Technical performance and principles of system design

Thermal insulation and condensation

Legislation and guidance documents

Building Regulations – Thermal insulation

Minimum energy efficiency requirements in Ireland are set out in Building Regulation documents below:

Republic of Ireland

- TGD L – 2011 : Conservation of Fuel and Energy – Dwellings
- TGD L – 2008 : Conservation of Fuel and Energy – Buildings other than dwellings

Northern Ireland

- TB F1 – 2012 : Conservation of fuel and power in dwellings
- TB F2 – 2012 : Conservation of fuel and power in buildings other than dwellings

Compliance is based on both the carbon dioxide performance and the fabric energy efficiency of the dwelling. Compliance targets are given through the use of Dwelling Energy Assessment procedure (DEAP) in RoI and Standard Assessment Procedure (SAP calculation) in NI and although compliance cannot be demonstrated by the elemental U-value method, U-values are important requirements within the calculation. Limiting fabric parameter U-values are given but U-values better than these are likely to be required and the regulations include model U-values within a concurrent notional dwelling specification. Air permeability / airtightness is also a requirement within the SAP calculation. Refer to table 14a.

Compliance with the non-domestic regulations is based upon the carbon dioxide performance. Compliance targets are given through the use of the Simplified Building Energy Model (SBEM) and although compliance cannot be demonstrated by the elemental U-value method, U-values are important requirements within the SBEM calculation. Limiting fabric parameter U-values are given but U-values better than these are likely to be required and the regulations include model U-values within a concurrent notional building specification. Air permeability is also a requirement within the SBEM calculation. Refer to table 14b.

Conservation of fuel and power in existing dwellings and in existing buildings other than dwellings are based on fabric energy efficiency and carbon dioxide performance with the need to meet U-values targets. 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 required U-values has to be carried out. Refer to tables 15a and 15b.

Building Regulations – Condensation

In the Republic of Ireland the requirements are set out in Building Regulations Technical Guidance Document 'F'-Ventilation and 'L-Conservation of Fuel and Energy. In Northern Ireland the requirements are set out in Building Regulations Technical Booklet 'C' – site preparation and resistance to contaminants and moisture, 'K' – Ventilation and 'F1&2' Conservation of fuel and power. The walls, floors and roof of the building shall adequately protect the building and people who use the building from harmful effects caused by interstitial and surface condensation. To provide resistance to surface condensation and mould growth, guidance is also given to ensure that in simple terms the minimum internal surface temperature is not more than 25% below roof temperature.

Table 14a

New dwellings	Republic of Ireland (TGD L Dwellings)		Northern Ireland (TB F1)	
	U-value (W/m²K)		U-value (W/m²K)	
	Limiting fabric parameters	Example dwelling specification	Area weighted average	Maximum at any point
Wall	0.21	0.13	0.3	0.7
Floor	0.21 (0.15 if Underfloor heating)	0.14	0.25	0.7
Roof	0.16	0.11	0.2	0.35
Party Wall	n/a	n/a	0.2	0.7

Table 14b

New buildings other than dwellings	Republic of Ireland (TGD L Buildings other than Dwellings)	Northern Ireland (TB F2)
	U-value (W/m²K)	U-value (W/m²K)
	Average elemental U-values	Area weighted average
Wall	0.27	0.35
Floor	0.25	0.25
Party Wall	-	0.2
Pitched roof, insulation at ceiling level	0.16	0.25
Pitched roof, insulation at rafter level	0.2	-
Flat roof or roof with integral insulation	0.22	0.2

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Table 15a

Existing dwellings	Republic of Ireland (TGD L Dwellings) U-value (W/m²K)		Northern Ireland (TB F1) U-value (W/m²K)	
	Material alterations or material change of use	Average Elemental U-value - individual element or section of element	New thermal elements (including replacements for existing elements and non-exempt Conservatories & Porches)	Upgrading retained thermal elements
Wall	0.35 (0.55 Cavity Walls)	0.6	0.28	0.30 (0.55 Cavity insulation)
Floor	0.45 (0.25 Other exposed)	0.6	0.22	0.25
Pitched roof, insulation at ceiling level	0.16	0.35	0.16	0.16
Pitched roof, insulation at rafter level	0.25	0.35	0.18	0.18
Flat roof or roof with integral insulation	0.25	0.35	0.18	0.18

Table 15b

Existing buildings other than dwellings	Republic of Ireland (TGD L Buildings other than dwellings) U-value (W/m²K)	Northern Ireland (TB F2) U-value (W/m²K)	
	Material Alterations to, or Material Changes of Use of, Existing Buildings	New thermal elements (including replacements for existing elements)	Upgrading retained thermal elements
Wall	0.6	0.28	0.30 (0.55 Cavity insulation)
Floor	0.6	0.22	0.25
Pitched roof, insulation at ceiling level	0.35	0.16	0.16
Pitched roof, insulation at rafter level	0.35	0.18	0.18
Flat roof or roof with integral insulation	0.35	0.18	0.18

Guidance documents referenced in national building regulations

Acceptable (RoI) or Accredited (NI) Construction Details
Published by Local Government, these are intended to assist the construction industry to comply with the performance standards published in the guidance documents. These are focused on issues concerning insulation continuity and airtightness, providing theoretical information and large scale indicative drawings. It can be accessed via the websites www.planningportal.gov.uk (NI) or www.environ.ie/housing/building-standards/tgd-part-l-conservation-fuel-and-energy/technical-guidance-document-l-2 (RoI)

BR443 U-value conventions
Published by the Building Research Establishment (BRE), it provides calculation methods for the determination of U-values of building elements and includes common issues, together with data on typical constructions and the thermal conductivity of materials.

BR262 Thermal insulation avoiding risks
Published by the BRE,it highlights risks, causes and solutions of thermal design. The guidance supports the Building Regulations and represents the recommendations on good design and construction practice associated with thermal standards.

BS EN 12524: 2000 Building material and products - Hygrothermal properties - Tabulated design values
This 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 13788: 2012 Hygrothermal performance of building components and building elements. Internal surface temperature to avoid critical surface humidity and interstitial condensation – Calculation method
This deals with the critical surface humidity likely to lead to problems such as mould growth on the internal surfaces of buildings and interstitial condensation within a building component. It also deals with estimation of the time taken for a component, between high vapour resistance layers, to dry, after wetting from any source, and the risk of interstitial condensation occurring elsewhere in the component during the drying process.

BS EN ISO 6946: 2007 Building components and building elements. Thermal resistance and thermal transmittance - Calculation method
This 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: 2011 Code of practice for control of condensation in buildings
This describes the causes and effects of surface and interstitial condensation in buildings, and gives recommendations for their control.

BS 9250: 2007 Code of practice for design of the airtightness of ceilings in pitched roofs
This describes methods that can be used to meet the “well sealed ceiling” requirements defined in BS 5250 for cold and warm pitched roofs and provides robust design details for the construction of more airtight ceilings and for the control of air movement into pitched roofs.

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Thermal insulation and condensation (continued)

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 reduce heating costs. To comply with Building Regulations, levels of thermal performance are required 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 and subsequent corrective measures. 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.

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 externally insulated solid leaf walls or to a lesser extent double leaf cavity walls, can effectively exploit the ‘heat store’ concept when thermal insulation is positioned within the cavity. Note however that this is more applicable in our climate to non-domestic buildings because residential construction neither gains from extreme external temperatures or high internal heat outputs. These may be present in office buildings for example due to the number of staff or other high internal gains from server rooms or kitchens. 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 50Pa). The lower the air leakage rate, the greater the airtightness. For example, within TGD L (RoI domestic) an upper limit on air permeability of 7m³/hour/m² and within TB F1 (NI) 10m³/hour/m² 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, doors, roof windows and AOVs
- Loft hatches
  - Tubular rooflights
- Skirting boards
- Chimney and flues
- Service entries, ducts and electrical components
  - Light fittings
  - Ventilators, and extraction outlets
- Areas of un-plastered walls

To improve airtightness when using a plasterboard internal drylining system, e.g. **DriLyner**, continuous ribbons of adhesive should be applied around the perimeter of the wall and around openings / penetrations to seal airpaths. Gyproc Airtite Quiet 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, alternatively Gyproc Hard Coat combined with our finish plaster may be used as an airtight solid plastered wall finish.

Terminology

Thermal conductivity (λ)

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

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Thermal insulation and condensation (continued)

have low conductivity and can be efficient thermal insulants. The lower the λ 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 m²K/W. The thermal resistance of a material is obtained by the following calculation:

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

Where t = thickness in (m) and λ = 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/m²K. 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-value calculations 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 (i.e. lower performance) 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 also be achieved 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.

Thermal mass / heat sink

Thermal mass (also discussed under 'regularly heated buildings above'), describes a material's capacity to absorb, store and release heat. For example, water and concrete have a high capacity to store heat and are referred to as 'high thermal mass' materials. Insulation foam, by contrast, has very little heat storage capacity and is referred to as having 'low thermal mass'. Gyproc plasterboards and Rigidur are effective in contributing towards the thermal mass effect. Thermal mass design, for example in school buildings, is a means of ensuring overheating is kept under control.

This principle is included with the SBEM and SAP or DEAP procedure within which it is expressed as a Kappa (κ) value in calculating the thermal mass parameter to characterise the thermal mass of the building. As an example within SAP, the heat capacity κ of a single layer plasterboard partition is given as 9 kJ/m²K.

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 health risk to the occupants and or 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 the necessary water vapour control and ventilation, where appropriate, should ensure trouble-free design.

How condensation occurs

At any given temperature, air is capable of containing a specific maximum amount of water in 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 also 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.

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Thermal insulation and condensation (continued)

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.

Refer to figure 36 – 'Surface condensation'. 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. Refer to figure 37 – 'Interstitial condensation'.

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 an appropriate calculation procedure, for example as described in I.S. EN IS0 13788: 2002 and/or I.S. EN 15026: 2007. Refer to table 17 for typical hygrothermal properties.

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. Where the greater part of the insulation is located to the internal surface, strategies must be employed to ensure interstitial condensation does not occur behind the insulation. Please contact our technical department for further advice in these scenarios.

Where the insulation is being 'topped up' with internal insulation, this is far less of a concern, e.g. where adding internal insulation to a cavity wall This will also reduce the thermal bridge effects in a building, e.g. at lintels and reveals and at the gable wall below an attic.

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 can be managed but must be considered in the context of the complete wall as a 'system' including external render and use of the building/room.

Thermal bridging, particularly at junctions, abutments and openings can occur and therefore good detailing is essential. This is now a critical issue in the context of new buildings based on imminent mandatory standards for nearly Zero Energy Buildings (nZEB). Information on Psi (φ) values (linear thermal transmission) relating to thermal bridging details is contained within SAP, and within Accredited Construction Details (ACDs) which are available to view at www.planningportal.gov.uk (NI) or www.environ.ie/housing/building-standards/tgd-part-l-conservation-fuel-and-energy/technical-guidance-document-l-2 (RoI).

Note that providing a simple calculation of the 'y factor', essentially the average u-value for all thermal bridges in the building can reduce the costs and need for alternative efficiency measures including renewable energy solutions.

Heating

Adequate heating helps to keep the temperature of the internal surfaces above the dew point. Ideally, an air temperature above 10°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 main requirements for ventilation in buildings are given in BS 5250 and referenced in national building regulations, TGD F (RoI) and TB K (NI). Note that

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Thermal insulation and condensation (continued)

in accordance with BS 5250, pitched roofs may not require active ventilation where a low resistance (LR) underlay is used in combination with a permeable roof finish such as natural slates or concrete tiles. Please contact our the Gyproc Technical Department for further information.

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. Refer to table 16 for a few example 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 I.S. EN IS0 13788: 2002 and/or I.S. EN 15026: 2007.

Existing masonry walls

The Isover Optima system incorporating Gyproc plasterboard, metal framing, Metac insulation and Optima clips is agrément certified by the NSAI and BBA for internal insulation of a range of masonry wall types. Suitability and the level of insulation in the system depends on the exposure and porosity of the external leaf as well as internal humidity. High risk areas include porous unrendered solid brick walls and where intermediate floors are built into the wall. Please contact the Gyproc Technical Department for further information.

New masonry walls

Full fill or partial fill cavity

Positioning Isover CWS 32 or 36 Batt insulation within the cavity, either full fill or partial fill, can maintain the internal surface of the wall above dew point temperature. Therefore a water vapour resistant treatment to the surface of internal plaster finishes is not always necessary because any interstitial condensation will occur on the inner surface of the outer leaf. Gyproc plasters, or Gyproc WallBoard, fixed in the DriLyner or GypLyner systems, form suitable linings. Gyproc WallBoard **DUPLEX** can be specified in conjunction with the (mechanically fixed) DriLyner **MF** or GypLyner systems, however exposed blockwork is typically highly porous and should first be sealed with a parge coat layer of plaster such as Gyproc Airtite Quiet. For higher levels of airtightness and moisture management we recommend Isover Vario KM duplex be used (taped and sealed) behind our non-duplex boards.

Timber / steel 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, refer to NHBC (Technical Standards for domestic applications) at nhbc.co.uk. Isover timber frame insulation is positioned within the stud cavity and Gyproc **DUPLEX** grade plasterboards can be used as the internal face lining or Isover Vario KM Duplex membrane and an alternative Gyproc plasterboard. The dew point will then fall within the outer cavity or external cladding.

Where the insulation does not meet the U-value requirement alone, a drylining system using a thermal laminate could be considered which will provide both thermal performance and a vapour control layer however, system designers and installers must ensure that fire performance of the system is fully validated by appropriate fire test evidence where required. Note that in order to mitigate risks of interstitial condensation, a maximum of one third the total resistance of insulation in the construction may be provided to the inside of the vapour control layer. This is commonly referred to as the 'one third rule'.

Pitched roofs

Horizontal insulated ceilings, e.g. cold loft space

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 significant for heat losses and water vapour transfer from convection / migration than diffusion through the ceiling itself. Appropriate cross-ventilation of the roof space is necessary.

Insulation, e.g. Isover Spacesaver range, is located on top of and between the ceiling joists and Gyproc plasterboard fixed to the underside. Gyproc **DUPLEX** grade plasterboards can be used as the ceiling lining if a vapour control layer is required. The amount of ventilation is set out in TGD F (RoI) and TB K (NI). An alternative compliance method is set out in BS 5250 and depends on the permeability of roof finish and airtightness of ceiling below.For a pitched roof (>15° pitch), generally a minimum 50mm clear cavity well vented space above the insulation to the external air is required with the equivalent of a continuous 10mm gap in the eaves/soffit at the perimeter. With a low resistance roof underlay (<0.4 MNs/g) and a well sealed ceiling below, this may be reduced to a 3mm gap or equivalent. For well-sealed ceilings, it is recommended to use Isover Vario membranes, taped and sealed.

Sloping insulated ceilings, e.g. warm room-in-the-roof

Isover Metac insulation is located between the rafters and a minimum 50mm ventilation zone above the insulation is typically required. However, per BS 5250 if the roof finish is air permeable or the tiling batten / counter batten cavity is vented and a low resistance underlay is used, the 50mm vented zone may not be required. This will also improve the wind-tightness of the assembly.

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Thermal insulation and condensation (continued)

Warm construction

In warm roof construction, the thermal insulation (by others) 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. Specific requirements in BS5250 set out that ceilings under warm pitched roofs must be 'well sealed' in order to minimize the transfer of water vapour by air movement, diffusion and convection. In addition, recent building science has shown that a warm roof must provide either no insulation above the rafters (so that solar gains on a dark colour slate/tile roof may keep the top of the rafters warm) or a minimum of 50mm rigid insulation be provided (which will block out solar gain to the rafters but maintain sufficient temperatures below.)

Flat roofs (<15° pitch)

Cold construction

In a cold roof construction, the thermal insulation, e.g. Isover Metac, is located directly above the ceiling. Most of the structure is on the unheated side of the insulation and is therefore vulnerable to the risk ofinterstitial condensation. To reduce this risk, cross-ventilation must be provided above the insulation to disperse water vapour to the outside. Generally a minimum 50mm clear cavity well vented to the external air is required. Flat roofs will require 25mm fresh air gap or equivalent at each end of the cavity. An effective vapour control layer should be provided at ceiling level and perforations for pipes, electrical wiring drops, etc., should be sealed. Refer to figure 38 – 'Timber flat roof, cold type'. Gyproc DUPLEX grade plasterboards can be used as the internal face ceiling lining.

Table 16 – Recommendations for the use of vapour control layers to reduce the risk of interstitial condensation in some example external wall and roof constructions in dwellings

Element	Type of external wall	Vapour control layer required?	Comments
External walls	Timber or metal frame (brick outer leaf)	Yes	Low vapour resistance sheathing board and breather membrane.
	Brick / insulated cavity / block Gyproc plasterboard lining or plaster	No	Consider vapour control layer in adverse conditions
	Solid masonry	Yes	Please contact Technical Department for further information.
Roofs	Cold pitched roof, tiles or slates on battens on membrane over loft space	Recommended	Especially important with higher levels of insulation
	Ceiling and insulation horizontal	Recommended	Ventilated in accordance with *BS 5250* and Approved Document F. Consider vapour control layer in adverse conditions.
	Warm pitched roof, tiles or slates on battens on membrane Ceiling and insulation inclined	Yes	Ventilated in accordance with BS 5250 and TGD F / TB K. Minimum 50mm ventilation zone above insulation (unless permeable or ventilated tiling battens/counter batten cavity over breathable membrane used)
	Cold flat roof Insulation at ceiling level (horizontal)	Yes	Ventilated in accordance with BS 5250 and TGD F / TB K. Minimum 50mm ventilation zone above insulation and 10mm continuous gap at eaves

Where a vapour control layer is used, it must be airtight, e.g. holes and penetrations for services etc., cut neatly and suitably sealed.

Table 17 – Hygrothermal properties

Material	Specific heat capacity, Cp [1] J/(kgK)	Water vapour resistance factor, dry [1] μ	Equivalent water vapour resistivity [2] MNs/gm	Typical vapour resistance MNs/g
Gypsum plasterboard	1000	10	50	0.63 (12.5mm thickness)
Gypsum plaster	1000	10	50	0.65 (13mm thickness)
Mineral wool	1030	1	5	0.25 (50mm thickness)
Expanded polystyrene	1450	60	300	15.0 (50mm thickness)
Extruded polystyrene	1450	150	750	37.5 (50mm thickness)
Phenolic foam	1400	50	250	12.5 (50mm thickness)
Polyisocyanurate foam	1400	60	300	15.0 (50mm thickness)
Vapour Control layer in DUPLEX grade Gyproc plasterboard	-	-	-	60

[1] Taken from *BS EN 12524 Building materials and products - Hygrothermal properties - Tabulated design values.*

[2] Using conversion factor as per *BS 5250 Code of practice for control of condensation in buildings.*

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Figures

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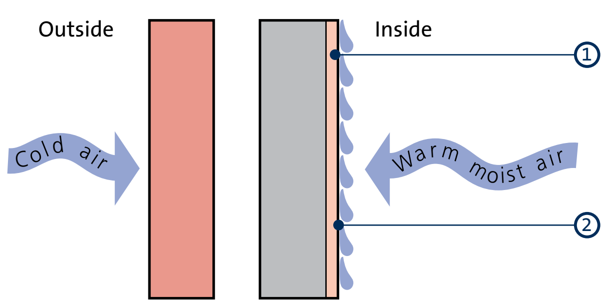

Surface condensation

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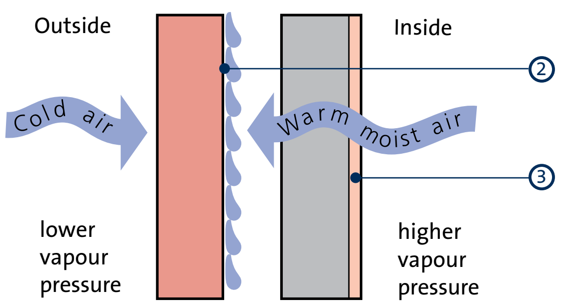

Interstitial condensation

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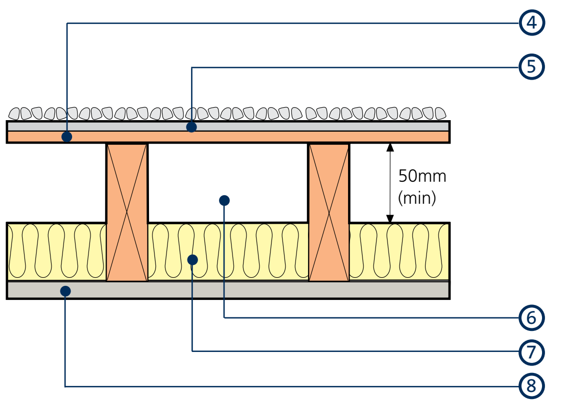
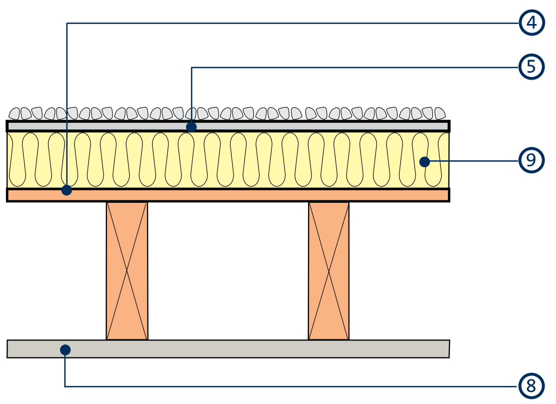


Timber flat roof, cold type

39



Timber flat roof, warm 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 acoustic insulation
8 12.5mm Gyproc WallBoard DUPLEX
9 Insulation (by others)