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

This document defines the test requirements of the STEREO Deployable Booms thermal testing. 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 Thermal Vacuum Chamber.

## 2. Unit Under Test (UUT)

### 2.1. Description

UUT 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 deploy in orbit to extend the sensing devices approximately 6 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 9.5 Kg.

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).

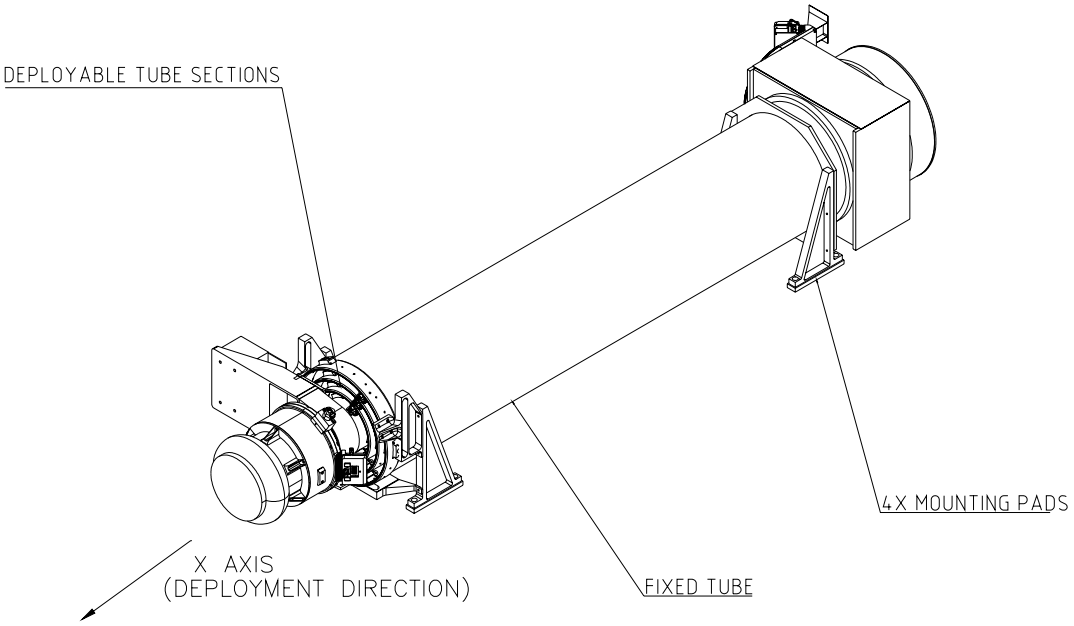



**Figure 1: STEREO BOOM ASSY, STOWED CONFIGURATION**

## 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 10 hours at a minimum temperature of 60 degrees C.

### 3.2. Thermal Vacuum

In the stowed configuration, under vacuum the assembly will be thermally cycled from a low of -50° C to a high of +40° C (all temps TBC). At each extreme, the unit shall be thermally soaked for a minimum of 2 hours. See Table I for more detailed information and sequencing.

### 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 only once in the testing sequence. Due to the nature of the design, the Boom must be deployed vertically.

### 3.4 Thermal Balance

A Thermal Balance Test will be required on the Protoflight Boom Assembly. This test will occur with the device in the Stowed Configuration.

## 4. Schedule and Durations

Testing shall take place in three distinct phases for the 3 separate units. Approximate duration and test dates for each test as follows.

**4.1. Test #1: TBD**
**4.2. Test #2: TBD**
**4.3. Test #3: TBD**

## 5. Tank Configuration

### 5.1. Geometry

Tank to be as shown in addendum and is able to accept UUT in both Stowed and Deployed configurations (See Figures 1,2, and 3). Orientation of UUT to be so that X Axis is vertical in tank to allow 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 to be approximately 400mm by 1 meter and have inserts or tapped holes to accept bolts as shown in Figure 2. The UUT to be attached to the Base Plate via Bolts. No additional thermal interface materials (G-10 spacers, thermal greases, Teflon) are required for all tests except for the Thermal Balance (one unit only) which will have thermal isolators installed.

### 5.3. Heater Methods

Heating and Cooling Devices are provided by controlled Kapton heaters and Liquid Nitrogen cooling loops. UUT will require full thermal vacuum cycling as shown in Table I.

Penetrations and Feedthru Plates

In addition to all facility thermal control and monitoring electrical feedthrus, the STEREO Boom Assembly requires one 15 Pin D-Connector on the feedthru plate to activate and control the component during test deployment.

### 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 Shroud, and any other required heating plates.

## 6. Vacuum System Requirements

The Vacuum System shall be sufficient to run continuously at $<10^{-5}$ Torr. 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.

**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 Fixtures | |
| 4 | Installation of Flight Hardware and Blankets | UCB |
| 5 | Hook-Up of Controls and Heaters | UCB/Facility Technicians |
| 6 | Vacuum Pump-Down | $<10^{-5}$ Torr |
| 7 | Bake Out UUT | +60° C Bake for minimum 24 Hours or until TQCM rate increase <1 Hz/Hr/Hr for 5 consecutive hours or a maximum 48 Hours |
| 7a | Start of Thermal Balance (Protoflight Unit only) | Vent and open chamber, install blankets, thermal isolators, ground strap |
| 7b | Vacuum Pump-Down | |
| 7c | Thermal Balance Testing (Protoflight Unit) | Test TBD; at discretion of Thermal Engineer |
| 7d | Reconfigure Test Article for T-VAC | Vent and open chamber; remove blankets and ground strap |
| 8 | Cool to -50° C | Rate not to exceed 3°C/Minute |
| 9 | Cold Soak | -50° for 4 Hours |
| 10 | Heat to +40°C | Rate not to exceed 3°C per Minute |
| 11 | Hot Soak | 40° for 4 Hours |
| 12 | Repeat Sequence 8-11 for a total of 7 Cycles | |
| 13 | Certification of Chamber (Post TV) | Contaimination Engineer decision point on Cleanliness Status of UUT |
| 14 | Cool to -50°C | Soak for 4 Hours |
| 15 | Deploy Boom | UCB Operation |
| 16 | Verify Full Deployment | Real Time Visual Inspection |
| 17 | Return System to Room Temp | |

| | | |
|---|---|---|
| 18 | Shut off Vacuum | Back-fill with Dry Nitrogen |
| 19 | Stow Deployed Elements of Boom | UCB Technician Hand operation; requires access to entire deployed Sections by person |
| 20 | Remove UUT from Tank | END OF TEST |

## 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.

## 8. Monitoring and Control

Deployment of Boom will require verification of full and complete deployment. Visual inspection will be necessary and provided by the Facility without opening the Chamber door and breaking vacuum. Acceptable inspection features include Inspection Ports with acceptable field of view to see entire boom deployment or internal camera. Viewing to be required only once during test to verify full deployment; constant monitoring will not be required.

## 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 Components shall be maintained in a Class 1,000 Clean Room or better. For short periods (loading/unloading into chamber, short transitions) the Components may be exposed to Class 10,000 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.

### 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. Level of Cleanliness shall be less that 100 Hz/Hour with the TQCM at -20°C.

## 10. Safety

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

## 11. Hardware Responsibility

Hardware responsibility as defined in Table 2.

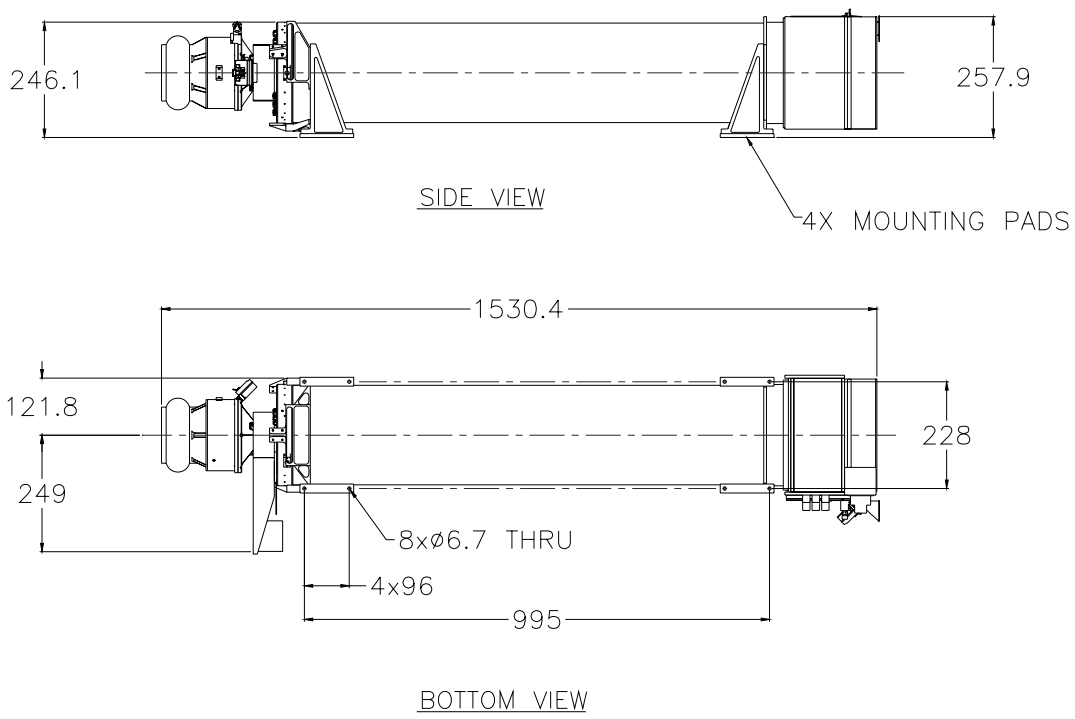



**Figure 2: OVERALL DIMS OF STOWED BOOM ASSY (Dimensions in mm)**



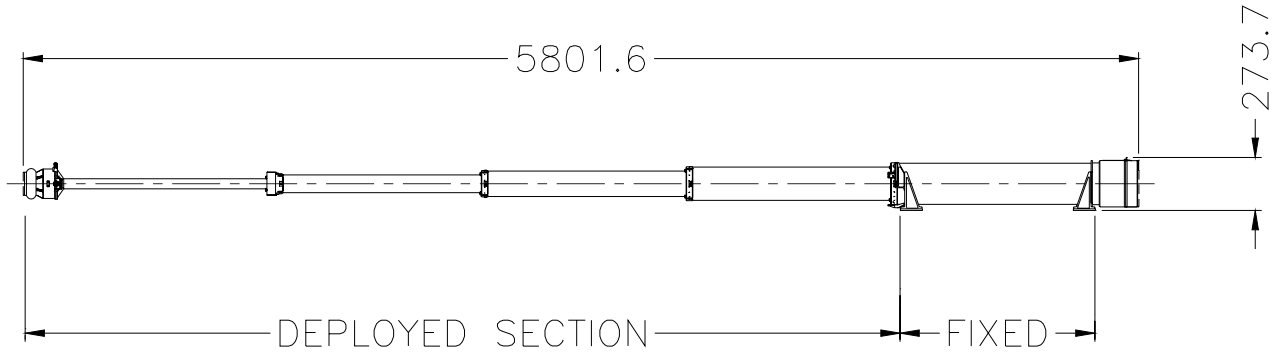
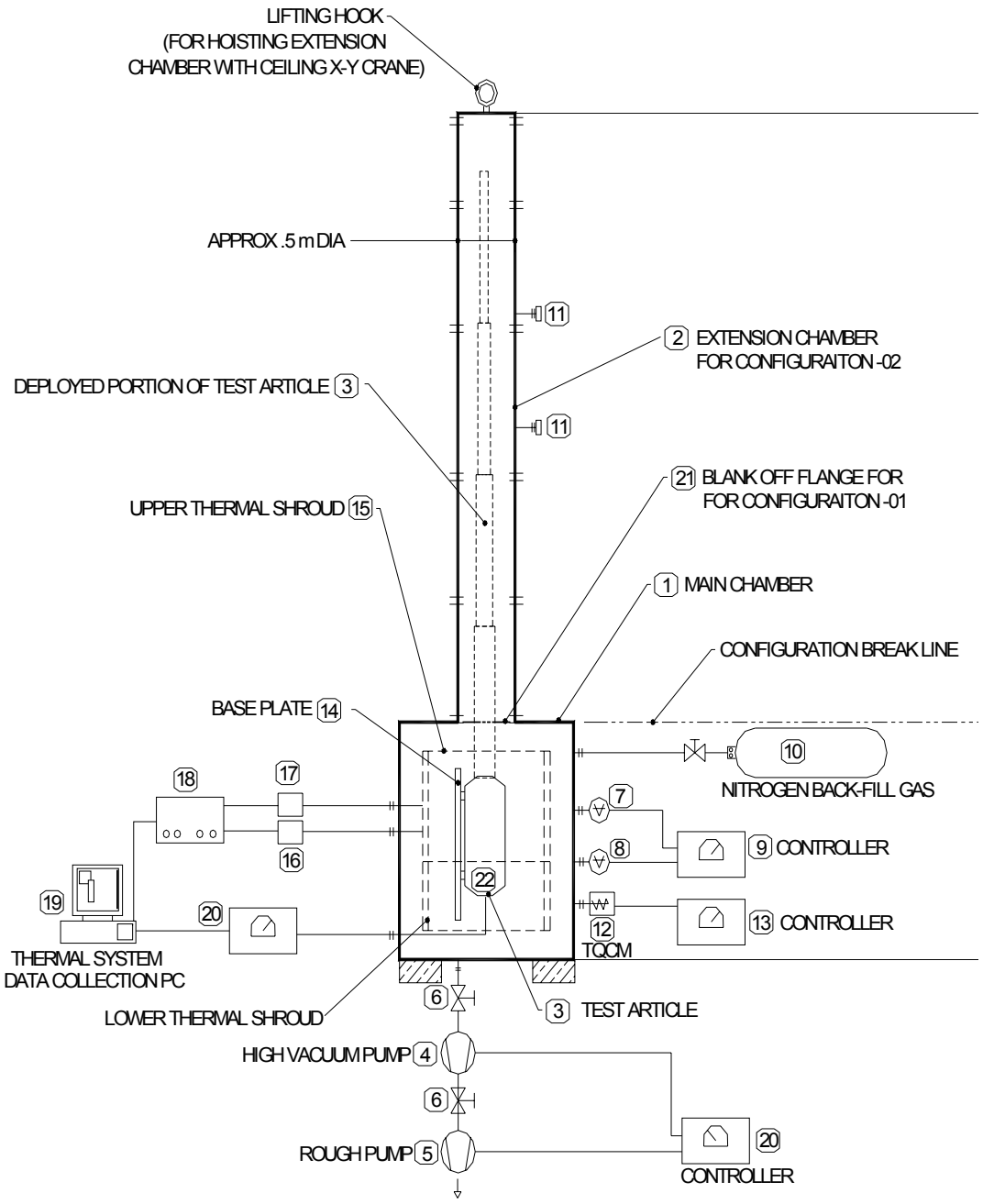



**Figure 3: DEPLOYED CONFIGURATION (Dimensions in mm)**

**TABLE 2: Hardware Responsibility Matrix**

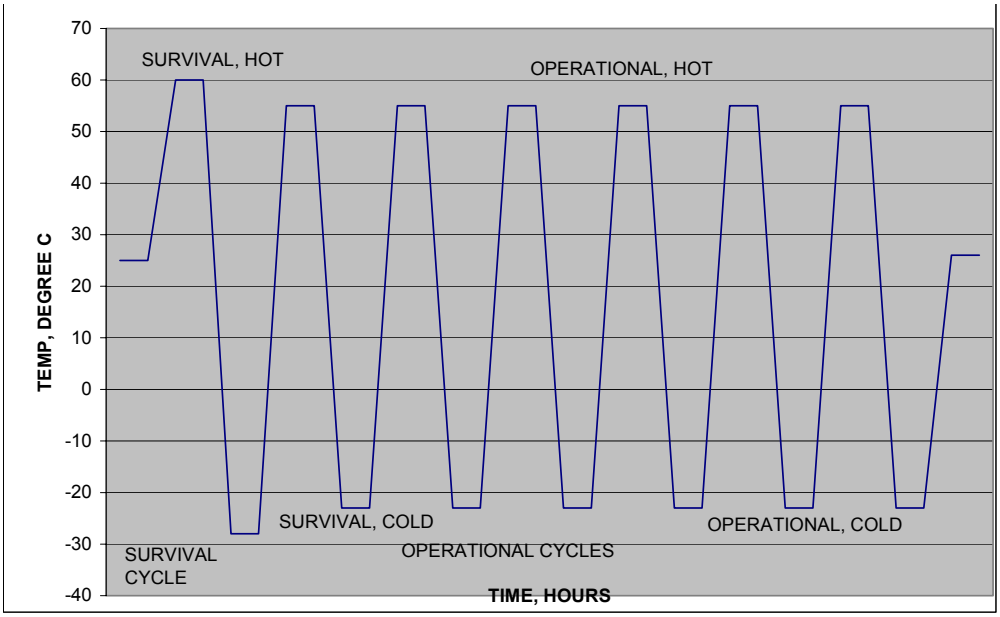
| Item | Provider | Remarks |
|---|---|---|
| UUT | UCB | See Figures 1,2,& 3 |
| UUT Attach Bolts | UCB (Quantity: 8) | |
| Base Plate | Test Facility | Tapped Holes required per Figure 2. |
| Thermal Shroud/Heating Plates | Test Facility | |
| Thermocouples | Test Facility | In addition to Test Facility 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 | |
| Thermal Blankets for Boom | UCB | |




STEREO TEST CHAMBER SCHEMATIC

TWO CONFIGURATIONS OF CHAMBER:
-01: MAIN CHAMBER (1) WITH BLANK-OFF FLANGE (21) AT BREAKLINE
FOR USE WITH (3) TEST ARTICLE STOWED
-02: MAIN CHAMBER (1) PLUS EXTENSION CHAMBER (2) BOLTED AT BREAKLINE
FOR USE WITH (3) TEST ARTICLE IN DEPLOYED STATE

ADDENDUM: Thermal Profile




Thermal Vacuum Test Cycles

- One Survival Cycle
- 7 Operational Cycles
- Transition Rates not to Exceed 3 Degrees C per Minute
- Dwell Time at Temperature Extremes Minimum 4 Hours

| Temperature Description | Temperature, Degrees C | Remarks |
|---|---|---|
| Survival, Cold | -28 | All Temperatures preliminary (TBD). Final Temperature ranges to be determined following thermal analysis (ongoing as of this revision). |
| Survival, Hot | +65 | |
| Operational, Cold | -23 | |
| Operational, Hot | +60 | |