Arctic Fox 10ft Shelter System – Functional Solar Test

Customer:

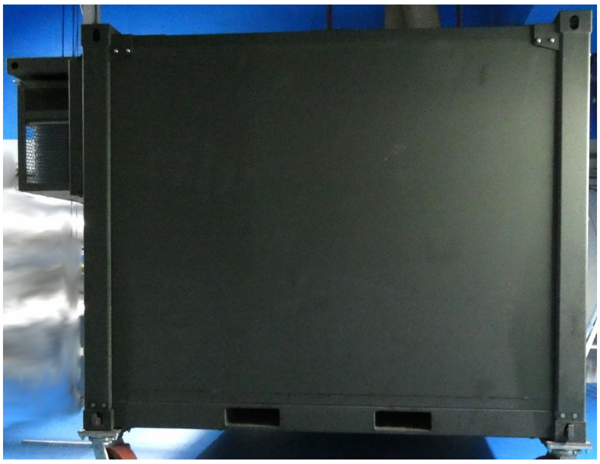
Senop Oy
Lentolantie 7
FI-36220 Kangasala

Target:

Arctic Fox 10ft Shelter System
Part number: AF00001C002
Serial number: A608G000001
ODA-code: A608G

Version: A

Length	3684 mm	Weight	1700 kg
Width	2438 mm	Payload	4000 kg
Height	2438 mm	Gross weight	5700 kg



Side view

View from the door

Fig. 1. *Equipment under test: Arctic Fox 10ft Shelter System.*

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Testing Time:

The start of the test: 10th February, 2020
The end of the test: 14th February, 2020

Purpose of the Test:

To determine the heating effects of direct solar radiation on the equipment under test.

- To determine the highest temperature that the test item will reach during an exposure to direct sunlight in hot climates.
- To evaluate the possible changes, like deformation or degradation caused by solar radiation.

Particular attention shall be paid to the roof of the container and any changes therein.

Test Method:

Exposure
Modified test method based on MIL-STD-810G METHOD 505.5 Procedure I, Cycle A1
Test cycle 24 h (see Fig. 2):
Irradiance: 0 W/m² – 1120 W/m²
Ambient temperature: 32°C – 49°C
Duration: 3 cycles (72 h)

Measurements
Continuous surface temperature logging at selected positions (outside/inside the roof)
Continuous ambient temperature measurement (outside/inside the shelter)
Continuous solar radiation intensity measurement

Functional Inspection
Checking the operation of the air conditioner before testing and during the third test cycle

Other Inspections
Inspection of the possible deformation of the roof

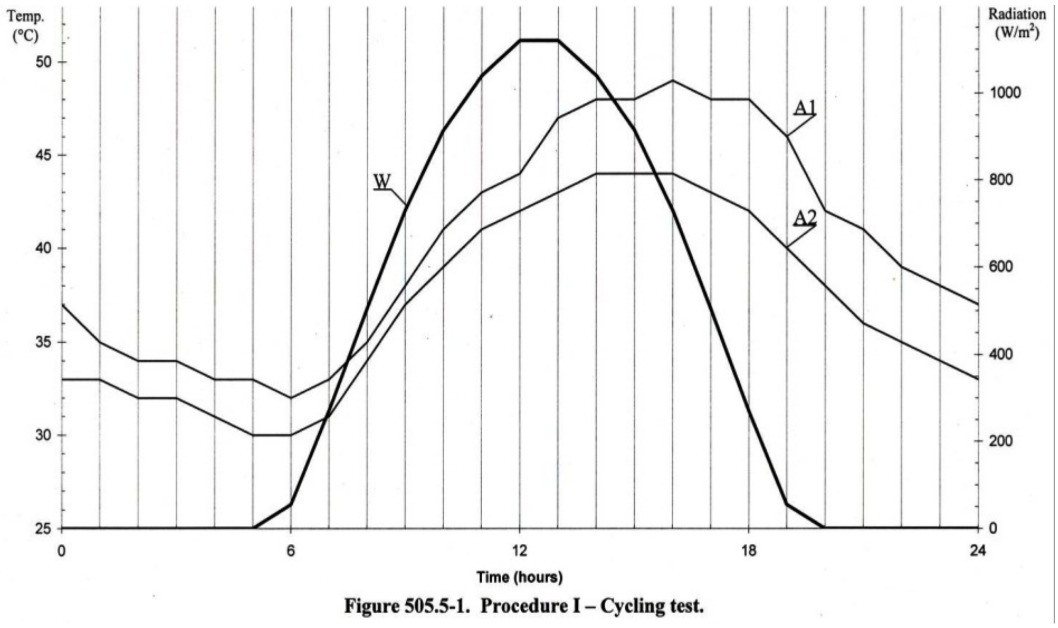


Fig. 2. *MIL-STD-810G METHOD 505.5 Procedure I, Cycle A1 was followed.*

Performed Actions:

Solar Radiation

The properties of the simulated solar radiation used in this test, and those of natural sunlight, are described in Fig. 3 and Table 1. Figure 3 shows the spectrum of sunlight according to CIE 85-1989 (for AM 1.5) and the spectrum of the solar simulator SSF42-2004-Artificial-Sun used in this test in the wavelength range of 250 - 2500 nm. Table 1 shows the spectral distribution according to MIL-STD-810G METHOD 505.5, and that of the solar simulator SSF42-2004-Artificial-Sun in the ranges of ultraviolet (UV), visible, and thermal radiation (IR).

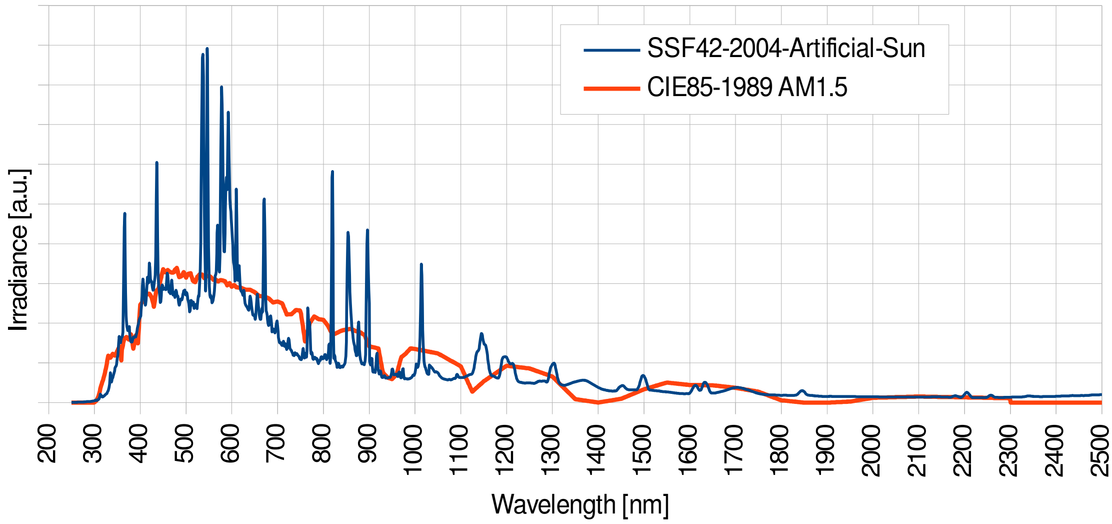


Fig. 3. *Spectrum of the simulated solar radiation used in this test (blue curve) and spectrum of natural sunlight according to CIE 85-1989 (red curve). The spectra are scaled to the same total intensity.*

Table 1. Spectral distribution of the simulated solar radiation and according to MIL-STD-810G METHOD 505.5 in the ranges of ultraviolet (UV), visible (VIS), and thermal radiation (IR). Spectral irradiance is given for the total irradiance of 1120 W/m^2.

Spectral Region		MIL 810G 505.5		Solar simulator	
		Spectral Distribution	Spectral Irradiance	Spectral Distribution	Spectral Irradiance
	[nm]	[%]	[W/m^2]	[%]	[W/m^2]
UV	280-320	0.5	5.6	0.15	1.7
	320-360	2.4	26.9	1.4	16
	360-400	3.2	35.8	4.0	44
VIS	400-520	17.9	200.5	16.6	186
	520-640	16.6	185.9	23.5	263
	640-800	17.3	193.8	13.3	149
IR	800-3000	42.1	471.5	41.0	459
Totals		100	1120	100	1120

Test Configuration
The test arrangement is shown schematically in Fig. 4 and a photograph of the actual test situation can be seen in Fig. 5.

K-type thermocouple temperature sensors were used to measure the surface temperatures of the roof and the ambient air temperature inside the shelter. The surface temperature sensors were placed in five pre-selected positions on the roof, at the same positions inside and outside the roof. The ambient air temperature sensor was in the center of the shelter interior. The thermocouple sensors were numbered as 1 – 11. The positions and numbering of the sensors are shown schematically in Fig. 6, and in more details in Fig. 7.

In addition, a Black Panel Thermometer (BPT) was placed on the roof, see Figs. 6 and 7.

The solar irradiation levels throughout the test area were measured and adjusted before testing with a precision pyranometer. During testing, the irradiance was monitored with a pyranometer placed on the roof, see Figs. 6 and 7.

The ambient temperature in the laboratory room was controlled and monitored by a temperature sensor placed away from direct solar irradiation (see Fig. 6).

A straight and rigid metal bar with bolts of suitable length was used to evaluate the deformation of the roof. The metal bar is shown in Fig. 8.

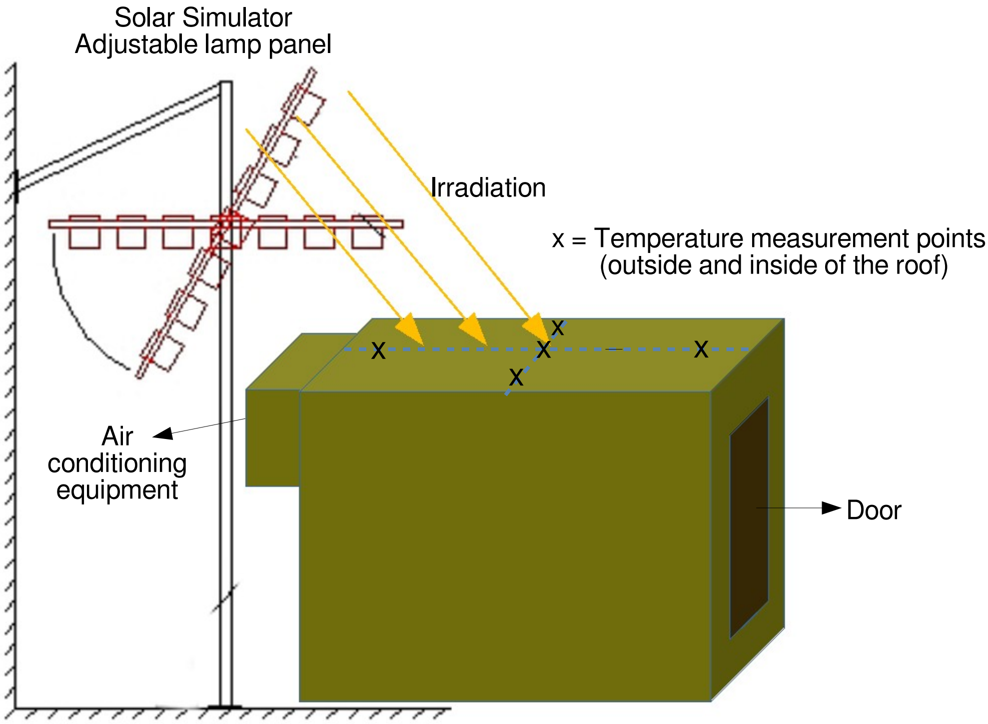


Fig. 4. Schematic representation of the solar testing arrangement.

Fig. 5. Actual test situation.

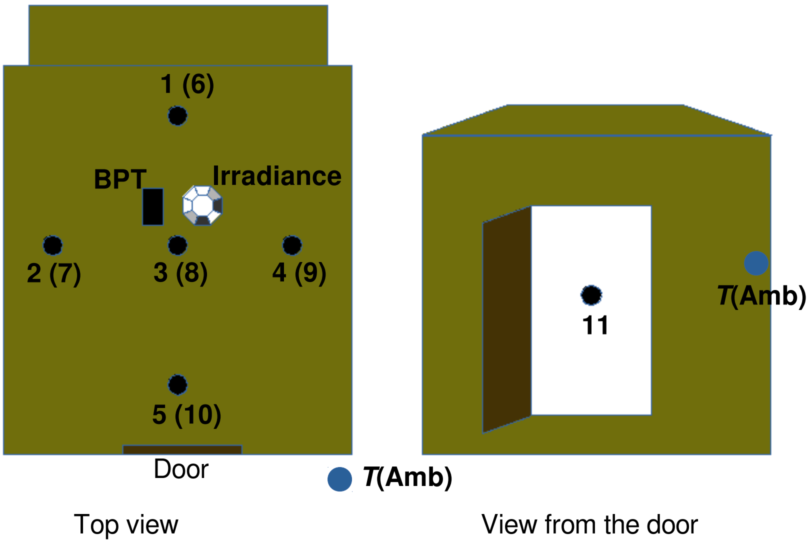
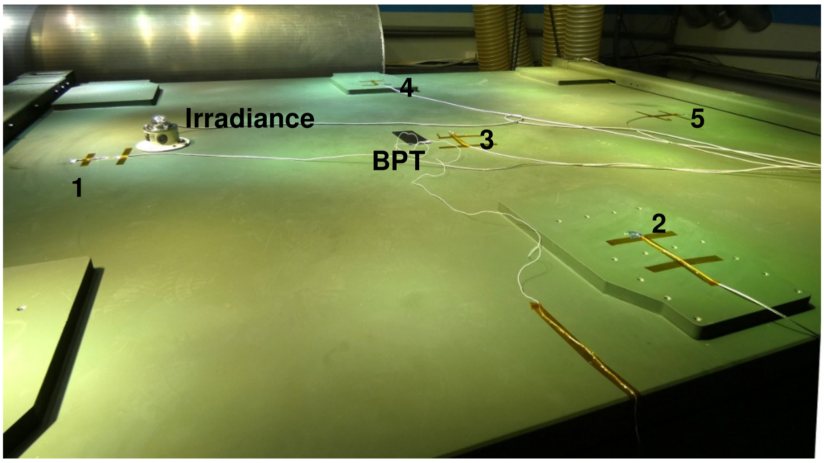


Fig. 6. *Placement of the temperature and irradiance sensors shown schematically.*

No. 1 – 5:	*Roof surface temperature, outside*
No. 6 – 10:	*Roof surface temperature, inside*
No. 11:	*Ambient air temperature inside the shelter, in the center of the interior*
BPT:	*Black Panel Thermometer*
Irradiance:	*Movable pyranometer for irradiance monitoring*
T(Amb):	*Temperature sensor for controlling and recording the laboratory ambient temperature*



Roof, outside

Inside

Fig. 7. *Placement of the temperature and irradiance sensors. Heat-conductive adhesive was used to attach the sensors to the shelter surface, as can be seen in the close-up image of sensor No. 10.*

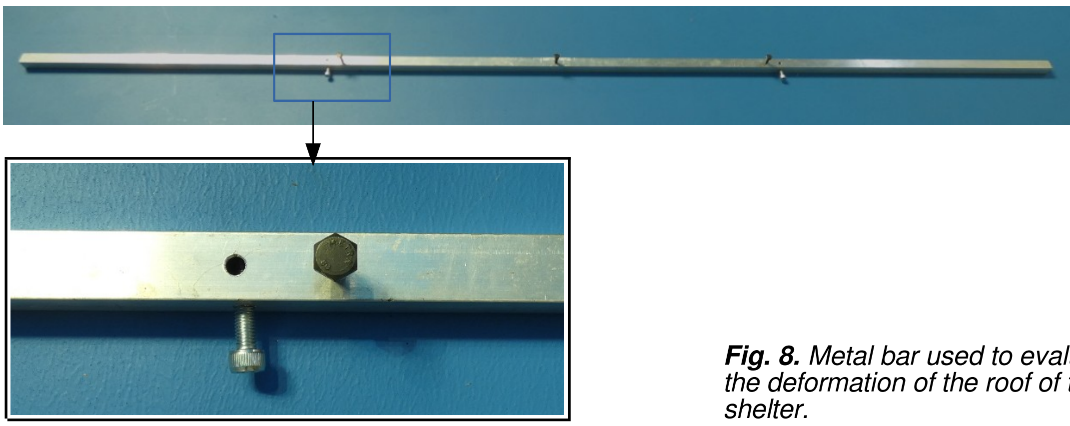


Fig. 8. *Metal bar used to evaluate the deformation of the roof of the shelter.*

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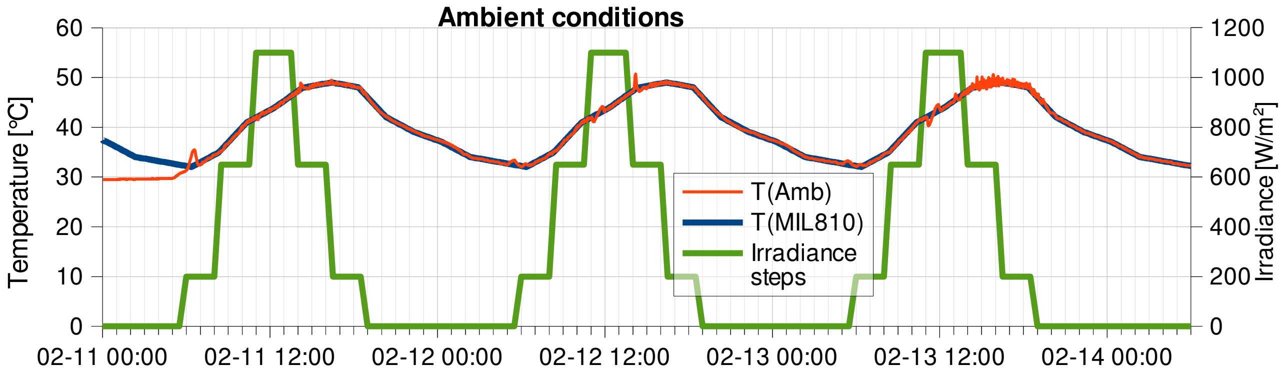
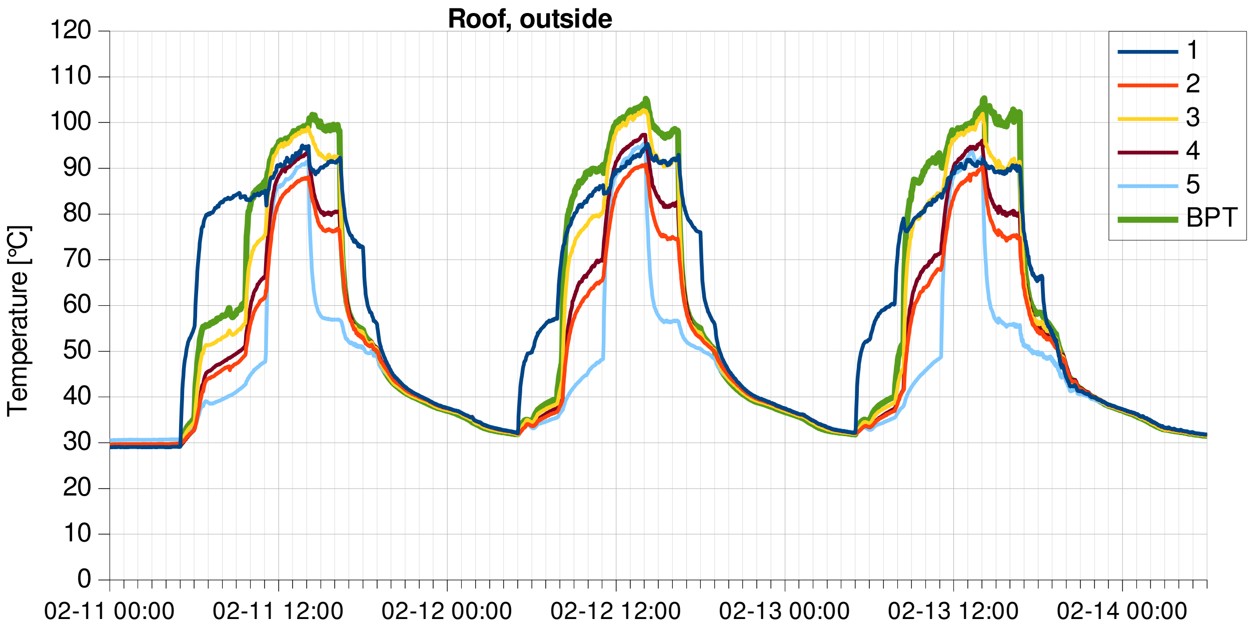
Test Conditions: Ambient Conditions and Surface Temperatures
The ambient temperature and the specification of temperature given in MIL-STD-810G METHOD 505.5 Procedure I, Cycle A1, are shown in the upper graph in Fig. 9. The irradiance curve was implemented in a simplified manner in a few steps, which are also shown in the upper graph in Fig. 9.

The temperatures logged during the exposure with the thermocouple sensors No. 1 –11 and the BPT, at the locations indicated in Fig. 6, are shown in Fig. 9. The middle graph in Fig. 9 includes the measurements outside the shelter whereas the lower graph shows the measured temperatures inside the shelter. The highest surface temperatures of the roof were: 90°C – 100°C (outside) and 55°C – 60°C (inside).

The surface temperatures measured at the center of the roof, outside and inside, are compared to each other in Fig. 10. The difference between the outside and inside surface temperatures was 40°C – 45°C when the ambient temperature and irradiance were high. When the air conditioner was operating, the corresponding surface temperature difference was 70°C – 80°C. Therefore, there is a large temperature gradient in the roof material.

Air velocity in the vicinity of the test item was negligible and therefore had no effect on the test conditions.





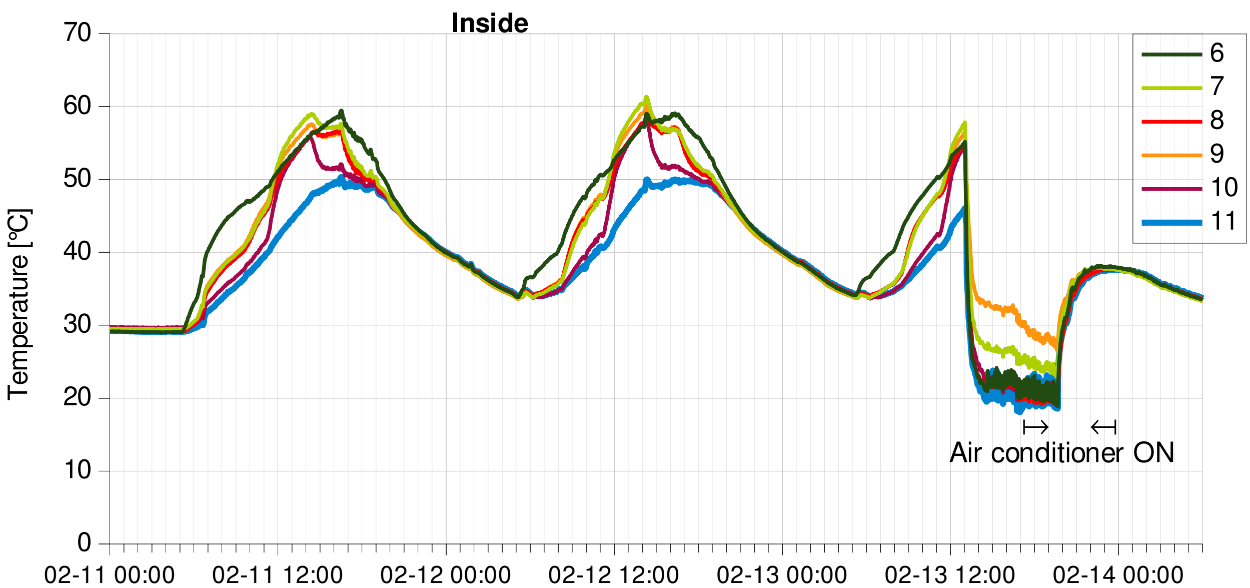


Fig. 9. *Temperatures measured at positions No. 1 – 11 (as indicated in Figs. 6 and 7), and the ambient temperature and irradiance conditions.*

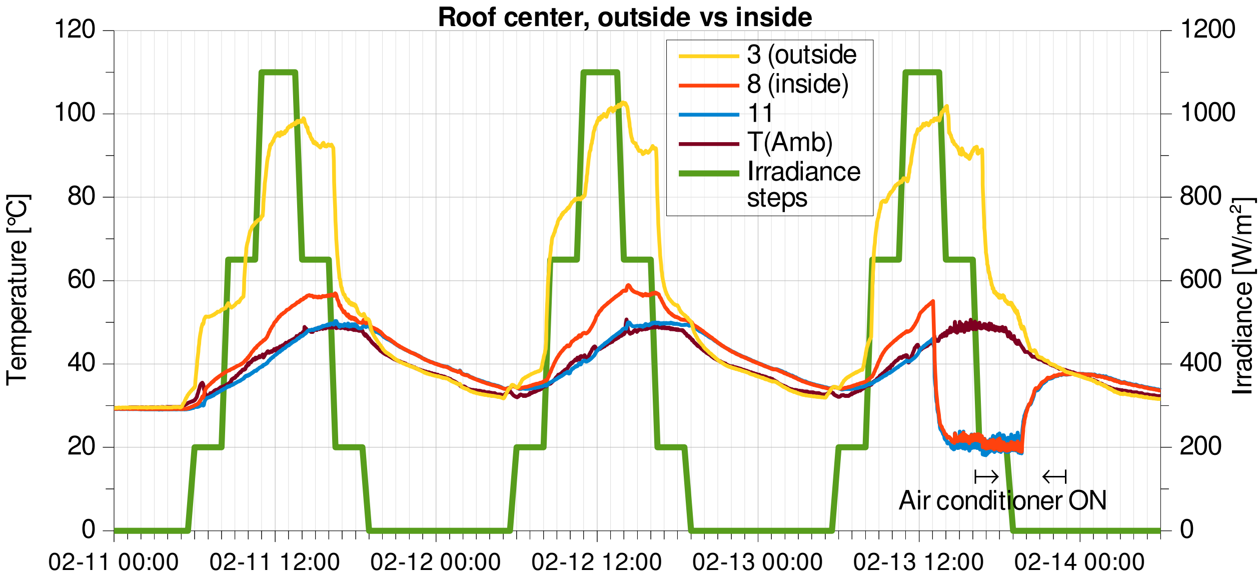


Fig. 10. *Surface temperatures measured at the center of the roof; outside (sensor No. 3) vs inside (sensor No. 8). It can be seen that the difference between the outside and inside surface temperatures was 40°C – 45°C when the ambient temperature and irradiance were high. When the air conditioner was operating, the corresponding surface temperature difference was 70°C – 80°C. Sensor No. 11 shows the ambient air temperature inside the shelter.*

Functional Inspections

The operation of the air conditioner was inspected before testing and during the third test cycle. During testing, the air conditioner was started when the ambient temperature and solar irradiance were high and continued until the irradiance period was over.

The air conditioner worked properly. The decrease in the surface and ambient temperatures during the operation of the air conditioning inside the shelter can be seen in Fig. 9. There is some difference between the temperatures measured at different points, the cooling at the side edges (sensors No. 7 and 9) is not as efficient as at other measuring points.

Inspection of Deformations

A deformation was observed on the roof. There was a depression located in the area between the center and the air conditioner. The depression was measured to be about 1.5 cm at its maximum. Photographs of the inspections are shown in Fig. 11.

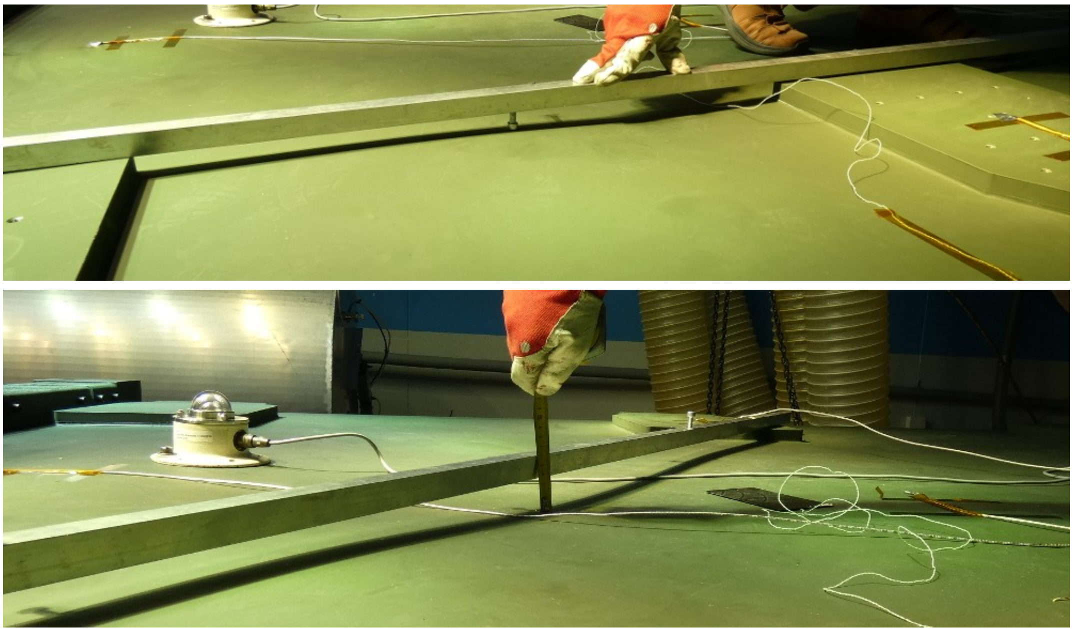


Fig. 11. *Inspections of the deformations of the roof.*

Used Equipment:

The calibration is valid for one year from the date given, unless otherwise stated.
Solar Simulator SSF42-2004-Artificial-Sun No. 20
Solar Lab No. 74

Irradiation:	Pyranometer No. 25, calibrated 21st May, 2019. Calibration is valid due to May, 2021.
	Multimeter No. 24, calibrated 18th February, 2019. Calibration is valid.
	Pyranometer No. 11, calibrated 17th April, 2019. Calibration is valid.
	Datalogger No. 79, calibrated 5th June, 2019. Calibration is valid.
Temperature:	74_T, calibrated 22nd August, 2019. Calibration is valid.
	Datalogger No. 79 + *K*-type thermocouples, calibrated 5th June, 2019 (datalogger), calibration completed during commissioning (thermocouples). Calibration is valid.

Analysis:

N/A

Recommendations:

N/A

Conclusions:

The equipment under test, Arctic Fox 10ft Shelter System, was exposed to solar radiation and heat based on MIL-STD-810G METHOD 505.5 Procedure I, Cycle A1. The duration of the test was three cycles.

The surface temperature was logged during the exposure at five pre-selected positions on the roof of the shelter, at the same positions inside and outside the roof. The ambient air temperature was measured in the center of the shelter interior.

The highest surface temperatures of the roof were reached when both the ambient temperature and irradiance were high: 90℃ - 100℃ (outside) and 55℃ - 60℃ (inside).
The difference between the outside and inside surface temperatures at the center of the roof was 40℃ – 45℃ during the period of high ambient temperature and irradiance. When the air conditioner was operating, the corresponding surface temperature difference was 70℃ – 80℃.

The operation of the air conditioner was inspected before testing and during the third test cycle when the ambient temperature and solar irradiance were high. The air conditioner worked properly.

A depression of 1.5 cm was observed on the roof in the area between the center and the air conditioner.

Remarks:

A customer representative was present when the sample arrived.
A customer representative was present during the test preparation and conducted a pre-test inspection of the air conditioner.
Customer representatives were present during the first test cycle.

Document history: This test report is derived from the original test report Senop__tr100220RP.pdf

Actions, operations and reporting are in accordance with IEC/ISO 17025 'General requirements for the competence of testing laboratories'.

Signatures:

Riitta Perälä
Littoinen, 26th February, 2020
Solar Simulator Finland

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