REPORT No. 070764-a

CUSTOMER	B.R. S.A.
APPLICANT	
ADDRESS	SPAIN
PURPOSE	DETERMINATION OF LUMINOUS AND SOLAR CHARACTERISTICS AND THE THERMAL TRANSMITTANCE (UNE-EN 1051-2:2008)
SAMPLE TESTED	DOUBLE BLOCK WITH GLASS REF. «DIBE»
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CHARACTERISTICS OF THE SAMPLES

On 1st December 2017, TECNALIA received from the company B.R. S.A., four panels of two glass blocks measuring 190 mm x 190 mm x 80 mm and coated glass measuring 190 mm x 190 mm x 4 mm which forms the assembly referenced as:

«DIBE»

The **«DIBE»** assembly consists of the following elements:

- Glass block measuring 190 x 190 x 80 mm referenced as «Neutro B-Q 19 O»
- Air cavity of 16 mm consisting of the Technoform spacer REF «TGI®-Spacer M» filled with desiccant in bulk, bonded to the glass with «LOXEAL UV 30-23» and sealed around the whole perimeter with «Sikasil SG-20»
- Coated glass 4 mm thick referenced as «ClimaGuard® Premium T2»
- Air cavity of 16 mm consisting of the Technoform spacer REF «TGI®-Spacer M» filled with desiccant in bulk, bonded to the glass with «LOXEAL UV 30-23» and sealed around the whole perimeter with «Sikasil SG-20»
- Glass block measuring 190 x 190 x 80 mm referenced as «Neutro B-Q 19 O»

The characteristics of the glass block referenced as «Neutro B-Q 19 O» are the following:

- Average thickness of each panel of the glass block in its central area: 8.0 mm
- Total mass of the block: 2.32 kg
- Mass of the block in its central area: 1.33 kg
- Measurements of the central area: 177 mm x 177 mm

TEST REQUESTED

The test requested is the determination of **luminous and solar characteristics** and the determination of the **thermal transmittance** based on the annexes C and D of UNE-EN 1051-2:2008 standard *«Glass in building. Glass blocks and glass pavers - Part 2: Evaluation of conformity/Product standard»*

TEST CARRIED OUT

Luminous and solar characteristics

The determination of the transmittance and reflectance between 280 and 2,500 nm was carried out using a Perkin-Elmer Spectrometer Lambda 900 UV/VIS/NIR spectrophotometer with an integrating sphere of 150 mm in diameter, quartz standard and white standard.

The method used has the following characteristics:

- Wavelength interval: 5 nm
- Scan speed: 284.6 nm/min
- Slit UV/VIS:1
- Detector gain NIR:4

Six transmittance measurements on both sides and three reflectance measurements on both sides of the block pane were taken and three transmittance measurements and three reflectance measurements on both sides of the coated glass were taken.

According to Annex D of standard UNE-EN 1051-1:2008, a glass block can be modelled with a double glazing unit of the same width and length as the hollow glass block with equivalent thickness for each panel in accordance with the following equation:

$$h_{eq} = \frac{m}{2 \cdot \rho \cdot A}$$

where m is the mass
ρ is the density
A is the area

Taking into account the above equation, that the mass of the block is 2.32 kg and that the area of the block is 0.0361 m^2, an equivalent thickness of each leaf is obtained of 12.85 mm.

Therefore, in accordance with section A.1 of standard UNE-EN 410:2011, the spectral transmittance and reflectance factors of a non-coated glass panel 12.85 mm thick are calculated from their spectral transmittance factor measured for a thickness of 8.0 mm.

From these transmittance and spectral reflectance factors of the glass panel of the block and the spectral transmittance and reflectance measured of the coated glass, the **transmission** and the **diffuse reflection of the solar energy**, **light transmission, light reflection** and the **ultraviolet transmission** of the assembly were calculated in accordance with standard UNE-EN 410:2011.

Given that the model of the assembly is made up of five panels, the calculation is made following the procedure below:

- ✓ Calculation of the spectral transmittance and reflectance of the glass block and coated glass assembly considering it to be a triple insulated glass unit.
- ✓ Calculation of the spectral transmittance and reflectance of the glass block considering it as a double insulated glass unit.

The corrected emissivity considered on all the surfaces except the surface with coating is that of a surface of base soda lime silicate glass which in accordance with standard UNE-EN 673:2011 is 0.837. The corrected emissivity of the surface with coating is 0.03; this data has been provided by the customer.

Thermal transmittance

In order to calculate the thermal transmission coefficient U of the assembly «DIBE», on the one hand, Annex C of standard UNE-EN 1051-2:2008 was used for calculating the thermal transmission coefficient of the block and, on the other, the thermal resistance intake of the two air chambers on the sides of the coated glass and of the coated glass itself were calculated using finite elements.

Thermal transmittance of the block

According to Annex C of standard UNE-EN 1051-1:2008, a glass block can be modelled with a double glazing unit with the same width and length as the hollow glass block with equivalent thickness for each panel in accordance with the following equation:

$$h_{eq} = \frac{m_c}{2 \cdot \rho \cdot A_c}$$

where m_c is the mass of the centre

ρ is the density

A_c is the area of the centre

The equivalent thickness for the sealed edges is calculated in accordance with the following equation:

$$t_{eq} = \frac{m_e}{2 \cdot \rho \cdot W \cdot (B + H))}$$

where m_e is the mass of the edge

ρ is the density

W is the thickness of the block

B y H are the dimensions of the block

Taking into account the previous equations, that the mass of the centre is 1.33 kg and that the area of the centre is 0.0313 m^2, an equivalent thickness of 8.5 mm for each panel and of 6.5 mm for the sealed edges of 6.5 mm is obtained.

Based on these thicknesses, and taking into account standard UNE-EN 673:2011 and Annex C of standard UNE-EN 1051-2:2008, the thermal transmittance coefficient of the block is **3.14 W/m²K**.

Thermal resistance of the system air cavity - coated glass – air cavity

The simulation was performed using the THERM 7 program, developed at Lawrence Berkeley National Laboratory (LBNL). It is a computer tool is based on the finite element method to solve the two-dimensional heat transfer equation. This computational tool has been conveniently tested using the calculation examples proposed by different standards, such as UNE-EN ISO 10077-2:2012, «Thermal performance of windows, doors and shutters. Calculation of thermal transmittance. Part 2: Numerical method for frames", or UNE EN 1745:2002 "Masonry and masonry products. Methods for determining design thermal values".

The calculation is performed by importing the corresponding section into THERM and creating a model for simulation based on this template using polygon combinations. It is then necessary to define the properties of the materials involved and the boundary conditions to be applied.

Using this information, THERM draws a wire frame to be used in the finite element analysis and to calculate the heat transfer in the simulated system.

The following table lists the thermal conductivity values of the materials used in the calculation:

Material	**λ (W/m·K)**
Soda lime silicate glass [(1)]	1.00
Silicone [(2)]	0.50
Spacer [(3)]	0.193

Tabla 1: Conductividad térmica de los materiales.

(1) *Source: UNE-EN_572-1=2012+A1=2017 standard «Glass in building - Basic soda lime silicate glass products - Part 1: Definitions and general physical and mechanical properties»*
(2) *Source: Norma UNE-EN 12524:2000 «Building materials and products – Hygrothermal properties – Tabulated design values».*
(3) The spacer was considered as a solid element with thermal conductivity equal to that of the spacer itself.

The next figure shows the distribution of temperature and heat flow del system air cavity – coated glass – air cavity.

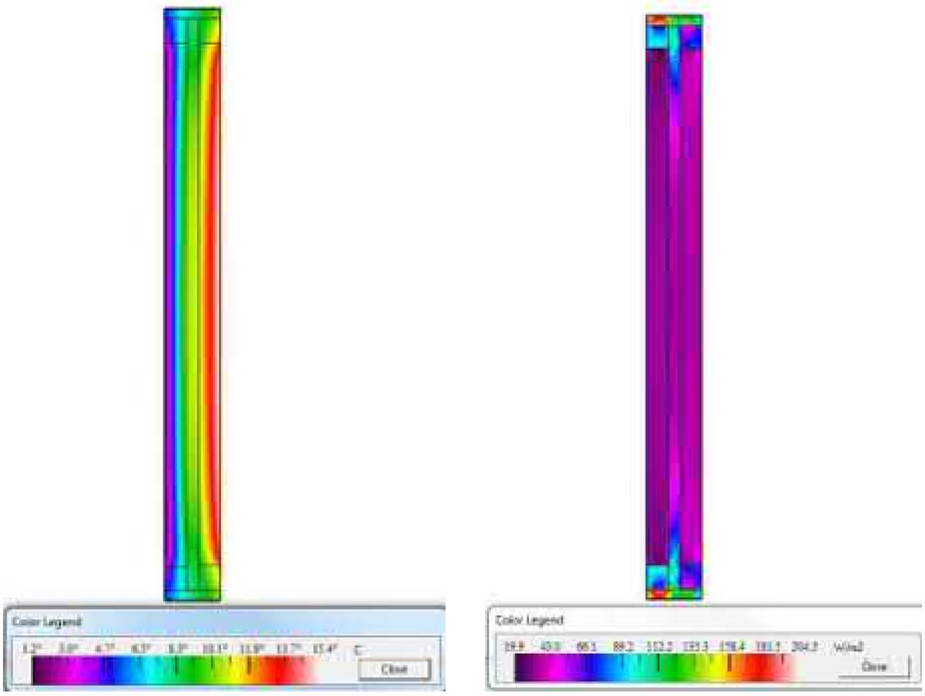


Figure 1: Distribution of temperature and heat flow with their related scales.

The next figure shows the distribution of temperature and heat flow in detail.

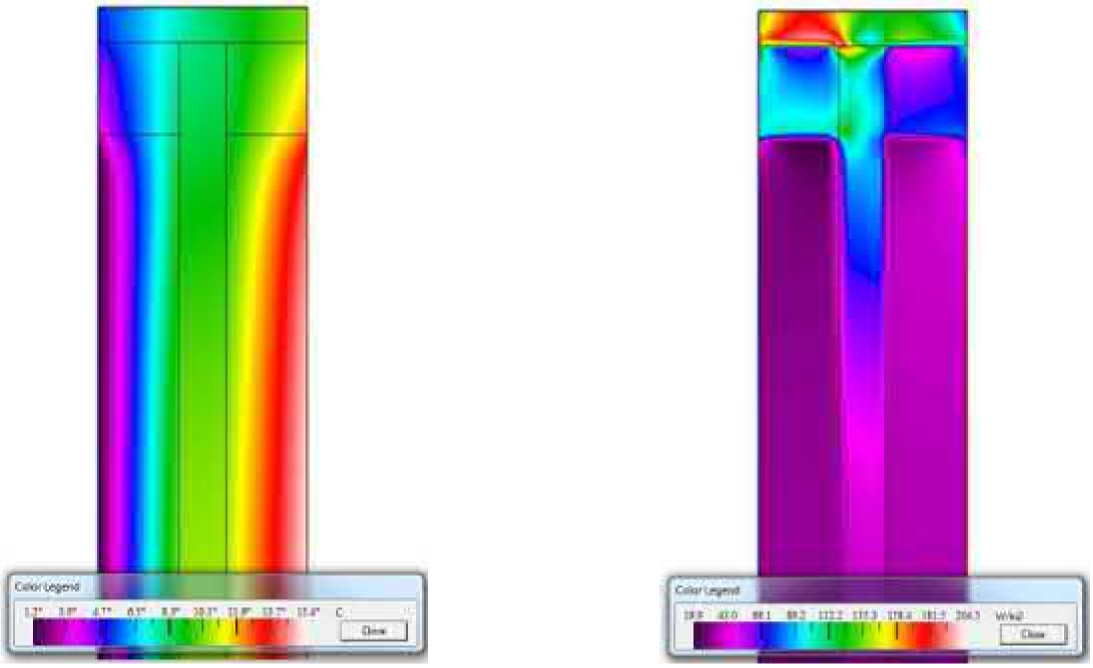


Figure 2: Detail of the distribution of temperature and heat flow with their related scales.

From the simulation, using finite elements of the system air cavity - coated glass - air cavity, its thermal resistance was calculated at 0.489 m^2K/W.

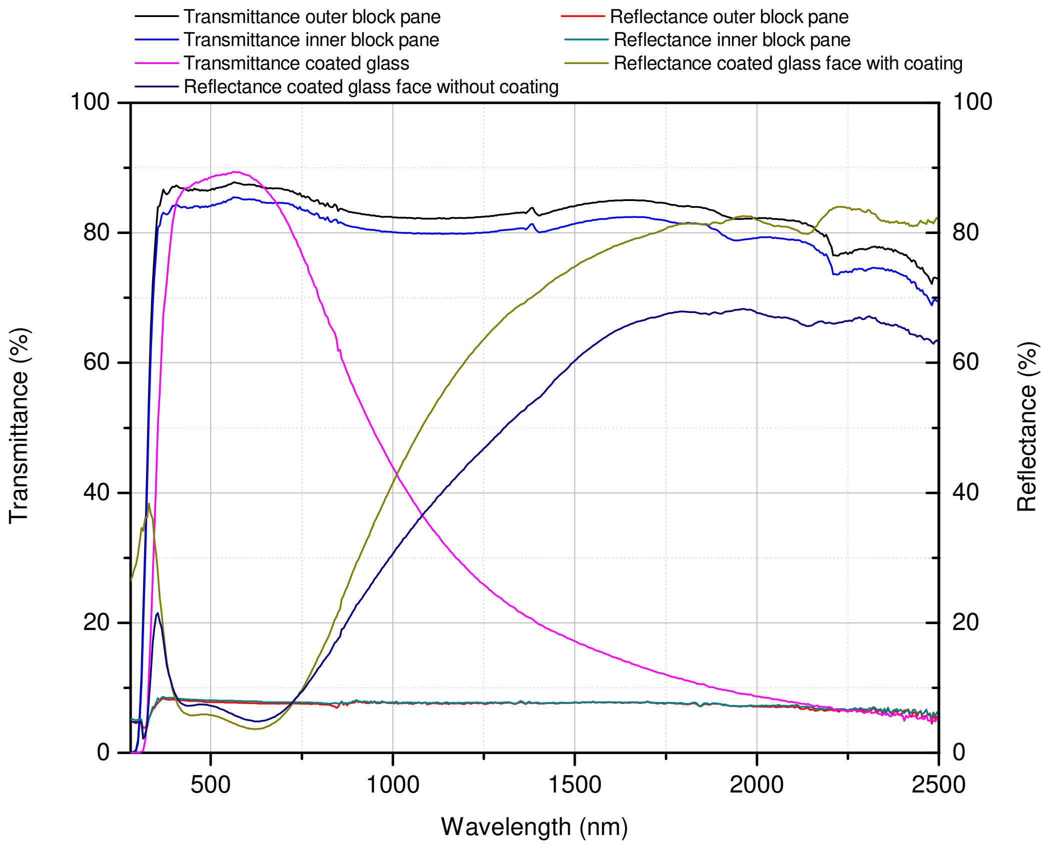
RESULTS

The results of the luminous and solar characterization and the thermal transmittance of the system glass unit referenced as «**DIBE**» are:

Light transmittance (%)	**42.8**
Light reflectance (%)	**20.3**
Ultraviolet transmittance (%)	**15.5**
Solar direct transmittance (%)	**28.6**
Solar direct reflectance (%)	**23.7**
Solar factor (Expressed per unit)	**0.38**
U (W/m^2K)	**1.04**

Table 2: Results de the luminous and solar characterization and the calculation of the thermal transmittance.

The following graph shows the data of the spectral transmittance and the reflectance of the test specimens received.



Graph 1: Spectral transmittance and reflectance.