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AMS-02 QM J-crate Thermal Vacuum/ Thermal Balance Test Procedure

National Space Program Office
國 家 太 空 計 畫 室

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APPENDIX

TABLES

FIGURES

SAFETY ALERTS

Listed below are the paragraph numbers and brief descriptions of the detailed alerts/cautions contained within this procedure.

Safety Alert	Located in Paragraph	On Page	Area of Concern
1	2.2	13	Special Hazards & Precautions
2	2.2(c)	13	Safe Chamber Oxygen Levels
3	2.2.3	13	Electrostatic Discharge
4	5.17	36	Safe Chamber Oxygen Levels

AMS-02 QM J-crate
THERMAL VACUUM/THERMAL BALANCE TEST PROCEDURE

1.0 SCOPE

1.1 Introduction. This procedure defines the thermal vacuum environment and detailed procedure for the environmental **THERMAL CYCLE/ THERMAL BALANCE** testing of the **QM J-crate.**

1.2 Equipment to be Tested. The article to be thermal vacuum tested per this procedure is the QM J-crate.

1.3 Test Objectives.

1.3.1 Thermal Cycle Test Objectives. The purpose of the thermal cycle test is to demonstrate the ability of the QM J-crate to meet design requirements under vacuum conditions and temperature extremes four (4) hot/cold cycles at protoflight levels.

1.3.2 Thermal Balance Test Objectives. The purposes of the thermal balance test are to obtain thermal data for the correlation and correction of the QM J-crate Thermal Analytical Model.

1.4 Test Description. The QM J-crate shall be subjected to a total of five (5) temperature cycles. A temperature cycle begins at room ambient temperature, proceeds to hot test temperatures, then to cold test temperatures, and finally back to room ambient.

- Hot and Cold Thermal Balance Tests will be conducted during the last (5^{th}) cycle.

During the thermal balance and thermal cycle test the QM J-crate mounting interface will be subjected to the thermal extremes under vacuum conditions.

1.5 Test Method. The QM J-crate will be mounted on thermal baseplate inside Small Thermal Vacuum Chamber (STVC), shown in Figure 1. The test will be conducted in that STVC under vacuum conditions.

Only mounting interface of QM J-crate will be thermally cycled with test adapter attached with test heaters and STVC thermal baseplate filled with GN2.

Figure 2 graphically depicts the thermal test profile and Table I lists the temperature controlling criteria applicable to each phase.

Details of the test article instrumentation and the test set-up are depicted in Figures 3 through 158.

1.6 QM J-crate Test Configuration. The QM J-crate will be mounted on test adapter with thermal filler, Cho-Therm, between them. Test adapter will be mounted on thermal baseplate with thermal filler, Cho-Therm, between them. Thermal baseplate is hanged on STVC door, shown in figure 1.

Test thermal blankets (MLI) will cover the external surfaces of QM J-crate except the bottom one, shown in figure 3.

2.0 CONDITIONS

2.1 Personnel. The following personnel will be present to conduct or observe the test or on-call during the set-up and conduct of the test, as required.

CTC **C**rate **T**est **C**onductor:

Has overall responsibility for the thermal vacuum testing of the QM J-crate, installation and hook-up of test sets and the QM J-crate into the STVC.

ETE **E**lectrical **T**est **E**ngineer:

The Electrical Test Engineer has responsibility for the J-crate test procedure, Automated Test Sequence (ATS), test aids, and test set software development. ETE also support T/V test preps activities. ETE lead trouble shooting activities and anomaly resolution teams.

TDE **T**hermal **D**esign **E**ngineer:

Prior to the T/V test, shall perform the pre-T/V test thermal analysis to determine the thermocouple and test-only heater locations and powers for each phase of T/V testing. Shall monitor the overall thermal operation of the test and, with the aid of the TTE, be responsible for maintaining the temperature requirements specified in Table I of this document during the test.

TTE **T**hermal **T**est **E**ngineer:

TTT **T**hermal **T**est **T**echnician:

During test preparations and setup activities prior to the T/V test, the TTE or TTT will be responsible for all activities directly related to the test. Will install all instrumentation particular to the T/V test, i.e. thermocouples and test only heaters. TTE or TTT will have responsibility for control of the test only heaters and monitor the temperature sensors during the conduct of the test. Will record the thermal data as directed. Will operate the thermal vacuum test chamber and other vacuum related tasks as directed.

TTE will be the primary contact between TVC control room and all other organizations before, during and after the test. During the test will monitor the overall vacuum chamber operations, thermal test section personnel activities, and support the CTC and TDE as needed.

TIE **T**hermal **I**nsulation **E**ngineer:

Will install and manage thermal insulation as directed by the TDE.

MTC **M**echanical **T**est **C**onductor:

Will be responsible for all QM J-crate related ground handling activities.

QA **Q**uality **A**ssurance Representative:

Will monitor the handling operation of the QM J-crate during transportation, installation into, and removal from the STVC. Will review and verify the acceptance or rejection of all test data.

2.2 Special Hazards and Precautions.

(a) Wrist-stats (ground straps) will be worn at all times when working near or when in actual contact with QM J-crate.

(b) The number of personnel present will be kept to an absolute minimum at all times while QM J-crate is in the T/V area.

(c) All personnel will observe oxygen deficiency safety rules.

****************************CAUTION***************************
NO ONE WILL BE ALLOWED TO ENTER THE THERMAL VACUUM TEST CHAMBER UNTIL THE OXYGEN LEVEL HAS BEEN VERIFIED SAFE USING AN OXYGEN ANALYZER. (OXYGEN LEVELS ARE CONSIDERED SAFE WHEN THE CHAMBER AIR CONTAINS A MINIMUM OF 19.5% OXYGEN.)
****

(d) All personnel shall maintain continuous vigilance for conditions which may endanger personnel conducting the test or the equipment being tested. Any conditions which appear hazardous shall promptly be brought to the attention of the CTC and/or the TTE.

2.2.1 QM J-crate Handling.

The MTC shall be responsible for all QM J-crate handling operations. The TTE or TTT will assist as directed by the MTC.

2.2.2 Contamination Control.

The contamination control engineer will inspect the chamber and grant approval prior to the installation of the QM J-crate into the STVC. All test cables inside STVC shall be vacuum approved.

2.2.3 Electrostatic Discharge.

The possibility of an electrostatic discharge to the QM J-crate will be minimized.

2.3 Test Preparation.

2.3.1 Communications.

Verbal communications will be sufficient to cover these procedure operations.

2.3.2 Utilities.

Only normal test utilities are required.

In the event of a facility power outage, an interlock system will close all gate valves on the test chamber. Power will be automatically supplied by UPS located in the TV machine room.

2.3.3 Documentation.

Documents Required on Hand.

A current revision of the following documents must be on hand at the start of and throughout the T/V test.

Test Procedure for J-Crate (QM) Environmental Tests (CERN)
Functional Test Descriptions for J-Crate (QM) Environmental Tests (CERN)
J-Crate (Qualification Module) Thermal Vacuum Test Interface Document (CERN)
NSPO-PROC-0031..... AMS-02 QM J-crate Thermal Vacuum/ Thermal Balance Test Procedure.

NSPO-PROC-0029.....Small Thermal Vacuum Chamber Operation Procedure
NSPO-PROC-0030.....Small Thermal Vacuum Chamber Emergency Procedure
NSPO-PROC-0027.....TDHS/HCS-II Operation Procedure
NSPO-PROC-0028.....TDHS/HCS-II Emergency Procedure
NSPO-PROC-0006.....Heater Installation/ Removal/Checkout Process Specification
NSPO-PROC-0020.....Thermocouple End-to-end Verification Procedure
NSPO-PROC-0021.....Thermocouple Installation/ Removal/Checkout Process Specification

Reference Documents.

2.3.4 Environmental Test Equipment.

The following equipment or their equivalent is required for the conduct of this test.

NOTE: All equipment that require calibration shall have current calibration stickers. Calibration dates shall not expire during the anticipated test duration.

(a) Small Thermal Vacuum Chamber with its associated operating equipment. The chamber will be capable of maintaining a pressure of 1.0 X 10^{-5} mbar, or less, while containing the QM J-crate under test. The STVC thermal baseplate will be filled with GN_2 ranging from –60°C to +100°C.

(b) A temperature readout/recording device. The device will be of the multi-channel variety capable of reading copper/constantan (type T) thermocouples with an accuracy of ±1.0°C or better.

(c) Thermal Data Handling System and Heater Control System, or equivalent.

(d) The vacuum chamber feedthrough requirements are as follows:

5 24 pin Deutsch power feedthrough (DM5623-37-2P/P)
6 37 pin Deutsch T-type thermocouple feedthrough
4 55 pin Deutsch feedthrough (951-B07H-2-55-PS-50)

Record the environmental test in the Custodial Test Equipment (CTE) listing embodied in this procedure as Appendix A.

CTE List Completed _____TTE or TTT

2.3.5 Test Adapter.

Test adapter is treated as simulated thermal interface, AMS-02 radiator panel. The QM J-crate will be mounted on thermal baseplate with test adapter, shown in Figure 4. This test adapter is used as an interface to solve problem of unfitted screw holes between QM J-crate and thermal baseplate. Besides, test heaters will be applied on test adapter to precisely control its temperature.

2.3.6 Emergency Power.

A 160KW UPS located inside the TV machine room will provide emergency power for STVC control system should the normal facility power be interrupted. The UPS is programmed to start automatically in the event of a facilities power outage, and the emergency power generator will take over the normal power supply to STVC within 15 seconds without interrupting the power supply to test facilities. When normal facility power is restored, the

UPS and EPS will return to their normal standby condition.

2.4 Definitions

2.4.1 Test conditions.

The thermal vacuum test sequence is graphically depicted in Figure 1 and described in Section 5.0. In the event that special tests, i.e. partial repeat testing, are required, they may be performed by STP or documenting on a TRS.

2.4.2 QM J-crate Test Equipment Set-up.

Test equipment set-up prepared by AMS-02 team is shown in Figure 5. There will be four personal computers located around STVC. Power supply will be used to provide DC voltage power to QM J-crate because JPD is not ready yet. Another 3 personal computers will be located in TVC control room to monitor test data.

Four 55 pin feedthroughs will be used for communication signals and two 24 pin feedthroughs will be used for power supply. Four small boxes for RS232 cable will be installed inside STVC and will be thermally isolated with thermal baseplate with Teflon block.

2.4.3 Test Article Control Temperature.

Control thermocouples used to monitor the test article and any additional required thermocouples as listed in Table II.

2.4.4 Room Ambient. Room ambient conditions are defined as:

- Pressure: 1013±40 mbar
- Temperature: 22±3°C
- Relative Humidity: 50±20%

2.4.5 Temperature Stabilization.

2.4.5.1 Thermal Cycle Testing.

For the purpose of thermal cycle testing, unless otherwise specified by the TDE, temperature stabilization shall be considered attained when:

1. The mounting feet, TTC# 44 - 47, are within 2°C of the specified proto-flight temperature limit.

and

2. No crate mounted thermocouple is varying at a rate greater than 1°C/hr as measured over a period not less than one (1) hour.

2.4.5.2 Thermal Balance Testing.

For the purpose of thermal balance testing, unless otherwise specified by the TDE, temperature stabilization shall be considered attained when:

1. No crate mounted thermocouple is varying at a rate greater than 0.5°C/hr as measured over a period not less than one (1) hr.,

and

2. All heater settings remain unchanged over a two (2) hour period which will include the 1 hour period outlined above.

2.4.6 Temperature Transition Rates.

The temperature transition rate shall be limited to a rate equal to or less than 1°C/min as measured by the test article control thermocouples.

2.4.7 Test Tolerance.

The maximum allowable tolerances, excluding instrument error, for environmental test conditions as follows:

- All temperatures shall be controlled to within 1°C.
- All vacuum levels shall be maintained at $1X10^{-5}$ mbar or less.

NOTE: Closer tolerances may be imposed during the thermal balance portion of the test at the discretion of the TDE.

2.4.8 QM J-Crate Thermal Control and Temperature Limits.

Test control parameters are detailed in Table I. Temperature limits of test thermocouples can be found in Table II.

3.0 DATA REQUIREMENTS.

3.1 Environmental Data to be Recorded.

Temperature data recording shall be initiated immediately prior to chamber evacuation. All temperature data shall be acquired and recorded by means of a multi-channel temperature measurement system. The record format shall be a sequential tabulation in engineering units (°C) identified per thermocouple number in conformance with the environmental data sheets presented as Table II in this document. Records shall be annotated for time, date, test phase, temperature cycle number, and any other information that may be pertinent, to facilitate subsequent data evaluation.

Test heater data recording shall be initiated when the first individual heater is activated and will be recorded in watts on the environmental data sheets presented as Table III in this document. The TTE or TTT will be to alert to any sudden or unexpected change in power to a circuit. It may be a precursory warning of a impending malfunction of that heater circuit.

3.2 Recording Frequency.

Temperature and power data shall be printed on multi-channel recorders at thirty (30) minute intervals during temperature transitions and at sixty (60) minute intervals, or more often, during and after stabilization. However, the scanning frequency shall be much less than the recording frequency, such as short as 1 minute. Manual entry of environmental data shall be made on the data sheets provided and in the chamber log book at intervals of sixty (60) minutes, or less, and at the end of each test condition.

3.3 Data Trends.

Test personnel shall be alert to temperature data trends indicating degradation which could lead to an out-of-tolerance condition if the test condition were extended. In such cases the CTC shall be apprised of the situation.

3.4 Out-of-Tolerance Condition.

Operation outside the tolerance limits, or failure to meet the requirements prescribed in this document or in the spacecraft test procedure shall be handled.

Testing shall not continue until satisfactory corrective action has been taken. If the failure is of such a nature that additional testing are required or deemed advisable, special tests may be conducted via STP.

4.0 TEST PREPARATION.

It is strongly advised that, whenever possible, preparation of the QM J-crate should be performed prior to installation into the small thermal vacuum chamber. Working in the test chamber increases difficulty of any task.

4.1 QM J-crate Instrumentation.

The order of hook-up of the thermocouple and test heaters will be at the discretion of the thermal test personnel.

4.1.1 Test Thermocouples.

Test thermocouples (T/C) will be used to measure the temperatures on the QM J-carte. T/Cs are also used to monitor and control the operation of the test heaters employed for this test. The thermocouple locations along with temperature limits are catalogued in Table II and graphically depicted in various figures contained in this document.

Thermocouple installation instructions, wiring assignments, and check-out procedures can be found in NSPO-PROC-0021.

4.1.2 Test Only Heaters.

Test only heaters are installed on test adapter to control its temperature during test. Each of these heaters will have both of the primary and redundant circuits. Additionally, guard heaters will be installed as needed. The test only heater locations along with power limits are indexed in Table III and pictured in various figures contained in this document.

Test only heater control criteria along with associated thermocouples can be found in Tables I and III. That control can take the form of either regulating to a specific temperature or constant power setting.

Heater installation instructions, wiring assignments, and check-out procedures can be found in NSPO-PROC-0006.

4.2 Chamber Configuration.

Verify the chamber cleanliness is acceptable for the receiving of the AMS-02 QM J-crate.

Contamination Control Eng. _____

Init & Date

4.2.1 Port Plates.

The required TVC port plates are installed utilizing the feedthroughs identified in Paragraph 2.3.4 (d).

4.2.2 STVC Instrumentation.

- The thermocouples are installed on main shroud walls and thermal baseplate to monitor the temperatures of these areas. These thermocouples are connected to the chamber control system.
- The pressure sensors monitoring the chamber pressure are connected to the chamber control system.

4.2.3 Test Set Placement.

- Real-time monitoring system is located at TV test checkout room, which is south side of the test chamber.
- STVC, TDHS/HCS-II, and J-crate control consoles are located at TV test control room, which is south side of the test chamber.

4.3 Chamber Loading.

4.3.1 QM J-crate and STVC Thermal Baseplate.

The STVC thermal baseplate will be installed onto the chamber door and secured properly. The maximum loading capacity of thermal baseplate is 200kg. Hence, 100 kg will be the maximum weight of test article which will be placed on thermal baseplate under 2g proof-load requirement.

The QM J-crate will be mounted on thermal baseplate with test adapter.

ALL QM J-CRATE HANDLING OPERATIONS AROUND THE CHAMBER AREA WILL BE PERFORMED UNDER THE DIRECTION OF THE MTC WITH THE CONCURRENCE OF THE CTC AND TTE!!

4.4 Final Hook-up and Check-out.

4.4.1 Test Set to QM J-crate Connections.

Connect and verify the operation of all test set and QM J-crate.

Test Set and QM J-crate Check-out Complete _____
ETE

4.4.2 Test Heater Verification.

Connect and verify the operation of all test heaters and thermocouples.

Test Heater & T/C Check-out Complete _____
TTE or TTT

4.4.3 Chamber Fixture Thermocouples.

Install/hook-up all chamber fixture thermocouples and record their channel identification and locations in the chamber log book.

Fixture T/C Hook-up Complete: _____
TTE or TTT

4.4.4 Thermal Insulation Installation.

Thermal insulation will be installed after QM J-crate is mounted on thermal baseplate inside STVC. Final completion of thermal insulation installation will be accomplished just prior to the “ready to start” walk-around.

Thermal Insulation Installation Complete _____
TIE

4.4.5 Contamination Witness Plates.

NA

5.0 TEST CONDUCT.

Thermal cycle/thermal balance tests shall be conducted in accordance with the following detailed procedure. Test personnel shall thoroughly familiarize themselves with the procedures and equipment prior to the start of the test and/or each operation performed.

Test data shall be acquired per the requirements detailed in section 3 of this document. Test personnel shall be alert to data trends indicating situations which could lead to an out-of-tolerance condition if the test period were continued without modification.

The Quality Assurance (QA) representative shall verify:

- Satisfactory completion of the test set-up,
- Monitor the QM J-crate installation into the test chamber,
- Monitor the data during the actual test in the surveillance mode and, upon satisfactory completion of testing, stamp on the lines provided with a

buy-off stamp.

5.1 **Test ΦA,** Chamber Evacuation.

(a) Verify test preps are complete. _____CTC

(b) Close the chamber door. _____CTC

(c) Verify QM J-crate is off. _____ETE

(d) Begin evacuation of the thermal vacuum chamber per NSPO-PROC-0029. Record start time below.

CHAMBER EVACUATION START:

_____ TIME _____ DATE

_____ TTE or TTT _____ QA

Test Phase A will be considered complete when the chamber pressure is 1.0×10^{-5} mbar, or less.

Test ΦA Complete. _____ Time _____ Date

_____ TTE or TTT _____ QA

5.2 **Test ΦB,** Non-operating Hot Cycle #1.

(a) Maintain a chamber pressure of 1.0×10^{-5} mbar, or less.

(b) Data Acquisition Requirements:

1. Record thermocouple and heater data every 20 sec throughout the test per NSPO-PROC-0027.
2. Tabulate thermocouple and heater data hourly and at the end of each test phase per NSPO-PROC-0027.
3. Record additional data and plot as directed by the TTE or TDE.

(c) Verify/adjust thermal baseplate and the test heaters and per NSPO-PROC-0029 and NSPO-PROC-0027 as required to attain the levels listed in Table I for Test Phase B1 and hold for stabilization.

_____TDE

(d) Change to Test Phase B2 as directed by TDE for a minimum of one (1) hour after mounting feet, TTC# 44-47, are within 2°C of their hot protoflight operating temperature limit listed in Table II.

_____TDE

NOTE: Heater power settings listed in Table I may be modified at the discretion of the TDE to expedite temperature transition or maintain component temperature levels.

(d) At the end of the hold, the TTE or TTT will notify the CTC and when directed by the CTC, record all environmental and proceed to the next step.

Non-operating Hot Cycle #1 Complete._____ Time_____ Date

_____ TDE _____ ETE _____QA

5.3 **Test ΦC,** Operating Hot Cycle #1.

(a) Maintain a chamber pressure of 1.0×10^{-5} mbar, or less.

(b) Data Acquisition Requirements:

1. Record thermocouple and heater data every 20 sec. throughout the test per NSPO-PROC-0027.
2. Tabulate thermocouple and heater data hourly and at the end of each test phase per NSPO-PROC-0027.
3. Record additional data and plot as directed by the TTE or TDE.

(c) Verify/adjust thermal baseplate and the test heaters and per NSPO-PROC-0029 and NSPO-PROC-0027 as required to attain the levels listed in Table I for Test Phase C1 and hold for stabilization.

_____TDE

(d) Power on QM J-crate per Appendix B.

_____ETE

(e) Change to Test Phase C2 as directed by TDE. When the mounting feet, TTC# 44-47, are within 2°C of their hot protoflight operating temperature limit listed in Table II, TDE informs ETE that hot protoflight operating temperature limit is reached. Keep the temperature for a minimum of two (2) hours

NOTE: Heater power settings listed in Table I may be modified at the discretion of the TDE to expedite temperature transition or maintain component temperature levels.

_____TDE

(f) Perform functional test of QM J-crate per Appendix B. Complete functional test.

_____ETE

(d) At the end of the hold, the ETE will notify the CTC and when directed by the CTC, record all environmental and proceed to the next step.

Operating Hot Cycle #1 Complete._____ Time_____ Date

_____ TDE _____ ETE _____QA

5.4 **Test ΦD,** Non-Operating Cold Cycle #1.

(a) Maintain a chamber pressure of 1.0×10^{-5} mbar, or less.

(b) Data Acquisition Requirements:

1. Record thermocouple and heater data every 20 sec. throughout the test per NSPO-PROC-0027.
2. Tabulate thermocouple and heater data hourly and at the end of each test phase per NSPO-PROC-0027.
3. Record additional data and plot as directed by the TTE or TDE.

(c) Verify/adjust thermal baseplate and the test heaters and per NSPO-PROC-0029 and NSPO-PROC-0027 as required to attain the levels listed in Table I for Test Phase D1 and hold for stabilization.

_____TDE

(d) Turn off QM J-crate per Appendix B.

_____ETE

(e) Change to Test Phase D2 as directed by TDE. When the mounting feet, TTC# 44-47, are within 2°C of their hot protoflight operating temperature limit listed in Table II, TDE informs ETE that functional test can be started. Keep the temperature for a minimum of two (2) hours.

NOTE: Heater power settings listed in Table I may be modified at the discretion of the TDE to expedite temperature transition or maintain component temperature levels.

_____TDE

(f) At the end of the hold, the TTE or TTT will notify the CTC and when directed by the CTC, record all environmental data and proceed to the next step.

Non-Operating Cold Cycle #1 Complete._____ Time_____ Date

_____ TDE _____ ETE _____QA

5.5 **Test ΦE,** Operating Cold Cycle #1.

(a) Maintain a chamber pressure of 1.0×10^{-5} mbar, or less.

(b) Data Acquisition Requirements:

1. Record thermocouple and heater data every 20 sec. throughout the test per NSPO-PROC-0027.
2. Tabulate thermocouple and heater data hourly and at the end of each test phase per NSPO-PROC-0027.
3. Record additional data and plot as directed by the TTE or TDE.

(c) Verify/adjust thermal baseplate and the test heaters and per NSPO-PROC-0029 and NSPO-PROC-0027 as required to attain the levels listed in Table I for Test Phase E1 and hold for stabilization.

_____TDE

(d) Power on QM J-crate per Appendix B.

_____ETE

(e) Change to Test Phase D2 as directed by TDE. When the mounting feet, TTC# 44-47, are within 2°C of their cold protoflight operating temperature limit listed in Table II, TDE informs ETE that cold protoflight operating temperature limit is reached.. Keep the temperature for a minimum of two (2) hours

NOTE: Heater power settings listed in Table I may be modified at the discretion of the TDE to expedite temperature transition or maintain component temperature levels.

_____TDE

(f) Perform functional test of QM J-crate per Appendix B. Complete

functional test.

_____ETE

(g) At the end of the hold, the TTE or TTT will notify the CTC and when directed by the CTC, record all environmental data and proceed to the next step.

Operating Cold Cycle #1 Complete._____ Time_____ Date

_____ TDE _____ ETE _____QA

5.6 **Test ΦF,** Operating Hot Cycle #2.

(a) Maintain a chamber pressure of 1.0×10^{-5} mbar, or less.

(b) Data Acquisition Requirements:
1. Record thermocouple and heater data every 20 sec. throughout the test per NSPO-PROC-0027.
2. Tabulate thermocouple and heater data hourly and at the end of each test phase per NSPO-PROC-0027.
3. Record additional data and plot as directed by the TTE or TDE.

(c) Verify/adjust thermal baseplate and the test heaters and per NSPO-PROC-0029 and NSPO-PROC-0027 as required to attain the levels listed in Table I for Test Phase F1 and hold for stabilization.

_____TDE

(d) Change to Test Phase F2 as directed by TDE for a minimum of one (1) hour after mounting feet, TTC# 44-47, are within 2°C of their hot protoflight operating temperature limit listed in Table II.

NOTE: Heater power settings listed in Table I may be modified at the discretion of the TDE to expedite temperature transition or maintain component temperature levels.

_____TDE

(e) At the end of the hold, the TTE or TTT will notify the CTC and when directed by the CTC, record all environmental data and proceed to the next step.

Operating Hot Cycle #2 Complete._____ Time_____ Date

_____ TDE _____ ETE _____QA

5.7 **Test ΦG,** Operating Cold Cycle #2.

(a) Maintain a chamber pressure of 1.0 x 10^{-5} mbar, or less.

(b) Data Acquisition Requirements:

1. Record thermocouple and heater data every 20 sec. throughout the test per NSPO-PROC-0027.
2. Tabulate thermocouple and heater data hourly and at the end of each test phase per NSPO-PROC-0027.
3. Record additional data and plot as directed by the TTE or TDE.

(c) Verify/adjust thermal baseplate and the test heaters and per NSPO-PROC-0029 and NSPO-PROC-0027 as required to attain the levels listed in Table I for Test Phase G1 and hold for stabilization.

_____TDE

(d) Change to Test Phase G2 as directed by TDE for a minimum of one (1) hour after mounting feet, TTC# 44-47, are within 2°C of their cold protoflight operating temperature limit listed in Table II.

NOTE: Heater power settings listed in Table I may be modified at the discretion of the TDE to expedite temperature transition or maintain component temperature levels.

_____TDE

(e) At the end of the hold, the TTE or TTT will notify the CTC and when directed by the CTC, record all environmental data and proceed to the next step.

Operating Cold Cycle #2 Complete._____ Time_____ Date

_____ TDE _____ ETE _____QA

5.8 **Test ΦH,** Operating Hot Cycle #3.

(a) Maintain a chamber pressure of 1.0 x 10^{-5} mbar, or less.

(b) Data Acquisition Requirements:

1. Record thermocouple and heater data every 20 sec. throughout the test per NSPO-PROC-0027.

2. Tabulate thermocouple and heater data hourly and at the end of each test phase per NSPO-PROC-0027.
3. Record additional data and plot as directed by the TTE or TDE.

(c) Verify/adjust thermal baseplate and the test heaters and per NSPO-PROC-0029 and NSPO-PROC-0027 as required to attain the levels listed in Table I for Test Phase H1 and hold for stabilization.

_____TDE

(d) Change to Test Phase H2 as directed by TDE for a minimum of one (1) hour after mounting feet, TTC# 44-47, are within 2°C of their hot protoflight operating temperature limit listed in Table II.

<u>NOTE:</u> Heater power settings listed in Table I may be modified at the discretion of the TDE to expedite temperature transition or maintain component temperature levels.

_____TDE

(e) At the end of the hold, the TTE or TTT will notify the CTC and when directed by the CTC, record all environmental data and proceed to the next step.

Operating Hot Cycle #3 Complete._____ Time_____ Date

_____ TDE _____ ETE _____QA

5.9 **<u>Test ΦI,</u>** <u>Operating Cold Cycle #3.</u>

(a) Maintain a chamber pressure of 1.0×10^{-5} mbar, or less.

(b) Data Acquisition Requirements:
1. Record thermocouple and heater data every 20 sec. throughout the test per NSPO-PROC-0027.
2. Tabulate thermocouple and heater data hourly and at the end of each test phase per NSPO-PROC-0027.
3. Record additional data and plot as directed by the TTE or TDE.

(c) Verify/adjust thermal baseplate and the test heaters and per NSPO-PROC-0029 and NSPO-PROC-0027 as required to attain the levels listed in Table I for Test Phase I1 and hold for stabilization.

_____TDE

(d) Change to Test Phase I2 as directed by TDE for a minimum of one (1) hour after mounting feet, TTC# 44-47, are within 2°C of their cold protoflight operating temperature limit listed in Table II.

NOTE: Heater power settings listed in Table I may be modified at the discretion of the TDE to expedite temperature transition or maintain component temperature levels.

_____TDE

(e) At the end of the hold, the TTE or TTT will notify the CTC and when directed by the CTC, record all environmental data and proceed to the next step.

Operating Cold Cycle #3 Complete._____ Time_____ Date

_____ TDE _____ ETE _____QA

5.10 **Test ΦJ,** Non-operating Hot Cycle #4.

(a) Maintain a chamber pressure of 1.0×10^{-5} mbar, or less.

(b) Data Acquisition Requirements:

1. Record thermocouple and heater data every 20 sec. throughout the test per NSPO-PROC-0027.
2. Tabulate thermocouple and heater data hourly and at the end of each test phase per NSPO-PROC-0027.
3. Record additional data and plot as directed by the TTE or TDE.

(c) Verify/adjust thermal baseplate and the test heaters and per NSPO-PROC-0029 and NSPO-PROC-0027 as required to attain the levels listed in Table I for Test Phase J1 and hold for stabilization.

_____TDE

(d) Turn off QM J-crate per Appendix B.

_____ETE

(e) Change to Test Phase J2 as directed by TDE. When the mounting feet, TTC# 44-47, are within 2°C of their hot protoflight operating temperature limit listed in Table II, TDE informs ETE that functional test can be started. Keep the temperature for a minimum of one (1) hours

NOTE: Heater power settings listed in Table I may be modified at the discretion of the TDE to expedite temperature transition or maintain

component temperature levels.

_____TDE

(f) At the end of the hold, the TTE or TTT will notify the CTC and when directed by the CTC, record all environmental and proceed to the next step.

Non-operating Hot Cycle #4 Complete._____ Time_____ Date

_____ TDE _____ ETE _____QA

5.11 **Test ØK,** Operating Hot Cycle #4.

(a) Maintain a chamber pressure of 1.0 x 10^{-5} mbar, or less.

(b) Data Acquisition Requirements:

4. Record thermocouple and heater data every 20 sec. throughout the test per NSPO-PROC-0027.
5. Tabulate thermocouple and heater data hourly and at the end of each test phase per NSPO-PROC-0027.
6. Record additional data and plot as directed by the TTE or TDE.

(c) Verify/adjust thermal baseplate and the test heaters and per NSPO-PROC-0029 and NSPO-PROC-0027 as required to attain the levels listed in Table I for Test Phase K1 and hold for stabilization.

_____TDE

(d) Power on QM J-crate per Appendix B.

_____ETE

(e) Change to Test Phase K2 as directed by TDE. When the mounting feet, TTC# 44-47, are within 2°C of their hot protoflight operating temperature limit listed in Table II, TDE informs ETE that hot protoflight operating temperature limit is reached. Keep the temperature for a minimum of two (2) hours

NOTE: Heater power settings listed in Table I may be modified at the discretion of the TDE to expedite temperature transition or maintain component temperature levels.

_____TDE

(f) Perform functional test of QM J-crate per Appendix B. Complete functional test.

_____ETE

(g) At the end of the hold, the TTE or TTT will notify the CTC and when directed by the CTC, record all environmental and proceed to the next step.

Operating Hot Cycle #4 Complete._____ Time_____ Date

_____ TDE _____ ETE _____QA

5.12 **Test ΦL,** Non-Operating Cold Cycle #4.

(a) Maintain a chamber pressure of 1.0×10^{-5} mbar, or less.

(b) Data Acquisition Requirements:

1. Record thermocouple and heater data every 20 sec. throughout the test per NSPO-PROC-0027.
2. Tabulate thermocouple and heater data hourly and at the end of each test phase per NSPO-PROC-0027.
3. Record additional data and plot as directed by the TTE or TDE.

(c) Verify/adjust thermal baseplate and the test heaters and per NSPO-PROC-0029 and NSPO-PROC-0027 as required to attain the levels listed in Table I for Test Phase L1 and hold for stabilization.

_____TDE

(d) Turn off QM J-crate per Appendix B.

_____ETE

(e) Change to Test Phase L2 as directed by TDE for a minimum of one (1) hour after mounting feet, TTC# 44-47, are within 2°C of their cold protoflight non-operating temperature limit listed in Table II.

NOTE: Heater power settings listed in Table I may be modified at the discretion of the TDE to expedite temperature transition or maintain component temperature levels.

_____TDE

(d) At the end of the hold, the TTE or TTT will notify the CTC and when directed by the CTC, record all environmental data and proceed to the next step.

Non-Operating Cold Cycle #4 Complete._____ Time_____ Date

_____ TDE _____ ETE _____QA

5.13 **Test ΦM,** Operating Cold Cycle #4.

(a) Maintain a chamber pressure of 1.0 x 10^{-5} mbar, or less.

(b) Data Acquisition Requirements:

1. Record thermocouple and heater data every 20 sec. throughout the test per NSPO-PROC-0027.
2. Tabulate thermocouple and heater data hourly and at the end of each test phase per NSPO-PROC-0027.
3. Record additional data and plot as directed by the TTE or TDE.

(c) Verify/adjust thermal baseplate and the test heaters and per NSPO-PROC-0029 and NSPO-PROC-0027 as required to attain the levels listed in Table I for Test Phase M1 and hold for stabilization.

(d) Power on QM J-crate per Appendix B.

_____ETE

(e) Change to Test Phase M2 as directed by TDE. When the mounting feet, TTC# 44-47, are within 2°C of their hot protoflight operating temperature limit listed in Table II, TDE informs ETE that cold protoflight operating temperature limit is reached. Keep the temperature for a minimum of two (2) hours

NOTE: Heater power settings listed in Table I may be modified at the discretion of the TDE to expedite temperature transition or maintain component temperature levels.

_____TDE

(f) Perform functional test of QM J-crate per Appendix B. Complete functional test.

_____ETE

(g) At the end of the hold, the TTE or TTT will notify the CTC and when directed by the CTC, record all environmental data and proceed to the next step.

Operating Cold Cycle #4 Complete._____ Time_____ Date

_____ TDE _____ ETE _____QA

5.14 **Test ΦN,** Cold Thermal Balance Test.

Objective: To achieve thermal equilibrium in the test article under simulated cold-case conditions.

Completion Criteria: Maintain test conditions until thermal stabilization has been attained or until the TDE terminates the test phase.

(a) Maintain a chamber pressure of 1.0×10^{-5} mbar, or less.

(b) Verify/adjust thermal baseplate and the test heaters per NSPO-PROC-0029 and NSPO-PROC-0027 as required to attain the levels listed in Table I for Test Phase N.

NOTE: Heater power settings listed in Table I may be modified at the discretion of the TDE.

_____TDE

(c) Change QM J-crate power on configuration to one JMDC, i.e. JMDC1, per Appendix B.

_____ETE

(d) Hold until thermal stabilization has been attained.

For the purpose of thermal balance testing, unless otherwise specified by the TDE, temperature stabilization shall be considered attained when:

1. *No QM J-crate mounted thermocouple is varying at a rate greater than 0.5℃/hr as measured over a period not less than one (1) hour.*

and

2. *All heater settings remain unchanged over a two (2) hour period which will include the 1 hour period outlined above.*

(e) Data Acquisition Requirements:

1. Record thermocouple and heater data every 20 sec. throughout the test per NSPO-PROC-0027.
2. Tabulate thermocouple and heater data hourly and at the end of each test phase per NSPO-PROC-0027.
3. Record additional data and plot as directed by the TTE or TDE.

(f) When stabilization has been declared by the TDE, proceed to Test Phase O.

Test ΦN Complete: _____ Time _____ Date

TDE _____ Init

5.15 **Test *Φ*O,** Hot Thermal Balance Test.

Objective: To achieve thermal equilibrium in the test article under simulated Hot-case conditions.

Completion Criteria: Maintain test conditions until thermal stabilization has been attained or until the TDE terminates the test phase.

(a) Maintain a chamber pressure of 1.0×10^{-5} mbar, or less.

(b) Verify/adjust thermal baseplate and the test heaters per NSPO-PROC-0029 and NSPO-PROC-0027 as required to attain the levels listed in Table I for Test Phase O.

NOTE: Heater power settings listed in Table I may be modified at the discretion of the TDE.

(c) Hold until thermal stabilization has been attained.

For the purpose of thermal vacuum testing, unless otherwise specified by the TDE, temperature stabilization shall be considered attained when:

1. *No QM J-crate mounted thermocouple is varying at a rate greater than 0.5℃/hr as measured over a period not less than one (1) hour.*

and

2. *All heater settings remain unchanged over a two (2) hour period which will include the 1 hour period outlined above."*

(d) Data Acquisition Requirements:

1. Record thermocouple and heater data every 20 sec. throughout the test per NSPO-PROC-0027.
2. Tabulate thermocouple and heater data hourly and at the end of each test phase per NSPO-PROC-0027.
3. Record additional data and plot as directed by the TTE or TDE.

(e) When stabilization has been declared by the TDE, proceed to Test Phase P.

Test ΦO Complete: _____ Time _____ Date

TDE _____ Init

5.16 **Test ΦP,** Transient Cool-Down Test.

Objective: To obtain transient thermal performance data for the test article during a controlled cool-down.

Completion Criteria: Maintain test conditions for a 4 hour period, or until the TDE terminates the test phase.

(a) Maintain a chamber pressure of 1.0×10^{-5} mbar, or less.

(b) At the direction of the TDE, verify/adjust thermal baseplate and the test heaters per NSPO-PROC-0029 and NSPO-PROC-0027 as required to attain the levels listed in Table I for Test Phase P.

NOTE: Heater power settings listed in Table 1 may be modified at the discretion of the TDE.

_____ TDE

(c) Turn off QM J-crate per Appendix B.

_____ ETE

(d) Crate power-off will signify the beginning of the cool-down transient period.

(e) Data Acquisition Requirements:
1. Record thermocouple and heater data every 20 sec. throughout the test per NSPO-PROC-0027.
2. Tabulate thermocouple and heater data hourly and at the end of each test phase per NSPO-PROC-0027.
3. Record additional data and plot as directed by the TTE or TDE.

(f) When the end of the cool-down is declared complete by the TDE, proceed to the next test phase.

Test ΦP Complete: _____ Time _____ Date

TDE _____ Init

5.17 **Test ΦQ,** Return to Room Ambient Conditions.

(a) Data Acquisition Requirements:
   1. Record thermocouple and heater data every 20 sec. throughout the test per NSPO-PROC-0027.
   2. Tabulate thermocouple and heater data hourly and at the end of each test phase per NSPO-PROC-0027.
   3. Record additional data and plot as directed by the TTE or TDE.

(b) Adjust thermal baseplate and the test heaters per NSPO-PROC-0029 and NSPO-PROC-0027 as required to attain the levels listed in Table I for test phase Q.

(c) When the conditions defined in Step (b) are met, turn off thermal control of thermal baseplate and all test heaters per NSPO-PROC-0029 and NSPO-PROC-0027.

(d) Hold until all temperatures inside the chamber are 20°C ± 3°C.

(e) When the conditions in Step (d) are met, return the test chamber to room ambient pressure per NSPO-PROC-0029.

(f) Test Phase Q will be considered complete when the test article, test adapter, and thermal baseplate are at room ambient conditions.

Test ΦQ Complete._____ Time _____ Date

THERMAL VACUUM/THERMAL BALANCE TEST COMPLETE:

_____ CTC _____ TDE _____ ETE

_____ TTE _____ QA

_____ Time _____ Date

**********WARNING**********

UPON THE RETURN TO AMBIENT CONDITIONS, THE TEST CHAMBER WILL BE FILLED WITH NITROGEN GAS. NITROGEN IS A COLORLESS, ODORLESS GAS THAT WILL NOT SUPPORT LIFE. ***UNCONSCIOUSNESS AND POSSIBLE DEATH WILL RESULT FROM BREATHING PURE NITROGEN.*** *NO ENTRY WILL BE PERMITTED INTO THE CHAMBER UNTIL THE CHAMBER HAS BEEN VENTILATED WITH ROOM AIR, USING CIRCULATION FANS, FOR A MINIMUM OF ONE (1) HOUR.* ***ENTRY WILL NOT BE PERMITTED UNTIL THE CHAMBER ATMOSPHERE HAS BEEN VERIFIED TO CONTAIN A MINIMUM OF 19.5% OXYGEN.*** *THIS WILL BE VERIFIED VIA A CALIBRATED*

OXYGEN ANALYZER. TTE APPROVAL IS NECESSARY FOR INITIAL ENTRY INTO THE CHAMBER FOLLOWING GN_2 PURGING.

****

(h) Vent chamber to 1013 mbar and STVC open door per NSPO-PROC-0029.

Chamber Safe For Entry _____%O_2_____ TTE_____QA

_____ TIME _____ DATE

Table I Test Only Heater Control Requirements

HTR#	Location	Test Phase										
		Pump down	Non-Operating Hot cycle #1		Operating Hot cycle #1			Non-Operating Cold cycle #1			Operating Cold Cycle#1	
		A	B1	B2	C1	Unit on	C2	D1	Unit off	D2	E1	Unit on	E2
1	Adapter 1	20°C	80°C	85°C	50°C		55°C	-20°C		-45°C	-20°C		-25°C
2	Adapter 2	20°C	80°C	85°C	50°C		55°C	-20°C		-45°C	-20°C		-25°C
3	Adapter 3	20°C	80°C	85°C	50°C		55°C	-20°C		-45°C	-20°C		-25°C
4	Adapter 4	20°C	80°C	85°C	50°C		55°C	-20°C		-45°C	-20°C		-25°C
5	Adapter 5	20°C	80°C	85°C	50°C		55°C	-20°C		-45°C	-20°C		-25°C
STVC	baseplate	20°C	50°C	50°C	0°C		0°C	-60°C		-60°C	-60°C		-60°C

Table I Test Only Heater Control Requirements (Continued)

HTR#	Location	Test Phase							
		Operating Hot Cycle #2		Operating Cold Cycle #2		Operating Hot Cycle #3		Operating Cold Cycle#3	
		F1	F2	G1	G2	H1	H2	I1	I2
1	Adapter 1	50°C	55°C	-20°C	-25°C	50°C	55°C	-20°C	-25°C
2	Adapter 2	50°C	55°C	-20°C	-25°C	50°C	55°C	-20°C	-25°C
3	Adapter 3	50°C	55°C	-20°C	-25°C	50°C	55°C	-20°C	-25°C
4	Adapter 4	50°C	55°C	-20°C	-25°C	50°C	55°C	-20°C	-25°C
5	Adapter 5	50°C	55°C	-20°C	-25°C	50°C	55°C	-20°C	-25°C
STVC	baseplate	50°C	50°C	-60°C	-60°C	50°C	50°C	-60°C	-60°C

Table I Test Only Heater Control Requirements (Continued)

		Test Phase										
		Non-Operating Hot Cycle #4			Operating Hot Cycle #4			Non-Operating Cold Cycle #4			Operating Cold Cycle#4	
HTR#	Location	J1		J2	K1		K2	L1		L2	M1		M2
1	Adapter 1	50°C	Unit off	85°C	50°C	Unit on	55°C	-20°C	Unit off	-45°C	-20°C	Unit on	-25°C
2	Adapter 2	50°C		85°C	50°C		55°C	-20°C		-45°C	-20°C		-25°C
3	Adapter 3	50°C		85°C	50°C		55°C	-20°C		-45°C	-20°C		-25°C
4	Adapter 4	50°C		85°C	50°C		55°C	-20°C		-45°C	-20°C		-25°C
5	Adapter 5	50°C		85°C	50°C		55°C	-20°C		-45°C	-20°C		-25°C
STVC	baseplate	50°C		50°C	0°C		0°C	-60°C		-60°C	-60°C		-60°C

Table I Test Only Heater Control Requirements (Continued)

HTR#	Location	Test Phase				
		Cold Balance	Hot Balance	Transient cool down		Return to ambient
		N	O	P		Q
1	Adapter 1	-4°C	34°C	-4°C	Unit off	20°C
2	Adapter 2	-4°C	34°C	-4°C		20°C
3	Adapter 3	-4°C	34°C	-4°C		20°C
4	Adapter 4	-4°C	34°C	-4°C		20°C
5	Adapter 5	-4°C	34°C	-4°C		20°C
STVC	baseplate	-30°C	0°C	-30°C		20°C

Table II Monitoring and Heater-Controlled Thermocouple Locations and Limits

TTC#	Location	Fig#	Temperature Limits (°C)											
			Pump down		Non-Operating Cycles #1,4		Operating Cycles #1,2,3,4		Thermal Balance		Transient cool down		Return to ambient	
			min	max	min	max	min	max	min	max	min	max	min	max
1,2,3,4,5,6,7,8	Top main wall	6	-45	100	-45	100	-25	90	-25	90	-45	100	-25	100
9,10,11,12 13,14,15,16	Bottom main wall	7	-45	100	-45	100	-25	100	-25	100	-45	100	-25	100
17,18,19,20	Right side wall	8	-45	100	-45	100	-25	100	-25	100	-45	100	-25	100
21,22,23,24	Left side wall	9	-45	100	-45	100	-25	100	-25	100	-45	100	-25	100
25,26,27,28,29	Back plane	10	-45	100	-45	100	-25	100	-25	100	-45	100	-25	100
30,31,32,33	Front cover	11	-45	100	-45	100	-45	100	-45	100	-45	100	-25	100
34, 35, 36, 37, 38	JSBC (slot#6)	12	-45	100	-45	100	-45	100	-45	100	-45	100	-25	100
39, 40, 41, 42, 43	JHIF (slot#11)	13	-45	100	-45	100	-45	100	-45	100	-45	100	-25	100
44,45,46,47	Mounting feet	14	-45	85	-45	85	-45	85	-45	85	-45	85	-45	85
48,49,50,51,52 53 54,55,56,57	Test adapter	15	-45	85	-45	85	-45	85	-45	85	-45	85	-45	85
60,61,62,63 64,65,66,67	Thermal baseplate	16	-60	100	-60	100	-60	100	-60	100	-60	100	-60	100
68,69,70,71	EGSE boxes	17	0	60	0	60	0	60	0	60	0	60	0	60

Table III Test Only Heater Locations & Requirements

Heater #	Control TC#	Location	Heater resistance (Ω)	Maximum Current (A)	Required Heater Power (W)	Available Heater Power (W)
HTR 1	TTC 48, 49	Test adapter 1	8	2.8	50	62
HTR 2	TTC 50, 51	Test adapter 2	8	2.8	50	62
HTR 3	TTC 52, 53	Test adapter 3	8	2.8	50	62
HTR 4	TTC 54, 55	Test adapter 4	8	2.8	50	62
HTR 5	TTC 56, 57	Test adapter 5	8	2.8	50	62

Figure 1 QM J-crate TV Test Configuration

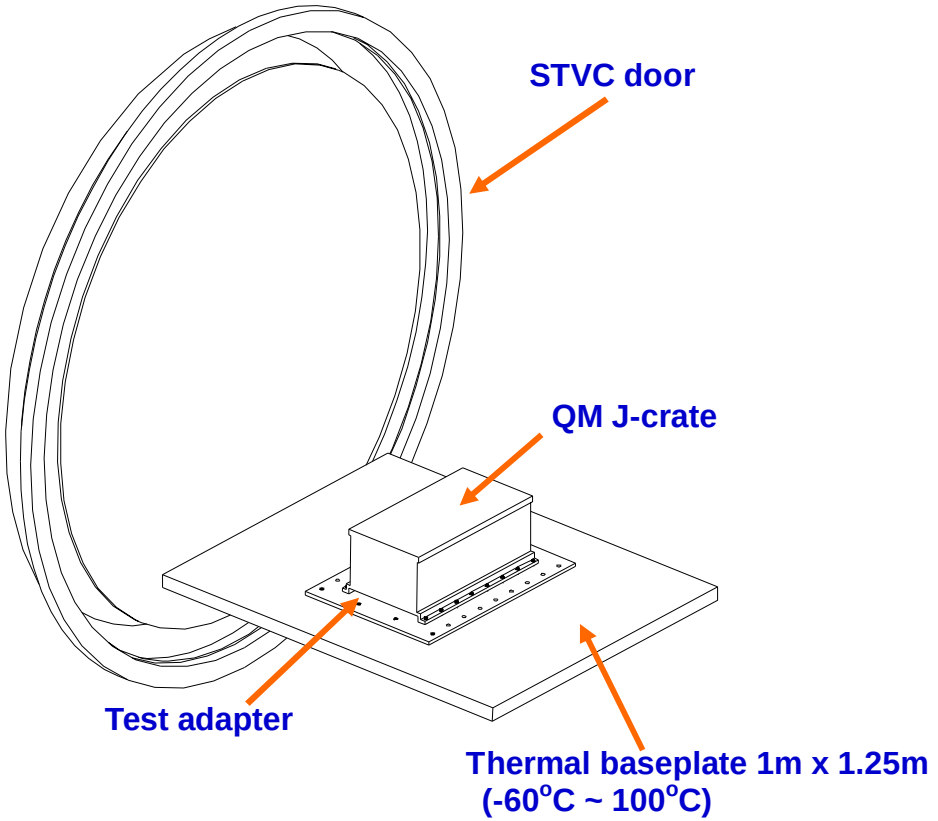


Figure2 QM J-crate Thermal Vacuum/ Thermal Balance Test Sequence

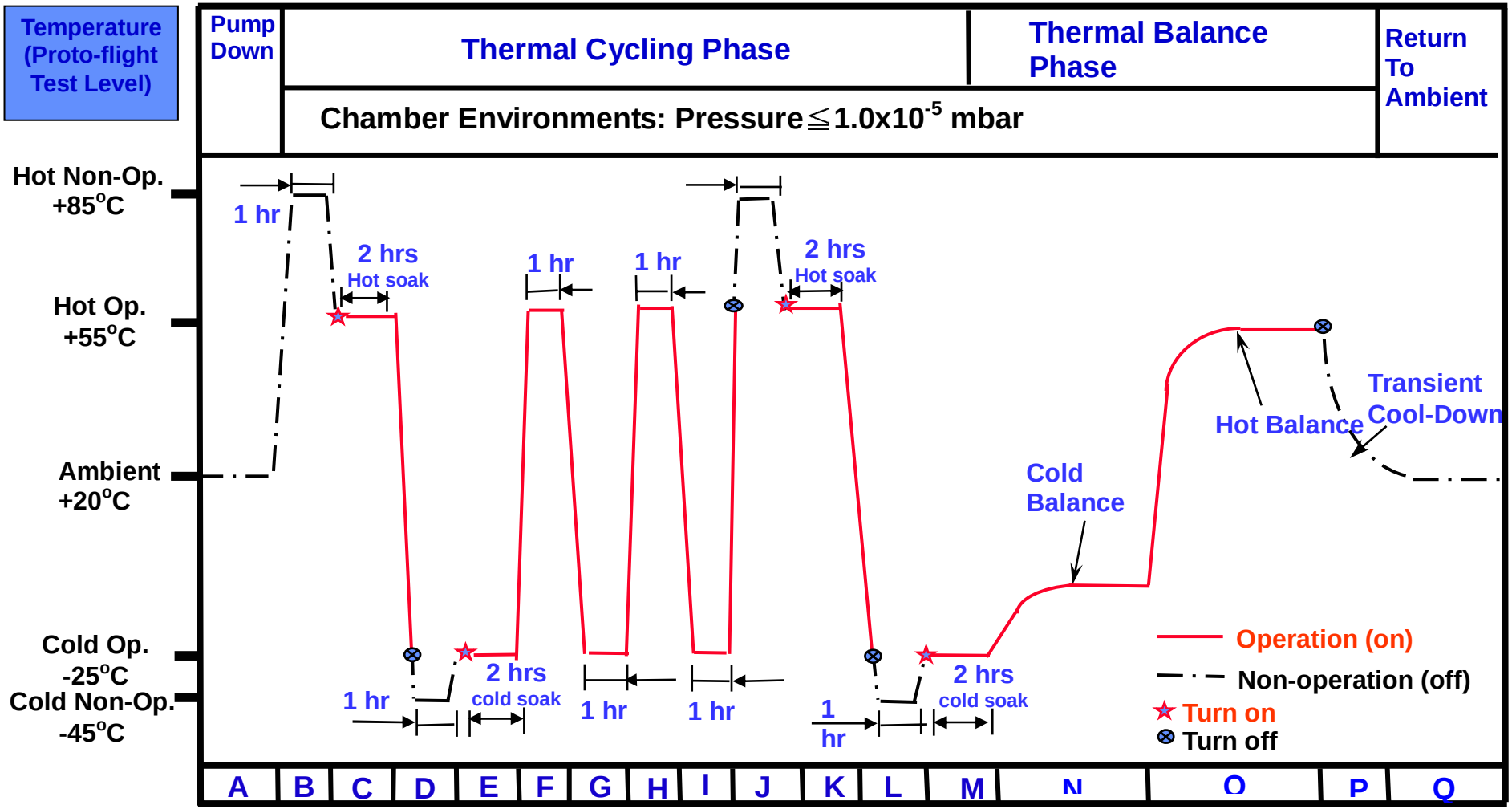


Figure 3 External surfaces of QM J-crate test configuration

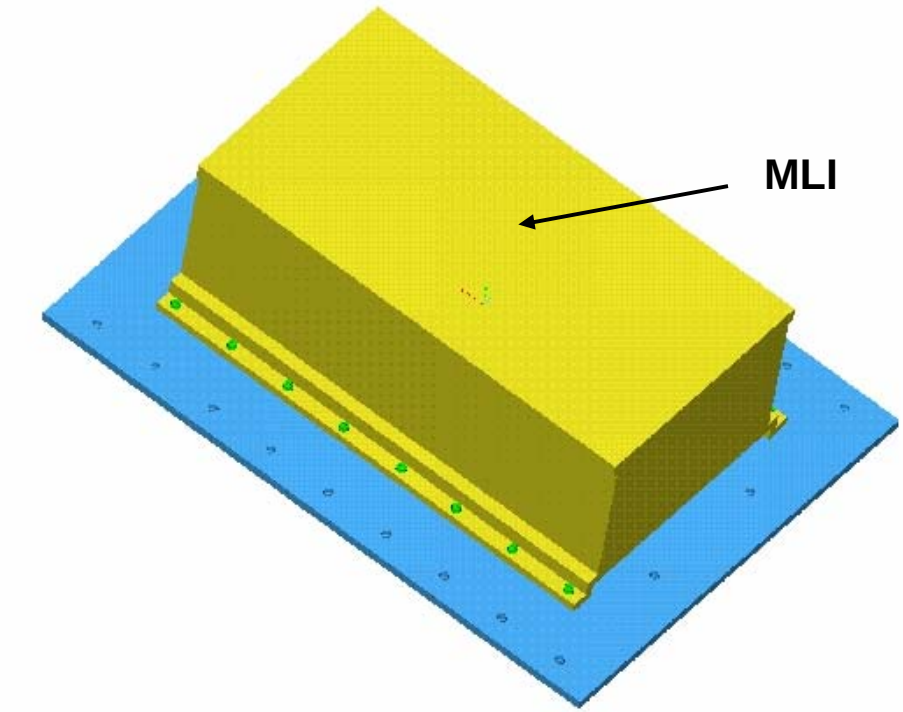


Figure 4 Test adapter

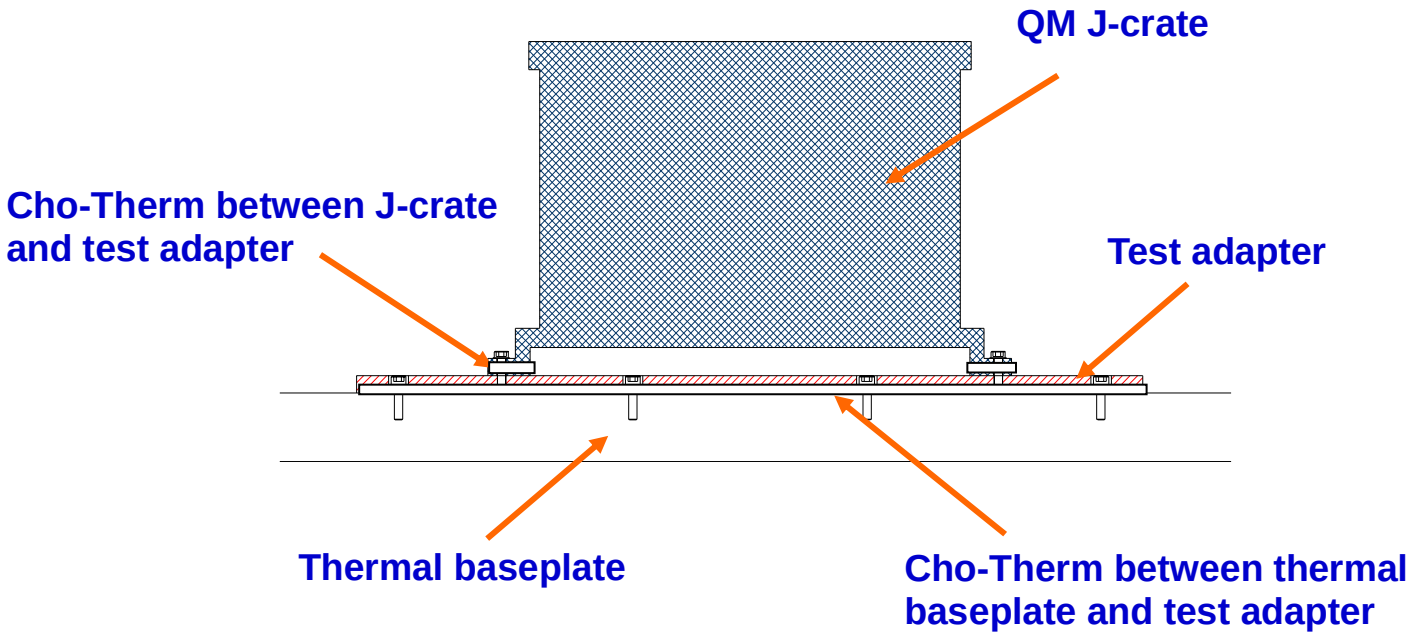


Figure 5 QM J-Crate Thermal Vacuum Test Electrical Test Set-up (provided by Dr. Cai from CERN)

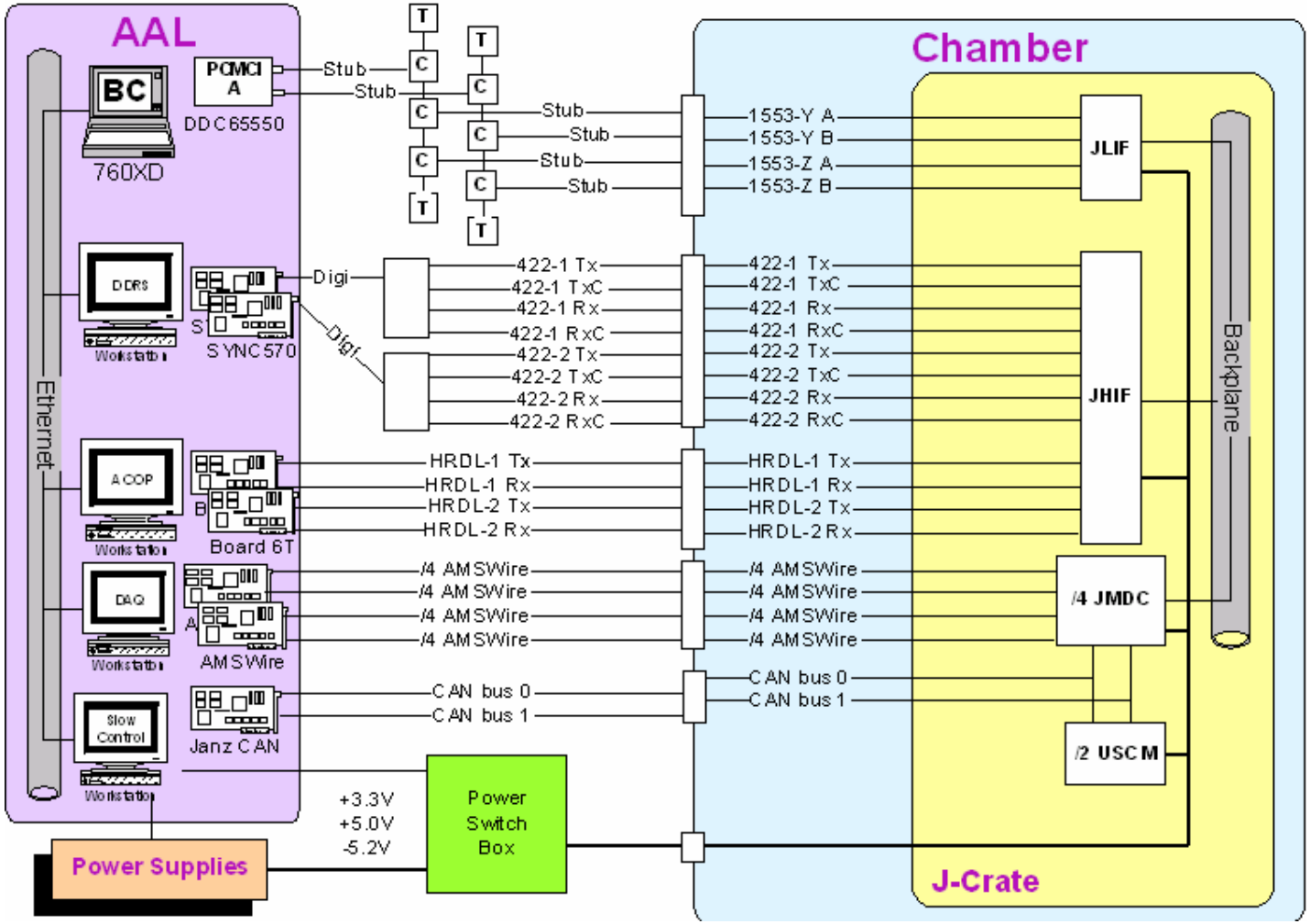


Figure 6 Test only heaters and thermocouples locations for top main wall

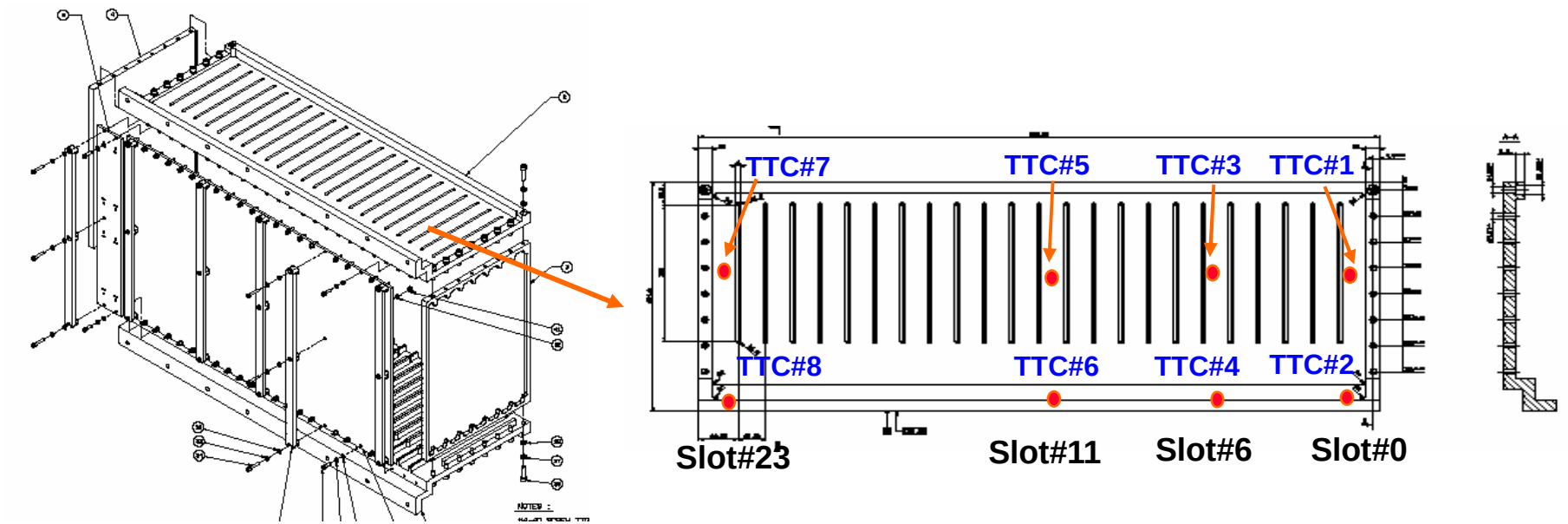


Figure 7 Test only heaters and thermocouples locations for bottom main wall

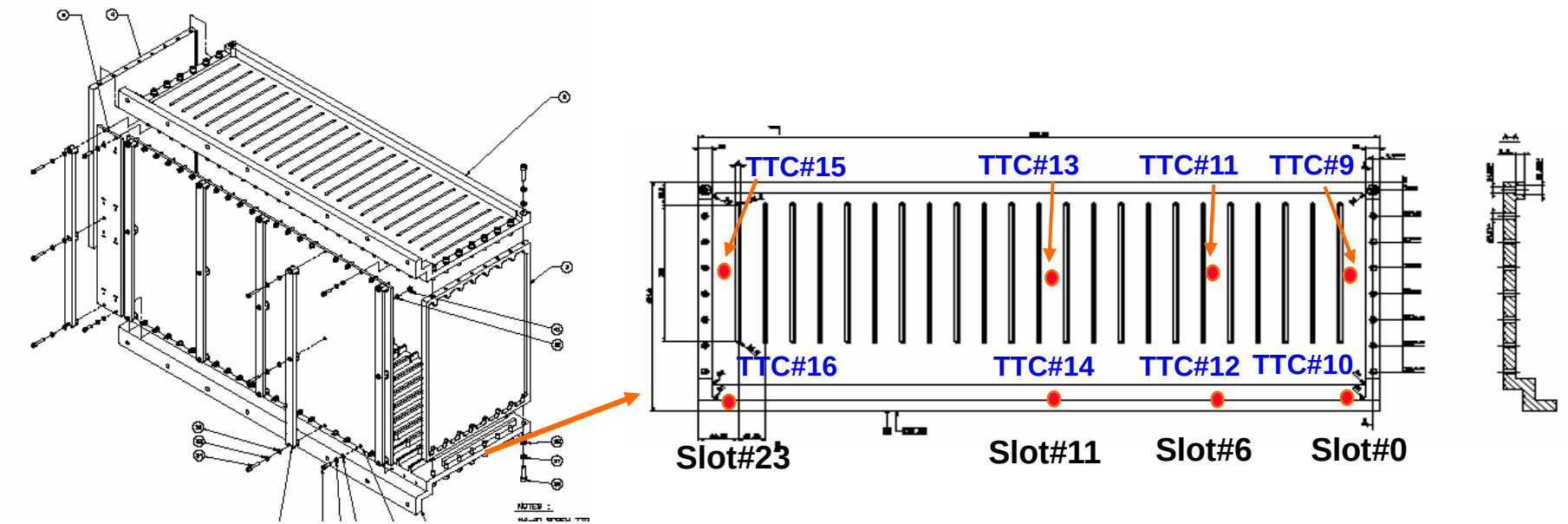


Figure 8 Test only heaters and thermocouples locations for right side wall

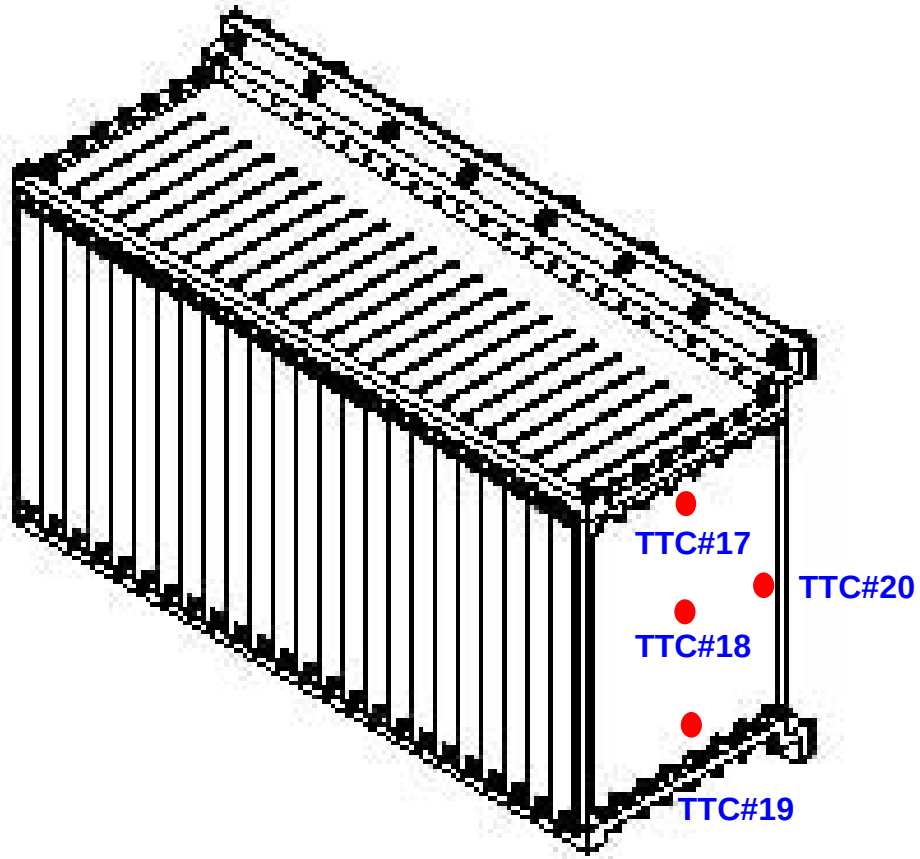


Figure 9 Test only heaters and thermocouples locations for left side wall

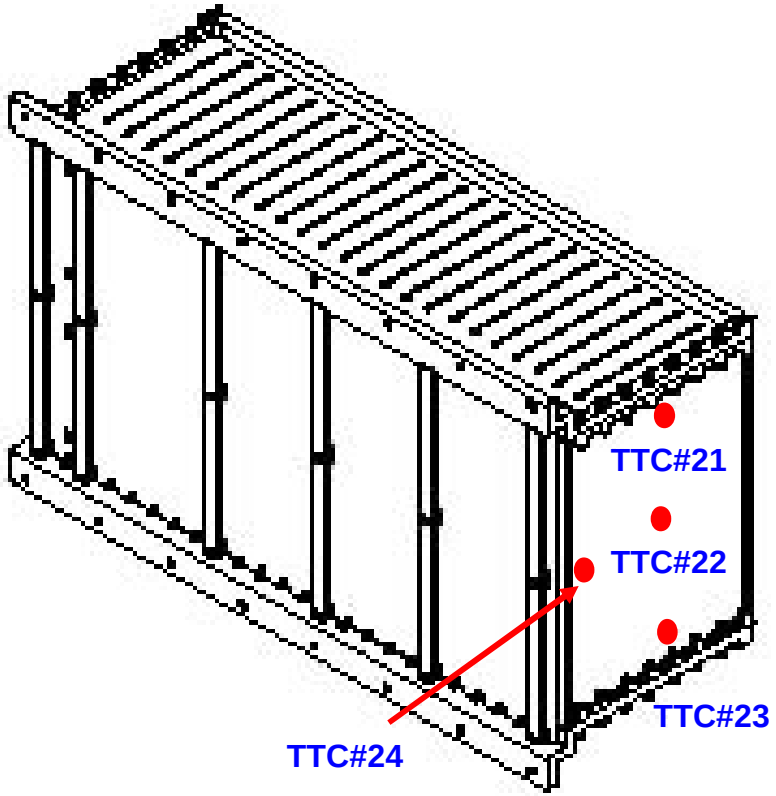


Figure 10 Test only heaters and thermocouples locations for back plane (mother board)

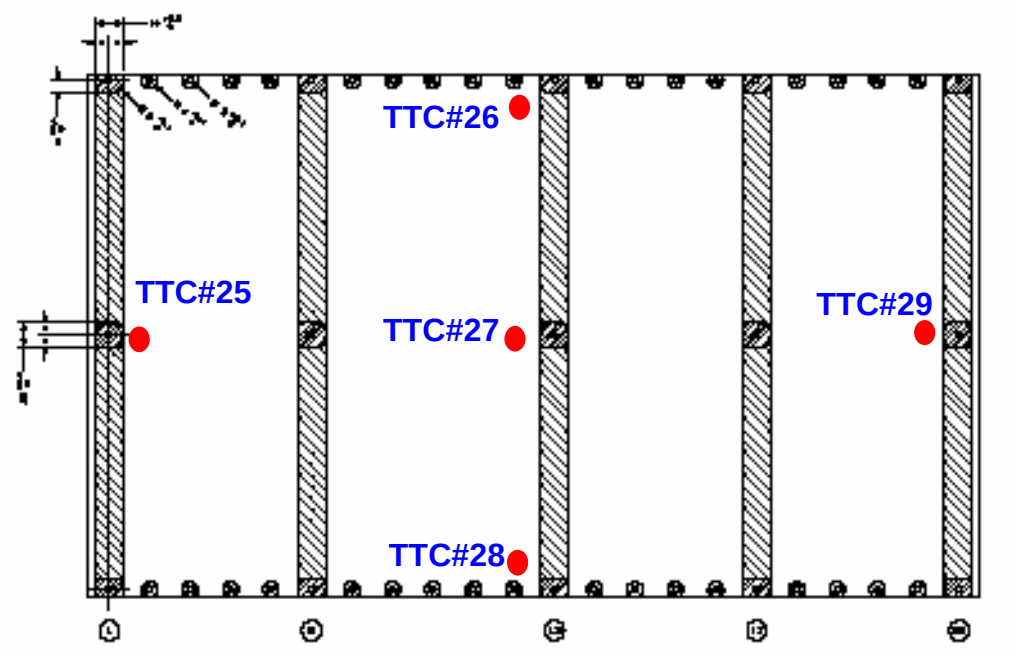


Figure 11 Test only heaters and thermocouples locations for front cover

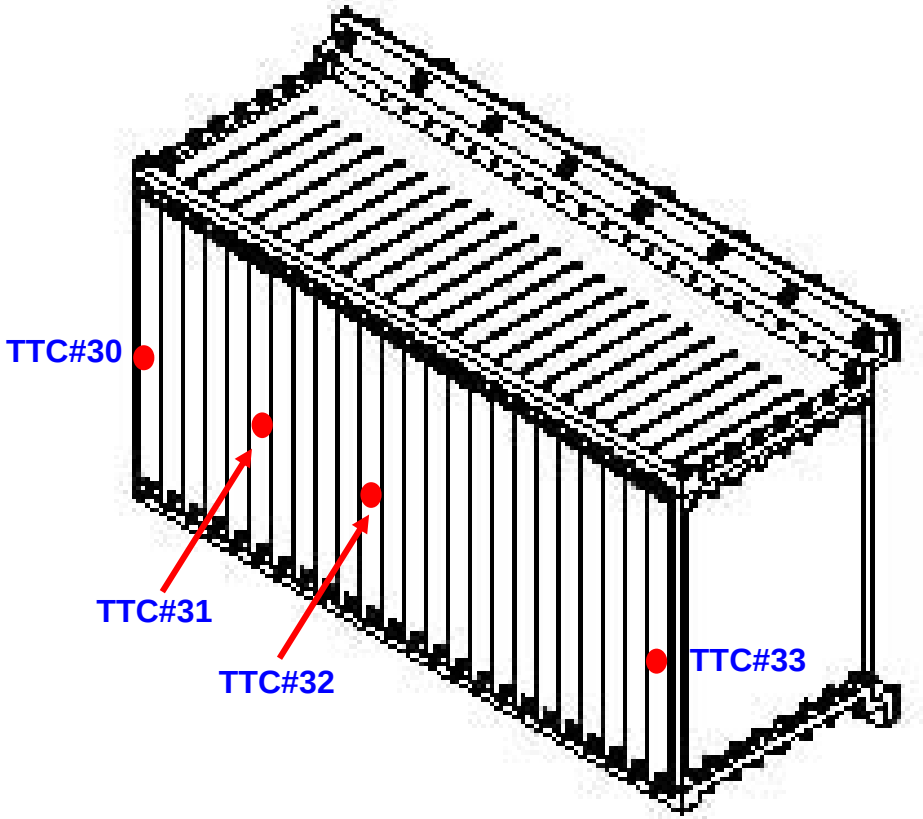


Figure 12 Test only heaters and thermocouples locations for JSBC (SLOT#6)

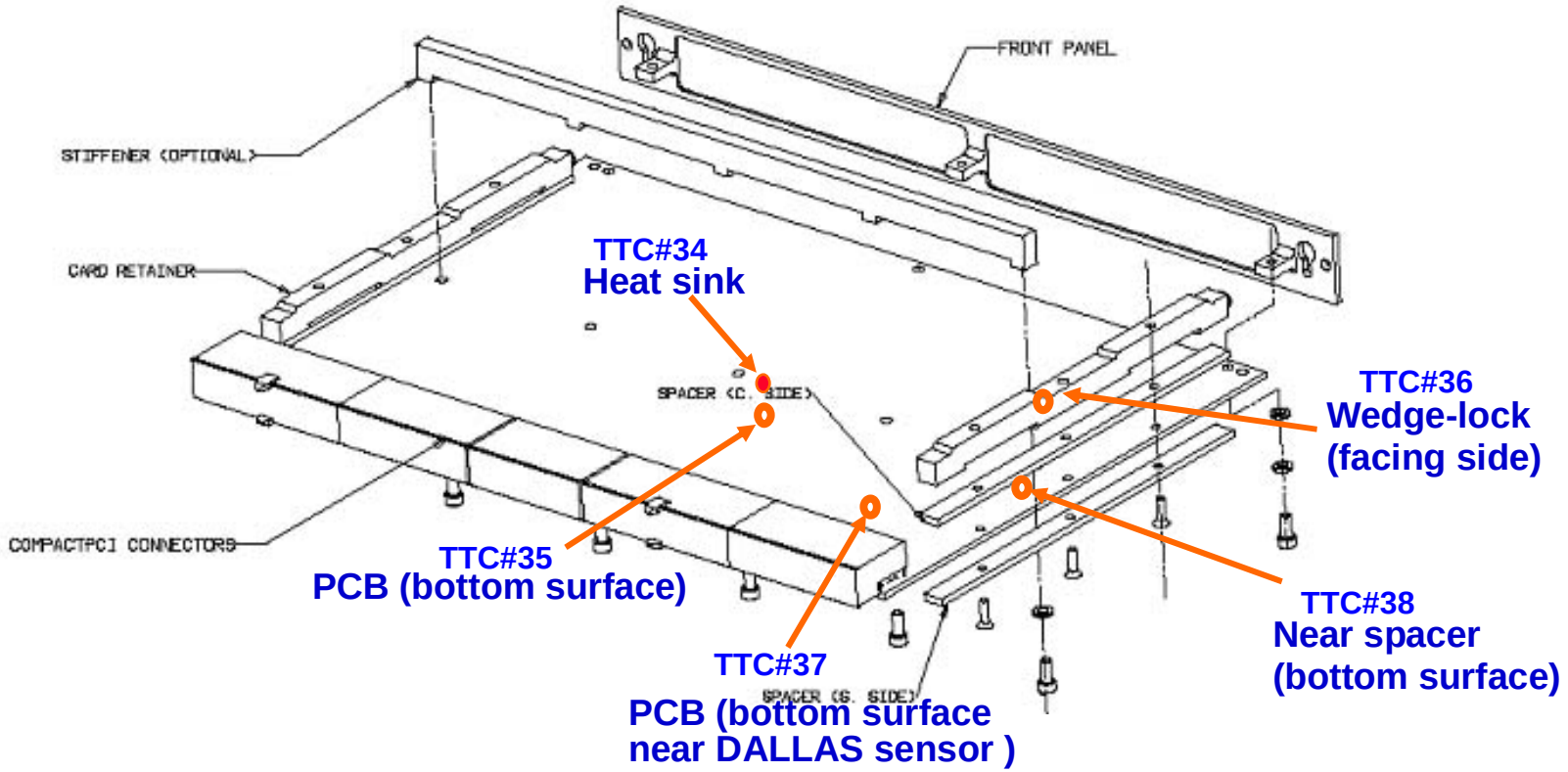


Figure 13 Test only heaters and thermocouples locations for JHIF board

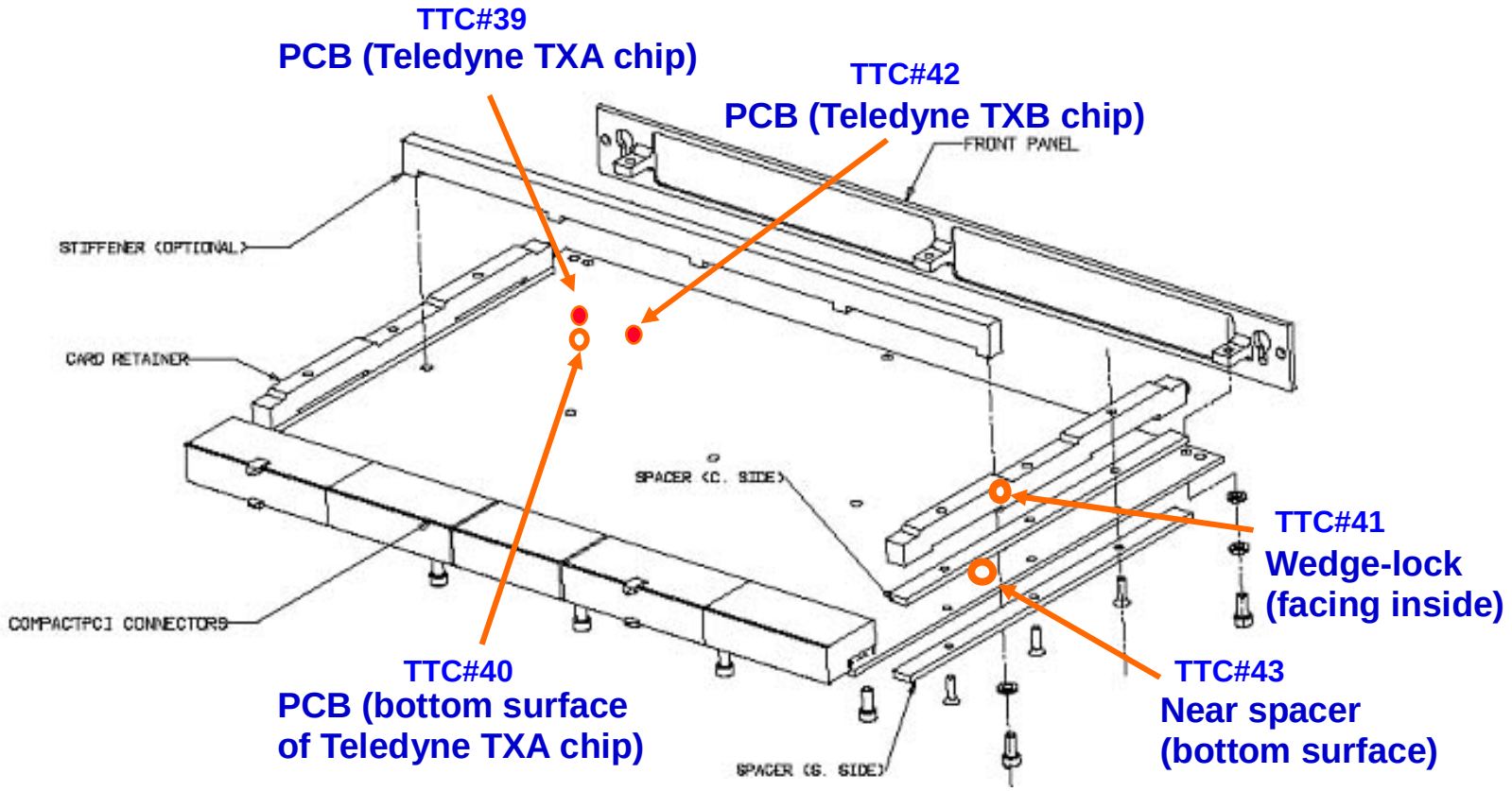


Figure 14 Test only heaters and thermocouples locations for mounting feet

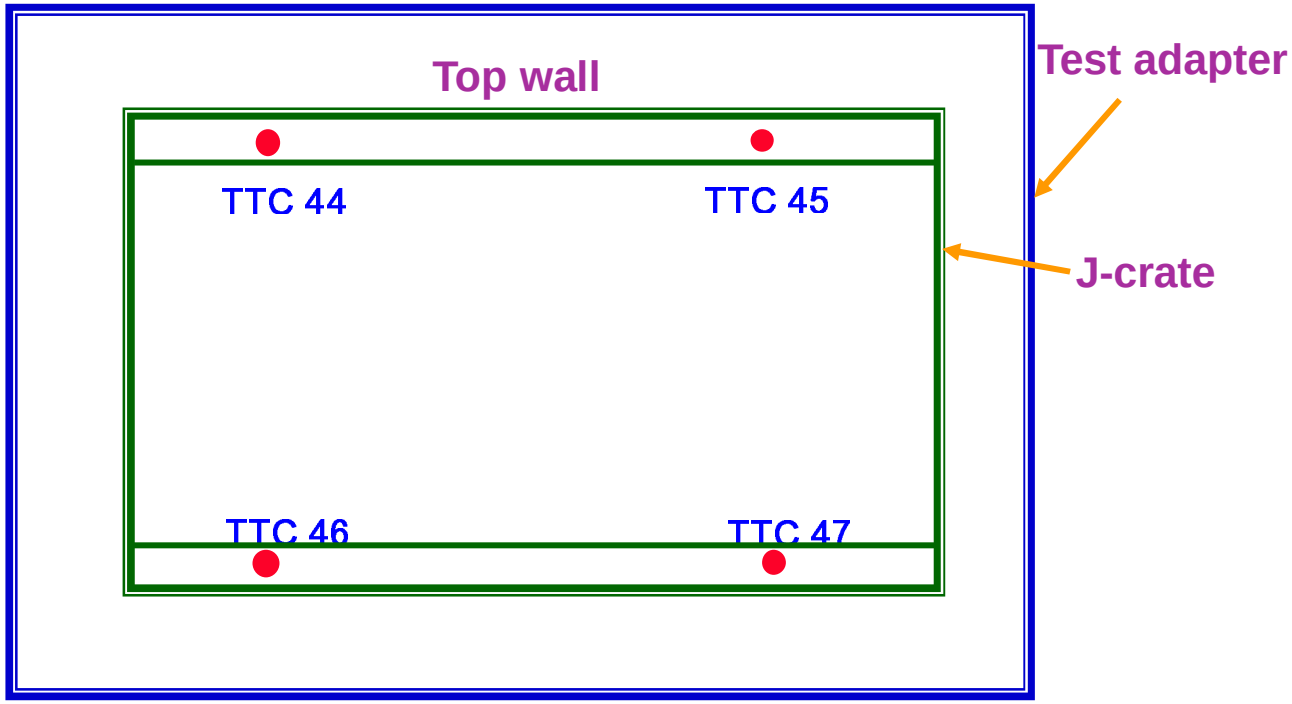


Figure 15 Test only heaters and thermocouples locations for test adapter

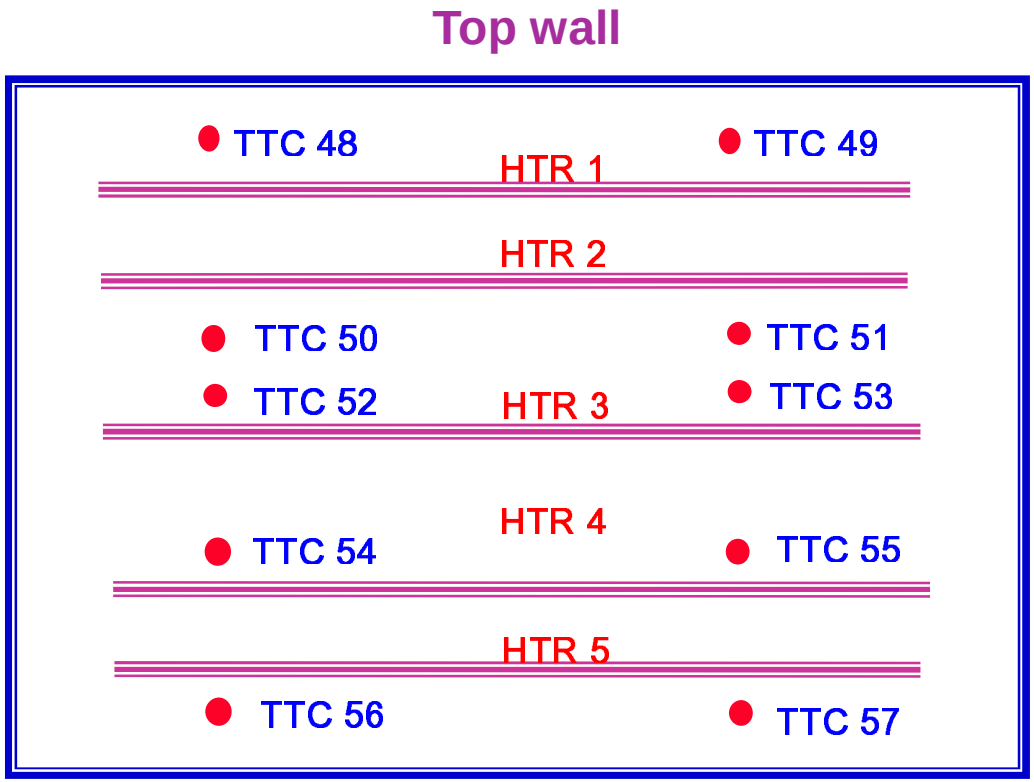


Figure 16 Test only heaters and thermocouples locations for thermal baseplate

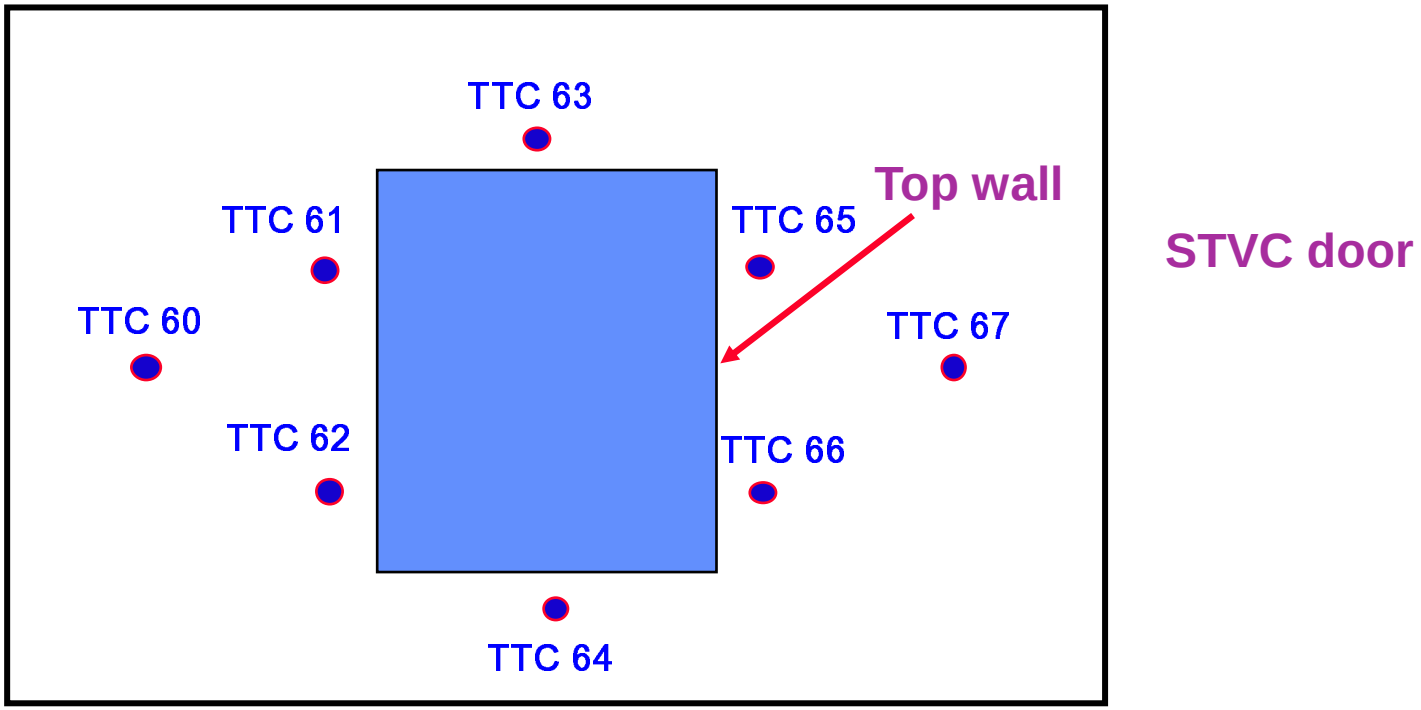
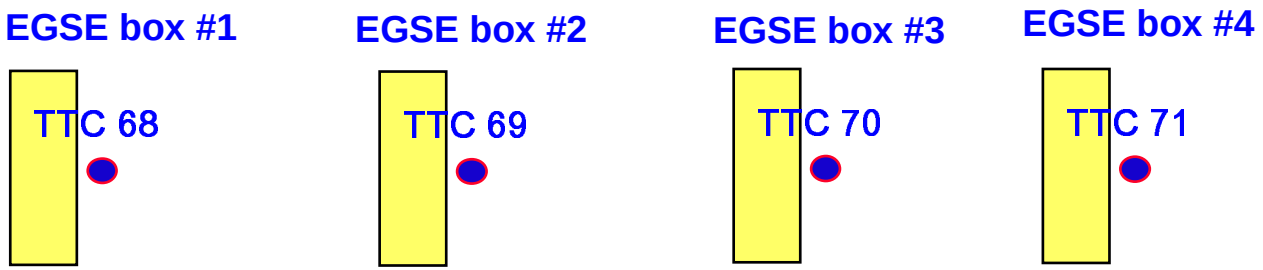


Figure 17 Test only heaters and thermocouples locations for EGSE boxes



APPENDIX A

CUSTODIAL TEST EQUIPMENT LISTING

(CTE)

CUSTODIAL TEST EQUIPMENT (CTE) LISTING

DATE_____

1 No.	2 Manufacturer	3/4 Model No./ Serial No.	5 CTE Note	6 GEN Note	7 Calibration due date	8 Remarks
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						

5. Custodial Test Equipment Notes

*R. Routine Calibration
*S. Special Calibration
*M. Maintenance (Preventative or corrective)
*C. Checkout

6. General Notes

1. This items is, or part of, a measurement system.
2. This item is support equipment.

_____QA

APPENDIX B

Test Procedures for J-Crate (QM) Environmental Tests

Test Procedures for J-Crate (QM) Environmental Tests

Version 2.0

November 11, 2002

1. Scope

This document is to specify the test procedures of all environmental tests for qualification modules (QM) of AMS-02 J-crate. The purpose of the test is to qualify the J-crate for use in a space environment.

The J-crate is specified by the design requirement document (rev. 6) and specification for each board. The interface details and functional test details are described in separate documents.

2. Software in J-Crate

There are four main DAQ computers (JMDC) in J-crate. They can be powered independently. Each JMDC has a single board computer (JSBC), a data buffer (JBU), an AMSWire and 1553 interface (JIM-AMSW/1553), a high rate data interface (JIM-HRDL/422) and an internal slow control interface (JIM-CAN). They are connected together by Compact-PCI bus.

The high rate data interface can use either fiber optical signals or synchronous RS422 signals. Both types of high rate data signals are interfaced by a single module (JHIF) to the outside. Only one link can be used at a time. Therefore, they cannot be tested in the same.

During the tests, each JMDC is running independently. The JDMC software have two parts, ROM monitor and test software. The ROM monitor processes only the startup related task. For test, it will load default test software from flash memory automatically after start up initializations when power is on. The special procedure will be described in appendix for download and boot new test software.

The test software is based on Hardhat Linux 2.4.2 operating system kernel. The operating system, test applications and configuration files are packed into one image file and stored into flash memory. ROM monitor will load the package from the flash memory and start its self-unpack and startup process. After the operating system starts, it will load all the device drivers and test applications automatically. The test applications will run according to the default configuration files stored in the package. Changing of the configuration files is possible only with a new test software package being loaded to the system. A few of the configuration values can be changed by commanding the system.

The services running on JMDC and related hardware are listed in the Table 1. Where, the master and slave is the meaning of the JMDC actions. The details about echo test, HK data report and command requests functions are described in J-crate functional tests document.

Table 1. JMDC Services and Related Hardware

Item	Hardware	Mode	Services
1	AMSWire Link 0 – 3	Slave	Serve for echo test, HK and command requests
2	AMSWire Link 4 – 6	Master	Echo test only
3	AMSWire Link 7 – 9	Slave	Serve for echo test only
4	CAN Buses	Slave	Serve for echo test, HK and command requests
5	JBU Memory	-	Memory test only
6	HRDL Fiber Link	Duplex	Send test data out, check the received data and serve for HK and command requests
7	HRDL RS422 Link	Slave	Serve for echo test, HK and command requests

Specially, software running on two universal slow control modules (USCM) are independent. They are only slaves to serve continuously the report of temperature data measured from the J-crate.

3. Software on Test Systems

Four PC computers are used to run test software outside the system under test. One PC is used to control and monitor powers for J-crate. It is named as PC-Power. The second PC has two AMSW-PCI cards. It will be called PC-AMSW. It will support AMSWire tests over 16 links. The third PC has one HRDL6 (Board 6) card, one Digi Sync570-PCI card and one Janz CAN card. It will be called PC-HRDL or PC-CAN. It handles all HRDL/422 tests and Can bus tests. The last one is named as PC-1553 and will test the STS 1553 bus interface of J-crate.

The test software are independent applications on each PC. They are to be started manually by the operators. The shortcuts of the test applications will be put to both start menu and desktop. The test applications and their functions are listed in Table 2.

Table 2. Applications on Test Systems and Their Functions

Item	Name	Hardware	Mode	Functions
1	amsw_test	AMSW-PCI cards	Master	Make echo test and HK & command requests
2	hrdl_test	HRDL6 cards	Duplex	Send echo data, check received data and process HK and command replies
3	ddrs2	Digi 570 cards	Master	Send echo data and check received data. The received data can be recorded
4	can_test	Janz CAN card	Master	Make echo test to all JMDC, request for HK data and USCM temperature data
5	minicom	PC COM ports	-	Terminal emulator JSBCs
6	ams power control	NI DAQ card	-	Control power supplies and power switching box operations. The power supplies voltages and currents should be recorded.
7	hrdl_boot	HRDL6 card	Master	Send boot command and load file to JMDC via HRDL link
8	hrdl_load	HRDL6 card	Master	Load file to JMDC via HRDL link
9	hrdl_time	HRDL6 card	Master	Set time to all JMDC via HRDL link
10	amsw_boot	HRDL6 card	Master	Send boot command and load file to JMDC via HRDL link
11	amsw_load	HRDL6 card	Master	Send boot command and load file to JMDC via HRDL link
12	amsw_time	HRDL6 card	Master	Send boot command and load file to JMDC via HRDL link
13	hrdl_ctrl	AMSW-PCI cards	Master	Send command to HRDL process via AMSWire links

4. Common Procedures

This section defines the common test procedures in some typical test condition. They are used in different environment test and referred as a single step.

4.1.1.1.4.1. Power On Procedure

We will use common power up procedure to turn on the system in all cases. This procedure will be referred as “power on” in all following sections. The procedure includes the following steps:

1. Stop all running processes for AMSWire, HRDL/422 and CAN if any of them are running.
2. Start four “minicom” terminal emulators for four JMDCs to monitor each JMDC boot up status.

3. Start a terminal on PC-HRDL to be ready for sending “time” command.

4. Turn on AC for all power supplies and power switching box.
5. Set power switches for JFOM-A, JLIF and USCM to position “on”.
6. Set switches for the JMDCs you would like to turn on to position “on”.
7. Use software to turn on the power supplies together.
8. Watch all JMDCs boot status in minicom.
9. When ROM monitor initialization has finished, using “hrdl_time” command on PC-HRDL to all JMDCs.

4.1.1.2.4.2. Power Off Procedure

The power down is also a common procedure for all cases. It will be referred as “power off” in the following sections. The steps are as below.

1. Use software on PC-Power to turn off DC of all power supplies together.
2. Stop to record valtages and currents.
3. Stop CAN test program on PC-CAN.
4. Stop amsw_test program on PC-AMSW.
5. Stop hrdl_test program or ddrs2 program on PC-HRDL.

4.1.1.3.4.3. Switching HRDL and RS422 links

There are four parts of high rate data interface, JFOM-A, JFOM-B, J422-A and J422-B in J-crate. The JFOM-A, JFOM-B and J422 are not powered at the same time. Two RS422 links are powered together but only one of them can transmit data. There are special procedures to switch these links.

The procedure is to specify the test for different parts of high rate interface. It is referred as “HRDL switching”. The switching time is related on the requirements of environmental tests. They will be defined later in this document. The switching steps are listed as following.

6. All JMDCs will be started in HRDL RX mode only by default after power is on.
7. Use “hrdl_ctrl” program on PC-AMSW to enable the HRDL TX on the first JMDC.
8. When HRDL switching time reached, use “hrdl_ctrl” to disable HRDL TX on the first JMDC and then enable the TX on the second JMDC.
9. Repeat step 3 for all JMDCs which are powered.
10. After the last JMDC has been tested with JFOM-A, change JFOM-A power switch to “off” state and then switch on JFOM-B. The loopback test will continue on this JMDC. The PC-HRDL stop receiving data.
11. Stop “hrdl_test” program on PC-HRDL.
12. At HRDL switching time, use “hrdl_ctrl” to disable current HRDL TX and enable the HRDL TX for the next JMDC.

13. Repeat step 7 until the last JMDC.
14. After the last JMDC, use “hrdl_ctrl” to set all JMDCs to RS422 receiving mode only.
15. Switch off JFOM-B and switch on J422 power.
16. Connect Digi570 cable to J422-A box.
17. Start “ddrs2” program on PC-HRDL.
18. Use “hrdl_ctrl” to enable RS422 TX on the first JMDC.
19. Like HRDL part, disable previous JMDC TX and enable the next until the last JMDC.
20. Change Digi570 cable to J422-B box.
21. Repeat step 14 for check J422-B.
22. Switch off J422 power.
23. The step 2 – 17 can be repeated as many times as you want, but before going back to step 2, you have to use “hrdl_ctrl” to set all JMDC in HRDL RX mode and then switch on JFOM-A power.

4.1.1.4.4.4. Power-on Test Procedure

The processors booting is the most difficult step during system powered on especially for the temperature cycles and thermal-vacuum test. It is important to make special tests on this part. The steps are listed here.

24. Power on
25. Watch all four JMDC’s booting status until all test applications started in all JMDCs.
26. Power off
27. Wait for about 1 min.
28. Repeat 3 – 5 times of step 1 – 4. The test can be ended at the power on stage (step 2) to continue four JMDCs tests.

4.1.1.5.4.5. Test Procedure for JMDCs

This section specifies the procedure for test JMDCs. The number of JMDCs under test can be 1 to 4. When four JMDCs are testing together, it may be dangerous at the high temperature and should take special care this case. We will limit maximum running time for this situation to 20 min. at high temperature.

The following items will be done for the test. The HRDL switching time can be calculated by the total test time divided by 4 and the divided by number of JMDCs under test.

29. Power on or continue of power-on test.
30. Start amsw_test on PC-AMSW.

31. Start hrdl_test on PC-HRDL
32. Start CAN test program on PC-CAN to make “echo” test with JMDCs and read temperature data fromUSCMs.
33. Using hrdl_ctrl program on PC-AMSW to turn on TX for the first JMDC which is on.
34. Switching HRDL according to the HRDL switching time defined.
35. The test continues until the total test time reached.
36. Power off or continue with other tests.

5. Environmental Test Procedures

The AMS-02 J-crate environmental tests has following items:

37. Temperature cycles.
38. Vibration test
39. Electro-Magnetic Interference (EMI) test
40. Thermal Vacuum Test

Since they have different test requirements, we will use different test procedure during each test. They are described in the following sections.

5.1.1.1.5.1. Vibration Test Procedure

The vibration test will be done for three directions. The total test time for each direction is about 10 min. Since time is short, there will be no time to switch JMDCs. In order to test all JMDCs in during the vibration, we will use the test procedure for four JMDCs here and the vibration should start only when all test applications are started (step 4).

The test will not be stopped until the vibration is stopped.

41. Power on before vibration started
42. Start test for four JMDCs
43. Power off after vibration stopped.

5.1.1.2.5.2. Temperature Cycles

The temperature cycles will use the test profile shown in Figure 1. The functional test will be in the first 2 – 4 cycles and the last 2 – 4 cycles. The middle cycles will run without functional tests. Each functional test time is about 1 - 2 hours.

Since the worst case is different in the high and low temperature stages, the test procedures will be different in these two cases. The test procedure at the high temperature is the following.

44. Power-on test should be at the beginning.
45. Continue with four JMDCs test for 10 – 20 min.

46. Power off
47. Power on with two JMDCs. The first high and low stages start with group A first and the next high and low stages start with group B.
48. Test two JMDCs together. The group testing time is about one hour.
49. Power off
50. Power on the other group of JMDCs.
51. Repeat step 5 – 7 until the end of test.
52. Power off.

The test procedure at the low temperature is specified as the following.

53. Power-on test should be at the beginning.
54. Continue with two JMDCs test as specified for high temperature stage.
55. At the last 10 – 20 min. power off.
56. Power on with four JMDCs
57. Start four JMDCs test until the end.
58. Power off.

5.1.1.3.5.3. Electro-Magnetic Interference (EMI) Test

The EMI test consists of a lot of short tests to test different items. Each test will last about 20 – 30 min. The worst case is to running all four JMDCs. Therefore we will use the test procedure for four JMDCs during the whole test period.

59. Power on.
60. Start four JMDCs test.
61. Power off.

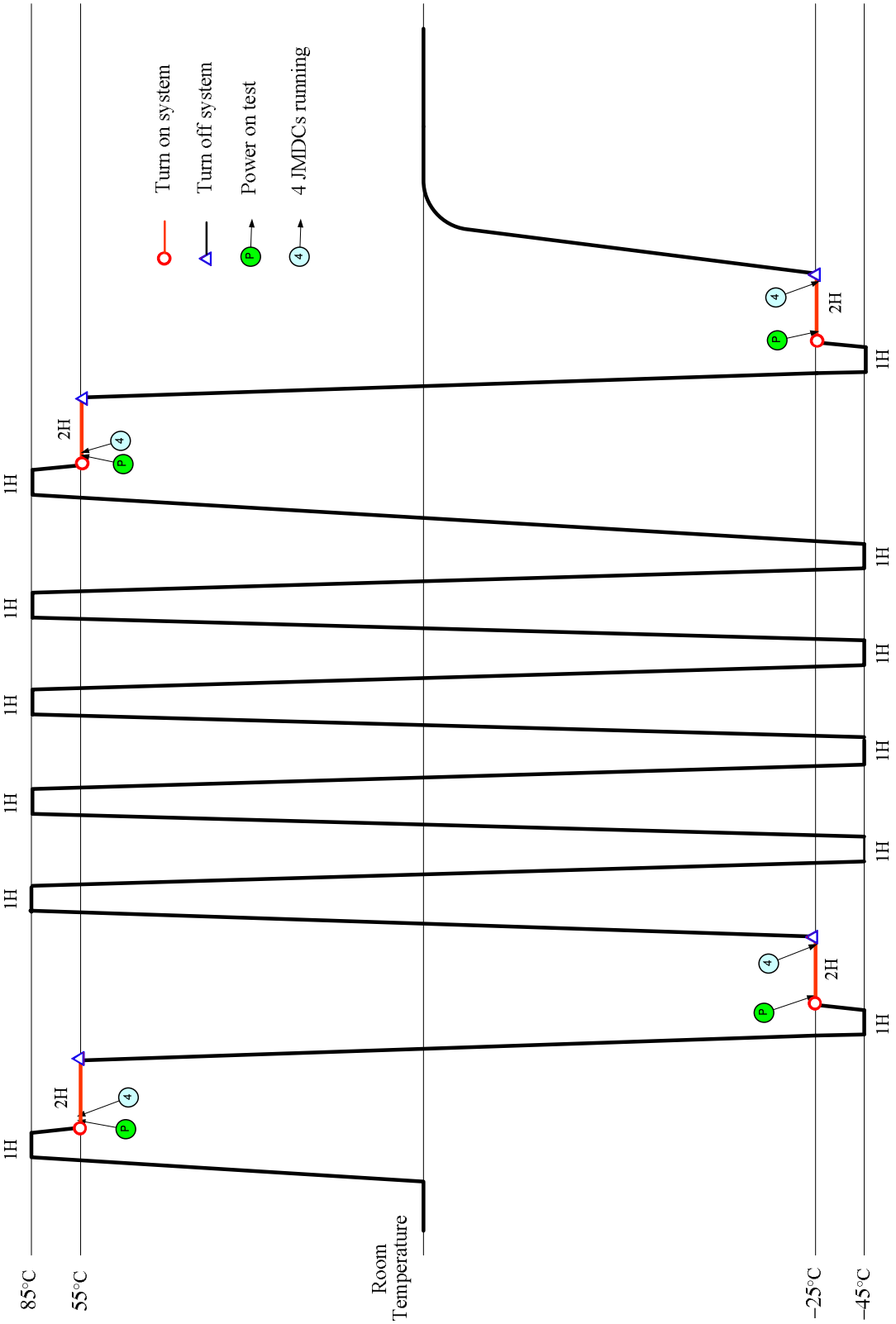


Figure 1. Test Profile for Temperature Cycles

5.1.1.4.5.4. Thermal Vacuum Test

The thermal vacuum test profile is shown in Figure 2. The functional test time is much longer than the temperature cycles. But it still has the different worst case at high and low temperature as temperature cycles.

The tests at both high temperature and low temperature will be the same as the temperature cycles. There will be no special tests during the middle cycles. The test for two JMDCs will run alternatively for two groups until the specified stop time.

In the cold and hot balance test, we will use only JMDC 1 for test and no HRDL switch during this test.

62. Power-on JMDC 1.
63. Start one JMDC test procedure nothing to touch again until the end of test.
64. Power off.

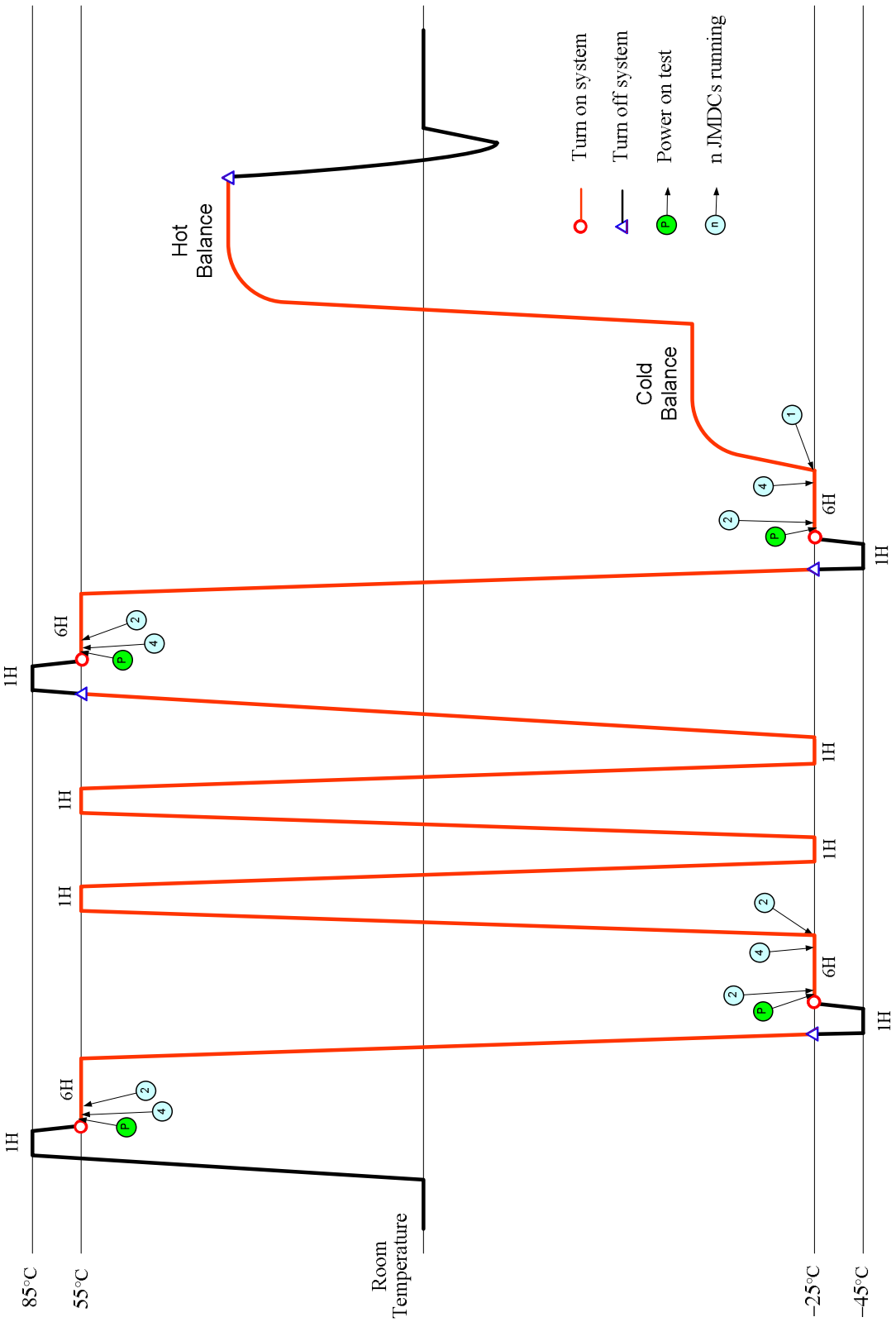

Turn on system
Turn off system
Power on test
n JMDCs running
Hot Balance
Cold Balance
Room Temperature
85°C
55°C
−25°C
−45°C
1H
6H

Figure 2. Thermal-Vacuum Test Profile

5.1.2. Appendix A. Procedure to Load New Programs

The boot command with file load will follow the steps in below.

65. Power off all JMDCs.
66. Stop “amsw_test” on PC-AMSW
67. Stop “hrdl_test” on PC-HRDL
68. Stop “can_test” on PC-CAN
69. Power on the JMDC you want to boot and JFOM-A.
70. After JMDC start to wait for time, use “hrdl_boot” to reboot JMDC and send file to JDMC.

The “hrdl_boot” software has options to select JMDC number, to choose file, flag for save file to flash and to choose the flash number (0 – 7).

5.1.3. Appendix B. Check List for Vibration Test

(add later)

5.1.4. Appendix C. Check List for Temperature Cycles

(add later)

5.1.5. Appendix B. Check List for EMI Test

(add later)

5.1.6. Appendix B. Check List for Thermal-Vacuum Test

(add later)