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R.N.W Blenkal

NIMBUS-D SOLAR-CONVERSION POWER SUPPLY SUBSYSTEM

QUARTERLY TECHNICAL REPORT NO. 6
15 MARCH 1969 THROUGH 15 JUNE 1969

Contract No. NAS5-10470

Prepared by

RCA Astro-Electronics Division
Defense Electronic Products

for

Goddard Space Flight Center
National Aeronautics and Space Administration
Greenbelt, Maryland

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PREFACE

This is the sixth in a series of quarterly technical reports on the development of the Solar-Conversion Power Supply Subsystem for the Nimbus-D Meteorological Satellite. This project is being conducted by the Astro-Electronics Division (AED) of the RCA Corporation for the National Aeronautics and Space Administration (NASA) under Contract No. NAS5-10470. This report contains data on RCA activities and plans that relate to the technical and schedule pursuance of the contract objectives, and covers the period from March 15, 1969 through June 15, 1969.

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SECTION I

INTRODUCTION

A. CONTRACT OBJECTIVES

The objective of Contract No. NAS5-10470 is to furnish a Solar Conversion Power Supply Subsystem for use with the Nimbus-D Meteorological Satellite. This configuration will be identified as the Nimbus-D Solar Conversion Power Supply Subsystem.

The contract provides for the manufacture of one flight model and a set of three spare storage modules. The solar conversion power supply subsystem, consisting of one control module, eight storage modules, and solar array (2 solar platforms), will be nearly identical to the equipment supplied under Contract NAS5-9668. Assembly numbers are as follows:

Control Module	RCA-1759712-502
Storage Module	RCA-1759580-503
Solar Array (Nimbus-B2)	RCA-1975606-501 and -502
Solar Array (Nimbus-D)	RCA-1976429-501 and -502

All special test equipment required for the manufacture and test of the flight model equipment was manufactured and assembled under previous contracts.

B. SUBSYSTEM DESCRIPTION

The Solar Conversion Power-Supply Subsystem consists of eight identical storage modules, one control module, and one solar array. Each storage module contains a battery consisting of 23 series-connected, nickel cadium cells and a group of electronic circuits designed to provide control and protection for the battery and other power subsystem components. These circuits and the battery are housed in cast-magnesium containers with sheet-magnesium covers. The control module consists of additional power subsystem electronic circuits housed in a machined-aluminum container. The solar array consists of two solar-cell platforms containing N-on-P silicon solar cells which are mounted on one side of the sun-oriented platforms. The purpose of the subsystem is to provide the spacecraft with electrical power; during satellite day, the solar array converts solar radiation to electrical energy that is supplied to the spacecraft subsystems and the batteries (charge cycle). During satellite night and peak daytime-load periods, the batteries supply the power to operate the spacecraft subsystems.

C. CONTRACT DATA

Failure of the Nimbus-B spacecraft to achieve orbit resulted in a planning effort for a Nimbus-B2 mission. The final plan provided for the qualification of one flight system (two solar platforms, one control module, and eight storage modules) and the following back-up equipment, one control module and three storage modules. Specific tasks defined by the Nimbus-B2 program plan are as follows:

- Manufacture and electrically qualify one solar array from equipment diverted from the Nimbus-D program
- Evaluate, refurbish, and rework 11 storage modules (serial numbers 01 thru 09, 16, and 20) and two control modules (serial numbers 03 and 05) supplied as GFE from the General Electric Co.

Delivery of the Nimbus-B2 solar array and the issuance of the final test report, Appendix I of Quarterly Technical Report No. 5, completes the requirement for periodic reports (quarterly) pertaining to the Nimbus-B2 Solar Conversion Power Supply Subsystem. Subsequent quarterlies will contain data pertinent to RCA support of Spacecraft Integration and pre-launch activities requested by the customer.

D. CONTRACT MODIFICATIONS

Two Contract modifications (Nos. 11 and 14) were issued during the report period. These modifications specified that an additional output connector for operating the ACS/CLB of the Nimbus Spacecraft would be added to the control module. The modification was initiated by conducting joint meetings with NASA, the General Electric Co., and the RCA Corporation to determine the technical requirements. The results of these meetings specified that a 15-pin connector would be mounted on the inboard side of the control module (RCA1759712) above the A14 capacitor bank in the RFI compartment. The installation would be designed to mount two filters (RCA 1846600-1) and maintain the RFI seal. The resistance between the capacitor bank and the outside of the control module was specified as 0.004 ohms maximum.

A program plan developed for the design, installation and test of the filter is as follows:

- Incorporate the feed-through filter into control module EM-01 (engineering model 01) to ascertain the feasibility of the modification.

- Deliver modified control module EM-01 to The General Electric Co., for electrical tests.
- Modify control module 03 if the electrical test at the General Electric Co., are satisfactory and perform vibration and thermal tests.
- Modify control module 06 if the vibration and thermal tests of control module 03 are satisfactory and qualify the design for flight use (thermal-vacuum tests).

The status of the modification program is contained in Section 4 of this report.

SECTION 2

SOLAR ARRAY

A. GENERAL

Each solar array consists of two solar cell platforms comprised of a solar-cell mounting structure (substrate), solar-cell modules, a transition section, a latching assembly, a motor drive and gear reduction unit, and a control-shaft clamp.

B. NIMBUS-B2 ARRAY

A broken solar-cell tab discovered by launch-site personnel was confirmed by RCA engineering personnel on April 3, 1969. The break occurred at the positive tab of Module 68, Board M (RCA Part No. 1975606). The nature of the break is shown on Figure 1.

Two possible methods of repair were considered,

1) solder a hard wire to the shortened tab, or
2) short the module out of the circuit.

The second method was used as the repair (hard wire to hard wire) provided a greater degree of reliability than the first method of repair (hard wire to tab). The repair is shown on Figure 2.

Current losses due to the repair are listed in Table 1. The worst case operating conditions occur at high temperatures where current losses show up at lower array voltages. At 50°C, the current loss is 10 ma at 39 volts dc, and increases to 60 ma at 48V. At 35°C and -55°C, the current losses occur at voltages far below the knee of the I-V characteristics. (Ref. Figure I-1 of Quarterly Report No. 5.)

The cause of the failure was attributed to improper handling. On March 10, 1969, the hard wire-tab joint, noticeably distorted, was discovered at the G.E. Co. Facility. The joint, reformed to eliminate sharp bends or stress points in the copper tab, was inspected by RCA and G.E. Co. engineering personnel and accepted by G.E. Co. quality control personnel. The tab failure is attributed to the method used to attach the spacecraft lifting hardware (handlers reaching inside the folded platforms from the top).

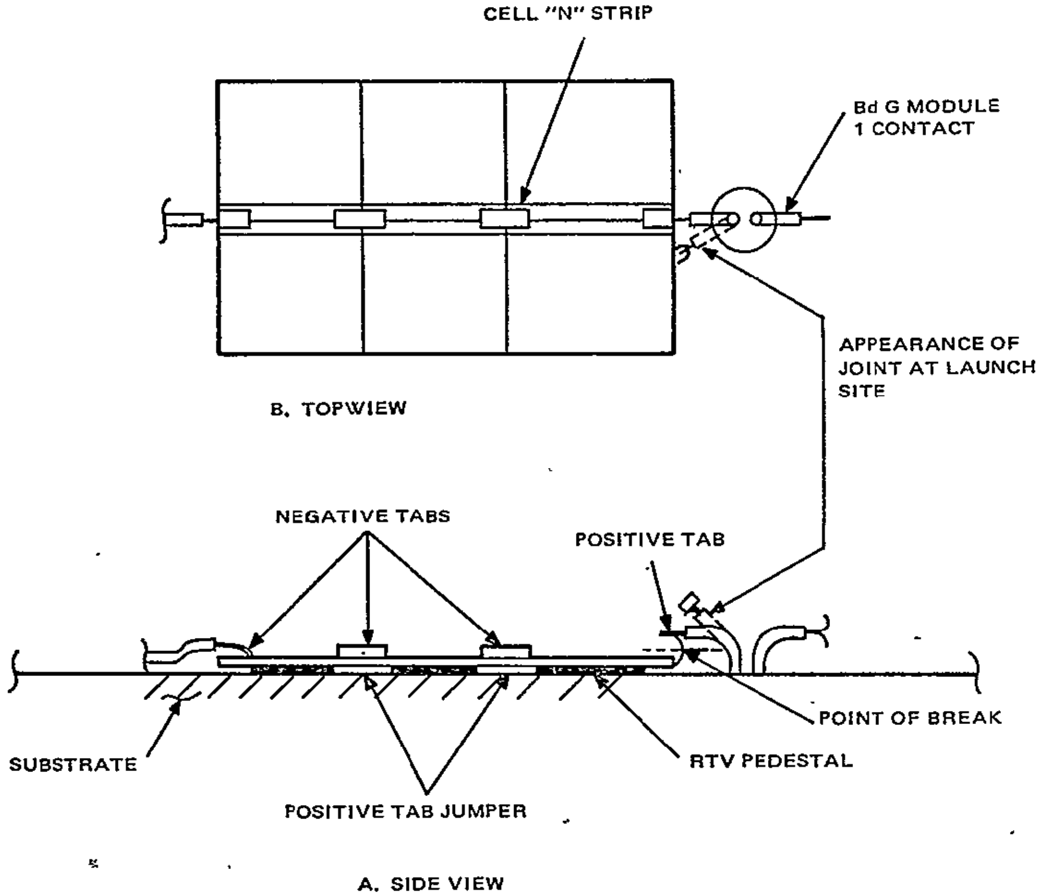


Figure 1. Board M, Module 68 Broken Tab Configuration

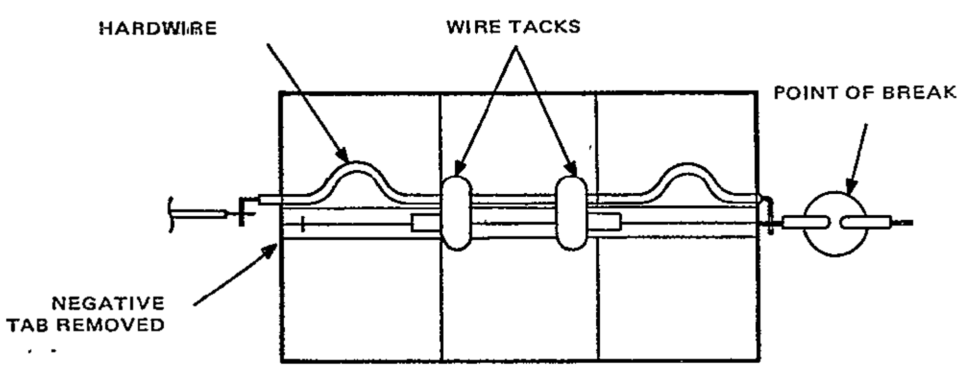


Figure 2. Board M, Module 68 Repair Technique

TABLE 1. MAXIMUM CURRENT LOSSES, NIMBUS-B2 ARRAY

Temp. (°C)	Current Loss (ma)	Array Voltage (Vdc)
-55	90	72
+35	70	52
+50	60	48

C. NIMBUS-D ARRAY

1. Substrate Fabrication

Two substrates were fabricated for the Nimbus-D Array during the report period. The left hand platform (Serial No. 017) was completed on March 27, 1969 and delivered to the RCA Corporation. A detailed test report containing the acceptance test data are contained in Appendix I, Paragraph B. The right hand platform (Serial No. 018), completed by mid-April, 1969, was rejected because one of the sample coupons did not meet the peel test requirements set forth in RCA Drawing 1750081, Revision A, specifically Paragraph 4.4.2.4. This paragraph specifies that the peel test values shall meet the limitations shown in Figure 3; the actual test data obtained from the sample coupons prepared with the rejected substrate are also shown. A complete test report including the acceptance test data is contained in Appendix I, Paragraph C.

On May 6, 1969, the RCA Corporation presented a summary of the test data and the production processes used on the rejected unit. The data presented and applicable technical discussions are contained in Appendix I, Paragraph D. This presentation, conducted at the Goddard Space Flight Center, was attended by GSFC, G.E. Co., and RCA Corporation personnel. Its purpose was to consider an RCA recommendation that an MRB action be undertaken to waive the specification limit for S/N 018 sample coupons. This recommendation was not accepted. On May 11, 1969, the Goodyear Aerospace Corporation (GAC) was directed to perform a series of tests to verify the production-process specified in the GAC RDB-5342 specification. Part one directed that two sample coupons (S-I and S-II) and three test coupons (MF, MC, and MB) be prepared as specified in RDB-5342 and evaluated in accordance with RCA Drawing 1750081, Rev. A. The five coupons were placed in the mold as shown in Figure 4, cured, and evaluated. The results of the first part were to clarify the RDB-5342 specification, if necessary. Part two directed that a second set of coupons be prepared using the original or modified RDB-5342 specification to further verify the production process. When these tests were completed satisfactorily, GAC was directed to fabricate a replacement substrate. The results of the special test are contained in Appendix I, Para E.

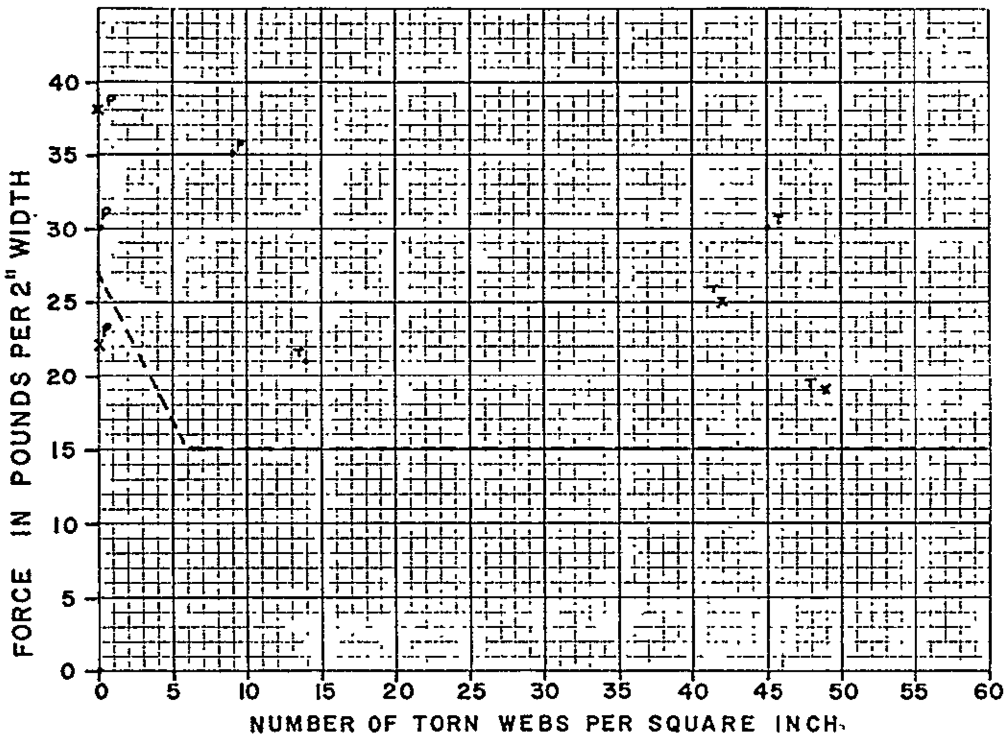
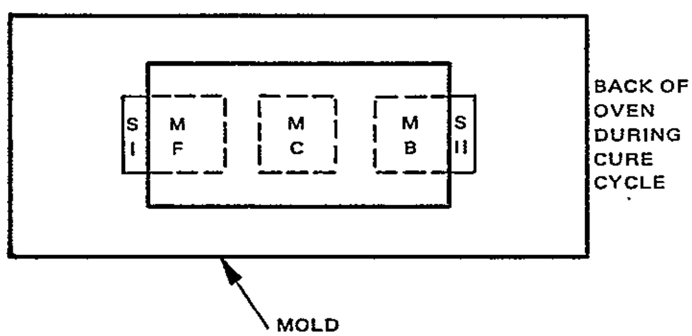


Figure 3. Peel Test Limitations and Sample Coupon Peel Test Data for Platform 018



SI	6 x 16 x 1/2
SII	6 x 16 x 1/2
MF	16 x 16 x 1/2
MC	16 x 16 x 1/2
MB	16 x 16 x 1/2

Figure 4. Test Configuration for Verification of RDB-5342 Specification

2. Solar-Cell Module Fabrication and Test

Fabrication of the 10- and 6-cell solar modules was completed March 28, 1969 and post-manufacturing electrical confidence tests were completed satisfacotrily.

3. Platform 017 Fabrication

Fabrication of the platform consists of preparing the substrates (platform and transition) for application of the solar-cell modules, electronic circuits, and wiring. During this reporting period, the left-hand substrate was drilled, painted, and cleaned in preparation for bonding the solar-cell modules and component boards.

4. Plans For Next Report Period

During the next report period, assembly of platform 017 will be completed and post-assembly electrical tests will be performed.

Assembly of the right-hand platform, Serial No. 19, will be initiated when the Goodyear Aerospace Corporation completes fabrication of the substrate. The contractual delivery data is August 1, 1969.

SECTION 3

STORAGE MODULE

A. GENERAL

Each storage module consists of a two-piece magnesium housing, 23 nickel-cadmium storage cells, and an electronic board. Eleven storage modules are supplied with each flight system, eight for use on the Spacecraft and three as spares.

B. STORAGE MODULE FABRICATION

Fabrication of eight storage modules (serial No. 022 through 029) was completed by February 28, 1969. Fabrication of the three spare storage modules (serial No. 030 through 032) was completed in June, 1969. The eight flight units were integrated with a control module and subjected to system tests. The three spare modules were prepared for unit tests.

C. STORAGE MODULE UNIT TEST

Unit test of storage modules 022 through 029 was completed March 5, 1969; a test data summary is contained in Appendix V, Para C of Quarterly Technical Report No. 5 (R-3443) issued June 18, 1969. Due to test anomalies observed during system test, storage module 028 was replaced by storage module 030. A complete test data summary for the storage modules qualified with control module 06 is contained in Appendix II Para C. Unit test of spare storage modules 028, 031, and 032 will be completed when rework of storage module 028, presently in process, is completed.

D. STORAGE MODULE SYSTEM TEST

System test of a control module and eight storage modules was completed on May 19, 1969 and the eight storage modules (Serial No. 022 through 027, 029, and 030) were delivered to the General Electric Company. System test data for the storage modules are presented in a system test data summary contained in Appendix II, Para D.

E. PLANS FOR NEXT REPORT PERIOD

Rework of storage module 028 and subsequent unit tests will be completed, system test of the spare storage modules (028, 031 and 032) and a control module will be completed, and the units will be delivered to the General Electric Co.

SECTION 4

CONTROL MODULE

A. GENERAL

The control module contains the electrical circuits that regulate the d-c voltage outputs for the spacecraft loads, limits the solar array voltage to safe load levels, provides telemetry signals for system evaluation, and provides the interface between the solar array, storage module, and spacecraft loads. The configuration of the Nimbus-D and Nimbus-B control module is identical except for the temperature telemetry circuits and the regulated bus output connector added to the Nimbus-D control module. The additional telemetry circuits are described in "Quarterly Technical Report No. 2," (R-3340) issued July 15, 1968. The additional regulated-bus output connector is described in Appendix III, Para. B.

B. UNIT TEST

1. Control Module 03

Fabrication of control module 03 was completed in December 1966, and was designated as the prototype qualification model for the Nimbus-B program (Contract NAS5 9668). Prototype qualification tests, conducted from February 1967 to May 1967, included temperature-humidity, vibration, acceleration, and thermal vacuum exposures. In 1968, the unit was reclassified as a back-up unit for the Nimbus-B2 program which was instigated after the launch failure of the Nimbus-B mission in May 1968. The Nimbus-B-2 spacecraft, launched April 13, 1969, contained the Nimbus-B spare flight-control module (serial No. 05) and the back-up unit (prototype, serial No. 03) was retired from service.

On April 28, 1969, control module 03 was returned to the RCA Corporation for modification to the Nimbus-D configuration. The modifications included the addition of two telemetry sensors (RT-1 and RT-2) and a regulated bus output filter (A-17). The telemetry sensors are described in "Quarterly Technical Report No. 2", (R3340) issued July 15, 1968. The regulated-bus output filter is described in Appendix III, Para B. After modification, storage module 03 was subjected to flight level vibration exposures and a series of thermal tests in order to qualify the unit for flight use on the Nimbus-D spacecraft. A test data summary is contained in Appendix III, Para C. An historical summary of control module 03 vibration and thermal exposures are contained in Tables 2 and 3, respectively.

The test data obtained during the acceptance program indicates that control module 03 is electrically suitable for flight use on the Nimbus-D program. However, the RCA Corporation recommends that this unit be designated as the flight back-up, not the primary flight unit. This recommendation is based on the large number of vibration and thermal exposures, reference Tables 2 and 3.

TABLE 2. SUMMARY OF CONTROL MODULE 03 VIBRATION EXPOSURES

Date	Type of Exposure	Exposure Level (g)	Estimated Exposure Time (min)	Comments
3-6-67	Thrust, Sine Thrust, Random Tangential, Sine Tangential-Random	20* 40* 20* 40*	8 4 8 4	Prototype Vib - Failed, Capacitor C5 on bd A12 broke away from bd. (C5 not potted)
3-7-67	Radial, Sine Radial, Random	20* 40*	8 4	Prototype Vib - Failed, PCB connectors damaged, Capacitors on bd A14 open.
3-19-67	Radial, Sine Radial Random	10 20	8 4	Prototype Vib - Repeat, AUTO SIG SELECTOR used instead of AVERAGER on Sine exposure.
3-19-67	Thrust, Sine Thrust, Random	10 20	8 3	Prototype Vib - Repeat, Shaker failed during random run.
3-20-67	Thrust, Random	20	1	Prototype Vib - Repeat-Failed, two screws to mount the A9 harness board came loose and shorted two fuses.
3-20-67	Thrust, Random	20	1	Prototype Vib - Repeat-Shaker failure during exposure.
3-21-67	Thrust, Random	20	1	Prototype Vib - Repeat-Exposure complete, re-run required after fuse replacement.
3-22-67	Tangential, Sine Tangential, Random	10 20	8 3	Prototype Vib - Repeat-Shaker failure during random.
3-28-67	Radial, Sine Radial, Random	10 20	8 4	Prototype Vib - Repeat after all repairs - (PCB support added and fuses replaced) Passed.

* Exposure levels were twice the prototype levels because the accelerometers were mounted incorrectly.

TABLE 2. SUMMARY OF CONTROL MODULE 03 VIBRATION EXPOSURES (Continued)

Date	Type of Exposure	Exposure Level (g)	Estimated Exposure Time (min)	Comments
3-28-67	Thrust, Sine	10	8	Prototype Vib - Repeat-Shaker failed during random run.
	Thrust, Random	20	1	
3-31-67	Thrust, Random	20	3	Prototype Vib - Random run completed. Passed.
3-31-67	Tangential, Sine	10	8	Prototype Vib - Repeat, tangential exposure completed. Passed.
	Tangential, Random	20	4	
6-5-69	Radial, Sine	5	4	Flight Vib - Nimbus-D program. Passed.
	Radial Random	11.7	2	
	Tangential, Sine	5	4	
	Tangential, Random	11.7	2	
	Thrust, Sine	5	4	
	Thrust, Random	11.7	2	
6-16-69	Radial, Random	11.7	2	Workmanship vibration after replacement of Capacitor C6 on bd A8.
6-16-69	Radial, Random	11.7	2	Workmanship vibration after replacement of connectors J1, J5, J6, and J8.

TABLE 3. SUMMARY OF CONTROL MODULE 03 THERMAL EXPOSURES

Date	Temp (°C)	Estimated Exposure Time (Hrs)	Comments
2-25-67	5	8	Past-potting Test Sequence, Nimbus-B program.
	40	2	
2-26-67	45	8	
	55	2	
2-28-67	30	14	Humidity test at 95 percent relative humidity.
3-1-67	55	24	Post-humidity dry-out.
3-17-67	50	4	Oven cure (bonding of harness clamp)
3-18-69	40	16	Oven cure (bonding of capacitor, ass' y A14)
	55	24	
4-10 thru 4-25-67	-5	24	Prototype thermal-vacuum test sequence, Nimbus-B program.
	0	96	
	45	96	
	5	8	
6-8 thru 6-10-69	0	2	Past-vibration Test Sequence, Nimbus-D program.
	45	8	
	55	2	

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C. SYSTEM TEST

System test consists of integrating eight storage modules and one control module into a system and conducting an initial test and thermal vacuum tests with a simulated array input. System tests were conducted from May 2, 1969 to May 19, 1969; a test data summary is contained in Appendix II, Para D. The simulated array input, based on predicted array output parameters, is described in Section 4, Para B2 of "Quarterly Technical Report No. 5", (R3443) issued June 18, 1969.

D. PLANS FOR NEXT REPORT PERIOD

Modification of control module 06 and electrical confidence checks will be completed. Upon completion, the unit will be integrated with the spare storage modules (028, 031, and 032) and subjected to system tests.

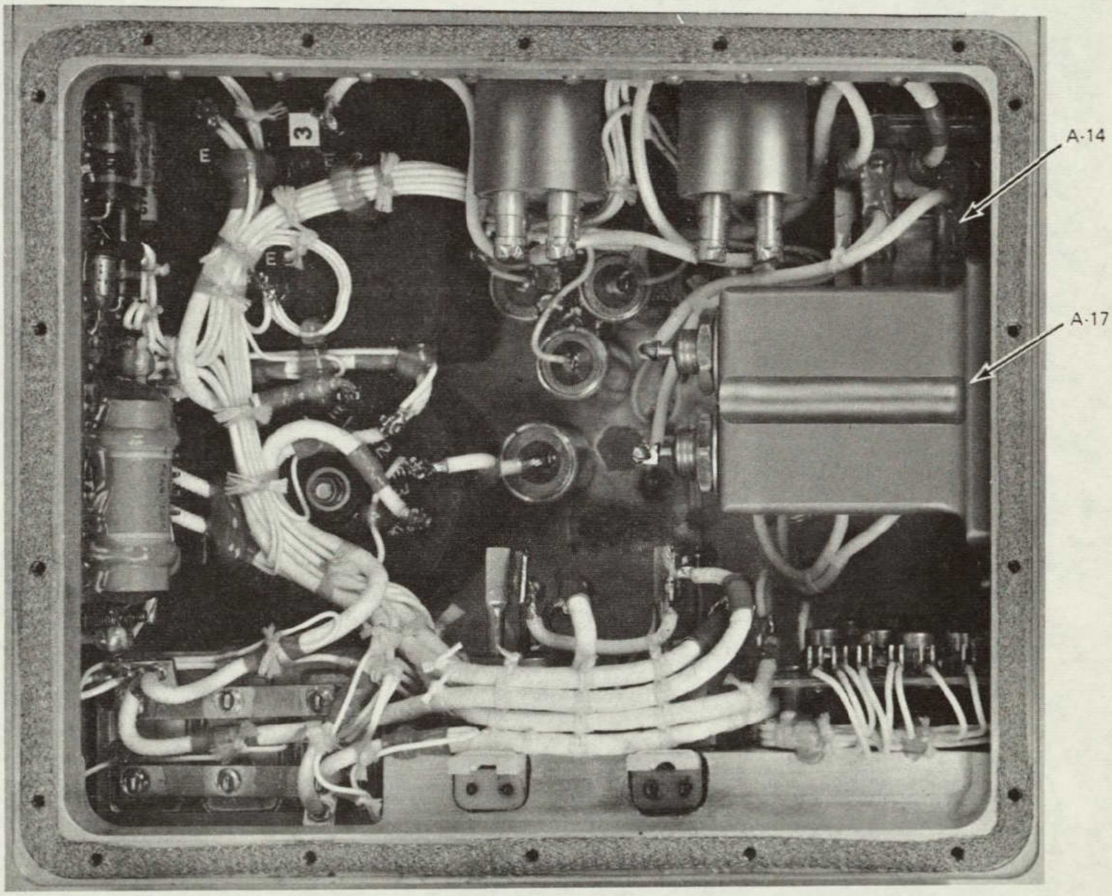


Figure 5. Filter Assembly A17 Installation, RFI Compartment of Flight Quality Control Module

SECTION 5

ENGINEERING RELIABILITY

A. INTRODUCTION

Reliability and Quality assurance Engineering provided consulation on the resolution of technical part problems encountered during the acceptance test program. Seven test descrepancy reports were issued during the report period.

B. TEST DESCREPANCY REPORT SUMMARY

A summary of all the test descrepancy reports issued on this program are contained in Table 4. A description of the descrepancy and the corrective action are contained in Table 5 and the following paragraphs.

C. TEST DESCREPANCY ANALYSIS SUMMARIES

Test descrepancy analysis summaries are performed when the cause of the failure cannot be readily determined. Four analysis have been performed as of this report period. The problem and the related TDR's are contained in Table 6.

1. Heat Sink Transistor Problem

The 2N2016 transistor used in the shunt dissipator circuit of the heat sink assembly was replaced by a Solitron SDT9903 transistor (RCA Dwg 1970655-1) as multiple failures were experienced during unit test and pre-conditioning tests. A complete report is contained in Section 3, Para Cb2 of Quarterly Technical Report No. 5 (R3443) issued June 18, 1969.

2. Zener Diode Problem

Six TDR's involving the JAN IN944B Zener diode were initiated during manufacture and test of the Nimbus-D Power Supply Subsystem from July 1, 1968 to March 27, 1969. All the failed units, manufactured by Motorola, had a single date code of 6750. In an effort to isolate the problem, all the JAN IN944B devices were removed from controlled stares and subjected to electrical tests under dynamic environmental conditions. The environmental conditions impart mild

TABLE 4. TEST DISCREPANCY REPORT SUMMARY

TDR No.	Issue Date	Initialed by	Equipment, Part or Document Affected	Status	Failure Mode	Description of Failure
STORAGE MODULES						
B2349	3-6-69	K. Worrell	Storage Module 023 Wiring	Closed	Workmanship	Refer to Table 5-2
B3920	11-14-68	R. Deckert	Storage Module 027, Heat Sink Ass'y 024, Transistor Q4 (2N2016)	Closed	Component Part	Refer to Table 5-2 and Par B Appendix V of "Quarterly Technical Report No. 5."*
B3921	11-14-68	R. Deckert	Storage Module 026, Heat Sink Ass'y 023, Transistor Q4 (2N2016)	Closed	Vendor Workmanship	Refer to Table 5-2 and Par B, Appendix V of "Quarterly Technical Report No. 5."*
B3922	11-14-68	R. Deckert	Storage Module 022, Heat Sink Ass'y 022, Transistor Q4 (2N2016)	Closed	Vendor Workmanship	Refer to Table 5-2 and Par B, Appendix V of "Quarterly Technical Report No. 5."*
B3929	11-19-68	R.A. Hoffmann	Storage Module 026, Heat Sink Ass'y 023, Transistor Q4 (2N2016)	Closed	Component Part	Refer to Table 5-2 and Par B, Appendix V of "Quarterly Technical Report No. 5."*

* (R-3443) issued June 18, 1969

TABLE 4. TEST DISCREPANCY REPORT SUMMARY (Continued)

TDR No.	Issue Date	Initialed by	Equipment, Part or Document Affected	Status	Failure Mode	Description of Failure
B3930	11-26-68	R. Hoffmann	Storage Module 027, Heat Sink 024, Transistor Q4 (2N2016)	Closed	Component Part	Refer to Table 5-2 and Par B, Appendix V of "Quarterly Technical Report No. 5."*
B3935	1-22-69	R. Devaux	Storage Module 024	Closed	Unknown	Refer to Table 5-2.
B3937	3-10-69	W. De Windt	Storage Module 025, Electronics Board, Zener Diode VR2 (1N944B)	Closed	Test Error	Refer to Table 5-2 and Par C2.
B3938	3-14-69	R. Czyzewski	Storage Module 023 Thermistor RT-3 on Storage Cell 19.	Closed	Workmanship	Refer to Table 5-2 and Par C3.
B3939	3-21-69	R. Czyzewski	Storage Module 026 Electronics Board Zener Diode VR2 (1N944B)	Closed	Test Error	Refer to Table 5-2 and Par C2.
B3940	3-27-69	R. Czyzewski	Storage Module 029, Electronics Board, Zener Diode VR2 (1N944B)	Closed	Vendor Workmanship	Refer to Table 5-2 and Par C2.
B3953	5-5-69	R. Devaux	Storage Module 023, Thermistor RT-3 on Storage Cell 19	Closed	Workmanship	Refer to Table 5-2 and Par C3.

* (R-3443) issued June 18, 1969

TABLE 4. TEST DISCREPANCY REPORT SUMMARY (Continued)

TDR No.	Issue Date	Initialed by	Equipment, Part or Document Affected	Status	Failure Mode	Description of Failure
B3954	5-6-69	R. Devaux	Storage Module 022, Thermistor RT-3 on Storage Cell 19	Closed	Workmanship	Refer to Table 5-2 and Par C3.
B3955	5-10-69	R. Devaux	Storage Modules 022 through 027, 029, and 030.	Closed	Test Equipment F	Refer to Table 5-2.
B3956	6-9-69	R. Devaux	Storage Module 024, eight Storage Cells	Closed	Workmanship	Refer to Table 5-2.
B3963	12-10-68	R. Czyzewski	Storage Module 028, Electronics Board Zener Diode VR2 (1N944B)	Closed	Vendor Workmanship	Refer to Table 5-2 and Par C2.
B3964	1-10-69	R.A. Hoffmann	Storage Module 023, Electronics Board, Zener Diode VR2 (1N944B)	Closed	Manufacturing Workmanship	Refer to Table 5-2 and Par C2.
B3965	1-23-69	R. Devaux	Storage Module 027, Heat Sink Ass'y 024 Transistor Q4 (2N2016)	Closed	Component Part	Refer to Table 5-2 and Par B, Appendix V of "Quarterly Technical Report No. 5."*
B3968	3-4-69	R. Worrell	Storage Module 028, Thermistor on Cell 12	Closed	Workmanship	Refer to Table 5-2.
B4837	4-27-69	R. Czyzewski	Storage Module 025, Buffer Cable	Closed	Test Equipment Broken Wire	Refer to Table 5-2.

* (R-3443) issued June 18, 1969

TABLE 4. TEST DISCREPANCY REPORT SUMMARY (Continued)

TDR No.	Issue Date	Initialed by	Equipment, Part or Document Affected	Status	Failure Mode	Description of Failure
CONTROL MODULE						
B0391	7-16-68	R. Deckert	Control Module 06 Shunt Dissipation Ass'y Zener Diode VR3 (1N944B)	Closed	Vendor Workmanship	Refer to Table 5-2 and Par C2.
B0399	6-27-68	R. Deckert	Control Module 06 Auxiliary Regulator Resistors R11 and R29	Closed	Vendor Workmanship	Refer to Table 5-2
B3923	11-19-68	R.A. Hoffmann	Control Module 06 Housing-Insulating Washers for Q8 and Q10	Closed	Workmanship	Refer to Table 5-2.
B3924	11-19-69	R.A. Hoffmann	Control Module 06 Housing-Wiring	Closed	Workmanship	Refer to Table 5-2.
B3933	12-3-68	R.A. Hoffmann	Control Module 06 Main Regulator Ass'y Transistor Q7 (2N491)	Closed	Vendor Workmanship	Refer to Table 5-2 and Par C4.
B3905	8-6-69	-	Control Module 06 Thermistor Rt-2	Closed	Test Equipment	Refer to Table 5-2

TABLE 5. TEST DISCREPANCY AND CORRECTIVE ACTION

TDR Number	Discrepancy	Corrective Action
B2349	Wire from K1-4 to cell 23 (negative) shorted at screw that secures the 37-pin connector.	Repaired wire and rerouted relay harness away from 37-pin connector.
B3920	Leakage current for transistor Q4 (2N2016) greater than 50 μa at 25°C on heat sink assembly 024.	Replaced Q4 with another 2N2016 transistor. Heat sink assembly subsequently installed in storage module 024.
B3921	Leakage current for transistor Q4 (2N2016) greater than 50 μa at low temperatures ($\approx$5°C) on heat sink assembly 023.	Replaced Q4 with another 2N2016 transistor. Heat sink assembly subsequently installed in storage module 026.
B3922	Leakage current for transistor Q4 (2N2016) greater than 50 μa at low temperature ($\approx$5°C) on heat sink assembly 022.	Replaced Q4 with transistor 1970655-1. Heat sink assembly 022 subsequently installed in storage module 022.
B3929	Leakage current for transistor Q4 (2N2016) greater than 50 μA at 25°C on heat sink assembly 023.	Replaced Q4 with transistor 1970655-1. Heat sink assembly 023 subsequently installed in storage module 026.
B3930	Leakage current for transistor Q4 (2N2016) greater than 50 μa at 25°C on heat sink assembly.	Replaced Q4 with another 2N2016 transistor. Heat sink assembly 024 subsequently installed in storage module 027.
B3935	Intermittent open line (From test rack simulated battery power supply to terminal E8 on Electronics Board)	Performed a thorough examination of module wiring and buffer connectors. Problem was not identified. Test rack harnesses was considered the cause of the problem. Module was put through the entire test program with no further indication of the problem.
B3937	Intermittent partial open in Zener diode VR2 on electronics board.	Replaced Zener diode (1N944B) with another part.

TABLE 5. TEST DISCREPANCY AND CORRECTIVE ACTION (Continued)

TDR Number	Discrepancy	Corrective Action
B3938	Input voltage to high temperature (Trickle-Charge) circuit measured 11.8 volts. Test limit is 11.5 volts.	Problem was not identified until the thermal-vacuum test. See TDR B3953.
B3939	Intermittent partial open in Zener diode VR2 on electronics board.	Replaced Zener diode (1N944B) with another part.
B3940	Open Zener diode VR2 on electronics board.	Replaced Zener diode (1N944B) with another part.
B3953	High temperature (Trickle-Charge) circuit activated at 45°C. Test limit is 51.7 ±2.8°C. Thermistor on cell 19 not bonded to cell.	Bonded new thermistor on cell 19 and ran special thermal-vacuum test to verify correct performance.
B3954	High temperature (Trickle-Charge) circuit activated at 48°C. Test limit is 51.7 ±2.8°C. Thermistor on cell 19 not bonded to cell.	Same as TDR B3953.
B3955	Digital voltmeter on data logging Unit 1 (System Data) not reading correctly during orbits 4 thru 16 of the 1st 40°C exposure.	Orbital cycling continued without interruption. Control of test maintained by using digital voltmeter on subsystem test rack. Digital voltmeter on logger repaired by orbit 17 of the 1st 40°C exposure.
B3956	Electrical short (In 25-pin connector of test harness) across 8 storage cells in module 024.	Replaced the 8 cells with flight qualified spares. Then ran workmanship vibration test, special thermal-vacuum test, and a series of electrical tests to verify correct performance.
B3963	Could not adjust charge current to 1.10 amperes with a voltage of 5.0 ±0.3 volts on base of Q4. Zener diode VR2 open.	Replaced Zener diode VR2 (1N944B) with a qualified part.

TABLE 5. TEST DISCREPANCY AND CORRECTIVE ACTION (Continued)

TDR Number	Discrepancy	Corrective Action
B3964	Intermittent open Zener diode VR2 (1N944B) on electronics board 023 in storage module.023.	Replaced VR2 with another 1N944B Zener diode.
B3968	The voltage temperature circuit did not limit the battery voltage.	Removed cell in position 12, repaired the thermistor assembly.
B3965	Collector current less than 200 ma for transistor Q4 (2N2016) on heat sink assembly 024.	Replaced Q4 with transistor 1970655-1. Heat sink assembly subsequently installed in storage module 027.
B4837	During vibration, all telemetry read erratic. The telemetry ground wire on the 9-pin buffer harness was found to be open.	Replaced buffer connector and completed vibration test sequence with no further problems.
B0391	VR3 (1N944B) on the shunt dissipator board intermittently open.	Replaced Zener diode 1N944B. Defective part turned over to Engineering Reliability for analysis.
B0399	R11 and R29 (each 3.83K) on the auxiliary regulator board were the wrong resistance value (38.3K).	Replaced resistors. The 38.3K resistors were labeled 3.83K by the vendor and mistake was not identified by the RCA incoming inspection cycle.
B3923	Q8 (2N1482) and Q10(2N1490) on the main module assembly had collectors shorted to case. Insulating washers for these two transistors were found to be broken.	Replaced insulating washers on Q8 and Q10.
B3924	Lead from thermistor RT-2 on the main module assembly shorted to case. Lead was pinched under bracket for capacitor C1.	Removed thermistor lead from under bracket and replaced sleeving on thermistor.
B3933	Q7(2N491) on the main regulator board intermittently open (emitter circuit).	Replaced transistor 2N491A. Defective part turned over to Engineering Reliability for analysis.
B3905	Out-of-tolerance readings at 40° C for RT-1 and RT-2	Temperature bridge out of calibration could not be zeroed. No other units available - test data was evaluated and tests were continued.

TABLE 6. TDR ANALYSIS SUMMARY

Problem	Related TDR
Heat Sink Transistor Problem (2N2016)	B3920 thru B3922, B3929, B3930, and B3965.
Zenor Diode Problem (IN944B)	B039, B3937, B3939, B3940, and B3964
High Temperature Thermistor Bonding Problem	B3938, 3953, and B3954
Unijunction Transistor Problem (2N491A)	B3933

bending and twisting stresses to the devices in a manner similar to that experienced when the board is bent or flexed. Six units were tested, two were found to be defective.

The remaining units (117) were tested in the normal manner on a curve tracer. Twenty-nine of these showed charges in the Zener voltage when minor stresses were applied to the leads, two were open initially. All the tests were performed with a test current of 7.5 mA; voltage instability from tenths to hundredth of millivolts was observed. Based on these findings, two investigations were conducted simultaneously, one at the vendor, one at RCA.

A data investigation at the vender disclosed no manufacturing test anomalies, nor any feedback from other companies that purchased these devices (data code 6750). The thirty one failed units and half of the passed units were supplied to the vendor. Monitoring the Zener characteristic under vibration quickly confirmed all but two of the intermittent failures. The devices, visually inspected under 20X to 30X magnification, exhibited distinct point contact characteristics of the arrowhead to the metallization surface of the Zener chip. Thus, both the visual inspection and electrical performance indicated the point contact condition as the problem. Further inspection revealed an overheating and sudden cooling condition as the solder fillet from the arrowhead to the metallization was lost in some cases even though signs of its presence was apparent on the arrowhead. It was the vendors opinion that the devices had been exposed to an excessive temperature condition, one that had no effect on the semi-conductor properties but charged the arrowhead interface.

Simultaneously, an investigation was being conducted at RCA to determine if conditions capable of causing excessive power dissipation in the devices occurred during the preconditioning cycle. Examination of the data disclosed that the devices were erroneously subjected to 80-percent of their rated power at ambient while operating at 100 °C. The actual dissipation was 400mw rather than 202 mw. The rating of the device (252mw at 100 °C) is based on the distance between the body of the device and point where the leads contact their electrical and heat sink terminals. The specified distance is 3/8 inch, in actual practice the distance was 3/4 to 1-inch. The above conditions raised to temperature well over 220° C for 300 hours during the preconditioning cycle. The 220° C temperature is marginal as the melting point of the pure-tin solder is 230° C.

During the investigation, the compromised units were replaced with units purchased from another vendor and preconditioned separately. There have been no other failures of the JAN IN944B diodes on this program.

3. High Temperature Thermistor Bonding Problem

During high temperature tests of storage modules of 022 and 023, the high-temperature trickle charge circuit cut in at 45° C, the specified temperature is 48.9° C. Investigation disclosed that the thermistors mounted on storage cell 19 were not bonded properly. When improperly bonded to the cell wall, the thermistors experienced higher temperatures then the normally sensed cell temperatures and the resistance values decreased prematurely. This caused Schmit trigger (Q15) actuations approximately2° C below the specified limit. The above failure mode was verified by satisfactory operation after the thermistors were bonded to the cell wall.

Circuit functions independent of the thermistor corrolated satisfactorily with design predictions. The measured Schmitt trigger actuation on storage module 023 was 12.08 volts, the calculated value is 11.95 volts. Both modules are activated by 13 kohm resistors used as thermistor sensors; the calculated threshold resistance is 13.04 kohms.

4. Unijunction Transistor Problem

During unit test of control module 06, the main regulator bus oscillated. The problem was traced to an open emitter in transistor Q7 (type 2N491A). The inoperative device was replaced with a qualified unit and was analyzed by engineering reliability. When opened, a visual examination disclosed that the emitter was broken at the chip bond. Examination of the wire lead disclosed several nicks that may have caused the failure and the fault was attributed to this device.

APPENDIX I

NIMBUS-D SOLAR ARRAY TEST DATA

A. INTRODUCTION

Nimbus-D solar array test data accumulated during the report period consists of the following:

- Platform 017 Acceptance Data, Paragraph B
- Platform 018 Acceptance Data, Paragraph C
- Platform 018 Data Review, Paragraph D
- Substrate Production Process Verification Test Report, Paragraph E

B. PLATFORM 017 ACCEPTANCE TEST REPORT

Evaluation of the fabricated substrate requires the analysis of all physical dimensions, documented control data, and the requirements of RCA drawing 1750081 Rev A, which includes peel tests, flexure tests, and lap shear tests. The latter tests are performed on sample coupons prepared simultaneously with the same production process and from the same materials of construction as those used to fabricate the substrates (platform and transition). Thermal profiles for the first and second cure heat up rates are shown in Figures I-1 and I-2. Detailed temperature data for the entire cure cycles or contained in the Equipment Log Books.

1. Flexural Strength Test Data

Flexural strength test data, determined by the test method shown on Figure I-3, are shown in Table I-1. The specified force required to buckle the test specimen shall exceed 30 lb per inch of width. The method of calculation is also shown on Figure I-3.

2. Lap Shear Test Data

Lap shear test data is obtained from eight test specimens prepared concurrently with each substrate and four specimens from the structural bar channels (hat). The test results are listed in Table I-2. The force required to shear the samples is 1000 psi minimum.

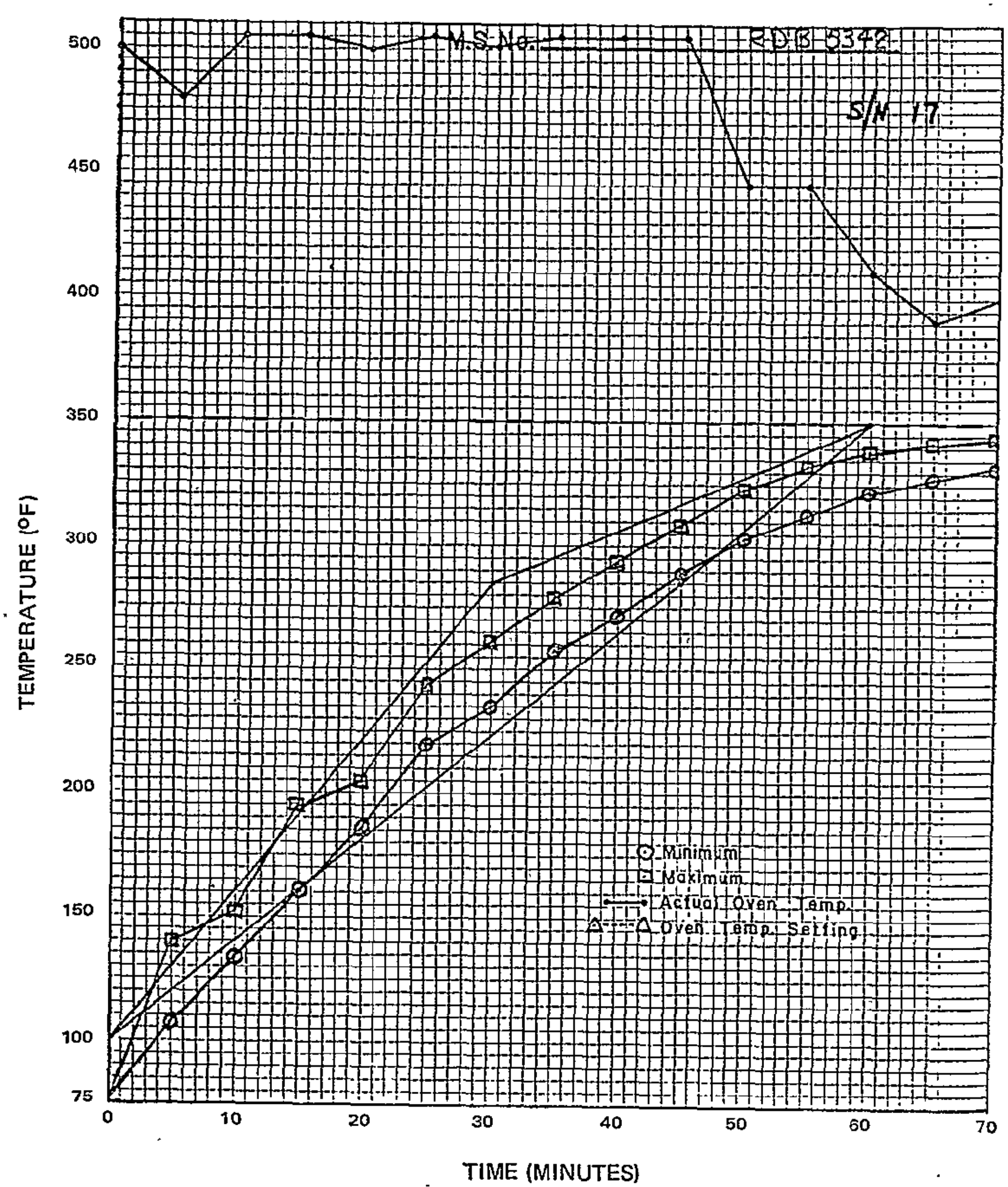


Figure I-1. Platform 017 Heat-Up Rate, First Cure

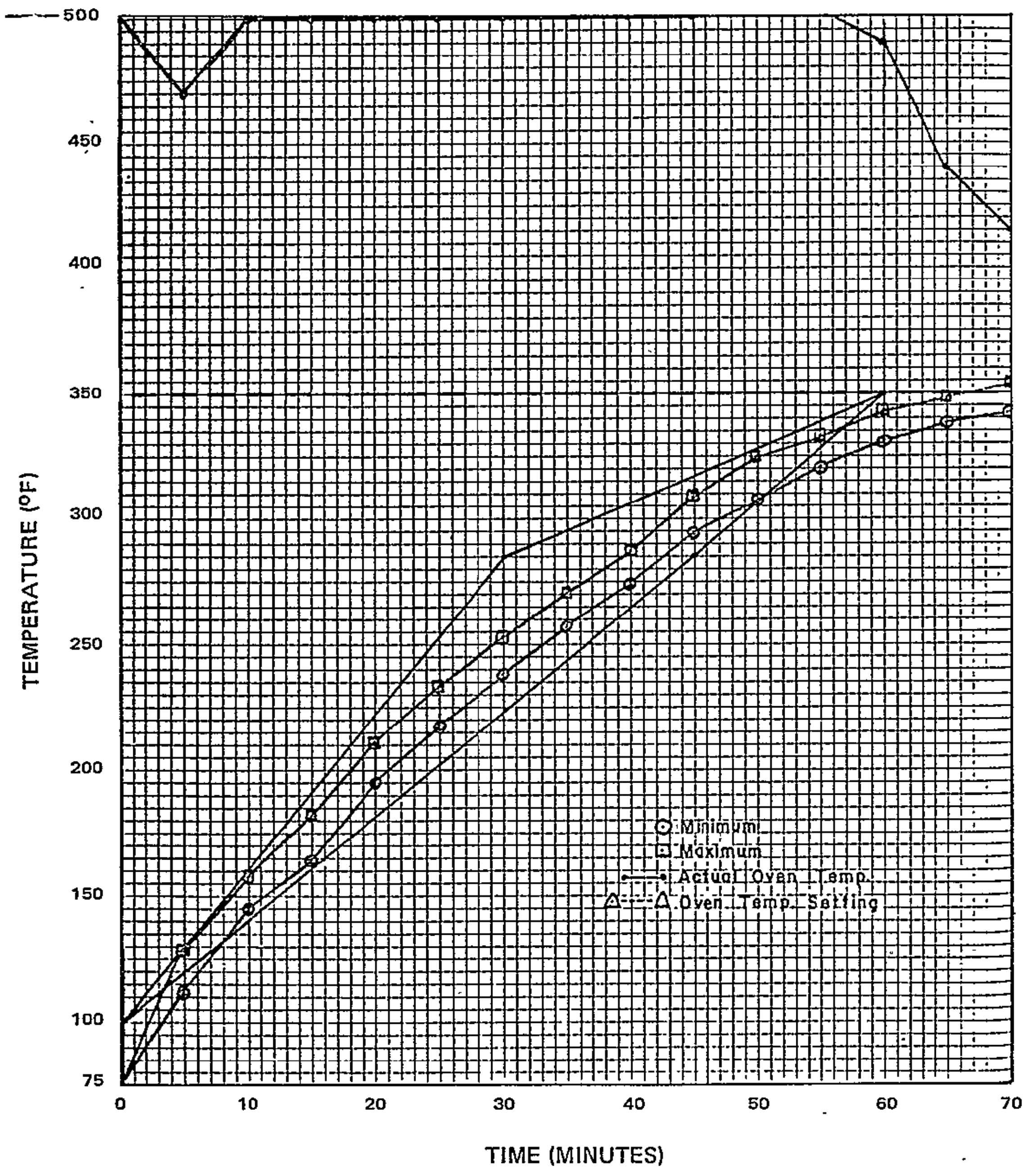
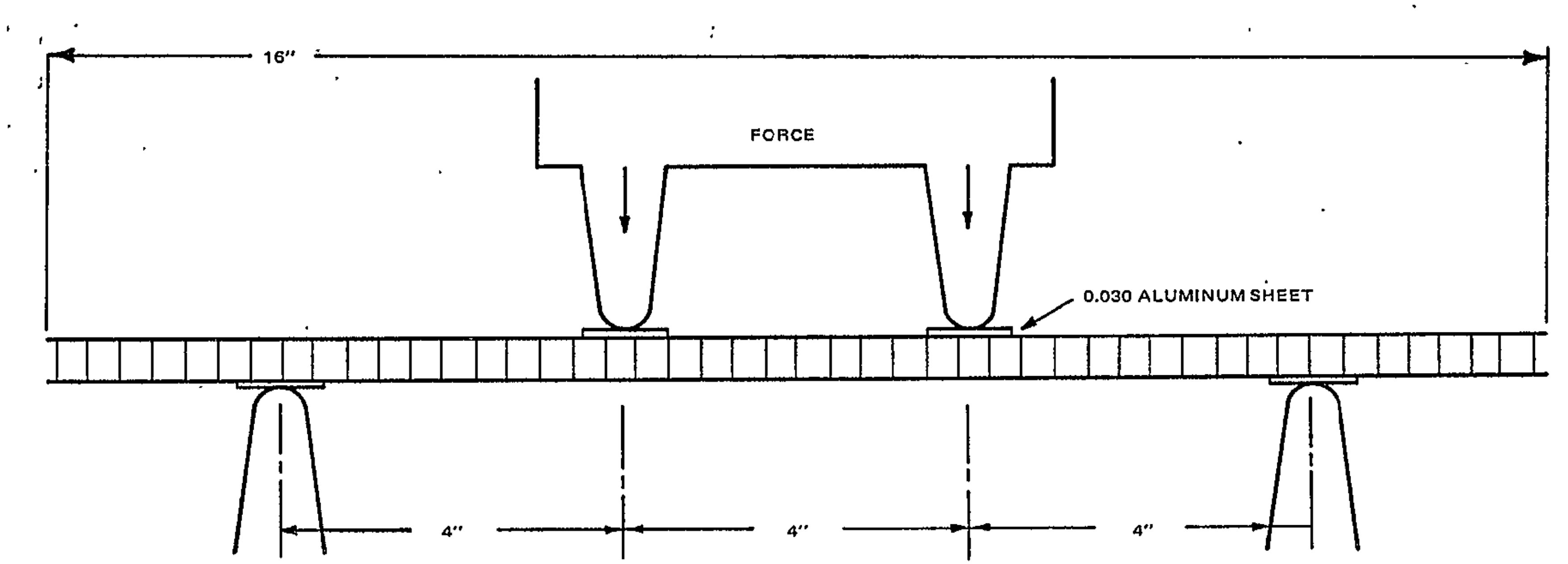


Figure I-2. Platform 017 Heat-Up Rate, Second Cure



$$\text{VALUE/INCH WIDTH} = \frac{\frac{E}{2} \times 4 \text{ MOMENT ARM}}{3 \text{ WIDTH}}$$

Figure I-3. Flexure Test Set-Up

TABLE I-1. FLEXURE TEST DATA, PLATFORM 017

Test Specimen	Force -f (lb)		Force/Inch Width (lb)	
	Front	Rear	Front	Rear
Platform				
Sun Side (bag)	89.0	—	59.3	—
Earth Side (mold)	—	106.0	—	70.6
Transition				
Sun Side (bag)	118.0	—	78.6	—
Earth Side (mold)	—	109.0	—	72.0

TABLE I-2. LAP SHEAR TEST DATA, PLATFORM 017

Test	Force/Square Inch (psi) Sample No.							
	1	2	3	4	5	6	7	8
Platform								
1st Cure	6064	6245	5954	6172	—	—	—	—
2nd Cure	—	—	—	—	6012	6210	6212	6393
Transition								
1st Cure	6315	6147	6274	6400	—	—	—	—
2nd Cure	—	—	—	—	4810	5331	4224	5010
Hat	2004	2322	2089	2028				

3. Peel Strength Test Data

The peel test involves the action of separating a face sheet of the honey comb sandwich from the honey comb itself. The method used is a 90-degree peel test performed in accordance with RCA Dwg. 1846329 (90° Peel Test-Ultralight Adhesive Bonded Honey comb Sandwiches). Acceptance test criteria are shown in Figure I-4; test data are listed in Table I-3.

4. Dimensional Test Data

The platform and transition substrates were dimensionally checked for general overall dimensions and interface dimensions.

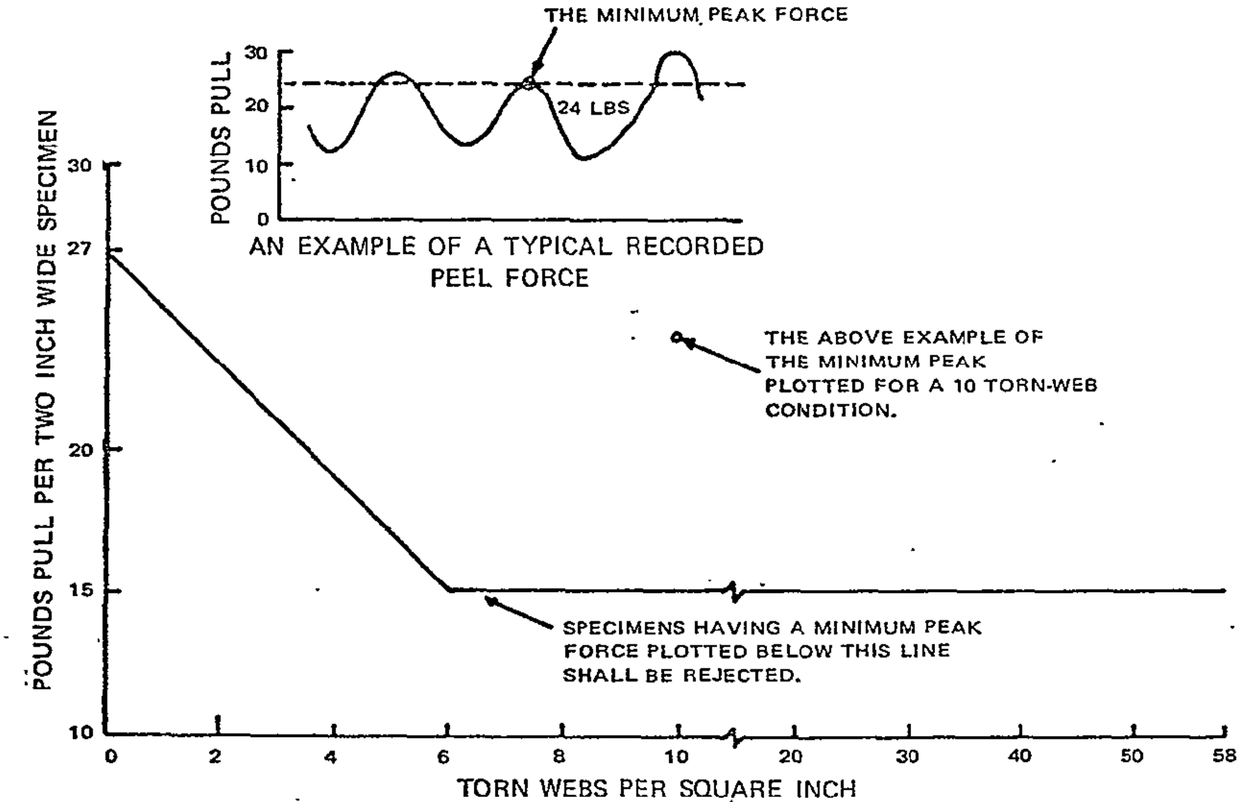


Figure I-4. Peel Test Requirements

TABLE I-3. PEEL TEST DATA, PLATFORM 017

Test Specimen	Pull Force (lb)		Torn Webs			
			(No.)		(%)	
	Sun Side	Earth Side	Sun Side	Earth Side	Sun Side	Earth Side
Platform						
Front Sample	30	30	0	0	0	0
Rear Sample	28	25	29	43	50	75
Transition						
Front Sample	30	35	23	0	40	0
Rear Sample	35	33	29	0	50	0

a. General Overall Dimensions

The majority of the dimensions were either within the specified tolerance or within 30 mils of the specified values. After a review of the parts, the requirements, and the dimensions by a Material Review Board (MRB), the unit was accepted for use. The test results are shown on Figure I-5.

b. Interface Dimensions

Critical interface dimensions are summarized in Table I-4. A complete set of interface dimensions are shown in Figure I-5.

5. Deployment Test Data

In this test, the hinge lines of the platform and transition are joined and pinned in accordance with the applicable drawing, and the force required to rotate the platform from the normal launch position to the deployed position was determined. Deployment requires that the platform move through an arc of 135° while the transition is in a stationary position (See Figure I-6). The torque required to move the platform from the folded (launch position) to the deployed position shall not exceed 18-inch lbs force. The starting torque obtained in four tests and the average running torque are listed in Table I-5. In addition to the four torque tests, the starting and running torque at five angular settings are listed in Table I-6.

6. Weight Data

The completed solar array platform structure which includes the platform, transition and the required hardware must not exceed 21.7 pounds. The weight of the individual parts are listed in Table I-7.

C. PLATFORM 018 ACCEPTANCE TEST REPORT

Acceptance test data was obtained as described in Paragraph B, Platform 017, Acceptance Test Data. Specific test data for platform 018 are contained in the following:

- Heat-up Cure Rates, First and Second Cures Figures I-7 and I-8
- Flexure Test Data Table I-8
- Lap Shear Test Data Table I-9

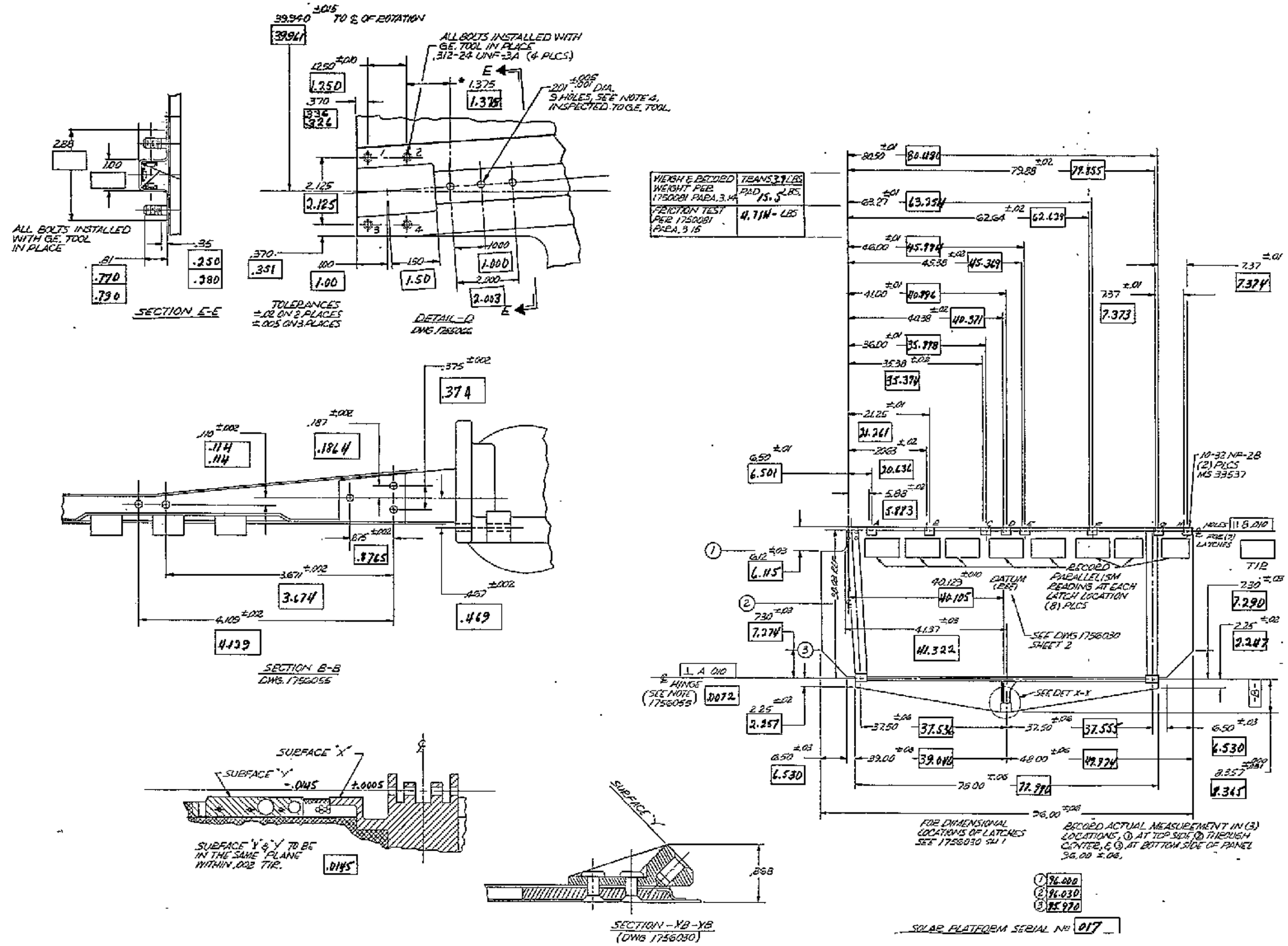
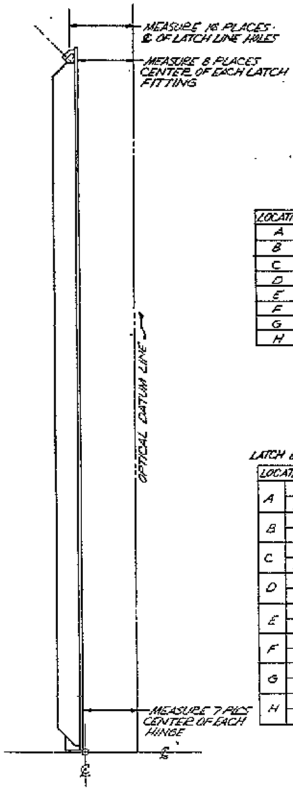


Figure I-5. Platform 017 Dimensional Test Data, Sheet 1 of 3

FOLDOUT FRAME 1

FOLDOUT FRAME 2

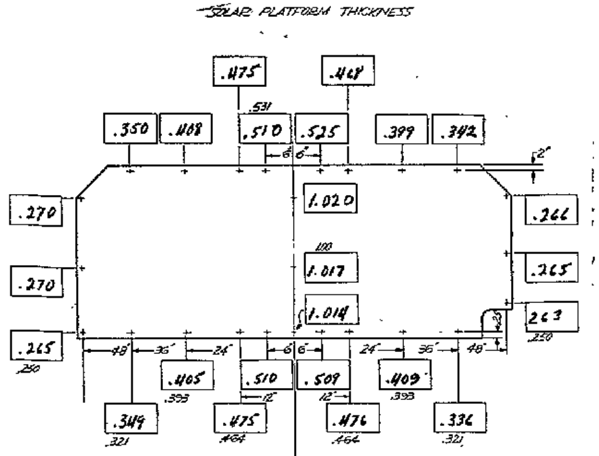


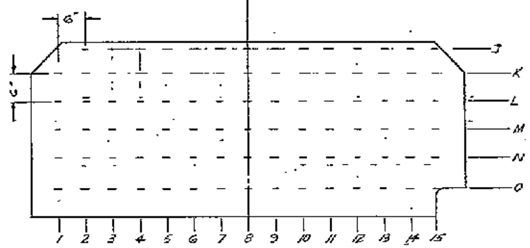
LOCATION	HINGE	LATCH
A	.704	.678
B	.764	.782
C	.792	.759
D	.797	.798
E	.778	.800
F	.776	.796
G	.708	.775
H	—	.715

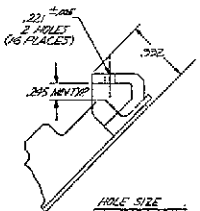
LATCH LINE HOLE

LOCATION		
A	1	1.344
	2	1.344
B	1	1.349
	2	1.352
C	1	1.427
	2	1.441
D	1	1.492
	2	1.484
E	1	CLAMP
	2	1.429
F	1	1.475
	2	1.453
G	1	1.464
	2	1.457
H	1	1.406
	2	1.443

SOLAR PLATFORM THICKNESS

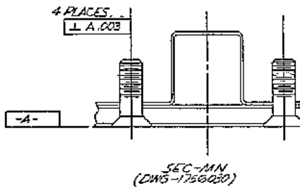






HOLE SIZE

A	.2213	.2214
B	.2217	.2219
C	.2220	.2220
D	.2218	.2218
E	.2217	.2223
F	.2218	.2223
G	.2213	.2215
H		



.392 RECORD MEASURE SEE DETAIL FOR LOCATION

A	
B	
C	
D	
E	
F	
G	
H	

4 HOLE PATTERN BOLT PARALLISM

1	.0035
2	.003
3	.003
4	1.000

SOLAR PLATFORM FLATNESS .122 TIR ↔ .033 TIR ↕

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
J	.062	.035	.014	.010	.020	.031	.047	.045	.047	.045	.033	.023	.014	.032	.070				
K	.055	.026	.003	.016	.029	.037	.049	.048	.050	.045	.039	.028	.066	.020	.053				
L	.051	.020	.002	.019	.030	.039	.049	.048	.050	.046	.036	.026	.005	.019	.044				
M	.036	.016	.012	.020	.031	.040	.047	.050	.049	.044	.038	.026	.007	.019	.046				
N	.043	.017	.000	.021	.031	.042	.042	.052	.048	.046	.038	.026	.006	.027	.053				
O	.051	.028	.006	.014	.025	.038	.037	.048	.045	.042	.033	.018	.063	.030	.065				

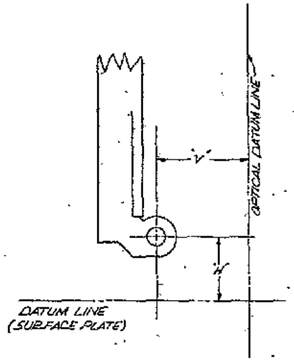
AREA WITHIN DOTTED ZONE ARE MINUS READINGS - ALL OTHERS ARE PLUS

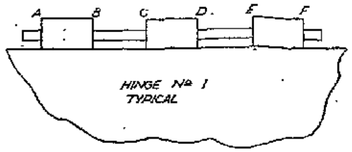
SOLAR PLATFORM SERIAL Nº 017

Figure I-5. Platform 017 Dimensional Test Data, Sheet 2 of 3

FOLDOUT FRAME 1

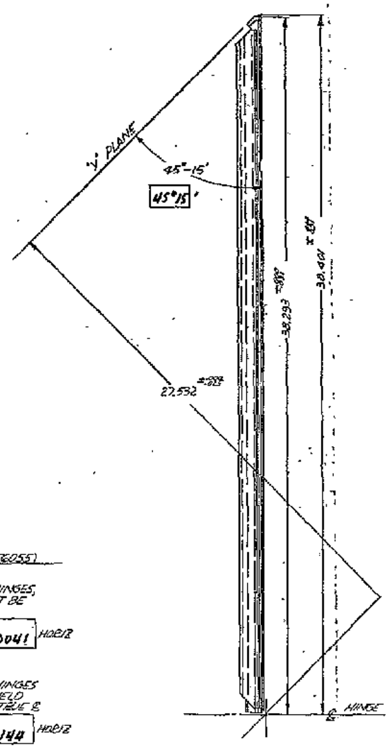
FOLDOUT FRAME 2





"H" HORIZONTAL HINGE LINE
"V" VERTICAL HINGE LINE

MEASURE HINGE LINE AT 6 LOCATIONS AT EACH HINGE FOR VERTICAL AND HORIZONTAL



SOLAR PLATFORM

HINGE Nº	POSITION	VERTICAL	HORIZONTAL
1	A	1.0518	1.1444
	B	1.0548	1.1453
	C	1.0568	1.1456
	D	1.0578	1.1455
	E	1.0588	1.1451
	F	1.0688	1.1445
2	A	1.1128	1.1440
	B	1.1158	1.1465
	C	1.1148	1.1466
	D	1.1168	1.1467
	E	1.1178	1.1463
	F	1.1198	1.1463
3	A	1.1468	1.1409
	B	1.1468	1.1425
	C	1.1468	1.1437
	D	1.1468	1.1439
	E	1.1468	1.1433
	F	1.1468	1.1425
4	A	1.150	1.1411
	B	1.150	1.1412
	C	1.149	1.1413
	D	1.148	1.1413
	E	1.148	1.1412
	F	1.149	1.1412
5	A	1.1508	1.1412
	B	1.1518	1.1432
	C	1.1518	1.1428
	D	1.1518	1.1430
	E	1.1518	1.1428
	F	1.1498	1.1423
6	A	1.1318	1.1451
	B	1.1308	1.1461
	C	1.1308	1.1466
	D	1.1298	1.1466
	E	1.1288	1.1459
	F	1.1258	1.1452
7	A	1.0648	1.1432
	B	1.0618	1.1451
	C	1.0608	1.1466
	D	1.0578	1.1463
	E	1.0548	1.1460
	F	1.0498	1.1454

TRANSITION

HINGE Nº	POSITION	VERTICAL	HORIZONTAL
1	A	1.0758	7.6263
	B	1.0758	7.6263
	C	1.0768	7.6265
	D	1.0778	8.6268
	E	1.0778	7.6273
	F	1.0788	7.6281
2	A	1.0998	7.6335
	B	1.1018	7.6340
	C	1.1028	7.6341
	D	1.1028	7.6301
	E	1.1028	7.6341
	F	1.1028	7.6340
3	A	1.1178	7.6382
	B	1.1168	7.6364
	C	1.1168	7.6352
	D	1.1168	7.6357
	E	1.1168	7.6360
	F	1.1168	7.6367
4	A	1.112	7.6398
	B	1.112	7.6392
	C	1.1122	7.6387
	D	1.112	7.6382
	E	1.112	7.6344
	F	1.112	7.6364
5	A	1.1168	7.6376
	B	1.1158	7.6381
	C	1.1148	7.6381
	D	1.1138	7.6381
	E	1.1128	7.6329
	F	1.1138	7.6378
6	A	1.1058	7.6339
	B	1.1038	7.6339
	C	1.1138	7.6338
	D	1.1028	7.6334
	E	1.1018	7.6331
	F	1.1008	7.6328
7	A	1.0798	7.6264
	B	1.0798	7.6261
	C	1.0798	7.6256
	D	1.0788	7.6254
	E	1.0778	7.6254
	F	1.0768	7.6254

SOLAR PLATFORM (1756030)

NOTE 3:
℄ (3 PER SOLAR PLATFORM) ITEMS 72, 73 & 74 MUST BE COINCIDENT WITHIN ±.002

.0050 VERT ℄ .0054 HORIZ

NOTE 4:
℄ (4 PER SOLAR PLATFORM) ITEM 75 MUST BE COINCIDENT WITHIN ±.004

.1002 VERT ℄ .0056 HORIZ

NOTE 6:
SURFACE "Y" OF ITEMS 76, 77, 78 & 79 TO BE COPLANER WITHIN ±.004

.012

NOTE 9:
HINGE CENTERLINE MUST BE PARALLEL WITH BRACKET SURFACE "Y" PLANE WITHIN ±.004

.208 at 45°-15'

TRANSION (1756055)

NOTE 4:
CENTERLINES OF HINGES, ITEMS 19, 20 & 41 MUST BE HELD WITHIN ±.002

.0058 VERT ℄ .0041 HORIZ
TO TRUE ℄

NOTE 5:
CENTERLINES OF HINGES ITEM 42 MUST BE HELD WITHIN ±.004 OF TRUE ℄

.0862 VERT ℄ .0144 HORIZ

LATCH LOCATIONS

	27.532	38.293	38.401
A	27.346 27.355	38.288 38.295	38.429
B	27.436 27.444	38.312	38.411
C	27.502	38.305 38.308	38.459
D	27.510	38.304 38.300	38.462
E	27.509	38.305	38.487
F	27.485 27.459	38.308 38.310	38.412
G	27.426 27.434	38.308 38.312	38.425
H	27.302 27.314	38.224 38.217	38.426

SOLAR PLATFORM SERIAL Nº 017

Figure I-5. Platform 017, Dimensional Test Data, Sheet 3 of 3

FOLDOUT FRAME 1

FOLDOUT FRAME 2

TABLE I-4. INTERFACE DIMENSIONS, PLATFORM 017

Parameters	Specified (Inches)	Measured Values (Inches)*	
		Platform	Transition
Centerline of 3 center Hinges			
Vertical	±0.002	0.0050	0.0058
Horizontal	±0.002	0.0054	0.0041
Centerline of 4 outer Hinges			
Vertical	±0.004	1.0020	0.0462
Horizontal	±0.004	0.0056	0.1440
Surface Flatness**			
Length	±0.030TIR†	0.122	———
Width	±0.030TIR†	0.038	———

* Out of Tolerance values reviewed by MRB Action. Acceptance based on torque measurement of transition/platform interface.

** Measured on Sun-Side of platform

† Total Indicator Run-out

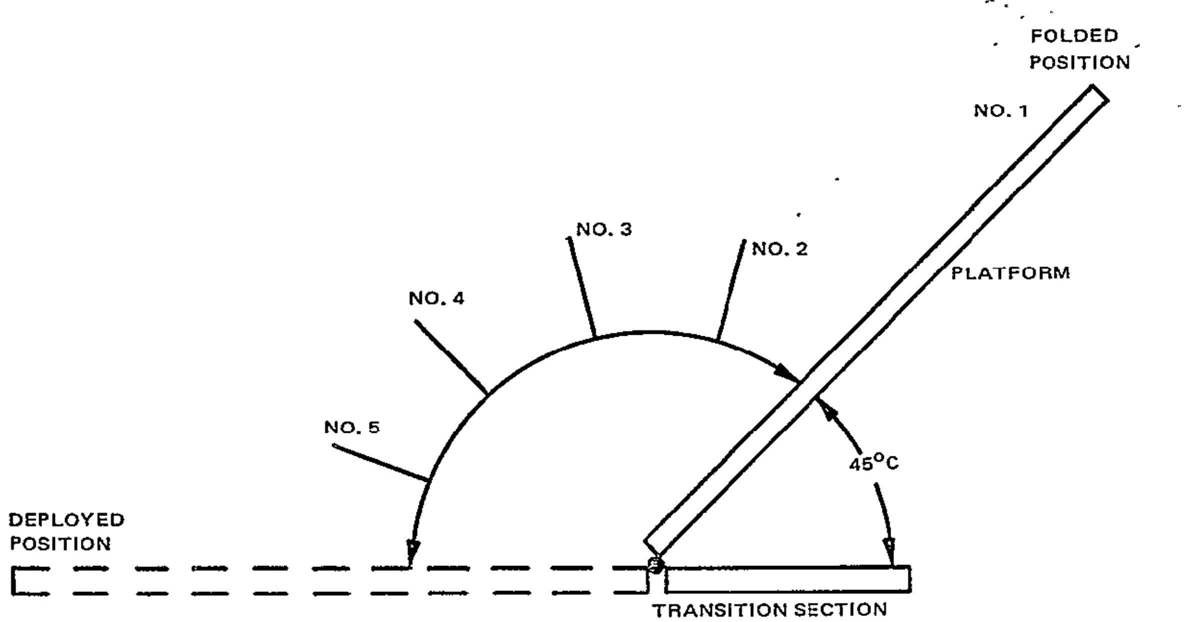


Figure I-6. Deployment Test Positions

TABLE I-5. DEPLOYMENT TEST RESULTS, PLATFORM 017

Run No.	Measured Values (Inch-ounces) at positions					Average Running Torque	
	1	2	3	4	5	(oz f · in)	(oz f · lb)
1	6	7	8	12	10	8.6	5.3
2	4	7	5	8	10	6.8	4.2
3	6	6	8	10	10	8.0	5.0
4	5	6	7	9	10	7.0	4.3

$$\text{*Inch-pounds} = \frac{\text{Torque (inch-ounces)} \times 10}{16}$$

TABLE I-6. ANGULAR DISPLACEMENT TEST RESULTS, PLATFORM 017

Start Position	Starting Torque* (oz f · lb)	Running Torque* (oz f · lb)
1	4	4
2	4	6
3	6	8
4	8	9
5	12	10

$$\frac{\text{*Inch-ounces of torque} \times 10}{16} = \text{Torque (in-lbs)}$$

TABLE I-7. PLATFORM WEIGHT

Item	Weight (lbs)	
	Platform 017	Platform 018
Platform	15.50	15.70
Transition	3.90	4.00
Hinge pins, shims and lock rings	0.07	0.07
Latching assembly, nut clamps and misc hardware	1.40	1.40
Total Weight	20.80	21.17

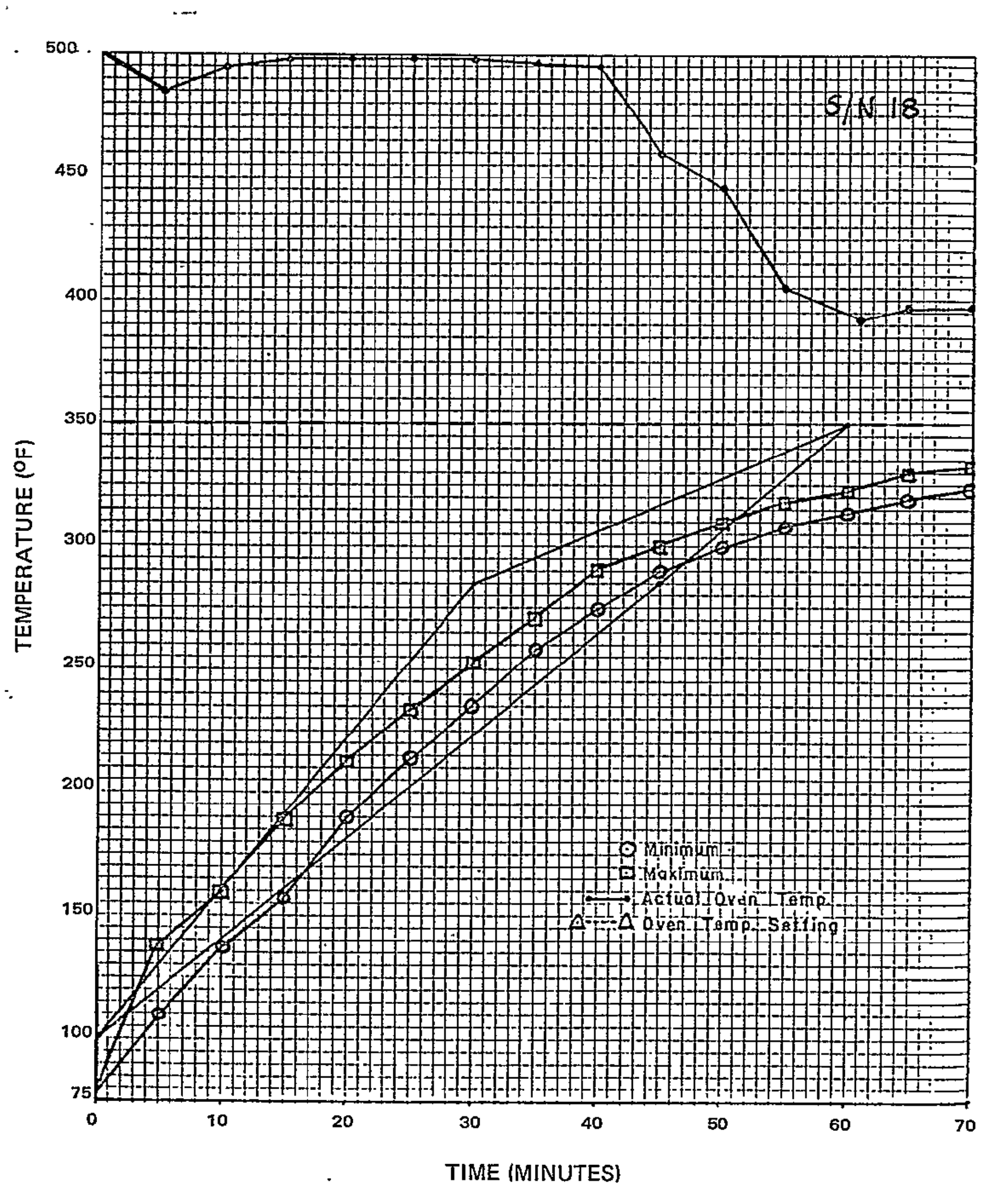


Figure I-7. Platform 018, Heat-Up Rates, First Cure

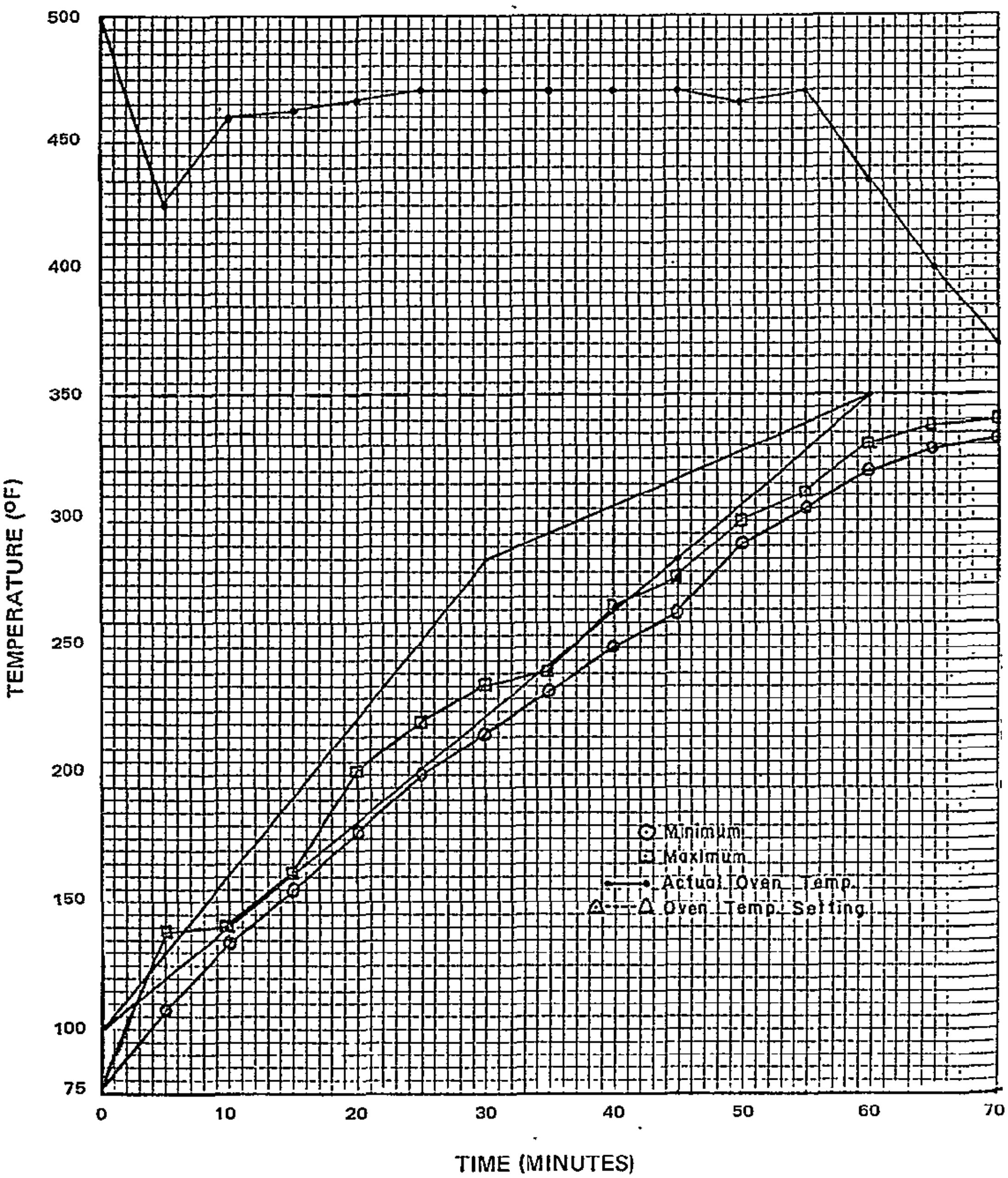


Figure I-8. Platform 018, Heat-Up Rates, Second Cure

TABLE I-8. FLEXURE TEST DATA, PLATFORM 018

Test Specimen	Force (lb)		Force/Inch Width (lb)	
	Front	Rear	Front	Rear
Platform				
Sun Side (bag)	122	—	81.3	—
Earth Side (mold)	—	100	—	66.6
Transition				
Sun Side (bag)	100	—	66.6	—
Earth Side (mold)	—	104	—	69.3

TABLE I-9. LAP SHEAR TEST DATA, PLATFORM 018

Test	Force/Square Inch (psi) for Sample Number							
	1	2	3	4	5	6	7	8
Platform								
1st Cure	5601	5205	5812	6032	—	—	—	—
2nd Cure	—	—	—	—	5639	5182	4785	5351
Transition								
1st Cure	5054	4417	4649	4533	—	—	—	—
2nd Cure	—	—	—	—	3931	4200	3006	3028
Hat	1882	1942	2004	1272	—	—	—	—

• Peel Strength Test Data	Table I-10
• Dimensional Test Data	
a. General Overall Dimensions	Figure I-9
b. Interface Dimensions	Table I-11 and Figure I-9
• Deployment Test Data	Not measured as unit was rejected on basis of peel test data.
• Weight	Table I-7

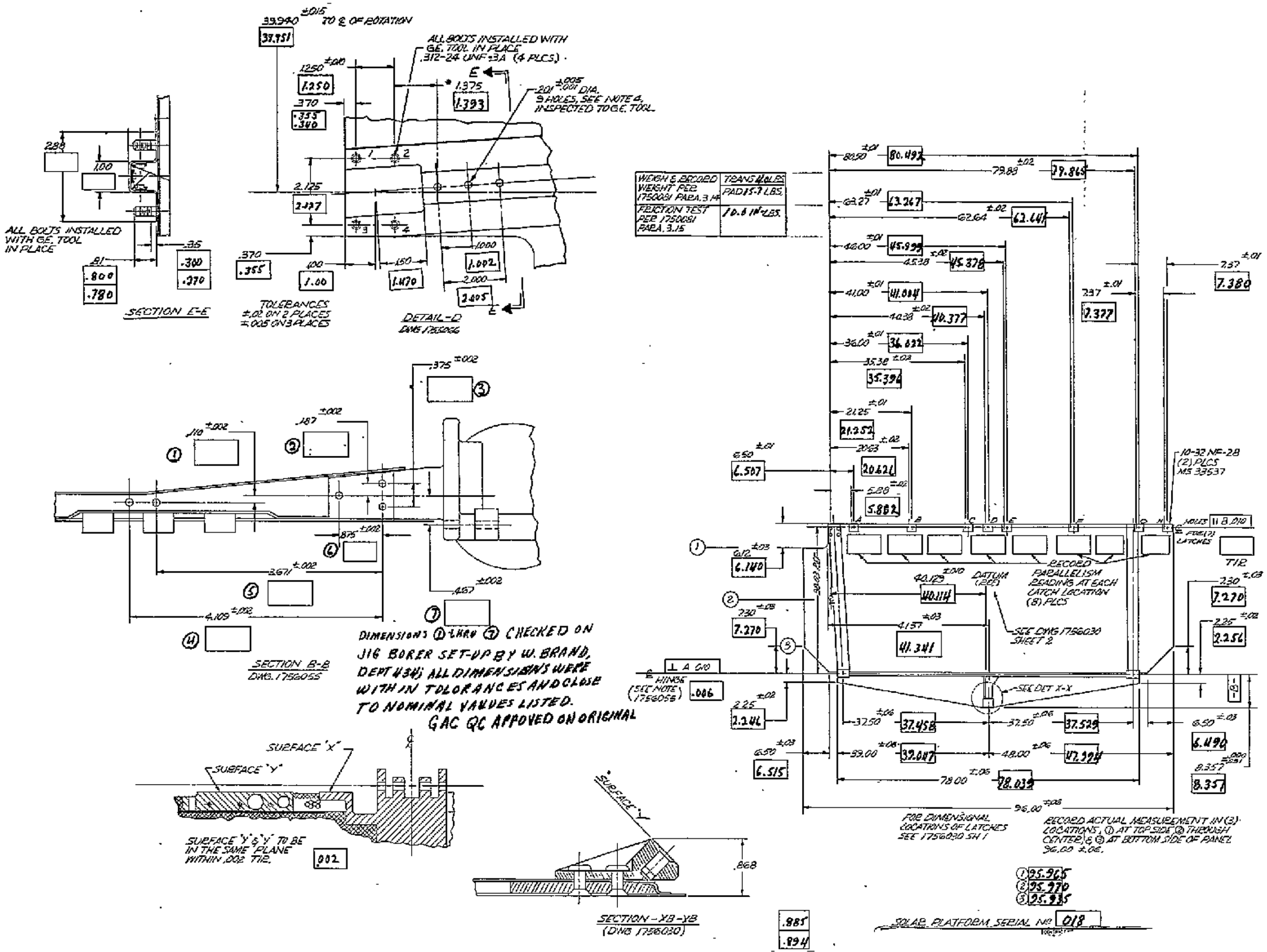
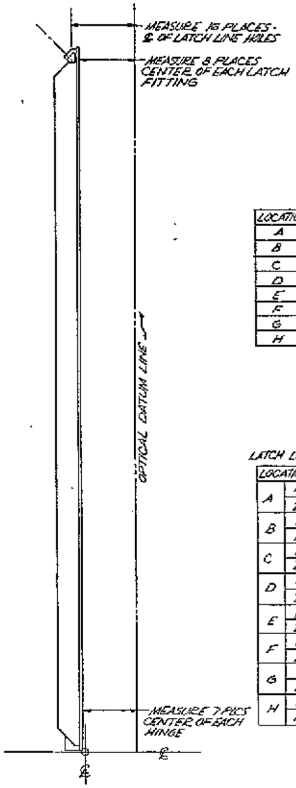


Figure I-9. Platform 018, Dimensional Test Data, Sheet 1 of 3

FOLDOUT FRAME 1

FOLDOUT FRAME 2

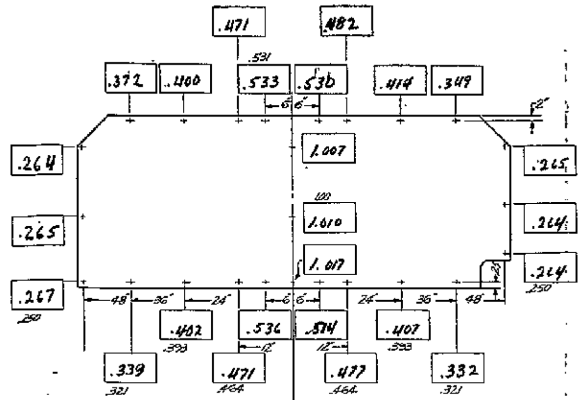


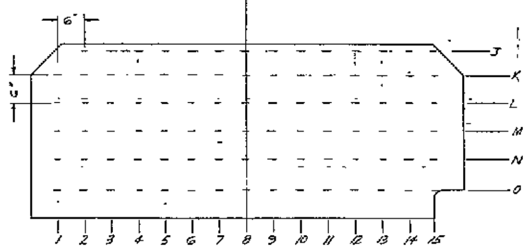
LOCATION	HINGE	LATCH
A	.610	.652
B	.675	.699
C	.701	.704
D	.705	.701
E	.705	.699
F	.678	.656
G	.661	.569
H	—	.512

LATCH LINE HOLE

LOCATION		
A	1	.350
	2	.358
B	1	.396
	2	.398
C	1	.400
	2	.407
D	1	.407
	2	.407
E	1	.403
	2	.397
F	1	.360
	2	.355
G	1	.263
	2	.263
H	1	.206
	2	.183

SOLAR PLATFORM THICKNESS

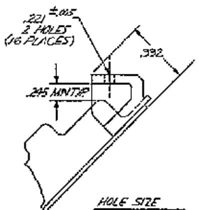




SOLAR PLATFORM FLATNESS .151 TIR.

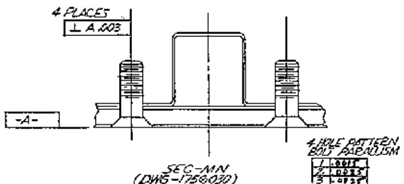
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
J	.064	.019	.012	.036	.056	.065	.066	.068	.063	.058	.050	.030	.009	.021	.062				
K	.066	.019	.011	.036	.053	.064	.069	.070	.070	.063	.055	.035	.022	.013	.040				
L	.068	.021	.007	.034	.049	.064	.067	.070	.070	.065	.060	.044	.027	.004	.035				
M	.073	.027	.006	.031	.049	.063	.068	.074	.073	.070	.062	.057	.030	.001	.030				
N	.078	.032	.002	.031	.047	.063	.070	.073	.073	.074	.067	.056	.032	.019	.024				
O	.052	.038	.018	.025	.043	.058	.063	.071	.071	.072	.065	.056	.035	.008	.022				

AREA BETWEEN DASHED LINES ARE PLUS READINGS - ALL OTHERS ARE NEGATIVE



HOLE SIZE

A	.221	.221
B	.221	.222
C	.221	.221
D	.222	.221
E	.221	.221
F	.221	.221
G	.221	.221
H	—	—



.392

A	
B	
C	
D	
E	
F	
G	
H	

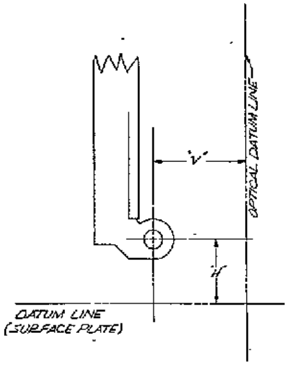
RECORD MEASURE SEE DETAIL FOR LOCATION

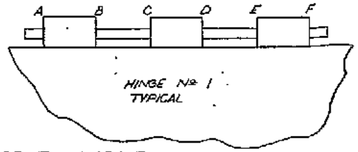
4 HOLE PATTERN BOLT PARALLISM

1	.0015
2	.0025
3	.0025
4	.0020

SOLAR PLATFORM SERIAL NO 018

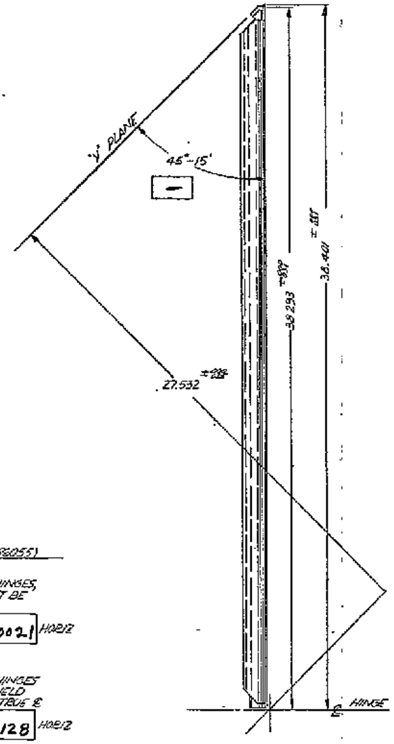
Figure I-9. Platform 018, Dimensional Test Data, Sheet 2 of 3





"H" HORIZONTAL HINGE LINE
"V" VERTICAL HINGE LINE

MEASURE HINGE LINE AT ℄ LOCATIONS AT EACH HINGE FOR VERTICAL AND HORIZONTAL.



I SOLAR PLATFORM

HINGE Nº	POSITION	VERTICAL	HORIZONTAL
1	A	.5508	1.9463
	B	.5568	1.9407
	C	.5598	1.9408
	D	.5658	1.9410
	E	.5698	1.9412
	F	.5718	1.9413
2	A	.6248	1.9428
	B	.6288	1.9430
	C	.6298	1.9483
	D	.6308	1.9436
	E	.6308	1.9434
	F	.6318	1.9431
3	A	.6588	1.9378
	B	.6598	1.9388
	C	.6608	1.9394
	D	.6608	1.9399
	E	.6618	1.9402
	F	.6628	1.9404
4	A	.6571	1.9382
	B	.6581	1.9380
	C	.6581	1.9378
	D	.6591	1.9375
	E	.6610	1.9374
	F	.6601	1.9372
5	A	.6618	1.9373
	B	.6618	1.9378
	C	.6628	1.9381
	D	.6638	1.9383
	E	.6638	1.9387
	F	.6638	1.9375
6	A	.6668	1.9397
	B	.6348	1.9407
	C	-.6328	1.9413
	D	.6318	1.9418
	E	.6308	1.9420
	F	.6288	1.9422
7	A	.5668	1.9379
	B	.5648	1.9385
	C	.5628	1.9389
	D	.5598	1.9393
	E	.5558	1.9394
	F	.5508	1.9401

TRANSITION

HINGE Nº	POSITION	VERTICAL	HORIZONTAL
1	A	3.3468	17.7719
	B	3.3478	17.7735
	C	3.3488	17.7738
	D	3.3498	17.7738
	E	3.3508	17.7738
	F	3.3518	17.7738
2	A	3.3818	17.7772
	B	3.3838	17.7785
	C	3.3838	17.7781
	D	3.3858	17.7782
	E	3.3868	17.7791
	F	3.3868	17.7780
3	A	3.3978	17.7831
	B	3.3978	17.7833
	C	3.3988	17.7833
	D	3.3978	17.7831
	E	3.3978	17.7828
	F	3.3958	17.7826
4	A	3.388	17.7847
	B	3.388	17.7846
	C	3.390	17.7842
	D	3.391	17.7839
	E	3.390	17.7836
	F	3.391	17.7835
5	A	3.3938	17.7847
	B	3.3928	17.7837
	C	3.3918	17.7832
	D	3.3898	17.7833
	E	3.3898	17.7837
	F	3.3898	17.7847
6	A	3.3688	17.7806
	B	3.3708	17.7798
	C	3.3698	17.7792
	D	3.3698	17.7789
	E	3.3688	17.7791
	F	3.3678	17.7796
7	A	3.3498	17.7744
	B	3.3488	17.7743
	C	3.3468	17.7744
	D	3.3476	17.7741
	E	3.3478	17.7734
	F	3.3468	17.7719

SOLAR PLATFORM (1756030)

NOTE 3:
℄ (3 PER SOLAR PLATFORM) ITEMS 72, 73 & 74 MUST BE COINCIDENT WITHIN ± .002
.0057 VERT & .0032 HORIZ

NOTE 4:
℄ (4 PER SOLAR PLATFORM) ITEM 75 MUST BE COINCIDENT WITHIN ±.004
.1093 VERT & .0064 HORIZ

NOTE 6:
SURFACE "V" OF ITEMS 76, 77, 78 & 79 TO BE COPLANER WITHIN ±.004
.1128

NOTE 3:
HINGE CENTERLINE MUST BE PARALLEL WITH BRACKET SURFACE "Y" PLANE WITHIN ±.004
.2198

TRANSION (1756055)

NOTE 4:
CENTERLINES OF HINGES, ITEMS 19, 20 & 41 MUST BE HELD WITHIN ±.002
.004 VERT & .0021 HORIZ
TO TRUE ℄

NOTE 5:
CENTERLINES OF HINGES ITEM 42 MUST BE HELD WITHIN ±.004 OF TRUE ℄
.052 VERT & .0128 HORIZ

LATCH LOCATIONS

	27.532	38.293	38.401
A	27.450 27.450	38.245	38.381
B	27.509 27.512	38.265	38.392
C	27.529 27.523	38.268	38.390
D	27.579 27.528	38.262	38.398
E	27.525 27.521	38.265	38.391
F	27.472 27.461	38.264	38.379
G	27.377 27.366	38.262	38.367
H	27.335 27.343	38.189	38.373

SOLAR PLATFORM SERIAL Nº 018

Figure I-9. Platform 018. Dimensional Test Data, Sheet 3 of 3

TABLE I-10. PEEL TEST DATA, PLATFORM 018

Test Specimen	Pull Force (lb)		Torn Webs			
			(No.)		(%)	
	Sun Side	Earth* Side	Sun Side	Earth Side	Sun Side	Earth Side
Platform						
Front Sample	35	38	9	0	14	0
Rear Sample	30	22	0	0	0	0
Transition						
Front Sample	30	25	45	42	80	75
Rear Sample	21	19	14	49	24	85

*Underlined value out-of-tolerance

TABLE I-11. INTERFACE DIMENSIONS, PLATFORM 018

Parameters	Specified (Inches)	Measured Values* (Inches)	
		Platform	Transition
Centerline of 3 Center Hinges			
Vertical	±0.002	0.0057	0.0040
Horizontal	±0.002	0.0032	0.0021
Centerline of 4 Outer Hinges			
Vertical	±0.004	0.1093	0.0520
Horizontal	±0.004	0.0064	0.0128
Surface Flatness**			
Length	0.030TIR†	0.151	———
Width	0.030TIR†	0.040	———

* Out of tolerance values reviewed by MRB Action. Acceptance based on torque measurement of transition/platform interface.

** Measured on Sun Side of Platform.

† Total Indicator Run-out

D. PLATFORM 018 DATA REVIEW

The data shown on charts 1 through 27 was shown at a presentation conducted at the Goddard Space Flight Center to consider an RCA recommendation that an MRB action be undertaken to waive the specification limit for the sample coupons of platform 018. Where necessary, a technical description explaining this is presented below the chart.

MATERIALS OF CONSTRUCTION

SKINS-SUN SIDE	5052-H-19 .0037 THK. (ONE SURFACE TREATED WITH TEDLAR)
EARTH SIDE	5052-H-19 .0037 THK
HONEYCOMB	1/4 X .001P-5052
	5/16 X .001P-5052
	1/8 X .001P-5052
	1/8 X .002P-5052
ADHESIVE	BLOOMINGDALE FM-1000 .045 LBS/SQ.FT. (.006 THK)
	BLOOMINGDALE HT-424 TYPE II FOAM

Chart I-1

Discussion: Chart I-1 contains a summary of the materials of construction. Additional data are contained in Appendix III, Paragraph B of Quarterly Technical Report No. 5, (R3443) issued June 18, 1969.

MATERIAL PROPERTIES

ALLOY		ALUM 5052
COEF OF THER. EXP. (68-212) PER DEG. F		13.2×10^{-6}
MOD OF ELASTICITY IN TENSION PSI		10.2×10^{6}
TENSILE STRENGTH (75°F) 1000 PSI	HARD	39 (H38)
	HARD	45 (H39)
YIELD STRENGTH (75°F) 1000 PSI	ANNEALED (O)	13
	HARD	33 (H38)
ELONGATION (IN 2IN, 75°F)%	ANNEALED	28
	HARD	3 (H38)
SHEAR STRENGTH 1000 PSI	ANNEALED	18
	HARD	23 (H38)

Chart I-2

Discussion: Chart I-2 contains a summary of aluminum alloy 5052 characteristics as supplied by the vendor.

VALUE OF SKIN MATERIAL	TENSILE PSI	YIELD PSI	% ELONGATION (0.2% OFFSET)
I AS REC'D			
BARE 1	48700	46000	6.0
2	48200	45400	3.0
3	48200	44900	4.0
II STABILIZED			
BARE 1	45700	43000	9
2	45400	43000	11
3	45700	43000	9
III AS REC'D			
TEDLAR 1	51900	48700	6
COATED 2	51900	48100	5
3	51900	48100	6
IV STABILIZED			
TEDLAR 1	49500	45700	10.0
2	49200	45400	10.0
3	50000	46300	10.0

TEST METHOD NO. 151 METHOD 211.1
TYPE F2 (FEDERAL).

Chart I-3

Discussion: Chart I-3 contains the test results obtained from 12 samples of aluminum alloy 5022. The method of test is listed on the bottom of the chart.

PROCESSING

SURFACE PREPARATIONS

SOLUTIONS

ALKALINE CLEANER

TURCO AVIATION
TAP WATER

ETCH

SODIUM DICHROMATE	4 PBW
SULPHURIC ACID (1.84 SP.GR.)	10 PBW
TAP WATER	30 PBW

RINSE WATER (DEMINERALIZED)

STEPS

1. DEGREASE IN TRICHLOROETHYLENE TANK
2. CLEAN PARTS IN SOLUTION MAINTAINED AT 170-190° F FOR A PERIOD OF 8 TO 10 MINUTES
3. SOAK IN WATER MAINTAINED AT 110 TO 120°F FOR 2 MINUTES
4. RINSE WITH WATER
5. ETCH IN SOLUTION MAINTAINED AT 140-150° F FOR A PERIOD OF 9 TO 11 MINUTES
6. SOAK IN WATER MAINTAINED AT 110 TO 120°F FOR 2 MINUTES
7. TAP WATER RINSE
8. WATER BREAK TEST

Chart I-4

Discussion: Chart I-4 outlines the cleaning process used during fabrication of the distruct, 017, and 018 substrates. The cleaning process was subsequently revised during a special test program. Refer to Paragraph E2 of this appendix.

PROCESSING

BONDING SEQUENCE

A CLEAN SKINS AND SHEET METAL PARTS
B DEGREASE CORE
C ASSEMBLE 1ST SKIN, CORE & SHEET METAL PARTS
D JOIN 1ST SKIN, CORE, SHEET METAL & MACHINED PARTS ALONG WITH ADHESIVES INTO MOLD
E APPLY VACUUM BAG & VACUUM (20 to 22 in.)
F PLACE MOLD, PARTS INTO PRE HEATED OVEN
G RAISE TEMP OF MOLD & GLUE LINE TO 340° F WITHIN 60 MINUTES
H CURE GLUE LINE FOR 45-50 MINUTES BETWEEN 340 TO 350 °F VACUUM APPLIED DURING ENTIRE TIME
I PLACE THERMAL BLANKET ONTO TOP SURFACE OF MOLD AT COMPLETION OF CURE PERIOD
J COOL MOLD & GLUE LINE TO 180°F WITH VACUUM APPLIED. COOLING RATE 1° PER MINUTE
K BOND SECOND SKIN FOLLOWING STEPS A, THROUGH J

Chart I-5

Discussion: Chart I-5 summarizes the bonding and curing process for both the first and second cure.

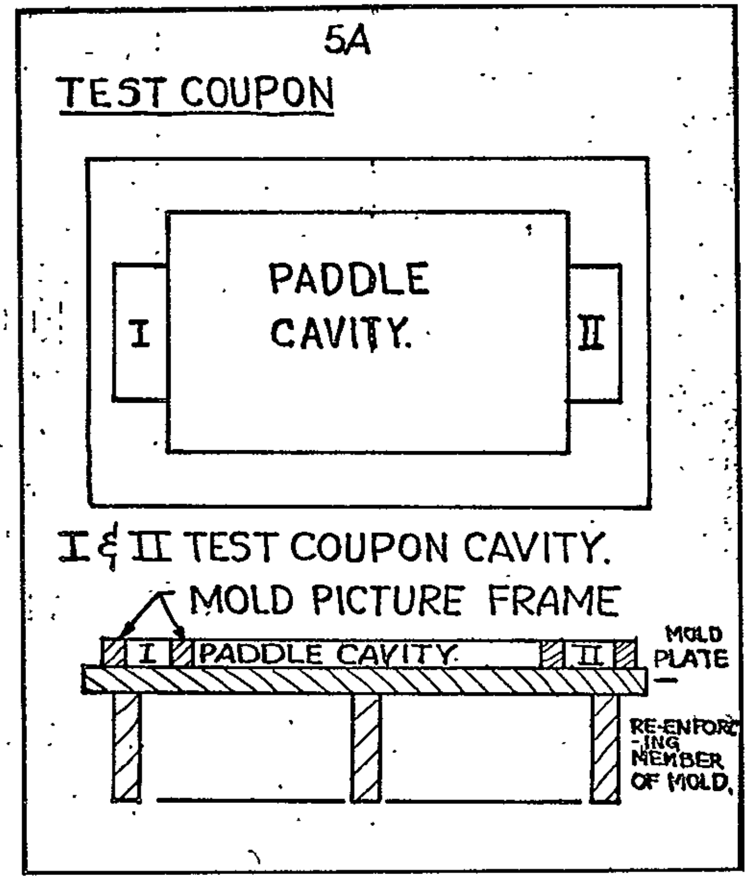


Chart I-6

Discussion: Chart I-6 delineates the relationship of the sample coupons prepared with the platform substrate. These coupons are destruct-tested to verify the quality of the substrate.

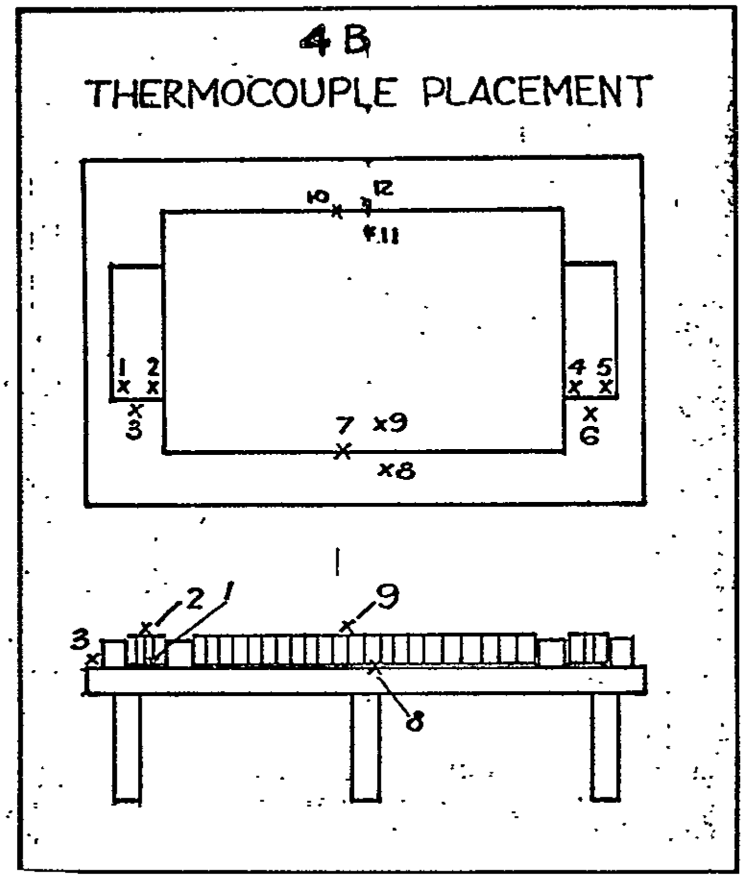


Chart I-7

Discussion: Chart I-7 delineates the location of the thérmo-couples used to monitor the substrate temperatures during both the first cure and the second cure.

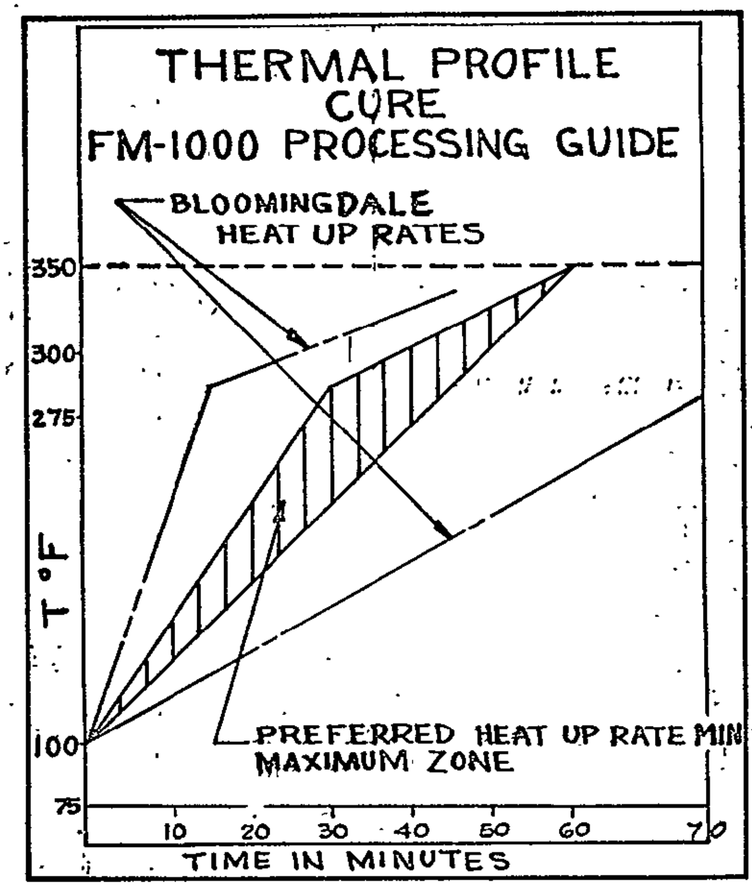


Chart I-8

Discussion: Chart I-8 presents the adhesive heat-up rate recommended by the vendor and the preferred heat-up rate specified for the Nimbus substrate. A discussion of the preferred heat-up rate is contained in Appendix III, Paragraph E5 of Quarterly Technical Report No. 5 (R3443) issued June 18.

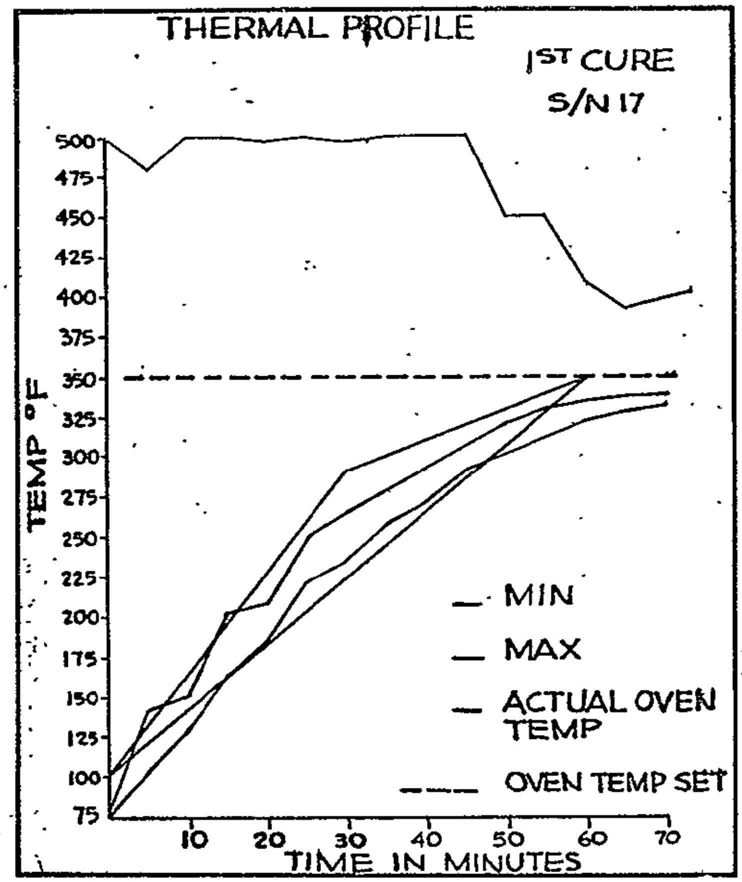


Chart I-9

Discussion: Chart I-9 shows the heat-up rate for the first cure of the 017 substrate, which was supplied for reference purposes. A detailed heat-up curve is shown on Figure I-1 of this appendix.

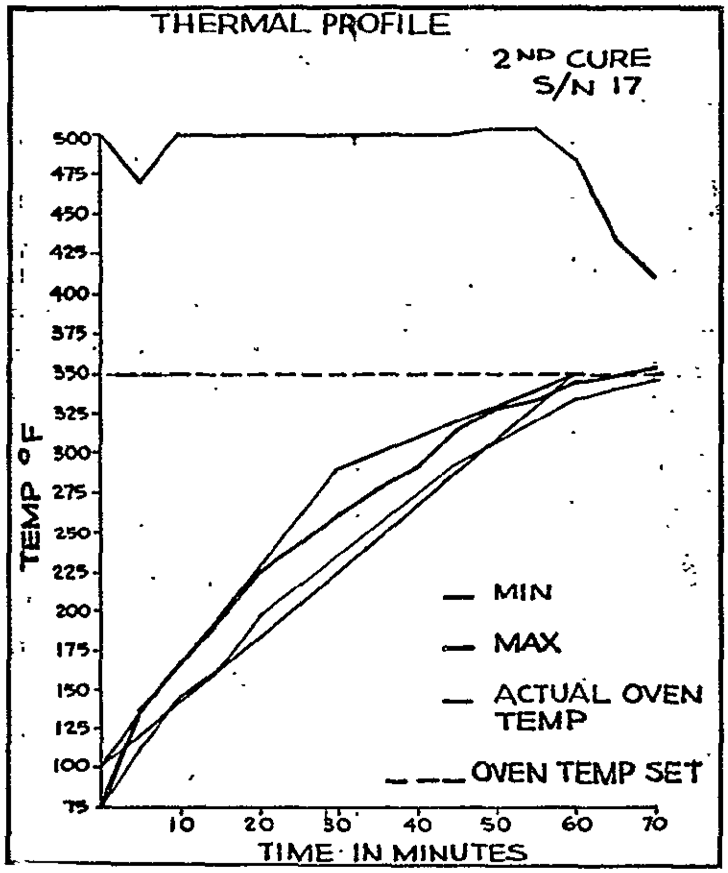


Chart I-10

Discussion: Chart I-10 shows the heat-up rate for the second cure of the 017 substrate, which was supplied for reference purposes. A detailed heat-up curve is shown on Figure I-2 of this appendix.

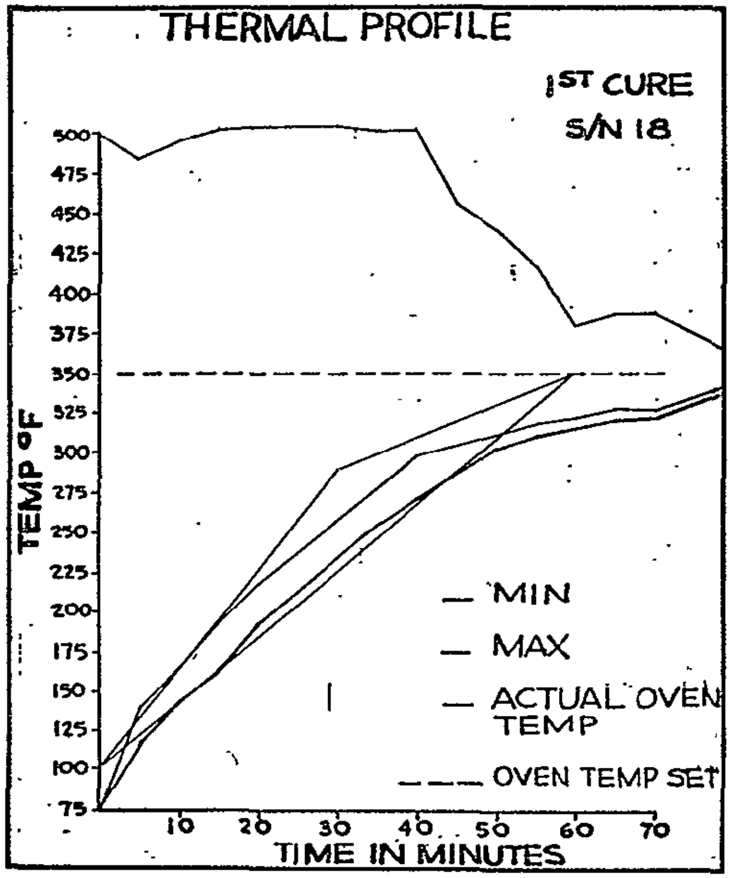


Chart I-11

Discussion: Chart I-11 shows the heat-up rate for the first cure of the 018 substrate. Detailed heat-up curves are shown in Figure I-7 of this appendix.

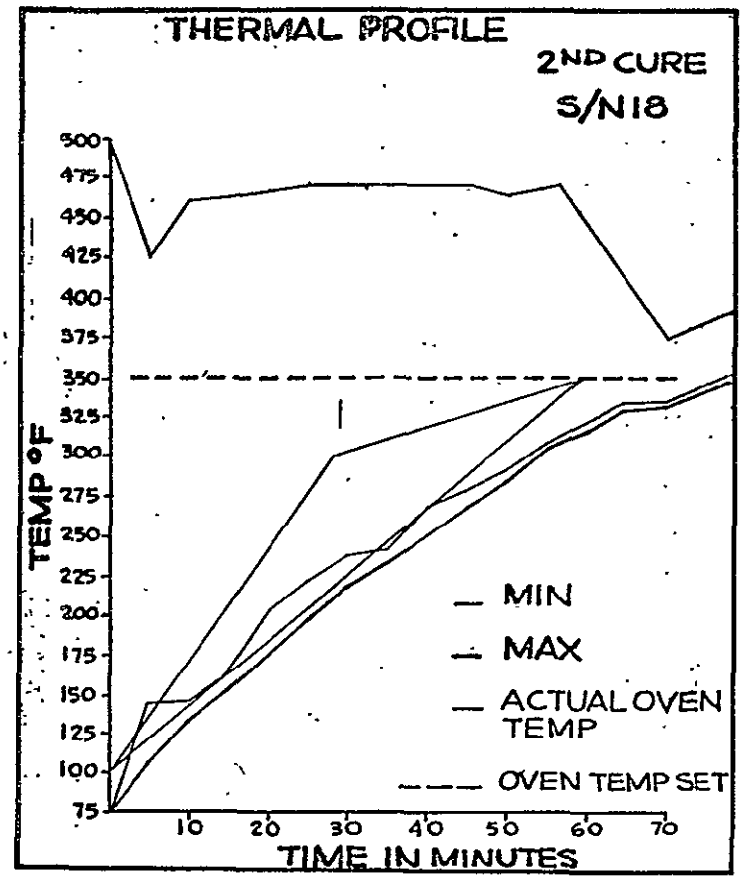


Chart I-12

Discussion: Chart I-12 shows the heat-up rate for the second cure of the 018 substrate. Detailed heat-up curves are shown in Figure I-8 of this appendix.

SAMPLE PREPARATION

TWO TYPE SAMPLES ARE PREPARED DURING THE PROCESSING OF THE PADDLE

I TEST COUPON

THESE UNITS (2) ARE PREPARED IN THE MOLD SIMULTANEOUSLY WITH THE PADDLE. THE SAME MATERIALS OR CONSTRUCTION AND SURFACE PREPARATION UTILIZED FOR THE PADDLE ARE EMPLOYED IN THEIR PREPARATION. (5052-H-19)

II LAP SHEAR SPECIMENS

THESE SAMPLES (4) ARE PREPARED ON THE MOLDS SURFACE AT THE SAME TIME AS THE PADDLE. ONE SET FOR FIRST CURE AND ONE SET DURING SECOND CURE. THE CLEANING ETC IS IDENTICAL TO THAT USED FOR PANEL METALLIC PARTS. THESE SAMPLES ARE STD. SAMPLE SPECIMEN BLANKS MADE FROM 2024 T3 ALLOY

Chart I-13

Discussion: Chart I-13 delineates the types of sample coupons prepared in conjunction with the substrate.

TESTS

LAP SHEAR
FLEXURE
PEEL

PURPOSE

LAP SHEAR - DATA DERIVED FROM THIS TEST INDICATES
1. ADHESIVE CAPABILITY
2. CHECKS CLEANING METHOD
3. CHECKS CURE TIME & TEMP & PRESSURE

FLEXURE - DATA DERIVED FROM THIS TEST DEMONSTRATES THE STRENGTH OF THE BONDED HONEYCOMB SANDWICH

PEEL - DATA DERIVED FROM THESE TESTS PROVIDES.
1. CHECK OF PROCESSING TECHNIQUE THAT INDICATE WHETHER PROCESS IS IN CONTROL
2. FAILURE MODE OF HONEYCOMB SANDWICH SYSTEM

Chart I-14

Discussion: Chart I-14 defines the tests and the purpose of the tests conducted on the sample coupons. Detailed discussions of the tests are contained in Appendix III, Paragraph G of Quarterly Technical Report No. 5, (R3443) issued June 18, 1969.

HONEYCOMB TESTING

YEAR	PROGRAM	VENDOR	TEST PEEL	TEST FLEX	TEST LAP
1961-62	NIMBUS	GOODYEAR	CLIMBING DRUM	MIL-STD 401	MIL-A-5090
1963	NIMBUS	MARTIN	"	"	"
1963	L.O.	RYAN	90°	"	"
1964-65	L.O.	MURDOCK	90°	"	"
1968-69	TIROS M	MURDOCK	90°	"	"
1968-69	NIMBUS	GOODYEAR	90°	"	"

Chart I-15

Discussion: Chart I-15 summarizes RCA experience related to substrate fabrication and test.

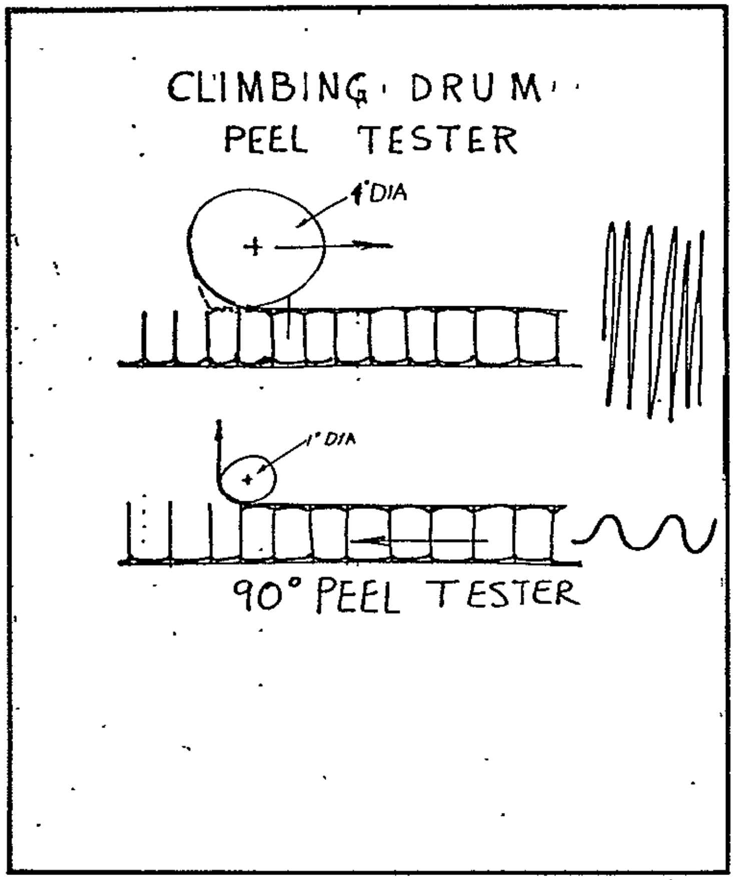


Chart I-16

Discussion: Chart I-16 illustrates the two methods of conducting peel tests.

COMPARISON OF PEEL TEST METHODS								
NO. OF	ADHESIVE	ROLLING DRUM			90°			
TESTS	WT	MIN	AVG	MAX	MIN	AVG	MAX	
4	.025	4.1	5.4	8.0				(1)
3	.025				3.4	4.8	8.1	(1)
7	.040		12.5					(2)
10	.040				6.2	11.6	18.2	(2)
8	.060		12.4					(1)
4	.060				6.6	11.0	16.2	(1)
3	.040		10.6					(2)
6	.040	8.7	13.2	18.5				
6	.040				6.1	7.8	9.9	(3)

(1) 20% CORE
80% ADHESIVE
(2) 40% CORE
60% ADHESIVE
(3) 100% ADHESIVE

Chart I-17

Discussion: Chart I-17 lists the test results obtained from a series of tests conducted with each peel test method.

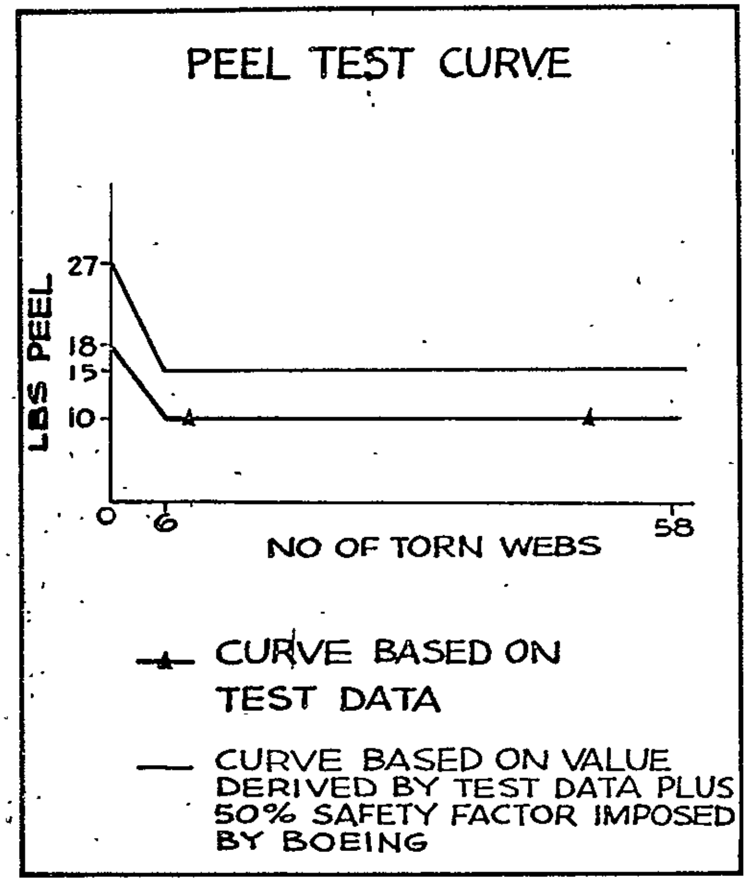


Chart I-18

Discussion: Chart I-18 shows the peel test limits established by analysis of test data obtained on the Nimbus program and the test limits containing a 50-percent safety factor for the Luner Orbiter program.

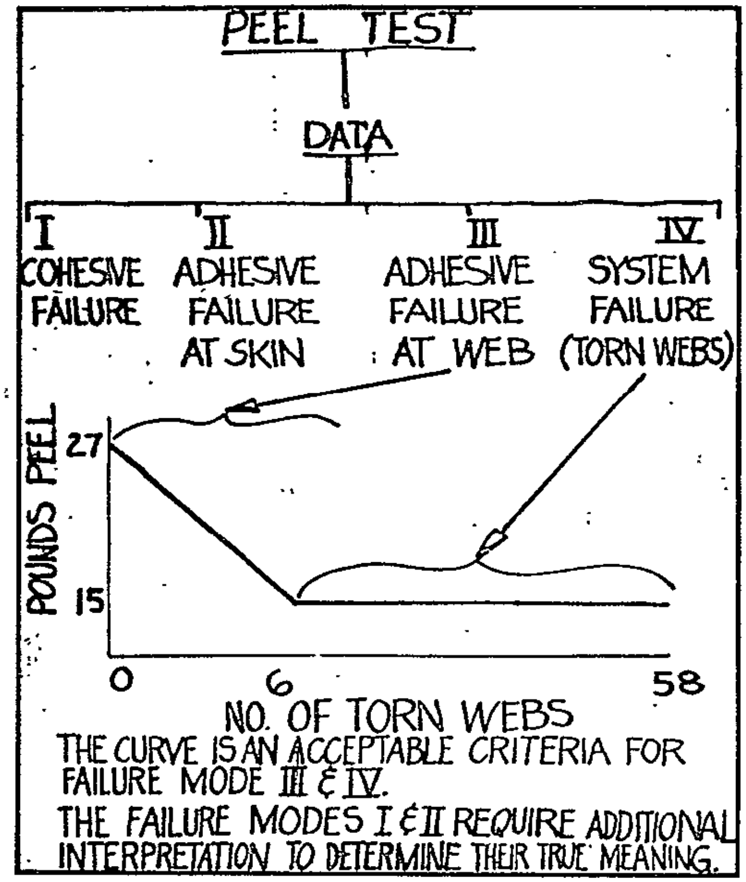


Chart I-19

Discussion: Chart I-19 defines the various failure modes experienced during peel tests.

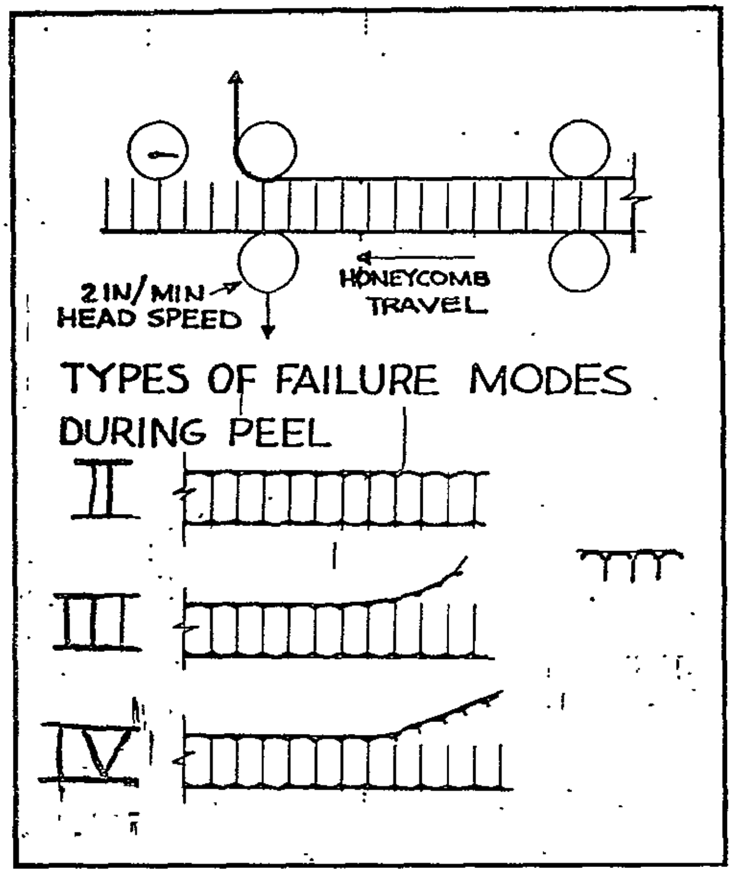
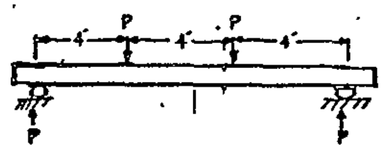


Chart I-20

Discussion: Chart I-20 shows pictorial views of the failure modes defined by Chart I-19.

FLEXURAL TEST



a) INTERCELLULAR BUCKLING

$F_{CR} = .943E(\frac{t}{s})^{3/2} = 17{,}000$ PSI FOR $\begin{cases} t = .0037 \text{ INCHES} \\ E = 10^7 \text{ PSI} \\ S = .25 \text{ INCHES} \end{cases}$

BENDING MOMENT = $F_{CR} t h$ = 31 IN-LB/IN.

CORRESPONDING $P = \frac{31}{4}$

(b) SHEAR STRESS (ADHESIVE TO CORE)

$f_s = \frac{P}{.013h} = 154P$ for h = .50 IN.

for P = 7.5 Lb (M = 30 $^{Lb\text{-}IN/IN}$), f_s = 1150 PSI

for P = 16.5 Lb (M = 66 $^{Lb\text{-}IN/IN}$), f_s = 2540 PSI

for FM 1000, F_s = 2500 PSI

Chart I-21

Discussion: Chart I-21 defines the flexure and sheer test requirements.

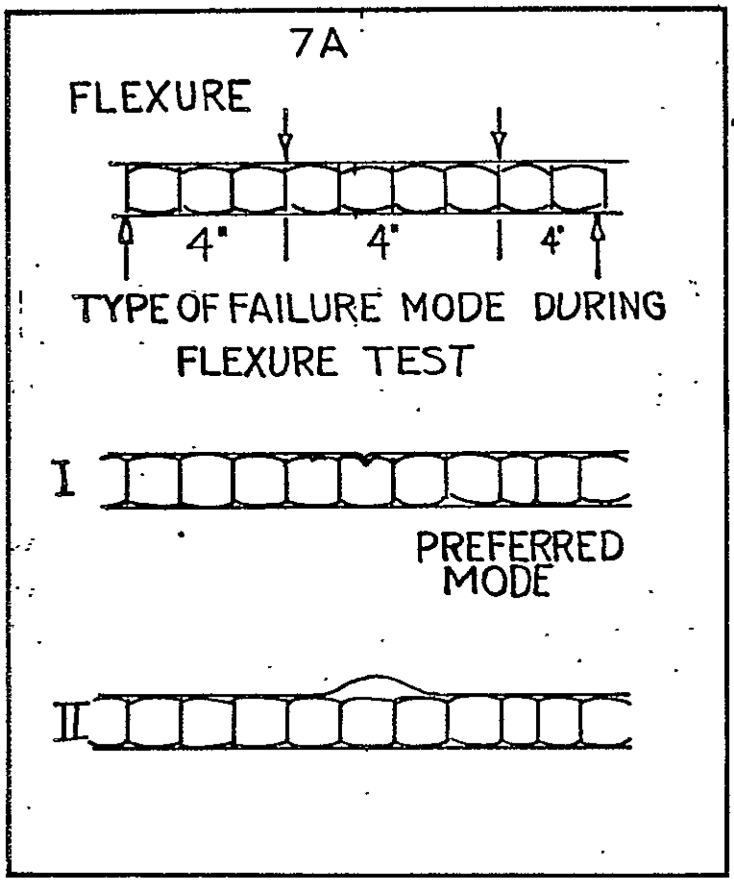


Chart I-22

Discussion: Chart I-22 illustrates the preferred failure mode for the flexure test. Detailed descriptions of the flexure and sheer tests are contained in Appendix III, Paragraph G of Quarterly Technical Report No. 5, (R3443) issued June 18, 1969.

8B

UNIT	LEFT HAND FLIGHT S/N 17			
PART	TRANSITION		PADDLE	
SAMPLE	FRONT	BACK	FRONT	BACK
PEEL TEST				
BAG SIDE	30	35	30	28
MOLD SIDE	35	33	30	25
TORN WEBS				
BAG SIDE	23	29	0	29
MOLD SIDE	0	0	0	43
%TORN WEBS				
BAG SIDE	40	50	0	50
MOLD SIDE	0	0	0	75
FLEXURE				
BAG SIDE	118		89	
MOLD SIDE		109		106
VAL/IN.WIDTH				
BAG SIDE	78.6		59.3	
MOLD SIDE		72.0		70.6

LAP SHEAR SAMPLE	1	2	3	4	5	6	7	8
1ST CURE (P)	6064	6245	5954	6072				
2ND CURE (P)					6012	6210	6212	6393
1ST CURE (T)	6315	6197	6274	6400				
2ND CURE (T)					4810	5331	4224	5010

Chart I-23

Discussion: Chart I-23 contains a summary of sample coupon test results for substrate 017, which were supplied for reference purposes.

NIMBUS "D"
SOLAR ARRAY PLATFORMS
PEEL, FLEXURE & LAP SHEAR TEST DATA

UNIT	RIGHT HAND FLIGHT S/N 18			
PART	TRANSITION		PADDLE	
SAMPLE	FRONT	BACK	FRONT	BACK
PEEL TEST				
BAG SIDE	30	21	35	30
MOLD SIDE	25	18	38	22
TORN WEBS				
BAG SIDE	45	14	9	0
MOLD SIDE	42	49	0	0
% TORN WEBS				
BAG SIDE	80	24	14	0
MOLD SIDE	75	85	0	0
FLEXURE				
BAG SIDE	100		122	
MOLD SIDE		104		100
VAL/IN. WIDTH				
BAG SIDE	66.6		81.3	
MOLD SIDE		69.3		66.6

LAP SHEAR								
SAMPLE	1	2	3	4	5	6	7	8
1ST CURE (P)	5601	5205	5812	6032				
2ND CURE (P)					5639	5132	4386	5351
1ST CURE (T)	5054	4417	4049	4833				
2ND CURE (T)					3931	4200	3006	3020

Chart I-24

Discussion: Chart I-24 contains a summary of sample coupon test data for substrate 018.

SAMPLE OF FM-1000 ADHESIVE FILM RETURNED TO BLOOMINGDALE FOR TEST.

SAMPLE	LAP SHEAR R.T.	LAP SHEAR 180°F	HONEYCOMB PEEL
B-2945 8-26-68	6225	3285	TOP 110
	6370	3430	BOTTOM 108
11/15/68	N.T.	N.T.	T-85
			B-116
10/3/68	N.T.	N.T.	T-114
			B-102
4/21/69 RETURNED FROM GOODYEAR	6600	3800	T-82
	6450	2550	B-97
		3200	

PEEL HAS DROPPED 17% BELOW ORIGINAL VALUE, PERHAPS NOT EVEN A SIGNIFICANT DIFFERENCE, AND LAP SHEAR VALUES ARE UNCHANGED.

Chart I-25

Discussion: As a result of the peel test failure of substrate 018 a sample of the adhesive lot was returned to the vendor for analysis and test. The test results are shown on Chart I-25.

NIMBUS
UNITS PRODUCED IN 1962

NO.	SPECIMEN	LOAD IN POUNDS	NO. TORN WEBS PER SQ.IN.	FAILURE MODE AT SKIN %	FAILURE MODE AT CORE %	FLEXURE TOTAL FORCE	FLEXURE VALUE #/IN.W
1	PRE PROTO(TOP)						
	MOLD SIDE	29	0	90	10	138	46
	BAG SIDE	22	0	5	95		
2	PRE PROTO(TOP)						
	MOLD SIDE(1)	24	0	70	30		
	BAG SIDE	20	1	5	95		
3	PRE PROTO(BOTTOM)						
	MOLD SIDE(1)	28	1	50	50	136	45.3
	BAG SIDE	27	1	5	95	-	
4	PROTO (TOP)						
	MOLD SIDE(1)	8	0	100	0	152	50.6
	BAG SIDE	18	0	90	10		
5	PROTO (BOTTOM)						
	MOLD SIDE	20	0	100	0	132	44
	BAG SIDE	42	0	100	0		

Chart I-26

Discussion: Chart I-26 contains a summary of flexure, peel, and sheer test data obtained from tests conducted on Nimbus program substrates.

NIMBUS "D" SAMPLE HISTORY

I	SERIES-A	SAMPLES MADE IN PRESS-INITIAL WORK ON PROCESSING TECHNIQUE
II	SERIES-B	SAMPLES MADE ON 1.00 IN AL. SHT. TO EST. PROCESSING TECHNIQUES
III	SERIES-C	SAMPLES MADE ON PADDLE MOLD TO EST. PRODUCTION PROCESS
IV	SERIES-D	SAMPLES MADE WITH DESTRUCT TRANSITION BY THE EST. PROCESS
V	SERIES-E	SAMPLES MADE WITH DESTRUCT UNIT-PADDLE
VI	SERIES-F	SAMPLES CUT FROM DESTRUCT TRANSITION
VII	SERIES-G	SAMPLES CUT FROM DESTRUCT PADDLE
VIII	SERIES-H	SAMPLES MADE WITH FLT. I PADDLE S/N 17
IX	SERIES-I	SAMPLES MADE WITH FLT. I TRANSITION S/N 17
X	SERIES-J	SAMPLES MADE WITH FLT. II PADDLE S/N 18
XI	SERIES-K	SAMPLES MADE WITH FLT. II TRANSITION S/N 18

Chart I-27

Discussion: Chart I-27 contains a summary of the Nimbus-D substrate fabrication program.

E. SPECIAL PRODUCTION PROCESS VERIFICATION TEST REPORT

As the result of Platform 018 failing to meet the peel test requirements set forth in the procurement document (RCA 1750081 Rev A), a special test program was initiated. A test series was designed to verify the capability of the existing Goodyear Aerospace Company (GAC) production process (GAC specification RDB 5342). The test series was divided into three parts, Sample Lot One, Sample Lot Two, and Data Evaluation.

1. Test Plan

Using the existing platform mold and the specified materials of construction, a set of five individual samples was processed in accordance with the GAC specification RDB 5342. During the actual building sequence, all the operations were monitored and pertinent data was recorded. At the completion of the manufacturing operation, the samples were sectioned and tested per RCA 1750081 Rev A. The test results and the notes made during the preparation of the samples were then evaluated to verify the production process and the quality of the samples. In addition, the data could be used to determine the true correlation between the standard test coupons and the samples bonded within the platform area of the mold.

The instructions governing the production processes were monitored carefully during fabrication and reviewed with the test data. Any deficiency or lack of detail would be corrected and used during the fabrication of Sample Lot No. 2.

A second set of five samples was produced in accordance with the existing or modified GAC RDB 5342 specification. The same ground rules applied to this test as those applied to Sample Lot No. 1. At the completion of the test, the test data from Sample Lot No. 2 was evaluated in the same manner as Sample Lot No. 1.

Data evaluation of entire test series was then conducted to insure the adequacy of the data and the production process. When completed, the Goodyear Aerospace Corporation was advised of additional controls and/or operations required to ensure the fabrication of flight quality substrates.

2. Sample Lot No. 1 Test Conditions and Results

Five samples were fabricated in accordance with the test plan; three samples (MF, MC, and MB), were 16 inches square, two samples (SI and SII) were 16 × 6 inches. Figure I-10 shows the position of the samples in the mold. Samples SI and SII are always made concurrently with a flight substrate and destructed after fabrication to validate the flight hardware. The materials of construction and the specifications used are as follows:

- The honeycomb used was 1/4-inch cell × 1-mil cell wall and purchased 0.62-inches thick. This material was then machined to 0.50 inches prior to bonding.
- The adhesive used was American Cyanamid FM-1000 with a 0.04-pound per square foot weight and the material is from Batch No. B-3137, Roll No. B-47452.
- The skins of the samples were 3.7 mil 5052 aluminum alloy, one plain and one coated with Tedlar.
- The processing of the samples was done in compliance with the Goodyear Specification for the fabrication of Nimbus Solar Cell Platform, RDB 5342, dated December 2, 1968.

After the machining process of the honeycomb, a problem arose in the cleaning process that removes the polyethylene glycol (type E-4000) used to hold the honeycomb to flat plates during the machining process. The problem was the presense of a heavy residue on the webs of the honeycomb after the prescribed cleaning process was completed. Since the residual stains could not be removed, four honeycomb blankets (Serial Nos. 1 through 4) were rejected. An analysis of the problem, conducted by the GAC Materials Group, indicated that the cause was city water that contained a high percentage of algae at this time.

Based on this conclusion, a series of samples were processed with the E-4000 glycol wax and used to develop a suitable cleaning method. This exercise produced the following cleaning method.

(a) Remove wax from core in oven set at 180°F.

(b) Steam clean the core to remove remaining wax residue.

(c) Rinse core in distilled water maintained at 145°F to remove last traces of wax.

(d) Rinse core in Acetone to remove water

(e) Dry

(f) Vapor degrease core prior to bonding.

The sample cores processed this way indicated a suitable cleaning method had been developed. However, during the cleaning of the replacement core blankets (Serial Nos. 5 through 8), it was found that there were still traces of the wax present.

At this point, a cleaning process was developed which cleaned the core satisfactorily. This method is as follows:

(a) Steam clean core with steam to remove from metal plate.

(b) Rinse core in water maintained at 145°F minimum.

(c) Wash core in detergent solution maintained at 145°F minimum.

(d) Rinse core in water maintained at 145°F minimum.

(e) Rinse in Acetone.

(f) Dry core on Kraft paper for 10 minutes at 300°F.

This method is now the standard for cleaning core blankets for the Nimbus project.

The bonding of the samples was performed in accordance with the standard RDB 5342 process, which is identical to that employed when processing the rejected platform substrate. Fourteen thermocouples and five samples were mounted on the platform mold as shown on Figure I-11. The test samples were constructed from honeycomb blankets Serial Nos. 5 and 6. The heat-up rate for both cures is shown on Figures I-12 and I-13; the temperature indications for all the thermocouples, recorded every 5-minutes, are listed in Tables I-12 and I-13.

When the bonding was completed, the samples were identified and cut as shown on Figure I-14; and subjected to peel, flexure, and lap shear tests as specified in RCA Dwg 1750081, Rev A. Peel test, flexure, and lap shear data are contained in Tables I-14, I-15, and I-16, respectively. The peel test data, plotted on graphs containing the acceptance criteria, are shown on Figures I-15 through I-22.

Based on the data obtained from Sample Lot No. 1, the Goodyear Aerospace Corporation was authorized to fabricate Sample Lot No. 2 using the RDB-3452 specification as modified during the fabrication of Sample Lot No. 1, and to perform evaluation tests identical to those specified for Sample Lot No. 1.

3. Sample Lot No. 2 Test Conditions and Data

Five samples, using materials of construction prepared in conjunction with the materials for Sample Lot No. 1, were prepared. The test samples, prepared from honeycomb blankets 07 and 08, were instrumented as shown on Figure I-11, and cured in the same manner as Sample Lot No. 1. The heat-up rate is shown on Figures I-23 and 24; the temperature indications for all the thermocouples, recorded every 5 minutes, are listed in Tables I-17 and I-18.

When the bonding was completed, the samples were identified and cut as shown on Figure I-25; and subjected to peel, flexure, and lap shear tests as specification RCA Dwg 170081, Rev A. Peel, flexure, and lap shear test data are contained in Tables I-19, I-20, and I-21, respectively. Peel test data, plotted on graphs containing the acceptance criterion, are shown on Figures I-26 through I-32.

The results of Sample Lot No. 2 were satisfiactory and a comparative evaluation of Sample Lots No. 1 and No. 2 was initiated.

4. Test Data and Fabrication Process Evaluation

A comparative evaluation of the data obtained from sample Nos. 1 and 2 was made and the following observations were made:

- Torn core was observed on all the samples
- Three peel values below specified levels were observed on Sample Lot No. 1.
- Two peel values below the specified levels were observed on Sample Lot No. 2.
- The core used in Sample Lot No. 2 had areas where the hex core had bowed or curved cell walls instead of angular configuration.
- In some areas of the machined surface of the core, there was evidence that the edges of the core where bent due to machining operation.
- The fillet of adhesive at the junction of the core walls was minimal. This was true for both lots and for both skin-bond lines.
- All flexure test data exceeded the requirement of 30 pounds per inch of width as specified in RCA Dwg 1750081 Rev A.
- The appearance of the bond line after peeling of the mold side and bag side were decidedly different. The mold side appearance was typical for honeycomb bonds. The bag side (machined side) displayed the effects of a bent core, yet the test data was adequate in all but five cases.
- The overall processing specification, Goodyear Aerospace Corporation document RDB 5342, describing the fabrication of the honeycomb substrate provides the direction necessary to ensure a good product.

- The detailed instructions used by floor personnel are vague and need to be clarified.
- Quality control provisions are not specific and require greater detail for the individual inspectors.
- The operation of the oven during the cure cycle requires greater control or automatic control to insure uniformity of heat-up profile.
- There is a lack of understanding of individual operations and their limitation by the engineering staff, more intimate contact with the product is required.

5. Conclusions

There were conditions such as bent and curved cores along with minimal fillets that contributed to the five low peel values. However, there is no correlation between specific test conditions and the out-of-tolerance data.

Further study of the samples would be beneficial as the findings could improve the processing technique which requires more stringent controls.

Based on the overall appearance, test data, and an analysis of the failure modes, the production process and materials of construction were considered capable of producing flight-level hardware if the changes, additions, and rework of the controlling documents are incorporated and used. This statement is based on the provision that the same level of control is exercised during the fabrication of the replacement substrate (Serial No. 019) as was exercised during the special tests.

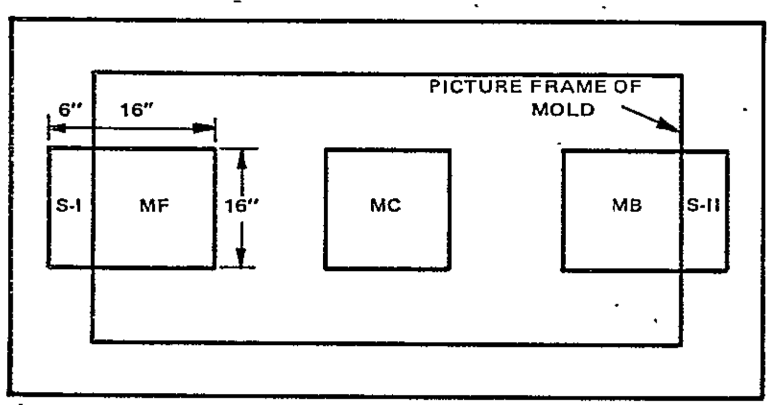
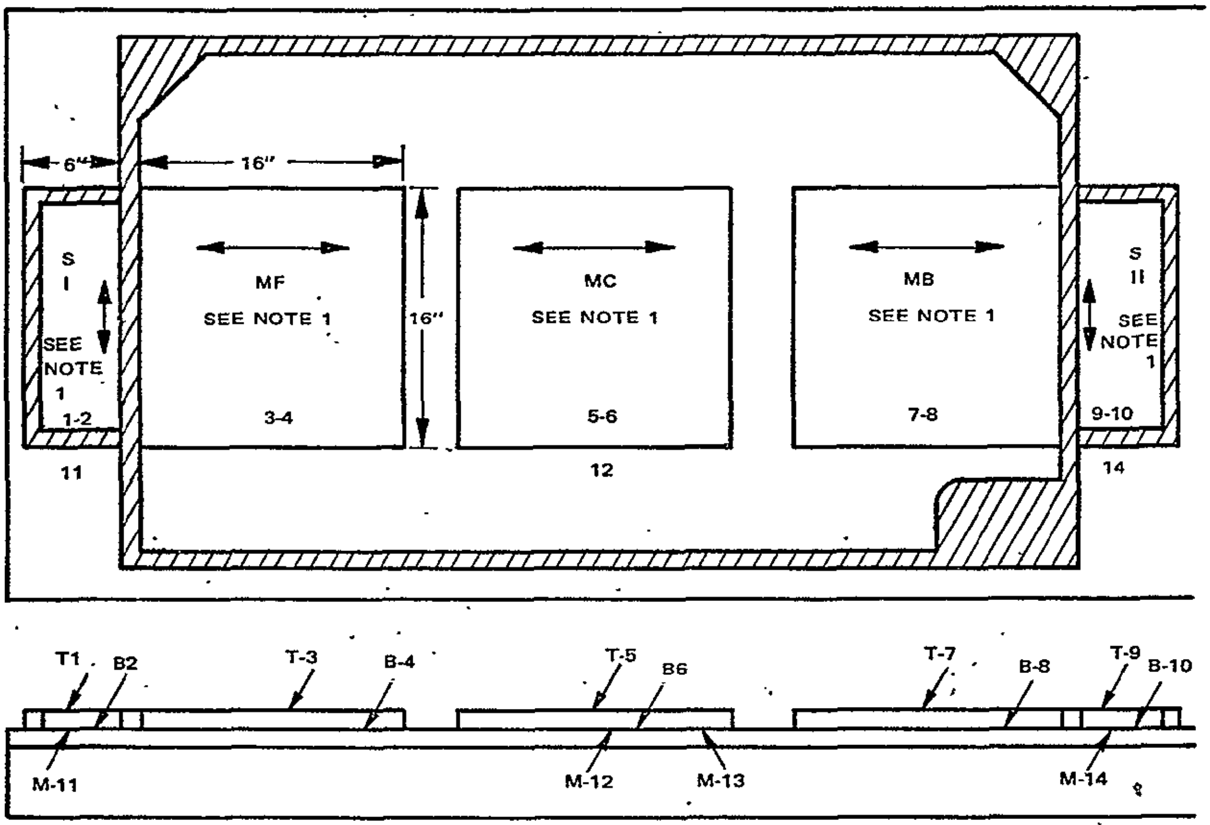


Figure I-10. Size of Samples and Layout in Platform Tool



NOTE 1. TEST LOT NO. 1 – HONEYCOMB BLANKET 06 WAS USED ON SAMPLES SI, SII, AND MF, HONEYCOMB BLANKET 05 WAS USED ON SAMPLES MC AND MB.
TEST LOT NO. 2 – HONEYCOMB BLANKET 07 WAS USED ON SAMPLES MF AND MC, HONEYCOMB BLANKET 08 WAS USED ON SAMPLES MB, SI, AND SII.

THERMOCOUPLES T-1, B-2, T-3, B-4, T-5, B-6, T-7, B-8,T-9, B-10, M-11 AND M-12 ARE HONEYWELL TYPE Y153X(67) P12-X-(106) SERIAL NO. 800671.

THERMOCOUPLES M-13 AND M-14 ARE HONEYWELL TYPE 153X72 P8X16 SERIAL NO. SN 814049.

Figure I-11. Sample Coupon Layout and Thermocouple Location

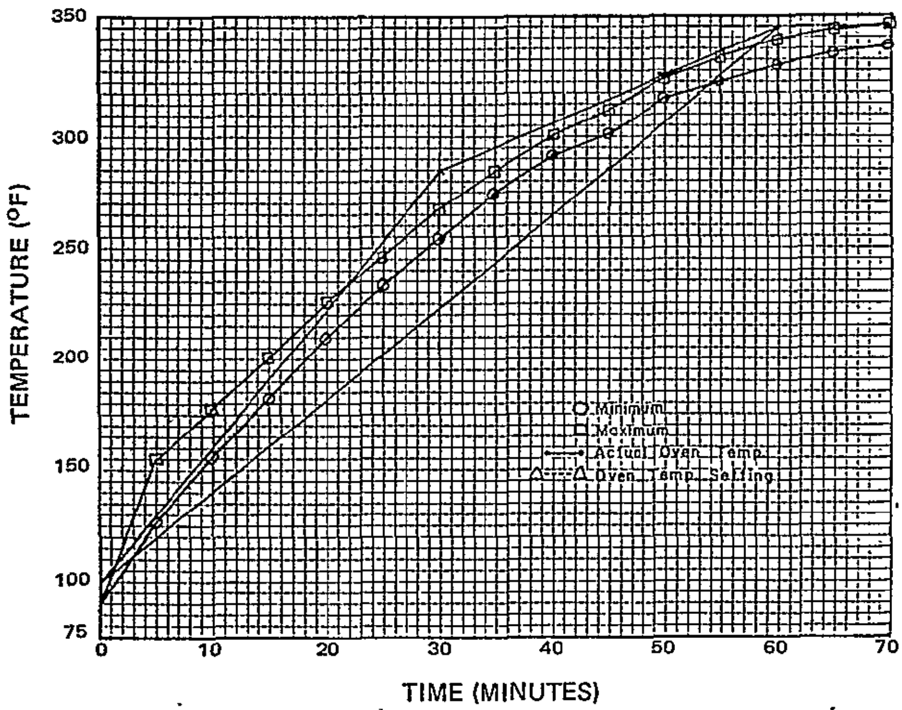


Figure I-12. Heat-Up Rate, First Cure, Lot No. 1

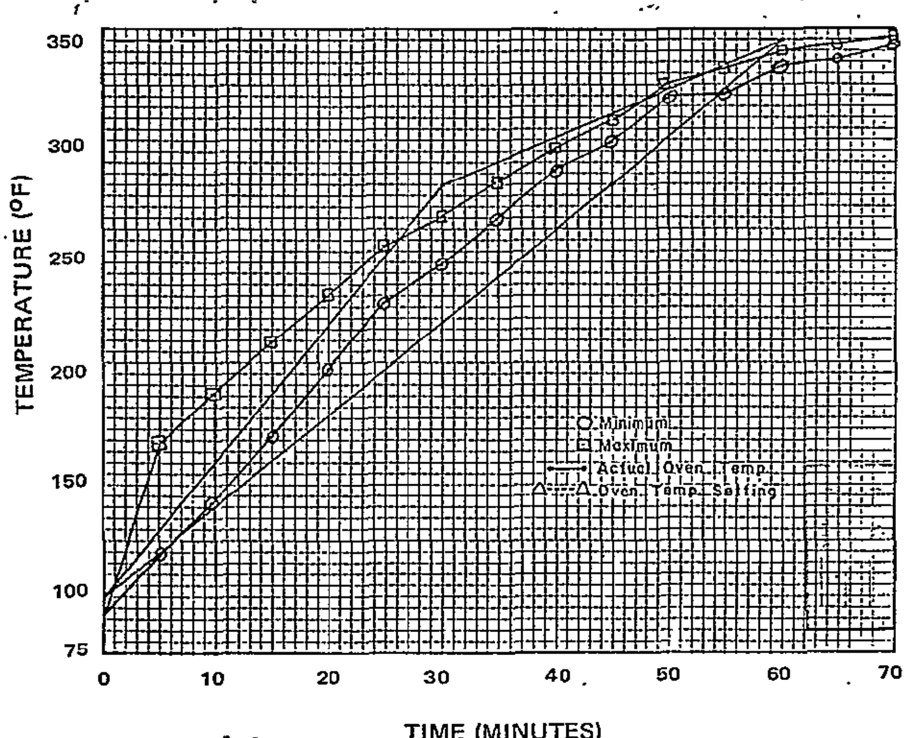
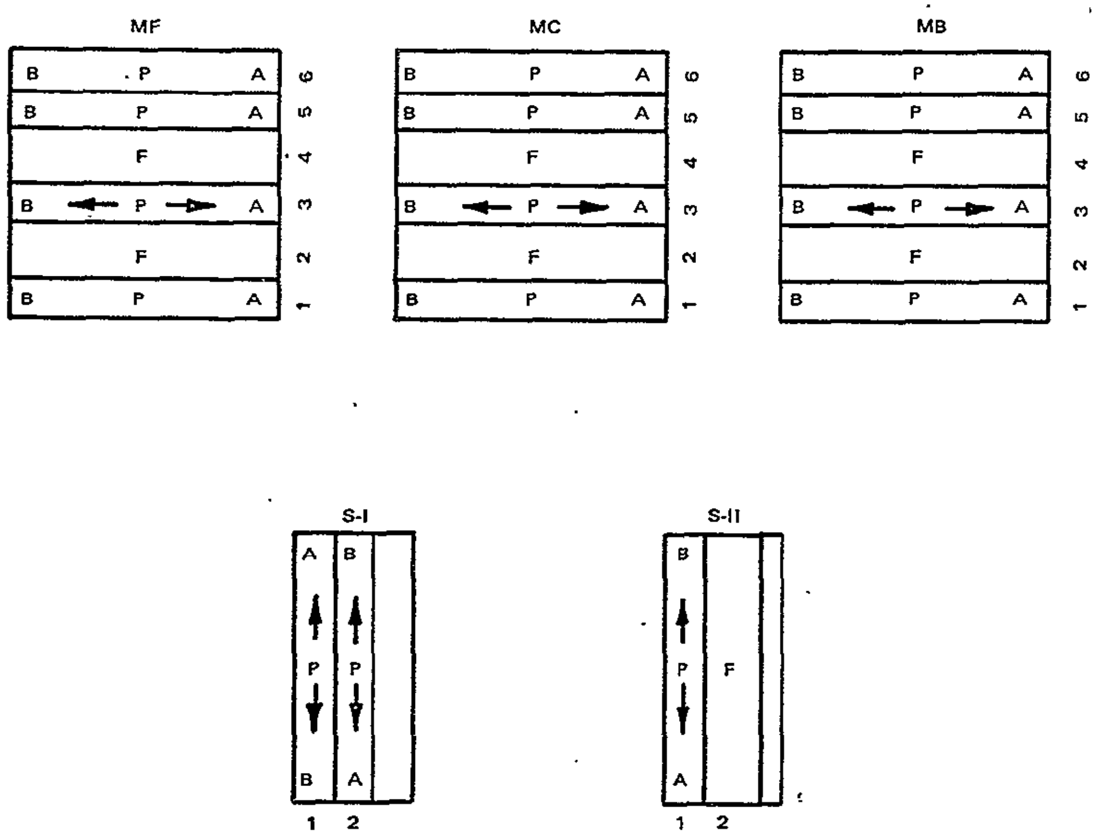


Figure I-13. Heat-Up Rate, Second Cure, Lot No. 1



← P → INDICATES RIBBON DIRECTION OF HONEYCOMB

A BAG SIDE PEEL TEST

B MOLD SIDE PEEL TEST

P PEEL TEST SPECIMEN

F FLEXURE TEST SPECIMEN

Figure I-14. Test Specimen Identification, Sample Lot No. 1

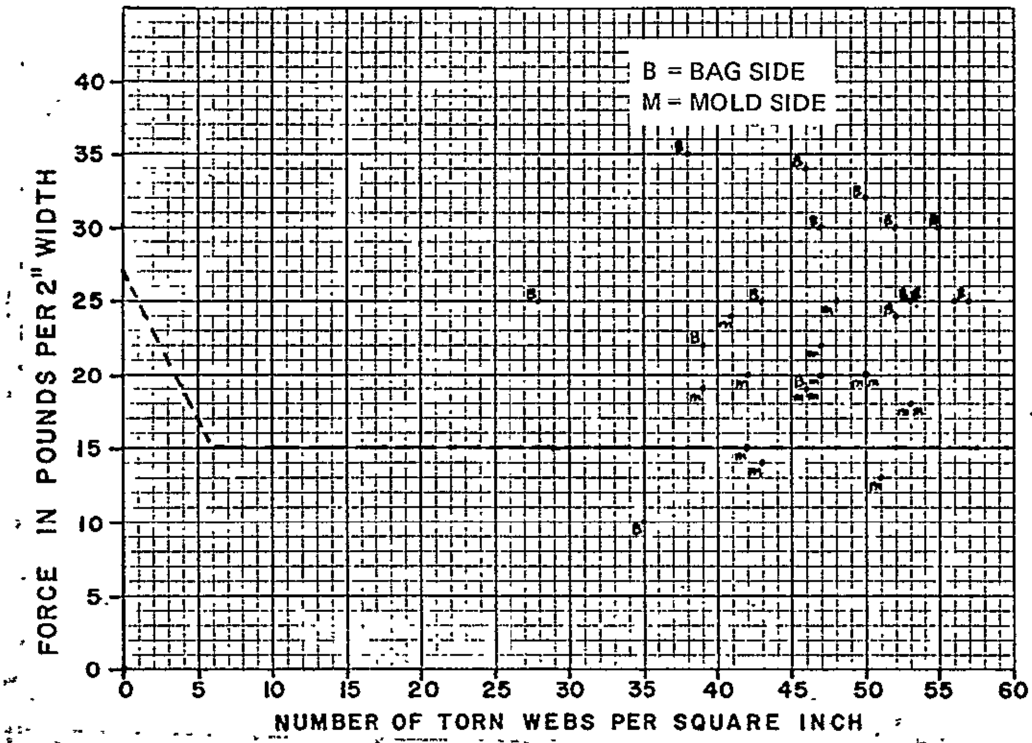


Figure I-15. Peel Test Data of Sample Lot No. 1, Mold and Bag Side

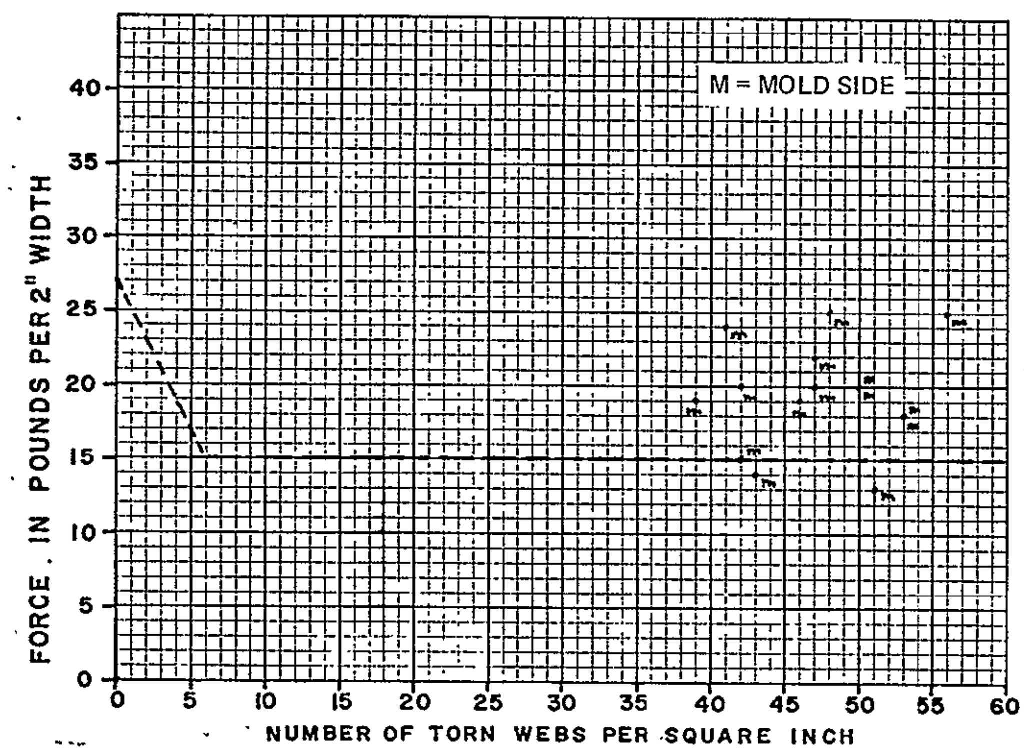


Figure I-16. Peel Test Data of Sample Lot No. 1, Mold Side

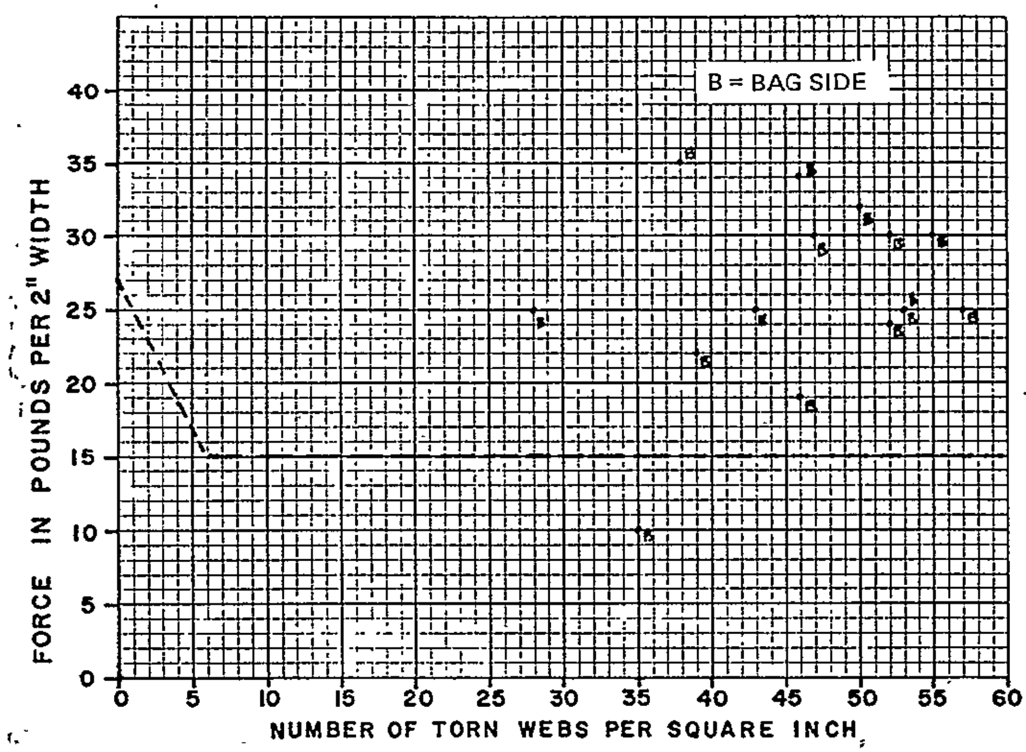


Figure I-17. Peel Test Data of Sample Lot No. 1, Bag Side

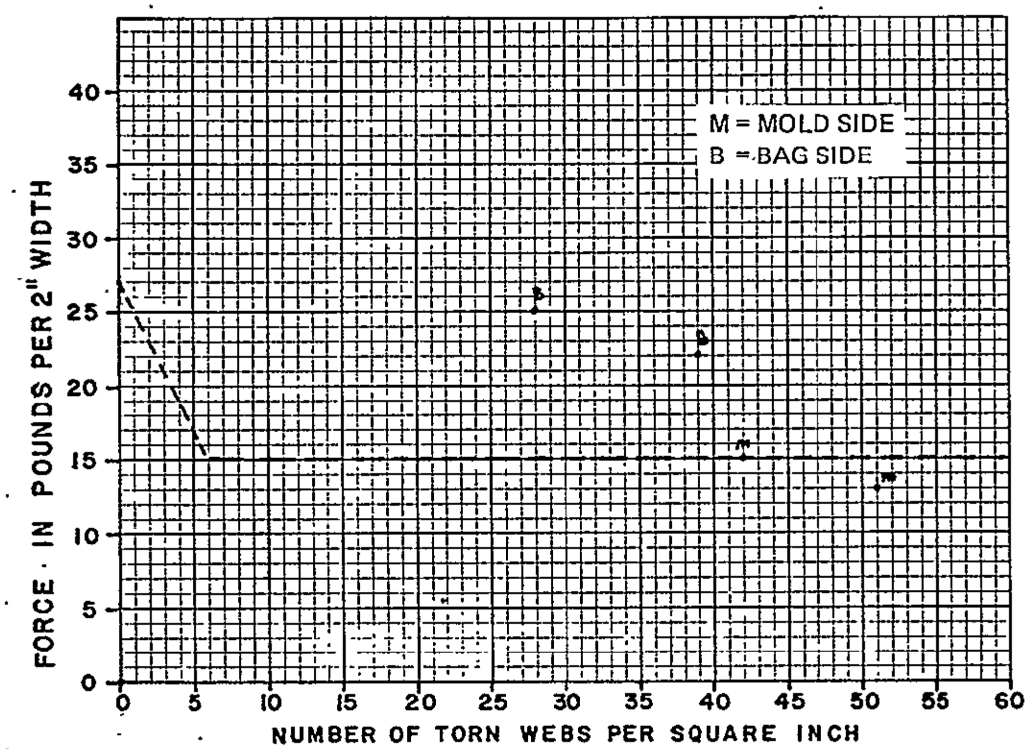


Figure I-18. Peel Test Data of Sample Lot No. 1, Samples SI-1, -2

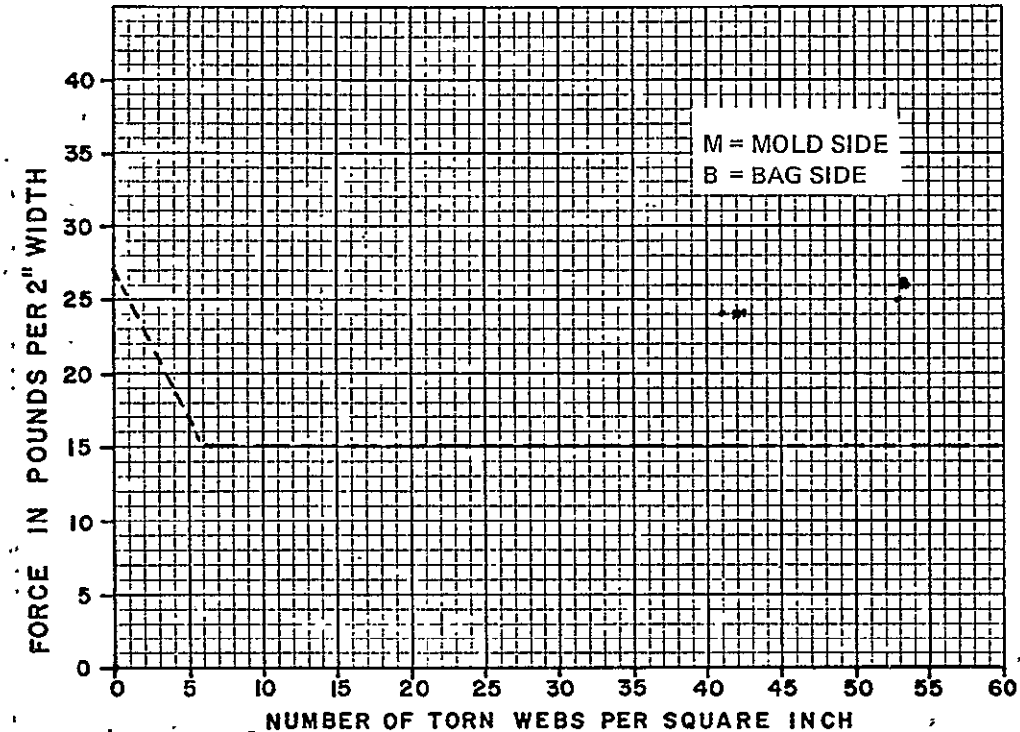


Figure I-19. Peel Test Data of Sample Lot No. 1, Sample SII-1

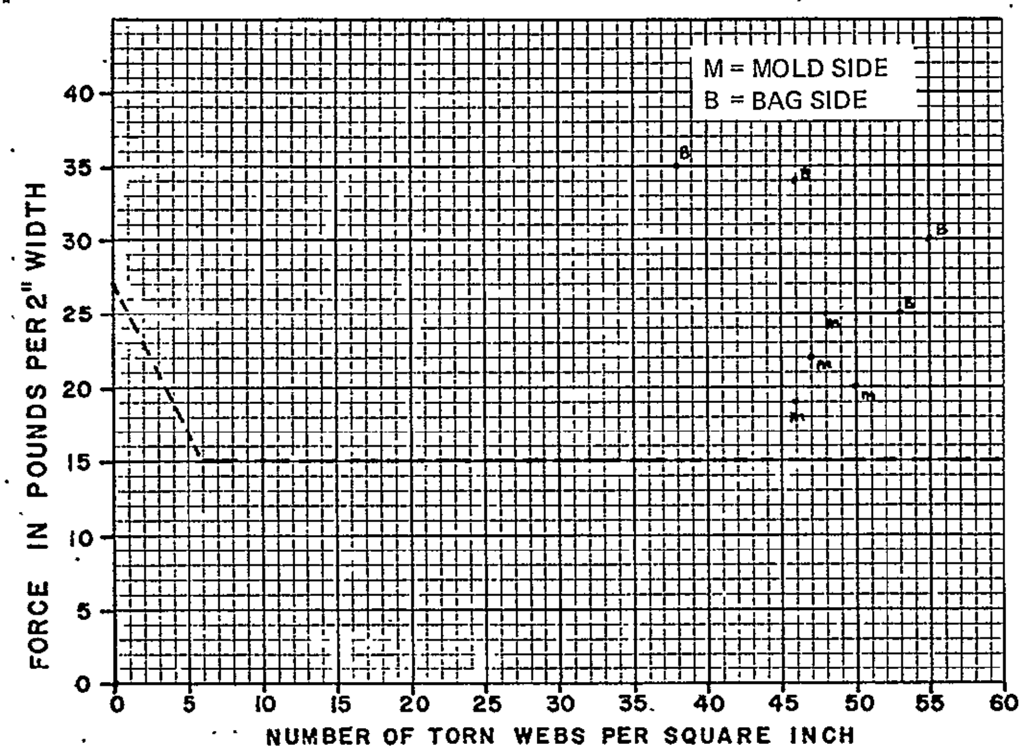


Figure I-20. Peel Test Data of Sample Lot No. 1, Samples MF-1, -3, -5, and -6

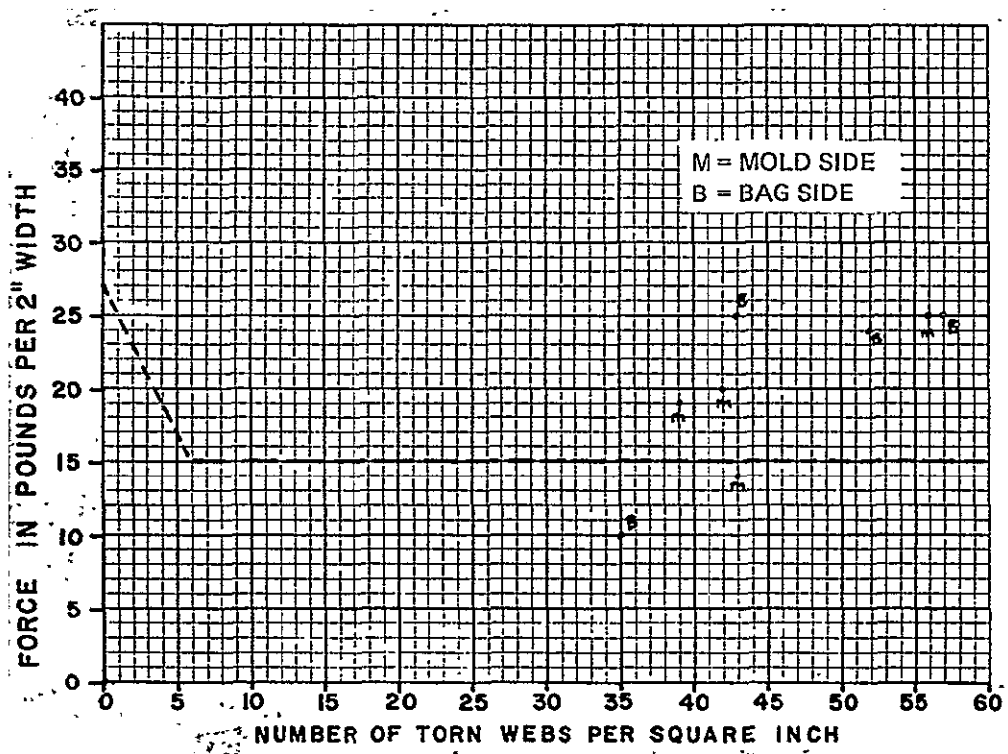


Figure I-21. Peel Test Data of Sample Lot No. 1
Samples MC-1, -3, -5, and -6

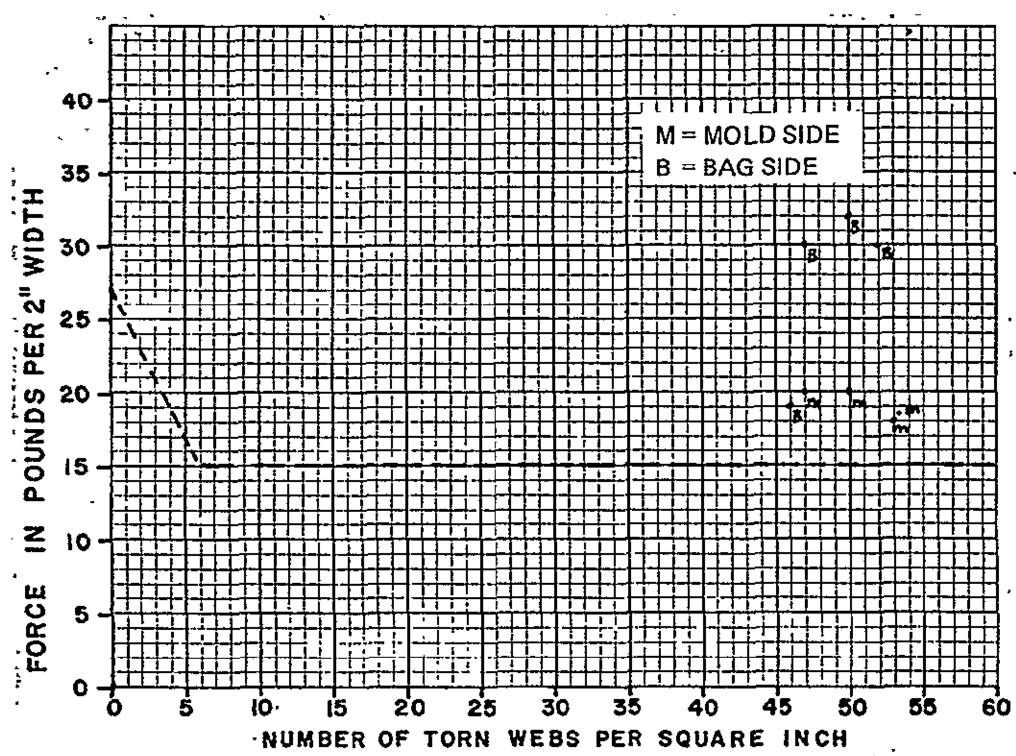


Figure I-22. Peel Test Data of Sample Lot No. 1,
Samples MB-1, -3, -5, and -6

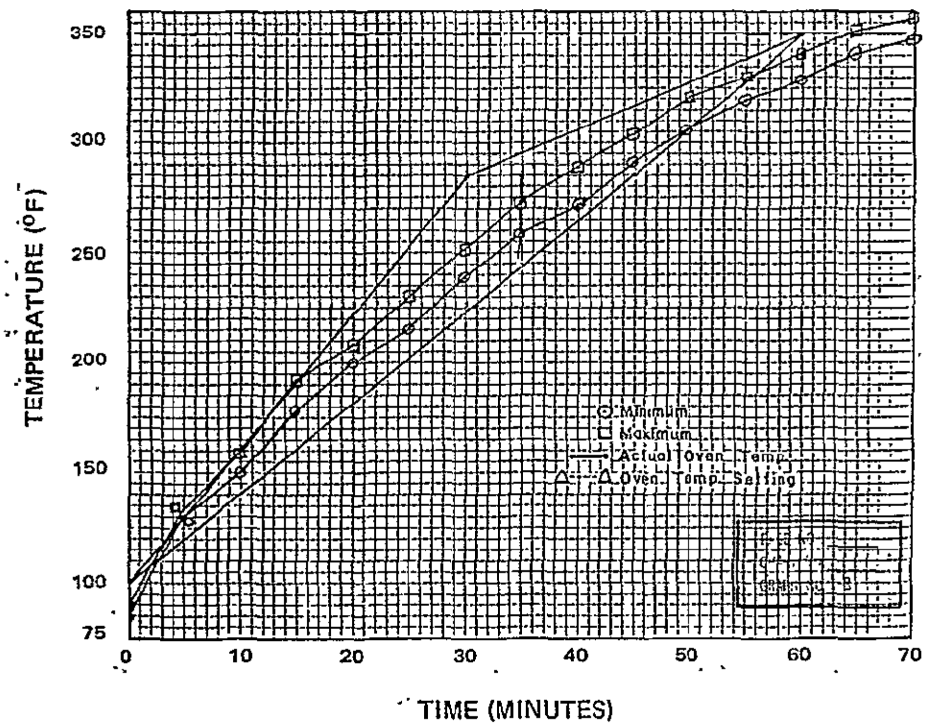


Figure I-23. Heat-Up Rate, First Cure Sample Lot No. 2

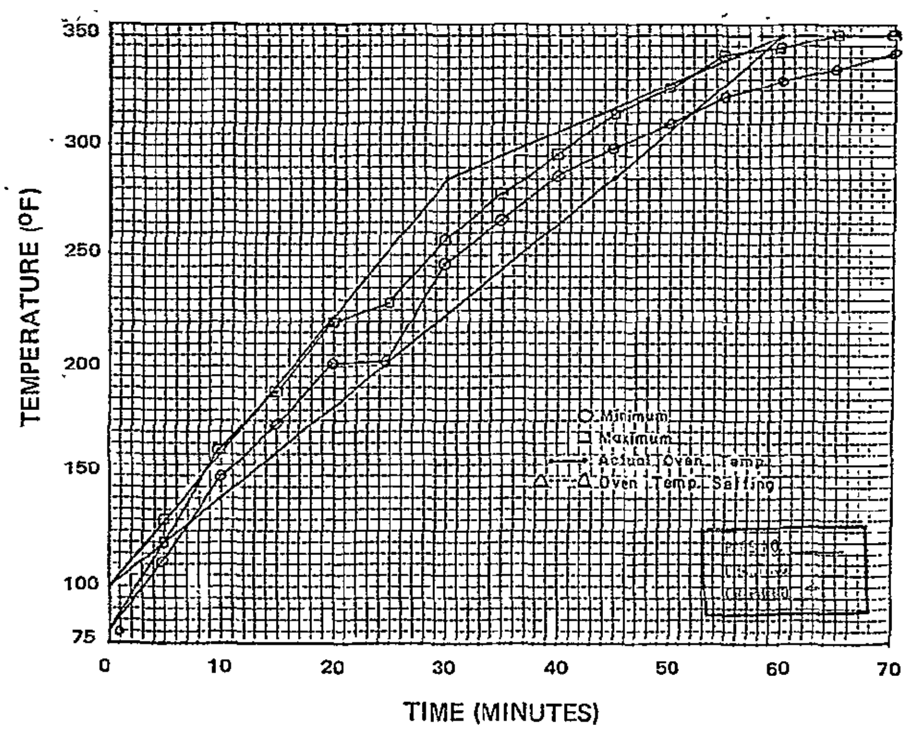


Figure I-24. Heat-Up Rate, Second Cure, Sample Lot No. 2

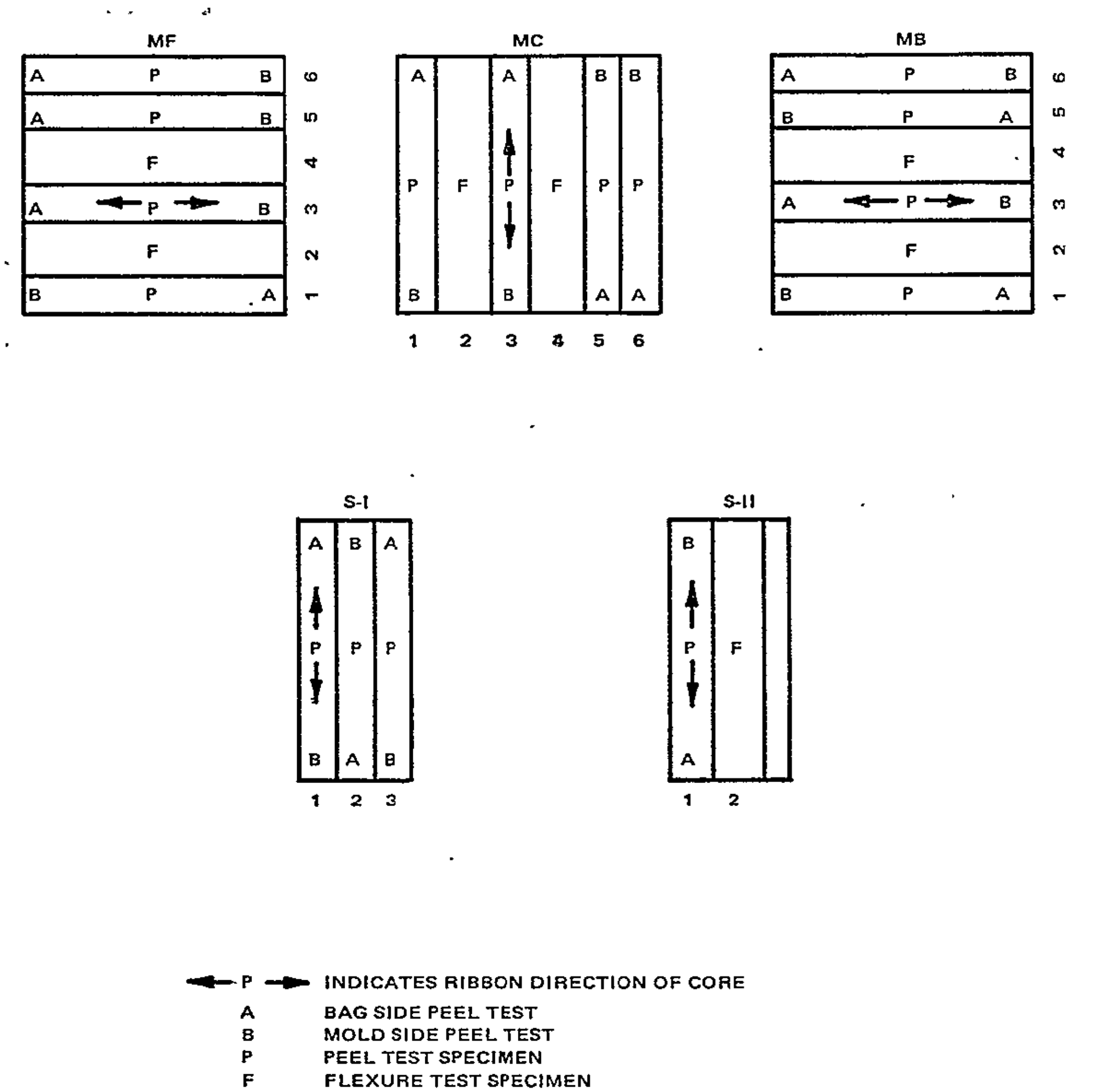


Figure I-25. Test Specimen Identification, Sample Lot No. 2

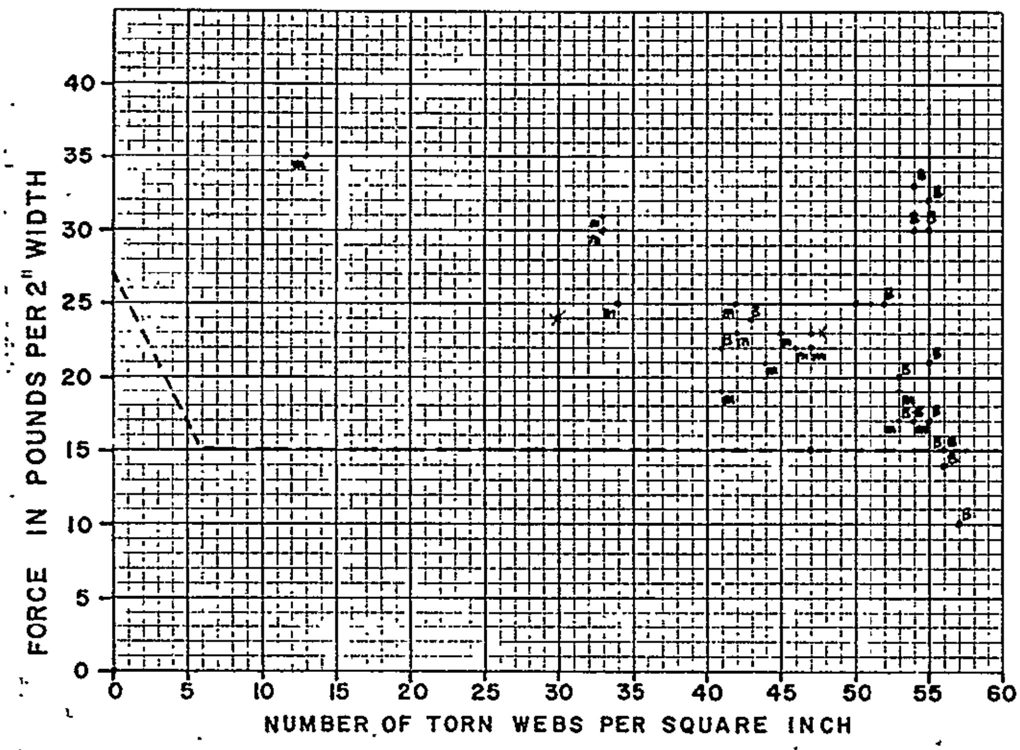


Figure I-26. Peel Test Data of Sample Lot No. 2, Mold and Bag Side

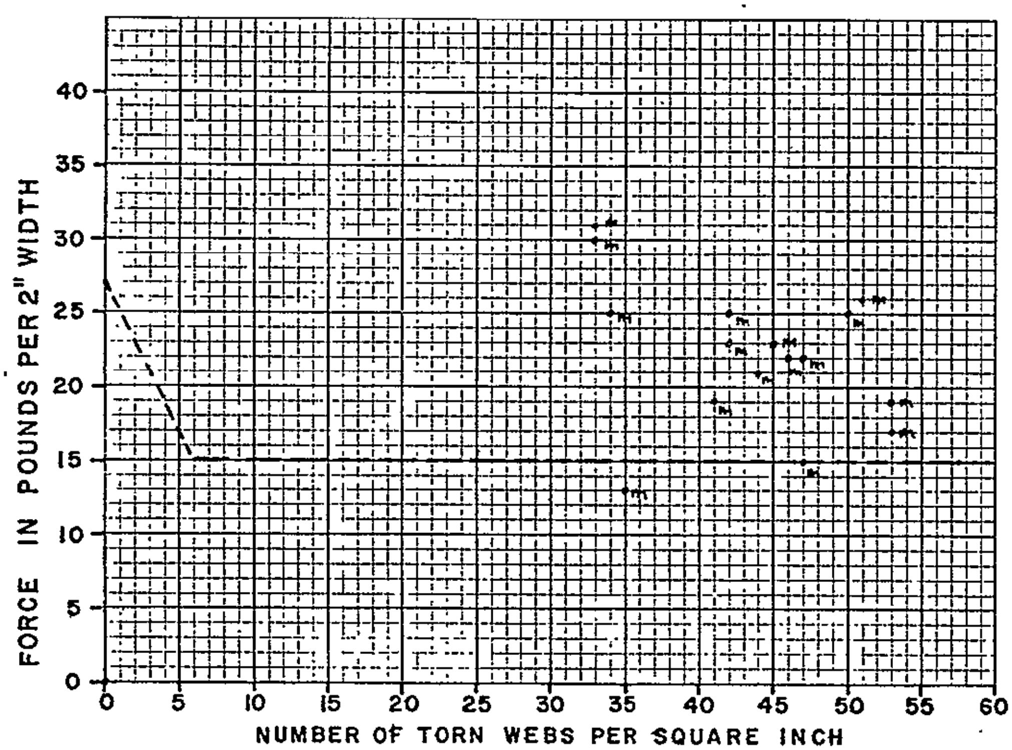


Figure I-27. Peel Test Data of Sample Lot No. 2, Mold Side

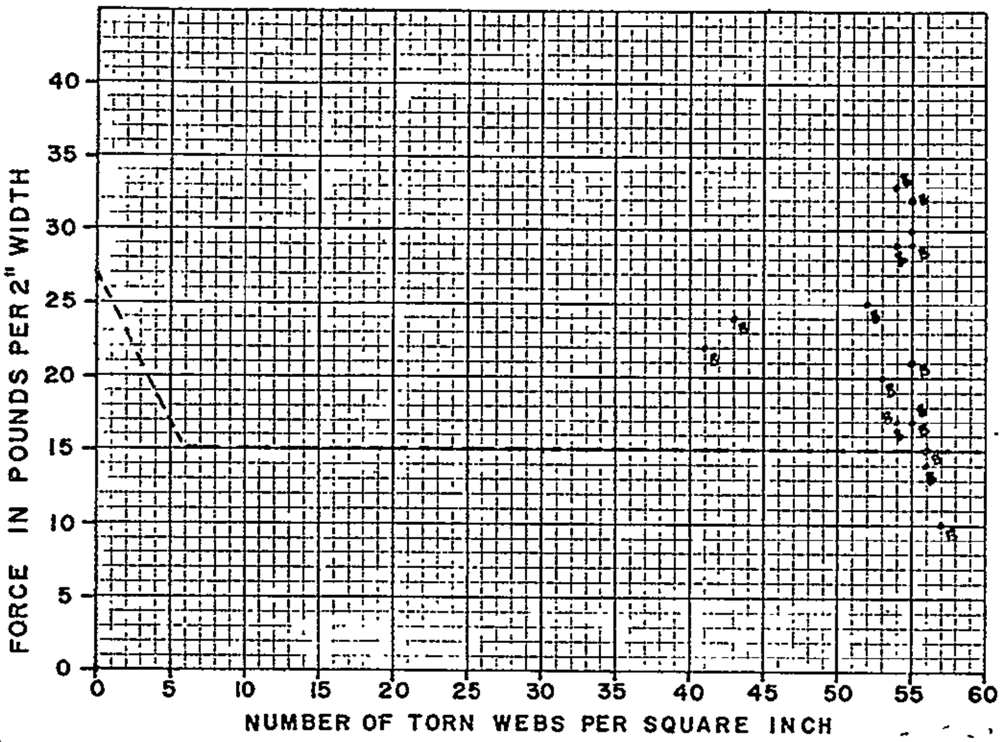


Figure I-28. Peel Test Data of Sample Lot No. 2 Bag Side

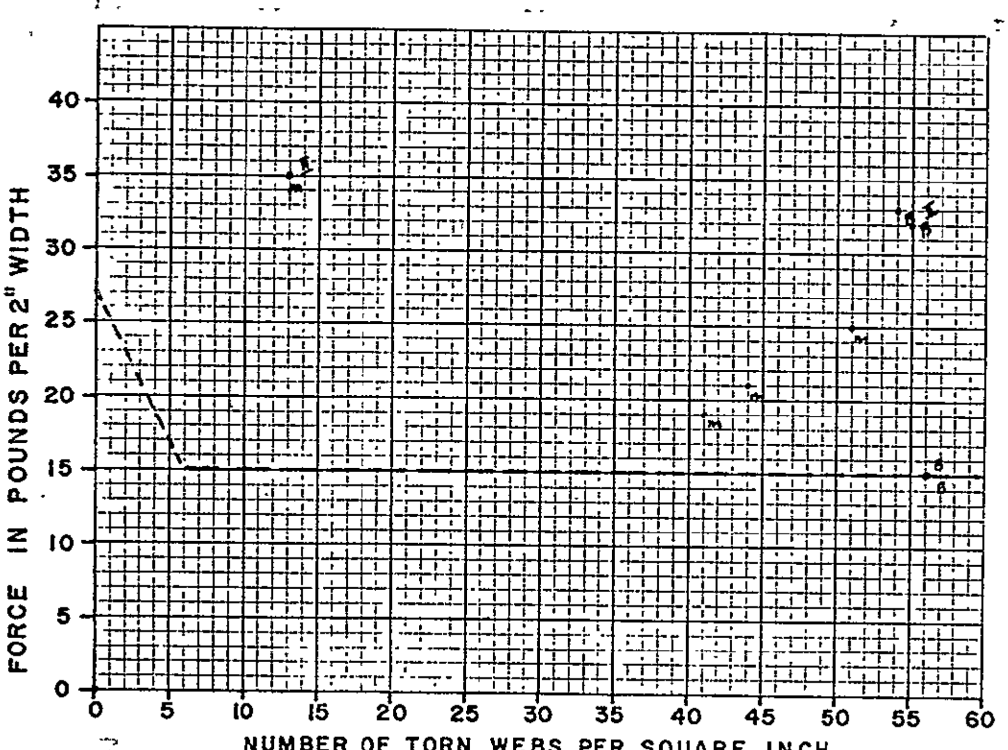


Figure I-29. Peel Test Data of Sample Lot No.2, Samples SI-1, -2, and -3

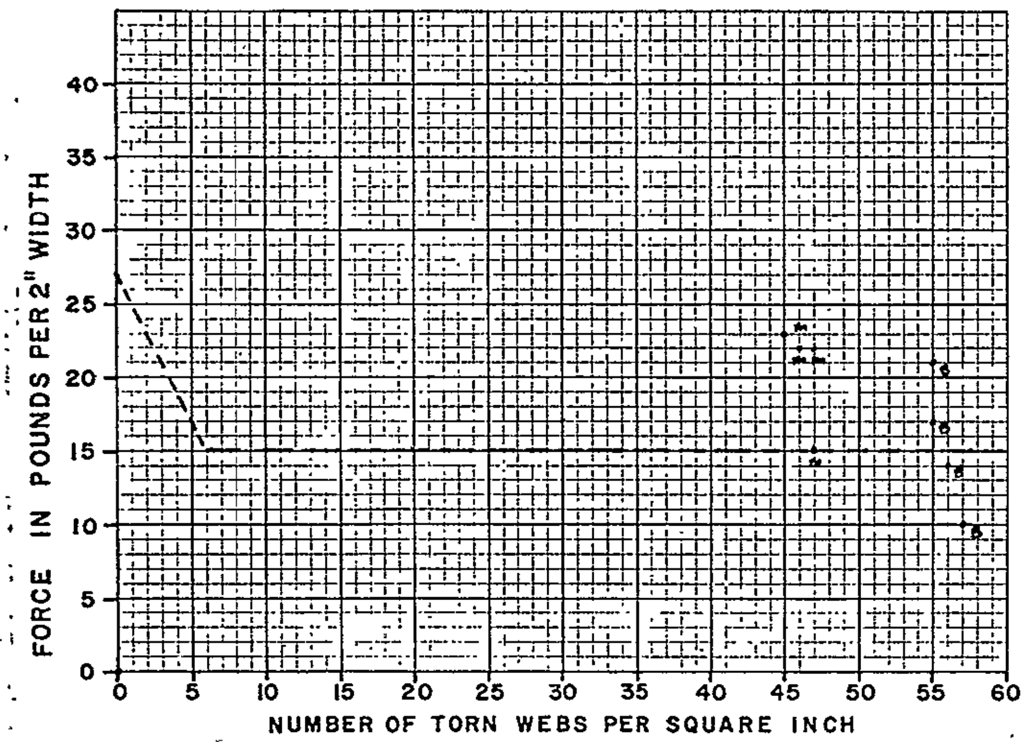


Figure I-30. Peel Test Data of Sample Lot No. 2, Samples MF-1, -3, -5, and -6

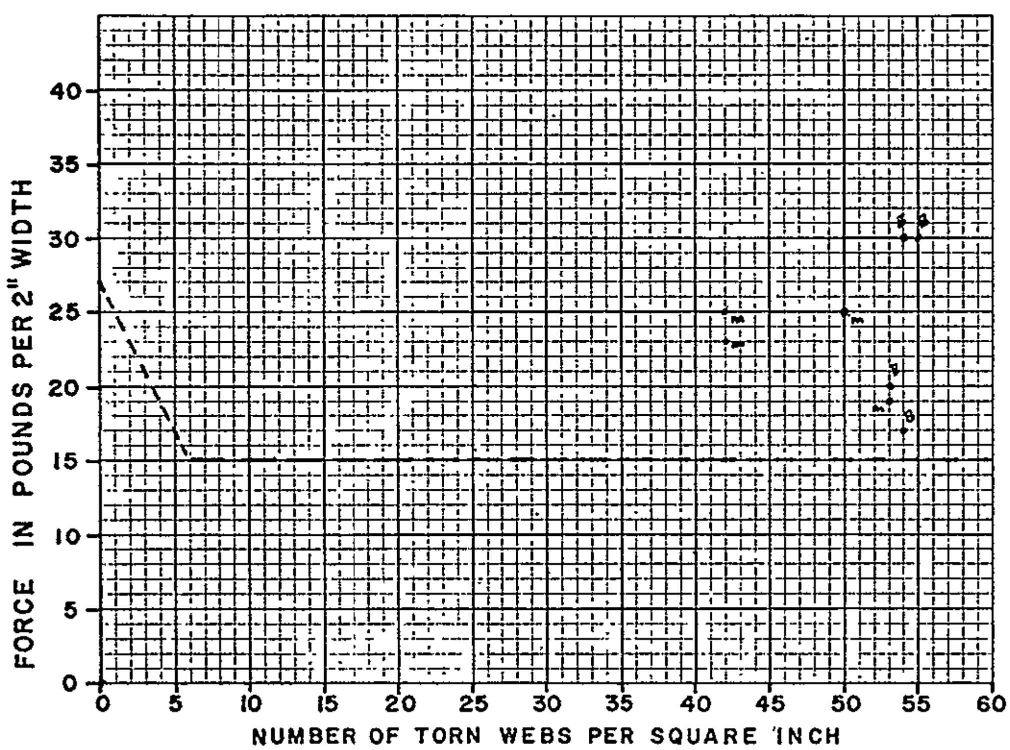


Figure I-31. Peel Test Data of Sample Lot No. 2, Samples MC-1, -3, -5 and -6

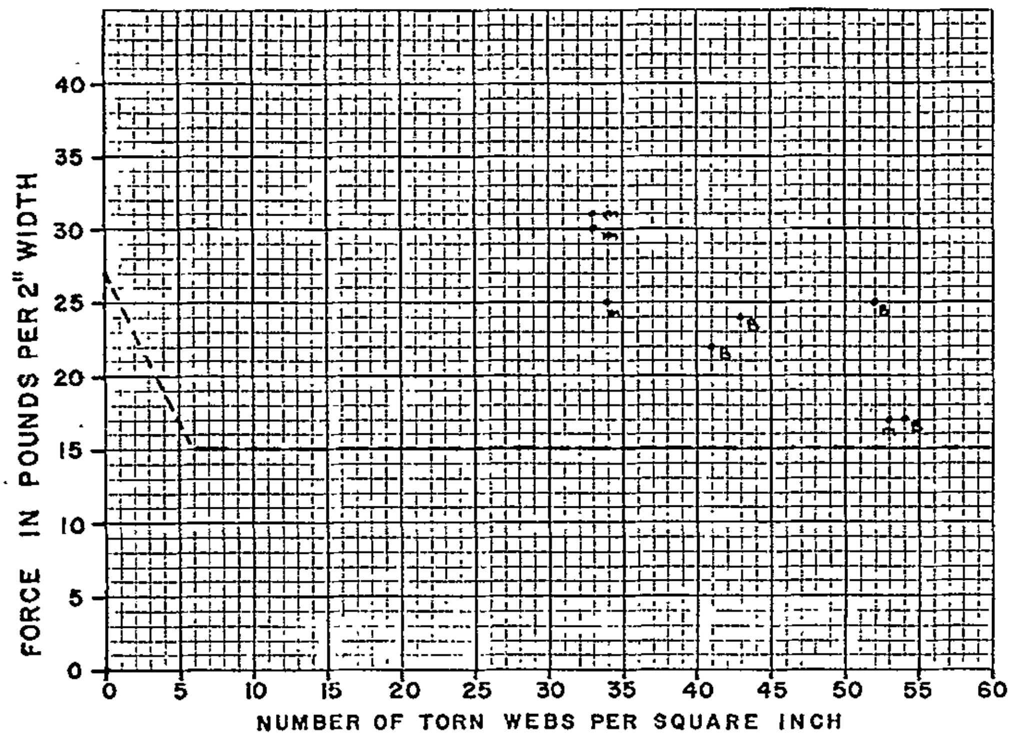


Figure I-32. Peel Test Data of Sample Lot No. 2, Samples MB-1, -3, -5, and -6

TABLE I-12. THERMOCOUPLE TEMPERATURE, FIRST CURE SAMPLE LOT NO. 1

Time		Oven Temperature		Thermocouple Nos.													
Hr/Min	Elapsed	Setting	Actual	T-1	B-2	T-3	B-4	T-5	B-6	T-7	B-8	T-9	B-10	M-11	M-12	M-13	M-14
2:25	0	500	460	107	99	125	105	151	128	137	115	102	100	97	96	94	96
2:30	5	500	495	150	135	183	143	207	155	180	146	144	127	127	122	111	113
2:35	10	500	495	181	163	208	161	228	178	202	169	168	151	159	148	133	140
2:40	15	500	495	210	192	233	187	251	200	225	191	197	178	189	173	158	165
2:45	20	500	497	240	224	258	218	271	226	249	218	224	210	221	203	190	189
2:50	25	500	500	260	247	277	240	285	246	267	238	247	234	245	225	200	210
2:55	30	500	499	280	267	284	260	299	263	282	257	266	254	265	244	220	232
3:00	35	500	499	298	284	308	278	306	279	300	275	285	274	285	264	266	270
3:05	40	500	499	313	300	320	293	316	293	312	290	302	291	303	282	269	284
3:09	45	500	500	322	312	328	302	324	302	321	301	312	303	315	295	285	301
3:15	50	475	500	336	326	340	318	334	316	333	318	326	330	338	307	300	317
3:20	55	425	465	343	337	342	329	336	325	339	327	336	330	339	322	311	327
3:24	60	425	430	348	344	347	332	338	332	341	335	342	339	345	330	321	337
3:29*	65	365	400	361	349	349	344	342	338	345	342	348	345	350	337	328	342
3:35	70	365	380	350	350	350	350	343	341	346	345	349	349	351	340	337	349
3:40	75	365	355	350	350	350	347	343	342	346	350	351	350	350	342	338	350
3:45	80	365	360	350	350	349	348	345	343	348	348	350	350	350	343	340	349
3:50	85	365	358	350	350	349	349	346	344	349	349	351	351	351	344	342	350
3:55	90	365	360	350	350	349	350	346	344	350	350	351	351	351	345	342	350
4:00	95	365	360	350	349	349	350	346	345	350	349	351	351	350	345	343	350
4:05	100	365	360	350	350	349	350	346	346	350	350	352	351	351	346	343	350
4:10	105	365	358	348	347	347	347	347	346	350	350	351	351	350	346	344	350
4:15	110	365	360	348	347	347	347	347	347	349	350	351	351	350	346	344	350
4:20	115	365	360	348	347	347	347	347	347	349	350	351	351	346	346	345	350
4:25	120	365	360	348	347	346	346	347	347	349	350	351	351	346	346	346	349
4:30**	125	365	360	336	346	346	346	344	345	342	345	342	350	344	344	342	345
4:35	130	***	280	334	337	327	337	334	338	340	345	342	344	340	340	341	342
4:40	135		265	332	334	327	334	333	337	339	342	340	338	336	337	336	337
4:45	140		240	328	329	326	330	330	333	333	336	332	333	329	334	331	351
4:55	150		220	316	317	318	322	322	324	322	327	329	322	317	326	320	318
5:05	160		210	304	304	306	310	310	312	310	314	306	308	304	314	310	308
5:15	170		190	292	293	296	300	300	304	299	302	284	294	294	304	296	294
5:25	180		180	276	277	280	284	284	290	284	288	278	281	278	290	283	276
5:35	190		175	264	264	268	272	276	280	272	274	267	268	264	279	273	264
5:45	200		170	252	252	256	259	264	267	260	264	256	256	253	268	252	261
5:56	210		160	238	239	244	246	252	256	250	252	244	245	244	256	250	240
6:05	220		155	229	230	234	236	243	246	232	240	233	234	230	248	240	230
6:15	230		150	220	220	224	228	234	238	228	230	223	224	220	236	234	221
6:25	240		145	211	211	215	218	224	226	218	220	214	215	212	228	224	212
6:35	250		140	202	204	207	210	215	218	211	212	206	206	204	219	219	203
6:45	260		135	195	196	202	204	208	210	202	203	198	196	196	210	206	196
6:55	270		130	188	189	192	196	202	202	194	197	190	190	190	202	198	186
7:05	280		120	180	181	184	186	190	192	186	187	181	182	181	192	189	179
7:15	290		115	174	174	176	179	182	184	176	177	174	174	175	186	183	172

* Cure period started
** Cure period ended
*** Oven heat turned off, fans left on

TABLE I-13. THERMOCOUPLE TEMPERATURE, SECOND CURE SAMPLE LOT NO. 1

Time		Oven Temperature		Thermocouple Nos.													
Hr/Min	Elapsed	Setting	Actual	T-1	B-2	T-3	B-4	T-5	B-6	T-7	B-8	T-9	B-10	M-11	M-12	M-13	M-14
11:55	0	500	460	88	84	105	87	119	92	105	89	88	88	102	101	81	81
12:00	5	500	475	118	109	152	110	169	110	133	104	129	102	106	106	–	–
12:05	10	509	500	142	139	176	137	192	140	157	132	150	137	140	141	150	150
12:10	15	509	499	172	169	198	165	215	174	187	164	181	161	170	166	170	176
12:15	20	509	500	203	197	220	191	235	194	207	187	204	187	197	191	192	198
12:20	25	509	500	233	227	248	221	258	221	232	217	232	218	228	219	202	206
12:25	30	509	500	250	243	264	239	270	238	249	232	249	235	246	235	227	226
12:30	35	509	500	270	269	282	260	286	258	268	253	269	258	267	256	246	246
12:35	40	509	500	292	292	299	285	300	281	291	279	292	283	292	279	260	262
12:40	45	509	500	309	309	304	302	313	300	306	297	307	301	308	300	290	293
12:45	50	475	500	328	328	330	321	330	317	324	319	327	323	330	317	305	310
12:50	55	400	465	337	337	337	331	335	325	332	328	326	331	337	325	317	324
12:55	60	375	445	343	345	345	340	340	333	338	336	342	342	344	332	327	335
1:00*	65	375	400	348	348	348	345	345	339	342	342	346	346	346	339	334	344
1:05	70	365	380	351	351	351	351	347	346	349	349	349	349	351	344	340	348
1:10	75	365	350	351	351	351	351	RE-INK PAD ON RECORDER								341	350
1:15	80	365	360	357	351	351	351	345	344	349	349	349	352	351	345	341	350
1:20	85	365	355	350	350	350	349	345	346	350	349	352	352	350	346	343	350
1:25	90	365	358	349	350	350	348	348	346	350	351	352	352	350	346	349	350
1:30	95	365	358	349	349	348	349	347	347	350	350	351	351	349	347	346	350
1:35	100	365	358	348	348	348	348	348	347	351	350	351	351	348	347	345	349
1:40	105	365	358	347	347	348	348	348	347	350	350	351	351	347	347	346	349
1:45	110	365	355	348	348	348	341	348	348	350	350	351	351	347	347	346	349
1:50	115	365	360	347	347	347	347	348	348	350	350	351	351	347	347	347	349
1:55	120	365	355	346	346	347	347	348	348	350	350	350	351	346	347	346	348
2:00**	125	***	290	337	333	333	340	335	340	340	343	340	343	339	341	342	342
2:05	130		260	332	333	331	334	332	336	336	339	335	336	333	336	336	336
2:10	135		245	328	326	330	327	331	331	334	333	330	328	332	332	331	332
2:15	140		220	324	324	323	325	322	326	326	329	322	325	328	327	325	325
2:25	150		200	310	308	308	310	309	313	306	308	307	309	308.	306	310	310
2:35	160		188	287	287	286	289	290	296	293	295	286	288	287	296	295	297
2:45	170		178	273	273	273	276	278	283	280	282	273	275	278	283	282	281
2:55	180		169	260	260	260	264	266	271	277	279	260	262	259	271	268	265
3:05	190		162	247	247	247	251	254	259	254	256	247	250	297	259	259	251
3:15	200		157	235	236	236	240	243	248	242	244	238	240	233	249	244	236
3:25	210		150	227	227	227	232	234	239	235	236	239	230	228	241	233	228
3:35	220		150	219	219	219	223	227	231	225	226	220	220	220	231	223	218
3:45	230		145	210	210	210	214	216	221	215	215	210	211	212	222	214	209
3:55	240		140	202	202	202	206	209	212	206	207	201	203	204	212	206	201
4:05	250		130	192	192	193	198	200	202	196	198	192	194	195	204	198	192
4:15	260		125	188	188	188	196	192	194	190	190	185	186	186	196	190	184
4:25	270		120	180	181	181	183	182	187	182	183	178	179	181	188	182	176
4:35	280																
4:45	290			72	73	73	76	77	79	72	75	72	72	75	110	174	170

*Cure period started
**Cure period ended
***Oven heat turned off fans left on

TABLE I-14. PEEL TEST DATA, SAMPLE LOT NO. 1

Test Specimen Number	Pull Force (lb)	Torn Webs	
		(No.)	(%)
SI-1			
A-Bag Side	25	28	48
B-Mold Side	15	42	72
SI-2			
A-Bag Side	22	39	67
B-Mold Side	13	51	88
SII-1			
A-Bag Side	25	53	91
B-Mold Side	24 See Note 1	41	71
MC-1			
A-Bag Side	25	57	98
B-Mold Side	25	56	97
MC-3			
A-Bag Side	10	35	60
B-Mold Side	19	39	67
MC-5			
A-Bag Side	25	43	74
B-Mold Side	14	43	74
MC-6			
A-Bag Side	24	52	90
B-Mold Side	20	42	72
MB-1			
A-Bag Side	32	50 See Note 2	86
B-Mold Side	18	53	91
MB-3			
A-Bag Side	19	46	79
B-Mold Side	18	53	91
MB-5			
A-Bag Side	30	52 See Note 3	90
B-Mold Side	20	50	86
MB-6			
A-Bag Side	30	47	81
B-Mold Side	20	47	81

Note 1. 9-cell area-adhesive pulled from skin
Note 2. 22-cell area-adhesive pulled from skin
Note 3. 2-cell area-adhesive pulled from skin

TABLE I-14. PEEL TEST DATA, SAMPLE LOT NO. 1 (Continued)

Test Specimen Number	Pull Force (lb)	Torn Webs	
		(No.)	(%)
MF-1			
A-Bag Side	25 See Note 4	53 See Note 4	91
B-Mold Side	20	50 See Note 5	86
MF-3			
A-Bag Side	30	55 See Note 6	95
B-Mold Side	25	48 See Note 7	83
MF-5			
A-Bag Side	35	38 See Note 8	66
B-Mold Side	19	46	79
MF-6			
A-Bag Side	34	46 See Note 9	79
B-Mold Side	22	47	81

Note 4. 15-cell area-adhesive pulled from skin
Note 5. 3-cell area-adhesive pulled from skin
Note 6. 9-cell area-adhesive pulled from skin
Note 7. 5-cell area-adhesive pulled from skin
Note 8. 18-cell area-adhesive pulled from skin
Note 9. 9-cell area-adhesive pulled from skin

TABLE I-15. FLEXURE TEST DATA, SAMPLE LOT NO. 1

Test Specimen		Force (lb)	Force/Inch Width (lb)	Comments
No. *	Size			
S-II-2-MT	≈3.0 × 0.509 inch	101	67.3	Failure in test area
MB-4-BT		98	65.3	Failure in test area
MB-2-MT		94	62.7	Failure at skin
MF-4-BT		103	68.7	Failure in test area
MF-2-MT		93	62.0	Failure in test area
MC-4-BT		94	62.7	Failure in test area
MC-2-MT		92	61.3	Failure in test area

*MT — Mold Side Test
BT — Bag Side Test

TABLE I-16. LAP SHEAR TEST DATA SAMPLE LOT NO. 1

Test Specimen See Note 1	Force/Square Inch (psi) for Sample No.							
	1	2	3	4	5	6	7	8
1st Cure*	6638	6625	6547	6695	6910	7232	-	-
2nd Cure	5912	5577	5826	4910	5015	5752	5110	4870
Extras**	6540	6533	6593	6593	6748	6796	-	-
1st & 2nd Cure▲	-	-	-	-	-	-	6182	6291

*Samples joined incorrectly
**Samples made during first batch, cured during second cure
▲Samples made during first cure, also given second cure
Note 1. Approximate size of samples was 0.98 × 0.49 × 0.475 inch

TABLE I-17. THERMOCOUPLE TEMPERATURES, FIRST CURE, LOT NO. 2

Time		Oven Temperature		Thermocouple Nos.													
Hr/Min	Elapsed	Setting	Actual	T-1	B-2	T-3	B-4	T-5	B-6	T-7	B-8	T-9	B-10	M-11	M-12	M-13	M-14
7:25	0	509	452	84	84	85	86	85	88	87	85	88	88	87	87	88	88
7:30	5	509	495	139	132	164	130	160	132	175	132	144	128	132	132	114	116
7:35	10	509	495	168	158	182	154	186	156	188	150	162	148	154	153	138	136
7:40	15	509	499	194	186	208	179	208	180	212	178	190	176	188	192	172	162
7:45	20	509	499	217	209	225	200	225	200	229	200	208	197	211	202	192	182
7:50	25	509	498	237	230	244	220	244	220	247	215	224	213	228	217	212	211
7:55	30	509	499	256	252	262	241	261	239	264	239	248	238	248	238	231	231
8:00	35	509	499	280	273	284	262	281	259	286	260	267	254	273	257	253	254
8:05	40	509	495	294	289	297	275	292	271	295	273	282	272	289	273	270	272
8:10	45	509	500	309	304	310	295	306	292	310	293	299	292	305	289	285	290
8:15	50	509	500	325	321	325	310	319	306	322	308	313	307	321	306	302	307
8:20	55	509	500	336	330	339	322	329	319	333	321	325	320	332	316	313	316
8:25	60	475	461	341	340	340	332	335	328	339	331	334	331	342	328	326	332
8:30*	65	450	460	355	352	352	345	346	391	350	344	347	395	353	341	336	343
8:35	70	365	417	357	357	356	351	350	347	354	351	352	352	358	347	342	350
8:40	75	365	390	357	358	356	355	352	350	355	355	355	355	359	350	345	352
8:45	80	365	370	357	357	356	356	352	352	W I	356	357	357	358	352	347	356
8:50	85	365	356	356	357	356	356	352	352	R E	356	357	357	357	352	348	357
8:55	90	365	357	355	355	355	355	352	352		357	357	357	357	353	349	357
9:00	95	365	360	354	355	355	355	354	354	D	357	358	358	356	353	349	358
9:05	100	360	350	354	354	353	353	353	353	E A	357	357	357	357	353	350	358
9:10	105	360	355	353	353	353	353	353	353	D	356	356	356	354	353	349	354
9:15	110	360	350	351	351	352	352	352	352		356	356	356	352	352	349	355
9:20**	115	360	352	351	351	351	351	351	351		355	355	355	350	351	349	355
9:25	120	***	300	344	344	340	346	343	347	346	350	349	350	346	348	346	332
9:35	130		245	335	335	335	337	337	341	341	342	342	342	337	342	335	338
9:40	135		220	327	327	327	328	329	335	336	337	337	337	329	336	330	315
9:45	140		210	319	319	319	321	324	330	330	331	328	328	319	328	324	310
9:55	150		190	300	300	300	305	310	316	316	316	314	313	300	315	310	296
10:05	160		175	284	283	283	290	299	304	304	304	298	298	284	302	297	284
10:15	170		165	267	267	267	271	283	288	288	290	285	285	269	290	281	279
10:25	180		160	254	253	257	261	273	279	277	277	271	271	254	277	270	269
10:35	190		150	243	243	247	250	262	267	266	266	260	260	254	267	258	254
10:45	200		150	235	235	235	238	250	253	253	253	249	249	234	253	246	242
10:55	210		145	227	226	226	231	240	244	243	243	239	239	224	243	237	233
11:05	220		140	215	214	215	219	227	231	230	230	226	226	214	228	224	220
11:15	230		135	209	207	208	212	219	221	221	220	217	218	206	222	215	212
11:25	240		130	200	200	201	203	211	214	213	214	214	210	200	203	208	204
11:35	250		128	193	193	193	194	200	203	202	202	201	201	195	197	197	194
11:45	260		125	187	187	187	187	193	196	196	196	193	193	188	190	190	187
11:55	270		120	182	181	181	181	186	189	189	189	187	187	182	185	184	179

* Cure period started

** Cure period ended

*** Oven heat turned off, fans left on

TABLE I-18. THERMOCOUPLE TEMPERATURES, SECOND CURE, LOT NO. 2

Time		Oven Temperature		Thermocouple Nos.													
Hr/Min	Elapsed	Setting	Actual	T-1	B-2	T-3	B-4	T-5	B-6	T-7	B-8	T-9	B-10	M-11	M-12	M-13	M-14
10:00	0	509	460	80	80	80	80	80	80	80	80	80	80	80	80	80	80
10:05	5	509	470	112	107	132	110	134	103	125	102	120	102	107	106	98	95
10:10	10	509	500	150	142	162	144	158	132	160	132	154	134	142	136	128	132
10:15	15	509	500	173	166	187	163	185	157	184	150	174	159	167	153	157	154
10:20	20	509	500	202	196	211	188	218	180	206	182	198	170	196	174	168	162
10:25	25	509	500	228	198	226	224	239	214	202	228	207	203	229	204	206	210
10:30	30	509	499	246	240	256	238	252	222	248	228	250	246	253	223	228	230
10:35	35	509	500	276	272	278	258	267	242	268	298	270	257	273	245	247	255
10:40	40	509	500	294	290	296	272	286	265	288	272	294	282	292	262	260	269
10:45	45	509	500	314	312	316	304	298	282	302	288	308	298	314	282	282	298
10:50	50	475	500	326	326	326	314	310	294	314	303	330	312	326	294	288	300
10:55	55	425	465	341	336	338	330	323	312	328	322	336	332	341	313	312	327
11:00	60	425	440	344	342	341	334	326	317	332	326	339	335	345	318	318	334
11:05	65	385	415	350	350	348	343	334	326	338	336	346	344	350	327	322	340
11:10*	70	365	390	350	350	350	350	344	341	341	342	346	346	350	341	330	346
11:15	75	365	365	352	353	353	353	346	344	346	344	347	347	354	343	333	348
11:20	80	365	355	351	351	351	351	346	346	346	347	348	350	352	345	336	348
11:25	85	365	360	351	351	351	351	349	346	347	347	347	350	351	348	336	348
11:30	90	365	360	350	350	350	351	349	348	349	350	351	351	351	349	337	348
11:35	95	365	355	350	350	350	350	350	349	349	350	351	352	352	349	340	348
11:40	100	365	360	350	350	350	350	350	350	350	350	350	351	351	350	340	348
11:45	105	365	360	351	351	351	351	351	351	351	351	351	351	351	351	340	348
11:50	110	365	360	351	351	351	351	351	351	351	351	351	351	351	351	341	348
11:55	115	365	360	351	351	351	351	351	351	351	351	351	351	351	351	342	348
12:00	120	365	360	351	351	351	351	351	351	351	351	351	351	351	351	342	348
12:05**	125	***	360	351	351	351	351	351	351	351	351	351	351	351	351	343	348
12:10	130		300	340	340	336	342	335	342	340	346	340	346	341	341	342	342
12:15	135		265	336	336	337	332	337	337	341	338	340	334	338	338	338	338
12:20	140		240	326	326	326	332	330	333	335	337	333	334	336	334	330	330
12:30	150		225	318	318	319	324	325	328	328	332	326	326	318	328	324	325
12:40	160		210	310	310	312	316	319	325	322	326	320	320	310	324	316	318
12:50	170		200	302	302	304	310	314	319	316	320	312	312	302	318	310	301
1:00	180		192	299	295	296	304	310	319	310	313	307	307	293	314	301	301
1:10	190		185	286	286	288	294	302	306	301	304	296	298	284	310	277	300
1:20	200		179	275	274	278	283	296	300	294	297	288	288	273	300	285	294
1:30	210		172	267	267	270	276	288	293	286	288	280	280	264	294	278	286
1:40	220		170	258	258	263	268	282	287	279	281	272	272	258	288	267	280
1:50	230		168	252	252	257	261	277	286	272	276	266	267	250	281	264	276
2:00	240		163	246	246	250	255	271	275	266	270	261	261	246	266	260	270
2:10	250		155	231	231	237	240	258	263	252	254	206	246	230	261	260	248
2:20	260		150	219	219	225	229	246	251	241	243	234	234	218	250	247	233
2:30	270		145	209	209	214	217	234	240	230	232	224	223	209	238	236	221
2:40	280		140	200	198	204	208	226	230	220	222	214	214	198	229	218	212
2:50	290		138	191	191	196	200	218	220	212	212	208	210	190	220	212	204
3:00	300		132	182	186	190	192	206	210	202	204	196	182	185	210	208	194
	310		130	177	177	181	184	200	204	194	196	190	190	176	202	204	188
	320		122	172	172	175	178	192	196	186	188	182	182	170	195	194	180
	330		118	165	165	167	170	185	187	178	179	175	175	164	187	188	173

* Cure period started
** Cure period ended
*** Oven heater turned off, fans left on

TABLE I-19. PEEL TEST DATA, SAMPLE LOT NO. 2

Test Specimen Number	Pull Force (lb)	Torn Webs	
		(No.)	(%)
SI-1			
A-Bag Side	15	56	
B-Mold Side	19	41	
SI-2			
A-Bag Side	33	54 See Notes 1 & 2	
B-Mold Side	25	51	
SI-3			
A-Bag Side	15	56	
B-Mold Side	21	44	
SII-2			
A-Bag Side	32	55 See Note 3	
B-Mold Side	35	13 See Note 3	
MF-1			
A-Bag Side	17	55	
B-Mold Side	23	45	
MF-3			
A-Bag Side	10	57	
B-Mold Side	15	47	
MF-5			
A-Bag Side	14	56	
B-Mold Side	22	46	
MF-6			
A-Bag Side	21	55	
B-Mold Side	22	47	
MC-1			
A-Bag Side	30	55	
B-Mold Side	25	42	
MC-3			
A-Bag Side	30	54	
B-Mold Side	23	42	
MC-5			
A-Bag Side	20	53	
B-Mold Side	19	53	

Note 1. 6-cell area-adhesive pulled from skin
Note 2. One of three test areas had two torn webs
Note 3. 4-cell area-adhesive pulled from skin

TABLE I-19. PEEL TEST DATA, SAMPLE LOT NO. 2 (Continued)

Test Specimen Number	Pull Force (lb)	Torn Webs (No.)	(%)
MC-6			
A-Bag Side	17	54	
B-Mold Side	25	50	
MB-1			
A-Bag Side	24	43	
B-Mold Side	30	33	
MB-3			
A-Bag Side	25	52	
B-Mold Side	31	33	
MB-5			
A-Bag Side	22	41	
B-Mold Side	17	53	
MB-6			
A-Bag Side	17	54	
B-Mold Side	25	34	

TABLE I-20. FLEXURE TEST DATA, SAMPLE LOT NO. 2

Test Specimen No.*	Size	Force (lb)	Force/Inch Width (lb)	Comments
S-II-2-BT	≈3.0 × 0.512	74	47	Failure in test area
MF-2-MT		90	60	Failure in test area
MF-4-BT		87	57	Failure in test area
MC-2-MT		88	58	Failure in test area
MC-4-BT		83	54	—
MB-2-MT		86	57	Failure in test area
MB-4-BT		89	60	Failure in test area

*MT - Mold side test
BT - Bag side test

TABLE I-21. LAP SHEAR TEST DATA, SAMPLE LOT NO. 2

Test Specimen (See Note 1)	Force/Square Inch (psi) for Sample No.					
	1	2	3	4	5	6
1st Cure	7056	6839	7192	6895	-	-
2nd Cure	5982	5987	6299	6182	6391	5093
1st & 2nd Cure*	-	-	-	-	6938	6915

*Samples made during first cure, cured with 2nd cure.
Note 1. Approximate size 0.988 × 0.49 × 0.475

APPENDIX II

STORAGE MODULE TEST DATA

A. INTRODUCTION

This test data summary contains sufficient data to demonstrate that the eight flight storage modules (Serial No. 022 through 027, 028, and 030) and control module 06 have successfully met all the flight acceptance test requirements and are capable of performing their intended function in flight.

This report summarizes the test activities performed on the flight equipment listed above from January 1969 to July 1969. A chronological summary for the report period is contained in Table II-1. Significant events listed in the table are discussed in detail in the body of the report.

B. PROGRAM TEST PLAN

The flight acceptance test sequence for the Nimbus-D power supply subsystem (eight storage modules and one control module is presented in Table II-2.

The test program is essentially divided into five phases. Phase one includes all testing on the units after final assembly but prior to the final conformal-coating cycle. During phase one, both the electronic circuits and the battery performance are examined to ensure that the entire unit is functioning properly prior to final potting. Phase two testing is initiated after all potting has been completed and the unit is released from Manufacturing. Electrical circuit testing at 5, 25, 45, and 55°C includes calibration of the battery charge current, battery discharge current, and battery voltage telemetry circuits; and calibration of the battery temperature telemetry circuits from -5 to 55°C. Phase three includes all testing associated with the vibration exposure. Post-vibration electrical performance is assured by a battery short test and an electrical circuit test at 25°C. Phase four consists of three tests. The first two tests of phase four are conducted with the storage modules electrically connected to a control module for testing in a power subsystem configuration. The first test is a system bench test at room ambient environment. The initial system test is conducted to verify correct performance of the power subsystem configuration and the associated test equipment prior to the thermal-vacuum test cycle. The second test is the thermal-vacuum exposure where all aspects of storage module performance are examined. Successful completion of the thermal-vacuum test cycle demonstrates storage module flight acceptability. The third test of phase four is a post-environmental examination of the individual storage modules to ensure that each storage cell in the modules has remained sealed during the thermal-vacuum exposure. Since the unit has to be opened and partially disassembled for the electrolyte leakage examination, a final electrical circuit

TABLE II-1. CHRONOLOGICAL SUMMARY OF EVENTS, FLIGHT STORAGE AND CONTROL MODULES

Date	Storage Module Serial Number	Event
1-6-69	022	Unit delivered to engineering for pre-pot tests.
1-7-69	022	Circuit alignment and electrical test performed — results satisfactory.
1-9-69	023	Unit delivered to engineering for pre-pot tests.
1-10-69	023	Circuit alignment and electrical test started — failure of 1N944 B Zener diode (VR2 on the electronics board) occurred and TDR B3964 was generated. Unit returned to manufacturing for replacement of diode.
1-14-69	023	Unit returned to engineering for pre-pot tests after replacement of 1N944 B Zener diode.
1-15-69	023	Circuit alignment and electrical test performed — results satisfactory.
1-15-69	022, 023	Start battery conditioning cycle.
1-17-69	024	Unit delivered to engineering for pre-pot tests.
1-21-69	022, 023	Complete battery conditioning cycle — results satisfactory. Start battery short test.
1-22-69	022, 023	Complete battery short test — results satisfactory.
1-22-69	024	Circuit alignment started — simulated battery voltage could not be read at the test rack and TDR B 3935 was generated. Subsequent testing indicated problem was not in the module.
1-23-69	022, 023	Battery capacity test performed — results satisfactory.
1-24-69	022, 023	Units delivered to manufacturing for final module potting.
1-24-69	025	Unit delivered to engineering for pre-pot tests.
1-27-69	024, 025	Circuit alignment and electrical test performed — results satisfactory. Start battery conditioning cycle.
1-31-69	024, 025	Complete battery conditioning cycle — results satisfactory. Start battery short test.
2-1-69	024, 025	Complete battery short test — results satisfactory.

TABLE II-1. CHRONOLOGICAL SUMMARY OF EVENTS, FLIGHT STORAGE AND CONTROL MODULES (Continued)

Date	Storage Module Serial Number	Event
2-3-69	024, 025	Battery capacity test performed — results satisfactory.
2-4-69	024, 025	Units delivered to manufacturing for final module potting.
2-5-69	022, 023, 024, 025	While in the final potting operation a decision was made by the Nimbus Project Office to replace the 2N2016 transistor (shunt dissipator transistor Q4 on the heat sink assembly) with a new type of tranistor (RCA Part 1970655-1) in rack storage module. Rework of the four assembled units (022, 023, 024, 025) was started on this date.
2-25-69	022, 023, 024, 025	Units delivered to engineering for performance test sequence. Delivered units completely assembled and potted with new shunt dissipator transistor.
2-26-69	022, 023 024, 025	Electrical performance test at 25°C performed — results satisfactory. Telemetry calibration at 25°C performed — results satisfactory.
2-28-69	026, 027	Units delivered to engineering for pre-pot test (the new shunt dissipator transistor 1970655-1 already added to assembly).
3-3-69	026, 027	Circuit alignment and electrical test performed — results satisfactory. Start battery conditioning cycle.
3-4-69	022, 023	Electrical performance test at 55°C performed - results satisfactory. Telemetry calibration at 50 and 55°C performed — results satisfactory.
3-5-69	022, 023	Electrical performance test at 5°C performed — results satisfactory. Telemetry calibration at -5, 0, 5 and 10°C performed — results satisfactory.
3-5-69	029	Unit delivered to engineering for pre-pot test (the new shunt dissipator transistor 1970655-1 already added to assembly).
3-6-69	022	Electrical performance test at 45°C performed - results satisfactory. Telemetry calibration at 40 and 45°C performed — results satisfactory.

TABLE II-1. CHRONOLOGICAL SUMMARY OF EVENTS, FLIGHT STORAGE AND CONTROL MODULES (Continued)

Date	Storage Module Serial Number	Event
3-6-69	023	Electrical performance test at 45°C started — holding screw for the 37-pin connector shorted power line of battery to module casting and TDR B 2349 generated. Battery was not affected by this failure because power return line in open condition by test rack switches at the time of failure.
3-6-69	026, 027	Complete battery conditioning cycle — results satisfactory. Start battery short test.
3-7-69	022	Harness rerouted away from the 37-pin connector by engineering. Repeated electrical performance test at 25°C after rerouting work — results satisfactory.
3-7-69	023	Unit delivered to manufacturing for repair of damaged battery power line and for a rerouting of harness away from the 37-pin connector.
3-7-69	024, 025	Harness rerouted away from the 37-pin connector by engineering.
3-7-69	026, 027	Complete battery short test — results satisfactory.
3-7-69	029	Circuit alignment and electrical test performed — results satisfactory. Start battery conditioning cycle.
3-10-69	024, 025	Electrical performance test at 5°C performed — results satisfactory. Telemetry calibration at -5, 0, 5, and 10°C performed — results satisfactory.
3-10-69	024	Electrical performance test at 55°C performed — results satisfactory. Telemetry calibration at 50 and 55°C performed — results satisfactory.
3-10-69	025	Electrical performance test at 55°C started — failure of 1N944B Zener diode (VR 2 on the electronics board) occurred and TDR 3937 was generated. Unit delivered to manufacturing for replacement of diode.
3-11-69	026, 027	Battery capacity test performed — results satisfactory.
3-11-69	029	Complete battery conditioning cycle — results satisfactory. Start battery short test.

TABLE II-1. CHRONOLOGICAL SUMMARY OF EVENTS, FLIGHT STORAGE AND CONTROL MODULES (Continued)

Date	Storage Module Serial Number	Event
3-12-69	026, 027	Units delivered to manufacturing for final module potting.
3-12-69	029	Complete battery short test — results satisfactory.
3-13-69	023	Unit returned to engineering after repair of damage wire (see 3-7-69 entry). Harness routing inspected — was found to be sufficiently clear of the 37-pin connector.
3-13-69	029	Battery capacity test performed — results satisfactory.
3-14-69	023	Electrical performance test at 45° C started — high temperature circuit input voltage was too high and TDR B 3938 was generated. Subsequence testing revealed that the problem was an unbonded thermistor on storage cell 19.
3-14-69	029	Unit delivered to manufacturing for final module potting.
3-17-69	026, 027	Units delivered to engineering for performance test sequence. Delivered units completely assembled and potted.
3-18-69	026, 027	Electrical performance test at 25° C performed — results satisfactory.
3-19-69	026, 027	Electrical performance test at 5° C performed — results satisfactory. Telemetry calibration at -5, 0, 5, and 10° C performed — results satisfactory.
3-20-69	026, 027	Electrical performance test at 45 and 55° C performed — results satisfactory. Telemetry calibration at 45, 50, and 55° C performed — results satisfactory.
3-21-69	023, 024	Electrical performance test at 45° C performed — results satisfactory. Telemetry calibration at 40 and 45° C performed — results satisfactory.
3-21-69	026, 027	Telemetry calibration at 25 and 40° C performed — results satisfactory.
3-21-69	026	Electrical performance test at 25° C repeated — failure of 1N944 B Zener diode (VR2 on the electronics board) occurred and TDR B 3939 was generated. Unit delivered to manufacturing for replacement of diode.

TABLE II-1. CHRONOLOGICAL SUMMARY OF EVENTS, FLIGHT STORAGE AND CONTROL MODULES (Continued)

Date	Storage Module Serial Number	Event
3-21-69	030	Unit delivered to engineering for pre-pot tests.
3-24-69	030	Circuit alignment and electrical test performed — results satisfactory. Started battery conditioning cycle.
3-26-69	029	Unit delivered to engineering for performance test sequence. Delivered unit completely assembled and potted.
3-27-69	029	Electrical performance test at 25°C started — failure of 1N944 B Zener diode (VR2 on the electronics board) occurred and TDR B 3940 was generated. Unit delivered to manufacturing for replacement of diode.
3-27-69	030	Complete battery conditioning cycle — results satisfactory. Start battery short test.
3-28-69	022, 023, 024, 027, 029	Units delivered to manufacturing for replacement of Zener diode 1N944 B (VR2 on the electronics board). The replacement of the 1N944 B diodes in each storage module was directed by the Nimbus Project Office. Subsequent investigation revealed that the repeated failures of the 1N944 B diodes was the result of electrical overstressing during the power burn-in cycle.
3-28-69	030	Complete battery short test — results satisfactory.
3-31-69	030	Battery capacity test performed — results satisfactory.
4-1-69	030	Unit delivered to manufacturing for final module potting and replacement of the 1N944 B diode (see 3-28-69 entry).
4-9-69	022, 023, 024, 025, 026, 027, 029	Units returned to engineering after replacement of the 1N944 B diodes.
4-10-69	022, 023, 024, 025, 026, 027, 029	Realignment and electrical circuit test of the charge controller performed — results satisfactory.
4-11-69	025	Electrical performance test at 25 and 55°C performed — results satisfactory. Telemetry calibration at 25, 50, and 55°C performed — results satisfactory.

TABLE II-1. CHRONOLOGICAL SUMMARY OF EVENTS, FLIGHT STORAGE AND CONTROL MODULES (Continued)

Date	Storage Module Serial Number	Event
4-14-69	025	Electrical performance test 5°C performed — results satisfactory. Telemetry calibration at -5, 0, 5, and 10°C) performed — results satisfactory.
4-14-69	029	Electrical performance test at 25°C performed — results satisfactory. Telemetry calibration at 25°C performed — results satisfactory.
4-15-69	025	Electrical performance test at 45°C performed — results satisfactory. Telemetry calibration at 40 and 45°C performed — results satisfactory.
4-15-69	029	Electrical performance test at 5°C performed — results satisfactory. Telemetry calibration at -5, 0, 5, and 10°C performed — results satisfactory.
4-15-69	029	Electrical performance test at 45 and 55°C performed — results satisfactory. Telemetry calibration 40, 45, 50, and 55°C performed — results satisfactory.
4-16-69	022, 023, 024, 025, 026, 027, 029	Performance test data review completed and all units released for vibration test sequence.
4-17-69	030	Unit delivered to engineering for performance test sequence. Delivered unit completely assembled and potted, including replacement of the 1N944 B diode (see 3-28-69 entry).
4-21-69	030	Electrical performance test at 25°C performed — results satisfactory. Telemetry calibration at 25°C performed — results satisfactory.
4-22-69	030	Electrical performance test 5°C performed — results satisfactory. Telemetry calibration at -5, 0, 5, and 10°C performed — results satisfactory.
4-23-69	030	Electrical performance test at 45 and 55°C performed — results satisfactory. Telemetry calibration at 40, 45, 50, and 55°C performed — results satisfactory.

TABLE II-1. CHRONOLOGICAL SUMMARY OF EVENTS, FLIGHT STORAGE AND CONTROL MODULES (Continued)

Date	Storage Module Serial Number	Event
4-24-69	030	Performance test data review completed and unit released for vibration test sequence.
4-24-69	022, 023, 024, 025, 026, 027, 029, 030	Pre-vibration charge performed — results satisfactory.
4-26-69	022, 023, 024, 025, 026, 027, 029, 030	Vibration test started.
4-28-69	022, 023, 024, 025, 026, 027, 029, 030	Vibration test completed — results satisfactory.
4-29-69	022, 023, 024, 025, 026, 027, 029, 030	Post-vibration battery short test performed — results satisfactory.
4-30-69	022, 023, 024, 025, 026, 027, 029, 030	Post-vibration electrical test at 25°C performed — results satisfactory.
5-1-69	022, 023, 024, 025, 026, 027, 029, 030	Units connected electrically with control module 06 and charged as a system — results satisfactory.
5-2-69	022, 023, 024, 025, 026, 027, 029, 030	Initial system test at room ambient temperature performed using control module — results satisfactory.
5-3-69	022, 023, 024, 025, 026, 027, 029, 030	Thermal-vacuum test cycle started (control module 06 used with the eight storage modules).

TABLE II-1. CHRONOLOGICAL SUMMARY OF EVENTS, FLIGHT STORAGE AND CONTROL MODULES (Continued)

Date	Storage Module Serial Number	Event
5-20-69	022, 023, 024, 025, 026, 027, 029, 030	Thermal-vacuum test cycle completed — with the exception of the high temperature trickle charge circuit on modules 022 and 023, all test results were satisfactory. The high temperature circuit thermistors in modules 022 and 023 (located on storage cell 19 in each module) were not properly bonded to the storage cell. The result was premature operation of the trickle charge circuit during high temperature testing. TDR B 3953 and TDR B 3954 were generated at the first occurrance of the premature operation.
5-22-69	022, 023, 024, 025, 026, 027, 029, 030	Electrolyte leakage test performed on each battery — results satisfactory.
5-23-69	022, 023, 024, 025, 026, 027, 029, 030	Special resistance measurement made on the high temperature circuit thermistors in each module — results satisfactory.
[illegible]	024, 025, 026, 027, 029, 030	Post thermal-vacuum electrical test at 25°C performed — results satisfactory.
5-27-69	022, 023	Mechanical examination of the high temperature circuit thermistor (on storage cell 19) in each unit was performed. Thermistor was not bonded to the storage cell (see 5-20-69 entry).
5-28-69	022, 023	Units delivered to manufacturing for replacement of cell 19 thermistors.
6-2-69	022, 023	Units returned to engineering after replacement and rebonding of cell 19 thermistors.
6-2-69	022, 023	Electrical test at 25°C performed — results satisfactory.
6-2-69	022, 023	Pre-vibration charge performed — results satisfactory.
6-3-69	022, 023	Workmanship vibration test performed — results satisfactory.

TABLE II-1. CHRONOLOGICAL SUMMARY OF EVENTS, FLIGHT STORAGE AND CONTROL MODULES (Continued)

Date	Storage Module Serial Number	Event
6-5-69	022, 023	Post vibration electrical test at 25°C performed — results satisfactory.
6-6-69	022, 023	Special thermal-vacuum test started.
6-7-69	022, 023	Special thermal-vacuum test completed — results satisfactory.
6-8-69	022, 023	Post thermal-vacuum electrical test at 25°C performed — results satisfactory.
6-9-69	024	During set-up for final system test, storage cells 15 through 22 short-circuited by test harness. TDR B 3956 was generated at the occurrence of this failure.
6-10-69	024	Unit delivered to manufacturing for replacement of storage cells 15 through 22.
6-19-69	022, 023, 025, 026, 027, 029 030	Units connected electrically with control module 03 and charged as a system — results satisfactory.
6-20-69	022, 023, 025, 026, 027, 029, 030	Final system test at room ambient temperature performed using control module 03 — results satisfactory.
6-20-69	024	Unit returned to engineering after replacement of the eight storage cells.
6-21-69	024	Battery short test performed — results satisfactory.
6-21-69	022, 023, 025, 026, 027, 029, 030	Pin retention test performed — results satisfactory.
6-22-69	024	Electrical circuit test performed — results satisfactory.
6-22-69	024	Pre-vibration charge performed — results satisfactory.
6-22-69	024	Workmanship vibration test performed — results satisfactory.

TABLE II-1. CHRONOLOGICAL SUMMARY OF EVENTS, FLIGHT STORAGE AND CONTROL MODULES (Continued)

Date	Storage Module Serial Number	Event
6-22-69	024	Post vibration electrical test performed — results satisfactory.
6-23-69	024	Battery short test performed — results satisfactory.
6-24-69	022, 023, 025, 026, 027, 029, 030	Units shipped to GE Co., Valley Forge, Pa.
6-25-69	024	Special thermal-vacuum test started.
6-27-69	024	Special thermal-vacuum test completed — results satisfactory.
6-30-69	024	Post-thermal-vacuum capacity test performed — results satisfactory.
7-1-69	024	Post thermal-vacuum electrical test performed — results satisfactory.
7-2-69	024	Pin retention test performed — results satisfactory.
7-3-69	024	Unit shipped to GE Co., Valley Forge, Pa.

TABLE II-2. NIMBUS-D POWER SUPPLY SUBSYSTEM TEST PROGRAM

Phase	Test Sequence	Test Procedure
1	Electrical Circuit Alignment and Test (1) Battery Short Test (1) Battery Capacity Test (1)	TP-CT-1759580 TP-BT-1759580 TP-BT-1759580
2	Electrical Performance Test (1) Telemetry Calibration (1)	TP-CT-1759580 TP-TM-1759580
3	Vibration Test (1) Battery Short Test (1) Electrical Circuit Test (1)	TP-HVA-1759580 TP-BT-1759580 TP-CT-1759580
4	Initial System Test (2) Thermal-Vacuum Test (2) Battery Electrolyte Leakage Test (1) Electrical Circuit Test (1)	TP-FTV-1846666 TP-FTV-1846666 1846070 TP-CT-1759580
5	Final System Test (2)	TP-FTV-1846666

NOTES: (1) Flight storage modules tested as individual units.
(2) Flight storage modules tested as part of the power subsystem.

test at 25°C after reassembly of the storage modules, is performed to complete the post thermal-vacuum testing sequence. Phase five of the test program is a final system bench test in an ambient environment before sell-off of the units. The customer witnesses the final system test.

The vibration testing was performed on each storage module individually during the Nimbus-D flight acceptance program. The exposure conditions for vibration were:

- Sinusoidal (all axes; thrust and two transverse)
  Frequency Range: 5 to 2000 Hz
  Vibration Level: 5g (0 to peak)
  Sweep Rate: two octaves per minute, all axes, from the lowest to the highest frequency.
- Random (all axes)
  Frequency Band: 20 to 2000 Hz
  Spectral Density: 0.07 g^2/Hz
  Vibration Level: 11.7g (RMS)
  Duration: 2 minutes each axis

The test fixture used during vibration tests, shown in Figure II-1, mounts directly to the vibration table. The table vibration levels were controlled by signals from the control accelerometers (also shown in Figure II-1). During the sinusoidal exposure, four control accelerometers actually determined the vibration level, during the random exposures the average of the four control accelerometers determined the vibration level.

The thermal-vacuum tests were performed with the eight flight storage modules and the control module electrically connected in a power subsystem configuration. A functional block diagram of the subsystem configuration is presented in Figure II-2. The thermal-vacuum installation for the Nimbus-D flight power subsystem was identical to that used on the Nimbus-B flight acceptance program. The installation details for the Nimbus-B program are fully described in the Nimbus-B "Quarterly Technical Report No. 7", (R3205) issued August 15, 1967. The thermal-vacuum temperature profile and electrical test sequence for the Nimbus-D power subsystem is shown in Figure II-3. The major portion of thermal-vacuum testing consisted of repetitive electrical cycling of the subsystem in a simulated orbital condition consisting of 35 minutes of battery discharge followed by 73 minutes of solar array illumination. The regulated bus load was maintained at the maximum energy-balance value throughout each orbit, and included a simulated S-band transmitter load of 73 watts superimposed for 5 minutes on the constant load, beginning at 18 minutes before the end of spacecraft daytime. Three consecutive minimum load orbits were run at each of the points shown in Figure II-3. During the minimum load orbits, the regulated bus load was maintained at 50 watts. A system performance test was conducted near the end of exposure at each temperature plateau. The purpose of system tests was to examine electrical parameters not normally measured during the simulated orbital cycling. The thermal vacuum test sequence was concluded with a system capacity test and a system short test.

C. STORAGE MODULE UNIT TEST

1. Electrical Circuit Performance

With the exception of the charge-controller circuitry in the storage module, all electrical circuits performed satisfactory during unit testing. Failures in Zener diode IN944 B (VR-2 on the electronics board) caused numerous charge-controller test discrepancies and lead to the replacement of that Zener diode in all storage modules during phase two of the test program. The details of the IN944 B Zener diodes failures are discussed further in Paragraph E, Test Discrepancies of this appendix.

The electrical circuit performance for each flight unit is summarized in Table II-3. This summary includes performance data taken after the replacement of the IN944 B Zener diode.

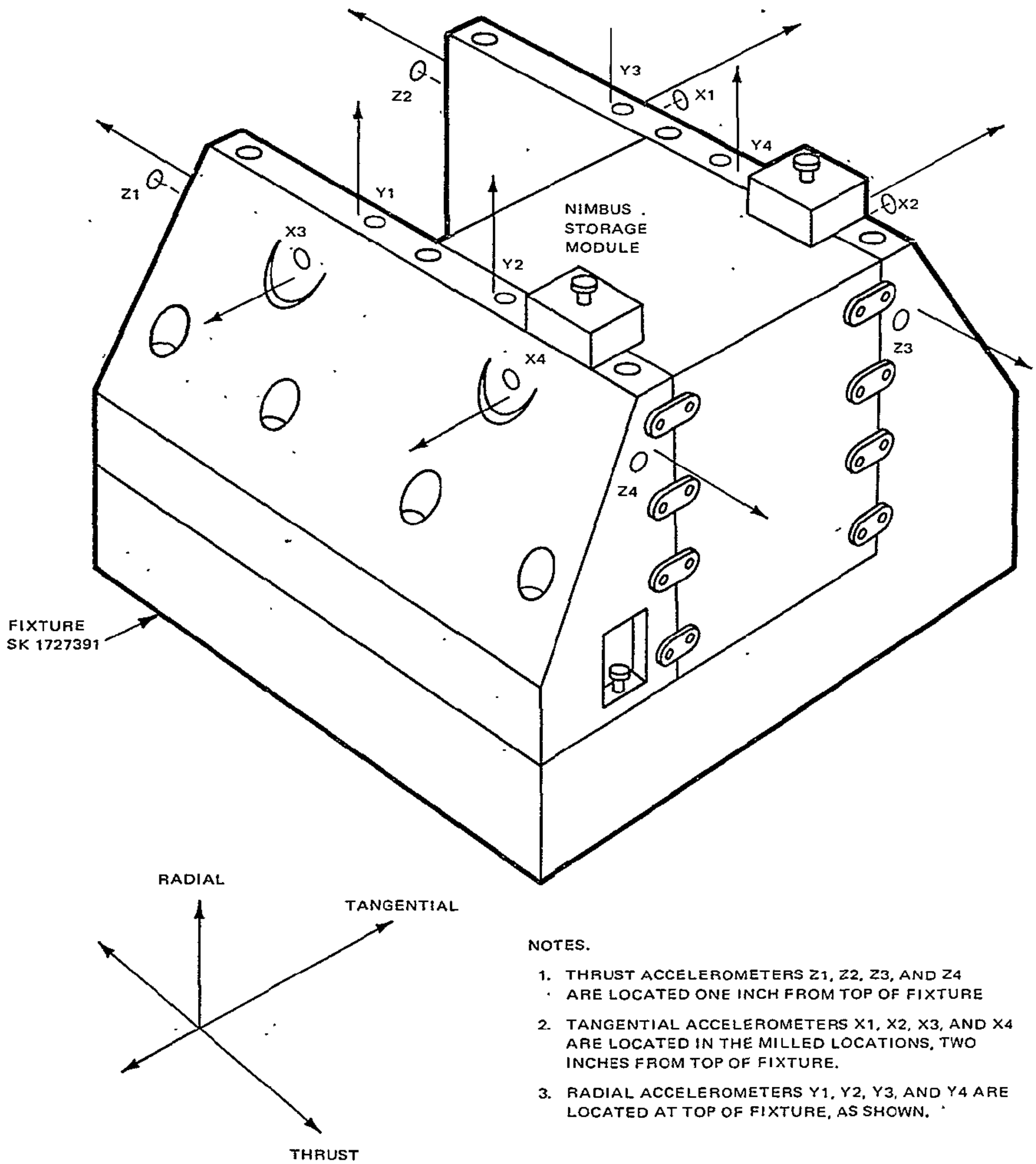


Figure II-1. Storage Module Vibration Test Fixture and Instrumentation

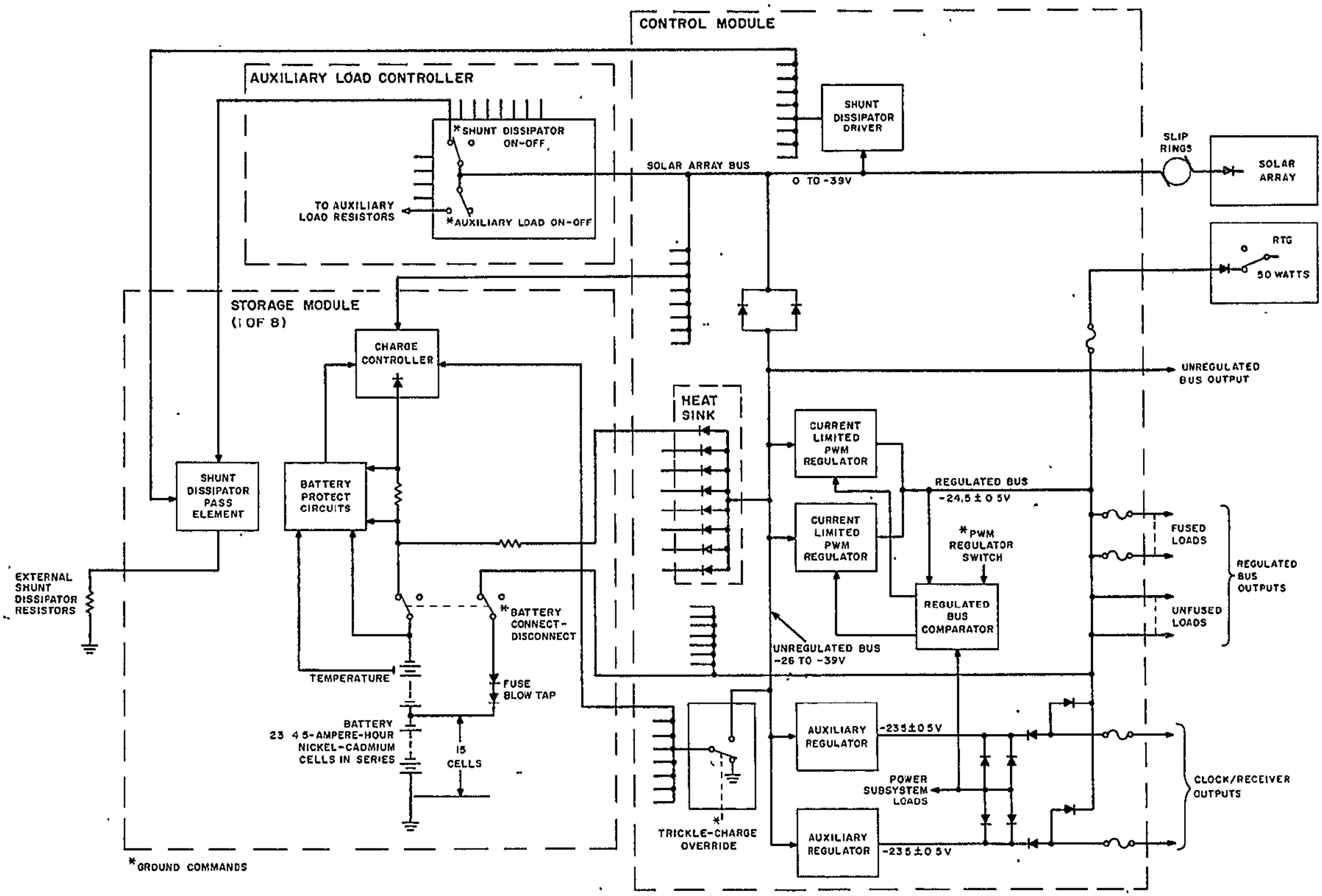


Figure II-2. Functional Block Diagram of Nimbus-D Power Subsystem

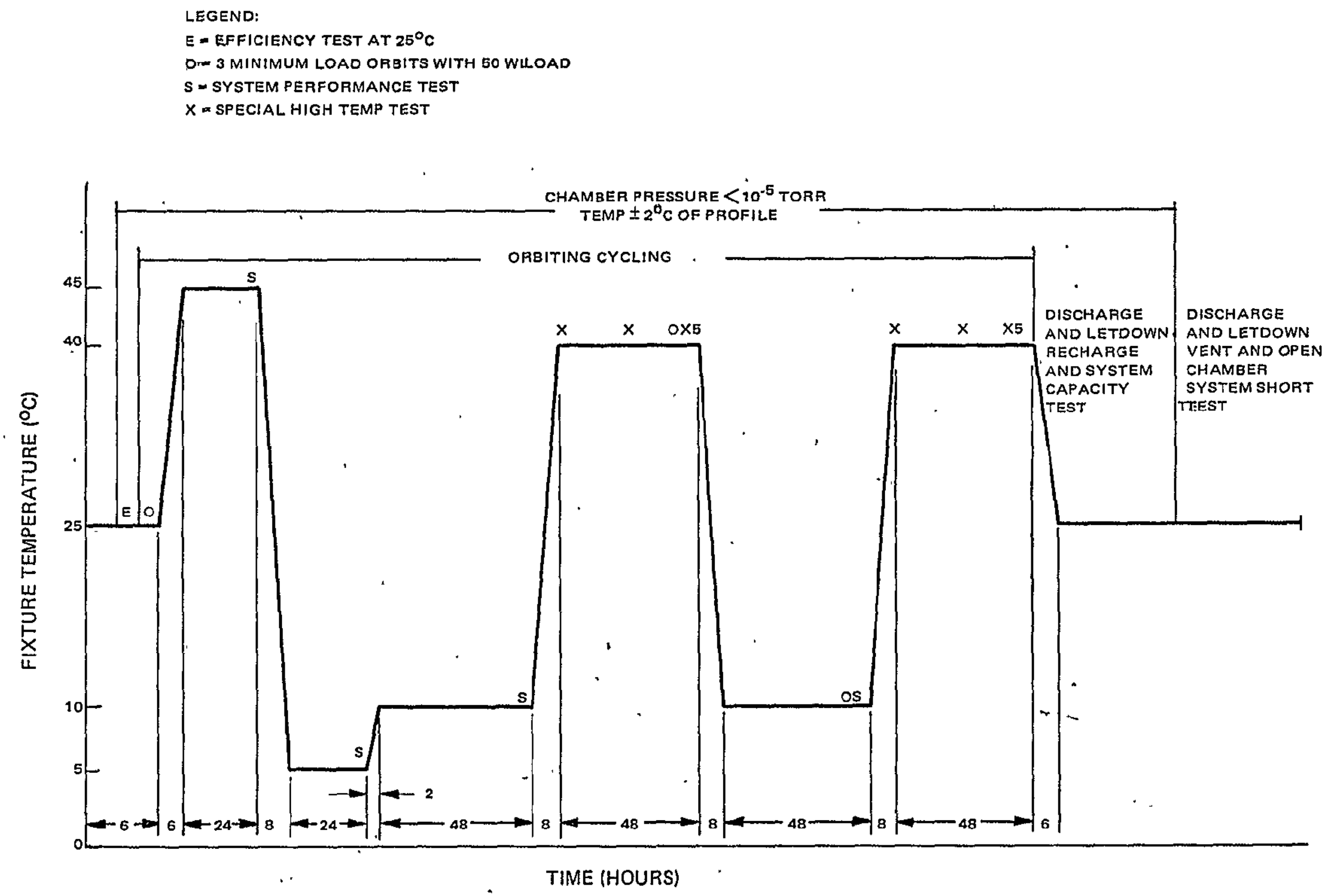


Figure II-3. Nimbus-D Thermal Profile and Electrical Test Sequence

TABLE II-3. ELECTRICAL CIRCUIT PERFORMANCE FOR FLIGHT STORAGE MODULES

Parameter	Temperature	Test Limiter	Measured Data For Storage Module Serial Numbers Shown Below							
			022	023	024	025	026	027	029	030
Maximum Charge Current (In Amperes)	5°C	1.100 ±0.050A	1.098	1.100	1.095	1.101	1.100	1.099	1.098	1.098
	25°C		1.101	1.100	1.100	1.102	1.101	1.101	1.101	1.100
	45°C		1.101	1.105	1.106	1.109	1.108	1.106	1.109	1.104
Trickle Charge Current (In Amperes) Simulated High Temperature Signal at 5°C, 25°C, and 45°C. Actual High Temperature Signal at 55°C.	5°C	0.150 ±0.025A	0.147	0.148	0.150	0.150	0.147	0.148	0.152	0.150
	25°C		0.150	0.150	0.150	0.151	0.147	0.150	0.152	0.150
	45°C		0.152	0.150	0.155	0.154	0.155	0.154	0.157	0.154
	55°C		0.152	0.151	0.155	0.156	0.156	0.155	0.156	0.154
Battery Voltage Limit (In Volts)	5°C	34.5 ±0.2V	34.5	34.5	34.5	34.6	34.6	34.5	34.6	34.6
	25°C	33.6 ±0.2V	33.5	33.5	33.5	33.6	33.5	33.5	33.6	33.6
	45°C	32.7 ±0.2V	32.7	32.7	32.7	32.6	32.6	32.6	32.6	32.7
Charge Current T/M Voltage at 1.2A (In Volts)	5°C	6.0 ±0.2V	6.023	6.035	6.047	5.982	6.038	6.020	6.049	6.040
	25°C		6.006	6.024	6.037	5.978	6.025	6.010	6.028	6.037
	45°C		5.985	6.013	6.018	5.970	5.995	5.990	6.002	6.020
Discharge Current T/M Voltage at 2.4A (In Volts)	5°C	5.8 ±0.2V	5.812	5.855	5.821	5.791	5.801	5.800	5.855	5.843
	25°C		5.796	5.830	5.816	5.769	5.790	5.800	5.835	5.833
	45°C		5.773	5.811	5.800	5.731	5.769	5.785	5.811	5.808
Battery Voltage T/M Voltage at 30V (In Volts)	5°C	3.1 ±0.2V	3.110	3.105	3.139	3.111	3.105	3.102	3.147	3.136
	25°C		3.110	3.108	3.138	3.110	3.107	3.100	3.147	3.135
	45°C		3.110	3.110	3.138	3.108	3.105	3.098	3.146	3.132
Battery Temperature T/M Voltage (In Volts)	5°C	1.7 ±0.2V	1.728	1.715	1.730	1.715	1.695	1.710	1.701	1.702
	25°C	3.1 ±0.2V	3.178	3.120	3.131	3.151	3.150	3.130	3.120	3.111
	45°C	4.5 ±0.2V	4.580	4.555	4.550	4.587	4.572	4.541	4.546	4.550
Shunt Dissipator Voltage at 2A (In Volts)	5°C	less than 38.3V	38.20	38.16	38.16	38.16	38.21	38.17	38.19	38.15
	25°C		38.16	38.20	38.21	38.17	38.18	38.16	38.20	38.16
	45°C		38.16	38.20	38.16	38.16	38.18	38.16	38.21	38.16

2. Battery Performance

The battery performance for each storage module was measured during phase one of the test program. Prior to the initial battery short test, each unit was conditioned in accordance with the following schedule:

(1) a 40-hour, 200 milliampere charge

(2) a 2-ampere discharge until the voltage of one cell equals 1.150 volts

(3) a 4-hour letdown (a one-ohm resistor connected across each cell)

(4) a 20-hour, 400 milliampere charge

(5) a 2.0 ampere discharge until the voltage of one cell equals 1.150 volts

(6) a letdown until each cell voltage was less than 20 millivolts.

The initial battery short-test results were excellent. Table II-4 presents the 20-hour open-circuit cell voltage data for the test. An examination of this data reveals that the lowest storage cell voltage was 1.184 volts (module 026) after the 20-hour stand. The specified lower limit for this test sequence is 1.150 volts. The battery capacity-test conducted after the initial short test, produced excellent results. Tables II-5 and II-6 present the end-of-charge and the end-of-discharge cell voltage data. Table II-7 presents the capacity measurements. All capacities were well over 5 ampere-hours; the specified lower limit for this test sequence is 4.5 ampere-hours.

During phase three of the test program, a second battery short test was performed. (No conditioning cycle was run before this test.) Table II-8 presents the 20-hour open-circuit cell voltage data for this test. As with previous battery tests the results of this short test were excellent.

3. Vibration Test Performance

During the vibration test exposure, each unit was discharged at 700 milliamperes. Individual cell voltages were continuously monitored with a Tektronix Scope, and electrical circuit parameters (including discharge current) were continuously monitored with the Digital Voltmeter on the test rack. All the storage modules performed excellently throughout the vibration test sequence. The post-vibration tests indicated no significant deviations from prior performance data.

TABLE II-4. SHORT TEST, TWENTY-HOUR OPEN-CIRCUIT CELL VOLTAGES (IN VOLTS)

Cell Position Number	Storage Module Serial Numbers							
	022	023	024	025	026	027	029	030
1	1.211	1.230	1.221	1.205	1.206	1.211	1.227	1.220
2	1.225	1.229	1.224	1.220	1.211	1.209	1.225	1.219
3	1.225	1.232	1.222	1.211	1.193	1.218	1.230	1.226
4	1.242	1.230	1.221	1.216	1.214	1.215	1.228	1.224
5	1.240	1.232	1.222	1.218	1.194	1.218	1.222	1.221
6	1.228	1.229	1.224	1.213	1.216	1.218	1.227	1.216
7	1.229	1.224	1.221	1.218	1.203	1.214	1.226	1.221
8	1.228	1.232	1.222	1.215	1.216	1.210	1.231	1.221
9	1.220	1.233	1.221	1.211	1.217	1.219	1.228	1.224
10	1.230	1.227	1.221	1.211	1.200	1.219	1.232	1.221
11	1.232	1.229	1.218	1.212	1.186	1.219	1.233	1.195
12	1.226	1.229	1.221	1.215	1.216	1.218	1.230	1.222
13	1.231	1.227	1.222	1.216	1.190	1.219	1.231	1.222
14	1.218	1.220	1.219	1.210	1.216	1.219	1.232	1.211
15	1.226	1.216	1.220	1.216	1.216	1.216	1.229	1.193
16	1.209	1.232	1.209	1.220	1.213	1.216	1.237	1.210
17	1.229	1.229	1.221	1.209	1.188	1.218	1.225	1.222
18	1.228	1.231	1.208	1.218	1.184	1.216	1.230	1.220
19	1.229	1.229	1.222	1.211	1.212	1.214	1.230	1.220
20	1.226	1.229	1.222	1.220	1.214	1.213	1.229	1.203
21	1.227	1.231	1.222	1.214	1.212	1.216	1.225	1.213
22	1.221	1.231	1.208	1.212	1.188	1.210	1.228	1.214
23	1.228	1.237	1.218	1.211	1.195	1.217	1.221	1.219

TABLE II-5. CAPACITY TEST, END-OF-CHARGE CELL VOLTAGES (IN VOLTS)

Cell Position Number	Storage Module Serial Numbers							
	022	023	024	025	026	027	029	030
1	1.407	1.403	1.418	1.416	1.426	1.423	1.417	1.408
2	1.406	1.409	1.418	1.414	1.425	1.428	1.419	1.417
3	1.410	1.405	1.421	1.419	1.428	1.427	1.416	1.413
4	1.414	1.405	1.419	1.419	1.426	1.426	1.419	1.411
5	1.411	1.406	1.419	1.418	1.425	1.423	1.414	1.418
6	1.405	1.401	1.418	1.421	1.425	1.424	1.418	1.417
7	1.405	1.405	1.421	1.419	1.425	1.424	1.418	1.411
8	1.404	1.402	1.419	1.419	1.420	1.424	1.414	1.410
9	1.409	1.404	1.420	1.418	1.420	1.423	1.418	1.411
10	1.410	1.407	1.423	1.418	1.420	1.423	1.420	1.410
11	1.407	1.405	1.424	1.422	1.420	1.419	1.418	1.411
12	1.406	1.406	1.419	1.421	1.421	1.419	1.419	1.410
13	1.405	1.403	1.420	1.420	1.421	1.419	1.418	1.411
14	1.410	1.405	1.421	1.417	1.417	1.418	1.420	1.411
15	1.406	1.402	1.418	1.417	1.417	1.421	1.416	1.410
16	1.407	1.404	1.414	1.419	1.421	1.421	1.427	1.409
17	1.409	1.401	1.416	1.421	1.420	1.420	1.415	1.410
18	1.408	1.402	1.417	1.418	1.421	1.419	1.421	1.409
19	1.405	1.401	1.414	1.421	1.428	1.424	1.418	1.411
20	1.408	1.402	1.417	1.426	1.421	1.418	1.419	1.413
21	1.413	1.402	1.418	1.422	1.420	1.421	1.415	1.412
22	1.406	1.403	1.416	1.424	1.423	1.431	1.415	1.410
23	1.408	1.401	1.418	1.421	1.425	1.419	1.421	1.410

TABLE II-6. CAPACITY TEST, END-OF-DISCHARGE CELL VOLTAGES (IN VOLTS)

Cell Position Number	Storage Module Serial Numbers							
	022	023	024	025	026	027	029	030
1	1.167	1.173	1.167	1.182	1.173	1.176	1.166	1.188
2	1.176	1.167	1.180	1.186	1.171	1.173	1.164	1.184
3	1.182	1.173	1.176	1.171	1.177	1.168	1.179	1.189
4	1.176	1.176	1.169	1.174	1.190	1.179	1.180	1.189
5	1.168	1.164	1.160	1.168	1.179	1.181	1.111	1.189
6	1.179	1.178	1.174	1.161	1.188	1.192	1.182	1.187
7	1.183	1.180	1.170	1.168	1.188	1.181	1.138	1.174
8	1.180	1.179	1.166	1.174	1.186	1.183	1.188	1.175
9	1.161	1.185	1.178	1.177	1.186	1.169	1.180	1.174
10	1.185	1.178	1.143	1.172	1.182	1.165	1.177	1.179
11	1.180	1.185	1.169	1.171	1.190	1.178	1.180	1.148
12	1.182	1.179	1.174	1.164	1.180	1.180	1.168	1.179
13	1.182	1.172	1.176	1.174	1.183	1.171	1.175	1.172
14	1.168	1.174	1.168	1.162	1.176	1.173	1.179	1.181
15	1.179	1.182	1.160	1.177	1.184	1.183	1.182	1.171
16	1.101	1.184	1.178	1.172	1.184	1.177	1.182	1.140
17	1.182	1.158	1.175	1.168	1.184	1.167	1.169	1.178
18	1.178	1.160	1.169	1.156	1.183	1.184	1.155	1.177
19	1.182	1.166	1.169	1.168	1.076	1.126	1.183	1.155
20	1.178	1.176	1.174	1.159	1.176	1.179	1.170	1.171
21	1.128	1.166	1.175	1.168	1.166	1.173	1.179	1.172
22	1.146	1.168	1.153	1.168	1.157	1.183	1.174	1.185
23	1.164	1.172	1.158	1.147	1.159	1.184	1.146	1.173

TABLE II-7. STORAGE MODULE CAPACITY MEASUREMENTS

Storage Module Number	Capacity (ampere-minutes)
022	316
023	317
024	328
025	326
026	327
027	323
029	331
030	321
NOTE: Measurements made at 25°C	

TABLE II-8. POST VIBRATION SHORT TEST, TWENTY-HOUR OPEN-CIRCUIT CELL VOLTAGES (IN VOLTS)

Cell Position Number	Storage Module Serial Numbers							
	022	023	024	025	026	027	029	030
1	1.247	1.249	1.247	1.248	1.236	1.239	1.242	1.238
2	1.246	1.247	1.248	1.247	1.235	1.243	1.243	1.239
3	1.245	1.249	1.248	1.245	1.210	1.242	1.245	1.241
4	1.245	1.248	1.248	1.246	1.235	1.243	1.242	1.241
5	1.246	1.247	1.248	1.246	1.235	1.243	1.241	1.240
6	1.245	1.246	1.248	1.243	1.237	1.246	1.244	1.239
7	1.246	1.249	1.247	1.244	1.237	1.242	1.243	1.241
8	1.248	1.245	1.247	1.244	1.234	1.244	1.242	1.239
9	1.243	1.249	1.245	1.244	1.234	1.244	1.242	1.241
10	1.248	1.247	1.248	1.241	1.236	1.244	1.244	1.239
11	1.247	1.247	1.245	1.243	1.235	1.241	1.245	1.240
12	1.247	1.248	1.246	1.242	1.236	1.244	1.246	1.240
13	1.247	1.247	1.248	1.242	1.237	1.243	1.244	1.242
14	1.248	1.249	1.247	1.247	1.234	1.242	1.246	1.239
15	1.247	1.247	1.246	1.246	1.232	1.242	1.243	1.240
16	1.246	1.249	1.246	1.247	1.236	1.243	1.238	1.240
17	1.247	1.247	1.247	1.245	1.235	1.243	1.240	1.239
18	1.247	1.247	1.244	1.248	1.236	1.241	1.243	1.240
19	1.247	1.249	1.245	1.246	1.238	1.239	1.243	1.240
20	1.246	1.248	1.246	1.249	1.237	1.240	1.242	1.241
21	1.247	1.247	1.248	1.246	1.234	1.244	1.241	1.242
22	1.248	1.246	1.246	1.249	1.237	1.242	1.243	1.217
23	1.248	1.249	1.246	1.246	1.237	1.244	1.244	1.239

4. Post Thermal-Vacuum Unit Test

After completing the thermal-vacuum test sequence, the eight flight modules were partially disassembled and subjected to the standard electrolyte leakage test specified in RCA test procedure 1846070. No leakage was observed in any of the 184 storage cells. Storage modules 024, 025, 026, 027, 029, and 030 were then reassembled, and subjected to their final unit electrical test at 25° C. Modules 022 and 023 were removed from the normal test program for a special investigation of the high-temperature trickle-charge circuit (refer to Paragraph E, Test Discrepancies, of this Appendix). Modules 024, 025, 026, 027, 029 and 030 successfully passed the final unit electrical test with no significant deviations from the performance test data listed in Table II-3.

5. Telemetry Calibration

During phase two of the test program, telemetry data was measured for each flight storage module. This data was used to generate the computerized telemetry calibration tables listed in Tables II-9 through II-16. The same telemetry data, expanded into smaller increments by means of linear interpolation, was used to verify the storage module telemetry performance during the thermal-vacuum test sequence.

TABLE II-9. CHARGE CURRENT (AMPERES) TELEMETRY AT 25°C

TELEMETRY VOLTS	- CHARGE CURRENT (IN AMPERES) - S/N 022	S/N 023	S/N 024	S/N 025	S/N 026	S/N 027	S/N 029	S/N 030
0.300	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.400	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.000
0.500	0.010	0.010	0.010	0.013	0.006	0.027	0.017	0.000
0.600	0.032	0.032	0.032	0.036	0.028	0.049	0.039	0.017
0.700	0.054	0.055	0.054	0.058	0.050	0.071	0.061	0.040
0.800	0.077	0.077	0.076	0.081	0.073	0.093	0.083	0.062
0.900	0.099	0.099	0.098	0.103	0.095	0.115	0.105	0.085
1.000	0.121	0.122	0.121	0.125	0.117	0.137	0.127	0.107
1.100	0.143	0.144	0.143	0.148	0.140	0.159	0.149	0.130
1.200	0.166	0.166	0.165	0.170	0.162	0.181	0.172	0.152
1.300	0.188	0.188	0.187	0.192	0.184	0.203	0.194	0.174
1.400	0.210	0.211	0.209	0.215	0.207	0.225	0.216	0.197
1.500	0.233	0.233	0.231	0.237	0.229	0.247	0.238	0.219
1.600	0.255	0.255	0.254	0.260	0.251	0.269	0.260	0.242
1.700	0.277	0.277	0.276	0.282	0.274	0.291	0.282	0.264
1.800	0.300	0.300	0.298	0.304	0.296	0.313	0.304	0.286
1.900	0.322	0.322	0.320	0.327	0.318	0.335	0.326	0.309
2.000	0.344	0.344	0.342	0.349	0.341	0.357	0.348	0.331
2.100	0.367	0.366	0.365	0.371	0.363	0.379	0.371	0.354
2.200	0.389	0.389	0.387	0.394	0.385	0.401	0.393	0.376
2.300	0.411	0.411	0.409	0.416	0.407	0.422	0.414	0.398
2.400	0.432	0.432	0.430	0.437	0.429	0.444	0.436	0.420
2.500	0.454	0.454	0.451	0.459	0.450	0.465	0.457	0.442
2.600	0.475	0.475	0.473	0.480	0.472	0.486	0.478	0.464
2.700	0.497	0.497	0.494	0.502	0.494	0.507	0.500	0.485
2.800	0.518	0.518	0.516	0.523	0.515	0.529	0.521	0.507
2.900	0.540	0.540	0.537	0.545	0.537	0.550	0.542	0.529
3.000	0.561	0.561	0.559	0.566	0.558	0.571	0.564	0.550
3.100	0.583	0.583	0.580	0.588	0.580	0.592	0.585	0.572
3.200	0.605	0.604	0.602	0.609	0.601	0.613	0.606	0.594
3.300	0.626	0.626	0.623	0.631	0.623	0.635	0.628	0.616
3.400	0.648	0.647	0.645	0.653	0.644	0.656	0.649	0.637
3.500	0.669	0.669	0.666	0.674	0.666	0.677	0.670	0.659
3.600	0.691	0.690	0.687	0.696	0.687	0.698	0.691	0.681
3.700	0.712	0.712	0.709	0.717	0.709	0.719	0.713	0.702
3.800	0.734	0.733	0.730	0.739	0.731	0.741	0.734	0.724
3.900	0.755	0.755	0.752	0.760	0.752	0.762	0.755	0.746
4.000	0.777	0.776	0.773	0.782	0.774	0.783	0.777	0.768
4.100	0.798	0.798	0.795	0.803	0.795	0.804	0.798	0.789
4.200	0.819	0.819	0.816	0.824	0.816	0.825	0.819	0.811
4.300	0.840	0.840	0.837	0.846	0.837	0.846	0.840	0.832
4.400	0.862	0.860	0.858	0.867	0.858	0.866	0.861	0.853
4.500	0.883	0.881	0.878	0.888	0.879	0.887	0.881	0.874
4.600	0.904	0.902	0.899	0.909	0.900	0.908	0.902	0.896
4.700	0.925	0.923	0.920	0.930	0.921	0.928	0.923	0.917
4.800	0.946	0.944	0.941	0.951	0.943	0.949	0.944	0.938
4.900	0.967	0.965	0.962	0.972	0.964	0.970	0.965	0.959
5.000	0.988	0.986	0.983	0.993	0.985	0.991	0.986	0.980
5.100	1.009	1.007	1.004	1.015	1.006	1.011	1.007	1.001
5.200	1.030	1.028	1.025	1.036	1.027	1.032	1.027	1.023
5.300	1.051	1.049	1.046	1.057	1.048	1.053	1.048	1.044
5.400	1.072	1.070	1.067	1.078	1.069	1.074	1.069	1.065
5.500	1.093	1.090	1.088	1.099	1.090	1.094	1.090	1.086
5.600	1.114	1.111	1.109	1.120	1.111	1.115	1.111	1.107
5.700	1.136	1.132	1.129	1.141	1.132	1.136	1.132	1.129
5.800	1.157	1.153	1.150	1.162	1.153	1.156	1.152	1.150
5.900	1.178	1.174	1.171	1.184	1.174	1.177	1.173	1.171
6.000	1.199	1.195	1.192	1.205	1.195	1.198	1.194	1.192
6.100	1.220	1.216	1.213	1.226	1.216	1.219	1.215	1.213
6.200	1.241	1.237	1.234	1.247	1.237	1.239	1.236	1.235
6.300	1.262	1.258	1.255	1.268	1.258	1.260	1.257	1.256
6.400	1.283	1.279	1.276	1.289	1.279	1.281	1.278	1.277

TABLE II-10. DISCHARGE CURRENT (AMPERES) TELEMETRY AT 25°C

TELEMETRY VOLTS	- DISCHARGE CURRENT (IN AMPERES) -							
	S/N 022	S/N 023	S/N 024	S/N 025	S/N 026	S/N 027	S/N 029	S/N 030
0.300	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.400	0.000	0.000	0.000	0.006	0.000	0.000	0.000	0.000
0.500	0.011	0.000	0.000	0.052	0.021	0.000	0.019	0.013
0.600	0.057	0.035	0.041	0.098	0.067	0.043	0.065	0.059
0.700	0.104	0.082	0.087	0.144	0.113	0.090	0.111	0.105
0.800	0.150	0.128	0.134	0.190	0.160	0.136	0.157	0.151
0.900	0.196	0.175	0.180	0.236	0.206	0.183	0.203	0.197
1.000	0.243	0.221	0.227	0.281	0.252	0.230	0.249	0.243
1.100	0.289	0.268	0.273	0.327	0.298	0.277	0.295	0.289
1.200	0.335	0.314	0.320	0.373	0.345	0.323	0.341	0.335
1.300	0.381	0.361	0.367	0.419	0.391	0.370	0.387	0.381
1.400	0.428	0.407	0.413	0.465	0.437	0.417	0.432	0.427
1.500	0.474	0.454	0.460	0.511	0.483	0.463	0.478	0.473
1.600	0.520	0.500	0.506	0.557	0.530	0.510	0.524	0.519
1.700	0.567	0.547	0.553	0.603	0.576	0.557	0.570	0.565
1.800	0.613	0.593	0.599	0.649	0.622	0.603	0.616	0.611
1.900	0.659	0.640	0.646	0.694	0.669	0.650	0.662	0.657
2.000	0.706	0.686	0.692	0.740	0.715	0.697	0.708	0.703
2.100	0.752	0.733	0.739	0.786	0.761	0.743	0.754	0.749
2.200	0.798	0.780	0.786	0.831	0.807	0.790	0.800	0.795
2.300	0.843	0.825	0.831	0.875	0.852	0.836	0.844	0.840
2.400	0.888	0.870	0.876	0.920	0.897	0.881	0.889	0.885
2.500	0.933	0.915	0.921	0.964	0.942	0.926	0.933	0.929
2.600	0.978	0.960	0.966	1.008	0.986	0.971	0.978	0.974
2.700	1.022	1.005	1.011	1.053	1.031	1.016	1.022	1.018
2.800	1.067	1.050	1.056	1.097	1.076	1.061	1.067	1.063
2.900	1.112	1.095	1.101	1.141	1.121	1.107	1.111	1.108
3.000	1.157	1.141	1.146	1.186	1.166	1.152	1.155	1.152
3.100	1.202	1.186	1.191	1.230	1.211	1.197	1.200	1.197
3.200	1.247	1.231	1.236	1.274	1.255	1.242	1.244	1.241
3.300	1.291	1.276	1.282	1.319	1.300	1.287	1.289	1.286
3.400	1.336	1.321	1.327	1.363	1.345	1.332	1.333	1.330
3.500	1.381	1.366	1.372	1.407	1.390	1.377	1.377	1.375
3.600	1.426	1.411	1.417	1.452	1.435	1.423	1.422	1.419
3.700	1.471	1.456	1.462	1.496	1.479	1.468	1.466	1.464
3.800	1.516	1.501	1.507	1.540	1.524	1.513	1.511	1.509
3.900	1.561	1.546	1.552	1.584	1.569	1.558	1.555	1.553
4.000	1.605	1.591	1.597	1.628	1.614	1.603	1.600	1.598
4.100	1.650	1.635	1.641	1.672	1.658	1.647	1.643	1.642
4.200	1.694	1.680	1.685	1.716	1.701	1.692	1.687	1.685
4.300	1.738	1.724	1.730	1.759	1.745	1.736	1.730	1.729
4.400	1.782	1.768	1.774	1.803	1.789	1.780	1.774	1.773
4.500	1.827	1.812	1.818	1.846	1.833	1.824	1.818	1.817
4.600	1.871	1.856	1.862	1.890	1.877	1.869	1.861	1.860
4.700	1.915	1.901	1.906	1.934	1.921	1.913	1.905	1.904
4.800	1.959	1.945	1.951	1.977	1.965	1.957	1.949	1.948
4.900	2.004	1.989	1.995	2.021	2.009	2.002	1.992	1.992
5.000	2.048	2.033	2.039	2.065	2.053	2.046	2.036	2.035
5.100	2.092	2.077	2.083	2.108	2.097	2.090	2.079	2.079
5.200	2.136	2.122	2.128	2.152	2.141	2.134	2.123	2.123
5.300	2.181	2.166	2.172	2.195	2.185	2.179	2.167	2.167
5.400	2.225	2.210	2.216	2.239	2.229	2.223	2.210	2.210
5.500	2.269	2.254	2.260	2.283	2.273	2.267	2.254	2.254
5.600	2.313	2.298	2.304	2.326	2.317	2.311	2.297	2.298
5.700	2.358	2.343	2.349	2.370	2.360	2.356	2.341	2.342
5.800	2.402	2.387	2.393	2.414	2.404	2.400	2.385	2.386
5.900	2.446	2.431	2.437	2.457	2.448	2.444	2.428	2.429
6.000	2.490	2.475	2.481	2.501	2.492	2.489	2.472	2.473
6.100	2.534	2.519	2.526	2.544	2.536	2.533	2.516	2.517
6.200	2.579	2.564	2.570	2.588	2.580	2.577	2.559	2.561
6.300	2.623	2.608	2.614	2.632	2.624	2.621	2.603	2.604
6.400	2.667	2.652	2.658	2.675	2.668	2.666	2.646	2.648

TABLE II-11. BATTERY VOLTAGE (DC) TELEMETRY

TELEMETRY VOLTS	BATTERY VOLTAGE (IN VOLTS) S/N 022	S/N 023	S/N 024	S/N 025	S/N 026	S/N 027	S/N 029	S/N 030
0.000	19.39	19.39	19.29	19.39	19.40	19.43	19.28	19.31
0.100	19.73	19.73	19.64	19.73	19.74	19.77	19.62	19.65
0.200	20.07	20.07	19.98	20.07	20.08	20.11	19.96	19.99
0.300	20.41	20.41	20.32	20.41	20.42	20.45	20.30	20.33
0.400	20.75	20.75	20.66	20.75	20.76	20.80	20.64	20.67
0.500	21.10	21.10	21.00	21.10	21.10	21.14	20.98	21.01
0.600	21.44	21.44	21.34	21.44	21.44	21.48	21.32	21.35
0.700	21.78	21.78	21.68	21.78	21.78	21.82	21.66	21.70
0.800	22.12	22.12	22.02	22.12	22.13	22.16	22.00	22.04
0.900	22.46	22.46	22.36	22.46	22.47	22.50	22.34	22.38
1.000	22.80	22.80	22.71	22.80	22.81	22.84	22.68	22.72
1.100	23.14	23.14	23.05	23.14	23.15	23.18	23.02	23.06
1.200	23.48	23.49	23.39	23.48	23.49	23.52	23.37	23.40
1.300	23.82	23.83	23.73	23.82	23.83	23.86	23.71	23.74
1.400	24.17	24.17	24.07	24.17	24.17	24.20	24.05	24.08
1.500	24.51	24.51	24.41	24.51	24.52	24.55	24.39	24.42
1.600	24.85	24.85	24.75	24.85	24.86	24.89	24.73	24.77
1.700	25.19	25.19	25.09	25.19	25.20	25.23	25.07	25.11
1.800	25.53	25.53	25.44	25.53	25.54	25.57	25.41	25.45
1.900	25.87	25.88	25.78	25.87	25.88	25.91	25.75	25.79
2.000	26.21	26.22	26.12	26.21	26.22	26.25	26.09	26.13
2.100	26.55	26.56	26.46	26.55	26.56	26.59	26.43	26.47
2.200	26.90	26.90	26.80	26.90	26.90	26.93	26.77	26.81
2.300	27.24	27.24	27.14	27.24	27.25	27.27	27.11	27.15
2.400	27.58	27.58	27.48	27.58	27.59	27.61	27.45	27.49
2.500	27.92	27.92	27.82	27.92	27.93	27.95	27.80	27.83
2.600	28.26	28.27	28.16	28.26	28.27	28.30	28.14	28.18
2.700	28.60	28.61	28.51	28.60	28.61	28.64	28.48	28.52
2.800	28.94	28.95	28.85	28.94	28.95	28.98	28.82	28.86
2.900	29.28	29.29	29.19	29.28	29.29	29.32	29.16	29.20
3.000	29.62	29.63	29.53	29.62	29.63	29.66	29.50	29.54
3.100	29.97	29.97	29.87	29.97	29.98	30.00	29.84	29.88
3.200	30.31	30.31	30.21	30.31	30.32	30.34	30.18	30.22
3.300	30.65	30.65	30.55	30.65	30.66	30.68	30.52	30.56
3.400	30.99	31.00	30.89	30.99	31.00	31.02	30.86	30.90
3.500	31.33	31.34	31.23	31.33	31.34	31.36	31.20	31.24
3.600	31.67	31.68	31.57	31.67	31.68	31.70	31.54	31.58
3.700	32.01	32.02	31.91	32.01	32.02	32.04	31.88	31.92
3.800	32.35	32.36	32.25	32.35	32.36	32.38	32.22	32.26
3.900	32.69	32.70	32.59	32.69	32.70	32.73	32.56	32.60
4.000	33.04	33.04	32.93	33.03	33.04	33.07	32.90	32.95
4.100	33.38	33.38	33.27	33.37	33.38	33.41	33.24	33.29
4.200	33.72	33.72	33.61	33.71	33.72	33.75	33.58	33.63
4.300	34.06	34.06	33.96	34.05	34.07	34.09	33.92	33.97
4.400	34.40	34.40	34.30	34.39	34.41	34.43	34.27	34.31
4.500	34.74	34.75	34.64	34.73	34.75	34.77	34.61	34.65
4.600	35.08	35.09	34.98	35.08	35.09	35.11	34.95	34.99
4.700	35.42	35.43	35.32	35.42	35.43	35.45	35.29	35.33
4.800	35.76	35.77	35.66	35.76	35.77	35.79	35.63	35.67
4.900	36.10	36.11	36.00	36.10	36.11	36.13	35.97	36.01
5.000	36.45	36.45	36.34	36.44	36.45	36.47	36.31	36.35
5.200	37.13	37.13	37.02	37.12	37.13	37.15	36.99	37.03
5.300	37.47	37.47	37.36	37.46	37.47	37.49	37.33	37.37
5.400	37.81	37.81	37.70	37.80	37.81	37.83	37.67	37.71
5.500	38.15	38.15	38.04	38.14	38.15	38.18	38.01	38.05
5.600	38.49	38.50	38.38	38.48	38.50	38.52	38.35	38.39
5.700	38.83	38.84	38.72	38.82	38.84	38.86	38.69	38.73
5.800	39.17	39.18	39.06	39.16	39.18	39.20	39.03	39.07
5.900	39.51	39.52	39.40	39.50	39.52	39.54	39.37	39.42
6.000	39.86	39.86	39.74	39.84	39.86	39.88	39.71	39.76
6.100	40.20	40.20	40.08	40.19	40.20	40.22	40.05	40.10
6.200	40.54	40.54	40.42	40.53	40.54	40.56	40.39	40.44
6.300	40.88	40.88	40.76	40.87	40.88	40.90	40.73	40.78
6.400	41.22	41.22	41.10	41.21	41.22	41.24	41.07	41.12

TABLE II-12. BATTERY TEMPERATURE TELEMETRY (°C)

TELEMETRY	– BATTERY TEMPERATURE (IN DEGREES C) –							
VOLTS	S/N 022	S/N 023	S/N 024	S/N 025	S/N 026	S/N 027	S/N 029	S/N 030
1.200	-3.92	-3.76	-4.20	-4.12	-3.79	-4.17	-3.55	-3.55
1.300	-2.06	-1.96	-2.20	-2.20	-1.60	-2.08	-1.73	-1.73
1.400	-0.21	-0.16	-0.20	-0.29	0.48	-0.00	0.08	0.08
1.500	1.46	1.49	1.41	1.42	2.01	1.61	1.72	1.72
1.600	3.01	3.12	2.97	3.08	3.54	3.23	3.36	3.36
1.700	4.56	4.75	4.53	4.75	5.07	4.84	5.00	5.00
1.800	6.10	6.27	6.00	6.27	6.50	6.29	6.56	6.54
1.900	7.60	7.76	7.43	7.76	7.93	7.71	8.12	8.08
2.000	9.10	9.25	8.86	9.25	9.36	9.14	9.69	9.62
2.100	10.60	10.70	10.29	10.68	10.75	10.56	11.09	11.04
2.200	12.00	12.10	11.71	12.04	12.10	11.96	12.45	12.42
2.300	13.33	13.50	13.14	13.41	13.46	13.36	13.82	13.80
2.400	14.66	14.91	14.57	14.77	14.82	14.77	15.18	15.18
2.500	15.99	16.31	16.00	16.13	16.18	16.17	16.55	16.56
2.600	17.32	17.71	17.43	17.49	17.53	17.57	17.91	17.94
2.700	18.65	19.11	18.86	18.86	18.89	18.97	19.27	19.32
2.800	19.98	20.51	20.29	20.22	20.25	20.37	20.64	20.70
2.900	21.31	21.92	21.71	21.58	21.61	21.78	22.00	22.09
3.000	22.64	23.32	23.14	22.94	22.96	23.18	23.36	23.47
3.100	23.97	24.72	24.57	24.31	24.32	24.58	24.73	24.85
3.200	25.30	26.11	25.97	25.67	25.69	25.98	26.11	26.22
3.300	26.64	27.49	27.36	27.03	27.07	27.38	27.50	27.60
3.400	28.00	28.87	28.75	28.40	28.46	28.78	28.89	28.98
3.500	29.37	30.25	30.14	29.76	29.84	30.19	30.28	30.35
3.600	30.73	31.64	31.53	31.13	31.22	31.59	31.67	31.73
3.700	32.09	33.02	32.92	32.49	32.60	32.99	33.06	33.11
3.800	33.46	34.40	34.31	33.86	33.99	34.39	34.44	34.48
3.900	34.82	35.78	35.69	35.22	35.37	35.79	35.83	35.86
4.000	36.18	37.17	37.08	36.59	36.75	37.20	37.22	37.23
4.100	37.55	38.55	38.47	37.95	38.13	38.60	38.61	38.61
4.200	38.91	39.93	39.86	39.32	39.52	40.00	40.00	39.99
4.300	40.33	41.36	41.32	40.74	40.96	41.47	41.44	41.42
4.400	42.00	42.79	42.79	42.23	42.44	42.94	42.89	42.85
4.500	43.67	44.21	44.26	43.71	43.93	44.41	44.33	44.28
4.600	45.35	45.70	45.83	45.21	45.42	45.97	45.84	45.83
4.700	47.08	47.27	47.50	46.80	47.00	47.58	47.43	47.50
4.800	48.81	48.83	49.17	48.40	48.58	49.19	49.03	49.17
4.900	50.54	50.51	50.90	50.00	50.22	51.00	50.82	51.01
5.000	52.27	52.55	52.70	52.31	52.44	53.00	52.93	53.02

TABLE II-13. CHARGE CURRENT (AMPERES) TELEMETRY AT 5°C

TELEMETRY VOLTS	S/N 022	S/N 023	S/N 024	S/N 025	S/N 026	S/N 027	S/N 029	S/N 030
	- CHARGE CURRENT (IN AMPERES) -							
0.300	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.400	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000
0.500	0.006	0.008	0.006	0.013	0.003	0.025	0.013	0.000
0.600	0.028	0.030	0.028	0.035	0.025	0.047	0.035	0.017
0.700	0.050	0.052	0.050	0.057	0.047	0.069	0.057	0.039
0.800	0.072	0.075	0.072	0.080	0.070	0.091	0.079	0.062
0.900	0.094	0.097	0.094	0.102	0.092	0.113	0.102	0.084
1.000	0.117	0.119	0.117	0.124	0.114	0.135	0.124	0.106
1.100	0.139	0.141	0.139	0.147	0.137	0.157	0.146	0.129
1.200	0.161	0.164	0.161	0.169	0.159	0.179	0.168	0.151
1.300	0.183	0.186	0.183	0.191	0.181	0.201	0.190	0.174
1.400	0.206	0.208	0.205	0.214	0.204	0.223	0.212	0.196
1.500	0.228	0.230	0.227	0.236	0.226	0.245	0.234	0.218
1.600	0.250	0.253	0.249	0.259	0.248	0.267	0.256	0.241
1.700	0.272	0.275	0.272	0.281	0.271	0.289	0.278	0.263
1.800	0.294	0.297	0.294	0.303	0.293	0.311	0.300	0.286
1.900	0.317	0.319	0.316	0.326	0.315	0.333	0.322	0.308
2.000	0.339	0.342	0.338	0.348	0.338	0.355	0.344	0.331
2.100	0.361	0.364	0.360	0.370	0.360	0.377	0.366	0.353
2.200	0.383	0.386	0.382	0.393	0.382	0.399	0.389	0.375
2.300	0.405	0.408	0.404	0.415	0.405	0.421	0.410	0.398
2.400	0.427	0.430	0.426	0.436	0.426	0.442	0.432	0.420
2.500	0.449	0.451	0.447	0.458	0.448	0.463	0.453	0.441
2.600	0.470	0.473	0.469	0.479	0.469	0.484	0.474	0.463
2.700	0.492	0.494	0.490	0.501	0.491	0.505	0.495	0.485
2.800	0.513	0.516	0.512	0.522	0.512	0.527	0.517	0.506
2.900	0.535	0.537	0.533	0.544	0.534	0.548	0.538	0.528
3.000	0.556	0.559	0.555	0.566	0.555	0.569	0.559	0.550
3.100	0.578	0.580	0.576	0.587	0.577	0.590	0.581	0.572
3.200	0.599	0.602	0.598	0.609	0.598	0.611	0.602	0.593
3.300	0.621	0.623	0.619	0.630	0.620	0.633	0.623	0.615
3.400	0.643	0.645	0.641	0.652	0.641	0.654	0.645	0.637
3.500	0.664	0.666	0.662	0.673	0.663	0.675	0.666	0.658
3.600	0.686	0.688	0.684	0.695	0.685	0.696	0.687	0.680
3.700	0.707	0.709	0.705	0.716	0.706	0.717	0.709	0.702
3.800	0.729	0.731	0.727	0.738	0.728	0.739	0.730	0.724
3.900	0.750	0.752	0.748	0.759	0.749	0.760	0.751	0.745
4.000	0.772	0.774	0.770	0.781	0.771	0.781	0.773	0.767
4.100	0.794	0.795	0.791	0.803	0.792	0.802	0.794	0.789
4.200	0.815	0.816	0.813	0.824	0.813	0.823	0.815	0.810
4.300	0.836	0.837	0.834	0.845	0.834	0.844	0.836	0.831
4.400	0.857	0.858	0.855	0.866	0.856	0.864	0.856	0.853
4.500	0.878	0.879	0.876	0.887	0.877	0.885	0.877	0.874
4.600	0.899	0.900	0.896	0.908	0.898	0.906	0.898	0.895
4.700	0.920	0.921	0.917	0.929	0.919	0.926	0.919	0.916
4.800	0.942	0.942	0.938	0.950	0.940	0.947	0.940	0.937
4.900	0.963	0.963	0.959	0.971	0.961	0.968	0.961	0.958
5.000	0.984	0.984	0.980	0.993	0.982	0.989	0.981	0.980
5.100	1.005	1.004	1.001	1.014	1.003	1.009	1.002	1.001
5.200	1.026	1.025	1.022	1.035	1.024	1.030	1.023	1.022
5.300	1.047	1.046	1.043	1.056	1.045	1.051	1.044	1.043
5.400	1.068	1.067	1.064	1.077	1.066	1.071	1.065	1.064
5.500	1.089	1.088	1.085	1.098	1.087	1.092	1.086	1.086
5.600	1.111	1.109	1.106	1.119	1.108	1.113	1.106	1.107
5.700	1.132	1.130	1.127	1.140	1.129	1.134	1.127	1.128
5.800	1.153	1.151	1.148	1.162	1.150	1.154	1.148	1.149
5.900	1.174	1.172	1.169	1.183	1.171	1.175	1.169	1.170
6.000	1.195	1.193	1.190	1.204	1.192	1.196	1.190	1.192
6.100	1.216	1.214	1.211	1.225	1.213	1.217	1.211	1.213
6.200	1.237	1.234	1.232	1.246	1.234	1.237	1.231	1.234
6.300	1.259	1.255	1.253	1.267	1.255	1.258	1.252	1.255
6.400	1.280	1.276	1.274	1.288	1.276	1.279	1.273	1.276

TABLE II-14. DISCHARGE CURRENT (AMPERES) TELEMETRY AT 5°C

TELEMETRY VOLTS	- DISCHARGE CURRENT (IN AMPERES) -							
	S/N 022	S/N 023	S/N 024	S/N 025	S/N 026	S/N 027	S/N 029	S/N 030
0.400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.500	0.001	0.000	0.000	0.042	0.016	0.000	0.010	0.008
0.600	0.047	0.022	0.037	0.088	0.062	0.043	0.056	0.054
0.700	0.094	0.069	0.084	0.134	0.108	0.090	0.102	0.100
0.800	0.140	0.116	0.131	0.180	0.154	0.136	0.148	0.146
0.900	0.186	0.162	0.177	0.226	0.201	0.183	0.194	0.192
1.000	0.233	0.209	0.224	0.271	0.247	0.230	0.240	0.239
1.100	0.279	0.255	0.271	0.317	0.293	0.277	0.285	0.285
1.200	0.326	0.302	0.317	0.363	0.340	0.323	0.331	0.331
1.300	0.372	0.349	0.364	0.409	0.386	0.370	0.377	0.377
1.400	0.418	0.395	0.411	0.455	0.432	0.417	0.423	0.423
1.500	0.465	0.442	0.457	0.501	0.478	0.463	0.469	0.469
1.600	0.511	0.488	0.504	0.547	0.525	0.510	0.515	0.515
1.700	0.558	0.535	0.550	0.593	0.571	0.557	0.561	0.561
1.800	0.604	0.581	0.597	0.638	0.617	0.603	0.607	0.607
1.900	0.651	0.628	0.644	0.684	0.663	0.650	0.653	0.653
2.000	0.697	0.675	0.690	0.730	0.710	0.697	0.699	0.699
2.100	0.743	0.721	0.737	0.776	0.756	0.743	0.745	0.745
2.200	0.790	0.768	0.784	0.821	0.802	0.790	0.791	0.791
2.300	0.835	0.814	0.829	0.866	0.847	0.836	0.836	0.836
2.400	0.880	0.859	0.874	0.910	0.892	0.881	0.880	0.880
2.500	0.925	0.904	0.919	0.954	0.937	0.926	0.924	0.925
2.600	0.970	0.949	0.964	0.999	0.982	0.971	0.969	0.969
2.700	1.015	0.994	1.009	1.043	1.026	1.016	1.013	1.014
2.800	1.060	1.039	1.054	1.087	1.071	1.061	1.058	1.058
2.900	1.105	1.084	1.099	1.132	1.116	1.107	1.102	1.103
3.000	1.150	1.129	1.144	1.176	1.161	1.152	1.146	1.148
3.100	1.195	1.174	1.189	1.220	1.206	1.197	1.191	1.192
3.200	1.240	1.219	1.234	1.264	1.250	1.242	1.235	1.237
3.300	1.285	1.264	1.279	1.309	1.295	1.287	1.280	1.281
3.400	1.330	1.309	1.324	1.353	1.340	1.332	1.324	1.326
3.500	1.375	1.354	1.369	1.397	1.385	1.377	1.369	1.370
3.600	1.420	1.400	1.415	1.442	1.430	1.423	1.413	1.415
3.700	1.465	1.445	1.460	1.486	1.475	1.468	1.457	1.460
3.800	1.510	1.490	1.505	1.530	1.519	1.513	1.502	1.504
3.900	1.555	1.535	1.550	1.575	1.564	1.558	1.546	1.549
4.000	1.600	1.580	1.595	1.619	1.609	1.603	1.591	1.593
4.100	1.644	1.624	1.639	1.662	1.653	1.647	1.634	1.637
4.200	1.688	1.668	1.683	1.706	1.697	1.692	1.678	1.681
4.300	1.732	1.713	1.727	1.750	1.741	1.736	1.722	1.725
4.400	1.777	1.757	1.772	1.793	1.785	1.780	1.765	1.768
4.500	1.821	1.801	1.816	1.837	1.828	1.824	1.809	1.812
4.600	1.865	1.845	1.860	1.880	1.872	1.869	1.853	1.856
4.700	1.909	1.889	1.904	1.924	1.916	1.913	1.896	1.900
4.800	1.953	1.934	1.948	1.968	1.960	1.957	1.940	1.944
4.900	1.997	1.978	1.993	2.011	2.004	2.002	1.983	1.987
5.000	2.041	2.022	2.037	2.055	2.048	2.046	2.027	2.031
5.100	2.086	2.066	2.081	2.099	2.092	2.090	2.071	2.075
5.200	2.130	2.110	2.125	2.142	2.136	2.134	2.114	2.119
5.300	2.174	2.155	2.170	2.186	2.180	2.179	2.158	2.162
5.400	2.218	2.199	2.214	2.229	2.224	2.223	2.202	2.206
5.500	2.262	2.243	2.258	2.273	2.268	2.267	2.245	2.250
5.600	2.306	2.287	2.302	2.317	2.312	2.311	2.289	2.294
5.700	2.351	2.331	2.346	2.360	2.356	2.356	2.332	2.337
5.800	2.395	2.376	2.391	2.404	2.400	2.400	2.376	2.381
5.900	2.439	2.420	2.435	2.448	2.443	2.444	2.420	2.425
6.000	2.483	2.464	2.479	2.491	2.487	2.489	2.463	2.469
6.100	2.527	2.508	2.523	2.535	2.531	2.533	2.507	2.512
6.200	2.571	2.552	2.568	2.578	2.575	2.577	2.550	2.556
6.300	2.615	2.597	2.612	2.622	2.619	2.621	2.594	2.600
6.400	2.660	2.641	2.656	2.666	2.663	2.666	2.638	2.644

TABLE II-15. CHARGE CURRENT (AMPERES) TELEMETRY AT 45°C

TELEMETRY VOLTS	- CHARGE CURRENT (IN AMPERES) -							
	S/N 022	S/N 023	S/N 024	S/N 025	S/N 026	S/N 027	S/N 029	S/N 030
0.300	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.400	0.000	0.000	0.000	0.000	0.000	0.009	0.000	0.000
0.500	0.014	0.015	0.014	0.015	0.012	0.031	0.020	0.000
0.600	0.036	0.037	0.036	0.038	0.035	0.053	0.043	0.021
0.700	0.058	0.059	0.058	0.060	0.057	0.075	0.065	0.044
0.800	0.081	0.081	0.081	0.082	0.079	0.097	0.087	0.066
0.900	0.103	0.103	0.103	0.105	0.102	0.119	0.109	0.089
1.000	0.125	0.125	0.125	0.127	0.124	0.141	0.131	0.111
1.100	0.148	0.147	0.147	0.149	0.146	0.163	0.154	0.133
1.200	0.170	0.170	0.170	0.172	0.169	0.185	0.176	0.156
1.300	0.192	0.192	0.192	0.194	0.191	0.207	0.198	0.178
1.400	0.215	0.214	0.214	0.217	0.213	0.229	0.220	0.201
1.500	0.237	0.236	0.236	0.239	0.236	0.251	0.243	0.223
1.600	0.259	0.258	0.259	0.261	0.258	0.274	0.265	0.245
1.700	0.282	0.280	0.281	0.284	0.280	0.296	0.287	0.268
1.800	0.304	0.302	0.303	0.306	0.303	0.318	0.309	0.290
1.900	0.326	0.325	0.325	0.328	0.325	0.340	0.331	0.313
2.000	0.349	0.347	0.347	0.351	0.347	0.362	0.354	0.335
2.100	0.371	0.369	0.370	0.373	0.370	0.384	0.376	0.357
2.200	0.394	0.391	0.392	0.396	0.392	0.406	0.398	0.380
2.300	0.415	0.413	0.414	0.417	0.414	0.427	0.419	0.402
2.400	0.437	0.434	0.435	0.439	0.435	0.448	0.441	0.424
2.500	0.458	0.456	0.457	0.460	0.457	0.469	0.462	0.446
2.600	0.480	0.477	0.478	0.482	0.478	0.490	0.483	0.467
2.700	0.502	0.499	0.499	0.503	0.500	0.512	0.505	0.489
2.800	0.523	0.520	0.521	0.525	0.521	0.533	0.526	0.511
2.900	0.545	0.542	0.542	0.547	0.543	0.554	0.547	0.532
3.000	0.566	0.563	0.564	0.568	0.565	0.575	0.569	0.554
3.100	0.588	0.585	0.585	0.590	0.586	0.596	0.590	0.576
3.200	0.610	0.606	0.607	0.611	0.608	0.618	0.611	0.598
3.300	0.631	0.628	0.628	0.633	0.629	0.639	0.633	0.619
3.400	0.653	0.649	0.649	0.654	0.651	0.660	0.654	0.641
3.500	0.674	0.671	0.671	0.676	0.672	0.681	0.675	0.663
3.600	0.696	0.692	0.692	0.697	0.694	0.702	0.697	0.684
3.700	0.718	0.714	0.714	0.719	0.715	0.724	0.718	0.706
3.800	0.739	0.735	0.735	0.741	0.737	0.745	0.739	0.728
3.900	0.761	0.757	0.757	0.762	0.758	0.766	0.761	0.750
4.000	0.782	0.778	0.778	0.784	0.780	0.787	0.782	0.771
4.100	0.804	0.800	0.799	0.805	0.801	0.808	0.803	0.793
4.200	0.825	0.821	0.820	0.826	0.822	0.829	0.824	0.814
4.300	0.846	0.842	0.841	0.847	0.844	0.850	0.845	0.836
4.400	0.867	0.863	0.862	0.868	0.865	0.870	0.866	0.857
4.500	0.888	0.883	0.883	0.890	0.886	0.891	0.887	0.878
4.600	0.909	0.904	0.904	0.911	0.907	0.912	0.908	0.899
4.700	0.930	0.925	0.925	0.932	0.928	0.932	0.928	0.920
4.800	0.951	0.946	0.946	0.953	0.949	0.953	0.949	0.942
4.900	0.972	0.967	0.967	0.974	0.970	0.974	0.970	0.963
5.000	0.993	0.988	0.987	0.995	0.991	0.995	0.991	0.984
5.100	1.014	1.009	1.008	1.016	1.012	1.015	1.012	1.005
5.200	1.035	1.030	1.029	1.037	1.033	1.036	1.033	1.026
5.300	1.056	1.051	1.050	1.058	1.054	1.057	1.054	1.047
5.400	1.077	1.072	1.071	1.080	1.075	1.078	1.074	1.069
5.500	1.098	1.093	1.092	1.101	1.096	1.098	1.095	1.090
5.600	1.119	1.113	1.113	1.122	1.117	1.119	1.116	1.111
5.700	1.140	1.134	1.134	1.143	1.138	1.140	1.137	1.132
5.800	1.161	1.155	1.155	1.164	1.159	1.161	1.158	1.153
5.900	1.182	1.176	1.176	1.185	1.180	1.181	1.179	1.175
6.000	1.203	1.197	1.196	1.206	1.201	1.202	1.200	1.196
6.100	1.224	1.218	1.217	1.227	1.222	1.223	1.220	1.217
6.200	1.245	1.239	1.238	1.249	1.243	1.244	1.241	1.238
6.300	1.266	1.260	1.259	1.270	1.264	1.264	1.262	1.259
6.400	1.287	1.281	1.280	1.291	1.285	1.285	1.283	1.281

TABLE II-16. DISCHARGE CURRENT (AMPERES) TELEMETRY AT 45°C

TELEMETRY VOLTS	DISCHARGE CURRENT (IN AMPERES) S/N 022	S/N 023	S/N 024	S/N 025	S/N 026	S/N 027	S/N 029	S/N 030
0.300	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.400	0.000	0.000	0.000	0.022	0.000	0.000	0.000	0.000
0.500	0.022	0.000	0.001	0.068	0.030	0.008	0.030	0.024
0.600	0.068	0.044	0.047	0.114	0.077	0.055	0.076	0.071
0.700	0.115	0.090	0.094	0.160	0.123	0.101	0.122	0.117
0.800	0.161	0.137	0.140	0.206	0.169	0.148	0.168	0.163
0.900	0.208	0.183	0.187	0.252	0.216	0.195	0.214	0.209
1.000	0.254	0.230	0.234	0.298	0.262	0.241	0.260	0.255
1.100	0.300	0.277	0.280	0.344	0.308	0.288	0.306	0.301
1.200	0.347	0.323	0.327	0.390	0.354	0.335	0.352	0.347
1.300	0.393	0.370	0.374	0.436	0.401	0.382	0.398	0.393
1.400	0.440	0.416	0.420	0.482	0.447	0.428	0.444	0.439
1.500	0.486	0.463	0.467	0.528	0.493	0.475	0.490	0.485
1.600	0.532	0.509	0.514	0.574	0.539	0.522	0.536	0.531
1.700	0.579	0.556	0.560	0.620	0.586	0.568	0.582	0.577
1.800	0.625	0.602	0.607	0.666	0.632	0.615	0.628	0.623
1.900	0.672	0.649	0.654	0.712	0.678	0.662	0.674	0.669
2.000	0.718	0.695	0.700	0.758	0.725	0.708	0.720	0.715
2.100	0.764	0.742	0.747	0.804	0.771	0.755	0.766	0.761
2.200	0.810	0.788	0.793	0.848	0.817	0.802	0.812	0.807
2.300	0.855	0.834	0.839	0.892	0.861	0.847	0.856	0.851
2.400	0.900	0.879	0.884	0.937	0.906	0.892	0.900	0.896
2.500	0.945	0.924	0.929	0.981	0.951	0.937	0.945	0.940
2.600	0.990	0.969	0.974	1.025	0.996	0.982	0.989	0.985
2.700	1.034	1.014	1.019	1.069	1.041	1.027	1.034	1.030
2.800	1.079	1.059	1.064	1.114	1.085	1.071	1.078	1.074
2.900	1.124	1.104	1.109	1.158	1.130	1.116	1.122	1.119
3.000	1.169	1.149	1.154	1.202	1.175	1.161	1.167	1.163
3.100	1.214	1.194	1.199	1.247	1.220	1.206	1.211	1.208
3.200	1.258	1.239	1.244	1.291	1.265	1.251	1.256	1.252
3.300	1.303	1.284	1.289	1.335	1.310	1.296	1.300	1.297
3.400	1.348	1.329	1.334	1.380	1.354	1.341	1.345	1.341
3.500	1.393	1.374	1.379	1.424	1.399	1.386	1.389	1.386
3.600	1.438	1.419	1.424	1.468	1.444	1.431	1.433	1.431
3.700	1.483	1.464	1.469	1.513	1.489	1.476	1.478	1.475
3.800	1.527	1.509	1.514	1.557	1.534	1.521	1.522	1.520
3.900	1.572	1.554	1.559	1.601	1.578	1.566	1.567	1.564
4.000	1.617	1.600	1.604	1.645	1.623	1.611	1.611	1.609
4.100	1.661	1.644	1.648	1.689	1.667	1.655	1.654	1.653
4.200	1.705	1.688	1.692	1.732	1.711	1.699	1.698	1.696
4.300	1.749	1.732	1.737	1.776	1.755	1.743	1.742	1.740
4.400	1.793	1.776	1.781	1.819	1.799	1.787	1.785	1.784
4.500	1.838	1.821	1.825	1.863	1.842	1.832	1.829	1.828
4.600	1.882	1.865	1.869	1.907	1.886	1.876	1.872	1.871
4.700	1.926	1.909	1.914	1.950	1.930	1.920	1.916	1.915
4.800	1.970	1.953	1.958	1.994	1.974	1.964	1.959	1.959
4.900	2.014	1.997	2.002	2.038	2.018	2.009	2.003	2.003
5.000	2.059	2.042	2.046	2.081	2.062	2.053	2.047	2.046
5.100	2.103	2.086	2.090	2.125	2.106	2.097	2.090	2.090
5.200	2.147	2.130	2.135	2.168	2.150	2.141	2.134	2.134
5.300	2.191	2.174	2.179	2.212	2.194	2.186	2.177	2.178
5.400	2.235	2.218	2.223	2.256	2.238	2.230	2.221	2.221
5.500	2.279	2.263	2.267	2.299	2.282	2.274	2.264	2.265
5.600	2.324	2.307	2.312	2.343	2.326	2.318	2.308	2.309
5.700	2.368	2.351	2.356	2.386	2.370	2.362	2.352	2.353
5.800	2.412	2.395	2.400	2.430	2.414	2.407	2.395	2.396
5.900	2.456	2.439	2.444	2.474	2.458	2.451	2.439	2.440
6.000	2.500	2.484	2.488	2.517	2.501	2.495	2.482	2.484
6.100	2.544	2.528	2.533	2.561	2.545	2.539	2.526	2.528
6.200	2.589	2.572	2.577	2.605	2.589	2.584	2.569	2.572
6.300	2.633	2.616	2.621	2.648	2.633	2.628	2.613	2.615
6.400	2.677	2.660	2.665	2.692	2.677	2.672	2.657	2.659

6. Final Inspection and Clean-Up

After completing all electrical testing, each of the flight storage modules was subjected to a final inspection and clean-up. The inspection included; module weighting, a pin retention check of the connectors, and a check of the outer housing dimensions. The clean-up included; removal of all foreign materials from the outer housing surfaces and the connectors, touch-up of all surface scratches with DOW 18, and final packing for shipment.

The pin retention check was performed with a standard one-ounce go/no go gage. All flight modules passed the pin retention check without difficulty. Minor deviations from drawing specifications were found during the check of the outer housing dimensions. Each of these deviations were discussed with the customer and were judged to be insignificant. The weight of the flight storage modules are listed in Table II-17.

TABLE II-17. STORAGE MODULE WEIGHTS

Serial Number	Weight (lb)
022	15.29
023	15.28
024	15.16
025	15.29
026	15.21
027	15.28
029	15.35
030	15.48

D. NIMBUS-D POWER SUBSYSTEM TESTS

1. Thermal-Vacuum Test Sequence

The eight flight storage modules (Serial Nos. 022, 023, 024, 025, 026, 927, 029 and 030) and a control module (Serial No. 06) were subjected to flight acceptance testing in a thermal-vacuum environment from May 2, 1969 to May 20, 1969. The test plan followed is shown in Figure II-3. With the exception of the high-temperature trickle-charge circuit in storage modules 022 and 023, the test results for all the units were excellent and no deviations from the specified test limits were noted. This section of the report presents a summary of the test data measured during thermal-vacuum sequence. The details of the trickle-charge circuit failures are discussed in Paragraph E, Test Discrepancies, of this Appendix.

a. Maximum Load Orbital-Cycling Tests

Repetitive orbital cycles were run at each of the temperature plateau shown in Figure II-3. The regulated bus load current was varied from orbit to orbit until the charge/discharge ratio presented in Figure II-4 was achieved. The power subsystem was then cycled at that load value until the end of the temperature plateau. Maximum energy-balance load power was established during this test. Since the load capability of the power subsystem is a very sensitive function of the solar array output, the solar array simulator (located in the Subsystem Tester) was adjusted to correspond as closely as possible to that portion of the 40°C Nimbus-D solar-array I-V curve which lies between 31 and 38 volts, the region of operation during spacecraft daytime. Figure II-5 presents the predicted Nimbus-D solar-array characteristics. Figure II-6 presents the maximum energy-balance load for Nimbus-D. Figure II-7 and II-8 illustrate typical performance of the power subsystem during maximum load orbital cycling. After the recommended charge/discharge ratio had been established for several maximum load orbits at each temperature plateau, subsystem voltages and currents were recorded with the data logging equipment every two minutes during an entire 108-minute orbit cycle. A time integration of the eight storage module currents was performed in order to determine how closely the storage modules shared the charge and discharge ampere-minutes. The results are listed in Table II-18. The power subsystem performance specification requires that the ampere-minutes into or out of any battery during the charge or discharge portion of an orbit shall be within ±10-percent of the average charge or discharge. The actual percentage deviation of each battery from the average charge or discharge at the various temperature plateaus is shown in Figures II-9 and II-10.

Orbital cycling at the high temperature plateaus was interrupted at the points shown in Figure II-3 to conduct a special high temperature test. This special test was performed to measure the temperatures at which the trickle-charge circuit of each storage module operated. The internal temperatures of the modules were varied by charging the battery in a mode that would generate heat. This special test was instituted, with the full approval of the NASA technical officer after storage modules 022 and 023 went into premature trickle-charge during the 45° C exposure. A summary of the temperature measurements during that special test effort is presented in Table II-19. The specification limits for the trickle-charge set mode is 51.7 ±2.8° C and for the reset mode is 49.0 ±2.8° C. The data listed in Table II-19 clearly demonstrates that the trickle charge circuit was not working properly. During portions of the high temperature testing, the trickle-charge circuit in storage modules 022 and 023 was inhibited by the test equipment (only the high-temperature circuit and not the voltage-temperature circuit) so that orbital cycling at maximum load could continue unabated. The failure of the trickle-charge circuit did not in any way compromise the test results obtained from the maximum load orbital cycling test. Subsequent exam-

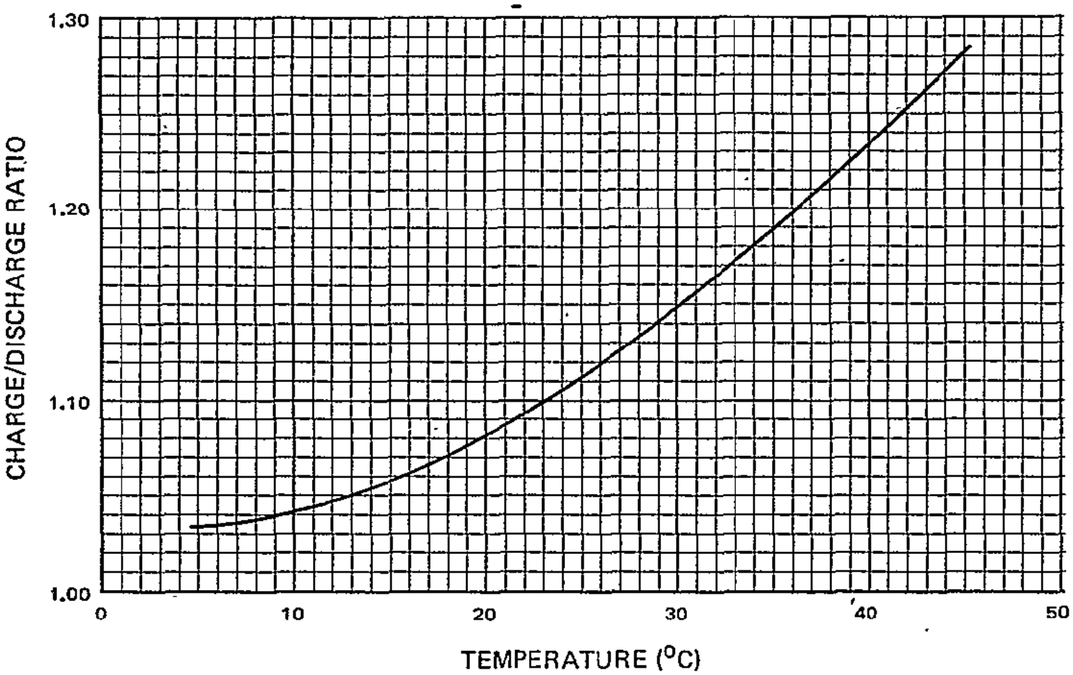


Figure II-4. Minimum Recommended Charge/Discharge Ratios

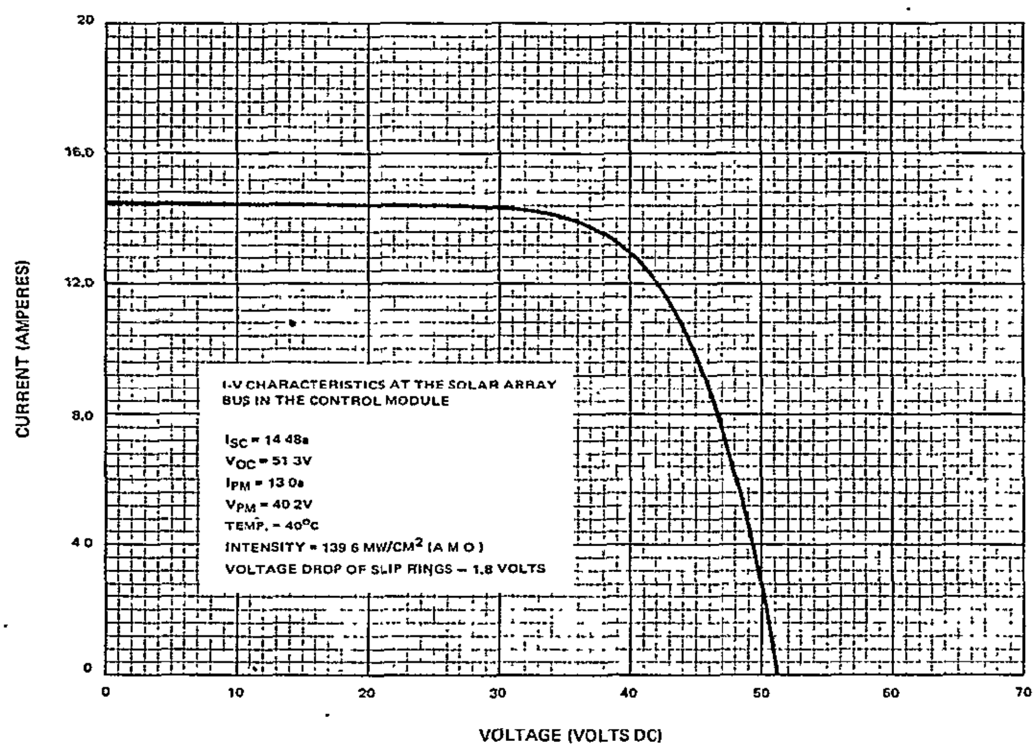
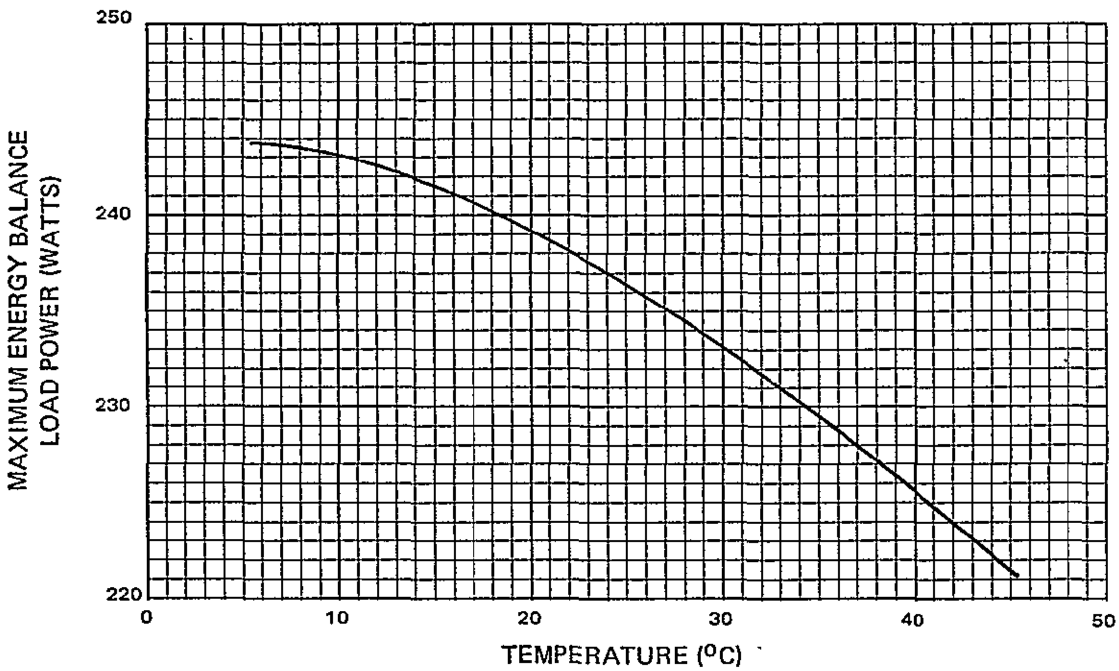


Figure II-5. Predicted Beginning-of-Life Solar-Array Characteristic



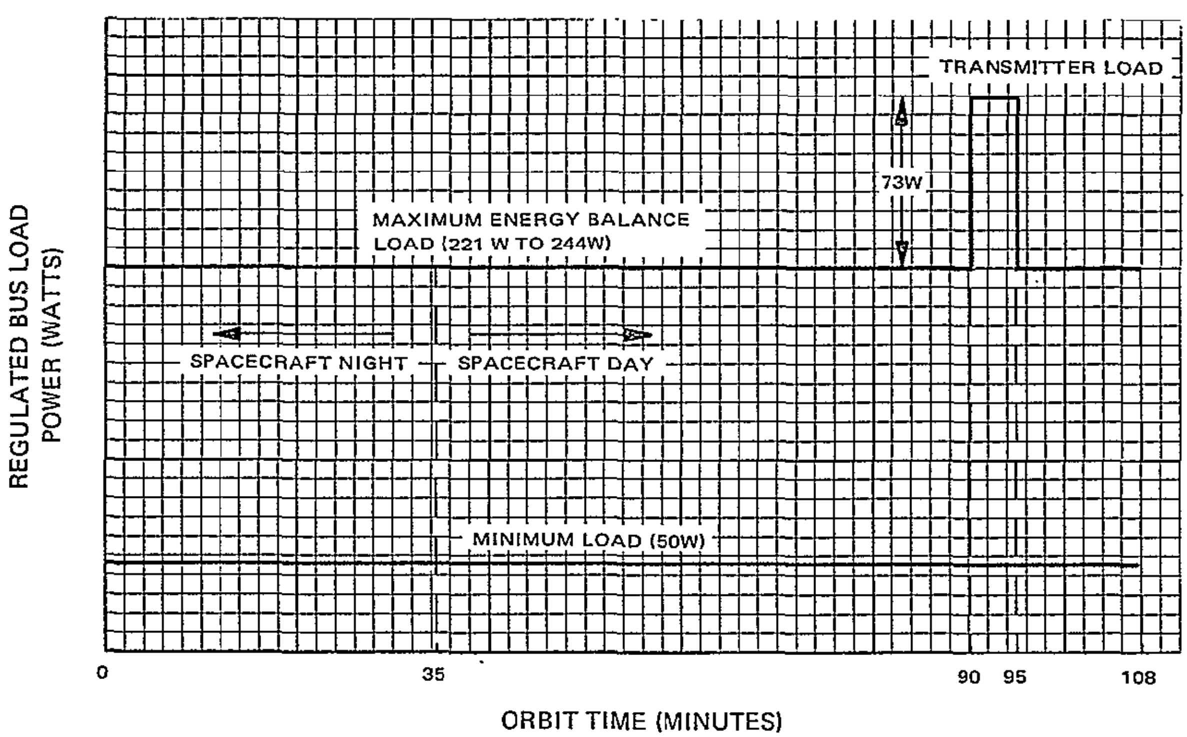


Figure II-6. Maximum Energy Balance Load

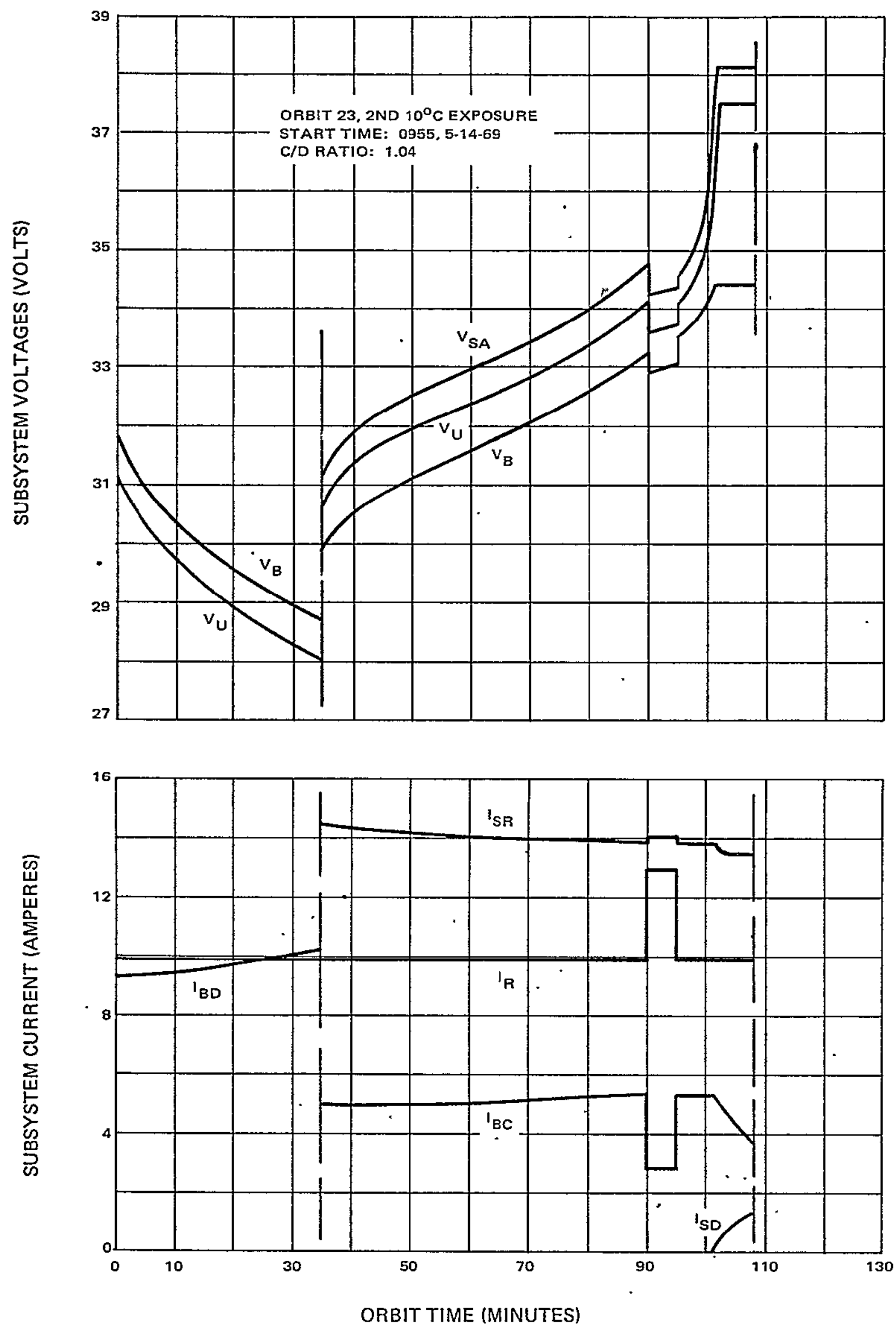


Figure II-7. Maximum Load, Orbital Cycling at 10°C

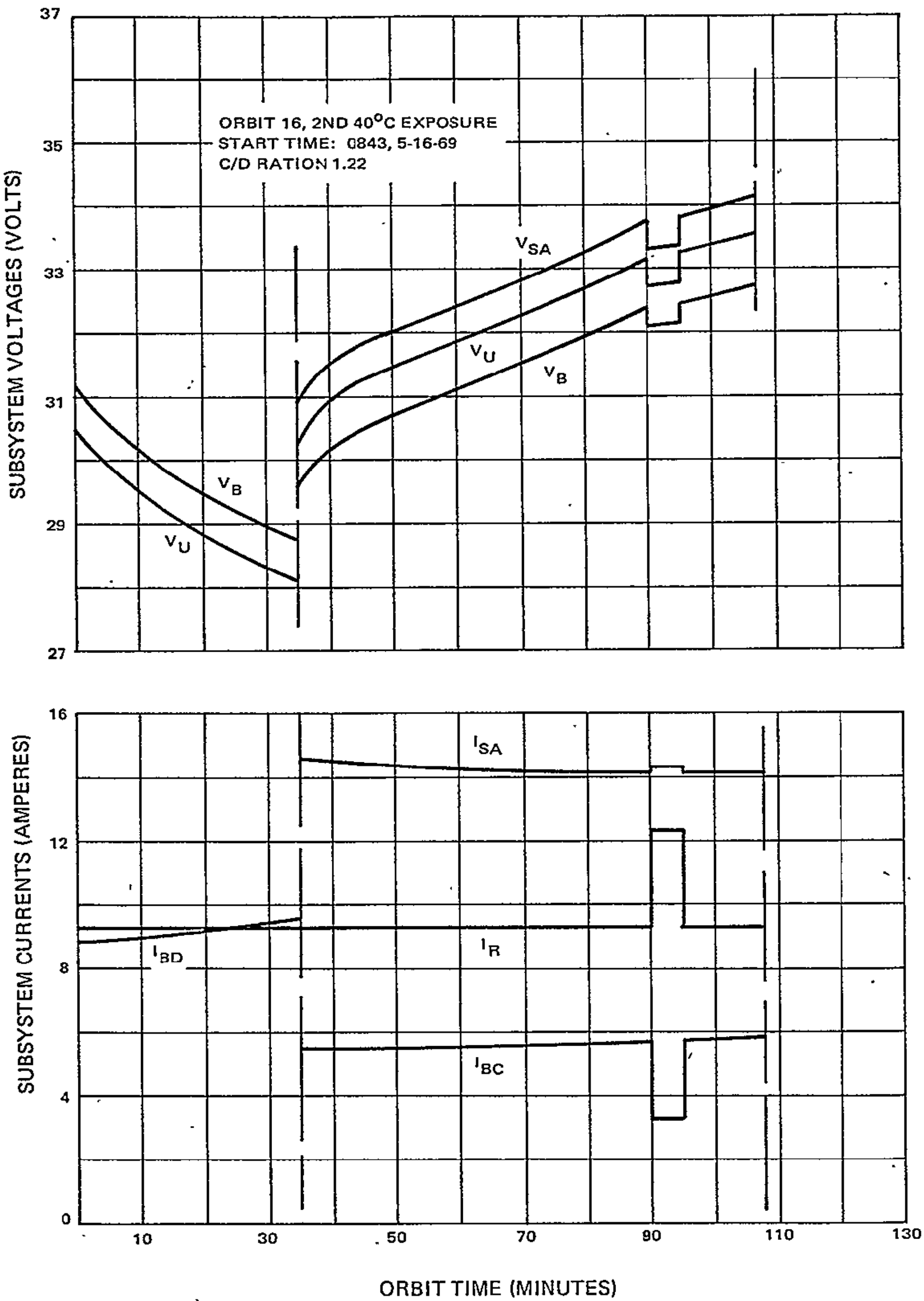


Figure II-8. Maximum Load, Orbital Cycling at 40°C

TABLE II-18. STORAGE MODULE CHARGE AND DISCHARGE SHARING DURING MAXIMUM LOAD ORBITS

Test Conditions	Storage Module No.	A-M Charge	A-M Discharge	C/D Ratio
Orbit 14 45°C Exposure	022	47.35	37.94	1.248
	023	49.63	39.46	1.258
	024	50.10	39.91	1.255
	025	47.25	38.21	1.237
	026	50.23	38.95	1.289
	027	52.89	39.83	1.328
	029	53.60	41.54	1.290
	030	55.51	41.95	1.323
	Average	50.82	39.72	1.279
Orbit 12 5° Exposure	022	42.31	40.96	1.033
	023	44.14	42.75	1.032
	024	43.08	41.72	1.033
	025	42.30	40.75	1.038
	026	43.47	41.94	1.036
	027	45.04	43.48	1.036
	029	44.75	43.46	1.030
	030	47.10	45.23	1.041
	Average	44.02	42.54	1.035
Orbit 18 First 10° C Exposure	022	42.95	41.24	1.041
	023	44.73	43.06	1.039
	024	43.67	42.09	1.038
	025	43.38	41.32	1.050
	026	44.47	42.36	1.050
	027	45.83	43.57	1.052
	029	45.42	43.68	1.040
	030	46.73	44.81	1.043
	Average	44.65	42.77	1.044
Orbit 16 First 40°C Exposure	022	46.52	38.41	1.211
	023	49.29	40.38	1.221
	024	48.75	40.00	1.219
	025	46.25	37.78	1.224
	026	49.26	39.67	1.242
	027	51.87	40.75	1.273
	029	52.98	42.48	1.247
	030	54.54	42.62	1.280
	Average	49.93	40.26	1.240

TABLE II-18. STORAGE MODULE CHARGE AND DISCHARGE SHARING DURING MAXIMUM LOAD ORBITS (Continued)

Test Conditions	Storage Module No.	A-M Charge	A-M Discharge	C/D Ratio
Orbit 23 Second 10°C Exposure	022	42.98	41.22	1.043
	023	45.50	43.77	1.039
	024	43.25	41.52	1.042
	025	42.09	40.15	1.048
	026	43.93	42.00	1.046
	027	45.57	43.55	1.046
	029	46.05	44.27	1.040
	030	48.01	45.65	1.052
	Average	44.67	42.77	1.045
Orbit 16 Second 40°C Exposure	022	45.46	38.32	1.186
	023	48.27	40.59	1.189
	024	48.38	39.63	1.221
	025	45.39	37.58	1.208
	026	48.01	39.55	1.214
	027	50.48	40.73	1.239
	029	52.06	42.86	1.215
	030	53.38	42.99	1.242
	Average	48.93	40.28	1.215

ination after the thermal-vacuum test revealed that the problem with the trickle-charge circuit was improper bonding of the high-temperature circuit thermistor to storage cell 19.

b. Minimum Load Orbital Cycling Tests

Three minimum load orbital cycles were run at fixture temperatures of 25, 10, and 40°C. Figure II-3 shows the points in the thermal-vacuum test sequence at which this effort occurred. A 50-watt regulated bus load (illustrated in Figure II-6) was used for the minimum load orbits. During these orbits, the storage modules were subjected to severe overcharging under the protection of the charge-controller circuitry. Typical storage module performance under these worst-case conditions is plotted in Figure II-11. When the solar array was turned on, the storage module voltages reached the voltage-temperature limits within seven to thirteen minutes. The rapid reduction in charge current to maintain

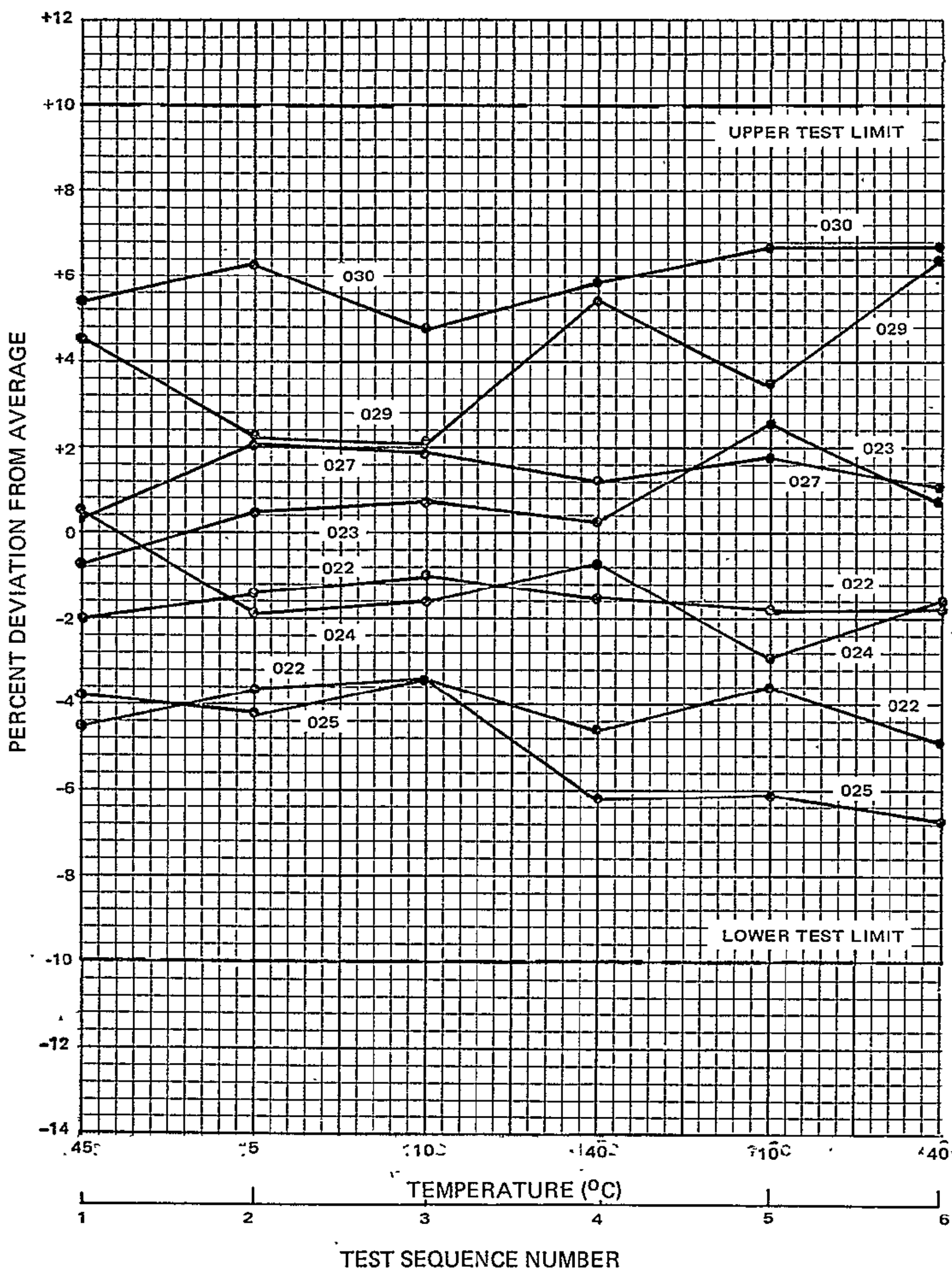


Figure II-9. Ampere-Minute Discharge Sharing

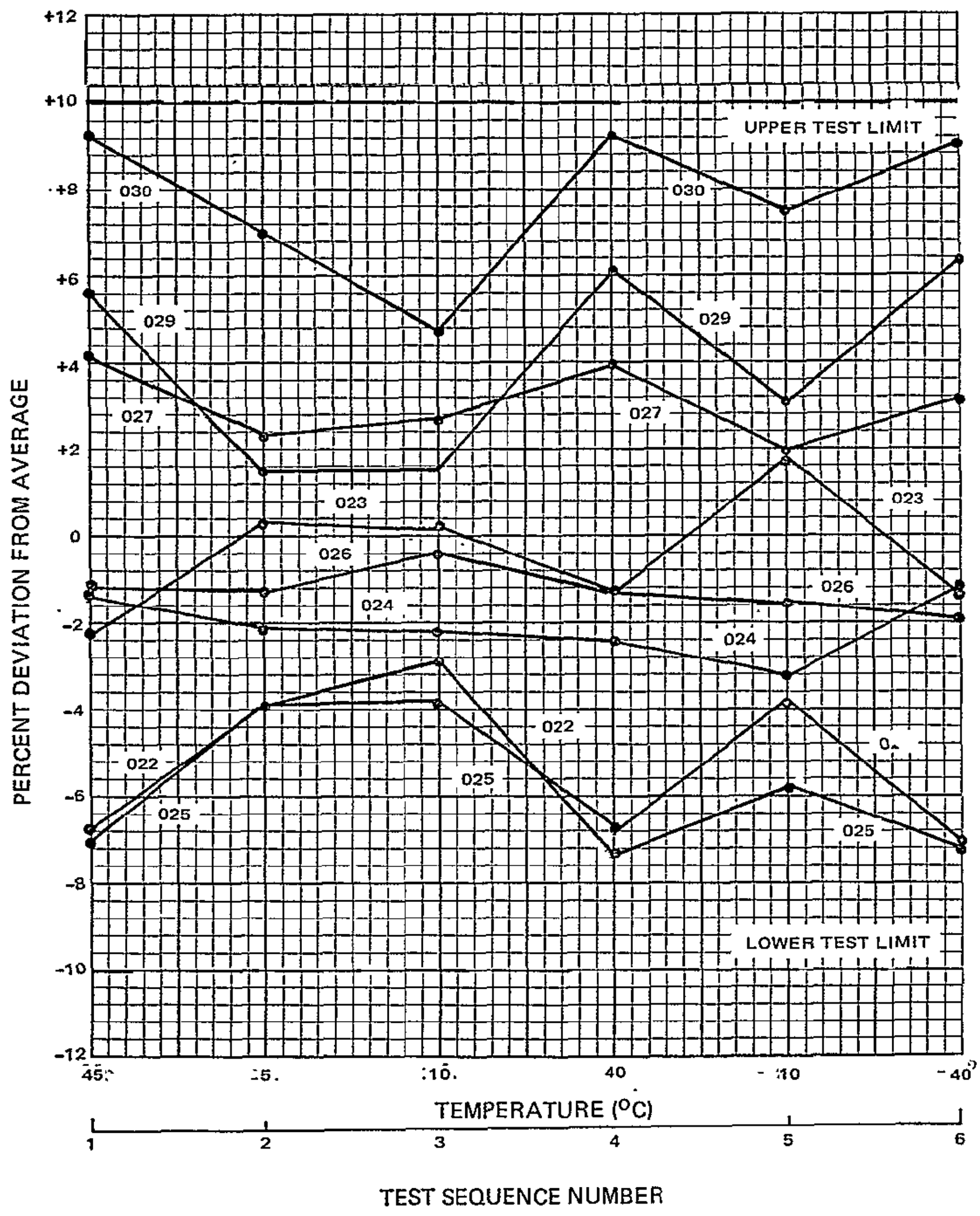


Figure II-10. Ampere-Minute Charge Sharing

TABLE II-19. TRICKLE CHARGE CIRCUIT PERFORMANCE

Storage Module Serial Numbers	Temperature (in °C)	
	Trickle-Charge On (Set Mode)	Trickle-Charge Off (Reset Mode)
022	48.2	45.0
023	44.9	42.2
024	51.1	48.5
025	50.6	48.3
026	51.9	49.1
027	51.3	49.3
029	51.2	49.1
030	51.6	48.9

NOTE: All temperature data measured by a thermocouple on the outside of storage cell 19.

the voltage limit can be seen in Figure II-11. The reduced charge current at 10°C was low enough to prevent a rise in the case temperature of the storage cells during the remainder of the orbit; therefore, the charge voltage and current remained constant. At 25 and 40°C, the higher value of tapered charge current generated enough heat within the storage modules to increase the cell temperatures and lower the corresponding voltage limits. At the 40°C fixture temperature, the cell temperatures became high enough during the orbit to activate the high-temperature cutoff circuit, which placed six of the eight batteries into trickle-charge operation (150 milliamperes). Figure II-11 shows the incremental charge reductions as each storage module is set in trickle-charge. The premature trickle-charge operation of storage module S/N 023 can also be seen in Figure II-11, as the circuit was not inhibited during the minimum load tests.

The constant 50-watt load supplied by the power subsystem during this orbital cycling test causes the charge-controller operation in the voltage-limiting mode during most of the daytime portion of the orbit. A summary of this operation for each storage module is presented in Table II-20.

During the 10°C minimum load orbital cycling charge, the worst-case condition of storage cell voltage divergence and the highest values of cell voltage throughout the thermal-vacuum test sequence were observed. Figure II-12 is a histogram of these cell voltages just prior to the onset of voltage limiting (the point of maximum spread in individual cell voltages). The highest cell voltage measurement was 1.530 volts. The maximum specification limit is 1.537 volts at 13°C. Figure II-13 is a second histogram of cell voltages, 22 orbital minutes after the first histogram. This histogram was presented to illustrate the normal regrouping of cell voltages and the reduction of the highest voltage to a lower level.

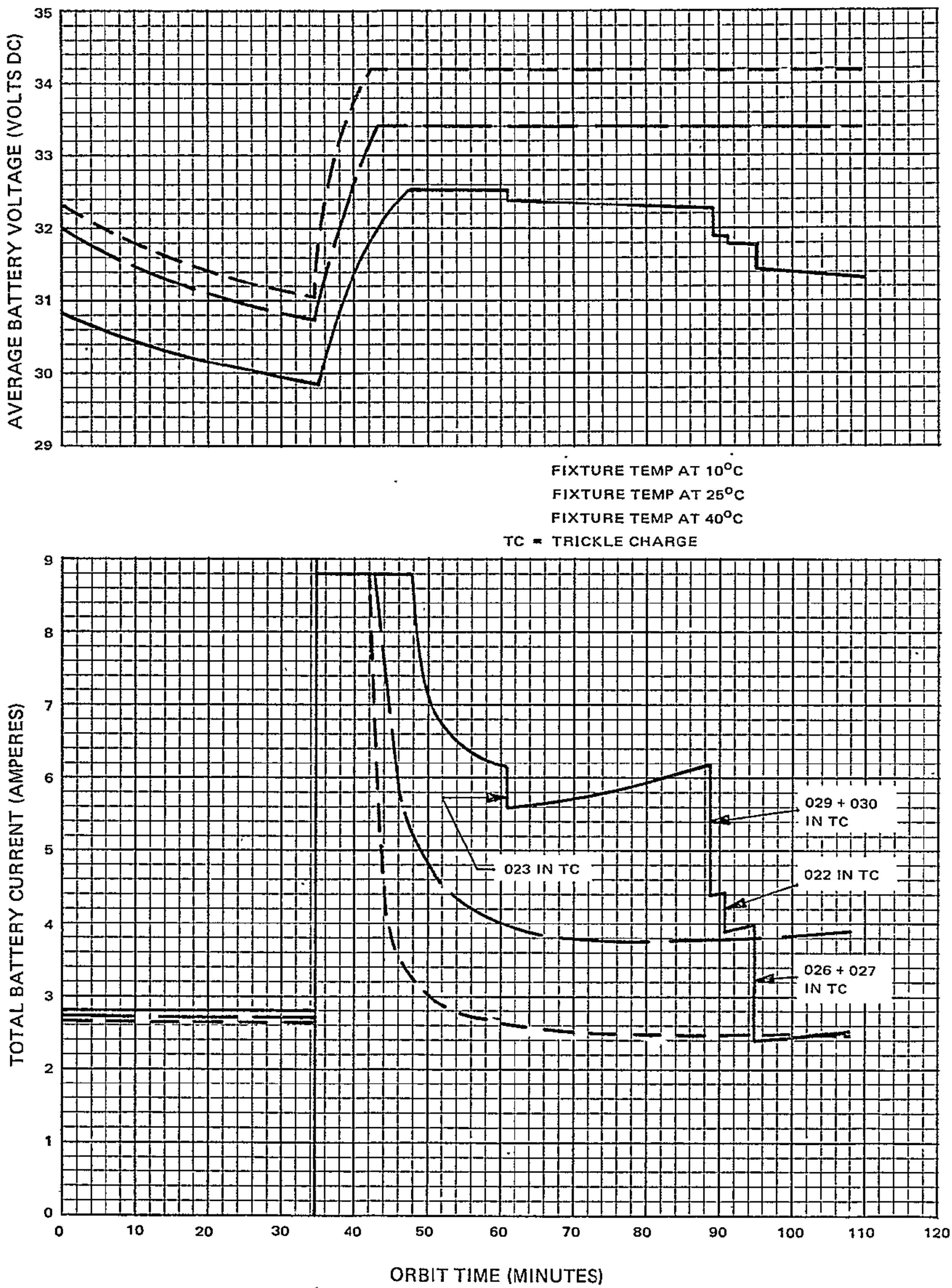


Figure II-11. Storage Module Performance During Minimum Load Cycling

TABLE II-20. VOLTAGE LIMITING DURING MINIMUM ORBITS

Test Parameters	Storage Module Serial Numbers							
	022	023	024	025	026	027	029	030
Fixture Temperature (°C)	25	25	25	25	25	25	25	25
Cell No. 5 Telemetry Temperature (°C)	26.2	27.2	27.1	26.6	28.0	28.0	28.1	27.9
Estimated Cell No. 12 Temperature (°C)	29	30	30	30	31	31	31	31
Upper Batt. Voltage Limit at Cell 12 Temperature (Volts)	33.65	33.60	33.60	33.60	33.55	33.55	33.55	33.55
Measured Batt. Voltage (Volts)	33.40	33.39	33.38	33.40	33.32	33.34	33.32	33.26
Lower Batt. Voltage Limit at Cell 12 Temperature (Volts)	33.18	33.13	33.13	33.13	33.08	33.08	33.08	33.08
Minimum Charge Current (Milliamperes)	377	400	401	359	464	561	560	678
Fixture Temperature (°C)	10	10	10	10	10	10	10	10
Cell No. 5 Telemetry Temperature (°C)	10.4	10.8	10.5	10.5	11.4	11.8	12.3	12.3
Estimated Cell No. 12 Temperature (°C)	13	14	14	14	14	15	15	15
Upper Batt. Voltage Limit at Cell 12 Temperature (Volts)	34.38	34.33	34.33	34.33	34.33	34.29	34.29	34.29
Measured Batt. Voltage (Volts)	34.22	34.20	34.19	34.22	34.18	34.16	34.10	34.09
Lower Batt. Voltage Limit at Cell 12 Temperature (Volts)	33.91	33.87	33.87	33.87	33.87	33.83	33.83	33.83
Minimum Charge Current (Milliamperes)	236	265	267	213	279	352	416	438
Fixture Temperature (°C)	40	40	40	40	40	40	40	40
Cell No. 5 Telemetry Temperature (°C)	41.2	41.3	43.2	42.7	43.4	43.4	43.3	43.2
Estimated Cell No. 12 Temperature (°C)	45	45	47	47	47	47	47	47
Upper Batt. Voltage Limit at Cell 12 Temperature (Volts)	32.92	32.92	32.83	32.83	32.83	32.83	32.83	32.83
Measured Batt. Voltage (Volts)	32.62	32.63	32.53	32.53	32.52	32.56	32.52	32.56
Lower Batt. Voltage Limit at Cell 12 Temperature (Volts)	32.45	32.45	32.35	32.35	32.35	32.35	32.35	32.35
Minimum Charge Current (Milliamperes)	606	704	699	590	736	857	984	1005

Notes: All data associated with the 25°C fixture was obtained from the 77-minute readout, all data associated with a 10°C fixture was obtained from the 107-minute readout, and all data associated with a 40°C fixture was obtained from the 61-minute readout.

c. System Performance Tests

During the thermal-vacuum test sequence, system performance tests were run to examine electrical parameters not normally measured during simulated orbital cycling. The tests were conducted at the end of each temperature plateau (see Figure II-3). For each test, the measurements were found to be well within specified limits. The greatest deviations observed during thermal-vacuum performance testing are presented in Table II-21.

The five ground commands that are available for the power subsystem were simulated during each of the performance tests. These commands are: PWM regulator switchover, trickle-charge override and reset, battery disconnect, and battery connect. The commands functioned properly at all times, as verified by telemetry voltages and hard-wire readings of battery currents.

The accuracy of all telemetry points in the power subsystem was examined during each of the performance tests. Acceptable tolerances for comparison of the telemetry voltages and the hard-wire readings of voltages and currents (taken simultaneously with the telemetry voltage printouts) were one-half of the specified accuracy of the individual circuits. All telemetry circuits performed well and met these stringent requirements. A thermocouple was placed on cell No. 5 of each storage module, and the temperature was read with a Leeds and Northrup potentiometer. All battery-temperature telemetry data agreed with the appropriate thermocouple reading within the accuracy of the instrumentation plus the tolerance for the telemetry circuit itself. The worst-case telemetry measurements are summarized in Tables II-22 and II-23.

d. Efficiency Test

The power subsystem was subjected to a special test to determine the power losses over the range of anticipated operating conditions. The tests were conducted in the thermal-vacuum chamber at a temperature of 25°C (see Figure II-3). With the solar array turned off, system voltages and currents were recorded for regulated bus load currents of 1, 3, 6, 9, 12, 16 and 20 amperes, and with the solar array simulator turned on, for load currents of 6, 9, 12, 16 and 20 amperes. With the solar array on and four batteries disconnected, system voltage and current printouts were taken at load currents of up to 9 amperes to obtain system losses under conditions of shunt dissipator operation. Figure II-14 is a plot of the measured system losses during spacecraft night (SL_N) and spacecraft day (SL_D) as a function of regulated bus load power. The nighttime losses (SL_N) were determined from the expression:

$$SL_N = V_B I_B - 24.5 \times I_L$$

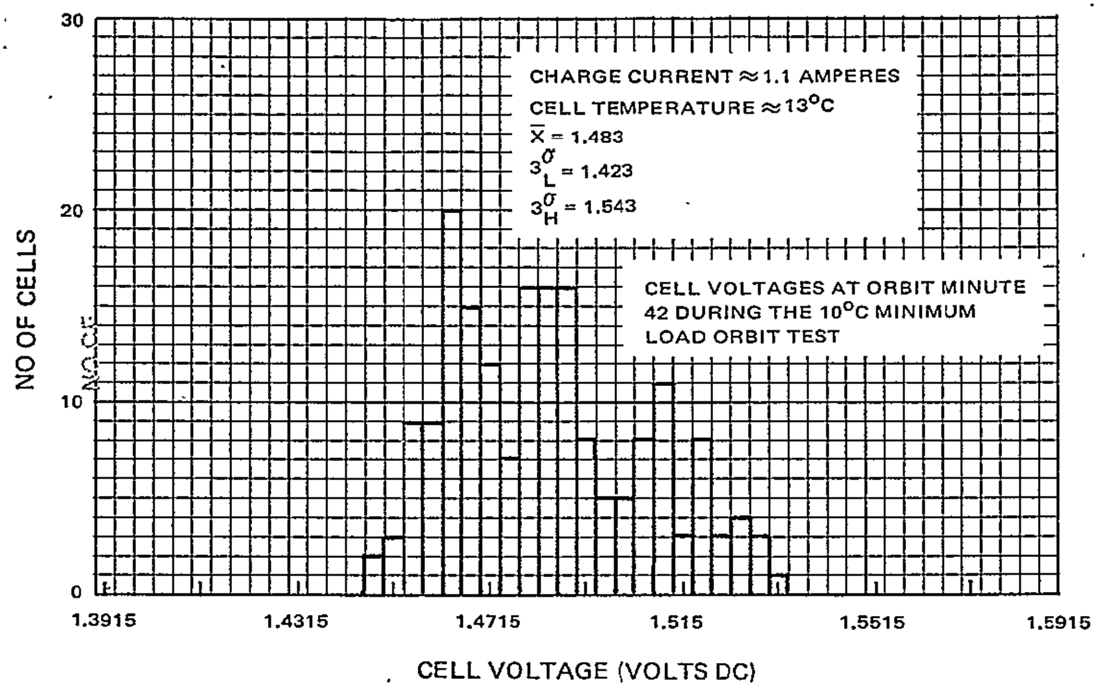


Figure II-12. Maximum Storage Cell Voltage Divergence

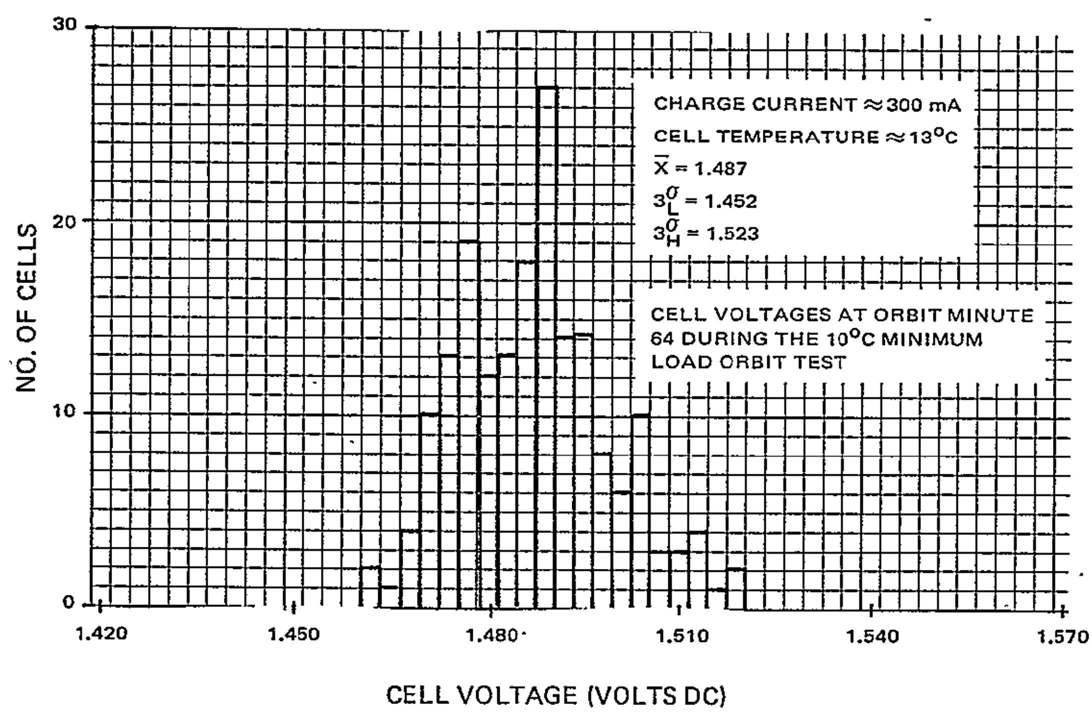


Figure II-13. Storage Cell Voltage Regrouping

TABLE II-21. WORST-CASE MEASUREMENTS DURING THERMAL-VACUUM TESTS

Function	Specified Limits	Test Conditions	Worst-Case Measurements	
			Temperature	Measured Value
PWM Regulator Voltage	24.5 ±0.25 V	I_R = 20 A	5°C	24.35 V
PWM Regulator Ripple Amplitude	less than 100 mVp-p	V_u = 37.6	5°C	90 mV
Auxiliary Regulator Voltage	23.5 ±0.25 V	I_L = 0.75 A	45°C	23.52 V
Clock Bus Voltage (From 24.5 V Bus)	23.8 ±0.25 V	I_L = 0.75 A	45°C	23.92 A
Clock Bus Voltage (From 23.5 V Bus)	22.5 ±0.25 V	I_L = 0.75 A	45°C	22.87 V
Bus Comparator Switching Voltages	26.0 ±0.25 V (high limit)	I_R = 10 A	40°C	26.05 V
	23.0 ±0.25 V (low limit)	I_R = 10 A	40°C	22.92 V
24.5 V Bus Deviation (During Switching)	1.0 V (max)	I_R = 8 A	10°C	0.04 V
Shunt Dissipator Current Sharing	5 to 20% at 2 A	I_{SD} = 2 A	40°C	11.4 to 13.4%
	10 to 15% at 7 A	I_{SD} = 7 A	5°C	12.2 to 12.8%
	10 to 15% at 11.3 A	I_{SD} = 11.3 A	45°C	12.3 to 12.8%
Maximum Charge Current	1.1 ±0.05 A	V_{SAB} = 38.0 V, I_R = 2 A	45°C	1.108 to 1.116 A
Trickle Charge Current	150 ±50 mA	Simulated high temperature signal	25°C	156 to 164 mA

Legend: V_u = Unregulated Bus Voltage, V_R = Regulated Bus Voltage,
I_L = Load Current, I_{SD} = Total Shunt Dissipator Current,
V_{SAB} = Solar Array Bus Voltage, I_R = Regulated Bus Current.

TABLE II-22. WORST-CASE STORAGE MODULE TELEMETRY DEVIATION DURING THERMAL-VACUUM TESTS

Telemetry Parameters	Test Limiter	Storage Module Serial Numbers							
		022	023	024	025	026	027	029	030
Charge Current	±0.02 A	0.015 A	0.014 A	0.012 A	0.011 A	0.015 A	0.016 A	0.017 A	0.016 A
Discharge Current	±0.04 A	0.021 A	0.021 A	0.029 A	0.012 A	0.009 A	0.022 A	0.023 A	0.021 A
Battery Voltage	±0.20 V	0.11 V	0.10 V	0.13 V	0.11 V	0.09 V	0.14 V	0.16 V	0.15 V
Battery Temperature	±2.5°C	1.8°C	1.7°C	1.8°C	2.0°C	1.9°C	1.7°C	1.8°C	1.9°C

TABLE II-23. WORST-CASE CONTROL MODULE 06 TELEMETRY DEVIATIONS DURING THERMAL-VACUUM TESTS

Telemetry Parameters	Test Limits	Measured Values
Solar Array Current	±0.18 A	0.09 A
Regulated Bus Current	±0.26 A	0.23 A
Regulated Bus Voltage	±0.20 V	0.06 V
Unregulated Bus Voltage	±0.25 V	0.05 V
Auxiliary Regulator Voltages	±0.20 V	0.04 V
Thermistor RT-1 Temperature	±2.5°C	1.1°C
Thermistor RT-2 Temperature	±2.5°C	1.9°C

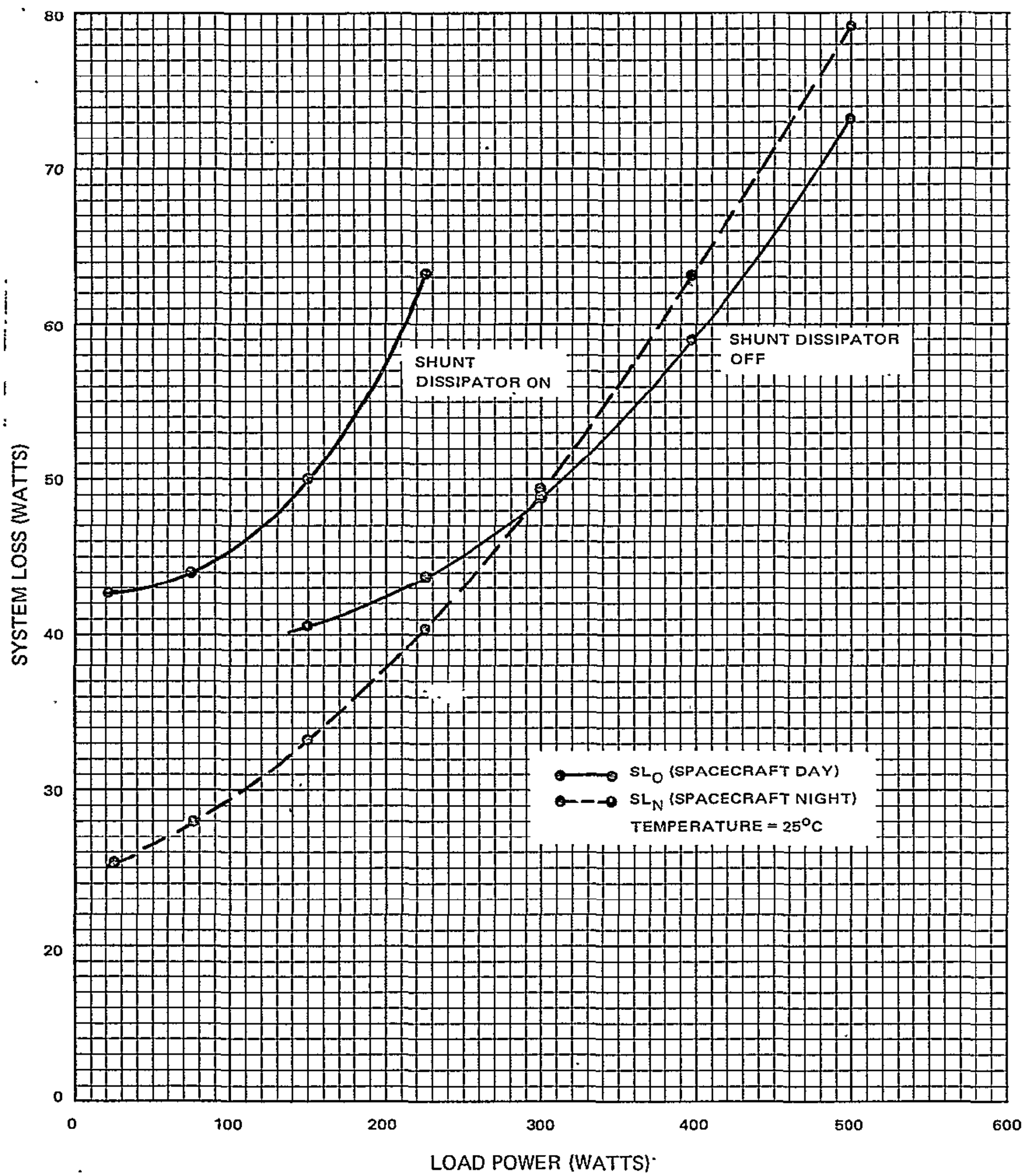


Figure II-14. System Power Losses

where

V_B is the average of the eight battery discharge voltages,

I_B is the sum of the eight battery discharge currents, and

I_L is the -24.5 V regulated-bus load current.

And the spacecraft daytime losses (SL_D) were determined from the expression:

$$SL_D = (I_{SA} - I_B - I_{SD}) \times V_{SAB} - 24.5 \times I_L$$

where

I_{SA} is the solar array output current,

V_{SAB} is the voltage on the solar array bus in the control module,

I_B is the sum of the eight battery charge currents,

I_{SD} is the sum of the eight shunt dissipator leg currents, and

I_L is the -24.5 V regulated-bus load current.

e. System Capacity Test

A system capacity test was performed at the completion of the thermal-vacuum test. The capacity test consisted of; a full letdown, system charge for 52 ampere-hours, and an 8-ampere system discharge until the unregulated bus voltage reached 26.5 volts. The system capacity measured was 42.99 ampere-hours — the specification limit for system capacity is 35.0 ampere-hours. Figures II-15 and II-16 present histograms of the storage cell voltage distributions at the end-of-charge and end-of-discharge for this system capacity test.

f. System Short Test

A system short test was performed after the thermal-vacuum chamber was vented but before the units were disassembled from the system test configuration. The storage modules were letdown and then charged for five minutes at approximately a 0.5 ampere rate per storage module (charging power was obtained from the solar array bus, set up at a reduced voltage level). After completing the five-minute charge, the storage modules were placed in a true open-circuit condition by removing the 9-pin and 37-pin connectors. The storage module cell voltages remained above the specification limit of 1.200 volts throughout the ensuing twenty-hour open-circuit stand. Figure II-17 presents a histogram of individual cell voltages at the end of the twenty-hour stand.

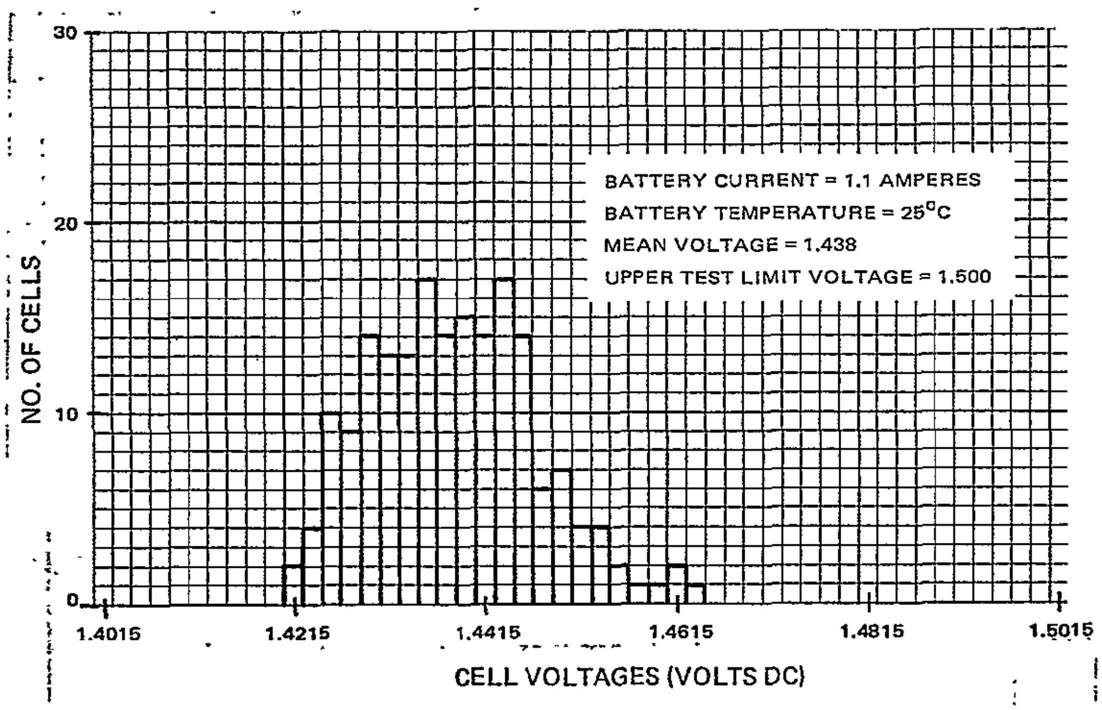


Figure II-15. Histogram of Cell Voltages at End-of-Charge Post-Thermal Vacuum Capacity Test

2. Initial System Test Sequence

The eight flight storage modules S/N 022, 023, 024, 025, 026, 027, 029, 030 together with control module 06 were subjected to the initial system test on May 1, 1969. The performance of the eight flight storage modules and control module 06 was excellent with no deviations from the specified test limits. The initial system test data is presented in Table II-24.

3. Final System Test Sequence

On June 9, 1969, while setting up for the final system test, storage module 024 was damaged by an external short circuit in the test harness. The short circuit, across storage cells 15 through 22, created a condition where some of the storage cells were reversed (voltage polarity change by a forced discharge situation). This module was temporarily removed from the test program (listed in Table II-2) and placed in a rework cycle. The details of the rework cycle plus the post-rework tests are discussed in Paragraph E, Test Discrepancies, of this Appendix.

On June 20, 1969, the seven remaining flight storage modules (Serial Nos. 022, 023, 025, 026, 027, 029, 030) were connected with a control module (Serial No. 03) for the final sell-off system test. Control module 03 was used in place of module

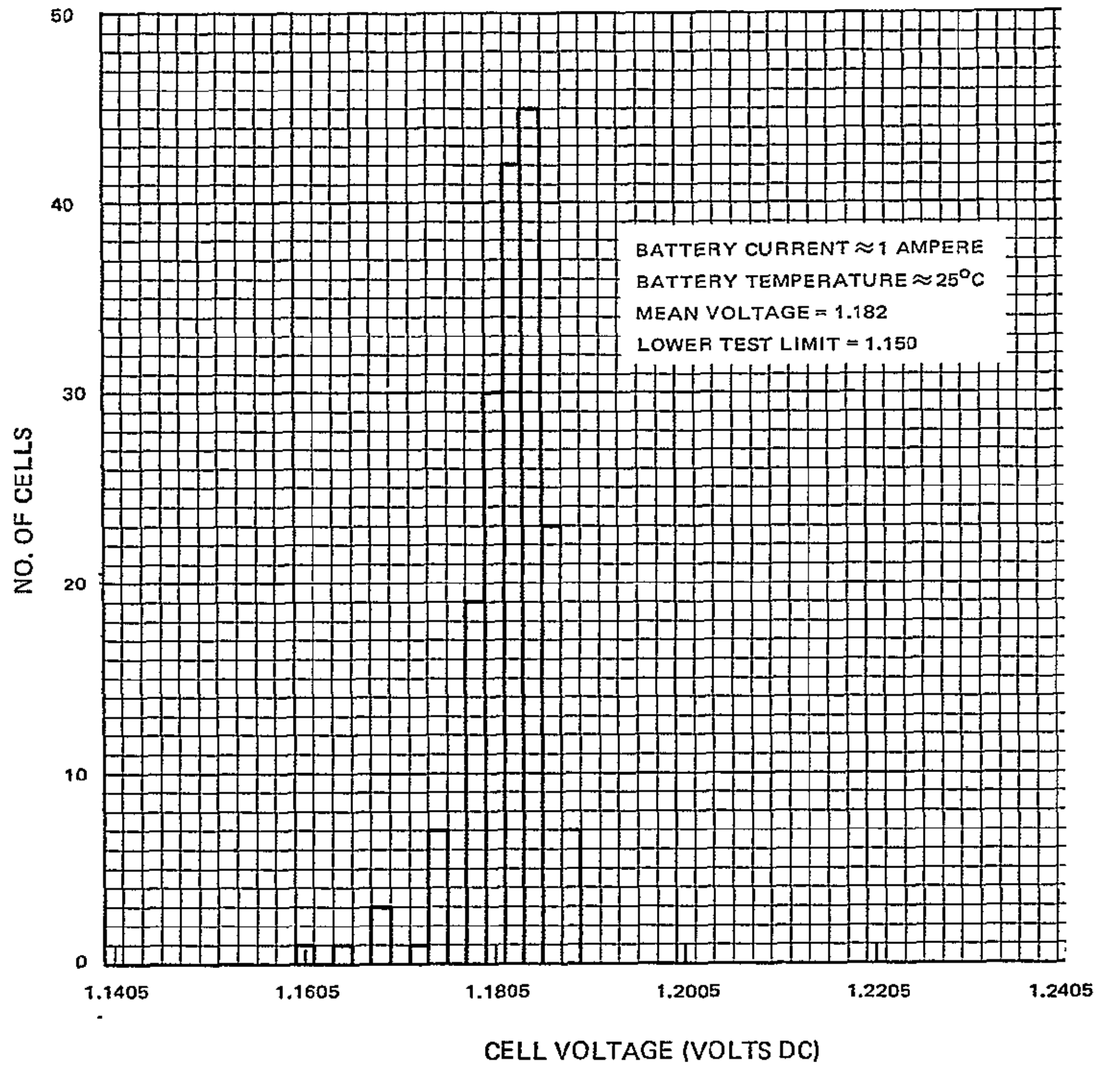


Figure II-16. Histogram of Cell Voltages at End-of-Discharge, Post-Thermal Vacuum Capacity Test

06 because module 06 was being modified with a new filter assembly at this time. The performance of the seven flight storage modules and control module 03 during this final system test was satisfactory with no deviations from the specified test limits. The test data is presented in Table II-25.

E. TEST DISCREPANCIES

The complete summary of all Test Discrepancy Reports (TDR's) issued against flight storage modules 022, 023, 024, 025, 026, 027, 029, 030 and control module 06 are presented in Section 5, Engineering Reliability, of this report. These discrepancies can be classified into four significant failure areas.

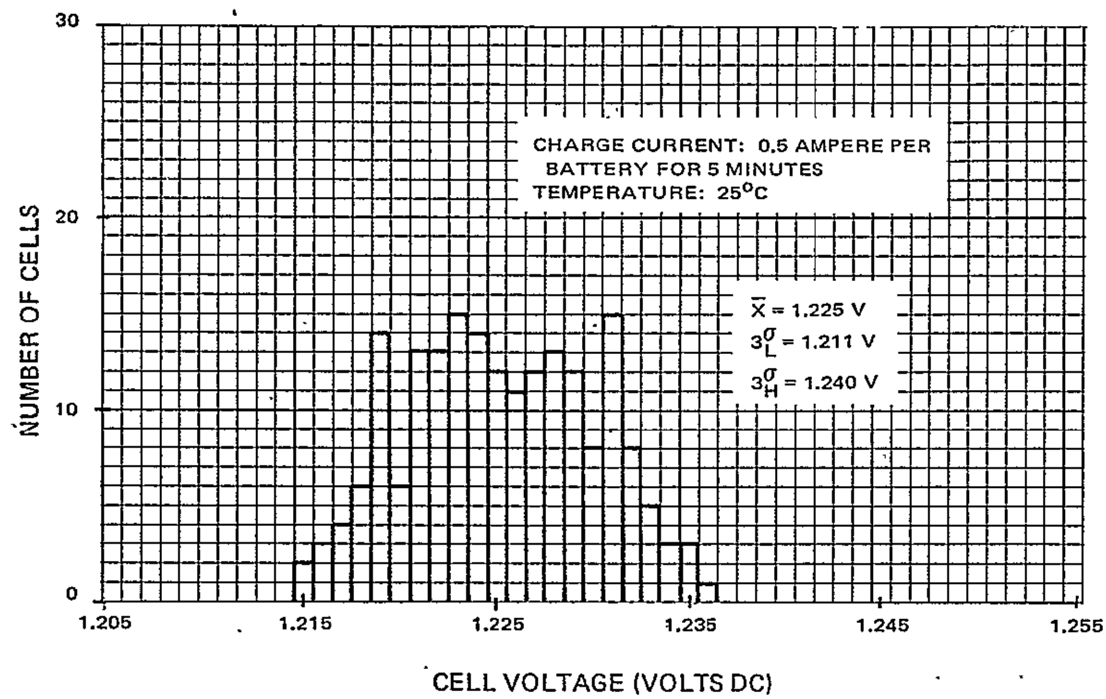


Figure II-17. Histogram of Cell Voltages at End of 20-Hour Open Circuit Voltage Stand, Post-Thermal Vacuum Short Test

1. Shunt Dissipator (2N2016) Transistor Failure

During the months of December 1968 and January 1969 multiple failures of the 2N2016 transistor, both during screening and assembly testing, forced a design change in the storage module shunt dissipator transistor. Six TDR's (No. B3920, B3921, B3922, B3929, B3930, and B3965) were generated against the 2N2016 transistor during the heat sink assembly test effort. The shunt dissipator transistor chosen for the replacement part was a Solitron Transistor SDT 9903 (RCA Part No. 1970655-1). This part was selected because it met the electrical, mechanical, and thermal requirements of the Nimbus-D program. The details of the part selection effort are presented in "Quarterly Report No. 5" (R-3443) issued June 18, 1969.

The replacement of the shunt dissipator transistor was completed during phase one of the test program (Table II-2 of this report). Since this part was a new item in the storage modules, particular attention was given to the performance of the shunt dissipator circuit during the subsequent test effort. Critical examinations, especially during the thermal-vacuum test sequence, verified that the

TABLE II-24. INITIAL SYSTEM TEST DATA

Function	Specified Limits	Test Conditions	Measured Value
PWM Regulator	24.5 ±0.25 V	I_R = 20 A	24.34 V
PWM Regulator Ripple Amplitude	less than 100 mVp-p	V_u = 37.6 V	60 mV
PWM Regulator Current Max	less than 26 A	V_R = 10 V	22.96 A
Auxiliary Regulator Voltage	23.5 ±0.25 V	I_L = 1.0 A	23.50 V
Clock Bus Voltage (From 24.5 V Bus)	23.8 ±0.25 V	I_L = 0.75 A	23.90 V
Clock Bus Voltage (From 23.5 V Bus)	22.5 ±0.25 V	I_L = 0.75 A	22.86 V
Bus Comparator Switching Voltages	26.0 ±0.25 V (high limit)	I_R = 10 A	26.01 V
	23.0 ±0.25 V (low limit)	I_R = 10 A	22.92 V
24.5 V Bus Deviation (During Switching)	1.0 V (max)	I_R = 8 A	0.03 V
Shunt Dissipator Current Sharing	5 to 20% at 2 A	I_{SD} = 2 A	11.6 to 13.4%
	10 to 15% at 7 A	I_{SD} = 7 A	12.2 to 12.6%
	10 to 15% at 11.3 A	I_{SD} = 11.3 A	12.4 to 12.6%
Maximum Charge Current	1.1 to ±0.05 A	V_{SAB} = 38.0 V, I_R = 2 A	1.104 to 1.109 A
Trickle Charge Current	150 ±50 mA	Simulated high temperature signal	153 to 161 mA

Legend: V_u = Unregulated Bus Voltage, V_R = Regulated Bus Voltage,
I_L = Load Current, I_{SD} = Total Shunt Dissipator Current,
V_{SAB} = Solar Array Bus Voltage, I_R = Regulated Bus Current.

TABLE II-25. FINAL SYSTEM TEST DATA

Function	Specified Limits	Test Conditions	Measured Value
PWM Regulator Voltage	24.5 ±0.25 V	I_R = 20 A	24.43 V
PWM Regulator Ripple Amplitude	less than 100 mVp-p	V_u = 37.6 V	55 mV
PWM Regulator Current Maximum	less than 26 A	V_R = 10 V	23.83 A
Auxiliary Regulator Voltage	23.5 ±0.25 V	I_L = 1.0 A	23.50 V
Clock Bus Voltage (From 24.5 V Bus)	23.8 ±0.25 V	I_L = 0.75 A	23.90 V
Clock Bus Voltage (From 23.5 V Bus)	22.5 ±0.25 V	I_L = 0.75 A	22.86 V
Bus Comparator Switching Voltages	26.0 ±0.25 V (high limit)	I_R = 10 A	26.07 V
	23.0 ±0.25 V (low limit)	I_R = 10 A	22.98 V
24.5 V Bus Deviation (During Switching)	1.0 V (max)	I_R = 8 A	0.08 V
Shunt Dissipator Current Sharing	5 to 20% at 2 A	I_{SD} = 2 A	11.4 to 13.1%
	10 to 15% at 7 A	I_{SD} = 7 A	12.2 to 12.6%
	10 to 15% at 11.3 A	I_{SD} = 11.3 A	12.3 to 12.6%
Maximum Charge Current	1.1 ±0.05 A	V_{SAB} = 38.0 V, I_R = 2 A	1.105 to 1.110 A
Trickle Charge Current	150 ± 50 mA	Simulated high temperature signal	153 to 162 mA

Legend: V_u = Unregulated Bus Voltage, V_R = Regulated Bus Voltage,
I_L = Load Current, I_{SD} = Total Shunt Dissipator Current,
V_{SAB} = Solar Array Bus Voltage, I_R = Regulated Bus Current.

performance of the shunt dissipator circuit with the replacement Solitron Transistor was identical to the performance of previous storage modules tested on the Nimbus-B program.

2. Zener Diode (1N944B) Failure

One 1N944B zener diode is used as part of the biasing circuitry in each of the storage module charge-controllers and one is used in the control module shunt dissipator circuit. Four TDR's (Nos. B3937, B3939, B3940, and B3964) for the flight storage modules and one TDR (No. B0391) for control module 06 was generated against this diode during the Nimbus-D program. The bulk of the failures occurred during phases one and two of the storage module test program (Table II-2 of this report). Subsequent investigation revealed that RCA had damaged a whole procurement lot by overstressing during the preconditioning power burn-in (further details are presented in Section 5, Engineering Reliability, of this report.

All 1N944B Zener diode failures on the Nimbus-D program were part of the overstressed lot. After the multiple failure condition became apparent, the 1N944B diodes were removed from all units and replaced with the identical part from a newly procured lot. Since the Zener diodes were replaced in the storage modules after the unit test program had begun and after the charge controller alignment had been completed, a repeat alignment and additional testing of the controller was performed prior to the release of the unit to phase three of the test program (vibration test sequence).

As was the case with the shunt dissipator circuit, the charge controller performance was given extra attention during the thermal-vacuum test cycle. The storage module charging circuits in all units performed flawlessly; with results similar to those previously measured on earlier Nimbus programs.

3. High-Temperature Trickle-Charge Circuit Failure

The function of the high-temperature trickle-charge circuit is to set the charge controller into the trickle-charge mode (150 milliamperes constant current) when the temperature of storage cell 19 reaches 51.7 ±2.8°C and to restore the charge controller to the maximum current level (1.1 amperes) when the temperature reduces to 49.0 ±2.8°C. Three TDR's (Nos. B3938, B3953, and B3954) were generated against the performance of the high-temperature circuit during the program. It was not until the thermal-vacuum test sequence, however, that the failure of this circuit was isolated to the thermistor on cell 19. During the first high-temperature exposure in the thermal-vacuum test, modules 022 and 023 went into the trickle-charge mode at temperatures below the lower specification limit of 48.9°C. Subsequent testing of the trickle-charge circuit using a simulated signal from the subsystem test rack, instead of the actual signal from the thermistor on cell 19, verified the performance of all elements of the high-temperature circuit except the thermistor itself. A post-thermal vacuum mechanical examination identified the problem to be an unbonded thermistor.

A new thermistor was installed on cell 19 in the two discrepant modules and the following additional test cycle was performed:

(1) Post-Rework Electrical Test

(2) Workmanship Vibration Test

(3) Post-Vibration Electrical Test

(4) Special Thermal Vacuum Test

(5) Post-Thermal Vacuum Test

This additional testing was carried out to verify performance after the installation of the replacement thermistors. The three electrical tests were performed at 25°C using the standard storage module circuit test procedure TP-CT-1759580 and the workmanship vibration was a flight level radial, random exposure only — following procedure TP-HVA-1759580. The special thermal-vacuum test exposure was one temperature cycle (two hours at 45° C and two hours at 10° C), followed by one-hour test period at 45° C, and a one-hour test period at 40° C. The pressure was maintained at less than 1×10^{-5} TORR, during the exposure. During the first one hour test period the storage modules were activated and charged in the maximum heat generation mode (but under control of the protection circuits). The internal heat rise triggered the high-temperature trickle-charge circuits and cell 19 temperature measurements were made at the onset of this trickle-charge operation. The fixture temperature was then reduced to 40° C for the second one-hour test period and the modules were operated in the minimum heat generation mode (low charging current and no shunt dissipator current). At the return of the charge controller to normal charge (trickle-charge circuit reset), the cell 19 temperature measurements were repeated. The results of this special test are presented in Table II-26.

The additional test cycle demonstrated satisfactory performance for storage modules 022 and 023. The two units were then returned to the normal test flow for the final system test sequence (phase five of the test program).

4. Storage Cells Short Circuit Failure

On 6-9-69, during the set-up for the final system test, the test harness caused a short circuit across cells 15 through 22 of storage module 024. TDR

TABLE II-26. TRICKLE-CHARGE CIRCUIT PERFORMANCE AFTER THERMISTORS REPLACEMENT

Storage Module Serial Number	Temperature (in °C)	
	Trickle-Charge On (Set Mode)	Trickle-Charge Off (Reset Mode)
022	51.0	50.0
023	50.5	49.2
NOTE: All temperature data measured by a thermocouple on the outside of storage cell 19.		

No. B3956 was generated to cover the test discrepancy. An examination of the test harness revealed that a small piece of solder, at the base of the wiring side of the connector, created the short circuit condition. This small piece of solder appeared to have been present since the day the harness was made (approximately five years ago) and had worked itself into the short condition during the handling of the harness just prior to the final system test. The initial discharge current from the eight storage cells at the start of the short circuit condition was estimated at 52 amperes. However, the available energy in the cells before the short was 15 ampere-minutes maximum thereby limiting high discharge currents to a very small time interval (probably less than two minutes). This discharge current limiting saved the module wiring from damage and confined the problem area to the eight storage cells. Seven of these eight cells were discharged into a voltage polarity reversal condition by the short circuit. Since the precise current levels and time duration of the discharge could not be defined for the period that the cells were reversed, it was agreed upon by RCA and the NASA technical officer that all eight storage cells should be replaced. A subsequent examination of the storage module wiring confirmed that no wiring damage had occurred as a result of the short circuit.

The module was delivered to manufacturing for cell replacement on June 10, 1969. The eight replacement cells were obtained from the spare-cell module (which was cycled at the same time and at the same test levels as the flight units during the thermal-vacuum test sequence). Selection of the replacement cells was made so that the new cells would match as closely as possible the electrical characteristics of the shorted cells. The installation of the eight replacement cells was completed on June 20, 1969 and the module was then subjected to an additional test cycle to verify module performance after rework. The eight shorted cells were sent to the Nimbus Project Office for subsequent delivery to NASA (The NASA Technical Officer requested that these shorted cells be delivered to him so that he could subject them to special testing).

The additional test cycle performed on storage module 024 was:

(1) Post Rework Battery Short Test

(2) Post Rework Electrical Test

(3) Workmanship Vibration Test

(4) Post Vibration Electrical Test

(5) Post Vibration Battery Short Test

(6) Special Thermal-Vacuum Test

(7) Post Thermal-Vacuum Battery Capacity Test

(8) Post Thermal-Vacuum Electrical Test

All electrical tests were performed at 25°C using the standard storage module circuit test procedure TP-CT-1759580 and all battery tests were performed using the standard battery test procedure TP-BT-1759580. The workmanship vibration was a flight level radial, random exposure only — following procedure TP-HVA-1759580. The special thermal-vacuum test was similar to the test performed on storage modules 022 and 023.

The data from the electrical circuit tests demonstrated that all circuits were performing satisfactory after the rework and the additional environmental exposures. The special thermal-vacuum test measured the new temperature values for trickle-charge on and off (the removal and replacement of cell 19 and its corresponding thermistor created the requirement for the test). The new value of trickle-charge on (set temperature) and the new value of trickle-charge off (reset temperature) was measured at 51.0°C and 48.2°C respectively. The results of the two battery short tests are presented in Figure II-18. The separation of replacement cell voltages from the balance of the cells during the first short test was the result of electrical inactivity prior to the installation into module 024. Cell voltage regrouping into one distinct class can be clearly observed at the post-vibration short test. The final battery capacity measurement yielded 320 ampere-minutes — very close to the original battery capacity. Table II-27 presents the end-of-charge and the end-of-discharge cell voltage data for this final capacity test.

The final electrical test, performed on July 1, 1969 and witnessed by the customer, was considered the sell-off test for this module.

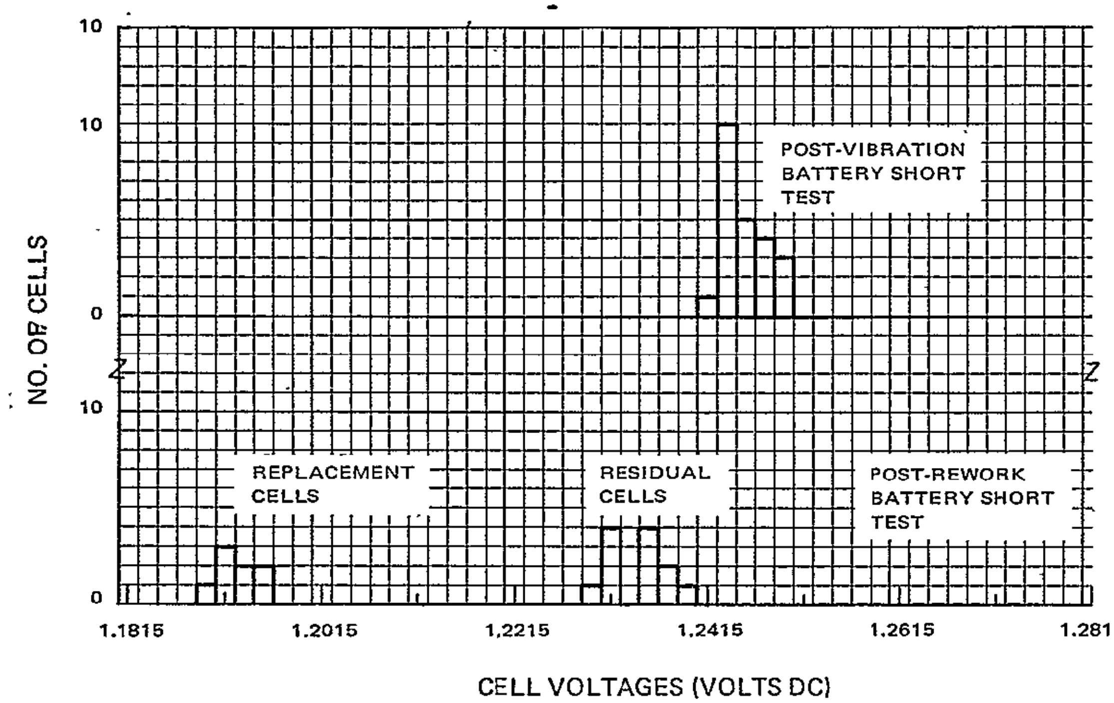


Figure II-18. Histogram of Cell Voltages at End of the 20-Hour Open-Circuit Stand, Battery Short Tests for Module 024

TABLE II-27. FINAL CAPACITY TEST FOR STORAGE MODULE 024, END-OF-CHARGE AND END-OF-DISCHARGE CELL VOLTAGES (IN VOLTS)

Cell Position Number	End of Charge	End of Discharge
1	1.424	1.177
2	1.423	1.181
3	1.425	1.178
4	1.422	1.175
5	1.426	1.177
6	1.424	1.180
7	1.425	1.180
8	1.423	1.177
9	1.429	1.177
10	1.428	1.175
11	1.427	1.182
12	1.426	1.179

TABLE II-27. FINAL CAPACITY TEST FOR STORAGE MODULE 024, END-OF-CHARGE AND END-OF-DISCHARGE CELL VOLTAGES (IN VOLTS) (Continued)

Cell Position Number	End of Charge	End of Discharge
13	1.432	1.183
14	1.426	1.180
15	1.426	1.166
16	1.425	1.172
17	1.425	1.174
18	1.425	1.177
19	1.424	1.170
20	1.423	1.165
21	1.427	1.157
22	1.423	1.134
23	1.419	1.172

APPENDIX III

CONTROL MODULE TEST AND MODIFICATION DATA

A. INTRODUCTION

Test data summaries and control module modifications performed during the report period are as follows:

- Design Changes
- Control Module 03 Unit Test Data Summary, Par. C
- Control Module 06 Unit Test Data Summary, Par. D
- Control Module EM-01 Unit Test Data Summary, Par. E.

B. DESIGN CHANGES

1. Introduction

The design changes incorporated into control module 03 are itemized by contract modifications 5, 11, and 14 of Contract NAS5-10470. Modification 5, issued May 6, 1968, authorized the addition of two internal temperature sensors (RT-1 and RT-2); modification 11 and 14, issued February 25 and May 23, 1969 authorized the addition of filter assembly A-17. In addition to the modifications, a survey of the control module components was made to ensure that all the parts conformed to the Nimbus-D program requirements. These changes are delineated on the following drawings.

- Assembly 1759712-502
- Schematic 1976286
- Wiring List 1970997

2. Temperature Sensors RT-1 and RT-2

At the start of the Nimbus-D program two thermistors designated RT-1 and RT-2 were added to control module 06. Design data are contained in "Quarterly Technical Report No. 2", (R-3340) issued July 15, 1968. Alignment and test data are contained in "Quarterly Technical Report No. 5", (R-3443) issued June 18, 1969. Control module 03 was returned as GFE equipment and the thermistors were installed.

3. Filter Assembly A17

a. Description

The filter assembly, mounted on the right-hand side wall of the RFI compartment (See Figure 5), provides power to the Attitude Control System of the spacecraft via a connector that projects through the housing (See Figure III-1). The filter assembly contains two high-current, hermetically sealed feed-through capacitors that isolate the PWM output (capacitor bd A14) from the external circuits (See Figure III-2).

b. Mechanical Analysis

(1) General

A mechanical stress analysis, conducted during the report period, indicates that the mounting configuration of the filter assembly, will withstand the stress requirements outlined by the Nimbus-D environmental specification (GSFC S-320-NI-3).

(2) Mounting Configuration

The mounting configuration consisted of cutting a hole in the housing wall to accept the new filter assembly, and securing the filter with six 4-40 steel (F_{TY} = 30,000 psi) bolts. The new filter was mounted in the center of the wall and remote from the main load paths of the remainder of the unit.

(3) Analysis

Based on the mounting configuration, it was deemed adequate to consider the local loads and stresses in the immediate vicinity of the filter assembly. A major stress induced in the vicinity of the new filter assembly was caused by capacitor assembly A14, therefore its effects were also considered. Specifically, the following items were investigated:

- The bolt clamping load required to transmit inertial shear loads.
- Adequacy of the bolt material
- Bolt torque required to develop a clamping load
- Structural adequacy of the wall
- Deflection of the filter assembly to preclude contact with other components

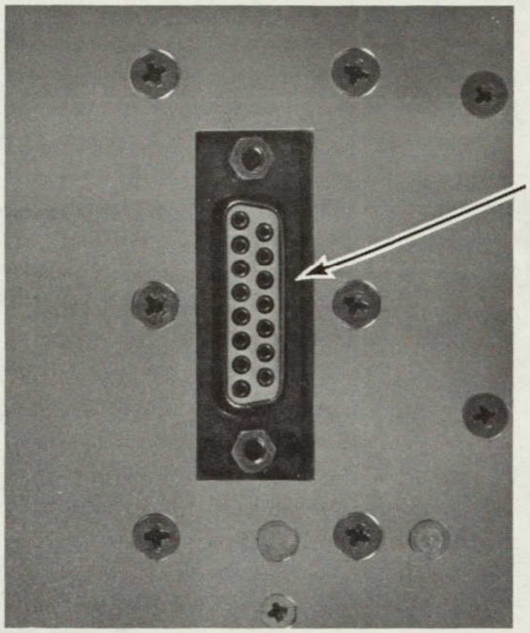


Figure III-1. Connector J15 Configuration

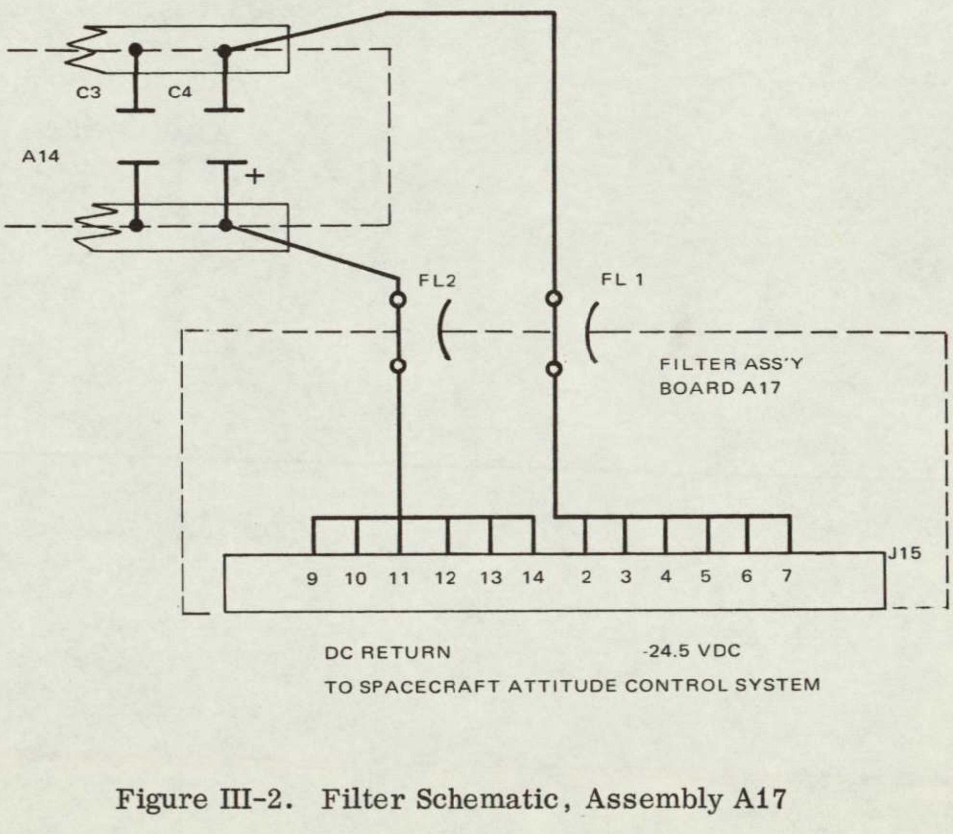


Figure III-2. Filter Schematic, Assembly A17

- Acceleration of the filter assembly to ensure that the filter is within its fragility curve
- Response frequency of the filter assembly and capacitor board A14 to determine system response accelerations, system deflections, number of damaging fatigue cycles, and allowable fatigue stress

The foregoing analyses were performed for both the sinusoidal and random qualifications test levels of the GSFC environmental specification; and were carried out for the three axes of excitation with transmissibilities obtained from the Prototype Qualification test data.

(4) Conclusions

The six mounting screws (4-40) are structurally adequate with a safety margin of +1.41 for the critical test condition (random excitation, thrust axis). The mounting torque is 1.95 in-lb above the locking feature for lubricated assemblies and 3.25 in-lb for dry assemblies.

The wall stress was critical for excitations in the radial plane. The calculated margin of safety was +0.015. This value was calculated by considering the wall as a beam; in reality it is a plate supported on four sides. Hence, the wall should be capable of carrying an additional 15-percent load. The critical section of the wall is located between the capacitor assembly and the filter assembly. The margin of safety was based on bending fatigue.

The deflections of the filter will cause no interference with any of the other components. The radial deflection is 0.0294 inch-limit; the tangential deflection is 0.0147 inch-limit at the filter center of gravity.

The resonant frequency of the capacitor assembly and filter assembly is 141 Hz for radial excitation, 850 Hz for thrust excitation and less than 500 Hz for tangential excitation. The corresponding critical response accelerations are 60 g for radial sine excitation, 120 g for thrust (3 sigma) random excitation and 92.5 g for tangential (3 sigma) random excitation.

The allowable bending-fatigue stress for the radial excitation (critical) is 36,500 psi. This is based on the need for three complete series of tests.

4. Component Parts Survey

As a result of the survey, capacitor C6 on board A8 was changed to correct the size (220 μf to 3.3 μf). The remaining parts meet the program requirements.

C. CONTROL MODULE 03 UNIT TEST DATA SUMMARY

Unit test of control module was conducted in accordance with the test procedures listed in Table III-1. A complete chronological summary of events for Nimbus-D acceptance is contained in Table III-2.

TABLE III-1. TEST SEQUENCE AND PROCEDURES, CONTROL MODULE 03

Test	Test Procedures	Completion Date
Electrical Test (Bench)	TP-BT-1759712	6-4-69
Vibration Tests	TP-HVA-1759712	6-5-69
Thermal Tests	TP-EA-1846689	6-10-69

The electrical performance of the unit compared favorably with the data accumulated on previously conducted programs. Typical performance of the unit is shown in Figures III-3, III-4, and III-5. Worst case measurements obtained during the Nimbus-D acceptance program are listed in Table III-3. An examination of the data reveals that the main regulator current limit is outside the specified test limits of 23.00 amperes at 24.5 ±0.25 volts dc. The 23.15 ampere indication at the regulated bus voltage of 24 volts is controlled by the current limit threshold adjustment in the control module which is approximately 0.5 ampere too high. The threshold adjustment was increased during the Nimbus-B2 program and was not re-adjusted during the Nimbus-D test sequence. The present adjustment level is considered safe. The current limiting operation at 25°C (See Figure III-4) maintains the maximum current at 24 amperes.

Figure III-6 presents the electrical measurements for the thermistors RT-1 and RT-2. The measured data is nearly identical with the measurements taken on control module 06.

Telemetry data, measured during the Nimbus-D test sequence, was used to generate up-to-date telemetry listings shown in Table III-4 through III-8. These listings are computer tabulations of measured information expanded into smaller increments using linear interpolation. The new telemetry tables from the Nimbus-D program were compared with the telemetry calibration tables generated during the Nimbus-B2 program. The Nimbus-B2 telemetry data agreed favorably with the recently measured data. The worst-case telemetry variation found during the comparison was the regulated bus current telemetry. At full scale (20 amperes) the difference in regulated bus current telemetry voltage was 59 millivolts (see Figure III-7). The specification limit for the regulated bus current telemetry voltage is ±2 percent of the full scale value of 120 millivolts maximum allowable variation.

TABLE III-2. CHRONOLOGICAL SUMMARY OF EVENTS FOR CONTROL MODULE 03 ACCEPTANCE

Date	Summary of Events
4-28-69	Unit returned to RCA Corporation from GE Co., Valley Forge, Pa. for the installation of the A17 filter assembly and internal thermistors RT-1 and RT-2.
6-2-69	Modification of unit completed.
6-4-69	Electrical Test at room temperature completed.
6-5-69	Full vibration test (flight level exposure) completed.
6-6-69	Electrical performance test and telemetry calibration started. Performance test temperature exposures at 5, 25, and 45°C. Telemetry calibration temperature exposures at 0, 5, 25, 45, and 55°C.
6-10-69	Electrical performance test and telemetry calibration completed.
6-12-69	Component parts survey made to ensure that the unit was completely upgraded to the Nimbus-D flight configuration. Capacitor C6 on the Board A8 (Current Sensing and Current T/M) was found to be the 220 μf instead of the 3.3 μf now required on flight units. Board A8 (1759582-501, S/N 03) was sent to manufacturing for replacement of capacitor C6. The new value is 3.3 μf.
6-16-69	Replacement of capacitor C6 on the Board A8 completed.
6-16-69	Electrical test of the regulated bus current telemetry performed.
6-16-69	Workmanship vibration (flight level, radial, random exposure only) performed.
6-17-69	Electrical Test at room temperature completed.
6-18-69	Unit weighed; new weight is 21.7 lb.
6-19-69	Engineering survey of vibration and thermal exposures started. The survey requested by the NASA Technical Offices on 6-17-69, survey contained on Tables 2 and 3 of this report.
6-19-69	Unit connected with seven flight storage modules for system performance test sequence.
6-20-69	System performance test using control module 03 and storage modules 022, 023, 025, 026, 027, 029, and 030 performed.
6-21-69	Pin retention test performed on all outer connectors. Four connectors (J1, J5, J6, and J8) failed the pin retention requirement of one ounce. Connectors J1, J5, J6, and J8 (part 1721489-5) replaced.

TABLE III-2. CHRONOLOGICAL SUMMARY OF EVENTS FOR CONTROL MODULE 03 ACCEPTANCE (Continued)

Date	Summary of Events
6-26-69	Connector replacements completed.
6-26-69	Engineering survey of vibration and thermal exposure history completed (see 6-19-69 entry).
6-27-69	Electrical test at room temperature completed.
6-30-69	Workmanship vibration (flight level, radial, random exposure only) performed.
6-30-69	Electrical test at room temperature completed.
7-2-69	Unit shipped to GE Co., Valley Forge, Pa.

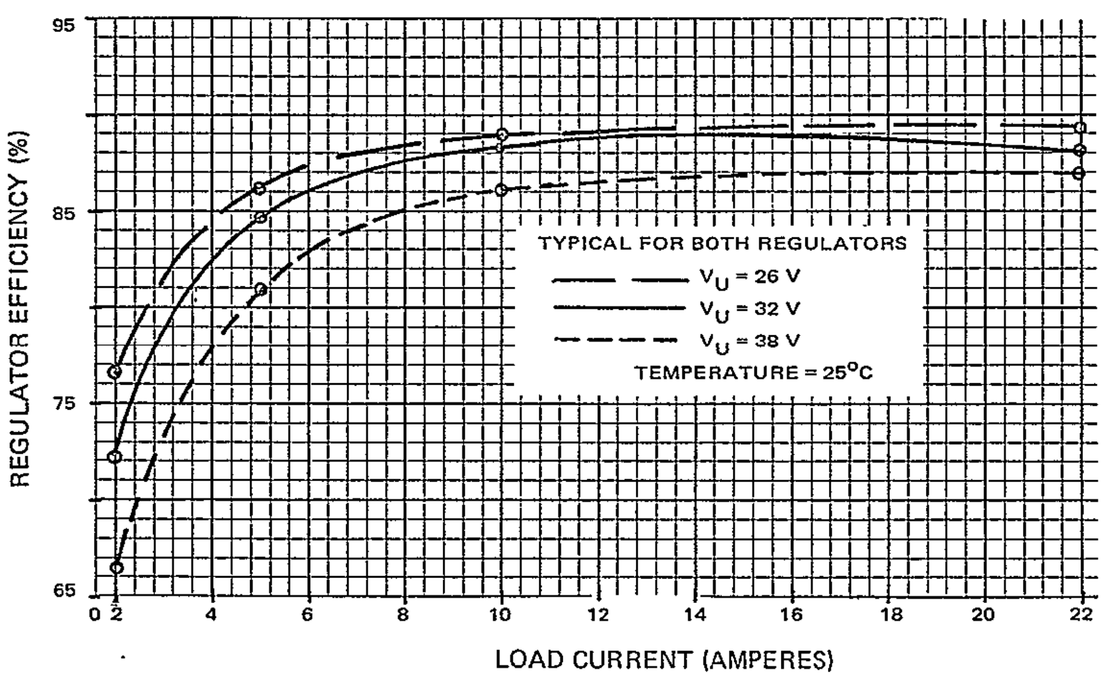


Figure III-3. Main Regulator Efficiency, Storage Module 03

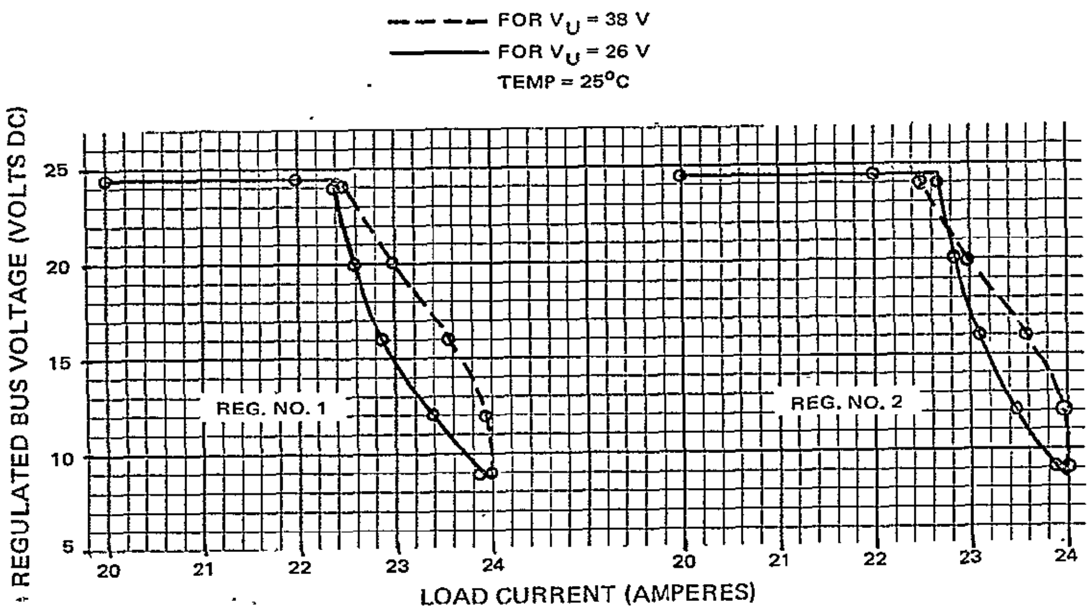


Figure III-4. Main Regulator Current Limiting, Storage Module 03

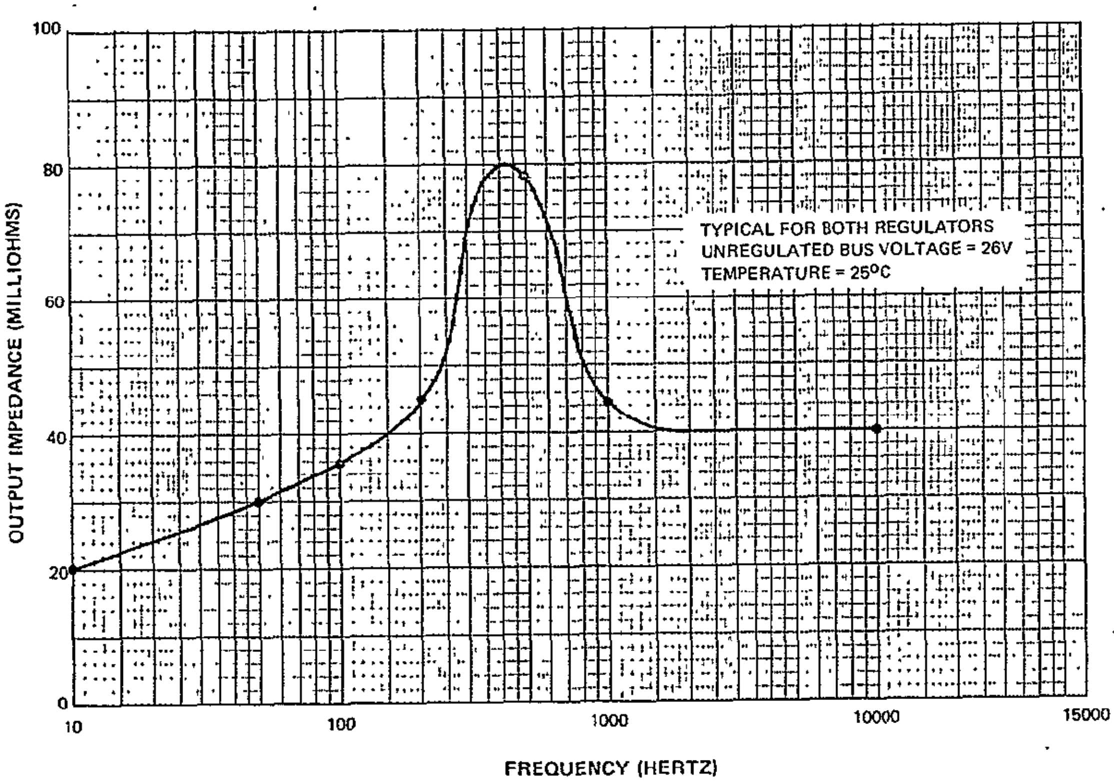


Figure III-5. Main Regulator Output Impedance, Control Module 03

TABLE III-3. WORST CASE MEASUREMENTS, FOR CONTROL MODULE 03

Parameter	Test Limits	Worst-Case Measurements	
		Measured Value	Measurement Conditions
Solar Array Diode Leakage	25 mA max	6.5 mA	$T = 45°C$, $V_u = 40$ V, $I_L = 2$ A
Battery Diode Leakage	25 mA max	1.0 mA	$T = 45°C$, $V_u = 40$ V
Battery Diode Current Sharing	±10% of average	2.4%	$T = 45°C$, $V_u = 32$,
Clock Bus Diode Voltage (From Main Bus)	less than 0.80 V.	0.73 V	$T = 5°C$, $V_R = 24.5$ V, Clock Bus A
Clock Bus Diode Voltage (From Auxiliary Regulators)	less than 0.80 V	0.75 V	$T = 5°C$, $V_A = 23.5$ V, Clock Bus B
Main Regulator Voltage Regulator (J8)	24.50 ±0.25 V	24.33 V	$T = 45°C$, $V_u = 26$ V, $I_L = 20$ A, Regulator #1
Main Regulator Ripple Peak (J8)	100 mv (p-p)	90 mv	$T = 25°C$, $V_u = 38$ V, $I_L = 20$ A, Both Regulators
Main Regulator Current Limit (At $V_R = 24$ V)	23 A max	23.15 A	$T = 5°C$, $V_u = 26$ V, Both Regulators
Main Regulator Output Impedance	less than 0.1Ω (10 to 10,000 Hz)	0.095Ω	$T = 5°C$, $V_u = 26$ V, $I_L = 5$ A, $I_{AC} = 1$ A, F = 500 Hz, Both Regulators
Main Regulator Transient Response (Recovery Time to 24.5 ±0.5 V)	less than 3 ms	2 ms	$T = 25°C$, $V_u = 26$ V, $I_L = 16$ A, $\Delta I_L = 4$ A, Both Regulators
Auxiliary Regulator Voltage Regulation	23.50 ±0.25 V	23.47 V	$T = 45°C$, $V_u = 38$ V $I_R = 1$ A, Both Auxiliary Regulators
Main Regulator Voltage Regulation (J15)	24.50 ±0.25 V	24.56 V	$T = 45°C$, $V_u = 38$ V, $I_L = 10$ A, Regulator #2
Main Regulator Ripple Peak (I15)	100 mv (p-p)	160 mv	$T = 25°C$, $V_u = 38$ V, $I_L = 10$ A, Both Regulators

Legend:
- T = temperature, V_u = unregulated bus voltage, I_L = load current
- I_{SA} = solar array current, V_R = regulated bus voltage
- V_A = auxiliary regulator voltage, I_R = auxiliary regulator current
- I_{AC} = a-c current, ΔI_L = change in load current
- ΔI_R = change in auxiliary regulator current, I_{SH} = shunt dissipator current
- F = frequency, TLM = Telemetry, P-P = peak-to-peak

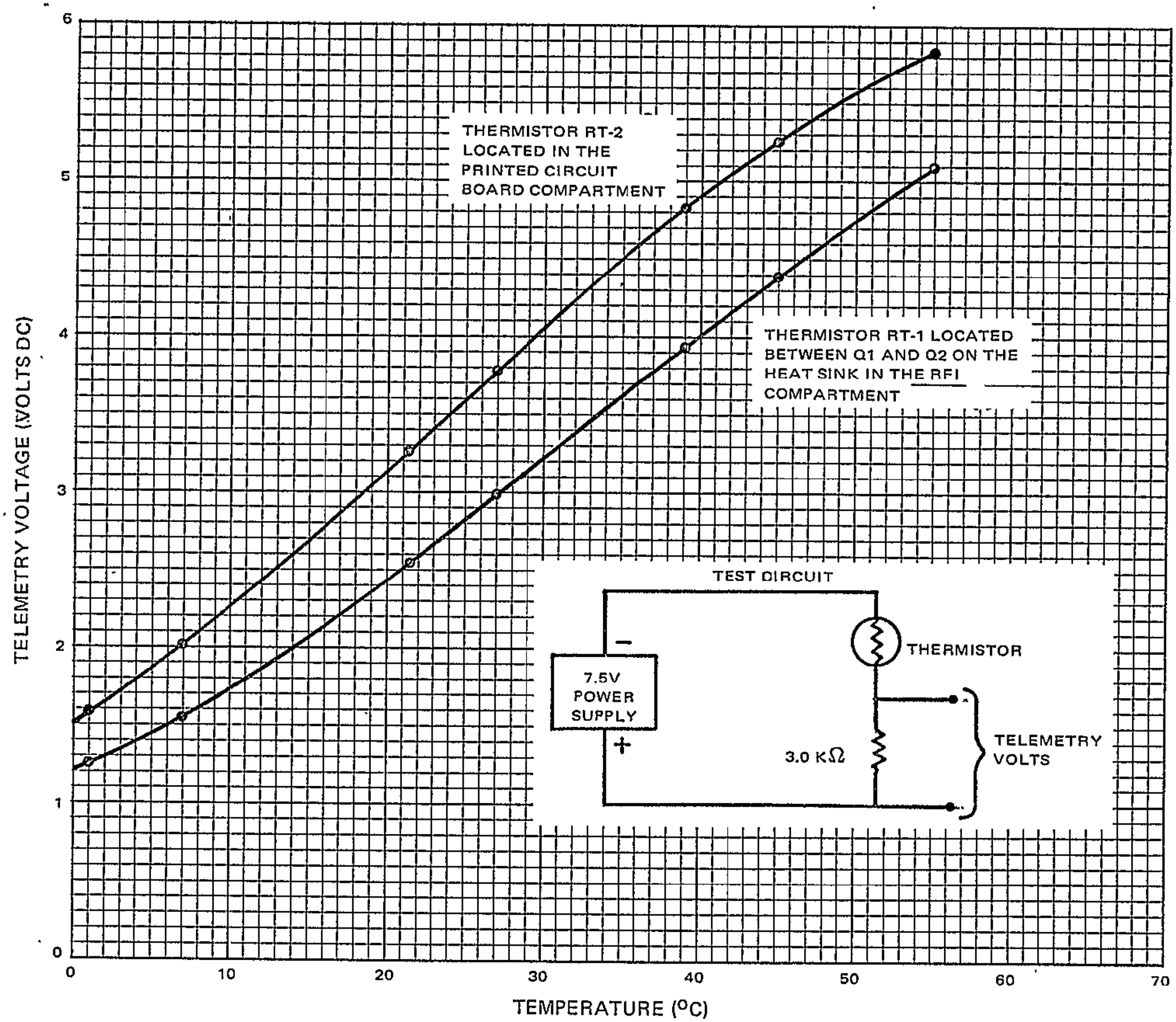


Figure III-6. Temperature Telemetry Test Circuit and Characteristics Control Module 03

TABLE III-4. CONTROL MODULE 03 CURRENT TELEMETRY

SOLAR ARRAY CURRENT (AMPERES)	TELEMETRY VOLTAGE (VOLTS)	SOLAR ARRAY CURRENT (AMPERES)	TELEMETRY VOLTAGE (VOLTS)	SOLAR ARRAY CURRENT (AMPERES)	TELEMETRY VOLTAGE (VOLTS)	SOLAR ARRAY CURRENT (AMPERES)	TELEMETRY VOLTAGE (VOLTS)	SOLAR ARRAY CURRENT (AMPERES)	TELEMETRY VOLTAGE (VOLTS)
2.00	0.560	4.70	1.310	7.40	2.141	10.10	3.008	12.80	3.868
2.05	0.574	4.75	1.324	7.45	2.157	10.15	3.024	12.85	3.883
2.10	0.587	4.80	1.339	7.50	2.173	10.20	3.040	12.90	3.899
2.15	0.601	4.85	1.354	7.55	2.189	10.25	3.056	12.95	3.915
2.20	0.614	4.90	1.369	7.60	2.205	10.30	3.072	13.00	3.937
2.25	0.628	4.95	1.384	7.65	2.221	10.35	3.088	13.05	3.946
2.30	0.641	5.00	1.399	7.70	2.237	10.40	3.104	13.10	3.962
2.35	0.655	5.05	1.414	7.75	2.253	10.45	3.120	13.15	3.978
2.40	0.668	5.10	1.429	7.80	2.268	10.50	3.136	13.20	3.993
2.45	0.682	5.15	1.444	7.85	2.284	10.55	3.152	13.25	4.009
2.50	0.695	5.20	1.459	7.90	2.300	10.60	3.168	13.30	4.025
2.55	0.709	5.25	1.473	7.95	2.316	10.65	3.184	13.35	4.041
2.60	0.722	5.30	1.488	8.00	2.332	10.70	3.200	13.40	4.056
2.65	0.736	5.35	1.503	8.05	2.348	10.75	3.216	13.45	4.072
2.70	0.749	5.40	1.518	8.10	2.364	10.80	3.232	13.50	4.088
2.75	0.763	5.45	1.533	8.15	2.380	10.85	3.248	13.55	4.103
2.80	0.776	5.50	1.548	8.20	2.396	10.90	3.264	13.60	4.119
2.85	0.790	5.55	1.563	8.25	2.412	10.95	3.280	13.65	4.135
2.90	0.803	5.60	1.578	8.30	2.429	11.00	3.296	13.70	4.151
2.95	0.817	5.65	1.593	8.35	2.445	11.05	3.312	13.75	4.166
3.00	0.830	5.70	1.608	8.40	2.461	11.10	3.328	13.80	4.182
3.05	0.844	5.75	1.622	8.45	2.477	11.15	3.344	13.85	4.198
3.10	0.858	5.80	1.637	8.50	2.493	11.20	3.360	13.90	4.213
3.15	0.871	5.85	1.652	8.55	2.509	11.25	3.376	13.95	4.229
3.20	0.885	5.90	1.667	8.60	2.525	11.30	3.392	14.00	4.245
3.25	0.898	5.95	1.682	8.65	2.541	11.35	3.408	14.05	4.261
3.30	0.912	6.00	1.697	8.70	2.557	11.40	3.424	14.10	4.276
3.35	0.925	6.05	1.713	8.75	2.573	11.45	3.440	14.15	4.292
3.40	0.939	6.10	1.729	8.80	2.590	11.50	3.456	14.20	4.308
3.45	0.952	6.15	1.745	8.85	2.606	11.55	3.472	14.25	4.324
3.50	0.966	6.20	1.760	8.90	2.622	11.60	3.488	14.30	4.339
3.55	0.979	6.25	1.776	8.95	2.638	11.65	3.504	14.35	4.355
3.60	0.993	6.30	1.792	9.00	2.654	11.70	3.520	14.40	4.371
3.65	1.006	6.35	1.808	9.05	2.670	11.75	3.536	14.45	4.386
3.70	1.020	6.40	1.824	9.10	2.686	11.80	3.552	14.50	4.402
3.75	1.033	6.45	1.840	9.15	2.702	11.85	3.568	14.55	4.418
3.80	1.047	6.50	1.856	9.20	2.718	11.90	3.584	14.60	4.434
3.85	1.060	6.55	1.872	9.25	2.734	11.95	3.600	14.65	4.449
3.90	1.074	6.60	1.887	9.30	2.751	12.00	3.616	14.70	4.465
3.95	1.087	6.65	1.903	9.35	2.767	12.05	3.632	14.75	4.481
4.00	1.101	6.70	1.919	9.40	2.783	12.10	3.647	14.80	4.497
4.05	1.116	6.75	1.935	9.45	2.799	12.15	3.663	14.85	4.512
4.10	1.131	6.80	1.951	9.50	2.815	12.20	3.679	14.90	4.528
4.15	1.146	6.85	1.967	9.55	2.831	12.25	3.695	14.95	4.544
4.20	1.161	6.90	1.983	9.60	2.847	12.30	3.710	15.00	4.559
4.25	1.175	6.95	1.999	9.65	2.863	12.35	3.726	15.05	4.575
4.30	1.190	7.00	2.014	9.70	2.879	12.40	3.742	15.10	4.591
4.35	1.205	7.05	2.030	9.75	2.895	12.45	3.757	15.15	4.607
4.40	1.220	7.10	2.046	9.80	2.912	12.50	3.773	15.20	4.622
4.45	1.235	7.15	2.062	9.85	2.928	12.55	3.789	15.25	4.638
4.50	1.250	7.20	2.078	9.90	2.944	12.60	3.805	15.30	4.654
4.55	1.265	7.25	2.094	9.95	2.960	12.65	3.820	15.35	4.670
4.60	1.280	7.30	2.110	10.00	2.976	12.70	3.836	15.40	4.685
4.65	1.295	7.35	2.126	10.05	2.992	12.75	3.852	15.45	4.701

TABLE III-5. CONTROL MODULE 03 REGULATED BUS CURRENT (CURRENT RANGE 1.50 TO 14.95 AMPS)

REGULATED BUS CURRENT (AMPERES)	TELEMETRY VOLTAGE (VOLTS)	REGULATED BUS CURRENT (AMPERES)	TELEMETRY VOLTAGE (VOLTS)	REGULATED BUS CURRENT (AMPERES)	TELEMETRY VOLTAGE (VOLTS)	REGULATED BUS CURRENT (AMPERES)	TELEMETRY VOLTAGE (VOLTS)	REGULATED BUS CURRENT (AMPERES)	TELEMETRY VOLTAGE (VOLTS)
1.50	0.414	4.20	1.170	6.90	2.017	9.60	2.880	12.30	3.737
1.55	0.427	4.25	1.185	6.95	2.033	9.65	2.895	12.35	3.753
1.60	0.440	4.30	1.201	7.00	2.049	9.70	2.911	12.40	3.768
1.65	0.453	4.35	1.216	7.05	2.065	9.75	2.927	12.45	3.784
1.70	0.466	4.40	1.232	7.10	2.081	9.80	2.943	12.50	3.799
1.75	0.479	4.45	1.247	7.15	2.097	9.85	2.959	12.55	3.815
1.80	0.492	4.50	1.263	7.20	2.113	9.90	2.975	12.60	3.830
1.85	0.505	4.55	1.278	7.25	2.129	9.95	2.991	12.65	3.846
1.90	0.518	4.60	1.294	7.30	2.145	10.00	3.007	12.70	3.861
1.95	0.531	4.65	1.309	7.35	2.161	10.05	3.023	12.75	3.877
2.00	0.544	4.70	1.325	7.40	2.177	10.10	3.039	12.80	3.893
2.05	0.558	4.75	1.340	7.45	2.193	10.15	3.055	12.85	3.908
2.10	0.572	4.80	1.356	7.50	2.209	10.20	3.071	12.90	3.924
2.15	0.586	4.85	1.371	7.55	2.226	10.25	3.087	12.95	3.939
2.20	0.600	4.90	1.387	7.60	2.242	10.30	3.103	13.00	3.955
2.25	0.614	4.95	1.402	7.65	2.258	10.35	3.118	13.05	3.970
2.30	0.629	5.00	1.418	7.70	2.274	10.40	3.134	13.10	3.986
2.35	0.643	5.05	1.433	7.75	2.290	10.45	3.150	13.15	4.001
2.40	0.657	5.10	1.449	7.80	2.306	10.50	3.166	13.20	4.017
2.45	0.671	5.15	1.464	7.85	2.322	10.55	3.182	13.25	4.032
2.50	0.685	5.20	1.480	7.90	2.338	10.60	3.198	13.30	4.048
2.55	0.699	5.25	1.495	7.95	2.354	10.65	3.214	13.35	4.063
2.60	0.713	5.30	1.511	8.00	2.370	10.70	3.230	13.40	4.079
2.65	0.727	5.35	1.526	8.05	2.386	10.75	3.246	13.45	4.095
2.70	0.741	5.40	1.542	8.10	2.402	10.80	3.262	13.50	4.110
2.75	0.755	5.45	1.557	8.15	2.418	10.85	3.278	13.55	4.126
2.80	0.770	5.50	1.573	8.20	2.434	10.90	3.294	13.60	4.141
2.85	0.784	5.55	1.588	8.25	2.450	10.95	3.310	13.65	4.157
2.90	0.798	5.60	1.604	8.30	2.466	11.00	3.325	13.70	4.172
2.95	0.812	5.65	1.619	8.35	2.481	11.05	3.341	13.75	4.188
3.00	0.826	5.70	1.635	8.40	2.497	11.10	3.357	13.80	4.203
3.05	0.840	5.75	1.650	8.45	2.513	11.15	3.373	13.85	4.219
3.10	0.854	5.80	1.666	8.50	2.529	11.20	3.389	13.90	4.234
3.15	0.868	5.85	1.681	8.55	2.545	11.25	3.405	13.95	4.250
3.20	0.882	5.90	1.697	8.60	2.561	11.30	3.421	14.00	4.265
3.25	0.896	5.95	1.712	8.65	2.577	11.35	3.437	14.05	4.281
3.30	0.911	6.00	1.728	8.70	2.593	11.40	3.453	14.10	4.297
3.35	0.925	6.05	1.744	8.75	2.609	11.45	3.469	14.15	4.312
3.40	0.939	6.10	1.760	8.80	2.625	11.50	3.485	14.20	4.328
3.45	0.953	6.15	1.776	8.85	2.641	11.55	3.501	14.25	4.343
3.50	0.967	6.20	1.792	8.90	2.657	11.60	3.517	14.30	4.359
3.55	0.981	6.25	1.808	8.95	2.673	11.65	3.532	14.35	4.374
3.60	0.995	6.30	1.824	9.00	2.688	11.70	3.548	14.40	4.390
3.65	1.009	6.35	1.840	9.05	2.704	11.75	3.564	14.45	4.405
3.70	1.023	6.40	1.856	9.10	2.720	11.80	3.580	14.50	4.421
3.75	1.037	6.45	1.872	9.15	2.736	11.85	3.596	14.55	4.436
3.80	1.052	6.50	1.888	9.20	2.752	11.90	3.612	14.60	4.452
3.85	1.066	6.55	1.905	9.25	2.768	11.95	3.628	14.65	4.467
3.90	1.080	6.60	1.921	9.30	2.784	12.00	3.644	14.70	4.483
3.95	1.094	6.65	1.937	9.35	2.800	12.05	3.659	14.75	4.498
4.00	1.108	6.70	1.953	9.40	2.816	12.10	3.675	14.80	4.514
4.05	1.123	6.75	1.969	9.45	2.832	12.15	3.691	14.85	4.530
4.10	1.139	6.80	1.985	9.50	2.848	12.20	3.706	14.90	4.545
4.15	1.154	6.85	2.001	9.55	2.864	12.25	3.722	14.95	4.561

TABLE III-6. CONTROL MODULE 03 REGULATED BUS CURRENT (CURRENT RANGE 7.0 TO 20.45 AMPS)

REGULATED BUS CURRENT (AMPERES)	TELEMETRY VOLTAGE (VOLTS)	REGULATED BUS CURRENT (AMPERES)	TELEMETRY VOLTAGE (VOLTS)	REGULATED BUS CURRENT (AMPERES)	TELEMETRY VOLTAGE (VOLTS)	REGULATED BUS CURRENT (AMPERES)	TELEMETRY VOLTAGE (VOLTS)	REGULATED BUS CURRENT (AMPERES)	TELEMETRY VOLTAGE (VOLTS)
7.00	2.049	9.70	2.911	12.40	3.768	15.10	4.607	17.80	5.433
7.05	2.065	9.75	2.927	12.45	3.784	15.15	4.623	17.85	5.448
7.10	2.081	9.80	2.943	12.50	3.799	15.20	4.638	17.90	5.463
7.15	2.097	9.85	2.959	12.55	3.815	15.25	4.654	17.95	5.478
7.20	2.113	9.90	2.975	12.60	3.830	15.30	4.669	18.00	5.493
7.25	2.129	9.95	2.991	12.65	3.846	15.35	4.685	18.05	5.508
7.30	2.145	10.00	3.007	12.70	3.861	15.40	4.701	18.10	5.524
7.35	2.161	10.05	3.023	12.75	3.877	15.45	4.716	18.15	5.539
7.40	2.177	10.10	3.039	12.80	3.893	15.50	4.732	18.20	5.554
7.45	2.193	10.15	3.055	12.85	3.908	15.55	4.747	18.25	5.569
7.50	2.209	10.20	3.071	12.90	3.924	15.60	4.763	18.30	5.584
7.55	2.226	10.25	3.087	12.95	3.939	15.65	4.778	18.35	5.599
7.60	2.242	10.30	3.103	13.00	3.955	15.70	4.794	18.40	5.615
7.65	2.258	10.35	3.118	13.05	3.970	15.75	4.809	18.45	5.630
7.70	2.274	10.40	3.134	13.10	3.986	15.80	4.825	18.50	5.645
7.75	2.290	10.45	3.150	13.15	4.001	15.85	4.840	18.55	5.660
7.80	2.306	10.50	3.166	13.20	4.017	15.90	4.856	18.60	5.675
7.85	2.322	10.55	3.182	13.25	4.032	15.95	4.871	18.65	5.690
7.90	2.338	10.60	3.198	13.30	4.048	16.00	4.887	18.70	5.706
7.95	2.354	10.65	3.214	13.35	4.063	16.05	4.902	18.75	5.721
8.00	2.370	10.70	3.230	13.40	4.079	16.10	4.917	18.80	5.736
8.05	2.386	10.75	3.246	13.45	4.095	16.15	4.932	18.85	5.751
8.10	2.402	10.80	3.262	13.50	4.110	16.20	4.948	18.90	5.766
8.15	2.418	10.85	3.278	13.55	4.126	16.25	4.963	18.95	5.781
8.20	2.434	10.90	3.294	13.60	4.141	16.30	4.978	19.00	5.796
8.25	2.450	10.95	3.310	13.65	4.157	16.35	4.993	19.05	5.812
8.30	2.466	11.00	3.325	13.70	4.172	16.40	5.008	19.10	5.827
8.35	2.481	11.05	3.341	13.75	4.188	16.45	5.023	19.15	5.842
8.40	2.497	11.10	3.357	13.80	4.203	16.50	5.039	19.20	5.857
8.45	2.513	11.15	3.373	13.85	4.219	16.55	5.054	19.25	5.872
8.50	2.529	11.20	3.389	13.90	4.234	16.60	5.069	19.30	5.887
8.55	2.545	11.25	3.405	13.95	4.250	16.65	5.084	19.35	5.903
8.60	2.561	11.30	3.421	14.00	4.265	16.70	5.099	19.40	5.918
8.65	2.577	11.35	3.437	14.05	4.281	16.75	5.114	19.45	5.933
8.70	2.593	11.40	3.453	14.10	4.297	16.80	5.129	19.50	5.948
8.75	2.609	11.45	3.469	14.15	4.312	16.85	5.145	19.55	5.963
8.80	2.625	11.50	3.485	14.20	4.328	16.90	5.160	19.60	5.978
8.85	2.641	11.55	3.501	14.25	4.343	16.95	5.175	19.65	5.994
8.90	2.657	11.60	3.517	14.30	4.359	17.00	5.190	19.70	6.009
8.95	2.673	11.65	3.533	14.35	4.374	17.05	5.205	19.75	6.024
9.00	2.688	11.70	3.548	14.40	4.390	17.10	5.220	19.80	6.039
9.05	2.704	11.75	3.564	14.45	4.405	17.15	5.236	19.85	6.054
9.10	2.720	11.80	3.580	14.50	4.421	17.20	5.251	19.90	6.069
9.15	2.736	11.85	3.596	14.55	4.436	17.25	5.266	19.95	6.085
9.20	2.752	11.90	3.612	14.60	4.452	17.30	5.281	20.00	6.100
9.25	2.768	11.95	3.628	14.65	4.467	17.35	5.296	20.05	6.115
9.30	2.784	12.00	3.644	14.70	4.483	17.40	5.311	20.10	6.130
9.35	2.800	12.05	3.660	14.75	4.499	17.45	5.327	20.15	6.145
9.40	2.816	12.10	3.675	14.80	4.514	17.50	5.342	20.20	6.160
9.45	2.832	12.15	3.691	14.85	4.530	17.55	5.357	20.25	6.175
9.50	2.848	12.20	3.706	14.90	4.545	17.60	5.372	20.30	6.191
9.55	2.864	12.25	3.722	14.95	4.561	17.65	5.387	20.35	6.206
9.60	2.880	12.30	3.737	15.00	4.576	17.70	5.402	20.40	6.221
9.65	2.896	12.35	3.753	15.05	4.592	17.75	5.418	20.45	6.236

TABLE III-7. CONTROL MODULE UNREGULATED BUS VOLTAGE TELEMETRY

UNREGULATED BUS VOLTAGE (VOLTS)	TELEMETRY VOLTAGE (VOLTS)	UNREGULATED BUS VOLTAGE (VOLTS)	TELEMETRY VOLTAGE (VOLTS)	UNREGULATED BUS VOLTAGE (VOLTS)	TELEMETRY VOLTAGE (VOLTS)	UNREGULATED BUS VOLTAGE (VOLTS)	TELEMETRY VOLTAGE (VOLTS)	UNREGULATED BUS VOLTAGE (VOLTS)	TELEMETRY VOLTAGE (VOLTS)
25.50	1.464	28.20	2.099	30.90	2.738	33.60	3.378	36.30	4.017
25.55	1.476	28.25	2.111	30.95	2.750	33.65	3.390	36.35	4.029
25.60	1.438	28.30	2.123	31.00	2.762	33.70	3.401	36.40	4.041
25.65	1.500	28.35	2.135	31.05	2.774	33.75	3.413	36.45	4.053
25.70	1.511	28.40	2.147	31.10	2.786	33.80	3.425	36.50	4.065
25.75	1.523	28.45	2.158	31.15	2.797	33.85	3.437	36.55	4.076
25.80	1.535	28.50	2.170	31.20	2.809	33.90	3.449	36.60	4.088
25.85	1.547	28.55	2.182	31.25	2.821	33.95	3.461	36.65	4.100
25.90	1.558	28.60	2.194	31.30	2.833	34.00	3.473	36.70	4.112
25.95	1.570	28.65	2.206	31.35	2.845	34.05	3.484	36.75	4.124
26.00	1.582	28.70	2.218	31.40	2.857	34.10	3.496	36.80	4.136
26.05	1.594	28.75	2.229	31.45	2.868	34.15	3.508	36.85	4.147
26.10	1.605	28.80	2.241	31.50	2.880	34.20	3.520	36.90	4.159
26.15	1.617	28.85	2.253	31.55	2.892	34.25	3.532	36.95	4.171
26.20	1.629	28.90	2.265	31.60	2.904	34.30	3.544	37.00	4.183
26.25	1.641	28.95	2.277	31.65	2.916	34.35	3.555	37.05	4.195
26.30	1.652	29.00	2.289	31.70	2.928	34.40	3.567	37.10	4.206
26.35	1.664	29.05	2.300	31.75	2.939	34.45	3.579	37.15	4.218
26.40	1.676	29.10	2.312	31.80	2.951	34.50	3.591	37.20	4.230
26.45	1.688	29.15	2.324	31.85	2.963	34.55	3.603	37.25	4.242
26.50	1.699	29.20	2.336	31.90	2.975	34.60	3.615	37.30	4.254
26.55	1.711	29.25	2.348	31.95	2.987	34.65	3.627	37.35	4.266
26.60	1.723	29.30	2.360	32.00	2.999	34.70	3.638	37.40	4.277
26.65	1.735	29.35	2.371	32.05	3.010	34.75	3.650	37.45	4.289
26.70	1.746	29.40	2.383	32.10	3.022	34.80	3.662	37.50	4.301
26.75	1.758	29.45	2.395	32.15	3.034	34.85	3.674	37.55	4.313
26.80	1.770	29.50	2.407	32.20	3.046	34.90	3.686	37.60	4.325
26.85	1.782	29.55	2.419	32.25	3.058	34.95	3.698	37.65	4.337
26.90	1.793	29.60	2.431	32.30	3.070	35.00	3.709	37.70	4.348
26.95	1.805	29.65	2.442	32.35	3.082	35.05	3.721	37.75	4.360
27.00	1.817	29.70	2.454	32.40	3.093	35.10	3.733	37.80	4.372
27.05	1.829	29.75	2.466	32.45	3.105	35.15	3.745	37.85	4.384
27.10	1.840	29.80	2.478	32.50	3.117	35.20	3.757	37.90	4.396
27.15	1.852	29.85	2.490	32.55	3.129	35.25	3.769	37.95	4.407
27.20	1.864	29.90	2.502	32.60	3.141	35.30	3.781	38.00	4.419
27.25	1.876	29.95	2.513	32.65	3.153	35.35	3.792	38.05	4.431
27.30	1.887	30.00	2.525	32.70	3.164	35.40	3.804	38.10	4.443
27.35	1.899	30.05	2.537	32.75	3.176	35.45	3.816	38.15	4.455
27.40	1.911	30.10	2.549	32.80	3.188	35.50	3.828	38.20	4.467
27.45	1.923	30.15	2.561	32.85	3.200	35.55	3.840	38.25	4.478
27.50	1.934	30.20	2.573	32.90	3.212	35.60	3.852	38.30	4.490
27.55	1.946	30.25	2.584	32.95	3.224	35.65	3.863	38.35	4.502
27.60	1.958	30.30	2.596	33.00	3.236	35.70	3.875	38.40	4.514
27.65	1.970	30.35	2.608	33.05	3.247	35.75	3.887	38.45	4.526
27.70	1.981	30.40	2.620	33.10	3.259	35.80	3.899	38.50	4.537
27.75	1.993	30.45	2.632	33.15	3.271	35.85	3.911	38.55	4.549
27.80	2.005	30.50	2.644	33.20	3.283	35.90	3.923	38.60	4.561
27.85	2.017	30.55	2.655	33.25	3.295	35.95	3.935	38.65	4.573
27.90	2.028	30.60	2.667	33.30	3.307	36.00	3.946	38.70	4.585
27.95	2.040	30.65	2.679	33.35	3.318	36.05	3.958	38.75	4.597
28.00	2.052	30.70	2.691	33.40	3.330	36.10	3.970	38.80	4.608
28.05	2.064	30.75	2.703	33.45	3.342	36.15	3.982	38.85	4.620
28.10	2.076	30.80	2.715	33.50	3.354	36.20	3.994	38.90	4.632
28.15	2.087	30.85	2.726	33.55	3.366	36.25	4.006	38.95	4.644

TABLE III-8. CONTROL MODULE 03 REGULATED AND AUXILIARY BUS VOLTAGE TELEMETRY

REGULATED BUS VOLTAGE (VOLTS)	TELEMETRY VOLTAGE (VOLTS)	REGULATED BUS VOLTAGE (VOLTS)	TELEMETRY VOLTAGE (VOLTS)	REGULATED BUS VOLTAGE (VOLTS)	TELEMETRY VOLTAGE (VOLTS)	AUXILIARY BUS VOLTAGE (VOLTS)	TELEMETRY VOLTAGE (VOLTS)
22.98	2.037	24.00	2.623	25.02	3.197	23.00	5.830
23.00	2.048	24.02	2.634	25.04	3.208	23.02	5.835
23.02	2.059	24.04	2.645	25.06	3.220	23.04	5.840
23.04	2.071	24.06	2.656	25.08	3.231	23.06	5.846
23.06	2.082	24.08	2.668	25.10	3.243	23.08	5.851
23.08	2.094	24.10	2.679	25.12	3.255	23.10	5.856
23.10	2.105	24.12	2.690	25.14	3.266	23.12	5.861
23.12	2.117	24.14	2.701	25.16	3.278	23.14	5.866
23.14	2.128	24.16	2.713	25.18	3.289	23.16	5.872
23.16	2.140	24.18	2.724	25.20	3.301	23.18	5.877
23.18	2.151	24.20	2.735	25.22	3.312	23.20	5.882
23.20	2.163	24.22	2.746	25.24	3.324	23.22	5.887
23.22	2.174	24.24	2.758	25.26	3.335	23.24	5.892
23.24	2.186	24.26	2.769	25.28	3.347	23.26	5.898
23.26	2.197	24.28	2.780	25.30	3.358	23.28	5.903
23.28	2.209	24.30	2.791	25.32	3.370	23.30	5.908
23.30	2.220	24.32	2.803	25.34	3.381	23.32	5.913
23.32	2.232	24.34	2.814	25.36	3.393	23.34	5.916
23.34	2.243	24.36	2.825	25.38	3.404	23.36	5.924
23.36	2.255	24.38	2.837	25.40	3.416	23.38	5.929
23.38	2.266	24.40	2.848	25.42	3.428	23.40	5.934
23.40	2.278	24.42	2.859	25.44	3.439	23.42	5.939
23.42	2.289	24.44	2.870	25.46	3.451	23.44	5.944
23.44	2.301	24.46	2.882	25.48	3.462	23.46	5.950
23.46	2.312	24.48	2.893	25.50	3.474	23.48	5.955
23.48	2.324	24.50	2.904	25.52	3.485	23.50	5.960
23.50	2.335	24.52	2.915	25.54	3.497	23.52	5.965
23.52	2.347	24.54	2.927	25.56	3.508	23.54	5.970
23.54	2.358	24.56	2.938	25.58	3.520	23.56	5.976
23.56	2.370	24.58	2.949	25.60	3.531	23.58	5.981
23.58	2.381	24.60	2.960	25.62	3.543	23.60	5.986
23.60	2.393	24.62	2.972	25.64	3.554	23.62	5.991
23.62	2.404	24.64	2.983	25.66	3.566	23.64	5.996
23.64	2.416	24.66	2.994	25.68	3.578	23.66	6.002
23.66	2.427	24.68	3.005	25.70	3.589	23.68	6.007
23.68	2.439	24.70	3.017	25.72	3.601	23.70	6.012
23.70	2.450	24.72	3.028	25.74	3.612	23.72	6.017
23.72	2.462	24.74	3.039	25.76	3.624	23.74	6.022
23.74	2.473	24.76	3.050	25.78	3.635	23.76	6.027
23.76	2.485	24.78	3.062	25.80	3.647	23.78	6.033
23.78	2.496	24.80	3.073	25.82	3.658	23.80	6.038
23.80	2.508	24.82	3.084	25.84	3.670	23.82	6.043
23.82	2.519	24.84	3.095	25.86	3.681	23.84	6.048
23.84	2.531	24.86	3.107	25.88	3.693	23.86	6.053
23.86	2.542	24.88	3.118	25.90	3.704	23.88	6.059
23.88	2.554	24.90	3.129	25.92	3.716	23.90	6.064
23.90	2.565	24.92	3.140	25.94	3.727	23.92	6.069
23.92	2.577	24.94	3.152	25.96	3.739	23.94	6.074
23.94	2.588	24.96	3.163	25.98	3.751	23.96	6.079
23.96	2.600	24.98	3.174	26.00	3.762	23.98	6.085
23.98	2.611	25.00	3.185	26.02	3.773	24.00	6.090

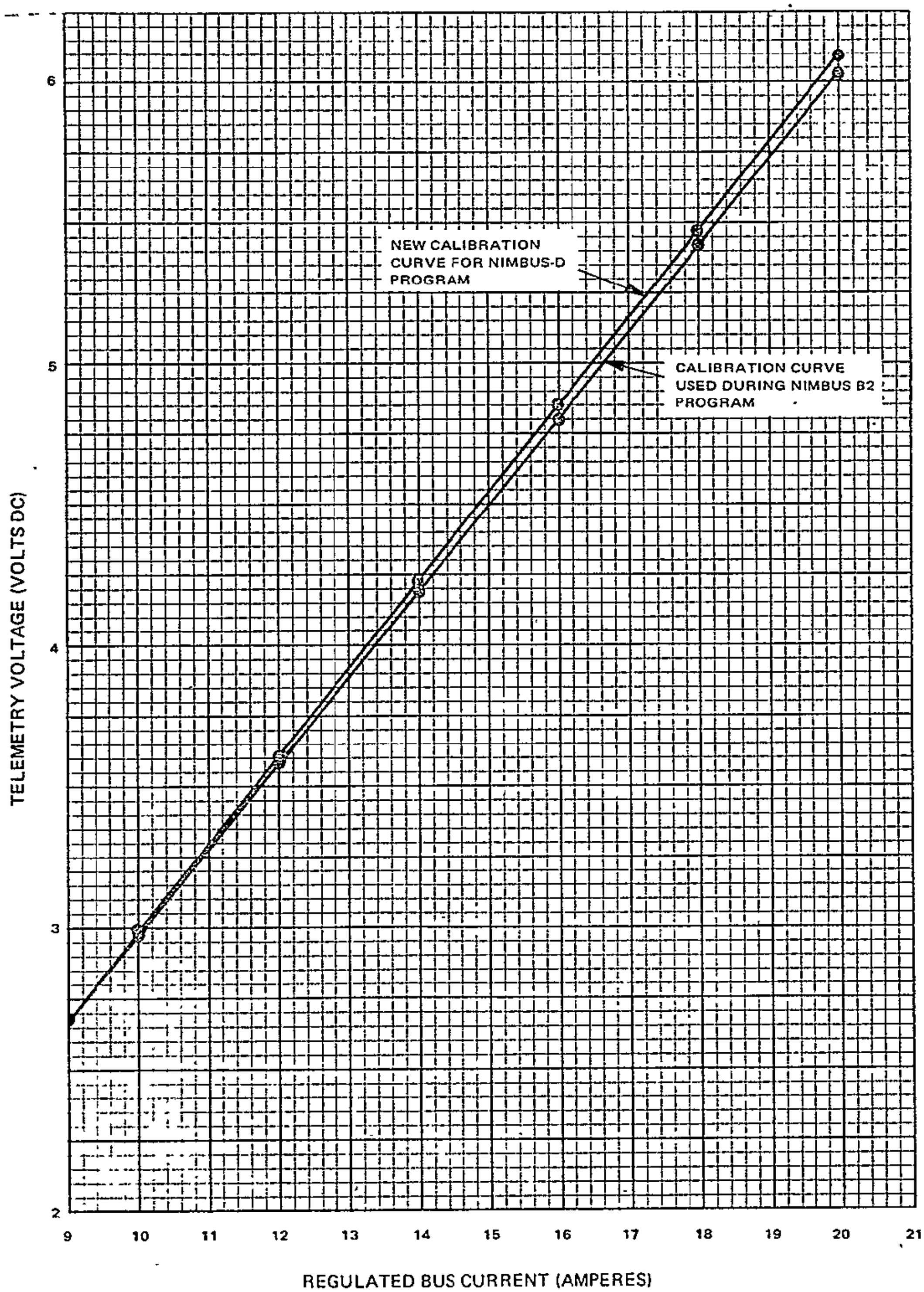


Figure III-7. Regulated Bus Current Comparison, Nimbus-B2 and -D

D. CONTROL MODULE 06 UNIT TEST DATA SUMMARY

A final unit test was performed in accordance with test procedure TP-BT-1759712. All the test results were well within the tolerances specified. A data summary of the final unit test is contained in Table III-9.

E. CONTROL MODULE EM-01 UNIT REWORK AND TEST DATA SUMMARY

Control module EM-01 was reworked to restore it to the original configuration prior to the completion of modification 11 and 14 (refer to Par. B of this Appendix). In April 1968 the unit was reworked to restore the regulated bus output voltage at connectors J5, J6, and J7. The following repairs were made.

- A wire was added from board A12-E3 to W13 (J6).
- A wire was added from W11 (J15) to W14 (J17).
- A broken wire was repaired from W14 (J7).
- Continuity checks were conducted on connectors J5, J6, J7, J8, and J12.

In May 1969, the unit was reworked to replace a blown fuse and remove the direct short.

The following repairs were made:

- Replaced fuse F16 on board A1.
- Removed the short between W15 (dc return) and W14 (-24.5 volts dc) by removing connector J8 and bonding a strip of insulation between W14 and W15.

At the end of each repair cycle an electrical test in accordance with test procedure TP-BT-1759712 was conducted at 25°C. A summary of the worst-case test data obtained from the post modification and rework tests is contained in Table III-10.

F. CONTROL MODULE 06, POST-REWORK QUALIFICATION TEST DATA SUMMARY

Post-rework qualification tests, listed in Table III-11, were completed on August 8, 1969. All the test results were within the limits specified in the test procedures; worst-case measurements obtained from the performance tests are contained in Table III-12. Regulator efficiency and current limiting, regulator

TABLE III-9. POST-THERMAL VACUUM PERFORMANCE TEST RESULTS FOR CONTROL MODULE 06

Parameter	Test Limits	Test Conditions	Measured Data
Solar Array Diode Leakage	25 ma max	V_u = 40 V, I_L = 2 A	0.95 mA
Battery Diode Leakage	25 ma max	V_u = 40 V	0.15 mA
Battery Diode Current Sharing	±10% of average	V_u = 32 V	8.6 percent
Clock Bus Diode Voltage (From Main Bus)	less than 0.80 V	V_R = 24.5 V	0.66 V (Clock Bus A) 0.68 V (Clock Bus B)
Clock Bus Diode Voltage (From Auxiliary Regulators)	less than 0.80 V	V_A = 23.5 V	0.68 V (Clock Bus A) 0.67 V (Clock Bus B)
Main Regulator Voltage Regulation	24.50 ±0.25 V	V_u = 26 V, I_L = 20 A	24.34 V (Regulator #1) 24.36 V (Regulator #2)
Main Regulator Ripple Peak	100 mv (p-p) max	V_u = 38 V, I_L = 20 A	65 mv (both regulators)
Main Regulator Current Limit (At V_R = 24 V)	23 A max	V_u = 38 V	21.94 A (both regulators)
Main Regulator Output Impedance	less than 0.1Ω (10 to 10,000 Hz)	V_u = 26 V, I_L = 5 A, I_{AC} = 1 A, F = 500-Hz	0.07Ω (both regulators)
Main Regulator Transient Response (Recovery Time to 24.5 ±0.5 V)	less than 3 ms	V_u = 26 V, I_L = 16 A, ΔI_L = 4 A	1 ms (both regulators)
Auxiliary Regulator Voltage Regulation	23.50 ±0.25 V	V_u = 38 V, I_R = 1 A	23.48 V (both auxiliary regulators)
Auxiliary Regulator Output Impedance	less than 1.1Ω (1 kHz to 20 kHz)	V_u = 26 V, I_R = 0.5 A, I_{AC} = 0.5 A, F = 10 kHz	0.08Ω (both auxiliary regulators)
Auxiliary Regulator Transient Response (Max Voltage Deviation/Recovery Time)	100 mv/10 ms max	V_u = 26 V, I_R = 2 A, ΔI_R = 0.5 A	45 mv/1 ms (both auxiliary regulators)
Bus Comparator Upper Voltage Limit	26.00 ±0.25 V	V_u = 32 V, I_L = 2 A	25.96 V
Bus Comparator Lower Voltage Limit	23.00 ±0.25 V	V_u = 32 V, I_L = 2 A	22.97 V
Shunt Dissipator Voltage	38.0 ±0.3 V	I_{SH} = 14 A	38.16 V
Main Regulator ON TLM Voltage	7.500 ±0.375 V	Regulator #1 ON Regulator #2 ON	7.189 V 7.203 V
Trickle Chg Override TLM Voltage	8.0 V max	V_u = 32 V	6.506 V
Solar Array TLM Current	0.18 A Variation max	I_{SA} = 14 A	0.02 A
Regulated Bus TLM Current	0.18 A Variation max	I_L = 20 A	0.07 A
Regulated Bus TLM Voltage	0.20 V Variation max	V_R = 24.5 V	0.02 V
Unregulated Bus TLM Voltage	0.25 V Variation max	V_u = 38 V	0.02 V
Auxiliary Regulator A TLM Voltage	0.20 V Variation max	V_A = 23.5 V	0.03 V
Auxiliary Regulator B TLM Voltage	0.20 V Variation max	V_A = 23.5 V	0.01 V

Legend: V_u = unregulated bus voltage, I_L = load current
I_{SA} = solar array current, V_R = regulated bus voltage
V_A = auxiliary regulator voltage, I_R = auxiliary regulator current
I_{AC} = a-c current, ΔI_L = change in load current
ΔI_R = change in auxiliary regulator current, I_{SH} = shunt dissipator current
F = frequency, TLM = Telemetry, P-P = peak-to-peak

Notes: 1. Test performed on May 22, 1969
2. Temperature during test maintained at 25°C

TABLE III-10. WORST CASE TEST MEASUREMENTS, CONTROL MODULE EM-01

Parameter	Test Limits	Worst-Case Measurements	
		Measured Value	Measurement Conditions
Solar Array Diode Leakage	25 ma max	0.7 ma	T = 25°C, V_u = 40 V, I_L = 2 A
Battery Diode Leakage	25 ma max	0.9 ma	T = 25°C, V_u = 40 V
Battery Diode Current Sharing	±10% of average	9.3%	T = 25°C, V_u = 32, I_{SA} = 8 A
Clock Bus Diode Voltage (From Main Bus)	less than 0.80 V	0.7 V	T = 25°C, V_R = 24.5 V, Clock Bus B
Clock Bus Diode Voltage (From Auxiliary Regulators)	less than 0.80 V	0.7 V	T = 25°C, V_A = 23.5 V, Clock Bus B
Main Regulator Voltage Regulation	24.5 ±0.5 V	24.33 V	T = 25°C, V_u = 26 V, I_L = 20 A, Regulator #1
Main Regulator Ripple Peak	100 mv (p-p)	95 mv	T = 25°C, V_u = 38 V, I_L = 20 A, Both Regulators
Main Regulator Current Limit	30 A max	A	T = 25°C, V_u = 26 V, V_R = 8 V Regulator #1 and 2
Main Regulator Output Impedance	less than 0.1Ω (10 to 10,000 Hz)	0.08Ω	T = 25°C, V_u = 26 V, I_L = 5 A, I_{AC} = 1 A, F = 500 Hz, Both Regulators
Main Regulator Transient Response (Recovery Time to 24.5 ±0.5 V)	less than 3 ms	2.5 ms	T = 25°C, V_u = 26 V, I_L = 16 A, ΔI_L = 4 A, Both Regulators
Auxiliary Regulator Voltage Regulation	23.5 ±0.5 V	23.48 V	T = 25°C, V_u = 38 V, I_R = 1 A, Auxiliary Regulator A
Auxiliary Regulator Output Impedance	less than 1.1Ω (1 kHz to 20 kHz)	0.12Ω	T = 25°C, V_u = 26 V, I_R = 0.5 A, I_{AC} = 0.5 A (p-p), F = 10 kHz, Both Auxiliary Regulators
Auxiliary Regulator Transient Response (Max Voltage Deviation/Recovery Time)	100 mv/10 ms max	60 mv/1ms	T = 25°C, V_u = 38 V, I_R = 2 A ΔI_R = 0.5 A, Regulator B
Bus Comparator Upper Voltage Limit	26.0 ±0.5 V	25.91 V	T = 25°C, V_u = 32 V, I_L = 2 A
Bus Comparator Lower Voltage Limit	23.0 ±0.5 V	23.12	T = 25°C, V_u = 32 V, I_L = 2 A
Shunt Dissipator Voltage	38.0 ±0.3 V	38.08 V	T = 25°C, I_{SH} = 14 A
Main Regulator ON TLM Voltage	7.500 ±0.375 V	7.246 V	T = 25°C, Regulator #1
Trickle Chg Override TLM Voltage	8.0 V max	6.722 V	T = 25°C, V_u = 32 V
Regulator Voltage at J15	24.5 ±0.5 V	24.53	T = 25°C I_L = 10 A

Legend: T = temperature, V_u = unregulated bus voltage, I_L = load current
I_{SA} = solar array current, V_R = regulated bus voltage
V_A = auxiliary regulator voltage, I_R = auxiliary regulator current
I_{AC} = a-c current, ΔI_L = change in load current
ΔI_R = change in auxiliary regulator current, I_{SH} = shunt dissipator current
F = frequency, TLM = Telemetry, P-P = peak-to-peak

TABLE III-11. TEST SEQUENCE AND PROCEDURES, CONTROL MODULE 06

Test	Test Procedure	Completion Date
Unit Performance Test	TP-BT-1759712	7- 1-69
Workmanship Vibration	TP-HVA-1759712	7- 1-69
Unit Performance Test	TP-BT-1759712	7- 9-69
Spare System Test	TP-SFTV-1846666	7-30-69
Thermal-Vacuum	TP-SFTV-1846666	8- 6-69
Unit Performance Test	TP-BT-1759712	8- 7-69

output impedance characteristics, and thermistor telemetry data are nearly identical to the data taken during the prethermal vacuum unit tests completed on February 5, 1969. Refer to Appendix VI of "Quarterly Technical Report No. 5," (R3443) issued June 18, 1969.

Vibration tests were limited to random level exposure in the radial plane (See Figure II-1) to verify workmanship. The test was completed satisfactorily on July 1, 1969.

Thermal-vacuum qualification was an abbreviated exposure conforming to the temperature profile shown on Figure III-8. The electrical tests were performed with the spare storage module test configuration shown on Figure III-9. Orbital cycles were run at each temperature with the simulated solar array input corresponding to the 31- to 38-volt portion of the I-V characteristic shown on Figure II-5. The regulated-bus loads are shown on Figure II-6. All the test data was within the limits specified in the test procedures; a list of worst-case measurements is contained in Table III-13.

TABLE III-12. WORST-CASE UNIT TEST MEASUREMENTS, POST-REWORK QUALIFICATION OF CONTROL MODULE 06

Parameter	Test Limits	Test Condition (See Legend)	Measured Values*
Solar Array Diode Leakage	25 mA max	$V_u = 40\,V$, $I_L = 2\,A$	1.6 mA
Battery Diode Leakage	25 mA max	$V_u = 40\,V$	0.19 mA
Battery Diode Current Sharing	±10% of average	$V_u = 32\,V$	3.9%
Clock Bus Diode Voltage (From Main Bus)	less than 0.80 V	$V_R = 24.5$ Clock Bus A	0.67 V
Clock Bus Diode Voltage (From Auxiliary Regulators)	less than 0.80 V	$V_A = 23.5$ Clock Bus A	0.67 V
Main Regulator Voltage Regulation on J8	24.5 ± 0.25 V	$V_u = 26\,V$, $I_L = 20\,A$, Reg No. 1	24.33
Main Regulator Ripple Peak on J8	100m Vp-p (max)	$V_u = 38\,V$, $I_L = 20\,A$, Both Reg	70 mv
Main Regulator Voltage Regulation on J15	24.5 ± 0.25 V	$V_u = 38\,V$, $I_L = 10\,A$, Reg No. 1	22.54
Main Regulator Current Limit	23 A max	$V_u = 38\,V$, $V_R = 24\,V$	22.19
Main Regulator Output Impedance	less than 0.1Ω (10 to 10,000 Hz)	$V_u = 26\,V$, $I_L = 5\,A$, $I_{AC} = 1\,A$ F = 500 Hz, Both Reg	0.084Ω
Main Regulator Transient Response (Recovery Time to 24.5 ±0.5 V)	less than 3 m	$V_u = 26\,V$, $I_L = 16\,A$, $\Delta I_L = 4\,A$ Both Reg	2 m
Auxiliary Regulator Voltage Regulation	23.5 ± 0.25 V	$V_u = 38\,V$, $I_R = 1A$, Both Aux. Reg.	23.49 V
Auxiliary Regulator Output Impedance	less than 1.1Ω (1 kHz to 20 kHz)	$V_u = 26\,V$, $I_L = 0.5\,A$, $I_{AC} = 0.5\,A$ F = 10 kHz, Aux Reg A	0.096Ω
Auxiliary Regulator Transient Response (Max Voltage Deviation/Recovery Time)	100 mv/10 ms max	$V_u = 26\,V$, $I_R = 2\,A$, $\Delta I_R = 0.5\,A$ Both Aux Reg	45 mv/mA
Bus Comparator Upper Voltage Limit	26.0 ±0.25 V	$V_u = 32\,V$, $I_L = 2\,A$	25.96 V
Bus Comparator Lower Voltage Limit	23.0 ±0.25 V	$V_u = 32\,V$, $I_L = 2\,A$	22.96 V
Shunt Dissipator Voltage	38.0 ±0.3 V	$I_{SH} = 14\,A$	38.16 V
Main Regulator ON TLM Voltage	7.500 ±0.375 V	Reg No. 1	7.182 V
Trickle Chg Override TLM Voltage	8.0 V max	$V_u = 32\,V$	6.528 V
Solar Array TLM Current	0.18 A Variation max	$I_{SA} = 14\,A$	0.04 A
Regulated Bus TLM Current	0.18 A Variation max	$I_L = 20\,A$	0.14 A
Regulated Bus TLM Voltage	0.20 V Variation max	$V_R = 24.5\,V$	0.02 V
Unregulated Bus TLM Voltage	0.25 V Variation max	$V_u = 38\,V$	0.02 V
Auxiliary Regulator A TLM Voltage	0.20 V Variation max	$V_A = 23.5\,V$	0.02 V
Auxiliary Regulator B TLM Voltage	0.20 V Variation max	$V_A = 23.5\,V$	0.02 V

Legend:
- V_u = unregulated bus voltage, I_L = load current
- I_{SA} = solar array current, V_R = regulated bus voltage
- V_A = auxiliary regulator voltage, I_R = auxiliary regulator current
- I_{AC} = a-c current, ΔI_L = change in load current
- ΔI_R = change in auxiliary regulator current, I_{SH} = shunt dissipator current
- F = frequency, TLM = Telemetry, P-P = peak-to-peak

Notes:
1. Test performed on August 8, 1969
2. Temperature during test maintained at 25°C

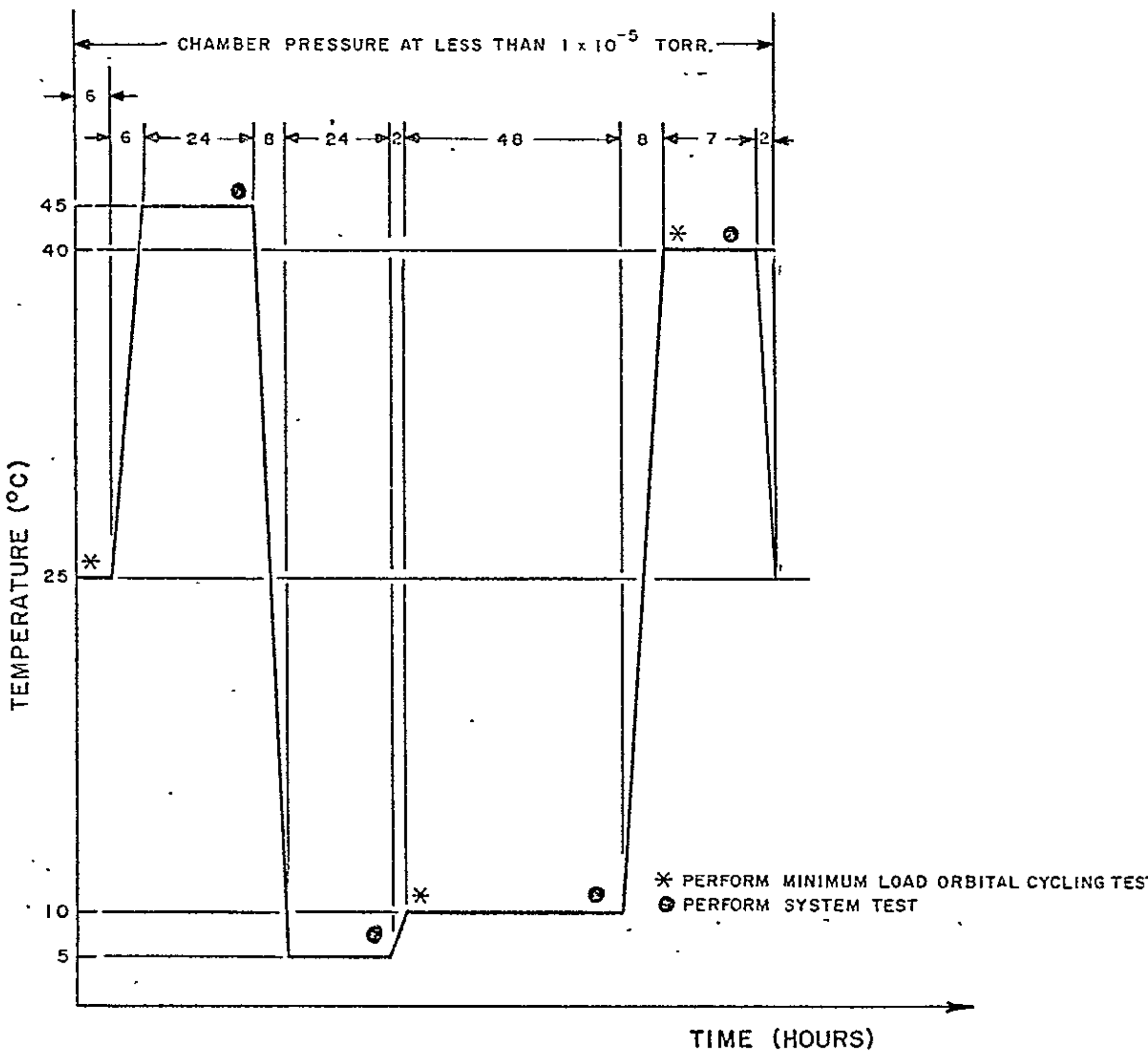


Figure III-8. Abbreviated Thermal-Vacuum Temperature Profile.

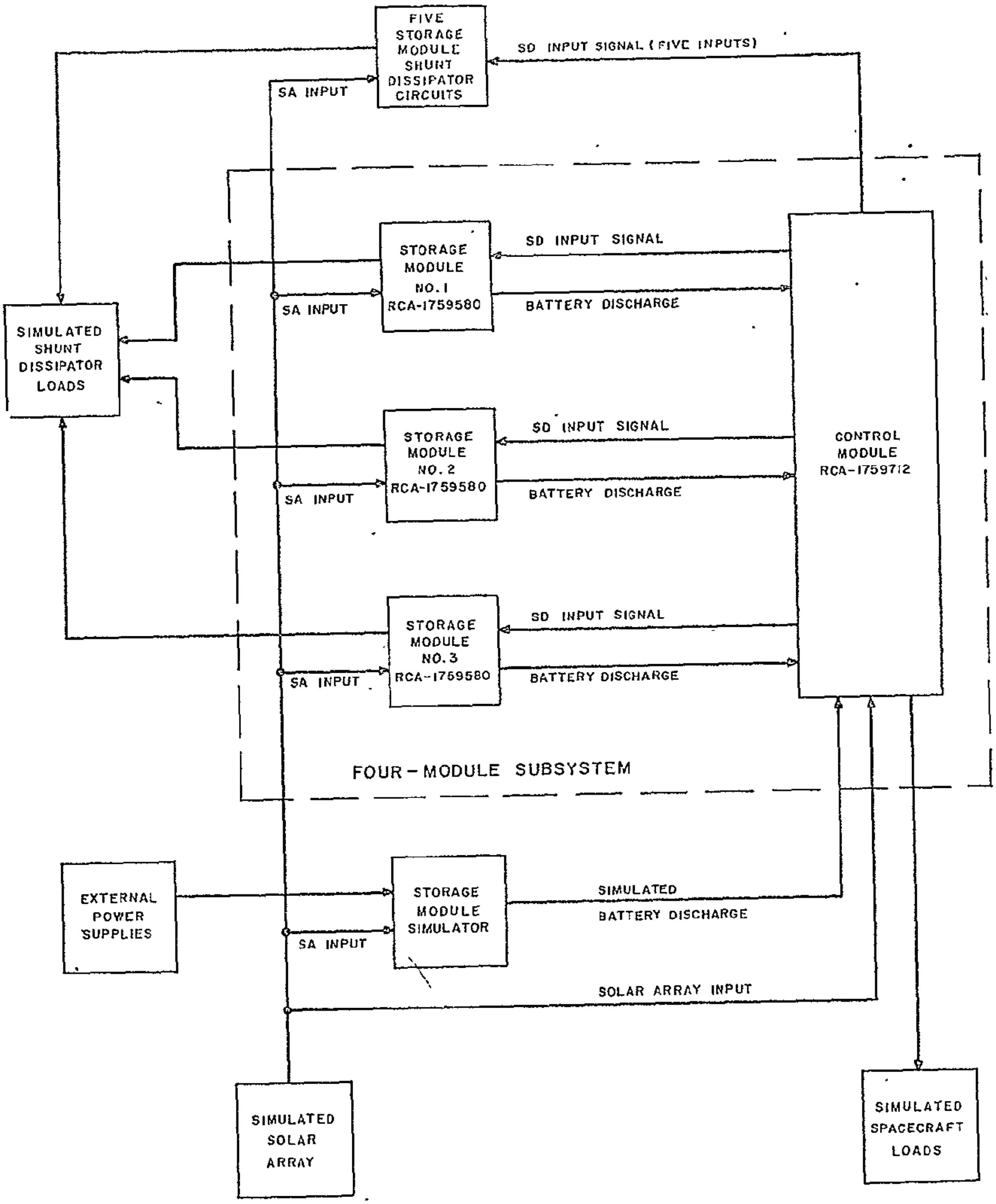


Figure III-9. Thermal-Vacuum Test Circuit. Simplified Block Diagram.

TABLE III-13. WORST CASE SYSTEM MEASUREMENTS, POST-REWORK QUALIFICATION OF CONTROL MODULE 06

Function	Specified Limits	Test Conditions		Measured Value
		See Legend	Temperature	
PWM Regulator Voltage at J8	-24.5 ±0.5 V	I_R = 9A, Reg No. 1	10°C	24.44 V
PWM Regulator Voltage at J15	- 24.5±0.5 V	I_R = 10A, Reg No. 1	45°C	24.43 V
PWM Regulator Ripple Amplitude	less than 100 m Vp-p	V_u = 37.7 V, Reg No. 1 and 2	5°C	50 m V
PWM Regulator Current Limiting	less than 26A	V ≈ 10V, Reg No. 2	5°C	23.40A
Auxiliary Regulator Voltage	23.5± 0.25 V	I_L = 1.0A, Aux Reg A	45°C	23.47 V
Clock Bus Voltage (From 24.5 V Bus)	23.8± 0.25 V	I_L = 0.75 A	5°C	23.98 V
Clock Bus Voltage (From 23.5 V Bus)	22.5 ± 0.25 V	I_L = 0.75 A	25° C	22.98 V
Bus Comparator Switching Voltages	26.0 ± 0.25 V (high limit)	I_R = 10 A	40°C	26.06 V
	23.0 ± 0.25 V (low limit)	I_R = 10 A	45°C	22.92 V
Regulator ON TLM Voltage	7.5± 0.375 V	Reg No. 1	5°C	7.180 V
TCOR ON TLM Voltage	7.5±2.5 V	——	40°C	8.688 V
Solar Array TLM Current	0.18 A variation max	I_{SA} = 13.60	25°C	13.55 A
Regulated Bus TLM Current	0.18 A variation max	I_R = 8.99	10°C	9.10 A
Regulated Bus TLM Voltage	0.20 V variation max	V_R = 24.40	25°C	24.50 V
Unregulated Bus TLM Voltage	0.25 V variation max	V_u = 30.98	10°C	30.95 V
Auxiliary Reg. A TLM Voltage	0.20 V variation max	V_{aux} = 23.41	45°C	23.50
Auxiliary Reg. B TLM Voltage	0.20 V variation max	V_{aux} = 23.41	40°C	23.48

Legend: V_u = Unregulated Bus Voltage, I_R = Regulated Bus Current,
I_L = Load Current, I_{SD} = Total Shunt Dissipator Current,
V_{SAB} = Solar Array Bus Voltage.