

## 3.3 Thermal insulation and condensation

### 3.3.1 Legislation and guidance

#### Building Regulations – Conservation of fuel and power

Building Regulations Approved Document L (AD L) comprises four Approved Documents (Scotland is covered by Technical Handbook Section 6):

- AD L1A for New dwellings
- AD L1B for Existing dwellings
- AD L2A for New buildings other than dwellings
- AD L2B for Existing buildings other than dwellings

With specific reference to **AD L1A for New dwellings**, compliance is based on the carbon performance of the whole dwelling, a measure of which is given through the use of the Standard Assessment Procedure (SAP calculation). Compliance is no longer demonstrated by the elemental U-value method, but U-value calculations are required as they form part of the SAP calculation. Although reference is made to 'Design Limit' U-values within **AD L1A**, U-values better than the 'Design Limit' are likely to be required to meet the required Carbon index level.

**AD L1B for Existing dwellings** includes extensions, creating new dwellings through material change of use and material alterations to existing dwellings. Whilst compliance is still based on carbon dioxide emissions, U-values to the levels detailed in **Table 9** should be met.

Where an existing element forms part of the thermal envelope it must have a certain thermal value. This is known as the 'threshold' value. If the existing value of the element equals or is better than the threshold, no thermal renovation will be required. If it is worse than the threshold value then thermal renovation to achieve the values in **Table 8** will be required.

**AD L2A for New buildings other than dwellings** is based on the carbon performance of the whole building. A calculation process has to be followed and the Simplified Building Energy Model (SBEM), developed by the Building Research Establishment (BRE), is the methodology for carrying out these calculations.

**AD L2B for Existing buildings other than dwellings.** Whilst compliance is still based on carbon dioxide emissions, U-values to the levels detailed in **Table 9** should be met.

Where an existing element forms part of the thermal envelope it must have a certain thermal value. This is known as the 'threshold' value. If the existing value of the element equals or is better than the threshold, no thermal renovation will be required. If it is worse than the threshold value, then thermal renovation to achieve the values in **Table 9** will be required.

#### CLG – Accredited Construction Details

This guide is intended to assist the construction industry to comply with the performance standards published in AD L. It focuses on issues concerning insulation continuity and airtightness, providing theoretical information and large scale indicative drawings. It can be accessed via [www.planningportal.gov.uk](http://www.planningportal.gov.uk)

**Table 8 - AD L1B**

#### Existing dwellings

	New thermal element W/m <sup>2</sup> K	Replacement thermal element and upgrading retained thermal element (threshold values shown in brackets) W/m <sup>2</sup> K
Wall	<b>0.30</b>	<b>0.35</b> <sup>1</sup> (0.70)
Floor	<b>0.22</b>	<b>0.25</b> (0.70)
Pitched roof - insulation at ceiling level	<b>0.16</b>	<b>0.16</b> (0.35)
Pitched roof - insulation between rafters	<b>0.20</b>	<b>0.20</b> (0.35)
Flat roof - or roof with integral insulation	<b>0.20</b>	<b>0.25</b> (0.35)

<sup>1</sup> Cavity walls suitable for the installation of cavity insulation can be 0.55 when upgrading retained thermal elements.

**Table 9 - AD L2B**

#### Existing buildings other than dwellings

	New thermal element W/m <sup>2</sup> K	Replacement thermal element and upgrading retained thermal element (threshold values shown in brackets) W/m <sup>2</sup> K
Cavity wall	<b>0.30</b>	<b>0.35</b> (0.30)
Other wall type	<b>0.30</b>	<b>0.35</b> (0.70)
Floor	<b>0.22</b>	<b>0.25</b> (0.35)
Pitched roof - insulation at ceiling level	<b>0.16</b>	<b>0.16</b> (0.16)
Pitched roof - insulation between rafters	<b>0.20</b>	<b>0.20</b> (0.35)
Flat roof - or roof with integral insulation	<b>0.20</b>	<b>0.25</b> (0.35)

**BRE BR443 – U-value conventions**

A guidance document that provides advice on the use of U-value calculation methods. Additional information about the methods is also included, together with data on typical constructions and the thermal conductivity of materials.

**BRE BR262 – Thermal insulation avoiding risks**

A guidance document highlighting risks, causes and solutions of thermal design. The guide supports the Building Regulations and represents the recommendations of BRE on good design and construction practice associated with thermal standards.

**BS 12524: 2000 – Building material and products – Hygrothermal properties – Tabulated design values**

Gives design data in tabular form for heat and moisture transfer calculations, for thermally homogeneous materials and products commonly used in building construction. It also gives data to enable calculations and conversion of design thermal values for various environmental conditions.

**BS EN ISO 6946: 1997 – Building components and building elements – Thermal resistance and thermal transmittance – Calculation method**

Gives the method of calculation of the thermal resistance and thermal transmittance of building components and building elements, excluding doors, windows and other glazed units; components that involve heat transfer to the ground; and components through which air is designed to permeate. The calculation method is based on the appropriate design thermal conductivities or design thermal resistances of the materials and products involved.

**BS 5250: 2002 – Code of practice for control of condensation in buildings**

A code of practice that describes the causes and effects of surface and interstitial condensation in buildings, and gives recommendations for their control.

**3.3.2 The provision of thermal insulation****Reducing heat loss**

Any building with an internal temperature higher than the external temperature will lose heat. Thermal insulation reduces this heat loss and therefore helps to conserve energy and therefore reduce heating costs.

Building Regulations specify minimum levels of thermal performance for the external walls, roof and floors of almost all building types. Adequate insulation must also be provided for hot water heating services, pipes, warm air ducts and hot water storage vessels.

Savings are maximised where insulation is supported by other measures such as automatic controls, which govern the operation and output of heating systems and the temperature of stored water.

In addition to providing high levels of thermal performance in newly constructed buildings, insulation products and systems are also incorporated into existing buildings where the energy

efficiency of the building may be inadequate. This will apply equally to both non-domestic buildings and to the existing housing stock. The scale of inefficiency for the latter has been highlighted by various Government surveys.

When specifying the insulation system for a particular building it is important to take into account both the heating regime and the pattern of usage of the building.

**Infrequently heated buildings**

If a building is only infrequently heated, thermal insulation materials should be located as near as possible to the internal surface of exposed building elements to provide a quick thermal response to heating input. This is essential in such conditions to reduce internal surface condensation during the warm-up period, when the maximum amount of water vapour is often produced. It will also ensure that comfortable room temperatures are quickly achieved.

Gyproc ThermaLine laminates are extensively used in both new and existing buildings to provide internal lining and insulation in one fixing operation. They can allow Building Regulation standards to be achieved using clear cavity external wall construction and provide a continuous insulation layer over the whole external wall area, helping to reduce the thermal bridge effects at lintels and reveals.

**Regularly heated buildings**

Heating regimes may be of a regular nature, with relatively equal periods of heating activity and non-activity, as may occur in housing during winter months. In this situation, traditional forms of high mass construction, such as double leaf cavity walls, can effectively exploit the 'heat store' concept when thermal insulation is positioned within the cavity. Extreme air temperature fluctuations within the building can be subdued as heat stored in components within the insulation 'envelope' is dissipated back into the building. Further benefits can be derived from the reduced size and complexity of space heating equipment necessary to maintain room temperatures.

**Airtightness**

Airtightness describes the air leakage characteristics of a building. This determines the uncontrolled background ventilation or leakage rate of a building.

Airtightness is expressed in terms of a whole building leakage rate at an artificially induced pressure (usually 50 Pa). The lower the air leakage rate, the greater the airtightness. For example, within AD L1A an upper limit on air permeability of 10m<sup>3</sup>/hr.m<sup>2</sup> is required. In practice, most designs will need to be significantly better than this. Improving a building's airtightness is crucial to improving the energy performance of a building.

Although air leakage can occur directly the majority of leaks occur indirectly. Air leakage paths are often complicated and therefore air leakage can be difficult to trace and seal effectively. However, the following is a list of some example air leakage paths:

- Cracks, gaps and joints in the structure
- Timber floors
- Joist penetrations of external walls
- Windows and doors
- Loft hatches
- Skirting boards
- Chimney and flues
- Service entries, ducts and electrical components
- Areas of unplastered walls

To improve airtightness when using a plasterboard internal drylining system, e.g. **Drilyner BASIC**, continuous ribbons of adhesive should be applied around the perimeter of the wall and around openings / penetrations to seal airpaths. Gyproc Soundcoat Plus can be used on most external masonry walls to seal air paths. This may also improve the airtightness before a drylining system is applied to the wall.

### 3.3.3 Terminology

#### Thermal conductivity ( $\lambda$ )

This is a measure of a material's ability to transmit heat, and is expressed as heat flow in watts per metre thickness of material for a temperature gradient of one degree Kelvin (K). It is expressed as W/mK.

Generally, dense materials have high thermal conductivity and are inefficient thermal insulants. Lightweight materials have low conductivity and can be efficient thermal insulants. The lower the  $\lambda$  value of a material, the better its insulating efficiency.

#### Thermal resistance (R)

This is the measure of the resistance to the passage of heat offered by the thickness of a material and is expressed as m<sup>2</sup>K/W. The thermal resistance of a material is obtained by the following calculation:

$$R = \frac{t}{\lambda}$$

Where  $t$  = thickness in metres and  $\lambda$  = thermal conductivity (W/mK)

#### Thermal transmittance (U-value)

This is a property of the whole construction, including air spaces, and is a measure of its ability to transmit heat under steady state conditions. It is calculated by taking the reciprocal of the sum of all the individual thermal resistances, taking into consideration any thermal bridging, and is expressed as W/m<sup>2</sup>K. The lower the U-value of the element the better its thermal insulation.

For the purpose of calculating U-values, thermal resistances for the inside and outside surfaces of a building element, and for any cavities within it, have to be taken into account. This is in addition to thermal resistances directly relating to the actual thickness of materials.

The R-values of inside surfaces, outside surfaces and of any cavities will vary according to the surface emissivity. Emissivity should be taken as high for all normal building materials other than polished or metal surfaces, such as aluminium foil, which are regarded as low.

U-values are used as a common basis for comparing different constructions or for meeting a stated figure. When calculating the U-value of some constructions the effect of components that repeatedly bridge the insulation layer, such as mortar joints in lightweight blockwork, studs in timber and metal framed walls, wall ties, and roof joists, should be taken into account. The U-value is calculated through the thermal bridge and combined with the U-value through the insulation in proportion to its face area, often resulting in a higher U-value for the element. More insulation may be needed to compensate for the presence of thermal bridges and return the U-value to a specified level. This can usually be achieved by increasing the insulation thickness or by changing to a more efficient insulant. The additional heat loss for non-repeating thermal bridges, such as details at window and door openings, is determined separately.

### 3.3.4 Condensation control in buildings

#### Harmful effects of condensation

Condensation can be one of the worst problems that designers, owners or occupants of buildings experience. Dampness and mould growth caused by surface condensation can not only be distressing to the occupants of a building, but can eventually lead to damage in the building itself.

The thermal insulation and ventilation requirements of Building Regulations aim to reduce the risk of condensation and mould growth occurring in new buildings. However, designers should take care to eliminate all problems caused by condensation, particularly in refurbishment projects on existing buildings, where situations exist that are not directly covered by the regulations.

#### Reducing the risk

Due to changes in building design, occupancy patterns and increased thermal requirements, all buildings, particularly houses, are more sensitive to condensation now than in previous years. Homes tend to be heated intermittently and moisture-producing activities are concentrated into relatively short periods of time.

Thermal insulation, correctly positioned within specific building elements, combined with adequate heating and, where appropriate, the necessary water vapour control and ventilation, should ensure trouble-free design.

#### How condensation occurs

At any given temperature, air is capable of containing a specific maximum amount of water in invisible vapour form. The warmer the air, the greater the amount of water vapour it can contain. Conversely, the lower the temperature, the smaller the amount.

Water vapour in air exerts a pressure, called the vapour pressure. Any differential in vapour pressure causes vapour to diffuse from high to low pressure areas.

Warm air inside a building usually contains more moisture than external air, due either to the occupants' activities or resulting from the evaporation of residual moisture in new construction. This creates a pressure differential across structural elements. Water vapour in the internal air, being at a higher pressure, tends to diffuse through the structure towards the colder, lower pressure exterior.

If moisture-laden air comes into contact with a cold surface it will cool. As it cools, the amount of water it can hold in vapour form reduces until, at a specific temperature called the dew point, it becomes saturated. Water is then deposited in the form of condensation.

#### Surface condensation

Surface condensation occurs when air containing water vapour comes into contact with highly vapour resistant surfaces, which are at, or below, the dew point temperature. See **Figure 18 - Surface condensation** (page 42). It usually shows itself as beads of water, damp patches, and, where the condition persists, mould growth.

Surface condensation can be in localised zones in a particular building element caused by the presence of 'cold bridges', such as mortar joints in walls, which can be colder than the rest of the wall structure.

In addition, warm moist air will diffuse through a building into colder rooms, such as poorly heated bedrooms and stairwells. This is one reason why surface condensation does not always occur in the room where water vapour is produced.

#### Interstitial condensation

Warm moist air will also diffuse through building elements to reach colder, lower pressure conditions outside. If the building materials have low water vapour resistance it is possible for condensation to occur within the building element. This will occur on the first cold surface, at or below dew point temperature, which is encountered by the moisture vapour on its passage through the structure. As an example, for double skin masonry walls, the position for condensation to form is on the inner face of the outer leaf whether or not insulation is included in the cavity. See **Figure 19 - Interstitial condensation** (page 42).

There is no evidence to suggest that interstitial condensation will occur within the core of building materials under general building and climatic conditions. For other types of building structure vapour control layers can help to eliminate the risk of interstitial condensation. It is recommended that the risk of harmful condensation be assessed using the calculation procedures given in *BS 5250*.

### 3.3.5 Designing to reduce condensation risk

#### Thermal insulation

Thermal insulation helps to reduce the risk of surface condensation by maintaining surfaces above the dew point temperature subject to adequate heating being provided.

In buildings that are heated infrequently, the thermal insulation should be located as near as possible to the internal surface of building elements to provide rapid thermal response. These surfaces will then be less prone to surface condensation during the warm-up period, which is often when the maximum amount of

water vapour is produced. Being located on the warm side of the structure, Gyproc ThermalLine laminates will help to provide this rapid thermal response and will also reduce the thermal bridge effects in a building, e.g. at lintels and reveals.

With some construction types the potential problem may be one of interstitial condensation. Gyproc ThermalLine laminates are available with integral vapour control to minimise the risk. Alternatively, the choice of construction may demand a different position for insulation, away from the surface lining. Surface condensation will not generally be a problem in these circumstances, particularly where adequate heating is provided. Consideration should be given to establishing whether the particular construction brings with it any increased risk of interstitial condensation.

For most constructions the use of vapour permeable insulation, in combination with other building materials of low vapour resistance, will allow the structure to breathe naturally. In this instance, the likely occurrence of interstitial condensation will be shifted to less problematic areas, such as masonry walls (inner face of the outer leaf).

#### Heating

Adequate heating helps to keep the temperature of the internal surfaces above the dew point. Ideally, an air temperature above 10°C to 12°C should be maintained in all parts of the building.

#### Ventilation

Ventilation removes the water vapour produced within a building to the outside air. Adequate ventilation, including the provision of small controllable slot ventilators in windows, electrical extractor fans controlled by humidistats in bathrooms and kitchens, and cooker hoods extracted to the outside air, will help to reduce harmful condensation and mould growth. Ideally, ventilation should control the internal air to between 40% and 70% relative humidity (RH) for human occupation.

Condensation can occur in roof spaces of slated or tiled pitched roofs of dwellings, and in timber joisted flat roofs with insulated ceilings, unless adequate ventilation is provided. Precautions should be taken, in particular the provision of adequate cross-ventilation of the roof spaces to the outside.

The requirements for ventilation in buildings are given in the Building Regulations.

#### Vapour control layer

A vapour control layer, usually in the form of a membrane, is used to substantially reduce the transfer of water vapour through a building element in which it is incorporated. See **Tables 11 and 12** (pages 40 and 41 respectively) for wall and roof constructions.

A vapour control layer, positioned on the warm side of the thermal insulation within a building element, helps to reduce the risk of interstitial condensation occurring within that element. However, other precautions may also be necessary, either in combination with, or as alternatives to, a vapour control layer. These include the use of ventilated cavities and the provision of materials of low vapour resistance, particularly on the colder side of the construction.

Vapour control layers should be as airtight as possible. Holes and penetrations for services should be cut neatly and suitably sealed, or localised condensation may still occur. It is recommended that the risk of harmful interstitial condensation is assessed using the calculation procedure given in *BS 5250*.

### Existing masonry walls

#### Internal lining

Gyproc products with vapour control layers can reduce interstitial condensation, providing the wall has low vapour resistance. The wall should not incorporate any other material of high vapour resistance.

#### Blown cavity fill

Where it is impractical to provide a new internal lining to existing cavity walls, mineral wool can be blown into the cavity. In conjunction with adequate heating, the internal surface of the wall will be kept above dew point temperature, and the permeability of the mineral wool material will not impede the natural diffusion of moisture vapour away from critical areas within the structure.

### New masonry walls

#### Full or partial cavity fill

Positioning Isover CWS or Hi-Cav 32 insulation batts within the cavity, either as full-fill or in conjunction with a residual cavity, can maintain the internal surface of the wall above dew point temperature or negate the cold bridging effects of mortar joints. Thus a water vapour resistant treatment to the surface of internal plaster finishes is not always necessary, as any interstitial condensation will occur on the inner surface of the outer leaf. Thistle building plasters, or Gyproc WallBoard fixed in the **Drilyner** or **Gplyner** systems, form suitable linings. Where water vapour resistance is required, the plasterboard lining surface can be treated with two coats of Gyproc Drywall Sealer. Alternatively, Gyproc WallBoard **DUPLEX** can be specified within the **Drilyner MF** system.

#### Thermal laminate drylining

A drylining of Gyproc ThermoLine laminates may also be considered, either with a clear cavity or in conjunction with Isover insulation for thermal insulation purposes and to provide a vapour control layer.

#### Metal frame walls

These walls comprise of light gauge roll-formed galvanised steel components engineered to form the structural frame. High levels of thermal insulation are a feature of this form of construction, and care must be exercised to ensure that there are no risks of interstitial condensation occurring within the structure.

In Metsec Steel Framing Systems, Isover Steel Frame Batt (SF1) or rigid foam insulation is located to the outside of the steel frame. Isover Steel Frame InFill Batts (SF2) are positioned in the stud cavity and Gyproc **DUPLEX** grade plasterboards can be used as the internal face lining. The dew point will then fall within the outer cavity or external cladding. This principle is often referred to as 'warm frame' or 'hybrid', and applies equally to roof conditions.

#### Timber frame walls

To reduce the risk of interstitial condensation occurring on the inner surface of the sheathing, a vapour control layer is required as part of the internal lining. This can be provided by using Gyproc **DUPLEX** grade plasterboards or appropriate Gyproc ThermoLine

laminates incorporating the vapour control, refer to NHBC (Technical Standards for domestic applications) at [www.nhbc.co.uk](http://www.nhbc.co.uk)

Provision should also be made for water vapour to escape outward, through very low vapour resistance sheathing boards, breather membranes, external claddings and by vented cavities. It is also good practice to ensure that any accumulation of moisture is directed outwards by incorporating flashings, drainage outlets and suitable timber detailing.

### Pitched roofs with insulated ceilings

Positioning a vapour control membrane at ceiling level should reduce the amount of water vapour migrating into the roof space. In practice, however, a continuous barrier is unlikely to be achieved because of the difficulty of sealing leaks through loft access hatches, electrical wiring drops, pipe penetrations and cracks. Gaps in the ceiling can be much more important in the mechanism of water vapour migration than diffusion through the ceiling itself.

A vapour control layer will reduce vapour transmission from the rooms below into what is probably the easiest part of the building structure to ventilate. Adequate cross-ventilation of the roof space is necessary and it is recommended that additional high level openings be provided for roof pitches of 35° or less, or spans in excess of 10m.

### Flat roofs

#### Cold construction

In a cold roof construction, the thermal insulation is located directly above the ceiling. Most of the structure is thus on the unheated side of the insulation and is therefore vulnerable to the risk of interstitial condensation.

To reduce this risk, adequate cross-ventilation must be provided above the insulation to disperse water vapour to the outside. An effective vapour control layer should be provided at ceiling level in adverse conditions, and perforations for pipes, electrical wiring drops, etc, should be sealed. See **Figure 20 - Timber flat roof, cold type** (page 42). Ceilings beneath cold flat roofs are not generally prone to surface condensation since they are relatively light and warm up quickly. They benefit from positioning insulation, such as Isover General Purpose Roll, directly behind the ceiling, which allows surface temperatures to build up quickly.

#### Warm construction

In warm roof construction, the thermal insulation is located on top of a high performance vapour control layer over the roof decking. The construction is referred to as a warm roof because in winter, with adequate heating, the temperature of the vapour control layer, and of the materials below it, is maintained close to that of the internal air. It is not necessary to include a vapour control layer at ceiling level or to ventilate the roof cavities. Consideration should be given, however, to the provision of vertical vapour control layers as necessary, e.g. the use of Gyproc **DUPLEX** grade plasterboards in roof voids between rooms, to reduce the movement of vapour to adjacent rooms, which may be at different temperatures.

### Hygrothermal properties

Table 10 provides typical hygrothermal properties that may be useful when carrying out condensation risk calculations.

**Table 10 - Hygrothermal properties**

Material	Specific heat capacity <sup>1</sup> Cp J/(kgK)	Water vapour resistance factor, dry <sup>1</sup> $\mu$	Equivalent water vapour resistivity <sup>2</sup> MN/gm	Vapour resistance MN/g
Gypsum plasterboard (BS EN 520)	1000	10	50	-
Gypsum plaster	1000	10	50	-
Mineral wool - Isover insulation and within Gyproc TriLine	1030	1	5	-
Expanded polystyrene - within Gyproc ThermaLine BASIC	1450	60	300	-
Extruded polystyrene - within Gyproc ThermaLine PLUS	1450	150	750	-
Phenolic foam - within Gyproc ThermaLine SUPER and Glasroc F SOFFITLINE	1400	50	250	-
Vapour control layer within Gyproc DUPLEX grade plasterboard	-	-	-	60
Vapour control layer within Gyproc ThermaLine SUPER and Glasroc F SOFFITLINE	-	-	-	100

<sup>1</sup> BS EN 12524 Building materials and products - Hygrothermal properties - Tabulated design values.

<sup>2</sup> BS 5250 Code of practice for control of condensation in buildings.

► Refer to **section 14 - Products**, for thermal conductivity performances.

**Table 11 - External walls**

Recommendations for the use of vapour control layers to reduce the risk of interstitial condensation in external walls of dwellings (with insulation to current standards)

Type of wall	Low vapour resistant outer leaf	Vapour control layer required	Comments
Timber frame (brick outer leaf)	Yes	Yes	Low vapour resistant sheathing and breather membrane. Ventilate cavity between outer and inner leaves to outside.
Metal frame (brick outer leaf)	Yes	Yes	Vapour control layer generally required
Brick / cavity / block Plasterboard lined or plastered	Yes	No	Consider vapour control layer in adverse conditions
Brick / insulated cavity / block Plasterboard lined or plastered	Yes	No	Consider vapour control layer in adverse conditions
Brick / cavity / block Aerated concrete blocks up to approximate density 750kg / m <sup>3</sup> ( $\lambda$ value up to 0.20). Thermal laminate lining.	Yes	No	Consider vapour control layer in adverse conditions
Brick / cavity / block Concrete blocks over 750kg / m <sup>3</sup> ( $\lambda$ value greater than 0.20). Thermal laminate lining.	Yes	Yes	N/A
Solid masonry Thermal laminates, or insulation between timber battens or metal framing.	Yes	Yes	Ventilation of lining cavity to outside desirable if fixing method permits
Concrete Thermal laminates, or insulation between timber battens or metal framing.	No	Yes	Ventilation of lining cavity to outside required between concrete and insulation
Existing solid walls Treated with vapour resistant finish (internally or externally). Thermal laminates, or insulation between timber battens or metal framing.	No	Yes	Ventilation of lining cavity to outside required or existing vapour resistance treatment considerably reduced

**Table 12 - Roofs**

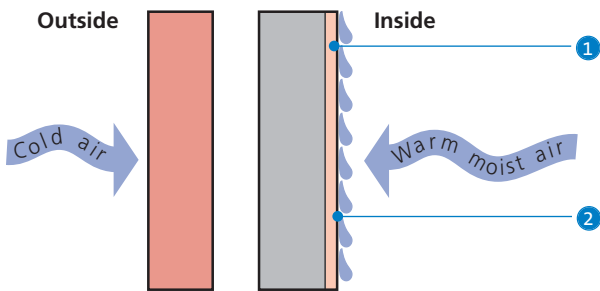
Recommendations for the use of vapour control layers in conjunction with plasterboard ceilings (fixed with all edges supported on framing), to reduce the risk of interstitial condensation in the roofs of dwellings (with insulation to current standards).

Type of roof	Roof void layer required	Vapour control	Comments
Pitched roofs, tiled or slated, above 15° pitch, ceiling and insulation horizontal.	Ventilated to BS 5250 or Approved Document F	No <sup>1</sup>	Separate consideration for adverse conditions, e.g. grouped bathrooms / kitchens in flats. Where designers wish to incorporate a vapour control layer at upper floor ceilings, the area or rooms should be ventilated.
Pitched roofs, tiled or slated, above 15° pitch, ceiling and insulation horizontal.	Without provision for adequate ventilation, e.g. existing dwellings.	Yes <sup>1</sup>	N/A
Pitched roofs, tiled or slated, 15° pitch or less, ceiling and insulation horizontal.	Ventilated to BS 5250 or Approved Document F	No <sup>1</sup>	N/A
Pitched roofs, tiled or slated, 15° pitch or less, ceiling and insulation horizontal, e.g. existing dwellings.	Without provision for adequate ventilation	Yes <sup>1</sup>	N/A
Pitched roofs, tiled or slated, insulation inclined, ceiling horizontal.	Not ventilated	No	Insulation of high vapour resistance. Gable walls should be insulated. Low vapour resistant under tiling membrane.
Pitched roofs, tiled or slated, insulation and ceiling inclined.	Ventilated to BS 5250 or Approved Document F	Yes <sup>1</sup>	Low vapour resistant under tiling membrane.
Pitched roofs, with high vapour resistance coverings.			Treat as appropriate for cold or warm flat roofs.
Flat roofs, cold type, insulation at ceiling level <sup>2</sup> .	Ventilated to BS 5250 or Approved Document F	Yes <sup>1</sup>	Minimum air space of 50mm between top of insulation and the soffit of the roof deck. Increase ventilation and air space for spans over 5m.
Flat roofs, warm type, top of the vapour control layer.	Not ventilated	No	Vapour control layer required above insulation on deck.
Flat roofs, warm type inverted, insulation on top of the weather proofing.	Not ventilated	No	Vapour control layer provided by weather proofing.

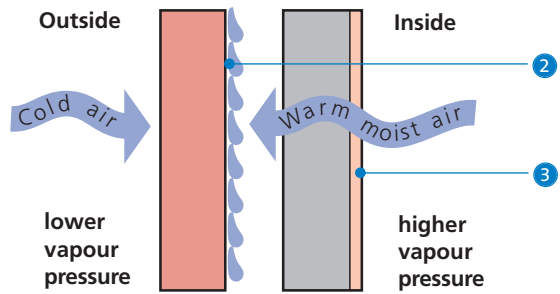
<sup>1</sup> Ceiling made airtight, e.g. service pipes and access hatches sealed.

<sup>2</sup> Not permitted by NHBC in Scotland.

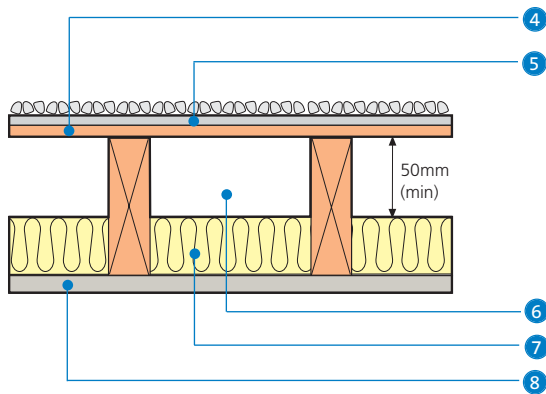
18 Surface condensation



19 Interstitial condensation



20 Timber flat roof, cold type



- 1 High vapour resistance surface
- 2 Surface at or below the dewpoint
- 3 Low vapour resistance surface
- 4 Timber roof decking
- 5 Built-up felt (or similar) with solar reflective finish

- 6 Cross-ventilated roof cavities
- 7 Isover General Purpose Roll
- 8 12.5mm Gyproc WallBoard DUPLEX