FREIE UNIVERSITÄT BOZEN
LIBERA UNIVERSITÀ DI BOLZANO
FREE UNIVERSITY OF BOZEN · BOLZANO

Test Report

REPORT CODE: Pr. 2018-12-HB2

CUSTOMER:

IDM Südtirol Alto Adige
Piazza Parrocchia 11
Bolzano 39100
Italy
email: paolo.bertoni@idm-suedtirol.it
Contact person: Mr Paolo Bertoni

Ligna Construct GmbH
Tusengrabl 23
St. Pankraz 39010
Italy
email: info@ligna-construct.com

Free University of Bozen/Bolzano
Faculty of Science and Technology
Building Physics LAB

Lab. C001a
Piazza Università 5
39100 Bolzano

T (+39) 0471 017632
F (+39) 0471 017009

SAMPLE: LW1-02-18

DESCRIPTION: Measurement of thermal conductance of a timber solid wall (ref. große schlitze).

DIMENSIONS AND CONDITIONS OF THE SPECIMEN: 1300 x 1300 x 200 mm, in full compliance with EN 1934

TEST TIMES:

Test Start time:	06-12-2018 15:38
Test End time:	17-12-2018 15:38
Steady State Start time (for calculations):	13-12-2018 15:38
Steady State End time:	17-12-2018 15:38
Time to reach Steady State:	168 Hours
Steady State measurement time:	96 Hours

Sampling rate: 60 s

Lab. Directors: prof. Andrea Gasparella, Ph.D.
prof. Marco Baratieri, Ph.D.

Scientific collaborators: eng. Giovanni Pernigotto, Ph.D.
eng. Maja Danovska
Mr Christian Platzgummer

Test Report

STANDARD: The test, the raw data analysis and the data validation are performed according to the rules of the international reference standards:

UNI EN 1934:2000

UNI EN 1946-3:1999

ASTM C518:2004

UNI CEI ENV 13005:2000

TEST METHOD: Hot box method using heat flow meter

EQUIPMENT: Heat flow meter in full compliance with EN 1934

Type-T thermocouples with a Pt100 reference joint

Hot box apparatus according to EN 1934

Additional RTD Pt100 for Hot Box temperature collection

Additional Capacitive hygrometer for Hot Box RH recording

Supplementary heat flow meter for imbalance heat flow rate verification

The above instruments meet or exceed all specifications as stated in the referenced procedure (unless otherwise noted). The heat flux meter has been calibrated and meets the requirements of standards.

CALIBRATION:

the latest calibration of heat flow meter was in May 2017

the latest calibration of temperature sensors was in May 2017

Annex	
Equipment description	Annex A
Specimen description	Annex B
Measurement points	Annex C
Measurement trends	Annex D2

Free University of Bozen/Bolzano
Faculty of Science and Technology
Building Physics LAB

Lab. C001a
Piazza Università 5
39100 Bolzano

T (+39) 0471 017632
F (+39) 0471 017009

Test Report

Free University of Bozen/Bolzano
Faculty of Science and Technology
Building Physics LAB

Lab. C001a
Piazza Università 5
39100 Bolzano

T (+39) 0471 017632
F (+39) 0471 017009

Quantity	Side	Value		Expanded Uncertainty (1)
Air Velocity	Hot Ch	5	m/s	± 0.1 m/s (2)
Air Temperature	Hot Ch	19.1	°C	± 0.3 °C
Air Relative Humidity	Hot Ch	27.7	%	± 2.0 % (2)
Air Velocity	Cold Ch	5	m/s	± 0.1 m/s (2)
Air Temperature	Cold Ch	-10.5	°C	± 0.2 °C
Air Relative Humidity	Cold Ch	41.2	%	± 2.0 % (2)
Specimen Mean Temperature	-	4.8	°C	± 0.2 °C
Metering Area average values				
Surface average Temperature	Hot Ch	18.1	°C	± 0.1 °C
Surface average Temperature	Cold Ch	-8.5	°C	± 0.2 °C
Heat flow density	-	9.31	W m^{-2}	± 0.6 W m^{-2}
Results				
Thermal Resistance		**2.847**	m^{-2} K^{-1} W	± 0.187 m^{-2} K^{-1} W
Thermal Conductance		0.351	W m^{-2} K^{-1}	± 0.023 W m^{-2} K^{-1}
Equivalent thermal conductivity		0.070	W m^{-1} K^{-1}	
Transmittance according to EN 6946		**0.331**	W m^{-2} K^{-1}	± 0.023 W m^{-2} K^{-1}

(1) **Coverage factor k = 2 (i.e., confidence level of 95 %)**
(2) Simple measurement error

The results obtained are tested values. This report is not an endorsement about the tested products and does not constitute a certification of the products tested.

Bolzano 31/12/2018

Test Report

Free University of Bozen/Bolzano
Faculty of Science and Technology
Building Physics LAB

Lab. C001a
Piazza Università 5
39100 Bolzano

T (+39) 0471 017632
F (+39) 0471 017009

ATTACHMENT A

DESCRIPTION OF THE EXPERIMENTAL SETUP

PRINCIPLE OF OPERATION

The hotbox setup with heat flux meter simulates, in steady state regime, the boundary conditions for a specimen arranged between two environments kept at homogeneous and constant temperatures. The heat is transmitted through the specimen and exchanged on its surfaces by convection and radiation. The magnitudes of these fluxes depend, respectively, on temperature and velocity of the air in the two chambers and on surface temperature and emissivity of the specimen and the hotbox elements.

DETERMINATION OF THE HEAT FLUX

A heat flux meter is installed on the hot side of the specimen in order to measure the heat flux $\boldsymbol{q}$ transmitted through the tested wall. The heat flux must be sufficiently homogeneous on the monitored area $\boldsymbol{A}$ at the center of the hot side of the specimen, where the heat flux meter is installed.

GUARD AREA

The surface of the specimen surrounding the monitored area is named "guard area": in order to ensure a homogeneous heat flux on the monitored area, the temperature of the guard area is kept as close as possible to the temperature of the monitored one, since this helps in limiting the lateral heat fluxes.

Test Report

Free University of Bozen/Bolzano
Faculty of Science and Technology
Building Physics LAB

Lab. C001a
Piazza Università 5
39100 Bolzano

T (+39) 0471 017632
F (+39) 0471 017009

CHARACTERISTICS OF THE TWO CHAMBERS

Each chamber of the hotbox setup is composed by:

- an envelope insulated with 10 cm of polyurethane, covered by an aluminum sheet and sealed in order to prevent air leakages;
- an evaporator and an electrical heater, respectively for air cooling and heating;
- a black screen parallel to the surface of the specimen, preventing uncontrolled heat exchanged by radiation between the surface of the specimen and the other elements of the chamber. The screen is used also to channel an air stream – moved by a circular fan, tangentially to the specimen's surface.

The control system works in the same way for both chambers. Inside each chamber a PT-100, i.e., a platinum thermal resistance of 100 Ω, is installed as main temperature probe. The measured signal is sent to a programmable logic controller, PLC, which commands the different subsystems, such as the evaporators and the electrical resistances. The control system is based on a closed-loop negative feedback and, specifically, on a PID control (i.e., proportional, integrative and derivative control). The PLC acquires the measurements from the various probes and compares with the reference setpoints. The found differences, i.e., the errors, are used to calculate the value of the output variables μ to control the subsystems ($\mu = \mu_1 \cdot P + \mu_2 \cdot I + \mu_3 \cdot D$), i.e., the absorbed power. In steady state conditions, the temperature is kept within ± 0.1°C.

Test Report

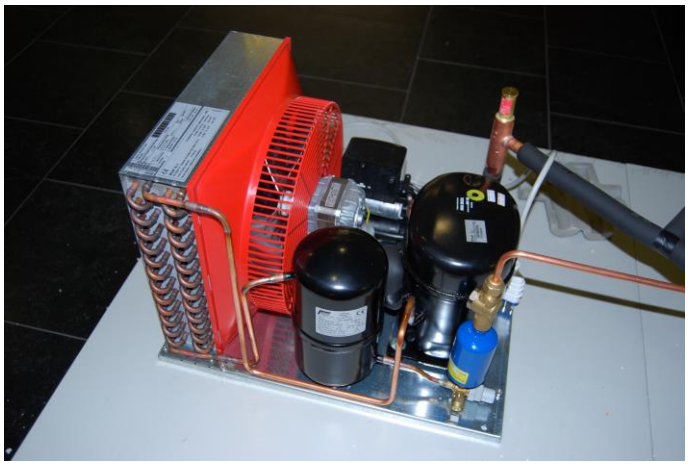
Free University of Bozen/Bolzano
Faculty of Science and Technology
Building Physics LAB

Lab. C001a
Piazza Università 5
39100 Bolzano

T (+39) 0471 017632
F (+39) 0471 017009

TEST CONDITIONS

As indicated by the technical standard UNI EN 1934:2000, the test conditions must be chosen according to the kind of specimen and its application. According to the suggestions of the technical standard, setpoints around -10 °C in the cold chamber and +20 °C in the hot one are chosen, leading to testing average temperatures between 0 and 20 °C and a temperature difference between the two chambers of about 30 °C. The duration of the test depends on the characteristics of the specimen, as well as on initial and chosen boundary conditions, which can affect the length of the transient period.



Test Report

Free University of Bozen/Bolzano
Faculty of Science and Technology
Building Physics LAB

Lab. C001a
Piazza Università 5
39100 Bolzano

T (+39) 0471 017632
F (+39) 0471 017009

Test Report

Free University of Bozen/Bolzano
Faculty of Science and Technology
Building Physics LAB

Lab. C001a
Piazza Università 5
39100 Bolzano

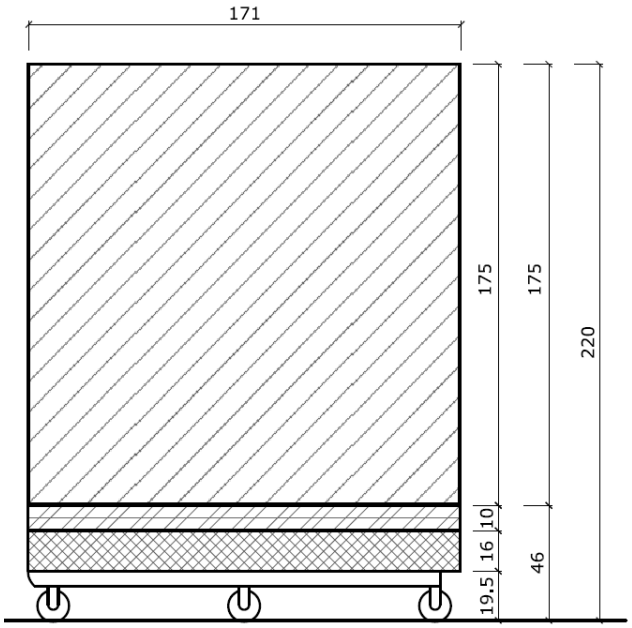
T (+39) 0471 017632
F (+39) 0471 017009

ATTACHMENT B

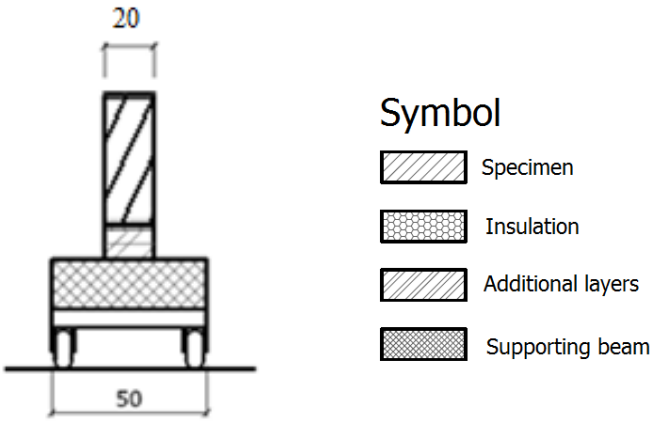
DESCRIPTION OF THE SPECIMEN

The following sketch (scale 1:20) reports the sizes of the tested specimen, whose thickness is 20 cm.

LONGITUDINAL SECTION



CROSS SECTION



Test Report

Free University of Bozen/Bolzano
Faculty of Science and Technology
Building Physics LAB

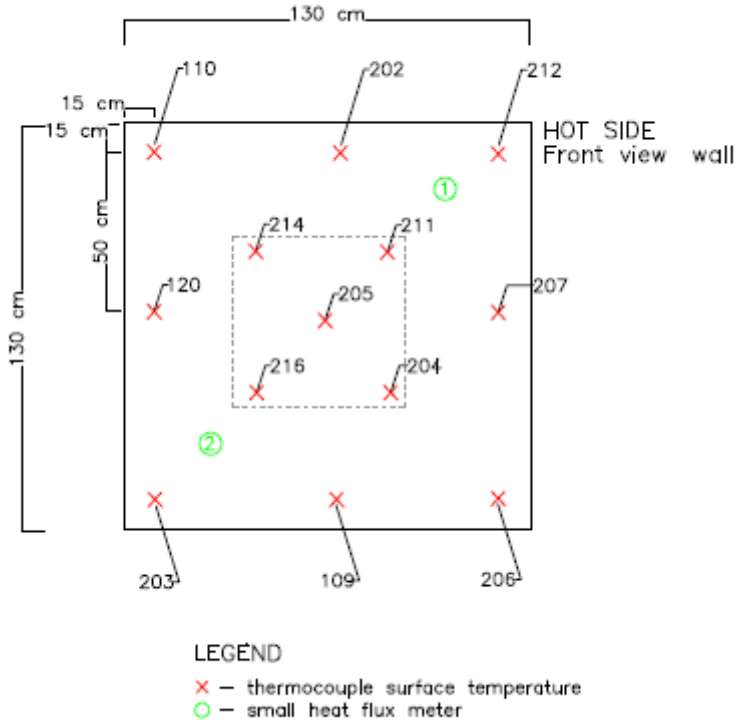
Lab. C001a
Piazza Università 5
39100 Bolzano

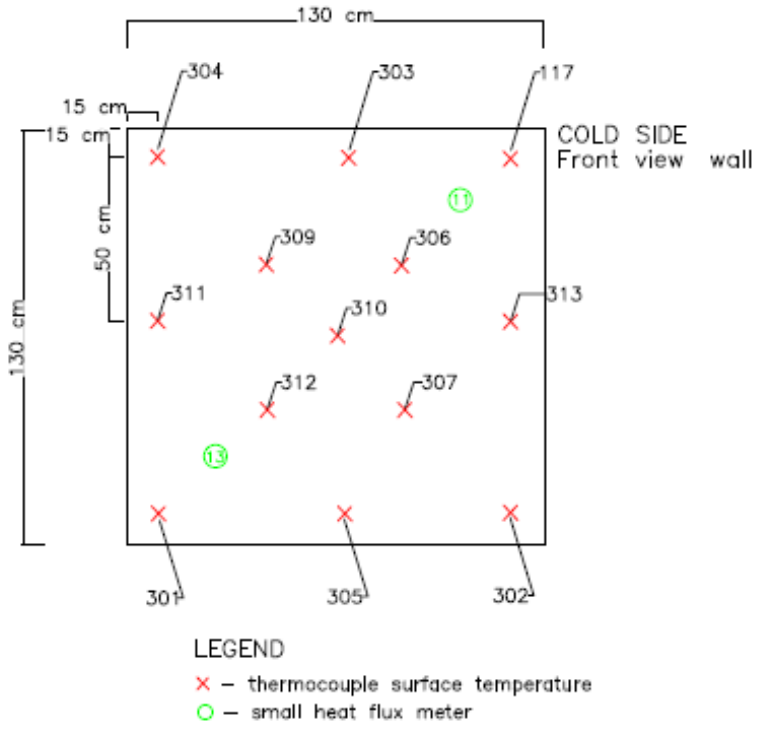
T (+39) 0471 017632
F (+39) 0471 017009

ATTACHMENT C

SCHEME OF THE MEASUREMENT POINTS

In the following sketches, the positions of the different measurement points are represented for both sides of the specimen: the dots indicate the different type T thermocouples while the rectangular area in the hot chamber side is the heat flux meter, i.e., a thermopile made of 250 type T thermocouples of area of 50 x 50 cm. This scheme has been studied in order to ensure an overall monitoring of the specimen's surfaces, with a higher sensitivity in the monitoring area and controls about the lateral heat fluxes on the guard area.



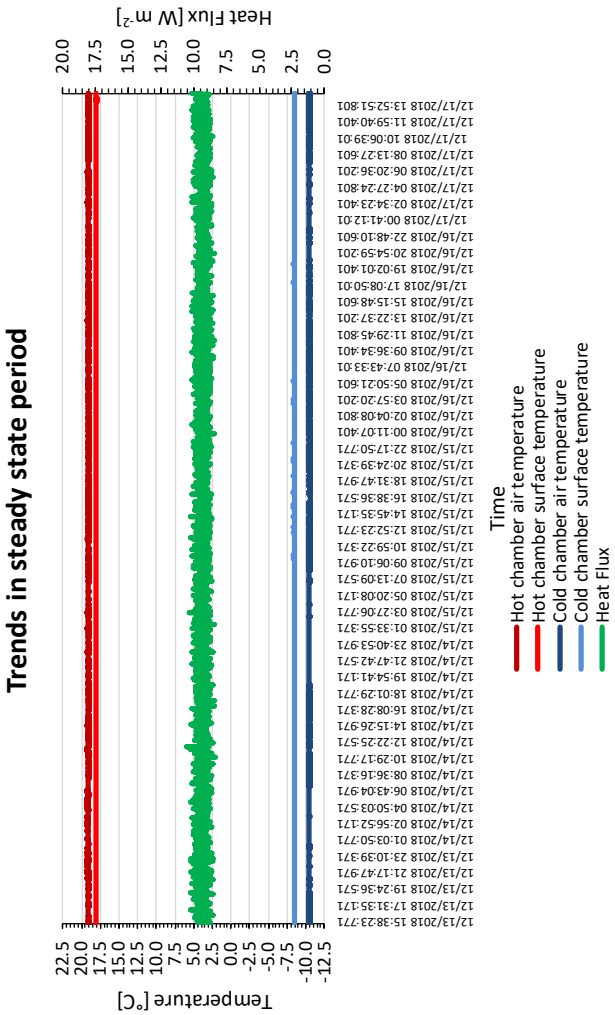

130 cm
304
303
117
15 cm
15 cm
COLD SIDE
Front view wall
50 cm
309
306
311
310
313
130 cm
312
307
301
305
302
LEGEND
× – thermocouple surface temperature
○ – small heat flux meter

Test Report

ATTACHMENT D

MEASUREMENTS TRENDS

In the following graph, the recordings of air temperature in the two chambers, surface temperature at the two sides of the specimen and heat flux are represented. The data are referred to the steady state period (i.e., from 13-12-2018 15:38 until 17-12-2018 15:38).



Free University of Bozen/Bolzano
Faculty of Science and Technology
Building Physics LAB

Lab. C001a
Piazza Università 5
39100 Bolzano

T (+39) 0471 017632
F (+39) 0471 017009