B2SPACE

PROCEDIMIENTO DE ENSAYO FUNCIONAL A BAJA PRESIÓN DEL HEAT TRANSFER LAB (B2SPACE)

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TABLE OF CONTENTS

List of Figures

No se encuentran elementos de tabla de ilustraciones.

List of Tables

1 INTRODUCTION

1.1 Purpose

1.2 Scope

2 GLOSARY AND DEFINITIONS

2.1 Acronyms and abbreviations

3 APPLICABLE AND REFERENCE DOCUMENTS

3.1 Applicable documents

3.2 Normative documents

3.3 Reference documents

4 TEST OVERVIEW

4.1 Test objectives

4.2 Test Facility

4.3 Environmental conditions

4.4 Test documentation

4.5 Participants

4.6 Safety

4.7 Equipment under test

5 TEST SET UP

5.1 Thermal interface

- Conductive interface: The cubesat is simply supported over the base plate through rubber supports without bolts.
- Radiative interface: Base plate and Shroud are the radiative interface.

5.2 Temperature sensors

Temperature sensors of the thermal vacuum chamber are thermocouples, and their locations are listed in Table 1.

Table 1 – Temperature sensors locations and number on the elements of the cubesat.

TC #	Sensor location	Element
1	Base plate below the cubesat	BP
2	Base plate at a corner	BP
3	Shroud surface	SHR
4	External surface of lower tray of the cubesat (Z-) (Battery tray)	Cubesat
5	External surface of upper tray of the cubesat (Z+)	Cubesat
6	External surface of lateral panel of the cubesat (X+), half upper area	Cubesat
7	External surface of lateral panel of the cubesat (X+), half lower area	Cubesat
8	External surface of lateral panel of the cubesat (Y+), half upper area	Cubesat
9	External surface of lateral panel of the cubesat (Y+), half lower area	Cubesat
10	External surface of lateral panel of the cubesat (X-), half upper area	Cubesat
11	External surface of lateral panel of the cubesat (X-), half lower area	Cubesat
12	External surface of lateral panel of the cubesat (Y-), half upper area	Cubesat
13	External surface of lateral panel of the cubesat (Y-), half lower area	Cubesat
14	Air horizontally separated from the cubesat (5 cm from the cubesat)	Air
15	Air between the lower tray and the base plate	Air

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5.2.1 Temperature Reference Point (TRP)

- **TBT HOC test:** Internal temperature sensors of the electronics (Raspberrry, pressure sensors, IMU).
- **TBT COC test:** TC_4 (battery tray).

5.3 Heat Transfer Lab functional and testing modes. Power consumption

- Mode A1: Ascent mode 1
- Mode A2: Ascent mode 2
- Mode F1: Float mode 1
- Mode F2: Float mode 2
- Mode F3: Float mode 3

MODE	HTL power dissipation (W)	Cubesat	End mode criterion	Safety criterion (turn OFF HTL)	Safety criterion (turn ON HTL)***
A1	0.8****	ON	$p \leq p$ (10 km) **AND** $t_{mission} \geq 30$ min	$T_{plate} \geq 65°C$ **OR** $\lvert T_{plate} - T_{air} \rvert \geq 60$ °C	$T_{plate} \leq 55$ °C **AND** $\lvert T_{plate} - T_{air} \rvert \leq 50$ °C
A2	0.6****	ON	$p \leq p$ (18 km) **OR** $t_{mission} \geq 80$ min		
F1	P_{A2}*	ON	$t_{F1} \geq 120$ min		
F2	$P_{F1}/2$**	ON	$t_{F2} \geq 120$ min		
F3	0	ON	Until end of mission	N/A	N/A

*Variable: At least the last power dissipation of Mode A2 or lower.

**Variable: At least ½ the last power dissipation of Mode F1 or lower.

***After meeting the Safety criterion (turn OFF HTL).

****New power update from Jonathan Martín Palomo (18/06/2021)

5.3.1 Functional Test - pressure:

- Ambient temperature
- Start the cubesat operating sequence. Vary the TVAC pressure in order to change between consecutive modes, meeting the end mode criterion of pressure.

5.3.2 Functional Test - time:

- Ambient temperature
- Start the cubesat operating sequence. Wait the specified time (reduce the time specified to 5-10 min each mode) to change between consecutive modes.

6 TEST PARAMETERS

6.1 Test requirements

6.2 Test tolerances

Temperature tolerances for temperature set point of Shroud and Base Plate are +/- 3 ºC.

Pressure tolerances for Functional Test - pressure are +/- 3 mbar.

6.3 Abortion criteria

If any of the thermocouples or temperature sensors (electronic temperature sensors, TC74 and PT1000 sensors) exceed the temperature limits shown in Table 2 the test shall be stopped or the thermal and pressure scenario shall be modified.

Table 2 – Temperature limits of the cubesat parts.

Element	Minimum Operating Temperature	Maximum Operating Temperature	Reference	Temperature sensors ID
Raspberry Presssure sensors IMU	0	+65	ref raspberry	Electronics internal temperature sensors
Battery	+5	+40*	Pindado meeting April 28th	TC_4
Heated plate	–15	+70	Defined by TASEC team	PT_5 PT_6
Structure	–15	+70	Defined by TASEC team	TC_5 to TC_13 TC74_1 to TC_5
Air	–15	+70	Defined by TASEC team	TC_14 TC_15 PT_1 to PT_4

*The battery resists a short period between 50ºC and 60ºC

CRITICAL TEMPERATURE SENSORS:

- PT1000 of the aluminum plate (PT_5) and of the heater (PT_6).
- Internal temperature sensors of the electronics (Raspberry, pressure sensors, IMU).
- TC4 (battery tray).

6.4 Test success criteria

The test will be successful if any part of the cubesat is not damaged and the temperature limits are not exceeded. The TBT test must accomplish the cubesat operatin sequence (A1, A2, F1, F2, F3) in both functional test (pressure and time).

7 STEP-BY-STEP TEST PROCEDURE

7.1 Stabilization criteria

Table 3 – Step by step TBT procedure.

Step #	Description	Expected Result	Date/Time	Sign	Comments
		PREPARATION			
00	• Preparation of the equipment under test: • Remove bolts from upper tray and fix it with kapton tape. • Clean all the parts intended to be inside of the thermal vacuum chamber. • Assembly the four aluminum lateral panels and the corresponding TC74 temperature sensors. • Tighten the anemometer connector in the lower tray. • Fix the wiring from converter to mosfet.		18/06/2021 9:30		Ok
05	• Fix the external temperature sensors (thermocouples) in the appropriate location over the cubesat. • Take photos of TC fixing.				Ok
10	• Cover base plate area below the anemometer connector with kapton avoiding electrical short-circuit. • Fix the Ethernet connection from the inside chamber interface of the chamber to the cubesat. • Fix the power wiring from the inside chamber interface to the battery terminals of the cubesat. Identify the wiring!!				Ok

	• Assembly the new wiring for external battery charge. • Fix the ground connections (if needed). • Take photos of the connections.				
15	• Take photos of the assembly.			LPP	OK
20	• Connect all the thermocouple wires to the TVAC I/F. • Check the thermocouple signals.	All signals at ambient temperature.		MSG FAA	OK
25	• Start to record the thermocouples signal. • Thermal vacuum chamber operation procedure. • Disconnect the turbo pump			MSG	OK
30	• Check the battery voltage	Voltage > 18 V		FAA	V_BAT = 24.12 11:00 LAUNCH FLIGHT SOFTWARE 11:45 STOP FLIGHT SOFTWARE
35	• Start recording the data for **Functional Test #1** • Perform Functional Test #1 • Fernando procedure • Check pressure, temperature and etc. signals of the cubesat. • Turn ON the plate heater and check the temperature variation.		12:59	FAA	12:50 CONNECT CUBESAT AGAIN SEE FUNCTIONAL TEST #1 END 13:06

40	• Stop Functional Test #1 • Continue recording the signals, etc.		13:06	FAA	OK
45	• Start recording the data for **Functional Test - pressure** • Start Functional Test – pressure • Mode A1 • Check pressure, temperature and etc. signals of the cubesat.	Ambient temperature and pressure		FAA LPP	
Step #	**Description**	**Expected Result**	**Date/Time**	**Sign**	**Comments**
TVAC commissioning phase & Functional Tests					
50	• Close the chamber • Start vacuum pump and wait until the required pressure level is reached for the **Functional Test - pressure** • Check the variation of pressure rate of change. It shall be similar to the variation in the ascent profile.	***p* > 265 mbar (10 km) time ≈ XX h**	13:25	AGP FAA MSF LPP	13:32 V_BAT = 23,4 V 13:46 P = 265 MBAR 13:54 Switch off heater at T>65ºC 13:54 Switch on heater at T>55ºC 13:54 Switch to A2 mode
55	• Vary the TVAC pressure to meet the end mode A1 criterion (automatic change to A2) (meeting the time criterion is also required) • Check pressure, temperature and etc. signals of the cubesat.	*p* ≤ 265 mbar (10 km) **AND** $t_{mission}$ ≥ 30 min P(W) = 0.8 W Voltage > 18 V	13:54		13:55 V_bat = 23.3 V

	• **Check every half hour the battery voltage**				
60	• Vary the TVAC pressure to meet the end mode A2 criterion (automatic change to F1) • Check pressure, temperature and etc. signals of the cubesat. • **Check every half hour the battery voltage**	$p \leq$ 84 mbar (18 km) **OR** $t_{mission} \geq$ 80 min P(W) = 0.6 W Voltage > 18 V	13:54		13:54 Fire alarm belled 14:16 Heater switch off T>65ºC 14:17 Heater switch on T<55ºC 14:19 Switch to F1 because p<84mbar
65	• Wait for mode F1 to end (automatic change to F2) • Check pressure, temperature and etc. signals of the cubesat. • **Check every half hour the battery voltage**	$t_{F1} \geq$ 15 min P(W) = 0.6 W Voltage > 18 V	14:19		14:21 p≈55mbar (20km) 14:24 Heater switches off because T>65ºC 14:26 Heater switches on T<55ºC and power lowers to 0.5W 14:33 Switch to F2
70	• Wait for mode F2 to end (automatic change to F3) • Check pressure, temperature and etc. signals of the cubesat. • **Check every half hour the battery voltage**	$t_{F2} \geq$ 15 min P_{F2} (W) = P_{F1} /2 Voltage > 18 V	14:34		Starts with 0.25W (0.5 W of F1 divided by 2) 14:42 p≈52 mbar (30km) 14:49 Switch to F3
75	• Wait for mode F3 to end • Check pressure, temperature and etc. signals of the cubesat. • **Check every half hour the battery voltage**	$t_{F3} \geq$ 15 min P_{F3} (W) = 0 Voltage > 18 V	14:49		Starts with 0W 15:04 End F3
80	• End of **Functional Test – pressure** • **Check the battery voltage**	Voltage > 18 V	15:04		V_bat = 23,02 V P = 20mbar
81	• Continue in vacuum • Set manually F1 • Open valves to increase the pressure until 541 mbar (5km)	Voltage > 18 V	17:44	FAA MSG	17:15 Cubesat turns on 17:20 V_bat = 22,8V 17:44 mode F1

	• Check it switches to F3 mode				P(W) = 0.1W 17:46 switches to F3 when P>541 mbar (5km)
82	• Lower the pressure until p>84mbar (18km) and p<541mbar(5km) • Set A2 mode • Open the valves to increase pressure until 541mbar • Check it switches to F3 mode		17:46	FAA MSG	17:47 mode A2 at 500mbar 17:47 switch to F3 automatically
	• Open valves to increase pressure until ambient	P=940mbar	17:48	MSG	17:50 P = P_amb
Step #	**Description**	**Expected Result**	**Date/Time**	**Sign**	**Comments**
85	• Start recording the data for **Functional Test - time** • Start Functional Test – time • Mode A1 • Check pressure, temperature and etc. signals of the cubesat.	Ambient temperature and pressure	17:48		17:55 V_bat = 22,6 V 17:56 Start goes wrong 17:57 starts goes right - mode A1
90	• Start vacuum pump and wait until the required pressure level is reached for the **Functional Test – time** • Check the variation of pressure rate of change. It shall be similar to the variation in the ascent profile.	***P<541mbar*** ***p* > 265 mbar (10 km)** **time ≈ XX h**	17:57		17:50 p_amb 18:24 p=500mbar

95	• Meet only the time criteria • Vary the TVAC pressure to meet the end mode A1 criterion (automatic change to A2) (meeting the time criterion is also required) • Check pressure, temperature and etc. signals of the cubesat. • **Check every half hour the battery voltage**	*P<541mbar* *(p* ≤ 265 mbar (10 km) **AND** $t_{mission}$ ≥ 30 min) *OR* ($t_{mission}$ ≥40 min) Voltage > 18 V	17:57		18:24 p=500mbar 18:24 v_bat=22.3V 18:37 End. Switches to A2
100	• Wait for mode A2 to end (automatic change to F1) WHITOUT meeting the pressure criterion. • Check pressure, temperature and etc. signals of the cubesat. **Check every half hour the battery voltage**	*p* ≤ 84 mbar (18 km) **OR** $t_{mission}$ ≥ 80 min Voltage > 18 V	18:37		18:49 P=180mbar 19:00 V_bat=22.05V 19:17 Switches to F1
105	• Wait for mode F1 t end (automatic change to F2) • Check pressure, temperature and etc. signals of the cubesat. **Check every half hour the battery voltage**	t_{F1} ≥ 5 min Voltage > 18 V	19:17		19:22 Ends. Switches to F2
110	• Wait for mode F2 to end (automatic change to F3) • Check pressure, temperature and etc. signals of the cubesat. **Check every half hour the battery voltage**	t_{F2} ≥ 5 min Voltage > 18 V	19:22		19:22 V_bat = 21,09V 19:27 Swithces to F3
	• Wait for mode F3 to end • Check pressure, temperature and etc. signals of the cubesat. **Check every half hour the battery voltage**	t_{F3} ≥ 5 min Voltage > 18 V	19:27		19:32 Ends of F3. It stays forever in F3

Step #	Description	Expected Result	Date/Time	Sign	Comments
120	• End of **Functional Test – pressure** **Check the battery voltage**	Voltage > 18 V	19:32		19:32 END
	Inspection				
125	Check that all temperatures are above 10 ºC. Go to ambient pressure Open the thermal vacuum chamber	T_amb P_amb		MSG	13:34 P_amb
130	Visual inspection (take photos).			LPP	OK
135	**Check the battery voltage**	Voltage > 18 V			19:36 V_bat = 21.9V
130	• Start recording the data for **Functional Test #2** • Perform Functional Test #2 • Fernando procedure • Check pressure, temperature and etc. signals of the cubesat. • Turn ON the plate heater and check the temperature variation. • Stop Functional Test #2 • Turn off the cubesat • Stop recording the thermocouple signals.		19:46		19:58 V_bat = 21.88V 19:58 ENDS

135	Dissasembly the cubesat from the chamber and wiring connections.				
140	Check the items if needed.				

8 GSE

The list of GSE items to be used during the test is indicated in Table 4.

Table 4 – List of materials, tools and items needed for the test.

#	Item	Manufacturer	Serial Number	Calibration Status	Stored in
1	Kapton tape				
2	Aluminun tape				
3					
4					
5					
6					
7					
8					
9					
10					

9 SPECIAL REMARKS

9.1 Anomalies

Anomalies written down in Table 5 will be reported in the final approved as-run test procedure as part of the test documentation.

Table 5 – List of anomalies.

#	Anomaly	Comments
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

9.2 Test deviations

Test deviations written down in Table 6 will be reported in the final approved as-run test procedure as part of the test documentation.

Table 6 – List of test deviations.

#	Time	Test Deviation	Comments
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			