CE17

Internal wall insulation in existing housing – a guide for specifiers and contractors

energy saving trust®

Contents

Cover image courtesy of Nottingham Eco Home

1. Introduction

Home energy use is responsible for over a quarter of UK carbon dioxide (CO_2) emissions which contribute significantly to climate change. To help mitigate the effects of climate change, the Energy Saving Trust offers a range of technical solutions to help UK housing professionals build to higher levels of energy efficiency.

The aim of this guide is to help specifiers and contractors decide when and how to apply internal insulation to existing houses with brick, block, no-fines, stone or timber-framed walls. Four basic types of internal insulation are described and illustrated, followed by detailed information on the factors that will influence the choice of insulation and installation method.

This publication is particularly concerned with encouraging best practice. While the requirements for satisfying building regulations in various parts of the UK are described, the main purpose is to explain how to achieve better performance through careful choice of materials and practices.

1.2 Why insulate?

- Increased comfort for the occupiers of the properties.
- Reduced ongoing costs for occupiers and increased affordability through reduced energy use.
- Reduced CO_2 emissions, which benefits the environment.

1.3 Benefits of internal insulation

- Cost-effective.
- External wall appearance maintained.
- Generally easier to install and maintain than external cladding.
- Readily available materials.

A brief glossary of terms used is shown below.

Vapour resistance
The tendency or ability of a layer of material to resist the movement of water vapour.

Vapour permeability
The tendency or ability of a material to enable water vapour to pass through it.

Vapour resistivity
The tendency or ability of a material to resist the movement of water vapour.

No-fines
A type of wall construction common in post-war housing which is made of concrete without any fine aggregates. Largely built in the late 1940s and early 1950s.

Insulated dry-lining
A composite board or structure which incorporates internal plasterboard affixed to insulation.

Plasterboard thermal laminate
A sheet of plasterboard bonded to an insulation material and sold as a single unit.

Thermal resistance
The tendency or ability of a building element (or of a layer within a building element) to resist the passage of heat between the inside and outside of a building.

U-value or 'thermal transmittance'
The rate of heat transfer through an element of a structure, expressed in W/m^2K. A lower U-value represents a reduction in heat transfer and an improved thermal performance.*

Thermal bridge
Region within a building element where the transfer of heat is higher than in other parts of the same element. A severe thermal bridge could lead to mould growth or condensation. A thermal bridge can also refer to a junction between two building elements where the transfer of heat is higher than in neighbouring elements.

* Strictly speaking the U-value can vary slightly with temperature or with temperature difference, but this variation is usually negligible.

2. Where to use internal insulation

Cavity fill is generally the most cost-effective way to improve the insulation of brick or masonry cavity walls (for details see 'Cavity wall insulation in existing dwellings' (CE252)). However, for solid walls where there is no cavity, insulation can be improved by installing either internal dry-lining or external cladding.

In most cases internal insulation is preferred because it costs less to install and maintain than external insulation, and does not require any scaffolding or specialist skills. It also has the advantage that the necessary materials are readily available and the building's external appearance is maintained. The drawbacks are that its installation disrupts the occupiers and reduces room size.

Internal insulation is especially suitable when it is installed:

- As part of a refurbishment that would involve disrupting the internal surfaces and fixtures (because the application of internal insulation would not lead to any additional disruption).
- In multi-storey buildings where establishing access for applying external insulation would be expensive.
- In buildings with an attractive external appearance which would be lost if external insulation was applied.
- In buildings that are in conservation areas.

Internal insulation is unsuitable if:

- Ornate plasterwork or wood panelling needs to be retained and/or the interior appearance is protected under a listed buildings order.
- It is difficult to avoid excessive thermal bridging.
- The walls are unsuitable because of rain penetration.
- Room sizes are too small to accommodate the reduction caused by the thicker internal lining.
- The disruption of fixtures would be excessive.
- The disruption to the occupants (or associated costs) would be too great.

In the above circumstances alternative forms of insulation, or methods of reducing CO_2 emissions, should be considered.

It is now a requirement in England, Wales, and Northern Ireland that if the existing wall has a U-value of more than 0.7W/m^{2}k, then the thermal resistance of an existing external wall be upgraded whenever any of its thermal layers (which include plaster and render layers) are renovated. The final U-value required varies from country to country across the UK, and you should determine this by discussing your proposals with your local authority's building control or building standards department. (For Scotland refer to www.sbsa.gov.uk)

3. Methods of internal insulation

In order to ensure that insulation is safe and effective, the manufacturer's instructions should always be referred to. When fixing to the substrate, particular attention should be paid to details. A careful assessment of material, strength and wetness is necessary to ensure a robust installation. There are also special considerations where electrical wiring comes into contact with polystyrene insulation. The main methods of applying internal insulation are listed below.

3.1 Method 1

Plasterboard thermal laminates incorporate a vapour control layer of high vapour resistance and can be fixed in a variety of ways:

- Secured to the wall using adhesive (figure 1), provided the wall surface is sufficiently even. Some insulation products may also require screw fixings (see section 4).
- Screwed to metal furrings or bonded to the wall with plaster dabs.
- Nailed or screwed to timber battens affixed to the wall.
- Nailed or screwed to existing timber-framed walling (figure 2).
- Screwed to smooth dry walls.

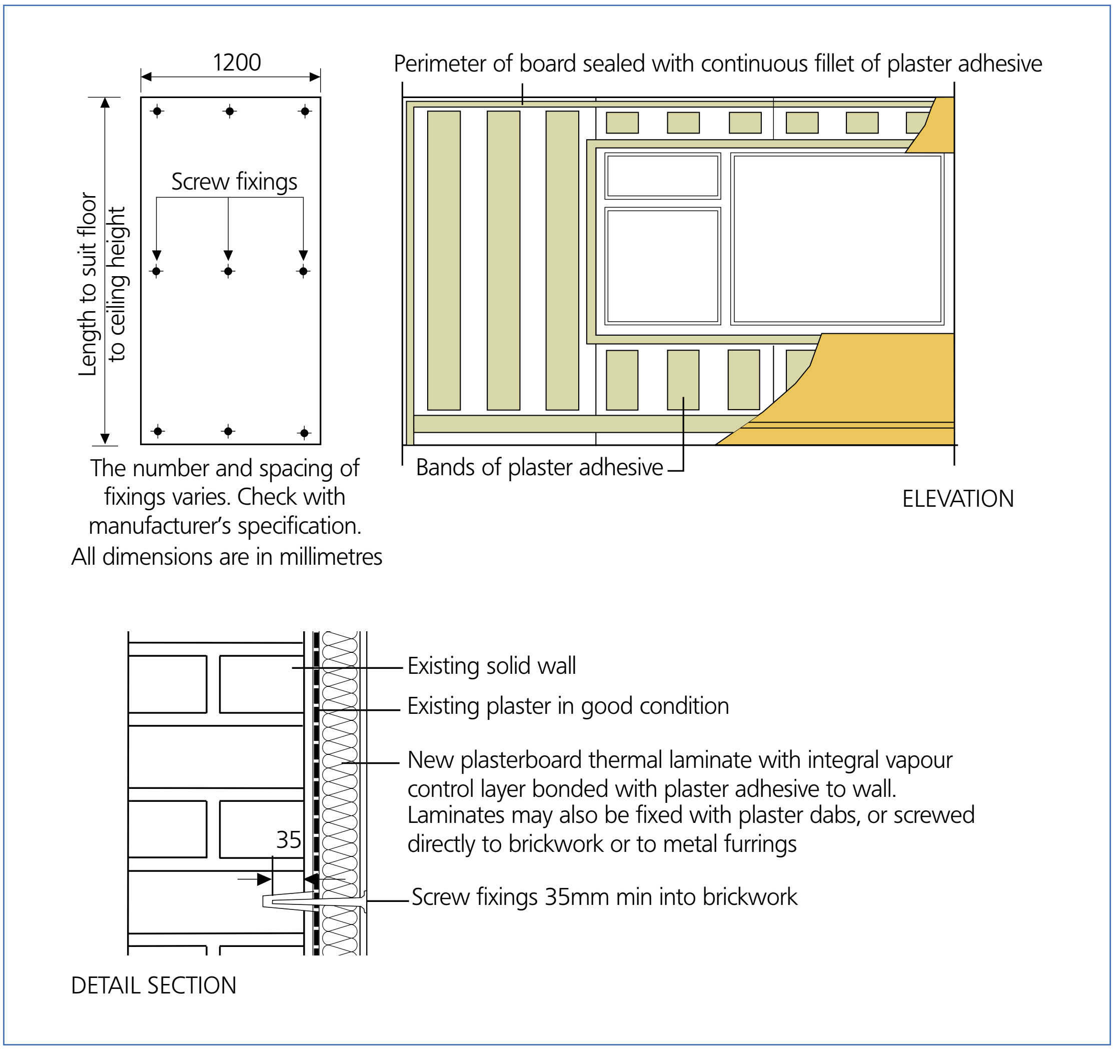
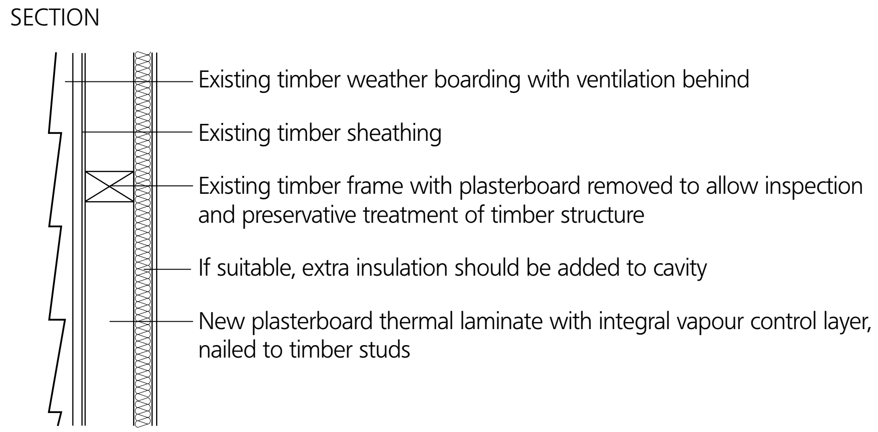


Figure 1: Plasterboard thermal laminate

Methods of internal insulation

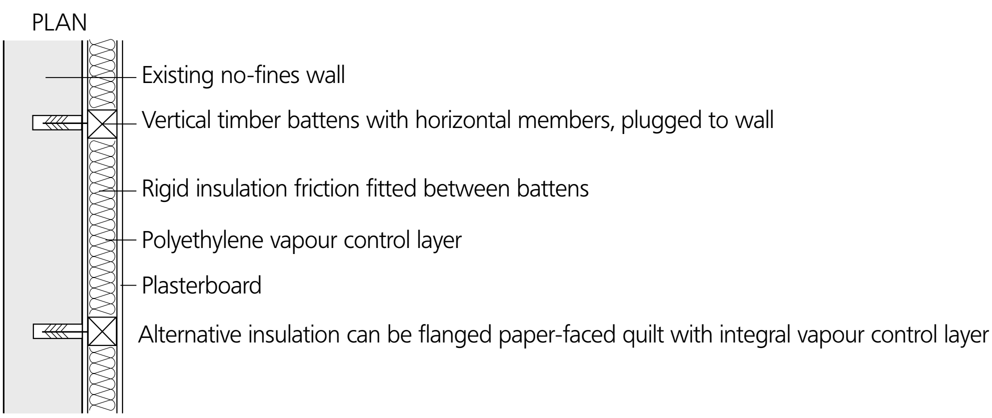


Note: An extra layer of plasterboard may be required for fireproofing. This should be fitted directly to the studs.

Figure 2: Timber-framed external wall with plasterboard laminate

3.2 Method 2

Rigid or semi-rigid insulation may be carefully cut and friction-fitted between battens, fixed to the wall and then covered with a vapour control layer, or with flanged paper-faced quilt insulation incorporating a vapour-control layer stapled to battens and taping joints, then finished with plasterboard (as shown in figure 3).



Notes:

- Tears or punctures in the vapour control layer which arise during the installation of services should be repaired before covering over with plasterboard.
- There may also be a regulatory requirement that no part of the wall should have a U-value exceeding 0.7W/m^{2}K – in all cases, national building regulations should be checked to ensure compliance.

Figure 3: Timber stud frame inside solid no-fines wall

Methods of internal insulation

3.3 Method 3

A timber frame may be installed, which is braced between the floor and ceiling and kept clear of the external wall. Insulation is then stapled to the frame with a vapour control layer and plasterboard finish (see figure 4).

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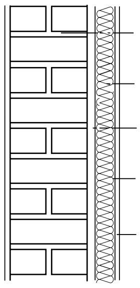


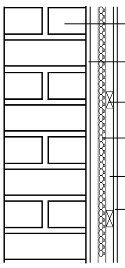
Notes

- The above construction consists of the existing solid wall with external render, with the internal studs set clear of the wall by at least 30mm. This is a safeguard against any rain penetration – note that ventilation of this air gap may be necessary. See also section 6.2 of this guide.
- The timber studs should be braced floor to ceiling and spaced to suit board dimensions.
- Flanged paper-faced insulation quilt with integral vapour control layer (vapour barrier) should then be stapled to the frame and have its joints taped.
- Alternative insulation materials between the studs could be used, provided the insulation material is cut neatly and held on clips to retain it between the studs, as recommended by the manufacturers.
- Any gaps that appear between the studs and the insulation could significantly reduce the performance of the insulation.
- Tears or punctures in the vapour control layer which arise during the installation of services should be repaired before covering over with plasterboard.
- The insulation should be designed so that no part of the wall will have a U-value exceeding $0.7W/m^2K$.

Figure 4: Insulation fitted to timber studs

3.4 Method 4

Aluminium-faced polyethylene air bubble sheet (or multi foil) may be attached to vertical battens that are fixed to the external wall. Counter-battens (arranged perpendicular to the first set of battens) should then be fixed over the insulation to receive the plasterboard finish (see figure 5). It is suggested that a horizontal batten is fixed below the ceiling in order to prevent any downward flow of cold air from the loft space into the space behind the plasterboard or internal insulation.



SECTION

Note: The insulation should be designed so that no part of the wall will have a U-value that exceeds $0.7W/m^2K$.

Figure 5: Insulation fixed to battens and counter-battens

4. Fixing methods

There are a wide range of insulating materials available for dry-lining which can be installed using the four basic methods covered in this guide. Indicative properties of insulating materials are set out in table 1, and table 2 gives U-values for a variety of typical constructions.

4.1 Adhesive fixing

Where the wall is dry and has a sound finish of plaster or concrete (and is not too uneven), laminate boards can be fixed directly to the wall with an adhesive recommended by the board manufacturer. The adhesive is normally applied in 200mm wide bands approximately 50mm from the vertical edges and in the centre of the board. Bands of adhesive are also applied around the periphery of the wall and window to ensure continuous contact at the edges of the boards.

To prevent collapse in the event of fire, boards that incorporate insulation made from plastics should be secured with screw fixings and fixed at least 35mm into the solid background. The number of fixings required will be specified by the board manufacturer; some will require nine fixings, and some only two. Positioned on dry, even walls, as shown in figure 1, mechanical fixing may be used without adhesive, subject to the manufacturer's recommendations.

4.2 Plaster dab fixing

If the wall is uneven (e.g. where it has been stripped of plaster) bonding thermal laminate to it with plaster-based adhesive dabs or strips is a suitable method, providing the wall is dry. The perimeter of the wall and the surround of any openings, such as windows, must be sealed with a continuous band of plaster adhesive to restrict air movement into the building. This would otherwise reduce the thermal effectiveness of the insulation. It is important that sufficient adhesive is used for the perimeter seals to make continuous contact with both the wall and insulation. Mechanical fixings, as for adhesive fixed boards, are also needed.

4.3 Fixing to metal furrings or timber battens

Walls that are uneven can also be insulated by first fixing metal furrings or preservative-treated timber battens to the walls and then screwing, or nailing, thermal laminate onto them. All four edges and the centre of the laminate require support. This method is suitable for walls that have previously been damp (for example: following treatments for rising damp, after curing rain penetration, or after taking measures to reduce condensation).

Non-traditional buildings, constructed with internal timber or metal frames, can also be insulated by nailing thermal laminate directly onto existing timber (provided it is in good condition) or onto a timber frame supported by the metal frame. Existing vapour control layers, if retained incorrectly within the construction, may cause condensation in the structure and should be removed. For this reason, the components of the existing wall (including any residual insulation) should be determined and a condensation risk calculation carried out, taking into account all the layers of the final construction.

4.4 Insulation between (and possibly across) timber battens or metal furrings

Walls can be insulated between vertical timber battens, commonly 50mm wide and at least the thickness of the insulation, which should be fixed to the wall at centres to suit the width of plasterboard. The boards should be supported by battens at the floor and ceiling, and by intermediate noggins in the middle of the boards.

All timber should be preservative-treated. Rigid or semi-rigid insulation boards can be fitted between the battens or flanged paper-faced quilt insulation, with joints taped, can be stapled to the battens. A continuous vapour control layer should be fixed on the warm side of the insulation. This layer may be a separate polyethylene sheet stapled to the battens or incorporated within the flanged paper facing to rolls of insulation (see figure 3). Torn sections should be repaired before covering over with plasterboard to maintain the vapour barrier.

4.5 Constructing a separate inner lining

If it is difficult to achieve a secure fixing to the wall, or if the wall is damp, an independent timber or metal inner frame can be constructed leaving a cavity behind the external wall. The frame, supported at floor and ceiling level, is usually of preservative-treated timber which is 50mm wide and of the same thickness as the insulation, or metal channel and I-sections dimensioned to take plasterboard laminates. Insulation is fixed (as in section 4.4) between the timber studs, and covered with a vapour control layer and plasterboard or, for additional thermal performance, a thermal laminate incorporating a vapour control layer (see figure 4).

4.6 Air bubble sheets and multi-foil sheets

The air bubble sheet (or multi-foil product) is fixed to vertical preservative-treated battens affixed to the external wall, taking care to lap and welt or tape joints between sheets of the material. Battens are then fixed over the insulation at appropriate centres (up to 600mm) to support the plasterboard thermal laminate ensuring an air gap of at least 25mm. Because the insulation performance of these systems depends on the surfaces being reflective to heat, it is important for their optimal performance that reflective surfaces are clean. Plasterboard fixed in contact with the insulation without the secondary battens is less thermally effective and is not recommended (see figure 5).

Treatment of service penetrations

In all cases, where services penetrate the plasterboard thermal laminate, adequate air-tightness* has to be achieved to prevent cold air leakage from the cold side of the insulation into the building. In addition, warm moist air leaking from the inside of the building through the construction could lead to condensation within the insulation or on the inside of the masonry wall. Recessed service fittings could also produce a cold bridge through the insulated layer, so fittings should either be surface mounted or backed by a sufficient level of insulation to reduce the effect of the thermal bridge.

* However, it should be borne in mind, that high levels of air-tightness could be detrimental to some historic buildings (see www.spab.org.uk).

5. Materials

Table 1: Typical properties of insulation materials		
Materials	Density (kg/m^3)	Approximate thermal conductivity (W/m^{2}K)
Mineral wool (stone or glass) for plasterboard laminates	50	0.038
Glass and mineral wool for fitting between battens	15-30	0.040
Expanded Polystyrene Board (EPS)	16	0.038
Graphite EPS	16	0.032
Extruded Polystyrene (XPS)	35	0.030
Polyurethane (PUR)	30	0.025
Polyisocyanurate (PIR)	30	0.025
Phenolic foam	45	0.025
Cellular glass	120	0.04-0.05
Reflective foil insulation (e.g. a bubble sheet or a multi-foil product)	N/A	The overall performance of this insulation method arises partly as a result of the surface reflecting heat back into the airspace.
Cellulose fibre (recycled)	30	0.04
Sheep's wool	25	0.04-0.05
Sprayed polyurethane	35	about 0.025
Further information about thermal conductivities of insulation materials can be found in 'Insulation materials chart – thermal properties and environmental ratings' (CE71).		

Table 2: Thermal insulation values for a selection of typical internally insulated walls

Existing wall	Insulation thickness (mm)	U-value (W/m²K) A	B	C	D	E
215mm existing solid brickwork with plaster finish ($U = 2.1W/m^2K$)	50	0.55	0.48	0.65	0.40	0.57
	60	0.48	0.42	0.58	0.34	0.50
	70	0.42	0.37	0.52	0.30	0.45
	80	0.38	0.33	0.47	0.27	0.40
	90	0.35	0.31	0.43	0.25	0.36
	100	0.33	0.28	0.39	0.23	0.33
	120	0.29	0.25	0.34	0.20	0.29
	125	0.28	0.24	0.33	0.20	0.28
	140	0.25	0.22	0.30	0.18	0.25
	150	0.24	0.21	0.28	0.17	0.24
200mm no-fines concrete ($1.5W/m^2K$) with plaster finish ($U = 2.2W/m^2K$)	50	0.60	0.52	0.72	0.42	0.62
	60	0.51	0.45	0.63	0.36	0.54
	70	0.45	0.39	0.56	0.31	0.47
	80	0.41	0.35	0.50	0.28	0.42
	90	0.37	0.31	0.46	0.26	0.38
	100	0.33	0.29	0.42	0.24	0.35
	120	0.28	0.24	0.36	0.21	0.30
	125	0.27	0.23	0.35	0.20	0.29
	140	0.25	0.21	0.31	0.18	0.26
	150	0.23	0.20	0.30	0.17	0.24
325mm concrete sandwich panel (incorporating polystyrene insulation, with bridging fraction of 15%) with plaster finish ($U = 1.7W/m^2K$)	50	0.50	0.44	0.57	0.37	0.53
	60	0.44	0.39	0.51	0.33	0.46
	70	0.39	0.35	0.46	0.29	0.42
	80	0.36	0.31	0.42	0.26	0.38
	90	0.33	0.29	0.38	0.24	0.34
	100	0.30	0.26	0.35	0.22	0.32
	120	0.26	0.23	0.31	0.20	0.27
	125	0.25	0.22	0.30	0.19	0.26
	140	0.23	0.20	0.27	0.17	0.24
	150	0.22	0.19	0.26	0.17	0.23

A. Insulated with white expanded polystyrene board (conductivity $0.038W/m^2K$) laminated to 12.5mm plasterboard and fixed to wall using plaster dabs or battens (for overall insulation thicknesses above 80mm it is assumed that the additional insulation is located between the battens).
B. Insulated with graphite expanded polystyrene board (conductivity $0.032W/m^2K$) laminated to 12.5mm plasterboard and fixed to wall using plaster dabs or battens (for overall insulation thicknesses above 80mm it is assumed that the additional insulation is located between the battens).
C. Insulated with mineral wool quilt (glasswool or stonewool, conductivity $0.038W/m^2K$) between timber battens and fixed to the wall and covered with 12.5mm plasterboard.
D. Insulated with phenolic foam (or polyurethane or polyisocyanurate, conductivity $0.025W/m^2K$) laminated to 12.5mm plasterboard and bonded to the wall with adhesive (for thicknesses of over 80mm it is assumed that the additional insulation is between battens with a timber fraction of 11.8%).
E. Insulated internally with cellular glass (conductivity $0.04W/m^2K$) applied to the existing plaster and an internal plaster finish applied to the insulation.

6. Design considerations

6.1 Choice of insulation materials

Use insulation materials that are free from ozone-depleting agents such as HCFCs and HFCs and avoid those with a high Global Warming Potential (GWP). Mineral wools are free from such agents and many plastic insulants also now satisfy this requirement (see section 10).

Before starting any work a detailed inspection of existing timbers for dry or wet rot and insect attack should be carried out. Decayed timbers should be replaced. Dry rot must be eradicated by appropriate treatment to timbers and walls and all replacement timber should be preservative treated. Guidance is given in BRE Digest 299 'Dry rot: its recognition and control' and BRE Digest 345 'Wet rot: recognition and control' on treatment of timbers, and the need for removing sources of moisture and providing adequate ventilation so that further rot does not occur.

6.2 Existing internal finishes and dampness

The internal wall surface should be checked for dampness and remedial action taken if any moisture is present. Dampness may have various causes including leaking pipes or overflows, or faulty damp proof courses and flashings. If dampness (and mould) is caused by condensation, the dwelling may require improved ventilation and heating in addition to insulation. Solid walls in older housing types may have plaster on timber laths and battens. Batten fixings are often likely to have experienced damp conditions, perhaps leading to corrosion, and these will usually not be sound enough to take any further thermal lining. Plaster, lath and battens should therefore be removed prior to an insulated dry-lining system being installed.

Solid brickwork and stonework may be damp from rain penetration. External pointing or rendering can sometimes reduce moisture penetration, but if any doubt remains the best method of internal insulation is to construct an inner frame of timber or metal located at least 30mm clear of the masonry wall, as described under 'Method 3' in section 3.3. The resulting air space may also require ventilation, and this should be taken into account when determining the new U-value of the construction.

Plaster or fibreboard linings to timber-framed or metal-framed walls should be removed to check the condition of the structure, and to allow any rot or corrosion of the frames to be treated. Insulation can be placed within the frame and an additional insulated lining can also be fixed over the frame. It is normally suitable to apply thermal laminates directly to plastered cavity walls, but ensure that the plaster is not loose and that any broken plasterwork is patched. Thermal linings can also be applied directly to self-finished large panel construction.

6.3 Thickness of insulation

Internal insulation reduces the size of rooms by the thickness of the insulation system. Most rooms can accept this reduction but it can be critical in bathrooms, WCs and small kitchens, and may therefore influence the choice of insulation. Thermal laminate wall boards bonded by adhesive to the wall will generally take up the least space, whereas a timber stud frame kept clear of the wall will intrude at least 90mm.

6.4 Exposure of wall to wind-driven rain

Dry-lining should not be used to isolate dampness. The source of dampness must be cured and the walls must be allowed to dry thoroughly. Solid walls should be examined for signs of dampness and assessed to determine what systems are suitable. 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'. This gives guidance on resistance to weather (with the exception of no-fines concrete). Solid walls subject to very severe driving rain should be externally clad. For conditions assessed as severe, brickwork at least 328mm thick, rendered dense aggregate concrete blockwork 250mm thick, or autoclaved aerated concrete 215mm thick may be suitable for dry-lining. A notional cavity is needed behind the dry-lining to provide a break in any moisture transmission path.

6.5 Interstitial condensation

Air inside a dwelling tends to carry more moisture than the same volume of air outside. If inside air is able to leak from the dwelling through the construction, the air cools quickly and can cause condensation on any surface that is on the cold side of this insulation. This can lead to mould or deterioration of timber in contact with the insulation. It is therefore important to separate the inside air from the insulation by applying a 'vapour barrier', also known as a 'vapour control layer', to the warm side of the insulation.

Design considerations

A vapour control layer can be achieved by using polyethylene sheet or treated paper facing to mineral wool quilts, or with an integral layer, e.g. in thermal laminate boards. In all cases, the weak points are at the joints between the sheets or boards and where pipes or other services penetrate the lining. Careful attention should be paid to the sealing and lapping of joints and sealing around penetrations. Plasterboard manufacturers supply a plasterboard primer that helps control vapour penetration at the surface of the board, but this should be an addition to and not an alternative to polyethylene sheet or an integral vapour control layer.

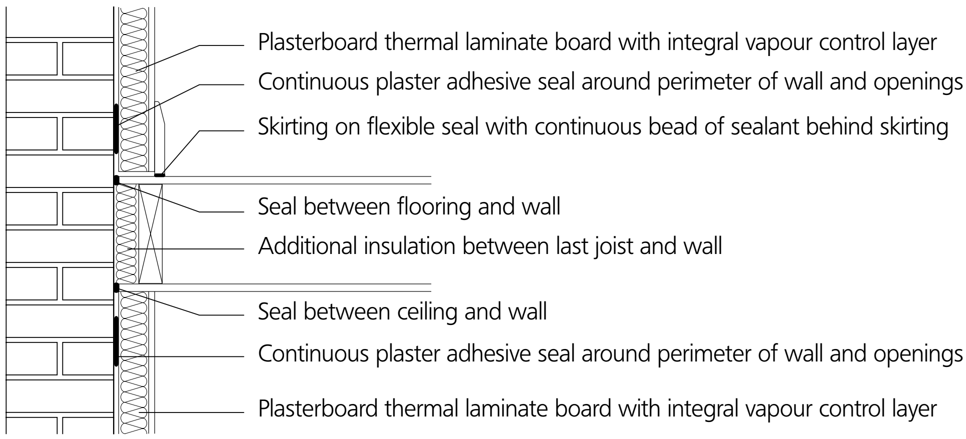
It is also recommended that mechanical extraction to bathrooms/kitchens should be installed in addition to vapour control measures as part of the renovation works. For damp, south-facing masonry walls less than 250mm thick, the cavity between the new frame and wall should be ventilated to the outside to prevent summer condensation (see BR262 'Thermal Insulation: avoiding risks').

6.6 Sealing for air leakage behind dry-lining

To ensure that the insulated dry-lining will perform thermally as intended, it is important that the wallboard is sealed with adhesive or battens around its perimeter with adjoining walls, the floor and ceiling. It must also be sealed around windows, doors and other openings. If the seal is omitted or incomplete, cold air from the space behind the insulation can leak into the room and reduce the effect of the insulated lining.

Any gaps behind the new insulated dry-lining (particularly when used for upgrading flats) should be sealed to stop the circulation of cold air, to restrict noise transmission, and to prevent (or slow down) the spread of fire and smoke. After ensuring that adequate sound-deadening and fire stopping has been provided (check the requirements of national building regulations), the flooring and ceiling board should be taken as close to the wall as possible, and the remaining gap filled with a continuous seal of plaster. The plasterboard lining to timber frames should be sealed around the ceiling, wall and skirting perimeter with plaster, and the skirting should be set on a flexible seal (see figure 6).

It should also be ensured that there is a vapour control layer to the warm side of the insulation, including the insulation located between a floor and the ceiling below. When dry-lining plastered or self-finished concrete walls, any gaps or major cracks should be filled to stop leakage of cold air into the dwelling.



Note: Separating or compartment floors may require additional components to meet acoustic and fire safety requirements

Figure 6: Timber stud frame – treatment of intermediate floors

Design considerations

6.7 Dry-lining window and door reveals

Window and door reveals can be sources of condensation and mould if not insulated correctly, but if the amount of visible window frame is too small the full thickness of the insulated dry-lining cannot be applied. If this is the case an insulated window lining board, e.g. expanded PVC, can be used. Ensure that the lining does not restrict ventilators or opening mechanisms. It may be necessary to remove the existing plaster to accommodate an adequate thickness of insulation within the limited space available.

If windows are to be replaced the new jamb and soffit details can be designed to accept the insulated lining. The sill board should generally also be insulated and will need to be deep enough to cover the edge of the wall insulation. Architraves and skirtings will need to be removed and refitted. Make sure that windows and doors will open properly after the insulation has been fitted.

6.8 Thermal bridging

Thermal bridging will occur whenever there is a break in the continuity of the insulation. This often occurs at the junctions of solid external walls with internal walls, where concrete floor edges are exposed on the external face of the building, and at the projection of balconies, etc. Thermal bridging results in a loss of heat and a risk of condensation and mould growth.

Stepped and staggered terraced housing (common in post-war years) can also present problems of thermal bridging, when the construction is of single leaf no-fines or foamed slag concrete. The effect of the thermal bridging in these conditions can be reduced by returning the dry-lining about 1m along the internal wall and continuing it 300mm along the ceiling soffit. In more usual circumstances, for example a flat fronted terrace, a return along the inside wall of around 400mm should be sufficient to limit the effects of thermal bridging.

6.9 Supports for fitments and fixtures

The position of any fitment or fixture (kitchen or storage fitments, sanitary ware, boilers, radiators, etc.) that needs to be fixed to the wall must be identified before dry-lining is installed, and adequate supports provided.

6.10 Provision of services

The penetration of the vapour control layer by services should be avoided wherever possible. Where possible, service outlets should be re-located on adjoining internal partitions. Where services do penetrate the vapour control layer, ensure that the hole is well sealed with vapour resistant tape or acrylic sealant.

Services should be installed before dry-lining starts. Dry-lining, based on a framing system, can ensure adequate space for locating most wires or pipes. Where laminates are bonded to the wall, the space behind the insulation board may be inadequate making it necessary to cut a channel either in the wall or in the insulation. Avoid contact between PVC-insulated electrical wiring and polystyrene insulation, as this can cause the PVC sheathing to age prematurely.

Cables covered by insulation should be protected by cover strips, to prevent overheating and reduce the risk of short-circuiting and fire. The rating of cables that are routed through the insulation should be increased, e.g. cables serving cookers, shower units and other appliances with high electrical loads will require larger cabling. Other circuits do not normally exceed their current-carrying capacity when covered with insulation. More detailed guidance is given in BS 7671 'Requirements for electrical installations (IEE Wiring Regulations 17th edition)'.

6.11 Sound transmission

When the insulation is returned along a separating wall, care should be taken to maintain an acceptable level of sound reduction between dwellings. The use of plastic thermal laminates returned along masonry walls can, due to resonance in the lining, show a marked reduction in sound insulation.

Where sound insulation is important, a mineral wool thermal laminate wallboard should be bonded directly to the wall surface. Alternatively, an independent timber frame, fixed clear of the wall at floor and ceiling only, should be used. The frame should be infilled with glasswool or mineral wool batts 50mm thick. For best results the frame should be covered with two layers of 12.5mm wallboard with staggered joints.

6.12 Fixings

Where metal fixings such as nails or screws are used to anchor the plasterboard, and particularly if the metal also penetrates insulation, water could condense preferentially on the fixings. This problem can be reduced by specifying stainless steel rather than galvanised steel fixings. As well as the obvious benefits in relation to corrosion, stainless steel has a lower thermal conductivity than galvanised steel and is therefore less likely to attract condensation. Care should be taken when mounting heavy items such as radiators to ensure that the method of mounting will provide sufficient mechanical support, and, where appropriate, fixings should be well anchored to the masonry rather than relying on the strength of the plasterboard.

6.13 Air-tightness

In order to benefit fully from insulation it is important to pay attention to the overall air-tightness of the building, since high air leakage can lead to loss of heat. To achieve air-tightness attention must be paid to workmanship and to ensuring that vapour control membranes are well sealed. It is important to ensure that unventilated air in gaps behind plasterboard and insulation, including services voids, cannot mix with external air or with cold ventilated areas such as that in loft spaces or underfloor spaces. Such air leakage paths could lead to the air behind the plasterboard becoming very cold, leading to heat loss.

Special care should be taken in the case of historic buildings where air-tightness measures could actually hasten their deterioration and harm the health of occupants. The SBAB publication 'The Control of Damp in Old Buildings' (SPAB Technical Pamphlet 8) provides more information.

Using service voids can improve air-tightness and the future integrity of the insulation because they permit new sockets and wiring to be installed without having to penetrate insulation or vapour control layers.

7. Thermal bridging

Thermal bridging will occur whenever there is a break in the continuity of the insulation. This often occurs at the junctions of solid external walls with internal walls, where concrete floor edges are exposed on the external face of the building, and at projecting balconies, etc. Thermal bridging results in a loss of heat and the risk of condensation and mould growth. Where the internal walls consist of stud partitions, the opportunity exists to partially remove the internal stud wall at the abutment to the external wall so that it is possible to install the new thermal lining as a continuous layer. The internal stud partition could then be repaired as part of the installation of surface finishes to the external wall.

7.1 Thermal bridging at openings

Before insulation is applied, the existing wall construction might typically consist of 220mm-thick, solid brick, with plaster applied to the internal surface. After applying insulation, the increased thermal performance can be seen in figure 7. This shows an insulated wall at a window or door jamb where the plaster was removed, internal battens added, insulation placed between and over the battens, and finished internally with plasterboard.

The temperature distribution in figure 7 shows that with this design the internal surfaces are generally kept warm, minimising the risk of mould growth.

7.2 Thermal bridging at separating walls

Figure 8 shows a junction between an external wall and a solid separating wall, demonstrating how internal insulation can be applied in a way that reduces the risk of internal surface mould.

Figure 7: The wall and reveal following application of the insulation

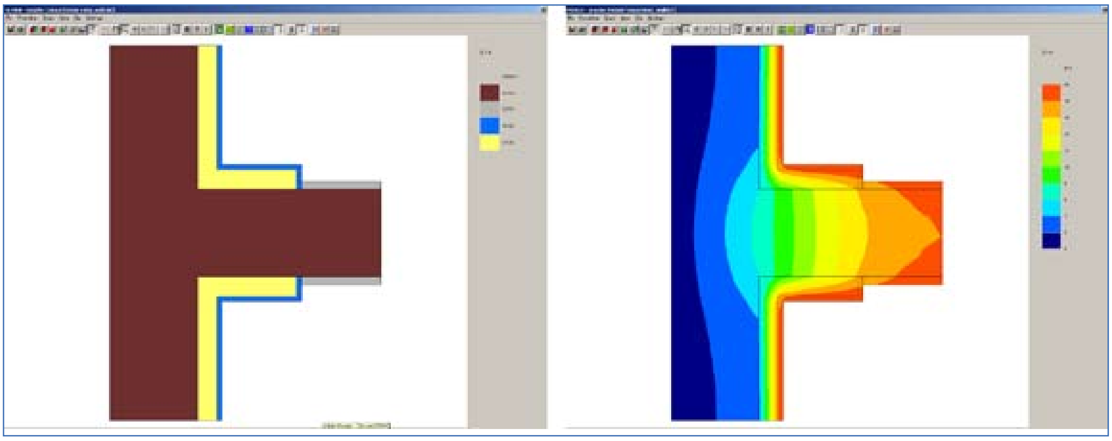


Figure 8: A junction between an external wall and a separating wall, looking from above, with internal insulation applied to external wall and to part of the separating wall

Thermal bridging

Figure 9 shows a junction between an external floor and a separating wall, demonstrating how internal insulation can be applied in a way that reduces the risk of internal surface mould.

7.3 Thermal bridging at ground floors

Figure 10 shows a wall-floor junction after the application of internal insulation.

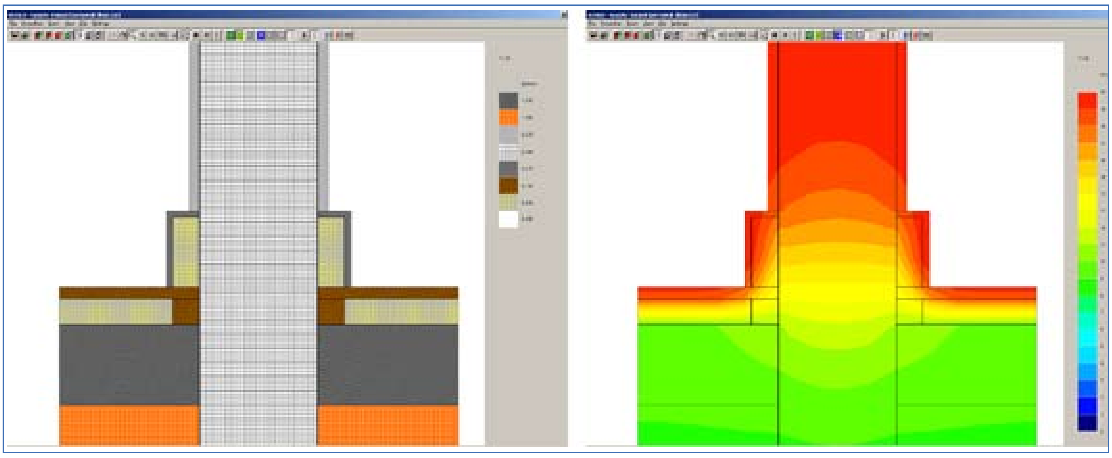


Figure 9: A junction between a separating wall and a ground floor, showing how insulation can be extended a short way up the party wall to minimise the risk of surface condensation and mould

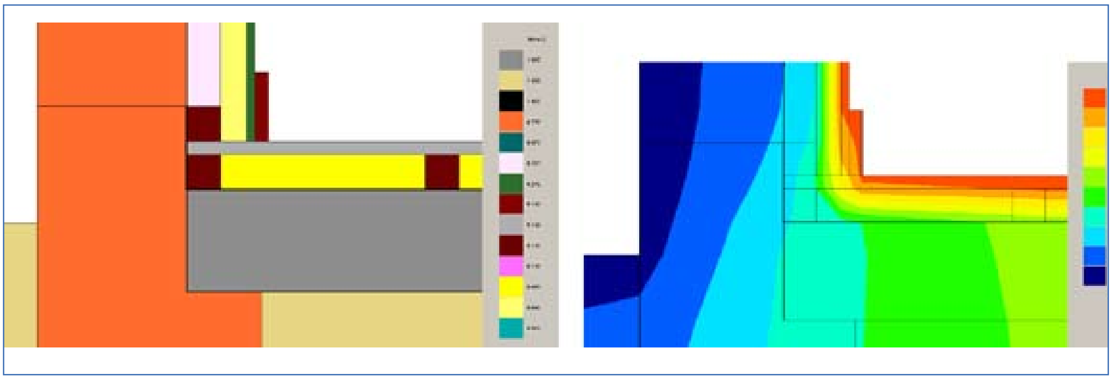


Figure 10: A junction between a wall and a ground floor showing a solid brick (or no-fines) wall supporting a concrete slab, with timbers laid along the length of the floor and insulation placed between the floor timbers. Above the floor timbers is a timber-based floor covering and above this is a plasterboard-insulation laminate with a 30mm air gap behind the laminate. N.B. Although not shown, a damp proof membrane should be provided between the new floor structure and the existing floor, and it should also be lapped up the external wall to protect the edge of the new floor structure.

7.4 Thermal bridging at solid separating floors and staircases

Figure 11 shows insulation applied to a junction between an external wall and a solid separating floor, or between an external wall and a solid staircase.

7.5 Thermal bridging at roofs

Figures 12 and 13 show a junction between an external wall and a ceiling where the space above the ceiling is a cold loft space. Figure 12 shows the junction prior to the application of insulation and figure 13 shows the junction following application of insulation.

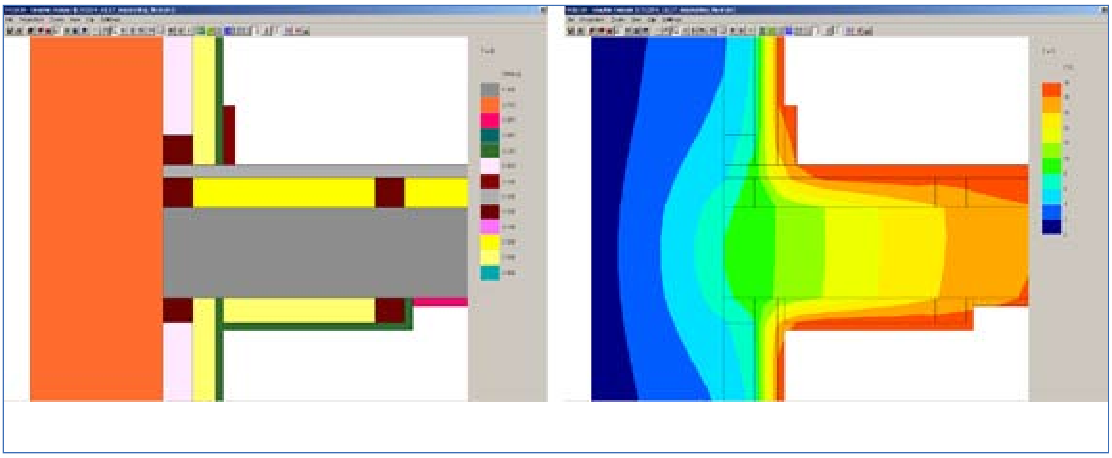


Figure 11: Solid separating floor and external wall, with internal insulation having been applied to the wall, to the floor and to a 300mm length of ceiling (a similar length of insulated soffit would be appropriate beneath solid masonry staircases adjoining external walls)

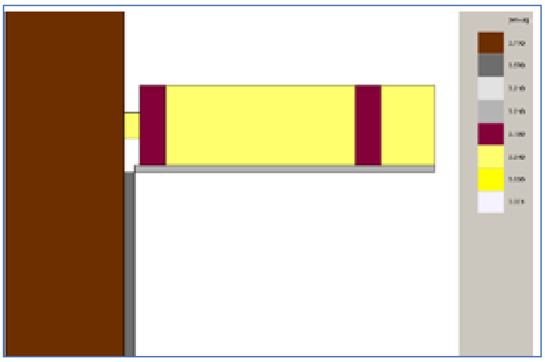


Figure 12: A wall-ceiling junction before any insulation improvement is made. The wall is shown on the left, with a layer of existing wet plaster on it. The ceiling above has quilt insulation between the joists. The joist nearest the wall will tend not to be flush against the wall and there will typically be a 30mm gap between the joist and the wall. In any case a minimum gap of 30mm should be maintained between the solid wall and the insulation to minimise risk of rain penetration.

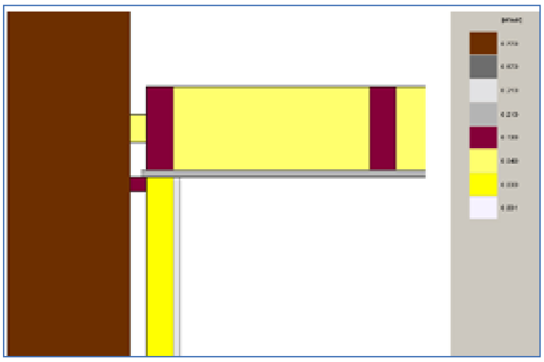


Figure 13: A wall-ceiling junction after the application of insulation. The insulation should be kept at least 30mm from the existing solid wall. Steps should be taken to prevent cold air from the loft space leaking into the space behind the insulation and plasterboard. Timber battens adjacent to the ceiling-wall junction, as shown, can help to prevent this, as can tucking insulation between the joist and the existing wall.

Thermal bridging

7.6 Thermal bridging at a corner where one façade has internal insulation and the other façade has external insulation

Figure 14 shows a wall corner, looking from above, where one part of the wall has internal insulation and the other part has external insulation. Excessive thermal bridging, which could cause mould and condensation, is avoided by arranging an area of overlap between the external insulation and the internal insulation. Running the internal insulation approximately 400mm from the corner can help to prevent thermal bridging.

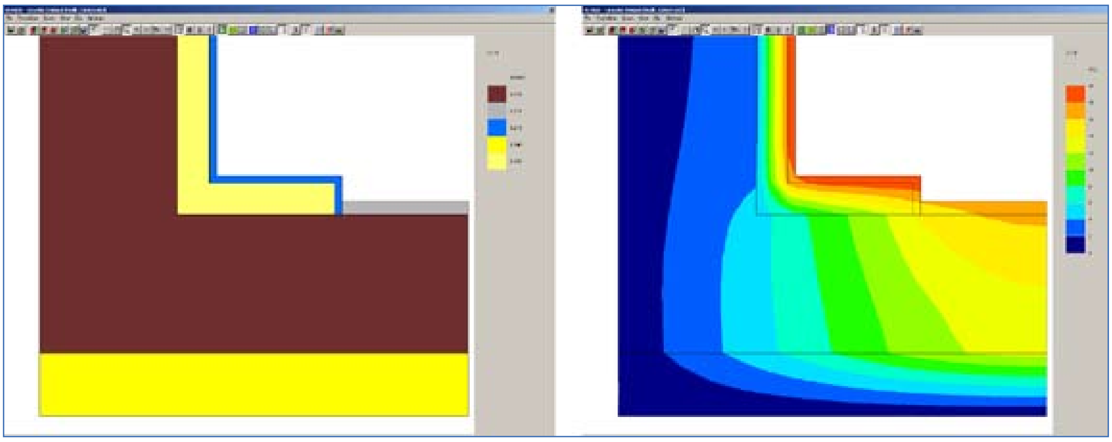


Figure 14: A wall corner, looking from above, where one wall has internal insulation and the other wall has external insulation.

8. Environmental considerations

The use of insulation in the building fabric will significantly reduce the environmental impact of the building over its lifetime. This benefit outweighs the environmental impact of the embodied energy of the insulation materials. However, to minimise the embodied impact, specifiers should avoid foamed plastics insulation materials using blowing agents that cause ozone-depletion or global warming, e.g. HCFCs or HFCs. Alternative blowing agents such as CO_2 or pentane are less environmentally damaging.

For the best overall environmental performance use recycled materials such as cork and cellulose, or more natural materials such as flax or sheep's wool, foams blown using pentane or CO_2 and low-density mineral wool or glass wool, all of which have high ratings in the 'Green Guide to Housing Specification' (see paragraph opposite).

Lower density glass and mineral wools should be used in preference to denser ones where possible, as their environmental impact increases proportionally with their weight (although higher density fibres might be less prone to air movement within the fibres).

'The Green Guide to Housing Specification' (Anderson and Howard, BRE, 2000) provides a useful reference for construction products, giving A, B and C environmental ratings for over 250 specifications. The guide has been developed over 20 years and is supported in its current form by the National House Building Council (NHBC). The information it contains is predominantly based on life cycle analysis, and the guide includes an extensive list of references to all of its sources of data. A revised version of the Green Guide was published on June 6th 2008, in which the environmental ratings have been expanded to A+ to E. This is available at www.thegreenguide.org.uk

9. National building regulations

Building regulations for the thermal insulation of walls can be downloaded from the internet. Relevant documents are:

- Part L (England & Wales)
  www.planningportal.gov.uk
- Section 6 (Scotland)
  www.sbsa.gov.uk
- Part F (Northern Ireland)
  www.dfpni.gov.uk
- Part L (Isle of Man)
  www.gov.im/dlge/planning/build/

Standard Assessment Procedure (SAP) and Energy Performance Certificates (EPCs)

SAP is the UK government's procedure for the energy rating of homes. The properties of a building, such as the insulation, determine its heat requirements, while the type of heating system and heating fuel determine the energy use, cost and CO_2 emissions under standard occupancy conditions.

The SAP rating is based on the energy costs associated with space heating, water heating, ventilation and lighting, less cost savings from energy generation technologies. The SAP rating is expressed on a scale of 1 to 100. The higher the number the lower the running costs.

To comply with building regulations (building standards in Scotland) all new homes must have a SAP assessment. SAP also calculates the environmental impact (CO_2) rating, the dwelling emission rate (DER) and the target emission rate (TER).

An Energy Performance Certificate needs to be issued whenever a property is sold or rented. EPCs remain valid for up to 10 years, but are invalidated after any alteration or refurbishment of the property, and a new EPC must be issued.

10. Further information

The Energy Saving Trust provides free technical guidance and solutions to help UK housing professionals design, build and refurbish to high levels of energy performance. These solutions cover all aspects of energy performance in domestic new build and renovation. They are made available through the provision of training seminars, downloadable guides, online tools and a dedicated helpline.

A complete list of guidance categorised by subject area can be found in 'Energy Efficiency is best practice' (CE279). To download this, and to browse all available Energy Saving Trust best practice publications, please visit www.energysavingtrust.org.uk/housing

The following may be of particular interest:

- Insulation materials chart – thermal properties and environmental ratings (CE71)
- Reducing overheating – a designer's guide (CE129)
- Cavity wall insulation in existing dwellings (CE252)

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

The following publications may also be of interest:

- The Building Regulations 2000 Part L: Conservation of fuel and power. Approved Document L-1A Work in new dwellings, L-1B Work in existing dwellings, L-2A Work in new buildings other than dwellings and L-2B Work in existing buildings other than dwellings, 2006 editions. See www.planningportal.gov.uk
- Code of Practice for use of masonry. Materials and components, design and workmanship, BS 5628: Part 3 2001
  See www.StandardsUK.com
- Requirements for electrical installations See IEE Wiring Regulations 17th edition, 2008, BS 7671
  See www.bsi-global.com
- Technical Handbook, section 6 energy, Scottish Building Standards Agency
  See www.sbsa.gov.uk
- SAP 2005
  See www.bre.co.uk/sap2005
- The Control of Damp in Old Buildings, SPAB Technical Pamphlet 8
  See www.spab.org.uk
- Thermal insulation – avoiding risks, BR 262
  See www.brebookshop.com
- The Green Guide to Housing Specification, BR 390
  See www.bre.co.uk/greenguide
- Conventions for U-value calculations, BR 443
  See www.brebookshop.com
- Dry rot: its recognition and control, Digest 299
  See www.brebookshop.com
- Wet rot: recognition and control, Digest 345
  See www.brebookshop.com
- Assessing the effects of thermal bridging at junctions and around openings, IP 1/06
  See www.brebookshop.com

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energy saving trust®

Energy Saving Trust 21 Dartmouth Street London SW1H 9BP
Tel 0845 120 7799 Fax 0845 120 7789
bestpractice@est.org.uk www.energysavingtrust.org.uk/housing