## DETERMINATION OF THE CONDUCTIVITY OF AFONTERMO FOR EXTERNAL USE – THERMAL PHASE SHIFT, SPECIFIC HEAT, SPECIFIC WEIGHT CERTIFICATES

Thermal-reflective skimming coat: additional internal component

**Stratigraphy (from inside to outside):**

1) AFONTERMO – Thickness 0,35 cm*
2) Inside smoothing sample - Lime and Cement - Thickness 0,6 cm
3) Masonry specimen - Thickness 31,50 cm
4) External smoothing sample – Lime and Cement - Thickness 0,6 cm

Masonry as described in laboratory certificate Report 1851-2-20 Lab CMR Archive

Numerical analysis necessary to determine the conductivity of thermo-reflective material according to the thermal conductivity formula proven by the scientific literature. This appendix will explain the analytical steps necessary to obtain, from the known and laboratory-certified values (Thermal Phase and Specific Heat), the conductivity of the material.

$$\lambda(T) = \rho(T) \cdot c_p(T) \cdot a(T)$$

If the thermal phase shift is certified it is possible to deduct the thermal diffusivity of the known material. Here are the necessary analytical steps.

| | | |
|---|---|---|
| **Rt,cert (h) =** | 1,5 hours | [Laboratory-certified Thermal phase on a 3.5mm thick specimen applied on the internal side (wich is the cold side during the laboratory test at 39,6°] |
| **Rt,cert (s) =** | 5400 s | [Rt,cert(h) x 3600 s] |
| V = | 6,48148E-07 (m/s) | [Thermal wave displacement speed: thickness/ Rt,cert (s)] |
| ω = | 0,000073 (1/s) | Obtained from the o.e. period of T = 86400 s |
| a = | 2,87737E-09 ($m^2$/s) | [Thermal diffusivity of the material obtained by the certified value "Rt,cert (h)" and determined by the expression $V^2$ / 2ω] |
| **cp,cert (40°) =** | 1493 j/kgK | [Laboratory **certified** Specific heat at a temperature of 40°C, and precautionary for the determination of the declared conductivity. Value certified at Lab. Innovhub report C80 n.885] |
| λ, cert = | 0,00210 W/mK | [Conductivity of the material returned through laboratory tests] |
| λ, prog, UNI 10456 = | 0,003 W/mK | [Design conductivity of the material increased by 42,5% compared to that certified, or rather declared. This increased value is to be considered distinguished by a level of confidence greater than 90%] |

The conductivity value stated and calculated through the above mentioned laboratory tests is valid for the application of **Afontermo on the external surface of opaque components** of the building envelope and returns the exact insulating capacity of the material, in line with the results on site. This value can be proven on site by the Competent authorities.

The following are Extracts of reference certificates to wich the calculation refers:

## TEST REPORT N° 1851-2-20

Test results

Determination of thermal performance during summer phase shift and attenuation P.O.I. (Operating Internal Procedure).
TEST WITH 3,5 MM OF PRODUCT APPLIED ON THE INTERNAL SIDE

| Sample | Phase shift Wa (hour): | Recurring Thermal transmittance Yie (W/ m2 K) | Attenuation fa(-) | Text max (°C) | Tint max (°C) |
|---|---|---|---|---|---|
| Masonry as such is | 10h 30' | 0.18 | 0.27* | 40.2 | 24.7 |
| Masonry with 3,5 mm of Afontermo applied on the inside | 12h | 0.12 | 0.32* | 39.6 | 22.8 |

### TEST RESULTS:

***Detection of the specific heat (C80 Test N° 885)***

The specific heat in the required temperature range: 30-90°C resulted detectable from a temperature of 40°C.
Table 1 shows the values of specific heat at the required temperatures. The data marked with (*) has been determined through a mathematical calculation.

| Temperature (°C) | Cp (J/g*K) |
|---|---|
| 30* | 1,340 |
| 40 | 1,493 |
| 50 | 1,571 |
| 60 | 1,647 |
| 70 | 1,741 |
| 80 | 1,861 |
| 90 | 2,089 |

**R.d.P. 120202-R-3456 Density of Afontermo, previously called Thermofon**

-Calculation of the bulk density based on the standard sample volume Vs of the sample amounting to: 0,000256 m3 and rounded to the closest 10 kg/m3 .

| Sample | Mass of the sample $m_{wet}$ (G) | Mass of the sample ms,dry (G) | Bulk density (kg/m3) | Apparent Bulk density (kg/m3) |
|---|---|---|---|---|
| 1 | 120.2 | 119.6 | 493 | AVARAGE VALUE 490 |
| 2 | 120.6 | 120.2 | 495 | |
| 3 | 121.5 | 121.0 | 495 | |

Table 1 measurement of the bulk density

**COMPARISON OF THE CALCULATION APPLIED BY MEANS OF CONDUCTIVITY DETERMINATION ON TRADITIONAL INSULATION**

Following the undertaken certification process, this Appendix reports the determination of **the conductivity of traditional insulation** better known as "thick thermal coat", in order to highlight the validity of the process itself, pursuant to Ministerial Decree D.M. 2/4/1998.
As indicated in the notes drawn up by ENEA on insulating materials, the rules in accordance with current legislation apply for the assessment of thermal conductivity, and, according to Ministerial Decree 2/4/1998, the energy performance of an insulating material must be determined by tests carried out in a third-party laboratory.
The certification package provided allows the thermal conductivity of Afontermo to be obtained through the classical thermal conductivity formula applied to certified values.
The suitability of the procedure used is additionally confirmed by the calculations performed on traditional insulators for which the following table is given, with reference to their values for each insulating material, in terms of: specific gravity, specific heat, thermal conductivity and thermal diffusivity.
The conductivity coefficients of the materials indicated in the table, obtained through the hot plate method, can also be acquired through the thermal conductivity formula, as shown by the following calculation.

**Numerical analysis for the determining the conductivity of traditional insulating material according to the formula for thermal conductivity:**

$$\lambda(T) = \rho(T) \cdot c_p(T) \cdot a(T)$$

| MATERIAL | ρ [kg/mc] | c [J/kgK] | λ [W/mK] | a [mq/s] |
|---|---|---|---|---|
| Mineralised wood wool | 450 | 1.811 | 0,065 | $0{,}08 \cdot 10^{-6}$ |
| OSB Wood | 650 | 1.700 | 0,13 | $0{,}12 \cdot 10^{-6}$ |
| Wood fiber | 150 | 2.000 | 0,040 | $0{,}13 \cdot 10^{-6}$ |
| Cork foam | 100 | 1.560 | 0,040 | $0{,}26 \cdot 10^{-6}$ |
| Plasterboard slabs | 900 | 837 | 0,21 | $0{,}28 \cdot 10^{-6}$ |
| Cellular concrete | 300 | 1.000 | 0,089 | $0{,}30 \cdot 10^{-6}$ |
| Rock wool | 100 | 1.030 | 0,035 | $0{,}34 \cdot 10^{-6}$ |
| Foamglas | 150 | 1.000 | 0,055 | $0{,}37 \cdot 10^{-6}$ |
| Glass wool | 80 | 1.030 | 0,035 | $0{,}42 \cdot 10^{-6}$ |
| Expanded Polyurethane | 43 | 1.400 | 0,028 | $0{,}46 \cdot 10^{-6}$ |
| Glass | 2.500 | 750 | 1,0 | $0{,}53 \cdot 10^{-6}$ |
| Solid Brick | 1.800 | 837 | 0,8 | $0{,}53 \cdot 10^{-6}$ |
| Hollow Brick | 650 | 837 | 0,35 | $0{,}6 \cdot 10^{-6}$ |
| Extruded polystyrene foam XPS | 35 | 1.450 | 0,035 | $0{,}70 \cdot 10^{-6}$ |
| Grey synthesised expanded polystyrene EPS | 30 | 1.450 | 0,031 | $0{,}71 \cdot 10^{-6}$ |
| Concrete | 2.400 | 1.000 | 2,16 | $0{,}90 \cdot 10^{-6}$ |
| White synthesised expanded polystyrene EPS | 25 | 1.450 | 0,036 | $0{,}99 \cdot 10^{-6}$ |
| Still air | 1,23 | 1.008 | 0,025 | $20{,}2 \cdot 10^{-6}$ |

Below is the calculation applied to a traditional coat indicated in the above table, **adopting the same of 42.5% amplification used for Afontermo** applied externally:

| | | |
|---|---|---|
| a = | 0,0000007($m^2$/s) | [Thermal diffusivity of the material obtained from the above table] |
| **cp =** | 1450 j/kgK | [Specific Heat obtained from the above table] |
| λ = | 0,03553 W/mK | [Conductivity of the material obtained from the table and in any case deriving from: $\lambda(T) = \rho(T) \cdot c_p(T) \cdot a(T)$ |
| Amplified λ = | 0,051 W/mK | [Conductivity increased by 42.5% as performed on Afontermo applied externally] |

# TEST REPORT N° 1851-2-20

This test report consists of: 4 pages

| | |
|---|---|
| Date of issue : | 21/01/2021 |
| Client: | AFON CASA SRL<br>VIA EMILIA ROMAGNA 1<br>56025 PONTEDERA (PI) |
| Test method: | Determination of the increase in thermal performance in summer phase shift and attenuation by means of P.O.I. (Operating Internal Procedure). |
| Subject: | Smoothing applied to a brick wall |
| Sample N°: | 1851-2-20 |
| Description: | A 3,5 mm layer of Afontermo was applied on a brick wall. |
| Purpose of test: | Determine the variation of the summer thermal properties of phase shift and attenuation after applying the finish.<br>The test has been undertaken with the product applied on the inside. |

Responsible for testing

Dr.ssa Roberta Giorio





CMR Center Materials Research snc - Via dei Montecchi 21 - 36100 VICENZA Tel. 0444/020452 e-mail: info@cmr-lab.it
R.E.A. n. 367338-VI - C.F./P.I. 03950950240

# TEST REPORT N° 1851-2-20

## INTRODUCTION – TEST METHOD – THERMAL PHASE SHIFT AND ATTENUATION

There are currently no standardised test methods for verifying the summer performance of building envelopes (UNI, EN, ISO standards).
The available standards concern the verification of summer performance using calculation methods:
UNI EN ISO 13786:2007 - Thermal performance of building components -- Dynamic thermal characteristics -- Calculation methods which defines a procedure based on the admittance method.

According to this method, each layer of the construction element is represented by an array of complex numbers, called heat transfer matrix, the elements of which depend on density, thickness, specific heat and thermal conductivity of the material.

The product of the various layers matrices gives the heat transfer matrix of the element as a whole, from which three characteristic parameters of the wall can be extrapolated: the periodic Thermic transmittance (Yie), the attenuation factor (fa) and the thermal wave phase shift (wa), which are defined as follows (UNI EN ISO 13786):

- Periodic Thermic transmittance Yie=|Ymn|: the complex amplitude of the heat flux density through the surface of the component adjacent to zone m, divided by the complex amplitude of the temperature in zone n, when the temperature in zone m is kept constant (where zones m and n are two thermal zones separated from the component). Periodic thermal transmittance is measured in W/m2K.
- Attenuation factor (fa): the relationship between the Yie periodic transmittance and the stationary transmittance U. being a ratio between two homogeneous quantities it is a dimensionless number.
- Thermal wave phase shift (wa): the time span between the maximum amplitude of a cause and the maximum amplitude of its effect, in mathematical terms is the argument of the complex number Ymn: ϕ a=arg(Ymn). Phase shift is usually measured in hours.

The CMR Laboratory on the basis of its experience and the available scientific literature, relating to tests in this field, has developed a simulation system, based on an Operating Internal Procedure (P.O.I) aimed to verify the parameters of phase shift and attenuation of a summer thermal wave on an opaque wall.

The system consists of:

- Dynamic hot chamber: climatic chamber able to vary its internal temperature in sinusoidal mode within a period of 24 hours
- Test wall
- Control chamber: climatic chamber able to keep  the "internal" side  of the masonry on Preset values
- Data acquisition unit and sensors: system consisting of surface temperature probes, air temperature probes, thermo-flux probes on both sides of the wall.


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# TEST REPORT N° 1851-2-20

## SAMPLE DESCRIPTION

The sample consists of a wall of dimensions 120x120 cm in brick blocks of dimensions 23x24x31.5 cm (HxWxD) bedded with traditional lime and cement mortar and finished with 0,6 cm of conventional lime and cement finishing coat.
The sample was tested under this condition to determine its initial thermal properties.
Subsequently, **a coating called Afontermo with a total thickness of 3.5 mm** was applied to one side of the wall according to the application cycle indicated by the manufacturer and then a new measurement of the thermal properties in a summer regime was performed. The test was carried out by placing the product on what is to be considered the **"internal" side of the wall**.

| | |
|---|---|
| **Initial data:** | |
| Equipment: | Hot chamber equipment consisting of:<br>N.01 Hot chamber able to perform sinusoidal thermal cycles over a period of 24 hours, complete of sensors, dimensions: 1.8x1.8x1.5 $m^3$;<br>N.01 Chamber able to keep constant temperature on the "internal side" of the sample;<br>Protection screen. |
| Conditioning: | 24 hours at 50% UR, 25°C before performing each test |
| Sensors used | STS-029 "External" side thermal flowmeter<br>STS -008 "Internal" side thermal flowmeter<br>STS-021 Pt100 probe in contact with "external" side<br>STS-019 probe Pt100 - air temperature "external" side<br>STS-010 Pt100 probe in contact with "internal" side<br>STS-022 probe Pt100 - air temperature "inside" side<br>BABUC A datalogger. |
| Fixing method: | Thermal paste |
| Sensor placement: | In the centre of two blocks |
| Orientation of the sample: | Vertical |
| Direction of the heat flow during the test: | Horizontal |
| Start date of measurements: | 21/07/2020 |
| END date of measurements: | 22/01/2021 |


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## TEST RESULTS

| Determination of thermal performance during summer phase shift and attenuation P.O.I. (Operating Internal Procedure). **TEST WITH 3,5 MM OFPRODUCT APPLIED ON THE INTERNAL SIDE** | | | | | |
|---|---|---|---|---|---|
| Sample | **Phase shift Wa (hour):** | **Recurring Thermal transmittance Yie (W/ m2 K)** | **Attenuation fa(-)** | **Text max (°C)** | **Tint max (°C)** |
| **Masonry as such is** | 10h 30’ | 0.18 | 0.27* | 40.2 | 24.7 |
| **Masonry with 3,5 mm of Afontermo applied on the inside** | 12h | 0.12 | 0.32* | 39.6 | 22.8 |

* The attenuation factor was calculated by software using the thermal transmittance U of the brickwork.
U block = 0.67 W/ $m^2K$
ʎ Afontermo (from data sheet) = 0.0029 W/mK
U block + Afontermo = 0.37 W/ $m^2K$

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**Committente:**

**AFON CASA S.r.l.**
Via Emilia Romagna N° 1
56025 Gello di Pontedera PI

## Test report N°: RPT-SSC-200281

# Specific heat of the sample of AFONTERMO IL NANOCAPPOTTO

Issue date: 25/11/2020

Your reference: Acceptance of the offer R-SSC-200995

## Test report concerning:

S-SSC-2003330: Name of the sample: AFONTERMO IL NANOCAPPOTTO

**Industrial Security Laboratory Manager**
**Antonella Mazzei**

**Area Manager**
**Responsabile di Area**
**Angelo Lunghi**





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## INTRODUCTION:

Afon Casa S.r.l. asked Innovhub SSI S.r.l. – fuel field - to detect the specific Heat of a sample.

For this purpose, the client, delivered a sample of:

- **AFONTERMO IL NANOCAPPOTTO**

## EQUIPMENT USED

- **Setaram C80 heat flow calorimeter.**





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## TEST RESULTS:

***Detection of the specific heat (C80 Test N° 885)***

The specific heat in the required temperature range: 30-90°C resulted detectable from a temperature of 40°C.
Table 1 shows the values of specific heat at the required temperatures. The data marked with (*) has been determined through a mathematical calculation.

| Temperature (°C) | Cp (J/g*K) |
|---|---|
| 30* | 1,340 |
| 40 | 1,493 |
| 50 | 1,571 |
| 60 | 1,647 |
| 70 | 1,741 |
| 80 | 1,861 |
| 90 | 2,089 |

Tab. 1





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# TEST REPORT

**120202 - R - 3456**

EXPERIMENTAL DETERMINATION OF THE APPARENT BULK DENSITY (UNI EN 1015-10) OF A PLASTERING MORTAR CALLED "THERMOFON" PRODUCED BY AFON CASA S.R.L.

**Experiment performed by:**

P.I. Germano Pederzoli

**Redacted by:**

Ing. Mattia Morganti

**Approved by:**

Ing. Martino Labanti

| | |
|---|---|
| PLACE AND DATE OF ISSUE: | Faenza, 27/05/2013 |
| CLIENT: | **Afon Casa S.r.L.** |
| HEADQUARTERS: | Via Emilia Romagna 1, 56025 Pontedera (PI) |
| TIPE OF PRODUCT: | **PLASTERING MORTAR** |
| STANDARD APPLIED: | UNI EN 998-1:2010 |
| DATE OF RECEPTION OF THE SAMPLES: | 20/03/2013 |
| TEST DATE: | May 2013 |
| TESTS PERFORMED AT: | CertiMaC, Faenza |

| | | | |
|---|---|---|---|
| Revision number -01- | This test report consists in 4 pages | | Page 1 of 4 |
| Classification | Prog. CNT | Ris. III | Arch. +5 |

## 1. Introduction

This report describes the test in order to:
- *Determine the apparent bulk density of plastering mortars,*
The test was performed on a product called “Thermofon” sent to CertiMaC laboratory in Faenza from the company “Afon Casa S.r.l.” with legal and production headquarters in Pontedera (PI) (Ref. 2-a, 2-b). The test was performed in accordance with the standards indicated in Ref.2-v, Ref.2-d.

## 2. References

***A)*** Quotation: Protocol 13076/lab dated 20/03/2013.
***B)*** Order confirmation: fax dated 24/03/2013
***C)*** UNI EN 998-1:2010 specifications for masonry mortars. Internal/externa masonry mortars.
***D)*** UNI EN 1015-2:2007. Test methods for masonry mortars. Part 10: determine the apparent bulk density of dried hardened mortar.
***E)*** UNI EN 1015-2:2007. Test methods for masonry mortars. Part2: sampling and preparation of the mortars for testing.

## 3. Object of the test

The test was performed on a sample of masonry mortar sent to the laboratory as:

- *Nr° 1 can of ready for use product.*

The test has been performed on three sample measuring approximately 160x40x40 mm (fig. 1), carried out by the laboratory in compliance with the standard at ref. 2-d. The tested material was created and seasoned at the laboratory in date 4th of April 2013.
Once the product dried and seasoned, as required from the standards ref. 2-c and 2-d, the testing was performed to determine what in object.
The figure 1 shows the samples at the end of the phases of creation and seasoning.

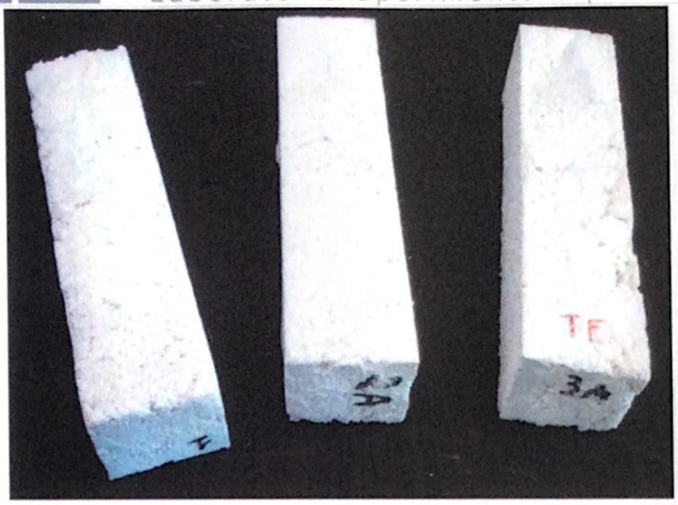

**Figure 1. Samples of mortar created at the laboratory.**

**4. Determination of the apparent bulk density of dried hardened mortar.**

The test has been performed, in compliance with the 2-d standard that sets methods to determine the apparent bull density of dried hardened mortar, by measuring mass and volume on regular-shaped samples (see fig.1).

$$\rho = \frac{m_{s,dry}}{v_s}$$

The standard test procedure involves the following steps:
-drying the samples in a fan assisted oven at the temperature od 105°±5°C until a constant mass value is not reached, in other words, untill between two successive weighings there is no change in mass of more than 0.2%. This way Ms,dry is determined (Table1).
-Calculation of the bulk density based on the standard sample volume Vs of the sample amounting to: 0,000256 m3 and rounded to the closest 10 kg/m3 .

| Sample | Mass of the sample $m_{wet}$ (G) | Mass of the sample ms,dry (G) | Bulk density (kg/m3) | Apparent Bulk density (kg/m3) |
|---|---|---|---|---|
| 1 | 120.2 | 119.6 | 493 | AVARAGE VALUE 490 |
| 2 | 120.6 | 120.2 | 495 | |
| 3 | 121.5 | 121.0 | 495 | |

**Table 1 measurement of the bulk density**

## 5. Conclusions

From the experiments performed, it is stated that the average bulk density value measured is **490 kg/m³.**

## 6.Distribution list

| | | |
|---|---|---|
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| **CertiMaC** | Archivio | 1 copy |
| **Committente** | Afon Casa S.r.l. | 1 copy |