Critical Design Review (CDR)
Of
ULTRA VIOLET IMAGING TELESCOPE (UVIT)
(June 17th -18th 2011, ISAC, Bengaluru)

Thermo-Vac Test

UVIT-CDR-01-003

Indian Institute of Astrophysics
Bangalore-560034

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Thermo-VAC Test of UVIT Payload (EM)

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Documents to be Referred:

1. ASTROSAT-Contamination Control notes V0.1
2. UVIT-990-00001-PRO Rev 1_5 - Functional Test Procedure.
3. UVIT-990-00002-PRO Rev 1_5 - Performance Test Procedure.
4. EM-UVIT TVAC Test Report.doc
5. UVIT-TVAC-Test-Plan-ISAC-V1.3_27April2011.doc

1.0 Introduction

This document describes the Engineering Model (EM) Thermo-Vacuum (TVAC) test plan for the UVIT system. The document describes the sequence of tests that will be performed during TVAC testing. As well, the document describes the equipment and facilities required for testing. This document is valid for flight model also wherein the test has to be carried out for acceptance level. The test profile includes the acceptance level testing of flight model.

2.0 Test Plan

2.1 Test Objectives

The objective of the testing is to show that the Engineering Model (EM) version of the UVIT system remains operational and not damaged during and after exposures to qualification levels of thermo vacuum conditions specified by ETLS. This test will also give us an experience and modalities that need to be addressed for achieving the cleanliness and to minimize the contamination levels for flight model payload/ spacecraft tests.

2.2 Test Description

Typical test profile and temperature limits for qualification level TVAC test with durations are shown in figure 2.1 and table 2.1.

In vacuum, verifying that the system is operational over repeated hot and cold cycles of prescribed temperatures. See figure 2.1 for the temperature profile.

In vacuum, verifying that the system is operation during a long duration hot and cold dwell temperature cycles.

The UVIT system has supplied items like door, primary and secondary mirror, filter wheel motor and its electronics, HVU (High Voltage Unit), detector and cables. These supplied items have been qualified separately. The other elements are only the telescope tubes, baffles, rings and other metallic structures. The engineering model of the UVIT system has one NUV channel and the mass simulated FUV channel. **During the TVAC test CPU, HVU, EU, FWM and FWDE were powered ON.**

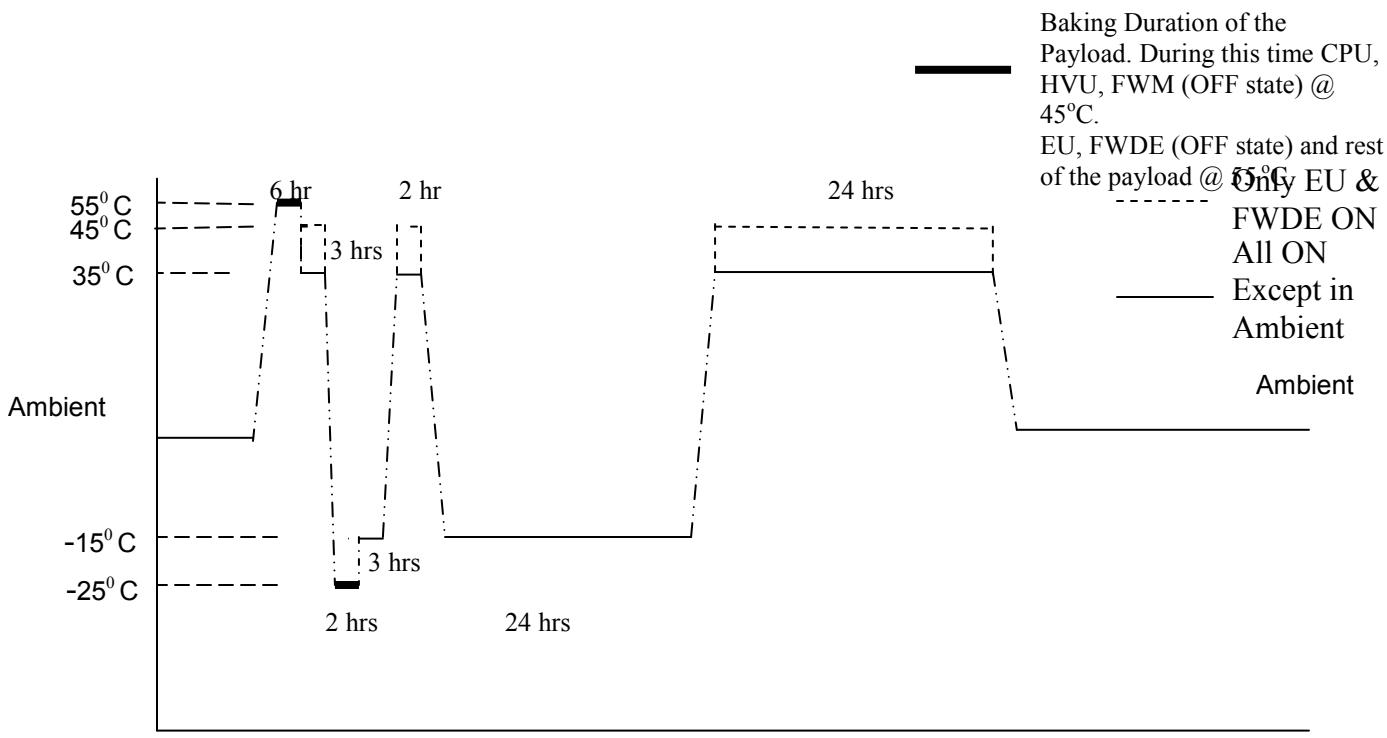


Figure 2. 1 EM UVITDS TVAC test Profile (Qualification Levels)

Table 2. 1 List of Environmental Temperature (Qualification) Limits of UVIT Subsystems

Name of Subsystem	Temperature Limits (ON State)		Temperature Limits (OFF State)		
CPU	-15°C	+35°C	-25°C	+45°C	
HVU	-15°C	+35°C	-25°C	+45°C	
EU	-15°C	+45°C	-25°C	+55°C	
FWM	-15°C	+35°C	-25°C	+45°C	
FWDE	-15°C	+45°C	-25°C	+55°C	

Critical Temperatures which need to be monitored and control

Name of Subsystem	Temperature Limits (ON State)		Temperature Limits (OFF State)		Temp. Sensor ID	IR Lamp ID
CPU	**-15°C**	**+35°C**	**-25°C**	**+45°C**	**841**	**L73 to L110**
HVU	**-15°C**	**+35°C**	**-25°C**	**+45°C**	**4572**	
EU	**-15°C**	**+45°C**	**-25°C**	**+55°C**	**TC 45/46**	**L 111 to L 114**
Door HOP Actuator		**+40°C +/- 2 °C**		**+40°C +/- 2 °C**	**TC 5/6**	**L 1 to 12**

2.3 Test Facility Aspects

The tests are planned in 6 mtrs CATVAC chamber at ISITE test facilities. The facility is chosen because of the better clean room environment. The chamber is in the clean room of 1 lakh class. However, it has been observed that cleanliness achieved in terms of particle count is better than 15000 with controlled man-material movement. The facility is equipped with TCQM equipment (for molecular contamination measurements) and also Residual Gas Analysis system within the chamber.

2.3.1. Test Methodology

In view of the high cleanliness and contamination requirements of the payload, it is required to adopt the test methodology of keeping the Shroud Temperature always at a constant Low temperature of -80 deg C and achieve the required differential temperature limits on the payload subsystems by using the combination of Heaters and the IR lamps.

The chamber need to develop a vacuum level better than 1 X 10^{-6} mbar as part of standard test specifications for performing the TVac tests.

3.0 Precaution and Contamination Control:

The UVIT system is a very sensitive system. All contaminations are to be avoided. A clean environment is required to be maintained. Even while down loading of UVIT the area has to be clean. Proper identification of clean area has to be done. The system requires continuous purging with nitrogen. Adequate precaution is required to be taken by covering the system before and after test with a proper cover. Each time a fresh cover has to be used. Reuse of cover is forbidden. Another precaution is that the UVIT system is ESD (Electro Static Discharge) sensitive. Necessary precautions with proper ESD protection are to be taken while handling the system.
During the test, it should be ensured that the components like detector/ HVU/any other component does not exceed the operational limit specified. Adequate precautions are to be taken for proper temperature maintenance.

CPU is very critical subsystem whose temperature to be maintained strictly. Temperature limits should be maintained at 35 +0 / -2 ^{o}C during its operation.

3.1 Requirement of Contamination Monitoring through TCQM

The chamber shall be baked at the highest possible temperature, say at 60 C, and be monitored by TCQM (operated at – 20 C). Baking shall continue till TCQM shows a rate $< 8.71 \times 10^{-12}\ gm/cm^2/\sec$, and a rate of change in rate of $< 3.03 \times 10^{-16}\ gm/cm^2/\sec^2$ for 8 hrs.

TV cleanliness needs to be verified prior to placing ASTROSAT parts inside. Therefore a test thermal cycle is performed, at plateau temperatures of + 40 C for 12 hrs and then a plateau temperature of – 20 C for 12 hrs with a witness sample (Mg F2 window) placed in the chamber for monitoring; the witness sample is used after its transmission, in 120 – 180 nm range has been measured After this test thermal cycle, the

witness sample is measured again for its transmission. Any reduction to < 95% of the original transmission is an indication of potential contamination in the chamber.

Finally the chamber was baked in 2 phases. In the first phase the shroud was baked at 60 deg C for 36 hours with all the fixtures and IR Lamp cage assembly inside the chamber. TCQM measurements were made by keeping the cold finger at -20 deg C to assess the contamination level inside the chamber.

In the second phase 2 witness sample window (MgF2) were placed inside the chamber and the chamber was baked at +40 deg C for 12 hours and at -20 deg C for 12 hours.

Results of the witness sample show the transmission loss is less than 5% which is an acceptable number. Hence the chamber is cleared for payload tests.

UVIT is prone to contamination in TVAC chamber at ISITE. A guideline to control contamination for ASTROSAT has been already issued from ASTROSAT project office. Please refer document ***"ASTROSAT-Contamination Control notes V0.1"*** for the details.

AS a necessary precaution, the TV chamber shall be free of any silicon compounds/greases, and the O'rings shall be coated with a thin layer of LVP Crytox grease of Dupont. Inside of the chamber shall be cleaned with lint free cloth with high grade Acetone etc. to remove any traces of contaminants.

3.1 Procedure for TQCM measurement

1. TCQM needs to maintain at -20^{o}C during measurement time and at +60^{o}C during baking and when not measuring the contamination.
2. Measurement of TCQM shall be made for at last 4 hours at every 15 minutes, of baking and first HOT operation cycle (combined). On completion of contamination measurements, the temperature of the TCQM need to be raised to +60^{o}C to ensure the TCQM surface is clean for the next measurements.
3. Next set of measurement will be done at last 8 hours of Long HOT cycle.

3.2 Contamination assessment using Witness Samples (MgF_2 window)

Two samples of MgF2 windows are placed in TVAC chamber to asses the cumulative contamination during the test. These samples will be taken out after completion of tests and transmission loss will be measured at IIA facility.

4.0 Test Configuration:

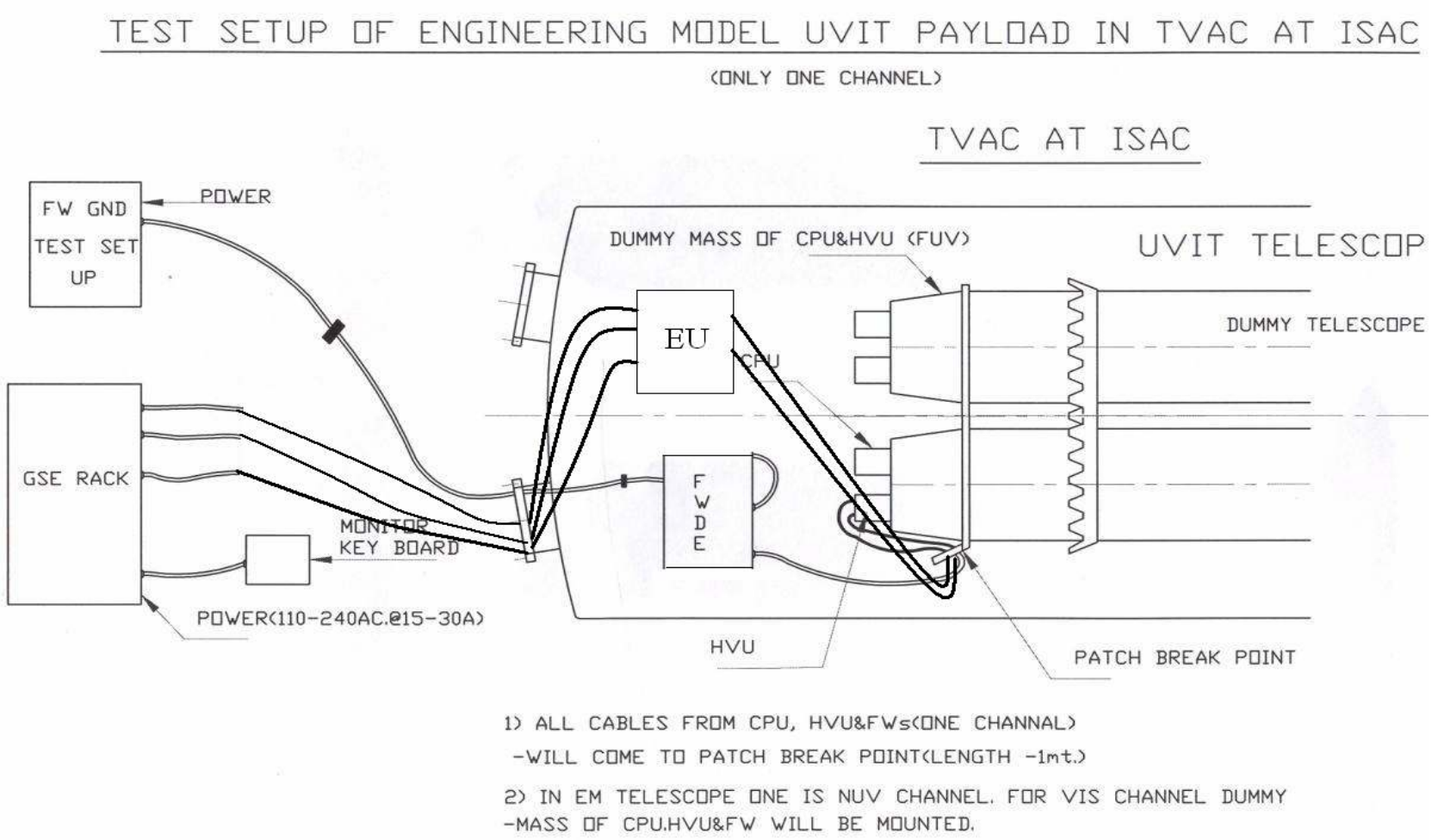


Figure 4. 1 Test Setup of EM UVIT Payload in TVAC at ISITE

4.1 Mounting Fixtures

The figure 4.2 and 4.3 shows the UVIT system with the special mounting fixtures. The mounting fixtures are designed to withstand the weight of the UVIT system. The mounting fixtures are further designed to withstand the temperature environment faced in the thermo-vacuum chamber and also to ensure that it does not load the UVIT system. The UVIT system along with the mounting fixtures will be inside the thermo-vacuum chamber during the test. During the test the temperature of the thermo-vacuum shroud is monitored. The system has several temperature sensors. These will be monitored. During the test, it should be ensured that the components like detector/ HVU/any other component does not exceed the operational limit specified. Adequate precautions are to be taken for proper temperature maintenance.

After the test is over the system should be immediately covered with proper cover. Also minimum electrical functional tests and mechanical checks will be carried out to ensure the system is functioning after thermo-vacuum test.

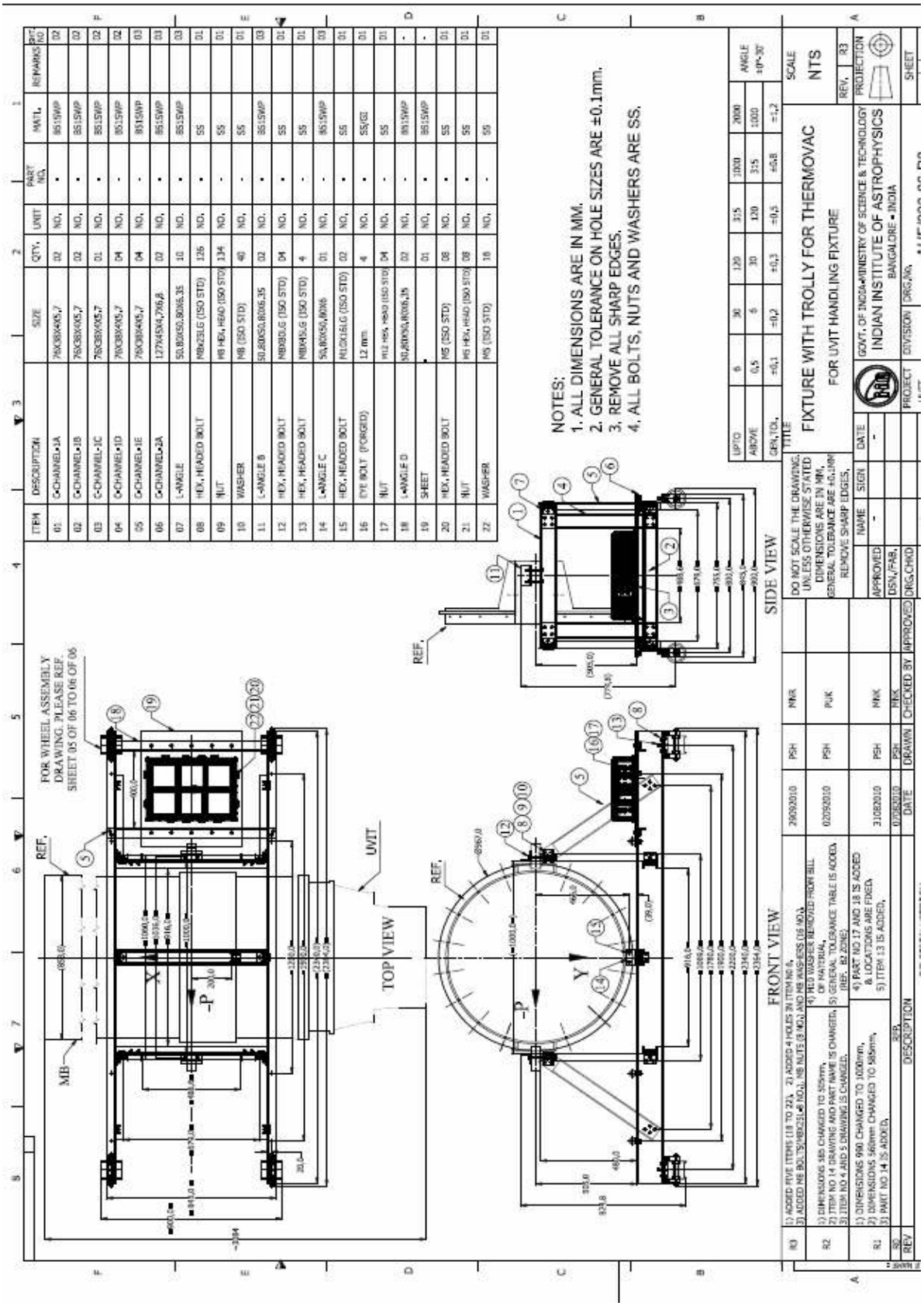


Figure 4. 2 Mounting Fixture for UVIT payload in TVAC

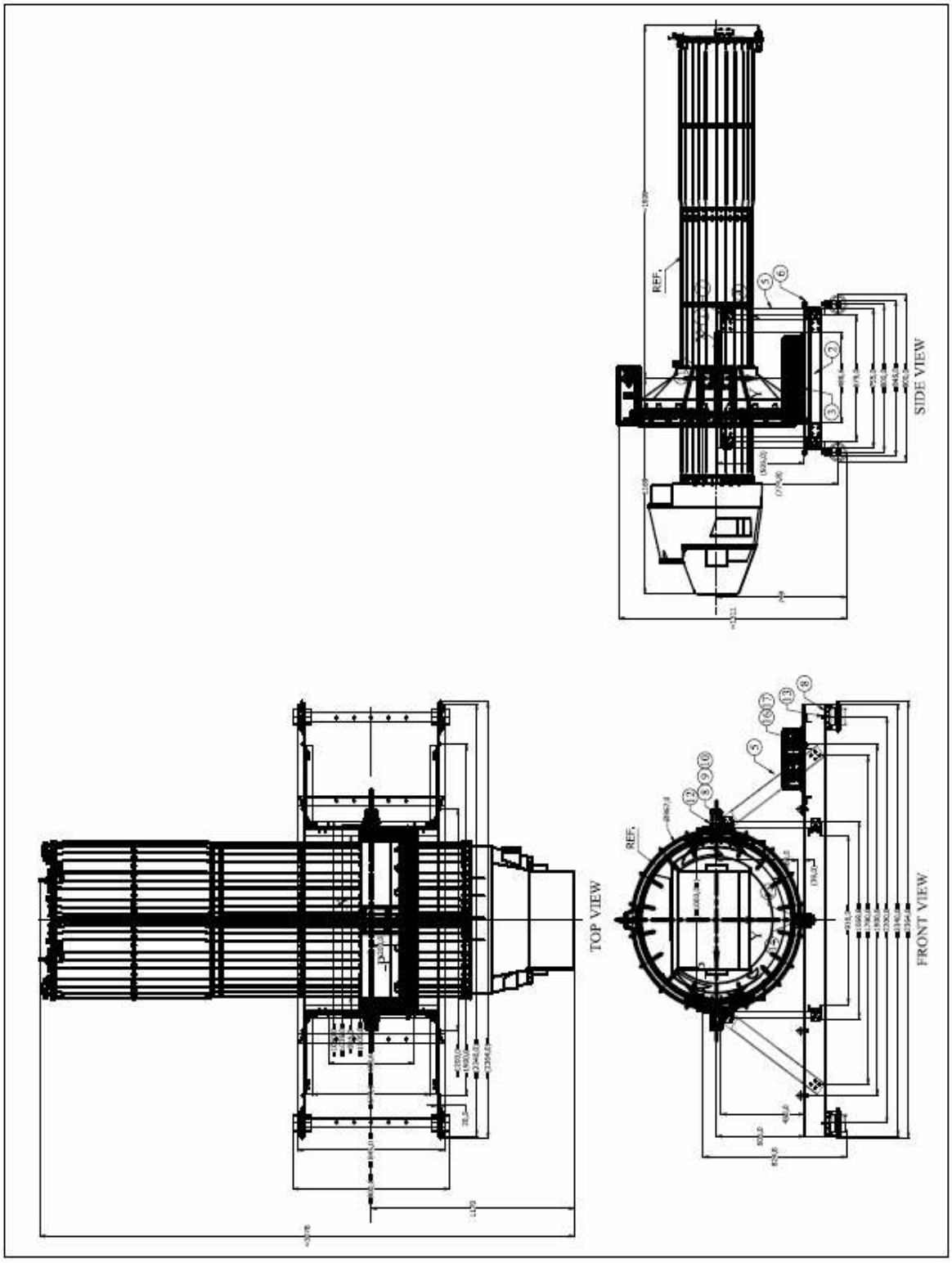


Figure 4. 3 UVIT payload on mounting fixture in TVAC

4.2 Instrumentation

Both, Thermal instrumentation aspects (IR Lamps, Heaters, Thermistors and Thermo couples and payload performance verification related instrumentation aspects are explained here.

4.2.1 Thermal Instrumentation:

Combination of Infra Red Lamps (mounted on IR cage) and foil heaters (bonded on the bottom surface of plate used for mounting EU and FWDE packages) are being used to realize the required temperature limits for different units of the payload system.
The temperature measurements are being done with the help of thermistors and thermocouples. The list of thermistors mounted on the payload area given in Table-E.1, given in Appendix-E. The details of the IR lamps and the temperature monitoring sensors and their locations are given in Appendix-E.

4.2.2 Payload Instrumentation

The payload performance in ambient and during Tvac tests will be performed with the help of Ground Support Equipments (GSE) developed by payload team. GSE will help in testing the detector system, Filter wheel motor with drive electronics and for monitoring the temperature at 13 locations on payload at the hot and cold plateaus during TVAC test of the UVIT payload.

For UVIT detector system, there is a dedicated system which will serve to supply Raw Power, Pulse commands, Tele-commands and receive telemetry and science data of the detector system.

Figure 4. 4 Ground Support Equipment for UVIT Detector System

For FWM and FWDE, there is a Labview based system, which will supply pulse commands and receive analog and digital telemetry of the FWM.

Figure 4. 5 Ground Support Equipment for FWM and FWDE

For Thermistors temperature monitoring also we have Labview based system, which can monitor and record the temperature of 14 thermistors at a time.
Following table 4.1 lists the location of thermistors fixed on the payload.
To supply data of thermistors from IIA system to TVAC facility system a RS232 based interface has been developed for 75 mt of cable length. The programming of RS 232 data transfer also has been done on Labview platform.

4.3 Harness Routing Plan for TVAC test

As shown in figure 4.1, the connection between EU, FWDE, thermistors and GSE will be mate through ISO320 K flange using circular feed-through.

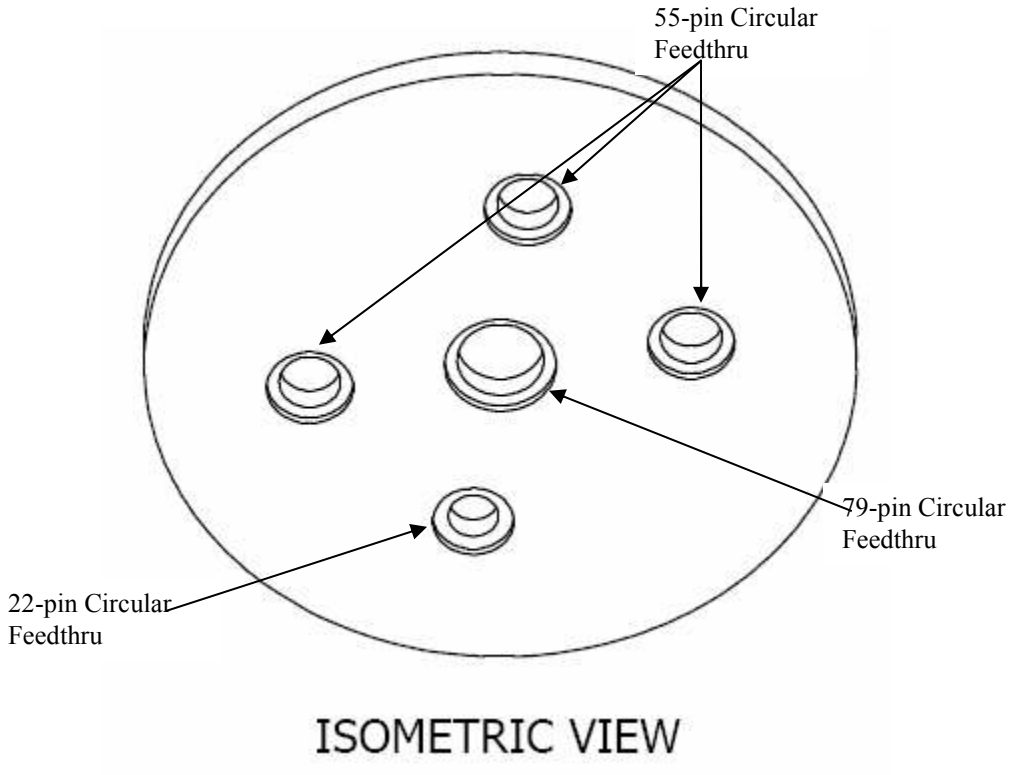


Figure 4. 6 ISO 320 K Flange

4.3.1 Grounding Requirement for UVITDS

UVITDS need to be connect a Grounding point (isolated from heavy electrical grounding point of Lab). EU box and CPU, HVU will be connected through existing EMI braid on the payload.

So we need a grounding connection till EU mounting plate from Lab isolated ground plane.

4.4 Thermal Control Implementation

To control the temperature of EM UVIT payload, thermal control hardware (i.e IR lamps, heaters and thermocouple) will be implemented by ISAC thermal group. To fix IR lamps around the payload, an IR Lamp cage has been designed and fabricated by IIA, see figure 4.7.

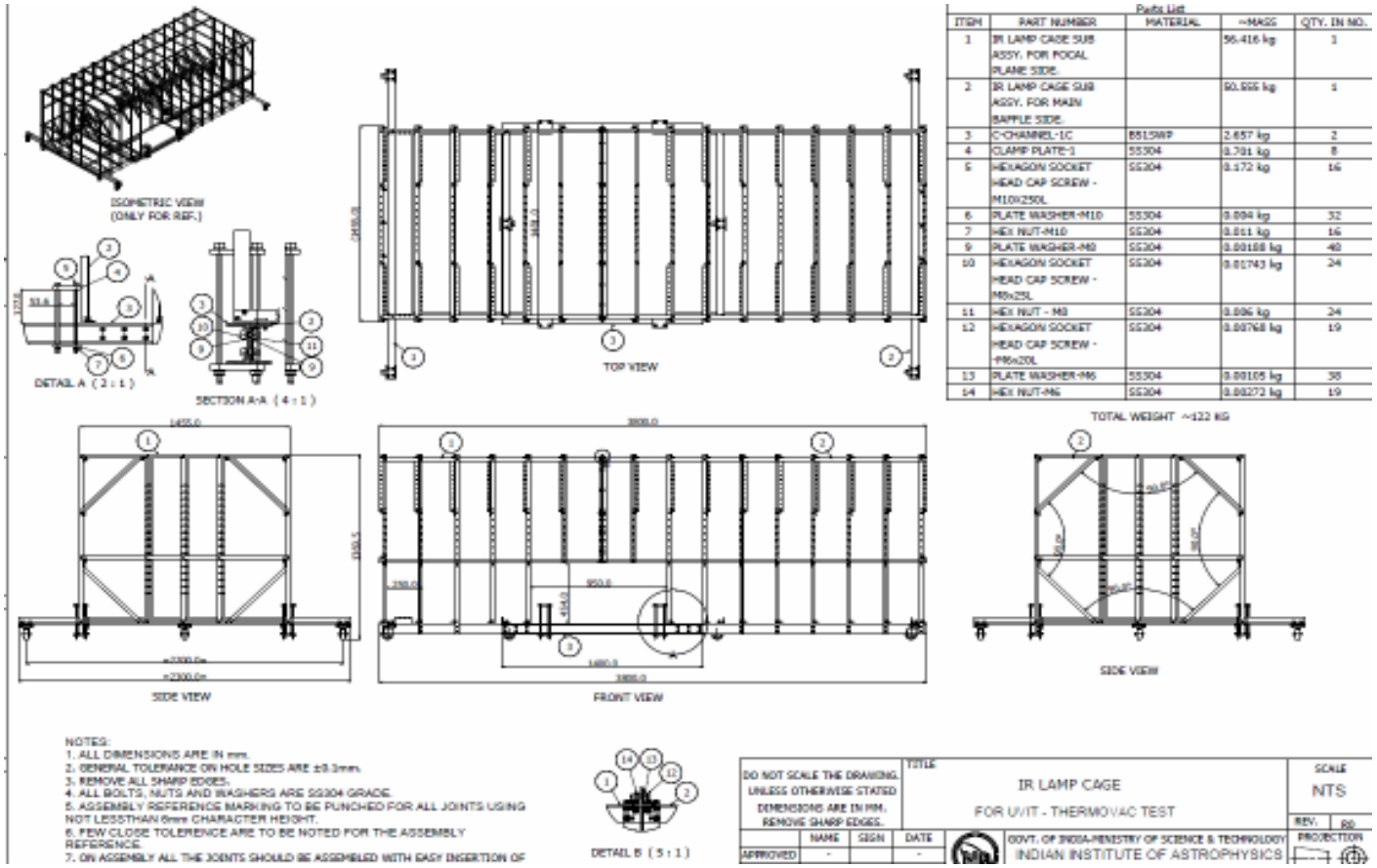


Figure 4. 7 IR Lamp cage

5. Test Results

5.1 Contamination Measurement

5.1.1 From Witness Samples

Two number of witness sample (MgF_2 window) was kept near (front and back) the payload inside TVAC chamber during the test.
Transmission loss was measured on the witness sample.
Attenuation in the transmission at 130nm-160nm band is the following:
i) 1-1.5% during the first phase of chamber baking (without payload, with IR Lamp Cage and mounting fixture).
ii) 2-2.5% during the TVAC test.

5.1.2 From Residual Gas Analyzer (RGA)

Data is not yet received from CATVAC Facility team.

5.1.3. From TCQM

TCQM of CATVAC facility was not working properly and there is lack of data. So, no conclusion can be made, based on TCQM measurement.

5.2 Payload Performance

5.2.1 Electrical Parameters Measurement

During the test and after test, instrument (UVIT detector system and Filter Wheel Mechanism) performance was normal. Please refer figure 2.1 for temperature profile, followed during TVAC test.

Table 5. 1 Electrical Parameter Results

Name of Parameter	First Hot Cycle	First Cold Cycle	Second Hot Cycle	24 Hrs Cold Cycle	24 Hrs Hot Cycle	Post TVAC at Ambient
Performance of UVITDS (CPU, HVU and EU)	Normal	Normal	Normal	Normal	Normal	Normal
Performance of FWM & FWDE	Normal	Normal	Normal	Normal	Normal	Normal

Detailed test results are available in EM-UVIT TVAC Test Report.

5.2.2 Temperature Measurements

The temperature of payload was measured as mentioned in 4.2.1. Thermistors were monitored by IIA checkout system. Thermistors were supplied by ISAC thermal group but the temperature curve was not given along with the Thermistors. So, there is a small deviation in temperature measurements of the Thermistors.

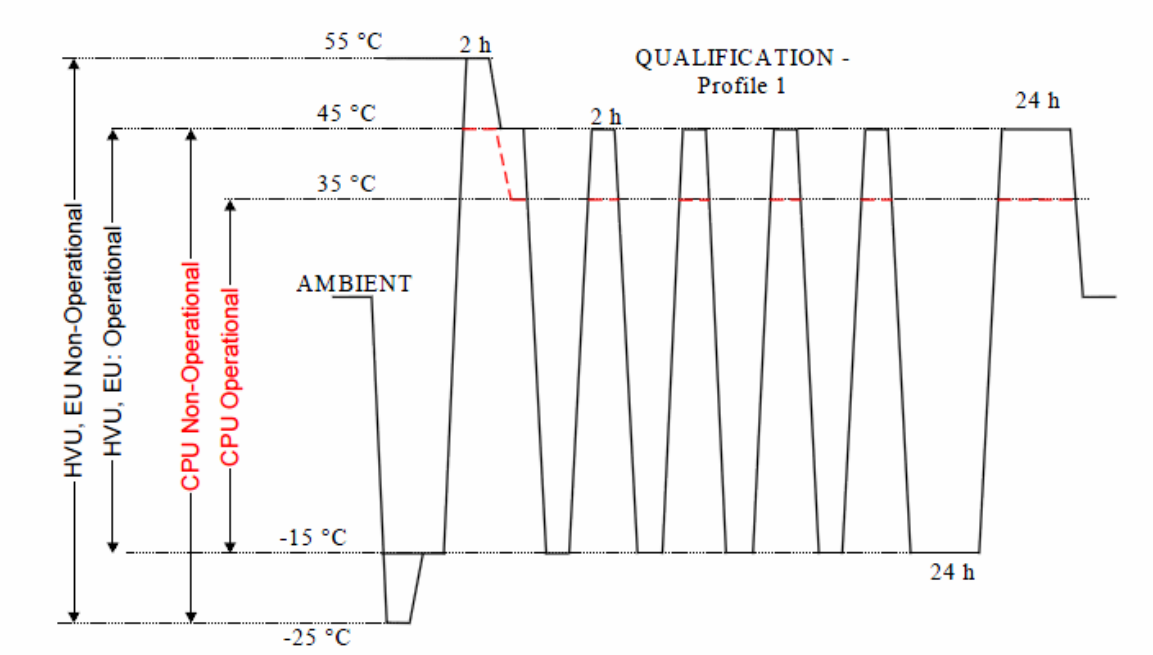
At the highest (lowest) temperatures, the temperature given by ISRO-table would have been higher (lower), i.e. if at al the errors have led to small over-testing.

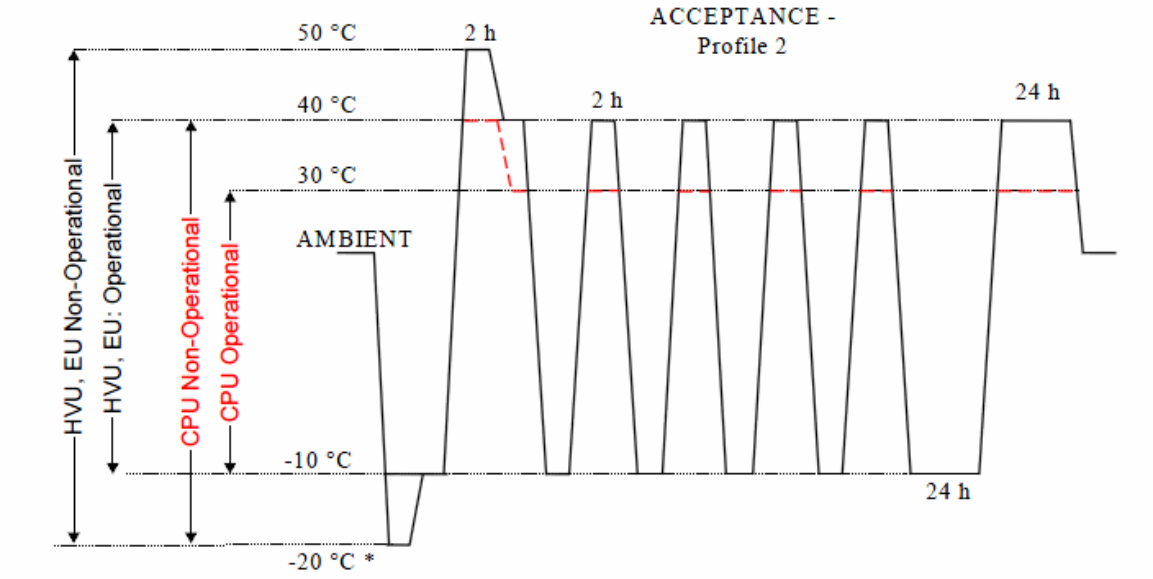
Table 5. 2 Resistance Vs Temperature

Resistance (Ohms)	**Temp (deg C) by formula used by IIA during Test**	**Temp (deg C) by Thermistor table**
3640	50	~ 51.5
5350	40	~ 41
8050	30	~ 30.5
12500	20	~ 19.5
19950	10	~ 9.5
32995	0	~ (-2)
56550	-10	~ (-12.5)
101000	-20	~ (-24)
137000	-25	~ (-29)

Appendix A

TVAC test Profile and Temperature limits, which subsystems have undergone TVAC tests at manufacturers' place.





Appendix-B (Instrumentation Aspects)

Details of the thermistors used for temperature measurement on the payload are given below

Figure B. 1 List of Thermistors mounted on EM UVIT Payload

S.No.	Location of Thermistor	Thermistor ID No.	Resistance Value @ ambient (KΩ)	Remarks
1.	MB1	959	11.48	
2.	MB2	4831	11.36	
3.	TT1 Top	4576	11.16	
4.	TT1 Bottom	4807	11.85	
5.	TT2 Top	4462	11.46	
6.	TT2 Bottom	4815	11.4	
7.	TT3 Top	4486	10.98	
8.	TT3 Bottom	4584	11.07	
9.	DMB NUV Top	4483	11.37	
10.	DMB NUV Middle	810	11.15	
11.	NUV Filter Wheel cover	4610	11.39	
12.	CPU	841		
13.	HVU	4572		

Figure B. 2 Position of IR Lamps on the IR Cage (which is mounted around the payload)

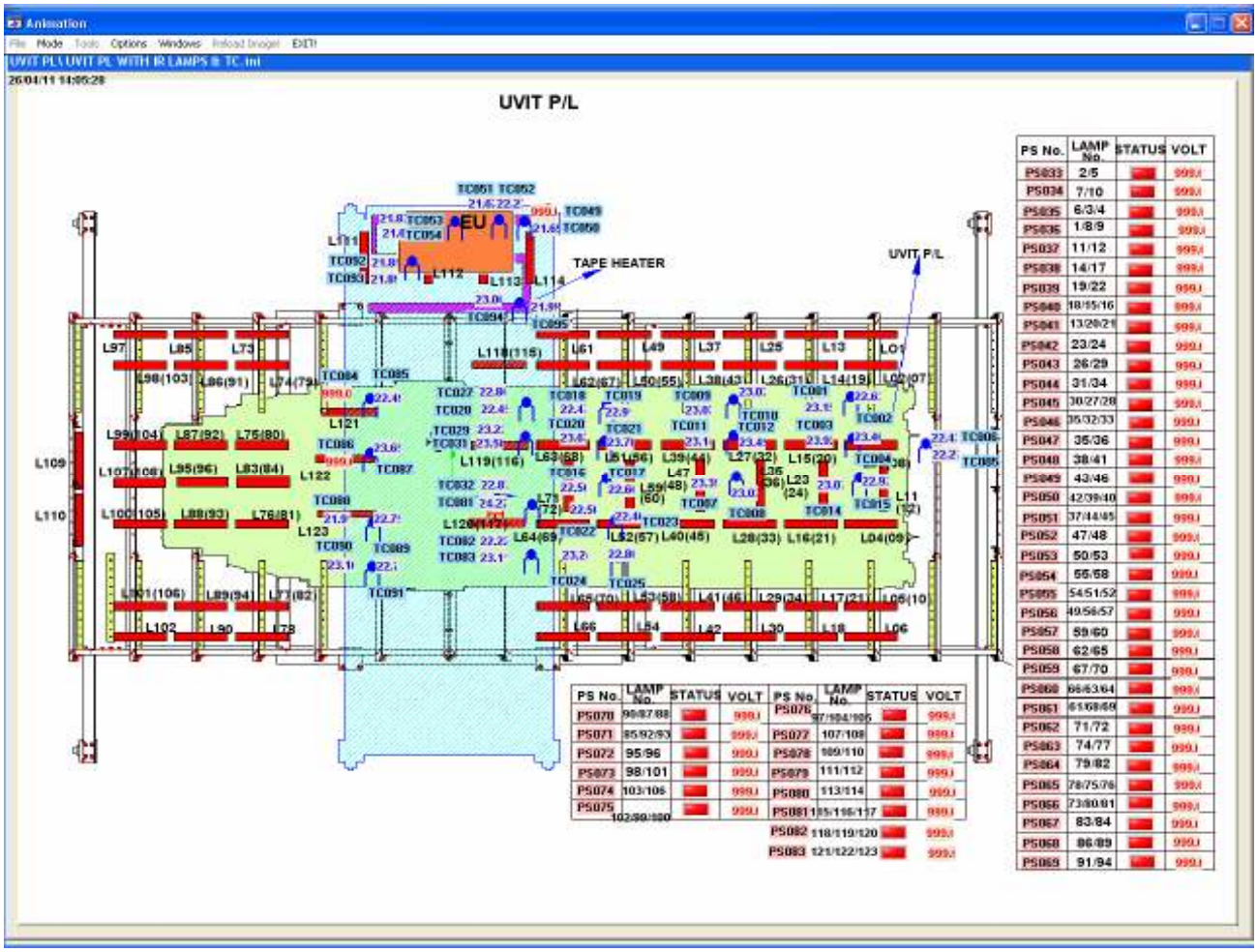


Figure B. 3 Position of Thermocouples and Heaters