CE184

Practical refurbishment of solid-walled houses

energy saving trust®

Contents

Note: This guide replaces the following documents:

- Refurbishment site guidance for solid-walled houses – ground floors (GPG294)
- Refurbishment site guidance for solid-walled houses – windows and doors (GPG295)
- Refurbishment site guidance for solid-walled houses – roofs (GPG296)
- Refurbishments site guidance for solid-walled houses – walls (GPG297)

Introduction

Our society has become increasingly dependent on fossil fuels such as oil, coal and natural gas. These are finite resources, having been created by natural processes over millions of years. Burning them to produce energy results in emissions of 'greenhouse gases', including carbon dioxide (CO_2). These gases trap solar radiation in the earth's atmosphere and cause undesirable changes in the climate.

Home energy use is responsible for over one quarter of all UK CO_2 emissions. Today, about one in five homes in the UK have traditional solid brick walls. This was the main form of construction until the mid-1930s. In addition to this there are a number of other solid wall construction types, including systems using no-fines concrete and pre-cast concrete panels.

Current estimates suggest that approximately two-thirds of the dwellings we will be occupying in 2050 are already in existence. Improving the energy efficiency of these existing dwellings, including those of solid wall construction, will play an important part in achieving the UK Government's CO_2 emission targets.

By following the Energy Saving Trust's best practice standards, refurbished housing will be more energy efficient and emissions will be reduced, thereby cutting energy consumption, saving money and safeguarding the environment.

Aimed at architects, builders and specifiers, this guide offers practical guidance on the most appropriate methods for the energy efficient refurbishment of solid-walled houses. Performance targets as well as installation details are provided for floors, walls, windows, doors and roofs. Additional issues such as draughtstripping and wider environmental considerations are also considered.

Using this guide

This document has five main sections, each relating to a specific construction element: the floor; walls; windows and doors; draughtstripping; and the roof.

Each section outlines the best practice specification and then examines key technical and installation issues. A table provides details of the performance that can be typically achieved with common construction materials.

Materials in this guide

A variety of insulation types have been included in each section. Various tables provide an indication of the insulation thickness required to achieve a particular thermal performance (U-value). The U-values quoted are only applicable to the exact construction given in each table.

The insulation manufacturer will be able to advise on the technical requirements for an individual building prior to the commencement of work. It is important to calculate the exact U-value achievable and assess the risk of condensation within the structure.

Further information regarding the performance of insulation materials can be found in 'Insulation materials chart – thermal properties and environmental ratings' (CE71).

Health and safety

Always follow the precautions recommended by the materials supplier. These may be in the form of safety instructions on the packaging, material safety data sheets or other written advice.

Regulations

Guidance in this document should be read in conjunction with the building regulations. These vary across the UK, and so local authority building control should be consulted on specific standards. Wherever appropriate, all aspects of national building regulations should be met.

For details of the current building regulations for existing dwellings in each part of the UK, see:

England and Wales
The Building Regulations 2000, Conservation of fuel and power, Approved Document L1B – Work in existing dwellings (2006 Edition).

Scotland
Section 6: Energy, of the Domestic Technical Handbook on possible ways of complying with the Building (Scotland) Regulations 2004 – currently under revision.

Northern Ireland
Building Regulations (Northern Ireland) 1994, Technical booklet F, Conservation of fuel and power (December 1998) – currently under revision.

Introduction

Technical terms

Where possible technical terms have been kept to a minimum. However, a few common industry terms have been used and an explanation of these is given here:

U-value: This is used to express the rate of heat loss through an external building element such as a wall or window. A construction with a U-value of $1W/m^2K$ would lose 1 Watt of energy through a $1m^2$ area for every 1ºC difference in temperature between the inside and outside. The lower the U-value, the better insulated the construction.

R-value: The R-value represents the resistance that a series of elements has to the passage of heat energy. It is affected by the thermal conductivity (λ) of the element and its thickness. The higher the R-value, the greater the resistance (the better the insulation effect). Because thermal properties of individual products vary, the thermal conductivity value should be checked with the manufacturer. The units used for thermal resistance are m^2K/W.

Vapour control layer: An impervious membrane, usually a polythene sheet. It is placed on the warm side of insulation to prevent water vapour generated in the house from passing through and condensing on the cold parts of the construction.

Low-e glass: This is glass with a microscopically thin coating applied to one side. The coating reflects long-wave radiation (heat that is radiated from internal room surfaces) and so reduces heat loss. The coating is barely noticeable and is effectively transparent.

Trickle vents: These are narrow ventilators fitted to the head (top) of the window frame to provide a controlled 'trickle' of fresh air when the windows are closed.

Breathable sarking membrane A roofing membrane located between the tiling battens and the rafters, which is water repellent but allows water vapour to pass through it. Its use in roofs minimises the risk of condensation forming in the roof structure.

Acoustics

Maximum value for money can be achieved if energy-related refurbishment is combined with other related improvements. One key issue to consider is acoustic performance.

Many insulation procedures can be cost-effectively combined with acoustic insulation. Typical examples are internal insulation and secondary glazing.

For details of current regulations in different parts of the UK, see:

England and Wales

- The Building Regulations 2000. Approved Document E: Resistance to passage of sound (2004).

Scotland

- Section 5: Noise, of the Domestic Technical Handbook on possible ways of complying with the Building (Scotland) Regulations 2004.

Northern Ireland

- Building Regulations (Northern Ireland) 1994, Technical booklet G, Sound (1990) and Technical booklet G1, Sound (conversions) (1994).

1 Improving performance

Table 1 illustrates increases in energy efficiency – as well as the consequent reductions in annual CO_2 emissions and costs – that can result from implementing a range of refurbishment options.

Table 1 Typical improvements in a mid-terrace, solid-wall property refurbished to best practice standards.

Specification	SAP 2005	Energy rating band	Annual CO_2 emissions (kg/yr)	Annual space and water heating costs (£)
Base house	56	D	3,250	263
Base house plus best practice roof only	58	D	3,090	250
Base house plus best practice floor only	58	D	3,060	248
Base house plus best practice windows, doors and draught stripping only	61	D	2,850	231
Base house plus best practice heating system (CHeSS – Year 2005) specification only	64	D	2,440	197
Base house plus best practice walls only	69	D	2,070	167
Base house plus all of the above best practice refurbishment specifications	81	B	960	78

Assumptions for SAP calculations in Table 1
Typical mid-terrace, solid-wall property – 2 storey

Original specification prior to refurbishment
Floor (uninsulated) U-value = 0.48W/m²K
Wall (solid) U-value = 2.10W/m²K
Window (poor double glazing) U-value = 3.50W/m²K
Roof (100mm insulation) U-value = 0.44W/m²K
Heating system = gas boiler (72 per cent efficiency), room thermostat only

Best practice refurbishment specification
Solid concrete floor U-value = approx 0.17W/m²K
Wall U-value = 0.30W/m²K
Window BFRC Rating in band C or better (U-value taken as 1.50W/m²K for calculation)
Door U-value = 1.0W/m²K
Roof U-value = 0.16W/m²K
Heating system – full CHeSS – Year 2005 specification

2 Ground floors

2.1 Common issues

As heat loss is greatest at the edges of a ground floor, its size and shape will affect its thermal performance. For this reason it is more difficult to achieve a given U-value in an end-terrace than a mid-terrace house: the end-terrace floor has a greater exposed perimeter and therefore greater likely heat loss.

Within a single terrace, insulation thicknesses would have to vary if the best practice specification were given as a U-value.

Specifying a best practice R-value (see page 2, Technical terms) is often more practical. Referring to an R-value means that a single thickness of insulation can achieve best practice performance, irrespective of the ground floor layout. The U-value will still vary between properties, but this approach will lead to identical floor insulation in a housing refurbishment scheme, which will simplify building work and project management.

Guidance is given in the following sections for timber floors and concrete floors.

2.2 Timber floors

Best practice specification

For best practice, aim for an insulation R-value of 3.75m²K/W. In the majority of timber ground floors this specification will achieve a U-value of 0.23W/m²K or better (see Table 2).

All timbers should be inspected for damp, rot or infestation. Remedial works should be carried out prior to insulation. Cross-ventilation must be maintained below the floor in order to remove moisture and prevent timber rot and mould growth. Do not block ventilation openings with insulation.

A vapour control layer should not generally be used with timber ground floors as it may trap moisture. Electrical cables must not come into contact with polystyrene insulation. Plasticised PVC cable can react with polystyrene.

It is important to seal any gaps in the floor. This prevents draughts entering the house from the ventilated space under the floor. Water pipes (e.g. for central heating) need to be well insulated.

Ventilation

Guidance on the ventilation of suspended floors can be found in:

England and Wales

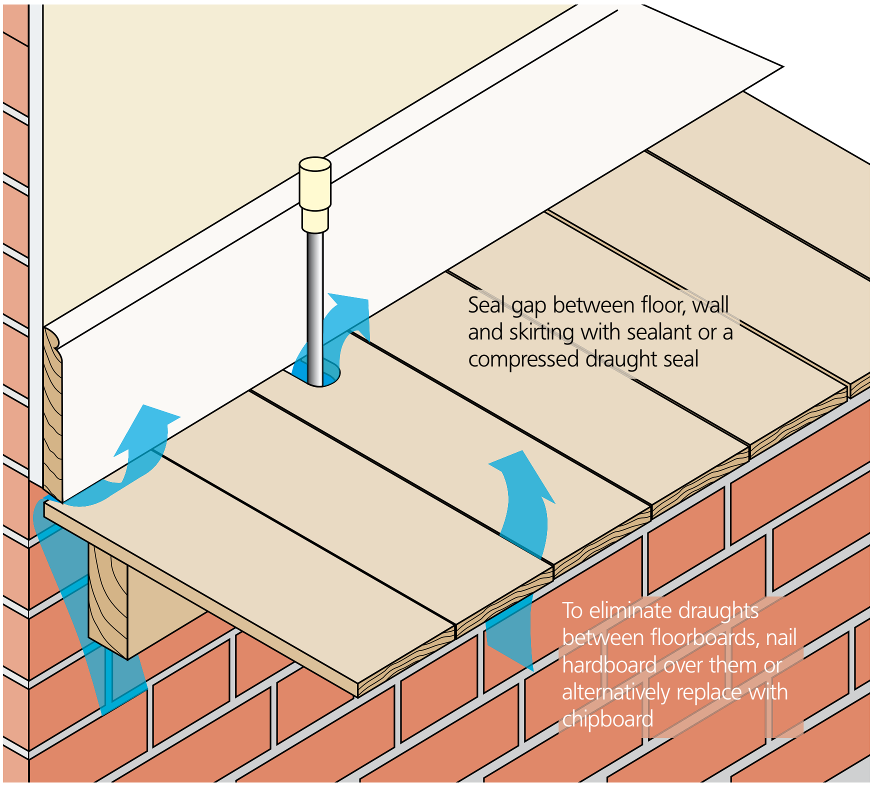
The Building Regulations 2000. Approved Document Part C – Site preparation and resistance to contaminants and moisture (2004).

Scotland

Section 1: Structure, of the Domestic Technical Handbook on possible ways of complying with the Building (Scotland) Regulations 2004.

Northern Ireland

Building Regulations (Northern Ireland) 1994 Technical booklet C, Site preparation and resistance to moisture (1994).



Ground floors

2.3 Access from above

When adding insulation, the floorboards will have to be taken up to allow access to the space between the joists, unless the house has a cellar or basement.

Insulation should fit tightly between the joists to minimise cold air entry routes. The addition of central heating will cause wood to gradually dry out and shrink over the first one or two heating seasons. The resulting gaps and cracks will allow cold air to enter from the ventilated space under the floor, especially in older houses with square-edged floorboards.

Draughts between the floorboards can be reduced by either fixing hardboard over them or replacing with chipboard.

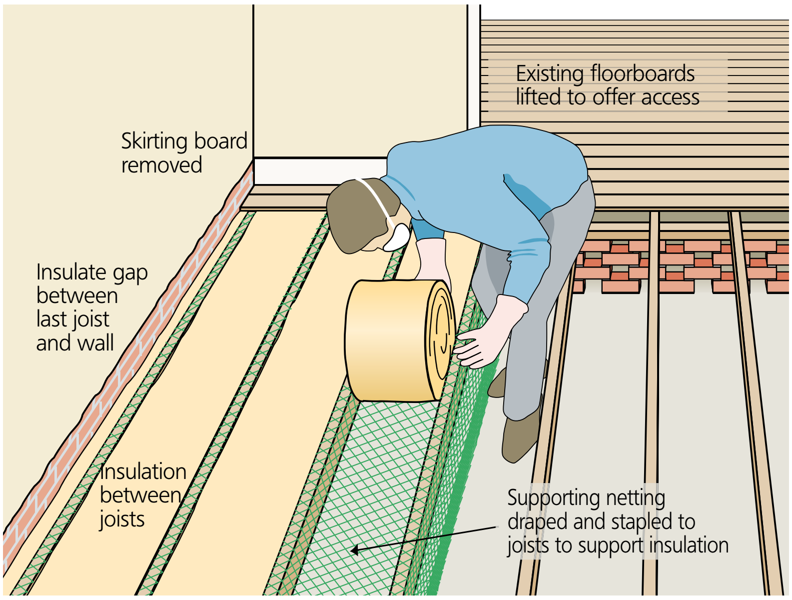


Table 2 Timber floor: Thicknesses of insulation required to achieve a best practice R-value of 3.75m²K/W or better, and the resulting U-values

Insulation type	Typical thermal conductivity (W/mK)	Suspended timber floor insulation				
		Joist depths				
		100mm	125mm	150mm	175mm	200mm
		U-values achieved when fully filled				
Phenolic	0.022	0.24	0.21	0.18	0.16	0.15
Polyisocyanurate and polyurethane	0.023	0.25	0.21	0.19	0.17	0.15
Cellulose	0.035	0.29	0.25	0.22	0.20	0.18
Flax	0.037	0.30	0.26	0.23	0.21	0.19
Expanded polystyrene	0.038	0.30	0.26	0.23	0.21	0.19
Sheep's wool and hemp	0.039	0.31	0.27	0.24	0.21	0.19
Mineral wool (quilt) and woodfibre	0.044	0.32	0.28	0.25	0.22	0.20
Vermiculite	0.063	0.37	0.33	0.30	0.27	0.25

Assumptions for Table 2 – timber floors
50mm timbers (Bridging fraction = 0.14), 225mm depth of underfloor below ground, 300mm floor height above ground, 250mm walls, no edge insulation.
These figures are based on a dwelling with a floor perimeter/area ratio of 0.6. This represents a typical period end-terrace with a rear extension. This type of structure has a relatively poor layout in terms of thermal performance.
The U-values quoted are only applicable to the exact construction described. Contact the manufacturer of the selected insulation to discuss the technical requirements and assess the potential for interstitial condensation. This should be done prior to commencing work.

Worse than best practice in refurbishment | Achieves best practice in refurbishment

2.4 Access from below

Insulation can be readily installed where cellars and basements exist below the timber ground floor.

Insulation must fit tightly between the joists to minimise cold air entry routes. Quilt insulation can be held up with netting, while foam insulation boards can be held in place by projecting nails, clips or battens as shown.

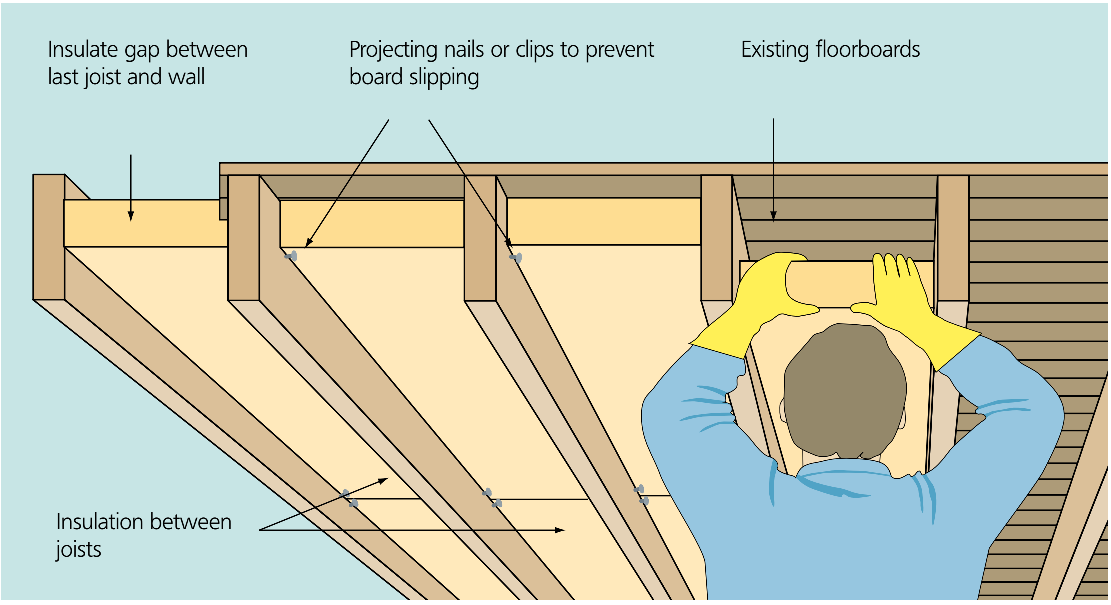
Loose-fill insulation will need a board between the joists to support it. Consult the manufacturer for further details.

The space between joists is usually less than 400mm, so standard 400mm wide loft insulation quilt can usually be 'friction fitted' between the joists. Do not over-compress quilted insulation, as this will restrict the amount of air between the fibres – which provides the thermal insulation.

Foam insulation boards will need to be cut to fit. Insulation should be tight up against the underside of the floorboards to prevent cold draughts getting through between the two. Electrical cables and pipes may make this difficult to achieve, particularly with insulation boards. In some situations it may be more practical to leave a service void between insulation and floor, and seal the ends.

Floors above cellars or basements must achieve the correct fire resistance performance. This typically requires foam insulation that is sufficiently resistant to surface spread of flame, or the fastening of plasterboard to the underside of the joists. Local authority building control will be able to advise.

A smoke alarm system may be required if the basement contains items with a higher fire risk: such as a boiler, tumbler drier, etc. Local authority building control will once again be able to advise.



Ground floors

2.5 Concrete floors

Best practice specification
For best practice when replacing an existing floor, aim for an R-value of 2.5m²K/W. Table 3 (page 10) shows that this will achieve a U-value of 0.24W/m²K or better in the majority of cases (see box for best practice strategy when using the existing floor slab). The finished floor level should coincide with the previous level. This will avoid unequal or excessive step heights at external doors or staircases.

2.6 Insulation above a new slab

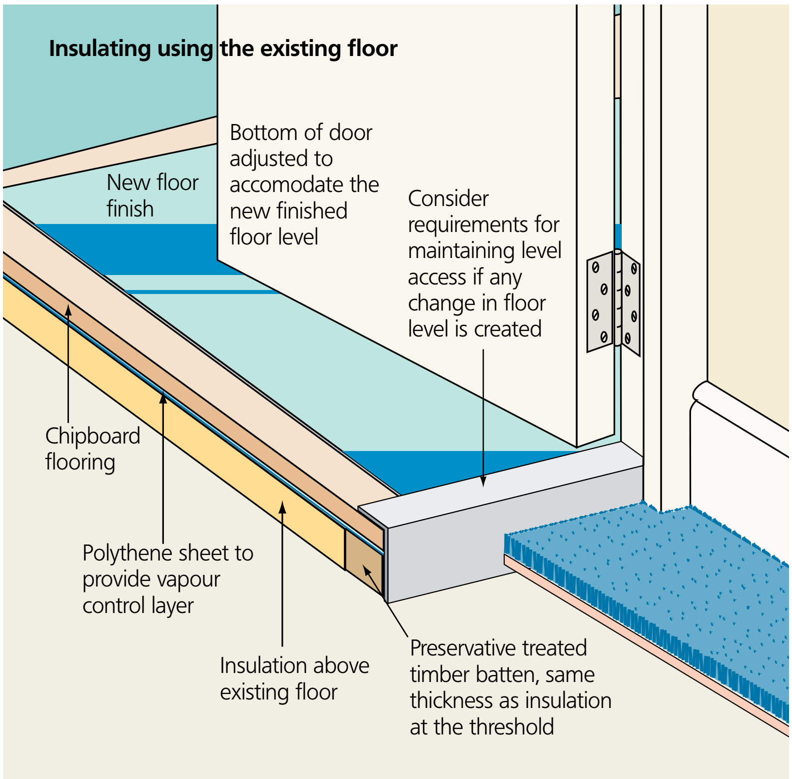
Insulation placed above the concrete slab will help the room to warm up quickly when the heating is switched on. The damp-proof membrane also needs to be above the concrete slab. Otherwise moisture from the drying concrete could affect the new floor finishes.

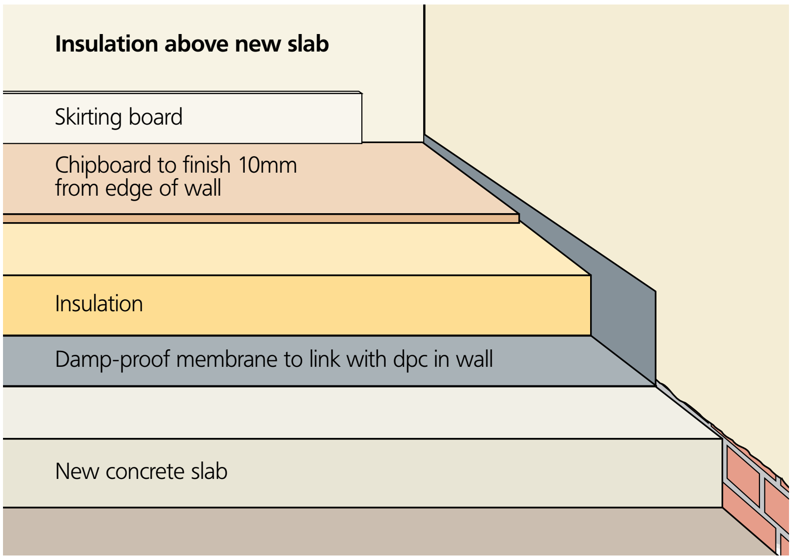
Any render finish on the wall needs to be undamaged down to the level of the damp-proof membrane. This is particularly important if a waterproof render has been applied as part of an injected damp proof course.

There is no need to wait for screeds or concrete floors to dry out if a chipboard floor deck and damp-proof membrane are used above the slab. The insulated chipboard can be walked on immediately after laying and is ready to receive any floor finish.

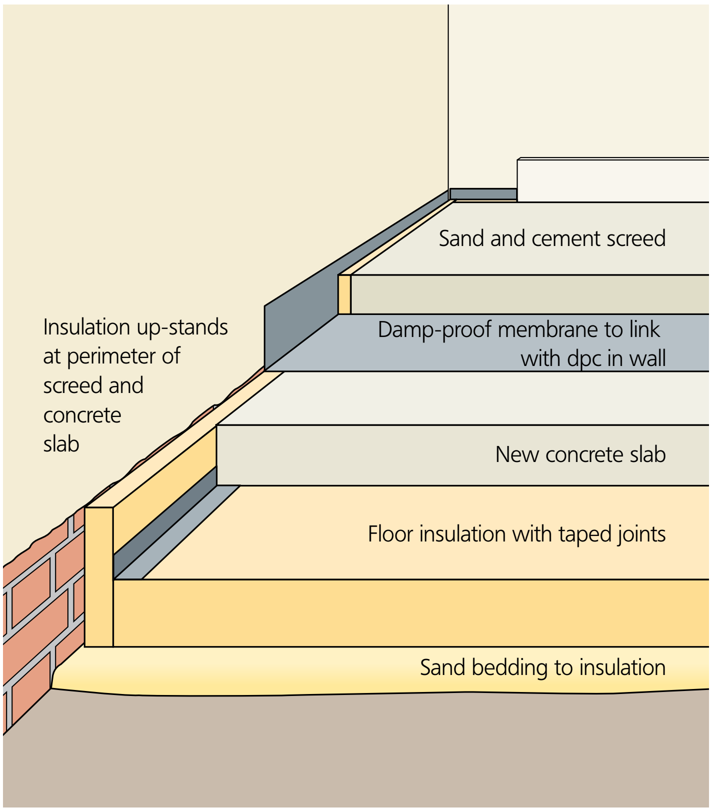
Tongue-and-groove joints in chipboard should be joined with a waterproof glue. Leave a 10mm gap between chipboard and the room perimeter. This accommodates expansion in the chipboard from moisture and temperature changes (the gap can be covered by the skirting board).

Use moisture-resistant, flooring grade chipboard with tongue-and-groove edges on all four sides (BS EN 13986). Ensure electrical cables do not come into contact with polystyrene. Plasticised PVC can react with polystyrene.





Insulating an existing floor slab
If the existing concrete floor suffers from damp, remedial works should be completed prior to any insulation works. The only simple way of insulating an existing concrete ground floor is to add insulation and then a new floor deck on top. The raised floor level will usually require the re-fixing of skirting boards and door heights will also have to be reduced. However, this can cause unequal or excessive step heights at staircases and external doors, incorrectly positioned door handles, a reduction in room height or necessitate adaptations to period features. Such effects may be ruled out by other building regulation requirements, making it impractical to insulate the floor. Further guidance can be found in 'Accessible thresholds in new housing: guidance for house builders and designers', published by The Stationery Office. Table 3 indicates the U-values that can be achieved with 40mm of typical insulation material. Several foam insulants can achieve U-values of 0.31W/m²K or better.



2.7 Insulation below a new slab

This is the better of the two options where the new floor is in a warm south-facing room. An exposed slab (not covered with carpets or rugs) will absorb heat on warm sunny days and limit overheating. Any render finish on the wall needs to be undamaged down to the level of the damp-proof membrane. This is particularly important if a waterproof render has been applied as part of an injected damp proof course.

The damp-proof membrane can be placed above or below the concrete slab. Contact the insulation manufacturer directly to check which is the correct configuration for a particular product. If the damp-proof membrane is above the slab, an additional membrane may be required to protect the insulation from ground contaminants.

An upstand of insulation with an R-value of 0.75m²K/W should be placed around the perimeter of the room at the same height as the concrete slab. This will limit heat loss through the edge of the slab. Joints between the insulation boards should be covered with a water-resistant tape, to stop concrete seeping between the joints.

Table 3. Concrete floor: Thicknesses of insulation required to achieve a best practice R-value of 2.5m²K/W or better, and the resulting U-values Details of upstand specifications are also included

Insulation type	Typical thermal conductivity (W/mK)	Insulation above and below concrete floor – Insulation thickness (mm) / U-values achieved						Up-stand insulation thickness – Thickness (mm) to achieve best practice R-value of 0.75m²K/W
		40	60	80	100	120	140	
Phenolic	0.022	0.30	0.23	0.19	0.16	0.14	0.13	18
Polyisocyanurate and polyurethane	0.023	0.31	0.24	0.20	0.17	0.15	0.13	18
Extruded polystyrene	0.029	0.35	0.28	0.23	0.20	0.18	0.16	23
Expanded polystyrene and mineral wool board	0.038	0.39	0.32	0.28	0.24	0.21	0.19	29
Cellular glass	0.042	0.42	0.34	0.29	0.26	0.23	0.21	32

Assumptions for Table 3 – concrete floors

Insulation above 19mm chipboard surface, no edge insulation, 250mm walls (concrete slab excluded from calculation as recommended in BRE 443 Conventions for U-value calculations).

Insulation below 75mm screed, 150mm dense concrete slab, no edge insulation, 250mm walls.

These figures are based on a dwelling with a floor perimeter/area ratio of 0.6. This represents a typical period end-terrace with a rear extension. This type of structure has a relatively poor layout in terms of thermal performance.

The U-values quoted are only applicable to the exact construction described. Contact the manufacturer of the selected insulation to discuss the technical requirements and assess the potential for interstitial condensation. This should be done prior to commencing work.

■ Particularly suitable for existing floor slabs ■ Worse than best practice in refurbishment ■ Achieves best practice in refurbishment

3 Walls

3.1 Common issues

Solid walls can be insulated externally or internally. External insulation systems typically comprise an insulation layer fixed to the existing wall and covered with a protective render or cladding. Internal insulation systems usually include: a laminated insulating plasterboard; a directly applied insulation board plus plasterboard; or an internal studwork structure with insulation set between the studs plus plasterboard.

Thermal performance can be improved to give U-values typically of 0.35W/m²K or better. This would comply with the revised Approved Document Part L1B Work in existing dwellings, which applies in England and Wales from April 2006.

3.2 External insulation

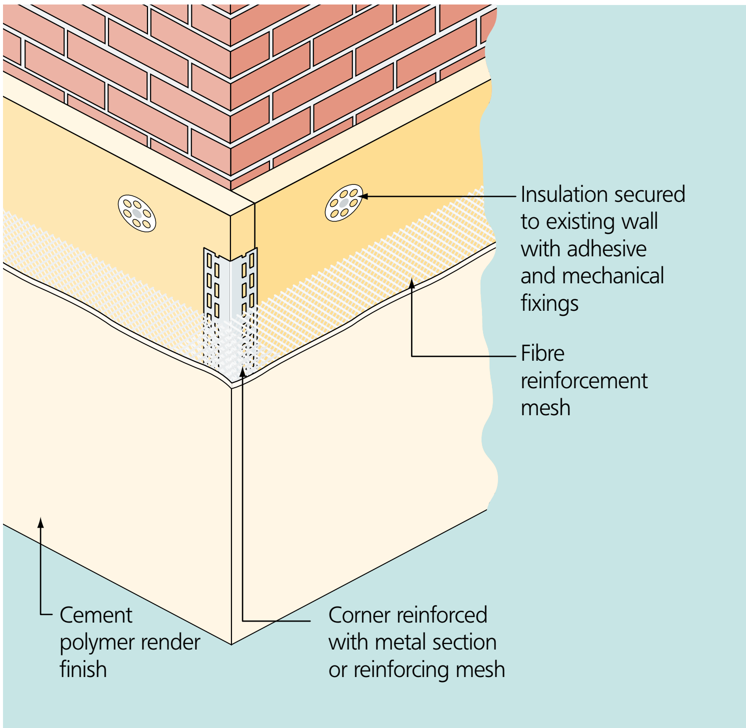
Unless the property is already rendered, external insulation will radically change its appearance. Planning permission may be required in such cases.

Best practice specification

For best practice, aim for a U-value of 0.30W/m²K or less. This method is frequently considered when an existing render finish requires replacement, or when the walls are suffering from damp penetration and remedial work is required.

The selected system should have an independent technical approval. The Insulated Render and Cladding Association (INCA) has a list of proven systems and approved installers. The work should be carried out by a specialist installer.

There are many render systems available. These are normally either a thick sand/cement render applied over a wire mesh, or alternatively a thinner, lighter, polymer cement render applied over reinforcing fibre mesh.



Flexible thermal linings and insulating renders

Flexible thermal linings and insulating renders can achieve more modest thermal improvement.

These materials alone will not achieve best practice standards, but they should be considered for difficult areas – such as window reveals – where wall thickness and mould growth are important factors.

These methods may also be used in situations where only cosmetic refurbishment work was originally planned, for example wallpaper replacement.

The extra thickness of the external insulation means special attention has to be given to the treatment of window sills, rainwater downpipes, places where the wall meets the roof and projections such as porches or conservatories. The specialist installer will be able to advise on how these junctions should be tackled. Further guidance regarding detailing of these areas can be found in 'External insulation systems for walls of dwellings' (CE118).

Insulation should be turned into window reveals to prevent condensation on the cold, uninsulated surfaces. Ideally, insulation with an R-value of 0.50m²K/W should be specified. However, window frame thickness may sometimes necessitate a reduced insulation depth. Insulation must not be allowed to block window trickle vents.

The choice of finish may affect future maintenance requirements. A 'pebbledash' finish should need less maintenance than painted render. Light colours that reflect the heat are less likely to suffer from cracking. Some renders may be more easily damaged than a brick wall. Consult the system manufacturer if the wall is adjacent to public areas such as car parks or footpaths.

If a combustible insulant is being used, the approvals certificate will show any precautions that need to be taken.

Table 4 External wall insulation: best practice U-values and details of reveal insulation thickness

Insulation type	Typical thermal conductivity (W/mK)	External wall insulation – Insulation thickness (mm) – U-values achieved: 40	60	80	100	120	140	Reveal insulation thickness – Thickness (mm) to achieve best practice R-value of 0.5m²K/W
Phenolic	0.022	0.44	0.32	**0.25**	**0.21**	**0.18**	**0.16**	12
Polyisocyanurate and polyurethane	0.023	0.45	0.33	**0.26**	**0.22**	**0.19**	**0.16**	12
Expanded polystyrene and mineral wool (slab)	0.038	0.65	0.49	0.39	0.33	**0.28**	**0.25**	19
Cellular glass and woodfibre	0.040	0.67	0.51	0.41	0.34	**0.30**	**0.26**	20

Assumptions for Table 4 – external wall insulation
20mm lightweight plaster, 220mm brick, insulation with 4 fixings per m² (fixings are 10mm² and 50W/mK), 20mm sand and cement render. The U-values quoted are only applicable to the exact construction described. Contact the manufacturer of the selected insulation to discuss the technical requirements and assess the potential for interstitial condensation. This should be done prior to commencing work.

Worse than best practice in refurbishment (unbolded values) — **Achieves best practice in refurbishment** (bold values)

3.3 Internal insulation

Best practice specification
For best practice, aim for a U-value of 0.30W/m²K. With internal insulation, the thermal performance can be improved without altering the external appearance. However, it will result in a loss of internal floor area and the installation process may cause disruption to occupants

The replacement of the existing plaster finish presents an ideal opportunity to install internal insulation. The condition of the existing wall must be properly assessed – and any necessary remedial work undertaken – before installing internal insulation (see box). This technique should not be used to isolate dampness.

Consider where heavy fixtures such as kitchen units, radiators and wash basins are to be located and provide timber fixing battens within the insulation layer. This will be increasingly important as larger thicknesses of insulation are used (see Table 5).

Internal cornices, coving and mouldings may need to be relocated to accommodate internal insulation. This is a particularly sensitive issue in period or historic properties.

Try to avoid covering cables in insulation as this will reduce the opportunity for heat dissipation. When this is not possible consult an electrician: an increase in cable size may be prudent. This is particularly so for high load cables such as those serving cookers and storage heaters.

PVC-sheathing on electrical cables may degrade when in contact with polystyrene insulation – cover cables with cover strips or place in ducts.

Cables less than 50mm from the surface of the plasterboard should be enclosed in metal conduits to avoid damage. Where ceilings, floors and internal walls join the main outside walls there will be a thermal bridge. In kitchens and bathrooms, it is advisable to return insulated dry-lining a short distance along these internal surfaces in order to avoid the risk of condensation. This will, however, create a 'step' in level of the surface of the wall/floor/ceiling which will need to be addressed in terms of appearance.

Assessment of existing walls
When assessing whether the wall is suitable for internal insulation, refer to BS 5628: Part 3 2001 Code of Practice for use of masonry materials and components, design and workmanship for guidance on resistance to weather.

High exposure locations will need a small cavity behind the dry lining. This will create a break in any moisture transmission path and reduce the risk of future damp. It is important to consult with the manufacturer to ensure the correct adhesive is used.

In such situations, best practice would employ an internal frame work as detailed in Section 3.6 of this guide.

Further details regarding internal insulation can be found in 'Internal wall insulation in existing dwellings' (CE17).

3.4 Directly-applied internal insulation

This can take the form of a plasterboard sheet laminated to an insulation board, or the insulation board may be separate. Insulation board with a built-in vapour control layer will stop moist internal air condensing on the cold brick behind the insulation.

If the brickwork is uneven (perhaps after the removal of existing plaster), the wall should be rendered to provide an even surface before fixing the boards.

Continuous ribbons of plaster adhesive at the wall perimeter and around all openings (such as sockets and plumbing) will prevent cold air behind the insulation leaking into the house. These adhesive ribbons should be sufficiently thick to create a small cavity between the internal wall surface and the insulation.

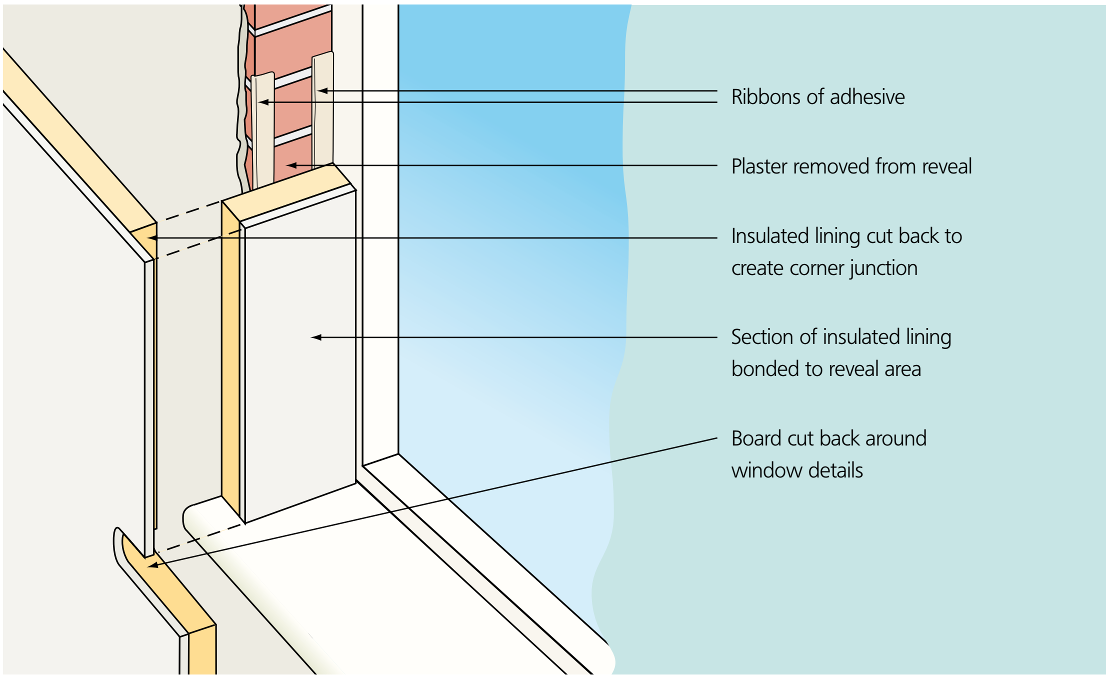
Consult the board manufacturer to check the correct adhesive is used (see box 'Assessment of existing walls' for more details). Consult the manufacturer to ensure the correct mechanical fixings are used. These perform an important safety function, holding the boards in place in the event of fire.

If window reveals are left uninsulated condensation may form on the cold surfaces. In order to prevent this insulation should be returned into the reveal areas. Ideally, insulation with an R-value of 0.34m²K/W should be specified. Window frame thickness may sometimes necessitate a reduced insulation depth, though. Do not allow insulation to block window trickle vents.

Acoustics

The close relationship between thermal and acoustic insulation works offers an opportunity to maximise financial and performance benefits by combining specifications during the planning stage of a project.

However, it is important to ensure that improvements in one area are not achieved at the expense of another. For further details regarding the relevant building regulations see the introduction to this document.



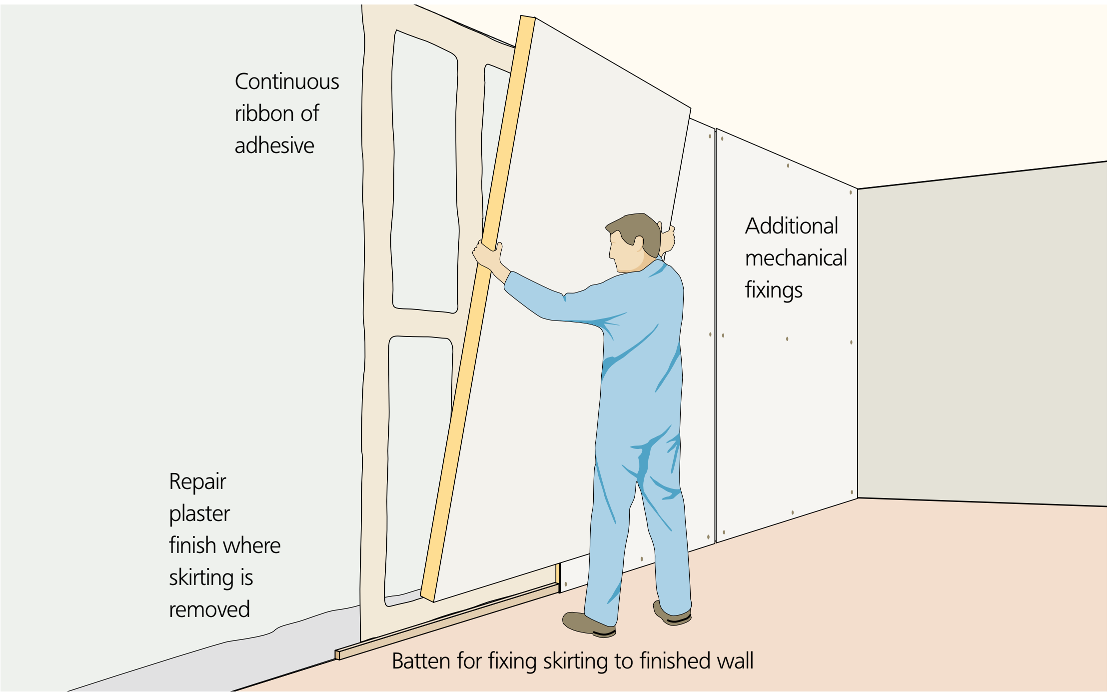
Walls

Table 5 U-values for directly-applied internal wall insulation, and details of insulated reveals: best practice R-value of 0.34m²K/W

Insulation type	Typical thermal conductivity (W/mK)	Internal wall insulation Directly applied – Insulation thickness (mm) / U-values achieved: 40	60	80	100	120	140	Reveal insulation thickness – Thickness (mm) to achieve best practice R-value of 0.34m²K/W
Phenolic	0.022	0.42	0.31	**0.25**	**0.21**	**0.18**	**0.16**	8
Polyisocyanurate and polyurethane	0.023	0.43	0.32	**0.26**	**0.21**	**0.18**	**0.16**	8
Extruded polystyrene	0.030	0.52	0.39	0.31	**0.26**	**0.23**	**0.20**	11
Expanded polystyrene and mineral wool (slab)	0.038	0.60	0.46	0.38	0.32	**0.28**	**0.24**	13
Cellular glass	0.040	0.62	0.48	0.39	0.33	**0.29**	**0.25**	14

Assumptions for Table 5 – directly-applied internal wall insulation
12.5mm plasterboard, insulation, plaster dabs/adhesive and 15mm airspace (Bridging Fraction = 0.20), insulation with 2 fixings per m² (fixings are 10mm² and 50W/mK), 220mm brick.
The U-values quoted are only applicable to the exact construction described. Contact the manufacturer of the selected insulation to discuss the technical requirements and assess the potential for interstitial condensation. This should be done prior to commencing work.

Worse than best practice in refurbishment | **Achieves best practice in refurbishment**



Walls

3.5 Internal insulation with studwork

Internal studwork should be used where internal insulation has been specified for a wall that has previously suffered from damp. This allows the creation of a cavity between the internal wall surface and the insulation (see box).

Studwork is also an effective solution where the wall is bowed or uneven and space is not at a premium. Systems are available using timber or steel. Steel systems with thermally broken sections will give improved performance. Timber should be treated with preservative, and this treatment should include any exposed end grain. A damp-proof membrane should be placed between the timber and internal wall surface.

Place 500 gauge polyethylene sheet between the insulation and plasterboard. This acts as a vapour control layer to stop moist air from the house condensing on the cold brick behind the insulation.

If window reveals are left uninsulated condensation may form on the cold surfaces. In order to prevent this insulation should be returned into the reveal areas. Ideally, insulation with an R-value of 0.34m²K/W should be specified. Window frame thickness may sometimes necessitate reduced insulation depth though. Insulation must not block window trickle vents.

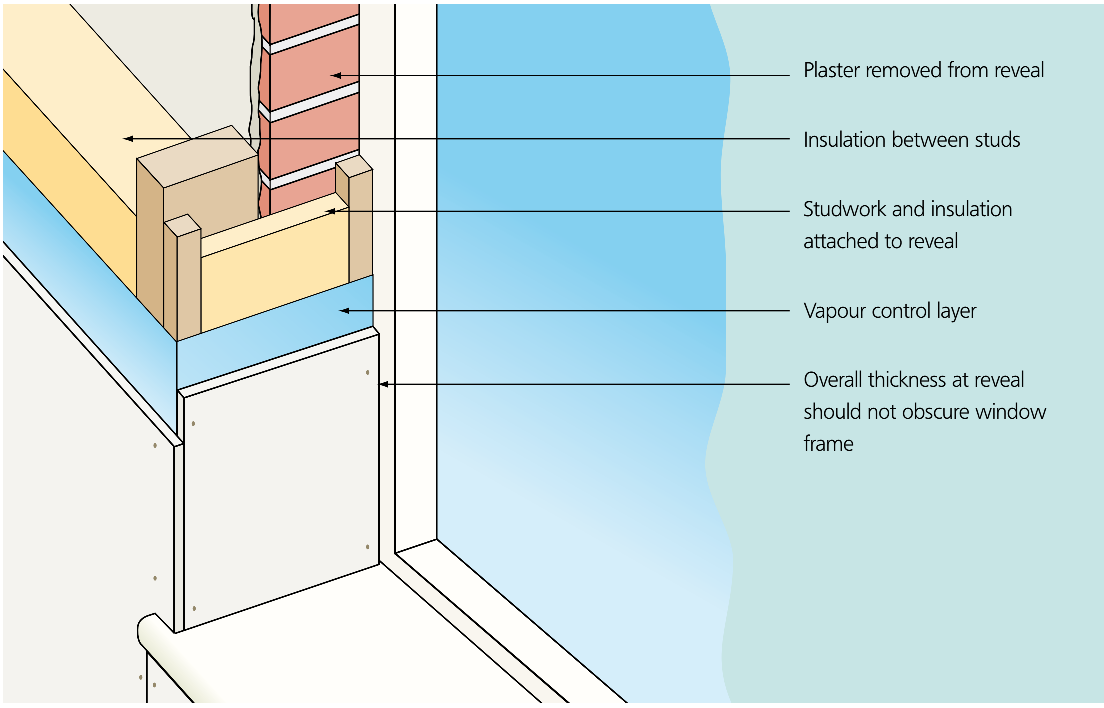
The diagram illustrates a wall consisting of vertical timber studs at 600mm centres to suit typical 1,200mm wide plasterboard. In some situations, for example in rented accommodation or where greater flexibility for hanging wall units is needed, a more robust structure featuring studs at 400mm centres may be more suitable. Increased studwork will reduce the thermal performance of the final wall, though.

Walls suffering from dampness and exposure

All sources of moisture penetration should be treated and the walls allowed to dry prior to insulation work. External pointing or rendering can reduce damp penetration. If concern remains about potential damp, an effective remedy is to construct an inner frame of timber or metal at least 30mm clear of the masonry wall.

Summer sun can drive water vapour located in damp south-, east- or west- facing walls deeper into the construction. This can cause condensation on the outside of the vapour control layer.

Further guidance can be found in BRE Report BR262 Thermal insulation: avoiding risks.



Walls

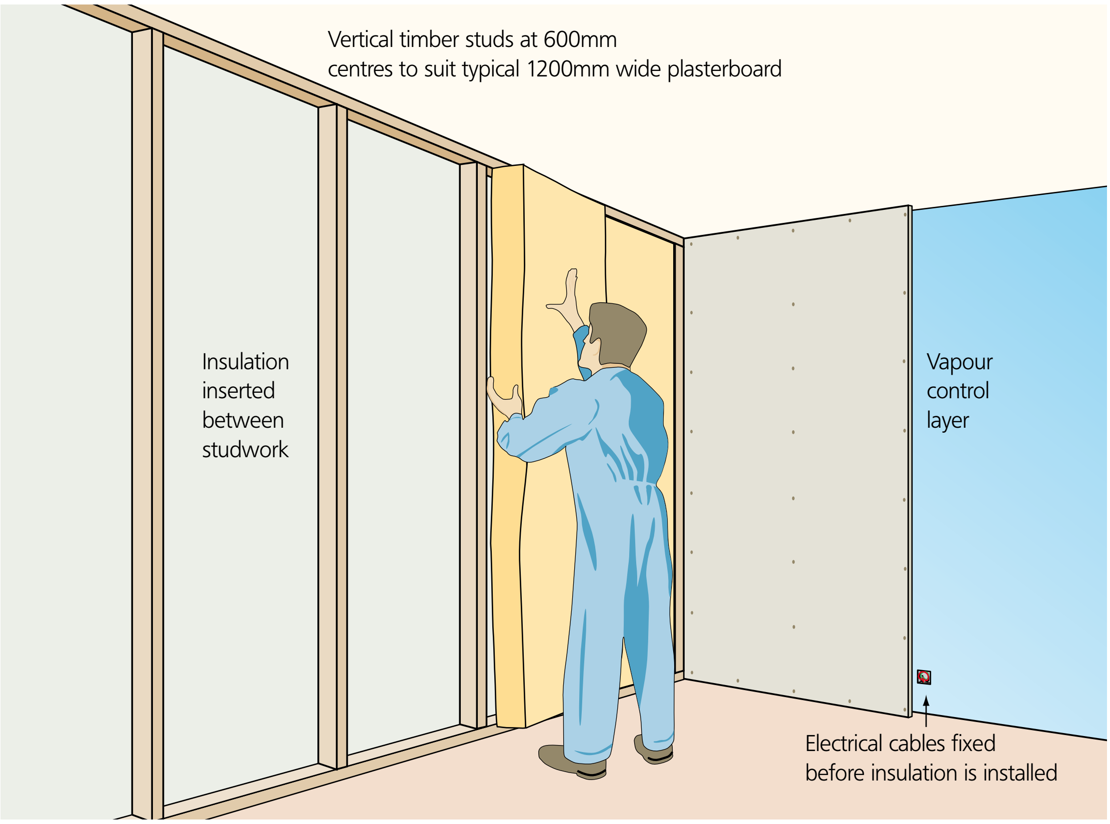
Table 6 U-values for studwork internal wall insulation, and details of insulated reveals: best practice R-value of 0.34m²K/W

Insulation type	Typical thermal conductivity (W/mK)	Internal wall insulation Studwork application – Insulation thickness (mm) – U-values achieved						Reveal insulation
		40	60	80	100	120	140	Thickness (mm) to achieve best practice R-value of 0.34m²K/W
Phenolic	0.022	0.51	0.39	0.32	**0.27**	**0.24**	**0.21**	8
Polyisocyanurate and polyurethane	0.023	0.52	0.40	0.33	**0.28**	**0.24**	**0.21**	8
Mineral wool (slab)	0.035	0.62	0.49	0.40	0.35	**0.30**	**0.27**	12
Expanded polystyrene	0.038	0.64	0.51	0.42	0.36	0.32	**0.28**	13
Woodfibre	0.044	0.69	0.55	0.46	0.39	0.34	0.31	15

Assumptions for Table 6 – studwork internal wall insulation
12.5mm plasterboard, insulation, 25mm non-ventilated air space, 47mm studs at 600mm centres plus top and bottom rails (Bridging Fraction = 0.118), 220mm brick.

The U-values quoted are only applicable to the exact construction described. Contact the manufacturer of the selected insulation to discuss the technical requirements and assess the potential for interstitial condensation. This should be done prior to commencing work.

Worse than best practice in refurbishment (light values) | **Achieves best practice in refurbishment** (bold values)



4 Windows and doors

4.1 Common issues

Proposals for replacement windows should be agreed with the building control body prior to work being carried out. Alternatively, in England and Wales, a more common route is to use a company registered under the Fenestration Self-Assessment Scheme (FENSA). It is important to consult with local authority building control and building conservation departments before replacing windows in historically sensitive buildings.

Windows can be assessed either in terms of heat loss (the U-value approach) or of an overall energy balance, such as the British Fenestration Rating Council (BFRC) approach. The U-value approach has been the traditional method for specifying windows and is included in the building regulations. The newer, energy balance approach considers not only the heat loss but also the effects of solar gain and losses due to air infiltration, and so provides an estimate of the total energy flow through a window.

The BFRC Rating approach satisfies the building regulations in England & Wales and Northern Ireland from April 2006 and June 2006 respectively. In Scotland, windows must achieve a U-value of either 2.0 or 1.8W/m²K, depending on the main heating fuel used. Care should be taken to ensure that the selected window meets the required U-value as well as the BFRC Rating. (See box below.)

In addition to replacement windows, there are many types of secondary glazing. The cheapest systems, from DIY stores, generally use acrylic sheets for glazing in place of glass and have plastic framing. The secondary glazing systems supplied by specialist installers are usually more robust. These installers will also provide a full service, including measuring up the windows before manufacture and installation.

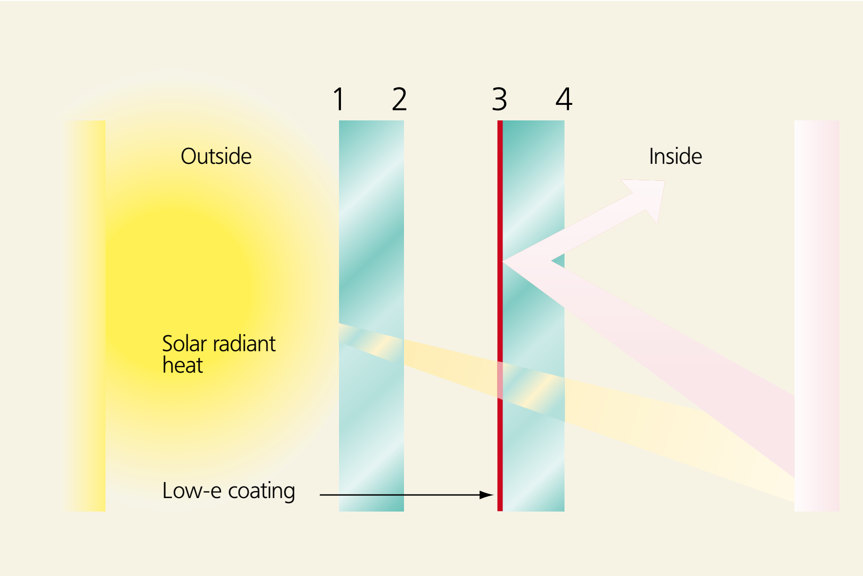
Detailed guidance on energy efficient windows can be found in 'Windows for new and existing housing, a summary of best practice' (CE66).

Glazing performance

Thermal performance depends on a number of factors, including design, the materials used and the combination of components.

BFRC Ratings and U-values show reasonable correlation. However, changing the specification of a window may not necessarily result in an improved U-value, even if it gives a better BFRC Rating.

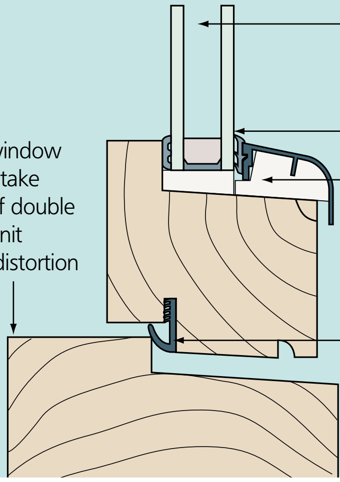
Some changes in specification, while improving the solar gain through a window, may actually detract from the U-value.



Windows and doors

4.2 Replacement windows

Best practice specification
For best practice, specify windows with a British Fenestration Rating Council (BFRC) Rating in band C (See Table 7). The Energy Saving Trust offers endorsement of windows that achieve a BFRC rating of C or better through the 'energy saving recommended' certification scheme.
A full list of certified products is available at:
www.est.org.uk/recommended



In addition to the rating, the following key issues should be considered to ensure best practice. The frames should be of high quality and designed for the chosen glazing units. Glazing units should normally be installed in a properly drained and ventilated frame. Solid bedding should only be used if windows are factory glazed or in the case where a drained-and-vented system is impractical or unavailable. Glazing units should comply with BS 6262. See the Glass and Glazing Federation manual (www.ggf.org.uk).

Units should be dual-sealed and certified in accordance with BS 5713:1979 (due to be replaced by EN 1279 in 2006). Correct site installation includes sealing round window and door frames. Filling the gaps between the frame and the surrounding wall with expanding foam will improve the window's thermal performance and reduce draughts.

Where low-e glass is used, make sure it is installed the right way round (usually indicated by a label). Safety glazing should be used for glass in windows within 800mm of the floor, or glass in doors and side panels within 1500mm of the floor. Check with the window manufacturer what type of safety glazing to use.

Replacement windows should incorporate 'trickle vents' in the top of the frame as well as draught seals.

Table 7 Sample BFRC Ratings and U-values for a range of window types*

Frame type	Glass layers	Glass type	Air gap (mm)	Gas fill	Spacer	BFRC Rating	Band	U-value
PVC-U (5 chamber)	3	2 x low iron 1x hard coat	16 x 2	Argon	Warm edge hybrid	+4	A	1.3
PVC-U (5 chamber)	2	Soft coat	16	Argon	Silicone rubber	-8	B	1.4
PVC-U (3 chamber)	2	Soft coat	16	Argon	Silicone rubber	-13	C	1.5
Timber	2	Soft coat	16	Argon	Corrugated metal strip	-16	C	1.5
PVC-U (5 chamber)	2	Soft coat	16	Argon	Hard polyurethane	-18	C	1.5
Timber	2	Soft coat	16	Air	Silicone rubber	-22	D	1.6
PVC-U (5 chamber)	2	Soft coat	16	Argon	Aluminium	-23	D	1.6
Aluminium (23mm polyamide breaks)	2	Soft coat	16	Argon	Silicone rubber	-26	D	1.8
Timber	2	Hard coat	16	Air	Silicone rubber	-27	D	1.8
PVC-U (3 chamber)	2	Hard coat	16	Air	Aluminium	-38	E	2.0

* Note: These are indicative values only, taken from specific products. Consult the manufacturer of the selected window for exact details.

Windows and doors

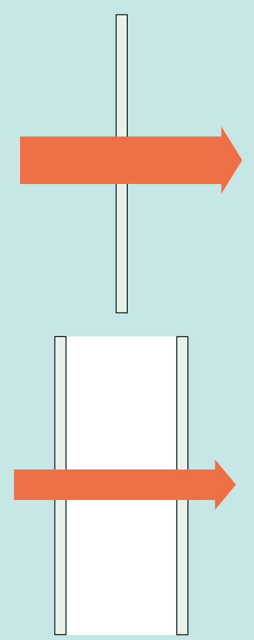
4.3 Secondary glazing

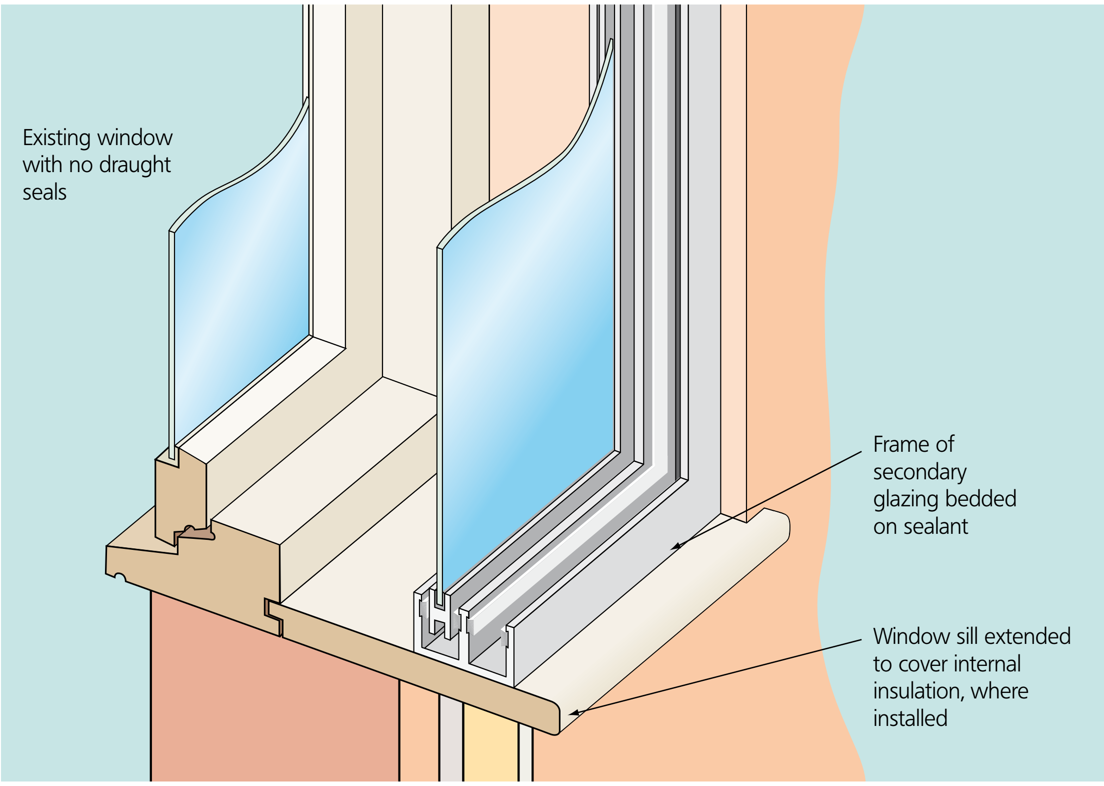
Best practice specification
For best practice, aim for a minimum 20mm gap between existing and secondary glazing. In a timber window this results in a U-value of approximately 2.9W/m²K, and in a metal window approximately 3.4W/m²K.

Secondary glazing should be draughtstripped, while the existing windows should be left without seals. This allows moisture in the cavity to be vented away to the outside. Some systems improve both thermal and acoustic performance. These may involve placing the secondary glazing at least 100mm from the existing glass, lining the reveals with fibreboard, or using heavier glass for the internal pane.

The selected system should be one that can be opened easily for ventilation. It should be possible to leave the secondary glazing slightly open and so allow a trickle of ventilation into the room. Windows are a valuable escape route in case of fire, so do not prevent them from opening. You should be able to escape through one window in every room.

Typical window U-values





Windows and doors

4.4 Replacement external doors

Best practice specification
For best practice, aim for: a U-value of 1.0W/m²K or less for a solid insulated door; and 1.5W/m²K or less for a half-glazed insulated door.

Most insulated doors have a steel, fibreglass or timber-veneered outer face. Steel-faced doors are normally supplied primed, ready for painting, while fibreglass can be painted or stained to imitate hardwood. Veneered doors are often factory finished.

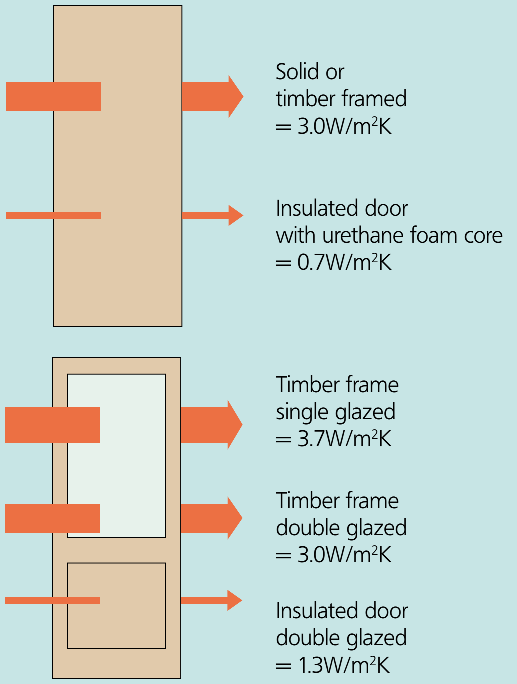
Nearly all insulated doors have a core of urethane foam insulation within a timber frame. This frame provides solid fixings for hinges and locks. The core provides most of the insulation: choice of facing material only has a small effect.

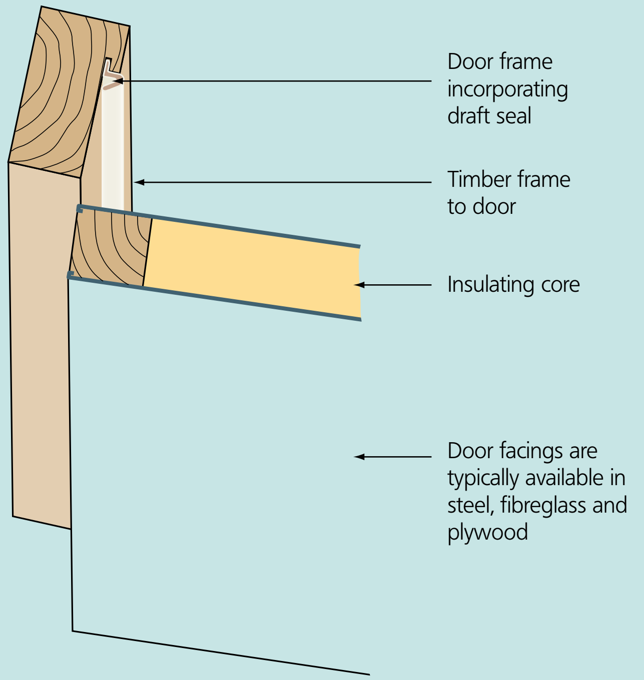
Laminated construction makes these products much less prone to warping than traditional timber doors.

Insulated doors are available on their own, or can be supplied with a frame incorporating a draught seal. The integral draught seals of insulated door sets achieve high levels of weather resistance.

Any glazed area that presents a security risk should be constructed of laminated glass. Choose a door construction that can incorporate the security measures you require, e.g. multi-point locking.

Typical solid door U-values





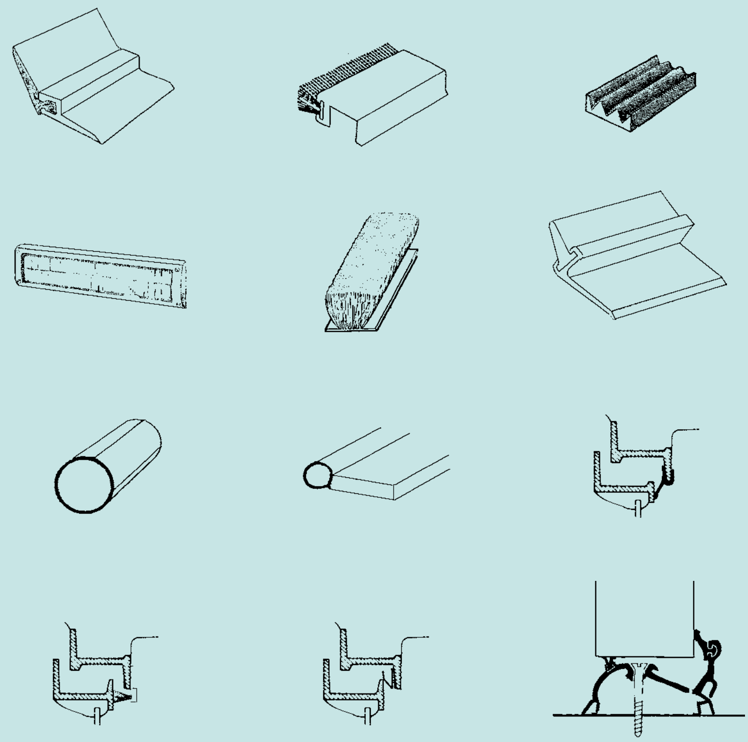
5 Draughtstripping

Best practice specification
Products should be manufactured to BS 7386: 1997, and installed to BS 7880: 1997 in order to achieve best practice. Installation guidance is also available from manufacturers and the Draught Proofing Advisory Association.

For exterior doors, draughtstrips with a range of 6mm and a compression allowance of 3mm are recommended. This will accommodate a seasonal variation in gap size of up to 3mm. As the gap expands, the seal is maintained; when it shrinks, closing the door is not affected.

For windows, both the seasonal movement and the opening length are likely to be less than for doors, and an initial compression of 3mm is recommended.

Draughtstripping



5.1 Common issues

Fitting draughtstrips into the gaps in existing windows and doors can be difficult because of the varying gap around the perimeter of the frame. It is essential that only strips recommended by a manufacturer for the actual gap size are used, if effective performance is to be achieved.

Some strips, for example, are intended for use only on a limited gap range, say of 3-5mm. Low profile strips, on the other hand, can compress to a lower gap size of 1-2mm, making them suitable for the majority of windows. Very small gaps along the length of a door or window can sometimes be tackled by making a gap large enough to take a strip or, alternatively, a strip can be fitted outside the gap (face fixed).

Face-fixed seals usually have two parts; a seal which moves against the door or window to close the gap, and a carrier (often made of rigid plastic or aluminium) which holds the seal firmly in place and is itself fixed to the frame. These draughtstrips can easily cope with the varying gaps around warped doors, simply by adjusting the position of the carrier. As the draughtstrip is exposed rather than hidden, its appearance will be one of the factors affecting selection.

For windows in historic buildings, a number of specialist companies will cut grooves into the frames so that they can take draughtstrips (essentially the same as those used in new windows). Similarly, hidden brushes or seals, which retract automatically upon opening, can be fitted into the bottom sections of wooden doors.

Further information can be found in 'Improving air tightness in dwellings' (GPG224) and 'Energy efficient ventilation in housing. A guide for specifiers on requirements and options for ventilation' (GPG268).

6 Roofs

6.1 Common issues

All timbers should be inspected for damp, rot or infestation. Remedial works should be carried out prior to installing insulation.

Appropriate ventilation must be provided when insulating the roof structure. Avoid recessed lights within the roof structure, unless they are housed in airtight, fire-proof enclosures. Poor installation can allow moisture and heat to migrate into the roofspace.

Try to avoid covering cables in insulation as this will reduce the opportunity for heat dissipation. When this is not possible consult an electrician: an increase in cable size may be prudent. This is particularly so for high load cables such as those serving cookers and storage heaters.

PVC-sheathing on electrical cables may degrade when in contact with polystyrene insulation – cover cables with cover strips or place in ducts.

Cables less than 50mm from the surface of the plasterboard should be enclosed in metal conduits to avoid damage.

6.2 Ceiling level insulation

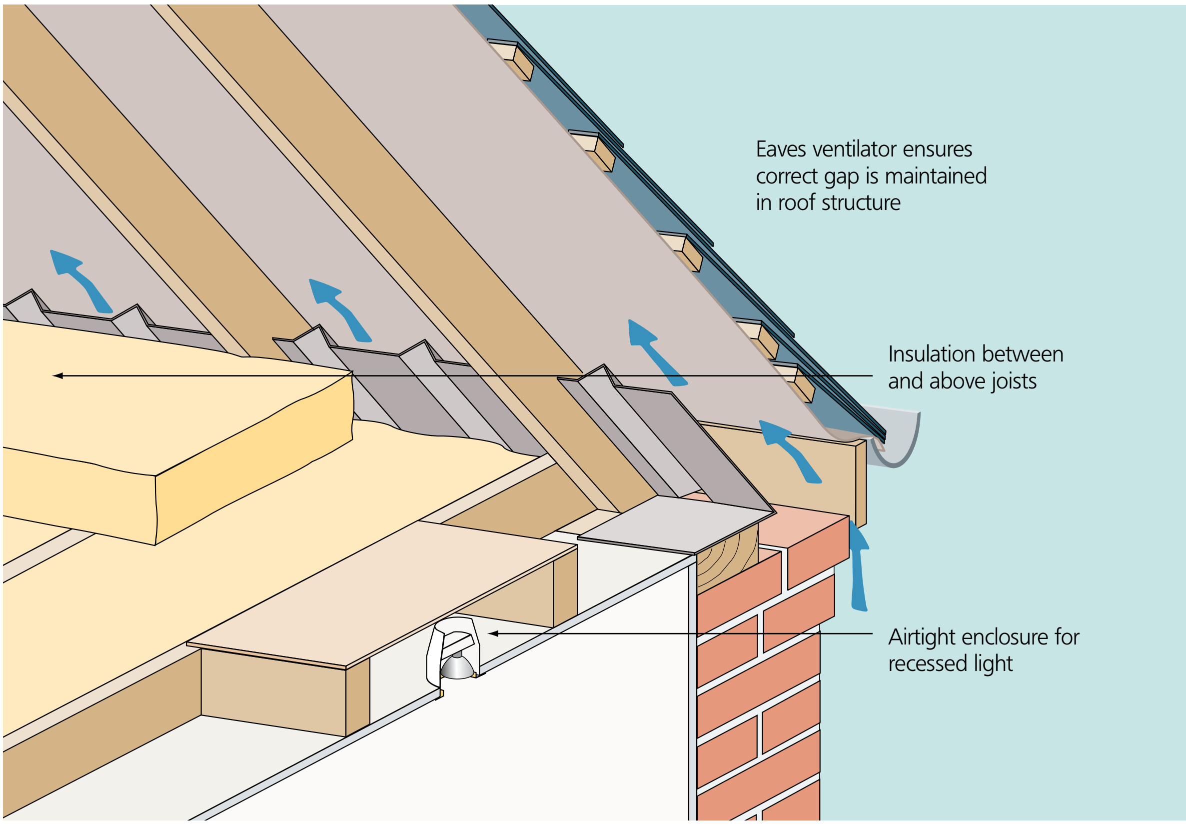
Best practice specification

For best practice, aim for a U-value of 0.16W/m²K or better. Quilted or loose-fill insulation materials are generally used. To minimise thermal bridging and improve airtightness, it is best practice to apply the insulation between – and across the top of – the ceiling joists.

Roof space ventilation

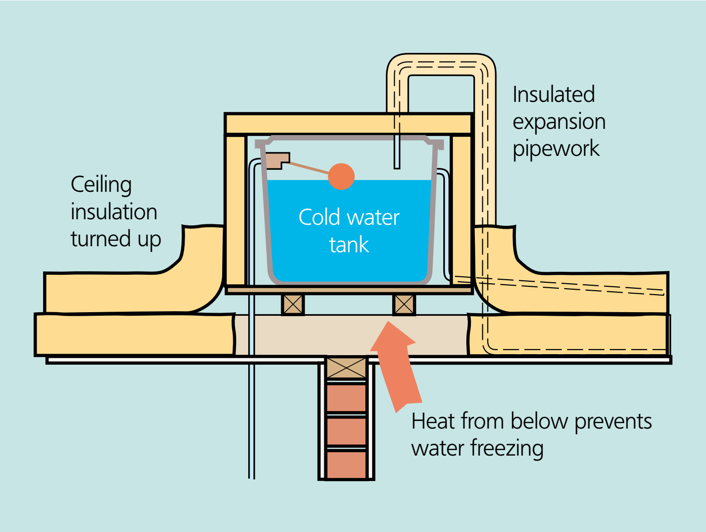
Roof pitch less than 15° – there should be the equivalent of a 25mm continuous gap around the roofspace at the eaves. Eaves ventilators are needed to maintain cross-ventilation of the roof space, preventing condensation. Roof pitch 15° or more – there should be the equivalent of a 10mm continuous gap around the roofspace at the eaves. Eaves ventilators are needed to maintain cross-ventilation of the roof space, preventing condensation.

Ventilators should be protected by a 3-4mm mesh at the openings, to prevent insects getting in. Low-pitched roofs and those with complex geometry may need extra ventilation. Extra ventilation will also be needed at the ridge of steeply pitched roofs. Proprietary ventilated slates are available for these situations.



Roofs

Where there is a sloping ceiling, such as in a 'room in the roof', insulation must not be stuffed between the roof timbers. This may obstruct vital cross ventilation. Instead, fix laminated insulating plasterboard over the existing ceiling – if over a stairwell or landing, ensure that minimum required headroom is maintained (see Section 6.5).



Remember to insulate all cold water tanks and pipes, as adding loft insulation makes the loft space colder. Do not insulate under tanks (unless they are raised well above the rafters) as this would prevent the tanks benefiting from useful heat rising from below.

Seal all cracks as well as holes around pipes and cables where they pass through the ceiling. This prevents moist air from the house entering the loft and condensing on cold surfaces.

Add further joists to provide a raised walkway or storage surface, which will not involve compressing the insulation.

Insulate and draught seal the loft hatch, or fit a proprietary insulated access hatch.

Blown insulation, such as mineral wool or recycled cellulose, should only be installed by a specialist. The National Insulation Association has a register of approved contractors.

Table 8 Roof insulation – ceiling level specifications and performance

Insulation type	Typical thermal conductivity (W/mK)	Ceiling level insulation 100mm joists filled with insulation – Additional thickness above joists (mm): 50	100	150	175	200
		U-values achieved				
Cellulose	0.035	0.24	0.18	**0.14**	**0.13**	**0.12**
Flax	0.037	0.25	0.19	**0.15**	**0.14**	**0.13**
Sheep's wool and hemp	0.039	0.26	0.20	**0.16**	**0.14**	**0.13**
Mineral wool (blown)	0.043	0.28	0.21	0.17	**0.16**	**0.14**
Mineral wool (quilt)	0.044	0.29	0.22	0.18	**0.16**	**0.15**
Vermiculite	0.63	0.38	0.30	0.24	0.22	0.20

Assumptions for Table 8 – roof insulation
12.5mm plasterboard, timber joists (Bridging Fraction = 0.09), loft hatch with 50mm insulation
The U-values quoted are only applicable to the exact construction described. Contact the manufacturer of the selected insulation to discuss the technical requirements and assess the potential for interstitial condensation. This should be done prior to commencing work.

Worse than best practice in refurbishment | **Achieves best practice in refurbishment**

6.3 Insulation between and below rafters

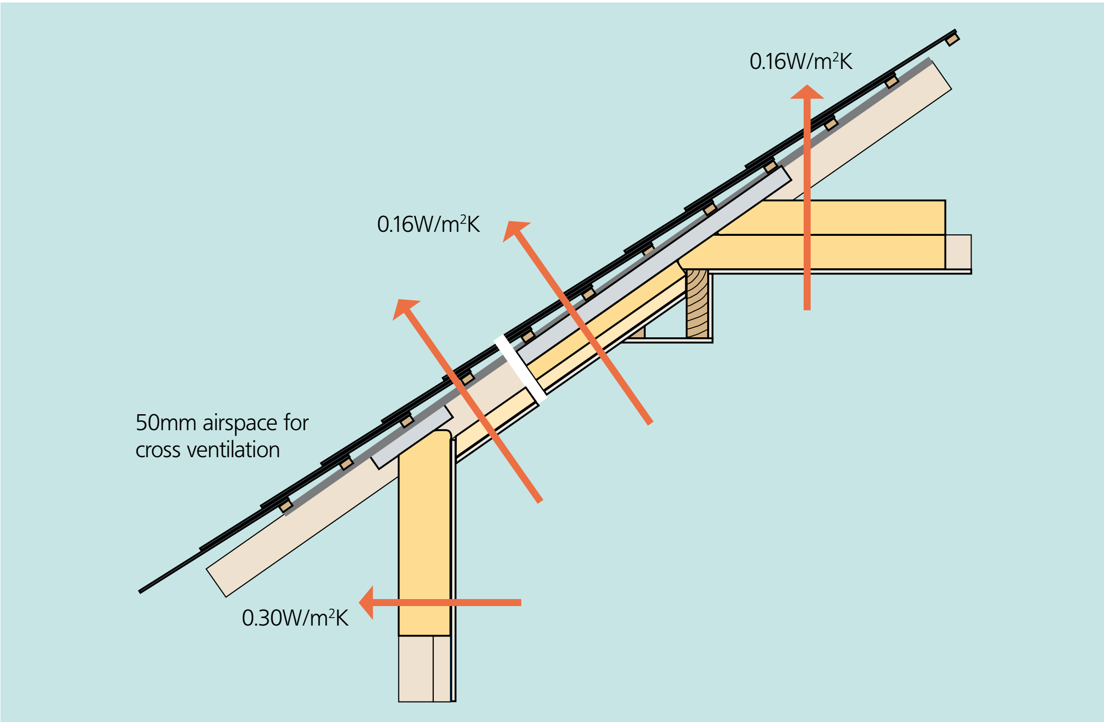
Best practice specification
For best practice, aim for a U-value of 0.16W/m²K (for stud walls and dormer cheeks a U-value of 0.3W/m²K should be the aim). This method is suitable for attic rooms, or 'room in the roof' conversions. Sometimes achieving best practice U-values may require large insulation thicknesses (for example over 60mm below rafters). This may reduce internal space and headroom. In these restricted situations, it may be more practical to aim for a U-value of 0.20W/m²K. Guidance on insulating dormer cheeks can be found in 'Energy efficient loft extensions' (CE120).

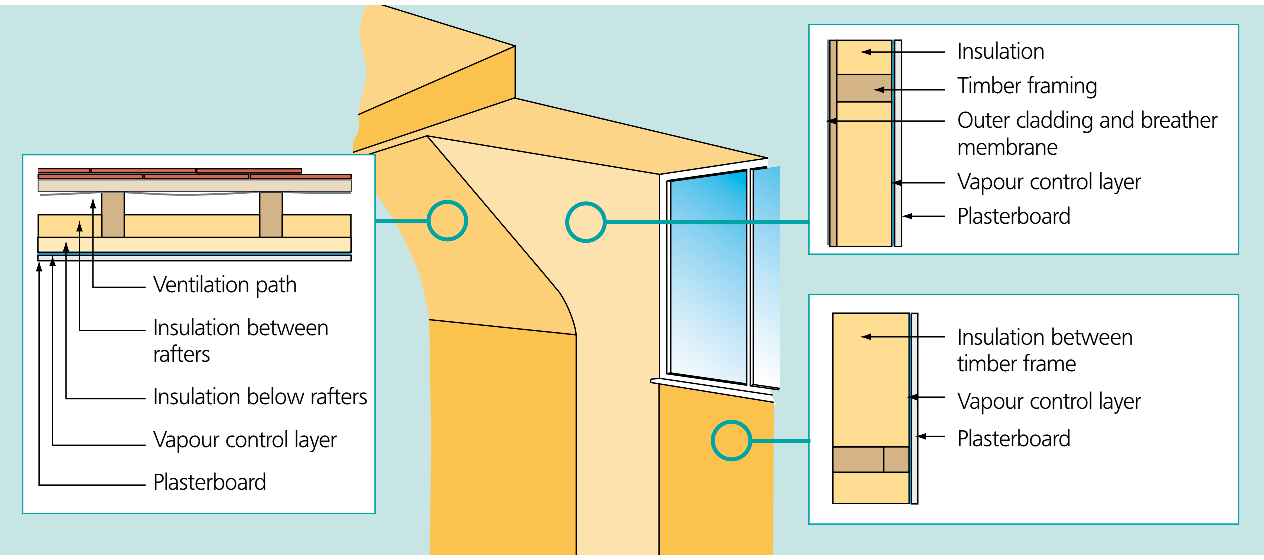
With sloping ceilings, provide a ventilation path above the insulation at least 50mm deep. Install purpose-made eaves vents that provide the equivalent of a 25mm continuous gap, as well as ventilation at the ridge in order to maintain cross ventilation of the roofspace and prevent condensation.

Interstitial condensation
Installing insulation at rafter level can achieve high thermal performance as detailed in Tables 9 and 10. However, there is a risk of interstitial condensation. It is particularly important to ensure a continuous vapour control layer on the warm side of the insulation. Contact the manufacturer of the selected insulation material to discuss the technical requirements and assess the risk of interstitial condensation. This should be done prior to commencing work.

Provide a vapour control layer, usually 500 gauge polyethylene, on the warm side of the insulation to prevent moist air passing through. This should be joined to any vapour control layer in the adjacent walls.

Do not puncture the vapour control layer. Instead, create a service zone, or route services on the warm side of the vapour control layer. Seal any holes that do occur; lap and seal all joints in the vapour control layer.





Flexible thermal linings

Although these materials alone will not achieve best practice standards, they should be considered for difficult areas where wall or roof thickness – or the risk of mould growth – are important factors. They may also be appropriate where only cosmetic refurbishment was originally planned, for example wallpaper replacement.

Table 9 Roof insulation – between and below rafter specifications

Insulation type	Typical thermal conductivity (W/mK)	Rafter level insulation and below											
		100mm rafter (50mm insulation between rafter and 50mm ventilated cavity)				125mm rafter (75mm insulation between rafter and 50mm ventilated cavity)				150mm rafter (100mm insulation between rafter and 50mm ventilated cavity)			
		Additonal insulation above rafters (mm)				Additonal insulation above rafters (mm)				Additonal insulation above rafters (mm)			
		40	60	80*	100*	40	60	80*	100*	40	60	80*	100*
		U-values achieved				U-values achieved				U-values achieved			
Phenolic	0.022	0.26	0.21	0.18	0.15	0.21	0.18	0.15	0.14	0.18	0.15	0.14	0.12
Polyisocyanurate and polyurethane	0.023	0.27	0.22	0.18	0.16	0.22	0.18	0.16	0.14	0.19	0.16	0.14	0.13
Extruded polystyrene	0.030	0.34	0.27	0.23	0.20	0.27	0.23	0.20	0.18	0.23	0.20	0.18	0.16
Mineral wool (slab)	0.035	0.38	0.31	0.27	0.23	0.31	0.26	0.23	0.20	0.26	0.23	0.20	0.18
Expanded polystyrene	0.038	0.41	0.34	0.29	0.25	0.33	0.28	0.25	0.22	0.28	0.24	0.22	0.20
Cellular glass	0.042	0.44	0.37	0.31	0.27	0.36	0.31	0.27	0.24	0.30	0.27	0.24	0.21

***Note** Insulation this thick may reduce internal space and headroom.

Assumptions for Table 9 – insulating between and below roof rafters

12.5mm plasterboard, insulation with 4 fixings per m^2 (fixings of 7.5mm^2 with 17W/mK), insulation between rafters, 50mm ventilated cavity (Bridging Fraction = 0.08), sarking felt, 25mm cavity, 15mm clay tiles.

The U-values quoted are only applicable to the exact construction described. Contact the manufacturer of the selected insulation to discuss the technical requirements and assess the potential for interstitial condensation. This should be done prior to commencing work.

Worse than best practice in refurbishment | Practical best practice in some difficult situations | Achieves best practice in refurbishment

6.4 Insulation between and above rafters

Best practice specification

This method is used when the roof tiling is being renewed. For best practice, aim for a U-value of 0.16W/m²K. Achieving best practice U-values may sometimes require large insulation depths (for example over 60mm above rafters). This raises the finished height of the new roof significantly. Such a strategy requires careful consideration, for example in the case of a terraced house where the tiling is continuous across neighbouring properties. It may be more practical to aim for a U-value of 0.20W/m²K.

Interstitial condensation

Installing insulation at rafter level can achieve high thermal performance as detailed in Tables 9 and 10. However, there may be a risk of interstitial condensation. To counter this, a continuous vapour control layer must be installed on the warm side of the insulation.

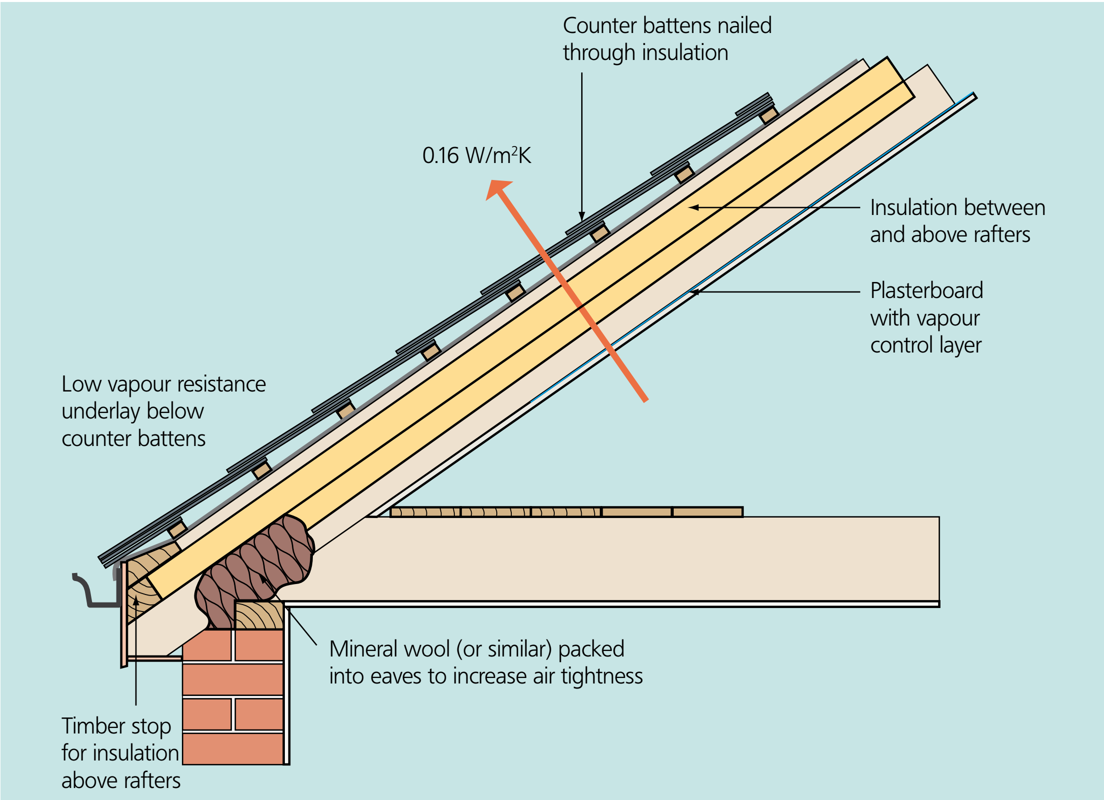
Contact the manufacturer of the selected insulation to discuss the technical requirements and assess the risk of interstitial condensation. This should be done prior to commencing work.

Increased insulation thicknesses are likely to affect the choice of fixings through the counter battens, insulation and rafters. Insulation boards with interlocking edge joints should be specified where possible. Seal the joints between foil-faced boards with self-adhesive aluminium tape. Any service penetrations in the vapour control layer should also be sealed.

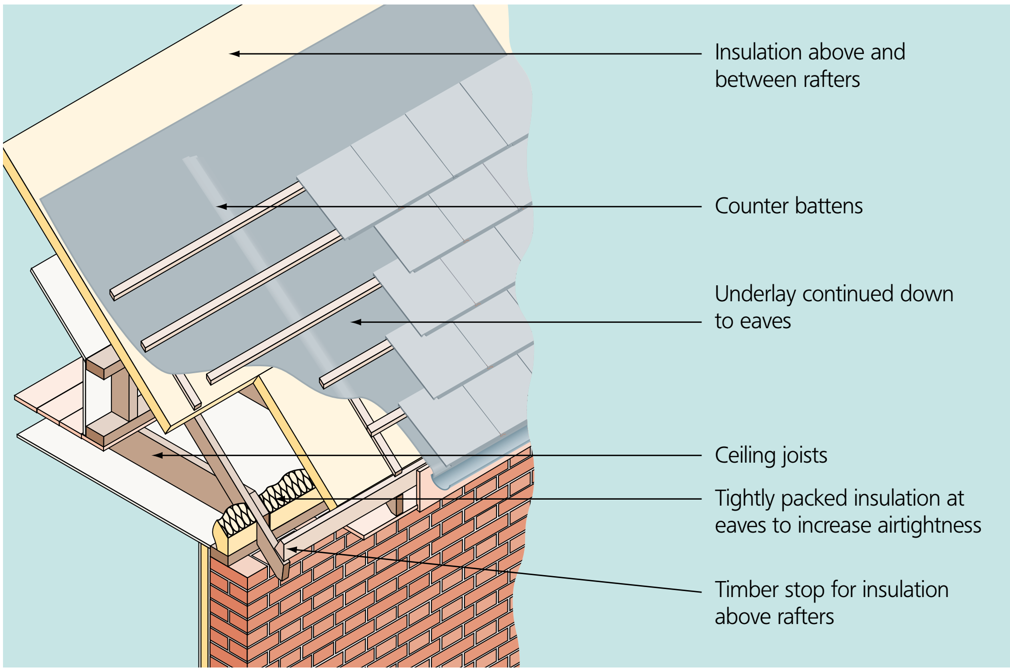
Fill the gap between wall and roof insulation at the eaves to reduce air leakage. Use a low vapour resistance underlay so that moisture does not get trapped in the roof timbers.

Batten and counter batten the roof so that the underlay drains moisture away to the gutter. Special proprietary fixings can be used to install the counter battens above the insulation.

If a cavity is created behind the plasterboard for services it is important that this is sealed at top and bottom. This will eliminate air movement and minimise heat loss.



Roofs



Flexible thermal linings
Although these materials alone will not achieve best practice, they should be considered for difficult areas where wall or roof thickness – or the risk of mould growth – are important factors. They may also be appropriate where only cosmetic refurbishment work was originally planned, for example wallpaper replacement.

Table 10 Roof insulation specifications – between and above rafter

Insulation type	Typical thermal conductivity (W/mk)	Rafter level insulation and above											
		100mm rafter (25mm service cavity and 75mm between rafter)				125mm rafter (25mm service cavity and 100mm between rafter)				150mm rafter depth (25mm service cavity and 125mm between rafter)			
		Additonal insulation above rafters (mm)				Additonal insulation above rafters (mm)				Additonal insulation above rafters (mm)			
		40	60	80*	100*	40	60	80*	100*	40	60	80*	100*
		U-values achieved				U-values achieved				U-values achieved			
Phenolic	0.022	0.21	0.17	0.15	0.13	0.18	0.15	0.13	0.12	0.15	0.14	0.12	0.11
Polyisocyanurate and polyurethane	0.023	0.21	0.18	0.16	0.14	0.18	0.16	0.14	0.13	0.16	0.14	0.13	0.11
Extruded polystyrene	0.030	0.26	0.22	0.20	0.17	0.22	0.20	0.17	0.16	0.20	0.17	0.16	0.14
Mineral wool (slab)	0.035	0.30	0.25	0.22	0.20	0.25	0.22	0.20	0.18	0.22	0.20	0.18	0.16
Expanded polystyrene	0.038	0.32	0.27	0.24	0.21	0.27	0.24	0.21	0.19	0.24	0.21	0.19	0.17
Woodfibre	0.040	0.33	0.28	0.25	0.22	0.28	0.25	0.22	0.20	0.25	0.22	0.20	0.18
Cellular glass	0.042	0.34	0.30	0.26	0.23	0.29	0.26	0.23	0.21	0.25	0.23	0.21	0.19

* Insulation this thick requires careful consideration in properties such as terraced housing where the roof tiling is continuous across neighbouring properties.

Assumptions for Table 10 – insulation between and above rafters
12.5mm plasterboard, 25mm unventilated services cavity, insulation between rafters, (Bridging Fraction = 0.08), insulation with 7 fixings per m^2 (fixings 7.5mm^2 and 17W/mK), underlay, 25mm cavity, 15mm clay tiles.
The U-values quoted are only applicable to the exact construction described. Contact the manufacturer of the selected insulation to discuss the technical requirements and assess the potential for interstitial condensation. This should be done prior to commencing work.

■ Worse than best practice in refurbishment ■ Practical best practice in some difficult situations ■ Achieves best practice in refurbishment

6.5 Flat roof insulation

Best practice specification
For best practice, aim for a U-value of 0.25W/m²K or better. If a flat roof is converted to a pitched roof, it should be insulated to the same standard as a conventional pitched roof (a value of 0.16W/m²K).

The preferred method is to locate the insulation above the roof deck. The insulation should be placed below the weatherproof membrane in a warm roof deck construction, but above the weatherproof membrane in an inverted warm deck construction.

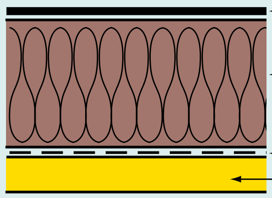
Poor installation can lead to condensation on the underside of the waterproof membrane in inverted deck constructions. This may cause problems internally or within the void between joists.

The manufacturer's installation and detailing instructions should therefore be followed closely. It is most economic to add insulation when replacing the existing roof covering.

Upstands and edge detailing

Careful detailing at the edge and parapet areas of flat roofs is important for high thermal performance and longevity. The correct specification and installation methods for these can be found in BRE Report BR262 Thermal insulation: avoiding risks and Robust details – Limiting thermal bridging and air leakage: Robust construction details for dwellings and similar buildings.

Warm deck construction



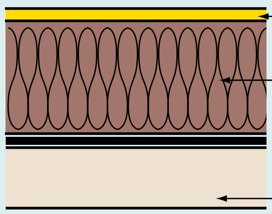
U-value: 0.25W/m²K

- Insulation boards to be rigid
- Insulation materials must be compatible with any bonding materials used for the weatherproof membrane
- Voids in timber roof must not be ventilated to the outside

Inverted warm deck U-values

Rain water percolates through the ballast as well as joints in the insulation of inverted warm roofs. When this comes into contact with the waterproof membrane, there is increased heat loss. It is therefore necessary to compensate for this in U-value calculations. The performance of a specific roof will be significantly influenced by the local annual rainfall. Discuss directly with the insulation manufacturer the suitability of an inverted roof for a specific building.

Inverted warm deck construction



U-value: 0.25W/m²K

- The existing roof structure must be capable of supporting the extra weight, particularly of the ballast layer

Table 11 Roof insulation specifications – warm deck flat roofs

Insulation type	Typical thermal conductivity (W/mK)	Flat roof insulation – warm deck					
		Insulation thickness (mm)					
		60	80	100	120	140	160
		U-values achieved*					
Polyisocyanurate and polyurethane	0.023	0.32	0.26	0.21	0.18	0.16	0.14
Expanded polystyrene and mineral wool (slab)	0.038	0.45	0.36	0.30	0.26	0.23	0.20
Cellular glass	0.042	0.51	0.42	0.35	0.30	0.27	0.24

Assumptions for Table 11 – warm deck roofs

Timber roof 12.5mm plasterboard, 150mm timber roof space with no insulation, 20mm timber decking, insulation, 6mm felt weather cover

Concrete roof 12.5mm plasterboard, 22mm battens, 150mm concrete deck, insulation, 6mm felt weather cover

The U-values quoted are only applicable to the exact construction described. Contact the manufacturer of the selected insulation to discuss the technical requirements and assess the potential for interstitial condensation. This should be done prior to commencing work.

Worse than best practice | Achieves best practice

* Concrete roof structures will typically have slightly higher U-values than those indicated.

7 Embodied energy

There is a growing urgency to reduce the environmental impacts of human activities.

Energy efficiency initiatives over the last 40 years have reduced the energy consumption of buildings considerably, but action to minimise the impact from construction materials has been relatively slow.

There are two key elements to the energy use of a building. Energy used by occupants to run the building during its lifespan – known as operational energy; and energy used during the manufacture, maintenance and replacement of the components that constitute the building during its lifespan. This is known as embodied energy.

In older buildings operational energy has traditionally represented the major impact. As the energy efficiency standards of modern buildings have been raised the importance of embodied energy has increased.

Where the selection of products and materials directly affect the operational energy, the most efficient option should be selected. For those looking to maximise environmental benefit, or where products are very similar in terms of operational performance, then embodied energy should also be taken into consideration.

Windows and doors represent a common example of this selection process. They typically contribute between 5-10 per cent of the embodied energy of a building. Although using double glazing increases this embodied energy, the savings from the improved insulation outweigh this additional impact within a year or so of installation.

Further reading

- BR390 The Green Guide to Housing Specification, Anderson and Howard, BRE, 2000
- Life Cycle Assessment of PVC and of principal competing materials. Commissioned by the European Commission, April 2004.

8 Contacts and further reading

Contacts

Draught proofing
National Insulation Association (NIA)
www.insulationassociation.org.uk
Tel: 01525 383313

Draught Proofing Advisory Association Limited
www.dpaa-association.org.uk
Tel: 01428 654011

Floors
British Standards Institution
www.bsi-global.com
Tel: 020 8996 9000

British Urethane Foam Contractors Association (BUFCA)
www.bufca.co.uk
Tel: 01428 654011

Roofs
National Insulation Association
www.insulationassociation.org.uk
Tel: 01525 383313

British Urethane Foam Contractors Association (BUFCA)
www.bufca.co.uk
Tel: 01428 654011

Walls
The Insulated Render and Cladding Association (INCA)
www.inca-ltd.org.uk
Tel: 01428 654011

National Insulation Association (NIA)
www.insulationassociation.org.uk
Tel: 01525 383313

British Urethane Foam Contractors Association (BUFCA)
www.bufca.co.uk
Tel: 01428 654011

Windows
British Fenestration Rating Council (BFRC)
www.bfrc.org
Tel: 08700 278 494

British Plastics Federation
www.bpf.co.uk
Tel: 020 7457 5037

British Woodworking Federation
www.bwf.org.uk
Tel: 020 7608 5050

Council for Aluminium in Building
www.c-a-b.org.uk
Tel: 01453 828851

Fenestration Self-Assessment Scheme (FENSA)
www.fensa.org.uk

Glass and Glazing Federation
www.ggf.org.uk
Tel: 020 7403 7177

Steel Window Association
Tel: 020 7637 3571

Further reading

BR 262: Thermal insulation: avoiding risks, Stirling, BRE, 2001

BR390 The Green Guide to Housing Specification, Anderson and Howard, BRE, 2000

Further information

The Energy Saving Trust sets energy efficiency standards that go beyond building regulations for use in the design, construction and refurbishment of homes. These standards provide an integrated package of measures covering fabric, ventilation, heating, lighting and hot water systems for all aspects of new build and renovation. Free resources including best practice guides, training seminars, technical advice and online tools, are available to help meet these standards.

The following publications may also be of interest:

- Central Heating System Specifications (CHeSS – Year 2005) (CE51/GIL59)
- Whole house boiler sizing method for houses and flats (CE54)
- Energy efficient lighting (CE61)
- Insulation materials chart – thermal properties and environmental ratings (CE71)
- Energy efficient refurbishment of existing housing (CE83/GPG155)
- Advanced insulation in housing refurbishment (CE97)
- Energy efficient refurbishment of existing housing – case studies (CE104/GPCS418)
- External insulation systems for walls of dwellings (CE118)
- Energy efficient loft extensions (CE120)
- Energy efficient garage extensions (CE121)
- Energy efficient domestic extensions (CE122)
- Post-construction testing – a professional's guide to testing housing for energy efficiency (CE128)
- Improving airtightness in existing homes (GPG224)
- Energy efficient ventilation in housing. A guide for specifiers on requirements and options for ventilation (GPG268)

To obtain these publications or for more information, call 0845 120 7799, email bestpractice@est.org.uk or visit www.est.org.uk/housingbuildings

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