Thermal insulation – Building elements In-situ measurement of thermal resistance and thermal transmittance: Summary of ISO 9869-1 (2014)

Background

The ISO (International Organization for Standardization) Norm 9869 was published in 1967 and got revised and extended in 2014. The norm contains standardized guidelines to determine a reliable and generally accepted U-Value based on the heat-flux method. The main points of the ISO Norm are summarized in the following. The focus will be on chapter 4 "Apparatus", Chapter 5 "Calibration procedure", Chapter 6 "Measurements", Chapter 7 "Analysis of data", Chapter 9 "Accuracy" and Chapter 10 "Test report". For more detailed information and additional insights, the ISO Norm 9869 should be consulted directly.

About 4. Apparatus

The device has to consist of at least one heat flow meter (HFM) and two temperature sensors (inside and outside). HFMs should be thin, with a low thermal resistance. Additionally, the HFM should be surrounded by heat conductive material to minimize disruptive factors. Suitable surface temperature sensors are thin thermocouples and flat resistance thermometers. These sensors must be suitable for the measurement circumstances and if necessary shielded against external influences such as solar radiation.

About 5. Calibration procedure

The calibration factor of a new type of heat flow meter shall be evaluated on various materials through an absolute test method. greenTEG calibrates their heat flux sensors in a measurement setup using NIST traceable thermal reference materials. The surface and air temperature sensors are calibrated for several temperatures in the relevant range (generally between -10°C to 50°C). greenTEG's Temperature sensors are factory calibrated. Where direct readout equipment is provided, adequate provision shall be made for calibration of this equipment.

About 6. Measurements

Sensors shall be mounted in such a way that it ensures a result, which is representative for the whole element. The HFM shall be mounted in the inside of the building and the temperature sensors has to be located in immediate surroundings inside and outside. The outer surface of the element should be protected from rain, snow, solar radiation, thermal heat or ventilation. To record accurate results the minimum test duration is 72 hours (3 days) if the temperature is stable. Otherwise, the duration should be extended up to 7 days. The data acquisition process should not be interrupted. To get a detailed analysis of the data at least two data logs should be done per hour.

About 7. Analysis of the Data

With the average method the average heat flux is divided by the average temperature difference.

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Formula:

$$U = \frac{\sum_{j=1}^{n} q_j}{\sum_{j=1}^{n} (T_{ij} - T_{ej})}$$

U= Thermal transmission coefficient
q= Density of heat flow rate
T_i= Inside temperature
T_e= Outside temperature

For elements with low heat capacity (< 20kJ/[m^2], e.g. window) it is recommended that the analysis is carried out only on data acquired at night. Measurements should be started one hour after sunset and finished before sunrise. The test may be stopped when the results after three subsequent nights do not differ by more than ± 5 %. Otherwise, it shall be continued.
For elements with high heat capacity (> 20kJ/[m^2], e.g. wall structures) the analysis shall be carried out over a period which is an integer multiple of 24 hours and at least 72 hours. The test shall be ended when the U-value obtained at the end of the test, does not deviate by more than ± 5 % from the value obtained 24 hours before. Moreover, the R-value (adapted from the U-value[1]) obtained during the first 2/3 of the analysis period should not deviate more than 5% from the value obtained during the last 2/3 of the analysis period. In the case that one or more of those criteria are not fulfilled, the measurement should be continued or restarted.

About 9. Accuracy
Variations, which can be caused by calibration deviation, slight differences in the thermal contact between the sensors and the surface or temperature variations within the space and differences between air and radiant temperatures, can be about 5%. The variation caused by the additional heat resistance of the sensor can be about 2 % - 3 %. Additional errors can be caused by the variations over time of the temperatures and heat flow. Consequently, the measured U-value may deviate by a maximum of 14% from the actual U-value (after taking into account all possible sources of errors).

About 10. Test report
The test report must contain data on the element which was measured, data on the measurements itself and data on the method of analysis.
The data regarding the measured element must contain information about location, purpose of the test, thickness and type of material. Furthermore, the data on the measurements must include date and time of the beginning and end of the measurement, the interval between records and the temperature measured. Furthermore, the report must contain graphs of the recorded data.

Final note
The paragraphs, which are not mentioned, are not particularly relevant for the execution and were thus not included in the summary. If there is an interest in the additional information, it can be reviewed in the ISO itself.
For further questions do not hesitate to contact us at info@greenteg.com.

[1] For further guidance please refer to the instruction manual or the readme of our software.