Introduction

This Technical Booklet has been prepared by the Department of the Environment for Northern Ireland and provides for certain methods and standards of building which, if followed, will satisfy the requirements of the Building Regulations (Northern Ireland) 1994 ("the Building Regulations").

There is no obligation to follow the methods or comply with the standards set out in this Technical Booklet.

If you prefer you may adopt another way of meeting the requirements of the Building Regulations but you will have to demonstrate that you have satisfied those requirements by other means.

Other regulations

This Technical Booklet relates only to the requirements of Regulations F2, F4 and F6. The work will also have to comply with all other relevant Building Regulations.

British Standards and European Technical Specifications

In this introduction and throughout this Technical Booklet any reference to a British Standard shall be construed as a reference to –

(a) a British Standard or British Standard Code of Practice;

(b) a harmonised standard or other relevant standard of a national standards body of any Member State of the European Economic Area;

(c) an international standard recognised for use in any Member State of the European Economic Area;

(d) any appropriate, traditional procedure of manufacture of a Member State of the European Economic Area which has a technical description sufficiently detailed to permit an assessment of the goods or materials for the use specified; or

(e) a European Technical Approval issued in accordance with the Construction Products Directive,

provided that the proposed standard, code of practice, specification, technical description or European Technical Approval provides, in use, equivalent levels of safety, suitability and fitness for purpose as that provided by the British Standard.

Products conforming with a European Council Directive

Any product designed and manufactured to comply with the requirements of a European Council Directive does not have to comply with any other standard or part of a standard, whether British, International or other, which relates to the same characteristic or specific purpose as the EC Directive.

CE marked construction products

Any construction product (within the meaning of the Construction Products Directive) which bears a CE Mark shall be treated as if it satisfied the requirements of any appropriate British Board of Agrément Certificate, British Standard or British Standard Code of Practice relating to such a product, where the CE Mark relates to the same characteristic or specific purpose as the Certificate, Standard or Code of Practice.

Testing of materials and construction

Where for the purposes of this Technical Booklet testing is carried out it shall be carried out by an appropriate organisation offering suitable and satisfactory evidence of technical and professional competence and independence. This condition shall be satisfied where the testing organisation is accredited in a Member State of the European Economic Area in accordance with the relevant parts of the EN 45000 series of standards for the tests carried out.

Materials and workmanship

Any work to which a requirement of the Building Regulations applies must, in accordance with Part B of the Building Regulations, be carried out with suitable materials and in a workmanlike manner. You can comply with the requirements of Part B by following an appropriate British Standard or you may demonstrate that you have complied with those requirements by other suitable means, such as an acceptable British Board of Agrément Certificate, Quality Assurance Scheme, Independent Certification Scheme or Accredited Laboratory Test Certificate.

Diagrams

The diagrams in this Technical Booklet supplement the text. They do not show all the details of construction and are not intended to illustrate compliance with any other requirement of the Building Regulations. They are not necessarily to scale and should not be used as working details.

Reference

Any reference in this Technical Booklet to a publication shall, unless otherwise stated, be construed as a reference to the edition quoted, together with amendments, supplements or addenda thereto current at 31 January 1998.

Contents

Section 1 – Building fabric

1.1 This Section gives the methods of satisfying the requirements of Regulation F2.

(a) For dwellings two methods are given, they are –

(i) the Elemental Method; and

(ii) the Target U-value Method.

(b) For buildings other than dwellings three methods are given, they are –

(i) the Elemental Method;

(ii) the Calculation Method; and

(iii) the Energy Use Method.

Paragraphs 1.3 to 1.11 and 1.33 to 1.35 apply to all five Methods.

The five Methods are followed by a range of Acceptable constructions (see Appendix A) for walls, floors and roofs. These constructions are accompanied by tables which give simple ways of determining the thickness of insulation to achieve a required U-value.

The incorrect application of energy conservation measures can increase the risk of rain penetration or interstitial condensation. Guidance on avoiding the technical risks which might arise is contained in Building Research Establishment (BRE) Report : Thermal insulation : avoiding risks.

1.2 Regulation A11(5)(d) requires a SAP energy rating to be calculated for every new dwelling in accordance with the Government's Standard Assessment Procedure. The SAP energy rating may be calculated manually or by using a computer program approved for this purpose by the Building Research Establishment on behalf of the Department of the Environment, Transport and the Regions.

Some guidance on SAP energy ratings and examples of typical ratings for different dwelling types are given in Appendix B.

Definitions

1.3 In this Technical Booklet the following definitions apply –

Exposed wall or floor – a wall or floor exposed to the external air or in contact with the ground, or a floor suspended over a void.

Opening – a window, rooflight or any opening for a door, ventilator or other purpose.

Residential buildings – buildings other than dwellings in which people reside including hotels and institutional buildings.

Semi-exposed wall or floor – a wall or floor between a building or part of a building to which Regulation F2 applies and a building or part of a building to which Regulation F2 does not apply.

U-value (thermal transmittance coefficient) – the rate of heat transfer in watts through 1 m^2 of a structure when the air temperatures at each side of the structure differ by 1°C (expressed in W/m^2K).

Ventilated space – a space which is enclosed by structure part of which is exposed to the external air and permanently ventilated to the external air by openings or ducts having an aggregate area exceeding 30% of the wall boundary area.

Wall – includes any internal or external surface finishes.

Window opening – an opening which is provided for a window irrespective of its size or purpose.

General rules

Walls, floors and roofs

1.4 (a) In calculating a U-value the effects of structural framing, timber joists and framing, mortar bedding, window frames and other elements significantly affecting the thermal transmittance shall be taken into account.

(b) The fabric of the building shall be designed and constructed to limit the effects of thermal bridging. Thermal bridging may be disregarded when the difference in thermal resistance between the bridged material and the bridging material is less than 0.1 m^2K/W.

(c) The area of a building element shall be that of its internal surface measured between the finished internal faces of the enclosing fabric of the building, and in the case of a roof, shall be measured in the plane of the ceiling, the area shall include any openings and the areas where partitioning elements abut the internal surface of the wall, floor or roof.

Walls

1.5 (a) The following shall be regarded as exposed walls –

(i) external walls, other than those enclosing a ventilated space;

(ii) external walls in contact with the ground;

(iii) internal walls exposed to a ventilated space; and

(iv) any part of a roof which has a pitch of 70° or more.

(b) The following shall be regarded as part of a wall and assumed to have the same U-value as the wall –

(i) an opening other than for a door, window or rooflight; and

(ii) a meter cupboard recess.

Floors

1.6 (a) A floor shall be regarded as an exposed floor when its undersurface is in contact with the ground or it is exposed to the external air, and shall include a suspended floor over a ventilated or unventilated void.

(b) Any part of a floor which serves as a roof shall be regarded as a roof in relation to that part of the building immediately beneath it.

Roof

1.7 Any opening other than a window, rooflight or door shall be regarded as part of the roof and assumed to have the same U-value as the roof.

Windows, doors and rooflights

1.8 (a) U-values of windows, doors and rooflights shall preferably be taken from manufacturer's independently certified data. In the absence of such data the standard U-values given in Table 1.1 shall be used.

(b) The standard U-values given in Table 1.1 can be achieved by windows having sealed double-glazed units or by other systems (such as secondary glazing) which incorporate two or more panes of glass, or other glazing material, with space between.

(c) Windows and doors with single glazed panels protected by an unheated draughtproof space such as an enclosed porch or conservatory may be assumed to have a U-value of 3.3 W/m^2K.

(d) Single glazed panels may be provided in external doors provided that they do not increase the average U-value for windows, doors and rooflights beyond the limit dependent upon the area of openings permitted by Table 1.3.

(e) Rooflights in any part of a roof at a pitch of 70° or more shall be regarded as a window.

Table **1.1 U-values (W/m^2K) for windows, doors and rooflights**

Item	**Type of frame**							
	Wood		**Metal**		**Thermal break**		**PVC-U**	
Air gap in sealed unit (mm)	6	12	6	12	6	12	6	12
Window, double-glazed	3.3	3.0	4.2	3.8	3.6	3.3	3.3	3.0
Window, double-glazed, low-E	2.9	2.4	3.7	3.2	3.1	2.6	2.9	2.4
Window, double-glazed, Argon fill	3.1	2.9	4.0	3.7	3.4	3.2	3.1	2.9
Window, double-glazed, low-E, Argon fill	2.6	2.2	3.4	2.9	2.8	2.4	2.6	2.2
Window, triple-glazed	2.6	2.4	3.4	3.2	2.9	2.6	2.6	2.4
Door, half double-glazed	3.1	3.0	3.6	3.4	3.3	3.2	3.1	3.0
Door, fully double-glazed	3.3	3.0	4.2	3.8	3.6	3.3	3.3	3.0
Rooflights, double-glazed at less than 70° from horizontal	3.6	3.4	4.6	4.4	4.0	3.8	3.6	3.4
Windows and doors, single-glazed	4.7		5.8		5.3		4.7	
Door, solid timber panel or similar	3.0		—		—		—	
Door, half single-glazed, half timber or similar	3.7		—		—		—	

Calculation of window, door and rooflight areas

1.9 In calculating the area of window, door and rooflight openings in a wall or roof –

(a) the area shall be measured internally between reveals and from head to sill;

(b) the floor area and area of window, door or rooflight openings in accommodation excluded by Regulation F1(2)(a), shall not be included; and

(c) in a shop, access doors and display windows at an access level shall not be included.

Calculation of U-values

1.10 Where the U-value of a wall, floor or roof is to be calculated it shall be calculated in accordance with CIBSE Guide A3 : Thermal Properties of Building Structures : 1986.

However, the U-value of –

(a) a ground floor may be calculated in accordance with the method given in Appendix C; and

(b) a wall, floor or roof containing thermal bridging may be calculated in accordance with the method given in Appendix D.

Limiting U-values

1.11 (a) In a dwelling the U-value of an exposed wall or floor shall be no greater than 0.7 W/m^2K and the U-value of a roof shall be no greater than 0.35 W/m^2K.

(b) In a residential building the U-value of an exposed wall or floor shall be no greater than 0.7 W/m^2K and the U-value of a roof shall be no greater than 0.45 W/m^2K.

(c) In a building other than a dwelling or a residential building the U-value of an exposed wall or floor, or a roof shall be no greater than 0.7 W/m^2K.

Elemental Method for dwellings

1.12 The Elemental Method considers each element of the exposed building fabric of a dwelling separately and a SAP energy rating must be calculated or assumed before it can be used.

In this method the U-value of a construction may be determined by calculation (see paragraph 1.10) or an Acceptable construction (see Appendix A) may be used. It is also permissible to use a mixture of calculated and Acceptable constructions.

(a) Where the SAP energy rating is 60 or less the dwelling shall be designed and constructed with walls, floors and roofs having U-values and areas of openings no greater than those given in column (2) of Table 1.2.

(b) Where the SAP energy rating is more than 60 the dwelling shall be designed and constructed with walls, floors and roofs having U-values and areas of openings no greater than those given in column (3) of Table 1.2.

(c) The maximum U-values and areas of openings for dwellings having a SAP energy rating of 60 or less are illustrated in Diagram 1.1(a) and for dwellings having a SAP energy rating of more than 60 in Diagram 1.1(b).

(d) Where the work consists solely of an extension to a dwelling, the extension shall be designed and constructed with walls, floors and roofs having U-values no greater than those given in column (3) of Table 1.2.

Demonstrating compliance

1.13 A procedure for demonstrating compliance by using the Elemental Method is given in Appendix E.

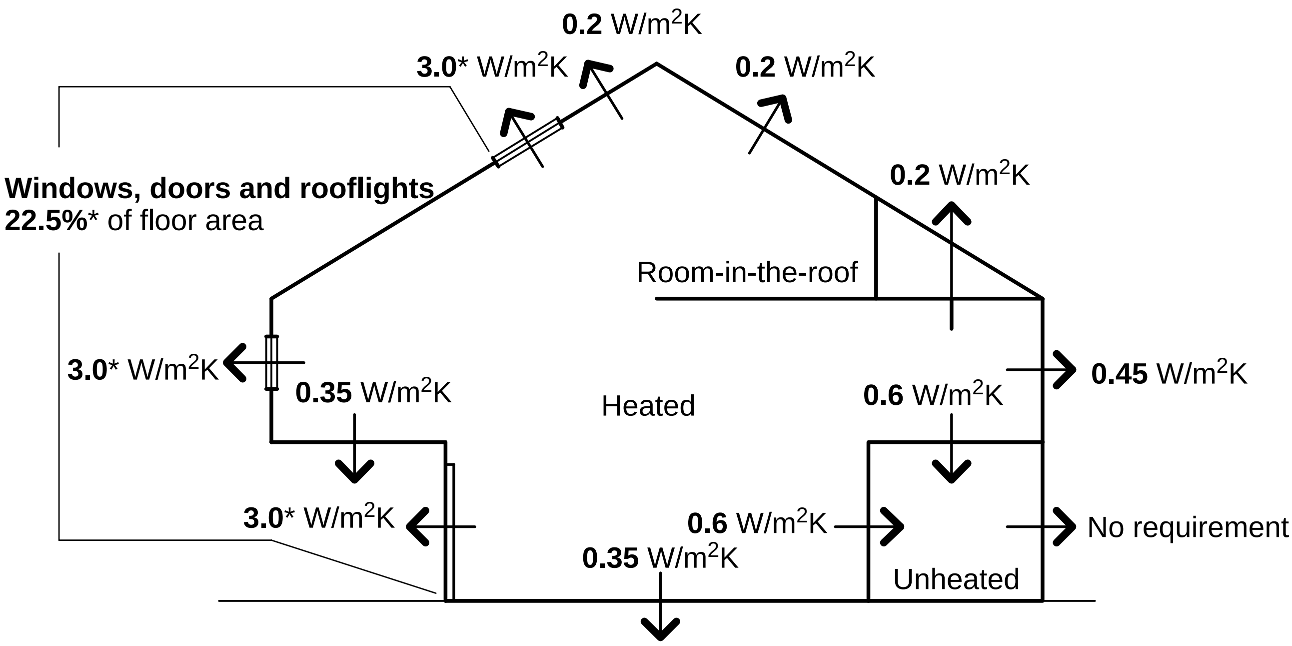
Table **1.2 Maximum U-values (W/m^{2}K) and areas of openings (% of total floor area)**

Element	**SAP Energy Rating**	
(1)	**60 or less** (2)	**more than 60** (3)
Exposed walls	0.45	0.45
Semi-exposed walls and floors	0.6	0.6
Exposed floors and ground floors	0.35	0.45
Flat roof or sloped ceiling of a room-in-the-roof	0.2	0.35
Roofs	0.2	0.25
Windows, doors and rooflights	3.0*	3.3*
Maximum area of glazing and doors	22.5%*	22.5%*

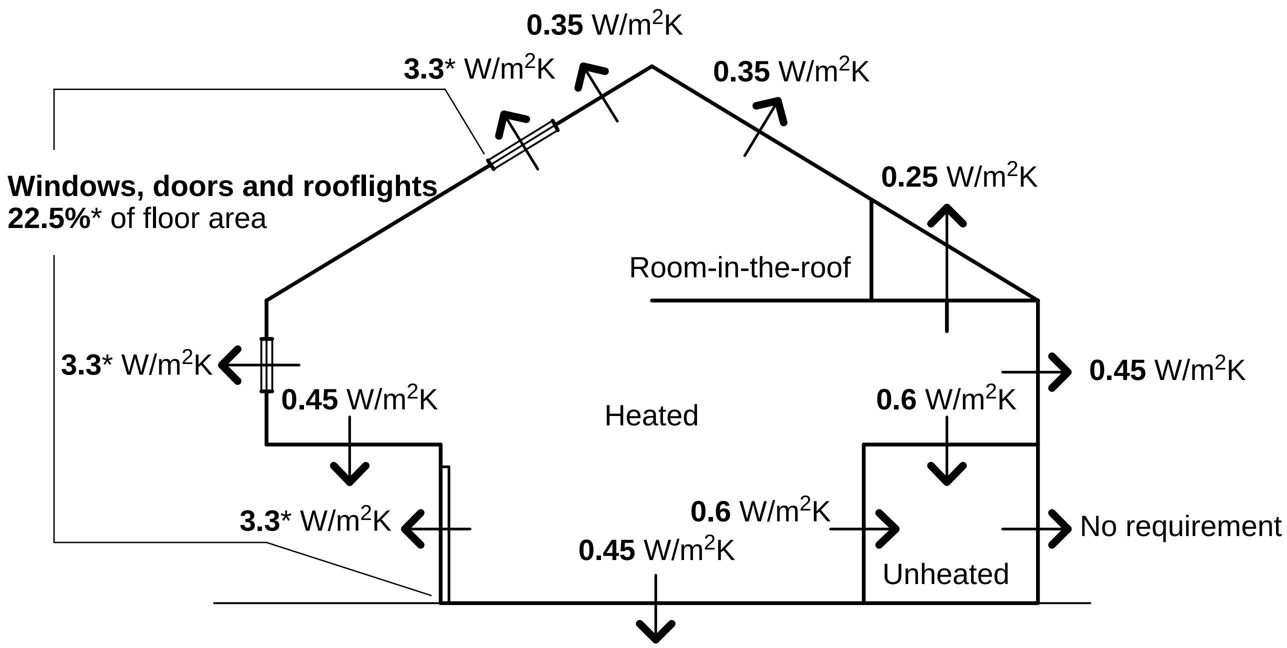
* These values may be modified in accordance with paragraph 1.14

Diagram **1.1** **U-values and areas of openings for dwellings**

see para 1.12(c)



(a) **SAP energy rating of 60 or less**



(b) **SAP energy rating of more than 60**

* These values may be modified in accordance with paragraph 1.14

Window, door and rooflight openings

1.14 The U-values of 3.3 and 3.0 W/m^{2}K given in Table 1.1 are standard values for double glazing and doors which are permitted to have a combined maximum area of 22.5% of the total floor area. Where those elements have different U-values which have been certified by test the maximum area of openings may be varied proportionally in accordance with Table 1.3.

Examples illustrating the method of calculating the permissible area of windows, doors and rooflights are given in Appendix F.

In calculating the maximum permitted area of windows, doors and rooflights in an extension to a dwelling the percentage may be based on either –

(a) the total floor area of the extension; or

(b) the total floor area of the existing dwelling and the extension together, in which case the allowable area shall be the permitted area less the area of the existing windows, doors and rooflights.

Conservatories

1.15 Where a conservatory is erected as part of a new dwelling –

(a) a wall or floor separating a conservatory from a dwelling shall be constructed as a semi-exposed wall or floor;

(b) any door and any window in the separating elements shall be constructed as an exposed door or window; and

(c) if the conservatory is heated, it shall be provided with temperature and on/off controls separate from the dwelling.

Table **1.3** Permitted variation in the area of windows and doors for dwellings

Average U-value (W/m^{2}K)	**Maximum permitted area of windows and doors as a percentage of floor area for SAP energy ratings of–**	
	60 or less	**more than 60**
2.0	37.0	41.5
2.1	35.0	39.0
2.2	33.0	36.5
2.3	31.0	34.5
2.4	29.5	33.0
2.5	28.0	31.5
2.6	26.5	30.0
2.7	25.5	28.5
2.8	24.5	27.5
2.9	23.5	26.0
3.0	**22.5**	25.0
3.1	21.5	24.0
3.2	21.0	23.5
3.3	20.0	**22.5**
3.4	19.5	21.5
3.5	19.0	21.0
3.6	18.0	20.5
3.7	17.5	19.5
3.8	17.0	19.0
3.9	16.5	18.5
4.0	16.0	18.0
4.1	15.5	17.5
4.2	15.5	17.0

Note
The data in this table is derived assuming a constant heat loss through the elevations amounting to the loss when the basic allowance for openings of 22.5% of floor area is provided and the standard U-values given in Table 1.2 apply. It is also assumed for the purposes of this table that there are no rooflights.

Target U-value Method for dwellings

1.16 The Target U-value Method calculates the average maximum permissible U-value of the exposed building fabric and a SAP energy rating must be calculated or assumed before it can be used.

In this method the U-value of a construction may be determined by calculation (see paragraph 1.10) or an Acceptable construction (see Appendix A) may be used. It is also permissible to use a mixture of calculated and Acceptable constructions.

(a) Where the SAP energy rating is 60 or less the dwelling shall be designed and constructed so that its average U-value does not exceed its Target U-value as calculated from –

$$\text{Target U-value} = \frac{\text{total floor area } (m^2) \times 0.57}{\text{total area of exposed elements } (m^2)} + 0.36$$

(b) Where the SAP energy rating is more than 60 the dwelling shall be designed and constructed so that its average U-value does not exceed its Target U-value as calculated from –

$$\text{Target U-value} = \frac{\text{total floor area } (m^2) \times 0.64}{\text{total area of exposed elements } (m^2)} + 0.4$$

1.17 The total floor area shall be taken as the area of all floors of the dwelling measured between the internal faces of the enclosing fabric of the dwelling.

1.18 The total area of exposed elements for purposes of paragraph 1.16 shall be taken as the total internal surface area of the dwelling and shall include the ground floor area.

1.19 Semi-exposed elements shall be omitted from the calculation. However, any semi-exposed elements shall have a maximum U-value of 0.6 W/m^2K.

Accounting for solar gains

1.20 The Target U-value equations assume an equal distribution of glazing on the north and south elevations. Where the area of glazing facing south exceeds that facing north the formula may be adjusted to take account of solar gains by reducing the total window area included in the calculation.

To take account of solar gains the window area may be taken as the actual window area less 40% of the difference in the area of glazing facing south and that facing north.

For the purpose of this method glazing facing +/- 30° of north or south may be regarded as facing north or south respectively.

Accounting for a high efficiency heating system

1.21 The Target U-value equations assume that the dwelling is heated by a conventional hot water central heating system having a boiler with a seasonal efficiency of 72%. Where manufacturer's independently certified data shows a higher seasonal efficiency the Target U-value may be increased by up to 10% as follows –

(a) when the boiler has a seasonal efficiency of 85% or more, for example, a condensing boiler, the Target U-value may be increased by 10%; and

(b) when the boiler has a seasonal efficiency between 72% and 85% the Target U-value may be increased on a pro-rata basis up to a maximum of 10%.

Where a dwelling has an electrical heating system with a heat pump and the system has a seasonal coefficient of performance of 2.5 or more (taking account of heating distribution losses) and mechanical ventilation with heat recovery, the Target U-value may be increased by 10%.

Demonstrating compliance

1.22 The procedure for demonstrating compliance by using the Target U-value Method is given in Appendix G.

Conservatories

1.23 Where a conservatory is erected as part of a new dwelling –

(a) a wall or floor separating a conservatory from a dwelling shall be constructed as a semi-exposed wall or floor;

(b) any door and any window in the separating elements shall be constructed as an exposed door or window; and

(c) if the conservatory is heated, it shall be provided with temperature and on/off controls separate from the dwelling.

Elemental Method for buildings other than dwellings

1.24 The Elemental Method considers each element of the exposed building fabric separately. Each element shall have U-values and areas of openings no greater than those given for the relevant building type in Table 1.4. These U-values and areas of openings are illustrated in Diagrams 1.2 and 1.3.

In this method the U-value of a construction may be determined by calculation (see paragraph 1.10) or an Acceptable construction (see Appendix A) may be used. It is also permissible to use a mixture of calculated and Acceptable constructions.

Table **1.4** **Maximum U-values (W/m^{2}K) and areas of openings (% of wall or roof area)**

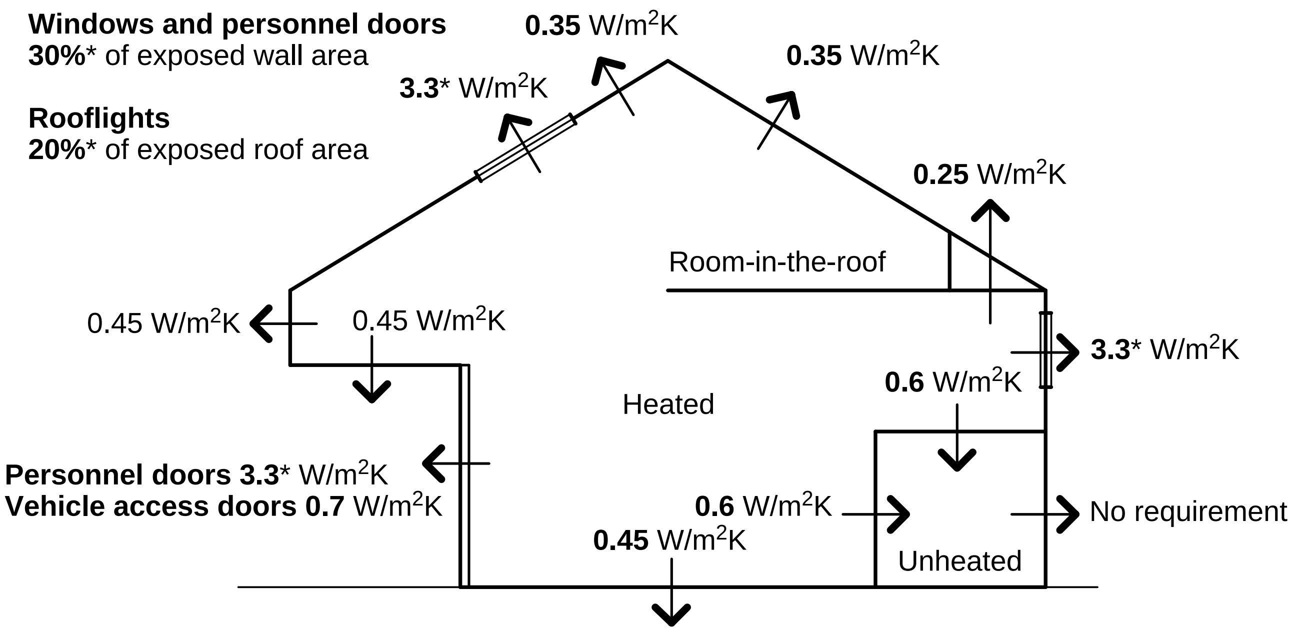
Element	**Building type**		
	Residential buildings	**Places of assembly, offices and shops**	**Industrial and storage buildings**
(1)	(2)	(3)	(4)
Exposed walls	0.45	0.45	0.45
Semi-exposed walls and floors	0.6	0.6	0.6
Exposed floors and ground floors	0.45	0.45	0.45
Flat roof or the sloped ceiling of a room-in-the-roof	0.35	0.45	0.45
Roofs	0.25	0.25	0.25
Windows, personnel doors and rooflights	3.3+	3.3+	3.3+
Vehicle access and similar large external doors	0.7	0.7	0.7
Maximum area (% of wall area) of windows and personnel doors*	30%+	40%+	15%+
Maximum area (% of roof area) of rooflights	20%+	20%+	20%+

+ These values may be modified in accordance with paragraph 1.25

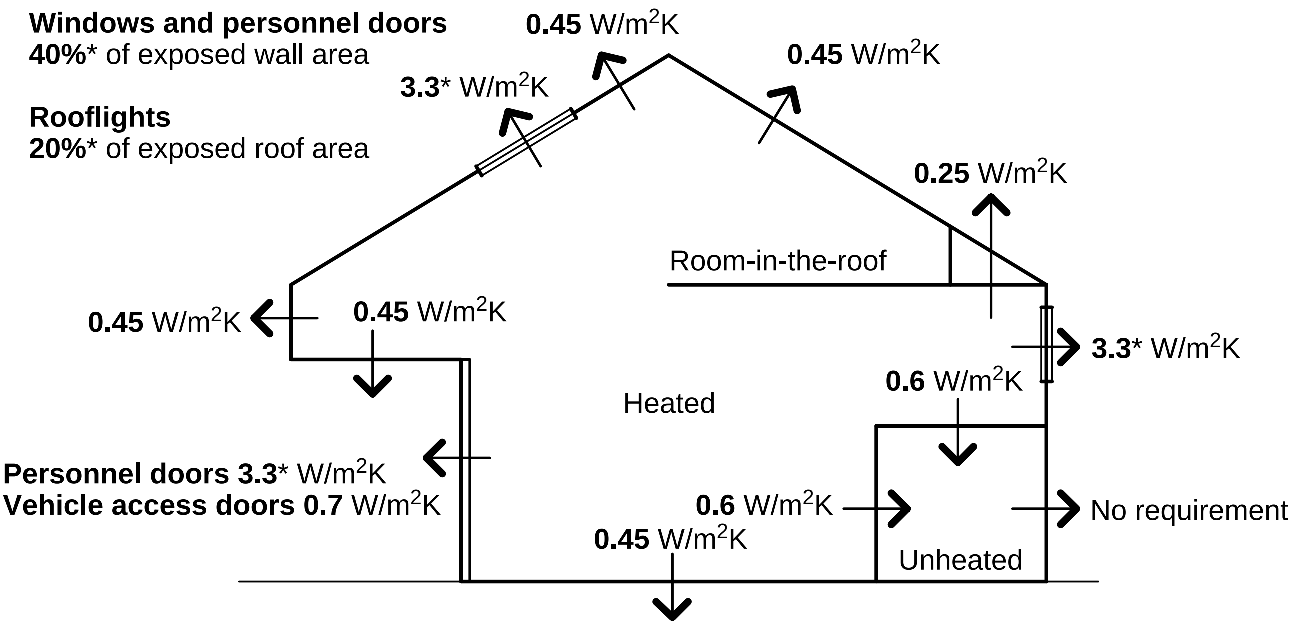
* There is no restriction on the area of vehicle access and similar large external doors

Diagram **1.2** U-values and areas of openings for buildings other than dwellings

see para 1.24



Residential buildings

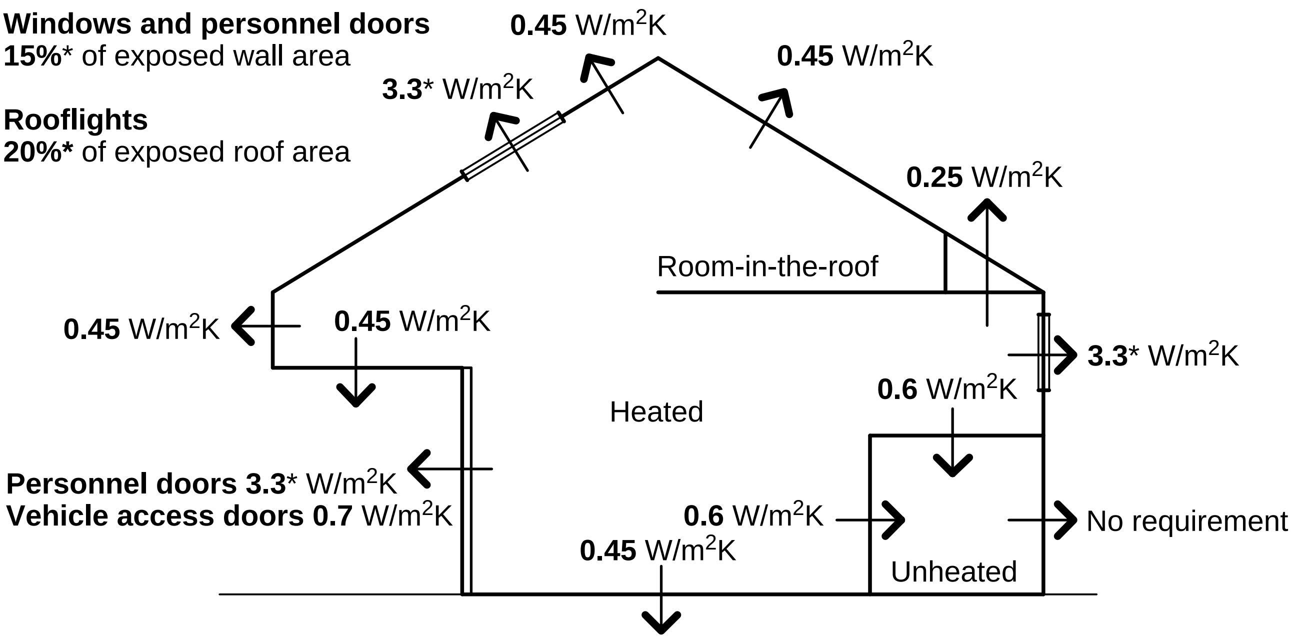


Places of assembly, offices and shops

*These values may be modified in accordance with paragraph 1.25

Diagram 1.3 U-values and areas of openings for buildings other than dwellings

see para 1.24



Industrial and storage buildings

*These values may be modified in accordance with paragraph 1.25

Window, door and rooflight openings

1.25 The U-value of 3.3 W/m^{2}K given in Table1.4 is a standard value for double glazing and doors. Table 1.4 also gives the maximum permitted area of window, door and rooflight openings for different building types. Where these elements have different U-values which have been independently certified by test the maximum area of openings may be varied proportionally in accordance with Table 1.5.

Examples illustrating the method of calculating the permissible areas of windows, doors and rooflights are given in Appendix F.

In calculating the maximum permitted areas of windows, personnel doors and rooflights in an extension to a building the percentage may be based on either –

(a) the wall and roof areas of the extension; or

(b) the wall and roof areas of the existing building and extension together, in which case the allowable areas shall be the permitted areas less the areas of the existing windows and personnel doors or rooflights as appropriate.

Calculation Method for buildings other than dwellings

1.26 The Calculation Method allows a building to be designed and constructed so that its total rate of heat loss is no greater than that of a notional building of the same shape and size designed to comply with Table 1.4.

In this method the U-value of a construction may be determined by calculation (see paragraph 1.10) or an Acceptable construction (see Appendix A) may be used. It is also permissible to use a mixture of calculated and Acceptable constructions.

When using this method a lower U-value in one element may be traded against a higher U-value in another or against a larger area of openings.

1.27 In addition to the **General rules** in paragraphs 1.4 to 1.11 the following rules apply –

(a) If the total area of openings in the proposed construction is less than that permitted by Table 1.4, this smaller area shall also be used when calculating the total rate of heat loss from the notional building.

(b) If the U-value of the floor next to the ground, without insulation, is less than 0.45 W/m^{2}K this lower value shall also be used when calculating the total rate of heat loss from the notional building.

1.28 A worked example of demonstrating compliance using the Calculation Method is given in Appendix H.

Table 1.5 Permitted variation in the areas of windows, doors and rooflights for buildings other than dwellings

Average U-value (W/m^{2}K)	**Residential buildings** percentage of wall area	**Places of assembly, offices and shops** percentage of wall area	**Industrial and storage buildings** percentage of wall area	**Rooflights (all)** percentage of roof area
2.0	55	74	28	37
2.1	52	69	26	35
2.2	49	65	24	33
2.3	46	62	23	31
2.4	44	58	22	29
2.5	42	56	21	28
2.6	40	53	20	27
2.7	38	51	19	25
2.8	36	49	18	24
2.9	35	47	17	23
3.0	34	45	17	22
3.1	32	43	16	22
3.2	31	41	16	21
3.3	**30**	**40**	**15**	**20**
3.4	29	39	14	19
3.5	28	37	14	19
3.6	27	36	14	18
3.7	26	35	13	18
3.8	26	34	13	17
3.9	25	33	12	17
4.0	24	32	12	16
4.1	23	31	12	16
4.2	23	30	11	15
4.3	22	30	11	15
4.4	22	29	11	14
4.5	21	28	11	14
4.6	21	27	10	14
4.7	20	27	10	13
4.8	20	26	10	13
4.9	19	26	10	13
5.0	19	25	9	13

Note

The data in this table is derived assuming a constant heat loss through the exposed wall or roof area as appropriate. The constant heat loss amounts to the loss through the wall or roof component plus the loss through the basic area allowance of windows, personnel doors or rooflights respectively as calculated using the U-values in Table 1.4.

Energy Use Method for buildings other than dwellings

1.29 The Energy Use Method calculates the energy consumption of a building (taking account of any useful heat gains) and this shall be no greater than that of a notional building of the same shape and size designed to comply with Table 1.4.

In this method the U-value of a construction may be determined by calculation (see paragraph 1.10) or an Acceptable construction (see Appendix A) may be used. It is also permissible to use a mixture of calculated and Acceptable constructions.

1.30 This method is only suitable for use with naturally ventilated buildings and buildings which have mechanical extract ventilation for the ventilation of kitchens, bathrooms and sanitary accommodation.

1.31 In addition to the **General rules** in paragraphs 1.4 to 1.11 the following rules apply –

(a) If the total area of openings in the proposed construction is less than that determined by applying Table 1.4, this smaller area shall also be used when calculating the energy consumption of the notional building.

(b) If the U-value of the floor next to the ground, without insulation, is less than 0.45 W/m^2K, that lower value shall also be used when calculating the energy consumption of the notional building.

1.32 The method for calculating the energy consumption shall be CIBSE Building Energy Code Part 2 - Calculation of Energy Demands and Targets for the design of new buildings and services - Section (a) Heated and Naturally Ventilated Buildings 1981 (Worksheets 1a to 1e).

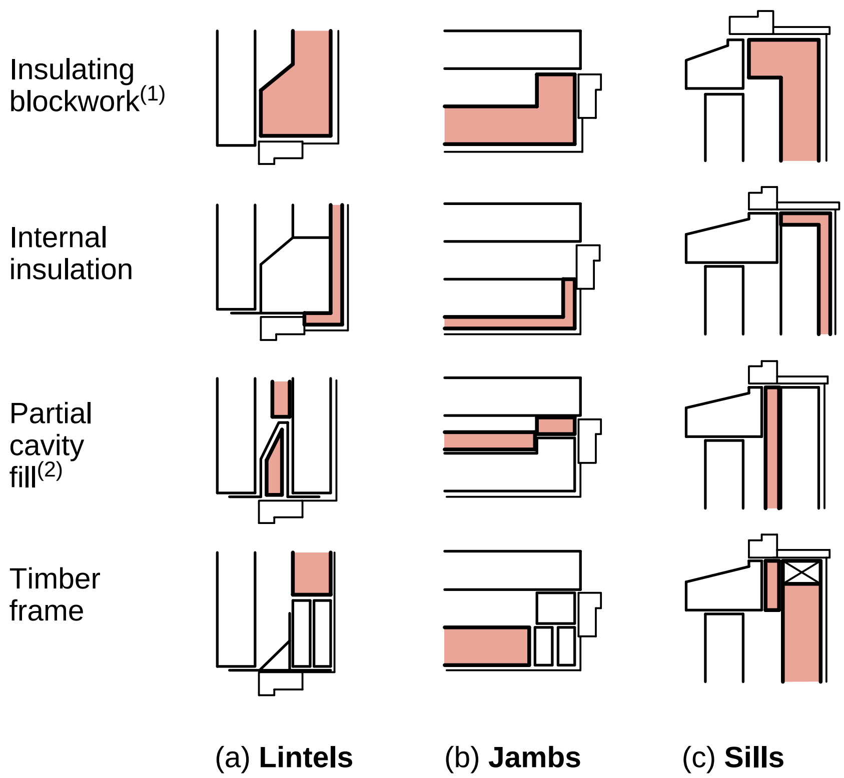
Limiting thermal bridging around openings in all buildings

1.33 To reduce heat losses around openings, lintels, jambs and sills shall be designed and constructed to limit the effects of thermal bridging.

1.34 Lintels, jambs and sills shall be either constructed in accordance with Diagram 1.4 or designed and constructed within the provisions of Appendix I. Alternatively, the method given in BRE IP 12/94 Assessing condensation risk and heat loss at thermal bridges around openings may be used.

Diagram 1.4 Limiting thermal bridging around openings

see para 1.34



Notes

1. The thermal conductivity of the blockwork shall not exceed 0.16 W/mK (e.g. autoclaved aerated concrete) and the frame shall overlap the blockwork by at least 30 mm for dry-lining or 55 mm for lightweight plaster.
2. The internal faces of metal lintels shall be covered with at least 15 mm of lightweight plaster; alternatively they can be dry-lined.

Limiting air infiltration in all buildings

1.35 To reduce the infiltration of cold air, leakage paths through the building fabric shall be limited by –

(a) sealing gaps between dry-lining and masonry walls at the edges of openings such as windows and doors and at junctions with walls, floors and ceilings;

(b) sealing gaps between frames and openings and draughtproofing the openable elements of windows, doors and rooflights;

(c) sealing hatches to unheated floor and roof voids;

(d) sealing service penetrations and at floor and ceiling junctions where services are not boxed in;

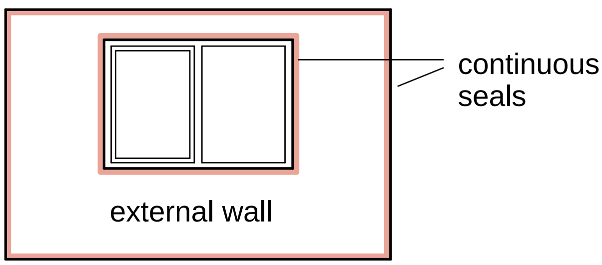
(e) sealing around joist ends where joists are built into the external walls; and

(f) sealing vapour control membranes in timber framed construction.

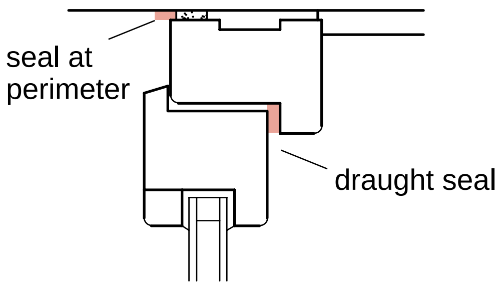
The provisions are illustrated in Diagram 1.5.

Diagram **1.5** **Methods of limiting air infiltration**

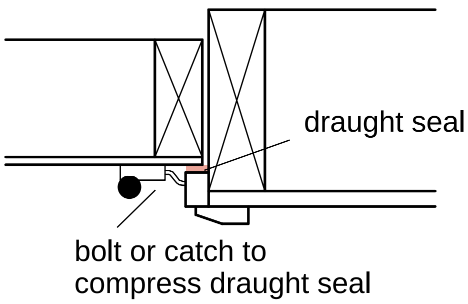
see para 1.35



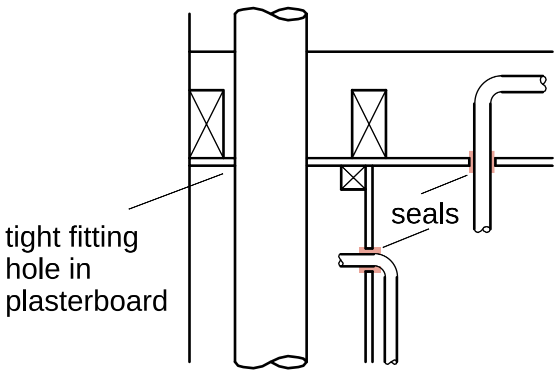
(a) **Continuous sealing strips around dry linings fixed to masonry walls**



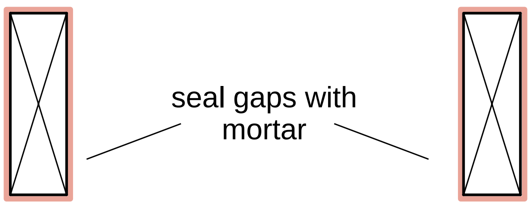
(b) **Sealing at windows and doors**



(c) **Sealing at hatches to unheated floor and roof voids**



(d) **Sealing around service pipes**



(e) **Sealing around joist ends where joists are built into external walls**

Section 2 – Control of space heating systems, hot water storage systems and the provision and control of artificial lighting systems

Dwellings

2.1 In a dwelling the output of a space heating system shall be controlled by –

(a) room thermostats or thermostatic radiator valves to control the temperatures independently in zones that require different temperatures (such as separate sleeping and living areas); and

[Sub-paragraph 2.1(a) shall not prevent the use of a radiator as a heat leak in a solid fuel system.]

(b) where heat is provided by a boiler, other than a solid fuel boiler which operates only by natural draught, a time clock shall be provided to control the periods when the heating system operates.

2.2 To minimise boiler cycling –

(a) a gas or oil fired boiler shall switch off when there is no demand for heat; and

(b) where a space heating system is controlled solely by thermostatic radiator valves, the system shall be fitted with flow control or other anti-cycling device.

2.3 The requirements of paragraphs 2.1 and 2.2 shall not apply to individual solid fuel, gas or electric fires and roomheaters with integral controls.

2.4 The provisions of paragraphs 2.1 and 2.2 shall not apply to ducted warm air systems or to flap controlled electric storage heaters but these systems shall be fitted with thermostats and time controls.

Buildings other than dwellings

2.5 In buildings other than dwellings, the space heating system shall be provided with –

(a) thermostats or thermostatic radiator valves for each part of the heating system designed to be separately controlled;

[Sub-paragraph 2.5(a) shall not prevent the use of a radiator as a heat leak in a solid fuel system.]

(b) where the system uses hot water, an external temperature sensing device (weather compensating control) to regulate the temperature of the water flowing in the heating circuit;

(c) where the system is other than off-peak electricity and operates intermittently, controls to ensure that the system operates only when the building is normally occupied –

(i) for a space heating system with an output of not more than 100kW, a clock control which can be manually set to give start and stop times; and

(ii) for a space heating system with an output of more than 100kW, a control arrangement which will give start and stop times appropriate to the rate at which the building will respond (optimising control); and

[Sub-paragraph 2.5(c) shall not prevent the provision of additional controls which will allow sufficient heating to prevent damage to the building structure, services or contents by frost, excessive humidity or condensation.]

(d) where a space heating system has more than one gas or oil-fired boiler which can work together to meet a heat demand of more than 100kW, boiler controls capable of detecting variations in the need for heat in the building, to start, stop or modulate the boilers to ensure efficient sequential boiler operation (sequence control).

2.6 The provisions of paragraph 2.5 may be met by using either individual controls or a building energy management system.

2.7 The provisions of paragraph 2.5 shall not apply to ducted warm air systems or to flap controlled electric storage heaters but these systems shall be fitted with thermostats and time controls.

Hot water storage system controls in all buildings

2.8 In a building an indirectly heated hot water storage vessel with a heat exchanger, having sufficient heating capacity for effective control, shall have –

(a) a thermostat to shut off the supply of heat to the hot water storage vessel when the storage temperature is reached (in the case of a hot water central heating system, this thermostat shall be linked with the space heating controls to switch off the boiler when heat is not required); and

(b) a time clock to shut off the supply of heat when water heating is not required.

2.9 The provisions of paragraph 2.8(a) shall not apply where the hot water storage vessel provides the heat leak in a solid fuel system.

2.10 The provisions of paragraph 2.8(b) shall not prevent the use of off-peak electricity for water heating.

Provision of artificial lighting in a building other than a dwelling

2.11 In a building other than a dwelling any artificial lighting shall –

(a) provide 95% of the artificial lighting capacity in circuit Watts with light fittings incorporating lamps which have a performance in use no worse than those listed in Table 2.1; or

(b) incorporate lamps with an average initial (100 hour) efficacy of not less than 50 lumens per circuit Watt.

[Circuit Watts includes the power consumed by lamps, their associated control gear and power factor correction equipment.]

Table **2.1** Types of high efficacy lamps

Light source	Types
High pressure Sodium	All types and ratings
Metal halide	
Induction lighting	
Tubular fluorescent	All 26 mm diameter (T8) lamps provided with low-loss or high frequency control gear
Compact fluorescent	All ratings above 11 W

Control of artificial lighting in a building other than a dwelling

2.12 To minimise the use of artificial lighting, lighting controls shall be designed to avoid unnecessary lighting of spaces or rooms which are unoccupied. However, the operation of automatically switched lighting systems shall not endanger the passage of people in and about the building.

2.13 In a building other than a dwelling any artificial lighting system shall be controlled by –

(a) manually operated switches where the distance measured on plan from a switch to the furthest light fitting it controls is not more than 8 metres or 3 times the height of the light fitting above finished floor level whichever is the greater; or

(b) automatic switching which turns the lighting off when the room is unoccupied.

[For the purposes of this paragraph, switch includes a dimmer switch which reduces rather than diverts the energy source.]

2.14 The requirements of paragraphs 2.11, 2.12 and 2.13 shall not apply to lighting intended to highlight displays of exhibits or merchandise (display lighting) or to emergency lighting.

[Emergency lighting provides illumination for the safety of people leaving an area or attempting to terminate a process before leaving an area.]

Demonstrating compliance

2.15 Worked examples of demonstrating compliance by a lighting calculation are given in Appendix J.

Section 3 – Insulation of pipes, ducts and hot water storage vessels in all buildings

Insulation of pipes and ducts

3.1 Unless the heat loss from a pipe or duct contributes to the useful heat requirement of a room or space it shall be thermally insulated –

(a) in the case of a pipe, with insulating material which has a thermal conductivity of not more than 0.045 W/mK and a thickness equal to the outside diameter of the pipe or 40mm, whichever is the lesser; or

(b) in the case of a pipe or duct, in accordance with the relevant recommendations of BS 5422 : 1990.

Insulation of hot water storage vessels

3.2 A normal domestic size (120 litres) hot water storage vessel complying with BS 1566 : 1984 (1990) or BS 3198 : 1981 or equivalent shall be thermally insulated either –

(a) to limit the standing heat loss to not more than 1W/litre when tested in accordance with BS 1566 : Part 1:1984 (1990): Appendix B4; or

(b) with a factory-applied coating of polyurethane foam not less than 35 mm thick and a minimum density of 30 kg/m^3.

3.3 A hot water storage vessel complying with BS 1566 : 1984 (1990) or BS 3198 : 1981 or equivalent and having a capacity of other than 120 litres shall be thermally insulated either –

(a) with the same material and thickness of insulation as that required for a 120 litre hot water storage vessel complying with paragraph 3.2(a); or

(b) with a factory-applied coating of polyurethane foam not less than 35 mm thick and a minimum density of 30 kg/m^3.

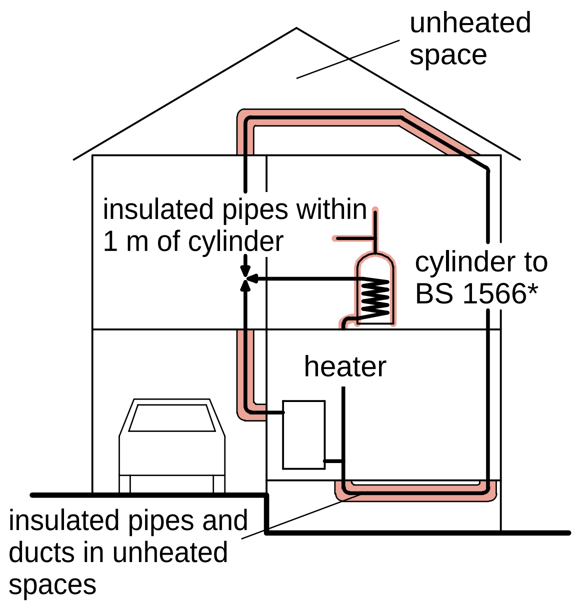
3.4 A hot water storage vessel complying with BS 853 : 1990 shall be thermally insulated with material which has a thermal conductivity of not more than 0.045 W/mK and a thickness of not less than 50 mm.

Insulation of hot water pipes connected to a hot water storage vessel

3.5 The hot water pipes connected to a hot water storage vessel, including the vent pipe and the primary flow and return to the heat exchanger, where fitted, shall be thermally insulated for at least 1 metre from their point of connection to the vessel, or to the point where they become concealed, with material which has a thermal conductivity of not more than 0.045 W/mK and a thickness of not less than 15 mm.

3.6 When providing insulation, care shall be taken to ensure that any insulating material does not impede the safe operation and visibility of warning discharges of any unvented hot water storage vessel.

Diagram **3.1** **Insulation of heating and hot water pipes and warm air ducts**



*Normally a 120 litre cylinder would have a coil with about five turns

Section 4 – Alterations, extensions and a material change of use

4.1 This Section deals with the measures which shall be provided where an existing building is altered or extended or when it undergoes a material change of use.

4.2 Where a structural alteration or extension to a building is constructed to a standard lower than those given in Section 1, the Elemental Method will be the only viable method of demonstrating compliance.

4.3 Where the building to be altered or extended was designed and constructed in accordance with any of the methods in this Technical Booklet then that method shall be used to demonstrate the compliance of the building as altered or extended.

Alterations

4.4 Where it is unreasonable to apply the standards given in Section 1 because it is impracticable or would necessitate a disproportionate amount of work, an alteration shall not be of a lower standard than that of the existing element being altered.

Extensions

4.5 Where an extension is added the new elements shall meet the provisions of Section 1 with the area of openings calculated in accordance with paragraph 1.14 or 1.25 as appropriate.

4.6 Where a building is extended by the addition of a conservatory, regardless of whether or not the conservatory is subject to control, any associated work to the building or its heating system is subject to control.

Material change of use

4.7 Where a building has an accessible roof void and an existing roof U-value of 0.45 W/m^{2}K or greater, additional insulation shall be provided to achieve a roof U-value no greater than 0.35 W/m^{2}K.

Services and fittings

4.8 Where the alteration, extension or material change of use to a building includes new work, alteration to or replacement of a service or fitting then that work is controlled in the same way as it would be if the building were being newly erected.
(See Regulation A8 and Section 2 or 3.)

Appendix A – Acceptable constructions

A.1 The Acceptable constructions may be used with any of the Methods given in Section 1.

The Acceptable constructions are a range of wall, floor and roof constructions with supporting tables. The tables give a simple means of determining the required thickness of insulating material (of various thermal conductivities [W/mK]) for a range of U-values.

The base thicknesses of insulating materials given in Tables A.2, A.9, A.10, A.12, A.13 and A.14 are the thicknesses which give the specified U-values assuming that other parts of the construction make no contribution to the thermal performance. The required thickness is the base thickness reduced to take account of the contribution of the other parts of the construction. The appropriate reductions are given in Tables A.3, A.4, A.5, A.11 and A.15.

In Tables A.2, A.9, A.10, A.12, A.13 and A.14 the base thickness corresponding with the U-values given in Tables 1.2 and 1.4 are shown in bold print.

Tables A.6, A.7 and A.8 give the thickness of insulation required to achieve floor U-values of 0.25, 0.35 and 0.45 W/m^{2}K for a range of perimeter/area ratios and thermal conductivities of insulating material.

Where a U-value, thermal conductivity or perimeter/area ratio is between the values given in a table, the thickness of insulating material may be obtained by linear interpolation.

Table A.1 gives the thermal conductivities for given densities of common building materials. Where a material or material density other than that given is to be used, or where a lower thermal conductivity is claimed for a given material or density, the thermal conductivity of the material shall be established in accordance with CIBSE Guide A3 : 1980 : Appendix A.

Table **A.1** Thermal conductivity of some common building materials

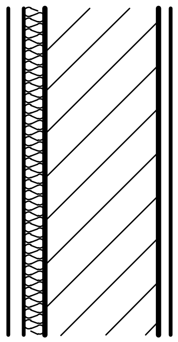
Material	**Density** (kg/m^3)	**Thermal conductivity** (W/mK)
Walls (external and internal)		
Brickwork (outer leaf)	1700	0.84
Brickwork (inner leaf)	1700	0.62
Cast concrete (dense)	2100	1.40
Cast concrete (lightweight)	1200	0.38
Concrete block (heavyweight)	2300	1.63
Concrete block (medium weight)	1400	0.51
Concrete block (lightweight)	600	0.19
Normal mortar	1750	0.8
Fibreboard	300	0.06
Plasterboard	950	0.16
Tile hanging	1900	0.84
Timber	650	0.14
Surface finishes		
External rendering	1300	0.50
Plaster (dense)	1300	0.50
Plaster (lightweight)	600	0.16
Calcium silicate board	875	0.17
Roofs		
Aerated concrete slab	500	0.16
Asphalt	1700	0.50
Felt/bitumen layers	1700	0.50
Screed	1200	0.41
Stone chippings	1800	0.96
Tile	1900	0.84
Wood wool slab	500	0.10
Floors		
Cast concrete	2000	1.13
Metal tray	7800	50.00
Screed	1200	0.41
Timber flooring	650	0.14
Wood blocks	650	0.14
Insulation		
Expanded polystyrene (EPS) slab	25	0.035
Mineral wool quilt	12	0.040
Mineral wool slab	25	0.035
Phenolic foam board	30	0.020
Polyurethane board	30	0.025

Note
If available, certified test values should be used in preference to those in the table.

Walls

A.2 Wall Types 1, 2 and 3 describe and illustrate the acceptable wall constructions to which Tables A.2 to A.5 apply. Table A.2 gives the base thickness of insulating material, of different thermal conductivities, required to achieve the given U-values (neglecting the thermal resistance of the other components of the wall construction). Tables A.3, A.4 and A.5 give the deductions which may be made, from the base thickness to allow for the thermal resistance of the other components of the wall construction. These tables equate the other components to a thickness of insulating material.

Example 1 – Determine the thickness of insulation required to achieve a U-value of 0.45 W/m^2K for the following wall construction. The chosen insulating material has a thermal conductivity of 0.035 W/mK.



Using Table A.2

From column E, row 4 the base thickness of the insulation layer is 71 mm. This base thickness may be reduced by taking account of the other materials as follows –

From Table A.3

Render column E, row 9	= 1
Plaster column E, row 3	= 1

and from Table A.4

Concrete block column E, row 12
adjusted for 200 mm thickness 2.0 x 5 = 10

12

The minimum thickness of the insulating layer to achieve a U-value of 0.45 W/m^2K is therefore –

Base thickness less total reduction =

71 – 12 = 59 mm.

Wall Type 1 – Solid masonry

Basic construction

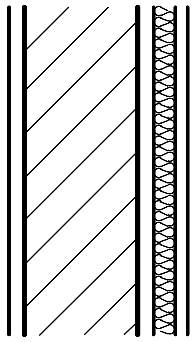
Solid wall at least 200 mm thick of bricks or blocks of clay, calcium silicate, concrete or cast stone.

A. Basic construction as above.

Insulation applied as a lining so that there is an airspace of at least 25 mm between the inside face of the wall and the insulation. The internal finish shall be plasterboard.

Where a vapour control layer is required it shall be fitted between the insulation and plasterboard.

External render required.

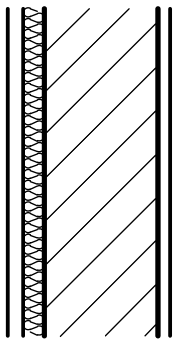


B. Basic construction as above.

Insulation applied to the external surface of the masonry. The insulation protected either by rendering or by a cladding of sheets, tiles or boarding. Where cladding is used provide a ventilated airspace between the cladding and the insulation.

Internal finish of plaster or plasterboard optional.

Where a vapour control layer is required it shall be fixed between the internal surface of the masonry and a plasterboard lining.



Wall Type 2 – Cavity masonry

Basic construction

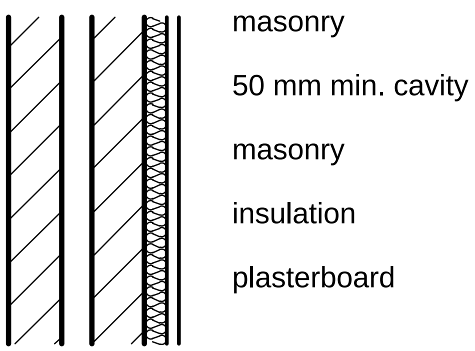
Cavity wall of 2 leaves of masonry separated by a cavity at least 50 mm wide; each leaf at least 100 mm thick of bricks or blocks of clay, calcium silicate, concrete or cast stone.

External render optional.

A. Basic construction as above.

Insulation applied as a lining to the internal surface of the wall with a plasterboard internal finish.

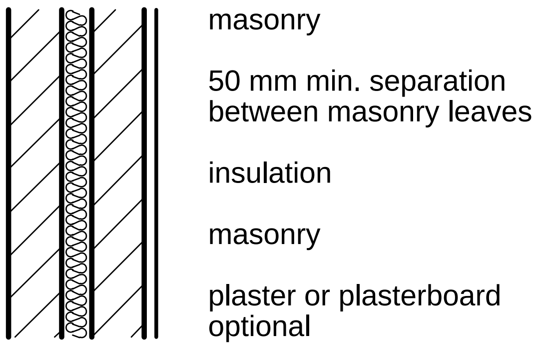
Where a vapour control layer is required it shall be fixed between the insulation and plasterboard.



B. Basic construction as above.

Insulation applied as a cavity fill.

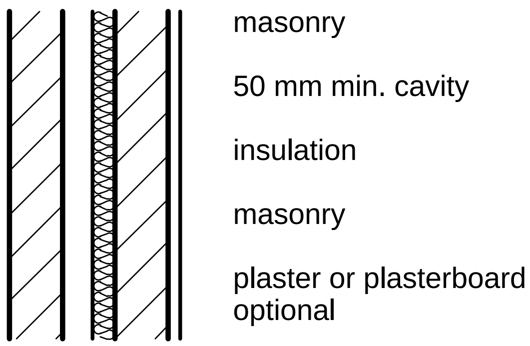
Internal finish of plaster or plasterboard optional.



C. Basic construction as above.

Insulation applied as a partial cavity fill so as to preserve a residual airspace of at least 50 mm wide.

Internal finish of plaster or plasterboard optional.



Wall Type 3 – Framed walls

A. Framed wall of timber studs and noggins with a vapour permeable sheathing material over the framing and covered with a breather membrane.

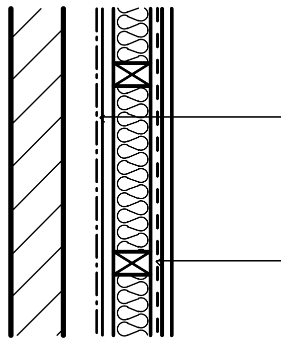
Masonry external leaf at least 100 mm thick of bricks or blocks of clay, calcium silicate, concrete or cast stone, with a ventilated cavity not less than 50 mm wide and not greater than 100 mm wide between the cladding and sheathing material.

The cavity shall be ventilated by means of open perpend joints at the top and bottom of the wall. There shall be at least one open perpend joint for every 1.2 m length of wall.

External render optional.

Insulation applied as an infill to the framing.

Internal finish of plasterboard on a vapour control layer.

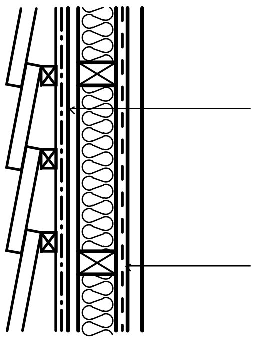


B. Framed wall of timber studs and noggins with a vapour permeable sheathing material over the framing and covered with a breather membrane.

Cladding of weatherboarding, tiles or slates on battens and counterbattens.

Insulation applied as an infill to the framing.

Internal finish of plasterboard on a vapour control layer.

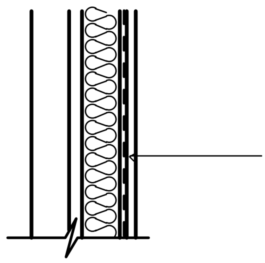


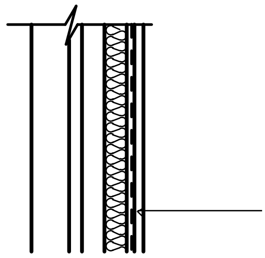
C. Framed wall of timber studs and noggins or of metal studs and rails.

Cladding of fibre cement, GRC, GRP, plastics or metal.

Insulation applied either to the internal face of the framing with a permanently ventilated cavity directly behind the cladding or, where the cladding system is vapour permeable as an infill to the framing.

An internal lining on a vapour control layer.

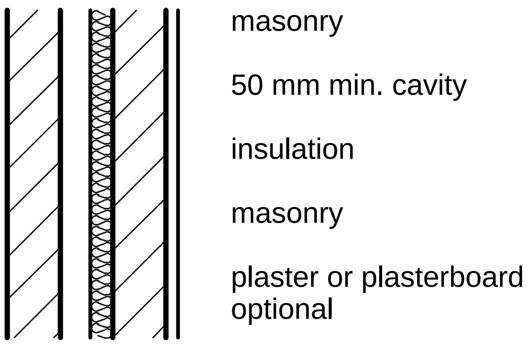




Example 2 – Cavity wall with partial cavity fill

(Wall Type 2C)

Determine the thickness of insulation required to achieve a U-value of 0.45 W/m^{2}K for the wall construction below.



The chosen insulating material has a thermal conductivity of 0.025 W/mK.

Using Table A.2

From column C, row 4 the base thickness of the insulation layer is 51 mm.

The base thickness may be reduced by taking account of the other materials as follows –

From Table A.3

Brick outer leaf,	column C, row 2	= 3
Cavity,	column C, row 1	= 5
Plaster,	column C, row 3	= 1

and from Table A.4

Concrete block,	column C, row 12	= 3
		12

The minimum thickness of the insulation layer to achieve a U-value of 0.45 W/m^{2}K is therefore –

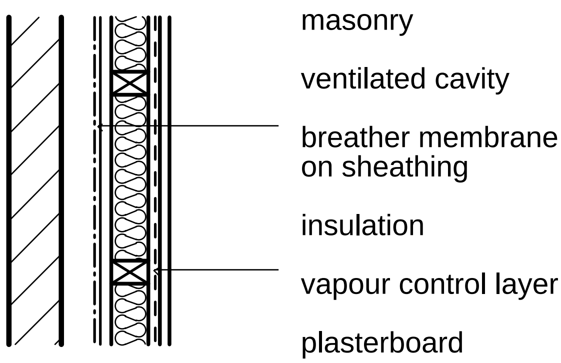
Base thickness less total reduction =

51 − 12 = 39 mm.

Example 3 – Timber framed wall with brick cladding

(Wall Type 3A)

Determine the thickness of insulation required to achieve a U-value of 0.45 W/m^{2}K for the wall construction below.



The chosen insulating material has a thermal conductivity of 0.035 W/mK.

Using Table A.2

From column E, row 4 of the table the base thickness of the insulation layer is 71 mm. The base thickness may be reduced by taking account of the other materials as follows –

From Table A.3

Brick outer leaf,	column E, row 2	= 4
Cavity,	column E, row 1	= 6
Sheathing ply,	column E, row 8	= 2
Plasterboard,	column E, row 6	= 3

and from Table A.5

Timber frame, column E, row 1

adjusted for shallower member

(0.9 x 74 mm)	= 67
Total reduction	= 82 mm

As the total reduction is greater than the required base thickness no additional insulation is required.

Table A.2 Base thickness of insulation layer

	Design U-value (W/m²K)	Thermal conductivity of insulant (W/mK) — Base thickness of insulating material (mm)						
		0.02	0.025	0.03	0.035	0.04	0.045	0.05
	A	B	C	D	E	F	G	H
1	0.30	63	79	95	110	126	142	158
2	0.35	54	67	80	94	107	120	134
3	0.40	46	58	70	81	93	104	116
4	**0.45**	41	51	61	71	82	92	102
5	0.60	30	37	45	52	59	67	74

Table A.3 Allowable reductions in base thickness for common components

	Component	Thermal conductivity of insulant (W/mK) — Reduction in base thickness of insulating material (mm)						
		0.02	0.025	0.03	0.035	0.04	0.045	0.05
	A	B	C	D	E	F	G	H
1	Cavity (25 mm min.)	4	5	5	6	7	8	9
2	Outer leaf brick	2	3	4	4	5	6	6
3	13 mm plaster	1	1	1	1	1	1	1
4	13 mm lightweight plaster	2	2	2	3	3	4	4
5	10 mm plasterboard	1	2	2	2	3	3	3
6	13 mm plasterboard	2	2	2	3	3	4	4
7	Airspace behind plasterboard dry-lining	2	3	3	4	4	5	6
8	9 mm sheathing ply	1	2	2	2	3	3	3
9	20 mm cement render	1	1	1	1	2	2	2
10	13 mm tile hanging	0	0	0	1	1	1	1

Table A.4 Allowable reduction in base thickness for concrete components

	Density (kg/m³)	Thermal conductivity of insulant (W/mK) — Reduction in base thickness of insulation (mm) for each 100 mm of concrete						
		0.02	0.025	0.03	0.035	0.04	0.045	0.05
	A	B	C	D	E	F	G	H
Concrete inner leaf								
1	600	9	11	13	15	17	20	22
2	800	7	9	11	13	15	17	19
3	1000	6	8	9	11	12	14	15
4	1200	5	6	7	9	10	11	12
5	1400	4	5	6	7	8	9	9
6	1600	3	4	4	5	6	7	7
Concrete outer leaf or single leaf wall								
7	600	8	10	13	15	17	19	21
8	800	7	8	10	12	14	15	17
9	1000	6	7	8	10	11	12	14
10	1200	4	6	7	8	9	10	11
11	1400	3	4	5	6	7	8	9
12	1600	3	3	4	5	5	6	7
13	1800	2	3	3	4	4	5	5
14	2000	2	2	2	3	3	4	4
15	2400	1	1	2	2	2	2	3

Table A.5 Allowable reduction in base thickness for insulated timber frame walls

	Thermal conductivity of insulation within frame (W/mK)	Thermal conductivity of insulant (W/mK) — Reduction in base thickness of insulation for each 100 mm of frame (mm)						
		0.02	0.025	0.03	0.035	0.04	0.045	0.05
	A	B	C	D	E	F	G	H
1	0.035	42	53	63	74	84	95	105
2	0.040	38	48	58	67	77	87	96

Note
The table is derived for walls for which the proportion of timber is 12%, which corresponds to 48 mm wide studs at 400 mm centres. For other proportions of timber the U-value can be calculated using the procedure in Appendix D.

Floors

A.3 Floor Type 1 describes and illustrates the acceptable floor constructions to which Tables A.6, A.7 and A.8 apply. Floor Type 2 describes and illustrates the acceptable floor constructions to which Tables A.9, A.10 and A.11 apply.

Tables A.6, A.7 and A.8 are based on the ratio of the perimeter of the floor to its area. When calculating the perimeter the length adjacent to an unheated space such as a porch or garage, shall be included but when calculating the area of the floor, the area of any such unheated space shall be excluded.

(a) Floors next to the ground

Table A.6 applies to ground supported concrete floors. Table A.7 applies to suspended concrete floors and Table A.8 to suspended timber floors. These tables give the thicknesses of insulating material, of different thermal conductivities, required for the given perimeter to area ratio, to achieve a U-value of 0·45, 0·35 or 0·25 W/m^{2}K.

(b) Exposed and semi-exposed floors

Tables A.9 and A.10 are for exposed and semi-exposed floors. These tables give the thicknesses of insulating material, of different thermal conductivities to achieve a U-value of 0·6 W/m^{2}K for a semi-exposed floor and a U-value of 0·45 or 0·35 W/m^{2}K for exposed floors.

Table A.11 gives the deductions which may be made from the base thickness, to allow for the thermal resistances of the other components of the floor construction. Where appropriate Table A.11 equates the other components to a thickness of insulating material.

Floor Type 1 – Floors next to the ground

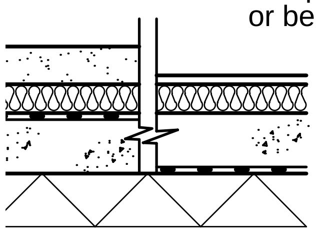
Ground supported concrete floors

A. Hardcore bed of well compacted inert material at least 100 mm thick, blinded with suitable fine material to form a smooth level surface.

Concrete slab at least 100 mm thick with a damp proof membrane laid either above or below the slab.

Insulation applied as a rigid material under a screed or board.

Floor finish optional.

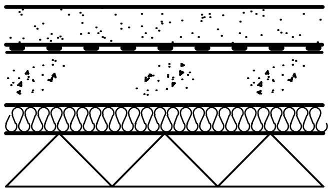


B. Hardcore bed of well compacted inert material at least 100 mm thick, blinded with suitable fine material to form a smooth level surface.

Insulation applied as a rigid material under the concrete.

Concrete slab at least 100 mm thick with a damp proof membrane laid as a sandwich between the concrete slab and a screed.

Floor finish optional.



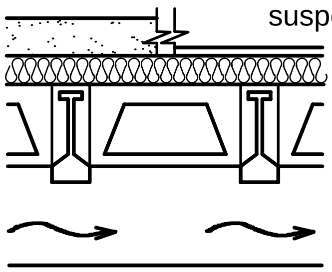
Suspended concrete floors

C. Suspended concrete floor of in situ or precast concrete slabs or beams with concrete or clay infill units.

Insulation applied as a rigid material under a screed or board.

Permanent underfloor ventilation is required.

Floor finish optional.



Suspended timber floors

D. Hardcore bed of well compacted inert material at least 100 mm thick, blinded with suitable fine material to form a smooth level surface.

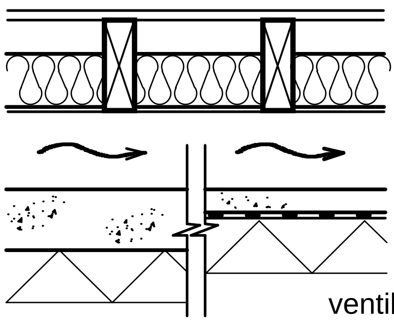
Ground cover of concrete at least 100 mm thick or concrete at least 50 mm thick on at least 1200 gauge polyethylene sheet.

Suspended floor of timber joists and boarding.

Insulation applied between the joists and supported with corrosion resistant fixings, battens or plastic mesh.

Permanent underfloor ventilation is required.

Floor finish optional.

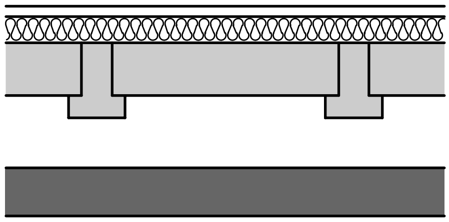


Ground Floors

Note: in using the tables for floors it is first necessary to calculate the ratio P/A, where –

P is the floor perimeter in metres and

A is the floor area in square metres.



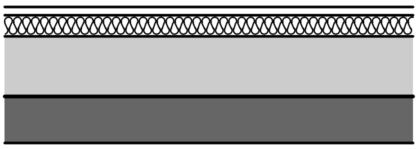


Table A.6 Insulation thickness for solid floors in contact with the ground

	P/A*	Thermal conductivity of insulant (W/mK) 0.02	0.025	0.03	0.035	0.04	0.045	0.05
		Insulation thickness (mm)						
	U-value of 0.25 W/m²K							
	A	B	C	D	E	F	G	H
1	1.00	62	77	93	108	124	139	155
2	0.90	61	76	91	107	122	137	152
3	0.80	60	75	90	105	119	134	149
4	0.70	58	73	87	102	116	131	145
5	0.60	56	70	84	98	111	125	139
6	0.50	52	66	79	92	105	118	131
7	0.40	47	59	71	83	95	107	119
8	0.30	39	49	59	69	79	88	98
9	0.20	24	30	36	42	48	54	60
	U-value of 0.35 W/m²K							
10	1.00	39	49	58	68	78	88	97
11	0.90	38	48	57	67	76	86	95
12	0.80	37	46	55	65	74	83	92
13	0.70	35	44	53	62	70	79	88
14	0.60	33	41	49	58	66	74	82
15	0.50	30	37	44	52	59	67	74
16	0.40	25	31	37	43	49	55	61
17	0.30	16	21	25	29	33	37	41
18	0.20	1	1	1	2	2	2	2
	U-value of 0.45 W/m²K							
19	1.00	26	33	39	46	53	59	66
20	0.90	25	32	38	44	51	57	63
21	0.80	24	30	36	42	48	54	60
22	0.70	22	28	34	39	45	51	56
23	0.60	20	25	30	35	40	45	50
24	0.50	17	21	25	30	34	38	42
25	0.40	12	15	18	21	24	27	30
26	0.30	4	5	6	6	7	8	9
27	<0.27	0	0	0	0	0	0	0

Note
*P/A is the ratio of floor perimeter (m) to floor area (m²)

Table A.7 Insulation thickness for suspended concrete beam and block ground floors

	P/A*	Thermal conductivity of insulant (W/mK) 0.02	0.025	0.03	0.035	0.04	0.045	0.05
		Insulation thickness (mm)						
	U-value of 0.25 W/m²K							
	A	B	C	D	E	F	G	H
1	1.00	60	75	90	104	119	134	149
2	0.90	59	73	88	103	118	132	147
3	0.80	58	72	86	101	115	130	144
4	0.70	56	70	84	98	112	126	140
5	0.60	54	67	80	94	107	121	134
6	0.50	50	63	75	88	101	113	126
7	0.40	45	57	68	79	91	102	113
8	0.30	37	46	56	65	74	84	93
9	0.20	22	27	33	38	43	49	54
	U-value of 0.35 W/m²K							
10	1.00	37	46	55	64	74	83	92
11	0.90	36	45	54	63	72	81	90
12	0.80	35	43	52	61	69	78	87
13	0.70	33	41	50	58	66	74	83
14	0.60	31	38	46	54	61	69	77
15	0.50	27	34	41	48	55	62	69
16	0.40	22	28	34	39	45	50	56
17	0.30	14	18	21	25	29	32	36
18	0.20	0	0	0	0	0	0	0
	U-value of 0.45 W/m²K							
19	1.00	24	30	36	42	48	54	60
20	0.90	23	29	35	41	46	52	58
21	0.80	22	28	33	39	44	50	55
22	0.70	20	25	31	36	41	46	51
23	0.60	18	23	27	32	36	41	45
24	0.50	15	18	22	26	29	33	37
25	0.40	10	12	15	17	19	22	24
26	0.30	2	2	2	3	3	4	4
27	<0.27	0	0	0	0	0	0	0

Note
*P/A is the ratio of floor perimeter (m) to floor area (m²)

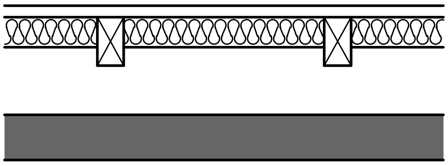


Table A.8 Insulation thickness for suspended timber ground floors

	P/A*	Thermal conductivity of insulant (W/mK) 0.02	0.025	0.03	0.035	0.04	0.045	0.05
		Insulation thickness (mm)						
	U-value of 0.25 W/m²K							
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
1	1.00	95	110	126	140	155	170	184
2	0.90	93	109	124	138	153	167	181
3	0.80	91	106	121	136	150	164	178
4	0.70	88	103	118	132	145	159	173
5	0.60	85	99	113	126	139	153	166
6	0.50	79	92	106	118	131	143	156
7	0.40	71	83	95	107	118	129	140
8	0.30	57	68	78	88	97	106	116
9	0.20	33	39	46	52	58	64	69
	U-value of 0.35 W/m²K							
10	1.00	57	67	77	87	96	106	115
11	0.90	55	66	75	85	94	103	112
12	0.80	53	63	73	82	91	100	109
13	0.70	51	60	69	78	87	95	104
14	0.60	47	56	64	73	81	89	97
15	0.50	42	50	57	65	72	79	87
16	0.40	34	41	47	53	60	66	72
17	0.30	22	26	31	35	39	43	47
18	0.20	1	1	2	2	2	2	3
	U-value of 0.45 W/m²K							
19	1.00	37	44	51	57	64	70	77
20	0.90	35	42	49	55	62	68	74
21	0.80	33	40	46	53	59	65	70
22	0.70	31	37	43	49	54	60	65
23	0.60	27	33	38	43	49	54	58
24	0.50	22	27	32	36	40	44	49
25	0.40	15	18	22	25	28	31	34
26	0.30	4	5	6	7	8	9	10
27	<0.27	0	0	0	0	0	0	0

Notes

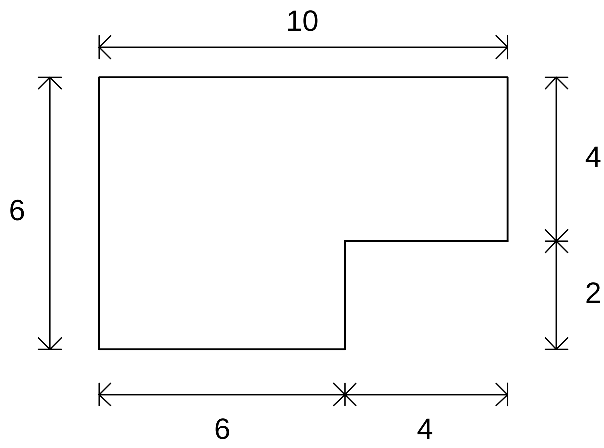
*P/A is the ratio of floor perimeter (m) to floor area (m^2).

The table is derived for suspended timber floors for which the proportion of timber is 12%, which corresponds to 48mm wide timbers at 400 mm centres.

For other proportions of timber the U-value can be calculated using the procedure in Appendix D.

Example 4 – Solid floor in contact with the ground

Determine the thickness of insulation required to achieve a U-value of **0.45** W/m²K for the ground floor slab shown below.



It is proposed to use insulation with a thermal conductivity of 0·02 W/mK

The overall perimeter length of the slab is –

(10 + 4 + 4 + 2 + 6 + 6) = 32 m

The *floor area* of the slab is –

(6 × 6) + (4 × 4) = 52 m²

The ratio –

$$\frac{\text{perimeter length}}{\text{floor area}} = \frac{32}{52} = 0{\cdot}6$$

Using Table A.6, column B, row 23 indicates 20 mm of insulation is required.

The insulation may be located above or below the concrete slab.

Example 5 – Suspended timber floor

If the floor shown above was of suspended timber construction, the perimeter length and floor area would be the same, yielding the same ratio of –

$$\frac{\text{perimeter length}}{\text{floor area}} = \frac{32}{52} = 0{\cdot}6$$

To achieve a U-value of 0·45 W/m²K, using insulation with a thermal conductivity of 0·04 W/mK, Table A.8, column F, row 23 indicates that the insulation thickness between the joists should be not less than 49 mm.

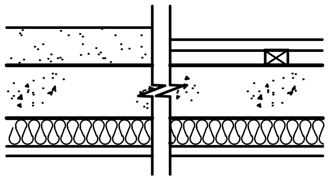
Solid floors

A. Concrete floor of in situ or precast slabs or beams.

High vapour permeability insulation applied to the soffit of the concrete floor.

External finish optional but if used shall be of high vapour permeability.

Floor finish optional.

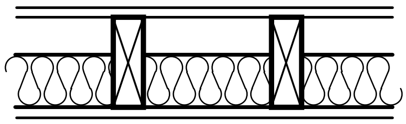


Joisted floors

B. Floor of timber joists and boarding.

High vapour permeability insulation applied between the joists.

High vapour permeability external finish.



Exposed and semi-exposed upper floors

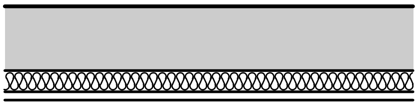


Table A.9 Base thickness of insulation layer for exposed and semi-exposed upper floors of concrete construction

Design U-value (W/m²K)	Thermal conductivity of insulant (W/mK) 0.02	0.025	0.03	0.035	0.04	0.045	0.05
	Base thickness of insulation (mm) to achieve design U-values						
A	B	C	D	E	F	G	H
Exposed floor							
1 **0.35**	52	65	78	91	104	117	130
2 **0.45**	39	49	59	69	79	89	98
Semi-exposed floor							
3 **0.60**	26	33	39	46	52	59	65

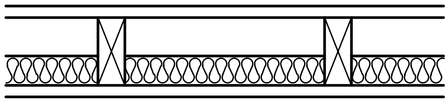


Table A.10 Base thickness of insulation layer for exposed and semi-exposed upper floors of timber construction

Design U-value (W/m²K)	Thermal conductivity of insulant (W/mK) 0.02	0.025	0.03	0.035	0.04	0.045	0.05
	Base thickness of insulation (mm) between joists to achieve design U-values						
A	B	C	D	E	F	G	H
Exposed floor							
1 **0.35**	61	76	92	107	122	146	162
2 **0.45**	42	53	63	74	84	95	106
Semi-exposed floor							
3 **0.60**	25	32	38	44	50	57	63

Note
Table A.10 is derived for floors with the proportion of timber at 12% which corresponds to 48 mm wide timbers at 400 mm centres. For other proportions of timber the U-value can be calculated using the procedure in Appendix D.

Table A.11 Allowable reduction in base thickness for common components

Component	Thermal conductivity of insulant (W/mK) 0.02	0.025	0.03	0.035	0.04	0.045	0.05
	Reduction in base thickness of insulation material (mm)						
A	B	C	D	E	F	G	H
1 10 mm plasterboard	1	2	2	2	3	3	3
2 19 mm timber flooring	3	3	4	5	5	6	7
3 50 mm screed	2	3	4	4	5	5	6

Roofs

A.4 Tables A.12, A.13 and A.14 give the base thicknesses of insulating materials, of different thermal conductivities, required to achieve the given U-value (neglecting the thermal resistances of the other components of the roof construction).

Table A.15 gives the deductions which may be made from the base thickness to allow for the thermal resistances of the other components of the roof construction. Where appropriate Table A.15 equates the other components to a thickness of insulating material.

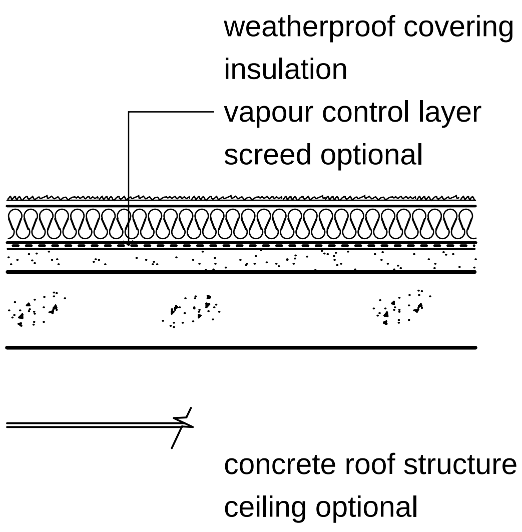
Tables A.12, A.13 and A.14 are only valid for the Acceptable constructions illustrated in Roof Types 1 and 2. (Where tapered components are used in a flat roof, or where a pitched roof contains a horizontal ceiling, special factors apply to the U-value calculations. For details see CIBSE Guide A3, Section A3-16, U-values of roofs).

Roof Type 1 – Flat roofs

A. Flat roof structure of in situ or precast concrete with or without a screed.

External weatherproof covering with insulation below, laid on a vapour control layer over the roof structure.

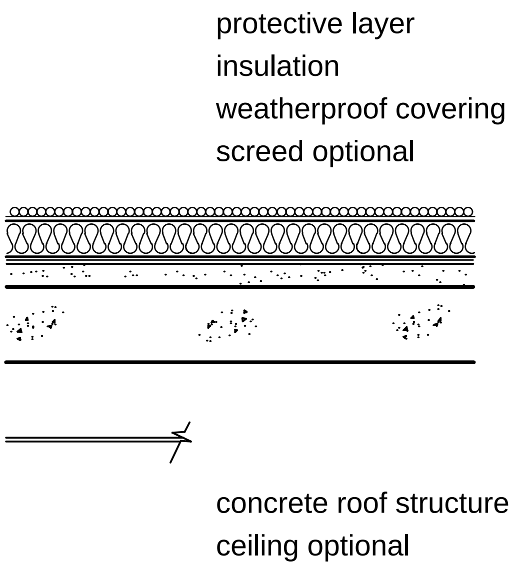
Suspended ceiling optional.



B. Flat roof structure of in situ or precast concrete with or without a screed.

Protective topping or ballast layer on low vapour permeability insulation, laid on a weatherproof covering over the roof structure.

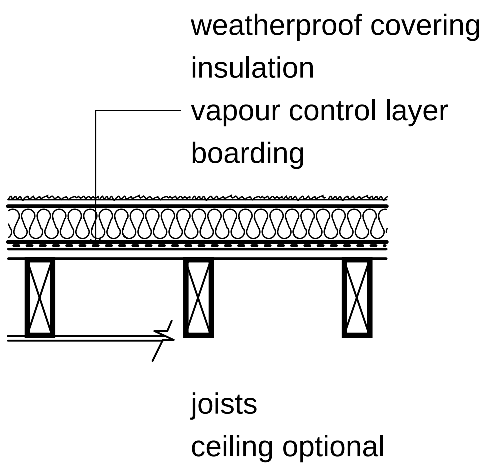
Suspended ceiling optional.



C. Flat roof structure of timber or metal framed construction overlaid with a board decking at least 19 mm thick.

External weatherproof covering with insulation below, laid on a vapour control layer over the board decking.

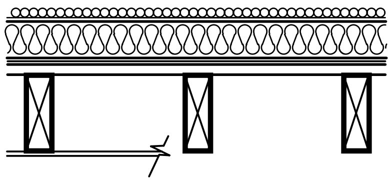
Ceiling optional.



D. Flat roof structure of timber or metal framed construction overlaid with a board decking at least 19 mm thick.

Protective topping on a low vapour permeability insulation, laid on a weatherproof covering over the roof structure.

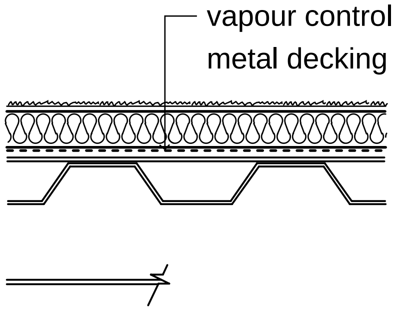
Ceiling optional.



E. Flat roof structure of timber or metal framed construction overlaid with a profiled metal decking.

External weatherproof covering with insulation below, laid on a vapour control layer over the metal decking.

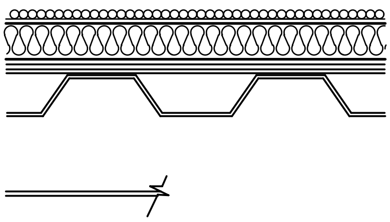
Suspended ceiling optional.



F. Flat roof structure of timber or metal framed construction overlaid with a profiled metal decking.

Protective topping on a low vapour permeability insulation, laid on a weatherproof covering over the roof structure.

Suspended ceiling optional.



Note
These provisions do not apply to sheet metal weatherproof coverings such as lead, copper, zinc, etc, which require joints to allow for thermal movement.

Roof Type 2 – Pitched roofs

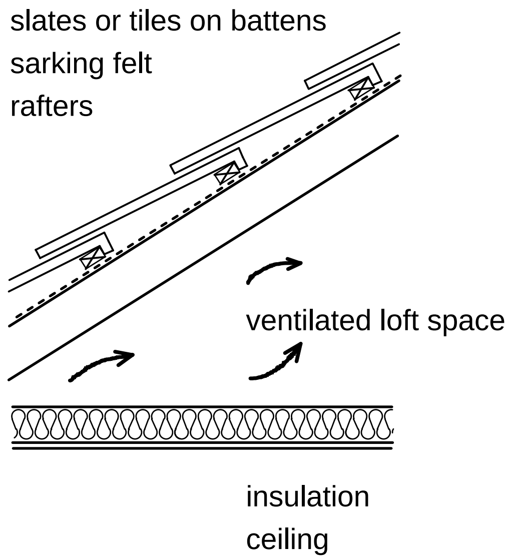
A. Pitched roof structure of timber or metal framed construction.

External weatherproof covering of slates or tiles on battens on sarking felt.

Insulation applied over a horizontal ceiling.

Permanent ventilation is required to the loft space.

Where a vapour control layer is required it shall be fitted between the insulation and ceiling.

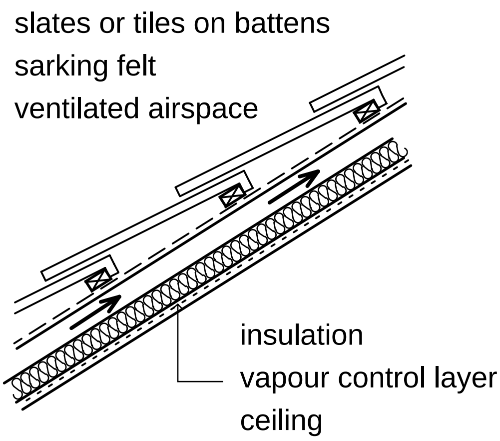


B. Pitched roof structure of timber or metal framed construction.

External weatherproof covering of slates or tiles on battens on sarking felt.

Insulation applied over a sloping ceiling with a vapour control layer between the insulation and the ceiling.

Permanent ventilation is required to the airspace.

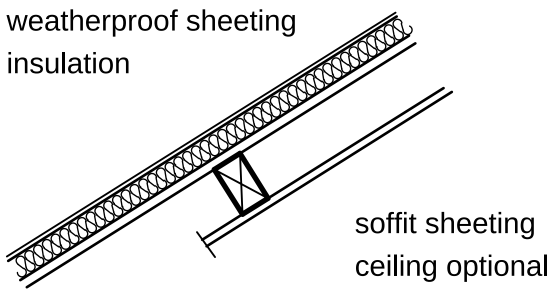


C. Pitched roof structure of timber or metal framed construction.

External weatherproof covering of metal or fibre cement sheeting.

Insulation applied as an interlayer between the external and soffit sheeting to form a composite construction.

Sloping ceiling optional.



Note
These provisions do not apply to sheet metal weatherproof coverings such as lead, copper, zinc, etc, which require joints to allow for thermal movement.

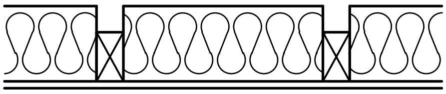


Table A.12 Base thickness of insulation between ceiling joists or rafters

	Design U-value (W/m²K)	Thermal conductivity of insulant (W/mK) 0.02	0.025	0.03	0.035	0.04	0.045	0.05
		Base thickness of insulating material (mm)						
	A	B	C	D	E	F	G	H
1	**0.20**	167	209	251	293	335	376	418
2	**0.25**	114	142	170	199	227	256	284
3	0.30	86	107	129	150	171	193	214
4	**0.35**	69	86	103	120	137	154	172
5	0.40	57	71	86	100	114	128	143
6	**0.45**	49	61	73	85	97	110	122

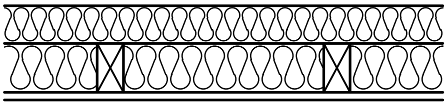


Table A.13 Base thickness of insulation between and over joists or rafters

	Design U-value (W/m²K)	Thermal conductivity of insulant (W/mK) 0.02	0.025	0.03	0.035	0.04	0.045	0.05
		Base thickness of insulating material (mm)						
	A	B	C	D	E	F	G	H
1	**0.20**	126	145	166	187	209	232	254
2	**0.25**	106	120	136	152	169	187	204
3	0.30	86	104	116	129	143	157	171
4	**0.35**	69	86	102	112	124	135	147
5	0.40	57	71	86	100	109	119	129
6	**0.45**	49	61	73	85	97	107	115

Note
Tables A.12 and A.13 are derived for roofs with the proportion of timber at 8%, corresponding to 48 mm wide timbers at 600 mm centres. For other proportions of timber the U-value can be calculated using the procedure in Appendix D.

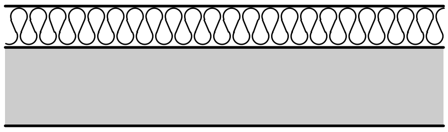


Table A.14 Base thickness for continuous insulation

	Design U-value (W/m²K)	Thermal conductivity of insulant (W/mK) 0.02	0.025	0.03	0.035	0.04	0.045	0.05
		Base thickness of insulating material (mm)						
	A	B	C	D	E	F	G	H
1	**0.20**	97	122	146	170	194	219	243
2	**0.25**	77	97	116	135	154	174	193
3	0.30	64	80	96	112	128	144	160
4	**0.35**	54	68	82	95	109	122	136
5	0.40	47	59	71	83	94	106	118
6	**0.45**	42	52	62	73	83	94	104

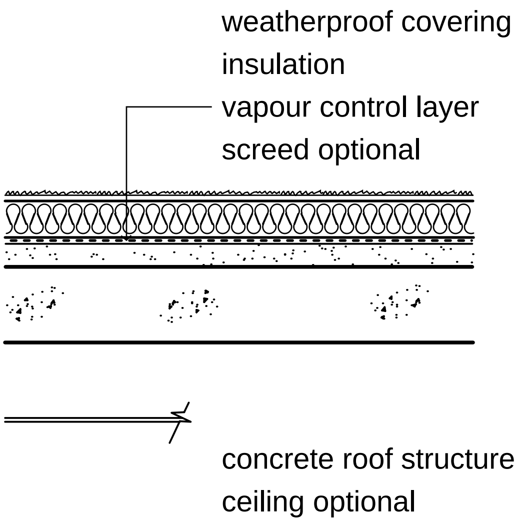
Table A.15 Allowable reductions in thickness for common roof components

	Concrete slab density (kg/m³)	Thermal conductivity of insulant (W/mK) 0.02	0.025	0.03	0.035	0.04	0.045	0.05
		Reduction in base thickness of insulating material (mm) for each 100 mm of concrete slab						
	A	B	C	D	E	F	G	H
1	600	11	13	16	18	21	24	26
2	800	9	11	13	15	17	20	22
3	1100	6	7	9	10	12	13	15
4	1300	5	6	7	8	9	10	11
5	1700	3	3	4	5	5	6	7
6	2100	2	2	2	3	3	4	4
	Other materials and components	Reduction in base thickness of insulating material (mm)						
7	10 mm plasterboard	1	2	2	2	3	3	3
8	13 mm plasterboard	2	2	2	3	3	4	4
9	13 mm sarking board	2	2	3	3	4	4	5
10	12 mm calcium silicate liner board	1	2	2	2	3	3	4
11	Roof space (pitched)	4	5	5	6	7	8	9
12	Roof space (flat)	3	4	5	6	6	7	8
13	19 mm roof tiles	0	1	1	1	1	1	1
14	19 mm asphalt (or 3 layers of felt)	1	1	1	1	2	2	2
15	50 mm screed	2	3	4	4	5	5	6

Example 6 – Flat roof of concrete

(Roof Type 1A)

Determine the thickness of insulation required to achieve a U-value of 0.45 W/m^2K for the roof construction below.



The chosen insulating material has a thermal conductivity of 0·035 W/mK.

Using Table A.14

From column E, row 6 the base thickness of the insulation layer is 73 mm.

The base thickness may be reduced by taking account of the other materials as follows –

From Table A.15

Concrete slab, column E, row 6

adjusted for 150 mm thickness 1·5 × 3	= 4·5
Roofing felt, column E, row 14	= 1
50mm screed, column E, row 15	= 4
	9·5 mm

The minimum thickness of the insulating layer to achieve a U-value of 0·45 W/m^2K is therefore –

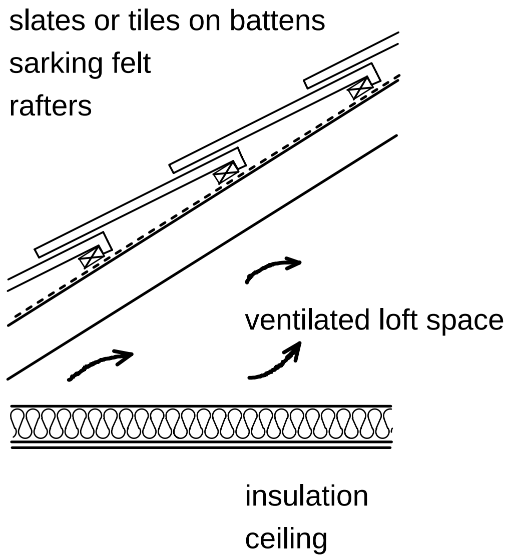
Base thickness less total reduction is

73 − 9·5 = 63·5 mm.

Example 7 – Pitched roof with insulation between and over the ceiling joists

(Roof Type 2A)

Determine the thickness of the insulation layer above the joists required to achieve a U-value of 0.25 W/m^2K for the roof construction shown below.



It is proposed to use mineral fibre insulation between and over the joists with a thermal conductivity of 0·035 W/mK.

Using Table A.13

From column E, row 2 of the table, the base thickness of the insulation layer = 152 mm.

The base thickness may be reduced by taking account of the other materials as follows –

From Table A.15

19 mm roof tiles	column E, row 13	= 1
Roofspace	column E, row 11	= 6
10 mm plasterboard	column E, row 7	= 2
Total reduction		= 9 mm

The minimum thickness of the insulating layer over the joists required in addition to the 100 mm insulation between the joists to achieve a U-value of 0·25 W/m^2K is therefore –

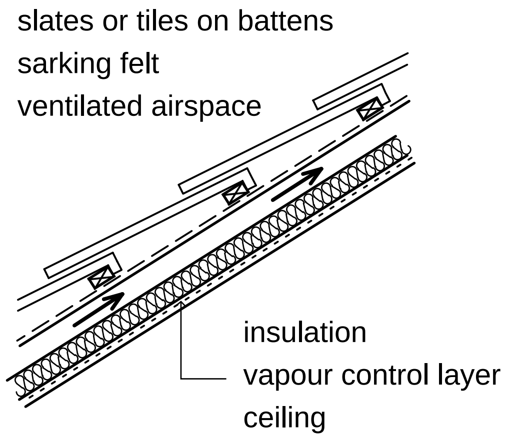
Base thickness less thickness of insulation between the joists, less total reduction is

152 − 100 − 9 = 43 mm.

Example 8 – Pitched roof with insulation between rafters

(Roof Type 2B)

Determine the thickness of insulation required to achieve a U-value of 0.35 W/m^{2}K for the roof construction below.



The chosen insulating material has a thermal conductivity of 0·03 W/mK.

Using Table A.12

From column D, row 4 the base thickness of the insulation layer is 103 mm.

The base thickness may be reduced by taking account of the other materials as follows –

From Table A.15

19 mm roof tiles	column D, row 13 =	1
10 mm plasterboard	column D, row 7 =	2
		= 3 mm

The minimum thickness of the insulating layer to achieve a U-value of 0·35 W/m^{2}K is therefore –

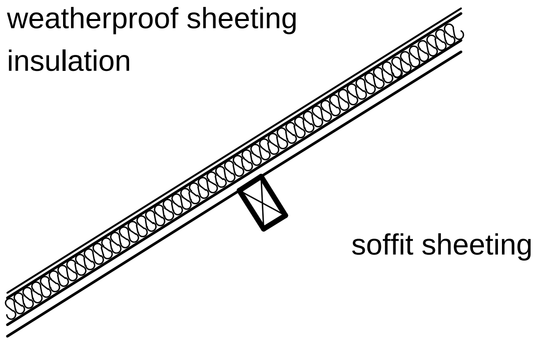
Base thickness less total reduction is

103 − 3 = 100 mm.

Example 9 – Pitched roof construction formed with a composite panel

(Roof Type 2C)

Determine the thickness of insulation required to achieve a U-value of 0.45 W/m^{2}K for the roof construction below.



The chosen insulating material has a thermal conductivity of 0·035 W/mK.

Using Table A.14

From column E, row 6 the base thickness of the insulation layer is 73 mm.

The composite panel has a metal inner and outer surface and therefore no reductions apply.

The minimum thickness of the insulating layer to achieve a U-value of 0·45 W/m^{2}K is therefore 73 mm.

Appendix B – SAP Energy rating calculation for a dwelling

B.1 When calculating the SAP energy rating the following considerations shall apply –

(a) The data used in calculations of SAP energy ratings shall be obtained from the tables in The Government's Standard Assessment Procedure for energy rating of dwellings;

(b) The calculation shall be carried out in accordance with the conventions supporting The Government's Standard Assessment Procedure for energy rating of dwellings;

(c) For each dwelling the SAP energy rating shall be calculated using the data current at the date of the deposit of plans or the giving of a building notice in accordance with Regulation A10;

(d) Where the heating system is unknown at completion of the dwelling, the SAP energy rating notified to the District Council in accordance with Regulation A11 shall be calculated assuming a main system of electric room heaters and a secondary system of electric heaters, both systems using on-peak electricity; and

(e) When undertaking SAP energy rating calculations for designs not intended for a specific site (e.g. type designs) the following assumptions shall be made –

(i) two sides of the dwelling will be in shade; and

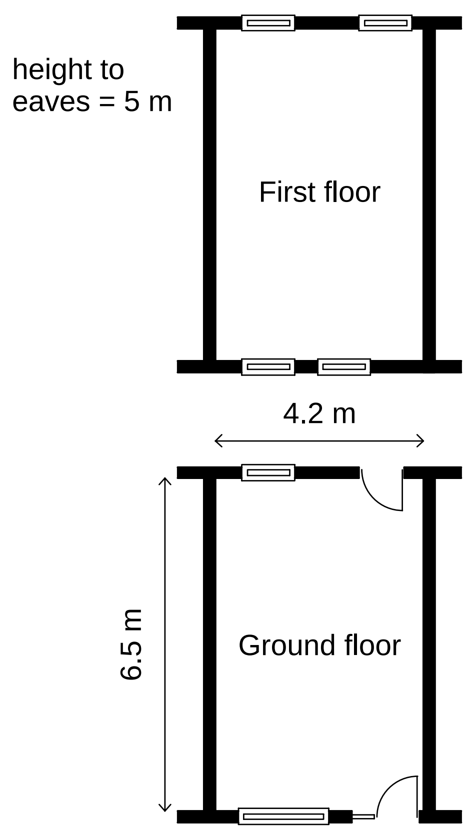
(ii) the windows, doors and rooflights are all on the east and west elevations.

Example SAP energy ratings for different dwelling types

Example 1 – Two bedroom mid-terrace house with electric storage heaters

Element	Description	Area	U-value
Wall	Brick/cavity/dense block with 70 mm blown fibre cavity insulation	30·3	0·44
Roof	Pitched roof, 100 mm insulation between joists 50 mm on top	27·3	0·25
Ground floor	Suspended timber, 25 mm insulation	27·3	0·37
Windows and doors	Double glazed (6 mm gap), wooden frame	11·7	3·3
Heating	Electric storage heaters (efficiency 100%)		
		SAP rating =	**68**

Diagram **B.1** **Plans of two bedroom mid-terrace house**



Example 2 – Three bedroom semi-detached house with solid fuel boiler

Element	Description	Area	U-value
Wall	Brick/cavity/dense block with 70 mm blown fibre cavity insulation	72·5	0·44
Roof	Pitched roof, 100 mm insulation between joists 50 mm on top	40	0·25
Ground floor	Solid concrete 25 mm insulation	40	0·43
Windows and doors	Double glazed (6 mm gap), PVC-U frame	18	3·3
Heating	Central heating with solid fuel boiler (efficiency 60%)		
		SAP rating =	**67**

Example 3 – Four bedroom detached house with oil fired boiler

Element	Description	Area	U-value
Wall	Brick/partial cavity fill/ dense block	116·5	0·45
Roof	Pitched roof, 100 mm insulation between joists 50 mm on top	50	0·25
Ground floor	Suspended timber, 35 mm insulation	50	0·45
Windows and doors	Double glazed (6 mm gap), PVC-U frame	24·9	3·3
Heating	Central heating with oil boiler (efficiency 70%)		
		SAP rating =	**90**

Diagram **B.2 Plans of three bedroom semi-detached house**

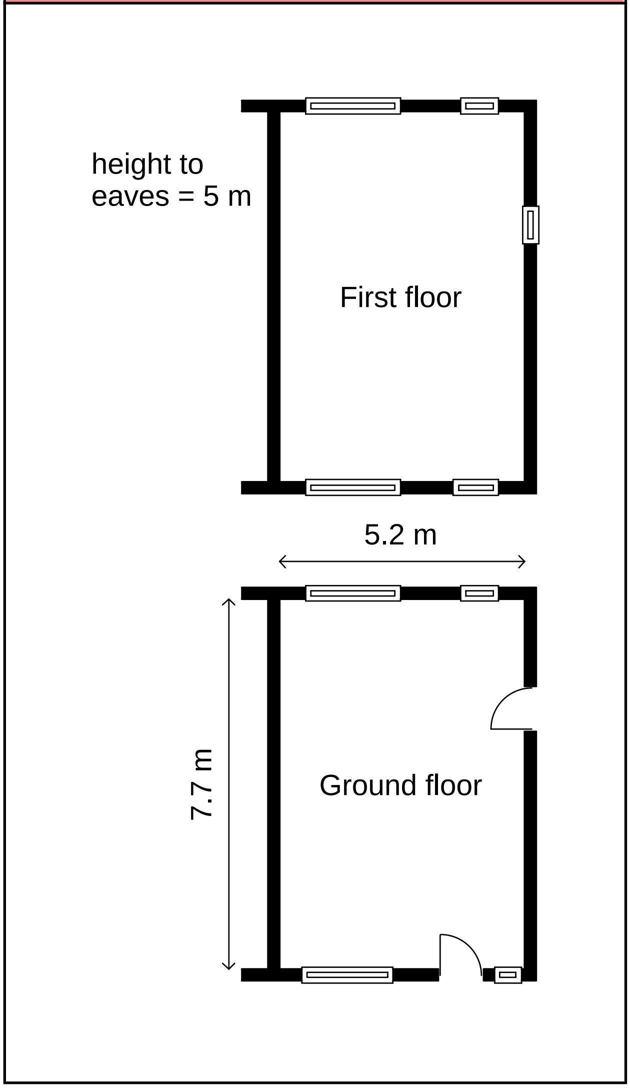
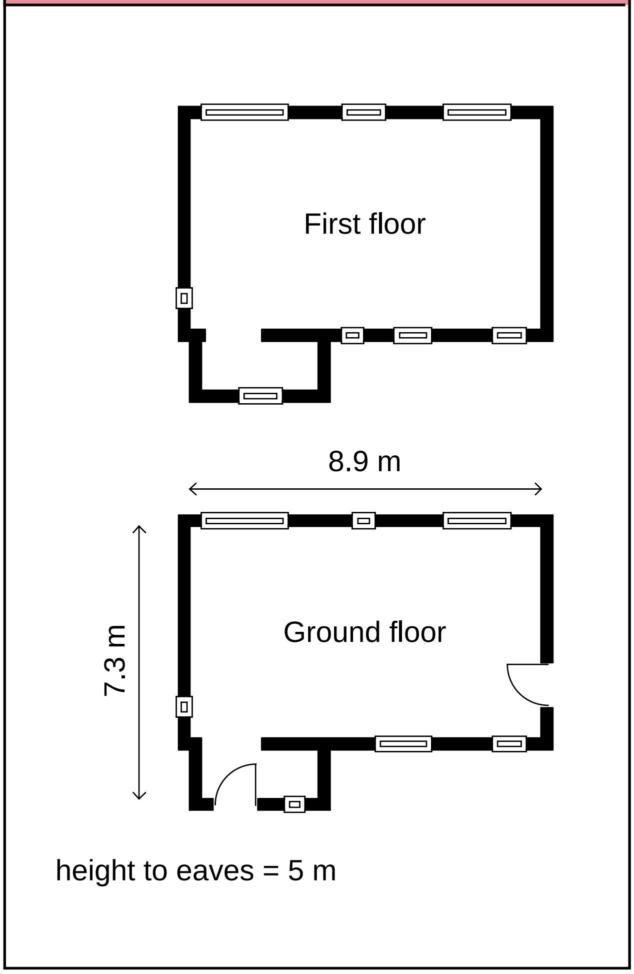


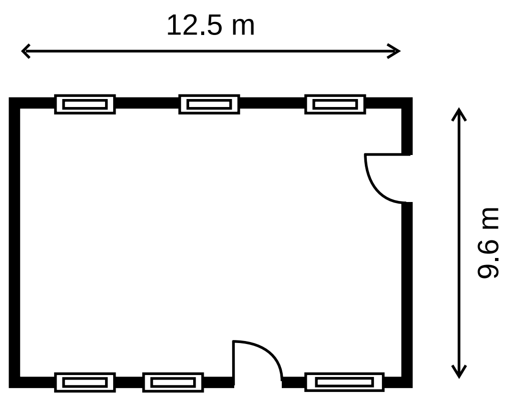
Diagram **B.3 Plans of four bedroom detached house**



Example 4 – Three bedroom bungalow with solid fuel boiler

Element	Description	Area	U-value
Wall	Brick/partial cavity fill/ dense block	84·7	0·45
Roof	Pitched roof, 100 mm insulation between joists 50 mm on top	120	0·25
Ground floor	Suspended timber, 35 mm insulation	120	0·41
Windows	Double glazed (6 mm gap), PVC-U frame	22·0	3·3
Doors	Timber	3·8	3·0
Heating	Central heating with solid fuel boiler (efficiency 65%)		
		SAP rating =	**68**

Diagram **B.4** **Plan of three bedroom bungalow**



Height to eaves = 2·5 m

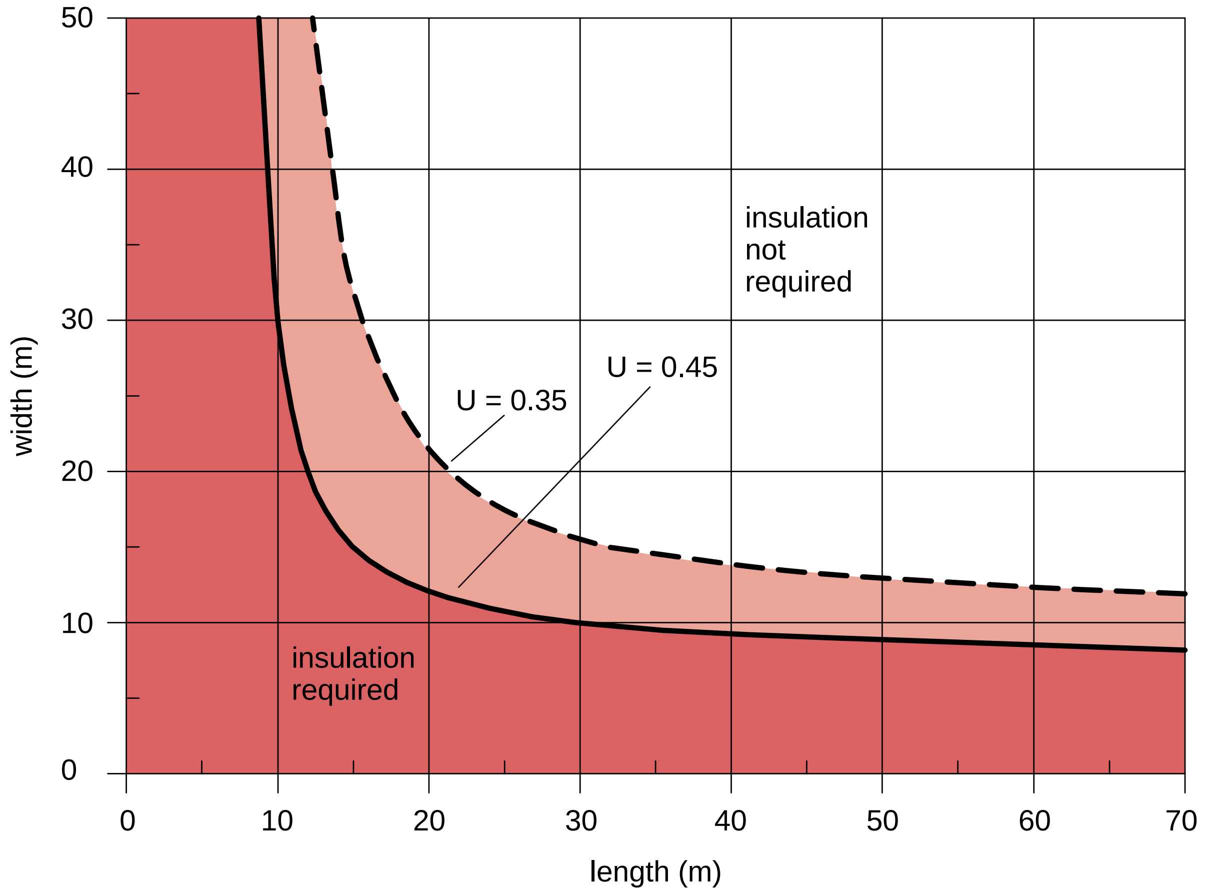
Appendix C – Calculation of the U-value of a ground floor

General

C.1 A ground floor may have a U-value of 0·45 W/m^{2}K, or 0·35 W/m^{2}K, without insulation if its area is sufficiently large. Diagram C.1 shows the range of floor dimensions for which insulation is required.

Diagram **C.1 Floor dimensions for which insulation is required**

see para C.1



C.2 Floor dimensions should be measured in accordance with the convention described in paragraph 1.4. In the case of semi-detached or terraced dwellings, blocks of flats and similar, the floor dimensions can either be taken as those of the dwelling or of the whole building. When considering extensions to existing buildings the floor dimensions can be taken as those of the complete building including the extension.

C.3 Care should be taken to control the risk of condensation caused by thermal bridging at the floor edge. See BRE Report : Thermal insulation : avoiding risks.

Determining the U-value of floors with no insulation

C.4 The U-value of an uninsulated floor may be determined from the ratio of its exposed perimeter to its area, using the equation –

$$\mathbf{U_o} = 0{\cdot}05 + 1{\cdot}65\left(\frac{P}{A}\right) - 0{\cdot}6\left(\frac{P}{A}\right)^2$$

where –

$\mathbf{U_o}$ = U-value of uninsulated floor (W/m^{2}K)

P = exposed perimeter of floor (m)

A = area of floor (m^2)

The equation applies to all types of uninsulated floors constructed next to the ground including slab-on-ground, concrete raft, suspended timber and beam-and-block.

Unheated spaces outside the insulated fabric, such as attached garages or porches, shall be excluded when determining **P** and **A** but the length of the wall between the heated building and the unheated space shall be included when determining the perimeter.

C.5 The data in Table C.1 has been derived from the equation in paragraph C.4. For the purposes of Part F it will be sufficient to use the table using linear interpolation where necessary.

Table **C.1 U-values of uninsulated floors**

Ratio P/A	U_o
0·1	0·21
0·2	0·36
0·3	0·49
0·4	0·61
0·5	0·73
0·6	0·82
0·7	0·91
0·8	0·99
0·9	1·05
1·0	1·10

U-value of insulated floors

C.6 The U-value of an insulated floor is obtained from –

$$\mathbf{U_{ins}} = \frac{1}{\dfrac{1}{\mathbf{U_o}} + \mathbf{R_{ins}}}$$

Where –

$\mathbf{R_{ins}}$ is the thermal resistance of the insulation, and $\mathbf{U_o}$ is obtained from Table C.1 or the equation in paragraph C.4.

In the case of suspended floors $\mathbf{U_{ins}}$ includes the thermal resistance of the structural deck and $\mathbf{R_{ins}}$ should only include –

(a) the resistance of added insulation layers; and/or

(b) any extra resistance of the structural deck over and above 0·2 m^{2}K/W.

C.7 For further information on floor U-values see BRE IP 3/90. BRE IP 7/93 shows how the U-value of a floor is modified by edge insulation (including low-density foundations), and BRE IP 14/94 gives procedures for basements.

Appendix D – Calculation method for structures containing repeating thermal bridges

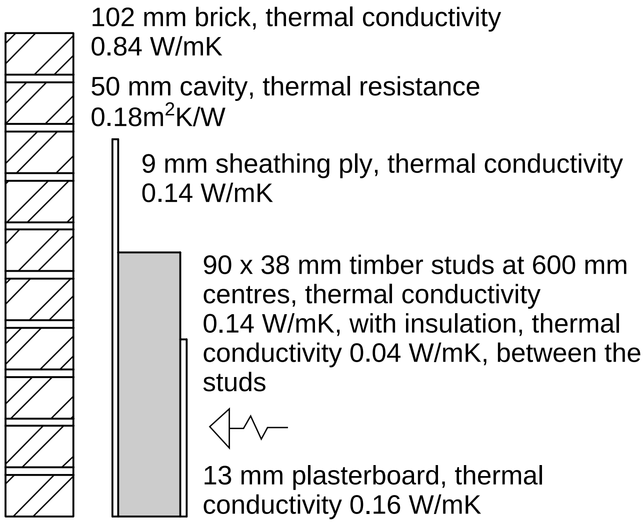
D.1 This Appendix illustrates the use of the proportional area method for calculating the U-value of an element which contains repeating thermal bridges. Full details of the calculation method are given in the Chartered Institute of Building Services Engineers (CIBSE) Design Guide : Section A3 : 1996.

D.2 Where the element design does not include a continuous cavity all the elements layers have to be analysed together. Where the design incorporates a continuous cavity, the element should be divided into 2 parts along the centre of the cavity and the parts analysed separately. The resistances of the 2 parts should be determined with half of the cavity resistance assigned to each. The thermal resistances of each part are added together to obtain the total resistance of the element.

D.3 Where the joists in timber roof and floor constructions project beyond the surface of the insulation, the calculations should take the depths of the joists to be the same as the depth of insulation, hence ignoring the effect of the projections. Joists which are wholly beneath insulation can also be ignored.

Example 1

Calculation for the U-value of the proposed wall construction shown below –



The resistance of the outside surface of the wall is 0·06 m²K/W and the inside surface resistance is 0·12 m²K/W.

Consider the wall as inner and outer parts with the boundary between the parts at the centre of the cavity.

Resistance of inner part

The thermal bridging of the insulation by the timber studs must be taken into account as follows –

(a) the resistance of each section through the part is calculated

Resistance through section containing timber stud –

Inside surface resistance	=	0·12
Resistance of plasterboard = 0·013/0.16	=	0·08
Resistance of timber stud = 0·09/0·14	=	0·64
Resistance of sheathing ply = 0·009/0·14	=	0·06
Half cavity resistance	=	0·09
Resistance of section through timber stud – R_t	**=**	**0.99 m²K/W**

Resistance through section containing insulation –

Inside surface resistance	=	0·12
Resistance of plasterboard = 0·013/0.16	=	0·08
Resistance of insulation = 0·09/0·04	=	2·25
Resistance of sheathing ply = 0·009/0·14	=	0·06
Half cavity resistance	=	0·09
Resistance of section through insulation – R_{ins}	**=**	**2.60 m²K/W**

(b) the fractional area of each section is calculated as follows—

Fractional area of timber stud –

$$F_t = \frac{\text{thickness of studs}}{\text{stud centres}} = \frac{38}{600} = 0{\cdot}063$$

Fraction area of insulation: $F_{ins} = (1 - F_t) = 0{\cdot}937$

(c) the resistance of the inner part is then obtained from –

$$R_{inner} = \frac{1}{\frac{F_t}{R_t} + \frac{F_{ins}}{R_{ins}}} = \frac{1}{\frac{0{\cdot}063}{0{\cdot}99} + \frac{0{\cdot}937}{2{\cdot}60}} = \mathbf{2{\cdot}36\ m^2K/W}$$

Resistance of outer part

The outer part is unbridged as the difference in resistance between brick and mortar is less than 0·1 m^2K/W.

Half cavity resistance		=	0·09
Resistance of brick = 0·102/0·84		=	0·12
Outside surface resistance		=	0·06
Resistance of outer part –	R_{outer}	=	**0.27 m^2K/W**

Total resistance of wall

The total resistance $\mathbf{R_{total}}$ of the wall is the sum of the resistances of the inner and outer parts –

$\mathbf{R_{inner}} + \mathbf{R_{outer}} = 2{\cdot}36 + 0{\cdot}27 =$ **2·63 m^2K/W.**

U-value of wall

The U-value is given by –

$$U = \frac{1}{\mathbf{R_{total}}}$$

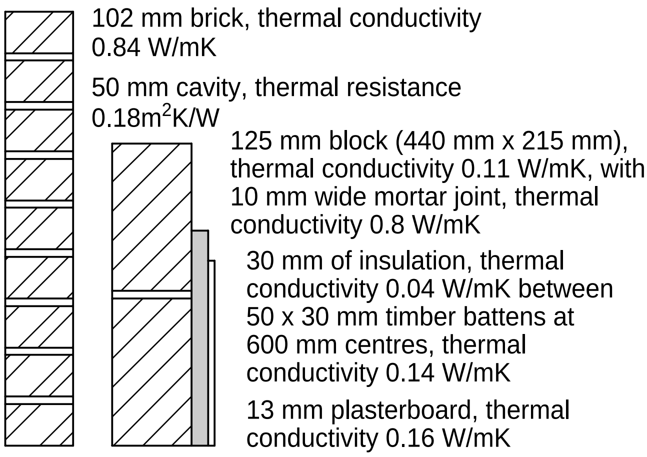
$$\mathbf{U} = \frac{1}{2{\cdot}63} = \mathbf{0{\cdot}38\ W/m^2K}$$

Example 2

If the proposed wall construction is as shown below there are 2 thermally bridged layers –

(a) that of the blockwork, by the normal mortar joints; and

(b) that of the insulation, by the timber battens.



Consider the wall as inner and outer parts with the boundary between the parts at the centre of the cavity.

Resistance of inner part

In this case there are two bridged layers and the precise location of the bridge in one layer with respect to the bridge in the other layer is generally unknown (or is not readily determined). There are four different combinations of paths through the blockwork and insulation and it is therefore assumed, because pitch centres do not coincide, that heat flows through them in proportion to their relative areas. The average resistance of the part is determined as follows –

Resistance of non-bridged layers –

Resistance of half the cavity		=	0·09
Resistance of plasterboard = 0·013/0·16		=	0·08
Resistance of inside surface		=	0·12
Resistance of non-bridged layers –	R_{nb}	=	**0.29 m^2K/W**

Resistance of bridged layers –

Heat flow paths

The 2 bridged layers create 4 paths –

block/insulation

block/timber

mortar/insulation

mortar/timber

Material resistances

Resistance of block	R_b = 0·125/0·11	= 1·14 m^2K/W
Resistance of mortar	R_m = 0·125/0·8	= 0·16 m^2K/W
Resistance of insulation	R_{ins} = 0·03/0·04	= 0·75 m^2K/W
Resistance of timber	R_t = 0·03/0·14	= 0·21 m^2K/W

Resistance of heat flow paths

Resistance of block/insulation –

$\mathbf{R_{b.ins}} = \mathbf{R_b} + \mathbf{R_{ins}} + \mathbf{R_{nb}} = 2{\cdot}18\ m^2K/W$

block/timber –

$\mathbf{R_{b.t}} = \mathbf{R_b} + \mathbf{R_t} + \mathbf{R_{nb}} = 1{\cdot}64\ m^2K/W$

mortar/insulation –

$\mathbf{R_{m.ins}} = \mathbf{R_m} + \mathbf{R_{ins}} + \mathbf{R_{nb}} = 1{\cdot}20\ m^2K/W$

mortar/timber –

$\mathbf{R_{m.t}} = \mathbf{R_m} + \mathbf{R_t} + \mathbf{R_{nb}} = 0{\cdot}66\ m^2K/W$

Fraction of face area of materials

block – $F_b = \dfrac{440 \times 215}{450 \times 225} = 0{\cdot}934$

mortar – $F_m = 1 - F_b = 0{\cdot}066$

insulation – $F_{ins} = \dfrac{550}{600} = 0{\cdot}917$

timber – $F_t = 1 - F_{ins} = 0{\cdot}083$

Fraction of face area of heat flow paths

block/insulation – $F_{b.ins} = F_b \times F_{ins} = 0{\cdot}856$

block/timber – $F_{b.t} = F_b \times F_t = 0{\cdot}078$

mortar/insulation – $F_{m.ins} = F_m \times F_{ins} = 0{\cdot}061$

mortar/timber – $F_{m.t} = F_m \times F_t = 0{\cdot}005$

Sum of parallel resistances

The sum of resistances in parallel is given by the formula –

$$\frac{1}{R_{inner}} = \frac{F_{b.ins}}{R_{b.ins}} + \frac{F_{b.t}}{R_{b.t}} + \frac{F_{m.ins}}{R_{m.ins}} + \frac{F_{m.t}}{R_{m.t}}$$

The figures in this case are –

$$\frac{1}{R_{inner}} = \frac{0{\cdot}856}{2{\cdot}18} + \frac{0{\cdot}078}{1{\cdot}64} + \frac{0{\cdot}061}{1{\cdot}20} + \frac{0{\cdot}005}{0{\cdot}66} = 0{\cdot}499$$

The resistance of the inner part is therefore –

$$R_{inner} = \frac{1}{0{\cdot}499} = \mathbf{2{\cdot}0\ m^2K/W}$$

Resistance of outer part

Resistance of outside surface = 0·06

Resistance of brick outer part 0·102/0·84 = 0·12

Resistance of half the cavity = 0·09

Resistance of outer part – R_{outer} **= 0·27 m²K/W**

Total resistance of the wall

The total resistance R_{total} of the wall is the sum of the inner and outer part resistances –

$$R_{inner} + R_{outer} = 2{\cdot}0 + 0{\cdot}27 = 2{\cdot}27\ m^2K/W$$

U-value of the wall

The wall U-value is given by –

$$U = \frac{1}{R_{total}} = \frac{1}{2{\cdot}27} = \mathbf{0{\cdot}44\ W/m^2K}$$

Appendix E – Demonstrating compliance using the Elemental Method for dwellings

Table **E.1 Checklist for the Elemental Method**

Steps to be followed	**How to check if your design is satisfactory**
1. Estimate the SAP energy rating of the proposed dwelling. The example dwellings in Appendix B will help you.	
2. Check that the roof achieves a maximum U-value of – (a) 0·25 (if the SAP energy rating is more than 60). (b) 0·2 (if the SAP energy rating is 60 or less).	Use the tables in Appendix A to calculate the thickness of insulation needed.(1)
3. Check that exposed walls achieve a maximum U-value of 0·45 and the semi-exposed walls achieve a U-value of 0·6.	Use the tables in Appendix A to calculate the thickness of insulation needed.(1)
4. Check that the ground floor achieves a maximum U-value of – (a) 0·45 (if the SAP energy rating is more than 60). (b) 0·35 (if the SAP energy rating is 60 or less).	(a) Use diagram C.1 to determine whether insulation is required. (b) Where insulation is required calculate the perimeter/area ratio as explained in Appendix C. (c) Use the perimeter/area ratio in the tables in Appendix A to calculate the thickness of insulation needed.(2)
5. Check that any exposed or semi-exposed upper floors achieve a maximum U-value of – (a) 0·6 for semi-exposed floors. (b) 0·45 for exposed floors (if the SAP rating is more than 60). (c) 0·35 for exposed floors (if the SAP rating is 60 or less).	Semi-exposed floors are defined in paragraph 1·3. Use the tables in Appendix A to calculate the thickness of insulation needed.(1)
6. Calculate the average U-value of the windows, doors and rooflights.	Use Table 1.1 to determine the U-values of the windows, doors and rooflights.(1) Example 1 in Appendix F illustrates how to calculate the average U-value.
7. Check that the total area of windows, doors and rooflights does not exceed the permitted amount.	Using the average U-value from step 6 use Table 1.3 to determine the maximum permitted area of windows, doors and rooflights. It is given as a percentage of the dwelling's floor area.
8. Complete the SAP worksheet (or get a competent person to do this for you) and verify that the correct U-values were used in steps 2, 4 and 5.	If the verified SAP energy rating is 60 or less and a rating of more than 60 was assumed in step 1, steps 2 to 7 must be repeated.

Notes

1 Manufacturers' independently certified test data shall be used where available.

2 Alternatively follow the procedures in Appendix C.

Appendix F – Calculation to determine the permissible area of windows, doors and rooflights in the Elemental Method

Example 1

A proposed dwelling has a total floor area of 80 m^2. It has two half-single-glazed doors and double-glazed windows as described in Table F.1.

Table F.1 Window and door openings for a proposed dwelling

Elements	Area (m^2)	U-value (W/m^2K)	Rate of heat loss (area × U-value) (W/K)
Windows	15·4	2·9	44·66
Doors	3·8	3·7	14·06
Totals	19·2	–	58·72

The average U-value for windows and doors is given by the ratio –

$$\frac{\text{Total rate of heat loss}}{\text{Total area of window and door openings}}$$

From Table F.1 above this is –

$$\frac{58{\cdot}72}{19{\cdot}2} = \mathbf{3{\cdot}1\ W/m^2K}$$

The percentage of openings is –

$$\frac{100 \times 19{\cdot}2}{80} = \textbf{24\% of the } \textbf{\textit{floor area}}$$

It can be seen from Table 1.3 that the permitted area of windows, doors and rooflights for a U-value of 3·1 W/m^2K is 21·5% of the *floor area* if the dwelling has a SAP energy rating of 60 or less, or 24% if the SAP energy rating is more than 60. The proposed design therefore satisfies the requirements of Part F only if the SAP energy rating is more than 60.

Example 2

A proposed single-storey assembly building has plan dimensions of 16 m by 8 m. Its height to the eaves is to be 4 m and the open-trussed roof is to be double pitched at 30° with insulation fixed between and over the rafters. Windows, personnel doors and rooflights are to be provided as indicated in Table F.2 below.

Table F.2 Proposed assembly building: windows, personnel doors and rooflights

Elements	Area (m^2)	U-value (W/m^2K)	Rate of heat loss (area × U-value) (W/K)
Windows	60	3·6	216·0
Personnel doors	9·5	3·0	28·5
Total for windows and personnel doors	69·5	—	244·5
Rooflights	25	3·8	—

The average U-value for windows and doors is given by the ratio –

$$\frac{\text{Total rate of heat loss}}{\text{Total area of windows and personnel doors}}$$

$$\frac{244{\cdot}5}{69{\cdot}5} = 3{\cdot}5\ W/m^2K$$

The gross wall area of the proposed building is 192 m^2 and thus the percentage of windows and personnel doors is –

$$\frac{100 \times 69{\cdot}5}{192} = \textbf{36·2\% of the } \textbf{\textit{wall area}}$$

The area of the roof in the plane of insulation is –

$$\frac{2 \times 4}{\text{Cos } 30°} \times 16 = \mathbf{147{\cdot}8m^2}$$

The rooflights are hence –

$$\frac{100 \times 25}{147{\cdot}8} = \textbf{16·9\% of the } \textbf{\textit{roof area}}$$

The proposed design meets the requirements because Table 1.5 indicates that –

(a) the permitted area of windows and personnel doors having an average U-value of 3·5 W/m^2K is 37% of the *wall area*; and

(b) the permitted area of rooflights having a U-value of 3·8 W/m^2K is 17% of the *roof area*.

Appendix G – Demonstrating compliance using the Target U-value Method for dwellings

Table G.1 Checklist for the Target U-value Method

Steps to be followed	How to check if your design is satisfactory
1. Estimate the SAP energy rating of the proposed dwelling. The example dwellings in Appendix B will help you.	
2. Check the exposed surface area and the U-value for each of the following parts of the dwelling – (a) roof. (b) exposed walls. (c) ground and other exposed floors. (d) windows, doors and rooflights.	Exclude semi-exposed elements from the calculations. (See paragraph 1.3 for the definition of semi-exposed.) Tabulate the figures to determine – (a) the total exposed surface area (m^2) of the dwelling. (b) the total rate of heat loss (W/K) for the dwelling. Table G.2 on the following page illustrates the procedure.
3. Check that any semi-exposed elements achieve a U-value of 0·6 or less.	Semi-exposed elements shall be insulated to at least the standard given in Table 1.2.
4. Calculate the Average U-value	Use the figures obtained in Step 2 to calculate the ratio – $\frac{\text{Total rate of heat loss}}{\text{Total area of exposed elements}}$ This is the Average U-value for the dwelling.
5. Calculate the Target U-value	Use the total floor area of the dwelling and the total exposed surface area, from Step 2, to calculate the Target U-value as set out in paragraph 1.16.
6. Compare the Average U-value for your design with the Target U-value.	If the Average U-value (from Step 4) does not exceed the Target U-value, (from Step 5), your design meets the requirements. If the Average U-value is more, the design may be modified by any combination of the following – (a) altering the design of the fabric elements (Step 2). (b) taking account of solar gains (Step 7). (c) providing a more efficient heating system (Step 8). Worked examples are given in this appendix.
7. If you wish to adjust the Target U-value to take account of solar gains.	The window area from Step 2 can be reduced if the area of glazing facing south (±30°) exceeds that facing north (±30°). See paragraph 1.20.
8. If you wish to adjust the Average U-value to take account of a more efficient heating system.	The Target U-value can be increased by up to 10% if, for example, a condensing boiler is used. See paragraph 1.21.
9. Complete the SAP worksheet (or get a competent person to do this for you) and verify that the correct U-values were used in Steps 2, 4 and 5.	If the verified SAP energy rating is 60 or less and a rating of more than 60 was assumed in Step 1, Steps 2 to 8 must be repeated

Examples illustrating the use of the Target U-value Method for dwellings

Example 1 – A detached dwelling

Consider the example in Diagram G.1 with the exposed elements detailed in Table G.2. It is proposed to adopt the Target U-value Method with U-values for the walls and roof a little higher (worse) than would otherwise be required in the **Elemental Method**. The SAP energy rating is to be more than 60. The cavity walls are to be dry-lined and the windows and doors are to have metal frames with thermal breaks and sealed double-glazing with 12 mm air gaps. The heating system has a seasonal efficiency of 72%.

Table **G.2 Data for the detached dwelling**

Exposed elements	**Exposed surface area** (m^2)	**U-value** (W/m^2K)	**Rate of heat loss (area × U-value)** (W/K)
Floor	56·2	0·45	25·29
Windows	24·8	3·3	81·84
Doors	3·8	3·3	12·54
Walls	121·4	0·5	60·7
Roof	56·2	0·3	16·86
Totals	**262·4**	–	**197·23**

The Target

The Target U-value for dwellings with SAP energy ratings of more than 60 is given by –

$$\frac{\text{Total floor area} \times 0{\cdot}64}{\text{Total area of exposed elements}} + 0{\cdot}4$$

In this example the Target U-value is –

$$\frac{112{\cdot}4 \times 0{\cdot}64}{262{\cdot}4} + 0{\cdot}4 = \mathbf{0{\cdot}67\ W/m^2K}$$

The Average U-value

The Average U-value for the dwelling is given by the ratio of the two values –

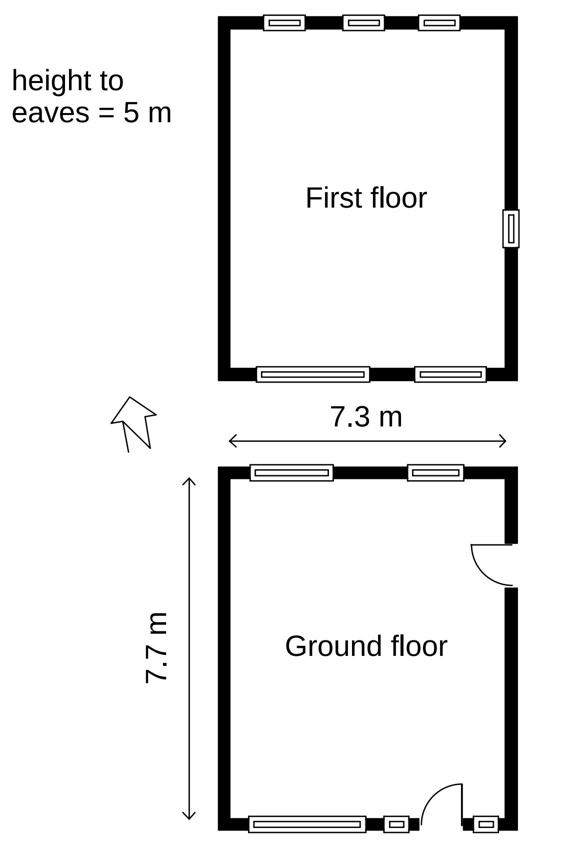
$$\frac{\text{Total rate of heat loss}}{\text{Total area of exposed elements}}$$

These values are calculated as shown in Table G.2. The Average U-value is –

$$\frac{197{\cdot}23}{262{\cdot}4} = \mathbf{0{\cdot}75\ W/m^2K}$$

The Average U-value is higher than the Target U-value and modifications must be explored. Possibilities include taking account of the benefits of solar gains and improving the thermal resistance of the windows, doors and exposed walls. For illustration purposes each is considered separately and then in combination.

Diagram **G.1 Plans of the detached dwelling**



Taking account of solar gains

The total window area in the example is 24·8 m^2 of which 15·0 m^2 faces south ±30° and 9·3m^2 faces north ±30° (the remaining 0·5 m^2 faces east). In accordance with paragraph 1·20 the area of windows and hence the total area of windows used in the calculation of the Average U-value can be reduced by –

40% of (15·0 − 9·3) = **2·28 m^2**

Improving the thermal resistance of the windows

Table 1.1 gives indicative figures for the U-values of various types of windows and doors although manufacturers' independently certified data should be used in preference if available. For the purposes of this example it is proposed to alter the window and door specifications to obtain U-values of 2·9 W/m^{2}K and 3·0 W/m^{2}K respectively.

Improving the thermal resistance of the walls

Appendix A can be used to develop wall designs to achieve a range of U-values. For the purposes of this example it is proposed to alter the wall specification to obtain a U-value of 0·45 W/m^{2}K.

Determination of the revised Average U-value

The revised data is shown in Table G.3 with the alterations highlighted.

Table **G.3 Revised data for the detached dwelling**

Exposed element	**Exposed surface area** (m^2)	**U-value** (W/m^{2}K)	**Rate of heat loss (area × U-value)** (W/K)
Floor	56·2	0·45	25·29
Windows	**22·52**	**2·9**	**65·31**
Doors	3·8	**3·0**	**11·4**
Walls	121·4	**0·45**	**54·63**
Roof	56·2	0·3	16·86
Totals	**260·12**	–	**173·49**

For the revised proposals the Average U-value is –

$$\frac{173{\cdot}49}{260{\cdot}12} = \mathbf{0{\cdot}67\ W/m^2K}$$

The Average U-value is now no greater than the Target U-value and compliance has been demonstrated.

Selecting a higher performance heating system

Another option would be to consider using a higher performance heating system.

In accordance with paragraph 1.21 a hot water central heating system incorporating a condensing boiler could be specified and the Target U-value increased by 10%. The target would therefore be increased from 0·67 W/m^{2}K to 0·74 W/m^{2}K.

Options for achieving compliance

The detached dwelling described in Diagram G.1 and Table G.2 may achieve compliance by, for example –

(a) taking solar gains into account and increasing the performance of the windows, doors and walls; or

(b) increasing the performance of one of the elements, such as the windows, and installing a hot water central heating system incorporating a condensing boiler.

Example 2 – A semi-detached dwelling

Consider the example in Diagram G.2 with the exposed elements detailed in Table G.4. It is proposed to adopt the Target U-value Method with the walls having a U-value of 0·55 W/m²K. To compensate for this the windows and doors are to have an Average U-value of 3·0 W/m²K. The SAP energy rating is to be more than 60.

The party wall and the semi-exposed wall at the garage (which has a U-value of 0·6 W/m²K) are not included in the Average U-value or Target U-value calculations.

The Target

The Target U-value for dwellings with SAP energy ratings of more than 60 is given by –

$$\frac{\text{Total floor area} \times 0{\cdot}64}{\text{Total area of exposed elements}} + 0{\cdot}4$$

In this example the Target U-value is –

$$\frac{80 \times 0{\cdot}64}{157} + 0{\cdot}4 = \mathbf{0{\cdot}73\ W/m^2K}$$

Diagram G.2 Plans of the semi-detached dwelling

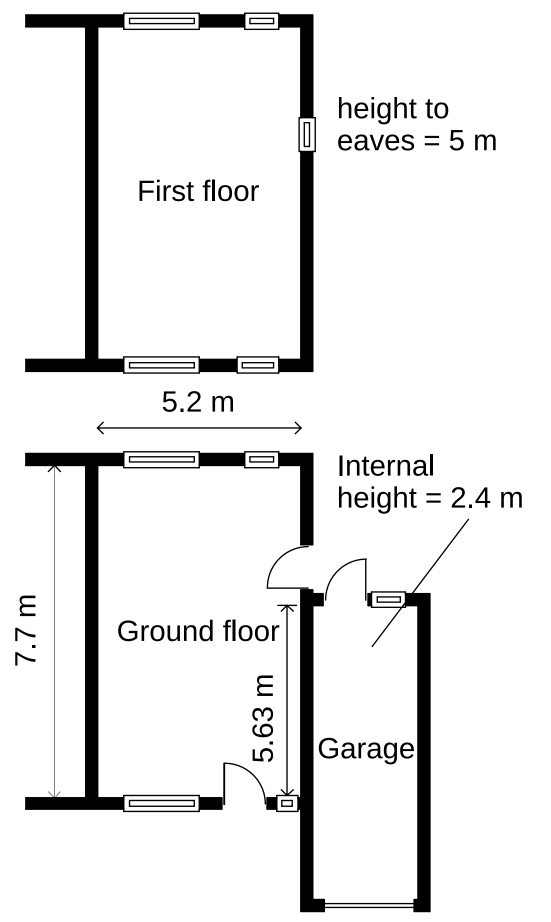


Table G.4 Data for the semi-detached dwelling

Exposed elements	Exposed surface area (m²)	U-value (W/m²K)	Rate of heat loss (area × U-value) (W/K)
Floor	40·0	0·45	18·0
Windows	14·2	3·0	42·6
Doors	3·8	3·0	11·4
Walls	59·0	0·55	32·45
Roof	40·0	0·25	10·0
Totals	**157·0**	–	**114·45**

The Average U-value

The Average U-value for the dwelling is given by the ratio of the two values –

$$\frac{\text{Total rate of heat loss}}{\text{Total area of exposed elements}}$$

These values are calculated as shown in Table G.4. For this example the Average U-value is –

$$\frac{114{\cdot}45}{157{\cdot}0} = \mathbf{0{\cdot}73\ W/m^2K}$$

The Average U-value is now no greater than the Target U-value and compliance has been demonstrated.

Appendix H – Demonstrating compliance using the Calculation Method for buildings other than dwellings

Example – Calculation procedure for showing the fabric insulation meets the requirements

Consider the example in Diagram H.1 which has details as given in Table H.1. It is a detached, 4 storey office building having internal dimensions of 45 m × 13 m in plan and a height of 15 m. It is to be constructed with 55% glazing, using windows which have metal frames with thermal breaks containing sealed double-glazed units with 12 mm air gaps and a low-emissivity coating. No rooflight glazing is proposed. The remaining exposed walls and the roof are to have U-values of 0·6 W/m^{2}K and 0·45 W/m^{2}K respectively, with the ground floor being uninsulated.

Diagram **H.1 Four storey office building**

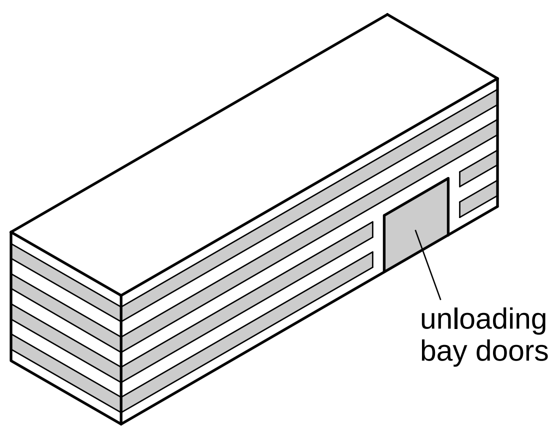


Table **H.1 Data for the proposed building**

Elements	**Exposed surface area** (m^2)	**U-value** (W/m^{2}K)	**Rate of heat loss (area × U-value)** (W/K)
Roof	585	0·45	263·3
Exposed walls	742	0·6	445·2
Windows	957	2·6	2488·2
Personnel doors	14	3·3	46·2
Vehicle loading bay doors	27	0·7	18·9
Ground floor	585	0·36	210·6
Total rate of heat loss		–	3472·4

Notional building

The area of openings in the proposed building is more than the basic allowance in Table 1.4. So the basic area allowance of 40% of exposed wall area and 20% of roof area should be assumed for the notional building.

The exposed perimeter of the ground floor of the proposed building is 116 m and its area is 585 m^2. So the ratio P/A is 0·2 and Table C.1 gives the U-value of the ground floor as 0·36 W/m^{2}K. This is less than the standard U-value in Table 1.4 so 0·36 W/m^{2}K must be the value used in the notional building calculation. The data for the notional building is given in Table H.2.

Table **H.2 Data for the notional building**

Elements	**Exposed surface area** (m^2)	**U-value** (W/m^{2}K)	**Rate of heat loss (area × U-value)** (W/K)
Rooflights	117	3·4	397.8
Roof	468	0·45	210·6
Exposed walls	1017	0·45	457·7
Windows and personnel doors	696	3·3	2296·8
Vehicle loading bay doors	27	0·7	18·9
Ground floor	585	0·36	210·6
Total rate of heat loss –		–	3592.4

The total rate of heat loss from the proposed building is less than that from the notional building and compliance has been demonstrated.

Appendix I – Thermal bridges at the edges of openings

I.1 As an alternative to the examples given in Diagram 1.4, this Appendix gives a procedure for establishing whether the degree of thermal bridging at the edges of openings is acceptable.

The procedure involves the assessment of the minimum thermal resistance between inside and outside surfaces at the edges of openings. This requires identification of minimum thermal resistance paths, and calculation of their thermal resistance, taking into account the effect of thin layers such as metal lintels.

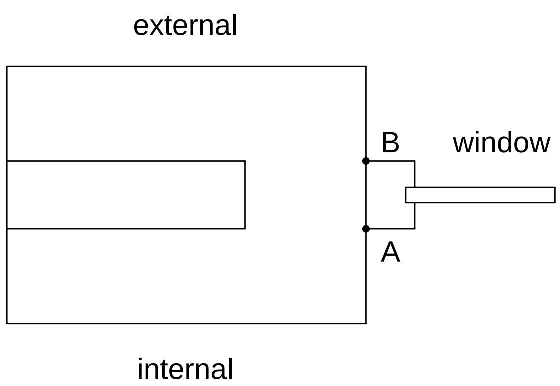
These minimum thermal resistances are then compared with satisfactory performance criteria to see whether corrective action is necessary.

Minimum thermal resistance path

I.2 The minimum thermal resistance path through a thermal bridge is that path from the internal surface to external surface which has the smallest thermal resistance, $\mathbf{R_{min}}$. Diagram I.1 illustrates this for a section through a window jamb.

Diagram I.1 Minimum thermal resistance path

see para I.1



The minimum thermal resistance path in this case is from the internal surface at A to the external surface at B.

$\mathbf{R_{min}}$ is equal to the total length from inside to outside (AB) divided by the thermal conductivity of the material of the jamb. An example calculation is given on the following page.

Additional calculation for thin layers such as metal lintels

I.3 For edge designs containing layers of thickness not exceeding 4 mm (such as metal lintels), a second modified calculation of minimum thermal resistance $\mathbf{R_{mod}}$ is made. In this, the thermal conductivity of the thin layer shall be taken to be the higher or highest of the thermal conductivities of the materials immediately on either side of it but in no case shall it be taken as less than 0·1 W/m^{2}K. An example of this more complex calculation is given in BRE IP 12/94 *Assessing condensation risk and heat loss at thermal bridges around openings.*

Avoiding excessive thermal bridging effects

I.4 Excessive thermal bridging effects at the edges of openings can be avoided if —

(a) for edges containing thin layers of thickness not exceeding 4 mm —

$\mathbf{R_{min}}$ (rounded to 2 decimal places) is at least 0·10 m^{2}K/W; and

$\mathbf{R_{mod}}$ (rounded to 2 decimal places) is at least 0·45 m^{2}K/W; or

(b) for other edge designs —

$\mathbf{R_{min}}$ (rounded to 2 decimal places) is at least 0·20 m^{2}K/W;

Additional heat loss

I.5 For the purposes of Part F the heat losses at the edges of openings are acceptable if —

(a) for edges containing thin layers of thickness not exceeding 4mm —

$\mathbf{R_{mod}}$ (rounded to 2 decimal places) is at least 0·45 m^2K/W; or

(b) for other edge designs —

$\mathbf{R_{min}}$ (rounded to 2 decimal places) is at least 0·45 m^2K/W.

Compensation for additional heat loss

I.6 Where the heat losses around the edges of openings are not acceptable they can be taken into account in calculations as follows —

(a) for dwellings the Target U-value Method may be used with the average U-value increased by the following amount —

$$\frac{0.3 \times \text{total length of relevant opening surrounds}}{\text{total area of exposed elements}} = (W/m^2K)$$

(b) for buildings other than dwellings the Calculation Method may be used with the rate of heat loss from the proposed building increased by the following amount —

$$0.3 \times \text{total length of relevant opening surrounds} = (W)$$

I.7 Compensating measures, such as reducing the U-value of one of the elements of the construction, should then be made so that —

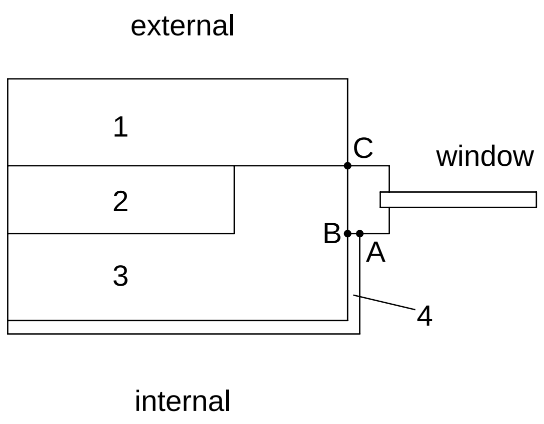
(a) for dwellings, the average U-value does not exceed the Target U-value; or

(b) for buildings other than dwellings the total rate of heat loss from the proposed building does not exceed that of the notional building.

Example

Diagram I.2 shows a window jamb in a masonry cavity wall with the blockwork returned towards the outer leaf at the reveal. By inspection it can be seen that ABC is the minimum resistance path.

Diagram I.2 Cavity wall showing window jamb with blockwork returned at the reveal



Note: numbers denote regions as in Table T1.

Table I.1 Thermal conductivity of materials in Diagram I.2

Region	Material	Thermal conductivity (W/mK)
1	Brick outer leaf	0·84
2	Insulation	0·04
3	Medium weight concrete block inner leaf	0·61
4	Lightweight plaster	0·16

Calculation of $\mathbf{R_{min}}$

Using the thermal conductivities from Table I.1, Table I.2 gives the resistance **R** for each segment of the path ABC, **R** for each segment is obtained by dividing the length of the path segment in metres by its thermal conductivity in W/mK. $\mathbf{R_{min}}$ is the sum of the resistances of each path segment.

Table I.2 Thermal resistance path in Diagram I.2

Path segments	Length (m)	Thermal conductivity (W/mK)	R (m^2K/W)
AB	0·015	0·16	0·094
BC	0·070	0·61	0·115
Minimum resistance $\mathbf{R_{min}}$			= 0·209

As $\mathbf{R_{min}}$ is greater than 0·20 m^2K/W there are no excessive thermal bridging effects. However, $\mathbf{R_{min}}$ is less than 0·45 m^2K/W and therefore the heat loss at this edge is not acceptable.

Improving the edge design

To reduce heat loss, instead of returning the blockwork at the reveal, the cavity could be closed using an insulated cavity closer, as in Diagram I.3. The revised calculation of the minimum resistance is shown in Table I.3.

Diagram I.3 Window jamb showing cavity closed with an insulated cavity closer

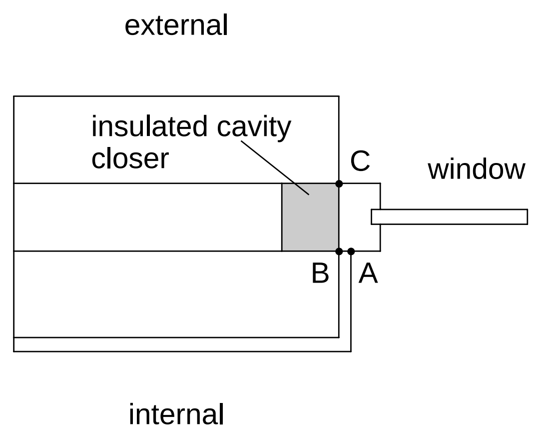


Table I.3 Minimum resistance path with insulated cavity closer

Path segments	Length (m)	Thermal conductivity (W/mK)	R (m^2K/W)
AB	0·015	0·16	0·094
BC	0·070	0·04	1·750
Minimum resistance $\mathbf{R_{min}}$			= 1·844

$\mathbf{R_{min}}$ is now greater than 0·45 m^2K/W and therefore the heat loss is acceptable.

Appendix J – Calculated examples for artificial lighting

Example 1 – Calculation to show that 95% of the artificial lighting capacity is given by high efficacy lamps

A hall and changing rooms are to be erected. The proposed lighting scheme incorporates lamps that are listed in Table 2.1 except for some low voltage tungsten halogen downlighters which are to be installed in the entrance area with local controls. A check therefore has to be made to show that the low voltage tungsten halogen lamps comprise less than 5% of the installed circuit capacity.

Main Hall

Twenty wall mounted uplighters with 250 W high pressure sodium lamps are to provide general lighting needs. The uplighters are to be mounted 7 m above the floor. On plan, the furthest light is 20·5 m from its switch which is less than 3 times the height of the light above the floor.

It is also proposed to provide twenty 18 W compact fluorescent lights as an additional system enabling instant background lighting whenever needed.

Changing rooms, corridors and entrance

Ten 58 W, high frequency fluorescent light fittings are to be provided in the changing rooms and controlled by occupancy detectors. Six more 58 W fluorescent light fittings are to be located in the corridors and the entrance areas and switched locally. Additionally, in the entrance area there are to be six 50 W tungsten halogen downlighters.

Table J.1 Data for the proposed lighting installation

Location	Number	Description of light source	Circuit Watts per lamp (W)	Total Circuit Watts (W)
Main Hall	20	250 W SON	286	5720
Main Hall	20	18 W compact fluorescent	23	460
Entrance, changing rooms and corridors	16	58 W HF fluorescent	64	1024
Entrance	6	50 W low voltage tungsten halogen	55	330
			Total =	**7534W**

The total circuit wattage of high efficacy lamps is —

$$5720 + 460 + 1024 = 7204\text{W}$$

The percentage of circuit watts is —

$$\frac{7204 \times 100}{7534} = 95{\cdot}6\%$$

More than 95% of the installed lighting capacity, in circuit Watts, is from high efficacy lamps and compliance has been demonstrated.

Example 2 – Calculation to show that the average circuit efficacy is not less than 50 lumens/Watt

A restaurant is to have a lighting installation comprising a mixture of concealed perimeter lighting using high frequency fluorescent fittings and individual tungsten lamps over tables. Lights in the dining area are to be switched locally from behind the bar. The over-table lamps also have integral switches for diners' use. Lighting to kitchens and toilets is to be switched locally.

Table J.2 shows data for the proposed lighting installation together with a calculation of the overall average circuit efficacy.

From Table J.2 the total lumen output of the installation is 131800 lumens and the total circuit Watts of the installation is 2538 Watts.

The average circuit efficacy is –

$$\frac{131800}{2538} = \mathbf{51{\cdot}9\ lumens/Watt}$$

As the average circuit effiicacy is not less than 50 lumens/Watt compliance has been demonstrated.

Table J.2 Data for the proposed lighting installation

	Number	Description	Circuit Watts (W) per lamp	Lumen output (lm) per lamp	Total circuit Watts (W)	Total lumen output (lm)
Over tables	20	60 W tungsten	60	710	1200	14200
Concealed perimeter and bar lighting	24	32 W T8 fluorescent with high frequency control	36	3300	864	79200
Toilets and circulation	6	18 W compact fluorescent with mains frequency control	23	1200	138	7200
Kitchens	6	50 W, 1500 T8 fluorescent with high frequency control	56	5200	336	31200
				Totals	**2538**	**131800**