SLOVENSKI STANDARD
SIST EN 1946-4:2001

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Toplotne značilnosti gradbenih proizvodov in delov stavb - Posebna merila za ocenjevanje laboratorijev, ki merijo lastnosti pri prenosu toplote - 4. del: Merjenje z metodo komorne naprave

Thermal performance of building products and components - Specific criteria for the assessment of laboratories measuring heat transfer properties - Part 4: Measurements by hot box methods

Wärmetechnisches Verhalten von Bauprodukten und Bauteilen - Technische Kriterien zur Begutachtung von Laboratorien bei der Durchführung der Messungen von Wärmeübertragungseigenschaften - Teil 4: Messungen nach dem Heizkasten-Verfahren

Performance thermique des produits et composants pour le bâtiment - Criteres particuliers pour l'évaluation des laboratoires mesurant les propriétés de transmission thermique - Partie 4: Mesurages selon les méthodes de la boîte chaude

Ta slovenski standard je istoveten z: **EN 1946-4:2000**

ICS:

91.100.60	Materiali za toplotno in zvočno izolacijo	Thermal and sound insulating materials
91.120.10	Toplotna izolacija stavb	Thermal insulation

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EUROPEAN STANDARD

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Thermal performance of building products and components - Specific criteria for the assessment of laboratories measuring heat transfer properties - Part 4: Measurements by hot box methods

Performance thermique des produits et composants pour le bâtiment - Critères particuliers pour l'évaluation des laboratoires mesurant les propriétés de transmission thermique - Partie 4: Mesurages selon les méthodes de la boîte chaude

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This European Standard was approved by CEN on 4 March 2000.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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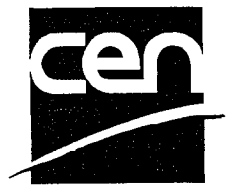

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Central Secretariat: rue de Stassart, 36 B-1050 Brussels

Contents

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 89, "Thermal performance of buildings and building components", the secretariat of which is held by SIS.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2000, and conflicting national standards shall be withdrawn at the latest by October 2000.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

No existing European Standard is superseded.

This European Standard is divided into parts. The first part covers common criteria applicable to all heat transfer property measurements; each subsequent part covers the specific technical criteria applicable to each heat transfer property measurement method described in appropriate standards.

The following parts have been developed:

Part 1: Common criteria
Part 2: Measurements by the guarded hot plate method
Part 3: Measurements by the heat flow meter method
Part 4: Measurements by hot box methods
Part 5: Measurements by the pipe test methods

Basic information on heat transfer in hot box apparatus and related temperature non-uniformities may be found in the CEN Technical Report " Heat transfer and errors in hot box apparatus", see [2] in the Bibliography.

Annex A of this European Standard is normative, annex B is informative.

1 Scope

This part 4 of this standard provides specific technical criteria for the assessment of laboratories to undertake steady-state heat transfer property measurements on products and components using calibrated or guarded hot box apparatus in accordance with EN ISO 8990:1996, including its application to doors and windows in accordance with EN ISO 12567, or using a heat flow meter in a hot box apparatus in accordance with EN 1934:1998.

It complements the common criteria in part 1. Guidance is given on the organization and contents of the equipment manual, the calibration and maintenance files and the measurement procedure document.

It provides information on mandatory equipment performance specifications and equipment description. It supplements error analysis and calculations for the equipment design not supplied in EN ISO 8990:1996, EN 1934:1998 and related standards.

It provides information on experimental procedures suitable for the assessment of instrument accuracy.

2 Normative references

This standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 1934:1998	Thermal performance of buildings - Determination of thermal resistance by hot box method using heat flow meter - Masonry
EN 1946-1:1999	Thermal performance of building products and components - Specific criteria for the assessment of laboratories measuring heat transfer properties - Part 1: Common criteria
EN ISO 6946	Building components and building elements - Thermal resistance and thermal transmittance - Calculation method (ISO 6946:1996)
EN ISO 7345	Thermal insulation - Physical quantities and definitions (ISO 7345:1987)
EN ISO 8990:1996	Thermal insulation - Determination of steady-state thermal transmission properties - Calibrated and guarded hot box (ISO 8990:1994)
EN ISO 12567:-[1)]	Thermal performance of windows and doors- Determination of thermal transmittance by hot box method (ISO 12567:-)

3 Definitions, symbols and units

3.1 Definitions

For the purposes of this standard, the following terms and definitions and the definitions given in part 1 of this standard, in EN ISO 7345, in EN 1934:1998, in EN ISO 12567 and those of EN ISO 8990:1996 not given in this standard, apply.

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[1] To be published

3.1.1 specimen surface-to-surface thermal resistance

Physical quantity defined by:

$$R_t = \frac{A(T_{si} - T_{se})}{\Phi_1} \qquad m^2 \cdot K/W$$

3.1.2 thermal transmittance of a specimen

Physical quantity defined by:

$$U = \frac{\Phi_1}{A(T_{ni} - T_{ne})} \qquad W/(m^2 \cdot K)$$

or defined (when R_t can be defined) as;

$$U = \frac{1}{R_{si} + R_t + R_{se}} \qquad W/(m^2 \cdot K)$$

3.1.3 environmental temperature

Physical quantity defined by:

$$T_n = \frac{Eh_{ro}}{Eh_{ro} + h_c} T_r + \frac{h_c}{Eh_{ro} + h_c} T_a \qquad K$$

3.2 Symbols and units

Symbol	Quantity	Unit
A	area perpendicular to the density of heat flow rate	m^2
E	emissivity factor dependent on surface emissivities and view factors, see EN ISO 8990:1996	
h_c	surface coefficient of heat transfer due to convection	$W/(m^2 \cdot K)$
h_r	surface coefficient of heat transfer due to radiation	$W/(m^2 \cdot K)$
h_{ro}	surface coefficient of heat transfer due to radiation between parallel black planes ($h_{ro} = 4\ \sigma T_m^3$)	$W/(m^2 \cdot K)$
p	metering area perimeter	m
R_s	surface resistance on one specimen surface	$m^2 \cdot K/W$
R_t	specimen thermal resistance (surface-to-surface)	$m^2 \cdot K/W$

Symbol	Quantity	Unit
T_a	mean temperature of the air surrounding one specimen surface	K
T_n	environmental temperature	K
T_r	mean radiant temperature of the surfaces "seen" by the specimen surface	K
U	thermal transmittance	$W/(m^2 \cdot K)$
Φ	heat flow rate	W
Φ_1	heat flow rate through the metering area of the specimen	W
Φ_2	imbalance heat flow rate between guard area and metering area in the specimen	W
Φ_3	heat flow rate through the metering box walls	W
Φ_4	flanking heat flow rate through the specimen frame	W
Φ_5	heat flow rate at the edge of the specimen	W
σ_n	Stefan Boltzmann constant ($5{,}67 \times 10^{-8}$)	$W/(m^2 \cdot K^4)$
λ	thermal conductivity	$W/(m \cdot K)$

Subscripts

For the purpose of this standard, the following subscripts apply, see also 4.4.2.2:

a	air
b	metering box surface
i	internal, usually hot side
e	external, usually cold side
g	guard box
m	metering area or the air enclosed in the metering box
n	environmental
r	radiation
s	surface
sg	specimen-(guard box)
sm	specimen-(metering box)

4 Equipment manual

4.1 General

The equipment manual shall provide the information specified in 5.2.2 to 5.2.5 of part 1 of this standard and the information specified in this clause.

NOTE Information common to more than one piece of equipment need not be duplicated, e.g. the principle, details of the design and operation of two pieces of equipment built to a common design.

Annex A gives all limiting values indicated in EN ISO 8990:1996, EN 1934:1998 or EN ISO 12567 for apparatus performance and testing conditions. This annex shall be used as a check-list during the assessment process by the parties concerned to ensure compliance with all the requirements of those standards.

4.2 Equipment performance specification

The upper and lower limits of the relevant tested properties and testing conditions, including possible interactions between them, shall be specified:

- minimum and maximum specimen thickness to be tested in the apparatus;
- minimum and maximum specimen thermal resistance;
- minimum and maximum surface coefficients required during tests;
- minimum and maximum temperature difference across the specimen;
- dimensions of expected inhomogeneities in the specimens;
- minimum cold side temperature;
- maximum hot side temperature;
- overall equipment accuracy and maximum acceptable error on measured property in a defined worst-case condition;
- requirements on the control of relative humidity on the hot and cold side;
- maximum mass for a specimen to be accommodated in a frame.

4.3 Equipment description

The following information shall be documented and made available for examination during the assessment:

- principle of operation (see 1.5 of EN ISO 8990:1996 or 4.1 of EN 1934:1998);
- type of apparatus: guarded hot box, see 1.5.2 of EN ISO 8990:1996, or calibrated hot box, see 1.5.3 of EN ISO 8990:1996;
- principal dimensions of apparatus, in particular height and width of the metering box or of the metering area of the heat flow meter in a hot box with a heat flow meter, height and width of the guard box for guarded hot boxes;
- simple diagrams illustrating the design of the equipment with special attention to the heat supply and air circulation (see 2.3.2 of EN ISO 8990:1996 or 6.2.3 of EN 1934:1998), the guard box (see 2.4 of EN ISO 8990:1996), the specimen frame and edge insulation (see in particular 2.5 of EN ISO 8990:1996) and the cold side chamber (see in particular 2.6 of EN ISO 8990:1996);
- position, connections and numbering of temperature sensors (see 2.7 of EN ISO 8990:1996 or 6.3 of EN 1934:1998);

- electrical components/instruments and main ancillary equipment (see 2.7.5 and 2.8 of EN ISO 8990:1996 or 6.3.4 and 6.4 of EN 1934:1998);
- details of data acquisition system and related computer programs for data analysis.

To avoid duplication, reference may be made to manuals supplied by the instrument manufacturers or to relevant clauses of EN ISO 8990:1996 or EN 1934:1998.

4.4 Equipment design and error analysis

4.4.1 General

With reference to the performance specification given in 4.2, details shall be given in the equipment manual on the design guidelines followed, and the related error analysis. A list of the errors to be considered in the error analysis precedes the description of the equipment design documentation in this clause. More specific information on some errors is given in the references of the Bibliography. The information given in this subclause 4.4 also supplements that given in EN ISO 8990:1996 or EN 1934:1998.

NOTE In most cases there are no general rules or simple expressions to evaluate errors. An accurate error analysis usually requires numerical calculations based on the specific equipment considered, nevertheless the knowledge of their existence can stimulate a detailed analysis for each piece of equipment.

Elementary conservative error calculations for some typical cases are given in annex B. For equipment having characteristics exactly as indicated in this subclause or design details as indicated in annex B, no further calculations are needed, unless more precise calculations are wanted. In other circumstances similar calculations can be performed by analogy.

4.4.2 Sources of errors

4.4.2.1 General

Measured heat transfer properties in hot box apparatus are either the specimen surface-to-surface thermal resistance, R_t, or the thermal transmittance, U. Surface thermal resistances R_s on either side of the specimen (R_{si} or R_{se}) play a relevant role in the error analysis: the heat flow rate, Φ, exchanged by a surface of area A is:

$$\Phi = A(Eh_{ro} + h_c)(T_n - T_s) = \frac{T_n - T_s}{R_s} A \qquad (1)$$

T_n is unknown from measurements of T_r and T_a unless h_{ro} and h_c are known or T_r is equal to T_a. Any non-uniformity in surface coefficients $E\,h_{ro}$ and h_c and/or in air temperature T_a, and in the temperatures of the surfaces seen from the surface considered, is a source of uncertainty in T_n.

NOTE 1 Information on the calculation of local coefficients of heat transfer $E\,h_{ro}$ and h_c may be found in [2], see Bibliography).

NOTE 2 The error propagation applied in equation (1) and those defining R_t and U makes possible the calculation of the error in R_t or U when the error affecting each of the quantities appearing in them is known.

Errors can be divided into those encountered when testing homogeneous specimens in ideal conditions and those additionally encountered when testing inhomogeneous specimens (i.e. the majority of hot box measurements).

When testing inhomogeneous specimens the estimation of errors follows the same guidelines and principles, but the evaluation of the lateral imbalance heat flow rate Φ_2, the flanking heat flow rate Φ_4, the area A through which the heat flow rate Φ_1 is transferred and surface temperatures becomes increasingly difficult with increasing inhomogeneities.

4.4.2.2 Guarded hot box errors

Figure 1 shows, for a guarded hot box, the link between error heat flow rates and temperature and surface coefficient non-uniformities and imbalances. In figure 1 the first subscript has the conventional meaning of hot box methods (s for surface, a for air and r for radiation); the second and third subscripts indicate the elements involved in the heat transfer considered (g for the guard box, s for the specimen, m for the metering area or the air enclosed in it, b for the surfaces of the metering box). The subscript s for surface thermal resistances has been omitted.

NOTE The figures in EN ISO 8990:1996 supply information needed for the correct understanding of the error in determining flanking heat flow rate, Φ_4, and the error heat flow rate, Φ_5, at the edge of the specimen. A detailed discussion on heat transfer and errors in hot box apparatus can be found in [2], see Bibliography.

The following shall be considered in guarded hot box error analysis.

a) Surface coefficients:

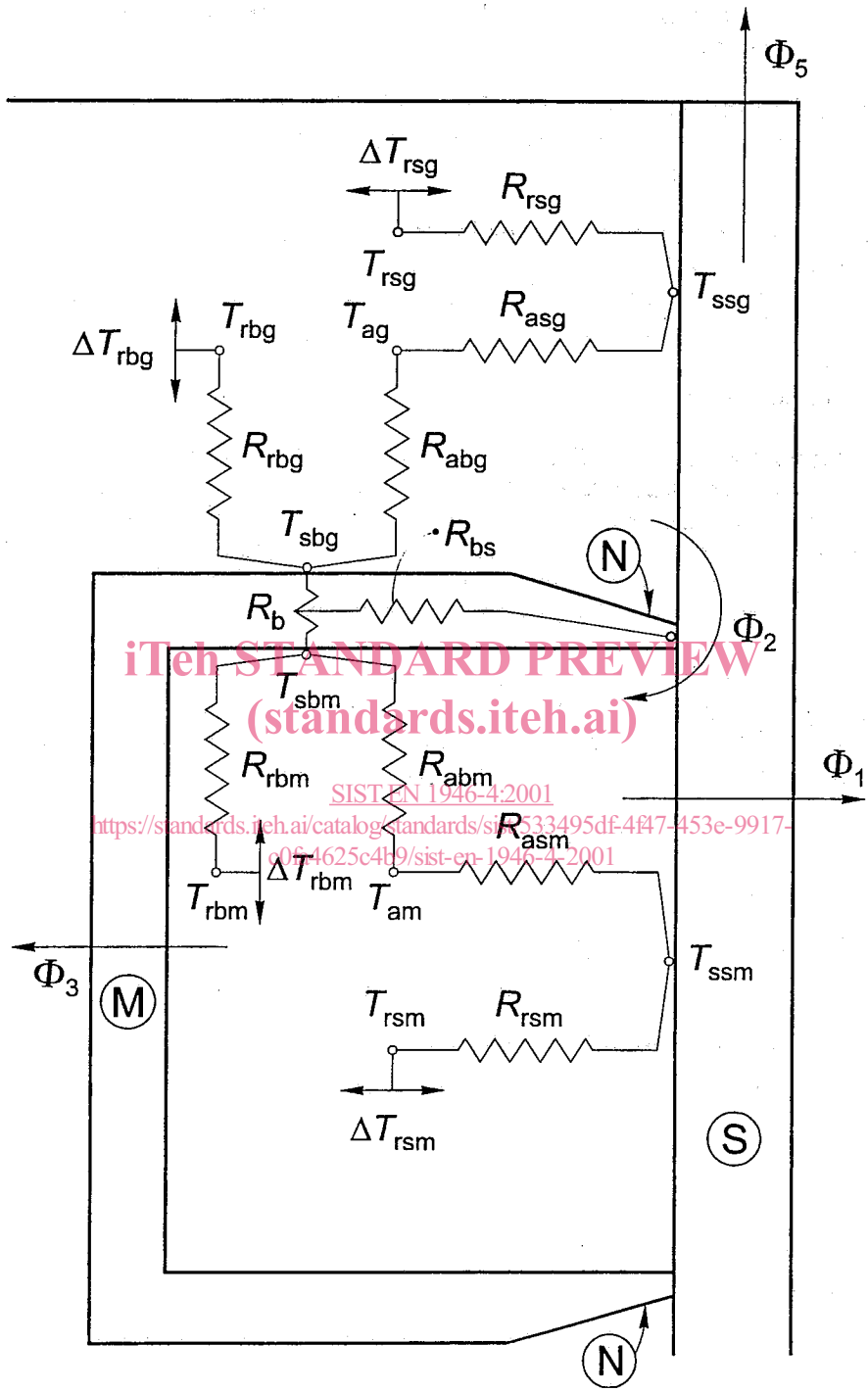
- definition of the air temperature;
- effect of combined heat transfer by convection and radiation;
- uniformity along the edge of the metering box;
- comparison of flat homogeneous specimens with other specimens;
- uniformity along the nose.

b) Temperature measurements:

- meaningfulness of measured temperatures (sensor positioning);
- temperature averaging;
- thermocouple wire calibration (or temperature sensor calibration);
- reference junction accuracy for thermocouples;
- thermocouple connections and compensation wires;
- accuracy in the determination of the output of temperature sensors (digital voltmeters and data acquisition systems).

c) Error heat flow rate due to insufficient guarding, Φ_5:

d) Lateral imbalance heat flow rate, Φ_2:



Key

M - Metering box
N - Nosing piece
S - Specimen

Figure 1 - Heat transfer by convection and radiation in the hot side of a guarded hot box

e) **Heat flow rate, Φ_3, through the metering box walls:**

- errors in the determination of the heat flow rate through the metering box walls;
- heat transfer from the metering box walls to the specimen through the metering box nose;
- field distortion in the specimen due to the contact with the metering box nose.

f) **Apparatus geometry:**

- definition of the metering area;
- accuracy in measuring the metering area;
- accuracy in the determination of specimen thickness.

g) **Power input:**

- line losses;
- wattmeter accuracy;
- fan power, accuracy in its measurement;
- cooling system in the metering box, accuracy in the measurement of the cooling power.

h) **Drifts and fluctuations:**

- definition of steady-state condition;
- long term drifts;
- short term fluctuations.

j) **Moisture effects**

k) **Effect of the inhomogeneities of the specimen:**

- effect on the definition of the metering area when an inhomogenous specimen replaces an homogeneous one;
- effect of masks (called surround panels in some standards, e.g. EN ISO 12567);
- additional effects of inhomogeneities.

4.4.2.3 Calibrated hot box errors

The following is a list of those items which pertain to the calibrated hot box only. Items described in a), b), e) to k) of 4.4.2.2 apply almost identically to both calibrated hot box and guarded hot box apparatus.

NOTE The layout of a calibrated hot box is shown in figure 2, taken from EN ISO 8990:1996.

a) **Errors in determining flanking heat flow rate, Φ_4**

b) **Error heat flow rate due to insufficient frame insulation, Φ_5**
(Usually considered together with a) of 4.4.2.3, see also c) of 4.4.2.2)