

Satellite Testing Hands-on tutorial

This tutorial is a hands-on (practical) training regarding the principles and procedures necessary to plan, setup, perform test, analyse obtained test results and report on the environmental testing of microsattellites/ CubeSats. The device-under-test (DUT) namely, component, subsystem or satellite is placed in or confined to a controlled simulated space/ launch environment.

Thermal Vacuum Test (TVT)

In the case of TVT, the tests are conducted to:

1. identify material, process, and workmanship errors/ defects.
2. demonstrate that the DUT satisfies the criteria for a qualification or an acceptance test.

The objective of this tutorial is to let participants:

- plan, prepare, define test scope, conditions, and document test procedure.
- monitor the thermal response of the DUT under extreme cold and hot temperature conditions.
- check the functionality and operation of the DUT under the defined temperature extremes. Analyse thermal results and prepare test report.

The training activities are described in the following table

Item №	Activity	Contents
1	Test Preparation (Planning & Documentation)	<ol style="list-style-type: none">1. Defining test purpose, scope, test conditions/ target2. Identifying critical components for worst hot and cold temperature settings3. Listing test flow, levels, conditions, and procedure4. Taking note of safety requirement procedures5. Documenting test plan and procedure
2	Test Preparation (Installation)	<ol style="list-style-type: none">1. Placing thermocouples (TCs) on DUT and heaters2. Installing DUT in vacuum chamber (VC) directly or using a TVT jig3. Connecting TCs and heater lines to VC feedthrough terminals4. Checking and confirming TCs temperature readings and resistances of heaters via LabVIEW program on PC5. Performing functional tests of DUT in atmospheric conditions6. Cleaning VC opening flanges and doors with pure ethanol solution; closing VC doors
3	Vacuuming	<ol style="list-style-type: none">1. Turning on and warming up rough pump (rotary pump) for approx. 10-15 minutes2. Rough vacuuming of VC to attain 10 Pa3. High vacuuming of VC with turbo molecular pump4. Turning on of ionization gauge to monitor pressure in high vacuum
4	LN2 injection (Shroud cooling)	<ol style="list-style-type: none">1. Performing DUT functional check when pressure is less than 5.0×10^{-3} Pa at room temperature condition2. Injecting liquid nitrogen (LN2) to cool shroud to approx. -170 °C

5	Thermal cycling	<ol style="list-style-type: none"> 1. Cycling DUT between defined low and high temperature extremes with heaters 2. Soaking DUT at worst cold and hot temperature conditions; and performing functional check afterwards 3. Controlling heaters to attain required ramp rates for temperature transitions
6	Chamber restoration and DUT recovery	<ol style="list-style-type: none"> 1. Stopping LN2 injection and draining unused LN2 from VC cooling line; controlled heating of shroud 2. Sequential stopping of pumps 3. Filling of VC with nitrogen gas to facilitate recovery 4. Restoring chamber with air when permissible temperature is attained 5. Performing DUT functional check for comparative analysis 6. Safe opening of VC using oxygen monitor and removal of DUT from chamber
7	Result analyses and Documentation	<ol style="list-style-type: none"> 1. Visual inspection of DUT 2. Analysing obtained test results 3. Preparing test report

Vibration Test (VT)

In the case of VT, the tests are conducted to:

1. demonstrate that the DUT can withstand the launch environment namely: sinusoidal vibration, random vibration, and quasi-static loads.
2. verify the structural integrity of the DUT ensuring no malfunctioning and damage to components.

The objective of this tutorial is to let participants:

- plan, prepare, define test scope, conditions, and document test procedure.
- monitor the mechanical/ frequency response of the DUT under simulated launch environment.
- acquire spectrum/ acceleration data. Check functionality and operation of the DUT in between tests. Analyse the data and prepare test report.

The training activities are described in the following table

Item №	Activity	Contents
1	Test Preparation (Planning & Documentation)	<ol style="list-style-type: none"> 1. Defining test purpose, scope, test conditions/ target 2. Listing test flow, levels, conditions, and procedure 3. Taking note of safety requirement procedures 4. Documenting test plan and procedure
2	Test Preparation (Installation)	<ol style="list-style-type: none"> 1. Checking and attaching accelerometers on DUT, picosatellite orbital deployer (POD) and vibration jig 2. Installing jig on vibration shaker with required torque values 3. Installing DUT inside POD and securing it with required torque values. Mark all screws with torque marks 4. Fixing POD to the jig firmly with appropriate torque values 5. Marking all external screws with torque mark 6. Connecting sensors to charge amplifiers and setting amplification values

		7. Checking and confirming responses/ waveform of sensors via LabVIEW program on PC
3	Equipment setting	<ol style="list-style-type: none"> 1. Turning on the vibration equipment and setting the parameters for different tests 2. Defining the parameters for each test on both control and measurement PCs 3. Tests to be performed in all 3 axes are as follows: <ul style="list-style-type: none"> • Modal survey • Sine burst • Sinusoidal vibration • Random vibration
4	Testing	<ol style="list-style-type: none"> 1. Controlling, monitoring, analysing, and saving test results 2. Changing POD direction for in-plane tests, and changing shaker orientation for out-of-plane test 3. Performing functional tests and visual inspection of DUT (inside POD) in between vibration tests
5	Result analyses and Documentation	<ol style="list-style-type: none"> 1. Detachment of POD from vibration shaker/ jig 2. Visual inspection of DUT (after removal from POD) 3. Analysing obtained test results 4. Preparing test report