J

CONSERVATION OF FUEL AND POWER

Contents

PROVISIONS DEEMED TO SATISFY THE STANDARDS

Rules for the use of Part J

(J2.1) Thermal conductivity and transmittance

Buildings in Purpose Group 1

(J4.1) Limiting thermal bridging at junctions and around openings
(J5.1) Limiting infiltration
(J6.1) Space heating controls
(J6.2) Hot water service system controls
(J6.3-J6.4) Insulation of pipes, ducts and vessels

Buildings in purpose groups 2 to 7

(J8.5) Heat loss method
(J8.7) Carbon emissions calculation method
(J9.1) Limiting thermal bridging at junctions and around openings
(J10.1) Limiting infiltration
(J11.1) Heating system efficiency
(J11.3) Space heating controls
(J11.5) Hot water service system controls
(J11.6-J11.7) Insulation of pipes, ducts and vessels
(J12.1) Artificial lighting
(J12.2) Display lighting
(J12.3) Controls for artificial lighting
(J13.1) Air conditioning and mechanical ventilation
(J14.1-J14.2) Commissioning of the building services

PART J APPENDICES

The appendices relevant to buildings in purpose group 1 and those to buildings in purpose groups 2 to 7 are listed separately below. Note that many of the appendices appear in both lists.

For buildings in purpose group 1:

A Tables of U-values
B Worked examples of U-value calculations using the Combined Method.
C U-values of ground floors and basements
D Thermal bridging at the edges of openings
E Determining U-values of windows, doors and rooflights in the Elemental Method
F Examples illustrating the use of the Target U-value Method
G Example SAP Energy Ratings and Carbon Indexes

For buildings in purpose groups 2 to 7:

A Tables of U-values
B Worked examples of U-value calculations using the Combined Method.
C U-values of ground floors and basements
D Thermal bridging at the edges of openings
E Determining U-values of windows, doors and rooflights in the Elemental Method
H Examples illustrating the use of the Heat Loss Method
J Example lighting calculations
K Performance assessment methods for building services

ASTERISKS

Throughout the Technical Standards an asterisk against a standard denotes either that a provision is deemed to satisfy the standard or that some aspect of the standard is specified at the end of the relevant Part.

ITALICS

Throughout the Technical Standards a term in Italics is a defined term. The definition is listed in Part A, General.

Introduction

1. The *construction* industry has a major role to play in the conservation of fuel and power. Energy use in *buildings* is a major source of carbon dioxide emissions which contribute to climate change. The intention of this Part is to ensure that effective measures for the conservation of fuel and power are incorporated in a *building*. It contains energy conservation provisions for the *building* fabric and the *building* services.

2. All *buildings* not exempted by Part A are required to conform to specific standards for the overall performance of the fabric. There are a variety of ways of demonstrating compliance, ranging from the simple calculation of the heat losses through each *building* element, to more sophisticated methods that provide greater flexibility for designers.

3. For *buildings* in purpose group 1, there are 3 alternative methods for showing compliance with this Part, the Elemental Method, the Target *U-value* Method and the Carbon Index Method. The different methods allow some design flexibility, for example, the benefits of solar heat gain or a more efficient heating system may be taken into account.

4. The Building (Procedure) (Scotland) Regulations 1981, as amended in 1997, continue to require all applications for *building* warrant for *buildings* in *purpose group* 1 to include an energy rating calculated in accordance with the Standard Assessment Procedure (SAP). Achievement of a particular level of SAP energy rating is no longer required to show compliance with this Part. However, the SAP worksheet and computer software is able to calculate CO2 emissions, expressed as the Carbon Index. Achievement of a given minimum Carbon Index figure is one of the ways for a *dwelling* to show compliance with this Part.

5. *Conservatories* with a floor area more than 8 square metres are no longer exempt from the requirements of the *Technical Standards*. However, where the floor area is not more than 30 square metres a less onerous standard applies to the *glazed* elements than for *glazing* elsewhere in the dwelling and the average *U-value* of the *dwelling* may be calculated independently of the *conservatory*.

6. *Buildings* other than *buildings* in *purpose group* 1 also require to conform to any one of 3 methods: the Elemental Method, the Heat Loss Method and the Carbon Emissions Calculation Method.

7. In addition to requirements for insulation of the fabric there are requirements for *building* services, including in the case of non-domestic *buildings*, requirements for artificial lighting, air conditioning and mechanical ventilation.

8. This Part must be read in conjunction with Part G (which deals with condensation), Part H (sound insulation) and Part K (ventilation). Reference should also be made to BS 5250: 1989, (note 2001 edition being prepared): "Code of practice for control of condensation in buildings", Building Research Establishment (BRE) Report, BR 262: "Thermal insulation, Avoiding risks", Second Edition, 1994, (note Third edition being prepared), and BRE report, BR 265: "Minimising air infiltration in office buildings".

Regulation 22

Conservation of fuel and power

22. (1) In a *building* to which this regulation applies, reasonable *provision* shall be made for the conservation of fuel and power.

(2) This regulation shall apply to all buildings, other than -

(a) a *building* which is unheated or which has a space heating system for protection against frost designed to give a maximum output not exceeding 25 watts per square metre of floor area; or

(b) unheated parts of a *building* of *purpose sub-group* 1A that do not form part of a *dwelling*.

The standards

J1 Application of Part J

J1.1 This Part sets out the required standards for Regulation 22.

J1.2 The standards apply as follows -

Buildings in *purpose group* 1: J2 to J7

Purpose in *purpose groups* 2 to 7: J2 and J7 to J14
except -

the standards do not apply to a *building* or part of a *building* specified in Regulation 22(2).

Note:
Regulation 22 applies in full where the intended level of provision of heating cannot be established because the use of the *building* is not known at the *construction* stage, e.g. speculative development.

J2 Rules for the use of Part J

THERMAL CONDUCTIVITY AND TRANSMITTANCE

J.2.1* Individual *U-values* of *building* elements must be established -

a. by providing insulation to a thickness derived from manufacturers' data relating to thermal conductivities (W/m·K) and thermal transmittances (*U-values*: W/m^{2}K) certified by a *notified body*; or

b. in the absence of certified manufacturers' data, by suitable alternative means.

Notes:
1. The thermal conductivity (the k-value) of a material is a measure of the rate at which that material will pass heat and is expressed in units of Watts per metre per degree of temperature difference (W/m·K).
2. Thermal transmittance (the *U-value*) is a measure of how much heat will pass through one square metre of a structure when the air temperatures on either side differ by one degree, and is expressed in units of Watts per square metre per degree of temperature difference (W/m^{2}K).

J2.2 For the purposes of Part J, any part of a floor that serves as a roof (e.g. an open deck) is to be treated as a roof.

J2.3 The *U-value* of a floor above, or a wall adjoining, a garage, unheated stairwell, atrium, underground car park or other unheated space must be calculated -

a. in the case of a *dwelling*, using the method given in SAP 2001, Clause 3.3, to take into account the thermal resistance of the unheated space; or

b. in any other case, by either of the following two methods:

• disregarding so that the element is considered as directly exposed to the outside, or

• by using the procedure in BS EN ISO 13789: 1999 to take account of the effect of the unheated space

J2.4 *Separating walls* or *separating floors* between 2 *buildings* in *purpose group* 1 or between other *buildings* or parts of a *building* intended to be heated to the same temperature may be ignored.

CALCULATION OF AREAS

J2.5 In calculating areas:

a. all areas are to be measured in m^2 unless otherwise stated; and

b. the area of a floor, wall or roof is to be measured between finished internal faces of the external *building* elements of the *building*, including any projecting bays and, in the case of a roof, in the plane of the insulation; and

c. floor areas are to include stair wells within the heated envelope and non-useable space such as service *ducts*; and

d. in calculating the maximum permitted area of *glazing* for an extension to a *dwelling*, the floor area of the whole *dwelling* may be used; and

e. the area of an opening is to be measured internally from reveal to reveal and from head to sill.

J3 *BUILDINGS* IN *PURPOSE GROUP* 1

BUILDING FABRIC

STANDARDS FOR *BUILDINGS* IN *PURPOSE GROUP* 1

J3.1 A *building* in *purpose group* 1 must have provision for conservation of fuel and power in accordance with either:

a. the Elemental Method; or
b. the Target *U-value* Method; or
c. the Carbon Index Method.

The following table illustrates the routes through the alternative methods of showing that *buildings* in *purpose group* 1 comply with Part J -

Table to 3.1: Routes to compliance with Part J for *buildings* in *purpose group* 1.

START:	**Choose method of compliance-**		
	Elemental Method		go to **1.**
	Target *U-value* Method		go to **6.**
	Carbon Index Method		go to **13.**
COMPLIANCE BY ELEMENTAL METHOD			
1	Is the heating by mains gas, LPG or oil?	YES	go to **3.**
		NO	go to **2.**
2	Are all *U-values* of the proposed *dwelling* not more than the corresponding values from Column B of Table 1 to J3.2?	YES	go to **5.**
		NO	FAIL by Elemental Method - revise *U-values* and repeat **2** or go to **START.**
3	Is the SEDBUK [Note 1] of the proposed heating system not less than the SEDBUK from Table 2 to J3.2?	YES	go to **4.**
		NO	go to **2.**
4	Are all *U-values* of the proposed *dwelling* not more than the corresponding values from Column A of Table 1 to J3.2?	YES	go to **5.**
		NO	FAIL by Elemental Method - revise *U-values* and repeat **4** or go to **START.**
5	Is the area of windows, doors and rooflights not more than 25% of total floor area?	YES	PASS by Elemental Method.
		NO	FAIL by Elemental Method - reduce area of openings and repeat **5** or go to **START.**

COMPLIANCE BY TARGET *U-value* METHOD			
6	Calculate the Target *U-value* from the equation in J3.5.		
7	Are the windows metal framed ?	YES	Multiply the Target *U-value* by 1.03 and go to **8.**
		NO	Go to **8.**
8	Is the heating by electricity, solid fuel or is it undecided?	YES	Divide the Target *U-value* by 1.15 and go to **10.**
		NO	go to **9.**
9	Is the SEDBUK for the proposed heating system less than the corresponding SEDBUK from the table to J3.6?	YES	Multiply the Target *U-value* by; The proposed boiler SEDBUK (%) divided by Referenced boiler SEDBUK (%) from Table to J3.6 and go to **10.**
		NO	go to **10.**
10	Is there a greater area of *glazing* facing south than is facing north?	YES	Subtract the north facing *glazing* area from the south facing, divide the result by the total area of *glazing*, multiply by 0.04 and add the result to the Target *U-value*; then go to **11.**
		NO	go to **11.**
11	Calculate the average *U-value* (U) by multiplying the area of each *building* element by its *U-value*, adding the results and dividing the total by the total area of all *exposed* elements.		
12	Is U not more than the Target *U-value*, and is the *U-value* of each *building* element not more than the corresponding value from the Table to J3.12?	YES	PASS by Target *U-value* Method.
		NO	FAIL by Target *U-value* Method - revise and go to **6** or go to **START.**

COMPLIANCE BY CARBON INDEX METHOD			
13	Calculate the Carbon Index (CI) as defined in SAP 2001.		
14	Is the Carbon Index (CI) at least 8.0, and is the *U-value* of each *building* element not more than the corresponding value from the Table to J3.12?	YES	PASS by Carbon Index Method.
		NO	FAIL by Carbon Index Method - revise and go to **13** or go to **START.**

Note:

1. SEDBUK is the Seasonal Efficiency of a Domestic Boiler in the UK, defined in "The Government's Standard Assessment Procedure for the Energy Rating of Dwellings 2001 Edition" (SAP 2001). For boilers for which the SEDBUK is not available the appropriate value from Table 4b of SAP 2001 may be used.

ELEMENTAL METHOD

J3.2 Individual *building* elements of a *building* in *purpose group* 1 must have *U-values* in accordance with those given in Table 1(as read with Table 2) and diagram A. to this standard

Table 1 to J3.2: Maximum *U-values* for *exposed building* elements when using the Elemental Method

Exposed building element	Type of heating system Column A Gas or oil central heating with boiler SEDBUK not less than the relevant entry in Table 2 to J3.2	Column B Other gas or oil central heating, or any electric heating system or solid fuel central heating or undecided
	Maximum *U-values* (W/m²K)	
Pitched roof - With insulation between rafters	0.20	0.18
Pitched roof - With insulation between joists	0.16	0.16
Flat roof	0.25	0.22
External wall [Note 1]	0.30	0.27
Floor	0.25	0.22
Windows, doors and rooflights (area-weighted average), *glazing* in metal frames [Notes 2, 3, 4]	2.2	2.0
Windows, doors and rooflights (area-weighted average), *glazing* in wood or PVC frames [Notes 2, 3, 4]	2.0	1.8

Notes:

1. Solid area of element only (i.e. excluding windows, doors and rooflights).
2. *U-values* for windows, doors and rooflights may vary provided that the average *U-value* for all windows, doors and rooflights is not more than the figure shown. For method of calculation see Appendix E.
3. Metal framed windows have slimmer frames and therefore provide a passive solar benefit, justifying a less onerous *U-value* standard.
4. The area of windows, doors and rooflights must comply with J3.3.

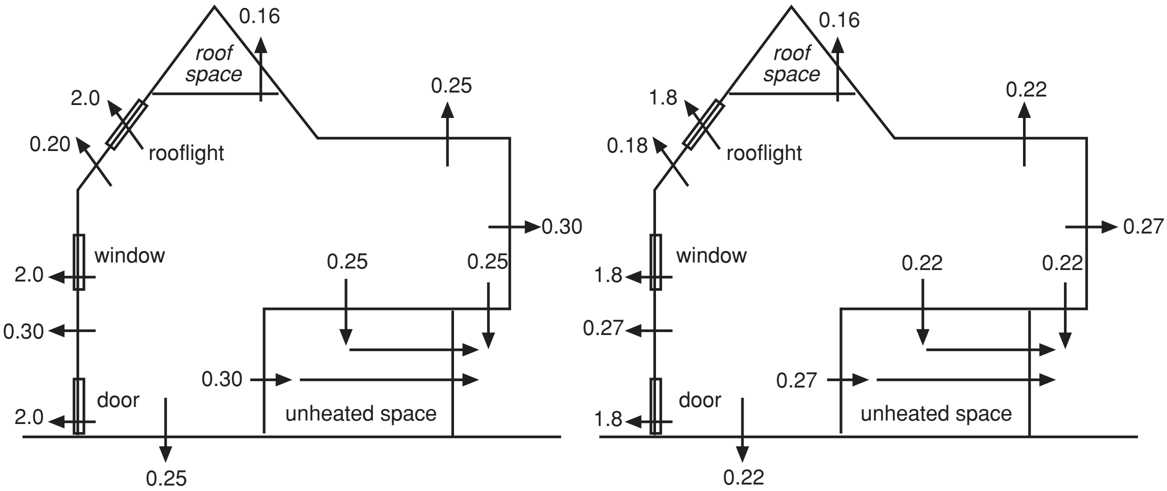
Table 2 to J3.2: Minimum boiler SEDBUK to enable adoption of *U-values* in Column A of Table 1 to J3.2

Central heating system fuel	Minimum SEDBUK (%)
Mains natural gas	78
LPG	80
Oil (Note)	85

Note:

For oil combination boilers the minimum SEDBUK (%) is 82%

Diagram to J3.2 Maximum *U-values* using the Elemental Method



(a) Gas or oil central heating with boiler SEDBUK not less than the relevant entry in Table 2 to J3.2

(b) Other gas or oil central heating, or any electric heating system or solid fuel central heating or undecided

Note:
The *U-value* of a floor above, or a wall adjoining, an unheated space must be calculated in accordance with the procedure in SAP 2001 (see J2.3).

J3.3 The area of windows, doors and rooflights (including frames) as a percentage of the total floor area of all *storeys* of the *dwelling* must not be more than 25%.

TARGET *U-VALUE* METHOD

J3.4 The average *U-value* of the exposed elements of a *building* in *purpose group* 1 must not exceed the Target *U-value*, corrected as necessary for the proposed method of heating and any solar gains.

Note:
This method allows greater flexibility than the Elemental Method. The aim is to achieve a level of performance broadly equivalent to that obtained through the Elemental Method by comparing the average fabric *U-value* of the proposed *building* in *purpose group* 1 with a Target *U-value* obtained from the formula in J3.5. For examples of the use of this method, see Appendix F.

J3.5 The base Target *U-value* for the *building* in *purpose group* 1 must be determined as follows:

$$U_T = [0.30 - 0.14(A_R/A_T) - 0.05(A_{GF}/A_T) + 0.425(A_F/A_T)]$$

where -

U_T is the base Target *U-value* prior to adjustment for heating system performance or solar gain;
A_R is the exposed roof area;
A_{GF} is the ground floor area;
A_F is the total floor area (all *storeys*);
A_T is the total area of exposed *building* elements of the *building* in *purpose group* 1 (including the ground floor).

Note:
The base Target *U-value* equation assumes a boiler SEDBUK that is equal to the tabulated value and equal distribution of *glazed* openings on north and south elevations.

J3.6 Where the proposed boiler has a SEDBUK that is less than the value in the table to this standard, the Target *U-value* must be improved by multiplying it by the factor f_e
where -

$$f_e = \frac{\text{Proposed boiler SEDBUK (\%)}}{\text{Reference Boiler SEDBUK (\%)}}$$

Table to J3.6: Minimum boiler SEDBUK using the Target *U-value* Method

Central heating system fuel	Minimum SEDBUK (%)
Mains natural gas	78
LPG	80
Oil (Note)	85

Note :
For oil combination boilers the minimum SEDBUK (%) is 82%

J3.7 Where the *dwelling* is heated by electricity or solid fuel, or where the proposed method of heating is not known, the base Target *U-value* must be divided by 1.15 to compensate partially for the higher CO_2 emission rate associated with these fuels.

J3.8 Where the *dwelling* has metal framed windows (including any rooflights and including thermally-broken frames), the base Target *U-value* may be increased by multiplying by 1.03, to take account of the additional solar gain due to the greater glazed proportion.

J3.9 The Target *U-value* equation assumes equal distribution of *glazed* openings on north and south elevations. Where the area of *glazed* openings, including frames, on the south elevations is greater than that on the north, the benefit of solar heat gains can be taken into account by adding:

$0.04 \times [(A_S - A_N) \div A_{TG}]$ to the Target *U-value*.

where A_S is the total area of *glazed* openings facing south;
A_N is the total area of *glazed* openings facing north;
A_{TG} is the total area of *glazed* openings;
North facing is defined as North plus or minus 30 degrees; and
South facing is defined as South plus or minus 30 degrees.

J3.10 Where adjustments to the Target *U-value* are being made for heating system or window frame type as well as for solar gain, the adjustment for solar gain must be applied last.

CARBON INDEX METHOD

J3.11 The Carbon Index for the *dwelling* must not be less than **8.0.**

Note:
This method allows much greater flexibility than either the Elemental Method or the Target *U-value* Method while still achieving an overall performance not less than that obtained through the Elemental Method. The Carbon Index adopted in this Method is that defined in SAP 2001 and is calculated using the SAP worksheet or by using BRE-approved computer software. Examples of *dwellings* with Carbon Index of 8.0 or more are given in Appendix G.

MAXIMUM PERMISSIBLE *U-VALUES*

J3.12 When using the Target *U-value* and Carbon Index Methods, the *U-value* of any *building* element must comply with the table to this standard -

Table to J3.12: Maximum permissible *U-values* for parts of *building* elements when using the Target *U-value* and Carbon Index Methods

***Exposed building* element**	**Maximum permissible *U-value***
Parts of roof	0.35
Parts of *external wall* or floor	0.70

J4 Limiting thermal bridging at junctions and around openings

J4.1* The *dwelling's* fabric must be *constructed* to limit thermal bridges and gaps in the insulation layer(s) -

a. within the various *building* elements; and

b. at the junctions between *building* elements; and

c. at the edges of *building* elements (e.g. around window and door openings).

J5 Limiting infiltration

J5.1* The infiltration of air through extraneous air paths must be limited as far as is *reasonably practical*.

J6 *Building* services

SPACE HEATING CONTROLS

J6.1* In a *building* in *purpose group* 1 the output of a space heating system must be controlled by -

a. *room* thermostats or thermostatic radiator valves for each part of the heating system designed to be separately controlled (e.g. separate living and sleeping areas); and

b. a manually adjustable 7-day automatic timing device or devices to control the periods of operation; and

c. in a system using a boiler,

i. an automatic control which shuts the boiler off when heat is not required (after an over-run time if this is specified by the manufacturer) or, if it is a solid fuel boiler, reduces the firing to the minimum burning rate, and

ii. where the system is fitted solely with thermostatic radiator valves, a thermostat, flow control or similar device to prevent boiler cycling,

except -

this standard shall not apply to individual solid fuel open fires, gas or electric fires, or controlled *room* heaters including electric storage heaters.

HOT WATER SERVICE SYSTEM CONTROLS

J6.2* A hot water service system must have controls that will switch off the heat when the required water temperature has been achieved and during periods when hot water is not required,
except -

this standard shall not apply to instantaneous combination boilers or storage combination boilers where the storage capacity in each case is not more than 15 litres.

INSULATION OF PIPES, *DUCTS* AND VESSELS

J6.3* Heating pipes, pipes used for the supply of hot water, and warm air *ducts* must be suitably insulated against heat loss,
except -

heating pipes and warm air *ducts* need not be insulated where the heat loss will always contribute to the heating requirements of a *room* or space.

J6.4* A hot water storage vessel must be adequately insulated against heat loss.

COMMISSIONING OF HEATING AND HOT WATER SERVICE SYSTEMS

J6.5 A heating and hot water service system must be inspected, commissioned and tested in accordance with manufacturer's instructions to ensure optimum efficiency in the conservation of fuel and power.

J6.6 Written information must be provided for the use of the occupier on the operation and maintenance of any heating and hot water service system to encourage optimum efficiency in the conservation of fuel and power.

J7 *Conservatories*

J7.1 a *conservatory* must comply with the requirements of J2-J6,
except -

where the floor area is not more than 30 square metres -

a. *glazing*, including frames, may have a *U-value* not more than 3.3 W/m^{2}K; and

b. in calculating the average *U-value* of the *dwelling*, the *conservatory* may be ignored.

Amdt: September 2001

BUILDINGS OTHER THAN *DWELLINGS*

J8 *Buildings* in *Purpose Groups* 2 to 7

J8.1 A *building* other than a *building* in *purpose groups* 2 to 7 must have provision for conservation of fuel and power in accordance with one of the three following methods:

a. the Elemental Method; or

b. the Heat Loss Method; or

c. the Carbon Emissions Calculation Method.

ELEMENTAL METHOD

J8.2 To comply with this method the *building* envelope must provide minimum levels of thermal insulation as set out in J8.3 and areas of windows, doors and rooflights as set out in J8.4.

J8.3 The individual specified *building* elements must have *U-values* in accordance with the table to this standard -

Table to J8.3: Maximum *U-values* of *exposed building* elements when using the Elemental Method [Note 1]

***Exposed building* element**	**Maximum *U-value* (W/m²K)**
Pitched roof - with insulation between rafters	0.20
Pitched roof - with insulation between joists	0.16
Flat roof	0.25
External wall [Note 2]	0.30
Floor	0.25
Windows, personnel doors and rooflights (area weighted average for the whole *building*) [Note 3], *glazing* in metal frames [Note 4]	2.2
Windows, personnel doors and rooflights (area weighted average for the whole *building*) [Note 3], *glazing* in wood or PVC frames	2.0
Vehicle access and similar large doors [Note 5]	0.7

Notes:
1. When an element is exposed to the outside via an unheated space, the unheated space may be disregarded or the *U-value* of the element calculated using BS EN ISO 13789: 1999 - see J2.3.
2. Solid area of element only (i.e. excluding windows, doors and rooflights).
3. For method of calculation, see Appendix E.
4. Metal framed windows have slimmer frames and therefore provide a passive solar benefit, justifying a less onerous *U-value* standard.
5. No requirement where for operational reasons doors have to be left open when *building* is in use.

J8.4 The specified *building* elements must have areas of windows, doors and rooflights not more than those prescribed in the table to this standard -

Table to J8.4: Maximum percentage areas of windows, doors and rooflights

Purpose group	Windows and doors as % of *exposed* wall area [Note 1]	Rooflights as % of roof area
2	30	20
3, 4, 5	40	20
6, 7	15	20

Note:

1. Excluding vehicle access and other similar large doors, shop entrances and shop display windows at an access level, for which there is no limit.

HEAT LOSS METHOD

J8.5* When using this method -

a. the total rate of heat loss through the envelope of the proposed *building* must not be more than that from a notional *building* of the same size and shape designed to comply with the Elemental Method; and

b. the *U-value* of any *building* element must not be more than that shown in the table to this standard.

Note:
This method allows greater flexibility than the Elemental Method since the *U-values* of some *building* elements, and the areas of windows, doors and rooflights, may be more than those required by J8.3 and J8.4, provided that these are "traded-off" against other elements having lower *U-values* than required by J8.3 and J8.4.

Table to J8.5: Maximum permissible *U-values* when trading off between *building* elements

Exposed *building* element	Maximum permissible *U-value* (W/m²K)
Roof	0.45
Wall or floor	0.70
Windows, doors and rooflights	No limit

J8.6 When comparing the proposed *building* with the notional *building* -

a. if the *U-value* of a floor next to the ground in the proposed *building* is less than that required by J8. 3, with no added insulation, then that lower value must be used in the notional *building*; and

b. if the total area of windows, doors and rooflights in the proposed *building* is less than the total area required by J8.4, then the average *U-value* of the roof, wall or floor cannot exceed the appropriate value given in the Table to J8.3 by more than 0.02 W/m²K; and

c. a maximum of half of the permitted rooflight area can be converted into an increased area of window and doors.

THE CARBON EMISSIONS CALCULATION METHOD

J8.7* To comply with this method the thermal insulation of the fabric and the efficiency of the *building* services systems must be such that the annual carbon emissions from the *building* are not more than from an equivalent notional *building* designed to comply with the Elemental Method.
except –

When using this method the standards for *building* services systems in J11, J12 and J13 may be ignored.

Note:
This method allows much greater flexibility than either the Elemental Method or the Heat Loss Method. It is a calculation method that allows completely free design of the *building* using any energy conservation measure.

J8.8 When using this method the *U-value* of any *building* element must be in accordance with the table to this standard -

Table to J8.8: Maximum permissible *U-values* when using the Carbon Emissions Calculation Method

Element	Maximum permissible *U-value*
Roofs	0.45
Exposed walls and floors	0.70
Windows, doors and rooflights	No limit

J8.9 In using this method -

if the *U-value* of a floor next to the ground without added insulation in the proposed *building* is less than 0.25 then that lower value must be used in the notional *building*.

J9 Limiting thermal bridging at junctions and around openings

J9.1* The *building's* fabric must be *constructed* to minimise thermal bridges and gaps in the insulation layer(s) -

a. within the various *building* elements; and

b. at the junctions between *building* elements; and

c. at the edges of *building* elements (e.g. around window and door openings).

J10 Limiting infiltration

J10.1* The infiltration of air into a *building* through extraneous air paths must be limited as far as is *reasonably practical*.

J11 *Building* services (space heating and hot water)

HEATING SYSTEM EFFICIENCY

J11.1* The heating system of a *building* must be designed and installed to make efficient use of energy for the conservation of fuel and power.

SPACE HEATING CONTROLS

J11.2 Boiler cycling must be limited by -

a. an automatic control which shuts the boiler off when heat is not required (after an over-run time if this is specified by the manufacturer) or, if it is a solid fuel boiler, reduces the firing to the minimum burning rate; and

b. where the system is fitted solely with thermostatic radiator valves, a thermostat, flow control or similar device to prevent boiler cycling,

except -

this standard does not apply to a *ducted* warm air system or to fanned output electric storage heaters.

J11.3* A space heating system must incorporate -

a. *room* thermostats or thermostatic radiator valves for each part of the heating system designed to be separately controlled; and

b. 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, comprising -

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

ii. for a space heating system with an output of not more than 100 kW, a manually adjustable 7-day automatic timing device or devices to control the periods of operation; and

c. controls to allow sufficient heating to prevent damage to the *building* structure, services or contents by frost, excessive humidity or condensation; and

d. 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; and

e. where the system has two or more gas or oil fired boilers which can work together to supply the heat demand, boiler controls which can detect variations in the need for heat in the *building* and start, stop, or modulate the boilers as required (sequence control), and hydraulic design to ensure stable control.

except -

this standard does not apply to a *ducted* warm air system or to flap controlled electric storage heaters.

J11.4 Thermostats and time controls must be fitted to -

a. *ducted* warm air systems; and

b. flap controlled electric storage heaters.

HOT WATER SERVICE SYSTEM CONTROLS

J11.5* A hot water service system must be designed to make efficient use of energy by providing controls that will switch off the heat when the required water temperature has been achieved.

INSULATION OF PIPES, *DUCTS* AND VESSELS

J11.6* Pipes and *ducts* for the provision of space heating, space cooling (including chilled water and refrigerants), and hot water supply must be adequately insulated against heat loss,
except -

pipes or *ducts* for space heating or space cooling need not be insulated where -

a. the heat loss will always contribute to the heating or cooling requirements of the *room* or space and the pipes are situated not more than 3 m above the floor; or

b. where pipes and/or *ducts* are installed solely as part of an industrial or commercial process.

J11.7* A hot water storage vessel must be -

a. adequately insulated against heat loss; and

b. *constructed* so that insulation to safety fittings on an unvented system does not impede safe operation or visibility of warning discharges,
except -

a vessel used to store hot water solely for an industrial process.

J12 Building services (artificial lighting)

ARTIFICIAL LIGHTING

J12.1* A *building* provided with artificial lighting must have general purpose artificial lighting systems designed to make efficient use of power,
except -

a. *emergency lighting*; and

b. specialist process lighting; and

c. *buildings* with a floor area not more than 100 m^2.

Note:
Specialist process lighting means lighting intended to illuminate specialist tasks within a space, rather than the space itself.

DISPLAY LIGHTING

J12.2* Every display lighting system provided in a *building* must be designed to make efficient use of power.

Note:
Display lighting means artificial lighting intended to highlight displays of exhibits or merchandise, or lighting used in spaces for public entertainment in a *building* of *purpose sub-group* 5A.

CONTROLS FOR ARTIFICIAL LIGHTING

J12.3* Every artificial lighting system in a *building* must have controls which encourage the maximum use of daylight and minimise the use of artificial lighting during the times when *rooms* or spaces are unoccupied,
except -

controls for lighting systems described in the exceptions to J12.1.

J13 *Building* services (air conditioning, mechanical ventilation)

J13.1* A *building* incorporating air conditioning or mechanical ventilation must be designed and *constructed* so that -

a. the form and fabric of the *building* do not result in a requirement for excessive installed capacity of cooling equipment; and

b. fans, pumps, refrigeration equipment and other components are reasonably efficient and appropriately sized to have no more capacity for demand and standby than is necessary; and

c. there are appropriate means of managing, controlling and monitoring the operation of equipment and systems.

J14 Commissioning of the *building* services

J14.1* The *building* services installation required to comply with this Part must -

a. be capable of operating at the manufacturer's specified efficiency; and

b. incorporate adequate provisions for testing and commissioning to be carried out satisfactorily.

J14.2* Written information must be provided for the *building's* occupier on the installed *building* services plant and controls required to comply with this Part, their method of operation, maintenance requirements, and details forecasting annual energy consumption for the *building*.

Amdt: September 2001

Provisions deemed to satisfy the standards

Rules for the use of Part J

THERMAL CONDUCTIVITY AND TRANSMITTANCE

(J2.1) The requirements of J2.1b. will be met -

a. by providing insulation to a thickness derived from the tables in Appendix A; or

b. by calculation taking into account thermal bridging effects of, e.g. timber joists, structural and other framing, normal bedding mortar and window frames, by using the Combined Method set out in BS EN ISO 6946 or CIBSE Guide Section A3, 1999 Edition (for worked examples see Appendix B) [Note 1]; or

c. for *basement storeys*, by using the method outlined in Appendix C and set out fully in BS EN ISO 13370 or CIBSE Guide Section A3, 1999 Edition; or

d. for *glazing*, by using BS EN ISO 10077-1 or BS EN ISO 10077-2.

Notes:

1 Thermal bridging may be disregarded where the difference in thermal resistance between bridging and bridged material is less than 0.1 m^2K/W. For example, normal mortar joints need not be taken into account in calculations for brickwork but must be taken into account for lightweight insulating blockwork.

2 Measurements of thermal conductivity should be made in accordance with BS EN 12664 or BS EN 12667, and of thermal transmittance in accordance with BS EN 8990.

Buildings in *purpose group* 1

LIMITING THERMAL BRIDGING AT JUNCTIONS AND AROUND OPENINGS

(J4.1) The requirements of J4.1, as regards minimising thermal bridges and gaps in the insulation, will be met by -

a. *constructing* the *dwelling* in accordance with Building Research Establishment (BRE) Report, BR 262: “Thermal insulation, Avoiding risks”, Second Edition, 1994 ; or

b. demonstrating by calculation that equivalent performance to sub-clause a. has been achieved.

LIMITING INFILTRATION

(J5.1) The requirements of J5.1, as regards minimising extraneous air leakage paths in the *dwelling’s* fabric, will be met by *constructing* the *dwelling* in accordance with BRE Report BR Building Research Establishment (BRE) Report, BR 262: “Thermal insulation, Avoiding risks”, Second Edition, 1994 [Note 1], including -

a. sealing the gaps between dry linings and masonry walls at the edges of window, door and *roof space* openings, and at the junctions between walls, floors and ceilings; and

b. sealing vapour control membranes in timber framed and other framed panel *constructions*; and

c. sealing at service penetrations of the fabric or around boxing for services; and

d. fitting draught seals to the openable parts of windows, doors and rooflights; and

e. sealing around joist ends built into the inner leaf of external cavity walls.

Note:

1. This document provides examples of acceptable design details and *construction* practice, but alternative details may be used if equivalent performance can be demonstrated.

SPACE HEATING CONTROLS

(J6.1) The requirements of J6.1 will be met for a *building* in *purpose group* 1 with a heating system with an output not greater than 100 kW by having space heating controls in accordance with BRECSU Good Practice Guide GPG 143: "Wet Central Heating Systems".

HOT WATER SERVICE CONTROLS

(J6.2) The requirements of J6.2 will be met by complying with sub-clauses a. or b. below -

a. for a system other than one heated by a solid fuel boiler -

i. the heat exchanger in the storage vessel should have sufficient heating capacity, such as one complying with BS 1566: Part 2: 1984 (1990) or BS 3198: 1981, and in particular it should comply with the requirements in these standards for the surface area of heat exchangers (i.e. pipe diameter and number of coils), and

ii. a thermostat should be provided which switches off the heat when the required storage temperature has been achieved, and which in the case of hot water central heating systems is interconnected with the room thermostat(s) to switch off the boiler when no heat is required, and

iii. a manually adjustable 7-day automatic timing device should be provided either as part of the central heating system or as a local device to control the periods of operation; or

b. for a solid fuel fired system where the cylinder is not providing the slumber load, a thermostatically controlled valve should be provided.

INSULATION OF PIPES, *DUCTS* AND VESSELS

(J6.3)
(J6.4) The requirements of J6.3 and J6.4 will be met by providing insulation in accordance with BS 5422: 1990 to all pipes, *ducts* and storage vessels. The requirement for storage vessels will be met by applying insulation in accordance with the provisions of BS 5422 for flat surfaces.

BUILDINGS OTHER THAN *DWELLINGS*

HEAT LOSS METHOD

(J8.5) The requirements of J8.5, for showing by calculation compliance with the Heat Loss Method, will be met by following the procedure set out below -

a. calculate the total rate of heat loss for the proposed *building* in accordance with the table to this standard;

b. repeat the calculation for a notional *building* in accordance with the table to this standard but using the values given in the Tables to J8.3 and J8.4 and applying the rules in J8.7;

c. the proposed *building* will comply with Part J if the total rate of heat loss is no greater than that for the notional *building*.

Table to (J8.5): Calculated total rate of heat loss through the enclosing fabric

Element	Gross Area (m^2)		Openings (m^2)		Net Area (m^2)		*U-value* (W/m^2K)		Area x *U-value*
exposed walls	________	-	________	=	________	x	________	=	________
exposed floors	________	-	________	=	________	x	________	=	________
roofs	________	-	________	=	________	x	________	=	________
							TOTAL A	=	________
windows					________	x	________	=	________
personnel doors					________	x	________	=	________
vehicle and similar large access doors					________	x	________	=	________
							TOTAL B	=	________
TOTAL RATE OF HEAT LOSS (TOTAL A + TOTAL B)								**=**	

Note:
For example calculations see Appendix H.

CARBON EMISSIONS CALCULATION METHOD

(J8.7) The requirements of J8.7 will be met by using a calculation procedure that -

a. has been tested satisfactorily against available benchmark tests as described in CIBSE Application Manual “Building Energy and Environmental Modelling”, AM11, 1998; and

b. has been accepted by the submitting organisation as having satisfied their in-house quality assurance procedures, for example by submitting with the calculations a completed and signed copy of Appendix B to AM11: “Checklist for choosing BEEM software”, showing that the software used is appropriate for the purpose to which it has been applied.

LIMITING THERMAL BRIDGING AT JUNCTIONS AND AROUND OPENINGS

(J9.1) The requirements of J9.1, as regards minimising thermal bridges and gaps in the insulation, will be met by -

a. *constructing* the *building* in accordance with Building Research Establishment (BRE) Report, BR 262: “Thermal insulation, Avoiding risks”, Second Edition, 1994 or

b. demonstrating by calculation that equivalent performance to (J9.1)a. has been achieved,.

LIMITING INFILTRATION

(J10.1) The requirements of J10.1 will be met by *constructing* the *building* in accordance with BRE Report BR 265 [Note 1].

Note 1:
This document provides examples of acceptable design details and *construction* practice, but alternative details may be used if equivalent performance can be demonstrated.

HEATING SYSTEM EFFICIENCY

(J11.1) The requirements of J11.1, as regards the efficiency of the boiler or other primary heat source, will be met -

a. where the rating-weighted average carbon intensity of the boiler or other primary heat source is in accordance with Table 1 to this standard; or

b. in the case of a liquid or gaseous fuelled boiler only, by compliance with the Boiler Efficiency Regulations 1993 and 1994.

Table 1 to (J11.1): Maximum carbon intensities of heating systems

Fuel	Maximum carbon intensities (kgC/kWh) [Notes 1-3]	
	at design capacity	at 30% of design capacity
Mains natural gas	0.068	0.064
Other fuels	0.088	0.088

Notes :

1. The carbon intensity of the heating plant is based on the carbon emitted per useful kWh of heat output and applies to boilers, heat pump systems and electrical heating, and is given by-

A = B ÷ C (Equation 1)

$$A = B \div C$$

where **A** is the carbon intensity of the heating system (kgC/kWh of useful heat);
B is the carbon emission factor of the fuel (kgC/kWh of delivered fuel) obtained from Table 2 to this specification;
C is the gross thermal efficiency of the heating system (kWh of heat divided by kWh of delivered fuel).

Amdt: September 2001

Table 2 to (J11.1): Carbon emission factors

Fuel type	Carbon emission factor (kgC/kWh)
Mains natural gas	0.053
LPG	0.068
Biogas	0.0
Oil (all grades of fuel oil)	0.074
Coal	0.086
Biomass	0.0
Electricity (grid-supplied)	0.113

2. Where a combined heat and power system (CHP) is proposed, the carbon intensity of the CHP can take account of the benefit of the on-site generation in reducing emissions from power stations feeding the national grid by using the following equation;

$$A = (B \div D) - (F \div E) \qquad \text{(Equation 2)}$$

where
- **A** is the carbon intensity of the heating system (kgC/kWh of useful heat);
- **B** is the carbon emission factor of the fuel (kgC/kWh of delivered fuel) obtained from Table 2 to this specification;
- **D** is the heat output ratio of the CHP engine (kWh of heat per kWh of delivered fuel);
- **E** is the electrical output ratio of the engine (kWh of electricity per kWh of delivered fuel);
- **F** is the carbon emission factor for grid supplied electricity (kgC/kWh). This should be taken as the factor for new generating capacity that might otherwise be built if the CHP had not been provided, i.e. the intensity of a new generation gas-fired station at 0.123 kg/kWh

This adjusted carbon intensity can then be used in equation 1 to determine the carbon intensity of the overall heating system at 100% and 30% of heating system output.

3. Where the CHP has no facility for heat dumping, the gross thermal efficiency is the CHP heat output divided by the energy content of the fuel burned. Where the CHP includes facilities for heat dumping, the gross thermal efficiency should be based on an estimate of the useful heat supplied to the building, i.e. the heat output from the CHP minus the heat dumped.

SPACE HEATING CONTROLS

(J11.3) The requirements of J11.3 will be met for small *buildings* (i.e. those with heating systems with an output not greater than 100 kW), where the space heating controls are in accordance with BRECSU Good Practice Guide GPG 132.

HOT WATER SERVICE SYSTEM CONTROLS

(J11.5) The requirements of J11.5 will be met by complying with sub-clauses a. or b. below -

a. for a system other than one heated by a solid fuel boiler -

i. the heat exchanger in the storage vessel should have sufficient heating capacity, such as one complying with BS 1566: Part 2: 1984 (1990) or BS 3198: 1981, and in particular it should comply with the requirements in these standards for the surface area of heat exchangers (i.e. pipe diameter and number of coils), and

ii. a thermostat should be provided which switches off the heat when the required storage temperature has been achieved, and which in the case of hot water central heating systems is interconnected with the room thermostat(s) to switch off the boiler when no heat is required, and

iii. a manually adjustable 7-day automatic timing device or devices should be provided either as part of the central heating system or as a local device to control the periods of operation; or

b. for a solid fuel fired system where the cylinder is not providing the slumber load, a thermostatically controlled valve should be provided.

INSULATION OF PIPES, *DUCTS* AND VESSELS

(J11.6) The requirements of J11.6, for insulation of pipes and *ducts*, will be met by providing insulation in accordance with BS 5422: 1990.

(J11.7) The requirements of J11.7 for insulation of hot water storage vessels will be met by applying insulation in accordance with the provisions of BS 5422: 1990 for flat surfaces.

ARTIFICIAL LIGHTING

(J12.1) The requirements of J12.1 will be met where the artificial lighting complies with a., b., or c. below -

a. 95% of the artificial lighting capacity in circuit Watts (i.e. the power consumed by lamps, their associated control gear and power factor correction equipment) is provided by lighting fittings using lamps with luminous efficacies not less than those of the types listed in the table to this specification -

Table to (J12.1)a. Artificial lighting

Light Source	Types
High pressure sodium	All types and sizes.
Metal halide	All types and sizes.
Induction lighting	All types and sizes.
Triphosphor tubular fluorescent	All 26mm diameter (T8) lamps, and 16mm diameter (T5) lamps rated above 11 W, provided with low-loss or high frequency control gear; 38mm diameter (T12) linear fluorescent lamps 2400 mm long.
Compact fluorescent	All ratings above 11 W.
Other	Any type and rating with an efficiency greater than 65 lumens per circuit Watt.

b. the installed lighting capacity comprises lighting fittings with lamps having an average initial (100 hour) efficacy of not less than 65 lumens per circuit Watt.

c. the lighting is in accordance with Part 4 of the CIBSE publication “Code for Interior Lighting”, 1994.

(J12.2) – (J12.3)

DISPLAY LIGHTING

(J12.2) The requirements of J12.2 will be met by display lighting -

a. whose installed capacity comprises lighting fittings incorporating lamps with an average initial (100 hour) efficacy of not less than 15 lumens per circuit Watt; or

b. at least 95% of whose installed capacity in circuit Watts (i.e. the power consumed by lamps, their associated control gear and power factor correction equipment) is provided by lighting fittings using lamps with luminous efficacies not less than those of the types listed in the table to this specification -

Table to (J12.2)b. Display lighting

Light Source	Types and ratings
High pressure sodium	All types and ratings.
Metal halide	All types and ratings.
Tungsten halogen	All types and ratings.
Compact and tubular fluorescent	All types and ratings.
Other	Any type and rating with an efficacy greater than 15 lumens per circuit Watt.

CONTROLS FOR ARTIFICIAL LIGHTING

(J12.3) The requirements of J12.3 will be met by an artificial lighting system having -

a. local manually operated switches where the distance measured directly 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 the finished floor level, whichever is the greater; or

b. lighting rows adjacent to windows controlled by photocells to monitor daylight and adjust the artificial lighting accordingly, either by switching or dimming; or

c. switches operated by ultrasonic, infra-red or other remote control handsets; or

d. automatic switching which turns the lighting off when it senses the absence of occupants; or

e. in *buildings* of *purpose groups* 4 to 6, in areas where continuous lighting is required during hours of operation, time switching or daylight-linked photo-electric switching; or

f. switching in accordance with Section 4.4.4 of the CIBSE publication "Code for Interior Lighting", 1994; or

g. for display lighting, dedicated circuits that can be switched off at times when people will not be inspecting exhibits or merchandise or being entertained [Note 1].

Note:

1. In a retail store, for example, (J12.3)g. could be achieved by timers to switch off the display lighting outwith opening hours, other than for displays intended to be viewed from outside the *building*).

AIR CONDITIONING AND MECHANICAL VENTILATION

(J13.1) The requirements of J13.1, for energy efficiency of air conditioning and mechanical ventilation, will be met -

a. for *buildings* of *purpose group* 3, by achieving a Carbon Performance Index [Note 1] of at least 100, or in the case of a conversion, at least 90; or

b. for *buildings* of *purpose groups* 2 and 4 to 7, by providing air conditioning or mechanical ventilation with a total specific fan power (i.e. the design power of all fans in the distribution system divided by the design ventilation rate through the *building*) not greater than 1.5 W/ls^{-1}.

Notes:

1. The Carbon Performance Index (CPI) relates the performance of the proposed building to a benchmark based on the measured consumption data contained in ECON 19 [“Energy use in offices - Energy Consumption Guide 19”, DETR, 1998].
2. The CPI calculation procedure is described in Appendix K.

COMMISSIONING OF THE *BUILDING* SERVICES

(J14.1) The requirements of J14.1, as regards the commissioning of the *building* services, will be met by certifying that commissioning of the installation has been done in accordance with CIBSE Commissioning Codes and BSRIA Commissioning Guides.

(J14.2) The requirements of J14.2, as regards the provision of information for energy efficient operation, will be met by a self-contained *building* log-book containing the following details -

a. a schedule of the floor areas of each of the *building* zones categorised by environmental servicing type (e.g. air-conditioned, naturally ventilated); and

b. the purpose of the individual *building* services systems; and

c. the location of the relevant plant and equipment; and

d. the installed capacities (input power and output rating) of the services plant; and

e. simple descriptions of the operational and control strategies of the energy consuming services in the *building*; and

f. operating and maintenance instructions that include provisions enabling the specified performance to be sustained during occupation.

Appendix A: Tables of *U–values*

Contents

Notes:

1. The values in these tables have been derived using the Combined Method, taking into account the effects of thermal bridging where appropriate.
2. Intermediate values can be obtained from the tables by linear interpolation.
3. As an alternative to using these tables, the procedures in Appendices B and C can be used to obtain a more accurate calculation of the thickness of insulation required.

EXAMPLE CALCULATIONS **Page**

Roofs

Walls

Ground floors

Appendix A

Windows, rooflights and doors

A1 Full details about calculating the *U-value* of a window or door are given in BS EN ISO 10077–1. This Appendix provides indicative *U-values* for windows, rooflights and doors. Table A1 applies to windows (and rooflights) with wood or PVC-U frames. Table A2 applies to windows with metal frames, for which the adjustments (for thermal breaks and/or rooflights) in Table A3 should be applied.

A2 The *U-value* of a window or rooflight containing low-E *glazing* is influenced by the emissivity, εn, of the low-E coating. Low-E coatings are of two principal types, known as ‘hard’ and ‘soft’. Hard coatings generally have emissivities in the range 0.15 to 0.2, and the data for $\varepsilon n = 0.2$ should be used for hard coatings, or if the *glazing* is stated to be low-E but the type of coating is not specified. Soft coatings generally have emissivities in the range 0.05 to 0.1. The data for $\varepsilon n = 0.1$ should be used for a soft coating if the emissivity is not specified.

A3 When available, manufacturers’ *U-values*, certified by a *notified body*, for windows, or rooflights or doors must be used in preference to the data given in these tables.

Table A1: Indicative *U-values* (W/m²K) for windows, rooflights and doors with wood or PVC-U frames [Note 1]

	Gap between panes 6 mm	Gap between panes 12 mm	Gap between panes 16 mm or more	Adjustment for rooflights in *dwellings* [Note 4]
Single glazing	4.8			+ 0.3
Double *glazing* (air filled)	3.1	2.8	2.7	
Double *glazing* (low-E, εn = 0.2) [Note 2]	2.7	2.3	2.1	
Double *glazing* ((low-E, εn = 0.15)	2.7	2.2	2.0	
Double *glazing* (low-E, εn = 0.1)	2.6	2.1	1.9	
Double *glazing* (low-E, εn = 0.05)	2.6	2.0	1.8	
Double *glazing* (argon filled) [Note 3]	2.9	2.7	2.6	
Double *glazing* (low-E, εn = 0.2, argon filled)	2.5	2.1	2.0	
Double *glazing* (low-E, εn = 0.1, argon filled)	2.3	1.9	1.8	
Double *glazing* (low-E, εn = 0.05, argon filled)	2.3	1.8	1.7	
Triple *glazing*	2.4	2.1	2.0	+ 0.2
Triple *glazing* (low-E, εn = 0.2)	2.1	1.7	1.6	
Triple *glazing* (low-E, εn = 0.1)	2.0	1.6	1.5	
Triple *glazing* (low-E, εn = 0.05)	2.0	1.5	1.4	
Triple *glazing* (argon filled)	2.2	2.0	1.9	
Triple *glazing* (low-E, εn = 0.2, argon filled)	1.9	1.6	1.5	
Triple *glazing* (low-E, εn = 0.1, argon filled)	1.8	1.4	1.3	
Triple *glazing* (low-E, εn = 0.05, argon filled)	1.7	1.4	1.3	
Solid wooden door [Note 5]	3.0			N/A

Notes:

1. The *U-values* in this table are based on the frame comprising 30% of the total window area.
2. The emissivities quoted are normal emissivities. (Corrected emissivity is used in the calculation of *glazing U-values*.) Uncoated glass is assumed to have a normal emissivity of 0.89.
3. The gas mixture is assumed to consist of 90% argon and 10% air.
4. No adjustment need be applied to rooflights in *buildings* other than *dwellings*.
5. For doors which are half-*glazed* the *U-value* of the door is the average of the appropriate window *U-value* and that of the non-*glazed* part of the door (e.g. 3.0 W/m²K for a wooden door).

Table A2: Indicative *U-values* (W/m²K) for windows with metal frames (4 mm thermal break)

		gap between panes		
		6 mm	12 mm	16 mm or more
Single *glazing*	5.7			
Double *glazing* (air filled)		3.7	3.4	3.3
Double *glazing* (low-E, εn = 0.2)		3.3	2.8	2.6
Double *glazing* (low-E, εn = 0.1)		3.2	2.6	2.5
Double *glazing* (low-E, εn = 0.05)		3.1	2.5	2.3
Double *glazing* (argon filled)		3.5	3.3	3.2
Double *glazing* (low-E, εn = 0.2,argon filled)		3.1	2.6	2.5
Double *glazing* (low-E, εn = 0.1, argon filled)		2.9	2.4	2.3
Double *glazing* (low-E, εn = 0.05, argon filled)		2.8	2.3	2.1
Triple *glazing*		2.9	2.6	2.5
Triple *glazing* (low-E, εn = 0.2)		2.6	2.2	2.0
Triple *glazing* (low-E, εn = 0.1)		2.5	2.0	1.9
Triple *glazing* (low-E, εn = 0.05)		2.4	1.9	1.8
Triple *glazing* (argon-filled)		2.8	2.5	2.4
Triple *glazing* (low-E, εn = 0.2, argon filled)		2.4	2.0	1.9
Triple *glazing* (low-E, εn = 0.1, argon filled)		2.2	1.9	1.8
Triple *glazing* (low-E, εn = 0.05, argon filled)		2.2	1.8	1.7

Note:
The *U-values* in this table are based on the frame comprising 20% of the total window area.

A4 For windows (or rooflights) with metal frames incorporating a thermal break other than 4 mm, the adjustments given in Table 3 should be made to the *U-values* given in Table A2.

Table A3: Adjustments to *U–values* in Table A2 for frames with thermal breaks

Thermal break (mm)	Adjustment to *U-value* (W/m²K)	
	Window, or rooflight in a *building* other than a *dwelling*	Roof window in a *dwelling* [Note 1]
0 (no break)	+ 0.3	+ 0.7
4	+ 0.0	+ 0.3
8	- 0.1	+ 0.2
12	- 0.2	+ 0.1
16	- 0.2	+ 0.1

Notes:
1. Where applicable, adjustments for both thermal break and rooflight should be made. For intermediate thicknesses of thermal breaks, linear interpolation may be used.

ROOFS

Table A4: Base thickness of insulation between ceiling joists or rafters

	Design *U-value* (W/m²K)	Thermal conductivity of insulant (W/m·K) 0.020	0.025	0.030	0.035	0.040	0.045	0.050
		Base thickness of insulating material (mm)						
	A	B	C	D	E	F	G	H
1	**0.15**	371	464	557	649	742	835	928
2	**0.20**	180	224	269	314	359	404	449
3	**0.25**	118	148	178	207	237	266	296
4	**0.30**	92	110	132	154	176	198	220
5	**0.35**	77	91	105	122	140	157	175
6	**0.40**	67	78	90	101	116	130	145

Table A5: Base thickness of insulation between and over joists or rafters

	Design *U-value* (W/m²K)	Thermal conductivity of insulant (W/m·K) 0.020	0.025	0.030	0.035	0.040	0.045	0.050
		Base thickness of insulating material (mm)						
	A	B	C	D	E	F	G	H
1	**0.15**	161	188	217	247	277	307	338
2	**0.20**	128	147	167	188	210	232	255
3	**0.25**	108	122	137	153	170	187	205
4	**0.30**	92	105	117	130	143	157	172
5	**0.35**	77	91	103	113	124	136	148
6	**0.40**	67	78	90	101	110	120	130

Note:
Tables A4 and A5 are derived for roofs with the proportion of timber at 8%, corresponding to 48 mm wide timbers at 600 mm centres, excluding noggings. For other proportions of timber the *U-value* can be calculated using the procedure in Appendix B.

Table A6: Base thickness for continuous insulation

	Design *U-value* (W/m²K)	Thermal conductivity of insulant (W/m·K) 0.020	0.025	0.030	0.035	0.040	0.045	0.050
		Base thickness of insulating material (mm)						
	A	B	C	D	E	F	G	H
1	**0.15**	131	163	196	228	261	294	326
2	**0.20**	97	122	146	170	194	219	243
3	**0.25**	77	97	116	135	154	174	193
4	**0.30**	64	80	96	112	128	144	160
5	**0.35**	54	68	82	95	109	122	136
6	**0.40**	47	59	71	83	94	106	118

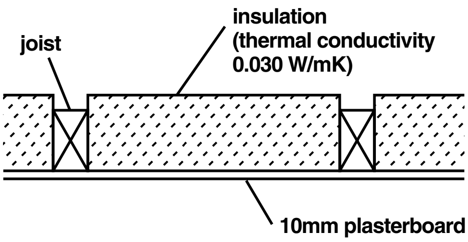
Table A7 Allowable reductions in thickness for common roof components

		Thermal conductivity of insulant (W/m·K)						
		0.020	0.025	0.030	0.035	0.040	0.045	0.050
	Concrete slab density (Kg/m²)	**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**	10	13	15	18	20	23	25
2	**800**	7	9	11	13	14	16	18
3	**1100**	5	6	8	9	10	11	13
4	**1300**	4	5	6	7	8	9	10
5	**1700**	2	2	3	3	4	4	5
6	**2100**	1	2	2	2	3	3	3
	Other materials and components	**Reduction in base thickness of insulating material (mm)**						
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
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	6	7	8	9	10
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 1 - Pitched roof with insulation between ceiling joists or between rafters

Determine the thickness of the insulation layer required to achieve a *U-value* of 0.20 W/m²K if insulation is between the joists, and 0.25 W/m²K if insulation is between the rafters.

For insulation placed between ceiling joists (*U-value* 0.20 W/m²K)



Using Table A4:

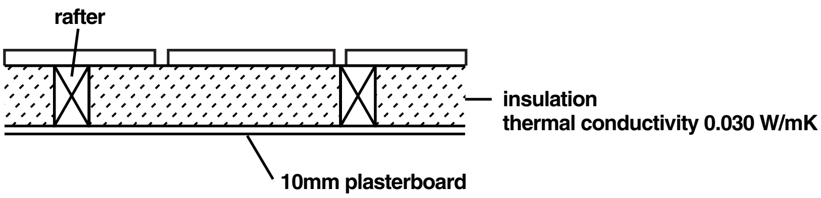
From **column D**, **row 2** of the table, the base thickness of insulation required is **269 mm**.
The base thickness may be reduced by taking account of the other materials as follows:
From Table A7:

19 mm roof tiles	column D, row 13	= 1 mm
Roof space (pitched)	column D, row 11	= 6 mm
10 mm plasterboard	column D, row 7	= 2 mm
Total reduction		= **9 mm**

The minimum thickness of the insulation layer between the ceiling joists required to achieve a *U-value* of 0.20 W/m^{2}K is therefore:

Base thickness less **total reduction** i.e. 269 – 9 = **260 mm**.

For insulation placed between rafters (*U-value* 0.25 W/m^{2}K)



Using Table A4:

From **column D**, **row 3** in the table, the base thickness of insulation required is **178 mm**.
The reductions in the base thickness are obtained as follows:
From Table A7:

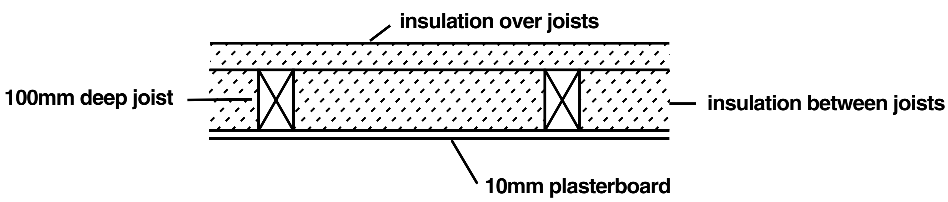
19 mm roof tiles	column D, row 13	= 1 mm
10 mm plasterboard	column D, row 7	= 2 mm
Total reduction		= **3 mm**

The minimum thickness of the insulation layer between the rafters required to achieve a *U-value* of 0.25 W/m^{2}K is therefore:

Base thickness less **total reduction** i.e.178 - 3 = **175 mm**.

Example 2 - Pitched roof with insulation between and over ceiling joists

Determine the thickness of the insulation layer above the joists required to achieve a *U-value* of 0.20 W/m^{2}K for the roof *construction* shown below:



It is proposed to use mineral fibre insulation between and over the joists with a thermal conductivity of 0.04 W/m·K. Using Table A5:

From **column F, row 2** of the table, the base thickness of insulation layer is **210 mm**.

Appendix A

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

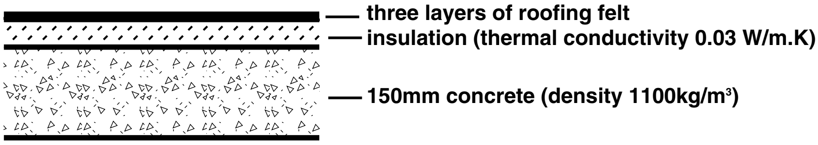
From Table A7:

19 mm roof tiles	column F, row 13	= 1 mm
Roof space (pitched)	column F, row 11	= 8 mm
10 mm plasterboard	column F, row 7	= 3 mm
Total reduction		= **12 mm**

The minimum thickness of the insulation layer over the joists, required in addition to the 100 mm insulation between the joists, to achieve a *U-value* of 0.20 W/m²K is therefore:
Base thickness less total reduction i.e. 210 - 1OO - 12 = **98 mm.**

Example 3- Concrete deck roof

Determine the thickness of the insulation layer required to achieve a *U-value* of 0.25 W/m²K for the roof *construction* shown below.



Using Table A6:

From **column D**, **row 3** of the table, the base thickness of the insulation layer is **116 mm.**

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

From Table A7:

3 layers of felt	column D, row 14	= 1 mm
150 mm concrete deck	column D, row 3	
adjusted for 150 mm thickness (1.5 × 8)		= 12 mm
Total reduction		= **13 mm**

The minimum thickness of the insulation layer required to achieve a *U-value* of 0.25 W/m²K is therefore:
Base thickness less **total reduction** i.e. 116 - 13 = **103 mm.**

Walls

Table A8 Base thickness of insulation layer

	Design *U-value* (W/m²K)	Thermal conductivity of insulant (W/m·K) 0.020	0.025	0.030	0.035	0.040	0.045	0.050
		Base thickness of insulating material (mm)						
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
1	**0.20**	97	121	145	169	193	217	242
2	**0.25**	77	96	115	134	153	172	192
3	**0.30**	63	79	95	111	127	142	158
4	**0.35**	54	67	81	94	107	121	134
5	**0.40**	47	58	70	82	93	105	117
6	**0.45**	41	51	62	72	82	92	103

Table A9 Allowable reductions in base thickness for common components

		Thermal conductivity of insulant (W/m·K)						
		0.020	0.025	0.030	0.035	0.040	0.045	0.050
	Component	Reduction in base thickness of insulating material (mm)						
	A	B	C	D	E	F	G	H
1	Cavity (25 mm or more)	4	5	5	6	7	8	9
2	Outer leaf brick	3	3	4	5	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	9.5 mm plasterboard	1	2	2	2	3	3	3
6	12.5 mm plasterboard	2	2	2	3	3	4	4
7	Air space behind plasterboard dry lining	2	3	4	4	5	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 A10 Allowable reductions in base thickness for concrete components

		Thermal conductivity of insulant (W/m·K)						
		0.020	0.025	0.030	0.035	0.040	0.045	0.050
	Density (Kg/m²)	Reduction in base thickness of insulation (mm) for each 100 mm of concrete						
	A	B	C	D	E	F	G	H
Concrete inner leaf								
1	**600**	9	11	13	15	17	20	22
2	**800**	7	9	10	12	14	16	17
3	**1000**	5	6	8	9	10	11	13
4	**1200**	4	5	6	7	8	9	10
5	**1400**	3	4	5	6	7	8	8
6	**1600**	3	3	4	5	6	6	7
7	**1800**	2	2	3	3	4	4	4
8	**2000**	2	2	2	3	3	3	4
9	**2400**	1	1	2	2	2	2	3

Continued overleaf

Amdt: September 2001

Table A10 continued

		Thermal conductivity of insulant (W/m·K)						
		0.020	0.025	0.030	0.035	0.040	0.045	0.050
	Density (Kg/m²)	Reduction in base thickness of insulation (mm) for each 100 mm of concrete						
	A	B	C	D	E	F	G	H
Concrete outer leaf or single leaf wall								
10	**600**	8	11	13	15	17	19	21
11	**800**	7	9	10	12	14	15	17
12	**1000**	5	6	7	8	10	11	12
13	**1200**	4	5	6	7	8	9	10
14	**1400**	3	4	5	6	6	7	8
15	**1600**	3	3	4	5	5	6	7
16	**1800**	2	2	3	3	3	4	4
17	**2000**	1	2	2	3	3	3	4
18	**2400**	1	1	2	2	2	2	3

Table A11 Allowable reductions in base thickness for insulated timber framed walls

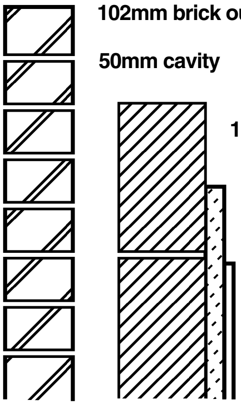
		Thermal conductivity of insulant (W/m·K)						
		0.020	0.025	0.030	0.035	0.040	0.045	0.050
	Thermal conductivity of insulation within frame (W/m·K)	Reduction in base thickness of insulation (mm) for each 100 mm of frame(mm)						
	A	B	C	D	E	F	G	H
1	**0.035**	42	53	63	74	84	95	105
2	**0.040**	38	48	58	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 B.

Example 4 - Masonry cavity wall with internal insulation

(For *buildings* other than detached *buildings*, this *construction* might not provide adequate resistance to flanking sound transmission)

Determine the thickness of the insulation layer required to achieve a *U-value* of 0.35 W/m²K for the wall *construction* shown below.



Using Table A8:

From **column C**, **row 4** of the table, the base thickness of the insulation layer is **67 mm**.

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

From Table A9:

Brick outer leaf	column C, row 2	= 3 mm
Cavity	column C, row 1	= 5 mm
Plasterboard	column C, row 6	= 2 mm

And from table A10

Concrete block adjusted for 150 mm block thickness (1.5 × 11)	column C, row 1	= 17 mm
Total reduction		= **27 mm**

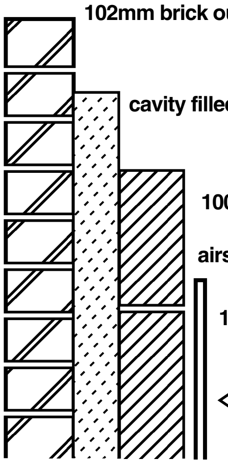
The minimum thickness of the insulation layer required to achieve a *U-value* of 0.35 W/m²K is therefore:

Base thickness less **total reduction** i.e. 67 – 27 = **40 mm**

Appendix A

Example 5 - Masonry cavity wall filled with insulation with plasterboard on dabs

Determine the thickness of the insulation layer required to achieve a *U-value* of 0.35 W/m^{2}K for the wall *construction* shown below. (This calculation assumes the effect of wall ties to be negligible).



Using Table A8:

From **column F**, **row 4** of the table, the base thickness of the insulation layer is **107 mm.**

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

From Table A9:

Brick outer leaf	column F, row 2	= 5 mm
Plasterboard	column F, row 6	= 3 mm
Air space behind plasterboard		
	column F, row 7	= 5 mm

And from Table A10:

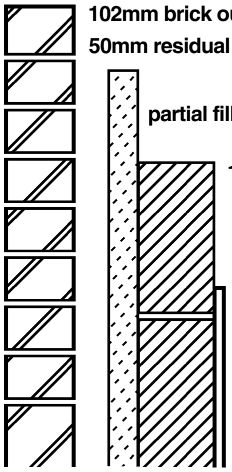
Concrete block	column F, row 8	= 3 mm
Total reduction		= **16 mm**

The minimum thickness of the insulation layer required to achieve a *U-value* of 0.35 W/m^{2}K is therefore:

Base thickness less **total reduction** i.e. 107 – 16 = **91 mm**

Example 6 - Masonry wall with partial cavity-fill

Determine the thickness of the insulation layer required to achieve a *U-value* of 0.30 W/m²K for the wall *construction* shown below.



Using Table A8:

From **column C, row 3** of the table, the base thickness of the insulation layer is **79 mm.**

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

From Table A9:

Brick outer leaf	column C, row 2	= 3 mm
Cavity	column C, row 1	= 5 mm
Lightweight plaster	column C, row 4	= 2 mm

And from Table A10:

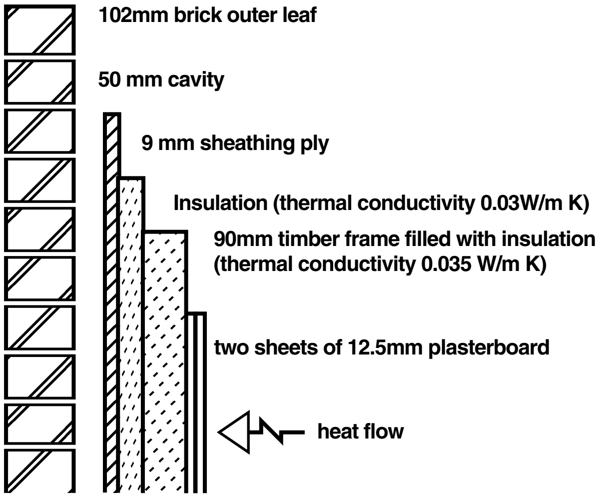
Concrete block	column C, row 5	= 4 mm
Total reduction		= **14 mm**

The minimum thickness of the insulation layer required to achieve a *U-value* of 0.30 W/m²K is therefore:

Base thickness less **total reduction** i.e. 79 – 14 = **65 mm**

Example 7 - Timber-frame wall

Determine the thickness of the insulation layer required to achieve a *U-value* of 0.30 W/m^{2}K for the wall *construction* shown below.



Using Table A8:

From **column D**, **row 3** of the table, the base thickness of the insulation layer is **95 mm.**

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

From Table A9:

Brick outer leaf	column D, row 2	= 4 mm
Cavity	column D, row 1	= 5 mm
Sheathing ply	column D, row 8	= 2 mm
Plasterboard	column D, row 6	= 2 mm
Plasterboard	column D, row 6	= 2 mm

And from Table A11:

Timber frame adjusted for shallower member (0.9 × 63 mm)	column D, row 1	= 57 mm
Total reduction		= **72 mm**

The minimum thickness of the insulation layer required to achieve a *U-value* of 0.30 W/m^{2}K is therefore:

Base thickness less **total reduction** i.e. 95 – 72 = **23 mm**

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 length in metres; and **A** is the floor area in square metres.

Table A12 Insulation thickness for solid floors in contact with the ground

		Thermal conductivity of insulant (W/m·K)						
	P/A	**0.020**	**0.025**	**0.030**	**0.035**	**0.040**	**0.045**	**0.050**
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
		Insulation thickness (mm) for *U-value* of 0.20 W/m²K						
1	1.00	81	101	121	142	162	182	202
2	0.90	80	100	120	140	160	180	200
3	0.80	78	98	118	137	157	177	196
4	0.70	77	96	115	134	153	173	192
5	0.60	74	93	112	130	149	167	186
6	0.50	71	89	107	125	143	160	178
7	0.40	67	84	100	117	134	150	167
8	0.30	60	74	89	104	119	134	149
9	0.20	46	57	69	80	92	103	115
		***U-value* of 0.25 W/m²K**						
10	1.00	61	76	91	107	122	137	152
11	0.90	60	75	90	105	120	135	150
12	0.80	58	73	88	102	117	132	146
13	0.70	57	71	85	99	113	128	142
14	0.60	54	68	82	95	109	122	136
15	0.50	51	64	77	90	103	115	128
16	0.40	47	59	70	82	94	105	117
17	0.30	40	49	59	69	79	89	99
18	0.20	26	32	39	45	52	58	65
		***U-value* of 0.30 W/m²K**						
19	1.00	48	60	71	83	95	107	119
20	0.90	47	58	70	81	93	105	116
21	0.80	45	56	68	79	90	102	113
22	0.70	43	54	65	76	87	98	108
23	0.60	41	51	62	72	82	92	103
24	0.50	38	47	57	66	76	85	95
25	0.40	33	42	50	59	67	75	84
26	0.30	26	33	39	46	53	59	66
27	0.20	13	16	19	22	25	28	32

Note:

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

Table A13 Insulation thickness for timber ground floors

		Thermal conductivity of insulant (W/m·K)						
	P/A	0.020	0.025	0.030	0.035	0.040	0.045	0.050
	A	B	C	D	E	F	G	H
		Insulation thickness (mm) for *U-value* of 0.20 W/m²K						
1	1.00	127	145	164	182	200	218	236
2	0.90	125	144	162	180	198	216	234
3	0.80	123	142	160	178	195	213	230
4	0.70	121	139	157	175	192	209	226
5	0.60	118	136	153	171	188	204	221
6	0.50	114	131	148	165	181	198	214
7	0.40	109	125	141	157	173	188	204
8	0.30	99	115	129	144	159	173	187
9	0.20	82	95	107	120	132	144	156
		U-value of 0.25 W/m²K						
10	1.00	93	107	121	135	149	162	176
11	0.90	92	106	119	133	146	160	173
12	0.80	90	104	117	131	144	157	170
13	0.70	88	101	114	127	140	153	166
14	0.60	85	98	111	123	136	148	161
15	0.50	81	93	106	118	130	142	154
16	0.40	75	87	99	110	121	132	143
17	0.30	66	77	87	97	107	117	127
18	0.20	49	57	65	73	81	88	96
		U-value of 0.30 W/m²K						
19	1.00	71	82	93	104	114	125	135
20	0.90	70	80	91	102	112	122	133
21	0.80	68	78	89	99	109	119	129
22	0.70	66	76	86	96	106	116	126
23	0.60	63	73	82	92	102	111	120
24	0.50	59	68	78	87	96	104	113
25	0.40	53	62	70	79	87	95	103
26	0.30	45	52	59	66	73	80	87
27	0.20	28	33	38	42	47	51	56

Notes:

1. **P/A** is the ratio of floor perimeter (m) to floor area (m²). The table is derived for suspended timber floors for which the proportion of timber is 12%, which corresponds to 48 mm wide timbers at 400 mm centres.
2. For other proportions of timber the *U-value* can be calculated using the procedure in Appendix B.

Table A14:Insulation thickness for suspended concrete beam and block ground floors

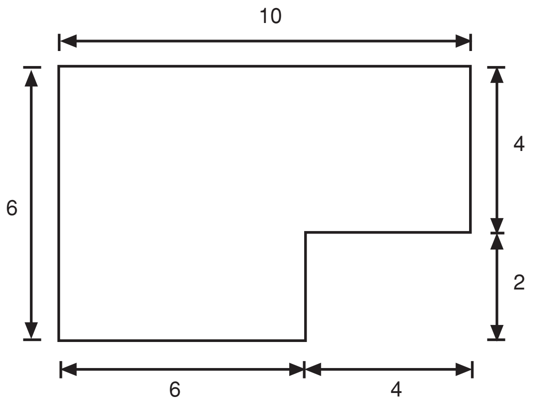
		Thermal conductivity of insulant (W/m·K)						
	P/A	0.020	0.025	0.030	0.035	0.040	0.045	0.050
	A	B	C	D	E	F	G	H
		Insulation thickness (mm) for *U-value* of 0.20 W/m²K						
1	1.00	82	103	123	144	164	185	205
2	0.90	81	101	122	142	162	183	203
3	0.80	80	100	120	140	160	180	200
4	0.70	79	99	118	138	158	177	197
5	0.60	77	96	116	135	154	173	193
6	0.50	75	93	112	131	150	168	187
7	0.40	71	89	107	125	143	161	178
8	0.30	66	82	99	115	132	148	165
9	0.20	56	69	83	97	111	125	139
		U-value of 0.25 W/m²K						
10	1.00	62	78	93	109	124	140	155
11	0.90	61	76	92	107	122	138	153
12	0.80	60	75	90	105	120	135	150
13	0.70	59	74	88	103	118	132	147
14	0.60	57	71	86	100	114	128	143
15	0.50	55	68	82	96	110	123	137
16	0.40	51	64	77	90	103	116	128
17	0.30	46	57	69	80	92	103	115
18	0.20	36	45	54	62	71	80	89
		U-value of 0.30 W/m²K						
19	1.00	49	61	73	85	97	110	122
20	0.90	48	60	72	84	96	108	120
21	0.80	47	59	70	82	94	105	117
22	0.70	45	57	68	80	91	102	114
23	0.60	44	55	66	77	88	98	109
24	0.50	41	52	62	72	83	93	104
25	0.40	38	48	57	67	76	86	95
26	0.30	33	41	49	57	65	73	81
27	0.20	22	28	33	39	44	50	56

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

Amdt: September 2001

Example 8 – Solid floor in contact with the ground

Determine the thickness of the insulation layer required to achieve a *U-value* of 0.3 W/m²K for the ground floor slab shown below.



It is proposed to use insulation with a thermal conductivity of 0.025 W/m·K.

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: $\frac{\text{perimeter length}}{\text{floor area}} = \frac{32}{52} = 0.6$

Using Table A12, **column C**, **row 23** indicates that **51 mm** of insulation is required.

Example 9 - 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:

$$\frac{\text{perimeter length}}{\text{floor area}} = \frac{32}{52} = 0.6$$

To achieve a *U-value* of 0.30 W/m²·K, using insulation with a thermal conductivity of 0.04 W/m·K, Table A13 **column F**, **row 23** indicates that the insulation thickness between the joists should be not less than **102 mm.**

UPPER FLOORS

Table A15 Upper floors of timber *construction*

	Design *U-value* (W/m²K)	Thermal conductivity of insulant (W/m·K)						
		0.020	0.025	0.030	0.035	0.040	0.045	0.050
		Base thickness of insulation between joists to achieve design *U-values*						
	A	B	C	D	E	F	G	H
1	0.20	167	211	256	298	341	383	426
2	0.25	109	136	163	193	225	253	281
3	0.30	80	100	120	140	160	184	208

Note:
Table A15 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 E.

Table A16 Upper floors of concrete *construction*

	Design *U-value* (W/m²K)	Thermal conductivity of insulant (W/m·K)						
		0.020	0.025	0.030	0.035	0.040	0.045	0.050
		Base thickness of insulation to achieve design *U-value*						
	A	B	C	D	E	F	G	H
1	0.20	95	119	142	166	190	214	237
2	0.25	75	94	112	131	150	169	187
3	0.30	62	77	92	108	123	139	154

Table A17 Upper floors: allowable reductions in base thickness for common components

		Thermal conductivity of insulant (W/m·K)						
		0.020	0.025	0.030	0.035	0.040	0.045	0.050
	Component	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

Table A18: Thermal conductivity of some common *construction* materials

	Density (kg/m³)	Conductivity (W/m·K)
Walls		
Brickwork (outer leaf)	1700	0.77
Brickwork (inner leaf)	1700	0.56
Lightweight aggregate concrete block	1400	0.57
Autoclaved aerated concrete block	600	0.18
Concrete (medium density)	1800	1.13
	2000	1.33
	2200	1.59
Concrete (high density):	2400	1.93
Reinforced concrete (1% steel)	2300	2.3
Reinforced concrete (2% steel)	2400	2.5
Mortar (protected)	1750	0.88
Mortar (exposed)	1750	0.94
Gypsum	600	0.18
	900	0.30
	1200	0.43
Gypsum plasterboard	900	0.25
Sandstone	2600	2.3
Limestone, soft	1800	1.1
Limestone, hard	2200	1.7
Fibreboard	400	0.1
Plasterboard	900	0.25
Tiles ceramic	2300	1.3
Timber	500	0.14
	700	0.18
Surface finishes		
External rendering	1300	0.57
Plaster (dense)	1300	0.57
Plaster (lightweight)	600	0.18
Roofs		
Aerated concrete slab	500	0.16
Asphalt	2100	0.70
Felt/bitumen layers	1100	0.23
Screed	1200	0.41
Stone chippings	2000	2.0
Tiles (clay)	2000	1.0
Tiles (concrete)	2100	1.5
Wood wool slab	500	0.10

Table A18 (continued)

	Density (kg/m³)	Conductivity (W/m·K)
Floors		
Cast concrete	2000	1.35
Metal tray (steel)	7800	50.0
Screed	1200	0.41
Hardwood timber	700	0.18
Softwood timber, plywood, chipboard	500	0.13
Insulation		
Expanded polystyrene (EPS) slab	15	0.040
Mineral wool quilt	12	0.042
Mineral wool batt	25	0.038
Phenolic foam board	30	0.025
Polyurethane board	30	0.025

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

Appendix B: Worked examples of *U-value* calculations using the Combined Method

Introduction

B1 For *building* elements which contain repeating thermal bridges, such as timber joists between insulation in a roof or floor, timber studs in a wall, or mortar joints in lightweight blockwork, the effect of thermal bridges should be taken into account when calculating the *U-value*. The calculation method, known as the Combined Method, is set out in BS EN ISO 6946 and the following examples illustrate the use of the method for typical wall, roof and floor designs.

B2 In cases where the joists in roof, wall or floor *constructions* project beyond the surface of the insulation, the depths of the joists should be taken to be the same as the thickness of insulation for the purposes of the *U-value* calculation (as specified in BS EN ISO 6946).

B3 Conductivity values for common *building* materials can be obtained from the CIBSE Guide Section A3 or from prEN ISO 12524. For specific insulation products, however, data must be obtained from manufacturers. Table A18 (Appendix A) gives typical thermal conductivities for some common *construction* materials.

B4 The procedure in this Appendix does not address elements containing metal connecting paths. For built-up sheet metal walls and roofs, BRE IP 5/98 may be used. For curtain walling, the reader is directed to the CAB publication (Guide for assessment of the thermal performance of aluminium curtain wall framing" (September 1996). For ground floors and basements the reader is directed to Appendix C.

The procedure

B5 The *U-value* is calculated by applying the following steps:

a. Calculate the upper resistance limit (R_{upper}) by combining in parallel the total resistances of all possible heat-flow paths (i.e. sections) through the plane *building* element.

b. Calculate the lower resistance limit (R_{lower}) by combining in parallel the resistances of the heat flow paths of each layer separately and then summing the resistances of all layers of the plane *building* element.

c. Calculate the *U-value* of the element from $U = 1 / R_T$,

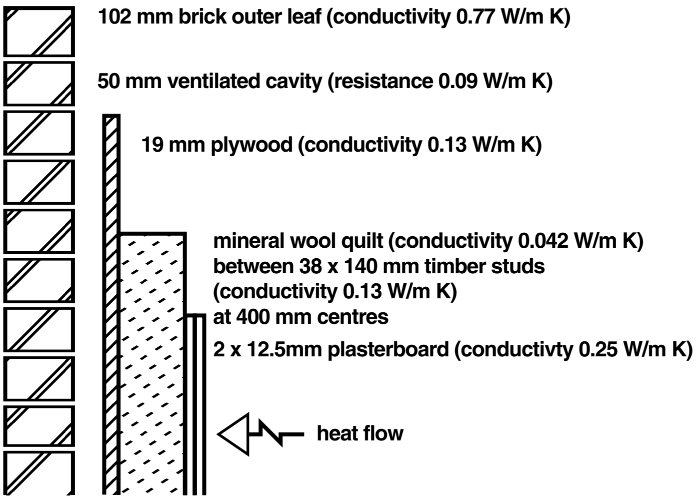
where $$R_T = \frac{R_{upper} + R_{lower}}{2}$$

d. Where appropriate, add a correction for air gaps and mechanical fasteners (including wall ties) as described in BS EN ISO 6946 Appendix D.

Example 1 - Timber framed wall

In this example there is a single bridged layer in the wall, involving insulation bridged by timber studs. The *construction* consists of outer leaf brickwork, a clear ventilated cavity, 19 mm plywood, 38 × 140 mm timber framing with 140 mm of mineral wool quilt insulation between the timber studs and 2 sheets of plasterboard each 12.5 mm thick.

Figure B1: Timber framed wall *construction*



(Total thickness: 336 mm; *U-value*: 0.29 W/m2K)

The thicknesses of each layer, together with the thermal conductivities of the materials in each layer, are shown below. The internal and external surface resistances are those appropriate for wall constructions. Layer 4 is thermally bridged and two thermal conductivities are given for this layer, one for the unbridged part and one for the bridging part of the layer. For each homogeneous layer and for each section through a bridged layer, the thermal resistance is calculated by dividing the thickness (in metres) by the thermal conductivity.

Table B1 Calculation of thermal resistance (timber frame)

Layer	Material	Thickness (mm)	Thermal conductivity (W/m·K)	Thermal resistance (m^2K/W)
	external surface	-	-	0.040
1	outer leaf brick	102	0.77	0.132
2	ventilated air cavity	50	-	0.090
3	plywood	19	0.13	0.146
4(a)	mineral wool quilt between timber studs	140	0.042	3.333
4(b)	48 mm × 140 mm timber studs at 400 mm centres	140	0.13	1.077
5	plasterboard	25	0.25	0.100
	internal surface	-	-	0.130

Appendix B

Both the upper and the lower limits of thermal resistance are calculated by combining the alternative resistances of the bridged layer in proportion to their respective areas, as illustrated below. The method of combining differs in the two cases.

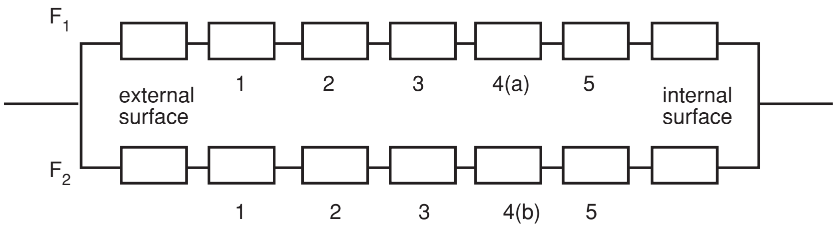
Upper resistance limit

When calculating the upper limit of thermal resistance, the building element is considered to consist of two thermal paths (or sections). The upper limit of resistance is calculated from:

$$R_{UPPER} = \frac{1}{\dfrac{F_1}{R_1} + \dfrac{F_2}{R_2}}$$

where F_1 and F_2 are the fractional areas of the two sections (paths) and R_1 and R_2 are the total resistances of the two sections. The method of calculating the upper resistance limit is illustrated conceptually below:

Figure B2 Conceptual illustration of how to calculate the upper limit of thermal resistance



Resistance through the section containing insulation

External surface resistance	= 0.040
Resistance of bricks	= 0.132
Resistance of air cavity	= 0.090
Resistance of plywood	= 0.146
Resistance of mineral wool (90.5%)	= 3.333
Resistance of plasterboard	= 0.100
Internal surface resistance	= 0.130
Total (R_1)	= 3.971 m^2K/W

Fractional area F_1 = 0.905 (90.5%)

Resistance through the section containing timber stud

External surface resistance	= 0.040
Resistance of bricks	= 0.132
Resistance of air cavity	= 0.090
Resistance of plywood	= 0.146
Resistance of timber studs (9.5%)	= 1.077
Resistance of plasterboard	= 0.100
Internal surface resistance	= 0.130
Total (R_2)	= 1.715 m^2K/W

Fractional area F_2 = 0.095 (9.5%)

The upper limit of resistance is then:

$$R_{upper} = \frac{1}{\frac{F_1}{R_1} + \frac{F_2}{R_2}} = \frac{1}{\frac{0.905}{3.971} + \frac{0.095}{1.715}} = 3.530 \text{ m}^2\text{K/W}$$

Lower resistance limit

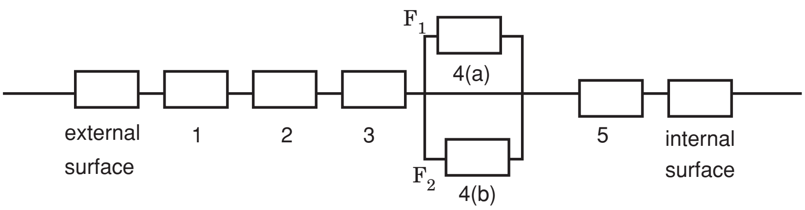
When calculating the lower limit of thermal resistance, the resistance of a bridged layer is determined by combining in parallel the resistances of the unbridged part and the bridged part of the layer. The resistances of all the layers in the element are then added together to give the lower limit of resistance.

The resistance of the bridged layer is calculated using:

$$R = \frac{1}{\frac{F_{insul}}{R_{insul}} + \frac{F_{timber}}{R_{timber}}}$$

The method of calculating the lower limit of resistance is illustrated conceptually below.

Figure B3 Conceptual illustration of how to calculate the lower limit of thermal resistance



The lower limit of resistance is then obtained by adding up the resistances of all the layers:

External surface resistance	= 0.040
Resistance of bricks	= 0.132

Resistance of air cavity = 0.090
Resistance of plywood = 0.146

Resistance of bridged layer = $\dfrac{1}{\dfrac{0.905}{3.333} + \dfrac{0.095}{1.077}}$ = 2.780

Resistance of plasterboard = 0.100
Internal surface resistance = 0.130
Total (R_{lower}) = 3.418 m^2K/W

Total resistance of wall (not allowing for air gaps around the insulation)

The total resistance of the wall is the average of the upper and lower resistance limits:

$$R_T = \frac{R_{upper} + R_{lower}}{2} = \frac{3.530 + 3.418}{2} = 3.474 m^2K/W$$

Correction for air gaps

If there are small air gaps penetrating the insulating layer a correction should be applied to the *U-value* to account for this. The correction for air gaps is ΔU_g where

$\Delta U_g = \Delta U'' \times (R_I / R_T)^2$

and where R_I is the thermal resistance of the layer containing gaps, R_T is the total resistance of the element and $\Delta U''$ is a factor which depends upon the way in which the insulation is installed. In this example R_I is 2.780 m^2K/W, R_T is 3.474 m^2K/W and $\Delta U''$ is 0.01 (i.e. correction level 1). The value of ΔU_g is then:

$\Delta U_g = 0.01 \times (2.780 / 3.474)^2 =$ **0.006 W/m²K**

U-value of the wall

The effect of air gaps or mechanical fixings should be included in the *U-value* unless they lead to an adjustment in the *U-value* of less than 3%.

$U = 1 / R_T + \Delta U_g$ (if ΔU_g is not less than 3% of $1 / R_T$)

$U = 1 / R_T$ (if ΔU_g is less than 3% of $1 / R_T$)

In this case $\Delta U_g = 0.006$ W/m^2K and $1 / R_T = 0.288$ W/m^2K. Since ΔU_g is less than 3% of $(1 / R_T)$,

$U = 1 / R_T = 1 / 3.474 =$ **0.29 W/m²K.**

Notes:

1. In the above calculation it is assumed that the noggings (or dwangs) do not penetrate the whole of the insulation. If, however, the noggings (or dwangs) penetrate the whole of the insulation thickness they should be included within the timber percentage used in the calculation.

2. In this example correction level 1 is appropriate. This is because air gaps are likely to exist, in some cases, between the insulation and the timber framing.

3. The additional timbers at the junctions of plane elements, for example wall/wall, wall/floor, and wall ceiling junctions, and the additional timbers surrounding openings are taken account of in the treatment of such details and so are not taken into account in the calculation of the *U-value* of the wall.

4. BS EN ISO 6946 states that if the insulation is installed in such a way that no air circulation is possible the warm side of the insulation the ΔU" is set to 0.01 W/m²K. If, on the other hand, air circulation is possible on the warm side then it should be set to 0.04 W/m²K. The possible correction levels and correction factors are summarised as follows:

Table B2 Correction for air gaps

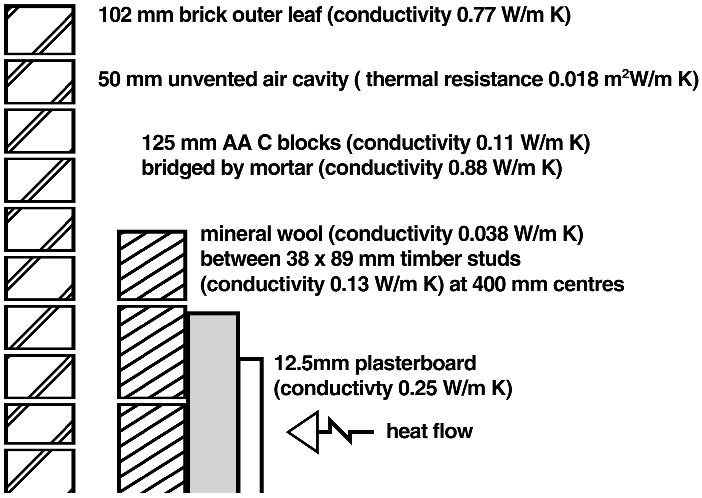
Description of air gap	Correction level	ΔU" W/m²K
Insulation installed in such a way that no air circulation is possible on the warm side of the insulation. No air gaps penetrating the entire insulation layer.	0	0.00
Insulation installed in such a way that no air circulation is possible on the warm side of the insulation. Air gaps may penetrate the insulation layer.	1	0.01
Air circulation possible on the warm side of the insulation. Air gaps may penetrate the insulation.	2	0.04

Appendix B

Example 2 Cavity wall with lightweight masonry leaf and insulated dry-lining

In this example there are two bridged layers - insulation bridged by timber and lightweight blockwork bridged by mortar. The *construction* consists of outer leaf brickwork, a clear cavity, 125 mm AAC blockwork, 38 × 89 mm timber studs (400 mm centre-to-centre spacing) with insulation between the studs and one sheet of 12.5 mm plasterboard.

Figure B4 Wall *construction* with two bridged layers



(Total thickness: 378.5 mm; *U-value*: 0.29 W/m²K)

The thicknesses of each layer, together with the thermal conductivities of the materials, are shown below, with appropriate internal and external surface resistances, these being, for a wall, 0.13 m²K/W and 0.04 m²K/W. Layers 3 and 4 are both thermally bridged and two thermal conductivities are given for each layer to reflect the bridged part and the bridging part in each case. For each homogeneous layer and for each section through a bridged layer the thermal resistance is calculated by dividing the thickness (expressed in metres) by the thermal conductivity.

Table B3: Calculation of thermal resistance (cavity wall)

Layer	Material	Thickness (mm)	Thermal conductivity (W/m·K)	Thermal resistance (m²K/W)
	external surface	-	-	0.040
1	outer leaf brick	102	0.77	0.132
2	air cavity	50	-	0.180
3(a)	AAC blocks (93.4%)	15	0.11	1.136
3(b)	mortar (6.6%)	(125)	0.88	0.142
4(a)	mineral wool (90.5%)	89	0.038	2.342
4(b)	timber studs (9.5%)	(89)	0.13	0.685
5	plasterboard	12.5	0.25	0.050
	internal surface	-	-	0.130

Both the upper and lower limits of thermal resistance are calculated by combining the alternative resistances of the bridged layer in proportion to their respective areas, as illustrated below. The method of combining differs in the two cases.

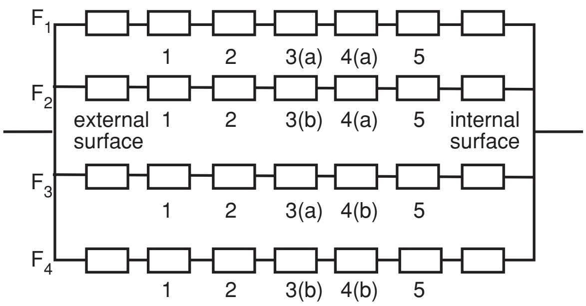
Upper resistance limit

When calculating the upper limit of thermal resistance, the *building* element is considered to consist of a number of thermal paths (or sections). In this example there are four sections (or paths) through which heat can pass. The upper limit of resistance, R_{upper}, is given by

$$R_{upper} = \frac{1}{\frac{F_1}{R_1} + \frac{F_2}{R_2} + \frac{F_3}{R_3} + \frac{F_4}{R_4}}$$

where F_1, F_2, F_3 and F_4 are the fractional areas of sections 1, 2, 3 and 4 respectively and R_1, R_2, R_3 and R_4 are the corresponding total thermal resistances of the sections. A conceptual illustration of the method of calculating the upper limit of resistance is shown in Figure B5 below:

Figure B5 Conceptual illustration of how to calculate the upper limit of thermal resistance



Resistance through section containing AAC blocks and mineral wool

External surface resistance	= 0.040
Resistance of bricks	= 0.132
Resistance of air cavity	= 0.180
Resistance of AAC blocks (93.4%)	= 1.136
Resistance of mineral wool (90.5%)	= 2.342
Resistance of plasterboard	= 0.050
Internal surface resistance	= 0.130
Total thermal resistance (R_1)	= 4.010 m^2K/W

Fractional area F_1 = 0.845 (93.4% × 90.5%)

Resistance through the section containing mortar and mineral wool

External surface resistance	= 0.040
Resistance of bricks	= 0.132
Resistance of air cavity	= 0.180
Resistance of mortar (6.6%)	= 0.142
Resistance of mineral wool (90.5%)	= 2.342
Resistance of plasterboard	= 0.050
Internal surface resistance	= 0.130
Total thermal resistance (R_2)	= 3.016 m^2K/W

Fractional area F_2 = 0.060 (6.6% × 90.5%)

Appendix B

Resistance through section containing AAC blocks and timber

External surface resistance	= 0.040
Resistance of bricks	= 0.132
Resistance of air cavity	= 0.180
Resistance of AAC blocks (93.4%)	= 1.136
Resistance of timber (9.5%)	= 0.685
Resistance of plasterboard	= 0.050
Internal surface resistance	= 0.130
Total thermal resistance (R_3)	= 2.353 m^2K/W

Fractional area F_3 = 0.089 (93.4% × 9.5%)

Resistance through section containing mortar and timber

External surface resistance	= 0.040
Resistance of bricks	= 0.132
Resistance of air cavity	= 0.180
Resistance of mortar (6.6%)	= 0.142
Resistance of timber (9.5%)	= 0.685
Resistance of plasterboard	= 0.050
Internal surface resistance	= 0.130
Total thermal resistance (R_4)	= 1.359 m^2K/W

Fractional area F_4 = 0.006 (6.6% × 9.5%)

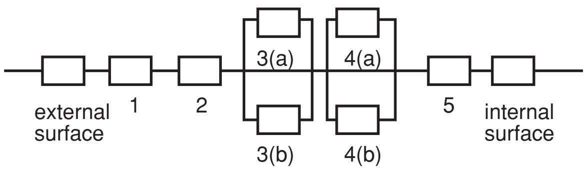
Combining these resistances we obtain:

$$R_{upper} = \frac{1}{\frac{F_1}{R_1} + \frac{F_2}{R_2} + \frac{F_3}{R_3} + \frac{F_4}{R_4}} = \frac{1}{\frac{0.845}{4.010} + \frac{0.060}{3.016} + \frac{0.089}{2.353} + \frac{0.006}{1.359}} = 3.665 \text{ m}^2\text{K/W}$$

Lower resistance limit

When calculating the lower limit of thermal resistance, the resistance of a bridged layer is determined by combining in parallel the resistances of the unbridged part and the bridged part of the layer. The resistances of all the layers in the element are then added together to give the lower limit of resistance. A conceptual illustration of the method of calculating the lower limit of resistance is shown below:

Figure B6 Conceptual illustration of how to calculate the lower limit of thermal resistance



The resistances of the layers are added together to give the lower limit of resistance. The resistance of the bridged layer consisting of AAC blocks and mortar is calculated using:

$$R_{first} = \cfrac{1}{\cfrac{F_{blocks}}{R_{blocks}} + \cfrac{F_{mortar}}{R_{mortar}}}$$

and the resistance of the bridged layer consisting of insulation and timber is calculated using:

$$R_{second} = \cfrac{1}{\cfrac{F_{insul}}{R_{insul}} + \cfrac{F_{timber}}{R_{timber}}}$$

The lower limit of resistance is then obtained by adding together the resistances of all the layers:

External surface resistance	= 0.040
Resistance of bricks	= 0.132
Resistance of air cavity	= 0.180
Resistance of polystyrene insulation	= 0.500
Resistance of first bridged layer	

$$R_{first} = \cfrac{1}{\cfrac{0.934}{1.136} + \cfrac{0.066}{0.142}} = 0.777$$

Resistance of second bridged layer

$$R_{second} = \cfrac{1}{\cfrac{0.905}{2.342} + \cfrac{0.095}{0.685}} = 1.904$$

Resistance of plasterboard	= 0.050
Internal surface resistance	= 0.130
Total (R_{lower})	= 3.213 m^2K/W

Appendix B

Total resistance of wall

The total resistance of the wall is the average of the upper and lower resistance limits:

$$R_T = \frac{R_{upper} + R_{lower}}{2} = \frac{3.665 + 3.213}{2} = 3.439 m^2K/W$$

Correction for air gaps between the timber studs

Since the insulation is entirely between studs (i.e. there is no continuous layer of insulation) a correction should be applied to the *U-value* in order to account for air gaps. The overall *U-value* of the wall should include a term ΔU_g, where

$\Delta Ug = \Delta U'' \times (R_I / R_T)^2$

and where $\Delta U'' = 0.01$ (referred to in BS EN ISO 6946 as correction level 1), R_I is the thermal resistance of the layer containing the gaps and R_T is the total resistance of the element. ΔU_g is therefore:

$\Delta U_g = 0.01 \times (1.904 / 3.439)^2 = 0.003$ W/m²K

U-value of the wall

The effect of air gaps or mechanical fixings should be included in the *U-value* unless they lead to an adjustment in the *U-value* of less than 3%.

$U = 1 / R_T + \Delta Ug$ (if ΔUg is not less than 3% of $1 / R_T$)

$U = 1 / R_T$ (if ΔUg is less than 3% of $1 / R_T$)

In this case $\Delta U_g = 0.003$ W/m²K and $1 / R_T = 0.291$ W/m²K. Since ΔU_g is less than 3% of $(1 / R_T)$,

$U = 1 / 3.439 = 0.29$ W/m²K.

Notes:

1. Since the cavity wall ties do not penetrate any insulation no correction need be applied to the *U–value* to take account of them.
2. In the above calculation it is assumed that the dwangs (or noggings) do not penetrate the whole of the insulation. If the dwangs (or noggings) do penetrate the whole of the insulation thickness they should be included as part of the timber percentage used in the calculation.

Appendix C: *U-values* of ground floors and basements

C1 A ground floor must not have a *U-value* exceeding 0.25 W/m²K, or 0.22 W/m²K for *dwellings* depending on the heating system, if the Elemental Method of compliance is to be used. This can normally be achieved without the need for insulation if the perimeter to area ratio is less than 0.15 m^{-1} for solid ground floors or less than 0.13 m^{-1} for suspended floors. For most *buildings*, however, some ground floor insulation will be necessary. For basement floors the standard Elemental *U-value* is also 0.25 W/m²K (or 0.22 W/m²K) but for basement walls it is 0.30 W/m²K (or 0.27 W/m²K). For exposed floors and for floors over unheated spaces the reader is referred to Appendix B.

C2 Full details about how to calculate the *U-value* of a ground floor, a basement floor or a basement wall are given in BS EN ISO 13370 and in CIBSE Guide Section A3 (1999 edition). This Appendix provides a summary of how to determine the *U-value* which will suffice for most common *constructions*.

C3 For ground floors and basements the *U-value* depends upon the type of soil beneath the building. Where the soil type is unknown, clay soil should be assumed as this is the most typical soil type in the UK. The tables which follow refer to this soil type. Where the soil is not clay or silt, the *U-value* should be calculated using the procedure in BS EN ISO 13370.

C4 Floor dimensions should be measured in accordance with J2. In the case of semi-detached or terraced premises, blocks of *flats* and similar, the floor dimensions can either be taken as those of the premises themselves, or of the whole *building*. When considering extensions to existing *buildings* the floor dimensions may be taken as those of the complete *building* including the extension.

C5 Care should be taken to avoid thermal bridging at the floor edge. See BRE Report BR262 “Thermal insulation: avoiding risks”.

C6 Unheated spaces outside the insulated fabric, such as attached garages or *porches*, should be excluded when determining the perimeter and area but the length of the wall between the heated *building* and the unheated space should be included when determining the perimeter.

C7 The following tables have been derived from BS EN ISO 13370. For the purposes of Part J it will be sufficient to derive the *U-values* from the tables using linear interpolation where necessary.

Amdt: September 2001

Appendix C

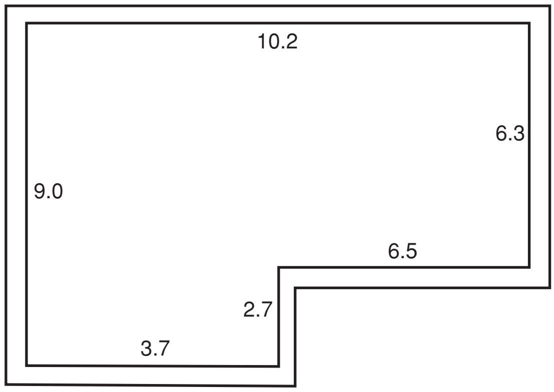
Example of how to obtain *U-values* from the tables

The following example serves as an illustration of how to use the tables supplied in this appendix, interpolating between appropriate rows or columns.

Example of the use of Table C.1 for a solid ground floor

A proposed *dwelling* has a perimeter of 38.4 m and a ground floor area of 74.25 m². The floor *construction* consists of a 150 mm concrete slab, 75 mm of rigid insulation (thermal conductivity 0.04 W/mK) and a 65 mm screed. Only the insulation layer is included in the calculation of the thermal resistance.

Figure C1



The perimeter to area ratio is equal to 38.4 ÷ 74.25 = 0.517 m^{-1}. Table C.1 provides values for perimeter/area ratios of 0.50 and 0.55 but not for any values between 0.50 and 0.55. In this case, the *U-value* corresponding to a perimeter to area ratio of 0.50 should be used since 0.517 is closer to 0.50 than to 0.55.

The thermal resistance of the insulation is obtained by dividing the thickness (in metres) by the conductivity. The resistance is then 0.075 ÷ 0.04 = 1.875 m^2K/W.

The relevant part of Table C1 is shown below:

	Thermal resistance (m^2K/W)	
Perimeter/Area	**1.5**	**2.0**
0.50	0.33	0.28

The *U-value* corresponding to a thermal resistance of 1.875 m^2K/W is obtained by linear interpolation as below:

$$U = 0.33 \times \frac{2.0 - 1.875}{2.0 - 1.5} + 0.28 \times \frac{1.875 - 1.5}{2.0 - 1.5}$$
$$= 0.33 \times 0.25 + 0.28 \times 0.75$$
$$= 0.29 \text{ W/m}^2\text{K}$$

The *U-value* of this ground floor is therefore **0.29 W/m²K.**

Note:

In the example for Table C.1 the appropriate row was chosen and interpolation was carried out between the appropriate columns. For all of the other tables, however, the appropriate column in the table should be selected and interpolation should be carried out between the appropriate rows.

Solid ground floors

Solid ground floors are taken to mean ground floors in which there is no significant air layer separating the *building* from the ground. Listed in the table below are *U-values* for solid ground floors. *U-values* are given in the following table for various perimeter-to-area ratios for a range of insulation levels. Where the floor is uninsulated the column corresponding to a thermal resistance of 0 should be used.

Table C1: *U-values* for solid ground floors (W/m²K)

	Thermal resistance of all-over insulation (m²K/W)				
Perimeter/Area	**0**	**0.5**	**1**	**1.5**	**2**
0.05	0.13	0.11	0.10	0.09	0.08
0.10	0.22	0.18	0.16	0.14	0.13
0.15	0.30	0.24	0.21	0.18	0.17
0.20	0.37	0.29	0.25	0.22	0.19
0.25	0.44	0.34	0.28	0.24	0.22
0.30	0.49	0.38	0.31	0.27	0.23
0.35	0.55	0.41	0.34	0.29	0.25
0.40	0.60	0.44	0.36	0.30	0.26
0.45	0.65	0.47	0.38	0.32	0.27
0.50	0.70	0.50	0.40	0.33	0.28
0.55	0.74	0.52	0.41	0.34	0.28
0.60	0.78	0.55	0.43	0.35	0.29
0.65	0.82	0.57	0.44	0.35	0.30
0.70	0.86	0.59	0.45	0.36	0.30
0.75	0.89	0.61	0.46	0.37	0.31
0.80	0.93	0.62	0.47	0.37	0.32
0.85	0.96	0.64	0.47	0.38	0.32
0.90	0.99	0.65	0.48	0.39	0.32
0.95	1.02	0.66	0.49	0.39	0.33
1.00	1.05	0.68	0.50	0.40	0.33

Note:
As an alternative to the above table, the methods described in BS EN ISO 13370 may be used.

Appendix C

Ground floors with edge insulation

Where horizontal or vertical edge insulation is used instead of all-over floor insulation, the *U-value* of the floor is adjusted by $\Psi \times P/A$ to account for the effects of edge insulation, where P/A is the perimeter (m) to area (m^2) ratio and Ψ is the edge insulation factor obtained from one of the following two tables:

Table C2: Edge insulation factor (Ψ) for horizontal edge insulation

Insulation width (m)	Thermal resistance of insulation (m^2K/W)			
	0.5	**1.0**	**1.5**	**2.0**
0.5	-0.13	-0.18	-0.21	-0.22
1.0	-0.20	-0.27	-0.32	-0.34
1.5	-0.23	-0.33	-0.39	-0.42

Table C3: Edge insulation factor (Ψ) for vertical edge insulation

Insulation depth (m)	Thermal resistance of insulation (m^2K/W)			
	0.5	**1.0**	**1.5**	**2.0**
0.25	-0.13	-0.18	-0.21	-0.22
0.50	-0.20	-0.27	-0.32	-0.34
0.75	-0.23	-0.33	-0.39	-0.42
1.00	-0.26	-0.37	-0.43	-0.48

Note:
As an alternative to the above table, the methods described in BS EN ISO 13370 may be used.

Uninsulated suspended ground floors

The following table gives *U-values* of uninsulated suspended floors for various perimeter to area ratios and for two levels of ventilation (expressed in m^2/m) below the floor deck. The data apply for the floor deck at a height not more than 0.5 m above the external ground level where the wall surrounding the underfloor space is uninsulated.

Table C4 *U-values* of uninsulated suspended floors

Perimeter to area ratio	Height of floor deck above ground level and ventilation opening area per unit perimeter of underfloor space (m^2/m) 0.0015 m^2/m	0.0030 m^2/m
0.05	0.15	0.15
0.10	0.25	0.26
0.15	0.33	0.35
0.20	0.40	0.42
0.25	0.46	0.48
0.30	0.51	0.53
0.35	0.55	0.58
0.40	0.59	0.62
0.45	0.63	0.66
0.50	0.66	0.70
0.55	0.69	0.73
0.60	0.72	0.76
0.65	0.75	0.79
0.70	0.77	0.81
0.75	0.80	0.84
0.80	0.82	0.86
0.85	0.84	0.88
0.90	0.86	0.90
0.95	0.88	0.92
1.00	0.89	0.93

Note:
As an alternative to the above table, the methods described in BS EN ISO 13370 may be used.

Insulated suspended floors

The *U-value* of an insulated suspended floor should be calculated using:

$$U = 1 / [(1/U_0) - 0.2 + R_f]$$

where U_0 is the *U-value* of an uninsulated suspended floor obtained using the above table or another approved method. R_f, the thermal resistance of the floor deck, is determined from U_f, the *U-value* of the floor deck, where

$$R_f = \frac{1}{U_f} - 0.17 - 0.17$$

and where U_f is calculated using the Combined Method, as described in BS EN ISO 6946, assuming thermal resistances of 0.17 m^2K/W for both the upper and lower surfaces of the floor deck.

Appendix C

Uninsulated basement floors

The *U-value* of an uninsulated basement floor must be calculated by using Table C5 below, or the methods described in BS EN ISO 13370.

Table C5 *U-values* of uninsulated basement floors

Perimeter to area ratio	Basement depth (m)				
	0.5	**1**	**1.5**	**2**	**2.5**
0.1	0.20	0.19	0.18	0.17	0.16
0.2	0.34	0.31	0.29	0.27	0.26
0.3	0.44	0.41	0.38	0.35	0.33
0.4	0.53	0.48	0.44	0.41	0.38
0.5	0.61	0.55	0.50	0.46	0.43
0.6	0.68	0.61	0.55	0.50	0.46
0.7	0.74	0.65	0.59	0.53	0.49
0.8	0.79	0.70	0.62	0.56	0.51
0.9	0.84	0.73	0.65	0.58	0.53
1.0	0.89	0.77	0.68	0.60	0.54

Insulated basement floors

Determine the *U-value* of an insulated basement floor from

$U = 1 / [(1/U_0) + R_{ins}]$

where U_0 is the *U-value* determined from Table C5 (or other approved method) for uninsulated basements and R_{ins} is the thermal resistance of the insulation in m^2K/W. The value of R_{ins} may be calculated from the thickness of the insulation divided by its conductivity.

Basement walls

Table C6 below provides the *U-value* of a basement wall for a given basement depth and basement wall resistance.

Table C6: *U-values* of basement walls

Basement wall resistance (m^2K/W)	Basement depth (m)				
	0.5	**1**	**1.5**	**2**	**2.5**
0.2	1.55	1.16	0.95	0.81	0.71
0.5	0.98	0.78	0.66	0.58	0.52
1.0	0.61	0.51	0.45	0.40	0.37
2.0	0.35	0.30	0.27	0.25	0.24
2.5	0.28	0.25	0.23	0.21	0.20

Appendix D: Thermal bridging at the edges of openings

Summary

D1 This Appendix gives a procedure for establishing whether:

- **a.** there is an unacceptable risk of condensation at the edges of openings; and/or
- **b.** the heat losses at the edges of openings are significant.

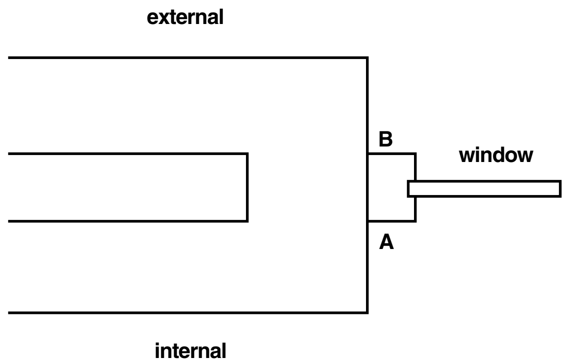
D2 The procedure involves the assessment of the minimum thermal resistance between inside and outside surfaces at the edges of openings. This requires identification of minimum thermal resistance paths, and calculation of their thermal resistance, taking into account the effect of thin layers such as metal lintels.

D3 These minimum thermal resistances are then compared with satisfactory performance criteria to see whether corrective action is indicated.

Minimum thermal resistance path

D4 The minimum thermal resistance path through a thermal bridge is that path from internal surface to external surface which has the smallest thermal resistance, R_{min}. Diagram D1 illustrates this for a section through a window jamb.

Diagram D1: Minimum thermal resistance path



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

D5 For details containing thin layers of thickness not exceeding 4 mm (such as metal lintels), a second modified calculation of minimum thermal resistance (R_{mod}) is made wherein the effective thermal conductivity of the thin layer is taken as the largest of 0.1 W/mK or the thermal conductivities of the materials immediately on either side of it. 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".

Appendix D

Risk of surface condensation

D6 The risk of surface condensation and mould growth at the edges of openings can be assumed to be negligible if:

a. for edges containing thin layers of thickness not exceeding 4 mm:
R_{min} (rounded to two decimal places) is at least 0.10 m^2K/W, and
R_{mod} (rounded to two decimal places) is at least 0.45 m^2K/W; or

b. for other edge designs:
R_{min} (rounded to two decimal places) is at least 0.20 m^2K/W.

Note:
These criteria do not apply to cases where internal surface projections are used to avoid surface condensation, e.g. curtain walling.

D7 In the event of an unacceptable risk being identified, marginal cases could be more rigorously analysed using numerical calculation methods, but in any case modification to improve the design should be considered.

Additional heat loss

D8 For the purposes of Part J, the additional heat losses at the edges of openings may be ignored if:

a. for edges containing thin layers of thickness not exceeding 4 mm,
R_{mod} (rounded to two decimal places) is at least 0.45 m^2K/W, or

b. for other edge designs:
R_{min} (rounded to two decimal places) is at least 0.45 m^2K/W.

Compensating for additional heat loss

D9 Where the additional heat losses around the edges of openings cannot be ignored they can be taken into account in calculations as follows:

a. for *dwellings* the Target *U-value* method could be used with the average *U-value* increased by the following amount:

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

b. for other *buildings* the calculation procedure could be used with the rate of heat loss from the proposed *building* increased by the following amount:

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

c. compensating measures, such as reducing the *U-value* of one of the *building* elements, should then be incorporated so that:

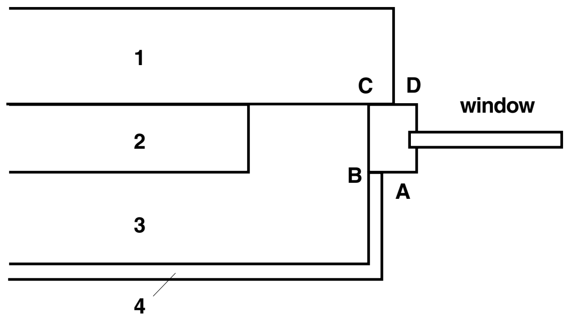
i. for *dwellings*, the average *U-value* does not exceed the Target *U-value*, or

ii. for other *buildings*, the rate of heat loss from the proposed *building* does not exceed that of the notional *building*.

Example

Diagram D2 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 ABCD is the minimum resistance path.

Diagram D2 70mm cavity wall showing window jamb with blockwork returned at the reveal



Note: Numbers denote regions in Table D1 below.

Table DI: Thermal conductivity of materials in Diagram D2

Region	Material	Conductivity (W/m·K)
1	Brick outer leaf	0.77
2	Insulation	0.035
3	Medium weight concrete block inner leaf	0.61
4	Lightweight plaster	0.16

Calculation of R_{min}

Using the thermal conductivities from Table Dl, Table D2 gives the resistance **R** for each segment of the path ABCD. **R** for each segment is obtained by dividing the length of the path segment in metres by its thermal conductivity in W/mK. R_{min} is the sum of the resistances of each path segment.

Avoidance of the risk of surface condensation and mould growth

Referring to paragraph D6, R_{min} in this example is greater than 0.20 m^2K/W and so the risk of surface condensation and mould growth is acceptably low.

Table D2: Thermal resistance path in Diagram D2

Path segments	Length (m)	Conductivity (W/m·K)	R (m^2K/W)
AB	0.015	0.16	0.094
BC	0.070	0.61	0.115
CD	0.023	0.77	0.177
		Minimum Resistance R_{min} =	0.386

Additional heat loss at the edge detail

Referring to paragraph D8, R_{min} in this example is less than 0.45 m^2K/W, and so the additional heat loss at this edge should not be ignored.

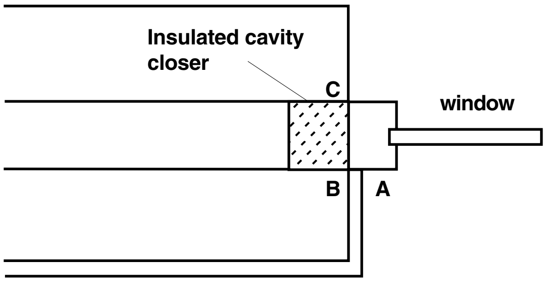
Amdt: September 2001

Appendix D

Improving the edge design

Instead of returning the blockwork at the reveal the cavity could be closed using an insulated cavity closer, as in Diagram D3.

Diagram D3 Window jamb showing cavity closed with an insulated cavity closer



The revised calculation of the minimum resistance is shown in Table D3. $\mathbf{R_{min}}$ is now greater than 0.45 m^2K/W and so the additional heat loss can be ignored.

Table D3 Minimum resistance path with insulated cavity closer

Path segments	Length (m)	Conductivity (W/m·K)	R (m^2K/W)
AB	0.015	0.16	0.094
BC	0.070	0.04	1.750
		Minimum resistance R_{min} =	1.844

Alternative method

D10 A heat loss factor for a particular detail could be obtained by a numerical method and used to modify the calculation of the average *U-value* or the total rate of heat loss. A calculation procedure for deriving such loss factors is given in BRE IP 12/94: "Assessing condensation risk and heat loss at thermal bridges around openings".

Appendix E: Determining *U-values* of windows, doors and roof windows in the Elemental Method

Within the Elemental Method of compliance it is permissible to have windows, doors or roof windows with *U-values* that exceed the standard Elemental *U-values* provided that the average *U–value* of all of the windows, doors and roof windows taken together does not exceed 2.0 (or 1.8 W/m²K in the case of *dwellings*, depending on the heating system). The following example illustrates how this can be done.

Example

A semi-detached house is to have a total window area of 16.9 m² (including frames) and a total door area of 3.8 m². It is proposed to use solid wooden doors with a *U-value* of 3.0 W/m²K. In order to use the Elemental Method, the additional heat loss due to the use of solid timber doors must be compensated for by lower *U-values* in the windows and/or roof windows so that the average *U-value* of openings does not exceed 2.0 W/m²K.

Windows with a *U-value* of 1.7 W/m²K can achieve this requirement, as shown in the following table and subsequent calculation:

Table to Part J Appendix E: Average *U-value* calculation

Element	Area (m²)	*U-value* (W/m²K)	Rate of heat loss per degree (W/K)
Windows	16.9	1.7 [Note 1]	28.73
Doors	3.8	3.0	11.4
Roof windows	0.9	1.9 [Note 1]	1.71
Total	21.6		41.84

Note:

1. These *U-values* correspond to double *glazed* windows or roof windows with a wood or PVC-U frame, with a 16 mm argon-filled space between the panes and a soft low-emissivity coating on the glass. Note that although the windows and roof windows have the same design the roof window *U-value* is 0.2 W/m²K higher than the window *U-value*.

This gives an average *U-value* of 41.84 ÷ 21.6, or 1.94 W/m²K, which is below 2.0 W/m²K. The windows, doors and roof windows therefore satisfy the requirements of the Elemental Method.

Appendix F: Examples illustrating the use of the Target *U-value* Method

F1 For a *building* in purpose group 1 with a heating system based on a gas or oil boiler, the Target *U-value* is given by

$$U_T = [0.30 - 0.14(A_R/A_T) - 0.05(A_{GF}/A_T) + 0.425(A_F/A_T)]$$

where U_T is the target *U-value* prior to any adjustment for heating system performance or solar gain, A_R is the exposed roof area, A_{GF} is the ground floor area, A_F is the total floor area (all storeys) and A_T is the total area of exposed elements (including the ground floor).

F2 A dwelling can comply by the Target *U-value* Method if the Target *U-value* is not less than the average *U-value*, where the average *U-value* is defined as the area-weighted average *U-value* of all *exposed building* elements of the *dwelling*. *Exposed* elements here include walls, roofs, floors, windows and doors, including elements adjacent to unheated spaces.

Example 1 – A semi-detached dwelling

F3 The following table gives the proposed surface areas and U-values. It is proposed to adopt the Target U-value method with the U-value of the walls a little higher (i.e. poorer) than would be required in the Elemental method. The walls are to have a U-value of 0.35 W/m²K. The area of windows and doors is equal to 25% of the total internal floor area and the efficiency of the gas boiler is 85%. The total area of North-facing glazed openings is 6.82 m² and the total area of South-facing glazed openings is 8.88 m². The windows are wood-framed.

Figure F.1: Plans of the semi-detached house

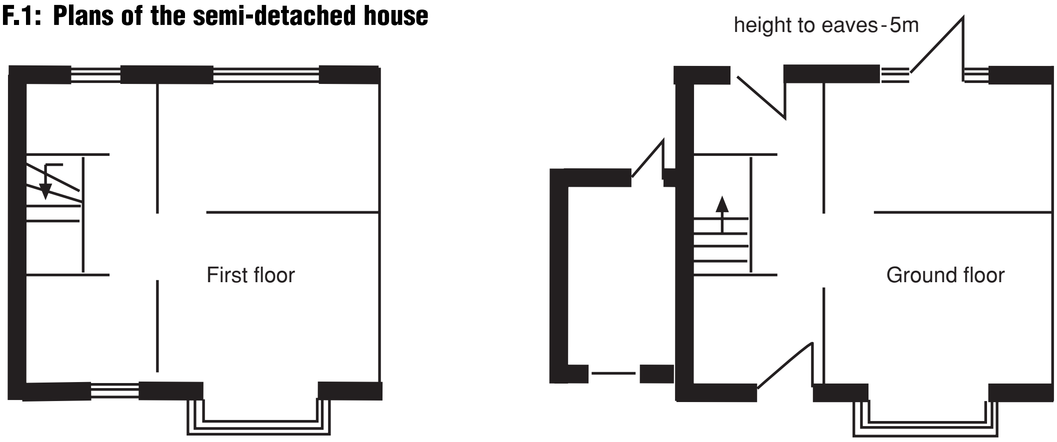


Table F1: Data for the semi-detached house

Exposed element	Exposed surface area	U-value	Rate of heat loss per degree
wall	80.3	0.35	28.10
roof	44.4	0.20	8.88
ground floor	44.4	0.25	11.10
windows	18.4	2.2	40.48
doors	3.8	2.2	8.36
Total	**191.3**	**-**	**96.92**

F4 The Target U-value is

$$U_T = [0.30 - 0.14(44.4/191.3) - 0.05(44.4/191.3) + 0.425(88.8/191.3)] = 0.453$$

Since the proposed boiler SEDBUK is greater than the reference boiler SEDBUK the Target *U-value* is not adjusted for boiler efficiency.

F5 Since the area of glazed openings on the South elevations exceeds that on the North, the benefit of solar heat gains can be taken into account to ease the target *U-value* by adding ΔS to the target *U-value*, where: -

$\Delta S = 0.04 \times [(A_S - A_N) / A_{TG}]$

and A_S = Area of glazed openings facing south; A_N = Area of glazed openings facing north;
A_{TG} = Total area of all glazed openings in the building;

So 0.04 x [(8.88 - 6.82) / 18.4], or 0.004, is added to the Target *U-value*, giving a Target *U-value* of 0.457 W/m²K.

F6 The average *U-value* is given by:

$$U_{avg} = \frac{\text{Total rate of heat loss per degree}}{\text{Total external surface area}}$$

These values are calculated in the above table, and in this case the average *U-value* is:

$$U_{avg} = \frac{96.92}{191.3} = 0.507 \text{ W/m}^2\text{K}$$

Since the average *U-value* is greater than the target *U-value* the proposed design does not meet the requirements and modifications must be made to the design. The Target *U-value* method may still be used, however, if the average *U-value* is reduced.

F7 A number of ways of modifying the proposed design in order to comply with the Target U-value Method are described below:

a) Reducing the total area of the windows and doors

If the total area of windows and doors is reduced from 25% of the floor area to 19% of the floor area the average *U-value* will be reduced by (6% of 88.8) × (2.2 – 0.35) / 191.3, or 0.052 W/m²K, which is sufficient to reduce the average *U-value* to below the Target *U-value*.
Average *U-value* = 0.507 – 0.052 = 0.455 W/m²K
Since the final average U-value is less than the final Target *U-value*, compliance with the Target *U-value* Method is achieved.

b) Specifying windows and doors with lower *U-values*.

Using windows and doors with a *U-value* of 1.7 W/m²K instead of 2.2 W/m²K will reduce the average *U-value* by [(2.2 – 1.7) × (18.4 + 3.8) / 191.3], or 0.058 W/m²K. This is sufficient to reduce the average *U-value* to below the Target *U-value*. Reducing the window *U-value* to 1.71 W/m²K is therefore sufficient to achieve compliance.

Average *U-value* = 0.507 – 0.058 = 0.449 W/m²K

Since the final average *U-value* is less than the final Target *U-value*, compliance with the Target *U-value* Method is achieved.

Example 2 – A detached *house*

F8 Consider the example in Figure F.2 which has details as given in the following table. It is proposed to adopt the Target *U-value* approach with the walls having a *U-value* of 0.35W/m²K. To compensate for this the floor *U-value* is reduced to 0.15 W/m²K, the roof *U-value* is reduced to 0.16 W/m²K and the window *U-value* is reduced to 1.7 W/m²K. The SEDBUK efficiency of the boiler is not less than the reference SEDBUK efficiency.

Figure F.2: Plans of the detached *house*

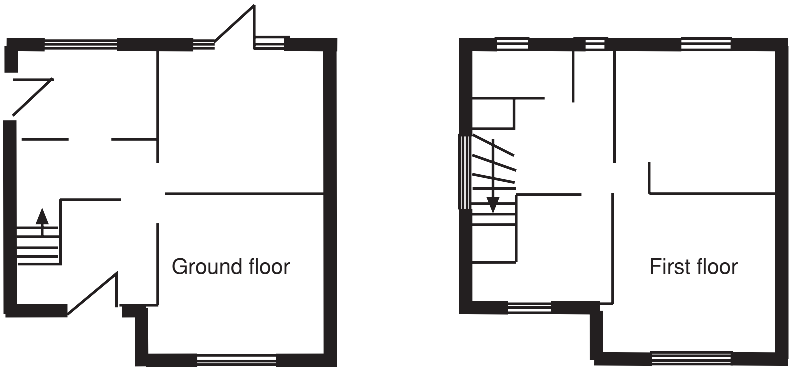


Table F2: Data for the detached *house*

Exposed element	Exposed surface area	*U-value*	Rate of heat loss per degree
wall	123.0	0.35	43.05
roof	52.0	0.16	8.32
ground floor	52.0	0.15	7.80
windows & glazed doors*	24.1	1.7	40.97
solid doors	1.9	3.0	5.7
Total	**253.0**		**105.84**

*this includes 7.0 m^2 of North facing glazing and 8.9 m^2 of South facing glazing

F9 The Target *U-value* is where:
$\mathbf{U_T = [0.30 - 0.14(A_R/A_T) - 0.05(A_{GF}/A_T) + 0.425(A_F/A_T)]}$
Then in this example
$U_T = [0.30 - 0.14(52/253) - 0.05(52/253) + 0.425(104/253)] = 0.436$ W/m²K.
No adjustment to the Target *U-value* for efficiency is applied since the heating system efficiency is not less than the base SEDBUK efficiency.

F10 Since the area of glazed openings on the South elevations exceeds that on the North, the benefit of solar heat gains can be taken into account to ease the target *U-value* by adding ΔS to the target *U-value*, where: -
$\mathbf{\Delta S = 0.04 \times [(A_S - A_N) / A_{TG}]}$
and A_S = Area of glazed openings facing south; A_N = Area of glazed openings facing north;
A_{TG} = Total area of all glazed openings in the building;

F11 The adjustment to the Target *U-value* for solar gains is:

$0.04 \times [(8.9 - 7.0) / 24.1] = 0.003$ W/m²K

This gives a final Target *U-value* of 0.436 W/m²K + 0.003 W/m²K, or 0.439 W/m²K.

F12 The average *U-value* is given by the following ratio:

$$\mathbf{U_{avg}} = \frac{\text{Total rate of heat loss per degree}}{\text{Total external surface area}}$$

For this example, therefore, the average *U-value* is

$$U_{avg} = \frac{105.8}{253.0} = 0.418 \text{ W/m}^2\text{K}$$

Since the average *U-value* is less than the Target *U-value* , the proposed design meets the requirements

Appendix G: Example SAP Energy Ratings and Carbon Indexes

THE SAP ENERGY RATING AND THE CARBON INDEX

The SAP energy rating method is the Government's chosen method for producing an energy cost rating for a *dwelling*, based on calculated annual energy cost for space and water heating, assuming a standard occupancy pattern, derived from the measured floor area of the *dwelling*, and a standard heating pattern. The Carbon Index is derived from the SAP procedure, but measures the annual carbon output of the heating system and fuel selected. Both the SAP rating and the Carbon Index (CI) are adjusted for floor area so that the size of the *dwelling* does not affect the results, which are expressed on a scale of SAP rating 1 to 120 and CI 0.0 to 10.0: the higher the number the better the standard.

The full procedure is described in "The Government's Standard Assessment Procedure for energy rating of *dwellings* - 2001 edition" (SAP 2001), published by the Building Research Establishment (BRE). This sets out the method of calculating the SAP rating and the CI in the form of a worksheet, accompanied by a series of tables. A calculation may be carried out by completing, in sequence, the numbered boxes in the worksheet, using the data in the tables as indicated. Alternatively, and more usually, a computer program approved for SAP/CI calculations by BRE may be used.

THE SAP ENERGY RATING, THE CARBON INDEX AND THE BUILDING REGULATIONS

The Building (Procedure) (Scotland) Regulations 1981, as amended in 1997, require all new *dwellings* to have an energy rating calculated in accordance with the Government's Standard Assessment Procedure (SAP). There is no requirement to achieve a particular level of SAP rating but the rating must be notified to the local authority. SAP ratings no longer form part of the Technical Standards for compliance with the Building Standards Regulations, but instead achievement of a specified CI is one of the ways of complying with Part J.

The following apply when calculating SAP ratings for Building Procedure Regulations purposes and the CI for Building Standards Regulations purposes -

1. The data used in calculations should be obtained from the tables in SAP 2001. The fuel cost data (for the SAP rating) will be revised in future editions.

2. When the final heating system is unknown, the SAP energy rating notified to the building control body must be calculated assuming a main system of electric *room* heaters and a secondary system of electric heaters, both systems using on-peak electricity.

3. When undertaking SAP energy rating calculations for designs not intended for specific *construction* sites (e.g. type designs) the following assumptions should be made -
   a. two sides of the *dwelling* will be sheltered; and
   b. the windows, doors and roof windows are all on the east and west elevations; and
   c. the solar access factor is 1.0 (average).

4. The rules in 1-3 above apply also when calculating the carbon index.

5. Where a housing development involves large numbers of *dwellings* it is acceptable for the worst case in that development to be identified and for a SAP energy rating to be calculated for that *dwelling* only.

Appendix G

Example 1 – Two bedroom mid-terrace *house*

Diagram G1 Plans of the two bedroom mid-terraced *house*

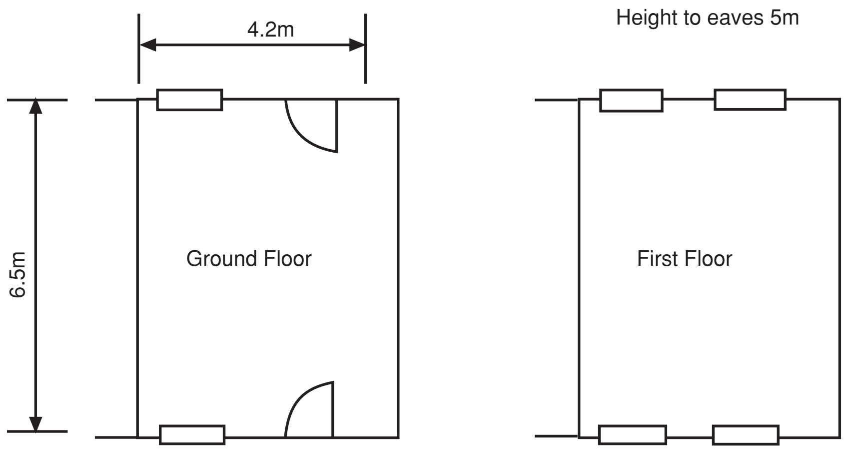


Table G1 Data for the two bedroom mid-terrace *house* with conventional gas boiler

***Construction* element**	**Description**	**Area**	***U-value***
Wall	Brick/cavity/dense block with 130 mm blown fibre cavity insulation	30.3	0.30
Roof	Pitched roof, 100 mm insulation between joists, 160 mm on top	27.3	0.16
Ground floor	Suspended timber, 115 mm insulation	27.3	0.25
Windows and doors	Double glazed low-E, wooden frame	13.7	2.0
Heating	Central heating with conventional gas boiler (efficiency 78%)		
		SAP energy rating =	**91**
		CI =	**8.2**

Example 2 – Three bedroom semi-detached *house*

Diagram G2 Plans of the three bedroom semi-detached *house*

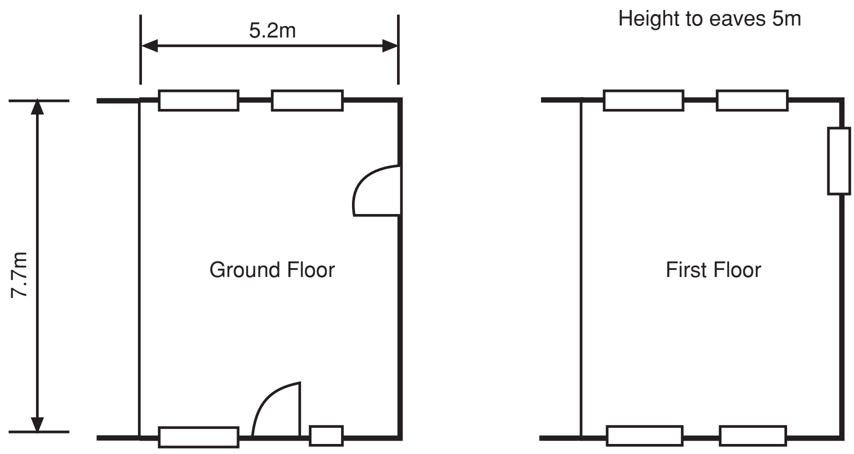


Table G2 Data for the three bedroom semi-detached *house* with gas condensing boiler

***Construction* element**	**Description**	**Area**	***U-value***
Wall	Brick/cavity/dense block with 130 mm blown fibre cavity insulation	72.5	0.30
Roof	Pitched roof, 100 mm insulation between joists, 160 mm on top	40	0.16
Ground floor	Solid concrete, 60 mm insulation	40	0.25
Windows and doors	Double *glazed*, low-E, PVC-U frame	20.0	2.0
Heating	Central heating with gas condensing boiler (efficiency 85%)		
		SAP energy rating =	**99**
		CI =	**8.3**

Appendix G

Example 3 – Three bedroom semi-detached *house*

Diagram G3 Plans of three bedroom semi-detached *house*

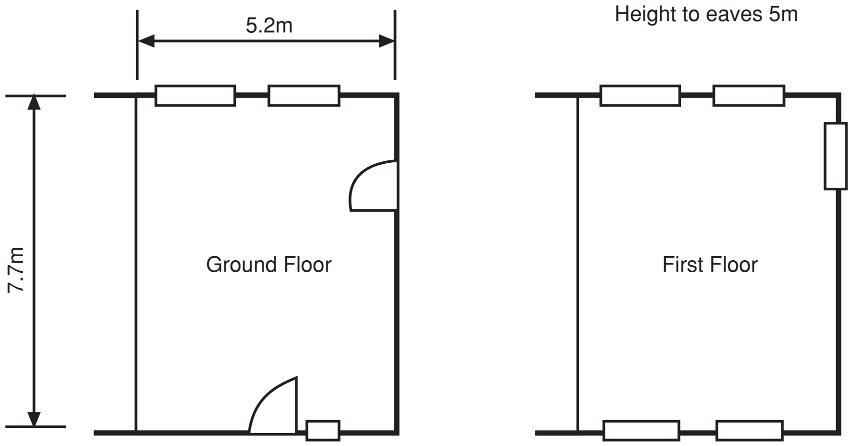


Table G3 Data for three bedroom semi-detached *house* with gas condensing boiler

***Construction* element**	**Description**	**Area**	***U-value***
Wall	Brick/cavity/dense block with 130 mm blown fibre cavity insulation	72.5	0.30
Roof	Pitched roof, 100 mm insulation between joists, 160 mm on top	40	0.16
Ground floor	Solid concrete, 60 mm insulation	40	0.25
Windows and doors	Double *glazed*, low-E, PVC-U frame	20.0	2.0
Heating	Central heating with gas condensing boiler (efficiency 85%)		
		LPG	**Gas**
	SAP energy rating =	**72**	**99**
	CI =	**7.4**	**8.3**

Example 4 – Four bedroom detached *house*

Diagram G4 Plans of four bedroom detached *house*

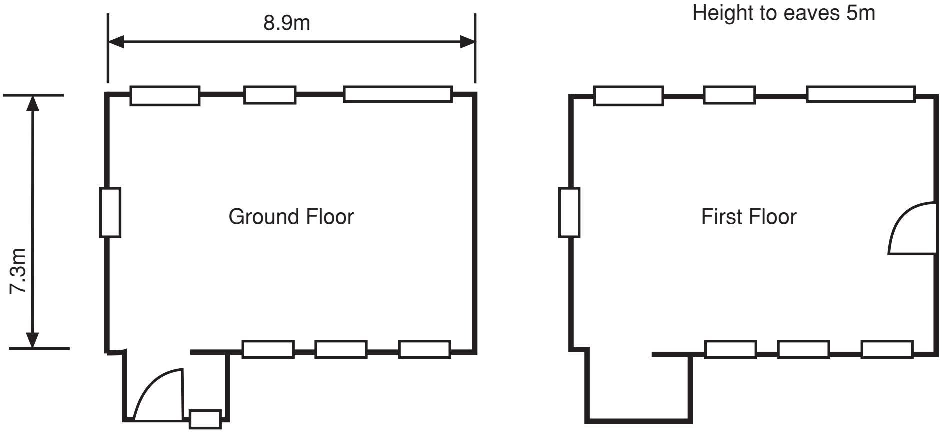


Table G4 Data for the four bedroom detached *house* with gas condensing boiler

***Construction* element**	**Description**	**Area**	***U-value***
Wall	Brick/partial cavity fill/medium density block with insulated plasterboard	116.5	0.30
Roof	Pitched roof, 100 mm insulation between joists, 160 mm on top	50	0.16
Ground floor	Suspended timber, 150 mm insulation	50	0.25
Windows and doors	Double *glazed* low-E, wood frame	25	2.0
Heating	Central heating with gas condensing boiler (efficiency 89%)		
		SAP energy rating =	**100**
		CI =	**8.2**

Appendix G

Example 5 – Two bedroom bungalow

Diagram G5 Plan of the two bedroom bungalow

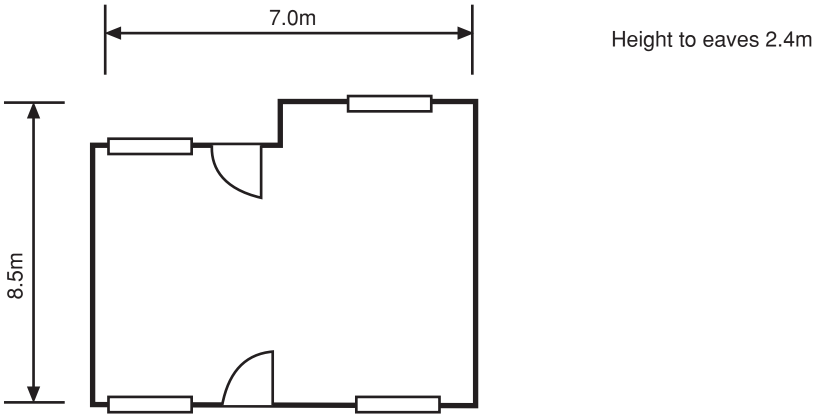
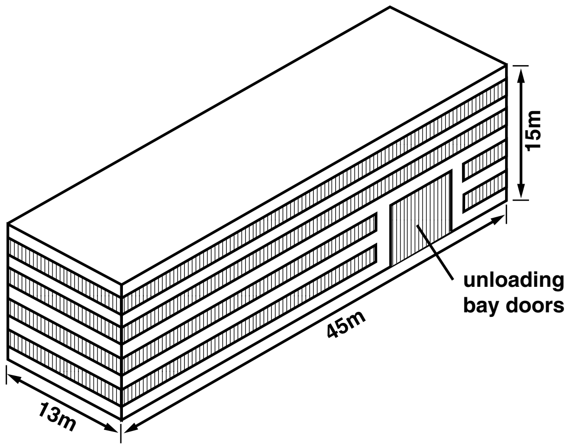


Table G5 Data for the two bedroom bungalow with gas condensing boiler

***Construction* element**	**Description**	**Area**	***U-value***
Wall	Brick/cavity/aerated concrete block with insulated plasterboard	64.2	0.30
Roof	Pitched roof, 100 mm insulation between joists, 160 mm on top	56.7	0.16
Ground floor	Concrete suspended beam and medium density, 70 mm insulation	56.7	0.25
Windows and doors	Double *glazed*, low-E, PVC-U frame	14.2	2.0
Heating	Central heating with gas condensing boiler (efficiency 87%)		
		SAP energy rating =	**92**
		CI =	**8.2**

Appendix H: Examples illustrating the use of the Heat Loss Method

A detached, four storey office *building* 45 metres × 13 metres in plan and height 15 metres is to be constructed with *glazing* occupying 48% of the *external wall* area, using windows with a measured *U–value* of 2.0 W/m²K. No rooflight *glazing* is proposed. The remaining *exposed* walls and the roof are to have *U-values* of 0.30 W/m²K and 0.20 W/m²K respectively, with the ground floor being insulated with 65 mm expanded polystyrene with thermal resistance of all-over floor insulation 1.76 m²KW, giving a *U-value* of 0.20 W/m²K (Appendix C).



Proposed *building*

Step 1 Calculate the areas of each *building* element:

area of roof (45 × 13)	=	585 m²
area of elevations (45 + 45 + 13 + 13) × 15	=	1740 m²
area of windows (48% of 1740 m²)	=	835 m²
area of personnel doors	=	14 m²
area of vehicle unloading bay doors	=	27 m²
area of *exposed* wall (1740 - 835 - 14 - 27)	=	864 m²
area of floor (45 × 13)	=	585 m²

Step 2 Calculate the rate of heat loss from the proposed *building* as follows:

***Building* element**	**Area (m^2)**	***U-value* (W/m^2K)**	**Rate of heat loss (W/K)**
Roof	585	0.20	117.0
Exposed walls	864	0.30	259.2
Windows	835	2.0	1670.0
Personnel doors	14	2.0	28.0
Vehicle loading bay doors	27	0.70	18.9
Ground floor	585	0.20	117.0
Total rate of heat loss			**2210.1**

Notional *building*

The area of openings in the proposed *building* is more than the basic allowance in the table to J7.4. So the basic area allowance of 40% of *exposed* wall area for windows and 20% of roof area for roof windows should be assumed for the notional *building*.

Step 1 Calculate the areas of each *building* element:

area of rooflights (20% of 585 m^2)	=	117 m^2
area of roof (45 × 13) -117	=	468 m^2
area of elevations (45 + 45 + 13 + 13) × 15	=	1740 m^2
area of windows and personnel doors (40% of 1740 m^2)	=	696 m^2
area of vehicle unloading bay doors	=	27 m^2
area of *exposed* wall (1740 - 696 - 27)	=	1017 m^2
area of floor (45 × 13)	=	585 m^2

Step 2 Calculate the rate of heat loss from the notional *building* as follows:

***Building* element**	**Area (m^2)**	***U-value* (w/m^2k)**	**Rate of heat loss (w/k)**
Rooflights	117	2.0	234.0
Roof	468	0.25	117.0
Exposed walls	1017	0.30	305.1
Windows and personnel doors	696	2.0	1392.0
Vehicle loading bay doors	27	0.7	18.9
Ground floor	585	0.25	146.25
Total rate of heat loss			**2213.25**

The rate of heat loss from the proposed *building* is less than that from the notional *building* and therefore the requirements of Part J are met.

Appendix J: Example lighting calculations

J1 Lighting calculation procedure to show that 95% of installed circuit power is comprised of lamps listed in the table to (J12.1)a.

A new hall and changing *rooms* are to be added to an existing community centre. The proposed lighting scheme incorporates lamps that are listed in the table to (J12.1)a. 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 overall installed capacity of the lighting installation.

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 metres above the floor. On plan, the furthest light is 20.5 metres from its switch, which is less than three 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 the six 50 W tungsten halogen downlighters noted above.

Calculation

A schedule of light fittings is prepared as follows:

Table J1 Schedule of light fittings

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

The percentage of circuit Watts consumed by lamps not listed in the table to (J12.1)a.:

$$= \frac{330 \times 100}{7534} = 4.4\%$$

Therefore, more than 95% of the installed lighting capacity, in circuit Watts, is from light sources listed in the table to (J12.1)a. The switching arrangements comply with J12.3. The proposed lighting scheme therefore meets the requirements of Part J.

Appendix J

J2 Lighting calculation procedure to show average circuit efficacy complies with (J12.1)b.

A lighting scheme is proposed for a new public house comprising a mixture of concealed perimeter lighting using high frequency fluorescent fittings and supplementary compact fluorescent lamps in the dining area. Lights in the dining and lounge areas are to be switched locally from behind the bar. Lighting to kitchens and toilets is to be switched locally.

Table J2 shows a schedule of the light sources proposed together with the calculation of the overall average circuit efficacy.

Table J2 Schedule of light fittings

Position	Number	Description	Circuit Watts (W) per lamp	Lumen output (lm) per lamp	Total circuit Watts (W)	Total lamp lumen output (lm)
Over tables	20	11 W compact fluorescent	16	900	320	18,000
Concealed perimeter and bar lighting	24	32 W T8 fluorescent high frequency ballast	36	3300	864	79,200
Toilets and circulation	6	18 W compact fluorescent with mains frequency ballast	23	1200	138	7,200
Kitchens	6	50 W, 1500 T8 fluorescent with high frequency ballast	56	5200	336	31,200
				Totals	**1658**	**135,600**

From Table J2, the total lumen output of the lamps in the installation is 135,600 lumens.

The total circuit Watts of the installation is 1658 Watts.

Therefore, the average circuit efficacy is:

$$= \frac{135{,}600}{1658} = 81.8 \text{ lumens/Watt}$$

The proposed lighting scheme therefore meets the requirements of Part J.

Note: If 60 W tungsten lamps were used in the dining area instead of the 11 W compact fluorescent lamps actually proposed, the average circuit efficacy would drop to 51.9 lumens/W, which would not be sufficient to comply with Part J.

Appendix K: Performance assessment methods for office *buildings*

K1. Assessing the contribution to carbon emissions due to building services design and operation

The efficiencies of *buildings*, and of the services systems that produce the indoor conditions required by occupants, can be compared provided that a consistent system is used to describe the *buildings* and their energy use.

Applying such a consistent approach to *buildings* of purpose group 3 has allowed energy consumption benchmarks to be developed with which the performance of existing *buildings*, or the likely performance of new designs, can be compared. The benchmarks result from information obtained from surveys of operational *buildings*, and are included in DETR's Energy Consumption Guide 19 "Energy use in offices" (ECON 19), available from BRECSU tel. 01923 664258.

K1.1 Performance benchmarks

The information contained in ECON 19 provides benchmarks for the energy consumed by air conditioning and mechanical ventilation (ACMV), heating and lighting services, together with benchmark information describing the hours of use of the equipment. Benchmarks also describe the energy consumed by the additional equipment necessary to support use of the *building* for typical office activities. The benchmarks refer to *buildings* of *purpose group* 3 described as representing 'typical' and 'good practice' for the sector.

K1.2 Design assessment

The annual energy likely to be consumed by a particular service can be estimated as the product of the total installed input power rating of the plant installed to provide the service and the annual hours of use of that plant at the equivalent of full load. The annual hours of use can be considered to be the result of combining a benchmark value for the 'typical' hours of use of the service with a management factor that acts to reduce or increase this value. The management factor is a number related to the provisions that the design incorporates that have the potential to help the occupier control and manage the use of the plant.

The Carbon Performance Index (CPI) referred to in Section K2 is a technique for assessing the likely performance of *building* services systems using this design information. It uses benchmarks consistent with ECON19 and is intended to estimate the potential for efficient operation of *building* services systems using information available at the design or *construction* stage.

Appendix K

K1.3 Performance assessment

The inclusion of meters improves the confidence with which occupiers may assess their *buildings*' performance by estimating the energy consumed by servicing plant and the additional equipment required for the full operation of the *building*.

K1.3.1 A technique of estimating and measuring operational energy consumption, and comparing the achieved performance of *buildings* with the ECON19 benchmarks, has been developed to assess the achieved performance of *buildings* of *purpose group* 3. This method is described in CIBSE Technical Memoranda TM22 "Energy Assessment and Reporting Methodology: Office Assessment Method".

K1.3.2 A means of comparing the design of services with benchmarks of installed load and energy use is described in CIBSE Guide "Energy Efficiency in Buildings", 1998.

K1.3.3 The results of ongoing performance assessment could be used to provide valuable information from which to maintain and improve performance benchmarks, and hence the CPI method, and to inform the design process.

K2 The carbon performance index (CPI)

K2.1 The CPI for mechanical ventilation - $CPI_{(MV)}$

The assessment is based on the calculation of a Carbon Performance Index using the following relationship:

$$CPI_{(MV)} = \frac{MV}{(PD \times HD \times CD \times FD)}$$

Where the value of the factor **MV = 800** has been set so that the design is considered to represent acceptable practice where the result of the calculation is 100 or greater.

For the system installed to provide mechanical ventilation, the factors **PD**, **HD**, **CD** and **FD** are as defined below:

PD is the total installed capacity (sum of the input kW ratings) of the fans installed to provide mechanical ventilation divided by the relevant treated area (square metres);

HD is the typical annual equivalent hours of full load operation, and is taken as 3 700 hours per year;

CD is the conversion factor relating the emissions of carbon to the fuel used, here electricity, in kgC/kWh. (Table K 0);

FD is a factor which depends on the provisions that are made to control and manage the installed plant and which could act to improve the annual efficiency of the plant above that of the typical installation, or to reduce the effective annual hours of use. (See Table K1)

K2.2 The CPI for air conditioning - $CPI_{(ACMV)}$

The assessment is based on the calculation of a Carbon Performance Index using the following relationship:

$$CPI_{(ACMV)} = \frac{ACMV}{(PD \times HD \times CD \times FD) + (PR \times HR \times CR \times FR)}$$

The value of the factor **ACMV = 1200** has been set so that the design is considered to represent acceptable practice where the result of the calculation is 100 or greater.

For the distribution system transferring cooled medium to the conditioned spaces, the factors **PD**, **HD**, **CD** and **FD** are as defined below:

PD is the total installed capacity (sum of the input kW ratings) of the fans and pumps installed to distribute air and/or cooled media around the *building* divided by the relevant treated area (square metres);

HD is the typical annual equivalent hours of full load operation, and is taken as 3 700 hours per year;

CD is the conversion factor relating the emissions of carbon to the fuel used, here electricity, in kgC/kWh. (Table K 0);

FD is a factor which depends on the provisions that are made to control and manage the installed plant and which could act to improve the annual efficiency of the plant above that of the typical installation, or to reduce the effective annual hours of use. (See Table K2).

For the refrigeration system, the factors **PR**, **HR**, **CR** and **FR** are as defined below:

PR is the total installed capacity (sum of the input kW ratings) of the plant installed to provide the cooling or refrigeration function divided by the relevant treated area (square metres);

HR is the typical annual equivalent hours of full load operation of the refrigeration plant, and is taken as 1 000 hours per year;

CR is the conversion factor relating the emissions of Carbon to the fuel used, here most frequently electricity, sometimes gas, in kgC/kWh, from Table K 0 below;

FR is a factor which depends on the provisions that are made to control and manage the installed plant and which could act to improve the annual efficiency of the plant above that of the typical installation, or to reduce the effective annual hours of use. (See Table K3).

Table K 0: Carbon emission factors

Delivered energy	Carbon emission factor (kgC/kWh)
Gas	0.053
Oil	0.074
Coal	0.086
Electricity (average)	0.139

K2.3 Plant control and management factors

Tables K1, K2 and K3 below itemise a number of control and management features which could act to improve the annual efficiency of the relevant plant above that of the typical installation, or to reduce the effective annual hours of use. Values to be associated with each feature are obtained from column A, B or C as appropriate and the resultant factor is obtained by multiplying together all of the individual values obtained. Values are selected from columns A, B and C of the table depending on the extent to which facilities for monitoring and reporting are provided, as follows:

Column C No monitoring provided.
Column B Provision of energy metering of plant and/or metering of plant hours run, and/or monitoring of internal temperatures in zones.
Column A Provision as B above, plus the ability to draw attention to 'out of range' values.

Table K1: To obtain factor (FD) for the air distribution system

Plant management features	Values		
	A	B	C
i. Operation in mixed mode with natural ventilation	0.85	0.9	0.95
ii. Controls which restrict the hours of operation of distribution system	0.9	0.93	0.95
iii. Efficient means of controlling air flow rate	0.75	0.85	0.95
Column product (FD)			

The plant management features for Table K1 are more fully described below:

i. Mixed mode operation available as a result of including sufficient openable windows to provide the required internal environment from natural ventilation when outdoor conditions permit. This may only apply where the perimeter zone is greater than 80% of the treated floor area.

ii. Control capable of limiting plant operation to occupancy hours with the exceptions noted below in which operation outside the hours of occupancy forms a necessary part of the efficient use of the system:
for control of condensation,
for optimum start/stop control, or
as part of a 'night cooling' strategy.

iii. Air flow rate controlled by a variable motor speed control which efficiently reduces input power at reduced output; variable pitch fan blades. (damper, throttle or inlet guide vane controls do not attract this factor).

Table K2: To obtain factor (FD) for the cooling distribution system

Plant management features	Values		
	A	B	C
i. Operation in mixed mode with natural ventilation	0.85	0.9	0.95
ii. Controls which restrict the hours of operation of distribution system	0.9	0.93	0.95
iii. Efficient means of controlling air flow rate	0.75	0.85	0.95
Column product (FD)			

The plant management features for Table K2 are more fully described below:

i. Mixed mode operation available as a result of including sufficient openable windows to provide the required internal environment from natural ventilation when outdoor conditions permit. This may only apply where the perimeter zone is greater than 80% of the treated floor area. This factor is credited only where interlocks are provided to inhibit the air conditioning supply in zones with opened windows.

ii., iii. are as described in Table K1 above for mechanical ventilation.

Table K3: To obtain factor (FR) for the refrigeration plant

Plant management features	Values		
	A	B	C
i. Free cooling from cooling tower	0.9	0.93	0.95
ii. Variation of fresh air using economy cycle or mixed mode operation	0.85	0.9	0.95
iii. Controls to restrict hours of operation	0.85	0.9	0.95
iv. Controls to prevent simultaneous heating and cooling in the same zone	0.9	0.93	0.95
v. Efficient control of plant capacity, including modular plant	0.9	0.93	0.95
vi. Partial ice thermal storage	1.8	1.86	1.9
vii. Full ice thermal storage	0.9	0.93	0.95
Column product (FR)			

The plant management features for Table K3 are more fully described below:

i. Systems that permit cooling to be obtained without the operation of refrigeration equipment when conditions allow. (e.g., 'strainer cycle'; 'thermosyphon'.)

ii. Systems that incorporate an economy cycle in which the fresh air and recirculated air mix is controlled by dampers, or where mixed mode operation is available as defined below Table K2.

iii. Controls that are capable of limiting plant operation to the hours of occupancy of the building, with the exceptions noted below in which operation outside the hours of occupancy forms a necessary part of the efficient use of the system:
  - for control of condensation,
  - for optimum start/stop control, or
  - as part of a strategy to pre-cool the *building* overnight using outside air.

iv. Controls that include an interlock or dead band capable of precluding simultaneous heating and cooling in the same zone.

v. Refrigeration plant capacity controlled on-line by means that reduce input power in proportion to cooling demand and maintain good part load efficiencies (e.g. modular plant with sequence controls; variable speed compressor). (Hot gas bypass control does not attract this factor).

vi. Partial ice storage in which the chiller is intended to operate continuously, charging the store overnight and supplementing its output during occupancy.

vii. Full ice storage in which the chiller operates only to recharge the thermal store overnight and outside occupancy hours.

K2.4 Example CPI calculation for an office proposal including air conditioning

In this example it is intended to include an air conditioning system in a new office *building*. The relevant details from the proposal are that:

The total area to be treated by the system is 3 000 m^2.
Cooling will be provided by two speed-controlled electrically powered compressors, with a total rated input power of 150 kW.
The refrigeration compressor energy consumption will be metered.
The fans used to distribute cooled air to treated spaces have a total rated input power of 35 kW.
The fan energy consumption will be metered.
A time clock control is to be provided so that the operation of the cooling system (refrigeration and air distribution) may be restricted to occupancy hours.
Windows in treated areas will be openable so that natural ventilation may be used, and the cooling system turned off, when required.

The CPI calculation for air conditioning is:

$$\mathbf{CPI_{(ACMV)}} = \frac{1200}{(PD \times HD \times CD \times FD) + (PR \times HR \times CR \times FR)}$$

In this proposal, for the cooling distribution system:

PD is the total installed capacity (sum of the input kW ratings) of the fans divided by the relevant treated area (square metres)
= **0.0117** (35/3000)

HD = **3 700** hours per year

CD is the carbon conversion factor for electricity, in kgC/kWh. (Table K 0)
= **0.139**

FD = **0.84**, determined from Table K2 as follows:
As the major plant will be metered, factors from Column B of the table are used. Then:
Factor for including the opportunity for natural ventilation (mixed mode operation) = 0.9;
Factor for including provision to restrict the hours of use of the system (time control) = 0.93;
Column product (**FD**) = **0.84**. (0.9 × 0.93)

And, for the refrigeration system:

PR = the total installed capacity (sum of the input kW ratings) of the refrigeration plant divided by the treated area (square metres),
= **0.05** (150/3000).

HR = **1 000** hours per year.

CR = the carbon conversion factor for electricity, in kgC/kWh. (Table K 0),
= **0.139**.

FR = **0.75**, determined from Table K3 as follows:
As the major plant will be metered, factors from Column B of the table are used. Then:
Factor for including the opportunity for natural ventilation (mixed mode operation) = 0.9;
Factor for including provision to restrict the hours of use of the system (time control) = 0.9;
Factor for providing efficient means of controlling plant capacity = 0.93;
Column product (**FR**) = **0.75**. (0.9 × 0.9 × 0.93)

The CPI calculation is then:

$$\mathbf{CPI_{(ACMV)}} = \frac{1200}{(0.0117 \times 3700 \times 0.139 \times 0.84) + (0.05 \times 1000 \times 0.139 \times 0.75)} \mathbf{= 114}$$

The proposal therefore achieves a calculated index of 114, which is better than the required target CPI of 100 and would therefore be acceptable on this basis.

[The index of 114 indicates that, under similar patterns of occupancy and use, the system proposed would be likely to cause about 10% less carbon emission than would be caused by the use of air conditioning in the typical air conditioned *building* defined in ECON 19].