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Glass in building — Determination of steady-state U values (thermal transmittance) of multiple glazing — Heat flow meter method

Verre dans la construction — Détermination du coefficient de transmission thermique, U, en régime stationnaire des vitrages multiples — Méthode du fluxmètre

Reference number
ISO 10293:1997(E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 10293 was prepared by Technical Committee ISO/TC 160, *Glass in building*, Subcommittee SC 2, *Use considerations*.

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Glass in building — Determination of steady-state U values (thermal transmittance) of multiple glazing — Heat flow meter method

1 Scope

This International Standard specifies a measuring method used to determine the U value (thermal transmittance) of multiple glazing with flat and parallel surfaces. Structured surfaces, e.g. patterned glass, may be considered to be flat.

This International Standard applies to multiple glazing with outer panes which are not transparent to far-infrared radiation which is the case for normal glass. However, internal elements may be far-infrared transparent.

This International Standard allows the U value in the central area of the multiple glazing to be determined. Edge effects, due to the thermal bridge through the spacer of a sealed glazing unit or through the frame are not included. Furthermore, energy transfer due to solar radiation is not taken into account.

The determination of the U value is performed for conditions which will correspond to the average situation for glazing in practice. In this way a fair comparison between different products is possible.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 8301:1991, *Thermal insulation — Determination of steady-state thermal resistance and related properties — Heat flow meter apparatus.*

ISO 8302:1991, *Thermal insulation — Determination of steady-state thermal resistance and related properties — Guarded hot plate apparatus.*

ISO 10292:1994, *Glass in building — Calculation of steady-state U values (thermal transmittance) of multiple glazing.*

3 Basic equations and units

The U value of glazing characterizes the heat transfer through the central part of the glazing, i.e. without edge effects, and defines the steady-state density of heat transfer per unit of time, per surface area and per temperature difference between the ambient temperatures on each side. The U value is given in watts per square metre kelvin [W/(m^2·K)].

The U value depends on the thermal resistance of multiple glazing and the external and internal surface heat transfer coefficients according to the relation:

$$\frac{1}{U} = R + \frac{1}{h_e} + \frac{1}{h_i} \qquad \ldots (1)$$

where

R is the thermal resistance of multiple glazing, in square metres kelvin per watt [(m^2·K/W)];

h_e is the external surface heat transfer coefficient, in watts per square metre kelvin [W/(m^2·K)];

h_i is the internal surface heat transfer coefficient, in watts per square metre kelvin [W/(m^2·K)].

In accordance with this International Standard, the thermal resistance of multiple glazing is measured using the heat flow meter method. The U value is then derived from equation (1).

4 Brief outline of the measuring method

The thermal resistance of the multiple glazing is determined by means of the heat flow meter method laid down in ISO 8301, the detailed recommendations of which shall be complied with.

Within this context further requirements are necessary. The sizes of the test specimens and the performance of the measurements are laid down to meet special requirements for measuring multiple glazings (see clauses 5, 6, 7, 8 and 9).

5 Test apparatus

The single-specimen apparatus with symmetrical configuration or a double apparatus as shown in figure 1 shall be used for the measurement of the thermal resistance of the specimen.

The single-specimen apparatus consists of a heating unit and a cooling unit between which the specimen or a reference sample for the calibration of the apparatus is sandwiched. The cooling unit shall have surface dimensions as large as those of the heating unit.

A heat flow meter is positioned in the centre of the hot plate surface and the cold plate surface. These heat flow meters face each other on either side of the specimen or the reference sample. A thin natural or synthetic foam rubber sheet is placed on each side of both heat flow meters to ensure sufficient thermal contact. Surface contact is obtained by applying pressure. The foam rubber sheets shall have the same surface area as the heating unit.

The double apparatus consists of heating unit and two outer cooling units. The heating unit is sandwiched between the specimen and a control sample. For calibration, a reference sample shall be introduced at the position of the specimen. Heat flow meters are placed on each side of the reference sample/specimen and the control sample. A thin foam rubber sheet is placed on each side of each heat flow meter to ensure sufficient thermal contact. The surface dimensions of all elements and the positioning of the heat flow meters in the central area of the assembly are the same as for the single-specimen apparatus.

Dimensions in millimetres

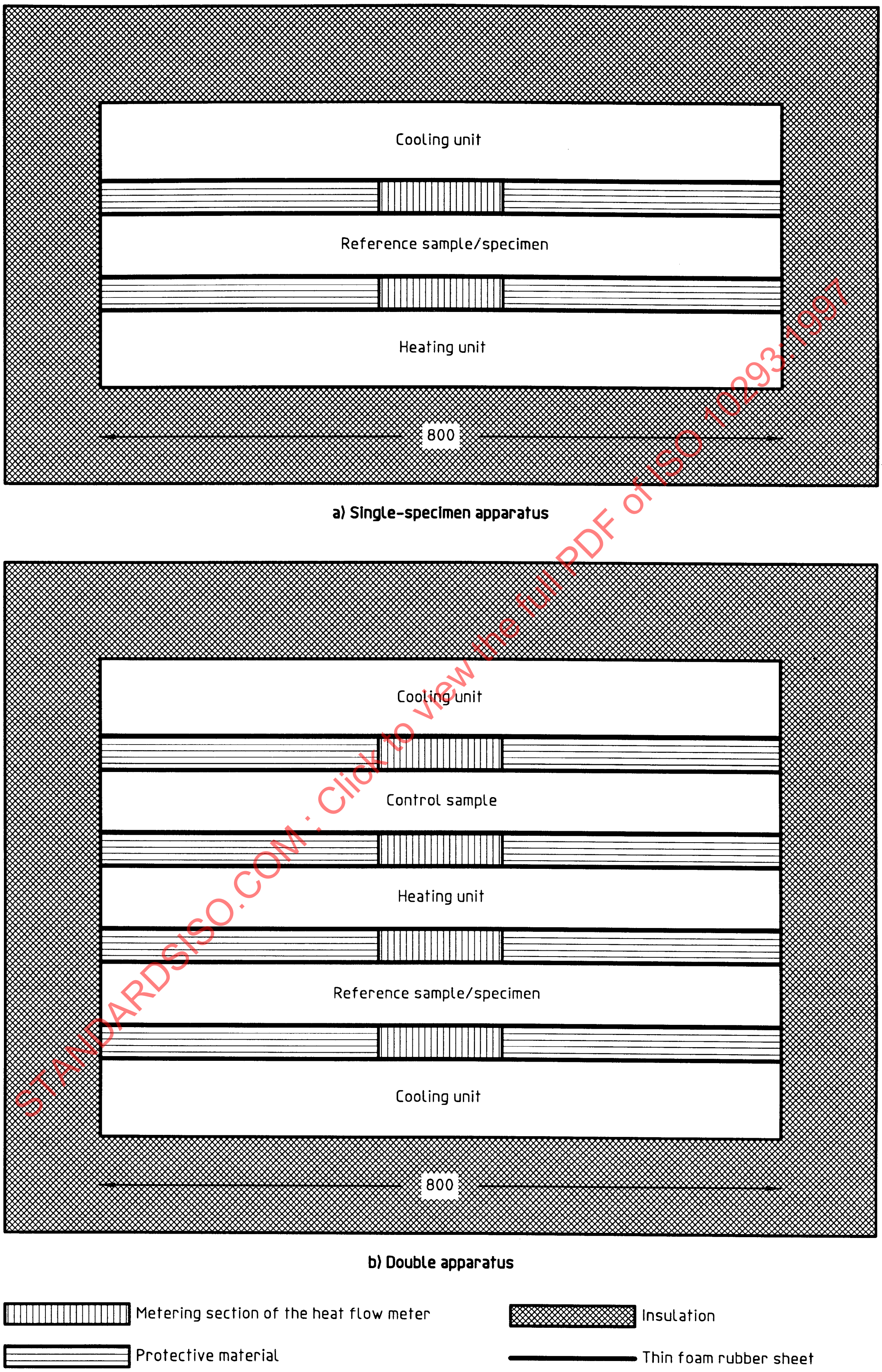

Figure 1 — Configuration of test apparatus

The heating unit, for both types of apparatus, shall be of such a size as to completely cover the surface of the reference sample/specimen and, in the case of the double apparatus, of the control sample. Heat losses from the outer edges of the heat flow meter shall be restricted by edge insulation or by controlling the surrounding air temperature or by both.

The metering section of the heat flow meters, for both types of apparatus, shall have a minimum surface area of 75 cm^2 and shall be circular or square. The maximum surface area of the metering section shall lie within an area of 50 cm × 50 cm. The metering section shall be surrounded by protective material, consisting of the same core material of the same thickness (with a tolerance of ± 0,1 mm), which covers the whole surface area of the sample (figure 1).

Thermocouples shall be mounted in pairs so that they are positioned to face each other and shall have direct contact with the surfaces of the reference sample/specimen and, in the case of the double apparatus, the control sample.

At least three thermocouple pairs shall be used. One pair shall be positioned in the centre of the metering section of the heat flow meters. The two other pairs shall be positioned diametrically opposite at a distance from the centre equal to 2/3 of the distance from the centre of the metering section to its perimeter. Additional pairs of thermocouples may be arranged in such a way that an optimum cover of the metering area is achieved.

6 Calibration of the test apparatus

The heat flow meter method is a relative measuring method since the ratio of the thermal resistance of the specimen to that of a reference sample is evaluated. The thermal resistance of the reference sample must be determined separately in accordance with ISO 8302 using the guarded hot plate apparatus. The reference sample shall consist of a homogeneous, non hygroscopic material and shall have flat parallel surfaces and a heat resistance comparable to that of the specimen to be measured.

The density of heat flow rate transferred through the heat flow meter is computed from the potential difference generated and the mean temperature of the heat flow meter metering section according to the equation

$$q = (C_1 + C_2 T_m) V \quad \ldots (2)$$

where

q is the density of heat flow rate, in watts per square metre;

C_1 is a constant, in watts per square metre volt;

C_2 is a constant, in watts per square metre volt kelvin;

T_m is the mean temperature of the heat flow metering section, in kelvins;

V is the potential difference, in volts.

The constants C1 and C2 of the heat flow meter shall be determined by calibration using a reference sample.

If measurements are performed with the single-specimen apparatus, calibrate both the single-specimen apparatus and the guarded hot plate apparatus, by measuring the reference sample, with appropriate regularity.

If measurements are performed using the double apparatus, the control sample is used to obtain an immediate control whenever a general calibration shift of the apparatus occurs.

7 Specimen dimensions

The specimens shall be square and preferably be 800 mm × 800 mm. The maximum range is from 750 mm × 750 mm to 850 mm × 850 mm.

Sizes down to 450 mm × 450 mm may be used if it can be shown that no significant convection occurs in the gas space(s) and that the errors occurring are not greater than those allowed for the 800 mm × 800 mm arrangement. For example, possible errors due to lateral heat flow through the glass of the specimen must be carefully controlled.

For specimen sizes less than 800 mm × 800 mm the maximum allowed metering section of the heat flow meter (see clause 5) shall be chosen such that on all sides there is an edge width of at least 100 mm that is not covered by the metering section.

The surface of the specimens must be flat and parallel.

8 Preparation of specimens

The sum of bowing or dishing of the outer panes in the central area of the specimens shall not exceed 0,5 mm. The check of bowing or dishing effects shall be carried out

— after cooling the specimens until isothermal equilibrium is reached at 10 °C and

— by measuring immediately before the specimens are positioned in the measurement apparatus.

In the case of excessive bowing, a correction of the thickness of the specimens in the central area may be made by a corresponding pressure change. In the case of excessive dishing, a correction by insertion of air, for gas fillings except air, is only allowed if the required correction does not exceed 0,5 mm.

9 Measurements

The measurements are usually made with the specimen vertical.

Measurements may also be carried out for other angles of inclination, for example with the specimen horizontal. The inclination and the direction of heat flow (upward or downward) shall be indicated in the test report.

Measurements are performed with the specimens at a mean temperature of (10 ± 0,5) °C. The mean temperature difference between the hot and the cold surfaces of the specimen is (15 ± 1) °C.

10 Calculation and expression of results

10.1 Thermal resistance of multiple glazing

The thermal resistance of the glazing, R, in square metres kelvin per watt, is calculated from:

$$R = 2(T_1 - T_2) / (q_1 + q_2) \quad \ldots (3)$$

where

q_1 is the density of heat flow rate measured by the heat flow meter positioned at the warm side of the specimen, in watts per square metre;

q_2 is the density of heat flow rate measured by the heat flow meter positioned at the cold side of the specimen, in watts per square metre;

T_1 is the mean temperature of the hot surface of the specimen, in kelvins;

T_2 is the mean temperature of the cold surface of the specimen, in kelvins.

10.2 *U* value

The *U* value is calculated from equation (1).

For normal multiple glazing, i.e. glazing without a low-emissivity coating on the outer surface of the glazing in a vertical position, the following values for the surface heat transfer coefficients shall be used for the purpose of comparing *U* values:

— internal surface heat transfer coefficient, h_i = 8 W/(m^2·K),

— external surface heat transfer coefficient, h_e = 23 W/(m^2·K),

NOTE — The reciprocal values of h_e and h_i, expressed to two significant decimals are as follows:
1/ h_e = 0,04 m^2·K/W and 1/ h_i = 0,13 m^2·K/W.

For multiple glazing with a low-emissivity coating on its outer surface adjacent to the inner room, h_i, in watts per square metre kelvin, is modified according to the equation:

$$h_i = 3{,}6 + 4{,}4\left(\varepsilon / 0{,}837\right) \qquad \ldots (4)$$

where

ε is the corrected emissivity of the surface for room temperature radiation (ε = 0,837 for float glass).

The corrected emissivity shall be determined in accordance with ISO 10292.

NOTE — Values of ε lower than 0,837 (due to low-emissivity coatings) are only to be taken into account if water condensation on the coated surface can be excluded.

Improvements of the *U* value due to externally coated surfaces with a modified emissivity are not taken into account.

If other values of h_e and h_i are used to meet special boundary conditions, these values shall be indicated in the test report.

11 Test report

The test report shall state the following elements:

a) identification of the specimens:
   - length, in millimetres,
   - width, in millimetres,
   - thickness measured at the edges, in millimetres,
   - thickness of the glass panes, in millimetres,
   - thickness of gas space(s) measured at the edges, in millimetres,
   - type of gas filling,
   - position of IR-reflecting coating(s),
   - bowing or dishing in the central area, in millimetres,
   - corrected emissivity of surface adjacent to the inner room;

b) cross-section of the specimen: a figure shall show the structure of the specimen [position and thickness of glass panes, position and thickness of gas space(s), type of gas filling, position of internal foils, position of IR-reflecting coating(s) etc.];

c) measurement results:
   - mean surface temperature on the hot side of the specimens, in kelvins,

- mean surface temperature on the cold side of the specimens, in kelvins,
- mean temperature difference between the hot and cold sides of the specimens, in kelvins,
- mean temperature of the specimens, in kelvins,
- thermal resistance in square metres kelvin per watt (to three significant figures),
- h_i and h_e, in watts per square metre kelvin, if non-standardized values have been used,
- the angle of inclination of the glazing, and the direction of heat flow (upward or downward) if the glazing is not vertical,
- U value in watts per square metre kelvin (to one decimal place).