# SLOVENSKI STANDARD
# SIST EN 1946-2:2000

**01-junij-2000**

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**Toplotne značilnosti gradbenih proizvodov in delov stavb - Posebna merila za ocenjevanje laboratorijev, ki merijo lastnosti pri prenosu toplote - 2. del: Meritve z zaščiteno vročo ploščo**

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

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Wärmetechnisches Verhalten von Bauprodukten und Bauteilen -Technische Kriterien zur Begutachtung von Laboratorien bei der Messungen von Wärmeübertragungseigenschaften - Teil 2: Messung nach Verfahren mit dem Plattengerät

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Performance thermique des produits et composants pour le bâtiment - Criteres particuliers pour l'évaluation des laboratoires mesurant les propriétés de transmission thermique - Partie 2: Mesurages selon la méthode de la plaque chaude gardée

**Ta slovenski standard je istoveten z:** **EN 1946-2:1999**

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**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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2003-01.Slovenski inštitut za standardizacijo. Razmnoževanje celote ali delov tega standarda ni dovoljeno.

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EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

**EN 1946-2**

January 1999

ICS 91.100.01; 91.120.10

Descriptors: building products, heat transfer, thermal resistance, testing, laboratory assessment, hot plate, error analysis, performance check

English version

# 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

Performance thermique des produits et composants pour le bâtiment - Critères particuliers pour l'évaluation des laboratoires mesurant les propriétés de transmission thermique - Partie 2: Mesurages selon la méthode de la plaque chaude gardée

Wärmetechnisches Verhalten von Bauprodukten und Bauteilen Technische Kriterien zur Begutachtung von Laboratorien bei der Durchführung der Messungen von Wärmeübertragungseigenschaften - Teil 2: Messung nach Verfahren mit dem Plattengerät

This European Standard was approved by CEN on 13 December 1998.

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

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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 1999, and conflicting national standards shall be withdrawn at the latest by July 1999

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 guarded hot plate method
Part 3: Measurements by heat flow meter method
Part 4: Measurements by hot box methods
Part 5: Measurements by pipe test methods

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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.

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# 1 Scope

This part 2 of this standard provides specific technical criteria for the assessment of laboratories to undertake steady-state heat transfer property measurements by the guarded hot plate method according to prEN 12667 and prEN 12664.

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, equipment description and on calculations for the equipment design and error analysis.

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

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# 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 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 |
| prEN 12664:1996 | Building materials - 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 |
| prEN 12667:1996 | Building materials - Determination of thermal resistance by means of guarded hot plate and heat flow meter methods - Products of high and medium thermal resistance |
| prEN 12939 | Building materials - Determination of thermal resistance by means of guarded hot plate and heat flow meter methods - Thick products of high and medium thermal resistance |
| ISO 8302:1991 | Thermal insulation - Determination of steady-state thermal resistance and related properties - Guarded hot plate apparatus |

# 3 Definitions

The definitions in EN 1946-1 and in ISO 8302:1991 also apply to this part of the standard.

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# 4 Equipment manual

## 4.1 General

The equipment manual shall provide the information specified in 5.2.2 to 5.2.5 of EN 1946-1:1999 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 B of prEN 12664:1996 or prEN 12667:1996, which indicates all limiting values for apparatus performance and testing conditions, 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 specifications

According to 2.3.1 of ISO 8302:1991, the upper and lower limits for the following relevant tested properties and testing conditions, including possible interactions among them, shall be specified:

- specimen thickness;
- thermal resistance;
- temperature difference across the specimen;
- heating and cooling unit temperature;
- surrounding environment (temperature, relative humidity) at the edge of the specimen during the test.

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## 4.3 Equipment description

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

- principle of operation (see 1.6.1 of ISO 8302:1991);
- type of apparatus (see 1.6.2.1, 1.6.2.2 and 1.6.4 of ISO 8302:1991);
- principal dimensions of apparatus, in particular heating unit width, guard width and gap width;
- simple diagrams illustrating the design of the equipment with special attention to the gap design (see 2.1.1.5 of ISO 8302:1991), the cooling unit piping (see 2.1.2 of ISO 8302:1991) and edge insulation (see 2.1.3 of ISO 8302:1991);
- position, connections and numbering of temperature sensors (see 2.1.4.1 of ISO 8302:1991);
- electrical components/instruments, apparatus enclosure and main ancillary equipment;
- details of data acquisition system and related computer programs for data analysis.

To avoid duplication, reference can be made to manuals supplied by the instrument manufacturers or to relevant clauses of ISO 8302:1991.

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## 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 of the design guidelines followed, and the error analysis based on 2.2 of ISO 8302:1991, as summarized in 4.4.2 to 4.4.11.

Some guidelines on error analysis are given in this subclause; more specific information on some errors is supplied in annex B, while error calculations are supplied in annex C for some typical cases. Examples of equipment conforming to annex C are supplied in D.2 of prEN 12664:1996 and in D.2 of prEN 12667:1996. For equipment having characteristics exactly as indicated in this subclause or design details as indicated in annex C of this part and in D.2 of prEN 12664:1996 or in D.2 of prEN 12667:1996, no further calculations are needed. In other circumstances similar calculations can be performed by analogy.

### 4.4.2 Edge heat losses and maximum specimen thickness

According to 3.2.1 of ISO 8302:1991, the sum of the imbalance error and edge heat loss error shall be kept within 0,5 %. In a good equipment design, the two errors will be of the same order of magnitude, hence a 0,25 % limit can be suggested for both. Table 1 shows for some apparatus dimensions the maximum allowed specimen thickness according to 2.2.1 of ISO 8302:1991, when there is no edge insulation and when the edge temperature ratio, $e$, is 0,25; $e$ is defined as $(T_e - T_2) / (T_1 - T_2)$, where $T_1$ and $T_2$ are respectively the temperatures of the hot and cold surfaces of the specimen, and $T_e$ is the temperature at the edge of the specimen, assumed to be uniform.

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**Table 1: Minimum and maximum allowed specimen thickness**

Dimensions in millimetres

| Overall size | Metering section | Guard width | Maximum thickness (edge limit for e = 0,25) | Flatness tolerance (0,025%) | Minimum thickness (flat. tol.) | Max. gap | Minimum thickness [1] (gap limit) |
|---|---|---|---|---|---|---|---|
| 200 | 100 | 50 | 30 | 0,05 | 10,0 | 1,25 | 12,5 |
| 300 | 200 | 50 | 35 | 0,08 | 15,0 | 2,50 | 25,0 |
| 300 | 150 | 75 | 45 | 0,08 | 15,0 | 1,88 | 18,8 |
| 400 | 200 | 100 | 60 | 0,10 | 20,0 | 2,50 | 25,0 |
| 400 | 100 | 150 | 80 | 0,10 | 20,0 | 1,25 | 12,5 |
| 500 | 300 | 100 | 65 | 0,13 | 25,0 | 3,75 | 37,5 |
| 500 | 250 | 125 | 75 | 0,13 | 25,0 | 3,13 | 31,3 |
| 500 | 200 | 150 | 85 | 0,13 | 25,0 | 2,50 | 25,0 |
| 600 | 300 | 150 | 90 | 0,15 | 30,0 | 3,75 | 37,5 |
| 800 | 500 | 150 | 100 | 0,20 | 40,0 | 6,25 | 62,5 |
| 800 | 400 | 200 | 120 | 0,20 | 40,0 | 5,00 | 50,0 |
| 1000 | 500 | 250 | 150 | 0,25 | 50,0 | 6,25 | 62,5 |

1) Thicknesses applicable for gap widths according to the seventh column of table 1 ; for thinner gaps see 4.4.3.

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EXAMPLE: $e$ = 0,25 corresponds to a temperature of the edge of the specimen 5 K below the mean test temperature, when the temperature difference between the hot and cold side of the specimen is 20 K.

NOTE: The edge heat loss error is zero for homogeneous isotropic specimens when $e$ is close to 0,5; the absolute value of the edge heat loss error increases almost symmetrically when $e$ deviates on either side from 0,5. In the range $0{,}25 \leq e \leq 0{,}75$, this error is maximum for $e$ = 0,25.

Larger specimen thicknesses can be used for some specimens if edge insulation or edge temperature control is used, if auxiliary or gradient guards are installed, or medium and high conductivity specimens are tested. See annex B for additional information.

When the maximum specimen thickness to be specified according to 4.2 exceeds the appropriate value given in table 1, lateral losses shall be calculated. If, according to these calculations they exceed those permitted by ISO 8302:1991, the performance check data shall be examined and, if no experimental evidence exists to justify the claimed maximum specimen thickness, the maximum specimen thickness to be specified according to 4.2 shall be reduced.

#### 4.4.3 Maximum gap width and minimum specimen thickness

According to 2.1.1.3 of ISO 8302:1991 the gap width, $g$, shall be such that the gap area is less than 5 % of the metering area, i.e. the gap width, $g$, shall not be greater than 1,25 % of the metering area side, $L$. The maximum gap width resulting from this requirement is given in the seventh column of table 1. The minimum specimen thickness, $d_m$, is related to the gap width. $d_m$ shall be at least ten times the gap width, see 1.7.6 of ISO 8302:1991. Thus, when the gap width reaches its maximum allowed value according to the above criteria, the minimum specimen thickness shall not be less than 12,5 % of the side $L$ of the metering section. The minimum specimen thickness resulting from these requirements is given in the eighth column of table 1. When the minimum specimen thickness to be specified according to 4.2 is less than those of the eighth column of table 1, the actual gap width, $g$, shall be used to compute $d_m = 10\,g$, see also 4.4.6. If this requirement is not met, then the minimum specified specimen thickness shall be increased to meet this requirement.

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Minimum specimen thickness shall also be checked against maximum allowed flatness tolerances, see 4.4.9, 4.4.10 and 4.4.11.

#### 4.4.4 Imbalance error

According to 2.2.1 of ISO 8302:1991, an error heat flow rate $\Phi_g$ can be expressed as follows:

$$\Phi_g = (\Phi_0 + \lambda\, c)\Delta T_g \qquad (1)$$

where $\Delta T_g$ is the actual gap temperature imbalance through the apparatus and $\Phi_0$, representing the heat flow rate for a 1 K gap imbalance through the apparatus itself, is the sum of:

- $\Phi_a$ through the air in the gap;
- $\Phi_r$ by radiation through the gap;
- $\Phi_m$ through the mechanical connections through the gap;
- $\Phi_c$ through copper wires;
- $\Phi_w$ through metal wires (excluding copper).

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To calculate these terms, the elementary equations of heat transfer through a plane layer can be used.

$\lambda c$ is the heat flow rate through both specimens due to a 1 K gap imbalance with $c$ expressed by the following equation:

$$c = (16\, l/\pi) \ln[4/(1 - \exp(-\pi g/d)] \qquad (2)$$

In this equation $2l = L$ is the side of the metering area (centre gap to centre gap), $g$ is the gap width and $d$ is the maximum expected specimen thickness.

If the edge heat loss error is 0,25 %, (see 4.4.2 of this standard and 3.2.1 of ISO 8302:1991), $\Delta T_g$ shall be such that $\Phi_g$ is smaller than 0,25 % of the heat flow rate through the metering section of both specimens.

This calculation changes according to the gap design and is the most critical part of the evaluation of guarded hot plate accuracy. Some calculations are offered as an example in annex C of this standard.

Because the balancing thermopile detects a temperature difference that does not correspond exactly with the actual temperature imbalance through the surfaces of the metering section and guard ring metal plates facing the gap, the maximum acceptable value for $\Delta T_g$ shall be larger than the uncertainty in the imbalance detection. A discussion on the imbalance detection through the gap is given in 2.1.1.5 of ISO 8302:1991.

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When the balancing thermopile is placed directly within the central section and guard ring metal plates, see figure 4 b) of ISO 8302:1991, the density of heat flow rate crossing them during the tests shall be evaluated and the corresponding temperature drop through the metal plates computed. If this temperature difference is smaller than $\Delta T_g$, the gap design is acceptable without further checks, otherwise the tolerances for the positions of thermopile junctions within the metal plates shall be checked.

When the balancing thermopile is embedded in plastic sheets either placed between the metal plates and the heaters or between the metal plates and the specimen, the effect of the resistances between the metal plates and the thermopile junctions due to the plastic sheets and possible air pockets shall be evaluated as a temperature difference equal to the product of the relevant thermal resistance and the density of heat flow rate crossing it.

The sum of imbalance and edge heat losses shall not be larger than 0,5 %.

The electrical instrumentation used for the imbalance detection shall be capable of detecting voltages less than $\Delta T_g$ multiplied by the number of elements of the balancing thermopile and by the thermoelectric power of each element. The electrical balance maintained during the tests shall therefore be better than the voltage computed in this way. If this requirement is not met, the measured data of the performance check shall be verified and if the sensitivity of the instrumentation for the imbalance detection is still not satisfactory, this shall be rectified. Particular care shall also be taken to ascertain that the quality of the electrical connections and the switches (with reference, in particular, to thermal electromotive forces) is compatible with the level of imbalance to be detected.

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### 4.4.5 Error in measured electrical power

The uncertainty in the measurement of electrical power shall be within 0,1 % to comply with B.1 of prEN 12667:1996 and B.1 of prEN 12664:1996.

### 4.4.6 Error in the definition of the metering area

The metering area is defined as the area enclosed by the line defining the centre of the gap (see 1.7.6 of ISO 8302:1991; see also 3.1 of ISO 8302:1991 for some special applications). This area is not equal in all testing conditions to the actual metering area of the specimen crossed by the heat flow rate supplied by the metering section of the heating unit; to this uncertainty shall be added the uncertainty in the measurement of the dimensions of the apparatus. An uncertainty due to mechanical tolerances in the measurement of the centre-gap to centre-gap distance up to 0,1 % can be accepted.

NOTE: The distance between the line defining the actual metering area of the specimen and the line defining the centre of the gap can be estimated to be within 5 % of the gap width.

### 4.4.7 Error in the temperature difference between the heating and cooling units of the apparatus

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According to 2.1.4.1.2 of ISO 8302:1991, the total error in the temperature difference measured by the temperature sensors permanently mounted in the apparatus shall not exceed 1 %, made up as follows:

- calibration of thermocouples (or other temperature sensors): less than 0,4 %;
- accuracy of measuring instruments: less than 0,2 %;
- uncertainty in the definition of the point where the temperature is measured by the sensor: less than 0,4 %

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NOTE 1: When special grade thermocouples (see annex B of ISO 8302:1991) mounted differentially are used, as in figure 6 b) or 6 c) of ISO 8302:1991, and no additional wire connections between the junctions are made, no calibration is required, and the uncertainty of 0,4 % at room temperature can be achieved for type T thermocouples.

NOTE 2: The absence of additional wire connections between two thermocouple junctions and the care taken to correctly fabricate these junctions and to keep them as isothermal as possible during the tests, are more important than the thermocouple calibration itself. Bad thermocouple connections can induce errors which change with changing test conditions, so derating the accuracy of the calibrations.

NOTE 3: The uncertainty in the definition of the point where the temperature is measured can be assumed to cause an error in the temperature reading not greater than the temperature drop through the metal plates when thermocouples are mounted in grooves in the apparatus metal plates. When thermocouples are mounted in thin sheets, the uncertainty becomes critical and can be assumed to be equal to the temperature drop through a layer of sheet of thickness equal to the diameter of the thermocouple junction.

NOTE 4: Additional errors occur due to contact thermal resistances or due to mounting techniques of the thermocouples on specimen surfaces, see 4.4.10 and 4.4.11.