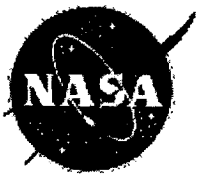

MEASUREMENT SYSTEM IDENTIFICATION

ISS-MPLM-PLAN-018
REVISION B
EFFECTIVE DATE: August 2003

National Aeronautics and Space Administration

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

PRESSURIZED CARRIERS GROUP
Multi Purpose Logistics Module

Programmable Thermostat
Test Plan

For Space Station Use Only. Category EAR. No License Required.

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VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE
MSFC-Form 454 (Rev. October 1992)

Signature Sheet

Prepared by: Dallas Clark/FD24 — Date: 9/15/2003

Concurred by: William Seiser — William R. Seiser/FD24 — Date: 9/15/03

Concurred by: Shawn E. Reagan — Shawn E. Reagan/FD24 — Date: 9/22/03

Concurred by: Jon B. Holladay/FD24 — Date: 9/22/03

Approved by: Randy K. McClendon — Randy K. McClendon/FD24 — Date: 22 SEP 03

DOCUMENT HISTORY LOG

Status (Baseline/ Revision/ Canceled)	Document Revision	Effective Date	Description
Baseline	-	Feb 2003	Baseline Document
Revision	A	May 2003	Deleted Figures 1 & 2. Reformated document per MWI 7120.4 and renumbered figures
	B	Sept. 22, 2003 B1	Updated Table. Removed Section 4, Protoflight Testing, and all figure / table referenced to protoflight tests descriptions.

Table of Contents

Table of Figures

List of Tables

1.0 INTRODUCTION

1.1 Purpose

The purpose of this document is to identify the planned tests, test facilities, and ground support equipment required to perform flight qualification and hardware acceptance testing of the programmable thermostat and data recorder components used in the Multi Purpose Logistics Module (MPLM) 28Vdc shell heater system. The qualification and acceptance testing defined in this plan will verify that these electronic components meet or exceed the International Space Station Program environmental test levels defined in the SSP41172 "Qualification and Acceptance Environmental Test Requirement" document.

A lot qualification/ flight acceptance test philosophy will be used to perform the flight certification of these components. Each programmable thermostat module (PTM) and data recorder module (DRM) will be acceptance-tested to ensure workmanship at the electronic box assembly level. Lot qualification testing will be performed on a sufficient quantity of the potted thermostat modules to address any potential manufacturing process issues. No component testing is planned at the printed circuit board piece part assembly level. Instead, quality surveillance will be maintained by NASA Quality Assurance representatives through visual workmanship and inspection audits at all levels during the printed circuit board manufacturing process. These audits will be performed prior to component testing of the potted electronic module assemblies.

The DRM assemblies will be tested to the same qualification and acceptance levels as the corresponding PTM's.

A series of engineering development tests have been completed prior to the formal qualification test phase to assess the design concept and feasibility of using the selected EEE electronic piece parts and proposed mechanical design. The development testing included two static load tests to evaluate the RTV-566 epoxy adhesive bonding process specified for mounting the thermostat carrier bracket to the MPLM pressure shell, and several levels of flight environmental testing (random vibration, EMI/EMC, thermal cycling, and radiation exposure). Appendix A contains a brief summary of these tests.

1.2 MPLM Shell Heater System Description

The MPLM shell heater system consists of 22 thermostatically-controlled strip heaters designed to operate from either the 28V power source generated from the Space Shuttle payload bay fuel cells, or the International Space Station's 120V power supply. This capability is needed to accommodate heater operations depending on the whether the MPLM is stowed in the Space Shuttle cargo bay or docked to the International Space Station.

The objective of this hardware upgrade is to replace the bi-metallic thermostats used in the 28Vdc distributed shell heater network with solid-state programmable devices. The solid- state

digital thermostat network will allow for continuous closed loop temperature control on future MPLM missions. This capability is needed to support MPLM missions containing refrigerated payloads.

In the upgraded 28V heater system, the programmable thermostats will be used in 20 of the 22 individual heater circuits. (One circuit will remain unchanged in the new design configuration, while the keel fitting stabilizer circuit will be removed.) Each thermostat will be connected to a common RS485 communications cable interface and an external Resistance Temperature Detectors (RTD's) to provide the remote temperature sensing.

During ground processing operations, command and data handling functions will be controlled thru Ground Support Equipment (GSE) laptop computer or equivalent. Real-time temperature monitoring is accomplished with the RTD's. No command or data monitoring functions are available during mission operations, but the flight data recorder stores information available (provided by the RTD's) for post-mission processing.

1.3 Test Description

1.3.1 Thermostats

Component-level flight qualification and hardware acceptance testing will be performed to validate the design and workmanship of the PTM and DRM assemblies.

The MPLM Thermostat Qualification Test Article used for the random vibration and thermal vacuum tests shall consist of a test fixture containing 10 PTM's and a single DRM, linked together thru a common RS485 Electrical Ground Support Equipment (EGSE) communication cable. This test configuration represents half of the upgraded programmable thermostat system network.

For the EMI/EMC qualification testing only, a single PTM and DRM will be evaluated.

The qualification test article will include all of the necessary EGSE cabling and associated RS485 flight connector/ backshell interfaces. The actual RS485 communications flight cable will not be used in this qualification program. This test configuration will be utilized in the qualification testing of the electronic assemblies to verify that the thermostats and all of the associated external electrical/ communication interfaces meet the environmental and functional design requirements of MSFC-SPEC-3274, "Thermostat End Item Specification".

The required thermostat RS-485 EGSE cabling will be defined in the applicable test procedures used during the qualification and flight acceptance test sequences described in the sections 2 and 3 below.

Additional test fixturing may be necessary to perform the thermostat hardware acceptance testing.

1.3.2 Data Recorders

Qualification and acceptance testing shall be performed to validate the design of the DRM assembly.

The same test article (Para 1.3.1) used for the PTM qualification testing shall be used to conduct environmental testing on the DRM assembly. The data recorder test configuration will be used to verify that the DRM and all external communication interfaces meet the environmental and functional design requirements contained in MSFC-SPEC-3322, "Data Recorder End Item Specification".

The required RS-485 communication cable EGSE will be defined in the applicable test procedures used during the test sequences described in the sections 2 and 3 below.

1.3.3 Component Test Matrix

Table 1 shows the component qualification test matrix planned for the MPLM programmable thermostat hardware development activity. This matrix contains the cross-reference for all of the environmental qualification and acceptance tests that each thermostat and data recorder unit will be subjected to. Module-level burn-in tests are planned for all of the PTM and DRM units.

Table I: MPLM Programmable Thermostat Component Test Matrix

Component	Burn-In	Qualification			Acceptance	
		EMI/EMC	Vibration	Thermal	Vibration	Thermal
Thermostat						
1	x	x	x	x		
2 thru 10	x		x	x		
11 thru 100	x				x	x
Data Recorder						
1	x	x	x	x		
2 thru 6	x				x	x

1.4 Safety Requirements

1.4.1 Safety Assessment

A safety assessment shall be performed for the operations outlined in the test plan. The FD24/ Pressurized Carriers Group S&MA safety representative will ensure safety assessments are conducted per the requirements of MWI 8715.15, "MSFC Safety Assessment Program". Hazards associated with the testing implemented by the test plan will be documented by Job Hazard Analyses and mitigated therein. Facility Assessment Plans will be part of test planning operations. There are no known safety critical or hazardous operations identified in this test plan.

1.5 Quality Plan

All quality assurance requirements implemented in the Thermostat Test Plan are outlined in ISS-MPLM-PLAN-019, "Pressurized Carriers Group Quality Plan". All test operations, including all electrical functional and burn-in tests, shall be monitored and accepted by the Space Vehicles Assurance Group (QS30), located in the Safety & Mission Assurance (S&MA) directorate, per MPG 8730.1, "Inspection and Testing". All non-conformances will be documented on MSFC Form 460 in accordance with MPG 8730.3, "Control of Nonconforming Product". The Test Discrepancy Reports (TDR) / Discrepancy Report (DR) troubleshooting and dispositions shall be in accordance with MPG 8730.3.

The MPLM programmable thermostat hardware cleanliness shall be maintained to Visibly Clean Level – Standard of SN-C-0005D.

The MPLM thermostat system contains electrostatic discharge (ESD) sensitive hardware. All ESD requirements for this hardware are defined in MSFC-RQMT-2918, "Requirements for Electrostatic Discharge Control".

1.6 Configuration Management Plan

The implementation of all configuration management requirements for this test plan shall be performed in accordance with FD24-CM01, "Pressurized Carriers Group Configuration Management Plan".

1.7 Handling

The MPLM thermostat hardware has not been classified as Program Critical Hardware (PCH) by the Project Manager. All moves and handling operations shall be performed in accordance with MPG 6410.1, "Handling, Storage, Packaging, Preservation, and Delivery".

1.8 Test Requirements

Environmental test levels for the qualification and acceptance testing of the thermostat and data recorders are defined in SSP41172 Rev P, "Qualification and Acceptance Environmental Test Requirements". The electromagnetic interference/ compatibility (EMI/EMC) test requirements are defined in NSTS-21000-IDD-ISS, "International Space Station Interface Definition Design Documents".

Verification test requirements for the thermostat and data recorder units are found in MSFC-SPEC-3274, "Thermostat End Item Specification" and MSFC-SPEC-3322, "Data Recorder End Item Specification", respectively.

1.9 Calibration Requirements

All test measuring equipment used in the execution of this test plan shall meet all calibration requirements set forth in MPG 8730.5F, " Control of Inspection, Measuring, and Test Equipment". It is permissible to use non-calibrated test equipment on non-critical measurements for "engineering use only" as determined by the test engineer.

1.10 Responsibilities

The MPLM programmable thermostat testing shall be defined by Flight Projects Directorate and conducted by Engineering Directorate personnel. A system test integration representative from the Systems Test Group, SD43, will assist with the test integration activities and coordinate the test sequences outlined in the flowcharts below.

Engineering Directorate organizational test responsibilities are listed as follows: The Control Electronics Group, ED17, will conduct all electrical and functional performance testing. The Structural and Dynamics Test Group, ED27, will perform all structural vibration testing. The Thermal and Fluid Systems Group, ED26, will perform all thermal vacuum/ thermal cycling testing. The Environments Group, ED44, will be responsible for completing all EMI/EMC testing. SD43 will lead the overall test integration activities per the negotiated task agreements (MSFC Customer Agreement, Form 4307) between FD24 and SD43.

SD43 will develop the following test documentation: Customer Agreement with Project, test procedures (including random vibration, thermal vacuum, EMI/EMC, and electrical functional), and generate the final test report for SD43 test operations.

ED17 will be responsible for the design and fabrication of the required Flight Qualification and Acceptance Test Articles.

ED17 will be responsible for the design of all Electrical Ground Support Equipment (EGSE) cabling hardware. All cabling shall be designed and tested by standard engineering practices. Connectors interfacing with flight hardware shall be flight equivalents.

1.11 Applicable Documents

The following documents, of the exact issue shown (or if no issue is specified, the issue in effect at the date of fabrication) form a part of this specification to the extent specified herein. In the event of conflict between documents the order of precedence for the test to requirements will be as follows:

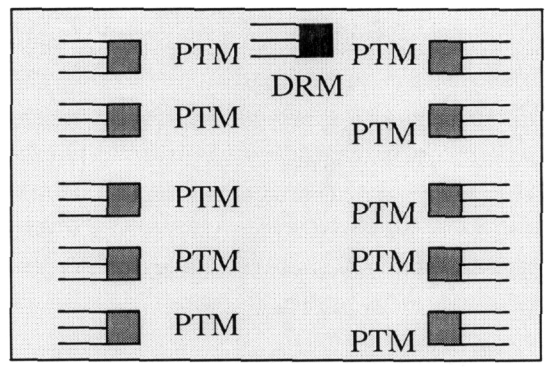
a. This test plan and any referenced test procedures
b. National Aeronautics and Space Administration (NASA) documents
c. Other documents

SSP41172	Qualification and Acceptance Environmental Test Requirements
NSTS-21000-IDD-ISS	International Space Station Interface Definition Documents
FPD-FD 24.01	Pressurized Carriers Group Risk Management Plan
FD24 – CM 01	Pressurized Carriers Group Configuration Management PlaISS-
MPLM-PLAN-019	MPLM Pressurized Carriers Group Quality Plan
MPG 1440.2	MSFC Records Management Program
MPG 6410.1	Handling, Storage, Packaging, Preservation, and Delivery
MPG 8715.1	Marshall Safety, Health, and Environmental (SHE) Program
MPG 8730.1	Inspection and Testing
MPG 8730.3	Control of Nonconforming Product
MPG 8730.5	Control of Inspection, Measuring, and Test Equipment
MWI 3410.1	Personnel Certification Program
MWI 8730.1	Equipment Logs/Records
MSFC-RQMT-2918	Requirements for Electrostatic Discharge Control
MSFC-SPEC-3274	Thermostat End Item Specification
MSFC-SPEC-3322	Data Recorder End Item Specification
MSFC-SPEC-521	Electromagnetic Compatibility Requirements on Payload Equipment And Subsystems
SN-C-0005	Contamination Control Requirements

2.0 QUALIFICATION TESTING

The following sections provide information about the types of environmental qualification tests to be performed on the MPLM Thermostat Qualification Test Article.

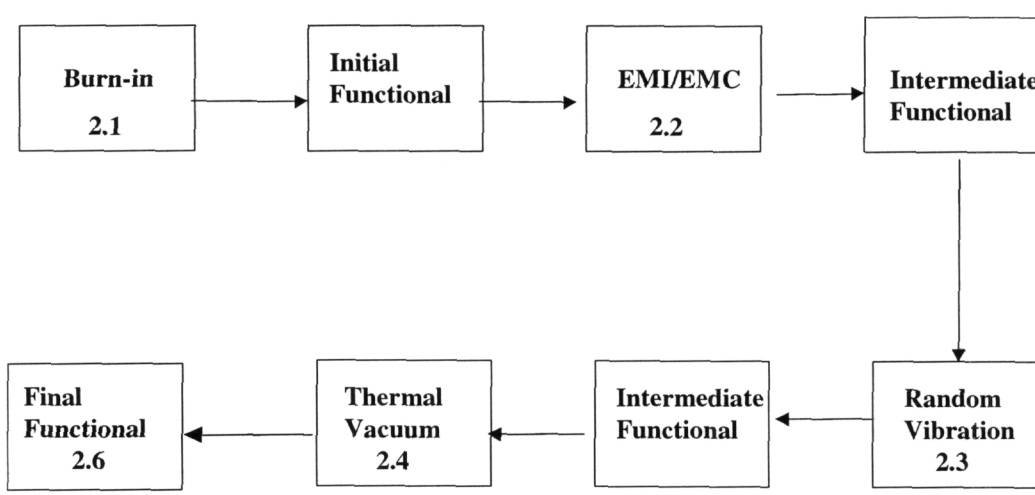
Figure 1: MPLM Thermostat Qualification Test Article Illustration



Qualification Test Configuration
10 PTM w/ 1 DRM

The qualification test sequences are illustrated in the Figure 2 below:

Figure 2 MPLM Thermostat Qualification Test Flowchart



2.1 Burn-In Test (SSP41172 Rev P, Section 5.1.8)

ED17 personnel will perform electrical burn-in functional tests on all flight qualification units in accordance with the test conditions outlined in Section 5.1.8 of SSP41172. A twenty-four hour initial burn –in test will be performed prior to the EMI/EMC qualification testing, with the remaining balance performed upon completion of the final electrical functional test (Qualification Test Flowchart, step 2.6).

After completion of the module burn-in tests, electrical functional tests (per MSFC-SPEC-3274 and MSFC-SPEC-3322, paragraph(s) 3.4, "Electrical Test Requirements) will be conducted by ED17 personnel. The initial electrical tests following module burn-in shall be conducted per the full functional test procedure outlined in these test procedures.

All intermediate operational electrical functional tests (to be performed prior to and during the thermal vacuum/cycling and random vibration tests) shall be conducted per the operational mode defined in these test procedures.

2.2 EMI/EMC Testing (MSFC-SPEC-3274/ 3322, Requirements 3.3.7.2, 3.3.7.3, 3.3.7.4)

ED44 personnel will perform all EMI/EMC flight qualification testing. This testing will be performed at the MSFC Electromagnetic Test Facility (METF). A *MSFC Form 4404 METF Customer Agreement Form* must be completed prior to testing.

Grounding and Isolation

This test will verify the EMI/EMC grounding and isolation requirements for the communication cabling and electrical circuitry. Test requirement levels shall be taken from NSTS-21000-IDD-ISS paragraph 10.7.6

Other applicable design verification test requirements shall be conducted as follows;

Bonding:
Use requirements in NSTS-21000-IDD-ISS , paragraph 10.7.5

Circuit classification:
Use requirements in NSTS-21000-IDD-ISS, paragraph 10.7.1
Use MSFC-SPEC-521 as reference

Test Methods:
CE01, CE03, and CE07 test to NSTS-21000-IDD-ISS, paragraph 10.7.3.1.1
Use MSFC-SPEC-521 for Conducted Emissions Test Methods

AC/DC Magnetic Fields test to NSTS-21000-IDD-ISS, paragraph 10.7.3.2.1

RE02 test to NSTS-21000-IDD-ISS
For broadband: Composite Payload Figure 10.7.3.2.2.1-1
For narrowband: Composite Payload Figure 10.7.3.2.2.1-2

CS01, CS02, and CS06:
Use MSFC-SPEC-521 Electromagnetic Susceptibility Requirements on Payload Equipment and Subsystems

RS03:
Use MSFC-SPEC-521 Electromagnetic Susceptibility Requirements on Payload Equipment and Subsystems

After completion of the EMI/EMC tests, electrical functional tests will be conducted by ED17 personnel. ED44 will generate the final EMI/EMC test report.

2.3 Random Vibration Test (MSFC-SPEC-3274/ 3322, Requirement 3.3.7.1)

The MPLM Thermostat Qualification Test Article will undergo a random vibration test that will be performed by the Structural and Dynamics Test Group (ED27) in the Structural Vibration test facility. All random vibration qualification testing shall be conducted in accordance with the test levels and durations outlined in the Section 4.2.5 of SSP41172, using the random vibration design levels listed in Table 4 of MPLM-SPEC-3274 and MPLM-SPEC-3322.

EGSE test cables will be routed and secured similar to the actual flight cable routing. Electrical functional tests, including visual inspection for damage, will be performed before and after each axis of vibration. The EGSE required for the electrical tests is being provided by ED17. SD43 will prepare the test procedure, while ED27 will prepare the facility operating procedure and perform the necessary qualification testing.

Torque measurements of the four thermostat carrier bracket screws and the EGSE RS-485 micro-D connectors shall be recorded before and then verified after the completion of the random vibration testing.

At the completion of the random vibration qualification test, electrical functional tests (per MSFC-SPEC-3274 and MSFC-SPEC-3322, paragraph(s) 3.4) will be performed. Upon completion of the electrical tests the thermostat hardware will be moved to the Environmental Test Facility. ED27 will generate the final test report.

2.4 Thermal Vacuum/ Cycle Test (MSFC-SPEC-3274/3322, Requirement 3.3.7.5)

Thermal vacuum/ cycle testing shall be performed on the MPLM Thermostat Qualification Test Article. All thermal vacuum qualification testing shall be conducted at the test levels and durations outlined in Sections 4.2.2 and 4.2.3 of SSP41172, and the qualification temperature limits listed in paragraph 3.3.7.5 of MSFC-SPEC-3274 and MSFC-SPEC-3322.

Qualification testing will consist of three vacuum (pressure < 1.0E-4 torr) cycles to the cold and hot temperature extremes of -24°F and 156°F, respectively, with a tolerance of +/- 5.4° F. These temperatures were derived from the operating design specifications listed in MSFC-SPEC-3274 and MSFC-SPEC-3322. The design operating limits are –4° F to 136°F.

During each cycle, there will be a dwell period at both the high and low temperature extremes. The dwell period will be at least one hour in duration and will occur once the temperature stability criteria have been met. The stability criteria is a rate of change of less than 5.4°F/hr. During the first cycle, the dwell period will be at least 12 hours at both the high and low temperature extremes. The rate of temperature change when transitioning between hot and cold extremes will be at least 1° F/min. Electrical functional tests will be performed, as a minimum, at the hot and cold temperature extremes during the first and last cycles, and at ambient temperature prior to cycling and after the last cycle. In addition to the thermal vacuum cycles, there will be 21 cycles conducted at ambient pressure. The requirements for the ambient pressure cycles will be the same as those for vacuum, except that there will be a 1 hour dwell on the first cycle.

Type T thermocouples will be used to measure test temperatures. As a minimum, each thermostat and the data recorder will be instrumented with one thermocouple. Additional thermocouples will be utilized as deemed necessary to measure environmental conditions inside the chamber. The thermocouple data will be recorded and displayed on the Environmental Test Facility PACRATS data acquisition system.

The thermal vacuum tests will be performed at the Environmental Test Facility by ED26.

SD43 will prepare the thermal vacuum test procedures. The thermal vacuum facility operating procedures will be prepared by ED26 facility engineer. The thermal vacuum tests will be conducted/directed by ED26.

2.5 Visual Inspection

A visual inspection of the MPLM programmable thermostat hardware and connectors shall be performed by S&MA (QS30).

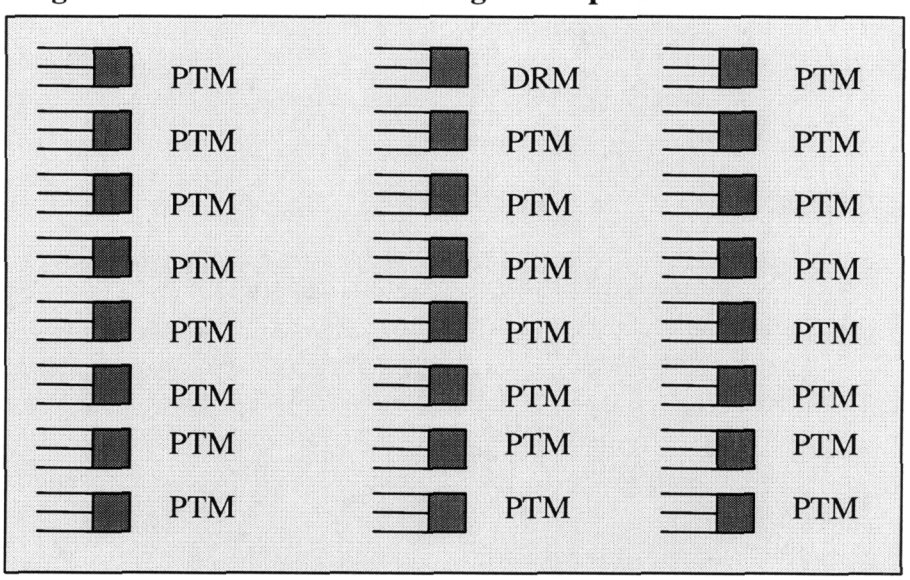
2.6 Final Electrical Functional Testing (MSFC-SPEC-3274/3322, Requirement 3.4)

Final electrical functional tests will be performed on the MPLM PTM's and DRM by ED17. These tests shall be conducted per the full functional test procedures outlined in MSFC-SPEC-3274 and MSFC-SPEC-3322, paragraph(s) 3.4.

3.0 FLIGHT ACCEPTANCE TESTING

The following sections provide information about the flight acceptance tests to be performed on the PTM and DRM assemblies utilizing the MPLM Thermostat Flight Acceptance Test Article. This test article will use the same base plate as the corresponding qualification test fixture, however the EGSE communications cable harness will be configured to accommodate a larger number of flight units during test. The hardware acceptance EGSE cable harness will accommodate a total of 24 PTM/DRM assemblies. An illustration of the MPLM Thermostat Flight Acceptance Test Article configuration is shown in Figure 3 below.

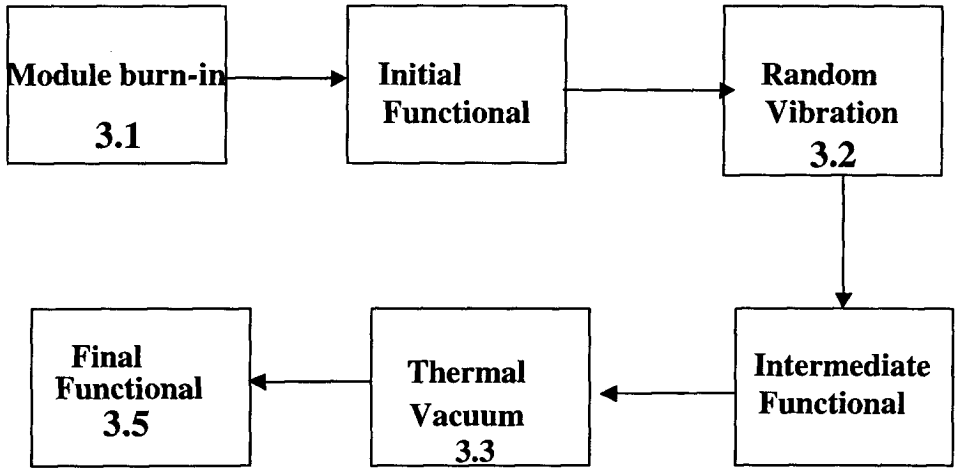
. Figure 3: MPLM Thermostat Flight Acceptance Test Article



Flight Acceptance Test Configuration
23 PTM w/ 1 DRM

The thermostat flight acceptance test sequences are illustrated in the Figure 4 below:

Figure 4: MPLM Programmable Thermostat Flight Acceptance Test Flowchart



3.1 Burn-In Test

ED 17 personnel shall perform electrical burn-in functional tests on all thermostat flight acceptance units in accordance with the test conditions outlined in Section 5.1.8 of SSP41172. A twenty-four hour initial burn –in test will be performed prior to the Random Vibration acceptance testing, with the remaining balance performed upon completion of the final electrical functional test (Flight Acceptance Test Flowchart, step 3.5).

After completion of the electrical burn-in tests, electrical functional tests will be conducted by ED17 personnel. These electrical tests shall be conducted per the full functional test procedures outlined in MSFC-SPEC-3274 and MSFC-SPEC-3322, paragraph(s) 3.4.

All intermediate electrical functional tests (to be performed during the random vibration and prior to thermal vacuum/cycling) shall be conducted per the operational mode test procedures outlined MSFC-SPEC-3274 and MSFC-SPEC-3322, paragraph(s) 3.4.

3.2 Random Vibration Test

The MPLM thermostat flight units shall undergo random vibration testing that will be performed by ED27. All random vibration acceptance testing shall be conducted in accordance with the test levels and durations outlined in the Section 5.1.4 of SSP41172, using the random vibration levels listed in Table 5 of MSFC-SPEC-3274 and MSFC-SPEC-3322.

Electrical functional tests, including visual inspection for damage, will be performed before and after each axis of vibration. The EGSE required for the electrical functional testing will be provided by ED17. SD43 will prepare the random vibration test procedures. ED27 will prepare the facility operating procedures. The test will be conducted/directed by ED27.

After completion of the random vibration flight acceptance testing, electrical functional testing will be conducted by ED17 personnel. Upon completion of the electrical functional testing, the MPLM thermostat flight units will be transported to the Environment Test Facility. ED27 will generate the final test report.

3.3 Thermal Vacuum/ Cycle Test

Thermal vacuum/ cycle testing shall be performed on the MPLM thermostat flight units. All thermal vacuum qualification flight acceptance testing shall be conducted at the test levels and durations outlined in Sections 5.1.2 and 5.1.3 of SSP41172, and the design acceptance limits listed in paragraphs 3.3.7.5 of MSFC-SPEC-3274 and MSFC-SPEC-3322.

Acceptance testing will consist of one vacuum (pressure < 1.0E-4 torr) cycle to the cold and hot temperature extremes of -4°F and 136°F, respectively, and seven ambient pressure thermal cycles between the these same temperature extremes. There will be a dwell period at both the high and low temperature extremes. The dwell period will be at least one hour in duration and will occur once the temperature stability criteria have been met. The temperature stability criteria is a rate of change of less than 5.4°F/hr. The rate of temperature change when transitioning between hot and cold extremes will be at least 1°F/min. Functional tests will be performed, as a minimum, at the hot and cold temperature extremes during the first thermal vacuum cycle (Cycle 1), and at the hot and cold temperature extremes during the last thermal cycles (Cycle 8), and at ambient temperature prior to the first vacuum cycle (Cycle 1) and after the last thermal cycle (Cycle 8). The requirements for the ambient pressure cycles will be the same as those for vacuum.

Type T thermocouples will be used to measure test temperatures. As a minimum, each thermostat and the data recorder will be instrumented with one thermocouple. Additional thermocouples will be utilized as deemed necessary to measure environmental conditions inside the chamber. The thermocouple data will be recorded and displayed on the Environmental Test Facility PACRATS data acquisition system.

The thermal vacuum tests will be performed in the Environmental Test Facility (ED26).

Electrical functional tests will be performed after installation into the chamber, following chamber pump down, and at the end of each soak period during the test. The EGSE required for the electrical functional tests is being provided by ED17.

SD43 will prepare the thermal vacuum test procedures. The thermal vacuum facility operating procedures will be prepared by ED26. The thermal vacuum tests will be conducted/directed by ED26.

3.4 Visual Inspection

A visual inspection of the MPLM programmable thermostat hardware and connectors shall be performed by S&MA (QS30).

3.5 Final Electrical Functional Testing

Final electrical functional tests will be performed on the MPLM programmable thermostat flight units by ED17. The final electrical tests will be conducted per the full functional test procedures outlined in MSFC-SPEC-3274 and MSFC-SPEC-3322, paragraph(s) 3.4.

3.6 Prep For Shipment

Following successful completion of the flight acceptance testing, the MPLM programmable thermostat and data recorder flight units will be removed from the flight acceptance test article, packaged per MPG 6410.1 and shipped to KSC.

4.0 TEST IMPLEMENTATION

4.1 Procedure Generation

All EMI/EMC, random vibration, thermal vacuum, and electrical functional test procedures will be prepared by SD43 with input from ED17, ED26, ED27, ED44, and FD24. The vibration and thermal vacuum facility operating procedures will be prepared by ED27 and ED26, respectively. The METF facility operating procedures will be prepared by ED44. All procedures shall be submitted to the responsible organizations for review and signature approval.

4.2 Test Readiness Reviews

Test Readiness Reviews will be conducted by SD43. The test conductor shall hold an informal pre-test briefing prior to the start of test operations with all participating test and Quality Assurance personnel to review the test requirements, set-ups, sequences, safety, and emergency shut down procedures.

4.3 Procedure Execution

SD43 will be the system test engineer and will be responsible for running the test procedures related to the flight qualification, acceptance, and protoflight test articles with MSFC quality coverage.

The ED44 Engineer will be the Facility Conductor for the EMI/EMC tests. The ED17 Engineer will be the Facility Conductor for the electrical and functional tests. The ED27 Engineer will be the Facility Conductor for the structural vibration tests. The ED26 Engineer will be the Facility Conductor for the thermal vacuum tests. The tests will be conducted in accordance with the responsible organizations OWIs.

All flight and qualification hardware testing shall be monitored and accepted by the Space Vehicles Assurance Group (QS30). Any nonconformances will be documented and processed in accordance with MPG 8730.3, "Control of Nonconforming Product."

4.4 Test Generated Documentation

The following documentation and test records shall be maintained during the MPLM thermostat test program:

Original Signature Procedures
"As-Run" Test Procedures
Test Procedure Deviations and log
Test Discrepancy Records and log
Discrepancy Records
Test Preparation Sheets (TPS)
Test Reports
Logbook

4.5 Records Retention

All documentation, test records, and project quality records generated during the execution of this test plan will be maintained by the FD24/ Pressurized Carriers Group in the MSFC MPLM library per MPG 1440.2, MSFC Records Management Program.

5.0 ACRONYMS AND ABBREVIATIONS

ADP	Acceptance Data Package
DC	Direct Current
DR	Discrepancy Record
ED	Engineering Directorate
EGSE	Electrical Ground Support Equipment

EMI/EMC	Electromagnetic Interference/Electromagnetic Compatibility
ESD	Electrostatic Discharge
FD	Flight Projects Directorate
FMEA	Failure Modes & Effects Analysis
IDD	Interface Definition Document
ISS	International Space Station
JSC	Johnson Space Center
KSC	Kennedy Space Center
METF	Marshall Electromagnetic Test Facility
MPLM	Multi-Purpose Logistics Module
MSFC	Marshall Space Flight Center
NSTS	National Space Transportation System
OWI	Organizational Work Instructions
PCH	Program Critical Hardware
PTCS	Passive Thermal Control Sub-system
RTD	Resistive Temperature Device
SD	Science Directorate
STS	Space Transportation System
S&MA	Safety & Mission Assurance
TDR	Test Discrepancy Record

Appendix A

Thermostat Engineering Development Test Summary

Bond Strength Tests

Two bond tests were performed to assess the bonding material and procedure which will be used for installing the Thermostat or Data Recorder carrier bracket to the MPLM pressure shell. This procedure is based on the Micro-Tau installation used at KSC. RTV-566 epoxy is the bonding agent used in these applications.

The thermostat was attached to the test fixture used for the random vibration development tests. The fixture chosen for the random vibration testing was previously used for earlier SRB component testing and had a radius of curvature approximately equal to the MPLM. The results from these tests will address surface curvature issues related to bonding the thermostat bracket to the MPLM

pressure shell.

Prior to performing the random vibration tests, a static load test was performed (in shear plane) on the bonded thermostat. The thermostat remained affixed to the SRB test fixture and successfully met the 70 lbf bond requirements provided by ALTEC for the Micro-Tau procedure.

Upon satisfactory completion of the random vibration development testing, a second bond test was performed to determine the ultimate tensile strength of the RTV-566 epoxy bond. The second bond test was a deliberately planned "pull to failure" test to determine the ultimate strength of the RTV-566 epoxy bond. The failure point in this test was 1116 lbs of force in the shear plane.

Random Vibration Tests

A series of Random Vibration tests (representing the most severe flight loads) were conducted. The test article was a Thermostat module assembly, however due to component design similarity, there is no concern with the Data Recorder. These tests were conducted in the Structural Dynamics Testing Group (ED27) East Vibration Test Facility. For these tests, the SRB test fixture was subjected random vibration environments in three orthogonal axes for 13.5 minutes per axis (25 mission life duration). The random vibration environments used in these tests are representative of the MPLM aft end cone region and are considered the most severe flight loads. The test objectives were to assure functionality of the thermostat following the ascent vibration exposure.

Pre- and post test torque measurements were made on the Thermostat carrier bracket mounting screws. The measured torque values were consistent, indicating that the proposed fastener design is adequate.

Electrical functional tests were performed both pre and post vibration . The thermostat passed each of these functionals. The random vibration test results are documented in MPLM-DEV-02-125 Test Report.

EMI/EMC Tests

The Environments Group (ED44) at MSFC performed a series of EMI/EMC tests on the Thermostat module assembly. This testing was conducted at the MSFC METF. The test article was a thermostat module assembly, however due to component design similarity, there is no concern with the Data Recorder module. The test objectives were to determine whether the thermostat module installation design configuration will meet electrical susceptibility and conducted emissions requirements applicable to the Space Shuttle Orbiter EMI/EMC specifications. The following EMI/EMC tests were performed: CS01, CS02, CS06, CE01, and CE03. The results from the CS test series were satisfactory, however there were a couple of minor out-of –spec conditions were detected in the CE test series. The exceedances were small enough to be waived if they also occur during the qualification tests. The EMI/EMC development test results have been documented in an informal report.

Thermal Cycling Tests

A series of thermal cycling tests (in excess of those specified in the Thermostat End Item Specification) were performed by the Control Electronics Group (ED17). The test article was a thermostat module assembly, however due to component design similarity, there is no concern with the Data Recorder. A thermostat was subjected to temperature cycles between the limits of -40°C and 110°C (vs -20°C and 58°C in Thermostat End Item Specification). The thermostat was successfully operated at the temperature extremes, and during the temperature transition from one extreme to the other.

Radiation Susceptibility Tests

Two Thermostats and a Data Recorder were subjected to Radiation Susceptibility Tests at Indiana University for radiation testing at their cyclotron facility. Both units were subjected to an equivalent amount of radiation that would be expected in ten years of operation on the International Space Station. No components showed any signs of Single Event Upset, Single Event Latchup, hard failure or soft failure. The thermostats were individually tested as completed units and each performed without error or incident during and after exposure to the radiation environment. The thermostats performed satisfactorily, but there were some anomalies with the data recorder that are being investigated. The data recorder was re-tested after design modifications were made to increase the internal operating voltage from 3 volts to 5 volts, similar to the internal electrical design of the thermostats.

The results of the second series of radiation tests demonstrated that the data recorder and thermostat units exceeded the on-orbit Mean Time Between Failure (MTBF) design requirement of 365 days (25 mission duration equivalent) without error or incident. The MTBF design limits for these components was calculated to be 447.5 days.

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FD24	(256) 544-3559	Randy K.McClendon	Randy K McClendon

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