STEREO BOOM Thermal Vacuum Cycling Test Procedure
Document #IMP-563-DOC
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REVISION: A
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1. Scope

This document defines the test procedure of the STEREO Deployable Booms thermal vacuum cycling. The STEREO Booms are designed, assembled, and tested by the Space Sciences Lab at the University of California, Berkeley (UCB). All testing will be performed at the newly constructed UCB 'High Bay' Thermal Vacuum Chamber. In addition to this thermal vacuum cycling test, a thermal balance test shall be performed on the Protoflight (Flight Spare) unit. That test procedure shall be in a separate document.

2. Unit Under Test (UUT)

2.1. Description

The UUT is to be a completed STEREO Boom mechanical assembly, consisting primarily of a compact nested series of composite tubes, mechanical releasing devices, electronics boxes, magnetometer, and blankets. The primary requirement of the device is to provide a compact structure during satellite integration, test, and launch and to deploy in orbit to extend the sensing devices approximately 3 and 4 meters from the spacecraft.

The Boom Assy has two configurations, Stowed and Deployed. The Stowed configuration (integration and test) is as shown in Figures 1 & 2 and the Deployed (in-orbit) configuration in Figure 3. The entire unit weighs approximately 11.8 Kg. without instruments,

The Deployment of the Boom must take place in the Vertical configuration to offset the effects of 1G loading. To achieve this testing, in addition to the Boom Assembly, the test set-up will have a counterweight system designed by UCB to allow removal of gravity loading on the Flight Hardware during deployment testing. (The system was designed for deployment in zero gravity and may not be deployed at one G.)

2.2. Quantity and Type

The STEREO program will construct and test three complete Boom Assemblies (two flight and one flight spare).

The two flight units will be tested with the Magnetometer instrument installed in flight configuration. The test will encompass the requirements for these instruments. The SWEA, STE-D, and STE-U instruments will not be installed to minimize the risk of damage due to the counterweight system and contamination from hardware that is not yet baked out.

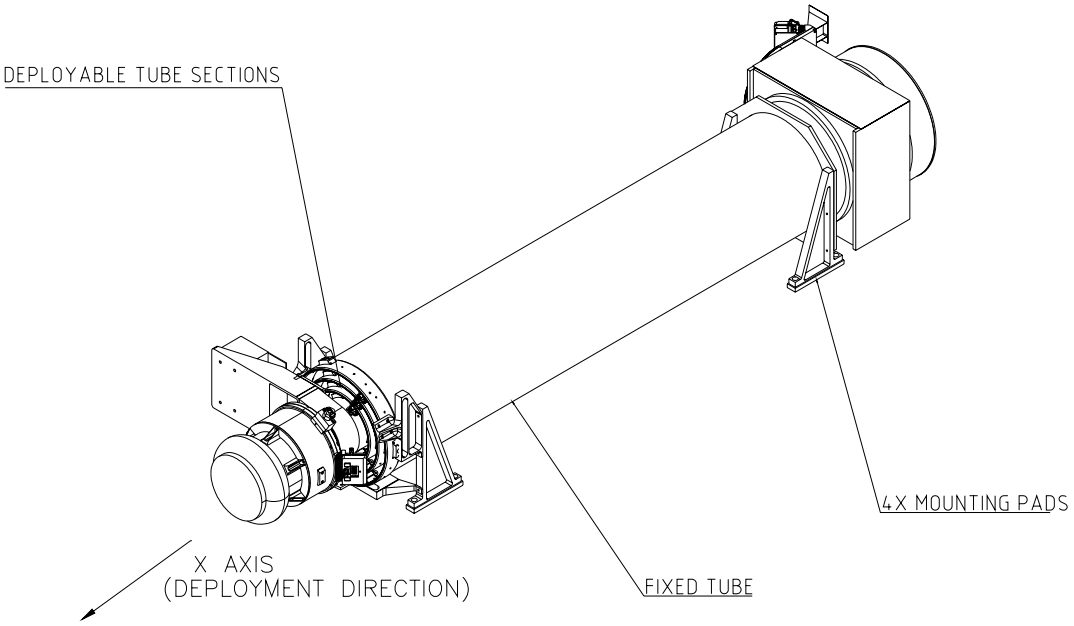


Figure 1: STEREO BOOM ASSY, STOWED CONFIGURATION

3. Testing Required

The thermal vacuum testing has four main goals in qualification of the assembly for Flight use:

3.1. Thermal Bakeout

In the Stowed configuration, the assembly will be baked out under vacuum for a minimum of 8 and a maximum of 48 hours at a minimum temperature of 40 degrees C. This bakeout shall be monitored by TQCM at a temperature of –20 degrees C for a period of 8 hours with a goal of reaching a TQCM measurement of no more than 165 Hz/hr rise from the TQCM, excluding background chamber rate.

3.2. Thermal Cycling

In the stowed configuration, under vacuum the assembly will be thermally cycled a total of seven times from a low of -33° C to a high of +40° C. This gives a minimum 10°C margin on the predicted temperature extremes of -22.5°C to +16.5°C. At each extreme, the unit shall be thermally soaked as specified in APL Document #7381-9003, “STEREO Environmental Definition, Observatory, Component and Instrument Test Requirements”, which states a soak is one (1) hour after all thermocouples are within three (3) degrees of the setpoint with a slope of less than one (1) degree rise per hour (See Figure 4). Based on data from the Protoflight Thermal Vacuum Cycling this will yield a cycle duration of approximately (5) hours per soak.

3.3. Functional Deployment

Following 3.1 and 3.2 and under vacuum, the stowed Boom Assembly will be energized and functionally deployed to its fully deployed configuration. This deployment will occur twice in the testing sequence, at the hot temperature after the hot soak of the 7^{th} cycle and at the low temperature following another complete thermal cycle of both hot and cold.

3.4. Instrument CPT

During thermal cycling, the Magnetometer instrument will be given Comprehensive Performance Tests (CPTs). These tests will occur during the hot and cold soaks of each dwell.

4. Schedule and Durations

Entire test will take approximately 4 days to get through all the required thermal cycles. The test will be monitored at all times during testing by UCB personnel.

5. Tank Configuration

5.1. Geometry

The tank is to be as shown in addendum and is able to accept UUT in both Stowed and Deployed configurations (See Figures 1,2, and 3). The orientation of the UUT is to be so that the X-Axis is vertical in the tank to allow for proper deployment configuration with counterweights. Additionally, the entire Boom, in the Deployed state, must be accessible by a technician to allow manual (hand) stowing. (Unit cannot be stowed automatically.) Approximately, tank must be at least 2 meters by 2 meters by 6 meters tall.

5.2. UUT Attachment

The Tank Base Plate is to be approximately 400 mm by 1 meter and have inserts or tapped holes to accept ¼" bolts as shown in Figure 2. The UUT is to be attached to the Base Plate via these bolts. No additional thermal interface materials (G-10 spacers, thermal greases, Teflon, etc.) are required.

5.3. Heater and Cooling Methods

Kapton Heaters will be used to heat and control the hot cycles; Liquid Nitrogen with associated valves and plumbing will control the cool cycles.

5.4. Real-Time Visual Inspection Feature

The majority of the testing sequence may be accomplished without visual inspections of the UUT. However, at the final deployment of the mechanism, it is required to have visual inspection to monitor progress and verify full deployment. An acceptable viewing/inspection port or ports or an electronic camera that provides real-time visual imagery of the deployment may fulfill this requirement.

5.5. Shroud and Additional Heating Plates

The facility shall provide Base Plate, Heating/Cooling Shrouds, and any other required heating plates.

6. Vacuum System Requirements

The Vacuum System shall be sufficient to run continuously at the range of low 10^{-5} Torr with goal of 10^{-6} range. Vacuum apparatus to be cryo system to prevent any contaminating oils from entering chamber at any time.

System to have provisions to supply super pure Nitrogen gas backfill at completion of testing.

7. Data Acquisition

In addition to SOP testing data acquisition, the STEREO Boom shall have a minimum of 8 thermal couples mounted on the UUT. Mount all TCs on Flight Hardware using Kapton tape; record all channel numbers.

8. Monitoring and Control

Deployment of Boom will require verification of full and complete deployment. Visual inspection will be necessary and will be provided by the Facility without opening the chamber door and breaking vacuum. Acceptable inspection features include Inspection Ports with acceptable fields of view to see entire boom deployment or an internal camera. Viewing is to be required only twice during test to verify full deployment after the hot and cold case deployments; constant monitoring will not be required.

TABLE I: Test Sequencing and Requirements

#	Event	Remarks
1	Hardware Arrival at Facility	
2	Certification of Chamber (Empty)	TQCM <100 Hz/Hr at -20°C; minimum of 8 Hours of TQCM data collection
3	Installation of Flight Hardware	UCB
4	Hook-Up of Controls and Heaters	UCB/Facility Technicians
5	Vacuum Pump-Down to High Vacuum	Low 10^{-5} Torr or better
6	Ramp to +40°C	Rate not to exceed 3°C/Minute
7	Hot Soak at +40°C	Hold +40° for 1 Hour, Mag CPT
8	Ramp to –33°C	Rate not to exceed 3°C per Minute
9	Cold Soak at –33°C	Hold -33° for 1 Hour, Mag CPT
10	Repeat Sequence 8-11 for a total of 6 Cycles–	
11	Ramp to +40°C	
12	Hot Soak at +40°C	Hold +40°C for 1 Hour, Mag CPT
13	Deploy Boom	Record with Video
14	Cool to RT/Vent/ Break System	
15	Remove and Stow Boom	Real Time Visual Inspection
16	Install stowed Boom into Chamber, Pump Down to High Vacuum	
17	Bakeout UUT	+40°C Bakeout for minimum of 8 hours or a maximum 48 hours or until TQCM at –20°C has a rate increase less than 165 Hz/Hr
18	Repeat Sequence 8-11 for a total of 1 Cycle	
19	After –33ºC Soak, Deploy Boom	Record with Video
20	Heat to RT/Vent/Break System	
21	Remove and Stow Boom	Real Time Visual Inspection, END OF TEST

Contained in Software Script STEREO TV 3.0

9. Contamination Control

9.1. General Guidelines

Flight hardware will be assembled clean prior to arrival at test facility. For the majority of the testing, the UUT shall be maintained in a Class 10,000 Clean Room or better. For short periods (loading/unloading into chamber, short transitions) the UUT may be exposed to Class 100,000 Environment.

9.2. TQCM Monitoring

During all testing, a minimum of one TQCM shall be provided by the Facility to constantly monitor NVR in the system. The TQCM shall be run at –20°C.

9.3. Certification of Empty Tank Prior to Testing

Prior to the start of testing, the tank shall be cleaned by the facility and certified via TQCM means to verify cleanliness. The Level of Cleanliness shall be less that 100 Hz/Hour with the TQCM at -20°C and the chamber at bakeout conditions.

10. Safety

The Boom Assy requires handling of delicate Flight Hardware and Instruments. No additional or unusual safety precautions are required. There are no pyrotechnic devices, radiation emitters, high voltage systems, high force preloaded energy mechanical devices, or dangerous chemicals.

11. Hardware and Test Responsibility

Hardware responsibility as defined in Table 2.

12. Control and Certification

All test control technicians will be trained and certified by UCB personnel prior to start of testing. This document assumes trained personnel and will not attempt to detail the operations of the vacuum system, thermal control system, and detailed procedures of using the equipment.

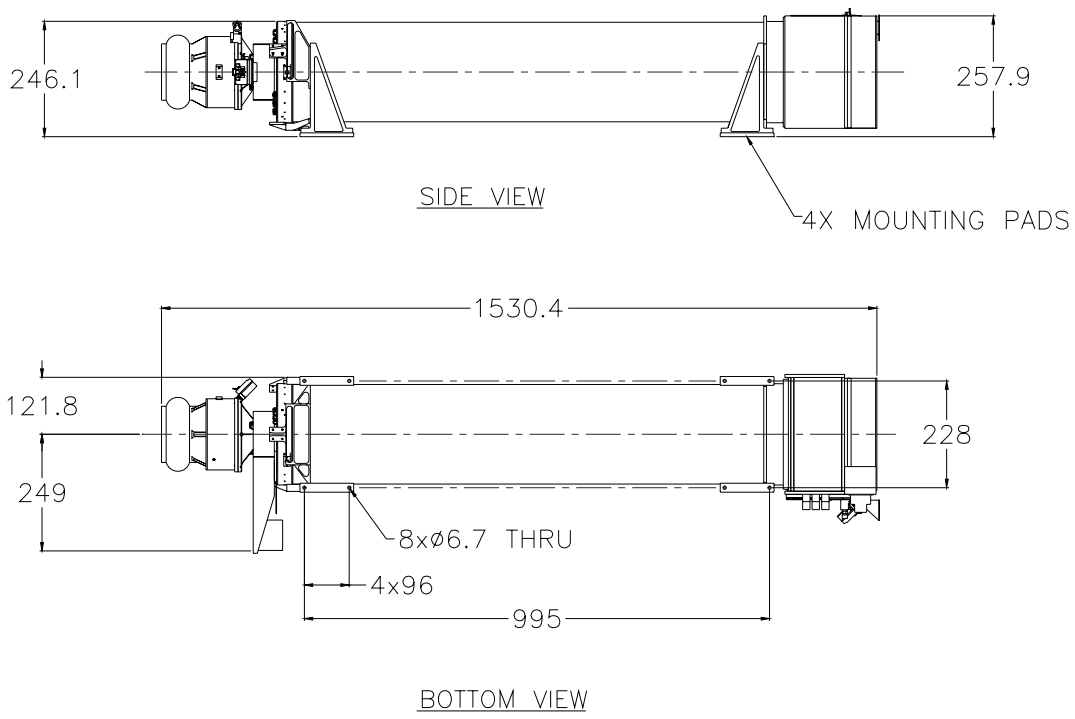


Figure 2: OVERALL DIMS OF STOWED BOOM ASSY (Dimensions in mm)

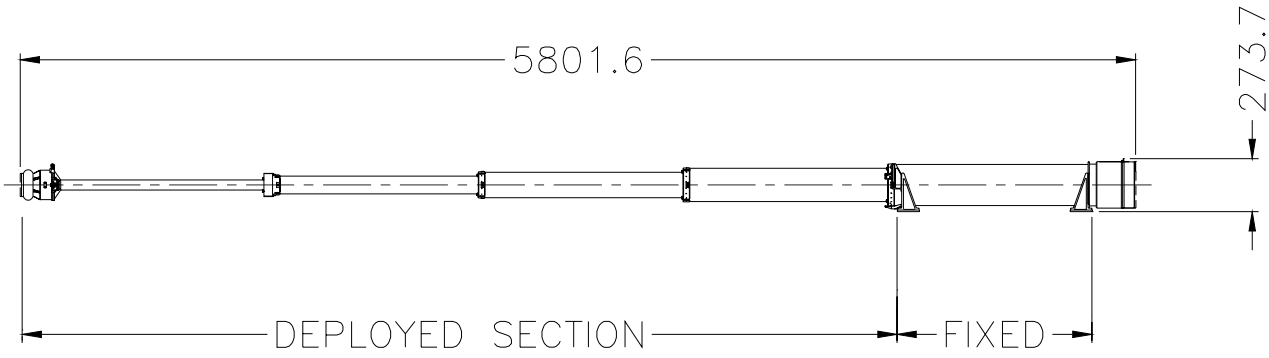


Figure 3: DEPLOYED CONFIGURATION (Dimensions in mm)

TABLE 2: Hardware Responsibility Matrix

Item	Provider	Remarks
UUT	UCB	See Figures 1,2, & 3
UUT Attach Bolts	UCB (Quantity: minimum 8)	
Base Plate	Test Facility	Tapped Holes required per Figure 2.
Thermal Shroud/Heating Plates	Test Facility	
Thermocouples	Test Facility	In addition to Test Facility Requirements, UUT requires minimum 8
Feedthru Plate and Feedthrus	Test Facility	UCB requests one 15-Pin Connector for Test Article Use (In addition to thermal monitor and control)
Clean Room and Supplies	Test Facility	
TQCM(s)	Test Facility	

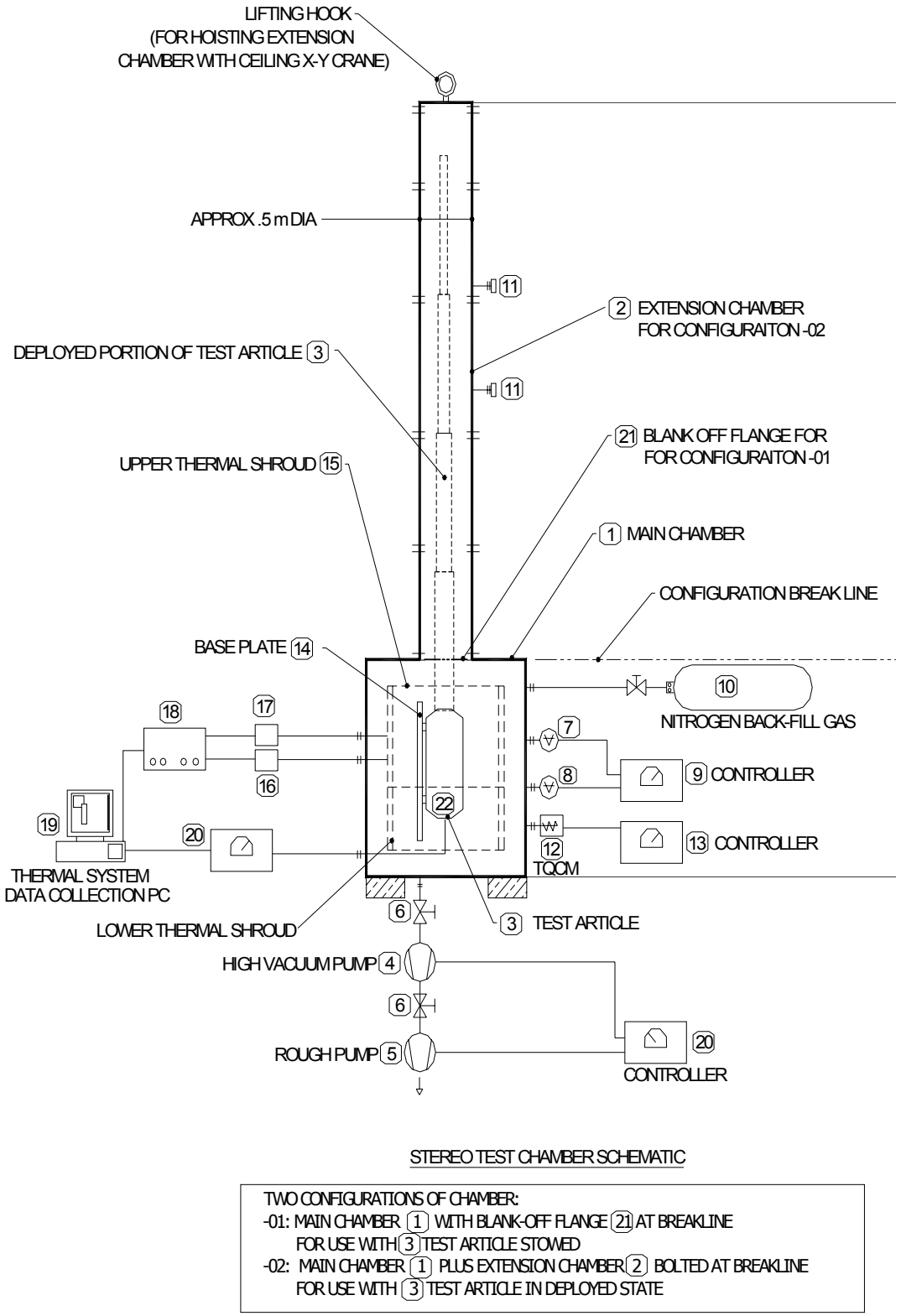
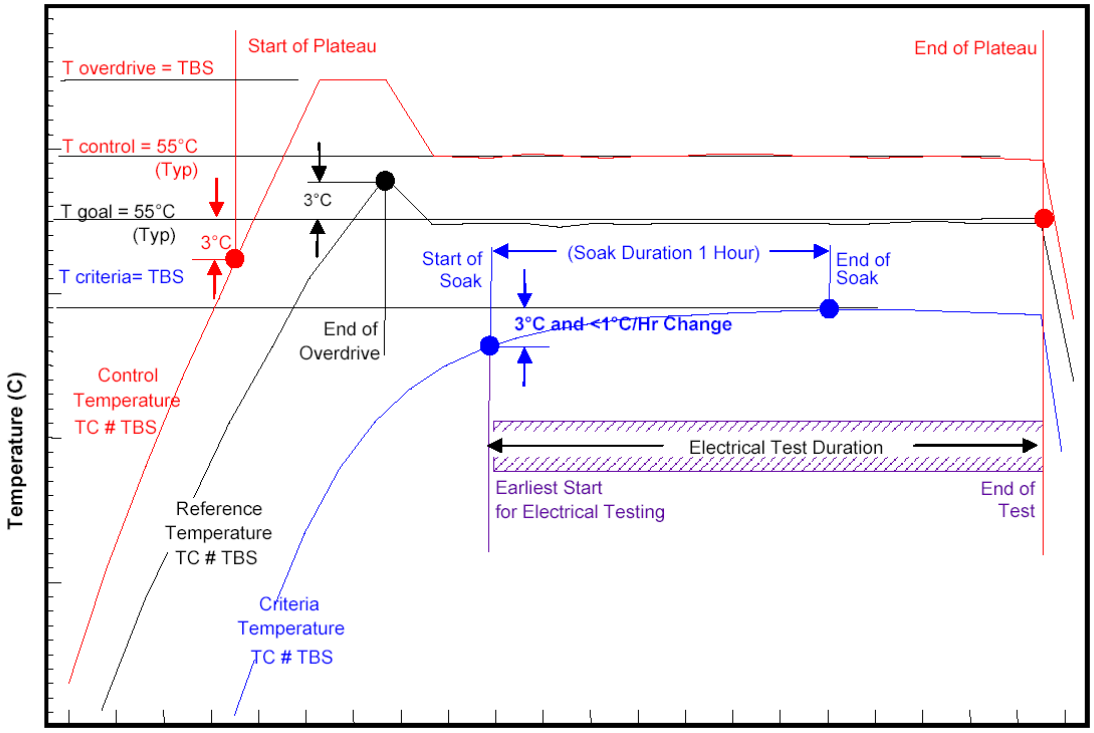


Figure 3: Stereo Test Chamber Schematic

Transition to Hot Soak



Transition to Cold Soak

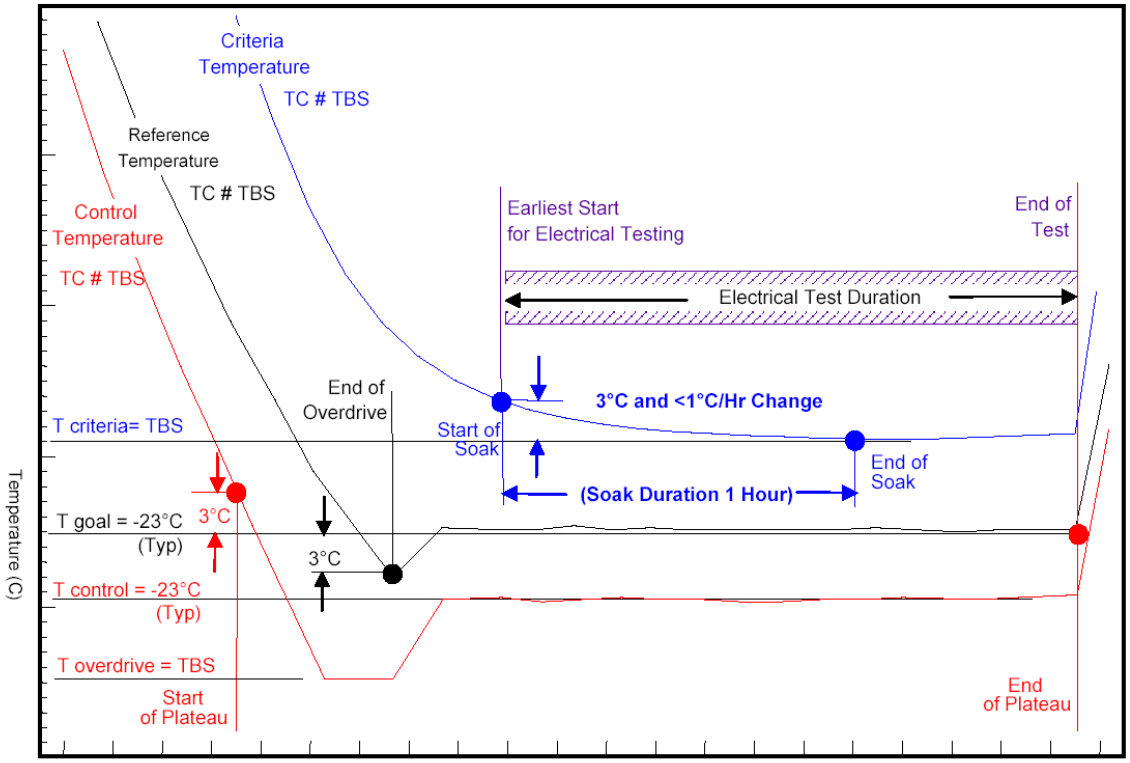
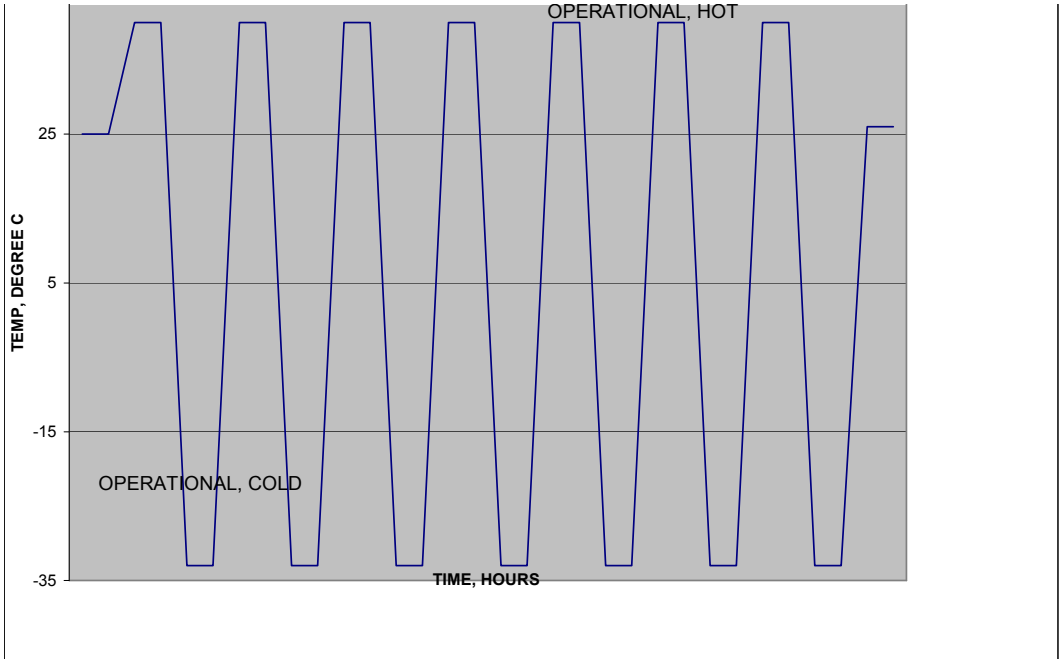


FIGURE 4: TV Soak and Performance Test Criteria

Addendum A: Thermal Profile



Description	Parameter	Remarks
Operational Temp, Cold	-33º	
Operational Temp, Hot	+40º	
Operation Cycles	7 Complete Cycles	
Transition Rate	3º /Minute Max	Hot to Cold and Cold to Hot
Soak Duration	4 Hours	Minimum

Addendum B: Thermal Vacuum Soak Profile