SPD 10003 – QM Thermal Vacuum Testing

Document Author(s):

Seongwhan Lee *swhan@khu.ac.kr*

Responsible Engineer(s):

Seongwhan Lee *swhan@khu.ac.kr*

Jungho Lee *overthewater@khu.ac.kr*

Revision History

Revision	Description	Author	Date
00	Draft Document	Seongwhan Lee	10/22/14
01	Temperature range updated	Seongwhan Lee	11/15/14
02	Test log format updated	Seongwhan Lee	11/20/14
03	Revision Update	Seongwhan Lee	12/15/14
04	Test Result Updated	Seongwhan Lee	01/14/15
05	Revision Update	Seongwhan Lee	06/19/15
06	FM Procedure Update	Seongwhan Lee	10/13/15

List of Abbreviations and Acronyms

SIGMA – Scientific cubesat with Instruments for Global Magnetic field and rAdiation

KHUSAT – Kyung Hee University SATellite

KHU – Kyung Hee Univeristy

SSR – School of Space Research

YU – York University, Canada

UNH – University of New Hampshire, USA

VT – Virginia Tech, USA

TestPOD - Test Picosatellite Orbital Deployer

UUT – Unit Under Test

TEPC – Tissue Equivalent Proportional Counter

MAG – miniaturized fluxgate MAGnetometer

IIB – Instrument Interface Board

OBC – On Board Computer

RBF – Remove Before Flight

P/N – Part Number

TVAC – Thermal Vacuum

QM – Qualifying Model

FM – Flight Model

TC – ThermoCouples

Special Notes

CAUTION

Note: CAUTION notes identify situations where flight hardware may be damaged without proper attention.

DANGER

Note: DANGER notes identify situations where bodily harm may occur without proper attention.

Table of Contents

1.0 Objective

This document describes TVAC test procedure of the KHUSAT-03 for QM. TVAC test consists of thermal cycling test and thermal balance test. The objective of thermal cycling test is to verify the system performance under the thermal vacuum condition which the spacecraft will encounter in space. The objective of thermal cycling test is subject the KHUSAT-03 satellites to the temperature extremes that have been derived from the combination of thermal analysis results and component-level operational temperature ranges. Functional TVAC tests will be performed in a thermal vacuum chamber at the KHU.

2.0 Personnel

KHUSAT-03	_____	Date: __/__/____
Mechanical Engineer(s):	_____	Date: __/__/____
KHUSAT-03	_____	Date: __/__/____
Electrical Engineer(s):	_____	Date: __/__/____
Test Facility Engineer(s):	_____	Date: __/__/____
	_____	Date: __/__/____

3.0 Proper Hardware Handling

All Flight Hardware to be bagged and kept clean. Personnel to handle hardware should only use appropriate gloves. Solar Panels should not be touched on the top surface, except by appropriate plastic covering.

4.0 Reference Documents

GSFC-STD-7000A GENERAL ENVIRONMENTAL VERIFICATION STANDARD (GEVS)
For GSFC Flight Programs and Projects

5.0 Thermal Vacuum Test Specification

5.1 Test Profile

Table 1KHUSSAT-03 Thermal Cycling Test Parameters

Item	Qualification	Acceptance
Number of Cycling	4 times	2 times
Soak Duration(Dwell Time)	2 hrs	2 hrs
Temperature Range	-20 ~ 40 ℃	-15 ~ 35℃
Temperature Transition Rate	≤ 2℃/min	≤ 2℃/min
Stabilization Condition	≤ 3℃/hr	≤ 3℃/hr
Pressure	≤ 10^{-5} Torr	≤ 10^{-5} Torr

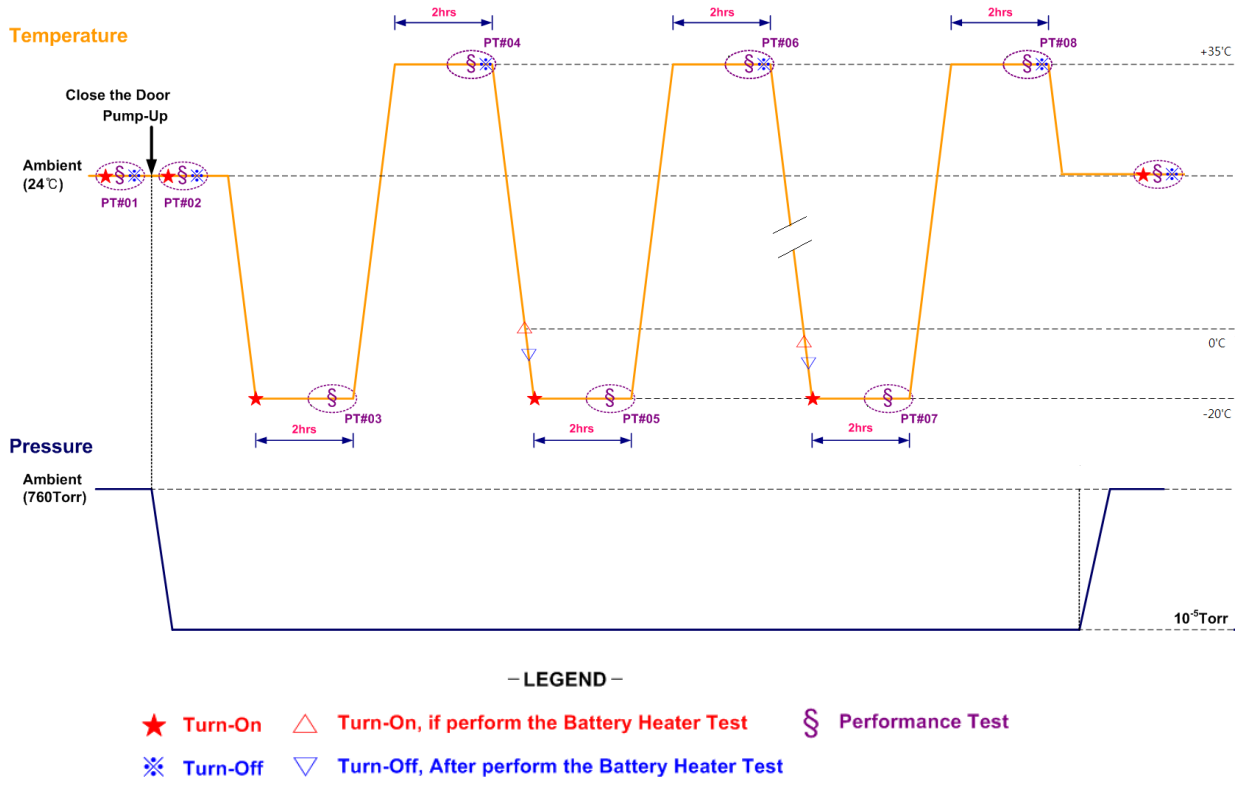


Figure 1 KHUSAT-03 QM Thermal Cycling Test Profile

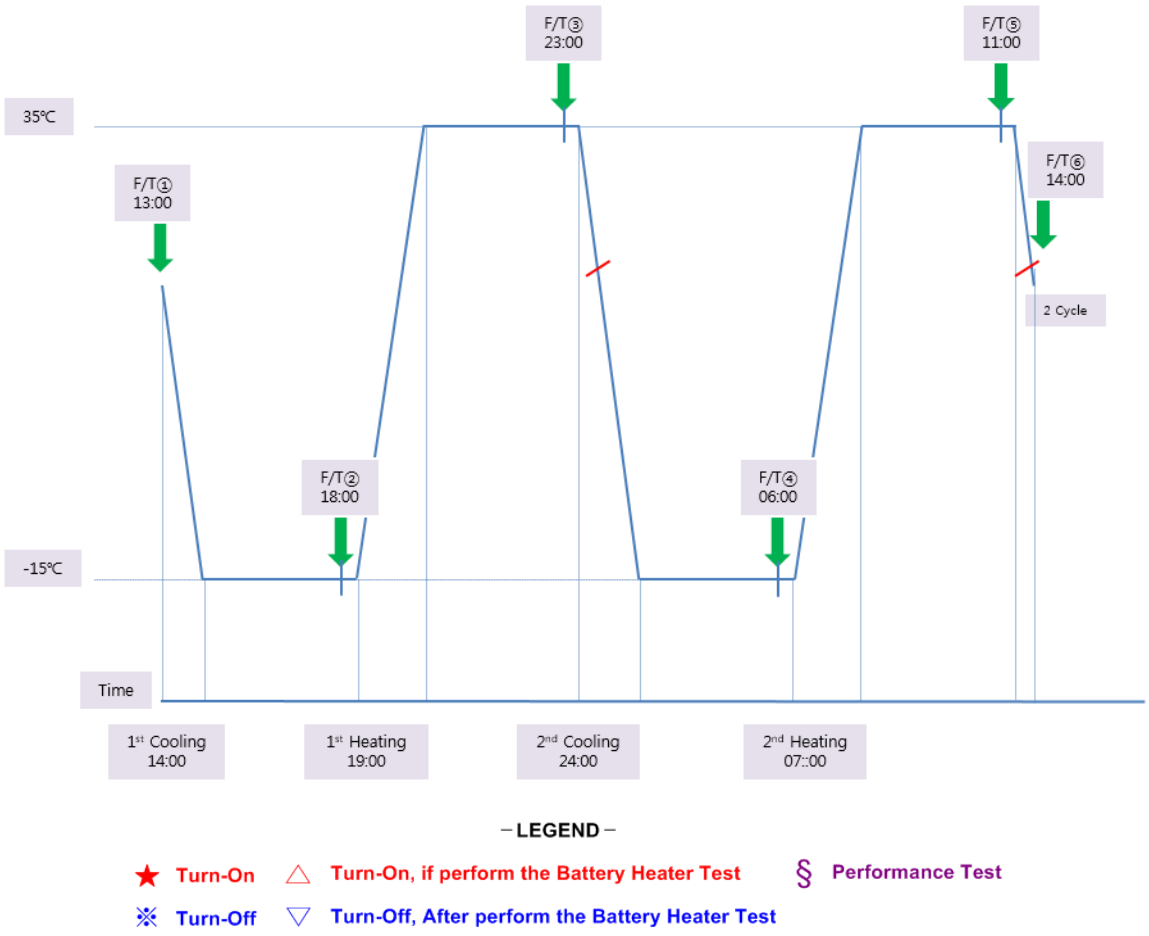


Figure 2 KHUSAT-03 FM Thermal Cycling Test Profile

5.2 Temperature Range

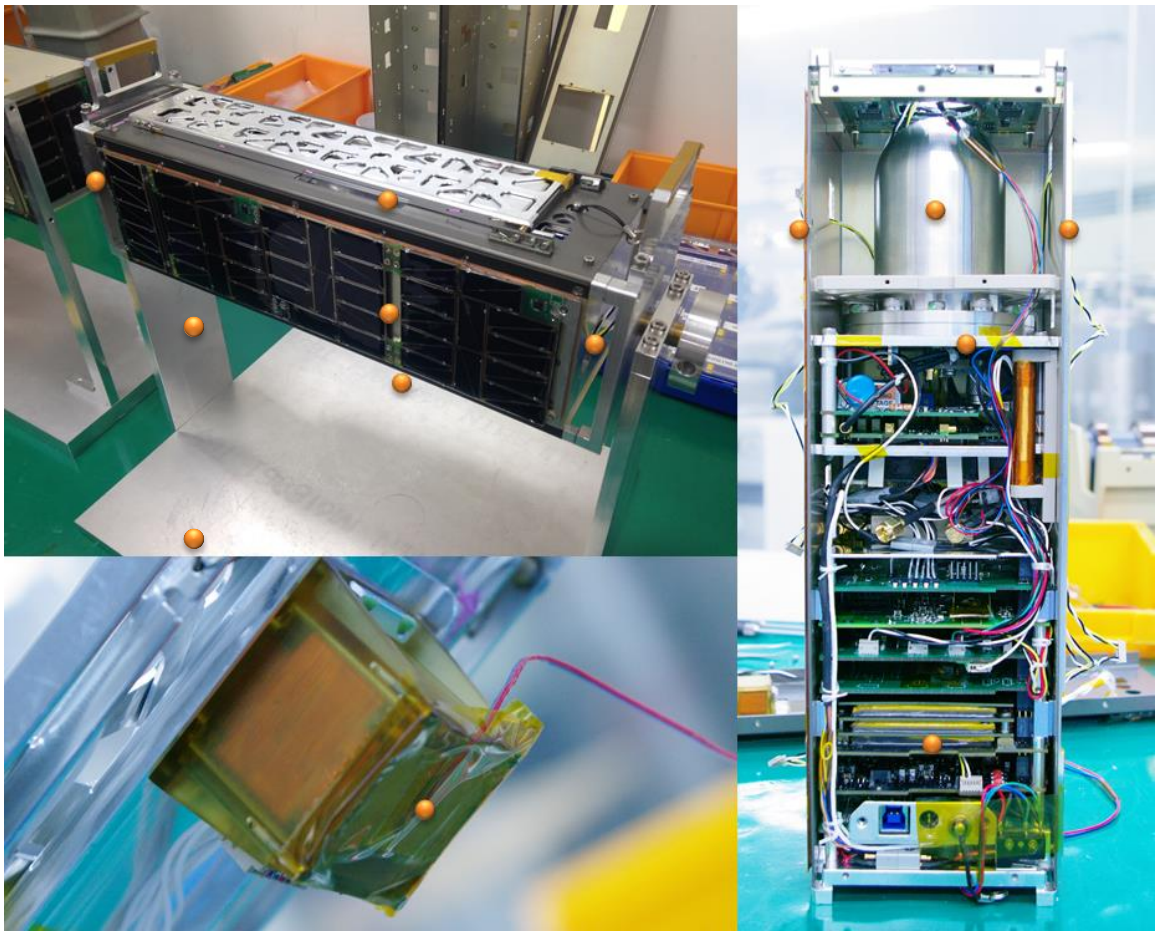
Component	Operating Temperature Limit (℃)
S-band Transmitter	-40 to +85
OBC	-40 to +85
SD card	-40 to +85
RTC coin battery	-30 to +80
EPS	-40 to +85
Battery	-40 to +85
Transceiver	-20 to +50
UHF/VHF Antenna	-20 to +60
IIB	-40 to +85
MAG Board	-40 to +70
ACS Board	-40 to +85
TEPC Board	-40 to +85
TEPC Sensor	-10 to +30
MAG Sensor	-40 to +80
Solar Cell	-100 to +100
Structure	-45 to +65

5.3 Thermo Couples

Omega Engineering 5TC-TT-T-30-36

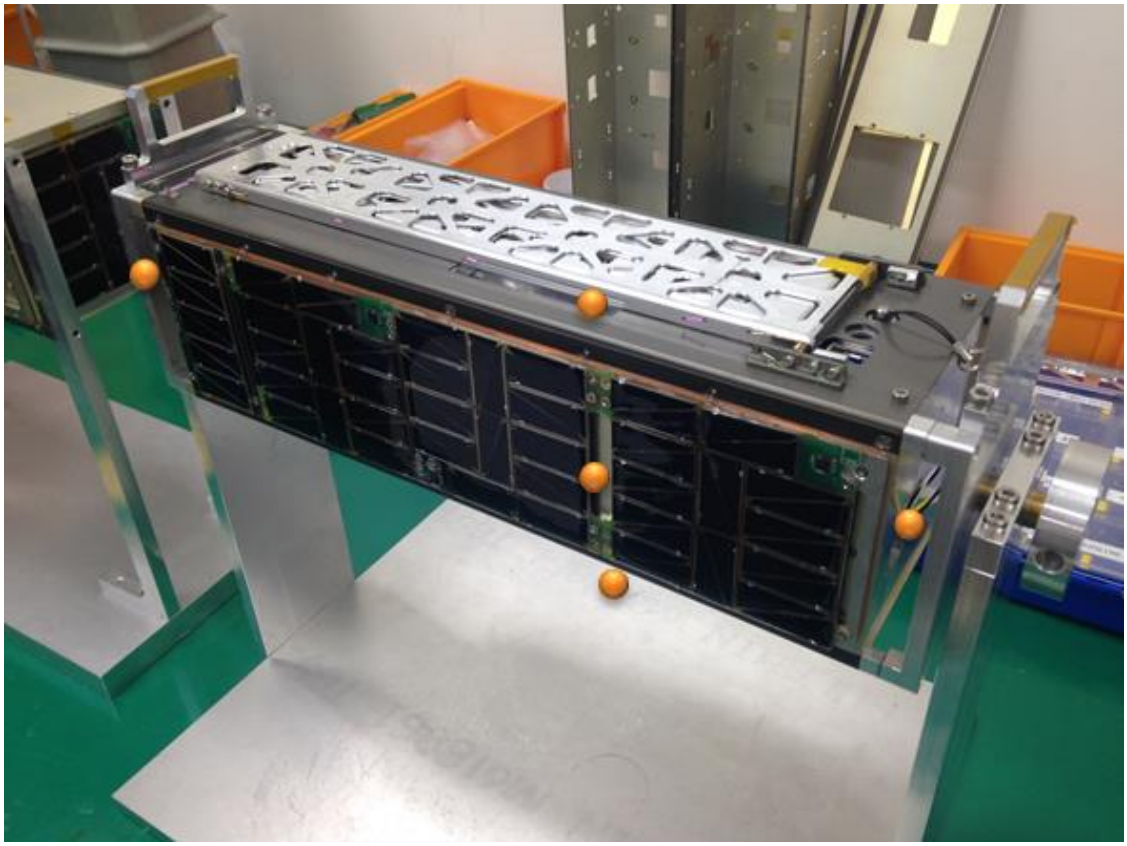
5.4 Location of Thermo Couples (QM)

Thermo couple	Location	Thermo couple	Location
T1	Shroud 1	T2	MAG Sensor
T3	Battery	T4	TEPC Mount
T5	TEPC Chamber	T6	UV ANT(+Y)
T7	Chassis +X	T8	Chassis -X
T9	Chassis –Y	T10	Chassis +Z
T11	Chassis –Z	T12	Shroud 2



5.5 Location of Thermo Couples (FM)

Thermo couple	Location	Thermo couple	Location
T1	+Z Chassis	T2	-Z Chassis
T3 (Optional)	+X Chassis	T4 (Optional)	-X Chassis



5.6 Check List of Functional Test

Component	Criterion
TEPC	No broken components or connections on electronics boards
	No loss of functionality
MAG	No loss of functionality in MAG boom deploy
	No loss of functionality in miniaturized fluxgate sensor
Torque coils/rod	No mechanical damage
	Retain full functionality
Avionics Bus	Deployment Switch – Plunger travels smoothly
	RBF Switch – remain closed
	OBC – Retains full functionality, no mechanical damage
	EPS – Retains full functionality, no mechanical damage
	Battery – Retains full functionality, no mechanical damage
	Transceiver – Retains full functionality, no mechanical damage
	IIB – Retains full functionality, no mechanical damage
	MAG board – Retains full functionality, no mechanical damage
	ACS board– Retains full functionality, no mechanical damage
Solar Panels	No structural damage that causes loss of functionality
	Electrical Functionality
Chassis	No galling on chassis rails
MAG Boom	No loss of deployment functionality
UHF/VHF Antenna	No loss of deployment functionality
S-band Antenna	No physical damage
	Electrical Functionality
DC-DC converter	Pins still intact and physically undamaged
Harnessing	Electrical Functionality

Note

MAG Boom 과 UHF/VHF antenna 는 Chamber 구동 환경에서 전개할 수 없기 때문에 Part 단위의 별도의 열진공시험 필요.

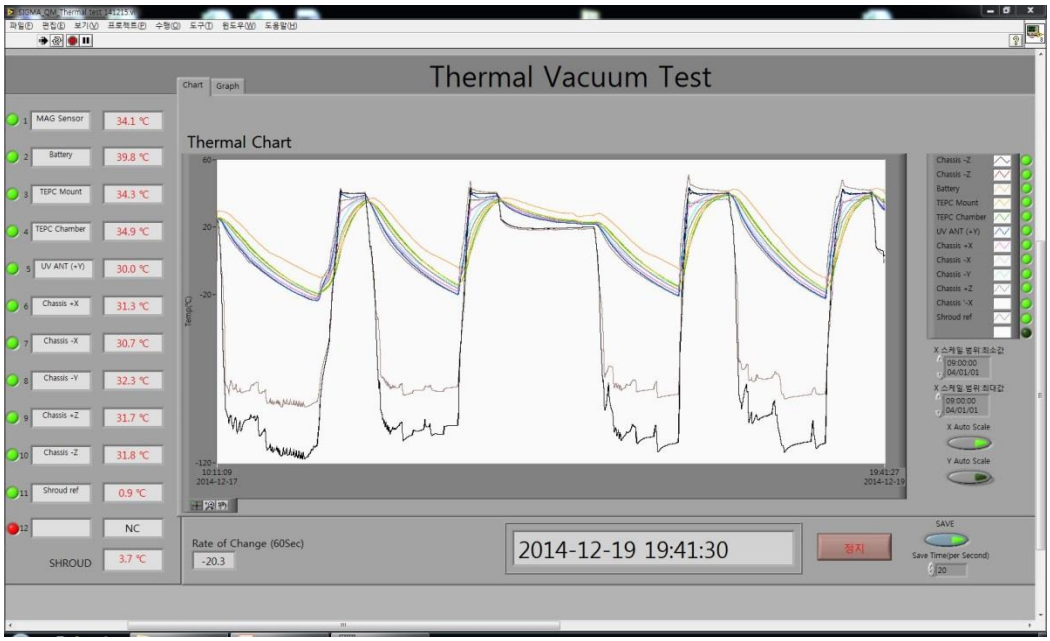
5.7 QM Test Environment

- Location

  B110, Clean Room, Kyung Hee Astronomical Observatory, Korea

- Monitoring S/W

  LabVIEW 2007(SIGMA_QM_Thremal test 141215.vi)



6.0 QM Thermal Vacuum Test

6.1 QM T-VAC Test Log and Issues

〈 2014 / 12 / 17 (수)
KHUSAT-3 QM T-VAC test. 〉

< Test log >
ㄴ. 스텝 바뀔때마다.
ㅇ 30 – 60분마다
한번씩!!

Kyung Hee University
School of Space Research
WCU Project

Yongin, Gyeonggi, 446-701, Korea
TEL : +82-31-201-3850~1 FAX: +82-31-201-3852
http://khusat.khu.ac.kr swhan@khu.ac.kr

SIGMA QM T-VAC Test Log

「 TC 1 센서가 그래프/차트에 제대로 출력되지 않는다. monitoring 하는데에는 문제없는것으로 판단. LabVIEW 상에서 DAQ 과정에 수정할 것들이 있는 것 같음. 」

Time [DD/HH:MM]	Shroud/T11 Temp [℃]	Vac [torr]	Note	Name
17 / 05:02	23.8 / 22.9	1.3×10^{-2}	Rotary pump 가동, 시스템 점검.	이석환
17 / 08:10	23.5 / 22.9	3.3×10^{-3}	Cryo pump 가동.	이석환
10:05	23.7 / 22.9	1.5×10^{-5}	# 1st cooling 시작.	이석환
10:39	-46.5 / -11.7	5.7×10^{-6}	1st cooling 중	이석환
11:21	-92.4 / -71.3	4.7×10^{-6}	"	이석환
12:29	-95.8 / -77.9	3.1×10^{-6}	"	이석환
13:44	-100.9 / -76.9	3.9×10^{-6}	1st cooling / 가운온도(TC9) -4.8℃ chassis +Z -	이석환
14:48	-112.7 / -84.1	3.3×10^{-6}	1st cooling 지연. (~2hrs) / chassis +Z : -10.1℃	이석환
15:48	-114.7 / -84.7	3.2×10^{-6}	1st cooling 지연 / Chassis +Z : -15.2℃	서도원
16:10	-111.6 / -82.4	3.2×10^{-6}	-111.7℃ shroud, 서도원 5h 47M 이으로 혼드.	서도원
16:52	-116.6 / -85.8	2.8×10^{-6}	1st cooling 지연, 그 전보다 온도감소 폭이 적음 / chassis +Z: -18.5℃	서도원
17:00	-114.3 / -84.7	2.9×10^{-6}	#1st cooling soak time 시작 (~2hrs).	이석환
~~18:45~~		*	위성체의 온도를 -25℃ 까지 내리는 것이 무리라고 판단하여 -20℃로 조정	
18:45	-109.7 / -83.7	2.8×10^{-6}	#1F/T 수행. TEPC 이상.	이석환
18:58	-101.1 / -80.4	2.7×10^{-6}	# 1st Heating 시작.	이석환
20:58	42.3 / 35.6	1.3×10^{-5}	# 1st Heating soak time	이석환
22:28	40.0 / 36.7	1.0×10^{-5}	# 2nd F/T 수행	서도원
22:55	40.1 / 37.0	1.0×10^{-5}	# 2nd Cooling 시작.	이석환
18/ 00:11	-74.4 / -48.4	2.8×10^{-6}	2nd Cooling / chassis +Z : 20.1℃	서도원
00:55	-100.8 / -74.2	2.8×10^{-6}	2nd Cooling / chassis +Z : 11.4C	서도원
02:41	-104.2 / -79.1	2.6×10^{-6}	2nd cooling / chassis +Z : -1.9℃	이석환
04:05	-102.8 / -77.4	2.4×10^{-6}	2nd cooling / TEPC : -6.5℃ (EPS 값 못읽음)	이석환
~~05:19~~	~~-98.0 / -75.4~~	~~2.4×10^{-6}~~	* 배터리 전압의 문제인지 TEPC의 문제인지?	
06:00	-98.0 / -75.4	2.4×10^{-6}	# 2nd cooling soak time 시작. (-17.2℃)	이석환
06:54	-97.6 / -74.7	2.2×10^{-6}	위성 shutdown ... ∴ 1시간 일찍 Heating으로 전환 (under voltage)	이석환
08:23	+40.3 / +42.1	1.9×10^{-5}		이정규
10:56	~~37.6~~ 27.1 / ~~24.1~~ 33.0	6.8×10^{-6}		이정규
11:18	21.4 / 31.5	6.5×10^{-6}		이정규
12:34	19.5 / 27.5	5.5×10^{-6}		이정규
14 / 06	19.2 / 24.8	4.9×10^{-6}		이정규

∨ Solar panel +X축 외에 전부 유효하지 않은 값으로 보임.
∨ TEPC -4.8℃부터 X. (EPS 응답없음) → TEPC 자체의 문제X, 전원부족 7.3 V.

Kyung Hee University
School of Space Research
WCU Project

Yongin, Gyeonggi, 446-701, Korea
TEL : +82-31-201-3850~1 **FAX:** +82-31-201-3852
http://khusat.khu.ac.kr swhan@khu.ac.kr

SIGMA QM T-VAC Test Log

Time [DD/HH:MM]	Shroud/T11 Temp [°C]	Vac [torr]	Note	Name
18/15:59	19.4/23	4.5×10⁻⁶		손재혁
18/18:35	20.3℃/22.2	4.3×10⁻⁶	#쿨링 재시작 (전원 Power supply 변경)	이효정
18/19:23	-88.1/13.3	2.4×10⁻⁶		이유경
18/19:51	~~-71.9/16.2~~ -75.9/10.2	~~2.5~~ 2.5×10⁻⁶	액화질소 교체	이유경
18/21:00	2.2×10⁻⁶ ↔ -106.5, 0.7			이효정
21:32	2.2×10⁻⁶ ↔ -102.2/-13.7		3rd cooling 중.	이서환
23:00	-105.3/-16.9	2.1×10⁻⁶	3rd cooling 중	이서환
19/00:27	-111.1/-80.7	1.9×10⁻⁶	3rd cooling 중...	이서환
01:35	-108.5/-79.6	1.9×10⁻⁶	#3rd cooling soak time 시작	이서환
01:55	-107.7/-79.3	1.9×10⁻⁶	# 3rd heating 시작 (~1~2°C/min)	이서환
04:46	40.1/36.3	5.8×10⁻⁶	↳heating 과정에서 overshoot가 +9°C를 넘음	이서환
05:20			LN_2 잔량 70%. (4th cooling 수행가능).	
⚠ 05:55			# 3rd heating F/T: MAG data 획득중 obc 빠짐	이서환
			→ switch로 리셋이 안됨. 스위치 off 하면 P/S 에서	CC로 변함.
05:59			※ 정호형 개인노트북으로 연결하고나서 정상 작동	(480mA.)
			⇒ switch 접촉의 문제이거나 테스트 PC의 프로그램 의	일시적 문제일 수도.
			① line 접촉불량으로 인한 program 정지	
			② MAG에서 data를 못받은 경우	
			③ SD Card에 저장을 못한 경우	
			④ OBC 오작동.	
06:14	30	5.6×10⁻⁶	#4th cooling 시작.	이서환
07:56	-89.4/18.0	2.0×10⁻⁶	4th cooling 中..	
09:49	-91.2/1.0	1.9×10⁻⁶	4th cooling 中 12.8 355mA	이효정
10:42	-105.5/-4.5	1.9×10⁻⁶	OBC reset 후 470mA 증가 → 10:46分 360mA	이유경
11:49	-109.4/-11.1	1.8×10⁻⁶	4th cooling 중	이효정
13:30	-95/-18.6	1.8×10⁻⁶	13:20 부터 Soak time 시작함	이효정
14:35	-108.2/-22.3	1.8×10⁻⁶	Soak time 종료 후 4th heating 시작	이효정
① 15:02	-20.8/-30.8	2.4×10⁻⁶	4th heating 중 (4th cooling 때 버터러	히터가 그래프상에서
				동작하지 않은것으로 보임)
				이서환

※ T-VAC 전원(P/S) 연결하여 Test 진행해야 함.

Kyung Hee University
School of Space Research
WCU Project

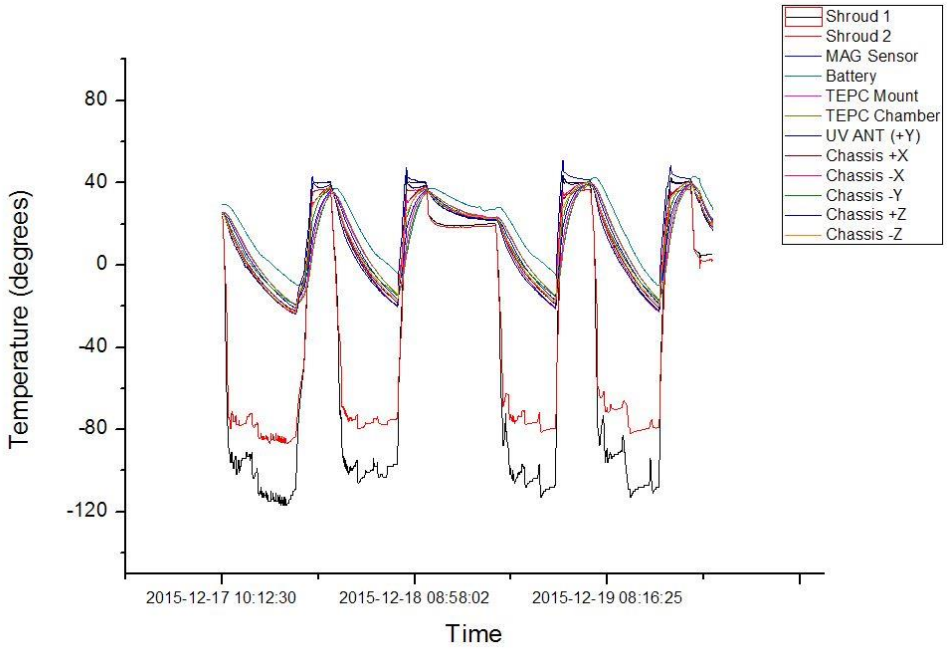
Yongin, Gyeonggi, 446-701, Korea
TEL : +82-31-201-3850~1 **FAX:** +82-31-201-3852
http://khusat.khu.ac.kr swhan@khu.ac.kr

SIGMA QM T-VAC Test Log

Time [DD/HH:MM]	Shroud/T11 Temp [℃]	Vac [torr]	Note	Name
19/15:49	30.8/24.9	6.9×10^{-6}	4th heating 中...	이상환
16:35			# 4th heating soak time	이상환
18:34	~~40.~~/	2.8×10^{-6}	# 4th heating ~~soak~~ F/T	
18:54	11.9/10.4	2.4×10^{-4}	상온 (20°C)로 온도유지.	
			진공유지 . cryo pump, chiller off.	이상환
21:16		3.5×10^{2}	QM TVAC test 종료 / Vent	이상환

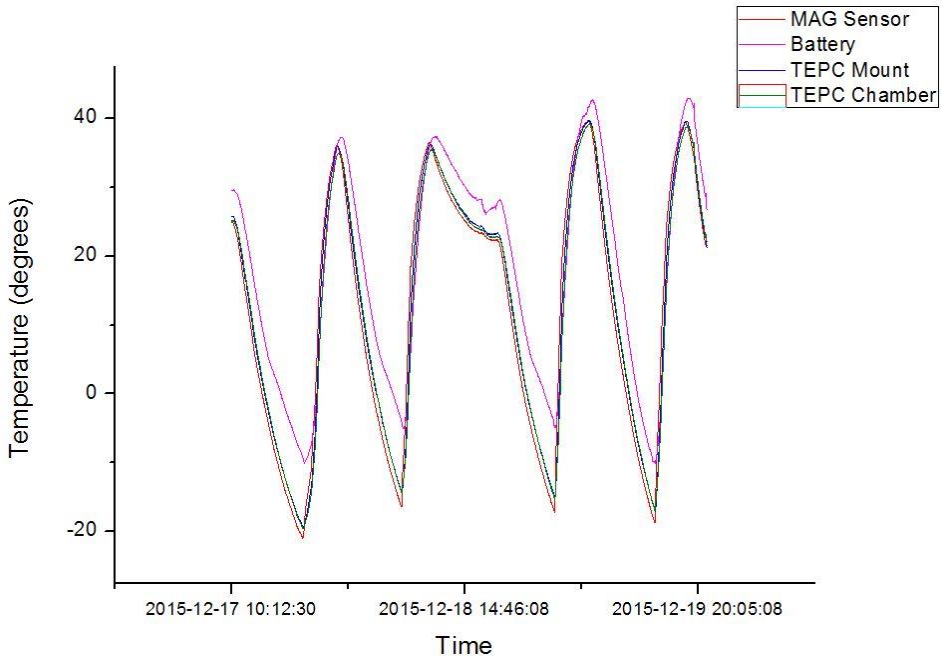
6.2 QM Test Result

6.2.1 Overview

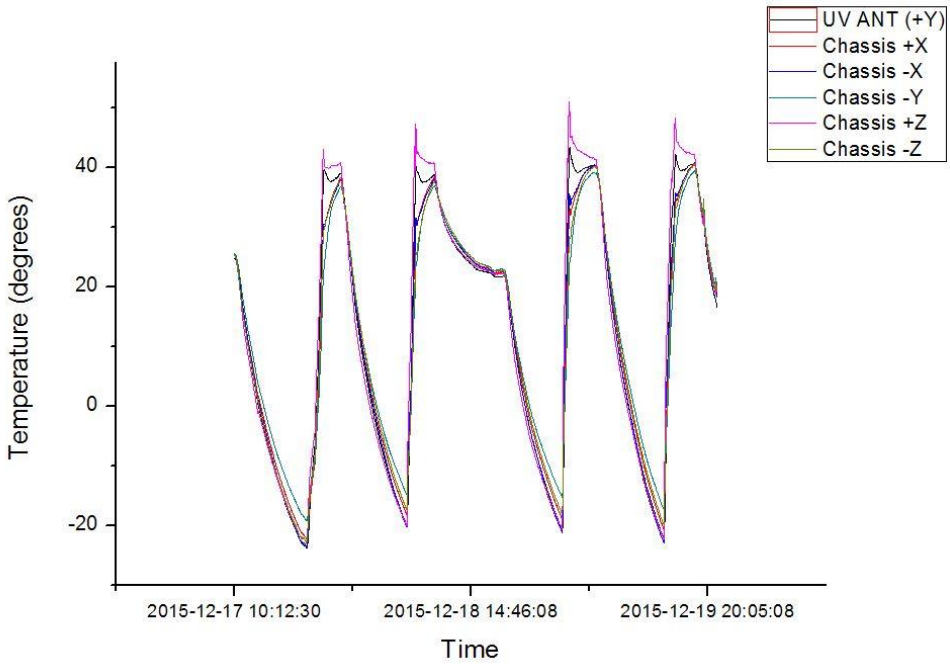


Thermal vacuum test was conducted at temperatures -20 to 40 degrees Celsius. Four cycles were completed with a hold at each extreme for 120 minutes. SIGMA was placed in the vacuum chamber and brought down to a hard vacuum (a least 5 x 10^{-5} Torr).

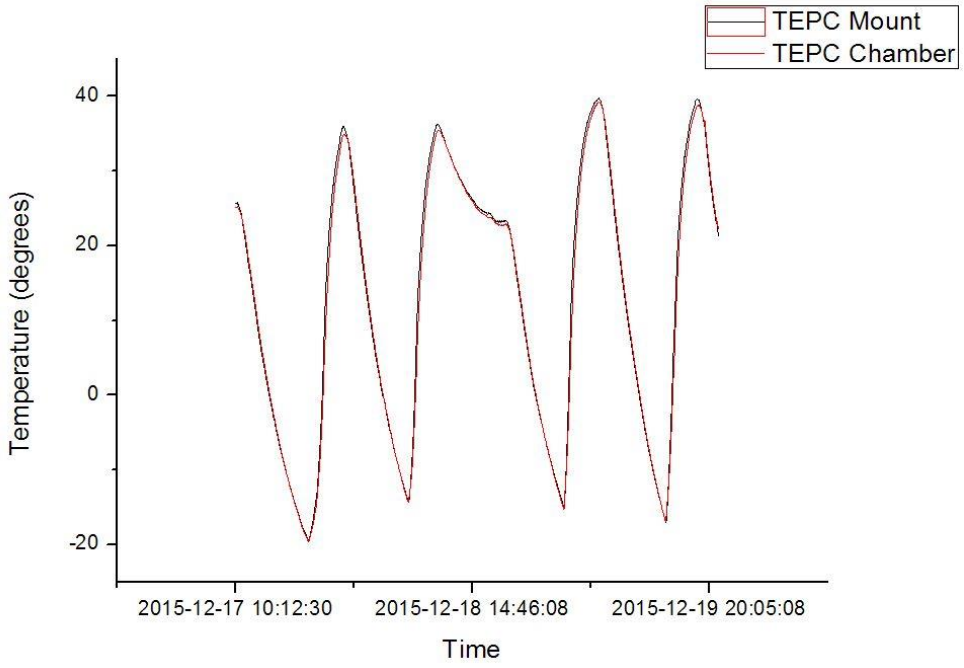
6.2.2 Inner Side



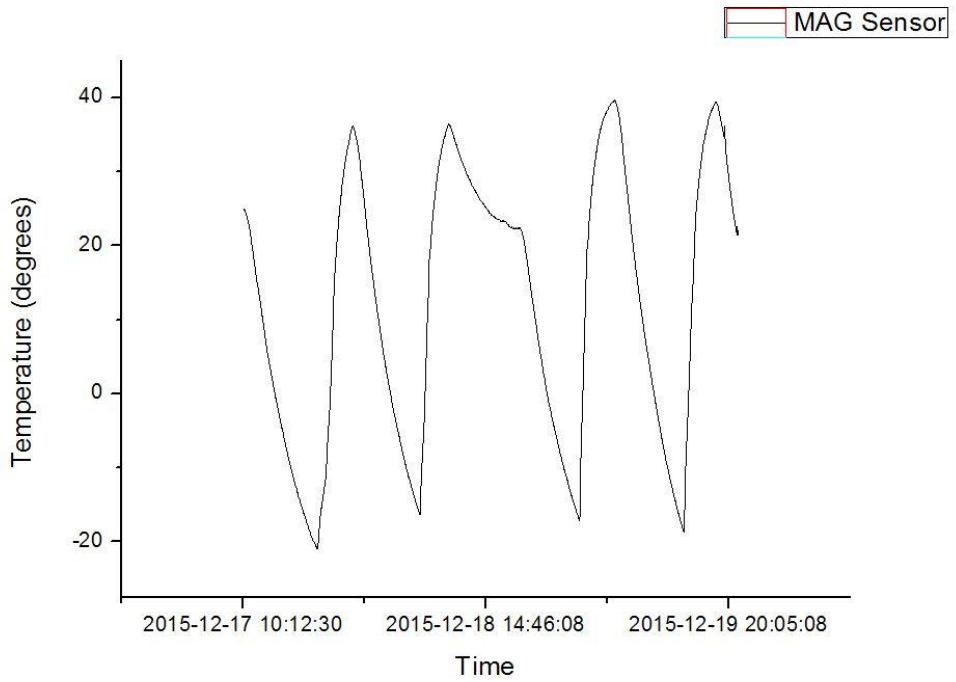
6.2.3 Outer Side



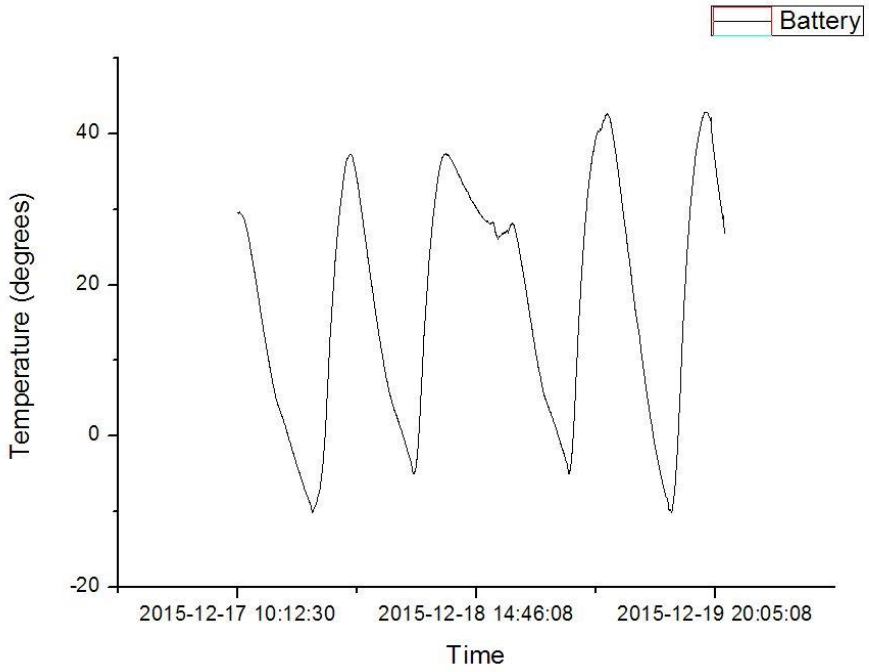
6.2.4 TEPC



6.2.5 MAG



6.2.6 Battery


Battery
40
20
0
-20
Temperature (degrees)
2015-12-17 10:12:30
2015-12-18 14:46:08
2015-12-19 20:05:08
Time

6.3 QM Pass/Fail criteria

Table 21. Check list of pass/fail criteria

NO	Category	Check Item	Home Check	#1 cycle	#2 cycle	#3 cycle	#4 cycle	Home Check
1. TEPC								
1	TEPC	No mechanical damage	P	N/A	N/A	N/A	N/A	P
2	TEPC	Electrical functionality	P	P	P	P	P	P
2. MAG								
1	MAG	No mechanical damage	P	N/A	N/A	N/A	N/A	P
2	MAG	Electrical functionality	P	P	P	P	P	P
3. Avionics stack								
1	Deployment switch	Plunger travels smoothly	P	N/A	N/A	N/A	N/A	P
2	RBF switch	Remains closed	P	N/A	N/A	N/A	N/A	P
3	Motherboard	Retains full functionality	P	P	P	P	P	P
4	Motherboard	No mechanical damage	P	N/A	N/A	N/A	N/A	P
5	EPS	Retains full functionality	P	P	P	P	P	P
6	EPS	No mechanical damage	P	N/A	N/A	N/A	N/A	P
7	Battery	Retains full functionality	P	P	P	P	P	P
8	Battery	No mechanical damage	P	N/A	N/A	N/A	N/A	P
9	UV Transceiver	No mechanical damage	N/A	N/A	N/A	N/A	N/A	N/A
10	IIB	Retains full functionality	P	P	P	P	P	P
11	IIB	No mechanical damage	P	N/A	N/A	N/A	N/A	P
4. Chassis								
1	Chassis	No galling on chassis rails	P	P	P	P	P	P
5. Torque coils								
1	Torque coils	No mechanical damage	P	P	P	P	P	P
2	Torque coils	Retain full functionality	P	N/A	N/A	N/A	N/A	P
6. Solar panels								

1	Solar panels	No structural damage that causes loss of functionality	P	P	P	P	P	P
2	Solar panels	Electrical functionality	P	P	P	P	P	P
7. UHF antenna assembly								
1	UHF antenna	No loss of deployment functionality	P	N/A	N/A	N/A	N/A	P
2	UHF antenna	No loss of radio functionality	P	N/A	N/A	N/A	N/A	P
8. Patch antennas								
1	Patch antennas	No physical damage	P	N/A	N/A	N/A	N/A	P
2	Patch antennas	Electrical Functionality	N/A	N/A	N/A	N/A	N/A	N/A
9. Calex DC-DC Converter								
1	Calex DC-DC converter	Pins still intact and physically undamaged	P	N/A	N/A	N/A	N/A	P
2	Calex DC-DC converter	Electrical Functionality	N/A	N/A	N/A	N/A	N/A	N/A
10. Harnessing								
1	Harnessing	No loss of captivity	P	P	P	P	P	P
2	Harnessing	Electrical Functionality	P	P	P	P	P	P

* P: Pass, F: Fail, N/A: Not Applicable