SLOVENSKI STANDARD
SIST EN 1745:2004

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Zidovje in zidarski proizvodi ï Metode za doloļ anje projektnih (raļ unskih) toplotnih lastnosti

Masonry and masonry products - Methods for determining design thermal values

Mauerwerk und Mauerwerksprodukte - Verfahren zur Ermittlung von Wärmeschutzrechenwerten

Maçonnerie et éléments de maçonnerie - Détermination des valeurs thermiques de calcul

Ta slovenski standard je istoveten z: **EN 1745:2002**

ICS:

91.080.30	Zidane konstrukcije	Masonry
91.120.10	Toplotna izolacija stavb	Thermal insulation

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Masonry and masonry products - Methods for determining design thermal values

Maçonnerie et éléments de maçonnerie - Détermination des valeurs thermiques de calcul

Mauerwerk und Mauerwerksprodukte - Verfahren zur Ermittlung von Wärmeschutzrechenwerten

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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 Management Centre has the same status as the official versions.

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COMITÉ EUROPÉEN DE NORMALISATION
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Contents

Foreword

This document (EN 1745:2002) has been prepared by Technical Committee CEN/TC 125 "*Masonry*", the secretariat of which is held by BSI.

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of an identical text or by endorsement, at the latest by October 2002, and conflicting national standards shall be withdrawn at the latest by October 2002.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

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

The following clauses in this Standard are the subject of an A-deviation resulting from a request by France:

4.1, 4.2.1, 4.2.2.4, 4.3, 5.1, 5.2.1, 6.2 and 6.3.1.2.

Further details on the A-deviation are given in annex ZA (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, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

This standard provides rules for the determination of design values for thermal conductivity and thermal resistance of both masonry and masonry products.

It also describes how the basic values for the calculation of design thermal values are determined and also the calculation methods to derive design values from basic values. It covers solid masonry units (clauses 4 and 5) and masonry units with formed voids and composite masonry units (clause 6).

Three procedures for the determination of thermal resistance and/or thermal conductivity are described. These procedures are:

— To use tabulated lambda - and/or *R*-values.

— To measure the lambda - and/or *R*-value.

— To calculate the equivalent lambda - and/or *R*-value.

It takes into account the major different types of masonry products:

— Solid masonry units.

— Masonry units with formed voids.

— Composite masonry units.

The **design value** of a product characteristic is the value determined for specific application and for use in calculations.

Design thermal values are determined, according to the procedure given in this standard by the user/designer and building authority according to the intended application, environmental and climatic conditions, bearing in mind the purpose of this determination, such as:

— energy consumption;

— design of heating and cooling equipment;

— surface temperature determination;

— compliance with national building codes;

— consideration of non steady state thermal conditions in buildings.

A specific building product can have different design thermal values according to the intended application. Normally the producers/distributors will supply design values for their products.

1 Scope

This European Standard gives procedures for the determination of design thermal values (thermal resistance and/or thermal conductivity) of masonry and masonry products.

2 Normative references

This European Standard incorporates by dated or undated references, 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 European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 771(all parts), *Specification for masonry units*

EN 772-3, *Methods of test for masonry units — Part 3: Determination of net volume and percentage of voids of clay masonry units by hydrostatic weighing*

EN 772-4, *Methods of test for masonry units — Part 4: Determination of real and bulk density and of total and open porosity for natural stone masonry units*

EN 772-13, *Methods of test for masonry units — Part 13: Determination of net and gross dry density of masonry units (except for natural stone)*

EN 772-16, *Methods of test for masonry units — Part 16: Determination of dimensions*

EN 1015-10, *Methods of test for mortar for masonry — Part 10: Determination of dry bulk density of hardened mortar*

EN 1934, *Thermal performance of buildings — Determination of thermal resistance by hot box method using heat flow meter — Masonry*

EN ISO 6946:1996, *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, *Thermal insulation — Determination of steady-state thermal transmission properties — Calibrated and guarded hot box (ISO 8990:1994)*

EN ISO 10211-1, *Thermal bridges in building construction — Heat flows and surface temepratures — Part 1: General calculation methods (ISO 10211-1:1995)*

EN ISO 10456, *Building materials and products —Products for determining declared and design values (ISO 10456:1999)*

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

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

prEN 12664, *Thermal performances 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*

3 Terms, definitions and symbols

For the purposes of this European Standard the following terms, definitions and symbols and those given in EN ISO 7345 apply.

3.1 Terms and definitions

3.1.1
masonry
assemblage of masonry units laid in a specified pattern and joined together with masonry mortar

3.1.2
masonry product
masonry units, masonry mortars, rendering and plastering mortars

3.1.3
solid masonry unit
masonry unit containing no perforations except e.g. external indentations such as gripholes, grooves etc

3.1.4
composite masonry unit
masonry unit made from more than one material

3.1.5
thermal value
common term for either the thermal conductivity [W/(m.K)] or the thermal resistance [m^2.K/W]

3.1.6
basic thermal value
value of a thermal property of a building material or product in a dry state determined according to this standard as a basis for the calculation of design thermal values

NOTE The basic thermal value can be expressed as thermal conductivity or thermal resistance.

3.1.7
design thermal value
value of a thermal property of a building material or product under specific external and internal conditions which can be considered as typical of the performance of that material or product when incorporated in a building component

NOTE The design thermal value can be expressed as the thermal conductivity or thermal resistance .

3.1.8
equivalent thermal conductivity
value which is derived by dividing the thickness of a given masonry unit or structure by its thermal resistance

3.1.9
reference conditions
set of conditions identifying a state of equilibrium selected as the base to which the thermal values of building materials and products are referred

3.1.10
dry state
state after drying under conventional conditions as stated in the relevant product standards

3.2 Symbols

Symbol	Quantity	Unit
$\lambda_{10,dry}$	thermal conductivity in dry state at an average temperature of 10 °C	W/(m.K)
λ_I	individual measured thermal conductivity	W/(m.K)
λ_U	design thermal conductivity	W/(m.K)
λ_{equ}	equivalent thermal conductivity	W/(m.K)
R_I	individual measured thermal resistance	m^2.K/W
R_U	design thermal resistance	m^2.K/W
T	temperature	K
μ	water vapour diffusion coefficient	
c	specific heat capacity	kJ/(kg.K)
l	length of a masonry unit	mm
w	width of a masonry unit	mm
H_U,h_U	height of a masonry unit	mm
H_M,h_M	thickness of a mortar joint	mm
F_m	moisture conversion factor	
f_u	moisture conversion coefficient	kg/kg
f_ψ	moisture conversion coefficient	m^3/m^3
u	moisture content mass by mass	kg/kg
ψ	moisture content volume by volume	m^3/m^3
U	thermal transmittance	W/(m^2.K)
P	fractile of population	%

4 Procedures to determine design thermal values for solid masonry units and mortars

4.1 General

For solid masonry units the λ-value of the material and the equivalent λ-value of the product are identical.

NOTE Gripholes not passing through the unit are not considered as perforations.

The basic λ-values of solid masonry units and of mortars can be determined from tests carried out on samples of the material or from tables or graphs which relate $\lambda_{10,dry}$ to density. In both cases the λ-value is to be representative of the material as defined in the product standard.

From these basic λ-values, design R_U- or λ_U-values can be calculated, taking into account the influence of moisture.

The design R_U- or λ_U-values of masonry built from solid masonry units can be determined from tables or from tests carried out on masonry samples or from calculations.

4.2 Basic λ-values for solid masonry units and mortars

4.2.1 Tabulated λ-values (determination based on λ-density relation only)

$\lambda_{10,dry}$-values for different materials used for masonry products are given in annex A, differentiated by the type of material and the dry density of the material. This annex also contains values for the water vapour diffusion coefficient, the specific heat and the moisture coefficient, which describes the increase of λ per percent increase of moisture content.

These tabulated values are valid for materials where there is production control of density but no directly measured λ-values. The values are given as 50 % and 90 % fractiles (P) of the existing range of λ-values for a certain material for a given density.

4.2.2 Measured λ-values (determination based on λ-density relation and initial type testing of λ)

When a manufacturer decides to determine a λ-value from test measurement, the following procedure shall be used:

4.2.2.1 Test specimens

Take detailed information about test specimens from ISO 8302 and from prEN 12664.

NOTE Care should be taken that the test specimens are representative of the masonry product itself. An appropriate way to ensure this, is to cut specimens from masonry units.

4.2.2.2 Conditioning of specimens

Normally masonry materials are tested in a dry condition. It is also possible to carry out tests in a moist condition (e.g. conditioned to constant mass in an environment of 23 °C ± 2 °C and 50 % ± 5 % relative humidity), in which case the measured value has to be converted to the dry state.

4.2.2.3 Test measurement

Use as the reference test method ISO 8302. More detailed information about the testing procedure for masonry materials is given in prEN 12664.

Alternative test methods, such as ISO 8301, which may require different test specimens and different conditioning methods, may be used, if the correlation between the reference test method and the alternative method can be given.

4.2.2.4 The determination of the basic λ-value

The determination of the basic λ-value is based on the mean λ-value and the limit λ-value. Three items of information are necessary for this determination procedure:

1) The tabulated λ-density-correlation for the given material (see annex A).

2) The product density range, which can be derived either from the production history or from the density tolerances which are given in the relevant product standards.

3) At least three individual test measurements on density and λ_i, which shall ensure that the basic λ-value is representative for the current material produced. The three tests have to be carried out on specimens from different production batches to represent the manufactured product density range. These three measurements are used to determine the distance of the individual λ-density-curve, for a defined production, from the tabulated λ-density curve.

Then use the following procedure:

Calculate the arithmetic mean value of the 3 λ-results.

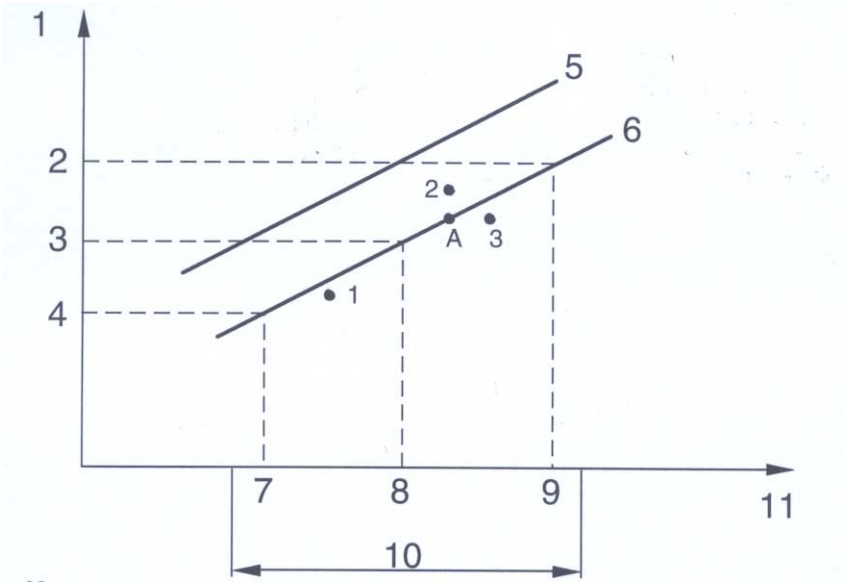
Measure the density of each of the three samples in accordance with EN 772-4 or EN 772-13 or EN 1015-10 and calculate the arithmetic mean value of the 3 results.

Through the point A representing mean thermal conductivity and mean density draw a λ/density-curve parallel to the general λ/density-curve obtained from plotting the tabulated λ- and density-values for the product (material) given in annex A.

Derive the mean λ-value of the product from the average density. Derive the upper and lower limit values as the values that represent 90 % and 10 % of the manufactured product density range with a confidence level of 90 % according to EN ISO 10456.

Express the basic λ-value as the mean λ-value together with the difference between the limit and the mean value.

Figure 1 shows this process in the form of a graph.



Key

1 $\lambda_{10,dry}$ (W/mK)
2 Upper limit λ value
3 Mean λ value
4 Lower limit λ value
5 Curve resulting from tabulated values (annex A)
6 Parallel curve drawn through point A
7 10 % of production
8 Mean density
9 90 % of production
10 Product density range
11 Density (kg/m^2)

Figure 1 — Derivation of the basic λ-value

NOTE For factory production control purposes thermal conductivity may be controlled indirectly from the dry density of the material.

4.3 Design R_U- or λ_U-values for solid masonry units and mortars

From the basic λ-values, design R_U- or λ_U-values are calculated using the moisture conversion coefficients given in annex A for each type of material and the nationally given design moisture content for a certain material in a certain application. The calculation shall be done according to EN ISO 10456, using the following formulae:

$$\lambda_2 = \lambda_1 \times F_m \text{ or } R_2 = \frac{R_1}{F_m}$$

with

$$F_m = e^{f\psi(\psi_2 - \psi_1)} \text{ or } F_m = e^{f_u(u_2 - u_1)}$$

5 Procedures to determine design thermal values (R_U or equivalent λ_U) of masonry built from solid masonry units and mortar

5.1 Test measurements

If a manufacturer decides to determine R_U or equivalent λ_U-values from test measurements, the following procedure shall be used:

— Select test samples from 3 different production batches.

— From each of these batches erect one wall.

— Measure the thermal resistance and/or the equivalent thermal conductivity on each of those walls, following EN ISO 8990 or EN 1934.

— Calculate the mean thermal resistance and/or equivalent thermal conductivity from the 3 test results.

— Obtain the design value for the thermal resistance and/or the equivalent thermal conductivity of the masonry wall on the basis of this mean value, taking into account the design moisture contents given nationally.

Quote the masonry unit type and its respective EN from EN 771 series, the accompanying unit mass (dry mass or mass at the nationally given design moisture content) and the geometry of the test specimens as well as the thermal conductivity and the geometry (e.g. twin strip) of the mortar joint used for the measurement.

For the calculation of R_U or equivalent λ_U-values at any other design moisture contents, it is necessary to cater for the influence of moisture. The values for the moisture correction coefficients can be derived from tests, carried out at several moisture contents. Alternatively the moisture correction coefficient can be taken from national documents. If neither of these possibilities exists, use a moisture correction coefficient for all types of materials and geometries of 6 %, (i.e. the thermal resistance of the masonry changes 6 % per volume percent change of moisture).

If there are unit types that are usually combined with different mortar types, provide thermal values for all these combinations.

NOTE As an approximation the measured values with low thermal insulation mortar may be converted to a corresponding value with high thermal insulation mortar and vice versa by a simple mean value calculation of the thermal coupling factors (*1/R*) according to the area ratio of mortar joints and units, provided that the ratio of the thermal resistances of the masonry unit layer and the mortar layer is not more than 1:5.

5.2 Calculation methods

5.2.1 General

Determine the λ-values of the materials, which are necessary input parameters for calculation methods, either according to 4.2.1 or 4.2.2.

Determine the R_U- or equivalent λ_U-value of the masonry according to the following procedure:

basic λ-value ($\lambda_{10,dry}$) $\rightarrow$ moisture $\rightarrow$

correction (see 4.3) $\rightarrow$ λ_U-value of the material$\rightarrow$ calculation $\rightarrow$

R_U- or equivalent λ_U-value of the masonry.

The moisture correction coefficients for materials given in annex A shall be used.

5.2.2 Numerical calculation

The requirements for appropriate calculation programs (accuracy, boundary conditions, etc.) are given in annex D.

NOTE Numerical calculation procedures (e.g. Finite Element Method or Finite Difference Method, etc.) lead to accurate calculation results, even where there are large differences between the lambda-values of the unit material and the masonry mortar.

5.2.3 Simplified calculation

The method described in EN ISO 6946:1996 may be used.

6 Procedures to determine design thermal values (R_U or equivalent λ_U) for masonry units with formed voids and composite masonry units and for walls built from such units and mortar

6.1 General

The thermal properties of masonry units with formed voids cannot fully be determined from the lambda-value of the material, there is also a high influence from the shape and the geometry of the holes in the unit.

The R_U- or equivalent λ_U-values of masonry built from masonry units with formed voids can be determined either from tables or from test measurements carried out on masonry samples or from calculations. The R_U- or equivalent λ_U-values of masonry built from composite masonry units can be determined either from test measurements carried out on masonry samples or from calculations.

6.2 R_U- or equivalent λ_U-values of masonry units with formed voids and composite masonry units

At present there are several different numerical methods in use (e.g. Finite Difference, Finite Element) for the calculation of the thermal properties of masonry units with formed voids or composite masonry units. The thermal conductivities of the materials are necessary input parameters for such calculations, and these have to be determined according to 4.3.

The requirements for appropriate calculation programs (accuracy, boundary conditions, etc.) are given in annex C.

The method described in EN ISO 6946:1996 may also be used.

6.3 R_U- or equivalent λ_U-values of masonry built from masonry units with formed voids or composite masonry units and mortar

6.3.1 Tabulated values

6.3.1.1 Application of annex B

Examples for basic values for the determination of R_U- or equivalent λ_U-values of masonry built from masonry units with formed voids are given in annex B, differentiated by:

— material;