Comparative tests of Aluthermo Optima ® vs Glasswool in simulated roof space

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INTRODUCTION

The aim of the test was to compare thermal insulation properties of Aluthermo Optima® thermo reflective insulation versus a 200mm mineral glasswool insulation (λ=0,04W/m.K).

In order to do so, a custom built enclosure replicating a roof top was insulated alternatively with both materials. 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.

INSULATING MATERIALS DEFINITION

	Aluthermo Optima®	**Glasswool – λ0,04**
Structure	Multi-layer thermo reflective	Homogeneous, no vapor barrier
Thickness	42 mm	200 mm (4x50mm)
Thermal conductivity λ(1)	- W/(m*K)	0,040 W/(m*K)

(1) provided by manufacturers

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TEST SETUP

Structure construction

A single enclosure was built to evaluate the comparative performance of Aluthermo Optima® against 200mm thick glasswool insulation with a thermal conductivity of 0,04 W/m.K. 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 40mm air gap between the insulating material and the internal side of the roof replica.

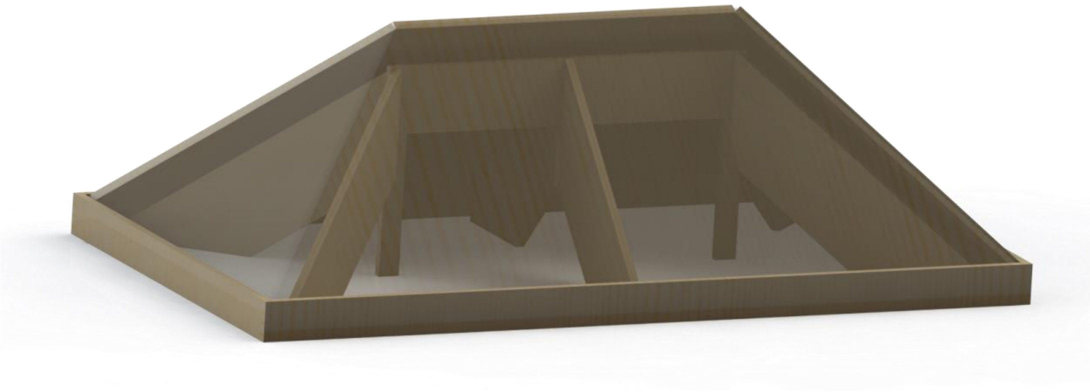

Figure 1 - CAO of test structure

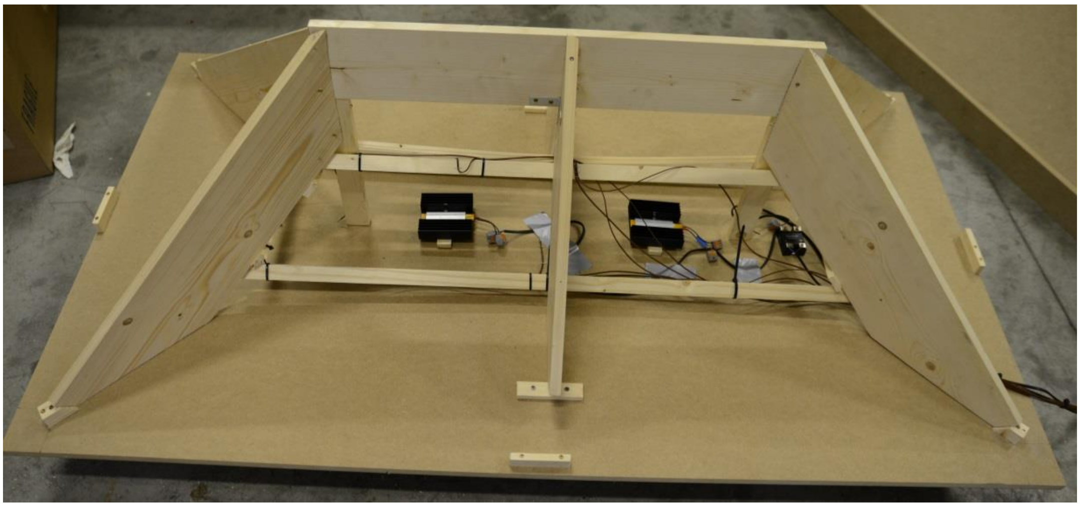

Figure 2 - Base wood structure and heating system

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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 40mm air gap was maintained between the insulating material and the roof replica, for both the glass fiber and the Aluthermo Optima®. This results in a different way to position both the materials, the glasswool being stuffed between the rafters while the Aluthermo Optima® was laid on top of them. Consequently, when using Aluthermo, the internal volume increases and the position of the top thermocouples is raised.

The external temperature was measured and regulated by the calibrated climatic chamber.

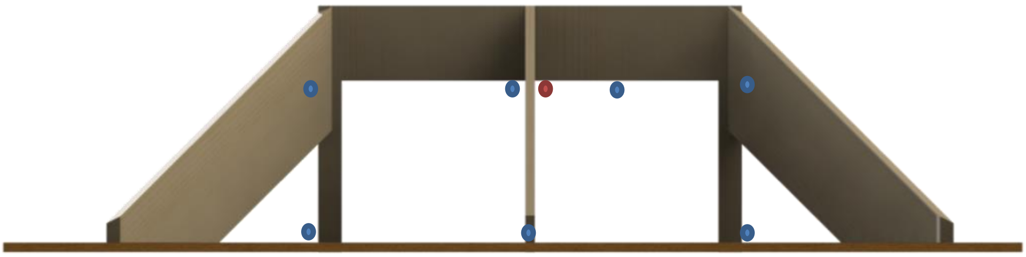

Figure 3 - Positions of thermocouples for Glasswool λ0,04 - face view

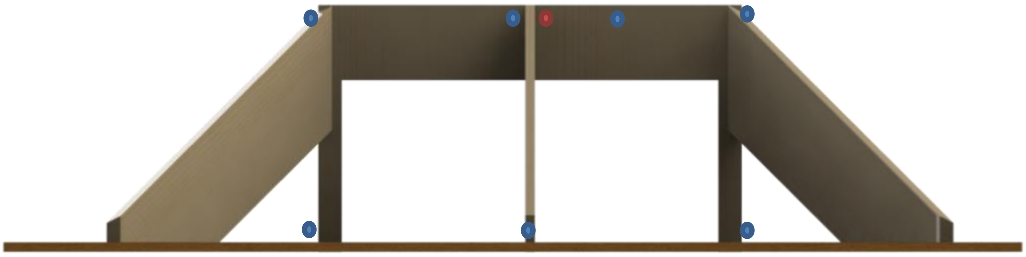

Figure 4 - Positions of thermocouples for Aluthermo Optima® - face view

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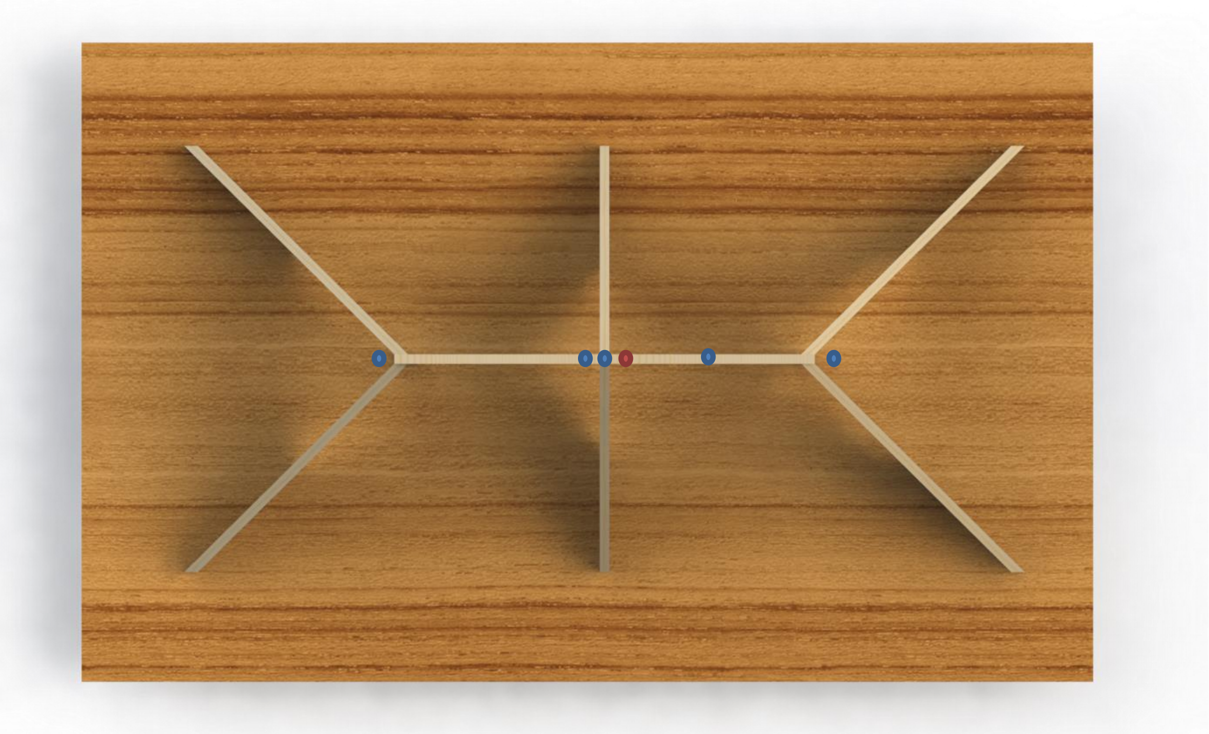

Figure 5 - Positions of thermocouples – top view

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.

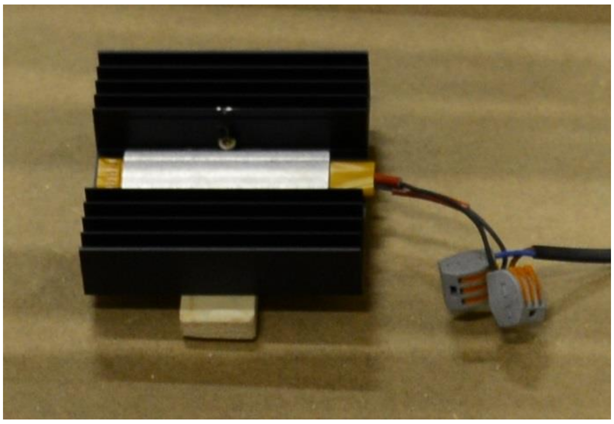

Figure 6 - Heating system

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DAQ system

Temperatures

The temperatures are measured by means of calibrated thermocouples with a precision of ±0.5°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 7 - National Instruments CompactDAQ system

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 8 - Energy monitoring system

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Insulation technics

Glasswool

The glasswool insulation was achieved by stacking four layers of 50mm thick glasswool in order to achive a total thickness of 200mm. In addition, strings were tied around the structure to insure the stability of the insulation along the extensive test period.

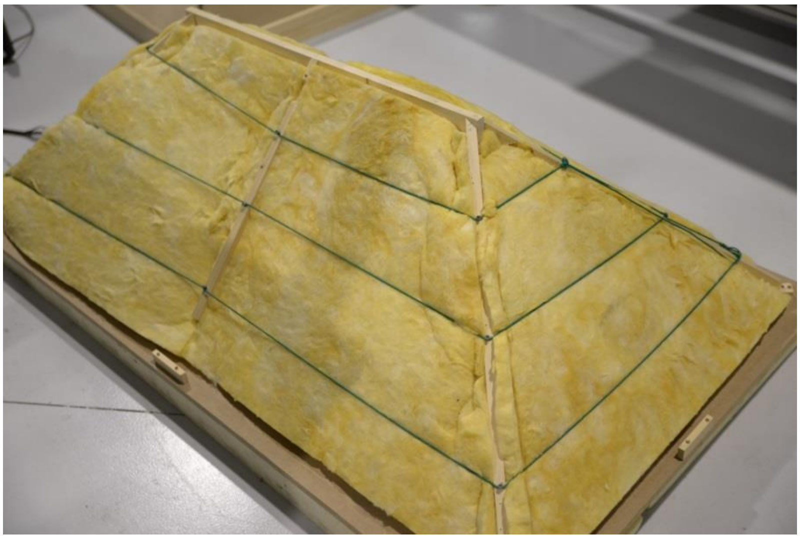

Figure 9 - Structure insulated with 4 layers of 50mm Glasswool λ0,04

Aluthermo Optima ®

The Aluthermo Optima ® was laid down according to manufacturer requirements (. Among other criteria, an overlapping distance of minimum 100mm was maintained (top and sides, see figure 10). The insulating sheet was fixed to the wood structure. The overlapping ends were maintained using Aluthermo ® aluminium tape.

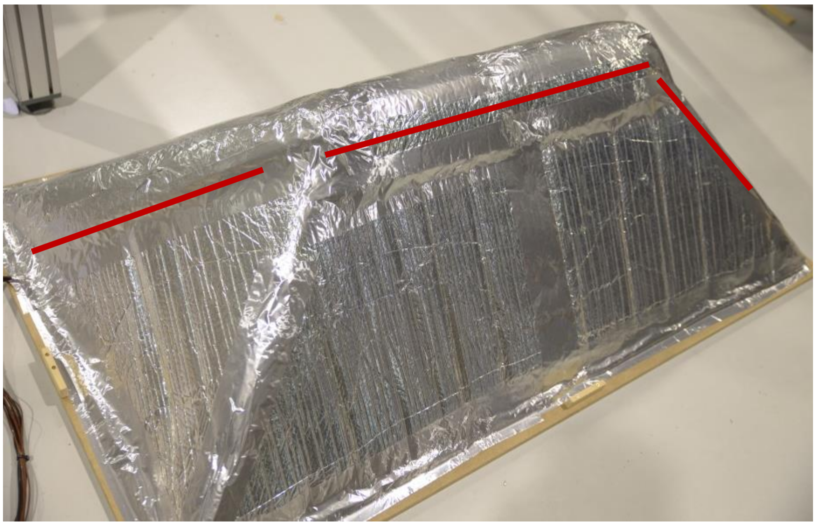

Figure 10 - Insulation with Aluthermo Optima ®

Overlapping zones

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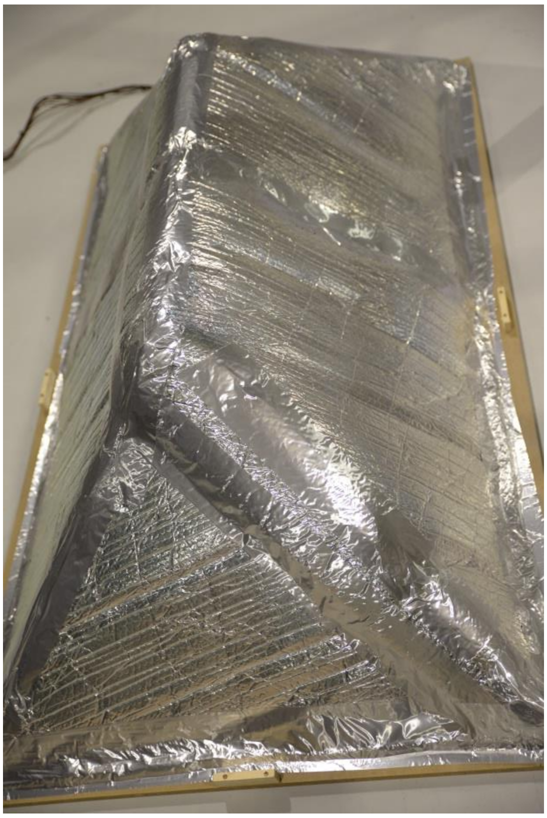

Figure 11 - Structure insulated with 1 layer of Aluthermo Optima®

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

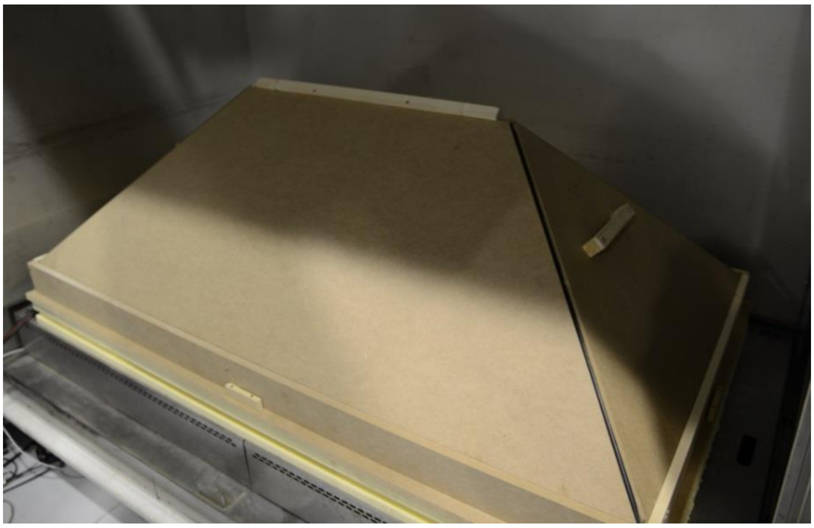

Figure 12 - Insulated structure covered with roof replica

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RESULTS

Preliminary measurements have shown that a steady state was reached after approximately 5h. 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:

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

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.

Values displayed in columns 3 and 4 show that there are substantial differences between average internal temperatures respectively for Aluthermo Optima® and glasswool – the average internal temperature being consistently higher withy Aluthermo Optima®. It is to be noted that this difference decreases when the external temperature increases.

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

A constant air density of 1,204 kg/m³ is used for the air inside the structure (column 7) and the volume of air inside the enclosure is estimated in column 8. The higher thickness displayed by the glasswool as compared to Aluthermo Optima® induces a smaller air volume enclosed in the test structure. The resulting air mass is given in column 9.

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

The percentage difference in specific heat shown in column 11 indicates that the performance of the Aluthermo Optima® is 29% more efficient than the glasswool when tested at -5°Cand 0°C. When tested at the highest external temperature of 5°C, this trend is slightly lower and the relative performance of Aluthermo Optima® is moving to 14%.

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1	2	3	4	5	6	7	8	9	10	11
	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]	Relative performance [%] [4]
Aluthermo Optima®	-5	15,8	20,8	972,50	3501000	1,204	0,1855	0,2233	754	29%
	0	16,8	16,8	730,13	2628468	1,204	0,1855	0,2233	701	29%
	5	17,5	12,5	554,49	1996164	1,204	0,1855	0,2233	715	14%
Glasswool λ0,04	-5	14,1	19,1	1165,69	4196471	1,204	0,0404	0,0486	1062	
	0	15,6	15,6	933,18	3359448	1,204	0,0404	0,0486	992	
	5	17,1	12,1	708,93	2552159	1,204	0,0404	0,0486	829	

[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 8 hours stabilisation period

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

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CONCLUSIONS

Along the range of temperature from -5 to 5°C, considering the volume of airspace and the temperature gradients in the enclosure, there is by far less heat required with the Aluthermo Optima ® to maintain the target temperature of 21°C. Even at the highest test temperature of 5°C, the Aluthermo Optima is outperforming the 200mm thick glasswool by 14%. At the colder temperatures of 0°C and -5°C the difference is even higher and rises to 29%.

The apparent specific heat calculated for the Aluthermo Optima® at -5°C, 0°C and 5°C is within 7% indicating that the insulation material is maintaining almost a constant performance in the range of temperatures, while a larger variation is observed for the glasswool with a maximal variation of 22%. In other words, Aluthermo Optima® exhibited a constant and higher performance under all target external temperatures (-5 ; 0 ; +5°C) whereas the performance of the 200mm thick glasswool varies across the 3 tests temperatures. This behavior can also be observed on the following graph.

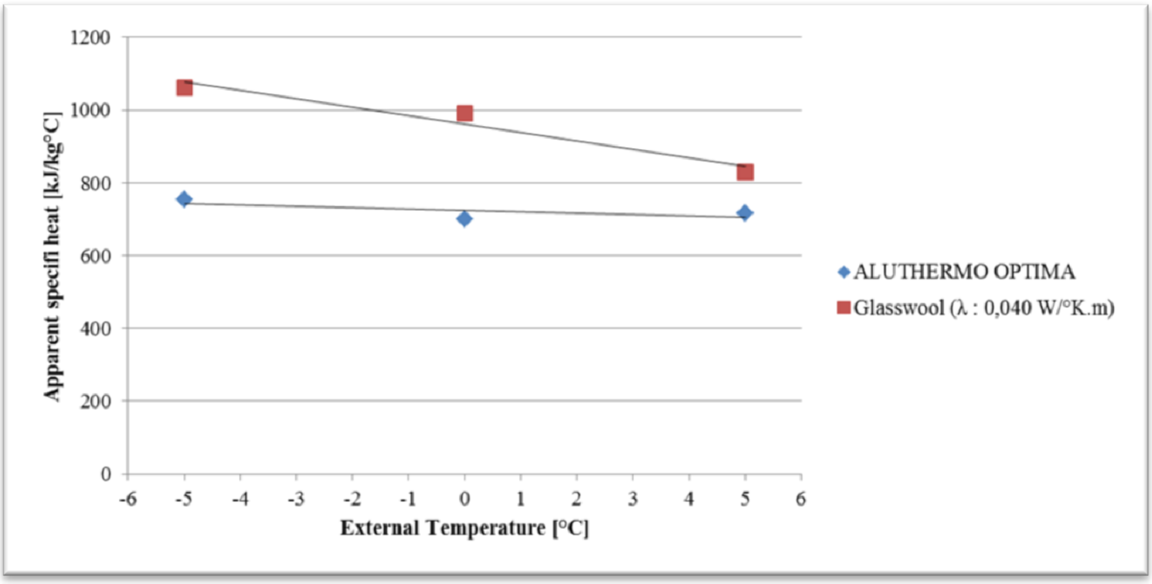

Figure 13 - specific heat evolution in respect of external temperature for Aluthermo Optima® and Glasswool λ0,04

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