C4 NATIONAL BUILDING CODE OF FINLAND

Thermal insulation
Guidelines 2003

Ministry of the Environment Decree on thermal insulation

Adopted in Helsinki on the 30th of October 2002

In accordance with the decision of the Ministry of the Environment the following is enacted on the basis of Section 13 of the Land Use and Building Act (132/1999) of 5th February 1999:

One acceptable method in construction is to follow the instructions on thermal insulation in Appendix 1.

The proposed instructions have been notified in accordance with Directive 98/34/EC of the European Parliament and of the Council as amended by Directive 98/48/EC laying down a procedure for the provision of information in the field of technical standards and regulations, and regulations on services of the information society.

This decree shall enter into force on the first of October 2003.
This decree shall rescind the decision on thermal insulation (C4) by the Ministry of the Interior adopted on the 27th of October 1978.

In Helsinki, on the 30th of October 2002

Minister *Suvi-Anne Siimes*

Senior Technical Adviser *Raimo Ahokas*

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Content

KEY TO SYMBOLS

Guidelines printed in the wide column contain acceptable solutions.

Explanations *in italics in the narrow column provide further information and contain references to provisions, regulations and instructions.*

DEFINITIONS

Thermal insulation material
Building material used primarily or in addition to other uses essentially for thermal insulation.

Thermal insulation
A uniform insulation structure made of one or more thermal insulation materials for a building component.

Wind barrier
A material layer in a building component with the main purpose of preventing a detrimental flow of air from outside to the internal part of the structure and back.

Air barrier
A material layer in a building component which prevents a detrimental flow of air through the building component from one side to the other.

Explanation
Often a material layer in a building component, provided for some other main purpose, acts as an air barrier.

Thermal bridge
A structural part in a building component made of material with high thermal conductivity in comparison to the adjacent materials where the steady-state heat flow density due to temperature difference through the surfaces of the building component is higher in comparison to the adjacent surface area.

Linear thermal bridge
A thermal bridge with a cross-section which continues uniformly in the direction of the surface of the building component.

Point thermal bridge
A thermal bridge which is local in structure and with no uniform cross-section in the direction of the surface of the building component.

Thermal conductivity (λ), W/(m · K)
Thermal conductivity indicates the density of heat flow in steady-state through a layer of homogenous material with a thickness of a unit of length when the temperature difference between the surfaces of the material layer is a unit of temperature.

Mean thermal conductivity (λ_{10}), W/(m · K)
The mean thermal conductivity indicates an arithmetic mean value of individual measurement results for thermal conductivity of a material when measurements are taken at the mean temperature of 10°C.

Explanation
If the material is hygroscopic or if thermal conductivity of the material changes with time, the conditions and factors prior to measurements affecting the moisture content or the changes to thermal conductivity by ageing must be stated.

Normative thermal conductivity (λ_n), W/(m · K)
Normative thermal conductivity of a building material refers to a design value of thermal conductivity provided by these guidelines or type approval decisions for calculations in practical building activities.

Thermal resistance (R), (m^2 · K)/W
Thermal resistance of a material layer of a uniform thickness or a layered structure in the thermal steady-state indicates the temperature difference between the isothermal surfaces on both sides of the structure divided by the heat flow density through the material layer.

Internal and external surface resistance (R_{si} and R_{se}), (m^2 · K)/W
Indicates the thermal resistance of the border layer between the surface of a building component and the internal or external environment.

Thermal transmittance (U), W/(m^2 · K)
Thermal transmittance indicates the heat flow density which permeates a building component in steady-state when the temperature difference between the environment on different sides of the building component is the unit of temperature.

Point additional thermal transmittance (X), W/K
Point additional thermal transmittance indicates an increase to the heat flow through the building component in steady-state caused by a point thermal bridge (e.g. steel tie) when the temperature difference between the environment on different sides of the building component is the unit of temperature.

Linear additional thermal transmittance (ψ), W/(m · K)
Linear additional thermal transmittance indicates an increase to the heat flow through the building component in steady-state caused by a linear thermal bridge (e.g. beam) of a unit of length in the building component when the temperature difference between the environment on different sides of the building component is the unit of temperature.

1

GENERAL

1.1 Scope of application

1.1.1 These instructions concern building components and structures of a building, abutted by the open air and the ground, and those between different spaces of a building; determining their *thermal transmittance*, and design and implementation of thermal insulation. The instructions concern practical structures in accordance with good building practices where the effect of minor *non-ideal faults* are taken into account when calculating U-values.

Explanation
These instructions contain an acceptable way to ascertain compliance with the requirements set for thermal transmittance (U) in Part C3 of the National Building Code of Finland.

The EN standards concerning calculation of thermal transmittance for the building envelope, building components and structures, and the EN standards supplementing these standards of calculation form a set of instructions according to which the thermal transmittance may also be determined in an acceptable way.

1.1.2 These instructions do not concern calculation of the effects of air flow directed through thermal insulation; of air leaking through the building components from one side to the other; or of solar radiation on the building or of any other heat loads on the structures fluctuating as a function of time.

2

DETERMINATION OF THERMAL TRANSMITTANCE

2.1 General

These instructions provide a method of calculating *thermal transmittance* (U) for building components and structures. Other methods may also be accepted if these instructions cannot be applied or the replacement method of calculation is at least as accurate as the one provided here. Test results may also be utilised when the calculation is unreasonably difficult or the *input* information necessary for calculation is determined experimentally.

Explanation
An individual measuring result of thermal transmittance is valid only for the tested structure under measuring conditions. When the calculation of thermal transmittance is unreasonably difficult, it is, however, possible to estimate the thermal transmittance for a structure applicable to practical design on the basis of test results. Then the aim must be to take into account any inaccuracies in measuring, any practical variations of the characteristics of the structure and the materials used in it, the effects of moisture content of the materials in accordance with the construction design and any possible irreversible changes to thermal conductivity of building materials during the service life.

2.2 Calculation of thermal transmittance

2.2.1 Thermal transmittances (U) for building components are calculated using thermal conductivity design values determined for building materials provided with a CE mark in accordance with the EN standards; tabulated design values for thermal conductivity stated in the EU standards; values of normative thermal conductivity (λ_n) or any other thermal conductivity design values suitable for the building component and determined in an acceptable way. If the same material is provided with several λ_n-values, the value suitable for the target on the basis of footnotes is selected.

Explanation
Footnotes relating to the values of normative thermal conductivity are given in table 1 and in the type approval decisions for normative thermal conductivity of thermal insulation.

2.2.2 Thermal transmittances (U) are calculated using the formula (1).

$$U = 1 / R_T \quad (1)$$

R_T total thermal resistance of a building component from one environment to another.

2.2.3 When the material layers in a building component are of uniform thickness and the heat is transmitted at right angles to the material layers, the total thermal resistance R_T of a building component is calculated using the formula (2).

$$R_T = R_{si} + R_1 + R_2 + ... + Rm + R_g + R_b + R_{q1} + R_{q2} + ... + R_{qn} + R_{se} \quad (2)$$

where $R_1 = d_1 / \lambda_1$, $R_2 = d_2 / \lambda_2$ ... $R_m = d_m / \lambda_m$

$d_1, d_2, ... d_m$ thickness of material layer 1, 2, ... m, m

$\lambda_1, \lambda_2, ... \lambda_m$ design thermal conductivity of material layer 1, 2, ... m, e.g. *normative* thermal conductivity

R_g thermal resistance of an air cavity in the building component

R_b thermal resistance of the ground

$R_{q1}, R_{q2}, ... R_{qn}$ thermal resistance of thin material layer 1, 2, ... n

$R_{si} + R_{se}$ sum of the internal and external surface resistances

If the thickness of a homogeneous material layer varies in the direction of the level of the structure, the mean value may be used as the thickness provided that the local minimum thickness is not below the mean value by more than 20 %.

2.2.4 When building components are inhomogeneous so that they have material layers in the direction of the surfaces with parallel sectors of different thermal resistance, the thermal resistance R_j of the inhomogeneous material layer j is calculated using the formula (3).

$$1 / R_j = f_a / R_{aj} + f_b / R_{bj} + ... + f_n / R_{nj} \quad (3)$$

$f_a, f_b, ... f_n$ a proportional part of the total area of a material layer of the homogeneous sub-area a, b, ... n in the inhomogeneous material layer j

$R_{aj}, R_{bj}, ... R_{nj}$ thermal resistance of the homogeneous sub-area a, b, ... n in the inhomogeneous material layer j where $R_{aj} = d_j / \lambda_{aj}$, $R_{jb} = d_j / \lambda_{bj}$, ... $R_{jn} = d_j / \lambda_{nj}$

$\lambda_{aj}, \lambda_{bj}, ... \lambda_{nj}$ design thermal conductivity of the material layer aj, bj, ... nj, e.g. normative thermal conductivity

2.2.5 If the design thermal conductivities of adjacent materials in an inhomogeneous material layer differ from each other over fivefold, the formula (3) is not suitable for use. In this case, the material and sub-sector with greater thermal conductivity is handled as a thermal bridge in accordance with item 2.3.

2.2.6 The total thermal resistance R_T of building components containing inhomogeneous layers is calculated using the formula (4) and the thermal transmittance U using the formula (1).

$$R_T = R_{si} + R_1 + R_2 + ... + R_n + \Sigma R + R_{se} \quad (4)$$

$R_1, R_2, ... R_n$ thermal resistance of the inhomogeneous material layer 1, 2, ... n calculated using the formula (3)

ΣR the sum of thermal resistances of homogeneous material layers, air cavity, thin material layers and the ground

$R_{si} + R_{se}$ the sum of the internal and external surface resistances

Explanation
The R_T-value calculated using the formula (4) is the lower approximate value.

2.3 Thermal bridges

2.3.1 Regularly repeated thermal bridges in the structure when they are characteristic to it are taken into account when ascertaining conformity of the thermal transmittances. This concerns, for instance, ties, brackets and supporting struttings and frames which are typical to the structure in the entire area of the envelope represented by it.

2.3.2 When calculating thermal transmittances, there is no need to take into account any individual thermal bridges in the building envelope, made for various reasons. An individual thermal bridge may be formed by a junction between the base floor or ceiling and the external wall; a balcony support; a column cutting through the base floor; a component for building service technology and any other such like separately designed and implemented single component in the structure.

Explanation
The temperature of the structure at the point of a thermal bridge is different in respect of the surrounding structure. The result of this could be a local decrease in thermal comfort, the surface getting dirty and, at its worst, moisture condensing on the inside surface of the structure or deeper in the structure. In respect of all thermal bridges, the structures are designed in such a way that there are no moisture problems, referred to, and that the thermal conditions in accordance with Part D2 of the National Building Code is achieved in the occupied zone.

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2.3.3 When the design thermal conductivity of the thermal bridge material is different from the corresponding design value of the adjacent material over fivefold, the increase $\Delta U_{\Psi X}$ of the thermal transmittance for building components due thermal bridges is calculated using the formula (6).

$$\Delta U_{\Psi X} = \Sigma \Psi_k (l_k / A) + \Sigma X_j (n_j / A) \quad (6)$$

Ψ_k linear additional thermal transmittance of a linear thermal bridge k in the building component, similar with each other, W/(m · K)

X_j point additional thermal transmittance of a point thermal bridge j in the building component, similar with each other, W/K

l_k total length of similar linear thermal bridges in the building component, m

n_j number of similar point thermal bridges in the building component

A area of the building component, m^2

Additional thermal transmittance of linear and point thermal bridges (Ψ_k, X_j) is calculated using a method of calculation appropriate for the purpose or is determined by experiment.

2.3.4 For instance, metal braces and ties cause *thermal* bridges. It may be assumed that the *thermal transmittance* U of building components increases by 0.006 W/($m^2 \cdot K$) when using 4 stainless steel ties of 4 mm diameter per m^2 and by 0.05 W/($m^2 \cdot K$) when using 4 copper ties of 4 mm diameter per m^2.

2.4 Taking into account any air flows in thermal insulation

2.4.1 If the effect of air flows in small cracks, air gaps and air permeable insulation material of thermal insulation, is not taken into account in the value for design thermal conductivity, the effect of air flows which increases the heat loss is separately assessed and taken into account as an increase in the thermal transmittance for building components.

Explanation
The EN standard concerning calculation of thermal transmittance requires that the effects of imperfection of thermal insulation are taken into account when calculating thermal transmittance.

Normative thermal conductivity (λ_n) of thermal insulation material takes into account the effect of slight air flows in thermal insulation.

2.4.2 The size of the increase (ΔU_g) added to the thermal transmittance (U) in order to take into account the effect of air flows in thermal insulation, depends on the installation method of thermal insulation, protection of the insulation and air permeability of the insulation material. When assessing the size of the increase, it is based on reliable examination or investigation.

3

DESIGN OF THERMAL INSULATION AND INSULATING

3.1 Design of thermal insulation

3.1.1 Thermal insulation materials should be suitable for their use and in accordance with the requirements imposed. They should retain their characteristics for the service life of the structure. In respect of realisation of the requirements, the designs provide sufficient information on the thermal insulation materials used, on the structure of thermal insulation and dimensions and, if necessary, on the details of carrying out the insulation works.

3.1.2 During both the construction stage and the use of the structures, the loads directed at thermal insulation materials are taken into account when selecting and protecting the insulation materials. Any possible permanent unavoidable but acceptable changes to the characteristics of thermal insulation are taken into account when dimensioning the insulation.

3.1.3 Values of design thermal conductivity determined in accordance with the EN standards are used as design values for thermal insulation materials provided with a CE mark. The values for normative thermal conductivity (λ_n), suitable for the structure under review on the basis of their description of installation and protection methods, or any other suitable values for design thermal conductivity, determined in an acceptable way, are used as design values for other insulation materials. The designs are drawn up in sufficient detail so that they show the method of installation and protection required by the selection of λ_n-values.

3.1.4 The designs itemise the intended thermal insulation materials or advise of the characteristics required from insulation materials. When designing spaces for thermal insulation in the structures, the aim is for solutions where insulation may be carried out using working methods suitable for the chosen insulation material. In difficult cases, the working method is provided. The expected settlement of mineral or wood fibre insulation installed into open insulation space of upper floor by dry blowing is taken into account by making the insulation thickness blown correspondingly greater than planned.

3.2 Handling, storage and installation of thermal insulation materials

3.2.1 At the building site, the compliance with the design of thermal insulation materials is checked and the insulation materials are protected from getting wet and damaged. The quality of insulation materials, different from the design or insufficiently identifiable, should be ascertained as equivalent to the design, before use.

3.2.2 Before installation of thermal insulation materials, the insulation spaces of the structures are checked and any possible defects are mended. During installation, special care is taken so that the insulation material fills the space provided for it as perfectly as possible. The joints in insulation installed in several layers are overlapped. Possible errors and defects are mended using the same or corresponding insulation material.

3.2.3 Insulation work should be timed in such a way that the structures protecting thermal insulation are completed or they are made without delay after insulation. If necessary, temporary protection is used. Completed insulation must not be loaded damagingly nor pressed thinner than designed. Installation of fibre insulation blown into the open insulation space of upper floor is completed when the structures protecting from wind and rain are sufficiently complete and the works that require walking in the insulated area are finished. The insulation thickness blown is checked with measurements and is compared with the design taking into account the allowance for settlement. If necessary, the insulated area is subsequently provided with walkways.

3.3 Protection from wind and air flows

3.3.1 If application of values for design thermal conductivity of thermal insulation materials require protection against wind and the structure has no layer made for any other purpose, also functioning as wind barrier, the thermal insulation is protected by a separate wind barrier. The air permeance for wind barrier may be $10 \cdot 10^{-6}$ $m^3/(m^2 \cdot s \cdot Pa)$ at the most.

3.3.2 Wind barrier refers to a layer attached to thermal insulation and entirely covering it. This must not have any open gaps or holes running to thermal insulation. Particular attention is paid to air tightness of the joints in wind barrier, in lower edge of the walls and corners and in jambs of lead-ins of window and door openings etc.

3.3.3 Joints and edges of wind barrier made of sheets are fitted, if possible, against the rigid surface. Fixings and their distances are chosen in such a way that the joints will not open after installation. Joints in thin wind barriers made of board etc. are sealed, for instance, by overlapping and compressing between the rigid surfaces. This or a corresponding method, which guarantees tightness, is also applied to the edges and corners of wind barrier.

3 3.4 It is often appropriate to lift the upper edge of wind barrier for external walls over the upper surface of the thermal insulation of the upper floor to protect the edges of the insulation. If there is a large ventilating air gap (height ≥ 200 mm) above horizontal or slightly pitched upper floor and this is surrounded by eaves structure throttling the ventilating air flow (e.g. conventional gap boarding), the continuous wind barrier may be omitted when the conditions of value for the design thermal conductivity of thermal insulation material so allows. However, it is advisable to fix wind directing strips, controlling the ventilating air flows, to the eaves edges if the air flow may hamper functioning of thermal insulation or if the insulation material is moving in the wind.

3.3.5 To prevent uncontrolled air leakages through the structure from one side to the other, at least one layer functioning as an air barrier is needed in the structure. Often, this is on the warm side of thermal insulation. Unless the structure has a separate air barrier it is necessary that air tightness of at least one layer attached to thermal insulation is sufficient in order to function as such.

3.3.6 Air tightness of an air barrier is designed and implemented as sufficient, so that when the ventilation system is used in accordance with the design, the system is able to keep the interior of the building, as a general rule, under negative pressure in respect of outdoors, and the thermal conditions in accordance with Part D2 of the National Building Code is achieved in the occupied zone.

4

THERMAL CONDUCTIVITY OF BUILDING MATERIALS

4.1 Values for design thermal conductivity and the options

4.1.1 The following may be used as values for design thermal conductivity: values for design thermal conductivity specified for building materials provided with a CE mark in accordance with the EN standards; values for design thermal conductivity stated in tables in the EU standards; values for normative thermal conductivity (λ_n) in column 5 of table 1 and values for normative thermal conductivity (λ_n) provided by type approval decisions or values for design thermal conductivity obtained in any other acceptable way.

4.1.2 The following are taken into account as an increase included in the values for design thermal conductivity: variation of thermal conductivity of materials due to technical reasons in manufacture; moisture content of materials in specific use in accordance with the design, and irreversible changes to thermal conductivity during the service life. Generally, values applicable to materials at the temperature of 10^{o}C are used as values for design thermal conductivity. If necessary, design values may be converted to correspond to another mean temperature when the dependency of thermal conductivity of materials on the temperature is taken into account.

4.1.3 The effect of slight air flows inside thermal insulation and through this, is taken regarded as an increase in the values for design thermal conductivity or in the thermal transmittance for a structure. When using the λ_{n}-values, there is no need for a separate increase in thermal transmittance provided that the conditions concerning installation and protection of thermal insulation are met. When using other design values for thermal conductivity where the effect of air flows referred to is not taken into account, this effect is estimated separately and it is taken into account as an increase in the thermal transmittance for building components.

Explanation
The EN product standards and the EN standard for thermal insulation materials for determining values for design thermal conductivity of thermal insulation materials, form a set of instructions for determining values for design thermal conductivity of thermal insulation materials. These values do not include the effect of slight air flows in thermal insulation which is taken into account separately as an increase in the thermal transmittance.

4.2 Normative thermal conductivity of building materials

4.2.1 The increases and corrections provided in items 4.1.2 and 4.2.3 are taken into account in normative thermal conductivity (λ_n). Unless otherwise stated in connection with the λ_n-values, the given values apply at the mean temperature of 10^{o}C.

4.2.2 The λ_n-values in column 5 of table 1 are valid in the usual service conditions of structures in Finland provided that the material conforms, in respect of dry density and other characteristics used as distinguishing features, to the requirements imposed and that the material is used appropriately, in respect of physics for heat insulation and conduction, in accordance with good building practices.

4.2.3 When installing and protecting material layers, the requirements stated in item 4.2.4 and in the footnotes for the λ_n-values (table 1 or type approval decisions on normative thermal conductivity of thermal insulation materials) are observed. If the materials have several λ_n-values, the selected one is the one which corresponds to the intended use on the basis of footnotes. If there is nothing suitable, the λ_n-value used in calculations is determined separately.

4.2.4 In table 1, the λ_n-values provided for thermal insulation materials concern products with no valid type approval of λ_n-values. In respect of the requirements for the method of installation and protection of thermal insulation materials, the footnote 1) in table 1 refers to the following requirements which may be deviated from in situations subject to other footnotes in table 1.

- one surface of insulation (usually the inner surface) is always attached to a tight surface in respect of air flows (e.g. concrete, brickwork, tight board, plastic membrane, insulation paper
- one surface of vertical and sloped insulations (slope with respect to the horizontal > 30 ^{o}) has wind barrier [air permeance $\leq 10 \cdot 10^{-6}$ $m^3/(m^2 \cdot s \cdot Pa)$ unless otherwise allowed for in the conditions for normative thermal conductivity of thermal insulation materials] such as a building board with nail fixings or building paper with pressed and overlapped joints
- there is a wide air cavity, provided with an eaves or border structure throttling the air flow, above the upper floor insulation with a maximum slope of 30^o with respect to the horizontal. The height of this cavity is in all areas a minimum of 200 mm (however, right at the eaves borders, a minimum of 50 mm)
- there is an air cavity in all areas underneath the insulation in the base floor with crawl space. All the edges of this cavity are protected by a uniform foundation wall provided with ventilation holes or a corresponding protective structure
- there is a drainage layer preventing capillary rise of moisture, underneath the thermal insulation of the permanently dry base floor against the ground in the heated space

4.2.5 If the mean moisture content of the material is higher than the value given in column 4 of table 1, the λ_n-value is correspondingly increased on the basis of a separate research.

4.2.6 The λ_n-values of materials do not normally include thermal transmittance through other structural elements and materials (support structures, jointing compounds, ties, fixtures etc.) permeating through a material layer or abutted to it nor the effect of thinning of a material layer (settlement, external pressure etc.) unless stated in the footnotes of table 1. The said factors are taken into account when calculating thermal transmittances.

4.2.7 The dry density in table 1 refers to the maximum permitted mean dry density of a material or the limits between which the mean dry density may vary. In respect of masonry walls, the column of dry density indicates the dry density of a masonry block. A gross density is used as a dry density of a perforated brick, i.e. mass divided with volume without taking into account a deduction for the holes.

4.2.8 The moisture content (w_n) refers to a mean moisture content accumulated in the material during the use in accordance with the design. Its effect is taken into account in the λ_n-value.

TABLE 1. NORMATIVE THERMAL CONDUCTIVITY OF BUILDING MATERIALS.

1	2	3	4	5	6
Material	Dry density	Thermal conductivity	Moisture content	Normative thermal conductivity	Footnote
	ρ kg/m^3	λ_{10} W/(m · K)	w_n % of dry weight	λ_n W/(m · K)	
THERMAL INSULATION MATERIALS					
cork board (expanded)	150	0.035	3	0.045	1)
			3	0.050	2)
	200	0.040	3	0.050	1)
			3	0.055	2)
wood wool board	150—350	0.070	8	0.080	3)
			8	0.10	4)
wood fibre board, bituminous	350	0.055	10	0.065	5)
wood fibre board, porous	300	0.045	10	0.055	5)
mineral wool board and mat 8)	10—300	0.045	0.5	0.055	1)
			0.5	0.060	2)
				0.070	6)
				0.10	7)
cellular plastic board, expanded polystyrene	30—60	0.033	2	0.041	1)
			2	0.045	2)
				0.050	6)
				0.060	7)
	17—29.9	0.037	2	0.045	1)
			2	0.050	2)
				0.055	6)
				0.065	7)
	13—16.9	0.041	2	0.050	1)
			2	0.055	2)
				0.065	6)
cellular plastic board, extruded polystyrene					
propellant CFC 12 x)	22—45	0.030	2	0.037	1)
			2	0.041	2) or 6)
				0.045	7)
				0.050	9)
other propellant	22—45	0.037	2	0.045	1)
			2	0.050	2) or 6)
				0.055	7)
				0.060	9)

1) Insulation is protected in accordance with the requirements described in 4.2.4
2) One side of insulation is attached to a tight surface and the other side has an air cavity or space other than the air cavity of the upper floor or the base floor with crawl space, referred to in 4.2.4.

1	2	3	4	5	6
Material	Dry density ρ kg/m³	Thermal conductivity λ_{10} W/(m · K)	Moisture content w_n % of dry weight	Normative thermal conductivity λ_n W/(m · K)	Footnote
cellular plastic, polyurethane					
CFC as propellant 11 x)	30—60	0.026	2	0.030	3) and 10)
			2	0.033	1)
			2	0.037	2) or 6)
				0.045	7)
		0.019	2	0.024	11)
pentane as propellant	30—60	0.030	2	0.033	3) and 10)
			2	0.037	1)
			2	0.041	2) or 6)
				0.050	7)
		0.024	2	0.030	11)
cellular glass board	180	0.060		0.070	12)
	150	0.055		0.065	12)
	130	0.050		0.060	12)
expanded clay lightweight aggregate					
in upper floors	250—320	0.09	0.5	0.10	3)
	300—330	0.10	0.5	0.11	3)
in base floors against ground	250—320	0.09	6	0.13	6)
as soil frost insulation	250—320	0.09	30	0.17	7)
blown loose-fill fibre insulation materials in upper floors xx)					
glass wool	18—50	0.050	0.5	0.060	1)
rock wool	30—60	0.050	0.5	0.060	1)
cellulose fibre insulation	30—60	0.050	12	0.060	1)

3) Insulation attached to air tight surface on both sides (e.g. concrete, brick cladding, tight board, plastic membrane, insulation paper etc. firmly jointed).
4) One side of insulation attached to tight surface and other side has an air cavity or space.
5) Regardless of the method of protection, in structures staying dry.
6) In plinth splitting or as internal vertical insulation of plinth against the ground or in the base floor against the ground in an unheated space or in the base floor against the ground directly on top of subgrade
7) As external insulation of foundation wall or cellar wall against the ground or between soil layers.
8) Medium thickness of fibre is a maximum of 6 µm, when ρ = 10...30 kg/m³, otherwise a maximum of 15 µm.
9) In roof structure above waterproofing.
10) Insulation expanded in the insulation space and fills it in whole.
11) Insulation expanded between metal layers of at least 50 µm thick and entirely adhered to these on both sides.
12) Insulation board jointed with, for instance, bitumen.
x) Manufacture of CFC products banned but old structures contain these products.
xx) Thickness of blown insulation includes an allowance for settlement. For mineral wool, this is 5 % and for wood fibre insulation, 20 % of the designed insulation thickness.

1	2	3	4	5	6
Material	Dry density ρ kg/m^3	Thermal conductivity λ_{10} W/(m · K)	Moisture content w_n % of dry weight	Normative thermal conductivity λ_n W/(m · K)	Footnote
AERATED CONCRETE					
as elements					
in upper floor above	400	0.095	4	0.10	
dry rooms	450	0.11	4	0.12	
	500	0.12	4	0.135	
	600	0.15	4	0.175	
in base floor against	450	0.11	4	0.12	
unheated space	500	0.12	4	0.135	
	600	0.15	4	0.175	
in external wall	400	0.095	6	0.105	
above ground	450	0.11	6	0.125	
	500	0.12	6	0.14	
with external lining in	400	0.095	4	0.10	14)
external wall above ground	450	0.11	4	0.12	14)
	500	0.12	4	0.135	14)
in external wall below ground	500	0.12	10	0.16	13)
as blocks with thin and glued					
joints indoors and with	400	0.11	4	0.12	14)
external lining outdoors	450	0.12	4	0.13	14)
	500	0.13	4	0.145	14)
	600	0.16	4	0.185	14)
above ground	400	0.11	6	0.125	15)
	450	0.12	6	0.135	15)
	500	0.13	6	0.15	15)
below ground	500	0.13	10	0.17	13)
	600	0.16	10	0.20	13)

13) Concerns bitumen coated cellar walls when the cellar is heated and well ventilated. If the cellar walls are provided with a material layer which stops capillary absorption but allows diffusion (e.g. mineral wood or a board forming an air cavity), thermal conductivity in column 5 may be deducted by 0.02 W/(m · K).

14) Lining refers to a panel facing outside a well ventilated air cavity.

15) Concerns plastered walls, not exposed to driving rain. Unless the walls exposed to driving rain are protected from water penetration, the λ_n-value must be increased from the given value by 4 % for aerated concrete and 2.5 % for lightweight-aggregate concrete per each increase of a percentage of moisture content.

1	2	3	4	5	6
Material	Dry density ρ kg/m^3	Thermal conductivity λ_{10} W/(m · K)	Moisture content w_n % of dry weight	Normative thermal conductivity λ_n W/(m · K)	Footnote
LIGHTWEIGHT-AGGREGATE CONCRETE					
as elements					
above ground	800	0.22	4	0.24	15)
	650	0.18	4	0.20	15)
below ground	800	0.22	10	0.29	16)
	650	0.18	10	0.23	16)
lightweight aggregate blocks as blockwork joints of 10 mm					
external walls					
filled joints	650	0.22	4	0.24	15)
open joints	650	0.18	4	0.20	15)
cellar walls or foundation wall					
filled joints	650	0.22	7	0.25	
open joints	650	0.18	7	0.21	
dense lightweight-aggregate					
concrete	1600	0.60	3	0.70	
cast-in-situ	1400	0.48	3	0.55	15)
or as elements	1200	0.39	3	0.45	16)
	1000	0.30	3	0.35	
insulations of cast lightweight-aggregate concrete					
in upper and base floor	600	0.16	2	0.17	
	500	0.12	2	0.13	
	400	0.10	2	0.11	
against the ground	600	0.16	6	0.19	
	500	0.12	6	0.15	
	400	0.10	6	0.12	
SAWDUST CONCRETE					
in dry space	1300	0.35	1	0.45	
FILLERS 17)					
lightweight concrete chippings	400		4	0.15	
cinder stone	700		3	0.25	18)
cutter chips,	80		12	0.14	
loose	120		12	0.08	
compacted	250		0.5	0.12	18)
blast-furnace slag, granulated	150		0.5	0.10	18)
sawdust, loose	120		12	0.12	
compacted	200		12	0.08	
cellular plastic chips of polystyrene	10—20		2	0.08	

16) Concerns external insulation of concrete foundation wall.

1	2	3	4	5	6
Material	Dry density ρ kg/m^3	Thermal conductivity λ_{10} W/(m · K)	Moisture content w_n % of dry weight	Normative thermal conductivity λ_n W/(m · K)	Footnote
BUILDING BOARDS					
fibrous cement board	1800	0.40	2	0.60	
	800	0.13	4	0.19	
	600	0.12	4	0.18	
gypsum board	800	0.20		0.21	
	900	0.22		0.23	
wood gypsum board	1200	0.24		0.25	
cement chipboard	1100	0.21	7	0.23	
chipboard	600	0.13	9	0.14	
wood fibre board					
hard	1000	0.12	8	0.13	
semi-hard	800	0.10		0.11	
plywood					
birch plywood	700	0.15	8	0.16	
mixed plywood	600	0.13	8	0.14	
spruce plywood	500	0.12	8	0.13	
MISCALLANEOUS BUILDING MATERIALS					
asphalt	2200			0.7	
concrete	2000		2	1.2	
	2300		2	1.7	
perforated concrete blocks					
as blockwork	1400	0.42	3	0.55	
non-perforated concrete blocks					
as blockwork	2000	0.70	2	1.2	
bitumen	1000	0.13			
calcium silicate blocks as					
blockwork	1900	0.70	3	0.95	
plaster mortars					
cement mortar	2000	0.70	2	1.2	
gauged mortar	1800	0.65	2	1.0	
lime mortar	1700	0.50	2	0.90	
burnt bricks as brickwork					
perforated bricks	1500	0.50	1	0.60	
	1300	0.45	1	0.50	
	1700	0.60	1	0.70	
non-perforated bricks	1500	0.55	1	0.65	
	1300	0.50	1	0.60	

17) Thermal conductivity provided only applies to fillers in dry spaces. If the material is in contact with the ground, thermal conductivity is determined on the basis of the corresponding higher water content.

18) When using fillers as insulation of the upper floor without an air tight layer above, 0.02 W/(m · K) must be added to the λ_n-value.

1	2	3	4	5	6
Material	Dry density ρ kg/m^3	Thermal conductivity λ_{10} W/(m · K)	Moisture content w_n % of dry weight	Normative thermal conductivity λ_n W/(m · K)	Footnote
timber, pine, spruce	450	0.10	14	0.12	
metals					
copper (pure)	8900			370	
aluminium (pure)	2700			220	
duralumin (3 - 5 % of copper)	2700			160	
brass	8400			120	
zinc	7100			110	
tin	7300			65	
iron, steel	7900			50	
lead	11300			35	
stainless steel	7900			17	
plastics					
acrylic	1050			0.20	
polycarbonate	1200			0.21	
PTFE	2200			0.23	
PVC, rigid	1390			0.18	
PVC, 40 % plasticizer	1200			0.14	
polyethylene HD	980			0.40	
polyethylene LD	920			0.32	
polystyrene	1050			0.18	
polyacetate	1410			0.30	
phenolic resin	1600			0.5	
polypropylene	910			0.22	
EPDM	1150			0.20	
PMMA (acrylate)	1180			0.18	
polyurethane	1200			0.25	
polyamide	1130			0.25	
epoxy resin	1200			0.23	
silicone	1200			0.30	
rubbers					
polyisobutylene	920			0.13	
butylene	1200			0.24	
polysulfide				0.19	
neoprene	1240			0.23	
glass	2500			1.0	
sealing and insulating compounds					
nylon	1140			0.23	
urethane (liquid)				0.36	
silicone foam				0.12	
vinyl (flexible)				0.12	
polyethylene foam	36			0.06	
earth materials					
clay or silt	1500			1.5	
sand, gravel, moraine	2000			2.0	

1	2	3	4	5	6
Material	Dry density ρ kg/m^3	Thermal conductivity λ_{10} W/(m · K)	Moisture content w_n % of dry weight	Normative thermal conductivity λ_n W/(m · K)	Footnote
types of rock					
basalt	2800			3.5	
limestone	2300			2.5	
granite	2700			2.8	
sandstone	2300			2.0	
natural pumice	400			0.08	
water, 10^{o}C				0.6	
ice, 0^{o}C				2.2	
ice, -10^{o}C				2.5	
snow, soft	200			0.12	
snow, compacted	500			0.70	

5

THERMAL RESISTANCES

5.1 Surface resistance

5.1.1 The values given in table 2 are used as surface resistances for building components abutting to the outside.

TABLE 2. INTERNAL AND EXTERNAL SURFACE RESISTANCE R_{si} AND R_{se}.

Internal surface resistance R_{si}, (m^2 · K)/W			External surface resistance R_{se}, (m^2 · K)/W		
Direction of the heat flow					
horizontal	upwards	downwards	horizontal	upwards	downwards
0.13	0.10	0.17	0.04	0.04	0.04

Intermediate values 0^o — 90^o are obtained by linear interpolation.

5.2 Thermal resistance of air cavity

5.2.1 Unventilated air cavity is a closed air gap in a building component with no opening for airflow coming from the outside.

5.2.2 Air cavity with no thermal insulation in *its* external part of the structure and with small openings from the outside, may be taken into account as unventilated air cavity in respect of its thermal resistance. In this case, the openings may not be located in such a way that they allow a ventilating air flow through air cavity from one side to the other. In addition, it is understood that the combined size of the openings does not exceed the following limit values.

- 5 cm^2/m per unit of length of vertical air cavity in a vertical structure
- 5 cm^2/m^2 per unit of area of horizontal air cavity

5.2.3 The values given in table 3 are used as thermal resistance of unventilated air cavity.

TABLE 3. THERMAL RESISTANCE R_g OF UNVENTILATED AIR CAVITY

Emissivity of abutting surfaces.	Thickness of air cavity d_g mm	Thermal resistance R_g, $(m^2 \cdot K)/W$		
		Direction of heat flow		
		horizontal	upwards	downwards
usual case:	5	0.11	0.11	0.11
non-reflective	10	0.15	0.15	0.15
surfaces	20	0.17	0.16	0.18
ε > 0.8	50—100	0.18	0.16	0.21
one surface	5	0.17	0.17	0.17
reflective	10	0.27	0.23	0.29
	20	0.36	0.25	0.43
ε < 0.2	50—100	0.34	0.27	0.61

The values given lower in table 3 only apply if the reflective surface stays clean all the time and its emissivity remains under 0.2.

5.2.4 Ventilated air cavity is an air gap in a building component with ventilating airflow through it from one edge of a building component to the other. Ventilated air cavity is either slightly ventilating or well ventilating depending on the size of the openings leading to the air gap.

5.2.5 Air cavity is slightly ventilating when the area of the opening abutting to the open air is within the following limits:

- more than 5 cm^2/m but a maximum of 15 cm^2/m per unit of length of vertical air cavity in a vertical structure
- more than 5 cm^2/m^2 but a maximum of 15 cm^2/m^2 per unit of area of horizontal air cavity

5.2.6 A half of thermal resistance of corresponding unventilated air cavity given in table 3 may be taken into account as thermal resistance of slightly ventilating air cavity. If thermal resistance of a structure from the air cavity to the environment outside is greater than 0.15 $(m^2 \cdot K)/W$, the value of 0.15 $(m^2 \cdot K)/W$ is used in calculations for this part of the structure.

5.2.7 The combined size of the openings leading to well ventilated air cavity is greater than 15 cm^2/m (vertical structures) or 15 cm^2/m^2 (horizontal structures).

5.2.8 If a structure has a well ventilated air cavity, its thermal resistance or that of the part of the building component outside the air cavity may not be taken into account when calculating the total thermal resistance of a structure. In this case, the values for internal surface resistance (R_{si}) in table 2 may be used as a surface resistance of the surface of the internal part of the structure abutting the air cavity.

5.2.9 Thermal resistance of air cavity ventilated mechanically must not be taken into account in calculations unless the effect that the air cavity and the material layer outside it have on the structure, is clarified separately.

5.2.10 The effect of ventilation on the total thermal resistance of a structure may be determined on the basis of a separate investigation when the instructions given here are not well suited (e.g. ventilation grooves) or the method used gives a more accurate result compared to the instructions.

5.2.11 With a roof structure where there is an air space left between a thermally insulated, generally horizontal upper floor and a sloping roof, the air space may be regarded as a thermally homogeneous cavity with thermal resistance in accordance with table 4.

TABLE 4. THERMAL RESISTANCE R_g OF THE ROOF AIR SPACE

Type of roof structure		Thermal resistance R_u, $(m^2 \cdot K)/W$
1.	tiled roof, felt roof in sections or equivalent, with roofing underlay or a corresponding material layer	0.2
2.	as in 1, but the lower surface of the roofing underlay is a low emissivity surface such as an aluminium layer	0.3
3.	continuous roofing of flexible sheets of bitumen or corresponding roofing without gaps	0.3

Explanation
Values in table 4 concern ventilated air space and a roof structure above it. The values do not include the external surface resistance (R_{se}).

5.3 Thermal resistance of thin material layers

5.3.1 Thin, comparatively air tight material layers include, for instance, plastic membranes, building papers, felt and cardboard layers with the maximum air permeance of $10 \cdot 10^{-6}$ $m^3/(m^2 \cdot s \cdot Pa)$. Their thermal resistance is given in table 5.

TABLE 5. THERMAL RESISTANCE R_q OF THIN MATERIAL LAYER

Location of a material layer	Thermal resistance R_q, $(m^2 \cdot K)/W$
One surface against a rigid surface, e.g. against a wall in timber boarding*)	0.02
Between rigid surfaces*)	0.04

*) Thermal resistance includes both the thermal resistance of a material layer and the thermal resistance of a thin air cavity formed between this and the rigid surface, the layer of timber boarding etc.

5.4 Building components against the ground

5.4.1 The building components against the ground should be well functioning in respect of heat and moisture physical properties in such a way that the desired level of insulation is achieved, and moisture, frost heaving and coldness of the surfaces do not cause any harm. When designing and implementing, the shape of the ground surface, the characteristics of the soil, the level of ground water and running of surface waters are taken into account.

5.4.2 The temperature of the inner surface of a structure near the junction of the external wall and the floor against the ground must not fall too low in respect of comfort. Thermal insulation of the outside wall, base floor and foundation wall is located, in respect of each other, in such a way that no detrimental thermal bridge exsists in the junction of the structures.

5.4.3 If the depth of the foundation of a heated building on frost-susceptible ground is left above the natural, frost-free depth, the foundations are protected with frost insulation. The insulation material used and the location and thermal resistance of insulation are chosen with the object that the building will function for its service life in accordance with the design.

5.4.4 Unless more detailed calculations or tests are carried out, the total thermal resistance of the building components against the ground is calculated in accordance with items 5.4.5 .... 5.4.11.

5.4.5 It is assumed that the base floor and the cellar wall are divided into edge and inner zones in accordance with figures 1 and 2. The values in table 6 are used as the thermal resistance (R_b) of the ground. The values include the external surface resistance (R_{se}). It is required then that the foundations and the base floor are permanently dried using appropriate solutions for drainage and conveyance of surface water. Also, the inspection pipes and wells of the drainage system should be covered with an air tight cover, a layer of earth, a layer of insulation etc. to prevent access of outside air and frost heaving.

5.4.6 When calculating the thermal resistance of a floor against the ground and an external cellar wall, the thermal resistance of the ground may be taken into account. In this case, the values for thermal resistance in table 6 are used unless more detailed calculations or tests regarding heat flow under the building are carried out.

5.4.7 The values given in columns 3 and 4 of table 6 are used as the thermal resistance of the ground under the base floor against the ground. Correspondingly, the values given in columns 5 and 6 of table 6 are used as the thermal resistance of the ground outside the cellar wall.

5.4.8 The values in table 6 may be used if the bottom surface of the floor structure is a maximum of 300 mm above the adjacent ground surface level and the thickness of the earth layer under the drainage layer is a minimum of 1 m.

Explanation
The surface of a structure against the top surface of the drainage layer is regarded as the bottom surface of the floor structure.

5.4.9 When calculating the thermal resistance of a floor structure and the ground, it is assumed that the ground begins below the drainage layer, however, a maximum of 200 mm below the bottom surface of a floor structure.

5.4.10 Thermal resistance of a drainage layer of gravel or shingles with a minimum thickness of 200 mm is 0.2 ($m^2 \cdot K$)/W.

5.4.11 If the cellar floor is situated a minimum of 1 m below the ground surface level, the values given for an inner zone in column 4 of table 6 may be used as thermal resistance R_b. For the cellar floor situated higher, the same values, as those in item 5.4.5 for the floor on the ground surface level, are used.

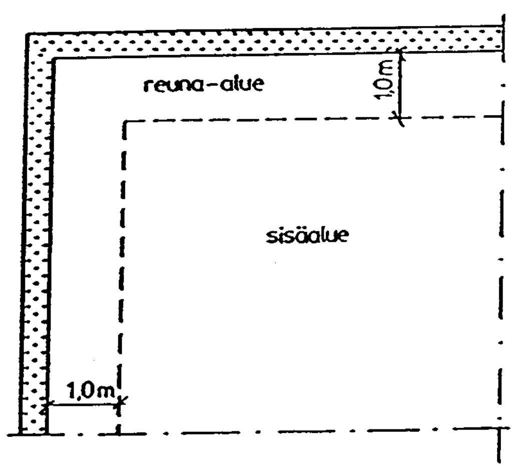

Figure 1. Division of the base floor against the ground into zones
reuna-alue = edge zone; sisäalue = inner zone

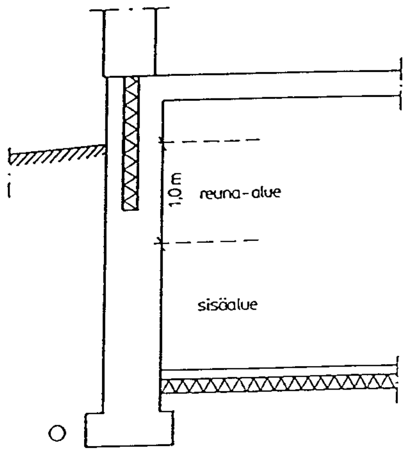

Figure 3. Division of the part of a wall against the ground into zones
reuna-alue = edge zone; sisäalue = inner zone

TABLE 6. THERMAL RESISTANCE R_b OF THE GROUND WHEN THE FOUNDATIONS AND BASE FLOOR ARE PERMANENTLY DRIED.

Type of soil	Normative thermal conductivity λ_n W/m K	Thermal resistance R_b of the ground m^2K/W			
		Ground below base floor		Ground adjacent to foundation wall	
		edge zone	inner zone	edge zone	inner zone
1	2	3	4	5	6
Clay Sand and gravel, drained	1.4	0.8	3.20	0.40	1.60
Silt and fine sand Sand and gravel, not drained Moraine	2.3	0.50	2.00	0.25	1.00
Rock	3.5	0.30	1.20	0.15	0.60

6

THERMAL TRANSMITTANCE FOR WINDOW, DOOR AND VENTILATION PANEL

6.1 General

6.1.1 In respect of the object of design, conformity with the regulations regarding each type of window, door and ventilation panel with a different structure is ascertained separately (Building Regulations, Part C3). The mean U-value for the most commonly used window, door or ventilation panel size in respect of the object is calculated or measured in accordance with the structural types. No U-value is necessary for structures of other sizes. There is no need to take into account the hinges, handles and other fittings of windows, doors or ventilation panels with the calculations.

Explanation

Glazing of a window refers to the transparent area formed by material layers of glass or similar. A window frame refers to the fixed frame structure abutting to the jambs of a window opening and to the movable casement frame with hinges. In a non-opening window, glazing is usually installed directly to the fixed frame structure in which case there is no movable casement frame in the structure.

The level area (projected area) abutted by the inner edges of the frame, installation aperture or installation shaft is regarded as the area of the glazing of a dome-shaped window.

The door and the ventilation panel generally consist of a frame with one or two hinged opening door panels or opening ventilation panel. A door panel may include an opaque part with a carcass and frame structure and a glazing. The opening ventilation panel usually consists of an opaque part with a carcass and frame structure.

The EN standard also includes a method of calculating thermal transmittances for windows and doors.

6.1.2 To attest the conformity with the requirements concerning a window structure, it is sufficient to show that the requirements in Part C3 of the Building Regulations are met as calculated in accordance with the outer measurements of the frame in a window structure of at least 1.4 m².

6.2 Thermal transmittance for window glazing

6.2.1 Thermal transmittance U_g for window glazing is calculated using formula (7).

$$U_g = \frac{1}{R_{si} + R_{se} + \sum_j \frac{\lambda_j}{d_j} + \sum_j R_{sj}} \quad (7)$$

$R_{si} + R_{se}$ sum of the internal and external surface resistances (table 2).
λ_j thermal conductivity of glass or a transparent material layer j, W/(m · K)
d_j thickness of glass or a transparent material layer j, m
R_{sj} thermal resistance of the gap j between the glass layers, $(m^2 \cdot K)/W$

6.2.2 The thermal resistance of the air gap of a horizontal window is obtained by deducting 20 % from the values given in table 7. Intermediate values 0^o — 90^o are obtained by linear interpolation.

6.2.3 Only washable coatings with low emissivity are used for washable surfaces.

Explanation

The gaps between the glass layers in the glazing of a window may be filled with air or they may have some other filler gas. The surfaces abutting to the gap may include conventional glass surfaces with the emissivity of 0.837, or one of the surfaces is coated with a coating of low emissivity. Thermal resistance of different gaps between glass are given in table 7.

TABLE 7. THERMAL RESISTANCE R_s OF ONE GAP BETWEEN GLASS IN DOUBLE AND TRIPLE GLAZED GLAZING WITH DIFFERENT FILLER GASES AND SURFACE EMISSIVITY.

Thermal resistance R_s, m^2K/W [x)]												
Thick-ness of gap be-tween glass, mm /double or triple glazing	Air emissivity				Argon emissivity				Krypton emissivity			
	0.04	0.16	0.4	0.837	0.04	0.16	0.4	0.837	0.04	0.16	0.4	0.837
9 / 2	0.336	0.280	0.214	0.154	0.462	0.362	0.258	0.176	0.715	0.502	0.322	0.204
12 / 2	0.438	0.348	0.251	0.173	0.597	0.440	0.296	0.193	0.745	0.516	0.328	0.206
15 / 2	0.536	0.407	0.280	0.186	0.707	0.498	0.321	0.203	0.702	0.495	0.319	0.203
18 / 2	0.539	0.408	0.281	0.187	0.688	0.488	0.316	0.202	0.647	0.467	0.308	0.198
9 / 3	0.336	0.280	0.214	0.154	0.462	0.362	0.258	0.176	0.715	0.502	0.322	0.204
12 / 3	0.438	0.348	0.251	0.173	0.597	0.440	0.296	0.193	0.909	0.590	0.356	0.217
15 / 3	0.536	0.406	0.280	0.186	0.724	0.506	0.324	0.205	0.903	0.587	0.355	0.217
18 / 3	0.630	0.458	0.303	0.196	0.843	0.561	0.345	0.213	0.864	0.571	0.349	0.215
20 / 2	0.527	0.401	0.277	0.185								
25 / 2	0.491	0.380	0.267	0.181								
30 / 2	0.445	0.352	0.253	0.174								
30-300 / 2	0.442	0.350	0.252	0.174								
20 / 3	0.671	0.480	0.313	0.200								
25 / 3	0.647	0.467	0.307	0.198								
30 / 3	0.613	0.449	0.300	0.195								
30-300 / 3	0.573	0.427	0.290	0.191								

[x)] Emissivity of one surface of the gap between glass is 0.837.

6.2.4 Tables 8 and 9 show pre-calculated thermal transmittances for glazings.

TABLE 8. THERMAL TRANSMITTANCES FOR SEALED MULTIPLE GLAZINGS

Thermal transmittance of glazing U_g, $W/(m^2 \cdot K)$									
Thickness of gap between glass, mm /triple or double glazing	Air emissivity			Argon Emissivity			Krypton emissivity		
	0.04	0.16	0.837	0.04	0.16	0.837	0.04	0.16	0.837
9 / 2	1.9	2.2	3.0	1.6	1.8	2.8	1.1	1.5	2.6
12 / 2	1.6	1.9	2.8	1.3	1.6	2.7	1.1	1.4	2.5
15 / 2	1.4	1.7	2.7	1.1	1.5	2.6	1.1	1.4	2.5
18 / 2	1.4	1.7	2.7	1.2	1.5	2.6	1.1	1.5	2.6
9 / 3	1.2	1.3	2.0	0.9	1.1	1.9	0.6	0.8	1.7
12 / 3	0.9	1.1	1.9	0.7	0.9	1.7	0.5	0.7	1.6
15 / 3	0.8	1.0	1.8	0.6	0.8	1.7	0.5	0.8	1.6
18 / 3	0.7	0.9	1.7	0.6	0.8	1.6	0.5	0.8	1.6

TABLE 9. THERMAL TRANSMITTANCES FOR GLAZINGS OF COMPOSITE WINDOWS WITH A SINGLE GLASS PANE AND A SEALED 2-GLASS UNIT

Thickness of gap between glass, mm Douple glazed unit / Separate glass	Thermal transmittance for glazing, U_g, W/(m^2 · K)											
	Air emissivity				Argon emissivity				Krypton emissivity			
	0.04	0.16	0.4	0.837	0.04	0.16	0.4	0.837	0.04	0.16	0.4	0.837
9 / 20-125	1.4	1.5	1.7	1.9	1.2	1.3	1.6	1.8	0.9	1.1	1.4	1.7
12 / 20-125	1.2	1.4	1.6	1.8	1.0	1.2	1.5	1.8	0.9	1.1	1.4	1.7
15 / 20-125	1.1	1.3	1.5	1.8	0.9	1.1	1.4	1.7	0.9	1.1	1.4	1.7
18 / 20-125	1.0	1.2	1.5	1.8	0.9	1.1	1.4	1.7	0.9	1.1	1.4	1.7

Explanation
A composite window refers to a window with a glazing which has both sealed multiple glazed units and separate glass.

6.3 Thermal transmittance for window frame

6.3.1 Thermal transmittance for a conventional timber window frame (U_f) is calculated using the formula (8).

$$U_f = \frac{1}{R_{si} + R_{se} + \dfrac{\beta \cdot d}{\lambda_n}} \qquad (8)$$

d mean thickness of frame and casement parts, m
λ_n normative thermal conductivity of frame and casement material
β correction coefficient which takes into account the 2- or 3-dimensional heat flow in reality, 0.7
$R_{si} + R_{se}$ sum of surface resistances (table 2).

6.4 Thermal interaction of the frame structure and glazing

6.4.1 The increased heat loss, characteristic to the junction of glazing and the frame structure on the edges of glazing is taken into account as a linear additional conductance (ψ_g) of a junction structure. Unless more detailed calculations are carried out, the values in table 10 may be used as the values for linear additional conductance due to a metal edge strip of sealed glass. The value of linear additional conductance of the junction of separate glass installed in a timber or plastic casement is 0 W/(m · K).

TABLE 10. LINEAR ADDITIONAL CONDUCTANCE Ψ_g DUE TO METAL EDGE STRIP OF SEALED GLAZING UNIT

	Additional conductance Ψ_g, W/(m · K)		
Frame material	Double or triple glazing, no low emissivity coating, gas or air gap	Triple glazing, low emissivity coating in the other gap	Double glazing with low emissivity coating, triple glazing with two low emissivity coatings, gas or air gap
Wood or plastic	0.04	0.05	0.06
Metal frame with thermal break	0.06	-	0.08
Metal frame without thermal break	0	-	0.02

6.5 Mean thermal transmittance for window

6.5.1 Mean thermal transmittance for window (U_w) is calculated using formula (9). The numerical value obtained is indicated with two significant figures.

$$U_w = \frac{A_g\, U_g + A_f\, U_f + l_g\, \psi_g}{A_g + A_f} \qquad (9)$$

A_g area of the glazing, m^2
U_g thermal transmittance for the glazing, W/(m^2 · K)
A_f projected area of the frame and casement part on the glazing level of the window, m^2.
U_f thermal transmittance for the frame and casement part, W/(m^2 · K)
l_g length of linear thermal bridge formed on the edge of the opening, m
ψ_g linear additional conductance on the edge of the glazing, W/(m · K).

6.6 Thermal transmittance for door and ventilation panel

6.6.1 Mean thermal transmittance (U_p) for the opaque part of a door panel and for the opening part of a ventilation panel is calculated in accordance with items 2.2 and 2.3. If the same door opening has two door panels and an air gap between them, the value in accordance with table 3 is used as thermal resistance of the air gap. In this case a seal in the gap between at least one door panel and the frame is required.

6.6.2 Thermal transmittance (U_f) for the frame part is calculated in accordance with item 6.3. Thermal transmittance for the possible window glazing in a door is calculated in accordance with item 6.2. Linear additional conductance for the edges of the glazing in the door panel is calculated in accordance with item 6.4.

6.6.3 If the same door opening has two door panels with windows, the windows are regarded as one window structure in the calculations and the value in accordance with table 3 is used as thermal resistance of the air gap between them provided that at least one door panel is provided with seals.

6.6.4 If the opaque part of a door panel or the ventilation panel has thermal bridges, the effect of linear and point thermal bridges is taken into account in the mean thermal transmittance (U_p) for the opaque part and the ventilation panel in accordance with item 2.3.

6.6.5 Mean thermal transmittance (U_D) for a door and ventilation panel is calculated using the formula (10).

$$U_D = \frac{A_g\,U_g + A_p\,U_p + A_f\,U_f + l_g\,\psi_g}{A_g + A_p + A_f} \qquad (10)$$

A_g	area of a glazing, m^2
U_g	U-value for a glazing, $W/(m^2 \cdot K)$
A_p	area of the opaque part of a door panel, m^2
U_p	mean thermal transmittance for the opaque part of a door panel, $W/(m^2 \cdot K)$
A_f	projected area of the frame to the door panel level, m^2
U_f	thermal transmittance for the frame, $W/(m^2 \cdot K)$
l_g	length of the linear thermal bridge formed on the edge of a glazing, m
ψ_g	linear additional conductance on the edge of a glazing, $W/(m \cdot K)$