Appendix A: Tables of U-Values

Contents

Tables

Note: The values in these tables have been derived using the combined method, taking into account the effects of thermal bridging where appropriate. Intermediate values can be obtained from the tables by linear interpolation. 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

Note: the examples are offered as indicating ways of meeting the requirements of Part L but designers also have to ensure that their designs comply with all the other parts of Schedule 1 to the Building Regulations.

Windows, doors and rooflights

The following tables provide indicative U-values for windows, doors and rooflights. Table A1 applies to windows and rooflights with wood or PVC-U frames. Table A2 applies to windows with metal frames, to which (if applicable) the adjustments for thermal breaks and rooflights in Table A3 should be applied. The tables do not apply to curtain walling or to other structural glazing not fitted in a frame. For the purposes of this Approved Document a roof window may be considered as a rooflight.

The U-value of a window or rooflight containing low-E glazing is influenced by the emissivity, ε_n, 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.

When available, manufacturers' certified U-values (by measurement or calculation according to the standards given in Section 0) should be used in preference to the data given in these tables.

Table A1 Indicative U-values (W/m²·K) for windows and rooflights with wood or PVC-U frames, and doors

	Gap between panes			Adjustment for rooflights in dwellings [3]
	6mm	**12mm**	**16mm or more**	
Single glazing		4.8		+0.3
Double glazing (air filled)	3.1	2.8	2.7	
Double glazing (low-E, ε_n = 0.2) [1]	2.7	2.3	2.1	
Double glazing (low-E, ε_n = 0.15)	2.7	2.2	2.0	
Double glazing (low-E, ε_n = 0.1)	2.6	2.1	1.9	
Double glazing (low-E, ε_n = 0.05)	2.6	2.0	1.8	
Double glazing (argon filled) [2]	2.9	2.7	2.6	
Double glazing (low-E ε_n = 0.2, argon filled)	2.5	2.1	2.0	
Double glazing (low-E ε_n = 0.1, argon filled)	2.3	1.9	1.8	
Double glazing (low-E ε_n = 0.05, argon filled)	2.3	1.8	1.7	+0.2
Triple glazing	2.4	2.1	2.0	
Triple glazing (low-E, ε_n = 0.2)	2.1	1.7	1.6	
Triple glazing (low-E, ε_n = 0.1)	2.0	1.6	1.5	
Triple glazing (low-E, ε_n = 0.05)	1.9	1.5	1.4	
Triple glazing (argon filled)	2.2	2.0	1.9	
Triple glazing (low-E ε_n = 0.2, argon filled)	1.9	1.6	1.5	
Triple glazing (low-E ε_n = 0.1, argon filled)	1.8	1.4	1.3	
Triple glazing (low-E ε_n = 0.05, argon filled)	1.7	1.4	1.3	
Solid wooden door [4]		3.0		

Notes
[1] 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.
[2] The gas mixture is assumed to consist of 90% argon and 10% air.
[3] No correction need be applied to rooflights in buildings other than dwellings.
[4] 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/m²·K) for windows with metal frames (4mm thermal break)

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

Note
For windows and rooflights with metal frames incorporating a thermal break other than 4mm, the following adjustments 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

	Adjustment to U-value (W/m²K)	
Thermal break (mm)	Window, or rooflight in building other than a dwelling	Rooflight in dwellings
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

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

Corrections to U-values of roofs, walls and floors

Annex D of BS EN ISO 6946 provides corrections to U-values to allow for the effects of:

- air gaps in insulation
- mechanical fasteners penetrating the insulation layer
- precipitation on inverted roofs.

The corrected U-value (U_C) is obtained by adding a correction term ΔU:

$$U_C = U + \Delta U$$

Table A4 gives the values of ΔU for some typical constructions.

If the total ΔU is less than 3% of U then the corrections need not be applied and ΔU can be taken to be zero. However, where corrections are to be applied, before using the following tables the following steps should be carried out:-

1) subtract ΔU from the desired U-value.

2) use this adjusted U-value in the tables when calculating the required thickness of insulation.

This thickness of insulation then meets the original desired U-value, having allowed for the ΔU correction(s).

Table A4 Corrections to U-values

Roofs	ΔU (W/m²K)
Insulation fixed with nails or screws	0.02
Insulation between joists or rafters	0.01
Insulation between and over joists or rafters	0.00
Walls	
Timber frame where the insulation partly fills the space between the studs	0.04
Timber frame where the insulation fully fills the space between the studs	0.01
Internal insulation fixed with nails or screws which penetrate the insulation	0.02
External insulation with metal fixings that penetrate the insulation	0.02
Insulated cavity wall with cavity greater than 75mm and tied with steel vertical-twist ties	0.02
Insulated cavity wall with a cavity less than or equal to 75mm tied with ties other than steel vertical-twist ties	0.00
Floors	
Suspended timber floor with insulation between joists	0.04
Floor insulation fixed with nails or screws	0.02

Roofs

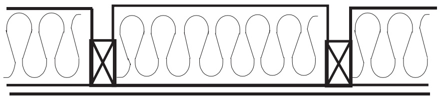


Table A5 Base thickness of insulation between ceiling joists or rafters

	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

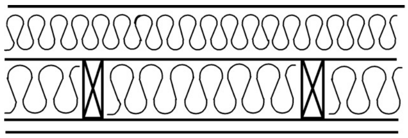


Table A6 Base thickness of insulation between and over joists or rafters

	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 A5 and A6 are derived for roofs with the proportion of timber at 8%, corresponding to 48mm wide timbers at 600mm centres, excluding noggings. For other proportions of timber the U-value can be calculated using the procedure in Appendix B.

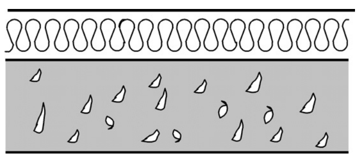


Table A7 Base thickness for continuous insulation

	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

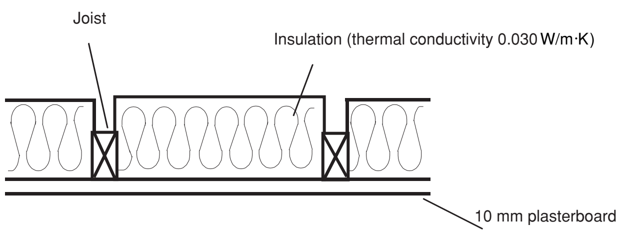
Table A8 Allowable reduction in base thickness for common roof components

	Concrete slab density (kg/m³)	Thermal conductivity of insulant (W/m·K) 0.020	0.025	0.030	0.035	0.040	0.045	0.050
		Reduction in base thickness of insulation for each 100mm 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	10mm plasterboard	1	2	2	2	3	3	3
8	13mm plasterboard	2	2	2	3	3	4	4
9	13mm sarking board	2	2	3	3	4	4	5
10	12mm 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	19mm roof tiles	0	1	1	1	1	1	1
14	19mm asphalt (or 3 layers of felt)	1	1	1	1	2	2	2
15	50mm 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 0.21 W/m²K if insulation is between the joists, and 0.26 W/m²K if insulation is between the rafters. From Table A4 there is a ΔU correction of 0.01 W/m²K which applies to both the following cases. To allow for this, the 'look-up' U-value is reduced by 0.01 W/m²K to 0.20 and 0.25 W/m²K respectively.

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



Using Table A5:

From **column D, row 2** of the table, the base thickness of insulation required is 269mm.

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

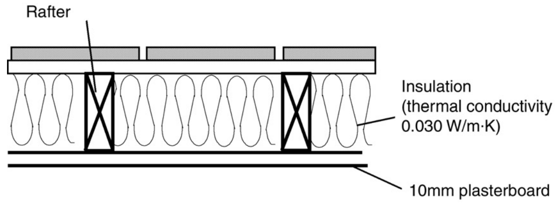
From Table A8:

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

The minimum thickness of the insulation layer between the ceiling joists required to achieve a U-value of 0.21 W/m²K (including the ΔU correction) is therefore:

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

For insulation placed between rafters (look-up U-value 0.25 W/m²K)



Using Table A5 :

From **column D, row 4** in the table, the base thickness of insulation required is 178mm.

The reductions in the base thickness are obtained as follows:

From Table A8:

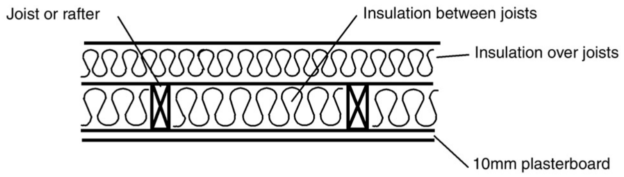
19mm roof tiles	**column D, row 13**	= 1mm
10mm plasterboard	**column D, row 7**	= 2mm
Total reduction		= 3mm

The minimum thickness of the insulation layer between the rafters required to achieve a U-value of 0.25 W/m²K (including the ΔU correction) is therefore:

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

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/m²K for the roof construction shown below:



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

Using Table A6:

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

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

From Table A8:

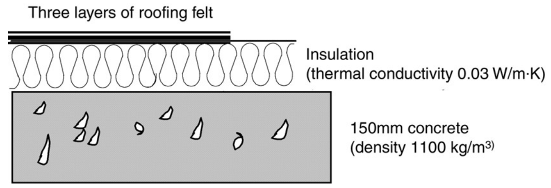
19mm roof tiles	**column F, row 13**	= 1mm
Roofspace (pitched)	**column F, row 11**	= 8mm
10mm plasterboard	**column F, row 7**	= 3mm
Total reduction		= 12mm

The minimum thickness of the insulation layer over the joists, required in addition to the 100mm insulation between the joists, to achieve a U-value of 0.20 W/m²K is therefore:

Base thickness less *total reduction*
ie 210 – l00 - 12 = **98mm**.

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 A7:

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

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

From Table A8:

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

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 = **103mm**.

Walls

Table A9 Base thickness of insulation layer

	Design U-value (W/m²K)	Base thickness of insulating material (mm) Thermal conductivity of insulant (W/m·K) 0.020	0.025	0.030	0.035	0.040	0.045	0.050
	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 A10 Allowable reductions in base thickness for common components

	Component	Reduction in base thickness of insulating material (mm) Thermal conductivity of insulant (W/m·K) 0.020	0.025	0.030	0.035	0.040	0.045	0.050
	A	B	C	D	E	F	G	H
1	Cavity (25mm or more)	4	5	5	6	7	8	9
2	Outer leaf brickwork	3	3	4	5	5	6	6
3	13mm plaster	1	1	1	1	1	1	1
4	13mm lightweight plaster	2	2	2	3	3	4	4
5	9.5mm plasterboard	1	2	2	2	3	3	3
6	12.5mm plasterboard	2	2	2	3	3	4	4
7	Airspace behind plasterboard drylining	2	3	4	4	5	5	6
8	9mm sheathing ply	1	2	2	2	3	3	3
9	20mm cement render	1	1	1	1	2	2	2
10	13mm tile hanging	0	0	0	1	1	1	1

Table A11 Allowable reductions in base thickness for concrete components

	Density (kg/m³)	Reduction in base thickness of insulation (mm) for each 100mm of concrete — Thermal conductivity of insulant (W/m·K) 0.020	0.025	0.030	0.035	0.040	0.045	0.050
	A	B	C	D	E	F	G	H
	Concrete blockwork 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
	Concrete blockwork 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

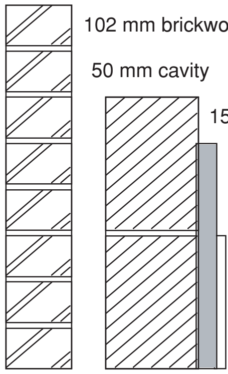
Table A12 Allowable reductions in base thickness for insulated timber framed walls

	Thermal conductivity of insulation within frame (W/m·K)	Reduction in base thickness of insulation material (mm) for each 100mm of frame (mm) — Thermal conductivity of insulant (W/m·K) 0.020	0.025	0.030	0.035	0.040	0.045	0.050
	A	B	C	D	E	F	G	H
1	0.035	39	49	59	69	79	89	99
2	0.040	36	45	55	64	73	82	91

Note
The table is derived for walls for which the proportion of timber is 15%, which corresponds to 38mm wide studs at 600mm centres and includes horizontal noggings etc. and the effects of additional timbers at junctions and around openings. 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

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.



Using Table A9:

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

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

From Table A10:

Brickwork outer leaf	**column F, row 2**	= 5mm
Cavity	**column F, row 1**	= 7mm
Plasterboard	**column F, row 6**	= 3mm

And from table A11

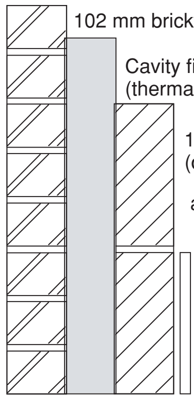
Concrete blockwork	**column F, row 1** adjusted for 150mm block thickness (1.5 x 17)	= 26mm
Total reduction		= 41mm

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 – 41 = **66mm.**

Example 5: Masonry cavity wall (tied with vertical-twist stainless-steel ties) filled with insulation with plasterboard on dabs

Determine the thickness of the insulation layer required to achieve a U-value of 0.37 W/m^{2}K for the wall construction shown below. From Table A4 there is a ΔU correction for the wall ties of 0.02 W/m^{2}K which applies. To allow for this, the 'look-up' U-value is reduced by 0.02 W/m^{2}K to 0.35 W/m^{2}K.



Using Table A9:

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

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

From Table A10:

Brickwork outer leaf	**column F, row 2**	= 5mm
Plasterboard	**column F, row 6**	= 3mm
Airspace behind plasterboard	**column F, row 7**	= 5mm

And from Table A11:

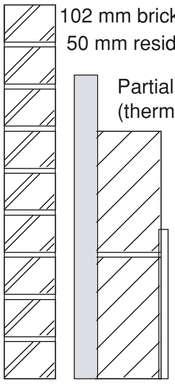
Concrete blockwork	**column F, row 1**	= 3mm
Total reduction		= 16mm

The minimum thickness of the insulation layer required to achieve a U-value of 0.37 W/m^{2}K (including ΔU for the wall ties) is therefore:

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

Example 6: Masonry wall (tied with vertical-twist stainless-steel ties) with partial cavity-fill

Determine the thickness of the insulation layer required to achieve a U-value of 0.32 W/m²K for the wall construction shown below. From Table A4 there is a ΔU correction for the wall ties of 0.02 W/m²K which applies. To allow for this, the 'look-up' U-value is reduced by 0.02 W/m²K to 0.30 W/m²K.



Using Table A9:

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

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

From Table A10:

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

And from Table A11:

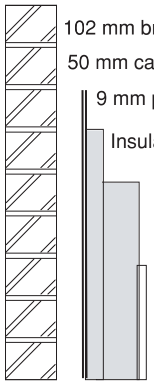
Concrete blockwork	**column C, row 5**	= 4mm
Total reduction		= 14mm

The minimum thickness of the insulation layer required to achieve a U-value of 0.3 W/m²K (including ΔU for the wall ties) is therefore:

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

Example 7: Timber-framed wall

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 A9:

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

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

From Table A10:

Brickwork outer leaf	**column F, row 2**	= 5mm
Cavity	**column F, row 1**	= 7mm
Sheathing ply	**column F, row 8**	= 3mm
Plasterboard	**column F, row 6**	= 3mm
Plasterboard	**column F, row 6**	= 3mm

And from Table A12:

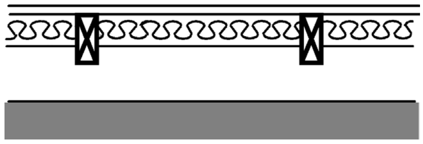
Timber frame	**column F, row 2** adjusted for stud thickness (73mm x 90/100)	= 66mm
Total reduction		= 87mm

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. 107 - 87 = **20mm.**

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.



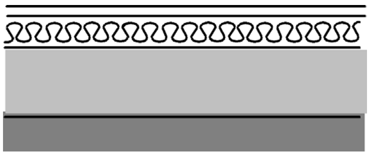


Table A13 Insulation thickness for solid floors in contact with the ground

	P/A	Thermal conductivity of insulant (W/m·K) 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 (m²).

Table A14 Insulation thickness for suspended timber ground floors

	P/A	Thermal conductivity of insulant (W/m·K) 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
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 48mm wide timbers at 400mm centres.

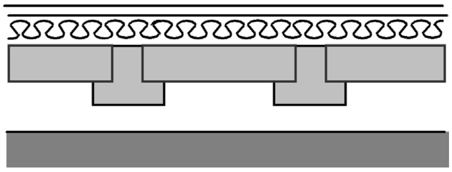


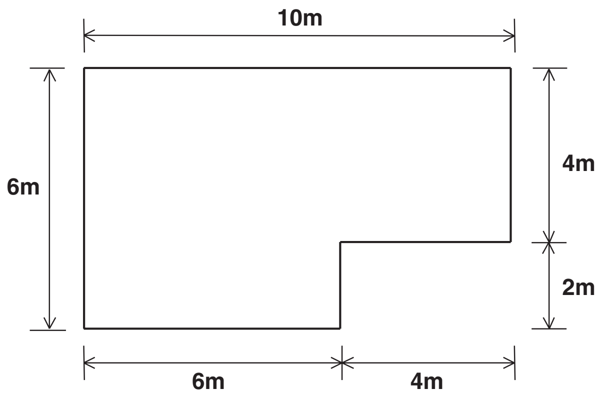
Table A15 **Insulation thickness for suspended concrete beam and block ground floors**

		Insulation thickness (mm) for U-value of 0.20 W/m²K						
		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
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).

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) = 32m.

The floor area of the slab is (6 x 6) + (4 x 4) = 52 m².

The ratio:

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

Using Table A13, **column C, row 23** indicates that **51mm** 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/mK, Table A14 **column F, row 23** indicates that the insulation thickness between the joists should be not less than **102mm**.

Upper floors

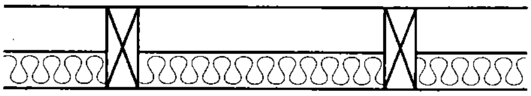


Table A16 Upper floors of timber construction

	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 joints 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 A16 is derived for floors with the proportion of timber at 12% which corresponds to 48mm wide timbers at 400mm centres. For other proportions of timber the U-value can be calculated using the procedure in Appendix B.

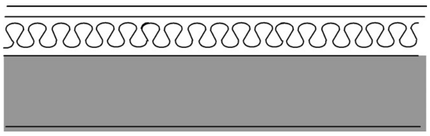


Table A17 Upper floors of concrete construction

	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-values						
	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 A18 Upper floors: allowable reductions in base thickness for common components

	Component	Thermal conductivity of insulant (W/m·K) 0.020	0.025	0.030	0.035	0.040	0.045	0.050
		Reduction in base thickness of insulating material (mm)						
	A	B	C	D	E	F	G	H
1	10mm plasterboard	1	2	2	2	3	3	3
2	19mm timber flooring	3	3	4	5	5	6	7
3	50mm screed	2	3	4	4	5	5	6

Building materials

Table A19 Thermal conductivity of some common building materials

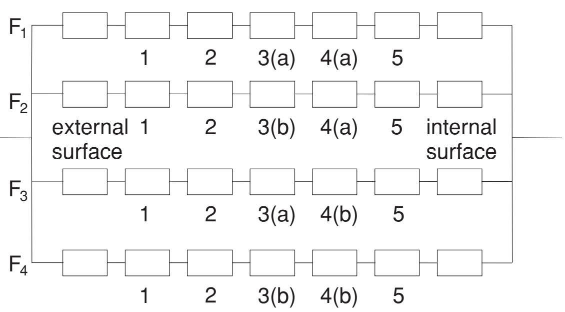
	Density (kg/m³)	Conductivity (W/m·K)
Walls		
Brickwork (outer leaf)	1700	0.77
Brickwork (inner leaf)	1700	0.56
Lightweight aggregate concrete block	1400	0.57
Autoclaved aerated concrete block	600	0.18
Concrete (medium density) (inner leaf)	1800	1.13
	2000	1.33
	2200	1.59
Concrete (high density)	2400	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	0.3
	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 (softwood, plywood, chipboard)	500	0.13
Timber (hardwood)	700	0.18
Wall ties (stainless steel)	7900	17.0
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	0.7
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	0.1
Floors		
Cast concrete	2000	1.35
Metal tray (steel)	7800	50.0
Screed	1200	0.41
Timber (softwood), plywood, chipboard	500	0.13
Timber (hardwood)	700	0.18
Insulation		
Expanded polystyrene (EPS) board	15	0.04
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 should be used in preference to those in the table.

Upper resistance limit

There are four possible sections (or paths) through which heat can pass. The upper limit of resistance is therefore given by $R_{upper} = 1/(F_1/R_1 + ... + F_4/R_4)$ where F_m is the fractional area of section m and R_m is the total thermal resistance of section m. A conceptual illustration of the upper limit of resistance is shown in Diagram B2.

Diagram B2: Conceptual illustration of the upper limit of resistance



Resistance through section containing AAC blocks and mineral wool

External surface resistance	= 0.040
Resistance of brickwork	= 0.132
Resistance of air cavity	= 0.180
Resistance of AAC blocks	= 0.909
Resistance of mineral wool	= 2.342
Resistance of plasterboard	= 0.050
Internal surface resistance	= 0.130
Total thermal resistance R_1	= 3.783 m²K/W

Fractional area F_1= 93% x 88% = 0.818

Resistance through section containing mortar and mineral wool

External surface resistance	= 0.040
Resistance of brickwork	= 0.132
Resistance of air cavity	= 0.180
Resistance of mortar	= 0.114
Resistance of mineral wool	= 2.342
Resistance of plasterboard	= 0.050
Internal surface resistance	= 0.130
Total thermal resistance R_2	= 2.988 m²K/W

Fractional area F_2= 7% x 88% = 0.062

Resistance through section containing AAC blocks and timber

External surface resistance	= 0.040
Resistance of brickwork	= 0.132
Resistance of air cavity	= 0.180
Resistance of AAC blocks	= 0.909
Resistance of timber	= 0.685
Resistance of plasterboard	= 0.050
Internal surface resistance	= 0.130
Total thermal resistance R_3	= 2.126 m²K/W

Fractional area F_3= 93% x 12% = 0.112

Resistance through section containing mortar and timber

External surface resistance	= 0.040
Resistance of brickwork	= 0.132
Resistance of air cavity	= 0.180
Resistance of mortar	= 0.114
Resistance of timber	= 0.685
Resistance of plasterboard	= 0.050
Internal surface resistance	= 0.130
Total thermal resistance R_4	= 1.331 m²K/W

Fractional area F_4= 7% x 12% = 0.008

Combining these resistances we obtain:

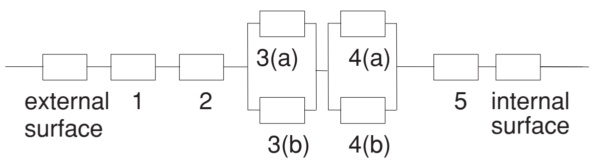
$$R_{upper} = \frac{1}{\frac{F_1}{R_1}+\frac{F_2}{R_2}+\frac{F_3}{R_3}+\frac{F_4}{R_4}} = \frac{1}{\frac{0.818}{3.783}+\frac{0.062}{2.988}+\frac{0.112}{2.126}+\frac{0.008}{1.331}}$$

= 3.382 m²K/W.

Lower resistance limit

A conceptual illustration of the lower limit of resistance is shown in the Diagram B3.

Diagram B3: Conceptual illustration of the lower limit of resistance



of the element and $\Delta U''$ is a factor which depends upon the way in which the insulation is fitted. In this example R_I is 2.703 m^2K/W, R_T is 3.354 m^2K/W and $\Delta U''$ is 0.01 (ie correction level 1). The value of ΔU_g is then

$\Delta U_g = 0.01 \times (2.703/3.354)^2 = 0.006$ W/m^2K.

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 $1/R_T = 0.298$ W/m^2K. Since ΔU_g is less than 3% of $(1/R_T)$,

$U = 1/R_T = 1 / 3.354 = 0.30$ W/m^2K.