SLOVENSKI STANDARD
SIST EN 1934:1999

01-september-1999

Toplotne karakteristike stavb – Določanje toplotnega upora s komorno metodo z uporabo merilnikov toplotnega toka - Zid

Thermal performance of buildings - Determination of thermal resistance by hot box method using heat flow meter - Masonry

Wärmetechnisches Verhalten von Gebäuden - Messung des Wärmedurchlaßwiderstandes Heizkastenverfahren mit dem Wärmestrommesser - Mauerwerk

Performance thermique des bâtiments - Détermination de la résistance thermique selon la méthode de la boîte chaude avec fluxmetre - Maçonnerie

Ta slovenski standard je istoveten z: **EN 1934:1998**

ICS:

91.080.30	Zidane konstrukcije	Masonry
91.120.10	Toplotna izolacija stavb	Thermal insulation

SIST EN 1934:1999 **en**

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 1934

March 1998

ICS 91.060.10; 91.080.30; 91.120.10

Descriptors: buildings, walls, laboratory tests, measurements, thermal properties, thermal resistance, heat transfer, fidelity, calibration

English version

Thermal performance of buildings - Determination of thermal resistance by hot box method using heat flow meter - Masonry

Performance thermique des bâtiments - Détermination de la résistance thermique selon la méthode de la boîte chaude avec fluxmètre - Maçonnerie

Wärmetechnisches Verhalten von Gebäuden - Messung des Wärmedurchlaßwiderstandes Heizkastenverfahren mit dem Wärmestrommesser - Mauerwerk

This European Standard was approved by CEN on 24 January 1998.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

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.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

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

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

Ref. No. EN 1934:1998 E

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 is one of a package on measurements with hot box apparatus. The basic principles of the method and the guarded and calibrated implementations are described in EN ISO 8990.

In this European Standard the basic principles of the method and the implementation of a heat flow meter in a hot box for measurements on masonry is described, keeping the style and structure as similar as possible to EN ISO 8990:1996. The numbering of clauses in this European Standard follows the clause numbering in EN ISO 8990:1996.

In the same package of European Standards the procedure to test window panes, window frames, complete windows and doors in a hot box are described.

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 September 1998, and conflicting national standards shall be withdrawn at the latest by September 1998.

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.

Introduction

Many masonry elements are such that in practice the heat transfer through them is a complex combination of conduction, convection, radiation and mass transfer. The method described in this standard determines the total amount of heat transferred from one side of the specimen to the other for a given temperature difference in defined testing conditions. However, the heat transfer properties often depend on the specimen itself and on the boundary conditions, specimen dimensions, direction of heat transfer, temperatures, temperature differences, air velocities and relative humidity. In consequence the test conditions either replicate those of the intended application or are convertible to them. For ease of intercomparison of results, conventional testing conditions are adopted during the tests. Tested values are the base used in conversion procedures to get the appropriate design values.

The results obtained from a single specimen are not necessarily representative or applicable to all samples of a masonry wall and product standards should be consulted for appropriate sampling.

The design and operation of the heat flow meter hot box is a very complex subject. It is essential that the designer and user of such apparatus has a thorough background knowledge of heat transfer, and has experience of precision measurement techniques.

For a particular specimen it should be decided whether the method is applicable or whether other measurement methods or calculations are more suitable. For homogeneous specimens the guarded hot plate apparatus (see ISO 8302) or the heat flow meter apparatus (see ISO 8301) should be preferred. For specimens not meeting the homogeneity criteria of 6.2.1 of this standard, or with a possibility of convection within internal cavities, the metering section of a heat flow meter might not cover a representative portion of the specimen: for such specimens the use of a guarded or calibrated hot box apparatus of suitable size should be considered (see EN ISO 8990).

1 Scope

This standard establishes the principles and criteria to be complied with for the determination of the laboratory steady-state heat transfer properties of masonry walls in a hot box by means of a heat flow meter mounted on one face of the masonry wall to be tested (i.e. the test specimen). It describes the apparatus, measurement technique and necessary data reporting. It does not, however, specify a particular apparatus design since requirements vary particularly in terms of size, and also to a lesser extent in terms of operating conditions.

The property that is measured is the surface-to-surface thermal resistance of the specimen, provided that the metering section of the heat flow meter covers a representative portion of the specimen, and the homogeneity criteria of 6.2.1 are met. From these measurements the thermal resistance for application in buildings is derived. The thermal transmittance of a masonry wall can then be calculated from this value with standardized surface coefficients.

This standard is applicable to measurements on both dry and moist specimens, provided that the conditions indicated in 5.3.3 are met. The influence of moisture content on the thermal properties of masonry can be taken into account by measurements at different moisture contents of the specimen in the range of the practical moisture content including the dry state, which corresponds to the most frequent testing condition.

The method is also suitable for horizontal elements such as ceilings and floors.

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 applies.

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)
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

3 Definitions, symbols and units

3.1 Definitions

For the purposes of this standard, the definitions in EN ISO 7345 and EN ISO 8990:1996 and the following definitions apply:

3.1.1 mean radiant temperature:[1)] Appropriate weighting of the temperatures of surfaces "seen" by the specimen for the purpose of determining the radiant heat flow rate to or from the surface of the specimen.

3.1.2 environmental temperature:[1)] Appropriate weighting of air and radiant temperatures, for the purpose of determining the heat flow rate to the surface of the specimen.

3.1.3 moderately inhomogeneous specimen: Specimen which, when tested, meets temperature uniformity criteria as stated in 5.3.2.

3.2 Symbols and units

Symbol	Quantity	Unit
A	area perpendicular to the density of heat flow rate	m^2
R_s	surface thermal resistance	$m^2 \cdot K/W$
R_t	specimen thermal resistance (surface-to-surface)	$m^2 \cdot K/W$
R_T	total thermal resistance (environment to environment)	$m^2 \cdot K/W$
T_a	air temperature	K
T_n	environmental temperature	K
T_r	mean radiant temperature	K
T_s	surface temperature	K
U	thermal transmittance ($1/R_T$)	$W/(m^2 \cdot K)$
d	specimen thickness	m
f	calibration factor of the heat flow meter	$W/(mV \cdot m^2)$
g	guard width	m
h	surface coefficient of heat transfer ($1/R_{si}$ or $1/R_{se}$)	$W/(m^2 \cdot K)$
l	half-side of the metering section	m
p	metering section perimeter	m
q	density of heat flow rate	W/m^2
ΔT_g	temperature difference between metering and guard section	K
Φ_1	heat flow rate through the metering section of the specimen	W
Φ_2	imbalance heat flow rate between guard section and metering section in the specimen	W
Φ_2'	portion of the imbalance heat flow rate Φ_2 credited to the average temperature imbalance ΔT_g	W

Symbol	Quantity	Unit
Φ_2''	portion of the imbalance heat flow rate Φ_2 credited to temperature non-uniformity on guard section and metering section	W
Φ_5	heat flow rate at the edge of the specimen	W

[1)] For more information see annex A of EN ISO 8990:1996

λ_f	thermal conductivity of the heat flow meter	W/(m·K)
λ_s	thermal conductivity of the material of the specimen in contact with the heat flow meter	W/(m·K)

Subscripts

For the purposes of this standard, the following subscripts apply:

i	internal, usually hot side
e	external, usually cold side
*	moist specimen

4 Principle of the method

4.1 Principle of the apparatus

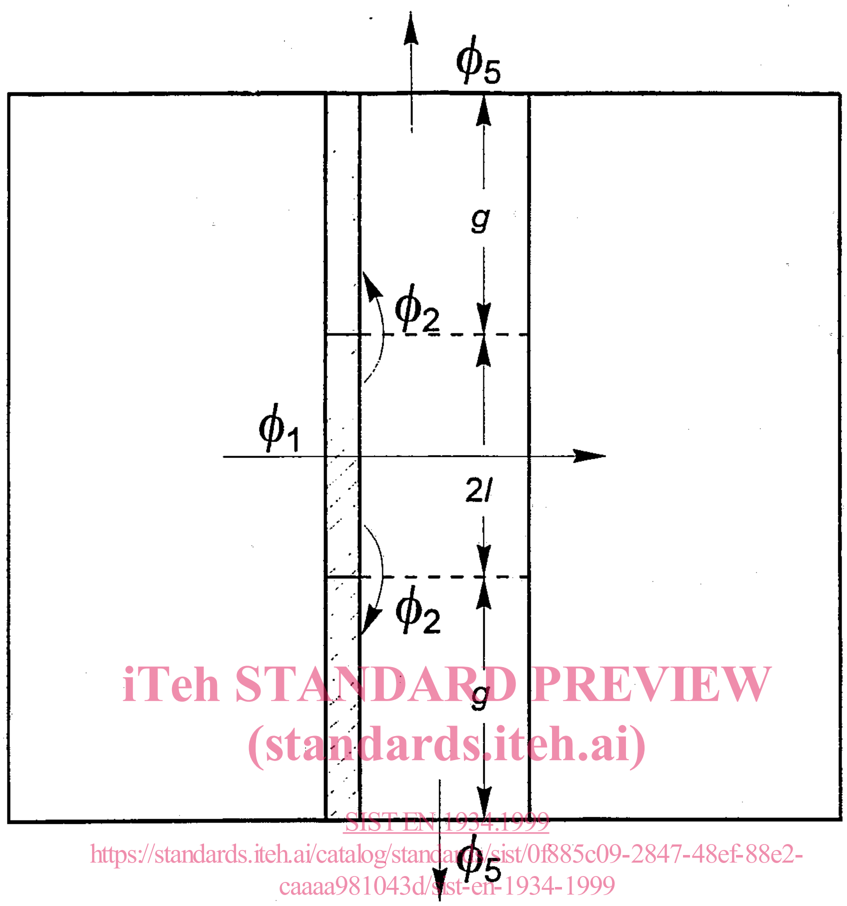
The heat flow meter hot box apparatus is intended to reproduce the boundary conditions of a specimen in steady state conditions between two environments, each at uniform temperature. A specimen is then placed between a hot and a cold chamber in which environmental temperatures are imposed. Heat exchanged at the surfaces of the test specimen involves both convective and radiative contributions. The former depends upon air temperatures and air velocity, and the latter depends upon the temperatures and the total hemispherical emissivities of the specimen surfaces and of surfaces "seen" by the test specimen surfaces. The effect of the heat transfer by convection and radiation are conventionally combined in the concept of an "environmental temperature" and a surface heat transfer coefficient.

For this method it is important to limit non-uniformities of temperature on the surface of the specimen and it is not necessary to reproduce exactly end use surface coefficients of heat transfer and environmental temperatures.

4.2 Determination of the density of heat flow rate

On the hot side of the specimen a heat flow meter is mounted to measure the density of heat flow rate, q, passing through the specimen and crossing a surface, of area A, located at its centre, see figure 1. Over this surface, called hereafter the metering section, it is necessary that the density of heat flow rate is sufficiently uniform. The metering section is also the active or sensing part of the heat flow meter.

In order to provide a uniform thermal resistance between the specimen surface and the hot side environment, a sheet of material is placed on the surface of the specimen not covered by the heat flow meter. The sheet should have a thermal resistance and thickness equal to that of the heat flow meter.



NOTE: Heat flows at a rate Φ_1 through the metering area $A = (2l)^2$; in the metering area the density of heat flow rate, q, is expected to be uniform; Φ_2 is an imbalance heat flow rate parallel to the specimen; Φ_5 is the transverse heat flow rate at the edge of the specimen; g is the guard width.

Figure 1: Principle of a heat flow meter hot box apparatus

NOTE: Some heat flow meters have the sensing elements distributed all over their surface, so that the heat flow meter active or sensing section is equal to the metering section of the specimen and the sheet section is equal to the guard section. Other heat flow meters have the sensing elements distributed only in a central section; that corresponds to the metering section of the specimen and is smaller than the total heat flow meter section.

4.3 Determination of the surface-to-surface thermal resistance of the specimen

Steady-state measurements are made of surface temperatures and of the density of heat flow rate through the specimen. From these measurements the surface-to-surface thermal resistance of the specimen is calculated.

4.4 Guarding and guard section

The surface of the specimen surrounding the metering section is called hereafter "guard section". To ensure a uniform density of heat flow rate in the metering section, the guard section shall be held as close as possible to the same temperature as the metering section, so that the lateral heat flow rate Φ_2 from the metering section to the guard section through the specimen is nearly zero, see figure 1.

The guard section shall be large enough to ensure that the edge heat loss error Φ_5 is low. The use of insulation on the edge of the specimen helps in reducing edge heat loss errors, hence it may be used to increase the maximum allowed specimen thickness for the apparatus.

5 Limitations and sources of errors

5.1 General

The operation of the apparatus, to a certain desired accuracy, is limited by a number of factors related to equipment design, calibration and operation and specimen properties, e.g. thickness, thermal resistance and homogeneity.

5.2 Limitations and errors due to apparatus

5.2.1 Limitations due to lateral heat flow rate

To keep the lateral heat flow rate Φ_2, equal to zero, even when testing homogeneous specimens, the hot and cold surfaces of the specimen should be kept at uniform temperatures; this in turn requires that environmental temperatures and local surface heat transfer coefficients be uniform both on the hot and on the cold side of the specimen. These requirements are always met with a certain approximation even with an adequate air flow on both surfaces of the specimen and correct choice of apparatus size and design. Consequently there is usually a temperature difference between the average temperatures of the metering and guard portion of the hot side surface of the specimen. Additionally, this temperature difference, due to the mentioned non-uniformities, is known with a level of uncertainty, so that, in practice, it is almost impossible to reduce to zero the lateral heat flow rate Φ_2. Furthermore, specimens tested in a heat flow meter hot box are not homogeneous (otherwise they could be tested with better accuracy in a guarded hot plate apparatus). To keep imbalance errors within acceptable limits when testing a wall made of elements (bricks, blocks), the heat flow meter should cover an integral number of wall elements.

The error due to the heat flow rate Φ_2 in the specimen due to imbalance between the metering and guard sections, is proportional to the perimeter of the metering section. The relative influence of this diminishes as the metering area is increased. This fact shall be compared with the increment of edge heat losses while reducing the guard width, see 5.2.2.

Table 1: Minimum and maximum allowed specimen thickness

Dimensions in millimetres

Overall size	Metering section width	Guard width	Max. specimen thickness (no edge insulation)	Max. specimen thickness (with edge insulation)
800	500	150	115	260
1000	500	250	175	315
1250	500	375	245	380
1500	500	500	315	450
2000	500	750	450	580

5.2.2 Size of metering section and edge heat loss error

The size of the metering section determines the maximum thickness of the specimen that can be tested in a given apparatus while keeping the error due to edge heat losses within acceptable limits (1 % for this standard test method). Assuming the worst case condition of no insulation at the edge of the specimen, kept at the same temperature as the hot surface, the maximum specimen thicknesses shall not exceed the values of the fourth column in table 1.

NOTE: The ratios specimen-side/specimen-thickness and guard-width/specimen-thickness are governed by the same principles as for the guarded hot plate, see 2.2.1 and 2.3.2 of ISO 8302:1991, on which table 1 is based for a hot box with a 500 mm x 500 mm heat flow meter.

Typical arrangements of heat flow meter hot box apparatus include edge insulation, see figure 2. If at least 100 mm of edge insulation is added with a thermal conductivity of at least 5 times lower than that of the specimen, and if the edge of the insulation not in contact with the specimen is kept at the temperature of the hot surface of the specimen, the maximum specimen thickness shall not exceed the values of the fifth column in table 1. The error due to edge heat losses remains 1 % if all the dimensions in one line of table 1, together with the thickness of edge insulation (when used), are multiplied by the same factor, e.g. a hot box with no edge insulation, an overall size of 3000 mm, and a heat flow meter of 1000 mm x 1000 mm can test specimens up to 630 mm, see the fourth line in table 1.

To allow a meaningful interpretation of measurement results, the size of the metering section shall be large enough to cover a representative portion of a specimen incorporating random irregularities or shall cover an integral number of regularly occurring inhomogeneities. As a consequence the metering section and hence the appropriate heat flow meter have to be chosen according to the type of test walls (size of blocks, influence of mortar layers, symmetry etc.).

5.2.3 Surface coefficients of heat transfer, contact thermal resistances between the specimen and the heat flow meter

Any non-uniformity in surface coefficients of heat transfer, or in the contact resistances between the specimen and heat flow meter is a source of non-uniform temperatures on the surface of the specimen. The thermal resistance of the specimen shall be large