump motor container helium pressure was measured. The coast period command was turned on, the LOX flight pressurization system was turned off, and the engine pump purge was started. The simulated ignition detected and simulated mainstage OK indications were turned off to complete the first burn sequence.

The engine restart preparations were conducted next. The 70 pound ullage engine command 1 was turned on and off, the LH2 continuous vent valves were opened, and the ullage engine command 2 was turned on and off. The engine pump purge was completed. The LH2 boiloff bias signal voltage was measured, then remeasured with the propellant utilization boiloff bias cutoff turned on. The LH2 continuous vent valves were then closed, and the LOX repressurization spheres and cold helium spheres pressures were measured.

The O2H2 burner spark excitation systems were verified to operate properly. The proper operation of the LOX and LH2 repressurization control valves was verified, and the LOX and LH2 tank cryogenic repressurization sequences were accomplished. The cold helium sphere pressure and the LOX repressurization spheres pressure were measured, and the LOX tank ambient repressurization sequence was accomplished. The LOX and LH2 chilldown pumps were turned on, and the chilldown inverter voltages were measured. The LH2 tank ambient repressurization sequence was then accomplished. With the propellant utilization valve hardover position command on, the ratio valve position was verified to be less than -20 degrees. The LH2 and LOX chilldown pumps were turned off, and the inverter operating frequencies and voltages were measured. The cold helium supply shutoff valves were then opened, completing the restart preparations.

4.2.37 (Continued)

The engine restart sequence was accomplished, with the simulated ignition detected indication and the simulated mainstage OK indication turned on to simulate a satisfactory engine restart. The cold helium supply shutoff valves were closed to complete the restart sequence. An LH2 second burn repressurization sequence was accomplished, with the LH2 pressurization control module helium pressure measured with the prepressurization supply open, and again after the pressure switch supply was closed. The engine cutoff was then accomplished, the simulated ignition detected indication was turned off, and the coast period command was turned on.

A series of checks verified that a dry condition of any one LOX or 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 only, the operating time of the LOX depletion engine cutoff timer was measured for each combination of LOX sensors.

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

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

Engineering comments noted that three IUM's were installed on the stage for systems checkout in lieu of the flight items. Two IUM's were the attitude control relay modules, P/N 50M35076, at locations 404A51A4 and 404A71A19. One IUM was the APS pitch control engine 2, P/N 1A39597-509.

4.2.37 (Continued)

Engineering comments also noted that:

a. During the EMC umbilicals-in run on 29 August 1968, while testing the level sensor cutoff, that the LH2 level sensor control units, 2 and 3, remained in the wet condition, after the simulate commands had been removed. It was found that the EMC detector "T" cables associated with the control units were RFI susceptible. Shielding of these cables permitted passage of the test, when it was rerun.

b. During the umbilicals-in run on 4 September 1968, the first two attemps to measure the LOX chilldown inverter current failed because the input cables to the inverters had inadvertently been left disconnected. After connectors P9 and P10 had been connected, the inverter current was successfully measured.

c. During the umbilicals-out run on 5 September 1968, the executive printed out three E01 error messages and entered a computer hold immediately prior to the -3 to 0 degree yaw step response checks. The test was resumed from the Test Operators Console without further occurrences of the problem. Post test investigation of the problem revealed that the executive did not receive requested data within 1 millisecond, after interrogating the response conditioner to update the engine yaw actuator executive monitor. It was felt this problem would have no effect on the validity of this test.

A review of the all systems telemetry data and digital events recorder output revealed that the following anomalies had occurred during the umbilicals-out run:

a. The auxiliary hydraulic pump motor gas measurement, D209, was intermittent throughout the test. Troubleshooting revealed that the transducer, P/N 1B31356-505, potentiometer resistance would not respond to pressure changes in a uniform manner. The transducer was replaced per FARR 500-353-091 and satisfactorily tested.

b. The oxidizer pump inlet pressure measurement, D003, was off scale low for 400 seconds during the test. The problem did not reappear during troubleshooting; however, as a precautionary action, the transducer was replaced per FARR 500-353-104 and satisfactorily tested.

c. The following abnormal conditions are documented on FARR 500-353-139:

   1. The PCM/FM transmitter output power, measurement N18, indicated a 12 percent dc level shift during transfer to the open loop mode of telemetry transmission.

4.2.37 (Continued)

2. The telemetry RF system reflected power channel 1, measurement N55, indicated a 6.4 percent dc level shift during transfer to the open loop mode of telemetry transmission.

3. The LOX point level sensor 4, event K499, cycled on and off at the same time the O2H2 burner propellant valve was closing.

4. The LH2 overfill sensor, event K608, cycled on and off at the same time the propellant utilization valve hard-over position command was turned off.

d. The switch selector output monitor, event K128, exhibited abnormal voltage transients. The spikes were of approximately 1-volt magnitude and 5-millisecond duration. The cause of the spikes was isolated to the O2H2 burner shutdown bus. Although this anomaly does not degrade the stage or component performance it has been documented on FARR 500-353-147.

The following FARR's were generated as a result of the all system test:

a. FARR 500-353-040 noted that the RF transmitter assembly, P/N 1B65788-1, S/N 15503, had a 29.71 watt output, which should have been 19 ±7.25 watts. The transmitter, S/N 15503, was removed and replaced by S/N 15505, which was satisfactorily tested.

b. FARR 500-353-066 noted that the pressure transducer, P/N 1B31377-1, S/N 1177, gave erratic indications when the fuel valve was in the open position. The transducer, S/N 1177, was removed and replaced with S/N 1182. The defective transducer was sent to the vendor for additional testing.

c. FARR 500-353-091 noted that the pressure transducer, P/N 1B31356-505, S/N 15-4, functioned erratic. The potentiometer resistance would not respond to pressure changes in a uniform manner. The transducer, S/N 15-4, was removed and replaced with S/N 25-2, which checked out satisfactorily.

d. FARR 500-353-104 noted that the pressure transducer, P/N 1B43324-603, S/N 45-3, functioned abnormally. The output dropped to 0 vdc, but during troubleshooting could not be repeated. The transducer, S/N 45-3, was removed and replaced with S/N 45-8, which checked out satisfactorily.

e. FARR 500-353-139 noted that the following anomalies occurred during the test:

1. The PCM/FM transmitter output power, measurement N18, indicated a 12 percent dc level shift during transfer to the open loop mode of telemetry transmission.

4.2.37 (Continued)

2. The telemetry RF system reflected power, channel 1, measurement N55, indicated a 6.4 percent dc level shift during transfer to the open loop mode of telemetry transmission.

3. The LOX point level sensor 4, event K499, cycled on and off at the same time the O2H2 burner propellant valve was closing.

4. The LH2 overfill sensor, event K608, cycled on and off at the same time the propellant utilization valve hardover position command was turned off.

Items 1 and 2 were acceptable to Engineering. These measurements are RFI susceptible when the stage is not stacked for flight. When stacked for flight the other stages provided RFI shielding thus eliminating the condition. Items 3 and 4 were acceptable because the cycling of the control units are a phenomenon associated with specific command function transients, and these anomalies do not represent launch constraints nor do they impede mission performance.

f. FARR 500-353-147 noted that the switch selector output monitor, event K128, exhibited abnormal voltage transients. The spikes were of approximately 1-volt magnitude and 5-millisecond duration. The cause of the spikes was isolated to the O2H2 burner shutdown bus. The FARR was dispositioned acceptable for use.

There were forty-three revisions written against the procedure for the following:

a. Two variation revisions were written to ensure that the range safety transmitter remained off during field strength measurements at range safety operating frequency. On Line Saturn Test Oriented Language (OSTOL) was used to determine that the range safety receivers, 1 and 2, low level signal strength were greater than 2.5 vdc.

b. One variation revision was written to preclude the possiblity of the DDAS ground station going of sync.

c. One revision was written to change the tape loading procedure to be compatible with the telemetry tape recorder unit.

d. One revision changed the record levels verification instructions to adjust the video level control on the DDAS receiver and the PCM receiver for 2.0 $\pm$0.1 volts peak to peak instead of 2.8 $\pm$0.1 volts peak to peak to ensure compatibility with the DDAS ground station test.

4.2.37 (Continued)

e. One revision to the PCM receiver local oscillator instructions added a step to turn the microvolts/DBM switch fully counterclockwise on the Boonton signal generator to eliminate the possibility of RF feedthrough affecting the DDAS data.

f. Three revisions were written to correct procedure and program errors.

g. One revision changed the manual instructions for obtaining the temperature of the environmental control system.

h. One revision provided manual instructions for setup of the ADU power supply prior to initiation of the all systems test.

i. One revision added additional post-test instructions to return the stage to the flight configuration and to remove checkout equipment.

j. One revision added a breakpoint to permit replenishment of the cold helium spheres to greater than 810 psia, prior to LOX tank repressurization, to permit completion of the test.

k. One revision changed the propulsion system manual setup initial paragraph to permit the setup to be performed at step 6002004 to conserve gases should the initial electrical scan encounter problems, and to avoid topping the spheres manually because of temperature losses.

l. One revision to the manual setup instructions reconnected the LOX childown pump purge module bypass purge pipe assembly, P/N 1B67710-1, to the tee to return the stage to the flight configuration for the test. The line was disconnected during leak checks to conserve gases.

m. One variation revision was written to prevent an over-voltage condition on the engine control package during the O2H2 burner spark system test.

n. One variation revision was written to retest the pneumatic connections disconnected during purging of the LOX tank.

o. One variation revision was written to retest the pneumatic connections disconnected during purging of the LH2 tank.

p. One revision was written to allow additional time for gas flow through the LOX repressurization control valves before the flight switch actuation closed the valves.

4.2.37 (Continued)

q. One revision changed the tolerance for the LOX chilldown inverter voltage from ±3.0 to $+2$, -5.5 to account for the line loss of approximately 5 volts between the chilldown simulator and the inverter. This revision also deleted another revision.

r. One variation revision base line umbilicals-in only, provided instructions to check the BO multiplexer power measuring channel.

s. One variation revision vented trapped pressure in the aft umbilical transducer lines to keep the lines at ambient during the all systems test and then returned the stage to the flight configuration.

t. One revision increased the time delay for the LOX repressurization flight switch de-energized off indication from 5 seconds to 30 seconds to permit the occurrence through the flight control switch.

u. One variation revision patched in a Model 545A Tektronix oscilloscope to replace the Hewlett-Packard oscilloscope in the DDAS ground station, which was out-of-service.

v. One variation revision, base line only, added a halt and instructions at step 6032431 to "Verify "F" = 0 ±0.25" and to "Verify that "Malf-flag" is 0." The all system EMC magnetic tape was missing steps 6032432 to 6032435.

w. One variation revision deleted the use of the VCL 2 tape unit because it would not operate in conjunction with the VCL 1 tape unit.

x. One variation revision requested that the period counter be reset in the response signal conditioner and resume to retry until the test passed main flow interrogation of the LOX and LH2 chilldown inverter frequency. The LOX and LH2 chilldown inverter frequency checks usually failed on the first attempts due to a malfunctioning period counter. A design investigation is underway to resolve this condition.

y. One variation revision changed the aft bus 2 power supply level from 56 ±2 vdc to 57.12 vdc to comply with the hardwire chilldown inverter frequency checks.

z. One variation revision, umbilicals-out, replaced the hardwire phase voltage measurements with T/M measurements to increase the accuracy of the measurements because there is a large offset involved with the chilldown simulator measurements.

4.2.37 (Continued)

aa. One variation revision, umbilicals-in, measured the APS module 1 fuel supply manifold pressure, D70, to verify the proper ambient output of the transducer for measurement D70. This transducer had been replaced after the EMC all system test run was completed.

ab. One variation revision, umbilicals-out, increased the upper limit for the unloaded battery measurements from 29.5 ±1.5 vdc to 29.5 +2.5, -1.5 vdc. New batteries were being used for the umbilicals-out test.

ac. One variation revision, umbilicals-in, permitted a retry of the LH2 level sensor control units 2 and 3 wet condition off indication after a malfunction print out indicated they were not off. The EMC detector "T" cables are RFI susceptible, therefore, the test sometimes failed when interrogated for a dry condition.

ad. One revision, umbilicals-out, increased the upper limits for the new batteries from 28 ±2 vdc to 28 +3, -2 vdc because of the slow decay characteristics.

ae. One revision increased the upper limits on the aft 2 unloaded battery from 60.5 ±1.5 vdc to 60.5 +2.5, -1.5 vdc. This was a result of the new battery maintenance procedure which gives the battery a fuller charge.

af. One revision, EMC AST, required a 2 minute wait after the LOX chill-down pump on indication printed out as a malfunction. The chilldown pump simulator had a slower starting time than an actual pump which results in a high out-of-tolerance current.

ag. One revision added the simulated flight battery power unit, P/N 1B39147-002, Model DSV-4B-170, to the End Item Equipment list.

ah. One variation revision, baseline umbilicals-in, increased the wait time to permit the LOX prepressurization flight switch to energize. The time was changed from 5 seconds to 15 seconds.

ai. One revision, to the post test instructions, installed a cap on the LOX repressurization control module pilot bleed connection to prevent the entry of foreign material during stage removal, painting, and shipment to A45. The cap is removed for checkout and flight.

aj. One variation revision, baseline umbilicals-in, deleted the 2 second delay after the LOX system pressure switch supply was turned on because the pressure surge from the GSE was sufficient to build up pressure in the line.

ak. One variation revision deleted a previous revision and changed the forward power detector output wattage from 19.0 ±7.25 to 19.0 +9.25, -7.25, because it was RFI susceptible when in the open loop condition.

4.2.37.1 Test Data Table, All Systems Test

Function	Umbil.-In	Umbil.-Out	Limits
Power Setup			
PU Inv and Elect Current (amps	4.900	4.300	5.0 max
PU Oven Voltage (vdc)	-0.123	-0.123	-0.023 ±0.1
Eng Cont Bus On			
Aft Bus 1 Current (amps)	1.699	1.899	2.7 ±3.0
Aft Bus 1 Voltage (vdc)	28.04	28.08	28.0 ±2.0
Eng Cont Bus Voltage (vdc)	27.906	27.906	28.04 ±1.0
Comp Test Power Voltage (vdc)	28.039	27.958	28.04 ±1.0
Eng Ign Bus On			
Aft Bus 1 Current (amps)	2.000	1.800	2.7 ±3
Aft Bus 1 Voltage (vdc)	28.079	28.039	28.0 ±2.0
Eng Ign Bus Voltage (vdc)	27.938	27.876	28.079 ±1.0
APS Bus On			
Aft Bus 1 Current (amps)	2.800	2.500	2.7 ±3.0
Aft Bus 2 Current (amps)	-0.399	0.000	5.0 max
Aft Bus 2 Voltage (vdc)	57.117	57.358	56.0 ±4.0
Propulsion System Setup			
Amb He Pneu Sphere Press. D236 (psia)	712.31	712.31	700.0 ±50.0
Cold Helium Sphere Press. D016 (psia)	808.63	816.25	825.0 ±25.0
Eng Cont He Supply Press. D019 (psia)	1486.06	1482.47	1450 min
Cont He Reg Discharge Press. D014 (psia)	531.19	531.19	515.0 ±50.0
LH2 Repress. He Sphere Press. D020 (psia)	656.23	656.23	*
LOX Repress. He Sphere Press. D088 (psia)	723.53	723.53	*
Eng Cont He Sup Backup Press.	1488.875	1488.875	1450 min
Aux Hyd Pump Air Tnk Press. (psia)	458.844	453.891	282.5 ±217.5
Aux Hyd Pump Mtr Cntr Press. (psia)	18.854	18.854	20.75 ±11.95
LH2 Prepressurization Sequence			
LH2 Press. Control Module GH2 Press. D104 (psia)	58.46	57.36	50.0 min
GH2 Start Bottle Backup Press. D241 (psia)	9.914	9.914	*

* Limits Not Specified

4.2.37.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
EBW and Telemetry Checks			
PCM RF Assembly Current (amps)	4.199	5.000	4.5 ±3.0
T/M RF Silence On			
PCM Transmitter Output Power (watts)	-0.15	**	*
T/M RF Silence Off			
T/M Antenna 1 Forward Power (watts)	23.913	23.476	21.75 ±6.75
T/M RF System Reflected Power (watts)	0.763	0.763	3.08 max
Telemetry System Closed Loop VSWR	1.435	1.439	2.0 max
Inv-Conv 115 vac Output (vac)	114.55	114.51	115.0 ±3.45
Inv-Conv 5 vdc Output (vdc)	5.02	5.03	4.8 ±0.3
Inv-Conv 21 vdc Output (vdc)	21.86	21.87	21.25 ±1.25
Inv-Conv Operating Frequency (Hz)	400.23	400.19	400.0 ±6.0
Hydraulic System Checks			
Reservoir GN2 Mass (lbs)	1.880	1.929	1.925 ±0.2
Corrected Reservoir Oil Level (%)	99.7	99.4	95.0 min
Hydraulic System Unpressurized			
Hydraulic System Pressure (psia)	1369.031	1369.031	*
Accumulator GN2 Pressure (psia)	2318.250	2364.625	*
Accumulator GN2 Temperature (°F)	73.313	70.182	*
Reservoir Oil Temperature (°F)	72.922	70.182	*
Reservoir Oil Level (%)	89.451	89.080	*
Reservoir Oil Pressure (psia)	70.266	72.010	*
Pump Inlet Oil Temperature (°F)	71.750	68.621	*
T/M Yaw Actuator Position (deg)	1.162	1.162	*
Corrected T/M Yaw Act. Pos (deg)	1.187	1.187	*
IU Yaw Actuator Position (deg)	1.289	1.274	*
Corrected IU Yaw Act. Pos (deg)	1.221	1.224	*
T/M Pitch Actuator Postion (deg)	-0.080	0.028	*
Corrected T/M Pitch Act. Pos (deg)	-0.102	0.007	*
IU Pitch Actuator Position (deg)	-0.194	-0.074	*
Corrected IU Pitch Act. Pos (deg)	-0.135	-0.030	*
IU Substitute 5v Power Supply (vdc)	5.039	5.029	*
Aft 5v Excitation Module (vdc)	4.985	4.985	*
Aft Bus 2 Current (amps)	-0.199	0.199	*
Hydraulic System Pressurized			
Hydraulic System Pressure (psia)	3591.500	3591.500	*
Accumulator GN2 Pressure (psia)	3592.125	3589.375	*
Accumulator GN2 Temperature (°F)	96.463	91.748	*

* Limits Not Specified
**Measurement Not Applicable

4.2.37.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
Reservoir Oil Temperature (°F)	72.922	70.182	*
Reservoir Oil Level (%)	37.030	39.022	*
Reservoir Oil Pressure (psia)	163.660	163.660	*
Pump Inlet Oil Temperature (°F)	72.533	69.402	*
T/M Yaw Actuator Position (deg)	-0.028	-0.028	*
Corrected T/M Yaw Act. Pos (deg)	-0.007	-0.007	*
IU Yaw Actuator Position (deg)	0.089	0.044	*
Corrected IU Yaw Act. Pos (deg)	0.030	-0.008	*
T/M Pitch Actuator Position (deg)	0.061	0.076	*
Corrected T/M Pitch Act. Pos (deg)	0.040	0.056	*
IU Pitch Actuator Position (deg)	-0.089	-0.044	*
Corrected IU Pitch Act. Pos (deg)	-0.030	0.008	*
IU Substitute 5v Power Supply (vdc)	5.039	5.034	*
Aft 5v Excitation Module (vdc)	4.985	4.985	*
Aft Bus 2 Current (amps)	48.00	47.800	*
Aux Hyd Pump Air Tank Press. (psia)	458.844	453.891	282.5 ±217.5
Aux Hyd Pump Mtr Cont Press. (psia)	19.442	19.115	20.75 ±11.95
FRATS Calibration			
LOX Circ Pump Flowrate Ind (vdc)	3.861	-	3.859 ±0.100
	-	3.855	3.859 ±0.100
LH2 Circ Pump Flowrate Ind (vdc)	3.861	-	3.859 ±0.100
	-	3.861	3.859 ±0.100
Static Inv-Conv Freq Ind (vdc)	2.507	-	2.438 ±0.100
	-	2.518	2.449 ±0.100
LH2 C/D Inv Freq Ind (vdc)	2.431	-	2.438 ±0.100
	-	2.436	2.449 ±0.100
LOX C/D Inv Freq Ind (vdc)	2.436	-	2.438 ±0.100
	-	2.440	2.449 ±0.100
LOX Flowmeter Indication (vdc)	1.682	1.682	1.667 ±0.100
LH2 Flowmeter Indication (vdc)	1.682	1.682	1.667 ±0.100
LOX Pump Speed Indication (vdc)	3.153	3.153	3.125 ±0.100
LH2 Pump Speed Indication (vdc)	1.276	1.276	1.250 ±0.100
Telemetry RF Checks			
T/M Antenna 1 Forward Power (watts)	26.917	26.738	19.0 +9.25,-7.25
T/M RF Sys Reflected Pwr (watts)	2.623	2.926	3.08 max
Telemetry System Open Loop VSWR	1.907	1.987	3.0 max
PU Oven Voltage (vdc)	2.163	2.163	0.3 min
Chilldown Inverter Hardwire Checks			
LOX C/D Inverter Current (amps)	23.20	20.80	20.0 ±5.0
LOX C/D Pump On			
Aft Bus 2 Voltage (vdc)	56.80	55.52	*
LOX C/D Inv AB Voltage (vac)	52.30	-	56.8 +2.0,-5.5
	-	51.2	55.52 +2.0,-5.5
LOX C/D Inv AC Voltage (vac)	52.50	-	56.8 +2.0,-5.5
	-	51.2	55.52 +2.0,-5.5

*Limits Not Specified

4.2.37.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
LOX C/D Pump On			
LOX C/D Inv A1B1 Voltage (vac)	52.30	-	56.8 +2.0,-5.5
	-	51.1	55.52 +2.0,-5.5
LOX C/D Inv A1C1 Voltage (vac)	52.10	-	56.8 +2.0,-5.5
	-	51.0	55.52 +2.0,-5.5
LOX C/D Inv Freq (Hz)	400.0	401.0	400 ±4.0
LH2 C/D Inv Current (amps)	19.40	22.80	20.0 ±5.0
LH2 C/D Pump On			
Aft Bus 2 Voltage (vdc)	56.16	54.64	*
LH2 C/D Inv AB Volt (vac)	51.67	-	56.16 +2.0,-5.5
	-	50.57	54.64 +2.0,-5.5
LH2 C/D Inv AC Volt (vac)	51.93	-	56.16 +2.0,-5.5
	-	50.76	54.64 +2.0,-5.5
LH2 C/D Inv A1B1 Volt (vac)	51.48	-	56.16 +2.0,-5.5
	-	50.37	54.64 +2.0, -5.5
LH2 C/D Inv A1C1 Volt (vac)	51.54	-	56.16 +2.0,-5.5
	-	50.31	54.64 +2.0, -5.5
LH2 C/D Inv Freq (Hz)	401.0	402.0	400.0 ±4.0
Chilldown Inverter Telemetry Checks			
LH2 C/D Inv Frequency (Hz)	400.3	400.3	400.0 ±4.0
Aft Bus 2 Voltage (vdc)	56.078	54.718	*
LH2 C/D Inv Phase AB Volt (vac)	56.1	54.9	56.078 ±3.0
LH2 C/D Inv Phase AC Volt (vac)	56.3	54.9	56.078 ±3.0
LOX C/D Inv Frequency (Hz)	399.9	399.8	400.0 ±4.0
Aft Bus 2 Voltage (vdc)	55.758	54.638	*
LOX C/D Inv Phase AB Volt (vac)	56.2	54.9	56.078 ±3.0
LOX C/D Inv Phase AC Volt (vac)	56.1	54.9	56.078 ±3.0
Pressure Measurements			
Common Bulkhead Pressure (psia)	14.422	14.477	14.7 ±0.5
Common Bulkhead 20% Calib (vdc)	1.015	1.024	1.0 ±0.1
Common Bulkhead Amb Press (psia)	14.840	14.866	14.7 ±0.5
Common Bulkhead 80% Calib (vdc)	4.020	4.015	4.0 ±0.1
Common Bulkhead Amb Press (psia)	14.813	14.866	14.7 ±0.5
LH2 Ullage Pressure (psia)	14.585	14.532	14.7 ±1.0
LH2 Ullage 20% Calib (vdc)	1.029	1.034	1.0 ±0.1
LH2 Ullage Amb Press (psia	14.532	14.532	14.7 ±0.5
LH2 Ullage 80% Calib (vdc)	4.024	4.029	4.0 ±0.1
LH2 Ullage Amb Press (psia)	14.585	14.585	14.7 ±0.5
LOX Ullage Pressure (psia)	14.664	14.664	14.7 ±1.0

* Limits Not Specified

4.2.37.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
LH2 EDS Transducer 1 Press. (psia)	14.8	14.6	14.7 ±1.0
LH2 EDS Transducer 2 Press. (psia)	14.6	14.7	14.7 ±1.0
LOX EDS Transducer 1 Press. (psia)	14.8	14.8	14.7 ±1.0
LOX EDS Transducer 2 Press. (psia)	15.0	15.0	14.7 ±1.0
LH2 C/D Pump Diff. Press. (psid)	0.124	0.187	0.0 ±1.2
LOX C/D Pump Diff. Press. (psid)	-0.438	-0.438	0.0 ±1.2
Final Prelaunch Checks			
Fwd Bus 1 Batt. Sim. (Bus 4D30) (vdc)	28.278	**	28.0 ±2.0
Fwd Bus 2 Batt. Sim. (Bus 4D20) (vdc)	28.239	**	28.0 ±2.0
Aft Bus 1 Batt. Sim. (Bus 4D10) (vdc)	28.079	**	28.0 ±2.0
Aft Bus 2 Batt. Sim. (Bus 4D40) (vdc)	56.718	**	56.0 ±4.0
Bus 4D20 ESE Load Bank (vdc)	-0.039	**	0.0 ±1.0
Bus 4D40 ESE Load Bank (vdc)	0.000	**	0.0 ±1.0
Bus 4D30 ESE Load Bank (vdc)	-0.039	**	0.0 ±1.0
Bus 4D10 ESE Load Bank (vdc)	0.000	**	0.0 ±1.0
Fwd Bus 1 C/O Batt. (Bus 4D30) (vdc)	**	31.039	29.5 +2.5,-1.5
Fwd Bus 2 C/O Batt. (Bus 4D20) (vdc)	**	31.079	29.5 +2.5,-1.5
Aft Bus 1 C/O Batt. (Bus 4D10) (vdc)	**	29.839	29.5 +2.5,-1.5
Aft Bus 2 C/O Batt. (Bus 4D40) (vdc)	**	62.237	60.5 +2.5,-1.5
Com Bulkhead Press. Transducer (vdc)	-0.010	-0.005	0.0 ±0.353
LH2 Ullage Press. Transducer (vdc)	-0.005	0.000	0.0 ±0.353
LOX Ullage Press. Transducer (vdc)	0.124	0.119	0.0 ±0.353
Fwd Bus 1 Internal (Bus 4D31) (vdc)	28.039	30.199	28.0 +3.0,-2.0
Fwd Bus 2 Internal (Bus 4D21) (vdc)	27.919	29.599	28.0 ±2.0
Aft Bus 1 Internal (Bus 4D11) (vdc)	29.039	29.358	28.0 ±2.0
Aft Bus 2 Internal (Bus 4D41) (vdc)	56.558	55.917	56.0 ±4.0
Receiver 1 Low Level Signal (vdc)	***	3.794	2.5 min
Receiver 2 Low Level Signal (vdc)	***	3.420	2.5 min
LH2 EDS 1 Ullage Pressure (psia)	14.722	14.722	14.7 ±1.0
LH2 EDS 2 Ullage Pressure (psia)	14.507	14.567	14.7 ±1.0
LOX EDS 1 Ullage Pressure (psia)	14.783	14.722	14.7 ±1.0
LOX EDS 2 Ullage Pressure (psia)	14.747	14.808	14.7 ±1.0
LH2 EDS Transducer 1 Press (psia)	14.768	14.827	14.7 ±1.0
LH2 EDS Transducer 2 Press (psia)	14.612	14.671	14.7 ±1.0
LOX EDS Transducer 1 Press (psia)	14.886	14.590	14.7 ±1.0
LOX EDS Transducer 2 Press (psia)	14.788	14.905	14.7 ±1.0
APS Roll Checks			
IU Substitute -28 volt Power (vdc)	-28.958	-28.839	-28.5 ±2.5
Attitude Control Nozzles I IV and III II On			
Engine 1-1 1-3 Valve Open Ind (vdc)	3.902	3.882	3.9 ±0.4
Engine 2-1 2-3 Valve Open Ind (vdc)	3.810	3.773	3.9 ±0.4

** Measurement Not Applicable
***Range Safety Transmitter off for field strength measurements

4.2.37.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
Attitude Control Nozzles I IV and III II Off			
Engine 1-1 1-3 Valve Open Ind (vdc)	-0.005	0.000	0.0 ±0.25
Engine 2-1 2-3 Valve Open Ind (vdc)	0.005	0.000	0.0 ±0.25
Attitude Control Nozzles I II and III IV On			
Engine 1-1 1-3 Valve Open Ind (vdc)	3.892	3.876	3.9 ±4.50
Engine 2-1 2-3 Valve Open Ind (vdc)	3.805	3.779	3.9 ±0.450
Attitude Control Nozzles I II and III IV Off			
Engine 1-1 1-3 Valve Open Ind (vdc)	-0.005	-0.005	0.0 ±0.25
Engine 2-1 2-3 Valve Open Ind (vdc)	0.000	0.000	0.0 ±0.25
Hydraulic Gimbal Step Response Check			
Ratio Valve Pos. (Relay Off) (deg)	0.15	0.21	0.0 ±1.5
Hydraulic System Pressure (psia)	3592.0	3601.0	3500.0 min
Ratio Valve Pos. (Relay On) (deg)	33.076	33.145	20.0 min
Hydraulic Gimbal 0.6 Hz Check			
Ratio Valve Pos. (Relay Off) (deg)	1.510	1.715	0.0 ±1.5
Hydraulic System Pressure (psia)	3601.0	3601.0	3500.0 min
Pitch Act. Piston Pos., AO (deg)	0.028	0.013	0.0 ±0.517
Yaw Act. Piston Position, AO (deg)	0.002	0.033	0.0 ±0.517
Engine Pitch Position, IU (deg)	-0.180	-0.104	0.0 ±0.517
Engine Yaw Position, IU (deg)	0.089	0.149	0.0 ±0.517
Hydraulic System Pressurized			
Hydraulic System Pressure (psia)	3601.375	3592.813	*
Accumulator GN2 Pressure (psia)	3619.375	3608.500	*
Accumulator GN2 Temperature (°F)	83.504	79.975	*
Reservoir Oil Temperature (°F)	91.355	139.461	*
Reservoir Oil Level (%)	35.411	45.373	*
Reservoir Oil Pressure (psia)	168.452	167.148	*
Pump Inlet Oil Temperature (°F)	105.904	147.777	*
T/M Yaw Actuator Position (deg)	-0.013	0.033	*
Corrected T/M Yaw Act. Pos. (deg)	0.009	0.055	*
IU Yaw Actuator Position (deg)	0.089	0.149	*
Corrected IU Yaw Act. Pos. (deg)	0.022	0.104	*
T/M Pitch Actuator Position (deg)	0.044	0.013	*
Corrected T/M Pitch Act. Pos. (deg)	0.022	-0.009	*
IU Pitch Actuator Position (deg)	-0.089	-0.104	*
Corrected IU Pitch Act. Pos. (deg)	-0.022	-0.061	*
IU Substitute 5v Power Supply (vdc)	5.044	5.029	*
Aft 5v Excitation Module (vdc)	4.985	4.984	*
Aft Bus 2 Current (amps)	47.0	**	*
Aft Checkout Battery 2 Current (amp)	**	52.399	*
Ratio Valve Pos. (Relay On) (deg)	-27.192	-27.192	-20.0 max

* Limits Not Specified

**Measurement Not Applicable

4.2.37.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
First Burn and Coast Period			
LOX Tank Pressure Sequence			
Cold He Shutoff Valve Open			
Heat Exch. Outlet Press D161 (psia)	286.891	287.594	*
LOX Press Mode He Press D105 (psia)	308.641	308.094	*
Cold He Cont Vlv Inlet Press D225 (psia)	286.82	288.45	*
LOX Sys Press SW Supply Closed			
Heat Ech Outlet Press D161 (psia)	122.779	122.779	*
LOX Press Mod He Press D105 (psia)	172.250	174.434	*
Cold He Cont Vlv Inlet Press D225 (psia)	110.61	110.61	*
LH2 Press. Module Helium Pressure D104:			
LH2 Prepress. Supply Open (psia)	100.11	100.11	*
LH2 Press. Sw. Supply Closed (psia)	70.65	72.83	*
LH2 First Burn Relay Off (psia)	55.37	55.37	*
LOX Motor Container He Press D103 (psia)	42.88	42.88	*
Engine Restart Preparations			
LH2 Boiloff Bias Signal M010:			
Bias Cutoff Off (vdc)	0.32	0.45	0.0 ±2.5
Bias Cutoff On (vdc)	11.587	11.910	4.0 min
LOX Repress Spheres, D088 (psia)	704.83	701.09	*
Cold Helium Spheres, D016 (psia)	694.05	697.86	*
Cold Helium Spheres, D016 (psia)	724.61	724.61	*
LOX Repress Spheres, D088 (psia)	704.83	701.09	*
Cold Helium Spheres, D016 (psia)	724.61	720.78	*
LOX Repress Spheres, D088 (psia)	618.83	600.14	*
Chilldown Pumps On			
LOX C/D Inv Phase AB Volt. (vac)	52.324	57.932	50.0 min
LOX C/D Inv Phase AC Volt. (vac)	52.389	57.932	50.0 min
LOX C/D Inv Phase A1B1 Volt. (vac)	52.324	**	50.0 min
LOX C/D Inv Phase A1C1 Volt. (vac)	52.129	**	50.0 min
LH2 C/D Inv Phase AB Volt. (vac)	51.868	56.198	50.0 min
LH2 C/D Inv Phase AC Volt. (vac)	52.129	56.465	50.0 min
LH2 C/D Inv Phase A1B1 Volt. (vac)	51.608	**	50.0 min
LH2 C/D Inv Phase A1C1 Volt. (vac)	51.739	**	50.0 min

* Limits Not Specified
**Measurement Not Applicable

4.2.37.1 (Continued)

Function	Umbil.-In	Umbil.-Out	Limits
Chilldown Pumps Off			
LH2 C/D Inv Frequency (Hz)	389.5	389.5	390.0 ±1.0
LH2 C/D Inv Phase AB Volt. (vac)	0.07	0.00	0.0 ±1.5
LH2 C/D Inv Phase AC Volt. (vac)	0.00	0.00	0.0 ±1.5
LOX C/D Inv Frequency (Hz)	389.5	389.5	390.0 ±1.0
LOX C/D Inv Phase AB Volt. (vac)	0.00	0.00	0.0 ±1.5
LOX C/D Inv Phase AC Volt. (vac)	-0.07	0.00	0.0 ±1.5
LH2 Second Burn Repressurization			
LH2 Press. Module Helium Pressure D104:			
LH2 Prepress. Supply Open (psia)	101.197	101.197	*
LH2 Press. Sw. Supply Closed (psia)	70.64	69.555	*
LOX Depletion Timer Check			
LOX Sensors 1 and 2 Dry (sec)	0.558	**	0.560 ±0.025
LOX Sensors 1 and 3 Dry (sec)	0.553	**	0.560 ±0.025
LOX Sensors 2 and 3 Dry (sec)	0.554	**	0.560 ±0.025
APS Yaw and Pitch Checks			
Attitude Control Nozzles I IV and III IV On			
Engine 1-1 Valve Open Ind (vdc)	3.769	3.814	3.9 ±0.4
Engine 2-3 Valve Open Ind (vdc)	3.661	3.718	3.9 ±0.4
Attitude Control Nozzles I IV and III IV Off			
Engine 1-1 Valve Open Ind (vdc)	0.000	0.000	0.0 ±0.25
Engine 2-3 Valve Open Ind (vdc)	0.000	-0.005	0.0 ±0.25
Attitude Control Nozzles I II and III II On			
Engine 1-3 Valve Open Ind (vdc)	3.764	3.800	3.9 ±0.4
Engine 2-1 Valve Open Ind (vdc)	3.671	3.712	3.9 ±0.4
Attitude Control Nozzles I II and III II Off			
Engine 1-3 Valve Open Ind (vdc)	0.000	0.00	0.0 ±0.25
Engine 2-1 Valve Open Ind (vdc)	-0.005	0.00	0.0 ±0.25
Attitude Control Nozzle I P On			
Engine 1-2 Valve Open Ind (vdc)	3.861	3.861	3.9 ±0.4
Attitude Control Nozzle I P Off			
Engine 1-2 Valve Open Ind (vdc)	0.00	0.00	0.0 ±0.25
Attitude Control Nozzle III P On			
Engine 2-2 Valve Open Ind (vdc)	3.779	3.779	3.9 ±0.4
Attitude Control Nozzle III P Off			
Engine 2-2 Valve Open Ind (vdc)	0.00	0.00	0.0 ±0.25

* Limits Not Specified

4.2.38 Forward Skirt Thermoconditioning System Postcheckout Procedure (1B62965 D)

This procedure secured the forward skirt thermoconditioning system following VCL automatic checkout activities, and consisted of a system cleanliness check, a drain and dry procedure, a leak check, and preparations for stage shipment to STC. Initiated on 11 September 1968, the procedure was completed and accepted on 18 September 1968, after 3 days of activity. Engineering acceptance of the procedure was dated 17 September 1968.

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

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

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

The stage thermoconditioning system was then purged with freon gas and pressurized to 32 ± 1 psig for a leak check. All system B-nuts and fittings, manifold weld areas, panel inlet and outlet boss welds, and manifold flexible bellows were leak checked using a gaseous leak detector, P/N 1B37134-1, with the sensitivity switch set to 1 on the R12-OZ/YR scale. No leaks were found in any of these areas.

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

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

5.0 POSTRETENTION

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

5.1 Stage Shipment

Transfer of the Saturn DSV-4B-1-1 (S-IVB-509) stage, for transport to the Sacramento Test Center, was made on 31 March 1969 at the Space Systems Center, Huntington Beach. A letter A3-131-KYAO-L-1018, dated 28 March 1969, from the McDonnell Douglas Astronautics Company Contracts Manager to the NASA/MSFC Resident Management Office, I-CO-SD/DAC, covered the submittal of documentation for purposes of technical transfer of the stage to STC.

5.2 Summary

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

5.2.1 Retention Activities

During the retention period, various modifications and rework activities were accomplished on the stage. This included FARR disposition reworks, and the activities normally scheduled for completion at SSC. (Reference paragraph 5.3.1.)

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

5.2.2 Postretention Activities

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

The final inspection of the stage was accomplished to locate and correct any remaining stage discrepancies. A final inspection was conducted between 3 and 4 October 1968, with a total of 177 discrepancies noted by MDAC inspection. A total of 61 discrepancies were noted by AFQA inspectors. All of these discrepancies were corrected before the stage went into storage. During the preshipment operations, the final inspection was reaccomplished between 13 and 20 March 1969, with a total of 87 discrepancies by MDAC inspection. A

5.2.2 (Continued)

total of 18 discrepancies were noted by AFQA inspectors. All of these discrepancies were corrected before the stage was shipped. Paragraph 5.4.2 presents a more detailed narration on the final inspection.

During the preshipment operation, the stage was rotated to a horizontal position, and prepared for the weight and balance operation. On 21 March 1969 the stage was weighed by means of a three point electronic weighing system. Three electronic load cells, one aft and two forward, measured the reaction forces of the otherwise unsupported stage. The reaction force measurements were then used to determine that the stage shipping and handling weight was 26,811.7 pounds, the stage weight corrected for Standard Gravity in a vacuum was 26,875.2 pounds, and the stage longitudinal center of gravity was located at station 328.4. Paragraph 5.4.3 presents a more detailed narration on these operations.

The final operation before the stage was shipped to STC was the preshipment purge. Gaseous nitrogen was used to purge the stage systems to dewpoints of -37°F for the LH_2 system, and -40°F for the LOX system. The necessary desiccants were installed to maintain the proper stage environment during the air transport operations. Paragraph 5.4.4 presents a more detailed narration on this operation.

5.3 Stage Configuration

This paragraph presents the variations to the basic stage configuration existing at the time of stage transfer to STC. Paragraph 5.3.1 comments on modifications made after VCL checkout of the stage; and paragraph 5.3.2 describes those flight critical items which deviate from the stage design.

5.3.1 Post Checkout Modifications

Subsequent to VCL checkout, various modifications were made to the stage during the retention period at Huntington Beach. A detailed listing of these modifications and the AO, FARR, and removal work accomplished, is provided by letter A3-850-KYCO-L-1196, dated 3 April 1969, from the Saturn Program Production Director of McDonnell Douglas Astronautics Company, Western Division, to the NASA/MSFC Resident Management Office. This letter also noted additional modifications that were to be accomplished at STC.

Paragraph 5.5 comments upon the retesting that will be required at STC to verify the acceptability of the accomplished stage modifications.

5.3.2 Stage Variations - Flight Critical Items

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

5.3.2.1 Fill and Drain Valve

Rework SEO 1A48240-007 modified the fill and drain valves, P/N 1A48240-505-007, S/N's 0017 and 0125, to minimize cracking of the valve electrical connector inserts and glass insulation at cryogenic temperatures. The existing bonded inserts and O-rings were removed from the connectors, and unbonded inserts and O-rings were installed.

5.3.2.2 Chill System Shutoff Valve

Rework SEO 1A49965-012 modified the LH_2 chill system shutoff valve, P/N 1A49965-523-012, S/N 0508, to minimize cracking of the valve electrical connector insert and glass insulation at cryogenic temperatures. The existing bonded insert and O-ring were removed from the connector, and an unbonded insert and O-ring were installed.

5.3.2.3 Chill System Shutoff Valve

Rework SEO 1A49965-013B modified the LOX chill system shutoff valve, P/N 1A49965-529-013B, S/N 0602, by removing the existing Drilube 822 lubricant from all areas that would be in direct contact with the liquid oxygen. This was necessary as the Drilube 822 was no longer compatible. The valve was relubricated with Krytox 240AC lubricant, which met the requirements of 1P20112.

5.3.2.4 Chilldown Inverter Electronics Assembly

Rework SEO 1A74039-016A modified the chilldown inverter electronics assemblies, P/N 1A74039-517-016A, S/N's 018 and 045, to ensure that the installed zener diode would meet the environmental and operational requirements. The diode, CR13 in the assembly circuit, was checked by reverse current, forward voltage, zener voltage, and surge current tests.

5.3.2.5 Oxygen-Hydrogen Burner Assembly

Rework SEO 1B62600-009C modified the O_2H_2 burner assembly, P/N 1B62600-509-009C, S/N 15, because a redesigned nozzle assembly was not available. The rework included the installation of an orifice, P/N 1B67799-1, and an injector assembly, P/N 1B67723-1; the alignment of the nozzle assembly, P/N 1B63780-1; changes in a pipe assembly to provide clearance for a transducer; and the capping of an unrequired back pressure system connection port.

5.4 Narratives

This paragraph presents narrations on the stage checkouts accomplished following the stage retention at SSC. Paragraph 5.4.1 comments on any postretention system checkouts accomplished to verify stage modifications; paragraph 5.4.2 covers the stage final inspection; and paragraphs 5.4.3 and 5.4.4 narrate on the stage weight and balance operation and the preshipment GN_2 purge.

5.4.1 Postretention Testing

No system checkouts were accomplished following the stage retention period. All modifications made to the stage were to be tested at STC, as indicated by the retest requirements in paragraph 5.5.

5.4.2 Final Inspection

A final inspection was accomplished by McDonnell Douglas and AFQA personnel on all stage mechanical and electrical areas to locate and correct any remaining discrepancies. The inspection was initially accomplished between 3 and 4 October 1968, to verify that the stage was in satisfactory condition for storage and retention. A total of 177 discrepancies were noted by MDAC inspectors during this inspection, 97 in the mechanical areas and 80 in the electrical areas. A total of 61 discrepancies were noted by AFQA inspectors during this inspection, 37 in the mechanical areas and 24 in the electrical areas. These defects were corrected, and the inspection and all reworks were accepted by 28 March 1968.

Following the removal of the stage from storage, the final inspection was repeated between 13 and 20 March 1969, to verify that the stage was in satisfactory condition for the preshipment operations and transfer to STC. A total of 87 discrepancies were noted by MDAC inspectors during this repeat inspection, 31 in the mechanical areas, and 56 in the electrical areas. A total of 18 discrepancies were noted by AFQA inspectors during this inspection, 13 in the mechanical areas and 5 in the electrical areas. The inspection results, and the corrective action reworks, were all accepted by 20 March 1969.

Most of these discrepancies, during the first inspection, were corrected immediately. However, two discrepancies were recapped to FARR's 500-445-904 and 500-445-921, which were acceptably resolved. During the second inspection two FARR's, 500-774-002 and 500-271-035, were written to cover discrepancies not immediately correctable; however, prior to stage shipment the FARR's were closed out acceptably to Engineering.

5.4.3 Weight and Balance Procedure (1B64539 C)

This procedure measured the stage weight with an accuracy of $\pm$0.1 percent, using a three point electronic weighing system, and determined the longitudinal center of gravity of the stage. The measured stage weight was corrected for gravity and air buoyancy forces to determine the weight at Standard Gravity in a vacuum. The procedure was satisfactorily accomplished on 21 March 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 the same date.

Before starting the weighing operation, the electronic weighing system, P/N 1A57907-1, was set up and calibrated. Three load cell assemblies, P/N CMU-1204 or 1B38965-1 and -501, were connected to the load cell readout indicator, P/N CMU-1204, checked for linearity and stability by the use of the indicator standardizer, and adjusted for a zero setting. The stage was verified to be level within 0.250 inches over the axial distance between stations 554.702 and 286.147. The dry bulb temperature, barometric pressure and relative humidity were measured in the weighing area, for use in

5.4.3 (Continued)

determining the air density. These measurements were repeated every half hour throughout the weighing operation.

Using the hand pumps on the aft jack, P/N 1A93232-1, and the two forward glide-aire jacks, P/N 1A83320-1, the stage was raised to just clear the cradles, and leveled to the previous limit. Regulator air pressure was applied to the forward glide-aire jacks to permit self-adjustment of the stage, and the stage levelness was reverified. After allowing 10 minutes for load cell creep stablization, load cell readings were taken as shown in Test Data Table 5.4.3.1. The stage was then lowered back onto the cradles, the load cells were allowed to creep stablize again, and the load cell zero was rechecked and adjusted if necessary. The weighing procedure was repeated three times, and the average reading for each load cell was determined and corrected for calibration. From the capacity of each load cell, and the load cell reading, the reaction force on each load cell was determined. These reaction forces were then used to determine the stage shipping and handling weight, the stage weight at Standard Gravity in a vacuum, and the longitudinal center of gravity. As shown in the Test Data Table, the stage shipping and handling weight was 26,811.7 pounds, the weight at Standard Gravity in a vacuum was 26,875.2 pounds, and the longitudinal center of gravity was at station 328.4.

No parts were short during this procedure, no revisions were written, and no problems were encountered.

5.4.3.1 Test Data Table, Weight and Balance Procedure

Air Density Data

Time	Barometric Press. (in. Hg)	Relative Humidity (%)	Dry Bulb Temp (°F)
09:00	29.890	70.0	57.0
09:30	29.890	64.0	62.0
10:00	29.890	62.0	63.0
10:30	29.890	62.0	65.0
11:00	29.890	59.0	64.0

Calculated Air Density: 0.0739 pounds per cubic foot.

Load Cell Collected Data

Reaction Load Cell	Aft (R1)	Forward (R2)	Forward (R3)
Serial Number	36246	34191	34184
Capacity (pounds)	25,000	10,000	10,000
Run 1 Reading (%)	79.390	37.041	39.556
Run 2 Reading (%)	79.427	36.988	39.606
Run 3 Reading (%)	79.428	36.981	39.594
Average Reading (%)	79.415	37.003	39.585
Calibration Correction	1.037	0.246	0.291
Corrected Reading (%)	80.452	37.249	39.876
Reaction (pounds)	20,113.0	3,724.9	3,987.6

5.4.3.1 (Continued)

Weight Determination (pounds)

Aft Reaction R1	20,113.0
Forward Reaction R2	3,724.9
Forward Reaction R3	3,987.6
Total Reactions as recorded	27,825.5
Minus Weighing Equipment "Tare"	-1,013.8
Shipping and Handling Weight	26,811.7
Plus Gravitational Correction	+ 29.7
Plus Buoyancy Correction	+ 33.8
Weight at Standard Gravity in a vacuum	26,875.2

Longitudinal Center of Gravity

Reaction R1 Moment at Sta. 189.3	3,807,390.9
Reaction R2 Moment at Sta. 684.0	2,547,831.6
Reaction R3 Moment at Sta. 684.0	2,727,518.4
Moment Sum	9,082,740.90
Tare Moment	- 278,870.75
Moment Sum Less Tare	8,803,870.15

As weighed Center of Gravity = Station 328.4
(Moment Sum Less Tare divided by Total Reactions Less Tare)

5.4.4 GN_2 - Electrical Air Carry Preshipment Purge (1B65783 K)

Just prior to stage shipment, this procedure purged the stage to a dewpoint of -30°F (235 ppm by volume) or less, using gaseous nitrogen, and installed the necessary desiccants for stage air carry shipment. The desiccants maintained a clean, dry environment and a safe differential pressure during air transportation.

The procedure was satisfactorily performed between 2 and 6 August 1968, and was accepted on 6 August 1968. The purge preparations started with the installation of the LOX and LH_2 desiccant support assemblies, P/N's 1B61272-1 and 1B61270-1. The LOX bellows, P/N 1A49971-501, and the LOX and LH_2 disconnects, P/N's 1A49970-503 and 1B66932-501, were removed for separate shipment with the stage. Covers and desiccators were installed at the LOX and LH_2 fill and drain vents, the LH_2 propulsive, non-propulsive, and ground vents, the LOX propulsive and non-propulsive vents, and the O_2H_2 burner nozzle.

The Model 1865 purge unit, 1B61117-1, was prepared for operation, and the electrical and pneumatic purge connections were made on the stage and between the purge unit and the stage. The engine LOX chilldown line and LH_2 feed duct, the LH_2 pressurization line, the LH_2 propulsive vent, non-propulsive vent, and ground vent, the LOX propulsive vent and non-propulsive vent, the O_2H_2 burner LOX and LH_2 ducts, and the LOX and LH_2 propellant tanks were all purged with gaseous nitrogen. The final dewpoints attained were -40°F for the

5.4.4 (Continued)

LOX system, and -37°F for the LH_2 system. During the tank purges, the LH_2 tank door was removed for separate shipment with the stage, and a manifold, P/N 1B61027-1, was installed in its place. Also, the LOX tank desiccant breather, P/N 1A79691-1, and the four LH_2 tank desiccant breathers, P/N 1A79691-501, were prepared, filled with desiccant material, and installed.

After the satisfactory completion of the purge operation, the purge unit was disconnected from the stage and secured. The aft skirt dust cover, P/N 1B61077-1, and the forward skirt dust cover, P/N 1B61099-1, were then installed to complete the procedure.

There were no parts shortages affecting this test. No particular problems were encountered, and no FARR's were written. Ten revisions were made to the procedure for the following:

a. Four revisions were written to provide setup, operate, and teardown instructions for the GN_2 heater.

b. Two variation revisions were written because the continuous vent regulator module was missing from the stage, and the continuous vent system required purging.

c. One revision added instructions to install a desiccant indicator on the desiccant breather.

d. One revision replaced an elbow with a tee to permit the continuous vents to breathe freely during air carry.

e. One variation revision was written to permit the Engineer in charge to determine the time interval for recording the tank dewpoint.

f. One revision deleted the instructions requiring removal of the protective wrapping from the relief valve on the desiccant tank, because it should not be removed until the stage is loaded aboard the Guppy.

5.5 Retest Requirements

As noted in paragraph 5.3.1, various modifications were accomplished on the stage during the SSC retention period, and additional modifications were scheduled at STC prior to stage acceptance firing. The retesting required to verify the acceptability of these modifications included manufacturing tests, and stage system checkouts. Some manufacturing tests were completed at SSC, with the remainder scheduled for STC, but no additional stage checkout procedures were accomplished at SSC prior to stage shipment. The completion of the following system checkout procedures was required at STC, prior to the acceptance firing, to verify all of the modifications.

5.5 (Continued)

1B41004	Hydraulic System Servicing
1B41005	Hydraulic System Setup and Operation
1B41955	Thermoconditioning System Checkout and Operation
1B49286	Common Bulkhead Vacuum Check
1B55813	Stage Power Setup
1B55814	Stage Power Turnoff
1B55815	Power Distribution System
1B55816	DDAS Calibration
1B55817	DDAS Automatic Checkout
1B55819	Range Safety Receiver Automatic Checkout
1B55821	Range Safety System Automatic Checkout
1B55822	EBW System Automatic Checkout
1B55823	Propellant Utilization System Automatic Checkout
1B55824	Hydraulic System Automatic Checkout
1B55825	APS (Simulator) Automatic Checkout
1B62753	Propulsion System Automatic Checkout
1B64367	Propellant Utilization System Manual Calibration
1B64678	Cryogenic Temperature Sensor Verification
1B64679	Telemetry and Range Safety Antenna
1B64680	Level Sensor and Control Unit Calibration
1B64651	Signal Conditioning Setup
1B70175	Final Leak Checks
1B71877	Propulsion System Leak Check

Most of the above tests are part of the normally planned STC prefire testing.

5.6 Post Checkout FARR's

This paragraph presents those FARR's which were generated and active against stage components during the SSC retention period following stage VCL checkout. Paragraph 5.6.1 summarizes those incomplete FARR's that were transferred open at the time of stage transfer to STC. Paragraph 5.6.2 presents the post checkout FARR's in tabular form.

5.6.1 Incomplete FARR's

FARR 500-639-423, against P/N 103826, S/N J2-2124, noted that the gate end and potentiometer end of the link to the piston is corroded. The FARR was dispositioned to be resubmitted to Liaison Engineering. This FARR was sent to STC as an open item.

5.6.2 Tabulated Post Checkout FARR's

The following table presents those FARR's that were generated and active against stage components during the SSC retention period.

FARR No.	Description of Defects	Disposition
A271035 12-1-67	a. The fuel turbopump assembly, P/N 460160-41, S/N 4092743, has a ding (1/4 in. by 3/8 in. by 1/16 in.) at 3 o'clock. b. The exhaust manifold assembly, P/N 204355-51, S/N 4087914, has a ding (2 in. by 2 in. by 3/16 in.) at 9 o'clock. Clocked from the aft end looking forward.	a and b. Acceptable to Engineering for use.
500-353-210 11-13-68	The following discrepancies were noted on the O_2H_2 burner assembly, P/N 1B62600-509, S/N 015, during line check A3-720-093: a. A red residue buildup around the faying surfaces of the spherical washers, P/N A40732, at the four bolt locations attaching the nozzle to the flange. b. AN cap assembly installed at 7 places; should be MC177C4W, and AN cap assembly installed at 1 place; should be MC177C6W.	a. The spherical washers were removed and replaced - one at a time to maintain burner alignment. The rework was acceptable to Engineering for use. b. Acceptable to Engineering for use.
500-445-904 10-4-68	The aclar sleeve, P/N 1A78053-19, on the fuel fill line was torn open.	The faying surfaces were prepared per DPS 30,000 and bonded together with DPM 3279 per DPS 32340. Then a patch 1 in. larger than the tear was applied to the sleeve to cover the tear. The rework was acceptable.
500-445-921 10-8-68	A 350 psig flex hose, P/N 1B63010-1, S/N 07380H500024, had a flat spot 2 in. from the bulkhead fitting on the thrust structure at stringer 14.	The discrepant hose was removed and replaced. The rework was acceptable to Engineering for use.

FARR No.	Description of Defects	Disposition
500-445-955 10-10-68	The tunnel cover, P/N 1B39628-1, has a 1/4 in. gap in the forward section of the cover. Ref. B/P 1A39313, Zone 23.	A shim was fabricated and installed in accordance with Engineering instructions to fill the gaps. The rework was acceptable to Engineering for use.
500-637-251 10-25-68	A permascope inspection of the forward and aft skirts revealed that the silicone seal coat was out-of-tolerance per B/P 1B65223.	Three coats of the silicone seal coat were brushed on in accordance with DPS 42210. The rework was acceptable to Engineering for use.
500-639-130 12-18-68	Two holes (0.221/0.224 in.) drilled in bracket, P/N 1B57145-501, should have been drilled in the assembly, P/N 1B57145, so the coolant return line could be installed in an unrestrained position.	The discrepant bracket was removed and a new bracket was installed with the holes (0.221/0.224 in.) omitted from the bracket. The rework was acceptable to Engineering for use.
500-639-181 12-20-68	The bellows, P/N 1A49986-1, S/N 6623-001, has dings and dents in the convolutes at both ends.	The discrepant bellows, S/N 6623-001, was removed per WRO 4036 and AO 1B74943 Job 2. The defective bellows was scrapped. The AO was sent to STC as an open item and will be worked at STC.
500-639-199 12-26-68	The LH_2 low pressure duct assembly, P/N 1A49320-513, S/N 40, has two dents in the outer jacket. One dent (0.312 in. long by 0.187 in. wide by 0.100 in. deep) is in the No. 8 convolute. One dent (0.500 in. long by 0.187 in. wide by 0.062 in. deep) is to the right of the center weld of the jacket between the seventh and eighth convolutions. Also, the identification label was partially destroyed obliterating the part number.	The dents were acceptable to Engineering, after they had been dye checked per DPS 15101. The identification label was removed and a new identification label was installed.

FARR No.	Description of Defects	Disposition
500-639-202 12-30-68	During the performance of H&CO 1B69571, the wave form analysis showed that the voltage for the IU command unit was out-of-tolerance. Trouble shooting revealed that the attitude control relay module, P/N 50M35076-1, S/N 322, was malfunctioning.	The control relay module, S/N 322, was an interim use material part and was removed, after VCL checkout completion. Control relay package, P/N 1B76452-501, S/N 35, was installed per AO 25ASO-147 prior to stage shipment.
500-639-229 1-2-69	a. The panel assembly, P/N 1B67418-1, has six misdrilled holes (0.279/0.289 in.) at the forward end. Ref. B/P 1B67418, Zones 6 and 7.	a. The holes that went through the sheet metal and the honeycomb were plugged with 1P20025 adhesive per 1P00098. The holes that went through only the metal were acceptable. The rework was acceptable to Engineering for use.
	b. The panel assembly also has two holes (0.279/0.289 in.) mislocated at the left end at the center and bottom. The holes should have been drilled 1.250 in. center line to center line. The hole at the center is drilled 1.312 in. from center line and the hole at the bottom is drilled 1.296 in. from center line.	b. Acceptable to Engineering for use.
500-639-237 1-6-69	The following parts of the LH_2 propulsive vent system were suspected of contamination, after contaminants were found at the forward skirt inspection points: a. Duct assembly, P/N 1A87755-501 b. Duct assembly, P/N 1A87234-1 c. Duct assembly, P/N 1A87436-501 d. Tee assembly, P/N 1A49987-1 e. Duct assembly, P/N 1A87436-502 f. Duct assembly, P/N 1A87234-2 g. Pipe assembly, P/N 1B67276-1 h. Pipe assembly, P/N 1B67277-1	The discrepant parts were removed and replaced. The replacement parts were retested and found to be acceptable to Engineering for use.

FARR No.	Description of Defects	Disposition
500-639-296 1-17-69	The probe assembly, P/N 1B42499-401.4, S/N 010, was identified as an L change part; however, a probe head, P/N 1B42968-503, was installed instead of P/N 1B37873-547. The head, P/N 1B37873-547, should have been installed to comply with the 1A69275 V change which constitutes part of the 1B42499-401.4 L change.	The head, P/N 1B42968-503, was removed and a new head, P/N 1B37873-547-001, was installed. The probe was tested and accepted by Engineering for use.
500-639-342 1-30-69	The sleeve, P/N 1A78053-19, on the fuel line had a 0.500 in. horizontal tear through the aclar at approximately station 230, stringer 26 in the aft skirt interior.	The aclar faying surfaces were prepared per DPS 30000. A patch of aclar was prepared and bonded to the sleeve with DPM 3279. The rework was acceptable to Engineering for use.
500-639-687 1-31-69	The transducer set, which consists of a sensor, P/N 1B40242-27, an amplifier, P/N 1B40242-83, and a cable, P/N 1B40242-105, is missing the sensor. The set was removed per AO 1B58006 BS, chart 23TSO.	The remaining portions of the set were returned to the vendor to be reworked or replaced as necessary.
500-773-910 2-11-69	a. The helium manifold, P/N 1B67299-505, had brown discoloration on the flange neck weld joints at the No. 4 and 5 external ports on the main tunnel. b. The helium manifold, P/N 1B67299-1, had brown discoloration on the flange neck weld joints at the No. 7, 8 and 9 external ports in the auxiliary tunnel.	a and b. The brown discoloration was removed per Engineering instructions using DPM 1571. The rework was acceptable to Engineering.
500-773-944 3-7-69	The nozzle, P/N 1B69234-1, has one hole (0.279/0.281) with an edge distance of 0.062 in. Edge distance should have been 0.125 in. Hole location is between stringers 62 and 63 at station 224.375.	Acceptable to Engineering for use.

FARR No.	Description of Defects	Disposition
500-774-002 3-14-69	During final acceptance checkout the following discrepancies were noted:	
	a. The outer insulation of the sensor cable, P/N 1B40242-95, S/N 593-5, was torn exposing the shielding in two places (1/16 in. in length). No strands of the shielding were frayed or broken.	a. The damaged insulation was repaired per DPS 54010.
	b. Connector P1 of wire harness, Ref. Des. 404A75A10W2, rides the head of the screw at the standoff and clamp on the firing unit cable, which did not permit proper stowage. Located in the aft skirt at stringer 145 at the firing unit cable.	b. Material (1/16 in.) was removed from the mounting surface of the standoff to permit clearance for the plug.
	c. The phenolic support bracket, P/N 1B37428 -513, had separated from the face of the panel, 404A60.	c. The remaining portion of the support was removed and a new support was installed per B/P.
	d. The lower fuel duct, P/N 1A49320-515, has a ding (approximately 0.049 in. deep), and a ding (approximately 0.030 in. deep) in the upper bellows.	d. After a dye check, which had revealed no defects, the duct was accepted for use.
		All rework was acceptable to Engineering

TABLE I. FAILURE AND REJECTION REPORTS OF PERMANENT NONCONFORMANCES, STRUCTURAL ASSEMBLIES

Section 1. Propellant Tank Assembly, P/N 1A39303-545

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A261512 11-1-67	The following adhesive test specimens for tensile bond of 3D foam tile did not meet requirements of DPS 23003, which require test specimens to produce an average tensile bond value of 150 psi or more with no value below 100 psi. a. Test specimen No. 3 for aft dome segment 4 had an average tensile bond of 149 psi and a minimum of 119 psi. b. Tensile specimen No. 5 for aft dome seam 6 and segments 6 and 7 had an average tensile bond of 122 psi and a minimum of 88 psi. c. Tensile specimen No. 10 for forward dome segment 7 had an average tensile bond of 83 psi and a minimum of 25 psi.	a. A retest of specimen No. 3 showed an average tensile bond of 206 psi and a minimum of 160 psi. Acceptable to Engineering for use. b. and c. A 2 1/2 in. diameter area of glass liner was removed from 3D tile at 3 places each on aft dome segment 6, aft dome segment 7 aft dome seam 6, and forward dome segment 7. Freshly grit blasted aluminum plugs 1 1/2 in. diameter were bonded to the exposed foam per Engineering instructions. When cured the foam was carefully cut vertically around the edge of the plugs. A special plug pull test was performed per procedure A659-1A39303-PDS1. Test results were satisfactory and the 3D tile was acceptable to Engineering for use.

TABLE I, Section 1 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A261513 11-3-67	The adhesive test specimen No. 15 representing 3D foam tile installed at forward dome segment 4 had an average tensile bond value of 91 psi and a minimum of 34 psi and should have been an average of 150 psi or more with no value below 100 psi per DPS 23003.	A 2 1/2 in. diameter area of glass liner was removed from 3D tile at 3 places on forward dome segment 4. Freshly grit blasted aluminum plugs 1 1/2 in. diameter were bonded to the exposed foam per Engineering instructions. When cured the foam was carefully cut vertically around the edge of the plugs. A special plug pull test was performed per procedure A659-1A39303-PDS1. Test results were satisfactory and the 3D title was acceptable to Engineering for use.
A261517 11-21-67	a. Seven pieces of 3D tile on the forward dome inside the LH2 tank does not have the "C" stamp visually affixed, indicating that they were not processed per DPS 23100 prior to installation and glass lining.	a. The insulation was cured per DPS 23003 and a reinspection showed that no swelling occurred. The tile installation was acceptable to Engineering for use.
	b. Several tile tension plug liner repair patches have excessive glass liner overlap from 1 to 2 3/4 in. and should be 3/4 $\pm$ 1/4 in. per DPS 23003.	b. Acceptable to Engineering for use.
A261518 12-4-67	Five strap assemblies, P/N 1B31140-1, one strap assembly, P/N 1B37414-1, one strap assembly, P/N 1B31139-1, four strap assemblies, P/N 1B31138-1, and one support, P/N 1B37889-521, showed evidence of acid contamination at bond line and between the strap assembly metal mating surfaces.	Two strap assemblies, P/N 1B31140-1, and one strap assembly, P/N 1B31138-1, were acceptable to Engineering for use without rework. The remaining parts were removed per DPS 32330 and reinstalled per blueprint instructions. The rework was acceptable for use, except for additional discrepancy and rework as noted on FARR A261521.

TABLE I, Section 1 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A261519 12-4-67	a. The bondline of support, P/N 1B27099-3, on the aft dome had indication of acid contamination.	a. Support, P/N 1B27099-3, was removed and reinstalled per DPS 32330.
	b. Several discolored areas on the aft dome appeared to be acid stains and acid appeared to be trapped between the thrust structure attach angle and the aft dome.	b. The discoloration and suspect areas were scrubbed with brush and cloth dampened with MEK (DPM 535) and the bare areas were reprimed. The rework was acceptable to Engineering for use.
A261546 10-12-67	a. Three studs, P/N S0717A428-7, failed to meet the 40 pound torque requirement and each sheared off at weld.	a. The weld material was removed and a smooth surface was obtained by spotfacing a 7/16 to 5/8 in. diameter area and not exceeding a depth of 0.030 in. where each stud was sheared off. New studs were installed per DPS 14170. The rework was acceptable to Engineering for use.
	b. Four studs, P/N S0717A428-4 and four studs, P/N S0717A428-7, are not identified per DPS 14170. Each should be identified by a small depression not to exceed 0.030 in. deep.	b. Acceptable to Engineering for use.
A261547 10-16-67	DPM 500-1 acetone was used for priming the bonding surface for 3D tile inside the LH2 tank and the 8 x 12 in. tensile test panels. DPM 500-2 acetate should have been used per DPS 23003.	Acceptable to Engineering for use.

TABLE I, Section 1 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A261548 10-19-67	The forward dome had several scratches and gouges as follows: a. Segment 1 had 5 scratches, 5/16 in. long and 0.010 in. deep, 1/8 in. long and 0.010 in. deep, 32 in. long and 0.003 in. deep, 4 in. long and 0.002 in. deep, and 10 in. long and 0.001 in. deep, also 4 gouges with a depth ranging from 0.001 in. to 0.010 in. b. Segment 2 had 2 scratches, 3/4 in. long and 0.003 in. deep and 1/2 in. long and 0.003 in. deep, also 3 gouges with a depth of 0.003 in. each. c. Segment 4 had a scratch 14 in. long and 0.001 in. deep. d. Segment 5 had a scratch 13 in. long and 0.001 in. deep. e. Segment 9 had 2 scratches 13 in. long and 0.001 in. deep, also 5 gouges with a depth ranging from 0.003 to 0.005 in.	a. The deep scratches and gouges were polished out with No. 400 aluminum oxide cloth without exceeding the original depth of defects. The shallow scratches were deburred with a plastic scraper. The rework was acceptable for use. b., c., and d. Acceptable to Engineering for use without rework. e. The superficial scratch was acceptable to Engineering for use without rework. The gouges were deburred with a plastic scraper. The rework was acceptable for use.
A261549 10-24-67	Vacuum readings were not recorded for a period of 1 1/2 hours during bonding cure of glass lining on segment 5 and tile and glass lining insulation on segments 2 and 4 at the forward dome. Readings should be recorded every 30 to 45 minutes per DPS 23003.	Acceptable to Engineering for use.

TABLE I, Section 1 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A271130 9-26-67	The forward dome to ring and cylinder outside weld showed a weld stop and start, leaving an underfill in the outboard edge 1 1/2 in. long and 0.213 in. deep, also underfill areas 0.090 to 0.158 in. deep exists intermittently throughout outboard circumference of second pass of weld.	The weld was chipped out and blended 2 1/2 in. on each side of stop and restart points. An X-ray of the entire weld was acceptable except for the underfill areas. A third weld pass was made to fill in blended and underfill areas. The rework was acceptable to Engineering for use.
A271157 9-20-67	Mismatch of punch mark on tank cylinder to scribe line on tool AJ1 is 3/32 in. Maximum allowable mismatch is 0.010 in.	Acceptable to Engineering for use.
A271162 9-25-67	Segment 5 in the forward dome has five canned areas, varying in depth from 0.060 to 0.125 in.	Acceptable to Engineering for use.
500-070-471 10-11-67	A dye check of the forward dome fittings and flange welds after hydrostatic check showed three 1/32 in. cracks and a 1/8 in. crack in the vent line port weld in segment 2, and a 1/4 in. star crack in the pressure sensor weld at segment 4.	The defects were ground out and blended not exceeding a maximum depth of 0.060 in. The rework was acceptable to Engineering for use.
500-074-191 12-13-67	The outer insulation at wire harness run 408W208 is cut too short and does not cover conductors inside the temperature sensor, P/N 1A67862-513, S/N 562. Refer to 1B42499P, view B-B.	Acceptable to Engineering for use.
500-074-221 12-26-67	Wire, C1 HIGH, in wire harness, P/N 1B58247-1, had a 7/8 in. damaged area in the outer jacket, located 1 in. from last clamping point. Refer to 1B42499-1, view B-B.	The damaged wire was reworked per DPS 54010. The rework was acceptable for use.

TABLE I, Section 1 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-133-333 12-13-67	The 3D tile is bulged and fractured under the glass liner in an area 2 in. wide, 6 in. long, and 3/16 in. high on the aft segment 9 inside the propellant tank assembly.	Acceptable to Engineering for use without rework.
500-133-368 12-29-67	The dew point requirements of DPS 43110 were not complied with during closure of the LH2 tank. The dew point was +48 degrees and should have been +32 degrees. The temperature closure was removed and an internal inspection of the LH2 tank showed water mark spots on most of the stainless steel that left a barely visible line when wiped off, and the four corner welds of the anti-vortex screen show a red discoloration.	Acceptable to Engineering for use without rework.
500-133-392 1-9-68	A visual inspection of the interior of the LH2 tank showed 160 raised areas throughout the tile insulation ranging from 1/32 to 1/16 in. high.	Acceptable to Engineering for use without rework.
500-133-406 1-10-68	Tensil test coupons were not produced per DPS 23003 for tile and glass installed in the LH2 tank per FARR 500-135-891.	Acceptable to Engineering for use.

TABLE I, Section 1 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-133-414 1-11-68	A visual inspection of the tile and liner insulation inside the LH2 tank revealed the following defects: a. Alodine stains and discoloration on glass liner at cylinder segments 2 and 3, forward dome segment 3, and aft dome segments 2 and 3. b. Excessive rubcoat on glass liner at cylinder segment 2 and aft dome segments 3 and 4. c. Tape, P/N 1B56518-5, has numerous voids and periphery has numerous debonds.	a. All stains were wiped down with demineralized water until discoloration on white wiper cloth was no longer perceptable. Remaining discoloration was acceptable to Engineering for use. b. and c. Acceptable to Engineering for use without rework.
500-133-422 1-17-68	a. The glass liner at cylinder segment 7 had a void exceeding 1/2 in. diameter. b. The glass liner at cylinder segment 6 had a 1 1/4 by 1 in. worn spot with threads protruding through liner.	a. and b. The void was reworked and a seal coat was applied to the worn area per DPS 23003. The reworked areas were cured per Engineering instructions. The rework was acceptable for use.
500-133-457 1-23-68	The hydro-honed surface of all (9) helium storage bottles installed inside the LH2 tank have scattered darkened stained areas that remain after detergent cleaning and hand cleaning with DPM 2482-1. Maximum size of stained areas is 1 1/4 in.	Acceptable to Engineering for use without rework.
500-133-465 1-23-68	Segment 3 on the forward face of the common bulkhead had a scratch on the anodized surface 1/2 in. long and 0.0005 deep.	The scratch was blended and smoothed to a 10 to 1 ratio. The reworked area was touched up with alodine per DPS 41410. The rework was acceptable for use.

TABLE I, Section 1 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-133-481 1-25-68	a. Stud, P/N 1B55899-1, is installed inside LH2 tank at segment 2 and should be stud, P/N 1B55898-1. b. Support, P/N 1A39644-1, inside LH2 tank at aft circumferential ring is broken off.	a. The nonconforming stud was acceptable to Engineering for use, however, the alignment fitting installation was reworked for compatibility to the stud by substituting fitting, P/N 1B58022-509, in place of fitting, P/N 1B58022-505, and adding spacers and bushings for proper fit. The rework was acceptable for use. b. The remaining portion of the support was removed and a new support was installed per Engineering instructions. The rework was acceptable for use.
500-133-490 1-29-68	a. Glass liner doublers have insufficient trim at base of baffle studs at 35 places causing liner to overlap base plate of the studs. b. Glass liner doubler has excessive trim at base of baffle stud, P/N 1B55693-1, exposing a 1/16 by 3/16 in. area of tile at cylinder segment 2.	a. Acceptable to Engineering for use without rework. b. A glass liner patch was applied to cover the exposed tile per DPS 23003 and cured at ambient temperature. The rework was acceptable for use.
500-133-503 1-30-68	A visual inspection of the interior of the LH2 tank showed 78 raised areas throughout the tile insulation averaging 1/32 in. high. These defects are in addition to those noted on FARR 500-133-392.	Acceptable to Engineering for use without rework.

TABLE I, Section 1 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-135-867 12-4-67	The rub coat inside the LH2 tank had a tacky quality after being cured per DPS 23003.	The rub coat was wiped down with a clean cloth saturated with demineralized water, which caused the liner to be less tacky than the origial condition. This condition was acceptable to Engineering without further rework.
500-135-891 12-28-67	a. Insulation liner, P/N 1A89613-3, was burned over a 15 by 15 in. area at cylinder segment 2 during elevated cure with use of heat blanket. b. The extent of damage to the tile, P/N 1A82300-501, below the burned liner could not be determined due to inaccessibility. c. Unauthorized manufacturing technique in controlling heat for cure of replacement tile in out-of-position repair. Ref. Air Force tag 50B.	a. and b. The damaged insulation liner and foam tile were removed, replaced, and cured per Engineering instructions. c. Tooling will design a new tool and provide adequate instructions for an improved method of curing out-of-position tile repair.
500-197-765 1-31-68	a. Fourteen Z threads on tile were exposed through glass liner at cylinder segment 3. b. Glass liner was delaminated in a 1 1/2 by 4 in. area at cylinder segment 6. c. Glass liner was delaminated in a 1 by 1 in. area at cylinder segment 7. d. A 0.375 in. tear in glass liner existed at forward dome segment 5. e. Glass liner has a 3/32 by 1/16 in. gap at bottle strap fittings 1 and 4 at segment 2.	a. Resin was injected under liner and around threads per DPS 23003 and cured at ambient temperature. b. and c. Resin was injected under liner per DPS 23003 and cured at ambient temperature. d. and e. Gap filler was worked into and under cracked liner flush to liner surface and cured at ambient temperature. The rework (items a. through e.) were acceptable for use.

TABLE I, Section 1 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-197-790 2-5-68	Duct assembly, P/N 1A69044-1, S/N 042, in the LOX oxidizer vent system has five dings in the bellows area with a maximum depth of 0.250 in.	Acceptable to Engineering for use without rework.
500-197-811 2-12-68	a. A mild corrosion existed in the weld areas of two support assemblies, P/N 1A89564-1. Located on the LOX vent duct assembly.	a. The oxidation was removed by applying a 10 percent phosphoric acid solution and wiping dry.
	b. Bracket assembly, P/N 1B32899-1, had a yellow discoloration adjacent to the propulsion utilization probe assembly inside the LOX tank.	b. Acceptable to Engineering for use without rework.
	c. Black and white substances of unknown origin were found emitting from the LOX vent purge system.	c. The contaminated area was detergent washed and then wiped down with instrument clothes saturated with demineralized water. The cleaned area was acceptable for use.

TABLE I (Continued) Section 2. Forward Dome, P/N 1B64442-503

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A253788 6-10-67	X-ray 67-B58 of pre-production forward dome fitting installation weld shows less dense inclusion.	Acceptable to Engineering for use.
A253793 6-12-67	a. X-ray 67-B58 of the C-C fitting to segment 2 inside weld showed a void and scattered porosity in the set up line.	a. Acceptable to Engineering for use without rework.
	b. A dye check of the C-C fitting to segment 2 inside weld showed a weld overlap.	b. The weld overlap was ground, scraped, and blended to an acceptable condition.
A266601 6-14-67	J-J clip to segment 2 weld was stopped when weld was 50 percent complete causing a crater with cracks at termination.	After an unsuccessful effort to grind out defects, the J-J clip was removed and scrapped, and a new J-J clip was installed.
A266604 6-15-67	A voltage recording was not made on weld chart during welding of the D-D fitting to segment 4 outside weld. Voltage should be recorded per DPS 14052.	Acceptable to Engineering for use.
A266610 6-19-67	The outside surface of the forward dome had several scratches near center of segment 7 with a maximum depth of 0.001 in.	The sharp edges of the scratches were broken and the reworked area was touched up with primer per Spec. F289. The rework was acceptable for use.
A266679 7-18-67	a. The outside surface of the forward dome had caustic etch splatter at weld seams 1, 2, 3, 5, 6, 7, 8, and 9.	a. The splattered areas where anodic had been removed were primed per Spec. F-289.
	b. Several scratches in outside anodized surface of segment 2 with a maximum depth of 0.001 in. also a scratch in outside surface of segment 6 with a maximum depth of 0.002 in.	b. The sharp edges of the scratches were broken and the reworked area was touched up with primer per Spec. F-289. The rework was acceptable for use.
	c. The inside surface of segment 1 has a scratch in the anodic finish.	c. Acceptable to Engineering for use without rework.

TABLE I, Section 2 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A266695 7-25-67	Fuel sensor support brackets, P/N 1B37283-501 and 1B37283-502, are installed on segments 6 and 7 with a total of 4 huckbolts and NAS 1080M collars. NAS 1080 collars should have been used per 1A59866.	Acceptable to Engineering for use.
A266704 7-26-67	An ovality check of the forward dome showed that the difference between the maximum and minimum diameters is 0.044 in. and should be a maximum of 0.022 in.	Acceptable to Engineering for use.

TABLE I (Continued) Section 3. Cylindrical Tank Assembly, P/N 1A39306-511

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A253638 4-21-67	X-ray 67-B34 showed a porosity cluster in clevis weld 9 and scattered porosity in clevis welds 2, 3, and 8. Located on cylinder segment 3.	Acceptable to Engineering for use without rework.
A253640 4-24-67	Two clevis fillet welds at pad 2 on segment 2 measure 9/64 in. and 5/32 in. respectively and should be a minimum of 3/16 in.	Acceptable to Engineering for use.
A253670 5-2-67	X-ray 67-B47 of the pre-production helium bottle support fitting weld shows less dense inclusion.	Acceptable to Engineering for use.
A253734 5-24-67	a. Parent clevis metal is undercut at fillet welds two places on pad 3 and one place each on pads 2, 4, and 5. b. Clevis fillet weld has a lack of fusion at one place on pad 2.	a. and b. Acceptable to Engineering for use without rework.
A261484 7-26-67	Lower stud broke off during 40 pound torque test per DPS 14170. Located at upper center stud pad between cylinder seams 5 and 6. Refer to 1A39306, view F.	The stud was removed and the pad was spotfaced to a maximum depth of 0.030 in. and a new stud was installed per DPS 14170. This stud also failed 40 pound torque test. See FARR A261486 for further disposition.
A261486 7-26-67	The new stud installed per FARR A261484 broke off during the 40 pound torque test.	The stud was removed and the pad was spotfaced to a maximum depth of 0.060 in. and a new stud was installed per DPS 14170. The rework was acceptable for use.

TABLE I, Section 3 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A271080 8-22-67	The inside surface of the cylindrical tank had numerous pasajel and etch splatter spots that caused small defects to the anodic coating 37 placed on segment 1, 24 places on segment 2, 39 places on segment 3, 17 places on segment 4, 33 places on segment 5, 32 places on segment 6, and 17 places on segment 7.	All residue was removed by lightly polishing each spot with alundum or carborundum paper and a 10 percent solution of chromic acid was applied to the reworked areas. The rework was acceptable for use.

TABLE I (Continued) Section 4. Liquid Oxygen Tank Assembly, P/N 1A39307-527

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-036-087 8-21-67	The aft dome flange was out of tolerance at gap "M" at location "C" with dome installed in the LOX welder and the common bulkhead located in dome prior to drilling. Gap "M" measured 0.180 in. and should be 0.023 to 0.148 in.	Acceptable to Engineering for use.
500-036-124 8-25-67	The thrust structure attach angles had a mismatch of 0.013 in. at gap 19 and a mismatch of 0.024 in. at gap 22. The mismatch should not exceed 0.010 in.	The defects were reworked per SEO 1A39307-011. The rework was acceptable for use.
500-036-354 8-29-67	a. The inner anodized surface of the LOX tank had a gouge with a depth of 0.020 in., located 2 1/4 in. aft of the common bulkhead and 40 in. from aft dome seam 1 toward seam 9.	a. The gouge was smoothed and blended without increasing depth of the defect and the reworked area was touched up with alodine per DPS 41410. The rework was acceptable for use.
	b. The outside bare areas of all segments adjacent to forward edge were scuffed and scratched at center area of each segment. The maximum depth of scratches were 0.001 in.	b. All sharp edges of the scratches were broken. The rework was acceptable for use.

TABLE I (Continued) Section 5. Common Bulkhead Assembly, P/N 1A39309-501

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A249160 3-30-67	X-ray 67-B22 of hoist fitting No. 1 weld on the forward face of the common bulkhead showed an elongated void.	Acceptable to Engineering without rework.
A249180 4-11-67	X-ray 67-B26 of the aft common ring assembly weld showed a crack.	The crack was ground out removing a minimum of metal. A subsequent x-ray and dye check revealed no defects remained. The rework was acceptable to Engineering for use.
A249191 4-14-67	The forward face skin of the common bulkhead had three canned areas as follows: a. A 6 by 6 by 0.135 in. can at forward end of segment 9 adjacent to intersection of seam 9 and center plate weld pads. b. A 4 by 4 by 0.050 in. can at forward end of segment 6 adjacent to intersection of seam 5 and center plate weld pads. c. A 10 by 16 by 0.250 in. can in segments 8 and 9 across meridian seam 8.	a., b., and c. Acceptable to Engineering for use without rework.

TABLE I, Section 5 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A249195 4-17-67	Contour deviations were noted on the forward common face as follows: a. A 1/2 by 3 1/2 by 0.025 in. ridge on segment 4 located 11 in. forward of aft trim line. b. A 5/8 by 17 1/2 by 0.025 in. ridge on segment 4 located 37 1/2 in. forward of aft trim line. c. A 1/2 by 9 1/2 by 0.030 in. ridge on segment 9 located 56 in. forward of aft trim line. d. A 1/2 by 5 by 0.025 in. ridge on segment 9 located 53 3/4 in. forward of aft trim line. e. A 1/2 by 30 by 0.015 in. ridge on segment 9 located 87 in. forward of aft trim line.	a., b., c., d., and e. Acceptable to Engineering for use without rework.
A253632 4-21-67	Numerous scratches and depression marks were noted on the outside meridian seams 2, 5, 6, 7, and 8 of the forward common face. The maximum depth of the scratches was 0.001 in. and the maximum depth of the depressions was 0.005 in.	All sharp edges on the scratches were broken and the depression marks were removed by lightly scraping. After dye check the rework was acceptable to Engineering for use.

TABLE I, Section 5 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A253677 5-4-67	The aft common face segment, P/N 1A39286-13, S/N 0322, had the following defects: a. A group of pits with a maximum depth of 0.003 in. were noted on inner side of segment near seam 6. b. A scratch with a maximum depth of 0.002 in. was noted on inner surface of segment near seam 6.	a. All pits were removed by light scraping. The rework was acceptable for use. b. All sharp edges were broken. The rework was acceptable for use.
A253739 5-25-67	X-ray 67-B48 and dye check of the aft face ring weld showed mechanical damage with a maximum depth of 0.008 in. between seams 6 and 7, and number 3 porosity between seams 1 and 2.	The mechanical damage was smoothed and blended and the number 3 porosity was ground out. After another dye check the rework was acceptable to Engineering for use.
A253771 6-5-67	The forward common face center plate has a can with a maximum contour deviation of 0.200 in.	Acceptable to Engineering for use without rework.

TABLE I, Section 5 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A253777 6-7-67	The aft face centerplate installation, P/N 1A39286-501, had the following defects:	
	a. The centerplate outer surface had a blended depression in a 1/8 by 3/16 in. area with a maximum depth of 0.006 in. adjacent to centerplate weld.	a. Acceptable to Engineering for use without rework.
	b. The centerplate outer surface had several gouges with a maximum depth of 0.003 in. at meridian seam 7 and 8 adjacent to centerplate weld.	b. The gouges were smoothed and blended without increasing depth of defect. A dye check showed no indication of defect. The rework was acceptable to Engineering for use.
	c. The centerplate inner surface had several nicks and rough spots with a maximum depth of 0.001 in. located 1/2 in. from centerplate weld between seams 3 and 4.	c. All sharp edges were broken and the defects were smoothed and blended. The reworked area was touched up with alodine per DPS 41410. The rework was acceptable for use.

TABLE I, Section 5 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A256867 6-27-67	The following deviations occurred during the common bulkhead core cure operations: a. The vacuum on the core and the tool was lost and vented to atmosphere five minutes after the cure was completed at 330 $\pm$2 degrees and cool down initiated. b. The temperature spread at 9:10 PM was 19 degrees and should not be more than 5 degrees. The temperature spread was unknown during the power failure. c. Vacuum was restored to the core but should have remained vented to atmosphere per DPS 31150-1, para. 6.3.6.20, Note 1. d. Autoclave pressure dropped to 39.5 psi and should have been 45 $\pm$5 psi. e. At 12:48 AM when the temperature reached 180 degrees, the power failed and vacuum was lost until 3:00 AM.	a., b., c., d., and e. Acceptable to Engineering for use without rework.
A266670 7-17-67	a. The common bulkhead forward face had a ding with a 5/16 in. diameter and 0.012 in. deep located 18 1/2 in. forward of ring weld in segment 2. b. The unmachined inside surface of the base leg on aft ring had intermittent gouges, nicks, pits, and scratches with a maximum depth of 0.010 in.	a. Acceptable to Engineering for use without rework. b. The pits were removed by scraping and sharp edges were broken on gouges, nicks, and scratches. The defects were smoothed and blended. The rework was acceptable for use.

TABLE I, Section 5 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A266677 7-18-67	The common bulkhead forward face has intermittent scratches on the anodized outside surface of segment 4 with a maximum depth of 0.001 in.	All sharp edges were polished per DPS 40160. The rework was acceptable for use.

TABLE I (Continued) Section 6. Aft Dome Assembly, P/N 1B63286-507

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A249057 3-9-67	X-ray 67-B20 of the F-F fitting inside fillet weld shows less dense inclusion.	Acceptable to Engineering for use without rework.
A266643 7-7-67	The following defects were noted at the aft dome flange weld: a. A low out of contour condition existed in segment 2 just forward of the flange weld in a 6 by 10 in. area with a maximum depth of 0.300 in. b. The flange weld had a lack of penetration 7 in. from seam 1 toward seam 2 and also 7 in. from seam 5 toward seam 6.	a. and b. After several rework attempts, the aft dome flange, P/N 1B63286-004-1, was removed and scrapped. A new flange was installed.
A266644 7-7-67	An indentation with a diameter of 3/64 in. and a depth of 0.020 in. was punched in wall of fitting at edge of fitting to segment 3 inside weld.	The indentation was smoothed, blended, and faired in with the edge of the fillet weld and tube, making an elliptical blended area favoring the tube side. The rework was acceptable to Engineering for use.
A266648 7-10-67	The aft dome segment 3, P/N 1B63286-423, S/N 055, had 2 cans adjacent to the A-A fitting. One can covered a 8 by 10 in. area and had a minimum contour deviation of 0.250 in. and the other can covered a 8 by 9 in. area and had a contour deviation of 0.180 in.	Aft dome segment 3, S/N 055, was removed and scrapped, and a new segment 3 was installed.
A266649 7-10-67	Aft dome segment 7, P/N 1B63286-427, S/N 08, had a punch mark with a 3/64 in. diameter and a 0.017 in. depth located on outside surface 1 1/2 in. aft of H-H fitting.	The punch mark was smoothed, blended, dye checked, and primed. The rework was acceptable to Engineering for use.

TABLE I, Section 6 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A266689 7-21-67	Aft dome segment 1, P/N 1B63286-481, S/N 01, had small spots of discoloration and minute pits scattered in intermittent areas on inside and outside anodized and etched surfaces.	The discoloration was removed per DPS 40160. The reworked areas were touched up per Spec. F-289. The pits were acceptable to Engineering for use.
A266713 7-28-67	Aft dome segment 1, P/N 1B63286-481, S/N 01, had small spots of black discoloration on the outside anodized surface.	The discolored areas were touched up with primer per DACO Specification F-289.
A266783 8-14-67	X-ray 67-B63 of the AC-AC elbow weld showed dense foreign material.	Acceptable to Engineering for use without rework.
A266784 8-14-67	X-ray 67-B63 of the U-U elbow weld showed a void with tail.	Acceptable to Engineering for use without rework.
A266785 8-14-67	X-ray 67-B63 of the E-E elbow weld showed inclusions.	Acceptable to Engineering for use without rework.
A266786 8-14-67	A dye check inspection of the AF-AF elbow showed cracks in weld.	The cracks were ground out and blended. A dye check showed that defects were removed. The rework was acceptable to Engineering for use.
A266790 8-16-67	Aft dome flange, P/N 1B63286-477, has a flatness deviation of 0.038 in. and should be a maximum of 0.025 per 1B63286, view AD-AD.	Acceptable to Engineering for use without rework.
A266792 8-16-67	The U-U LOX helium heater elbow to tube weld has a rough depression with a maximum depth of 0.040 in.	The depression was smoothed and blended without increasing depth of the defect. The rework was acceptable to Engineering for use.
A266796 8-17-67	The aft dome flange, P/N 1B63286-477, has an ovality of 0.056 in. and should be a maximum of 0.022 in. per 1B63286.	Acceptable to Engineering for use without rework.

TABLE I, Section 6 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A266797 8-17-67	Level sensor stud has damaged threads caused by welding operation. Stud is located on aft dome segment 6 adjacent to flange weld and 4 1/2 in. from seam 5.	Acceptable to Engineering for use without rework.
A266800 8-18-67	X-ray 67-B63 of the V-V flange to segment 4 weld shows more dense inclusions.	Acceptable to Engineering for use without rework.
500-036-010 8-18-67	X-ray 67-B63 of the AC-AC fitting to segment 1 weld shows more dense inclusions and cluster porosity.	Acceptable to Engineering for use without rework.

TABLE I, Section 6 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-036-044 8-18-67	A planes and radii check of the aft dome showed the following out of tolerance conditions: a. The 50 degree latitude and 180 degree longitude reading was +0.187 in. and should be -0.121 to +0.179 in. b. The 50 degree latitude and 220 degree longitude reading was +0.186 in. and should be -0.121 to +0.179 in. c. The 50 degree latitude average of 18 readings was +0.086 in. and should be +0.060 in. d. The "B" maximum to "B" minimum dimension at the AC-AC elbow is 0.075 in. and should be a 0.051 in. maximum. e. The "C" dimension at the A-A fitting is 0.150 in. and should be 0.129 in. maximum. f. The "D" dimension at the H-H sensor fitting is +0.150 in. and should be $\pm$0.072 in. maximum. g. The "D" dimension at the F-F fitting is -0.060 in. and should be 0.040 maximum. h. The "B" maximum to "B" minimum dimension at the U-U fitting is 0.100 in. and should be 0.051 in. maximum.	a., b., c., d., e., f., g., and h. Acceptable to Engineering for use without rework.

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-135-034 12-5-67	a. The circumference of angle segments, P/N 1A58608-1, had several dents and dings with a maximum depth of 1/16 in. Located by stringers 44, 55 to 56, and 67 to 68 at aft end of skirt. b. The upper surface of angle segments, P/N 1A58608-1, was damaged at two places to a depth of 0.022 in. when drilling drain holes. Located at stringers 73 to 74 and 76 to 77 at aft end of skirt. c. Aft attach holes in angle segment, P/N 1A58608-1, were excessively deburred causing eccentric countersinking effect to a width of 0.100 in. in a 32 hole area from stringer 85 to 101 at aft end of skirt.	a. and b. The defects were smoothed and blended not exceeding depth of original defects. The reworked areas were touched up with alodine per DPS 15101 and primed per finish Spec. F-289. The rework was acceptable for use. c. The angle segment, P/N 1A58608-1 was reworked per Salvage EO 1A39301-004. The rework was acceptable for use.
500-137-363 1-3-68	Two 0.190/0.195 in. holes were drilled too close to radius in bracket, P/N 1B54215-2, and unable to seat the AN960D10L washers.	The AN960D10L washers were replaced with AN960D10 washers which were reworked to match the radius of the bracket, P/N 1B54215-2. The rework was acceptable for use.
500-137-410 1-15-68	Clamp assembly, P/N TA501D1-750T, is located at a bend radius of pipe assembly, P/N 1B38423-505. Refer to 1B38426, zone 18, view DD.	The clamp assembly, P/N TA501D1-750T, and spacer, P/N 1A97550-1, were removed from stringer 13 and installed at stringer 12 in a position to properly secure the noted pipe assembly. An NAS1715D12F clamp was installed at stringer 13 where the clamp assembly was removed, and was used to secure the noted pipe assembly in that area. The rework was acceptable for use.

TABLE I, Section 7 (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-137-444 1-15-68	a. The outer insulation was nicked at 5 places on coaxial cable 425MT601, P/N 1B40242-583, S/N 583-22. Located at panel 15 near point where connector P2 connects to amplifier.	a. and b. The damaged insulation was wrapped with teflon tape per DPS 54010, paragraph 6.2.5. The rework was acceptable for use.
	b. The outer insulation was nicked 3 places on coaxial cable 409MT650, P/N 1B40242-97, S/N 595-1. Located at panel 15 near point where connector P2 connects to amplifier.	
500-137-461 1-26-68	Wire harness 411W17, P/N 1B66060-1, was preloaded at aft side of connector P1. This condition forced conductors to spread the cavity holes in the rubber grommet at connector P1. The wire harness exceeds the bend radius tolerance at aft side of connector P1.	The wire harness was reworked by moving the wire harness branch breakout point leading to connectors P1, P2, P8, and P17 two inches to the left. This rework caused excessive length to 20 gauge wires that terminated at connectors P3 and P4. The 20 gauge wires were cut to proper length and reterminated at connectors P3 and P4. After a megger and continuity check, the rework was acceptable for use.

TABLE I (Continued) Section 8. Aft Skirt Assembly, P/N 1A39295-513

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-073-233 10-24-67	Sixteen 5/32 in. holes through stringer, P/N 1A39295-281, and panel skin were drilled in a "stay out" area and interferred with the installation of twelve blind bolts, P/N BN330-1032, which have to be installed in this area.	The defective stringer was removed and replaced with a new stringer. The sixteen misdrilled 5/32 in. holes in the panel skin were filled with double flushed MS20426AD5 rivets. The rework was acceptable to Engineering for use.
500-137-231 1-10-68	Two MS20470-AD5 rivets are missing in aft skirt frame at station 240.937. One in frame cap, P/N 1A87649-21, at stringer 10 and the other in frame cap, P/N 1A87649-43, 1/8 in. to the left of stringer 82.	Acceptable to Engineering for use.

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-073-667 11-7-67	Skin, P/N 1A68349-501, has a 1 by 3/4 in. triangle shaped hole and a circular shaped ding approximately 1 in. long located 30 in. aft of the forward attach flange between stringers 13 and 13 1/4.	The triangle shaped hole was enlarged to 1 1/2 in. diameter and the ding was cutout by drilling a 1 in. diameter hole. 1 1/2 and 1 in. fillers were fabricated from 0.32 in. 7075T6 material and a 5 3/4 by 4 1/4 in. doubler was fabricated from 0.040 in. 7075T6 material and installed to the inboard surface of the skin securing the fillers in the skin cutouts. The reworked area was sealed per DPS 25081, alodined per DPS 41410, and primed per DPS 42000.
500-137-304 12-27-67	Standoff, P/N 1A88924-41, on panel, P/N 1A88924, was rotated 180 degrees causing interference with piping installation.	The high post of the standoff was cut off to a height of 1 1/2 in. and a KNL 1032 internal thread locking Keensert was installed in top of standoff per DPS 13154. The rework was acceptable for use.

TABLE II. PERMANENT NONCONFORMANCES AND FUNCTIONAL FAILURE AND REJECTION REPORTS DURING STAGE SYSTEM CHECKOUTS

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
A261184 5-24-68	Supports (6 each), P/N 1B57158-9, and supports (6 each), P/N 1B57158-10, are installed at weld seam 3 on the forward dome and should have been supports (6 each), P/N 1B57158-3, and supports (6 each), P/N 1B57158-4.	Acceptable to Engineering for use without rework.
A261186 5-28-68	During the curing process of (2 each) fittings, P/N 1B69904-1, located on the aft dome exterior, the temperature went to 175°F. The temperature should not exceed 170°F per DPS 32330.	Acceptable to Engineering for use without rework.
A261190 6-4-68	The thrust structure angle, P/N 1A39312, is located 5.875 in. from the upper surface of the vent line at stringer 22. Refer to 1B69013.	Acceptable to Engineering for use without rework.
500-238-178 5-16-68	The P2 connector of the transducer kit, P/N 1B40242-597, S/N 597-1, had the connector shell bent out-of-round, and the backshell was loose.	Connector P2 was removed and replaced. The rework was acceptable.
500-238-267 4-25-68	a. Connector P9 on wire harness 404W203, P/N 1B67089-1, had a punctured grommet adjacent to pin M.	a. Connector P9 was removed and a new connector was installed. The rework was acceptable for use.
	b. Pin M in connector J9 on the remote digital multiplexer, P/N 1B66051-501, S/N 07, was bent approximately 30 degrees. These defects (a and b) were noted during continuity/compatibility check, H&CO 1B59780.	b. Pin M was straightened per DPS 540002. The rework was acceptable for use.

TABLE II. (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-238-275 4-26-68	a. Connector P89 on wire harness 404W208, P/N 1B67209-1, had a punctured grommet adjacent to pin AA.	a. Connector P89 was removed and a new connector was installed. The rework was acceptable for use.
	b. Pin AA in connector J2 on module, P/N 1A96707-501, S/N 0606, was bent approximately 30 degrees. These defects (a and b) were noted during continuity/compatibility check, H&CO 1B59780.	b. Pin AA was straightened per DPS 540002. The rework was acceptable for use.
500-238-283 6-7-68	The 5 volt excitation module 411A98A2, P/N 1A77310-503.1, S/N 0143, had no 5 volt or -20 volt outputs during the signal conditioning setup, H&CO 1B64681.	The discrepant part was removed and replaced with S/N 180. The rework was acceptable.
500-238-291 6-10-68	The LOX fast fill sensor module, P/N 1A68710-511, S/N C31, failed to function and would not adjust. Output was zero vdc and should have been 28 ± 2 vdc. Defect was noted during level sensor and control unit calibration, H&CO 1B64680.	The defective LOX fast fill sensor module, S/N C31, was removed and returned to vendor for rework or replacement. A new unit, S/N C91, was installed.
500-238-305 6-10-68	The LOX liquid level sensor module, P/N 1A68710-511, S/N C34, located at 404A63A206, failed de-energized reading during test. The 1.165 pf reading should have been 1.5 ± 0.15 pf. The defect was noted during the level sensor and control unit calibration test, H&CO 1B64680.	The defective module, S/N C34, was removed and returned to vendor for rework or replacement and a new unit, S/N C86, was installed.

TABLE II. (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-238-313 6-11-68	Two (each) liquid level sensor modules, P/N 1A68710-509, S/N C63, located at 411A61A219 and S/N C67, located at 411A61A221 had no response and would not adjust for any reading. Defect occurred during the level sensors and control unit calibration, H&CO 1B64680.	The two defective liquid level sensor modules, S/N's C63 and C67, were removed and returned to vendor for rework or replacement. New units, S/N's C97 and C101, were installed.
500-238-321 6-13-68	The channel decoder, P/N 1A74053-503, S/N 365, did not have the proper RACS output. Defect occurred during the digital data acquisition test, H&CO 1B66564-1.	The defective channel coder, S/N 365, was removed and returned to vendor for rework or replacement. A new unit, S/N 171, was installed.
500-238-330 6-14-68	The yaw hydraulic actuator, P/N 1A66248-507, S/N 82, had an excessive leak at the overboard relief valve port. The defect occurred during the fill, flush, bleed, and fluid samples hydraulic system test, H&CO 1B40973.	The defective actuator, S/N 82, was removed and a new unit, S/N 85 was installed.
500-238-348 6-14-68	Potentiometer R6 in the power detector, P/N 1A74776-503, S/N 0142, would not adjust. Defect occurred during the telemetry and range safety antenna system checks, H&CO 1B64679.	The defective power detector, S/N 0142, was removed and returned to vendor for rework or replacement. A new unit, S/N 0319, was installed.
500-238-364 6-20-68	The bolt securing line, P/N 1B67829-1, to the O2H2 burner was broken off.	The broken bolt was removed from the blind nut and a new bolt was properly lubed and installed. The rework was acceptable for use.
500-238-372 6-20-68	The engine coil resistance on the APS engine No. 1, P/N 1A39597-509, S/N 817, was 22 to 23 ohms and should have been 25.7 ohms minimum.	The APS engine No. 1 was retested per A659-1B59663-PATP2-T9 and was acceptable to Engineering for use.

TABLE II (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-238-381 6-21-68	Two helium heater ignition system exciters, P/N 1B59986-503, S/N's 48 and 60, had center electrodes that were bent approximately 30 degrees.	The two exciters, S/N's 48 and 60, were removed and returned to vendor for rework or replacement. New units, S/N's 58 and 59, were installed.
500-238-399 6-24-68	The transducer kit assembly, P/N 1B40242-583, S/N 583-22, failed the DDA auto test. The ambient measurement read the low RACS value. Ambient output was 732.234 psia and should have been 14.700 ± 70.000 psia. Troubleshooting revealed that the amplifier would not accept low RACS reset command after low RACS set command had been set.	The discrepant assembly, S/N 583-22, was removed and replaced with S/N 583-44. The rework was acceptable.
500-238-402 6-26-68	Transducer, P/N 1B39293-519, S/N 169, located at 404A74, had low output readings for ambient, low RACS, and high RACS. Defect was noted during DDA system test, H&CO 1B66564.	The defective transducer, S/N 169, was removed and returned to vendor for rework or replacement. A new unit, S/N 299, was installed.
500-238-411 6-26-68	a. Pin u was bent approximately 30 degrees in connector J1 at bus module, P/N 1B57771-559.	a. The bent pin was straightened per DPS 54002.
	b. The grommet in connector P21 was punctured between pins DD and EE at wire harness, P/N 1B66969. Defects were noted during PU subsystem calibration, H&CO 1B64367.	b. The defective connector P21 was removed and a new connector was installed. The rework was acceptable for use.
500-238-429 6-26-68	Weld tube assembly, P/N 1B62801-1, failed leak test. Leak was caused by scratches in tapered face of threaded cross fitting. Defect was noted during cold helium system leak check, H&CO 1B59458.	The defective weld tube assembly was removed and a new unit was installed. The rework was acceptable for use.

TABLE II (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-238-437 6-27-68	Two wires were missing in wire harness, P/N 1B66969. The defect was noted during the operation of the PU calibration H&CO, 1B64367.	The wire harness was worked per 1B66969, EO "G", which added the missing wiring. The rework was acceptable for use.
500-238-453 7-1-68	During curing cycle of the insulation to the helium pipe assembly, P/N 1B67608, the temperature varied from 171 to 182°F. The temperature range should have been 150 to 170°F per DPS 32330.	Acceptable to Engineering for use without rework.
500-238-461 7-2-68	Quick disconnect assembly, P/N 1A49958-517, S/N 85, had deep scratches on mating face where it connected to ground half disconnect, P/N 1A49958-531, which caused connection to leak. Defect was noted during J-2 engine system leak check, H&CO 1B59461.	The defective quick disconnect assembly, S/N 85, was removed and returned to vendor for rework or replacement. A new unit, S/N 40, was installed.
500-238-470 7-9-68	The LH2 tank moisture dew point reading taken at duct to engine location was +53°F and should not exceed +32°F per DPS 43110.	The LH2 tank was re-purged per DPS 61101 with dry air until dew point sample read +3 degrees fahrenheit.
500-238-488 7-22-68	The voltage signature waveform analysis showed that valve L3 on engine No. 2, P/N 1A39597-509, S/N 812, at the auxiliary propulsion system No. 1, P/N 1A83918-535, S/N 509-1, was not closing properly. Defect was noted during the auxiliary propulsion system test, H&CO 1B69571.	The noted discrepancy was acceptable to Engineering for use through completion of the VCL checkouts.
500-238-496 7-29-68	Closing time of the LOX fill and drain valve 404A7, P/N 1A48240-505-007, S/N 0131, was 2.293 seconds and should have been a maximum of 2 seconds. Defect was noted during the propulsion system test, H&CO 1B66572.	The defective valve was removed and replaced by S/N 125. The replacement part was acceptable.

TABLE II (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-238-500 8-14-68	The sealing surface of two seals, P/N VD261-0046-0004, S/N's 15695 and 15700, were damaged several places and would not hold pressure. The defects were noted during the propellant tank system leak check, H&CO 1B59459.	The defective seals were removed and returned to vendor for rework or replacement. New seals were installed.
500-353-015 8-16-68	During the propellant tanks leak check, a plate, P/N 1B69608-5, holding a nutplate, fell inside the thrust structure in a blind area when two pipe assemblies, P/N 1B69994-1 and P/N 1B69992-1, were removed to repair leaks in the nonpropulsive vent valve coupling seal.	The plate, P/N 1B69608-5, and the nutplate were left where they fell and a new plate and nutplate were installed 1 7/8 $\pm$ 1/8 inches forward of the previously installed hardware. The new hardware was installed acceptably per advance EO 1B69608G.
500-353-023 8-16-68	The voltage wave form analysis showed that the instrument unit command was out of tolerance for engine No. 2, P/N 1A39597-509, S/N 816, on the auxiliary propulsion system No. 2, P/N 1A83918-535, S/N 509-2. The voltage readings were 154.0 to 164.0 vdc caused by voltage spike and should have been 7 $\pm$ 3 vdc. This condition caused the dropout time on the eight engine valves to be out of tolerance. The dropout time was 0.3 msec to 0.9 msec and should have been 1 to 5 msec. Troubleshooting determined that the above malfunctions were caused by a defective attitude control relay module, P/N XU-50M35076, S/N 322, which was an interum use material. The malfunction occurred during the SV APS module check, H&CO 1B69571.	The attitude control relay module, S/N 322, is an interum use material and remained installed in the stage throughout the SSC checkouts. The relay module will be removed and replaced with a new unit prior to static firing at STC per existing assembly order paper. A new FARR detailing the nonconformance will be written when unit is removed from the stage.

TABLE II (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-353-040 8-22-68	The RF transmitter assembly, P/N 1B65788-1, S/N 15503, had an output of 29.71 watts and should have been 19 $\pm$7.25 watts. Defect occurred during the EMC all systems test, H&CO 1B66571.	The defective transmitter, S/N 15503, was removed and returned to vendor for rework or replacement. A new unit, S/N 15505, was installed.
500-353-066 9-3-68	Pressure transducer 414MT640, P/N 1B31377-1, S/N 1177, had an erratic reading when the fuel valve was in the open position. The defect was noted during the EMC all systems test, H&CO 1B66571.	The transducer was retested per A659-1B31377-1-PATP1. The erratic condition could not be induced; however, the transducer was sent to the vendor for additional testing. A replacement transducer, S/N 1182, was installed and was acceptable for use.
500-353-091 9-10-68	Pressure transducer, P/N 1B31356-505, S/N 15-4, functioned erratically. During troubleshooting the potentiometer resistance would not respond to pressure changes between pins A and B in a uniform manner. Defect was noted during the all systems test, H&CO 1B66571.	The discrepant transducer, S/N 15-4, was removed and replaced with S/N 25-2. The rework was acceptable.
500-353-104 9-13-68	Pressure transducer, P/N 1B43324-603, S/N 45-3, functioned abnormally. Output fluctuated and at one time dropped to zero vdc. Failure was not repeatable during troubleshooting. Defect was noted during the all systems test, H&CO 1B66571.	The discrepant transducer was routed to the vendor for failure analysis. A replacement transducer, S/N 45-8, was installed on the stage. The replacement transducer was acceptable.

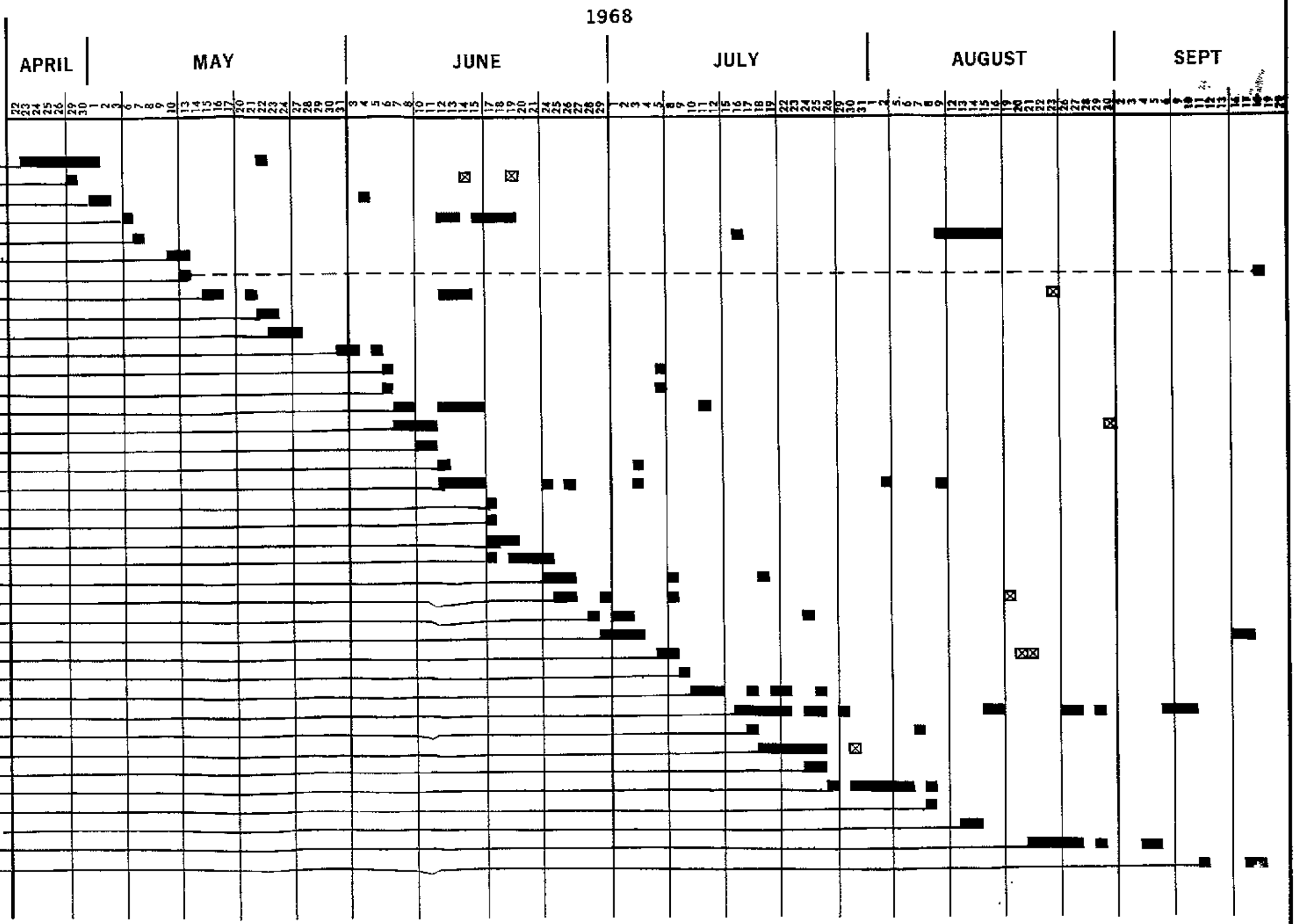
TABLE II (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-353-139 9-19-68	The following measurements exceed the noise level tolerance of SM47376. The allowable tolerance is 2 to 5 percent peak-to-peak for 1 second duration.	a. and b. Acceptable to Engineering. This is a test phenomenon which does not occur when the stage is stacked for flight.
	a. The PCM/FM transmitter output power, measurement N18, shifted up by 12 percent.	c. and d. Acceptable to Engineering. Cycling of the control units are phenomenena associated with specific command function transients, and the anomalies do not represent launch constraints nor do they impede mission performance.
	b. The T/M RF system reflected power, measurement N55, shifted up by 6.4 percent.	
	c. The LOX point level sensor 4, P/N 1A68710-511, S/N C38 cycled unexpectedly when the O2H2 burner fuel propellant valve was closed.	
	d. The LH2 overfill sensor, P/N 1A68710-509, S/N C68, cycled unexpectedly when the PU hardover command was turned off.	
500-353-147 9-27-68	Abnormal voltage transients were observed from the switch selector output monitor, measurement K128. The spikes were at approximately 1 volt magnitude and a 5 millisecond duration. The cause of the spikes were isolated to the O2H2 burner shutdown bus.	Acceptable to Engineering for use.
500-445-858 9-25-68	Two clips, P/N 1B37889-529, were erroneously removed from the aft dome near weld seam 1.	Two new clips were installed as replacements. The rework was acceptable.
500-445-904 10-4-68	The fuel line sleeve, P/N 1A78053-19, was torn open at station 230, stringer 26 in the aft skirt area.	The sleeve was resealed per General Note 5 of 1A78053. The rework was acceptable.

TABLE II. (Continued)

FARR NO.	DESCRIPTION OF DEFECTS	DISPOSITION
500-637-161 10-17-68	Permascope inspection of the forward and aft skirt revealed that the Korotherm coating did not meet B/P specifications.	The Korotherm coating was acceptable for use.

509 SSC VCL TESTING SEQUENCE



PARA		PROCEDURE
4.2.1	1B59780	CONTINUITY COMPATIBILITY
4.2.2	1B39095	ENGINE ALIGNMENT
4.2.3	1B64678	CRYO TEMP SENS VERIF
4.2.4	1B40973	HYD SYS FILL & BLEED
4.2.5	1B59459	PROP TK SYS L/C
4.2.6	1B41926	FWD SKIRT TCS C/O
4.2.7	1B42124	FWD SKIRT TCS OPER
4.2.8	1B64679	T/M & RS ANTENNA SYS
4.2.9	1B40544	AFT SKIRT PURGE
4.2.10	1B59455	PROP COMP INTL L/C
4.2.11	1B59782	UMBILICAL I/F COMPAT
4.2.12	1B66560	STAGE POWER SETUP
4.2.13	1B66561	STAGE POWER TURNOFF
4.2.14	1B64681	SIGNAL COND SETUP
4.2.15	1B64680	LEV SENS CONT CALIB
4.2.16	1B66563	DDAS CALIB
4.2.17	1B66562	POWER DISTRIB SYS
4.2.18	1B66564	DDAS
4.2.19	1B66569	APS SIMULATOR C/O
4.2.20	1B66566	EBW SYSTEM
4.2.21	1B59456	FUEL TK PRESS SYS L/C
4.2.22	1B59454	PROP SYS CONSOLE C/O
4.2.23	1B59458	COLD HE SYS L/C
4.2.24	1B64367	PU SYS CALIB
4.2.25	1B59461	J-2 ENGINE SYS L/C
4.2.26	1B69403	APS SYSTEM C/O
4.2.27	1B66567	PU SYSTEM
4.2.28	1B66570	HYDRAULIC SYSTEM
4.2.29	1B69571	APS MODULE C/O
4.2.30	1B64709	EMC RF SIGNATURE
4.2.31	1B66565	RANGE SAFETY RCVR C/O
4.2.32	1B59457	PNEU CONT SYS L/C
4.2.33	1B59460	REPRESS SYS L/C
4.2.34	1B66572	PROPULSION SYS
4.2.35	1B66568	RANGE SAFETY SYS C/O
4.2.36	1B74681	PROP TK DIFF PRESS SCAN
4.2.37	1B66571	ALL SYSTEMS
4.2.38	1B62965	FWD SKIRT TCS POST C/O

☒ INDICATES SECOND ISSUE

FOLDOUT FRAME

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