

Heating systems in buildings — Method for calculation of the design heat load

ICS 91.140.10

National foreword

This British Standard is the UK implementation of EN 12831:2003. Together with BS EN 12828:2003 and BS EN 14336:2004, it supersedes BS 5449:1990, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee RHE/24, Central heating installations.

A list of organizations represented on this committee can be obtained on request to its secretary.

Informative guidance on the use of BS EN 12831:2003 in the UK for forced circulation hot water central heating systems, which may include those for domestic hot water, with heat requirements up to a total of 45 kW is given in National Annex NA (informative).

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

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Heating systems in buildings - Method for calculation of the design heat load

Systèmes de chauffage dans les bâtiments - Méthode de calcul des déperditions calorifiques de base

Heizungsanlagen in Gebäuden - Verfahren zur Berechnung der Norm-Heizlast

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

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

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FOREWORD

This document EN 12831:2003 has been prepared by Technical Committee CEN/TC 228 "Heating systems in buildings", the secretariat of which is held by DS.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2003, and conflicting national standards shall be withdrawn at the latest by March 2004.

This document includes one normative annex, annex D, and three informative annexes, annex A, B and C.

This document includes a Bibliography.

The subjects covered by CEN/TC 228 are the following:

- Design of heating systems (water based, electrical etc.);
- Installation of heating systems;
- Commissioning of heating systems;
- Instructions for operation, maintenance and use of heating systems;
- Methods for calculation of the design heat loss and heat loads;
- Methods for calculation of the energy performance of heating systems.

Heating systems also include the effect of attached systems such as hot water production systems.

All these standards are systems standards, i.e. they are based on requirements addressed to the system as a whole and not dealing with requirements to the products within the system.

Where possible, reference is made to other European or International Standards, a.o product standards. However, use of products complying with relevant product standards is no guarantee of compliance with the system requirements.

The requirements are mainly expressed as functional requirements, i.e. requirements dealing with the function of the system and not specifying shape, material, dimensions or the like.

The guidelines describe ways to meet the requirements, but other ways to fulfil the functional requirements might be used if fulfilment can be proved.

Heating systems differ among the member countries due to climate, traditions and national regulations. In some cases requirements are given as classes so national or individual needs may be accommodated.

In cases where the standards contradict with national regulations, the latter should be followed.

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, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovak Republic, Spain, Sweden, Switzerland and the United Kingdom.

INTRODUCTION

This standard specifies a calculation method for calculation of the heat supply needed under standard design conditions in order to make sure that the required internal design temperature is obtained.

This standard describes calculation of the design heat load:

- on a room by room or heated space by heated space approach, for the purpose of dimensioning the heat emitters;
- on a whole building or building entity approach, for the purpose of dimensioning the heat supply.

This standard also provides a simplified calculation method.

The set values and factors required for calculation of the heat load should be determined in a national annex to this standard. Annex D tabulates all factors, which may be determined on a national level and gives default values for cases where no national values are available.

1 - SCOPE

This standard specifies methods for calculating the design heat loss and the design heat load for basic cases at the design conditions.

Basic cases comprise all buildings:

- with a limited room height (not exceeding 5 m);
- assumed to be heated to steady state conditions under the design conditions.

Examples of such buildings are: residential buildings; office and administration buildings; schools; libraries; hospitals; recreational buildings; prisons; buildings used in the catering trade; department stores and other buildings used for business purposes; industrial buildings.

In the annexes, information is also given for dealing with the following special cases:

- high ceiling buildings or large enclosure;
- buildings where air temperature and mean radiant temperature differ significantly.

2 - NORMATIVE REFERENCES

This European 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 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 673

Glass in building - Determination of thermal transmittance (U value) - Calculation method.

EN ISO 6946

Building components and building elements - Thermal resistance and thermal transmittance - Calculation method (ISO 6946:1996).

EN ISO 10077-1

Thermal performance of windows, doors and shutters - Calculation of thermal transmittance - Part 1: Simplified method (ISO 10077-1:2000).

prEN ISO 10077-2

Thermal performance of windows, doors and shutters - Calculation of thermal transmittance - Part 2: Numerical method for frames (ISO/DIS 10077-2:1998).

EN ISO 10211-1

Thermal bridges in building construction - Heat flows and surface temperatures - Part 1: General calculation methods (ISO 10211-1:1995).

EN ISO 10211-2

Thermal bridges in building construction - Calculation of heat flows and surface temperatures - Part 2: Linear thermal bridges (ISO 10211-2:2001).

EN ISO 10456

Building materials and products - Procedures for determining declared and design thermal values (ISO 10456:1999).

EN 12524

Building materials and products - Hygrothermal properties - Tabulated design values.

EN ISO 13370

Thermal performance of buildings - Heat transfer via the ground - Calculation methods (ISO 13370:1998).

EN ISO 14683

Thermal bridges in building construction - Linear thermal transmittance - Simplified methods and default values (ISO 14683:1999).

3 - TERMS, DEFINITIONS AND SYMBOLS

3.1 - TERMS AND DEFINITIONS

For the purposes of this European Standard, the following terms and definitions apply.

3.1.1

basement

a room is considered as a basement if more than 70% of its external wall area is in contact with the ground

3.1.2

building element

building component such as a wall, a floor

3.1.3

building entity

total volume of heated spaces served by one common heating system (i.e. single dwellings) where the heat supplied to each single dwelling can be centrally controlled by the occupant

3.1.4

design temperature difference

difference between the internal design temperature and the external design temperature

3.1.5

design heat loss

quantity of heat per unit time leaving the building to the external environment under specified design conditions

3.1.6

design heat loss coefficient

design heat loss per unit of temperature difference

3.1.7

design heat transfer

heat transferred inside a building entity or a building

3.1.8

design heat load

required heat flow necessary to achieve the specified design conditions

3.1.9

design transmission heat loss of the considered space

heat loss to the exterior as a result of thermal conduction through the surrounding surfaces, as well as heat transfer between heated spaces inside a building

3.1.10

design ventilation heat loss of the considered space

heat loss to the exterior by ventilation and infiltration through the building envelope and the heat transferred by ventilation from one heated space to another heated space

3.1.11

external air temperature

temperature of the air outside the building

3.1.12

external design temperature

external air temperature which is used for calculation of the design heat losses

3.1.13

heated space

space which is to be heated to the specified internal design temperature

3.1.14

internal air temperature

temperature of the air inside the building

3.1.15

internal design temperature

operative temperature at the centre of the heated space (between 0,6 and 1,6 m height) used for calculation of the design heat losses

3.1.16

annual mean external temperature

mean value of the external temperature during the year

3.1.17

operative temperature

arithmetic average of the internal air temperature and the mean radiant temperature

3.1.18

thermal zone

part of the heated space with a given set-point temperature and with negligible spatial variations of the internal temperature

3.1.19

unheated space

space which is not part of the heated space

3.1.20

ventilation system

system to provide specified air flow rates

3.1.21

zone

group of spaces having similar thermal characteristics

3.2 - SYMBOLS AND UNITS

For the purposes of this European Standard, the following symbols, units and indices apply.

Table 1 - Symbols and units

Symbol	Name	Unit
a, b, c, f	various correction factors	-
A	area	m^2
B'	characteristic parameter	m
c_p	specific heat capacity at constant pressure	$\text{J}/(\text{kg}\cdot\text{K})$
d	thickness	m
e_i	shielding coefficient	-
e_k, e_l	correction factors for the exposure	-
G_w	ground water correction factor	-
h	surface coefficient of heat transfer	$\text{W}/(\text{m}^2\cdot\text{K})$
H	heat loss coefficient, heat transfer coefficient	W/K
l	length	m
n	external air exchange rate	h^{-1}
n_{50}	air exchange rate at 50 Pa pressure difference between the inside and the outside of the building	h^{-1}
P	perimeter of the floor slab	m
Q	quantity of heat, quantity of energy	J
T	thermodynamic temperature on the Kelvin scale	K
U	thermal transmittance	$\text{W}/(\text{m}^2\cdot\text{K})$
v	wind velocity	m/s
V	volume	m^3
$\dot{V}$	air flow rate	m^3/s
ε	height correction factor	-
Φ	heat loss, heat power	W
Φ_{HL}	heat load	W
η	efficiency	%
λ	conductivity	$\text{W}/(\text{m}\cdot\text{K})$
θ	temperature on the Celsius scale	$^{\circ}\text{C}$
ρ	density of air at $\theta_{\text{int},i}$	kg/m^3
Ψ	linear thermal transmittance	$\text{W}/(\text{m}\cdot\text{K})$

Table 2 – Indices

a : air	h : height	o : operative
A : building entity	inf : infiltration	r : mean radiant
bdg,B : building	int : internal	RH : reheat
bf : basement floor	i, j : heated space	su : supply
bw : basement wall	k : building element	T : transmission
e : external, exterior	l : thermal bridge	tb : type of building
env : envelope	m : annual mean	u : unheated space
equiv : equivalent	mech : mechanical	V : ventilation
ex : exhaust	min : minimum	$\Delta\theta$: higher indoor temperature
g : ground	nat : natural	W : water, window/wall

4 - PRINCIPLE OF THE CALCULATION METHOD

The calculation method for the basic cases is based on the following hypotheses:

- the temperature distribution (air temperature and design temperature) is assumed to be uniform;
- the heat losses are calculated in steady state conditions assuming constant properties, such as values for temperature, characteristics of building elements, etc.

The procedure for basic cases can be used for the majority of buildings:

- with a ceiling height not exceeding 5 m;
- heated or assumed to be heated at a specified steady state temperature;
- where the air temperature and the operative temperature are assumed to be of the same value.

In poorly insulated buildings and/or during heating-up periods with emission systems with a high convection heat transfer, e.g. air heating, or large heating surfaces with significant radiation components, e.g. floor or ceiling heaters, there may be significant differences between the air temperature and the operative temperature, as well as a deviation from a uniform temperature distribution over the room, which could lead to substantial deviation from the basic case. These cases shall be considered as special cases (see annex B). The case of a non-uniform temperature distribution can also be considered in 7.1.4.

Initially, the design heat losses are calculated. These results are then used to determine the design heat load.

For the calculation of the design heat losses of a heated space, the following components shall be considered:

- the design transmission heat loss, which is the heat loss to the exterior as a result of thermal conduction through the surrounding surfaces, as well as heat transfer between heated spaces due to the fact, that adjacent heated spaces may be heated, or conventionally assumed to be heated, at different temperatures. For example, adjacent rooms belonging to another apartment can be assumed to be heated at a fixed temperature corresponding to an unoccupied apartment;
- the design ventilation heat loss, which is the heat loss to the exterior by ventilation or by infiltration through the building envelope and the heat transferred by ventilation from one heated space to another heated space inside the building.

5 - GENERAL CONSIDERATIONS

5.1 - CALCULATION PROCEDURE FOR A HEATED SPACE

The steps of the calculation procedure for a heated space are as follows (see Figure 1):

- a) determine the value of the external design temperature and the annual mean external temperature;
- b) specify the status of each space (heated or unheated) and the values of the internal design temperature of each heated space;
- c) determine the dimensional and thermal characteristics of all building elements for each heated and unheated space;
- d) calculate the design transmission heat loss coefficient and multiply by the design temperature difference to obtain the design transmission heat loss of the heated space;
- e) calculate the design ventilation heat loss coefficient and multiply by the design temperature difference to obtain the design ventilation heat loss of the heated space;
- f) obtain the total design heat loss of the heated space by adding the design transmission heat loss and the design ventilation heat loss;
- g) calculate the heating-up capacity of the heated space, i.e. additional power required to compensate for the effects of intermittent heating;
- h) obtain the total design heat load of the heated space by adding the total design heat loss and the heating-up capacity.

5.2 - CALCULATION PROCEDURE FOR A BUILDING ENTITY OR A BUILDING

For sizing of the heat supply, e.g. a heat exchanger or a heat generator, the total design heat load of the building entity or the building shall be calculated. The calculation procedure is based on the results of the heated space by heated space calculation.

The steps of the calculation procedure for a building entity or a building are as follows:

- a) sum up the design transmission heat losses of all heated spaces without considering the heat transferred inside the specified system boundaries to obtain the total design transmission heat loss of the building entity or the building;
- b) sum up the design ventilation heat losses of all heated spaces without considering the heat transferred inside the specified system boundaries to obtain the total design ventilation heat loss of the building entity or the building;
- c) obtain the total design heat loss of the building entity or the building by adding the total design transmission heat loss and the total design ventilation heat loss;
- d) sum up the heating-up capacities of all heated spaces to obtain the total heating-up capacity of the building entity or the building required to compensate for the effects of intermittent heating;
- e) obtain the total design heat load of the building entity or the building by adding the total design heat loss and the total heating-up capacity.

5.3 - CALCULATION PROCEDURE FOR THE SIMPLIFIED METHOD

The calculation procedure for the simplified method follows the procedure given in 5.1 and 5.2. However, simplifications are made when determining the different heat losses. The simplified method is described in clause 9.

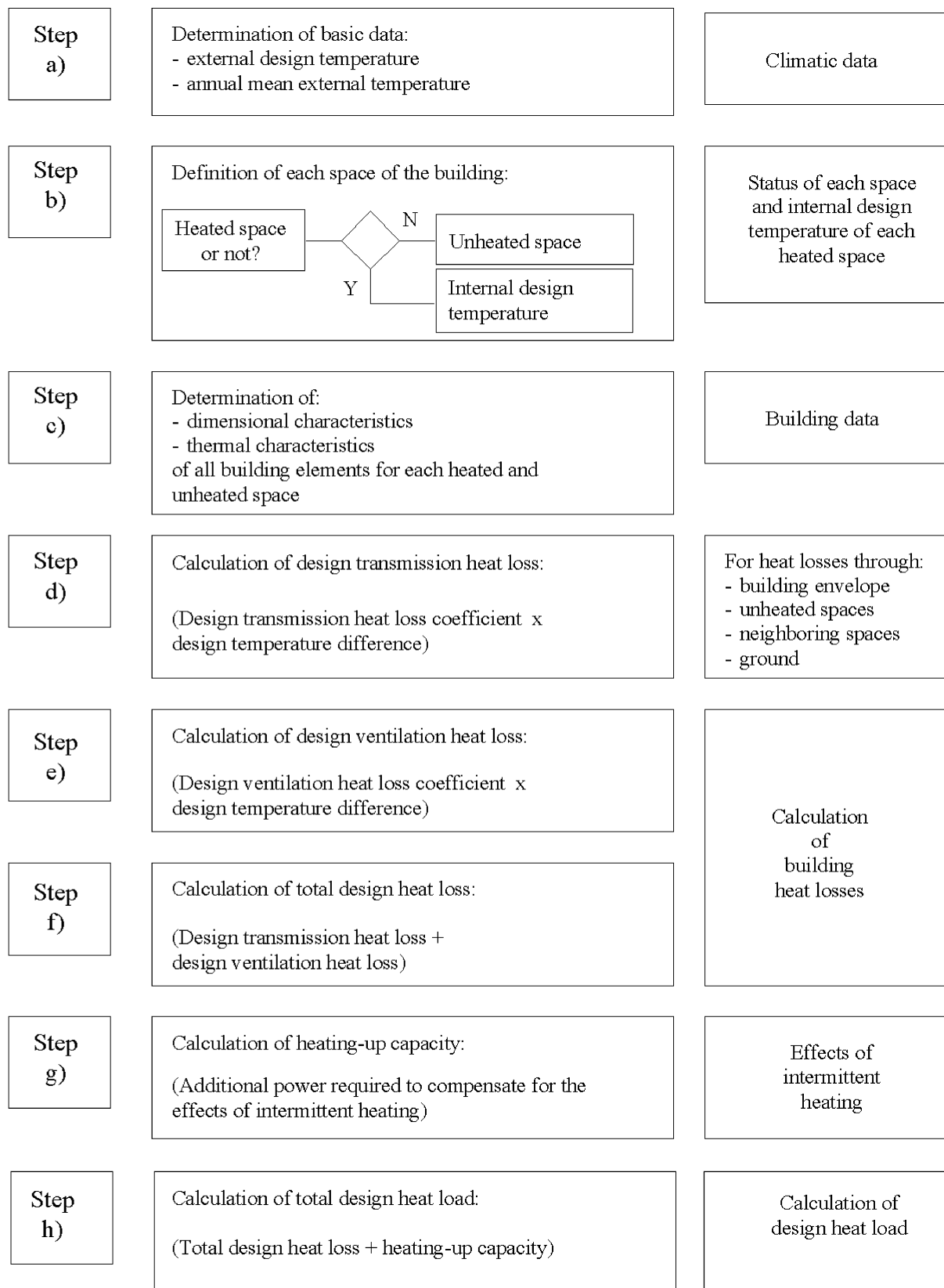


Figure 1 - Calculation procedure for a heated space

6 - DATA REQUIRED

Annex D of this standard provides information on the appropriate data required for performing the heat load calculation. Where no national annex to this standard is available as a reference providing national values, the necessary information may be obtained from the default values stated in annex D.

The following data is required.

6.1 - CLIMATIC DATA

For this calculation method, the following climatic data is used:

- external design temperature, θ_e , for the design heat loss calculation to the exterior;
- annual mean external temperature, $\theta_{m,e}$, for the heat loss calculation to the ground.

Calculations have to be made in order to determine the design climatic data. As there is not yet a European agreement on the calculation and presentation of these climatic parameters, defined and published national values shall be used.

For calculation and presentation of the external design temperature, national or public bodies can refer to prEN ISO 15927-5. Another possibility for determining the external design temperature is to use the lowest two-day mean temperature, which has been registered ten times over a twenty-year period.

6.2 - INTERNAL DESIGN TEMPERATURE

The internal temperature used for calculation of the design heat loss, is the internal design temperature, θ_{int} . For the basic case, the operative temperature and the internal air temperature are assumed to be of the same value. In cases where this does not apply, annex B gives more information.

Information on the internal design temperature and values to be used shall be given in a national annex to this standard or in the project specifications. Where no national annex is available, default values are given in D.2.

6.3 - BUILDING DATA

The input data required for a room by room calculation are listed below:

V_i	internal air volume of each room (heated and unheated spaces) in cubic metres (m^3);
A_k	area of each building element in square metres (m^2);
U_k	thermal transmittance of each building element in Watts per square metres per Kelvin ($W/m^2 \cdot K$);
Ψ_l	linear thermal transmittance of each linear thermal bridge in Watts per metres per Kelvin ($W/m \cdot K$);
l_l	length of each linear thermal bridge in metres (m).

Calculation of the thermal transmittance (U-value) of building elements shall be carried out with respect to the boundary conditions and the material characteristics which are defined and recommended in the (pr)EN-standards. An overview of all parameters, which are used when calculating U-values of building elements, together with reference to the appropriate standard to be applied, is given in the following table. National values can be used if typical local conditions or regulations apply. Such values shall be defined and published at a national level.

Table 3 – Parameters for calculation of U-values

Symbol and unit	NAME OF PARAMETER	Reference of related (pr)EN-standard
R_{si} ($m^2 \cdot K/W$)	Internal surface resistance	EN ISO 6946
R_{se} ($m^2 \cdot K/W$)	External surface resistance	EN ISO 6946
λ ($W/m \cdot K$)	Thermal conductivity (homogeneous materials): - determination of declared and design values (procedure) - tabulated design values (safe values) - ground types - local placement and humidity conditions (country dependent)	EN ISO 10456 EN 12524 EN ISO 13370 national standards
R ($m^2 \cdot K/W$)	Thermal resistance of (non) homogeneous materials	EN ISO 6946
R_a ($m^2 \cdot K/W$)	Thermal resistance of air layers or cavities: - unventilated, slightly and well ventilated air layers - in coupled and double windows	EN ISO 6946 EN ISO 10077-1
U ($W/m^2 \cdot K$)	Thermal transmittance: - general calculation method - windows, doors (calculated and tabulated values) - frames (numerical method) - glazing	EN ISO 6946 EN ISO 10077-1 prEN ISO 10077-2 EN 673
Ψ ($W/m \cdot K$)	Linear thermal transmittance (thermal bridges): - detailed calculation (numerical - 3D) - detailed calculation (2D) - simplified calculation	EN ISO 10211-1 EN ISO 10211-2 EN ISO 14683
χ (W/K)	Point-thermal transmittance (3D thermal bridges)	EN ISO 10211-1

For determining the ventilation heat loss coefficient, the following quantities are used as appropriate:

- n_{min} minimum external air exchange rate per hour (h^{-1});
- n_{50} air exchange rate at 50 Pa pressure difference between inside and outside per hour (h^{-1});
- $\dot{V}_{inf}$ infiltration air flow rate due to the untightness of the building envelope, taking into account wind and stack-effects, in cubic metres per second (m^3/s);
- $\dot{V}_{su}$ supply air flow rate in cubic metres per second (m^3/s);
- $\dot{V}_{ex}$ exhaust air flow rate in cubic metres per second (m^3/s);
- η_v efficiency of the heat recovery system on exhaust air.

The choice of building dimensions used shall be clearly stated. Whatever the choice, the losses through the total external wall area shall be included. Internal, external or overall internal dimensions can be used according to EN ISO 13789, but the choice of building dimensions shall be clearly stated and kept the same throughout the calculation. Be aware that EN ISO 13789 does not cover a room by room approach.

7 – TOTAL DESIGN HEAT LOSS FOR A HEATED SPACE - BASIC CASES

The total design heat loss for a heated space (i), Φ_i , is calculated as follows:

$$\Phi_i = \Phi_{T,i} + \Phi_{V,i} \quad [\text{W}] \quad (1)$$

where:

$\Phi_{T,i}$ = design transmission heat loss for heated space (i) in Watts (W);

$\Phi_{V,i}$ = design ventilation heat loss for heated space (i) in Watts (W).

7.1 - DESIGN TRANSMISSION HEAT LOSS

The design transmission heat loss for a heated space (i), $\Phi_{T,i}$, is calculated as follows:

$$\Phi_{T,i} = (H_{T,ie} + H_{T,iue} + H_{T,ig} + H_{T,ij}) \cdot (\theta_{int,i} - \theta_e) \quad [\text{W}] \quad (2)$$

where:

$H_{T,ie}$ = transmission heat loss coefficient from heated space (i) to the exterior (e) through the building envelope in Watts per Kelvin (W/K);

$H_{T,iue}$ = transmission heat loss coefficient from heated space (i) to the exterior (e) through the unheated space (u) in Watts per Kelvin (W/K);

$H_{T,ig}$ = steady state ground transmission heat loss coefficient from heated space (i) to the ground (g) in Watts per Kelvin (W/K);

$H_{T,ij}$ = transmission heat loss coefficient from heated space (i) to a neighbouring heated space (j) heated at a significantly different temperature, i.e. an adjacent heated space within the building entity or a heated space of an adjacent building entity, in Watts per Kelvin (W/K);

$\theta_{int,i}$ = internal design temperature of heated space (i) in degrees Celcius (°C);

θ_e = external design temperature in degrees Celcius (°C).

7.1.1 - HEAT LOSSES DIRECTLY TO THE EXTERIOR - HEAT LOSS COEFFICIENT $H_{T,IE}$

The design transmission heat loss coefficient from heated space (i) to the exterior (e), $H_{T,ie}$, is due to all building elements and linear thermal bridges separating the heated space from the external environment, such as walls, floor, ceiling, doors, windows. $H_{T,ie}$ is calculated as follows:

$$H_{T,ie} = \sum_k A_k \cdot U_k \cdot e_k + \sum_l \Psi_l \cdot l_l \cdot e_l \quad [\text{W/K}] \quad (3)$$

where:

A_k = area of building element (k) in square metres (m²);

e_k, e_l = correction factors for the exposure taking into account climatic influences such as different insulation, moisture absorption of building elements, wind velocity and temperature, provided these influences have not already been taken into account in the determination of the U-values (EN ISO 6946).

e_k and e_l shall be determined on a national basis. In the absence of national values, default values are given in D.4.1;

- U_k = thermal transmittance of building element (k) in Watts per square metres per Kelvin ($\text{W/m}^2\cdot\text{K}$), calculated according to:
- EN ISO 6946 (for opaque elements);
 - EN ISO 10077-1 (for doors and windows);
 - or from indications given in European Technical Approvals;
- l_l = length of the linear thermal bridge (l) between the interior and the exterior in metres (m);
- Ψ_l = linear thermal transmittance of the linear thermal bridge (l) in Watts per metre per Kelvin ($\text{W/m}\cdot\text{K}$). Ψ_l shall be determined in one of the following two ways:
- for a rough assessment, use of tabulated values provided in EN ISO 14683;
 - or calculated according to EN ISO 10211-2.

Tabulated values of Ψ_l in EN ISO 14683 are given for a whole building approach and not for a room by room approach. The proportional split of the Ψ_l -value between rooms is at the discretion of the system designer.

Non-linear thermal bridges are not taken into account in this calculation.

Simplified method for linear transmission heat losses

The following simplified method can be used for calculation of the linear transmission heat losses:

$$U_{kc} = U_k + \Delta U_{tb} \quad [\text{W/m}^2\cdot\text{K}] \quad (4)$$

where:

- U_{kc} = corrected thermal transmittance of building element (k), taking into account linear thermal bridges, in Watts per square metres per Kelvin ($\text{W/m}^2\cdot\text{K}$);
- U_k = thermal transmittance of building element (k) in Watts per square metres per Kelvin ($\text{W/m}^2\cdot\text{K}$);
- ΔU_{tb} = correction factor in Watts per square metres per Kelvin ($\text{W/m}^2\cdot\text{K}$), depending on the type of building element. Default values are given in D.4.1.

7.1.2 - HEAT LOSSES THROUGH UNHEATED SPACE - HEAT LOSS COEFFICIENT $H_{T,iue}$

If there is an unheated space (u) between the heated space (i) and the exterior (e), the design transmission heat loss coefficient, $H_{T,iue}$, from the heated space to the exterior is calculated as follows:

$$H_{T,iue} = \sum_k A_k \cdot U_k \cdot b_u + \sum_l \Psi_l \cdot l_l \cdot b_u \quad [\text{W/K}] \quad (5)$$

where:

- b_u = temperature reduction factor taking into account the difference between temperature of the unheated space and external design temperature.

The temperature reduction factor, b_u , can be determined by one of the following three methods:

- a) if the temperature of the unheated space, θ_u , under design conditions is specified or calculated, b_u is given by:

$$b_u = \frac{\theta_{\text{int},i} - \theta_u}{\theta_{\text{int},i} - \theta_e} \quad [-] \quad (6)$$

b) if θ_u is unknown, b_u is given by:

$$b_u = \frac{H_{ue}}{H_{iu} + H_{ue}} \quad [-] \quad (7)$$

where:

- H_{iu} = heat loss coefficient from the heated space (i) to the unheated space (u) in Watts per Kelvin (W/K), taking into account:
- the transmission heat losses (from the heated space to the unheated space);
 - the ventilation heat losses (air flow rate between the heated space and the unheated space);
- H_{ue} = heat loss coefficient from the unheated space (u) to the exterior (e) in Watts per Kelvin (W/K), taking into account:
- the transmission heat losses (to the exterior and to the ground);
 - the ventilation heat losses (between the unheated space and the exterior).

c) Reference to a national annex to this standard, providing values of b_u for each case. In the absence of national values, default values are given in D.4.2.

7.1.3 - HEAT LOSSES THROUGH THE GROUND - HEAT LOSS COEFFICIENT $H_{T,ig}$

The rate of heat loss through floors and basement walls, directly or indirectly in contact with the ground, depends on several factors. These include the area and exposed perimeter of the floor slab, the depth of a basement floor beneath ground level, and the thermal properties of the ground.

For the purpose of this standard, the rate of heat loss to the ground can be calculated according to EN ISO 13370:

- in a detailed manner;
- or in a simplified manner described below. In this case, the heat losses due to thermal bridges are not taken into account.

The design steady state ground transmission heat loss coefficient, $H_{T,ig}$, from heated space (i) to the ground (g) is calculated as follows:

$$H_{T,ig} = f_{g1} \cdot f_{g2} \cdot \left(\sum_k A_k \cdot U_{\text{equiv},k} \right) \cdot G_w \quad [\text{W/K}] \quad (8)$$

where:

- f_{g1} = correction factor taking into account the influence from annual variation of the external temperature. This factor shall be determined on a national basis. In the absence of national values, default value is given in D.4.3;

f_{g2} = temperature reduction factor taking into account the difference between annual mean external temperature and external design temperature, given by:

$$f_{g2} = \frac{\theta_{\text{int},i} - \theta_{\text{m},e}}{\theta_{\text{int},i} - \theta_e};$$

A_k = area of building element (k) in contact with the ground in square metres (m²);

$U_{\text{equiv},k}$ = equivalent thermal transmittance of building element (k) in Watts per square metres per Kelvin (W/m²·K), determined according to the floor-typology (see Figures 3 to 6 and Tables 4 to 7);

G_w = correction factor taking into account the influence from ground water. If the distance between the assumed water table and the basement floor level (floor slab) is less than 1 m, this influence has to be taken into account. This factor can be calculated according to EN ISO 13370 and shall be determined on a national basis. In the absence of national values, default values are given in D.4.3.

Figures 3 to 6 and Tables 4 to 7 provide values of $U_{\text{equiv},k}$ for the different floor-typologies distinguished in EN ISO 13370, as a function of the U-value of the building elements and the characteristic parameter, B' . In these figures and tables, the thermal conductivity of the ground is assumed to be $\lambda_g = 2.0 \text{ W/m}\cdot\text{K}$ and the effects of edge insulation are not taken into account.

The characteristic parameter, B' , is given by (see Figure 2):

$$B' = \frac{A_g}{0,5 \cdot P} \quad [\text{m}] \quad (9)$$

where:

A_g = area of the considered floor slab in square metres (m²). For a whole building, A_g is the total ground floor area. For part of a building, e.g. a building entity in a row of houses, A_g is the ground floor area under consideration;

P = perimeter of the considered floor slab in metres (m). For a whole building, P is the total perimeter of the building. For part of a building, e.g. a building entity in a row of houses, P includes only the length of external walls separating the heated space under consideration from the external environment.

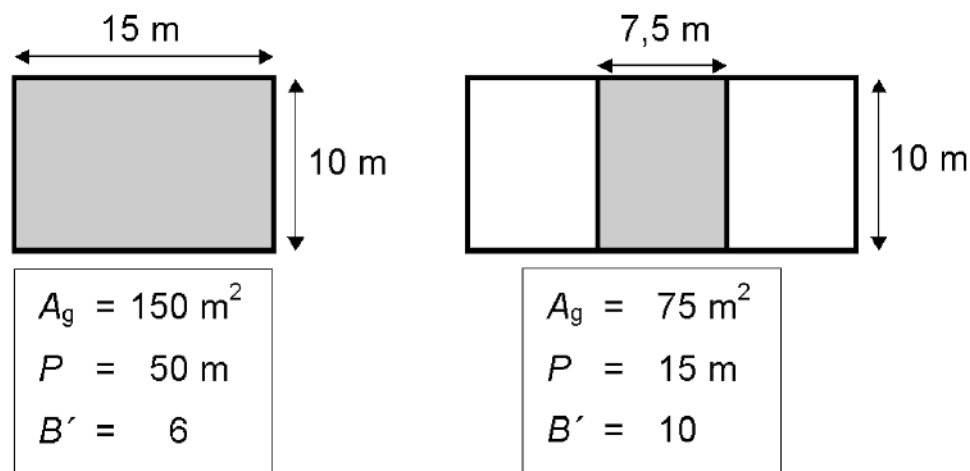


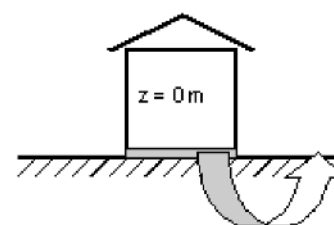
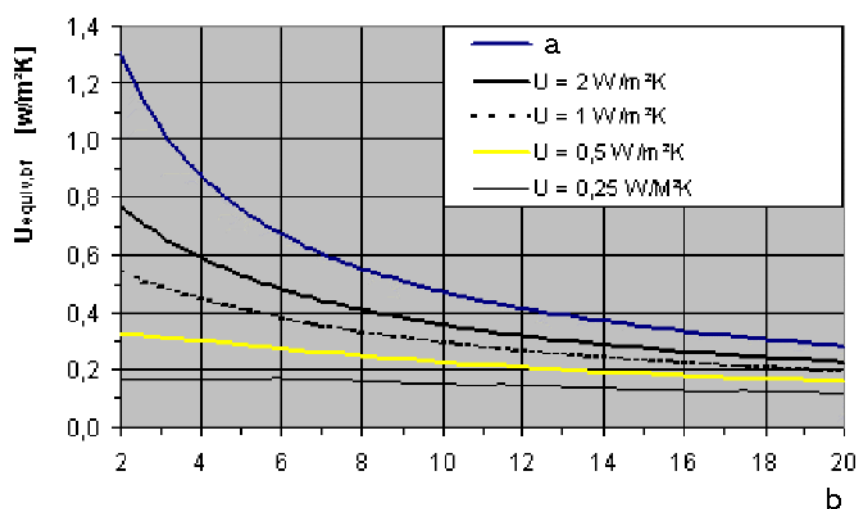
Figure 2 – Determination of the characteristic parameter B'

In EN ISO 13370, the parameter B' is calculated for the building as a whole. For a room by room approach, B' shall be determined for each room in one of the following three ways:

- for all rooms without external walls separating the heated space under consideration from the external environment, use the B' -value calculated for the building as a whole;
- for all rooms with well insulated floor ($U_{\text{floor}} < 0,5 \text{ W/m}^2\cdot\text{K}$), use the B' -value calculated for the building as a whole;
- for all other rooms, calculate separately the B' -value on a room by room approach (conservative calculation).

Floor slab on ground level

The equivalent thermal transmittance of the basement floor is given in Figure 3 and Table 4, as a function of the thermal transmittance of the floor and the characteristic parameter B' .



$U_{\text{equiv,bf}}$

Key

a Concrete floor (no insulation)

b B' -value [m]

Figure 3 - $U_{\text{equiv,bf}}$ -value of the basement floor for floor slab on ground level, as a function of thermal transmittance of the floor and the B' -value

Table 4 - $U_{\text{equiv,bf}}$ -value of the basement floor for floor slab on ground level, as a function of thermal transmittance of the floor and the B' -value

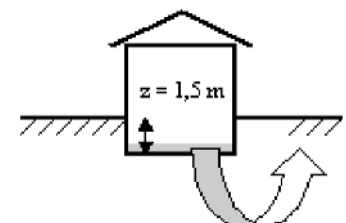
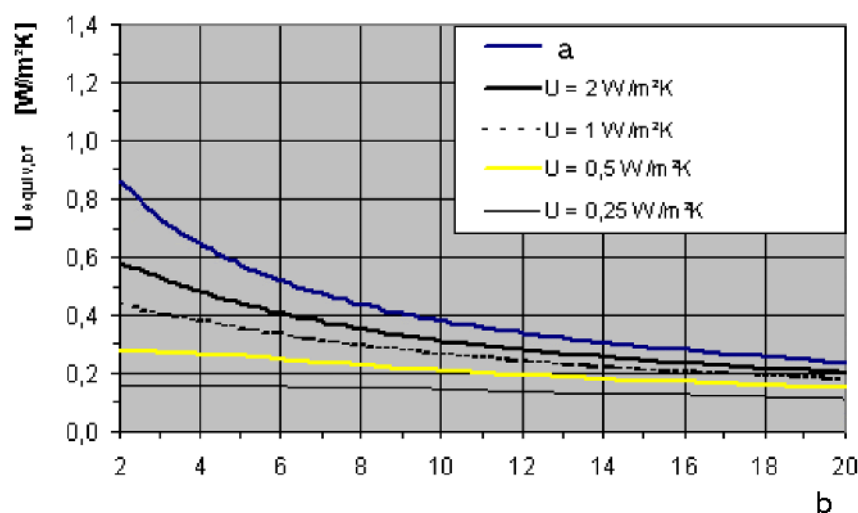
B' -value m	$U_{\text{equiv,bf}}$ (for $z = 0$ metre) $\text{W/m}^2\cdot\text{K}$				
	no insulation	$U_{\text{floor}} = 2,0 \text{ W/m}^2\cdot\text{K}$	$U_{\text{floor}} = 1,0 \text{ W/m}^2\cdot\text{K}$	$U_{\text{floor}} = 0,5 \text{ W/m}^2\cdot\text{K}$	$U_{\text{floor}} = 0,25 \text{ W/m}^2\cdot\text{K}$
2	1,30	0,77	0,55	0,33	0,17
4	0,88	0,59	0,45	0,30	0,17
6	0,68	0,48	0,38	0,27	0,17
8	0,55	0,41	0,33	0,25	0,16
10	0,47	0,36	0,30	0,23	0,15
12	0,41	0,32	0,27	0,21	0,14
14	0,37	0,29	0,24	0,19	0,14
16	0,33	0,26	0,22	0,18	0,13
18	0,31	0,24	0,21	0,17	0,12
20	0,28	0,22	0,19	0,16	0,12

Heated basement with floor slab beneath ground level

The basis for calculation of the equivalent thermal transmittance for a heated basement partly or fully beneath ground level is similar to that for the floor slab on ground level, but involves two types of building elements, i.e. $U_{\text{equiv,bf}}$ for floor elements and $U_{\text{equiv,bw}}$ for wall elements.

The equivalent thermal transmittance for floor elements is given in Figures 4 to 5 and Tables 5 to 6, as a function of the thermal transmittance of the floor and the characteristic parameter B' . The equivalent thermal transmittance for wall elements is given in Figure 6 and Table 7, as a function of the thermal transmittance of the wall and the depth beneath ground level.

For a heated basement partly beneath ground level, heat losses directly to the exterior from those parts of the basement which are above ground level, are determined according to 7.1.1 with no influences from the ground and considering only those parts of the building elements which are above ground level.

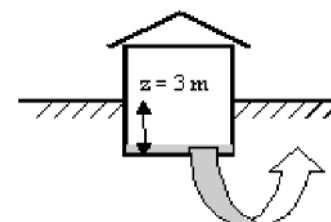
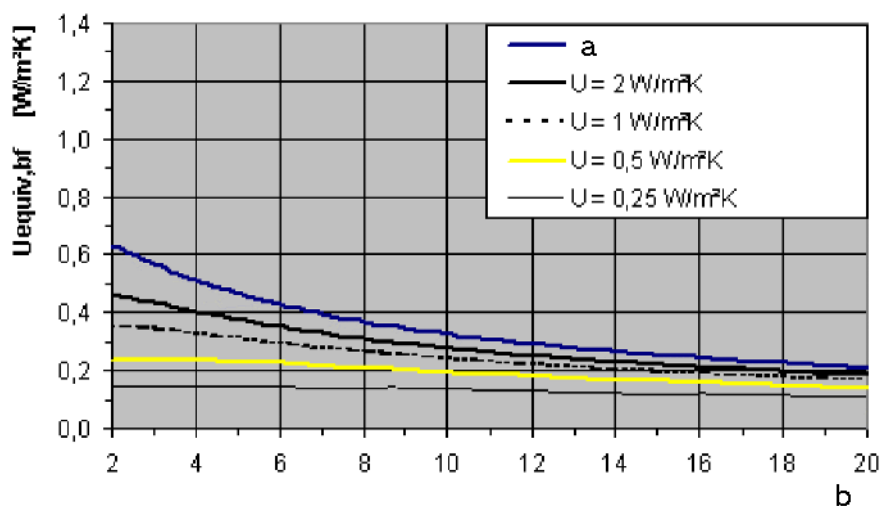

 $U_{\text{equiv,bf}}$
Key

a Concrete floor (no insulation)

b B' -value [m]**Figure 4 - $U_{\text{equiv,bf}}$ -value for floor elements of a heated basement with floor slab 1,5 m beneath ground level, as a function of thermal transmittance of the floor and the B' -value**

Table 5 - $U_{\text{equiv,bf}}$ -value for floor elements of a heated basement with floor slab 1,5 m beneath ground level, as a function of thermal transmittance of the floor and the B' -value

B' -value m	$U_{\text{equiv,bf}}$ (for $z = 1,5$ metres) $\text{W/m}^2\cdot\text{K}$				
	no insulation	$U_{\text{floor}} = 2,0 \text{ W/m}^2\cdot\text{K}$	$U_{\text{floor}} = 1,0 \text{ W/m}^2\cdot\text{K}$	$U_{\text{floor}} = 0,5 \text{ W/m}^2\cdot\text{K}$	$U_{\text{floor}} = 0,25 \text{ W/m}^2\cdot\text{K}$
2	0,86	0,58	0,44	0,28	0,16
4	0,64	0,48	0,38	0,26	0,16
6	0,52	0,40	0,33	0,25	0,15
8	0,44	0,35	0,29	0,23	0,15
10	0,38	0,31	0,26	0,21	0,14
12	0,34	0,28	0,24	0,19	0,14
14	0,30	0,25	0,22	0,18	0,13
16	0,28	0,23	0,20	0,17	0,12
18	0,25	0,22	0,19	0,16	0,12
20	0,24	0,20	0,18	0,15	0,11



$U_{\text{equiv,bf}}$

Key

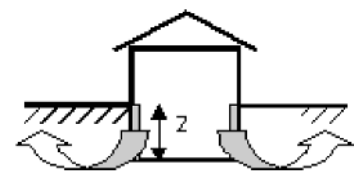
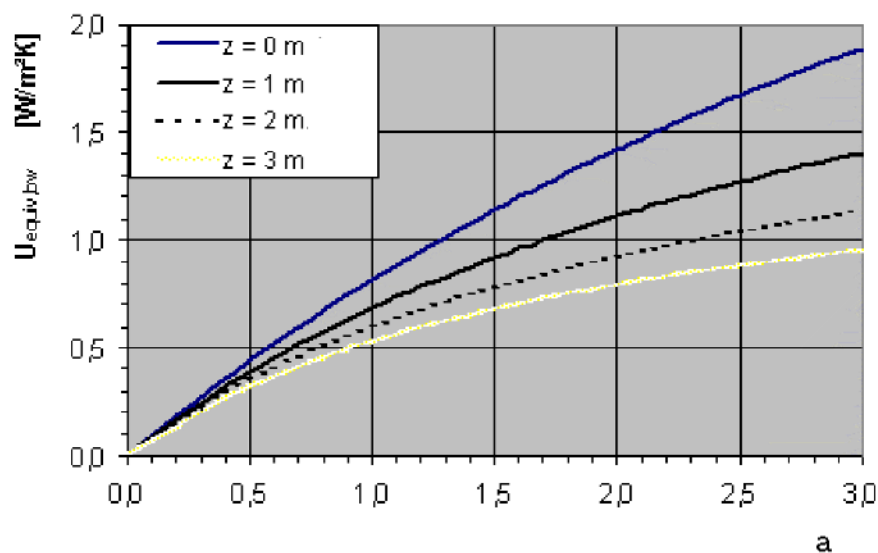
a Concrete floor (no insulation)

b B' -value [m]

Figure 5 - $U_{\text{equiv,bf}}$ -value for floor elements of a heated basement with floor slab 3,0 m beneath ground level, as a function of thermal transmittance of the floor and the B' -value

Table 6 - $U_{\text{equiv,bf}}$ -value for floor elements of a heated basement with floor slab 3,0 m beneath ground level, as a function of thermal transmittance of the floor and the B -value

B -value m	$U_{\text{equiv,bf}}$ (for $z = 3,0$ metres) $\text{W/m}^2\cdot\text{K}$				
	no insulation	$U_{\text{floor}} = 2,0 \text{ W/m}^2\cdot\text{K}$	$U_{\text{floor}} = 1,0 \text{ W/m}^2\cdot\text{K}$	$U_{\text{floor}} = 0,5 \text{ W/m}^2\cdot\text{K}$	$U_{\text{floor}} = 0,25 \text{ W/m}^2\cdot\text{K}$
2	0,63	0,46	0,35	0,24	0,14
4	0,51	0,40	0,33	0,24	0,14
6	0,43	0,35	0,29	0,22	0,14
8	0,37	0,31	0,26	0,21	0,14
10	0,32	0,27	0,24	0,19	0,13
12	0,29	0,25	0,22	0,18	0,13
14	0,26	0,23	0,20	0,17	0,12
16	0,24	0,21	0,19	0,16	0,12
18	0,22	0,20	0,18	0,15	0,11
20	0,21	0,18	0,16	0,14	0,11



$U_{\text{equiv,bw}}$

Key

a U -value of the walls [$\text{W/m}^2\text{K}$]

Figure 6 – $U_{\text{equiv,bw}}$ -value for wall elements of a heated basement, as a function of thermal transmittance of the walls and the depth z beneath ground level

Table 7 - $U_{\text{equiv,bw}}$ -value for wall elements of a heated basement, as a function of thermal transmittance of the walls and the depth z beneath ground level

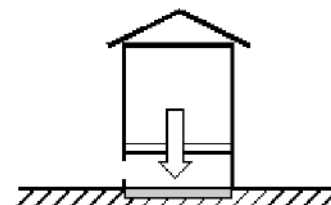
U_{wall} $\text{W/m}^2\cdot\text{K}$	$U_{\text{equiv,bw}}$ $\text{W/m}^2\cdot\text{K}$			
	$z = 0 \text{ m}$	$z = 1 \text{ m}$	$z = 2 \text{ m}$	$z = 3 \text{ m}$
0,00	0,00	0,00	0,00	0,00
0,50	0,44	0,39	0,35	0,32
0,75	0,63	0,54	0,48	0,43
1,00	0,81	0,68	0,59	0,53
1,25	0,98	0,81	0,69	0,61
1,50	1,14	0,92	0,78	0,68
1,75	1,28	1,02	0,85	0,74
2,00	1,42	1,11	0,92	0,79
2,25	1,55	1,19	0,98	0,84
2,50	1,67	1,27	1,04	0,88
2,75	1,78	1,34	1,09	0,92
3,00	1,89	1,41	1,13	0,96

Unheated basement

The transmission heat loss coefficient of the floor separating a heated space from an unheated basement is calculated according to 7.1.2. The U-value of the floor is calculated in the same way as for a floor with no influences from the ground, i.e. equation 8 (and thus factors f_{g1} , f_{g2} and G_w) does not apply.

Suspended floor

The transmission heat loss coefficient of a suspended floor is calculated according to 7.1.2. The U-value of the suspended floor is calculated in the same way as for a floor with no influences from the ground, i.e. equation 8 (and thus factors f_{g1} , f_{g2} and G_w) does not apply.



7.1.4 - HEAT LOSSES TO OR FROM SPACES HEATED AT A DIFFERENT TEMPERATURE - HEAT LOSS COEFFICIENT $H_{T,ij}$

$H_{T,ij}$ expresses the heat transferred by transmission from a heated space (i) to a neighbouring heated space (j) heated at a significantly different temperature. This can be an adjacent room within the building entity (e.g. bathroom, medical examination room, storeroom), a room belonging to an adjacent building entity, (e.g. apartment) or a room belonging to an adjacent building which may be unheated.

$H_{T,ij}$ is calculated as follows:

$$H_{T,ij} = \sum_k f_{ij} \cdot A_k \cdot U_k \quad [\text{W/K}] \quad (10)$$

where:

f_{ij} = temperature reduction factor taking into account the difference between

temperature of the adjacent space and external design temperature, given by:

$$f_{ij} = \frac{\theta_{\text{int},i} - \theta_{\text{adjacent space}}}{\theta_{\text{int},i} - \theta_e}$$

In the absence of national values of the temperature of adjacent heated spaces, default values are given in D.4.4. In a national annex to this standard, the clause corresponding to D.4.4 may include information on the effect of vertical temperature gradients;

- A_k = area of building element (k) in square metres (m²);
 U_k = thermal transmittance of building element (k) in Watts per square metres per Kelvin (W/m²·K).

The effects of thermal bridges are not taken into account in this calculation.

7.2 - DESIGN VENTILATION HEAT LOSS

The design ventilation heat loss, $\Phi_{V,i}$, for a heated space (i) is calculated as follows:

$$\Phi_{V,i} = H_{V,i} \cdot (\theta_{\text{int},i} - \theta_e) \quad [\text{W}] \quad (11)$$

where:

- $H_{V,i}$ = design ventilation heat loss coefficient in Watts per Kelvin (W/K);
 $\theta_{\text{int},i}$ = internal design temperature of heated space (i) in degrees Celsius (°C);
 θ_e = external design temperature in degrees Celsius (°C).

The design ventilation heat loss coefficient, $H_{V,i}$, of a heated space (i) is calculated as follows:

$$H_{V,i} = \dot{V}_i \cdot \rho \cdot c_p \quad [\text{W/K}] \quad (12)$$

where:

- $\dot{V}_i$ = air flow rate of heated space (i) in cubic metres per second (m³/s);
 ρ = density of air at $\theta_{\text{int},i}$ in kilograms per cubic metre (kg/m³);
 c_p = specific heat capacity of air at $\theta_{\text{int},i}$ in kilo Joule per kilogram per Kelvin (kJ/kg·K).

Assuming constant ρ and c_p , equation (12) is reduced to:

$$H_{V,i} = 0,34 \cdot \dot{V}_i \quad [\text{W/K}] \quad (13)$$

where $\dot{V}_i$ is now expressed in cubic metres per hour (m³/h).

The calculation procedure for determining the relevant air flow rate, $\dot{V}_i$, depends upon the case considered, i.e. with or without ventilation system.