BiSon64-ET SUN SENSOR

PRODUCT SPECIFICATION DOCUMENT

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DOCUMENT CHANGE RECORD

Issue	Date	Total pages	Pages affected	Brief description of change
1	28-09-2017	14	All	New document
1a	13-10-2017	17	All	Removed typo's like double Req. numbers to come in line with the verification control document. Added [AD] numbers where needed.
1b	05-10-2018	15	9,11-15	Update: 4 Optical interfaces, 6.1 storage conditions, 6.4 temp cycling, 6.5.3 Random vibrations, 6.5.4 Shock specification, 6.6 Cosmic radiation resistance
2	01-11-2018	15	6 10	Photo of BiSon64-ET proto added Accuracy specifications updated
2a	06-11-2018	17	8	Removed typo
3	03-05-2019	15	11, 14	Update shock specification and thermal cycling
4	28-05-2019	15	9	Update mass to come in line with VCD and ICD
4a	20-06-2019	17	10	Update transition resistance and random vibration time
5	09-12-2019	15	5, 7,9,10, 11,15	Offset paramters added to formula, optical angles referred to ICD, change of remounting accuracy, requirement on resistance of external surfaces deleted, Par 3. More attention to ICD, mechanical interface, accuracies for counterpart added, including ref. to assembly instructions and changed definition of reference points Req 5.3-1 uncalibrated accuracy set to <4° par 5.3 limit on temperature range added, Par 6.4 limit on temperature range for thermal cycling changed,

				Par 6.5 note added on PIND acceptance testing, Par 6.6 radiation withstanding definition changed
5a	11-12-2019	15	11	Par 5.3 Added detailed BOL and EOL accuracies and use of compensation parameters.
6	11-08-2020	17	All	Added the IC-document, replaced photo. Removed typos. Req 5.3-1 uncalibrated accuracy improved to <3.5° Par 6.2, update “within specification” Par 6.3, update “within specification” Par 6.4, update temperature cycles Par 6.5, update vibration specifications
6a	04-12-2020	17	8	Clarification update of equations

Contents

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Abbreviations

AD	Applicable Document
ADC	Analogue to Digital Converter
-B	Baffle
BOL	Begin of Life
COTS	Commercial Off The Shelf
CTE	Coefficient of Thermal Expansion
EMC	Electro Magnetic Compatibility
EOL	End of Life
-ET	Extended Temperature
FOV	Field of View
ICD	Interface Control Document
LOS	Line Of Sight
MAIT	Manufacturing Assembly Integration and Test
NTC	Negative Temperature Coefficient resistor (thermistor)
PIND	Particle Induced Noise Detection
PSD	Power Spectral Density
RD	Reference Document
Req	Requirement

Applicable documents

Nr	Document name	Document number	Issue
[AD-01]	BiSon64-ET interface control document	20-LRD-ICD-0001	1
[AD-02]	BiSon64-ET interface control drawing	110T701	04
[AD-03]	Precision fastener	500M085	01
[AD-04]	Washer vented	500M086	01
[AD-05]	Delivery, Packing, Storage, Handling, and Transportation procedure.	19-LRD-PR-0052	1

Reference documents

Nr	Document name	Document number	Issue

1 Introduction

The BiSon64-ET *sun sensor*, see Figure 1 is a high reliability sun sensor with a nominal field of view of 64 degrees in diagonal which is specifically designed for highly demanding satellite applications.

The ET stands for Extended Temperature and indicates that the sensor is developed to operate over a wide temperature range of up to -120°C…+120°C.

This document shall be read in conjunction with the interface control document [AD-01] and the interface control drawing [AD-02].

Figure 1 BiSon64-ET Sun sensor

2 Solar direction angles

Apart from the quadrant definition as given in [AD-02] it is necessary to define the reference frame of the sun sensor in order to avoid sign errors in the attitude control subsystem. All BiSon64-ET sun sensors use the reference definition given below.

These diagrams provide the definition of the angles α and β to be calculated by means of the formulas given in Equation 1. It can be deducted that a negative α means that the sun is to the top of the sensor and that a negative β means that the sun is to the right of the sensor (both when viewed from the top side).

The illumination given in Figure 2 is for positive α and positive β of the BiSon64-ET sun sensor.

All BiSon64-ET sun sensors use the reference definition given in Equation 1. The definition is applicable for the non-compensated utilization. In order to improve the accuracy further the sensor can be implemented with standard calibration tables or using a simplified compensation formula, see Equation 2.

$$S_a = \frac{Q_1 + Q_4 - Q_2 - Q_3}{Q_1 + Q_2 + Q_3 + Q_4} = \frac{\tan(\alpha)}{\tan(\alpha_{max})}$$

$$S_b = \frac{Q_1 + Q_2 - Q_3 - Q_4}{Q_1 + Q_2 + Q_3 + Q_4} = \frac{\tan(\beta)}{\tan(\beta_{max})}$$

Equation 1 BiSon64-ET α and β formulas

$$S_{a\_compensated} = S_a - C_a = \frac{Q_1 + Q_4 - Q_2 - Q_3}{Q_1 + Q_2 + Q_3 + Q_4} - C_a = \frac{\tan(\alpha)}{\tan(\alpha_{max})}$$

$$S_{b\_compensated} = S_b - C_b = \frac{Q_1 + Q_2 - Q_3 - Q_4}{Q_1 + Q_2 + Q_3 + Q_4} - C_b = \frac{\tan(\beta)}{\tan(\beta_{max})}$$

Equation 2 α and β formulas with correction in radian

C_a is the offset correction parameter used to compensate zenith offset in the α direction.
C_b is the offset correction parameter used to compensate zenith offset in the β direction.

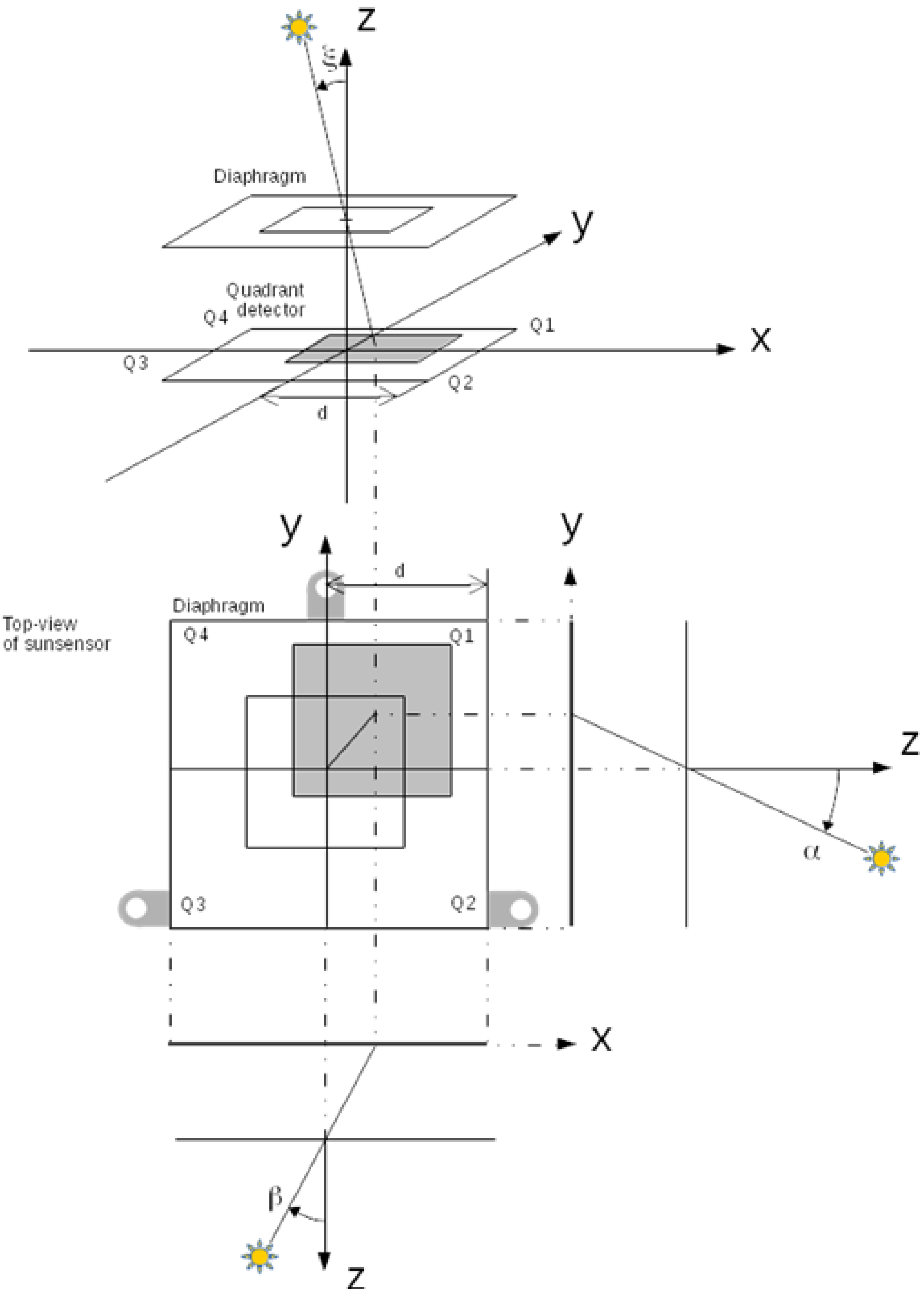

Figure 2 α and β reference frame and angle visualization

3 Mechanical interfaces

The dimensions of the mechanical interfaces are given in interface control drawing [AD-02]. The counterpart on which the Sensor will be mounted shall have at least the same accuracies as the sensor as defined in the IC- drawing.
The X axis of the right hand Cartesian reference system is defined by the line through the center of the lower right and lower left mounting points. The Z axis is fixed by means of the plane running through the three mounting feet.

3.1 Repeatability of mounting

Req. 3.1 The repeatability of mounting shall be better than 0.06 degrees, when using the prescribed mounting hardware (special fasteners with washers, [AD-03] and [AD-04]).
The dimensions and accuracies of the counterpart on which the sensor will be mounted shall be in line with the sensor specifcations as stated on sheet 1 of [AD-02] and assembly is according to the prescribed procedure as given in paragraph 6.3 of [AD-05].

3.2 Fastening torque

The special fasteners defined in [AD-03] shall be fastened with a torque of 1 Nm ± 10%.

3.3 Mass

Req. 3.3 The mass of the unit is ≤24 grams but more accurately given on sheet 1 of [AD-02].

3.4 Centre of gravity

The center of gravity is given on sheet 1 of [AD-02]. But there are no requirements on the CoG.

4 Optical interfaces

The optical interfaces are defined on sheet 2 of [AD-02] in combination with the reference frame definition as given in par 2.

Req. 4 The field of view of the sensor shall be >63° in both diagonals.

The actual angles and associated limits are given on sheet 2 of [AD-02].

5 Electrical interfaces

The electrical connections are given on sheet 3 of [AD-02].

The sensor will generate 4 analogue currents.

Req. 5-1 The currents generated shall be -1.45 mA ±20% at normal incidence at 20°C ±5°C.
Req. 5-2 Requirement deleted.
Req. 5-3 The currents generated shall be -1.45 mA±60% at normal incidence over the full temperature range.
Req. 5-4 Requirement deleted.

These values are at 1 AM(0) sun illumination and 0 bias (measured with a transimpedance amplifier) over the full temperature range.

Req. 5-5 The internal thermistor shall have a nominal value of 10kΩ ± 10% @ 25°C.

5.1 Grounding and isolation

Req. 5.1-1 The resistance from the common ground to case shall be 1MΩ<R<10MΩ.
Req. 5.1-2 The capacitance between the sensor and ground shall be < 100pF.
Req. 5.1-3 The resistance from sapphire window to housing shall be <1MΩ

5.2 Deleted

Req. 5.2-1 Requirement deleted.

5.3 Specified accuracy

Req. 5.3-1 The specified accuracy for the sensors is better than 3.5 degrees if no calibration table is used.

Req. 5.3-2 The specified accuracy for the sensors is better than 2 degree if a sensor specific offset and gain correction is implemented.

Req. 5.3-3 The specified accuracy for the sensors is better than 0.5 degree 3σ if calibration tables are used.

6 Environmental specifications

6.1 Storage conditions

Req. 6.1 The sensor should be stored in a dust free, dry and temperature controlled environment with a temperature range of 0°C to +30°C and a relative humidity of 40% to 60% storage lifetime under these conditions is longer than 5 years when kept in the original packaging.

6.2 Operating temperature range

Req. 6.2 The sensors shall perform within specifications when operated in the range of -120°C to +120°C.

6.3 Non-operating temperature range

Req. 6.3 The sensors shall survive a non-operating temperature range of -125°C to +125°C.

6.4 Temperature cycling

The sensor shall meet the following temperature cycling requirements as given in Table 1.

Req.	Conditions	Temperature range	Number of cycles
6.4-1	Deleted (replace by acceptance test)		
6.4-2	Full range high rate thermal cycle in vacuum (qualification)	-125°C….+125°C	10
6.4-3	Thermal vacuum cycling (qualification)	-40°C….+80°C -45°C….+105°C	1000 1000

Table 1 Thermal cycling specification

6.5 Vibration specifications

Vibration specifications of the sensor are given below. It should be noted that these are already verified qualification levels. Any safety margins required for the mission shall therefore be subtracted from the given level to see if the sensors meet mission requirements. The sine and random qualifications have been performed using the in [AD-03] and [AD-04] defined hardware and torqued to the level specified in chapter 3.2.

6.5.1 Eigenfrequency

Req. 6.5.1 The first eigenfrequency shall be > 200Hz.

6.5.2 Sine vibration

Req. 6.5.2 The sensor shall be able to function within specifications after being subjected to vibration test levels specified in Table 2 in all three axes.

Sine vibrations	
Frequency Hz	**Level**
5...44.6	20mm peak to peak 10mm zero to peak
44.6...100	40g
1 octave/minute 1 sweep up/1 sweep down	

Table 2 Sine vibrations (qualification)

6.5.3 Random vibration qualification

Req. 6.5.3-1 The sensor shall be able to function within specifications after being subjected to vibration test levels specified in Table 3 and Figure 3 in all three axes.

Random vibrations						
Frequency (Hz)	**ASD (G^2/Hz)**	**dB**	**OCT**	**dB/OCT**	**Area**	**Grms**
20.00	0.0810	*	*	*	*	*
100.00	2.0000	13.93	2.32	6.00	66.30	8.14
175.00	2.0000	0.00	0.81	0.00	216.30	14.71
500.00	1.5000	-1.25	1.51	-0.82	767.28	27.70
2000.00	0.0376	-16.01	2.00	-8.00	1174.02	34.26
Total RMS level: 34.26g						
Duration: 180 seconds						

Table 3 Random vibrations (qualification)

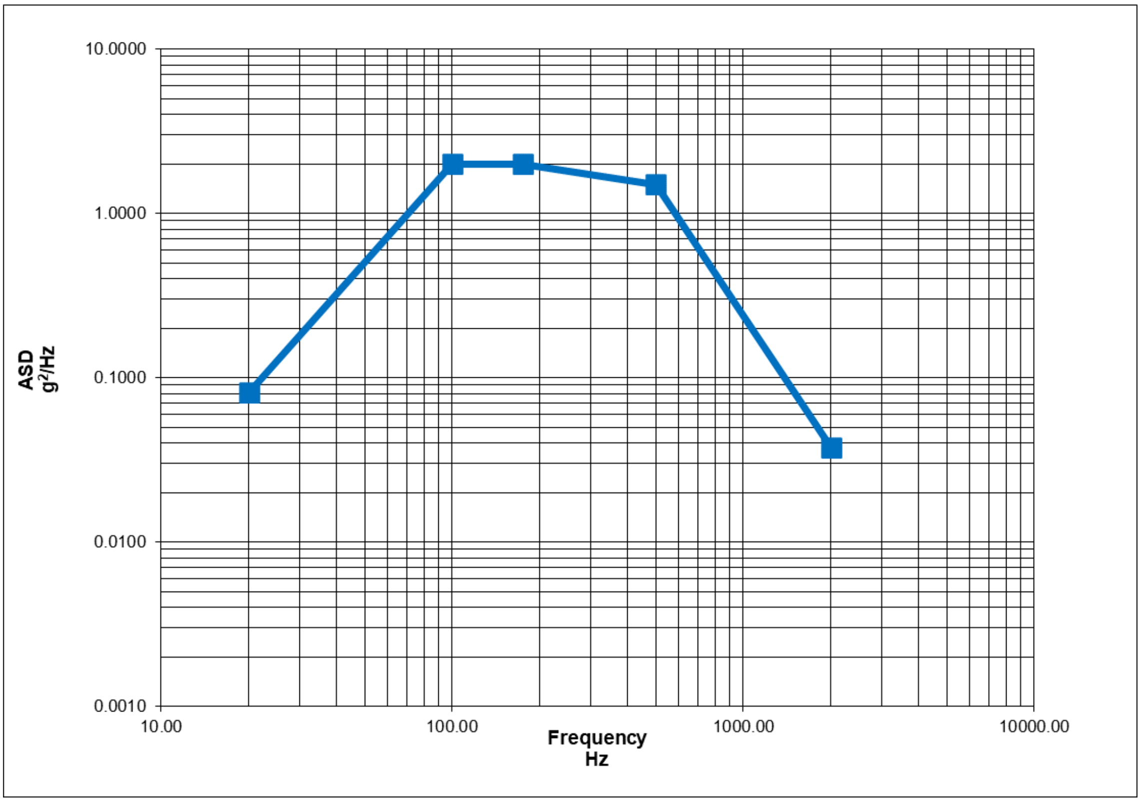

Figure 3 Random vibration profile (qualification)

6.5.4 Shock specification

Req. 6.5.4 The sensor shall be able to function within specifications after being subject to vibration test levels specified in Table 4 and Figure 4 in all three axes.

Pyro shock	
Frequency Hz	**Level g**
100	40
1000	2100
2000	3000
10000	3000
3 shocks in any direction	

Table 4 Pyro shock specifications (qualification)

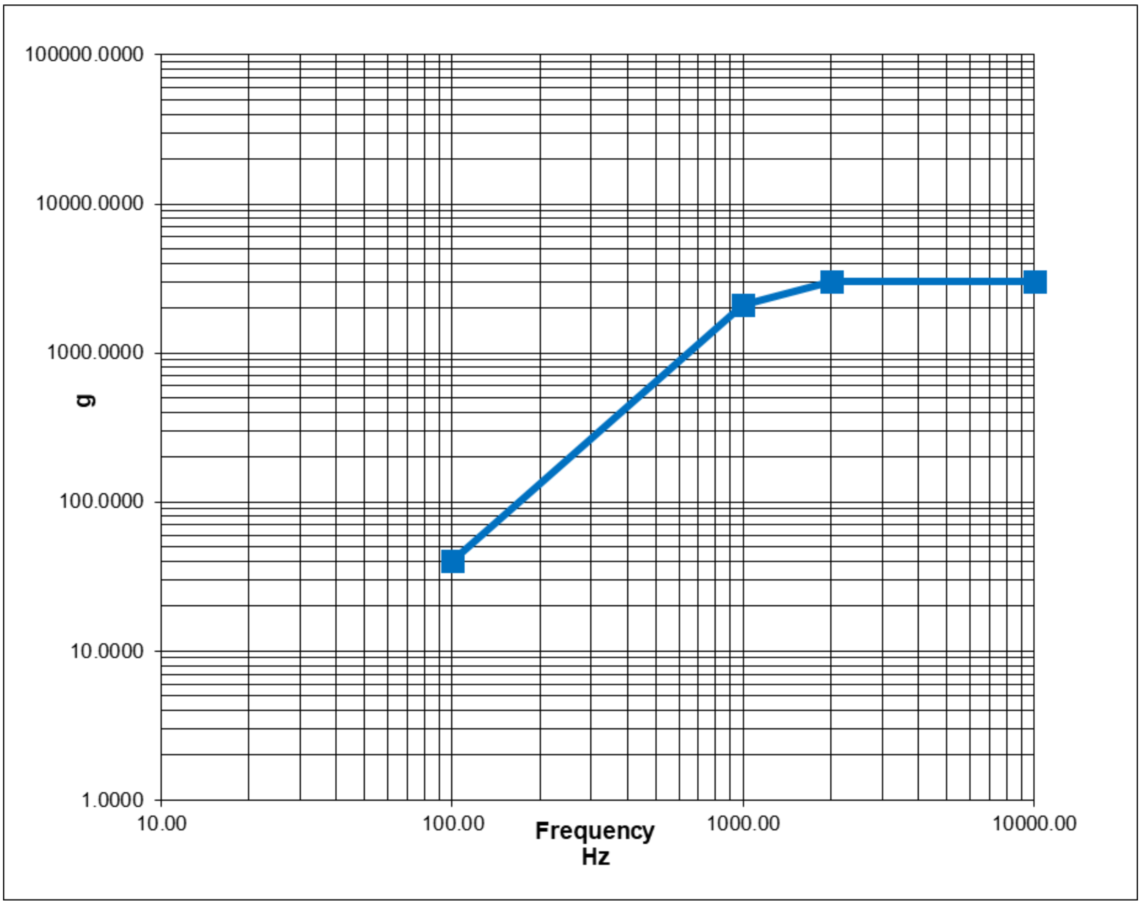

Figure 4 Pyro shock profile (qualification)

6.5.5 PIND testing

Req. 6.5.5 Requirement deleted.

6.6 Cosmic radiation resistance

Req. 6.6 Bare diodes shall sustain 4E14 1MeV electron testing without failure at a fluence of 1E11 electrons per second. Tolerance on radiation test parameters shall be ±5%.

6.7 Standard acceptance testing activities

6.7.1 Acceptance Vibration testing

Req. 6.7.1 Unless specifically agreed upon a deviation, the sensors shall be exposed to random vibration in the Z-axis only for which the levels are specified in Table 5 and Figure 5 as part of the acceptance test sequence.

Acceptance vibration test						
				Slope	Acceleration	
Frequency Hz	**ASD G²/Hz**	**dB**	**OCT**	**dB/OCT**	**Area**	**Grms**
20.00	0.0140	*	*	*	*	*
100.00	0.3500	13.98	2.32	6.02	11.57	3.40
200.00	0.3500	0.00	1.00	0.00	46.57	6.82
1000.00	0.0140	-13.98	2.32	-6.02	102.57	10.13
Total RMS level: 10.13 g						
Duration: 90 seconds						

Table 5 Random vibrations (acceptance)

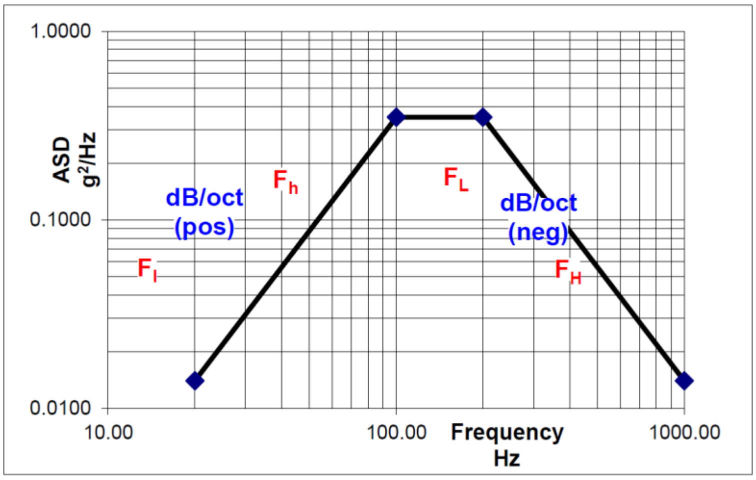

Figure 5 Random vibration profile (acceptance)

6.7.2 Acceptance thermal cycling

Req. 6.7.2 Unless specifically agreed upon a deviation, the sensors shall be exposed to 10 thermal vacuum cycles between -40°C and +80°C as part of the acceptance test sequence.

6.7.3 Acceptance calibration

Req. 6.7.3 Unless specifically agreed upon a deviation, the sensors shall be calibrated before delivery.

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