SLOVENSKI STANDARD
SIST EN 12664:2002

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Toplotne karakteristike gradbenih materialov in proizvodov - Ugotavljanje toplotne upornosti z zaščiteno vročo ploščo in/ali merilniki toplotnih tokov – Suhi ali vlažni proizvodi s srednjo ali nizko toplotno upornostjo

Thermal performance of building materials and products - Determination of thermal resistance by means of guarded hot plate and heat flow meter methods - Dry and moist products of medium and low thermal resistance

Wärmetechnisches Verhalten von Baustoffen und Bauprodukten - Bestimmung des Wärmedurchlasswiderstandes nach dem Verfahren mit dem Plattengerät und dem Wärmestrommessplatten-Gerät - Trockene und feuchte Produkte mit mittlerem und niedrigem Wärmedurchlasswiderstand

Performance thermique des matériaux et produits pour le bâtiment - Détermination de la résistance thermique par la méthode de la plaque chaude gardée et la méthode fluxmétrique - Produits secs et humides de moyenne et basse résistance thermique

Ta slovenski standard je istoveten z: EN 12664:2001

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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Thermal performance of building materials and products - Determination of thermal resistance by means of guarded hot plate and heat flow meter methods - Dry and moist products of medium and low thermal resistance

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This European Standard was approved by CEN on 25 June 2000.

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 Management Centre 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 Management Centre has the same status as the official versions.

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COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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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 July 2001, and conflicting national standards shall be withdrawn at the latest by December 2001.

This document is one of a series of standards on thermal test methods which support product standards for building materials.

The annexes A, B, C, D and E are normative. The annexes F and G are informative.

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

Steady state heat transfer properties may be measured by a number of standardized test methods: the choice of the most appropriate method depends on specimen characteristics. This standard covers the guarded hot plate and the heat flow meter methods only.

For routine testing, the operator of these two methods needs only this standard and the relevant product standard, which may impose additional requirements related to specimen preparation or testing conditions.

Detailed requirements for measurements in any testing condition of thermal resistance of any compatible plane specimen are given:

- for the guarded hot plate method, in ISO 8302:1991 and EN 1946-2:1999;
- for the heat flow meter method, in ISO 8301:1991 and EN 1946-3:1999.

This standard provides general information on the apparatus, all mandatory limits for the equipment design and operation, and the specification of testing procedure, for dry and moist specimens, with medium and low thermal resistance, described in relevant technical specifications (e.g. a European product standard or a European technical approval). The information given is technically equivalent to that in ISO 8301:1991 and ISO 8302:1991, for both these methods. It is only intended for the routine testing of specimens (within the limitations of thickness and inhomogeneity etc. given in annex A) using equipment which has been constructed according to 5.1 and which has already been validated according to EN 1946-3:1999 or EN 1946-2:1999.

It also includes examples of equipment designs that meet the requirements of 5.1, so that the assessment of the accuracy of an equipment designed accordingly does not need an error analysis but only the equipment performance check.

Although this standard can be used for testing dry specimens of high and medium thermal resistance, i.e. on products having a thermal resistance of not less than 0,5 m²·K/W, the simpler procedures of EN 12667:2001 are recommended for such specimens. Measurements on thick products of high and medium thermal resistance are covered in EN 12939, see the Bibliography.

1 Scope

This standard specifies principles and testing procedures for determining, by means of the guarded hot plate or heat flow meter methods, the thermal resistance of test specimens either in the dry state or conditioned to equilibrium with moist air, having a thermal resistance of not less than 0,1 $m^2 \cdot K/W$ and a (hygro)thermal transmissivity or thermal conductivity up to 2,0 W/(m·K). (It is expected that the thermal resistance of most masonry specimen will be less than 0,5 $m^2 \cdot K/W$).

NOTE 1 The lower limit for measurable thermal resistance is due to the effect of contact thermal resistances, which require special testing techniques described in this standard. Although this standard can be used for testing dry specimens of high and medium thermal resistance, i.e. on products having a thermal resistance of not less than 0,5 $m^2 \cdot K/W$, the simpler procedures of EN 12667:2001 are recommended for such specimens.

It applies in principle to any mean test temperature, but the equipment design in annex D is essentially intended to operate between a minimum cooling unit temperature of -100 °C and maximum heating unit temperature of +100 °C.

NOTE 2 Limits to the mean test temperature are only imposed by the materials used in the apparatus construction and by ancillary equipment.

It supplies additional limits for equipment performance and test conditions.

It does not supply general equipment design procedures, equipment error analysis, equipment performance check or the assessment of equipment accuracy.

It supplies example designs of equipment complying with the requirements set down in this standard.

This standard does not supply general guidance and background information (e.g. the heat transfer property to be reported, product-dependent specimen preparations, suggested materials for vapour-tight envelopes when testing moist specimens, procedures requiring multiple measurements, such as those to assess the effect of specimen non-homogeneities, those to test specimens whose thickness exceeds the apparatus capabilities, and those to assess the relevance of the thickness effect). Due to these limitations, this standard shall only be used in conjunction with the product standard relevant to the product to be tested.

Although intended primarily for building materials, it may also be used for specimens of any material that conforms to the requirements specified.

It may be used for specimens made from the core material of hollow masonry units but formed voids are not permitted in the specimen.

This standard does not cover measurements on thick products of high and medium thermal resistance.

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 (including amendments).

NOTE References to ISO 8301:1991 and ISO 8302:1991 do not cover the complete test methods, but are limited to such items as equipment design and performance check, not covered by European Standards or parts of them; references to ISO 8301:1991 or ISO 8302:1991 are not needed for routine testing according to this standard.

EN 1946-2:1999	Thermal performance of building products and components - Specific criteria for the assessment of laboratories measuring heat transfer properties - Part 2: Measurements by guarded hot plate method
EN 1946-3:1999	Thermal performance of building products and components - Specific criteria for the assessment of laboratories measuring heat transfer properties - Part 3: Measurements by heat flow meter method
EN 12667:2001	Thermal performance of building materials and products - Determination of thermal resistance by means of guarded hot plate and heat flow meter methods - Products of high and medium thermal resistance
EN ISO 7345	Thermal insulation - Physical quantities and definitions (ISO 7345:1987)
EN ISO 9288	Thermal Insulation - Heat transfer by radiation - Physical quantities and definitions (ISO 9288:1989)
EN ISO 9346	Thermal insulation - Mass transfer - Physical quantities and definitions (ISO 9346:1987)
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 Terms and definitions

For the purposes of this standard, the terms and definitions in EN ISO 7345, EN ISO 9288, EN ISO 9346 apply. Most relevant definitions for the measurement of heat transfer properties on medium and low thermal resistance products and the definition of hygrothermal transmissivity are to be found in A.2.

3.2 Symbols and units

Symbol	Quantity	Unit
A	metering area measured on a selected isothermal surface	m^2
A_d	area of the defect	m^2
A_m	area of the metering section	m^2
D_w	moisture diffusivity	m^2/s
E	temperature difference error in non-plane specimens	-

Symbol	Quantity	Unit
Fo	Fourier's number	-
R	thermal resistance	m²·K/W
$\mathcal{T}$	transfer factor	W/(m·K)
T_1	temperature of the warm surface of the specimen	K
T_2	temperature of the cold surface of the specimen	K
T_m	mean test temperature (usually $(T_1 + T_2)/2$)	K
V	volume	m³
Z_v	moisture resistance	s/m
a	moisture factor	W·m²/(kg·K)
c	specific heat capacity	J/(kg·K)
d	thickness; average thickness of a specimen	m
e	edge temperature ratio	-
e_h	heat flow meter output voltage	mV
er_p	percent error due to phase changes	-
er_d	percent error due to non-uniform moisture distribution	-
f	calibration factor of the heat flow meter	W/(mV·m²)
f_r	multiplying factor for measured thermal resistance	-
g	density of moisture flow rate	kg/(m²·s)
h_e	latent enthalpy of evaporation per mass	J/kg
m	mass (of the specimen)	kg
q	density of heat flow rate	W/m²
p	deviation of the specimen surface from a true plane	mm
r	thermal resistivity	K·m/W
t	time	s
v	humidity by volume	kg/m³
v_{sat}	humidity by volume at saturation	kg/m³
w	moisture content mass by volume	kg/m³
w_m	mean moisture content mass by volume	kg/m³
ΔR	increments of thermal resistance	m²·K/W
ΔT	temperature difference (usually $T_1 - T_2$)	K
Δd	increments of thickness	m
Δm	relative mass change	-
Δt	time interval	s
Δw	change in moisture content (mass by volume)	kg/m³

Symbol	Quantity	Unit
Φ	heat flow rate	W
γ	conditioning time factor	s/m² (or h/cm²)
δ_v	moisture permeability with regard to humidity by volume	m²/s
λ	thermal conductivity	W/(m·K)
λ_t	thermal transmissivity	W/(m·K)
λ^*	hygrothermal transmissivity	W/(m·K)
λ_0	thermal conductivity of dry material	W/(m·K)
ξ_d	moisture differential capacity, dw/dz	kg/m³
ξ	porosity	-
ξ_P	local porosity	-
ρ	density	kg/m³
φ	relative humidity	-

NOTE The meaning of some additional subscripts is specified in the text.

4 Principle

4.1 Apparatus

Both the guarded hot plate apparatus and the heat flow meter apparatus are intended to establish within homogeneous specimens with flat parallel faces, in the form of slabs, a unidirectional constant and uniform density of heat flow rate. The part of the apparatus where this takes place with acceptable accuracy is around its centre; the apparatus is therefore divided in a central metering section in which measurements are taken, and a surrounding guard section.

4.2 Measuring the density of heat flow rate

With the establishment of steady state in the metering section, the density of heat flow rate, q, is determined from measurement of the heat flow rate, Φ, and the metering area, A, that the heat flow rate crosses.

4.3 Measuring the temperature difference

The temperature difference across the specimens, ΔT, is measured by temperature sensors fixed at the surfaces of the apparatus in contact with the specimen and/or those of the specimens themselves, where appropriate.

4.4 Deriving the thermal resistance or transfer factor

The thermal resistance, R, is calculated from a knowledge of q, A and ΔT if the appropriate conditions given in A.3.2 are realized. From the additional knowledge of the thickness, d, of the specimen, the transfer factor, $\mathcal{T}$, is computed.

4.5 Computing thermal conductivity, thermal transmissivity or hygrothermal transmissivity

The mean thermal conductivity, λ, thermal transmissivity λ_t, or hygrothermal transmissivity λ^*, of the specimen may also be computed if the appropriate conditions to identify them and those given in A.4.3 are realised.

4.6 Apparatus limits

The application of the method is limited by the capability of the apparatus to maintain a unidirectional, constant and uniform density of heat flow rate in the specimen, coupled with the ability to measure power, temperature and dimensions to the limit of accuracy required, see annex A.

4.7 Specimen limits

The application of the method is also limited by the shape of the specimen(s) and the degree to which they are identical in thickness and uniformity of structure (in the case of two specimen apparatus) and whether their surfaces are flat or parallel, see annex A.

5 Apparatus

5.1 General

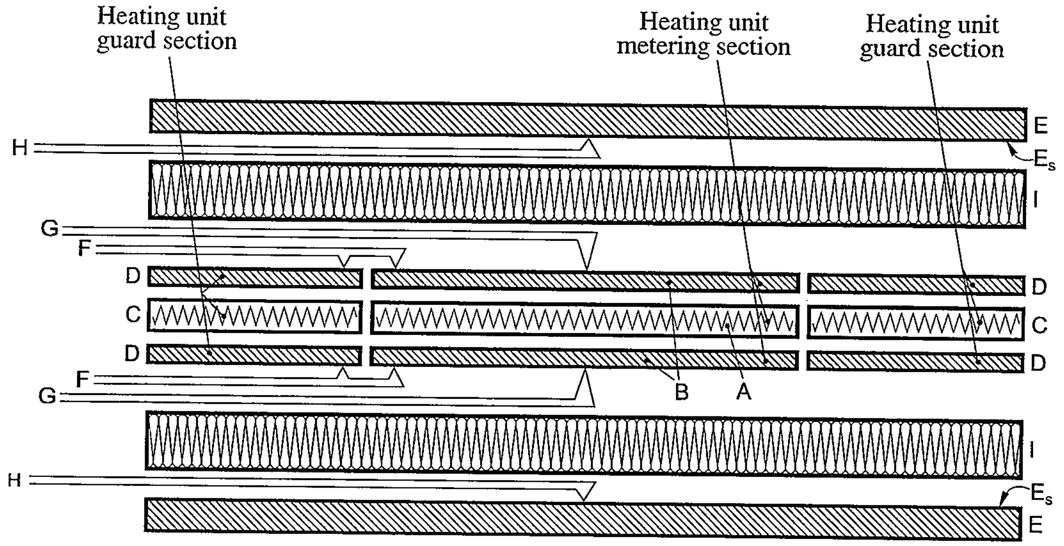
A guarded hot plate apparatus or a heat flow meter apparatus used for measurements according to this standard shall comply with the limits on equipment performance and test conditions given in annex B or annex C of this standard and shall conform with the requirements concerning the assessment of equipment accuracy given in EN 1946-2:1999 or EN 1946-3:1999: this requires that the equipment design, error analysis and performance check be according to section 2 of ISO 8302:1991 or ISO 8301:1991 respectively.

Annex D gives designs of guarded hot plate apparatus which conform with these requirements. For a heat flow meter apparatus see the annex D of EN 12667:2001. If the equipment used is designed precisely in accordance with one of these, an error analysis need not be carried out, even though in all cases a performance check according to EN 1946-2:1999 or EN 1946-3:1999 shall be undertaken for the initial assessment of the equipment.

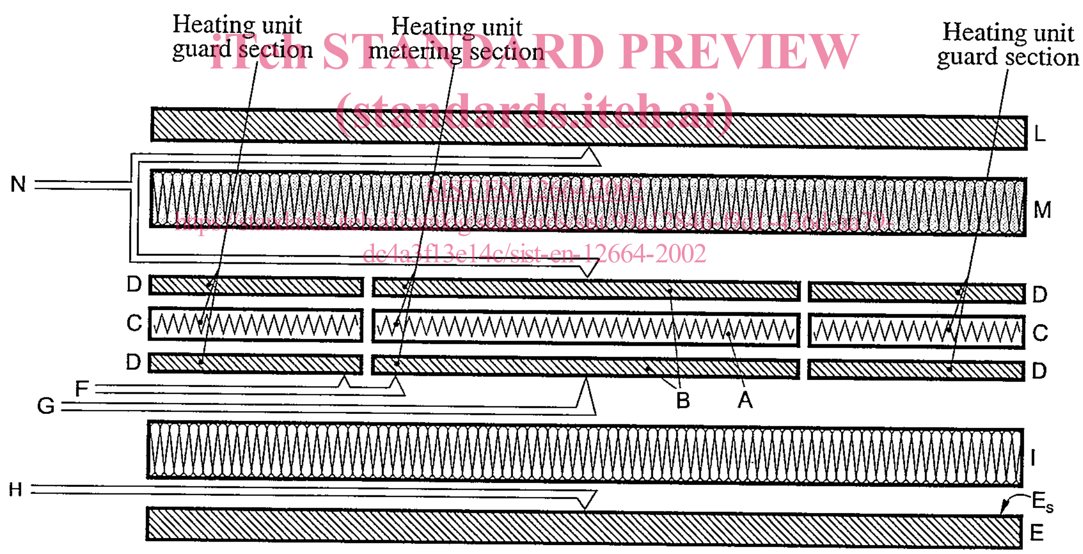
When it is not explicitly stated otherwise, guarded hot plate apparatus requirements are assumed as applicable also to heat flow meter apparatus.

Apparatus width or diameter shall be compatible with aggregate or pore size, see A.3.2.1.

NOTE The preferred overall apparatus width, or diameter, referred to in B.3 is 0,3 m or 0,5 m.



a) Two-specimen apparatus



b) Single-specimen apparatus

Key

A Metering section heater
B Metering section surface plates
C Guard section heater
D Guard section surface plates
E Cooling unit
E_S Cooling unit surface plate
F Differential thermocouples
G Heating unit surface thermocouples
H Cooling unit surface thermocouples
I Test specimen
L Guard plate
M Guard plate insulation
N Guard plate differential thermocouples

The gap is the separation between metering section (see A and B) and the guard section (see C and D)

Figure 1 - General features of two-specimen and single specimen guarded hot plate apparatus

5.2 Guarded hot plate apparatus

5.2.1 General

In a guarded hot plate apparatus the heat flow rate is obtained from the measurement of the power input to the heating unit in the metering section. The general features of the apparatus with specimens installed are shown in Figure 1.

There exist two types of guarded hot plate apparatus, which conform to the basic principle outlined in clause 4:

a) with two specimens (and a central heating unit);

b) with a single specimen.

5.2.2 Two specimen apparatus

In the two specimen apparatus [see Figure 1a)], a central round or square flat plate assembly, consisting of a heater and metal surface plates, called the heating unit, is sandwiched between two nearly identical specimens. The heat flow rate is transferred through the specimens to separate round or square isothermal flat assemblies, called the cooling units.

5.2.3 Single specimen apparatus

In the single specimen apparatus [see Figure 1b)], the second specimen is replaced by a combination of a piece of insulation and a guard plate. A zero temperature-difference is then established across this combination. Providing all other applicable requirements of this standard are fulfilled, accurate measurements and reporting according to this method may be accomplished with this type of apparatus, but particular reference to the modification of the normal hot plate with two specimens should be made in the test report.

5.2.4 Heating unit

The heating unit consists of a separate central metering section, where the unidirectional constant and uniform density of heat flow rate can be established, surrounded by a guard section separated by a narrow gap.

5.2.5 Metering area

The metering area is the central area of the specimen delimited by the centre line of the gap of the heating unit.

This definition, which applies in principle to thick specimens only, has been retained for all the specimens to be tested according to this standard: due to this approximation, the thickness of the specimen shall be at least ten times the width of the gap.

5.2.6 Edge insulation and auxiliary guards

Additional edge insulation and/or auxiliary guard sections are required especially when operating above or below room temperature, see annex B of EN 1946-2:1999.

5.2.7 Cooling units

The cooling units shall have dimensions at least as large as those of the heating unit, including the guard heater(s). They shall consist of metal plates maintained at a constant and uniform temperature.

5.2.8 Accuracy and repeatability

Accuracy and repeatability depend both on the equipment and on testing conditions. The complete assessment of testing errors in a guarded hot plate apparatus in any specific testing condition shall be carried out in accordance with EN 1946-2:1999. The following is rough information applicable for tests correctly executed when the mean temperature of the test is near the room temperature.

Equipment constructed and operated in accordance with this standard (see also annex B) is capable of measuring thermal properties of medium and low thermal resistance products accurate to within ± 2 %.

The repeatability of subsequent measurements made by the equipment on a specimen maintained within the apparatus without changes in testing conditions is typically better than ± 0,5 %.

When measurements are made on the same reference specimen removed and then mounted again, the repeatability of measurements is normally better than ± 1 %. This larger figure is due to minor changes in testing conditions, like the pressure of the plates on the specimen (which affects contact resistances), the relative humidity of the air around the specimen (which affects its moisture content), etc.

The repeatability of measurements on a moist specimen is a combination of the repeatability of the equipment, which should be better than 1 %, and the repeatability of the testing conditions, in particular moisture content, see annex F.

5.2.9 Accuracy and repeatability when testing low thermal resistance specimens

As stated in 5.2.8, the accuracy of measurements on good quality dry specimens having a thermal resistance equal to or greater than 0,1 $m^2 \cdot K/W$ should be better than 2 % for guarded hot plate apparatus. Specimens having thermal resistances between 0,1 $m^2 \cdot K/W$ and 0,02 $m^2 \cdot K/W$ can be tested according to ISO 8302:1991 only; the corresponding accuracy is progressively reduced to 5 %, see A.3.6.2. When testing moist specimens, there may be additional substantial errors, see 7.2.3.4.

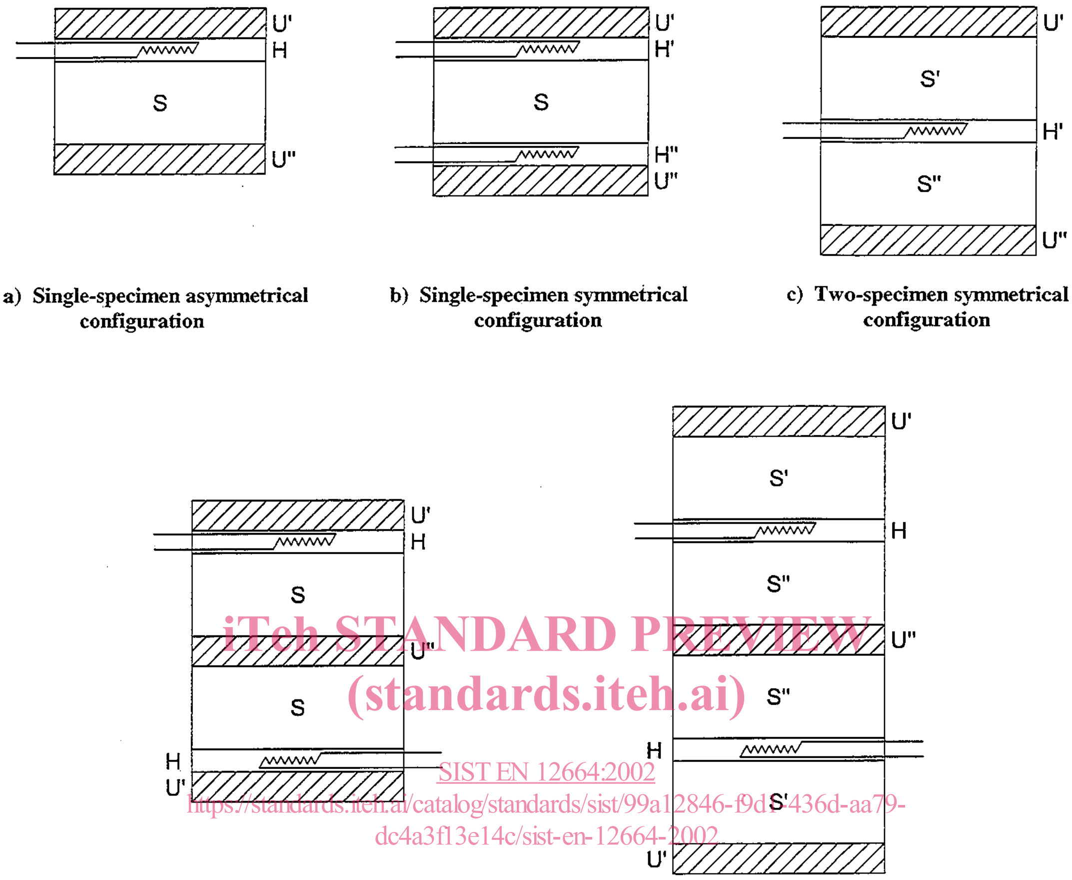
5.3 Heat flow meter apparatus

5.3.1 General

In the heat flow meter apparatus the density of heat flow rate is measured by means of one or two heat flow meter(s) placed against the specimen(s).

The general features of heat flow meter apparatus are shown in Figure 2; they consist of a heating unit, one or two heat flow meters, one or two specimens and a cooling unit. In configuration a), which is called "single-specimen asymmetrical", the heat flow meter may be placed against either unit; the configuration b) is called "single-specimen symmetrical"; in configuration c), which is called "two-specimen symmetrical", the specimens should be substantially identical. Each configuration yields equivalent results if used within the limitations stated in this standard.

NOTE There are distinct advantages for each method in practice; brief discussion is included in annex B of ISO 8301:1991.



d) Double apparatus

e) Double apparatus

Key

U', U"	Cooling and heating units
H, H', H"	Heat flow meters
S, S', S"	Specimens

Figure 2 - Typical layouts of heat flow meter apparatus configurations

5.3.2 Heat flow meters

The heat flow meter is an assembly that measures the density of heat flow rate through the specimen(s) by a temperature difference generated by this density of heat flow rate crossing the specimen(s) and the heat flow meter itself. Most commonly it consists of a homogeneous core, a surface temperature difference detector (a multi-junction thermopile) and a surface temperature detector(s). The heat flow meter region occupied by the core, where temperature difference detectors are placed, is called the metering area.

A density of heat flow rate q, through the metering area of the device results in an output e_h:

$$q = f\, e_h$$

The calibration factor f, which correlates e_h and q, is not a constant in all cases, but may depend upon temperature and, to a more limited extent, upon the density of heat flow rate.