INSTITUTE OF ARCHITECTURE AND CONSTRUCTION OF KAUNAS UNIVERSITY OF TECHNOLOGY

BUILDING PHYSICS LABORATORY

LIETUVOS NACIONALINIS AKREDITACIJOS BIURAS

BANDYMAI ISO/IEC 17025 Nr. LA.01.031

TEST REPORT No. 244 SF/22 U

Date: 20 of October 2022

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Determination of declared thermal resistance of reflective insulation product according LST EN 16012:2012+A1:2015 and LST EN ISO 8990:1999

(test title)

Test method: **LST EN 16012:2012+A1:2015**: Thermal insulation for buildings-Reflective insulation products-Determination of the declared thermal performance;
LST EN ISO 8990:1999: Thermal insulation - Determination of steady-state thermal transmission properties - Calibrated and guarded hot box (ISO 8990:1994).

(number of normative document or test method, description of test procedure, test uncertainty)

Specimen description: **Product:** reflective multilayer insulation product Type 3
Names of product: TECH PRO
Thickness of product installed in the „Hot box" – 80 mm
Declared thickness of product – 60 mm +/- 20 mm*
At the center of the specimen installed the beam of polyurethane. Dimension: Width – 3 cm, length – 1.13 m, thickness – 48 mm.
*Declared by the manufacturer

(name, description and identification details of a specimen)

Customer: SAS ATI FRANCE, 146 avenue du bicentenaire 01120 Dagneux, France

(name and address)

Manufacturer: SAS ATI FRANCE, 146 avenue du bicentenaire 01120 Dagneux, France

(name and address)

Test results:

Name of the indicator and unit	Test method reference no.	Test result
Declared corrected *R-core*$_{90/90}$ thermal resistance with 2 air gaps, (m^2·K)/W	LST EN ISO 8990:1999 LST EN ISO 16012:2012+A1:2015	**3.10**
Declared corrected *R-core*$_{90/90}$ thermal resistance of product **TECH PRO**, (m^2·K)/W	LST EN ISO 16012:2012+A1:2015	**2.50**
Declared thermal resistance values determined according to EN ISO 10456:2008** (**not accredited activity) Position of specimen: vertical (direction of heat flow – horizontal)		

Tested at: Building Physics Laboratory, Institute of Architecture and Construction of Kaunas University of Technology

(name of the test laboratory)

Specimen delivery date: 2022-09-16 **Date of testing:** 2022-10-05/ 2022-10-12/2022-10-14/2022-10-16

Sampling: The test specimen sampled by customer.

Additional information: Application 2022-09-19/2022-10-06
Used tests reports 202 SF/22 U; 200-2 SF/22 U; 225 SF/22 U; 226 SF/22 U

(any deviations, complementary tests, exceptions and any information related with particular test)

Annexes:
Annex 1. Test results;
Annex 2. Parameters of Guarded Hot Box measurement;
Annex 3. Specimen products and air gaps thermal properties;
Annex 4. Perimeter zone's linear thermal transmittance value of the specimen;
Annex 5. Specimen design data;
Annex 6. Scheme of climate chamber „Hot box".

(indicate annex numbers and titles)

Head of Laboratory: (approves the test results)	(signature)	K. Banionis (n., surname)
Tested by: (technically responsible for testing)	(signature)	A. Burlingis (n., surname)

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Annex 1. ***Test results:***

TECH PRO according to the test report 202 SF/22 U:

Data element	unit	Value
Air velocity on warm side, downwards, v_i	m/s	0.27
Air velocity on cold side, upwards, v_e	m/s	0.02
Total power input to metering box, Φ_{in}	W	13.656
Heat flow density through a specimen, q_{sp}	W/m^2	3.2419
Corrected heat flow density through a specimen, q_c	W/m2	3.2592
Warm side air temperature, θ_{ci}	°C	20.75
Cold side air temperature, θ_{ce}	°C	9.23
Surface temperature of the warm side, τ_{si}	°C	20.241
Surface temperature of the cold side, τ_{se}	°C	9.828
Temperature difference between surfaces, $\Delta\tau_s$	°C	10.413
Core thermal resistance of specimen, $R_{c,sp}$	m^2·K/W	3.195
Directly measured core thermal resistance of product, $R_{c,m,pr}$	m^2·K/W	2.647
Recalculated according to LST EN 16012:2012+A1:2015 core thermal resistance of product, $R_{c,pr}$	m^2·K/W	2.574
Extended uncertainty of the measurement, ΔR_{sp}	m^2·K/W	± 0.1109

Tested by: A. Burlingis *[signature]* Date: 2022-10-05

TECH PRO according to the test report 200-2 SF/22 U:

Data element	unit	Value
Air velocity on warm side, downwards, v_i	m/s	0.26
Air velocity on cold side, upwards, v_e	m/s	0.02
Total power input to metering box, Φ_{in}	W	13.623
Heat flow density through a specimen, q_{sp}	W/m^2	3.2319
Corrected heat flow density through a specimen, q_c	W/m2	3.2491
Warm side air temperature, θ_{ci}	°C	20.74
Cold side air temperature, θ_{ce}	°C	9.23
Surface temperature of the warm side, τ_{si}	°C	20.183
Surface temperature of the cold side, τ_{se}	°C	9.832
Temperature difference between surfaces, $\Delta\tau_s$	°C	10.351
Core thermal resistance of specimen, $R_{c,sp}$	m^2·K/W	3.2027
Directly measured core thermal resistance of product, $R_{c,m,pr}$	m^2·K/W	2.627
Recalculated according to LST EN 16012:2012+A1:2015 core thermal resistance of product, $R_{c,pr}$	m^2·K/W	2.565
Extended uncertainty of the measurement, ΔR_{sp}	m^2·K/W	± 0.1111

Tested by: A. Burlingis *[signature]* Date: 2022-10-12

TECH PRO according to the test report 225 SF/22 U:

Data element	unit	Value
Air velocity on warm side, downwards, v_i	m/s	0.25
Air velocity on cold side, upwards, v_e	m/s	0.03
Total power input to metering box, Φ_{in}	W	13.647
Heat flow density through a specimen, q_{sp}	W/m^2	3.2434
Corrected heat flow density through a specimen, q_c	W/m2	3.2607
Warm side air temperature, θ_{ci}	°C	20.72
Cold side air temperature, θ_{cc}	°C	9.27
Surface temperature of the warm side, τ_{si}	°C	20.186
Surface temperature of the cold side, τ_{se}	°C	9.830
Temperature difference between surfaces, $\Delta\tau_s$	°C	10.356
Core thermal resistance of specimen, $R_{c,sp}$	m^2·K/W	3.193
Directly measured core thermal resistance of product, $R_{c,m,pr}$	m^2·K/W	2.573
Recalculated according to LST EN 16012:2012+A1:2015 core thermal resistance of product, $R_{c,pr}$	m^2·K/W	2.555
Extended uncertainty of the measurement, ΔR_{sp}	m^2·K/W	± 0.1106

Tested by: A. Burlingis Date: 2022-10-14

TECH PRO according to the test report 226 SF/22 U:

Data element	unit	Value
Air velocity on warm side, downwards, v_i	m/s	0.25
Air velocity on cold side, upwards, v_e	m/s	0.03
Total power input to metering box, Φ_{in}	W	13.562
Heat flow density through a specimen, q_{sp}	W/m^2	3.2066
Corrected heat flow density through a specimen, q_c	W/m2	3.2238
Warm side air temperature, θ_{ci}	°C	20.72
Cold side air temperature, θ_{ce}	°C	9.28
Surface temperature of the warm side, τ_{si}	°C	20.234
Surface temperature of the cold side, τ_{se}	°C	9.844
Temperature difference between surfaces, $\Delta\tau_s$	°C	10.390
Core thermal resistance of specimen, $R_{c,sp}$	m^2·K/W	3.240
Directly measured core thermal resistance of product, $R_{c,m,pr}$	m^2·K/W	2.659
Recalculated according to LST EN 16012:2012+A1:2015 core thermal resistance of product, $R_{c,pr}$	m^2·K/W	2.602
Extended uncertainty of the measurement, ΔR_{sp}	m^2·K/W	± 0.1125

Tested by: A. Burlingis Date: 2022-10-16

Annex 2. ***Parameters of Guarded Hot Box measurement.***

Table 1. TECH PRO insulation system's specimen measured at 20°C/10°C temperature regime

Guarded Hot Box measurement. Parameters of "TECH PRO" insulation system's specimen:			
Specimen's area A, m^2	1,831	Actual mean thickness of specimen, mm	**≈ 140***
Position of a specimen	vertical	Length of specimen perimeter L, m	5,44
	Linear thermal transmittance of perimeter zone Ψ_L, W/(m·K)		-0,00056

Measurement data:							
Insulation system with product "TECH PRO":							***Result:***
Sample No.	Temperature regime, °C	Hot side surface temperature τ_h, °C	Cold side surface temperature τ_c, °C	Temperature difference $\Delta t = (t_h - t_c)$, °C	Measured heat flow density q, W/m²	Corrected heat flow density qc, W/m²	**R-value of insulation system, m²·K/W**
202/22	20 /10	20,2410	9,8283	10,4128	3,2419	**3,2592**	**3,195±0,1109**
200-2/22	20 /10	20,1828	9,8320	10,3508	3,2319	**3,2491**	**3,186±0,1111**
225/22	20 /10	20,1860	9,8298	10,3563	3,2434	**3,2607**	**3,176±0,1106**
226/22	20 /10	20,2338	9,8437	10,3900	3,2066	**3,2238**	**3,223±0,1125**
						Average:	**3.195**

* Previous test has shown that when installed on real building the average thickness of product is slightly larger than its nominal value. To keep surfaces of test sample as parallel as possible in the test setup, it is decided to install the product in a frame. After internal validation, the thickness of the frame is representative of the average thickness of an installed product, as requested by LST EN ISO 8990.

$$S_{R-sys} = \sqrt{\frac{\sum(R_i - R_{average})^2}{n-1}} = 0.020216;$$

$$R_{90/90-sys} = R_{average} - k_2 \cdot S_{R-sys} = 3.1305 = 3.10\ (m^2 \cdot K)/W;$$

Annex 3. ***Specimen product and air gaps thermal properties***

Table 2. TECH PRO insulation specimen product $R_{core,1}$ value measurements results

Product	*Thickness d, mm*	*Hot side temperature τ_h, °C*	*Cold side temperature τ_c, °C*	*Temperature difference $\Delta\tau$, °C*	*Heat flow density q_c, W/m²*	*Product's R-core, 1 value, m²·K/W*
TECH PRO – 202/22	80	19,0578	10,4298	8,6280	3,2592	**2,647**
TECH PRO – 200-2/22	80	18,9380	10,4023	8,5358	3,2491	**2,627**
TECH PRO – 225/22	80	18,8435	10,4983	8,3453	3,2607	**2,559**
TECH PRO – 226/22	80	19,0513	10,5238	8,5275	3,2238	**2,645**
					Average:	**2.620**

Table 3. TECH PRO insulation specimen air gaps corrected R-core values calculation results according to LST EN 16012:2012+A1:2015 and LST EN ISO 6946:2017

Sample No.	*Air gap number*	*Thickness d, mm*	*Measured temperature differences of surfaces, $\Delta\tau$, °C*	*Radiative heat transfer coefficient, h_r*	*Convective heat transfer coefficient, h_a*	*Air gap R- core value, $m^2\cdot K/W$*
202/22	Air gap #1	30	1.1833	1.3848	1.25	0.3795
	Air gap #2	30	0.6015	2.9001	1.25	0.2410
200-2/22	Air gap #1	30	1.2448	1.3836	1.25	0.3797
	Air gap #2	30	0.5703	2.8997	1.25	0.2410
225/22	Air gap #1	30	1.3425	1.3829	1.25	0.3798
	Air gap #2	30	0.6685	2.9011	1.25	0.2409
226/22	Air gap #1	30	1.1825	1.3847	1.25	0.3795
	Air gap #2	30	0.6800	2.9018	1.25	0.2409

Table 4. TECH PRO insulation specimen products

Specimen product	*Specimen surface layer*	*Declared emissivity, ε*
TECH PRO	External reflective Membrane	0.25**
	Needled linen	0.60**

** Declared by the manufacturer

R-core thermal resistance value calculation according to LST EN 16012:2012+A1:2015:

R_{core} (202/22) = 3.195 – 0.3795 – 0.2410 = 2.574 ($m^2\cdot K$)/W

R_{core} (200-2/22) = 3.186 – 0.3797 – 0.2410 = 2.565 ($m^2\cdot K$)/W

R_{core} (225/22) = 3.176 – 0.3798 – 0.2409 = 2.555 ($m^2\cdot K$)/W

R_{core} (226/22) = 3.223 – 0.3795 – 0.2409 = 2.602 ($m^2\cdot K$)/W

Average R-core thermal resistance value: 2.574 **($m^2\cdot K$)/W**

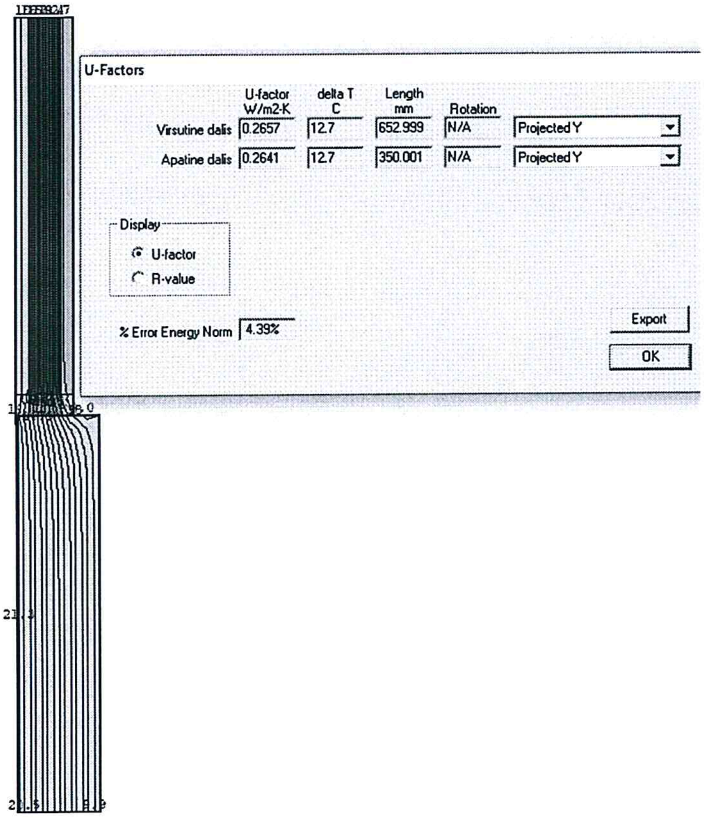
Standard deviation of derived R-value of insulation product:

$$S_{R-prod} = \sqrt{\frac{\sum(R_i - R_{average})^2}{n-1}} = 0.02216;$$

Declared derived R-value of insulation product:

$$R_{90/90-prod} = R_{average} - k_2 \cdot S_{R-prod} = 2.5095 = 2.50\ (m^2 \cdot K)/W;$$

Annex 4. ***Perimeter zone's linear thermal transmittance value of the specimen***



Perimeter zone's *U*-value: 0.2641 W/(m²·K); width "d"– 350 mm;

Central area *U*-value: 0.2657 W/(m²·K).

Perimeter's linear thermal transmittance: ψ= (0.2641-0.2657)·0.350= **-0.00056** W/(m·K).

The correction of measured heat flow density value due to perimeter zone is calculated according to equation:

$$q_c = \frac{Q_c}{A} = \frac{Q - \psi \cdot L \cdot \Delta t}{A} = \frac{q \cdot A - \psi \cdot L \cdot \Delta t}{A} = q - \psi \cdot \left(\frac{L \cdot \Delta t}{A}\right);$$

here:

A – area of a specimen, m²;

Q – measured mean heat flow through a specimen, W;

q – measured mean heat flow density through a specimen, W/m²;

Q_C – corrected mean heat flow through a central area of specimen, W;

q_C – corrected mean heat flow density through a central area of specimen, W/m²;

L – perimeter length of a specimen, m;

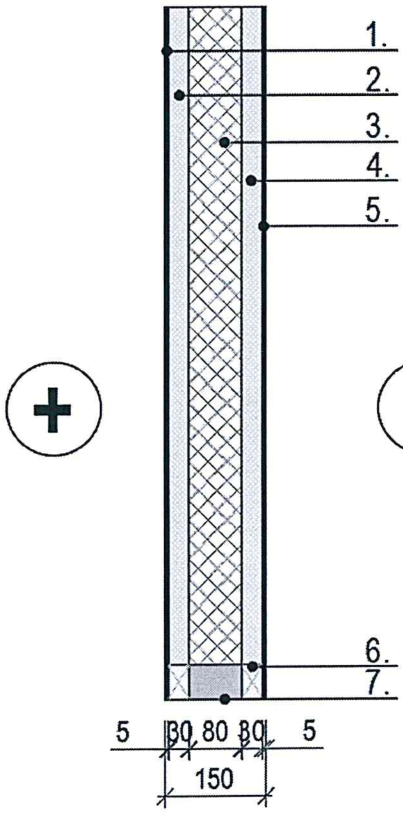
Δt – ambient temperature difference across a specimen, K;

ψ - perimeter's linear thermal transmittance of a specimen, W/(m·K).

Corrected R-value: $R_c = \frac{\Delta\tau}{q_c}$;

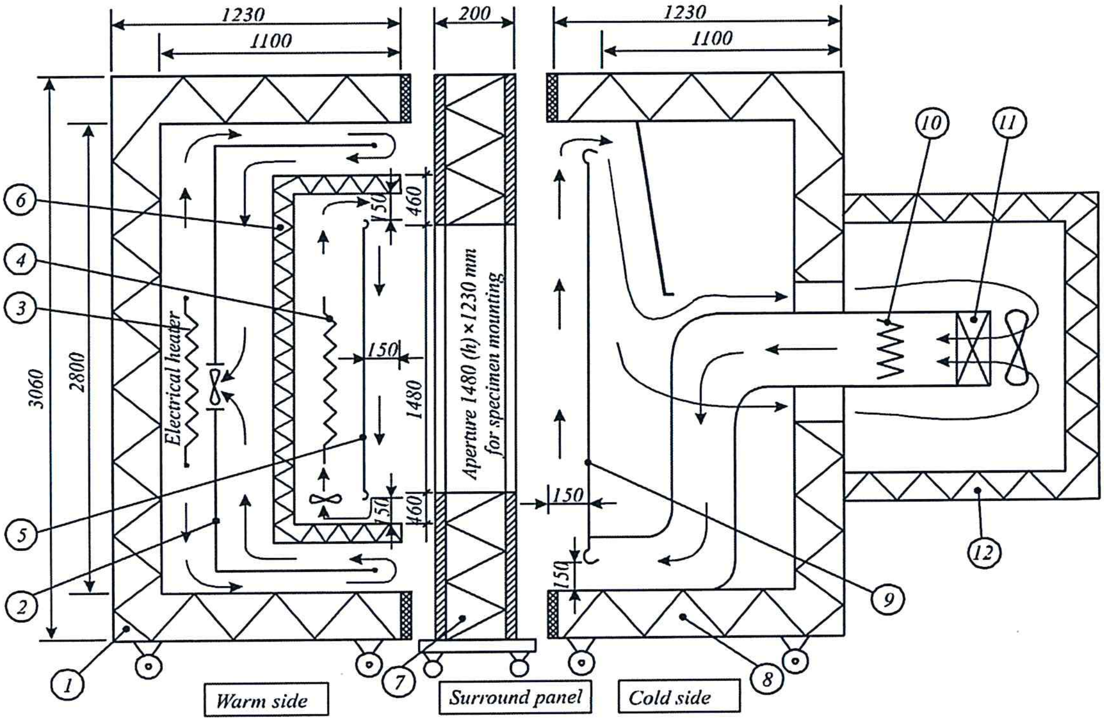
$\Delta\tau$ – temperature difference across a specimen, K.

Annex 5. ***Specimen design data***



1.	PVC 5 mm
2.	Air gap 30 mm (#1)
3.	**TECH PRO** 80 mm
4.	Air gap 30 mm (#2)
5.	PVC 5 mm
6.	EPS (polystyrene) 30 mm
7.	PUR 80 mm

Annex 6. Scheme of climate chamber „Hot box“



1. Warm side guard box:
   – internal dimensions 2800 × 2800 × 1100 mm;
   – wall thickness 130 mm, total thermal resistance about 3 $m^2 \cdot K/W$.
2. Guard air flows deflecting screen.
3. Electrical heater, power 660 W, controlled according to a set point temperature in metering box (6).
4. Electrical heater of metering box, power control from 13W to 660 W.
5. Warm side baffler (of metering box) with surface and air temperature sensors.
6. Metering box – internal dimensions 2400 × 2400 × 360 mm.
7. Surround panel: 200 mm thick, core material EPS polystyrene (faced with 3 mm thick cellular PVC plastic sheet on either side), thermal resistance about 6 $m^2 \cdot K/W$, 1484 x 1234 mm aperture for specimen mounting.
8. Cold side box:
   – internal dimensions 2800 × 2800 × 1100 mm;
   – wall thickness 130 mm, total thermal resistance about 3 $m^2 \cdot K/W$.
9. Cold side baffler with surface and air temperature sensors.
10. Cold side box controlled
11. Cold side controlled cooling air unit, max. cooling power up to 3 kW.
12. Cold side air cooling box with 5 speed motor fan. electrical heater, max. power 2 kW.