EURAC research

INTENT

INtegrated Energy walls — Test facility

Description of the INTENT laboratory

INTENT is a laboratory that can evaluate, either in dynamic or static mode, the thermal and energy performance of traditional building components (e.g. walls, windows and doors) and of innovative building envelope systems, such as walls and floors that integrate active solar systems for energy production or radiant circuits.

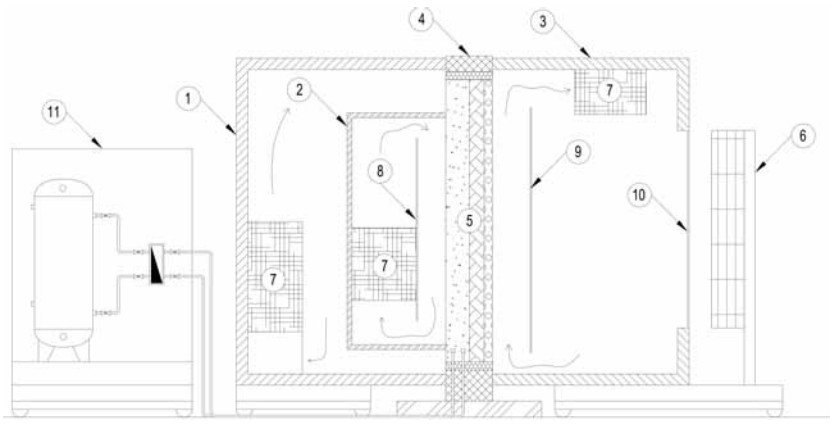
The laboratory consists of:

- a double chamber with a guard-ring (the Guarded Hot-Box) built in accordance with standards UNI EN ISO 8990 and UNI EN ISO 12567-1;
- a solar simulator with lamps that emulate solar radiation;
- an external hydraulic circuit for evaluating the energy performance of hydraulic systems integrated in building components;
- a detailed monitoring system of sensors and data acquisition instruments that measure significant physical parameters with the aim of determining the characteristics of the test sample.

Test sample equipped with measurement sensors

When conducting the tests, the specimen is inserted into a frame (Fig.1, no.4) located between the two climate chambers that simulate interior air conditions (a hot box consisting of a guard box (no.1) and a measurement box (no.2)) and exterior air conditions (cold box, no.3) by controlling the temperature, humidity and air velocity. The solar simulator (no.6) reproduces the irradiation conditions on the external surface of the test sample while the hydraulic circuit controls any active hydraulic systems integrated in the sample. The laboratory tests standard elements in accordance with the requirements of standard UNI EN ISO 8990.

The aperture in the panel at the bottom of the cold-box and the solar lamps permit the evaluation of the energy performance and thermal properties of active envelope elements with solar systems, in both static and dynamic modes. The hydraulic circuit can be used to calculate the heat absorbed by the active element as well as the heat removed or delivered throughout systems embedded in the construction element. For testing activated building systems (radiant wall/ceiling/floor systems), connection to the hydraulic circuit and local measurement of heat flows allow the evaluation of the static and dynamic yield performances of the element.



Legend

01. Guarded hot-box
02. Measurement hot-box
03. Cold-box
04. Frame
05. Test sample
06. Solar simulator
07. Air conditioning units
08. Opaque panel for regulating air flow
09. Transparent panel for regulating air flow
10. Glazed opening
11. Hydraulic circuit

Fig. 1: Cross-section of test bench

Technical specifications for INTENT test bench

Guarded hot box

	Dimensions [m]			Temperature [°C] *		Humidity [%] **	Air velocity [m/s] ***	
	Height	Width	Depth	Min.	Max.	Interval	Min.	Max.
Guarded hot box	3.22	3.12	2.10	18.0	40.0	RH <15%	---	---
Measurement hot box	2.42	1.92	1.00	18.0	40.0	RH <15%	0.1	0.3
Cold box	3.22	3.12	2.10	-20.0	40.0	40% <RH<80%	0.1	10.0
Regulator	3.22	3.12	0.50	---	---	---	---	---

NOTES:
* The temperature is continuously controlled and can vary with a maximum gradient of 0.2°C per minute. The measurement box is equipped only with an heating device. The guarded box and the cold box have air conditioning systems for both heating and cooling.
** The relative humidity in the hot boxes (guarded and measurement) can be maintained under 15% as prescribed in the reference standards, while in the cold box it can be controlled as specified in the table if the temperature is between 20°C and 40°C.
*** The air velocity can either be mechanically regulated by varying the dimensions of the channels in which the air is conveyed or automatically by regulating the speed of the installed fans.

Solar simulator *

Irradiation power [W/m²]	Spectral conformity	Spatial uniformity [%]	Temporal instability [%]
Interval **	Class (IEC 904-9)	Class (IEC 904-9)	Class (IEC 904-9)
350 <Irr<1100	B	B <5%	B <5%

NOTES:
* Data in the table relate to a maximum irradiated surface of 1.5m (width) x 2.0m (height). Increasing the irradiated surface reduces accuracy in comparison to spatial uniformity.
** The power of the solar radiation on the surface of the test sample can be continuously controlled in the specified interval.

Hydraulic circuit *

Flow rate [l/h]		Discharge temperature [°C]	
Min.	Max.	Min.	Max.
30	600	15	95

NOTES:
* The hydraulic circuit can maintain constant inlet temperature and flow rate as specified and can be used to measure the thermal power exchange between the inlet and outlet flows[W]. In addition pressure losses can also be measured.

Measurement sensors

Value measured	Sensor type	Number of sensors available	Unit of measure
Temperature	Surface thermocouples (Type T)	~70	°C
	Air thermocouples (Type T)	~40	°C
	PT100	~10	°C
Relative humidity	Relative humidity probe 4%	4	%
Air velocity	Hot-wire anemometer	3	m/s
Heat flow	Heat flow measuring plate	2 (50x50 cm) + 1 (10x10cm)	W/m²
Irradiation	Pyranometer	1	W/m²
Water flow	Ultrasound flow meter	1	l/h
Pressure difference	Differential barometer	1	Pa
Electrical power	Electrical consumption meter	~5	W

Portable measurement sensors that can be used in the laboratory and on site *

Value measured	Type of sensor	Number of sensors available	Unit of measurement
Heat transmittance	Heat flow measuring plate and	1	W/m^2
	surface thermocouple	2	°C
Heat radiation	Thermographic camera	1	°C
Illumination	Lux meter	2	lux
Blower door fan	Air flow rate	1	m^3/s
Air velocity	Hot-wire anemometer	1	m/s

NOTES:
* In addition to the instrumentation integrated into the fixed experimental station, the laboratory also has portable measuring instruments that can be used for measurements such as: heat transmittance of walls (U-value), illumination and calculation of the daylight factor, blower door test, air velocity.

What can be measured using INTENT

Heat transmittance – U [W/(m²K)] of both opaque and transparent elements
- Instruments used: instrumented guarded hot box
- Minimum test duration: approx. 48 hours

Dynamic properties of passive envelope elements (e.g. time constant [s], time lag [s], etc.)
(no reference standards)
- Instruments used: instrumented guarded hot box + heat flow measuring plates
- Minimum test duration: approx. 72 hours

Dynamic behaviour of active envelope elements
(systems with frame activation, radiant floors/ceilings, etc.)
- Instruments used: instrumented guarded hot box + heat flow measuring plates + solar simulator + hydraulic circuit
- Minimum test duration: approx. 72 hours

Performances of active envelope elements with solar installations (photovoltaic panels and solar thermal collectors)
- Instruments used: instrumented guarded hot box + heat flow measuring plates + solar simulator + hydraulic circuit
- Minimum test duration: approx. 72 hours

Measurements still under development
- Solar factor of transparent elements integrating shading devices (g-value)
- Thermal and energy performances of envelope elements integrating ventilation systems

Testing process

	Activities	Responsibility
Standard procedure	1. Define objectives and methods: a. What to measure? E.g. heat transmittance, energy yield, dynamic performances, etc. b. How to measure? Standards to be met, e.g. ISO 12567, definition of new procedures, etc.	Client and EURAC
	2. Design of test sample	Client and EURAC
	3. Production of test sample	Client
	4. Installation of test sample in laboratory	Client and EURAC
	5. Instrumentation of test sample	EURAC
	6. Conducting of test	EURAC
	7. Report of test results	EURAC
On request	*8. on request: provision of indications/nomograms for dimensioning and use of the element tested (for design and commissioning)*	EURAC
	For all phases from 1-7 it is possible to request numerical modelling of the sample tested: finite elements model (FEM) or concentrated parameters model (dynamic simulation software)	EURAC

Open guarded hot box with solar simulator

Numerical support for measurement
In parallel with the laboratory tests, heat transfer and fluid dynamic analyses throughout numerical models are offered for simulating the behaviour of samples . Two types of model are currently used: the finite element model (FEM) or the concentrated parameters model. The definition of the numerical model and its validation with the measurements in the laboratory offer a very useful tool:

- the optimisation of the component energy performance: instead of producing several prototypes, numerical models allow the evaluation of prototype changes of any type (e.g. geometry, materials used, etc.) in terms of the parameters to be optimised;
- the evaluation of the behaviour of the element when integrated into a more complex structure: as an example, the model of the tested element can be inserted into a larger model that simulates the behaviour of an entire building and calculates the overall building thermal and energy performance indexes.

Potential users of the test bench
INTENT is a laboratory conceived and designed for measuring the energy performances of traditional building components, both opaque (walls, etc.) and transparent (windows, etc.) and, above all, for the development of multifunctional envelope systems that integrate active elements (mass activation, solar thermal panels, photovoltaic modules, etc.). INTENT can therefore supply a measuring and verification service concerning building systems for companies that wish to test the thermal performance of their products in compliance with standards (e.g. wall panel prefabricators - > measuring panel transmittance; window fitters- > measuring frame transmittance, etc.). Moreover, INTENT offers the services needed for developing innovative products (from idea to design, prototyping, measurement and evaluation of energy performances and their optimisation).
Research activities are currently concentrated on envelope systems that can contribute to reduce the building energy demand and to optimise the energy production and storage. Envelope passive components (insulation, coverings and shading systems) can be integrated with active components (such as solar heat collectors, photovoltaic panels, etc.). Nowadays, trends in the construction sector include the development of new materials (PCM, VIP, thin and dynamic insulation, etc), new technologies (ventilation and energy production systems for integration in facades) and multifunctional envelope components. The heat and energy evaluation of these components by the INTENT laboratory has a fundamental role in verifying performances, functionality, quality and competitiveness of products that are to be placed on the market.

Related activities
The INTENT laboratory has been designed as part of a wider network of experimental labs able to meet numerous requirements and demands. As an example, for the evaluation of energy systems for the planning and realisation of Net Zero Energy Buildings, the laboratory interacts with other EURAC laboratories: COSMO (test bench for testing the energy performances of heat pumps and absorption machines) and SoLaRE-PV (laboratory for testing the performances and durability of photovoltaic panels). The laboratory tests are also compared with measurements under operational conditions by means of instrument monitoring. The integrated methodological approach permits the technological development of products from their construction and the evaluation of their performances both numerically and by means of instrumental analysis, in both controlled and actual working conditions.

The **EURAC Institute for Renewable Energy** conducts applied research in the fields of solar energy and building energy management. These activities include research projects at national and international level and direct collaborative ventures with industrial partners, leading in many cases to the development of innovative products and the evaluation of technological and construction solutions. The Institute also offers support in the development of complex energy systems such as Net Zero Energy Buildings. The scientific results are based on the experimental activities carried out in the laboratory and in operational conditions through the monitoring of buildings and systems that use solar energy. Dynamic simulation instruments are also widely employed.

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