The Canadian Satellite Design Challenge

Design, Interface, and Environmental Testing Requirements

Presented by the

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Change Record

Date	Version	Changes
Sept. 2021	6a	New version for CSDC-6.
Nov. 2023	7a	Updated Random Vibration spec.

1 Introduction

1.1 Overview

This document presents the design, interface, and environmental testing requirements for the Canadian Satellite Design Challenge (ñCSDCó or ñthe Challengeó).

For more information regarding the general structure and objectives of the CSDC, please see the ñCSDC Overviewò document, available on the CSDC web-site (www.Geocentrix.ca/CSDC).

1.2 Point of Contact

The point-of-contact for the CSDC is:

Lawrence Reeves, CSDC Manager,
5050 Elgin St., Vancouver, B.C. V5W 3J6
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E-mail: LReeves@CSDCMS.ca

Faculty Co-ordinators, Advisors, or student team leaders only may contact the CSDC Manager regarding any issues or questions about any details relating to the Challenge.

1.3 Interpretation of Requirements

The wording of statements in this document determines their applicability:

- ñ**SHALL**ò or ñ**MUST**ò are used to indicate a mandatory requirement.
- ñ**MAY**ò indicates an option.
- ñ**WILL**ò indicates a statement of fact or intention.

1.4 Reference Material

The following documents and material are for reference purposes only, unless otherwise stated in this requirements document.

[RD-1] *"NanoRacks CubeSat Deployer (NRCSD) Interface Control Document", Document NR-SRD-029, Current Revision.*
http://nanoracks.com/wp-content/uploads/Current_edition_of_Interface_Document_for_CubeSat_Customers.pdf

[RD-2] ñCubesat Design Specificationó, Rev. 14, Cal Poly SLO, July, 2020.
www.cubesat.org

[RD-3] NASA Outgassing Data for Selecting Spacecraft Materials
http://outgassing.nasa.gov

2 General Design and Interface Requirements

The following general requirements apply to all CubeSat entries.

The section and paragraph headings in this document are provided only to facilitate reading; they do not affect the paragraph contents.

2.1 Spacecraft Structure and Materials

[DIETR-0010] Configuration and Dimensions

The spacecraft configuration and physical dimensions shall be per Figure 2-3.

Comment*: This size and configuration is called a "3U" or triple-cubesat. These dimensions apply to the spacecraft in the stowed (launch) configuration only.*

[DIETR-0020] Co-ordinate System

The spacecraft shall use the co-ordinate system as defined in Figure 2-3. The -Z face of the spacecraft will be inserted first into the dispenser.

[DIETR-0030] Spacecraft Structure Material

Aluminum 7075, 6061, 5005, and/or 5052 shall be used for both the main spacecraft structure and the corner rails.

[DIETR-0040] Surface Protuberances

Protuberances are permitted on the spacecraft XZ and YZ faces (i.e., the 100.0 x 340.5 mm spacecraft surfaces) inside the rails; however, protuberances shall not exceed 6.5 mm normal to any of these faces.

Comment*: This requirement applies to the spacecraft in the stowed (launch) configuration only.*

[DIETR-0045] Corner Rails

The spacecraft shall have four (4) rails, one per corner, along the Z axis. Rail surfaces that contact the launch dispenser guide rails shall have a hardness equal to or greater than hard-anodized aluminum (Rockwell C 65-70).

[DIETR-0050] Corner Rail Anodisation

The spacecraft corner rails and standoffs shall be hard-anodised in order to prevent cold-welding within the dispenser.

[DIETR-0060] Corner Rail Roundness

The edges of the spacecraft corner rails shall be rounded to a radius of at least 1.0 mm.

[DIETR-0070] Corner Rail Contact in Dispenser

At least 75% of the spacecraft rails shall be in contact with the dispenser rails; i.e., up to 25% of the spacecraft rails may be recessed.

[DIETR-0080] Spacecraft Material Out-gassing

Spacecraft materials shall satisfy the following low-out-gassing requirements to prevent contamination of other spacecraft during integration, testing, and launch:

- Total Mass Loss (TML) ≤ 1.0%.
- Collected Volatile Condensable Material (CVCM) ≤ 0.1%.

Comment: *Refer to [RD-1] for a list of NASA-approved low-out-gassing materials.*

[DIETR-0090] Constraining Deployables

Deployable components shall be constrained by the spacecraft; the launch dispenser walls or guide-rails must not be used to constrain deployables.

[DIETR-0095] Timing of Deployables

Deployables shall not be deployed for at least 30 minutes following spacecraft ejection from the launch canister.

If deployment switches are released causing any deployment timer to start, the timer must automatically re-set whenever the Remove Before Flight (RBF) feature is replaced and/or the deployment switches are returned to the open state.

Comment: *For the purposes of final environmental testing and functional testing during the CSDC, teams may reduce the timing of any deployment systems (e.g., to 30 seconds).*

[DIETR-0100] Space Debris

All parts shall remain attached to the spacecraft during launch, ejection, and operation. The spacecraft shall not create space debris.

[DIETR-0110] Pyrotechnic Devices

Pyrotechnic devices shall not be used.

Comment*: Electrically-operated melt-wire systems for deployables are permitted.*

[DIETR-0120] Pressure Vessels

Any pressure vessels on the spacecraft shall have a pressure of no more than 2.0 standard atmospheres (121.6 kPa, 17.6 psi), and shall have a factor of safety of at least 4.0.

[DIETR-0125] Secondary Locking

CubeSats shall use a secondary locking feature for fasteners external to the CubeSat chassis. An acceptable secondary locking compound is LocTite. Other secondary locking methods must be approved prior to use.

***Comment**: The requirement is applicable to the final flight configuration of any spacecraft which will be launched, and is not applicable during the normal course of the CSDC.*

2.2 Mass Properties

[DIETR-0130] Spacecraft Maximum Mass

The spacecraft mass shall not exceed 4.0 kg.

[DIETR-0140] Spacecraft Centre of Mass

The spacecraft centre of mass shall be located within not more than 2.0 cm from the spacecraftôs geometric centre in the X and Y axes, and not more than 7.0 cm from the spacecraftôs geometric centre in the Z axis.

***Comment**: This requirement applies to the spacecraft in the stowed (launch) configuration only.*

2.3 Electrical Requirements

[DIETR-0150] General Electrical Systems Design

All electrical systems shall be inactive during launch to prevent any electrical or RF interference with the launch vehicle and other payloads.

The spacecraft electrical system design shall not permit the ground charge circuit to energise the satellite systems (load), including flight computer (see Figure 2-1). This restriction applies to all charging methods.

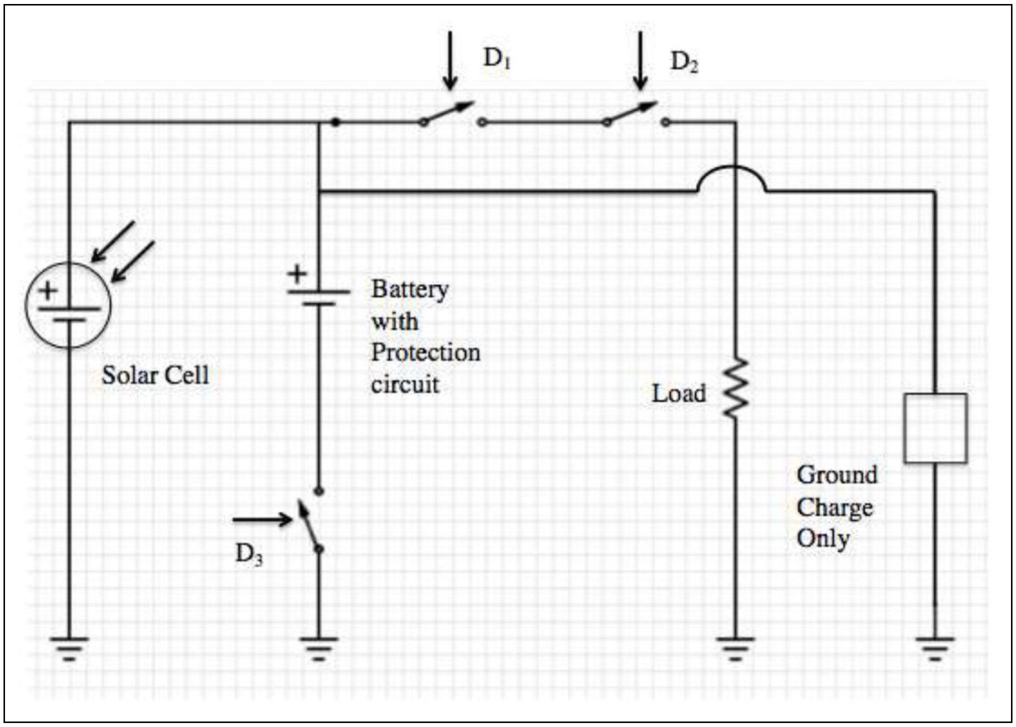

Figure 2-1. CubeSat Electrical Subsystem Block Diagram (note: RBF switch not shown)

[DIETR-0160] Spacecraft Deployment Switches

The spacecraft shall have a minimum of three (3) mechanical deployment switches corresponding to inhibits in the main electrical system. The spacecraft shall include at least one deployment switch on the ï Z rail standoffs (red or blue squares shown in Figure 2-3).

Deployment switches can be of the pusher variety (for switches located on the ï Z face), or roller/lever switches embedded in a corner rail and riding along the launch dispenser guide rail.

Deployment switches shall be centred with respect to the rail.

The force exerted by a deployment switch shall not exceed 3N.

In the actuated (depressed) state, the deployment switch shall be at or below the level of the standoff or rail in which it is installed.

[DIETR-0165] Spacecraft Separation Springs

The spacecraft shall have two separation springs. Separation springs shall be located at the ï Z end face of a diagonal pair of corner rails as shown in Figure 2-2.

Each spring shall be captive. When compressed the spring shall be contained within the maximum rail length.

Individual separation spring force shall not exceed 3.34 N (0.75 lbs) with the total force for both springs not to exceed 6.67 N (1.5 lbs).

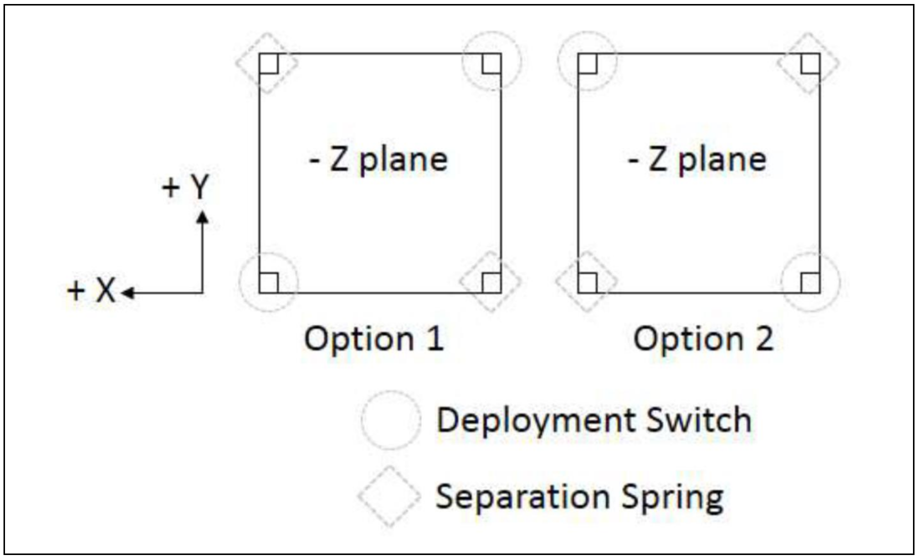

Figure 2-2. Separation Spring Placement Options.

[DIETR-0170] Spacecraft Umbilical Connectors

The spacecraft shall have one or more umbilical connectors, in order to allow for spacecraft diagnostic testing or battery charging after integration into the deployment dispenser. The umbilical connectors shall be located within the designated spacecraft Access Port locations (green-shaded areas, shown in Figure 2-3).

Through the umbilical connector, the following activities shall be able to be performed:

- battery charging and charge-state monitoring;
- send time-tagged or immediate commands to the spacecraft;
- request and receive the current status of the spacecraftÕs command queue;
- request and receive the current or saved telemetry sensor data;
- request and receive payload science data and any ancillary data;
- any other communications required to demonstrate proper operation of the spacecraft.

[DIETR-0175] Spacecraft Batteries

Batteries should maintain charge for a minimum of six (6) months from time of integration into the launch dispenser, until deployment on orbit.

[DIETR-0180] Battery Continuity Plug, or Remove Before Flight (RBF) Pin

The spacecraft shall incorporate a battery continuity plug which, when inserted, will disconnect batteries and solar cells from any other spacecraft electronics.

RBF pins must be capable of remaining in place during integration with the launch dispenser. It shall not be necessary to remove the RBF to facilitate loading into the NRCSD.

All RBF pins, switches, or jumpers utilized as primary electrical system and RBF inhibits must be accessible from the access panels (see Figure 2-3) for removal at the completion of loading into the launch dispenser.

[DIETR-0181] Battery Continuity Plug Location

The battery continuity plug shall be located inside one of the designated Access Port locations on either the +X or -X face (shown in Figure 2-3).

[DIETR-0182] Battery Continuity Plug Dimensions

When inserted, the battery continuity plug must not protrude more than 6.5 mm outside the edge of the spacecraft rails.

[DIETR-0190] Total Stored Chemical Energy

The total stored chemical energy on the spacecraft must not exceed 100 Watt-hours.

2.4 Launch Vehicle

[DIETR-0200] Fundamental Frequency

The spacecraft shall have a fundamental frequency of at least 90 Hz in each axis.

[DIETR-0210] Deployment

During deployment, the spacecraft shall be compatible with a deployment velocity between 0.5 m/s and 1.5 m/s, and an acceleration no greater than 2g in the +Z direction.

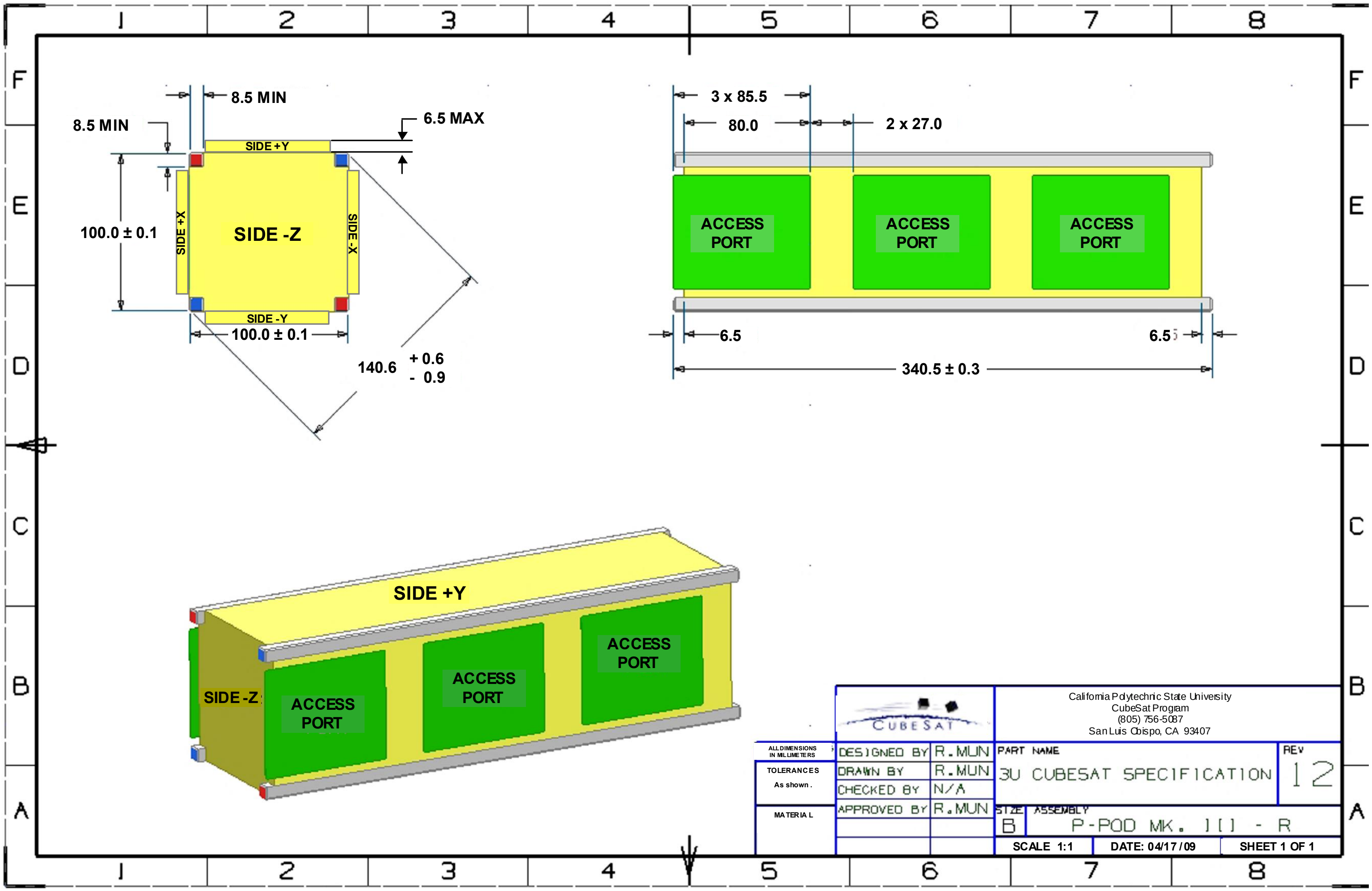

Figure 2-3. CubeSat Structure Specification [RD-2].

3 Environmental Testing Requirements

Spacecraft will undergo environmental testing to prove their ability to survive the launch and space environments and perform nominal operations.

The following tests will be performed (in order):

- random vibration
- separation shock
- thermal-vacuum and/or bake-out

A functional test, which will demonstrate that the spacecraft is working within its required parameters, will be performed prior to, during, and after the thermal-vacuum test.

3.1 General Testing Requirements

[DIETR-0300] Environmental Testing

The spacecraft shall be designed to withstand all of the environmental tests, then operate within the performance parameters required for its mission.

Comment: *The spacecraft will enter environmental testing in its completed state, as it is intended to be launched. Hardware modifications are not allowed during or after testing, other than removal of access panels to hook up umbilical connectors, or removal of protective caps for instruments. Flight software may be modified if requested.*

3.2 Launch Environment Tests

[DIETR-0310] Launch Quasi-static Acceleration Test

The spacecraft shall be designed to withstand a quasi-static acceleration of 12g (TBC).

Comment: *This environment is in every axis direction.*

[DIETR-0320] Launch Vibration Test

The spacecraft shall be designed to withstand the qualification-level launch random vibration environment shown in Figure 3-1.

Comment: *This environment is applicable at the interface between the spacecraft dispenser and the test platform, in each axis.*

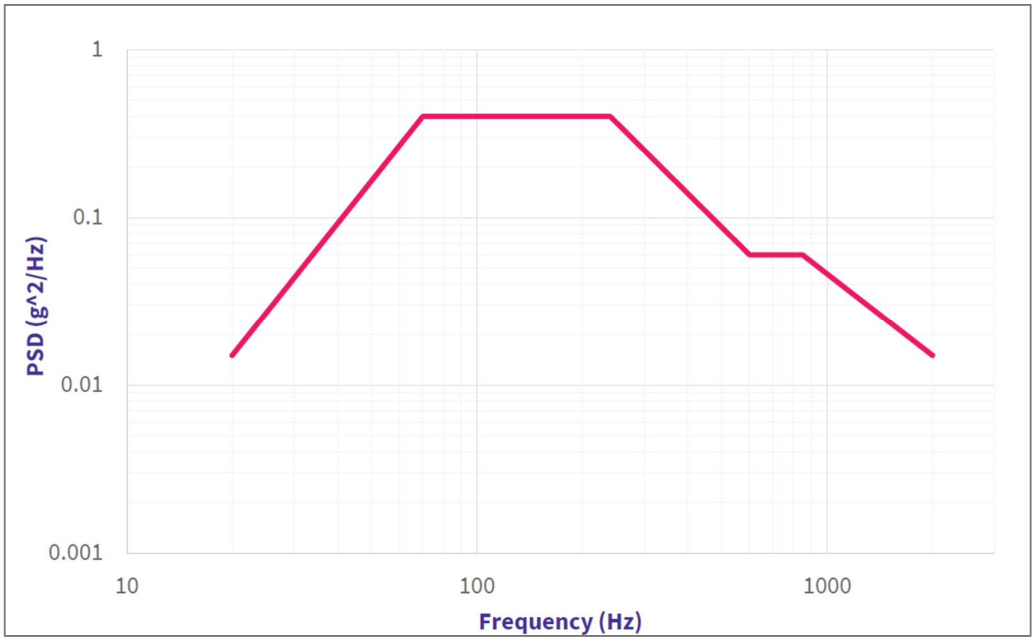

Figure 3-1. Launch Random Vibration Qualification Environment.

[DIETR-0330] De-pressurisation

The spacecraft shall be able to withstand a maximum depressurisation rate of ï 5 kPa/s.

3.3 Separation Test

[DIETR-0340] Separation Shock Test

There will be no separation shock test performed.

[DIETR-0350] Post-Environmental Test Deployment

During the deployment test, the spacecraft must exit the dispenser without jamming.

Comment: *The spacecraft will then be inspected to verify that it has not suffered any structural failure.*

3.4 Thermal-Vacuum Test

Thermal-Vacuum tests are performed simulate the thermal and vacuum conditions on-orbit, as well as to bake out hardware to ensure proper out-gassing, and to ensure predictable behaviour in different thermal conditions which will be experienced on orbit.

The vacuum-chamber pressure is taken down to a level of at least $5x10^{-5}$ Torr before the thermal cycle begins.

[DIETR-0360] Thermal-Vacuum Test

A Thermal-Vacuum test may not necessarily be conducted during the CSDC environmental testing phase, but will be required for any cubesat which is selected to be launched.

The spacecraft shall be able to withstand the thermal-vacuum qualification profile shown in Figure 3-2. The thermal-vacuum test will be conducted at a minimum vacuum level of 5 x 10^{-4} Torr.

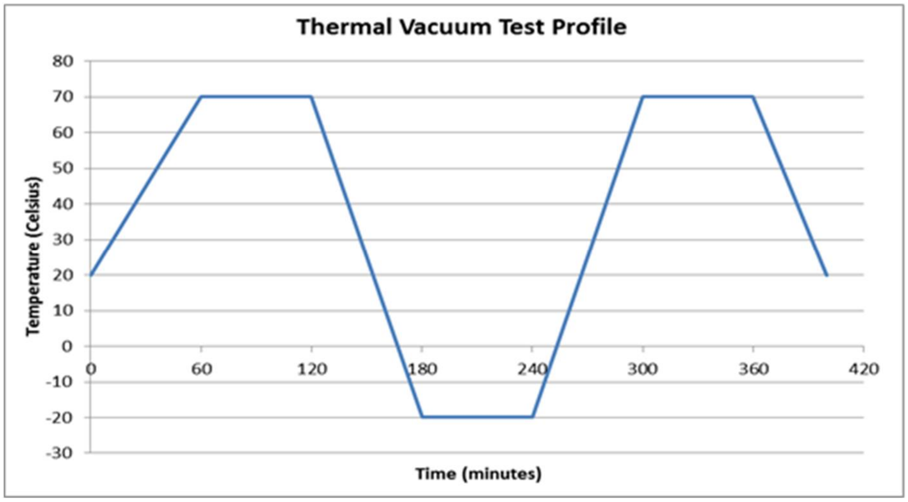

Figure 3-2. Thermal-Vacuum Qualification Profile.

Note that the cubesat is not required to be powered ON during the thermo-vacuum testing; however, teams can opt to do so if facilities permit (i.e., if there are proper pass-through cables available).

3.5 Environmental Functional Test

[DIETR-0370] Environmental Functional Test

Each team shall prepare a functional test procedure to demonstrate that their spacecraft is working within its required parameters, and is capable of fulfilling its mission.

At a minimum, the post-test procedure shall include verification of the following:

- spacecraft power system starts up and functions as required;
- Attitude Determination and Control System sensors and actuators function as required;
- spacecraft can receive and process commands;
- any deployments occur as planned;
- the payload is functional within requirements;
- the spacecraft can transmit telemetry and science data.

The functional test will be performed prior to the thermal-vacuum test, during the thermal-vacuum test (hot and cold conditions), and after the thermal-vacuum test.