Tests of Aluthermo DENSIMA®

in simulated roof space

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Material testing Testing

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Rev.	Date	Initiator	Modification
01	**13/02/2017**	**JT**	Original version
02	**17/05/2017**	**TB**	Modification of trade name

Introduction

The aim of the test is to determine the thermal insulation properties of Aluthermo DENSIMA® insulation in the same test conditions than the other Aluthermo product test (see ALUTHERMO_Rapport_20140117).

In order to do so, a custom-built enclosure replicating a roof top was insulated with Aluthermo DENSIMA®. The internal volume of the insulated structure was maintained at a constant temperature of 21°C through a twin convection heating system while the simulated outdoor temperature was varied from -5 to 5°C in increments of 5°C. Additionally, the internal volume's temperature was monitored through the use of thermocouples while the energy required to maintain the ambient temperature at 21°C was recorded through specific DAQ equipment.

Test setup

Structure construction

A single enclosure was built to evaluate the comparative performance of Aluthermo DENSIMA® against other insulation material. The structure was made of timber members set on an 18mm thick wood board. The assembly was supported by a 100mm thick polystyrene base in order to prevent heat loss to the ground.

The insulation materials were installed in accordance with standard procedures.

After being equipped with the insulating material, the structure was covered with a roof replica cover made of MDF boards. The design of this cover allows for a 20mm air gap between the insulating material and the internal side of the roof replica.

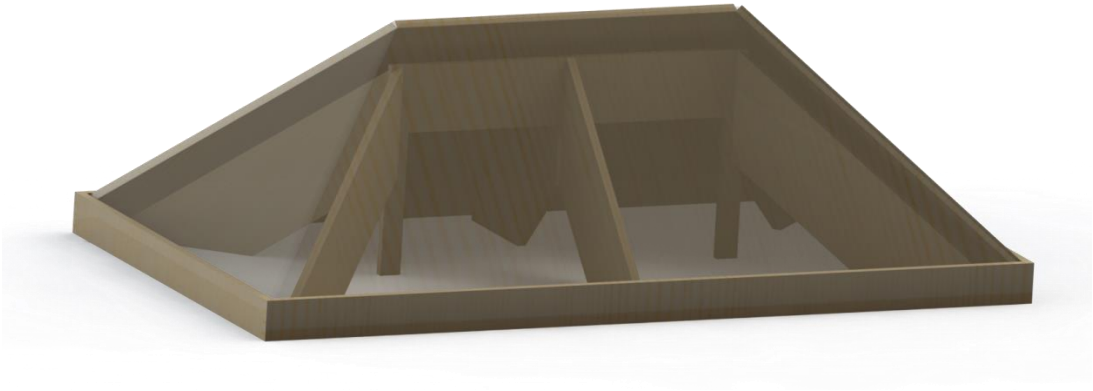

Figure 1 - CAO of test structure

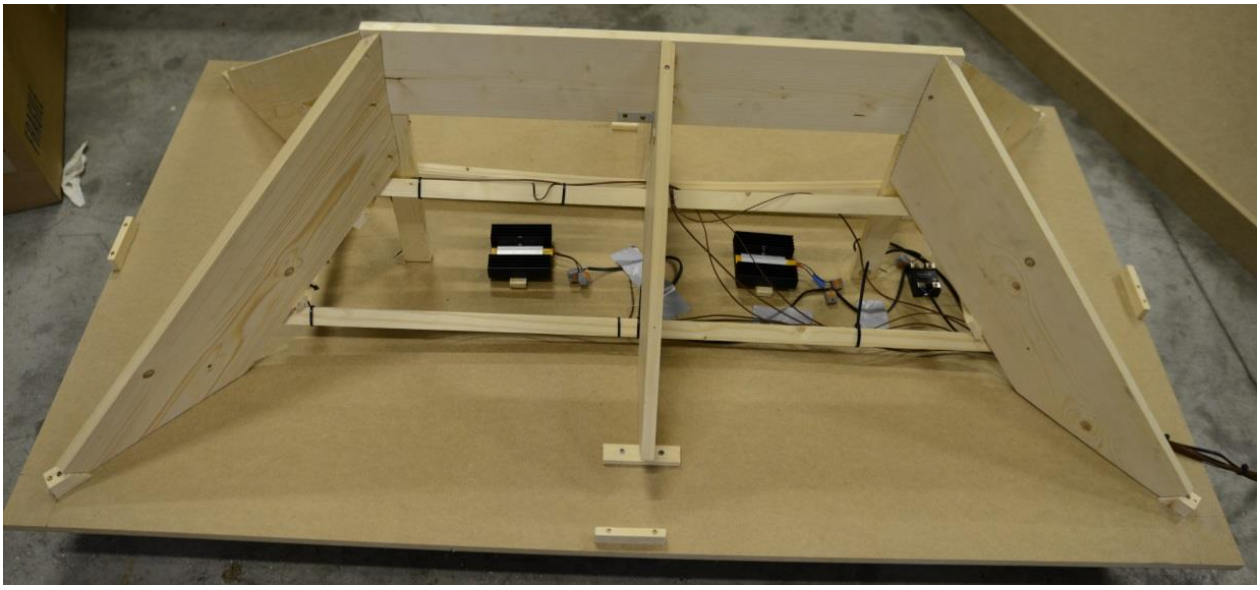

Figure 2 - Base wood structure and heating system

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Thermocouples

A total of 7 thermocouples were positioned inside the structure at different levels and positions in order to accurately record the internal temperature variations as well as the possible stratification. An additional thermocouple (represented as a red dot in the following figures) was used as reference for the regulation unit aiming at keeping the internal temperature of 21°C.

The structure was designed in such a way that an approximately 20mm air gap was maintained between the insulating material and the roof replica for the Aluthermo DENSIMA®.

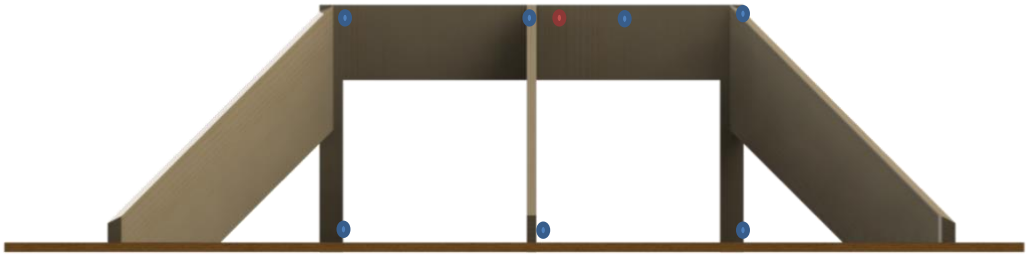

Figure 3 - Positions of thermocouples for Aluthermo DENSIMA® - face view

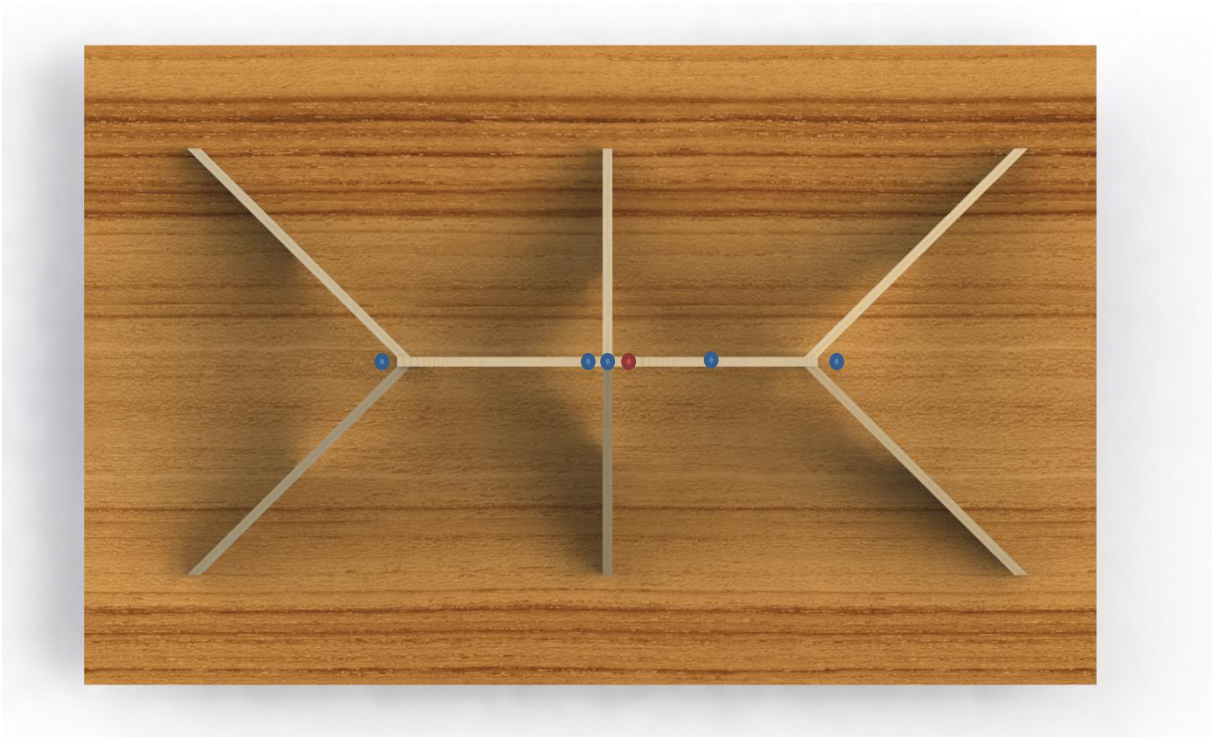

Figure 4 - Positions of thermocouples – top view

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Heating System

The heating system consists of two 200W electrical resistances, each coupled with its own heat dissipater. This setup provides heat mainly in the form of convection.

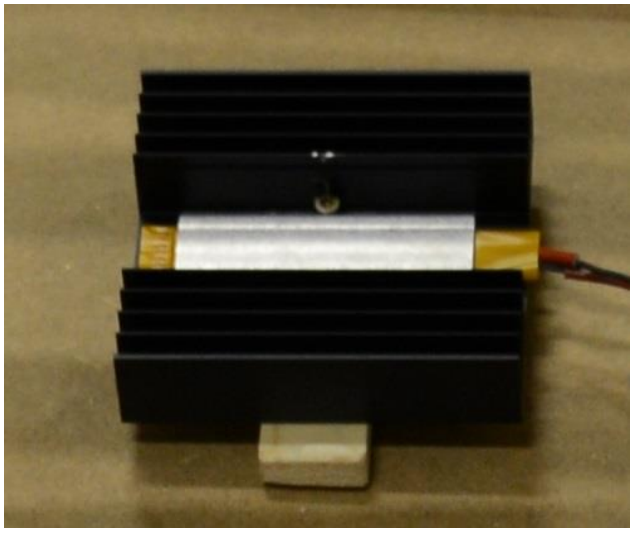

Figure 5 - Heating system

Temperatures

The temperatures are measured by means of calibrated thermocouples with a precision of ±0.2°C. The acquisition and storage of the temperature signals are done through a National Instruments system composed of a CompactDAQ and high precision thermocouples acquisition card.

Figure 6 - National Instruments CompactDAQ system

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Electrical values

The following values were measured and exported by a Socomec Diris Ap energy monitoring system with a frequency of 5 Hz:

1. Voltage (accuracy 0,5%)
2. Current (accuracy 0,5%)
3. Power (accuracy 1%)
4. Energy (class 1 according to CEI 61036)

Figure 7 - Energy monitoring system

Insulation technics : Aluthermo DENSIMA ®

The Aluthermo DENSIMA ® was laid down according to manufacturer requirements. Among other criteria, an overlapping distance was maintained with the element provided for this purpose (top, see figure 8).
The insulating sheet was fixed to the wood structure. The overlapping ends were maintained using Aluthermo ® tape.

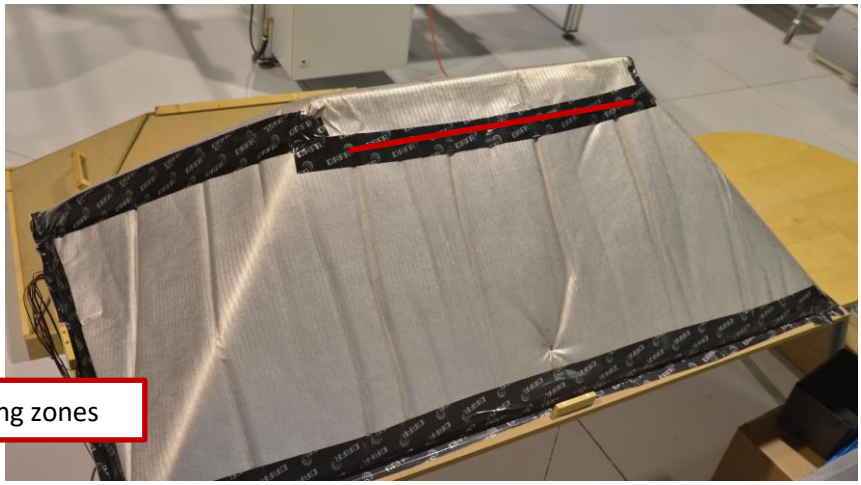

Figure 8 - Insulation with Aluthermo DENSIMA ®

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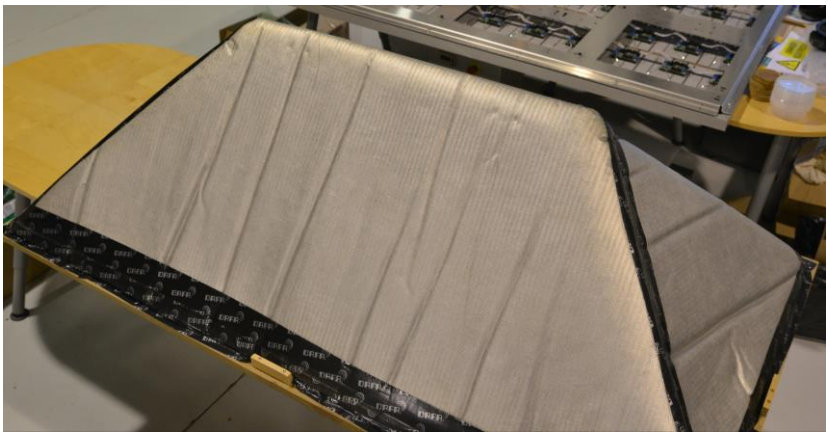

Figure 9 - Structure insulated with 1 layer of Aluthermo DENSIMA®

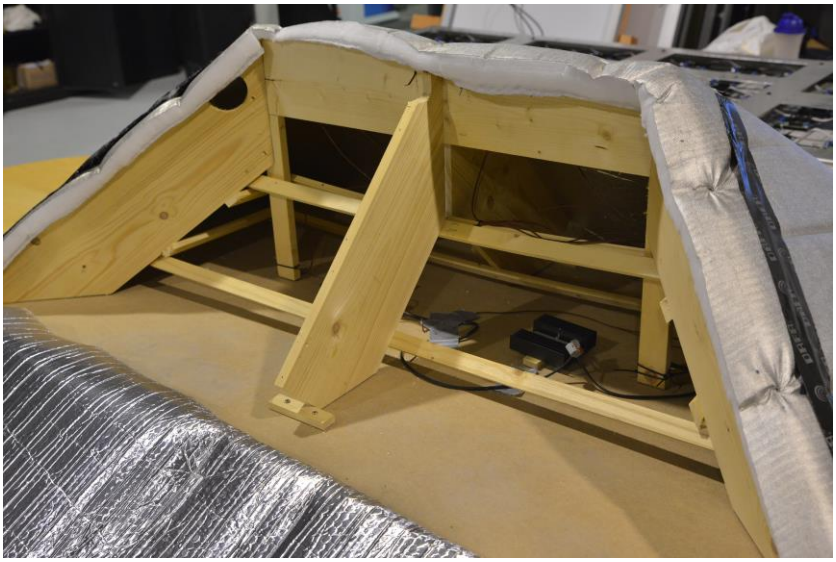

Figure 10: Inside view of structure insulated with Aluthermo DENSIMA®

Once the insulating material was laid down properly, the insulated structure was covered with the roof replica and placed in the climatic chamber.

Figure 11 - Insulated structure covered with roof replica

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Results

Preliminary measurements have shown that a steady state was reached after approximately 10h. Consequently, a stabilization period of 8 hours minimum was observed before gathering of the data for calculations.

The results obtained through the different tests sequences are presented in the following table. The data is used to calculate the apparent heat required to maintain the internal temperature at 21°C, taking into account differences such as internal air volume and measured average internal temperatures. The apparent specific heat *c* is calculated from the equation 1:

$$c = \frac{Q}{m\,\Delta T} \qquad \textit{Equation 1}$$

Where *c* is the apparent specific heat required to maintain the internal temperature at 21°C [kJ/kg°C]

Q is the cumulative heat input of the heater [kJ]

m is the mass of air [kg]

ΔT is the temperature gradient [°C]

Since the temperature in the respective roof increases from the base to the apex, the internal average temperature presented in column 3 is obtained through a process of integration to account for the variation in increasing temperature and decreasing volume along the height of the roof.

The cumulative energy consumed during the data acquisition period is displayed in column 5 (Wh) and 6 (J).

The apparent specific heat, *c*, calculated from Equation 1, is given in column 10.

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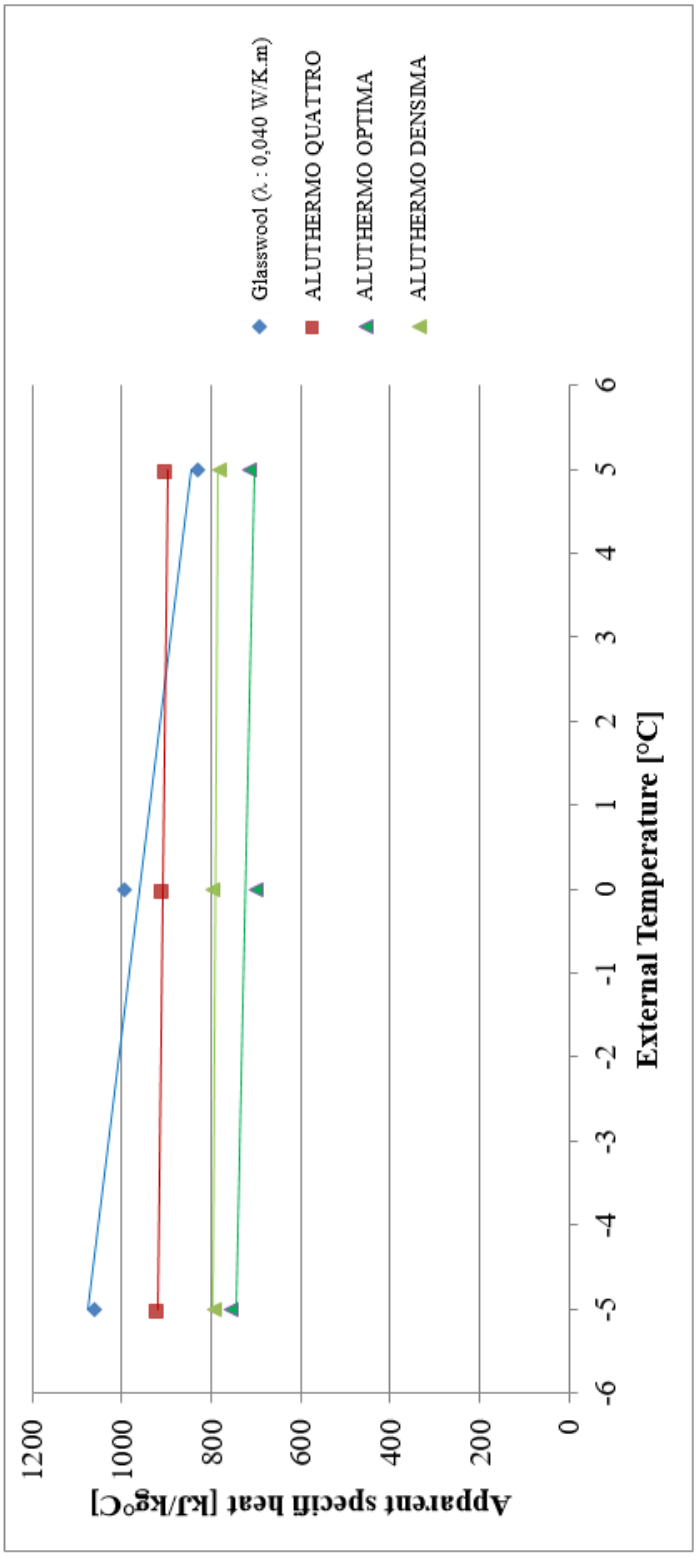
1	2	3	4	5	6	7	8	9	10
	Target External Temp [°C]	Average Internal Temp [1] [°C]	ΔT[3] [°C]	Energy consumption[2] [Wh]	Energy consumption[2] [J]	Air density [kg/m³]	Air volume [m³]	Air mass [kg]	Apparent specific heat, c[3] [kJ/kg°C]
Aluthermo DENSIMA ®	-5	14,5	19,5	1054,45	3796026	1,204	0,1948	0,2345	791
	0	15,8	15,8	814,07	2930652	1,204	0,1948	0,2345	797
	5	17,1	12,1	624,23	2247228	1,204	0,1948	0,2345	782

[1] the average temperature is calculated taking into account the variation in volume and in temperature along the structure height

[2] energy consumption calculated after the 10 hours stabilisation period

[3] difference between "average internal temp" and "external temp" (column 3 - column 2)



For ELIOSYS,
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CEO

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