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. 252 SF/22 U

Date: 07 of November 2022

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: ATI PRO
Thickness of product installed in the „Hot box" – 66÷67 mm
Declared thickness of product – 50 mm +/- 15 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, $(m^2 \cdot K)/W$	LST EN ISO 8990:1999 LST EN ISO 16012:2012+A1:2015	**2.60**
Declared corrected *R-core*$_{90/90}$ thermal resistance of product **ATI PRO**, $(m^2 \cdot K)/W$	LST EN ISO 16012:2012+A1:2015	**1.85**
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: 2022-09-15 **Date of testing:** 2022-09-20/ 2022-09-23/2022-10-07/2022-10-19

Sampling: The test specimen sampled by customer.

Additional information: Application 2022-07-19
Used tests reports 164 SF/22 U; 165 SF/22 U; 215 SF/22 U; 216 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)

S.P.

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

ATI PRO-2 according to the test report 164 SF/22 U:

Data element	unit	Value
Air velocity on warm side, downwards, v_i	m/s	0.37
Air velocity on cold side, upwards, v_e	m/s	0.01
Total power input to metering box, Φ_{in}	W	14.689
Heat flow density through a specimen, q_{sp}	W/m^2	3.7042
Corrected heat flow density through a specimen, q_c	W/m2	3.7192
Warm side air temperature, θ_{ci}	°C	20.77
Cold side air temperature, θ_{ce}	°C	9.09
Surface temperature of the warm side, τ_{si}	°C	20.092
Surface temperature of the cold side, τ_{se}	°C	9.754
Temperature difference between surfaces, $\Delta\tau_s$	°C	10.338
Core thermal resistance of specimen, $R_{c,sp}$	m^2·K/W	2.791
Directly measured core thermal resistance of product, $R_{c,m,pr}$	m^2·K/W	2.026
Recalculated according to LST EN 16012:2012+A1:2015 core thermal resistance of product, $R_{c,pr}$	m^2·K/W	2.008
Extended uncertainty of the measurement, ΔR_{sp}	m^2·K/W	± 0.0922

Tested by: A. Burlingis　　　　Date: 2022-09-20

ATI PRO-3 according to the test report 165 SF/22 U:

Data element	unit	Value
Air velocity on warm side, downwards, v_i	m/s	0.29
Air velocity on cold side, upwards, v_e	m/s	0.01
Total power input to metering box, Φ_{in}	W	14.645
Heat flow density through a specimen, q_{sp}	W/m^2	3.6828
Corrected heat flow density through a specimen, q_c	W/m2	3.6977
Warm side air temperature, θ_{ci}	°C	20.81
Cold side air temperature, θ_{ce}	°C	9.07
Surface temperature of the warm side, τ_{si}	°C	20.025
Surface temperature of the cold side, τ_{se}	°C	9.750
Temperature difference between surfaces, $\Delta\tau_s$	°C	10.275
Core thermal resistance of specimen, $R_{c,sp}$	m^2·K/W	2.790
Directly measured core thermal resistance of product, $R_{c,m,pr}$	m^2·K/W	2.026
Recalculated according to LST EN 16012:2012+A1:2015 core thermal resistance of product, $R_{c,pr}$	m^2·K/W	2.007
Extended uncertainty of the measurement, ΔR_{sp}	m^2·K/W	± 0.0049

Tested by: A. Burlingis　　　　Date: 2022-09-23

ATI PRO-4 according to the test report 215 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	14.531
Heat flow density through a specimen, q_{sp}	W/m^2	3.6153
Corrected heat flow density through a specimen, q_c	W/m2	3.6303
Warm side air temperature, θ_{ci}	°C	20.77
Cold side air temperature, θ_{ce}	°C	9.04
Surface temperature of the warm side, τ_{si}	°C	20.053
Surface temperature of the cold side, τ_{se}	°C	9.716
Temperature difference between surfaces, $\Delta\tau_s$	°C	10.337
Core thermal resistance of specimen, $R_{c,sp}$	m^2·K/W	2.847
Directly measured core thermal resistance of product, $R_{c,m,pr}$	m^2·K/W	2.160
Recalculated according to LST EN 16012:2012+A1:2015 core thermal resistance of product, $R_{c,pr}$	m^2·K/W	2.076
Extended uncertainty of the measurement, ΔR_{sp}	m^2·K/W	± 0.0952

Tested by: A. Burlingis Date: 2022-10-07

ATI PRO-5 according to the test report 216 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	14.414
Heat flow density through a specimen, q_{sp}	W/m^2	3.5659
Corrected heat flow density through a specimen, q_c	W/m2	3.5811
Warm side air temperature, θ_{ci}	°C	20.76
Cold side air temperature, θ_{ce}	°C	9.01
Surface temperature of the warm side, τ_{si}	°C	20.134
Surface temperature of the cold side, τ_{se}	°C	9.699
Temperature difference between surfaces, $\Delta\tau_s$	°C	10.435
Core thermal resistance of specimen, $R_{c,sp}$	m^2·K/W	2.926
Directly measured core thermal resistance of product, $R_{c,m,pr}$	m^2·K/W	2.223
Recalculated according to LST EN 16012:2012+A1:2015 core thermal resistance of product, $R_{c,pr}$	m^2·K/W	2.143
Extended uncertainty of the measurement, ΔR_{sp}	m^2·K/W	± 0.0973

Tested by: A. Burlingis Date: 2022-10-19

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

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

Guarded Hot Box measurement. Parameters of "ATI PRO" insulation system's specimen:			
Specimen's area A, m^2	1,831	Actual mean thickness of specimen, mm	**≈ 126***
Position of a specimen	vertical	Length of specimen perimeter L, m	5,44
		Linear thermal transmittance of perimeter zone Ψ_L, W/(m·K)	-0,00049

Measurement data:							
Insulation system with product "ATI 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/m^2	Corrected heat flow density qc, W/m^2	**R-value of insulation system,** m^2·K/W
164/22	20 /10	20,0920	9,7538	10,3383	3,7042	**3,7192**	**2,780±0,0922**
165/22	20 /10	20,0253	9,7503	10,2750	3,6828	**3,6977**	**2,779±0,0927**
215/22	20 /10	20,0530	9,7160	10,3370	3,6153	**3,6303**	**2,847±0,0952**
216/22	20 /10	20,1335	9,6987	10,4348	3,5659	**3,5811**	**2,914±0,0973**
						Average:	**2.83**

* 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.

$$S_{R-sys} = \sqrt{\frac{\sum(R_i - R_{average})^2}{n-1}} = 0.06441;$$

$$R_{90/90-sys} = R_{average} - k_2 \cdot S_{R-sys} = 2.625 = 2.60\ (m^2 \cdot K)/W;$$

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

Table 2. ATI 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/m^2*	*Product's R-core,1 value, m^2·K/W*
ATI PRO-2 – 164/22	66	18,1618	10,6255	7,5363	3,7192	**2,026**
ATI PRO-3 – 165/22	67	18,1125	10,6103	7,5022	3,6977	**2,029**
ATI PRO-4 – 215/22	66	18,2978	10,4550	7,8428	3,6303	**2,160**
ATI PRO-5 – 216/22	67	18,3868	10,4600	7,9268	3,5811	**2,213**
					Average:	**2.107**

Table 3. ATI 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, $m^2 \cdot K/W$
164/22	Air gap #1	30	1.9303	0.4490	1.25	0.5886
	Air gap #2	30	0.8718	4.2210	1.25	0.1828
165/22	Air gap #1	30	1.9128	0.4488	1.25	0.5887
	Air gap #2	30	0.8600	4.2206	1.25	0.1828
215/22	Air gap #1	30	1.7553	0.4493	1.25	0.5885
	Air gap #2	30	0.7390	4.2163	1.25	0.1829
216/22	Air gap #1	30	1.7468	0.4496	1.25	0.5884
	Air gap #2	30	0.7613	4.2161	1.25	0.1829

Table 4. TECH PRO insulation specimen products

Specimen product	*Specimen surface layer*	*Declared emissivity, ε*
ATI PRO	External reflective layer	0.08**
	External black Membrane	0.90**

** Declared by the manufacturer

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

$$R_{core}\,(202/22) = 2.780 - 0.5886 - 0.1828 = 2.008\ (m^2{\cdot}K)/W$$

$$R_{core}\,(165/22) = 2.779 - 0.5887 - 0.1828 = 2.007\ (m^2{\cdot}K)/W$$

$$R_{core}\,(215/22) = 2.847 - 0.5885 - 0.1829 = 2.076\ (m^2{\cdot}K)/W$$

$$R_{core}\,(216/22) = 2.914 - 0.5884 - 0.1829 = 2.142\ (m^2{\cdot}K)/W$$

***Average R-core thermal resistance value: 2.058* (m²·K)/W**

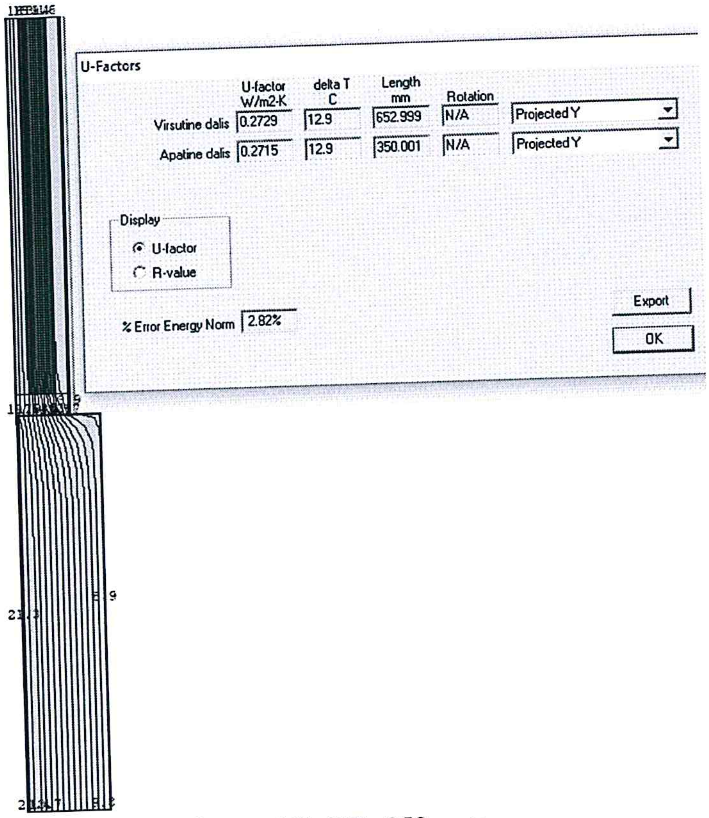
Standard deviation of derived R-value of insulation product:

$$S_{R-prod} = \sqrt{\frac{\sum(R_i - R_{average})^2}{n-1}} = 0.0645;$$

Declared derived R-value of insulation product:

$$R_{90/90-prod} = R_{average} - k_2 \cdot S_{R-prod} = 1.8525 = 1.85\ (m^2 \cdot K)/W;$$

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



Perimeter zone's U-value: 0.2715 W/(m²·K); width "d"– 350 mm;

Central area U-value: 0.2729 W/(m²·K).

Perimeter's linear thermal transmittance: ψ= (0.2715-0.2729)·0.350= **-0.00049** 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.

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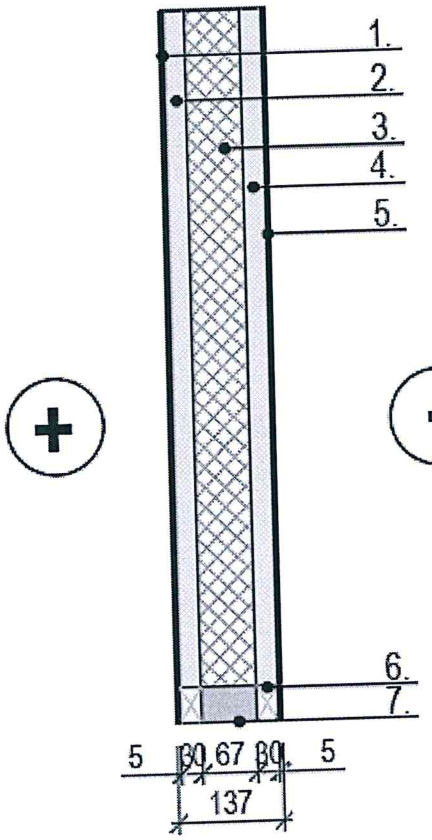
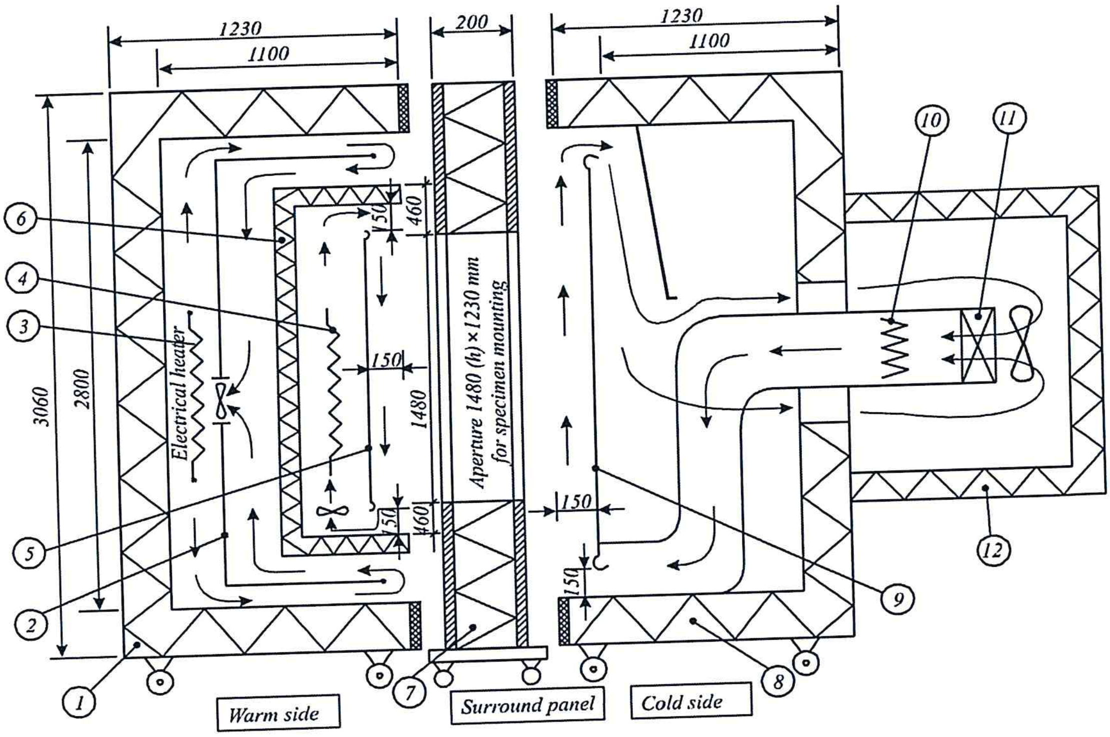
Annex 5. ***Specimen design data***



1.	PVC 5 mm
2.	Air gap 30 mm (#1)
3.	**ATI PRO 66÷67** mm
4.	Air gap 30 mm (#2)
5.	PVC 5 mm
6.	EPS (polystyrene) 30 mm
7.	PUR 65 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 m²·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 m²·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 m²·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.