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BRITISH STANDARD

Code of practice for design of the airtightness of ceilings in pitched roofs

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Foreword

Publishing information

This British Standard was published by BSI and comes into effect on 31 May 2007. It was prepared by Subcommittee B/542/1, *Slating and tiling*, under the authority of Technical Committee B/542, *Roofing and cladding products for discontinuous laying*. A list of organizations represented on this committee can be obtained on request to its secretary.

Information about this document

In the UK some 70% to 80% of houses and some larger buildings such as schools and hospitals have cold pitched roofs, with insulation on the horizontal ceiling and an accessible, cold loft space above. Gaps in the ceiling, such as around loft hatches and service pipes, allow air to flow from the living space to the loft. Some of the heat and moisture generated in the living space passes through the gaps into the loft contributing to the energy loss from the building and creating a risk of condensation in the loft space.

Buildings with warm pitched roofs, where the insulation is at rafter level, use the loft as living space. If the walls and ceilings of the "room in the roof" have gaps through which air can flow, this will provide a route for energy loss and an increased risk of condensation.

BS 5250, the code of practice for the control of condensation in buildings, recommends that air leakage through ceilings should be minimized and provides criteria for a "well sealed ceiling". This standard provides practical guidance on methods for fulfilling the "well sealed ceiling" criteria.

Use of this document

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

Although this standard is intended for the design of domestic buildings, it also has more general relevance to other buildings.

Any user claiming compliance with this British Standard is expected to be able to justify any course of action that deviates from its recommendations.

Presentational conventions

The provisions in this standard are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is "should".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

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1 Scope

This standard provides guidance on methods that can be used to meet the "well sealed ceiling" requirements defined in BS 5250 for cold and warm pitched roofs.

This standard provides architects, house builders, and building control officers with robust design details for the construction of more airtight ceilings and for the control of air movement into pitched roofs.

It provides guidance for dwellings and buildings of domestic type construction on the selection of materials, design principles, construction methods and design details covering: the junction of walls and ceilings; junctions of ceiling materials; penetration through ceilings (e.g. pipes, outlets, cables, light fittings, loft hatches, tubular rooflights and roof windows).

It includes cold and warm roof applications and will apply to new, and the refurbishment of existing, buildings.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 4255-1, *Rubber used in preformed gaskets for weather exclusion from buildings – Part 1: Specification for non-cellular gaskets*

BS 4533-102.1/EN 60598-2-1, *Luminaires – Part 102: Particular requirements – Section 102.1 Specification for fixed general purpose luminaires*

BS 5250, *Code of practice for control of condensation in buildings*

BS 6093, *Code of practice for design of joints and jointing in building construction*

BS 6213, *Selection of construction sealants – Guide*

BS 7116, *Specification for double sided pressure sensitive adhesive tapes*

BS 7412, *Plastics windows made from unplasticized polyvinyl chloride (PVC-U) extruded hollow profiles – Specification*

BS 8000-16, *Workmanship on building sites – Part 16: Code of practice for sealing joints in buildings using sealants*

BS EN 60598-2-2/IEC 598-2-2, *Luminaires – Part 2: Particular requirements – Section 2: Recessed luminaires*

BS EN 13141-1, *Ventilation for buildings – Performance testing of components/products for residential ventilation – Part 1: Externally and internally mounted air transfer devices*

BS EN 13963, J*ointing materials for gypsum plasterboards – Definitions, requirements and test methods*

3 Terms and definitions

For the purposes of this standard, the following terms and definitions apply.

3.1 air barrier
barrier comprising materials and/or components which are air impervious or virtually so, separating conditioned spaces (heated/cooled) from unconditioned spaces (unheated/cooled)

NOTE An air barrier will not necessarily be vapour impervious.

[From *Airtightness in Commercial Public Buildings* [1]]

3.2 air and vapour control layer
AVCL
single layer (often a membrane) controlling both air and vapour movement, thereby fulfilling the role of both an air barrier and a vapour control layer

NOTE 1 The term "air and vapour control layer" has been adopted throughout this standard recognizing that a well designed and installed vapour control layer also controls air movement.

NOTE 2 The performance of an air and vapour control layer is dependent upon the material, workmanship and buildability, all of which need to be assessed by the designer.

3.3 cold pitched roof
pitched roof that has insulation on the horizontal ceiling and an unheated loft above that ceiling

3.4 conditioned zone
occupied zone in a building requiring heating or cooling and bounded by an airtightness layer or an air and vapour control layer to separate it from unconditioned zones

[Based on *Airtightness in Commercial Public Buildings* [1]]

3.5 vapour control layer
VCL
material of construction which substantially reduces the water vapour transfer through any building element in which it is incorporated or applied by limiting vapour diffusion (see BS 5250)

NOTE 1 A well installed VCL will also control air movement and in this standard is referred to as an "air and vapour control layer".

NOTE 2 The term "vapour control layer" is preferred to the terms "vapour check" and "vapour barrier" which usually refer to the materials alone. The performance of a vapour control layer is dependent upon the material, workmanship and buildability, all of which need to be assessed by the designer.

3.6 warm pitched roof
pitched roof that has insulation at rafter level, providing a loft that can be used as a living space

3.7 well-sealed ceiling

ceiling that satisfies the following criteria:

a) The design avoids constructional gaps, especially at the wall/ceiling junction and holes in the ceiling.

b) No access door or hatch should be located in rooms where large amounts of moisture are produced, including kitchens or bathrooms.

c) The air leakage rate through an access hatch, including its frame, when tested to BS EN 13141-1:2004 **4.3** is less than 1 m^3/h at a pressure difference of 2 Pa.

d) Penetrations, such as those for services and rooflights, are permanently sealed with suitable proprietary products.

e) The ceiling is sealed to the external walls to limit any leakage through cracks.

f) The total leakage through all recessed light fittings should not exceed 0.06 $m^3/h{\cdot}m^2$ of ceiling at 2 Pa pressure difference across the ceiling.

g) The head of any cavity in any wall or partition should be sealed to prevent transfer of warm moist air into the loft

[Based on BS 5250]

4 Design criteria

4.1 Airtightness of ceilings

*COMMENTARY ON **4.1***

Measurements in a range of houses have shown that, typically, 20% of the air entering the occupied rooms will leave via a cold loft, taking with it moisture and heat. The proportion entering a warm roof will be smaller, but can have a relatively greater risk of condensation because of the smaller volumes within the roof.

Tests have shown that with 200 mm of mineral wool (an R-value of 4.50 m^2W/K) on the floor of a cold loft and a typical unmodified ceiling, about half the heat transport into the roof takes place by air movement, with the other half passing through the ceiling and insulation by conduction. Air movement was even more important in the case of moisture transport, carrying over 75% of the water vapour entering a cold loft from the rooms below, with the rest going by diffusion through the ceiling materials.

There are therefore two benefits from ensuring that air movement from the occupied rooms in a house into the roof is minimized as far as possible:

*a) The heat loss and total energy demand of the house will be reduced. The change from a typical unsealed ceiling to a well sealed ceiling (see **3.5**), which reduces the air transport into the roof by 70%, will save about 8% to 10% of the energy consumed in a typical house.*

b) The flow of moisture into the roof will be reduced very significantly, in most cases eliminating the risk of damaging condensation.

A well sealed ceiling is a precondition of most third-party certification of low vapour resistance underlays used in unventilated cold pitched roofs. However, where moisture loads in the building are likely to be high, an AVCL will be needed.

A BRE Information Paper, IP4/06, The airtightness of ceilings – energy loss and condensation risk *[2] provides a more detailed explanation of the building physics relating to the condensation risk and energy losses in cold pitched roofs.*

The procedure for assessing the risks of condensation within structures that was specified in BS 5250:2002, makes use of a calculation procedure in BS EN ISO 13788:2001. Because this procedure allows for only conduction and diffusion and specifically excludes structures with air flows through cracks and cavities, it cannot be used for assessing cold pitched roofs. This situation is noted in Amendment 1 of BS 5250:2002 and a second BRE Information Paper, IP 5/06 Modelling condensation and airflow in pitched roofs *[3], has been published to give recommendations for the necessary assessment procedure.*

Reducing the ventilation rate in the conditioned zone can potentially cause problems of condensation and mould within the occupied rooms. The provisions of Approved Document F [4] in England and Wales (Building Regulations (Northern Ireland) [5] Part K or Building (Scotland) Regulations 2004 Technical Handbook [6] Section 3) and its associated guidance documents always have to be followed to ensure that the moisture produced by normal household activities is removed at source.

4.1.1 General

At the design stage the following should be considered:

- the conditioned zones of the building and roof space (see **4.1.3**);
- in a warm roof, a continuous AVCL is required;
- halls and stairwells that connect directly to the ceiling at roof level (warm and cold roofs) see **4.1.4**; and
- bathrooms and kitchens that connect directly with the ceiling at roof level (warm and cold roofs) see **4.1.5**.

4.1.2 Airtightness requirements

*COMMENTARY ON **4.1.2***
The airtightness requirements of the building type can be obtained from the Table 1. Achieving a well sealed ceiling is a significant step in achieving the airtightness requirements for the building as a whole.

Table 1 **Whole building airtightness requirements by building type**

Building type	***Air permeability*** *m^3/hr per m^2 of envelope area at 50 Pa reference pressure difference.*	
	Best practice	***Current practice***
Houses, flats[A)]	*5.0*	*10.0*
Factories, warehouses	*2.0*	*10.0*
Naturally ventilated offices	*3.5*	*7.0*
Air-conditioned buildings	*2.0*	*3.5*
Low energy offices	*2.0*	*3.5*
Retail stores, supermarkets	*2.0*	*3.5*
Museums and archival stores	*1.25*	*1.7*
Cold storage	*0.4*	*0.8*

[A)] *An approximate conversion to number of air changes per hour (ACH) for houses and flats is to multiply the values in Table 1 by 0.05.*

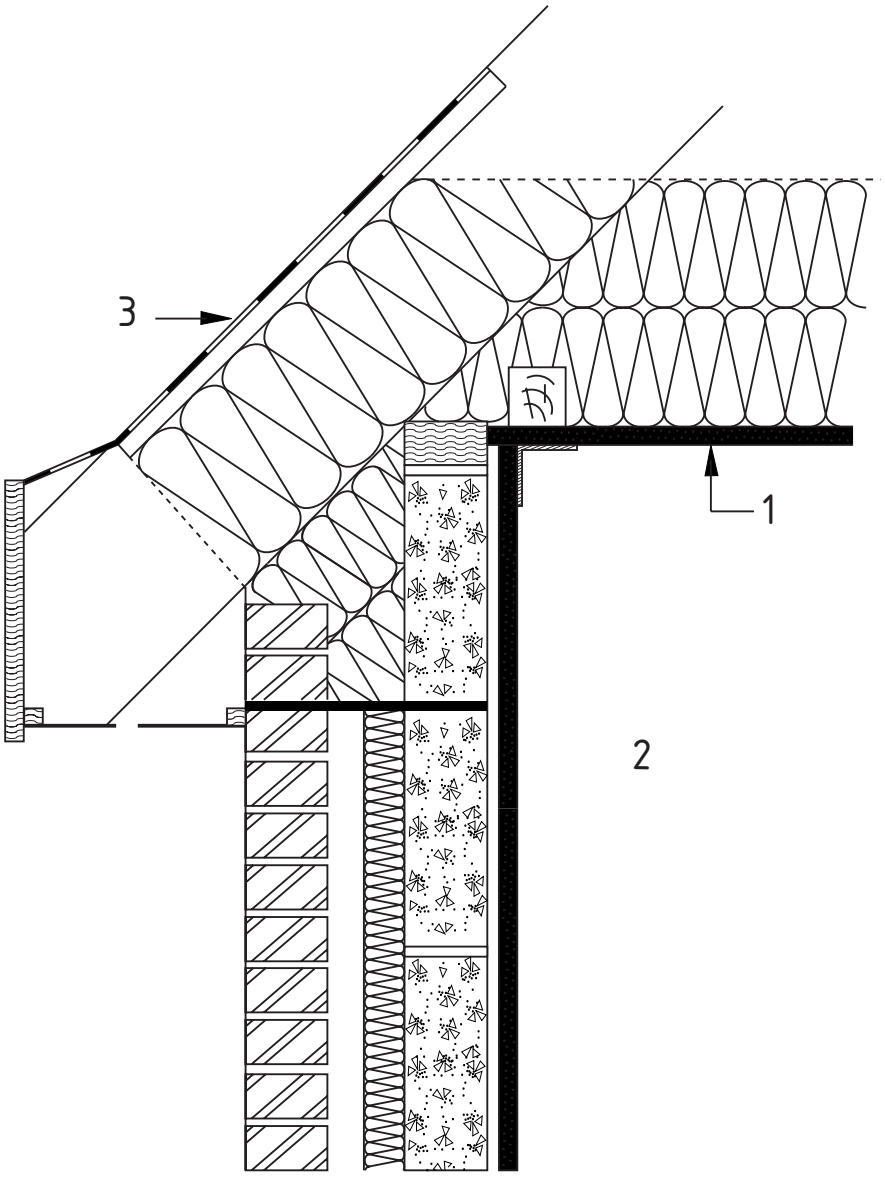
The figures in Table 1 are based on Approved Document L2 (2002), the air permeability requirements for buildings [7].

4.1.3 Conditioned zones of the building and roof space

4.1.3.1 Cold roof

The general principle for zoning a building with a ventilated roof space is illustrated in Figure 1.

Figure 1 **Defining the conditioned zone in a cold-roof building**



Key

1 Conditioned zone boundary

2 Conditioned zone

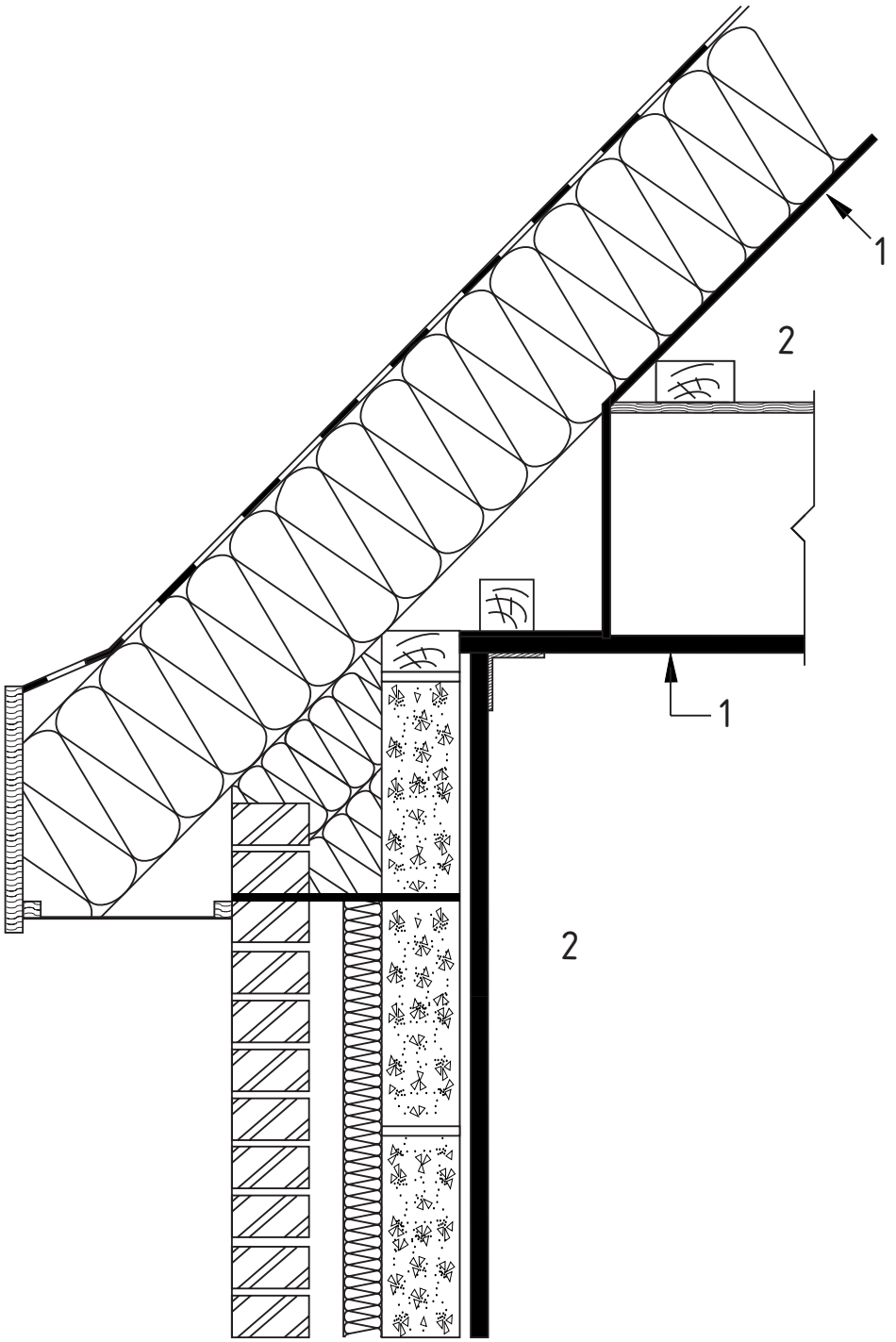
3 Ventilation duct

NOTE Roof covering (such as slating, tiling or roofing membrane) have been omitted for simplicity.

4.1.3.2 Warm roof

The general principle for zoning a building with a lived-in roof space is illustrated in Figure 2.

Figure 2 **Defining the conditioned zone in a warm-roof building**



Key

1 Conditioned zone boundary

2 Conditioned zone

NOTE Roof covering (such as slating, tiling or roofing membrane) have been omitted for simplicity.

4.1.4 Halls and stairwells that connect directly to the ceiling at roof level (warm and cold roofs)

Halls and stairwells which open to the outside of the building are sources of air infiltration and an airtightness barrier should be maintained on the internal and external walls and ceiling of the stairwell or hall. The joint at wall ceiling level should be sealed and, in cold roof designs, the loft hatch should include an appropriate seal.

4.1.5 Bathrooms and kitchens that connect directly to the ceiling at roof level (warm and cold roofs)

Where the bathroom or kitchen is situated directly below the ceiling at roof level the moisture load local to the ceiling will be high. The loft hatch access to cold roofs should not be installed in bathrooms or kitchens directly under the ceiling at roof level.

4.2 Air barrier

The measures required to achieve a functional air barrier should be carefully considered at the design stage. An air barrier should extend over the whole of the ceiling and it is imperative that it is integrated with and sealed to adjoining elements, such as masonry, drylining, loft hatches and glazing systems. Any unsealed holes, fixings, pipes, electrical fittings, etc., which pass through the air barrier, will downgrade performance: methods of avoiding or sealing around such penetrations should be considered at the design stage.

Where a rigid board forms the air barrier, joints between adjacent boards should be jointed or sealed to avoid air leakage. Where required, seals should be designed to accommodate thermal or other movement which might occur during the design life of the building.

4.3 Air and vapour control layers

To control vapour diffusion, an air and vapour control layer (AVCL) may be used. AVCLs may be formed with a separate membrane within the structure, a lining board with an integral membrane or with a suitable coating applied to the internal surface of an element, which is in itself, an air barrier. The membrane or element comprising the AVCL should be of the appropriate vapour resistance and should be situated on the warm side of the insulation.

NOTE Even where the criteria for a well sealed ceiling are fully met, it should be recognized that a small amount of unavoidable air leakage will still occur. The performance depends upon the vapour resistance of the materials selected, the practicability of the design and the standard of workmanship involved in installation.

Side and end joints in flexible sheet forming the AVCL should be kept to a minimum. Joints should be made over a solid backing member or substrate, lapped not less than 50 mm and sealed with an appropriate tape or sealant. Similarly, tears and splits should be repaired using the same material, jointed as above. Any unsealed holes, fixings, pipes, electrical fittings, etc., which pass through the AVCL should be sealed with a proprietary seal or sealant.

Some materials used as an AVCL should be protected from heat and sunlight to reduce the risk of degradation.

5 Materials, fittings and accessories

5.1 Air barriers/AVCLs

The air barrier may be an appropriately installed:

1) flexible plastic sheet (e.g. low density and high density polyethylene sheets are frequently used as air barriers); and/or

2) rigid material (e.g. plasterboard or plywood).

An AVCL has the additional requirement that the vapour resistance should be greater than 250 MNs/g.

5.2 Sealants

*COMMENTARY ON **5.2***
BS 6213 and BS 6093:1993 provide general guidance on the design of joints in buildings and the selection of sealants. BS 6093:1993 Table 1 includes an estimate of the life expectancy of the different joint types but adds a warning that: "The actual service life of a sealant is dependent not only on composition but also on environmental conditions and quality of application."

5.2.1 Sealing tapes

*COMMENTARY ON **5.2.1***
BS 7116 provides guidance for the selection of double-sided pressure sensitive self-adhesive tapes including self-adhesive foamed tapes.

Where joints are sealed with tape, either double-sided pressure sensitive adhesive tape conforming to BS 7116 or (for joins between plasterboard) paper tape conforming to BS EN 13963 should be selected, depending on the exact application. The tape manufacturer should be consulted to obtain details of the application requirements and advice on the expected durability of the installation with respect to airtightness.

5.2.2 Liquid sealants

*COMMENTARY ON **5.2.2***
Sealants for building construction joints are classified in British Standards by performance requirements, but the information given in Table 2 and Table 3 is given to help find a sealant with the properties needed in most applications.

Where joints are sealed with liquid sealant, the most appropriate products should be selected according to the procedures of BS 6093:1993 and BS 6213, and install the sealant in accordance with BS 8000-16.

Table 2 **Sealant types**

Type	Movement tolerance %	Typical uses	Practical considerations
Elastic and elastomeric sealants			
1-part polysulfide	25	Movement joints in heavy structures	Slow curing. Vulnerable to damage until cured
1-part polyurethane	30	Movement joints between lightweight components	
2-part polysulfide	30	Movement joints between heavy or lightweight wall components	Mixed on site and has to be used within "application life"
2-part polyurethane	30	Movement joints between heavy or lightweight wall components	Mixed on site and has to be used within "application life"
1-part silicone	50	Joints between plastics and metal components	High initial costs. Careful surface preparation needed.
Foam sealants			
Foam	not applicable	Used for sealing gaps that are too wide for elastomeric sealants.	Have to be protected from direct UV exposure

5.3 Compressible foam (draught stripping)

*COMMENTARY ON **5.3***
General information on choice of draught strips is given in Table 3.

Draught strips should be selected from either synthetic rubber gaskets conforming to BS 4255-1 or weatherstrips conforming to the relevant requirements of BS 7412.

Table 3 **Draught strips**

Type	Weather resistance	Resistance to air pollution	Resistance to acids and alkalis	Comment
Synthetic rubbers				
EPDM	Good	Yes	Yes	Low resistance to oils
Silicone	Good	Yes	No	Often used with plastic components against which it does not react
Chloroprene	Moderate	Yes	No	Resistant to oils
Thermoplastic elastomers				
PVC nitrile	Good	Yes	Yes	
Acrylic	Good	Yes	No	
Preformed flexible foams				
PE foam/rubber adhesive				Some flexible foams are open-cell and although water resistant, they are not suitable for air-resistance applications.
PE foam/acrylic adhesive				
High density PE foam/emulsion acrylic adhesive				
PE foam/pure acrylic adhesive				
Low density PE foam/emulsion adhesive				

5.4 Loft hatches

The hatch and frame should be manufactured from materials that minimize thermal bridging, water vapour escape into the loftspace and subsequent distortion after fitting. The rear of the hatch should be insulated to comply with Building Regulations. A push-up hatch should be heavy enough to compress a seal or be clamped against a seal. A drop-down hatch should be latched securely against a seal. Seals should be either closed cell or O-ring types and be continuous around the perimeter between the door and frame including at hinges and latches. A seal should also be made between frame and ceiling.

The air leakage rate through a loft hatch and frame, when tested to BS EN 13141-1:2004 **4.3**, should be less than 1.0 m^3/hr at a pressure difference of 2 Pa; wooden push-up loft hatches made on site with continuous compressible seals can meet this requirement provided the hatch is at least 5.5kg in weight.

NOTE Drop-down hatches are more difficult to seal and it is recommended that proprietary units with a supplied hatch in a frame are used. Manufacturers can provide third-party evidence that this leakage criterion is met.

An access hatch to eaves space should meet the same criteria as drop-down hatches.

5.5 Light fittings

NOTE Light fittings are often referred to as "luminaires".

Light fittings should conform to the following:

a) BS EN 60598-1 in conjunction with BS 4533-102.1/EN 60598-2-1 for pendant fittings and flush fittings; or

b) BS EN 60598-1 in conjunction with BS EN 60598-2-2 for recessed fittings.

The total air leakage through recessed fittings in a ceiling that forms the boundary between conditioned and unconditioned zones should not exceed 0.06 $m^3/h{\cdot}m^2$ at 2 Pa; the leakage of individual recessed light fittings can be tested using the method specified in **4.3** of BS EN 13141-1:2004.

The air leakage rate for their individual fittings can be requested from the manufacturer. The air leakage rate for each fitting should be used to establish the maximum density at which the fittings can be installed to comply with the permitted total air leakage of 0.06 $m^3/h{\cdot}m^2$ (see BRE IP 4/06 [2]).

Where the air leakage rate for a recessed downlighter is high, or is unknown, airtightness may be achieved by installing an airtight non-combustible enclosure over each downlighter and fully sealing the enclosure onto the ceiling. The manufacturer of the downlighter needs to be consulted to ascertain the dimensions and nature of the enclosure to avoid any overheating of the downlighter or its surroundings.

Pendant and flush light fittings are generally installed by connection to the fixed installation wiring through small holes in the ceiling. Gaps between the sides of the holes and the wiring should be filled with a suitable seal or sealant which will not react with the electrical insulation around the wires.

The roof insulation should be continuous over the recessed fitting/enclosure to avoid cold bridging. The manufacturer's installation instructions might require a certain air clearance around the back of the fitting to maintain safe working temperatures within the fitting. The addition of an enclosure and/or insulation over the light fitting should therefore be carried out strictly in accordance with the manufacturer's instructions. In the absence of manufacturer's instructions the light fitting should be assumed to be unsuitable for installation in a well sealed ceiling with continuous roof insulation above.

To avoid overheating it is essential that the downlighter manufacturer's guidance on the type of lamp to be used with their individual fittings is followed.

*COMMENTARY ON **5.5***
The type of lamp (bulb) specified by markings on the fitting can also have a consequence on the installation criteria for recessed fittings. For instance, a dichroic lamp projects light forward with most of the heat being projected back into the fitting, whereas an aluminized lamp will project both heat and light forward away from the fitting.

5.6 Pipe boots/top hats

*COMMENTARY ON **5.6***
Pipe boots or top hat seals around pipes are available in flexible single piece "pull over" or semi-rigid two part types. Such products may not be suitable for multi pipe penetrations.

The durability of such products should be considered particularly in the case of hot water pipes and flues.

5.7 Ventilators

Ventilators should be treated as a penetration, as addressed in **6.4.6**.

5.8 Fire alarms

Where installed with cables, the penetrations should be addressed in the same way as light fittings (see **5.5**).

6 Design details and installation

NOTE The figures in this clause are illustrative only and not exhaustive.

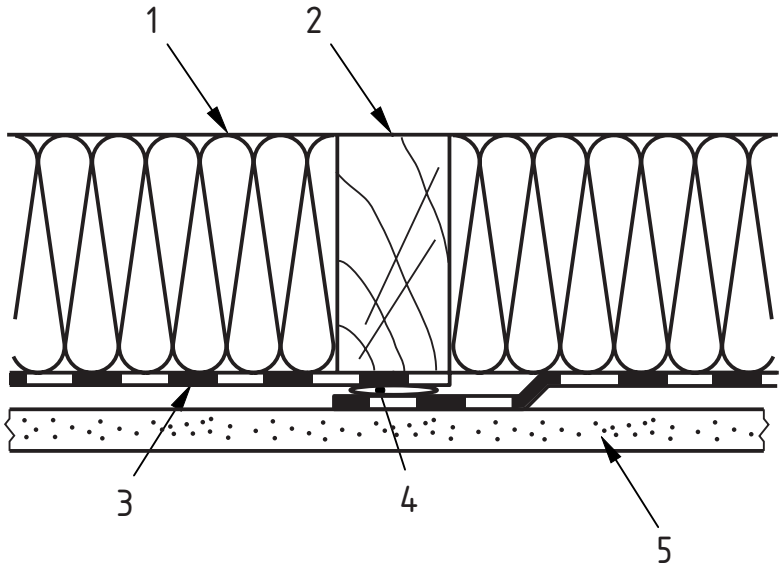
6.1 General – Details in both cold and warm roofs

6.1.1 Installation of AVCLs

AVCLs should be formed on the warm side of the insulation; if it is a membrane, it is essential they are lapped by at least 50 mm and the laps sealed to maintain their integrity. Care should be taken to seal around the perimeter, at junctions and at penetrations such as electrical cables, ducts and pipes, and access hatches; it is good practice to seal off the tops of the external walls to prevent water vapour from the wall entering the roof void.

Where laps in the AVCL can be made at a solid support such as a rafter or joist, the joint should be sealed with adhesive or double-sided tape (Figure 3), and can be further secured with a batten (Figure 4).

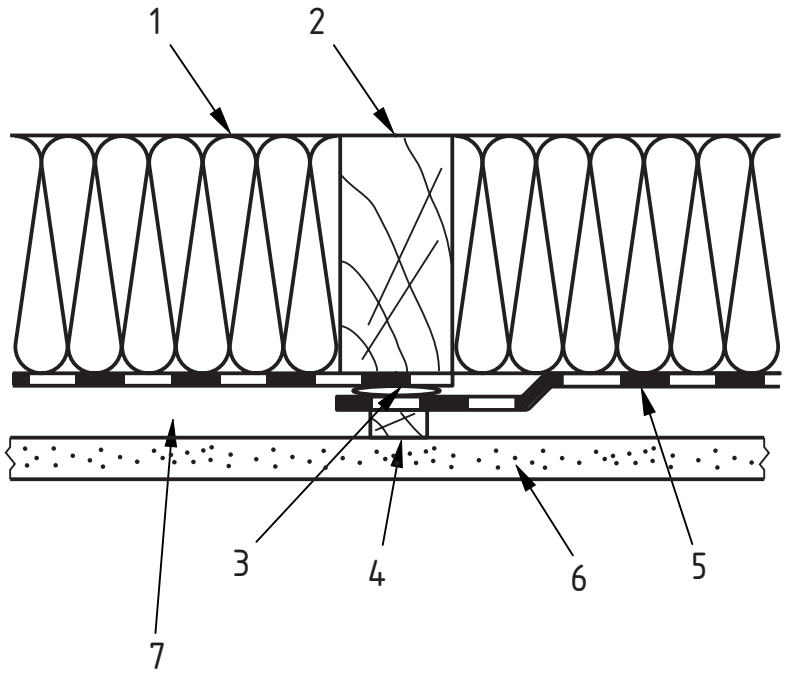
Figure 3 **Joint in AVCL as a membrane with solid support, sealed using adhesive or double-sided tape**



Key

1 Insulation
2 Rafter/joist
3 AVCL
4 Adhesive/double-sided tape shown (single-sided tape also suitable as in Figure 5)
5 Plasterboard

Figure 4 **Joint in AVCL as a membrane with solid support, sealed using adhesive or double-sided tape and secured with a compression batten**



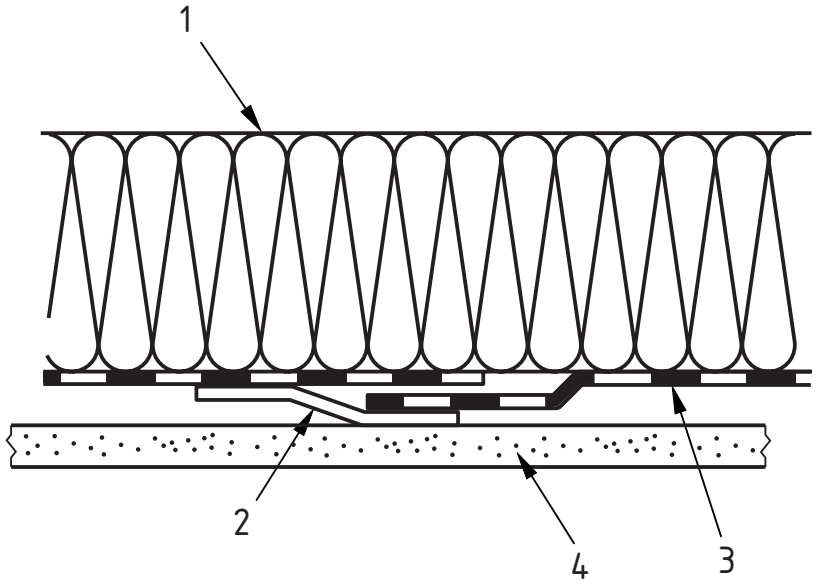
Key

1 Insulation
2 Rafter/joist
3 Adhesive/double-sided tape
4 Compression batten
5 AVCL
6 Plasterboard
7 Service void

Where laps in the AVCL cannot be made at a solid support (the preferred solution), the joint should be sealed with single- or double-sided tape (Figure 5).

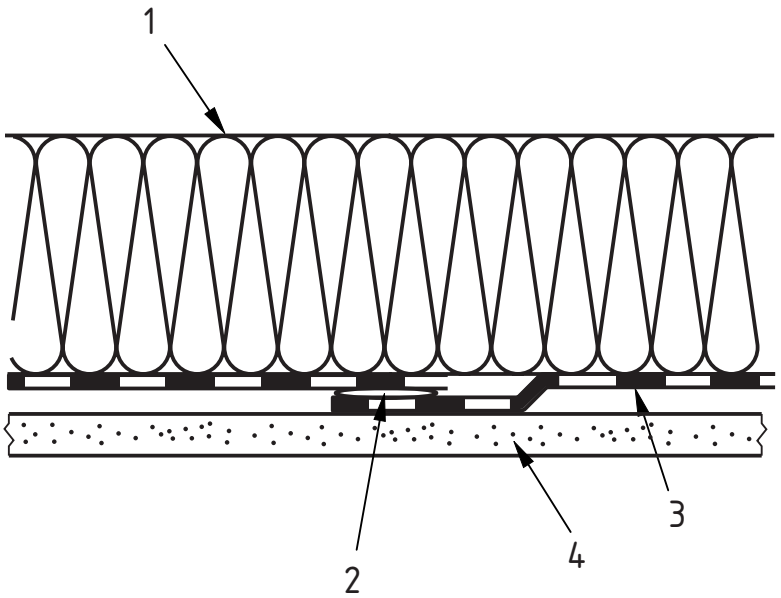
NOTE The installation of a nogging above the joint would make the joint more reliable.

Figure 5 **Joint in AVCL as a membrane without solid support, sealed using adhesive tape (non-preferred solution)**



Key
1 Insulation
2 Adhesive tape
3 AVCL
4 Plasterboard

a) Single-sided adhesive tape

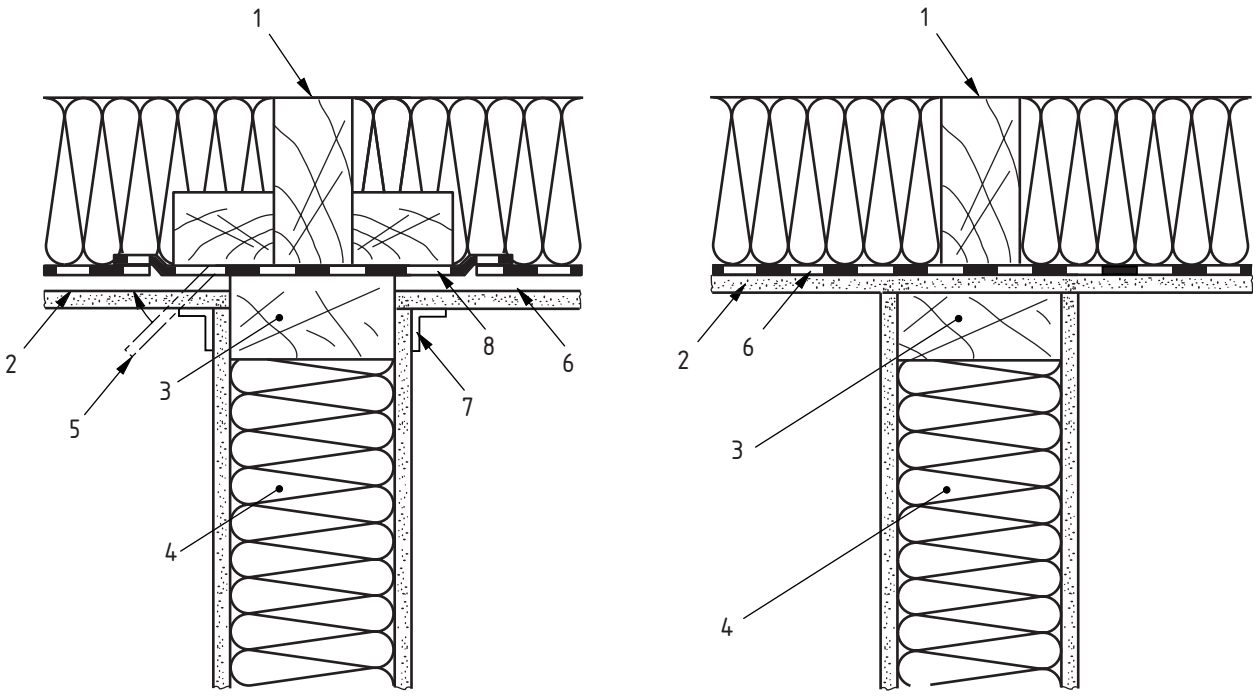


Key
1 Insulation
2 Adhesive/double-sided tape
3 AVCL
4 Plasterboard

b) Double-sided tape

At internal stud partitions, the continuity of the AVCL should be ensured by placing the AVCL over the partition prior to it being secured to the joists, and this AVCL cap then taped to the ceiling AVCL (Figure 6).

Figure 6 **Continuity of AVCL ensured at stud partition**



a) Wall erected before ceiling fixed

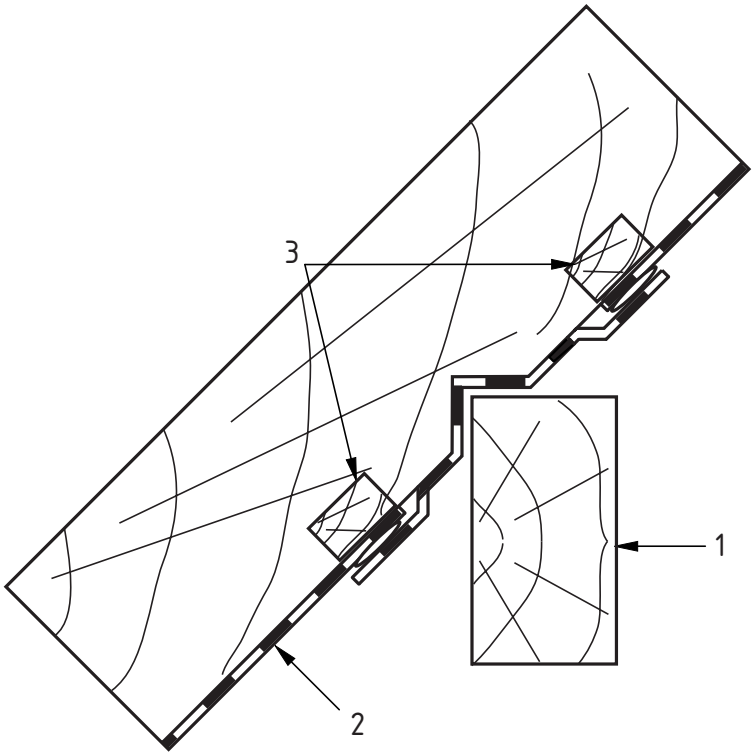
b) Ceiling fixed before wall erected

Key

1 Joist
2 Plasterboard
3 Studding
4 Insulation
5 AVCL overlapped and sealed with tape
6 AVCL
7 Corner tape
8 Wall-head section of AVCL

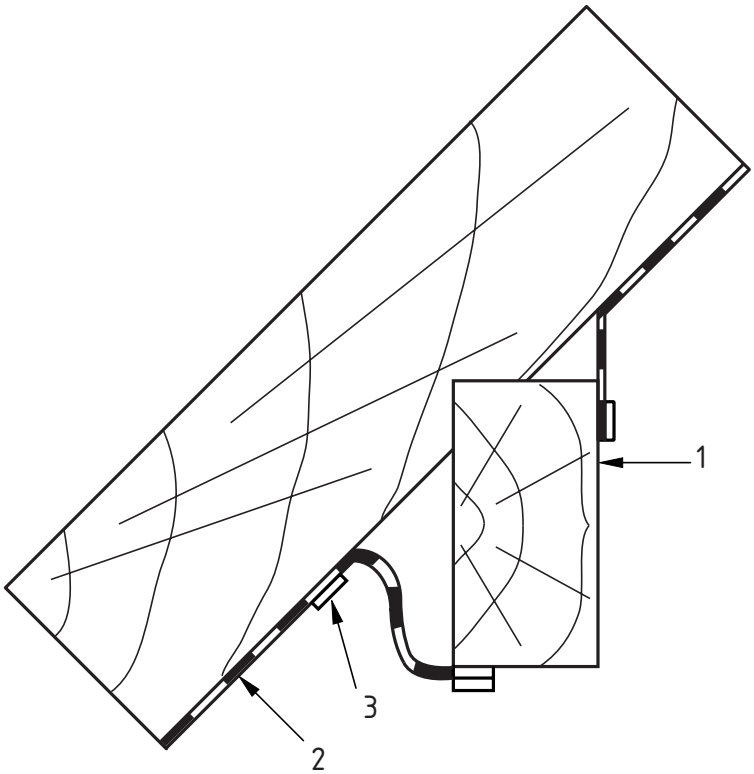
Where purlins or dwarf walls are required, the continuity of the AVCL should be ensured by one of the methods illustrated in Figure 7.

Figure 7 **Continuity of AVCL ensured at a purlin**



Key
1 Purlin
2 AVCL
3 Noggings between rafters

a) AVCL installed prior to fixing purlins



Key
1 Purlin
2 AVCL
3 Compression block over sealant

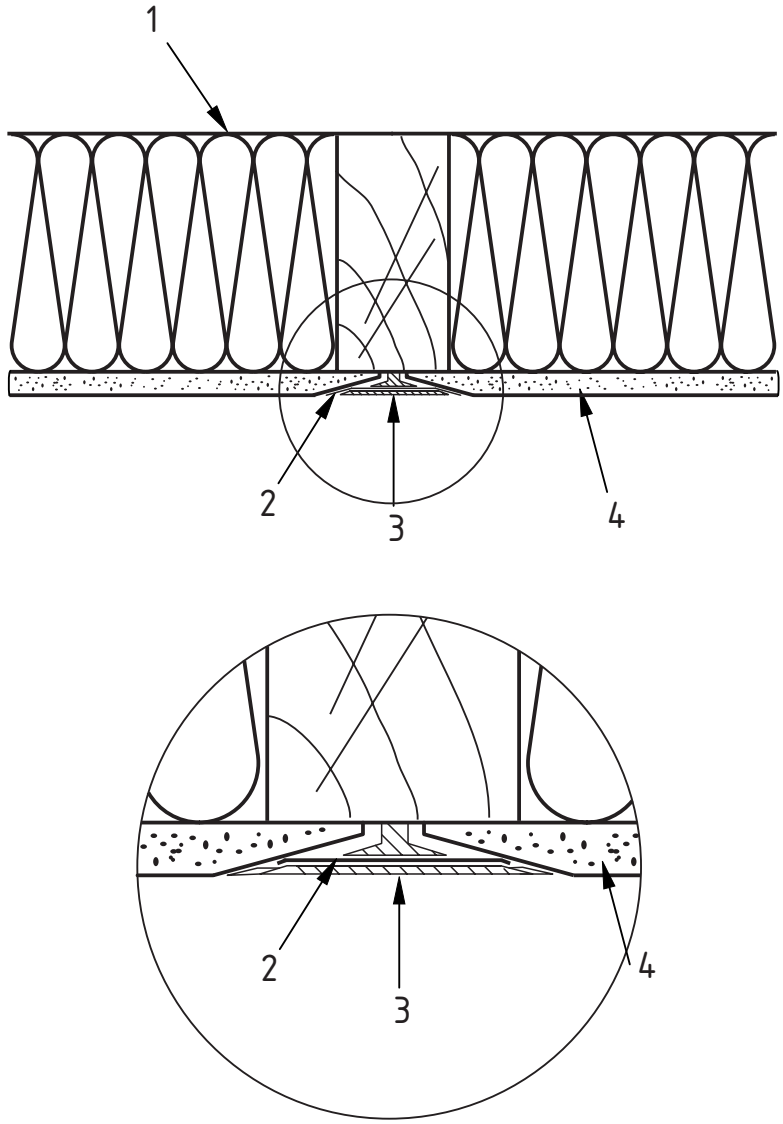
b) AVCL installed after purlins

NOTE Method a) is preferable, but method b) is acceptable if retrofitted where the AVCL is fixed to the purlin with suitable sealant and compression blocks.

6.1.2 Joints in an air barrier formed by plasterboard

Joints in bevel edge plasterboards should be made where there is solid support such as a joist or rafter, should be sealed using a jointing tape (usually crepe or smooth paper) to seal the joint, and the hollow of the joint should be filled with jointing compound (Figure 8).

Figure 8 **Joints in an air barrier formed by bevel-edged plasterboard, joined at a joist or rafter**

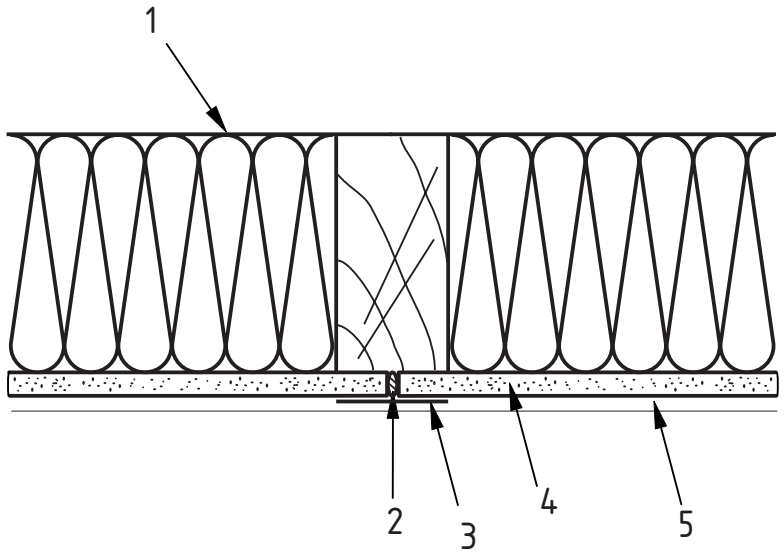


Key

1 Insulation
2 Tape over plaster
3 Plaster to fill
4 Plasterboard

Joints in square edge plasterboards should be made where there is solid support such as a joist or rafter, and should be sealed using a suitable filler compound to seal the joint (Figure 9).

Figure 9 **Joints in an air barrier formed by square-edged plasterboard, joined at a joist or rafter**



Key
1 Insulation
2 Filler
3 Tape
4 Plasterboard
5 Plaster

6.2 Cold roofs

6.2.1 Ceiling-to-wall junctions

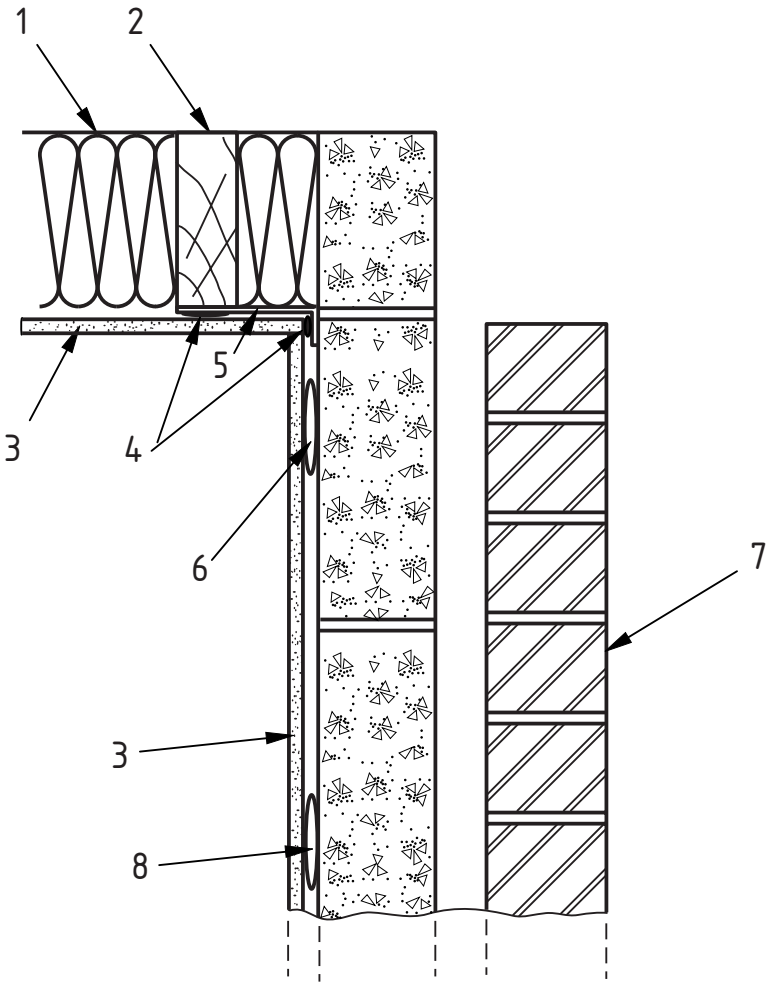
6.2.1.1 Plasterboard lined masonry cavity walls

*COMMENTARY ON **6.2.1.1***
Figure 13 illustrates the movement of air in a masonry cavity wall that could rise to the ceiling behind the plasterboard. Brick and block walls can be air permeable, particularly through the mortar joints. The air moving through the wall will penetrate to the plasterboard and rise up the cavity between the plasterboard and the block wall.

An airtight joint is required at ceiling level. Figure 10 shows an impermeable liner, installed under the plasterboard to provide a robust seal against any cracks that might appear at the ceiling-plasterboard junction, and to prevent any air rising up the cavity behind the plasterboard from entering the roof space.

The plasterboard should be installed with a continuous horizontal ribbon of bonding adhesive at the top of the wall to prevent air movement in the cavity behind the plasterboard.

Figure 10 **Ensuring an air-tight seal at the junction of a masonry cavity wall and ceiling using air-impermeable foil or lining paper**

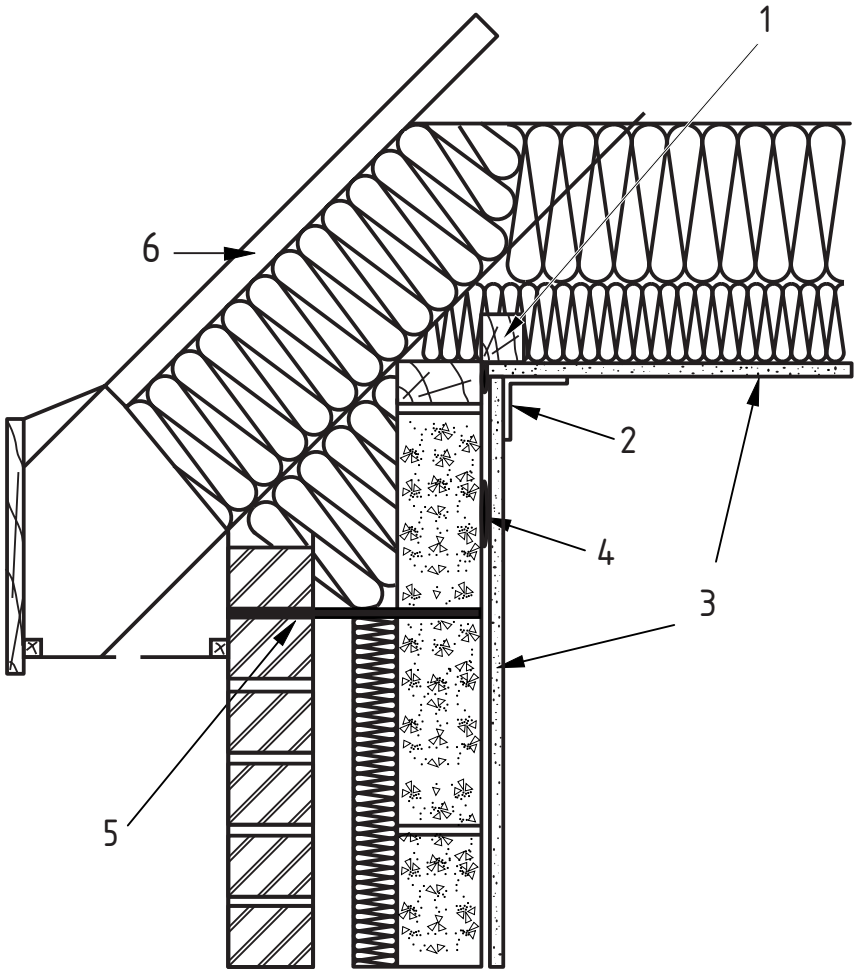


Key

1 Insulation
2 Joist
3 Plasterboard
4 Sealant
5 Air-impermeable foil or lining paper
6 Continuous ribbon of bonding adhesive
7 Brick
8 Dab of bonding adhesive

*COMMENTARY ON **6.2.1.1** (continued)*
In Figure 11, a continuous horizontal ribbon of bonding adhesive and the air-impermeable cavity closer, control the air movement in the wall. The ceiling-to-wall joint is reinforced with plasterboard tape prior to the finish plaster being applied.

Figure 11 **Ensuring an air-tight seal at the top of a masonry cavity wall using plasterboard jointing tape (cold roof)**



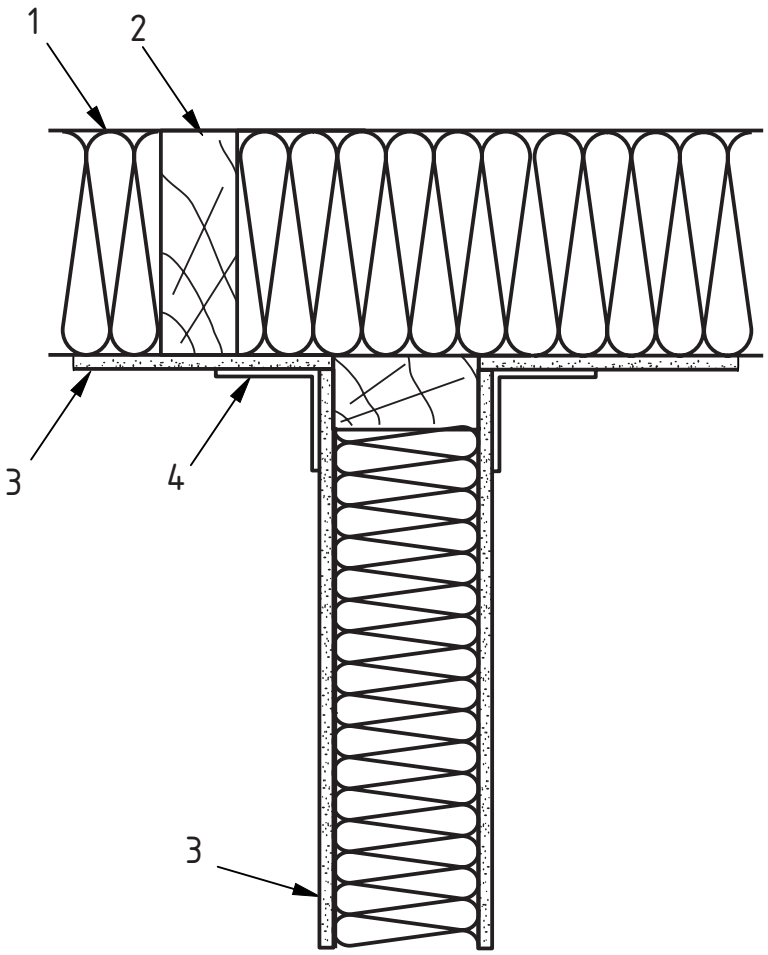
Key
1 Nogging
2 Plasterboard jointing tape
3 Plasterboard
4 Continuous horizontal ribbon of bonding adhesive
5 Air-impermeable cavity closer
6 Ventilation tray

NOTE Roof covering (such as slating, tiling or roofing membrane) have been omitted for simplicity.

6.2.1.2 Plasterboard lined timber frame walls

Plasterboard tape should be applied to the wall-to-ceiling junction as shown in Figure 12.

Figure 12 **Joints in an air barrier formed by a plasterboard-lined timber frame wall using plasterboard tape**



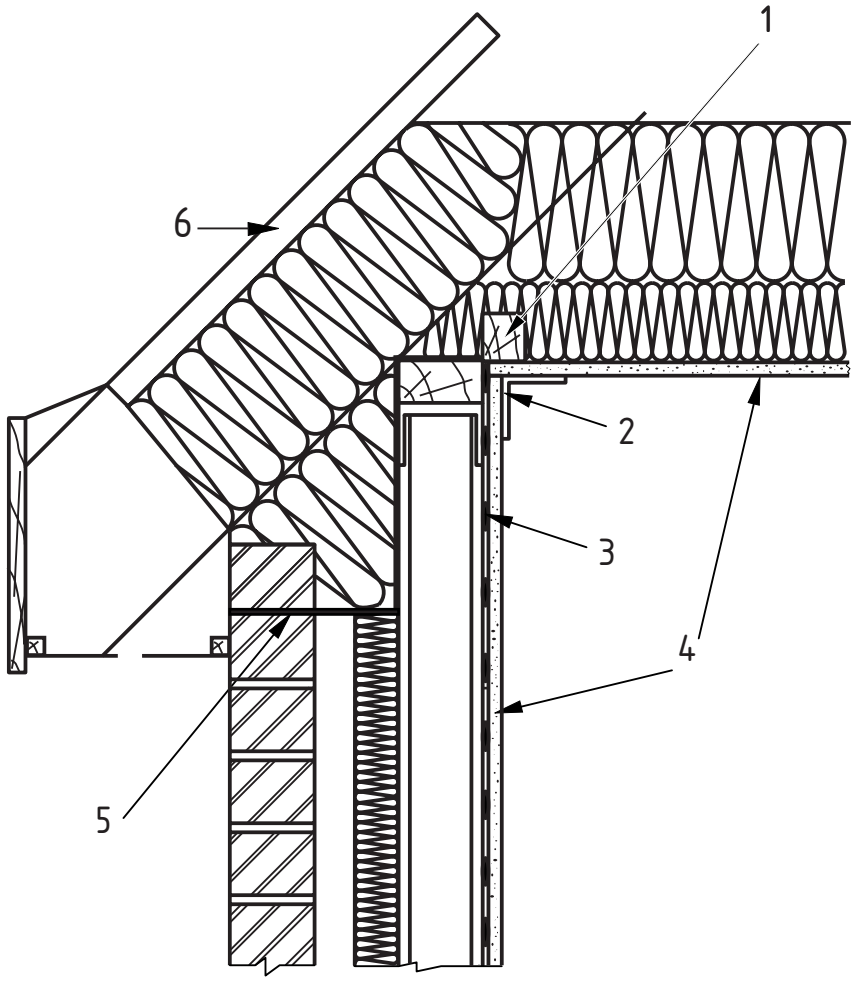
Key

1 Insulation
2 Joist
3 Plasterboard
4 Jointing tape

6.2.1.3 Plasterboard lined metal frame walls

*COMMENTARY ON **6.2.1.3***
Figure 13 illustrates a plasterboard lined metal frame wall.

Figure 13 **Joints in an air barrier formed by plasterboard lining a metal frame wall (cold roof)**



Key

1 Nogging
2 Plasterboard jointing tape
3 AVCL
4 Plasterboard
5 Air-impermeable cavity closer
6 Ventilation tray

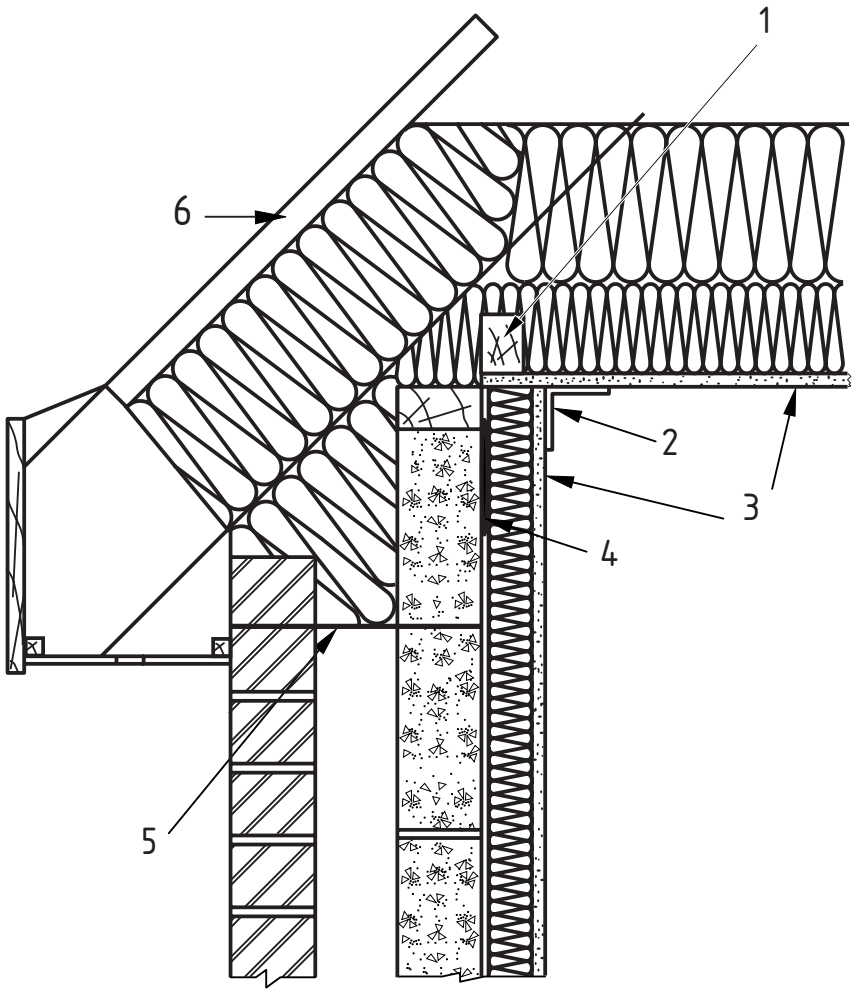
NOTE Roof covering (such as slating, tiling or roofing membrane) have been omitted for simplicity.

6.2.1.4 Plasterboard lined internally insulated solid walls

*COMMENTARY ON **6.2.1.4***

Figure 14 illustrates a plasterboard lined internally insulated solid wall.

Figure 14 **Joint in an air barrier formed by plasterboard lining an internally insulated wall (cold roof)**



Key

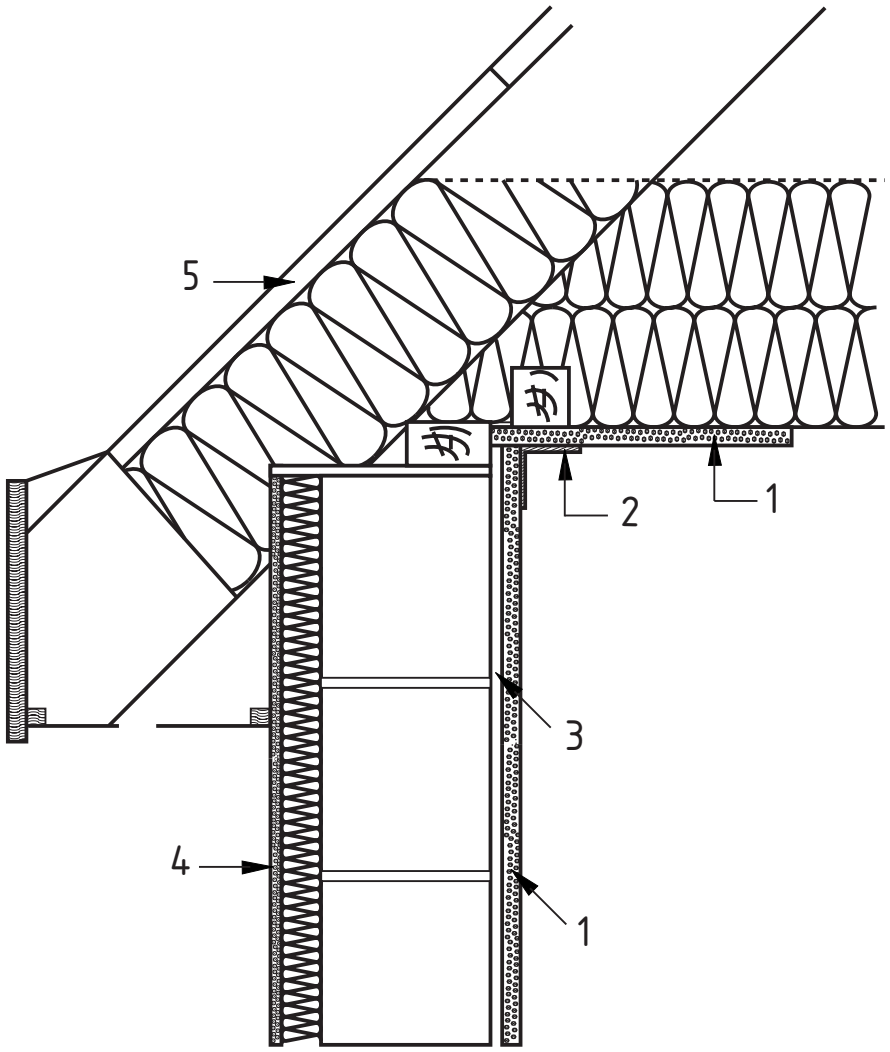
1 Nogging
2 Plasterboard jointing tape
3 Insulated plasterboard composite
4 Continuous horizontal ribbon of bonding adhesive
5 Air-impermeable cavity closer
6 Ventilation tray

NOTE Roof covering (such as slating, tiling or roofing membrane) have been omitted for simplicity.

6.2.1.5 Plasterboard lined externally insulated walls

*COMMENTARY ON **6.2.1.5***
Figure 15 illustrates a plasterboard lined externally insulated solid wall.

Figure 15 **Joint in an air barrier formed by plasterboard lining an externally insulated wall (cold roof)**



Key

1 Plasterboard
2 Plasterboard jointing tape
3 Continuous horizontal ribbon of bonding adhesive
4 External cladding/render
5 Ventilation tray

NOTE Roof covering (such as slating, tiling or roofing membrane) have been omitted for simplicity.

6.2.1.6 Plasterboard lined internal partitions

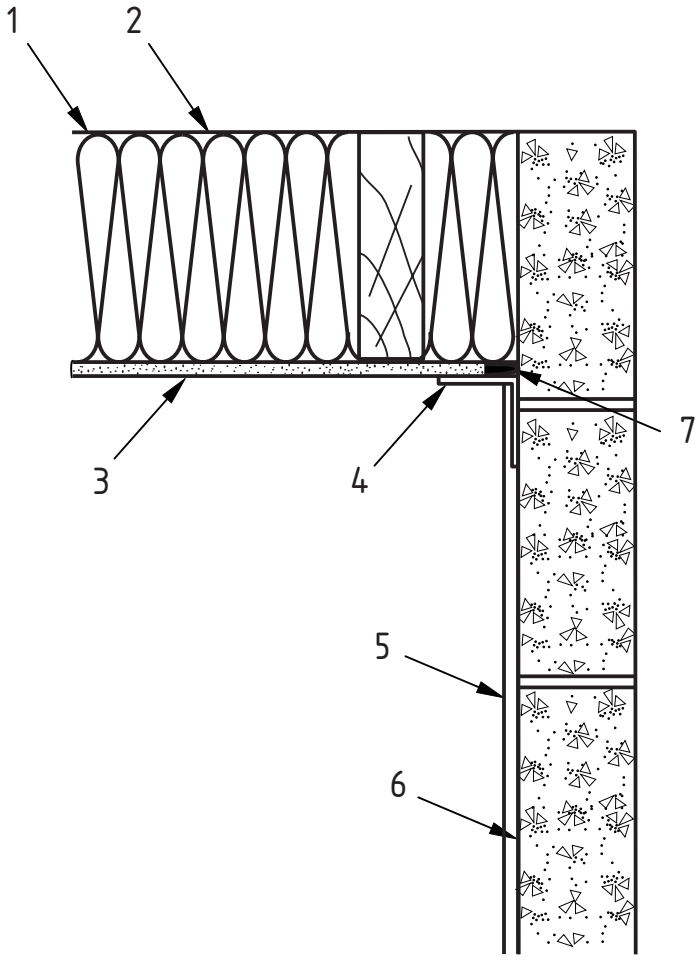
Recommendations for the installation of plasterboard lined internal partitions are given in **6.1.1** and illustrated in Figure 3.

6.2.1.7 Plastered masonry cavity walls

*COMMENTARY ON **6.2.1.7***
Figure 16 illustrates a masonry cavity wall that has been plastered and has a plasterboard ceiling. The wall to ceiling joint is taped with a plasterboard jointing tape that is later skimmed with plaster to provide the final finish to the walls and ceiling. The tape provides additional resistance to cracking of the wall to ceiling joint.

The tape at corners should not be more than two layers thick and some mitring of the tape at corners will be required.

Figure 16 **Join in a plastered masonry cavity wall using plasterboard jointing tape**



Key

1 Insulation
2 Joist
3 Plasterboard
4 Jointing tape
5 Plaster
6 Block
7 Sealant

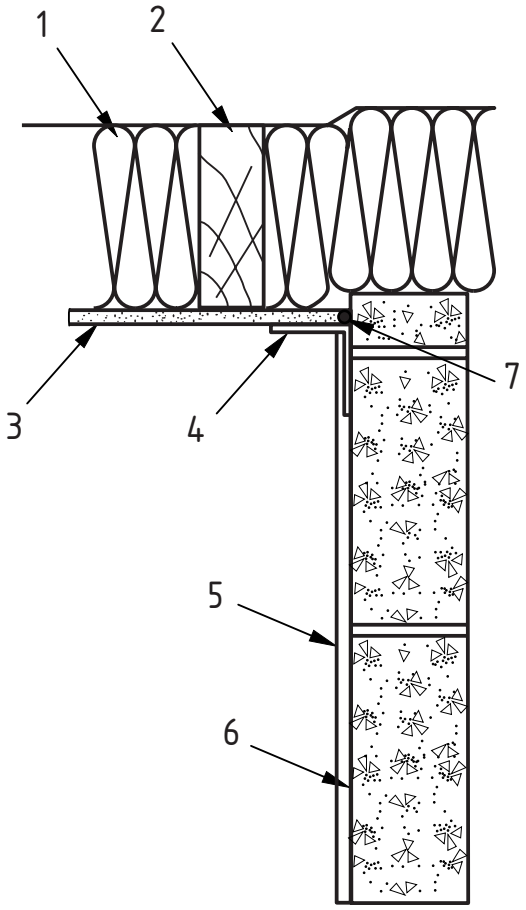
NOTE Jointing tape/sealant installation

6.2.1.8 Plastered internal partitions

*COMMENTARY ON **6.2.1.8***
Figure 17 shows an internal block wall that has been plastered and has a plasterboard ceiling. The wall-to-ceiling joint is taped with a plasterboard jointing tape that is later skimmed with plaster to provide the final finish to the walls and ceiling. The tape provides additional resistance to cracking of the wall-to-ceiling joint.

The tape at corners should not be more than two layers thick and some mitring of the tape at corners will be required.

Figure 17 **Join in a plastered internal block wall using plasterboard jointing tape**



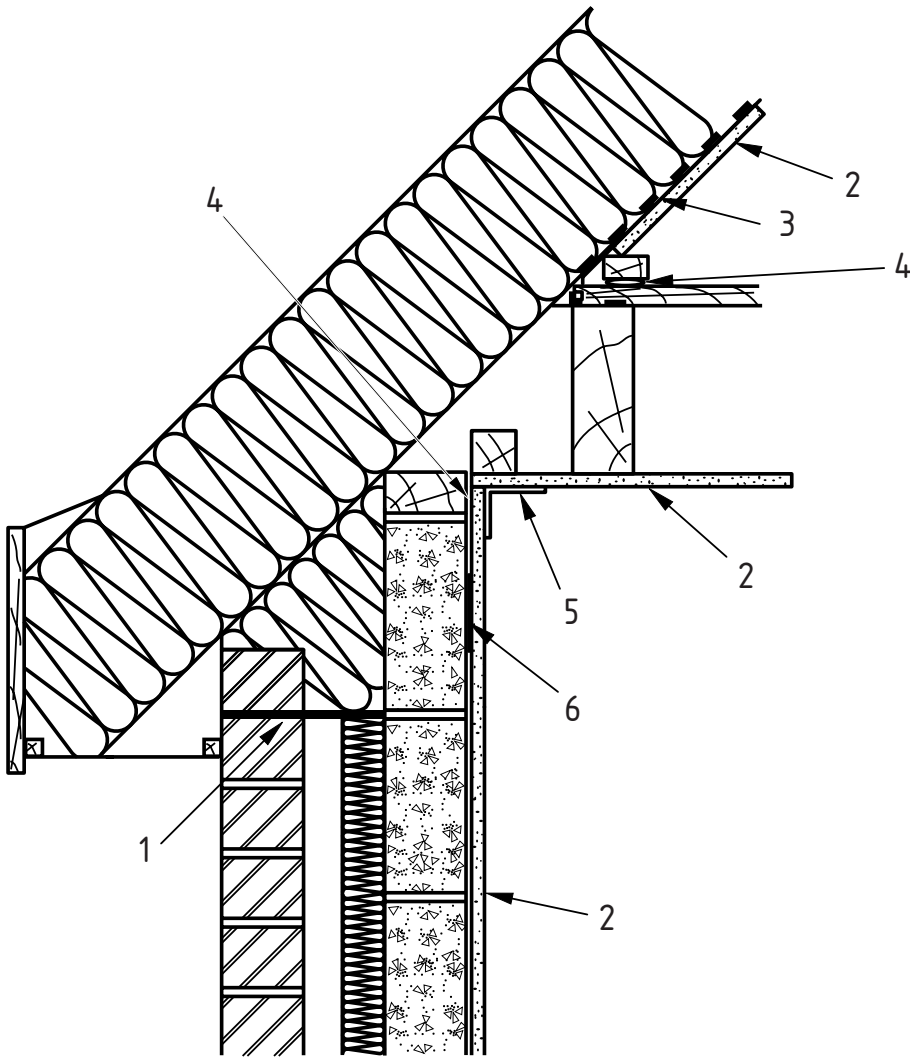
Key
1 Insulation
2 Joist
3 Plasterboard
4 Jointing tape
5 Plaster
6 Block
7 Sealant

6.3 Warm roofs

It is essential that warm roofs are provided with an airtight AVCL to prevent moisture entering the construction above. The AVCL should be sealed using the techniques given in **6.1.1**.

*COMMENTARY ON **6.3***
In Figure 18, the use of the air-impermeable cavity closer and the continuous horizontal strip of plasterboard adhesive behind the wall plasterboard control air movement in the wall. The ceiling to wall joint is reinforced with plasterboard tape. The AVCL in the roof space is the primary airtightness control boundary.

Figure 18 **Ensuring an air-tight seal at the top of a masonry cavity wall below a warm roof**



Key

1 Air-impermeable cavity closer
2 Plasterboard
3 AVCL
4 Sealant
5 Jointing tape
6 Continuous horizontal ribbon of bonding adhesive

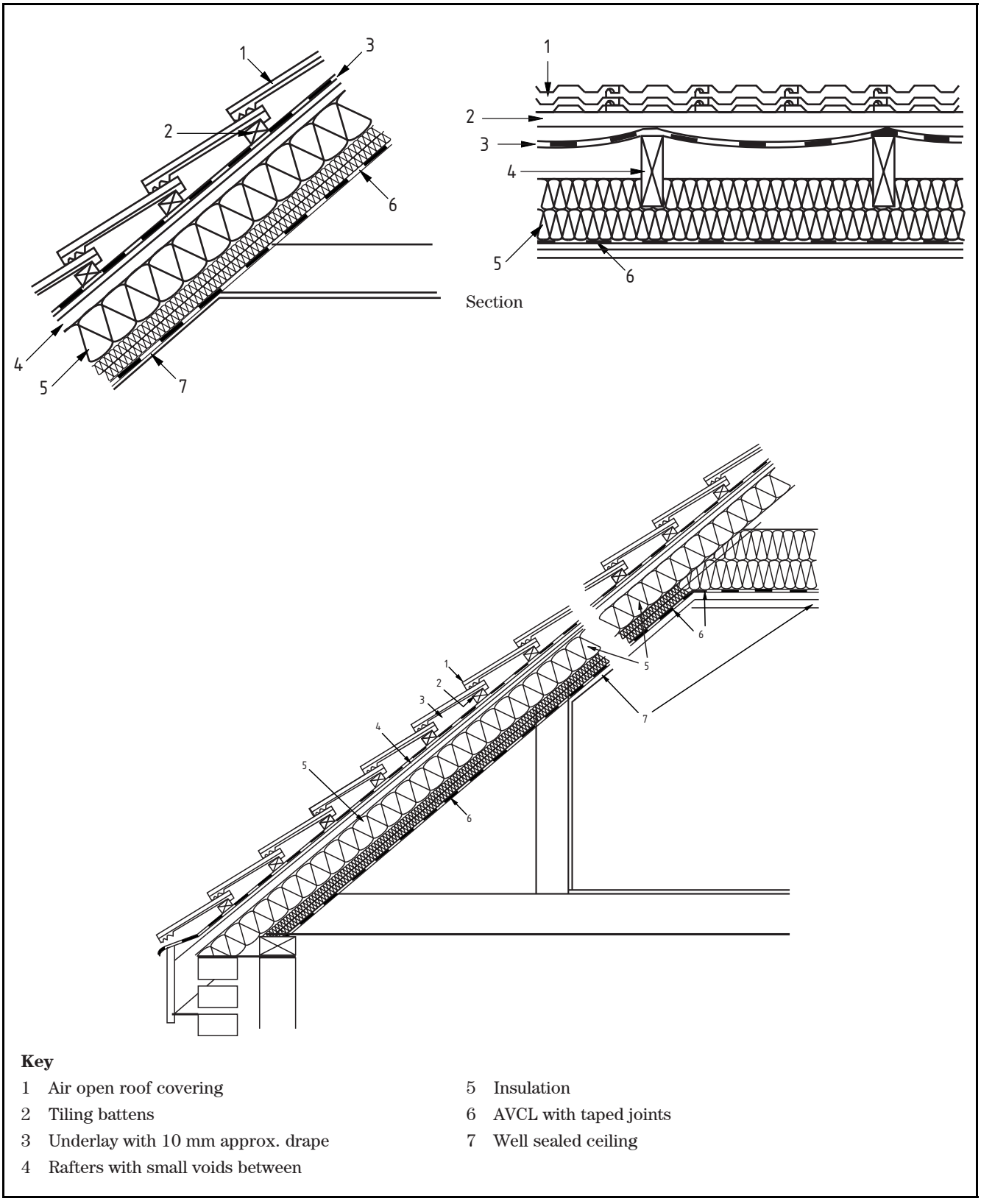
NOTE Roof covering (such as slating, tiling or roofing membrane) have been omitted for simplicity.

*COMMENTARY ON **6.3***

Figure 19 shows one of the many forms of warm roof construction where, for constructional reasons, there is a small void above the insulation.

The AVCL should be carefully cut and sealed around struts and joists, as illustrated in Figure 7 and Figure 18. This is particularly the case for trussed rafters.

Figure 19 **Warm roof construction with a small void above insulation**



Key

1 Air open roof covering
2 Tiling battens
3 Underlay with 10 mm approx. drape
4 Rafters with small voids between
5 Insulation
6 AVCL with taped joints
7 Well sealed ceiling

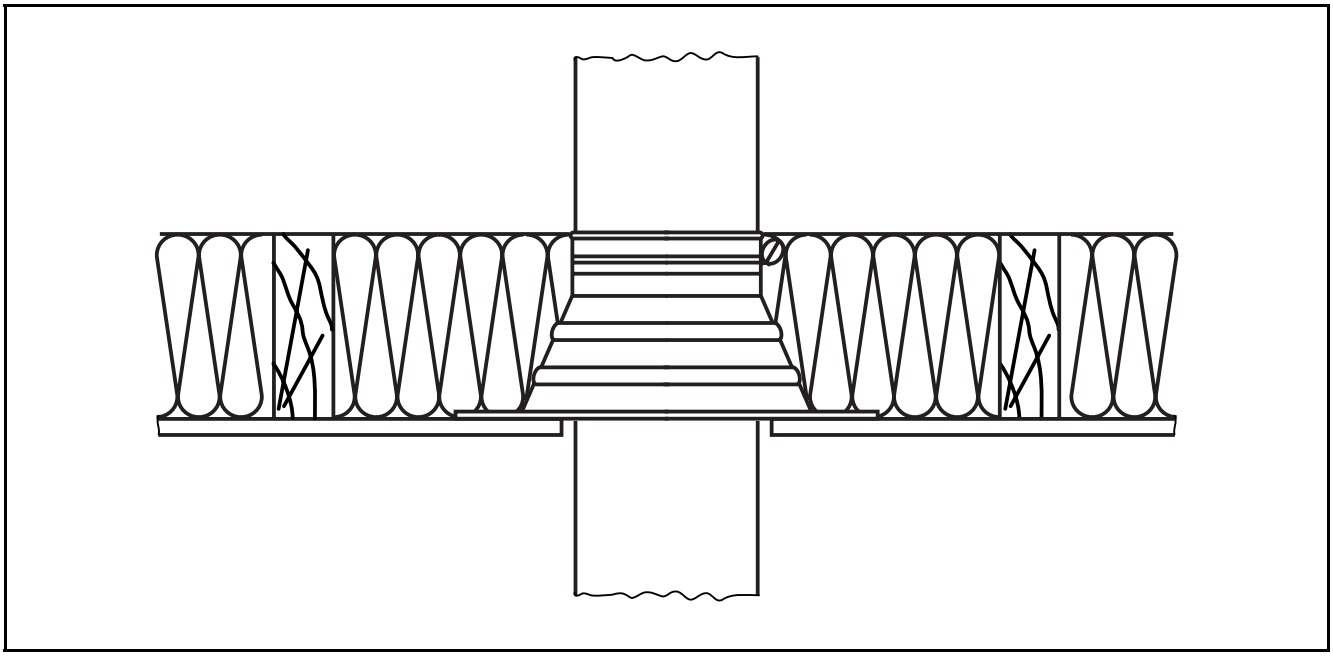
6.4 Penetrations through ceilings

6.4.1 Pipes

*COMMENTARY ON **6.4.1***
Where pipe seals or boot cannot be used it is important that any sealants or foams have some means of support during curing to ensure a well sealed junction.

Gaps around pipes should be sealed by means of pipe seals or boots where appropriate or with suitable sealants or foams (see **5.4** and **5.5**); it is important that the seal between pipe and pipe seal or boot is also clamped by means of a "jubilee clip" or tie (see Figure 20). The seal from the pipe seal or boot to the top side of the ceiling should be made on a dry, dust free surface.

Figure 20 **Illustrative detail of a pipe penetration with collar**

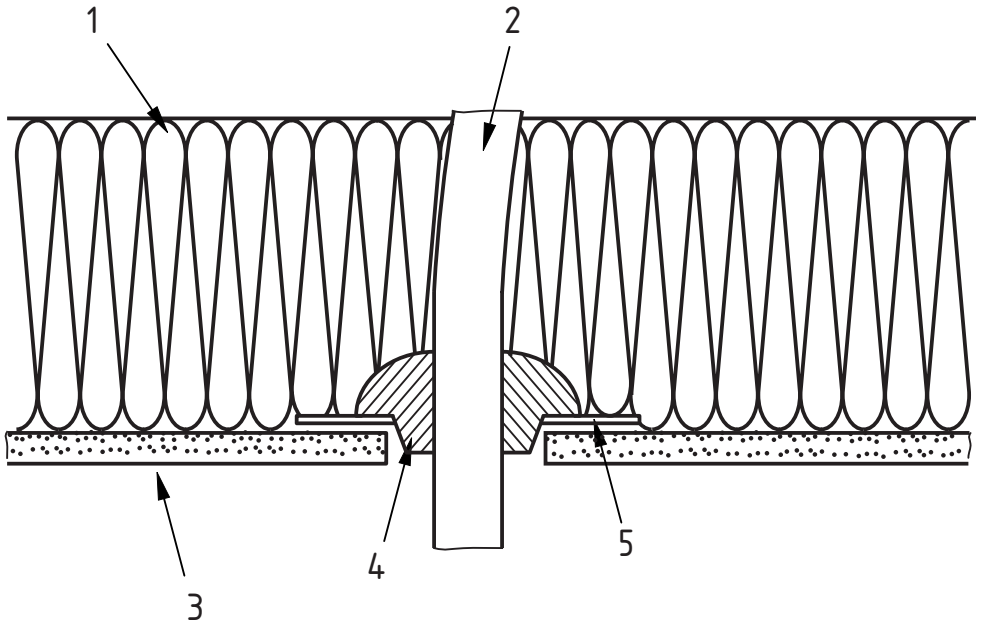


Where a number of small diameter pipes penetrate the ceiling in close proximity to each other the gaps between the pipes and edges of the ceiling board should be fully filled/sealed with suitable sealants or foams. The pipes should be spaced to permit full filling around each pipe without causing sagging of the filler/sealant during and after installation.

6.4.2 Cables

As mentioned in **6.1.1**, care should be taken to seal around the perimeter of the ceiling at penetrations such as electrical cables, as illustrated in Figure 21.

Figure 21 **Illustrative detail of a cable penetration with support and grommet**



Key

1 Insulation
2 Cable
3 Plasterboard
4 Rubber grommet
5 Self-adhesive support

6.4.3 Light fittings

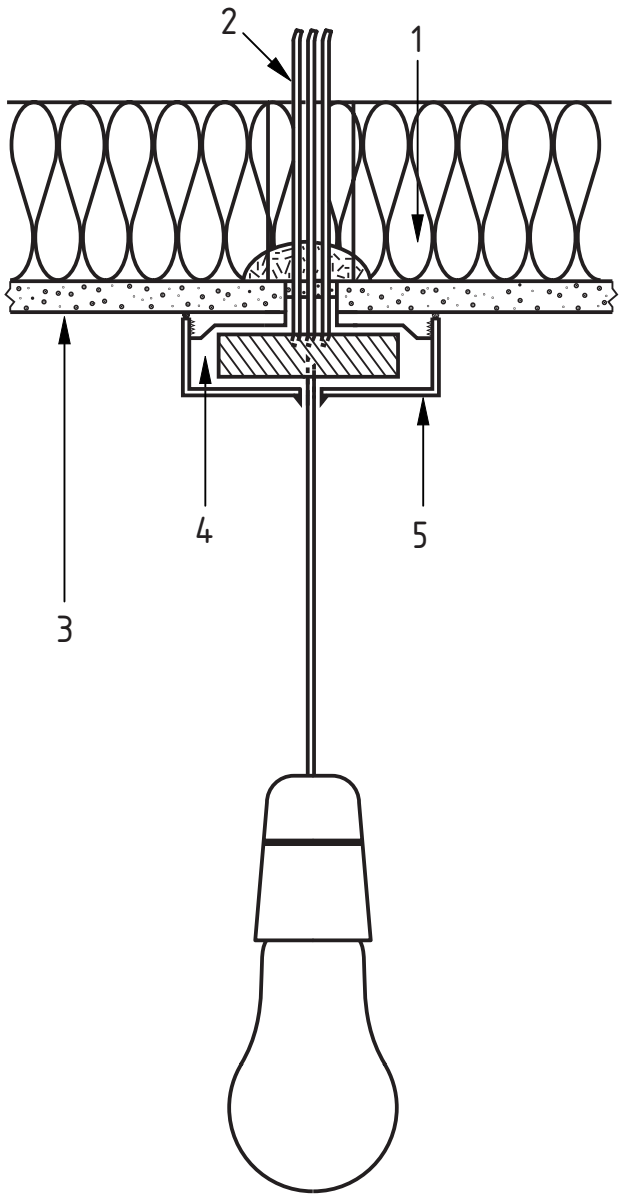
Installation of light fittings should be undertaken in accordance with the manufacturer's instructions.

*COMMENTARY ON **6.4.3***
*The leakage of individual downlighters can be tested using the method specified in **4.3** of BS EN 13141-1:2004.*

Typical installation methods for pendant, flush and recessed light fittings are shown in Figures 22, 23 and 24 respectively.

Installation of light fittings is required to be done in accordance with Part P of the Building Regulations [8]. It is also worth noting that any unauthorized modifications or additions can adversely affect the safe operation of the fitting.

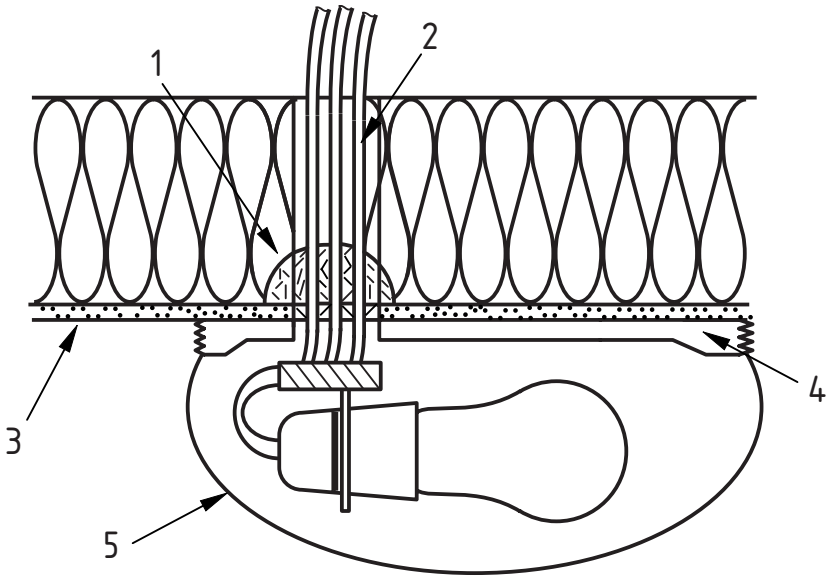
Figure 22 **Example of a pendant light fitting**



Key

1 Suitable sealant or filler applied from above or beneath
2 Power supply and switching cables
3 Plasterboard
4 Ceiling rose inner plate
5 Ceiling rose outer cover

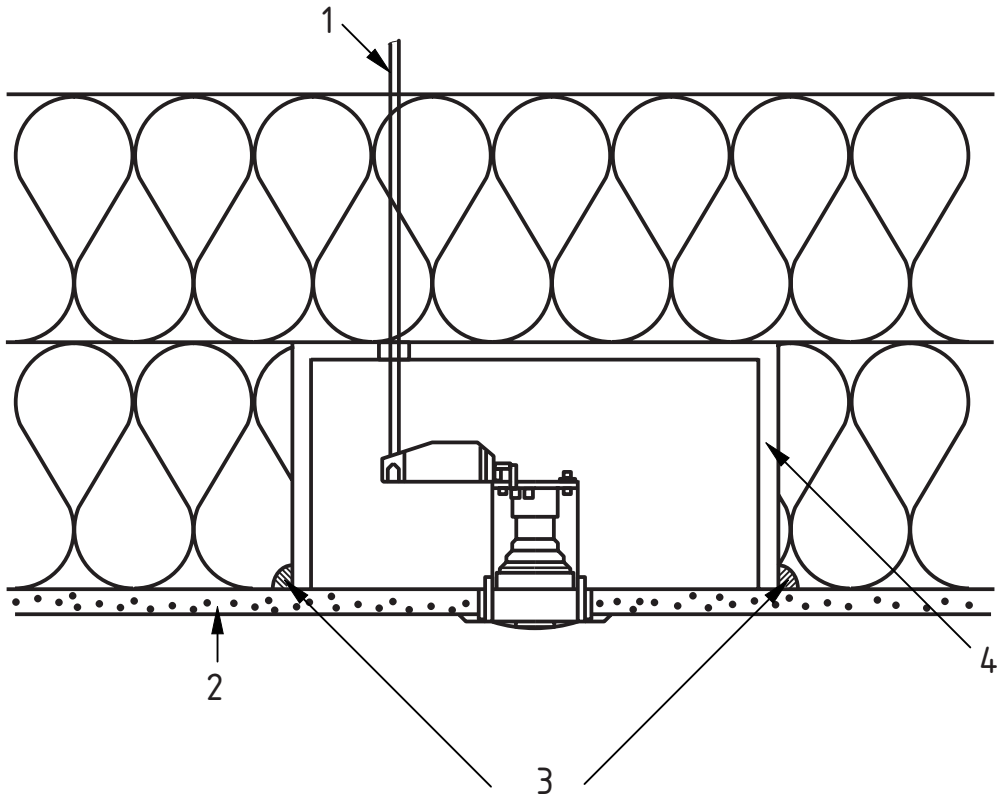
Figure 23 **Example of a flush light fitting**



Key

1 Suitable sealant or filler applied from above or beneath
2 Power supply and switching cables
3 Plasterboard
4 Baseplate
5 Cover

Figure 24 **Example of a recessed light fitting showing a sealed hood or box**



Key

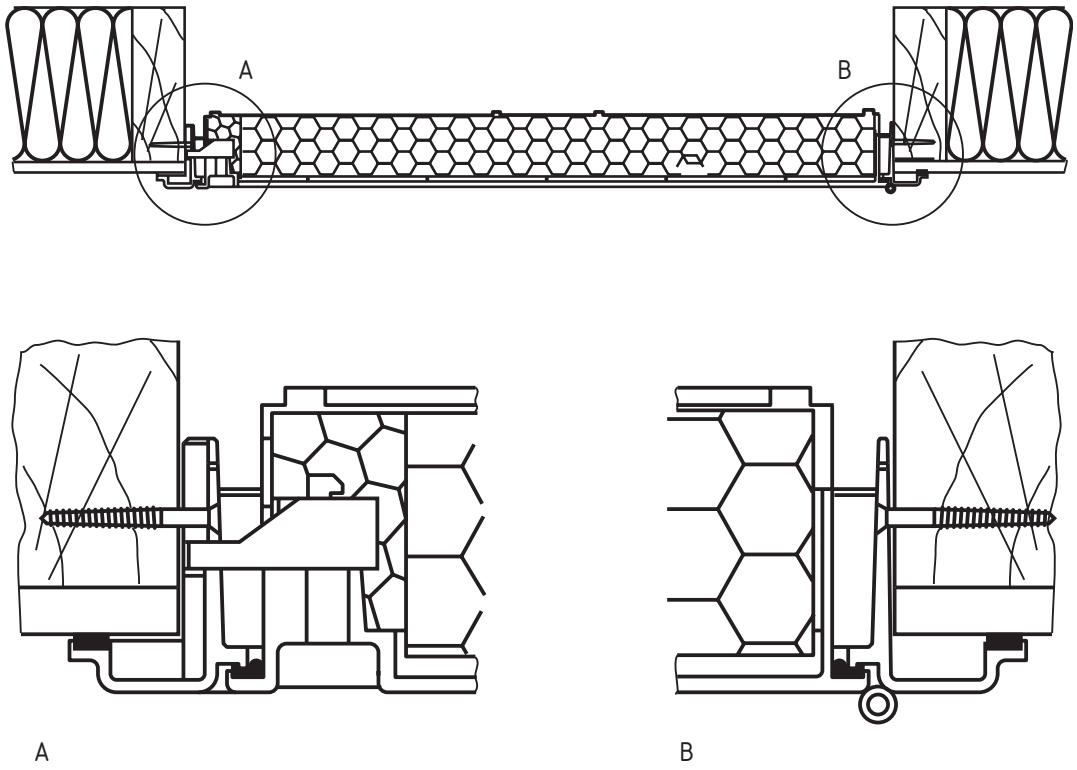
1 Power supply and switching cables
2 Plasterboard
3 Suitable sealant or filler
4 Non-combustible box

NOTE Airtightness may be achieved by the light fitting or the box and sealant.

6.4.4 Loft hatches

The compressible closed cell or O-ring gaskets should be continuous between door and frame and frame and ceiling (see Figure 25). This should also include the area around hinges and latches. Any movement in the door after fitting should be accommodated by the gaskets to ensure the seal is not compromised.

Figure 25 **Illustrative detail of a drop-down loft hatch with seals**

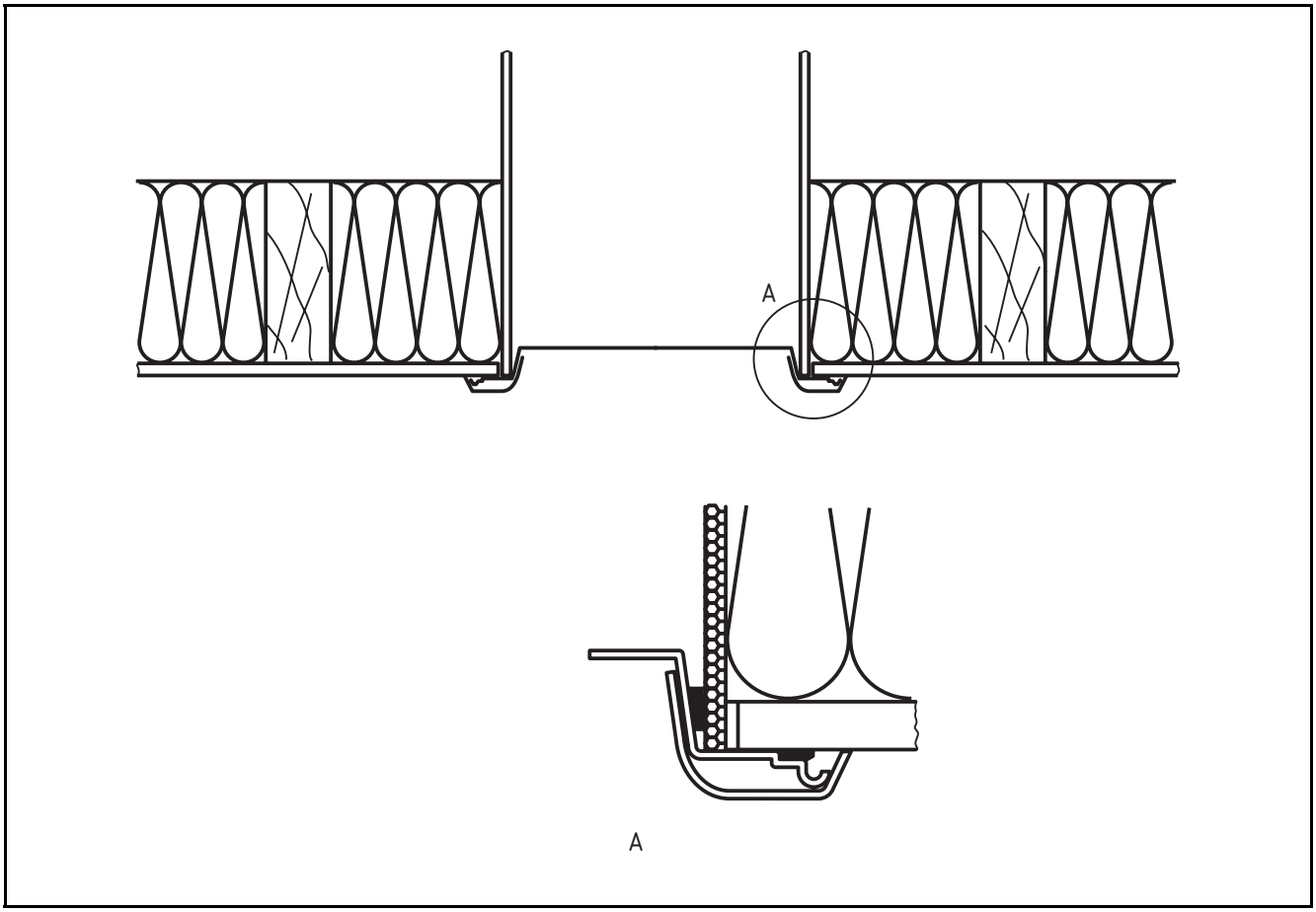


NOTE Seal is needed both between the plasterboard and frame, and between the frame and hatch lip.

6.4.5 Tubular rooflights

Where ceiling diffusers connected to tubular rooflights penetrate the ceiling, the diffuser should be both fixed and sealed to the ceiling and the tubular rooflight pipe system should also be sealed to the diffuser to minimize water vapour escape (see Figure 26). Pipes in cold loftspaces should be insulated.

Figure 26 **Illustrative detail of a tubular rooflight**

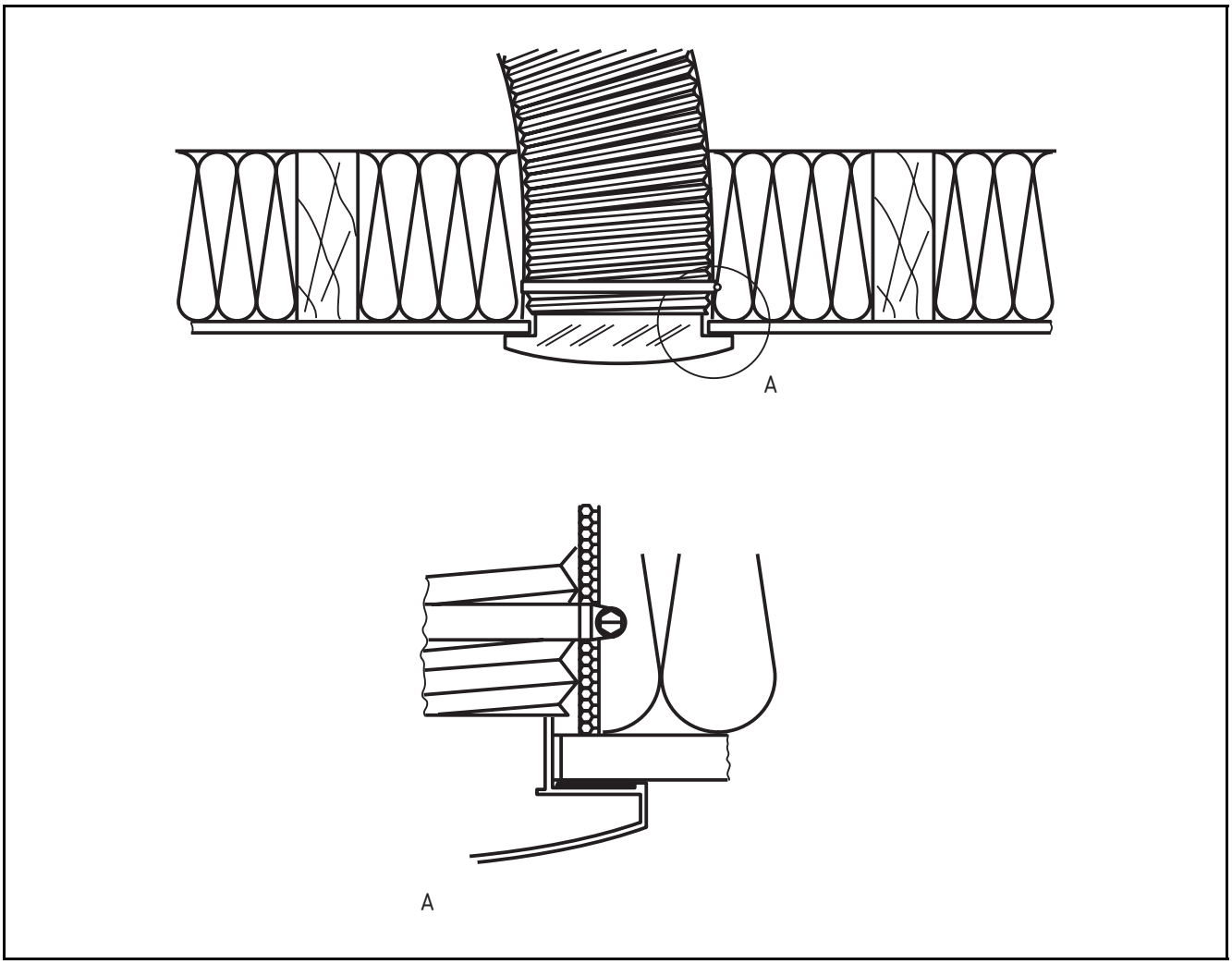


6.4.6 Extraction outlets

*COMMENTARY ON **6.4.6***
Extraction units, to which ducting is connected, remove unwanted water vapour from the building. It is important that the extraction unit is both fixed and sealed to the ceiling and the ductwork is clamped to the spigot at the rear of the unit to minimize water vapour escape (see Figure 27).

Ductwork in cold loftspaces should be insulated to minimize internal condensation.

Figure 27 **Illustrative detail of a sealed ventilation duct in a ceiling**

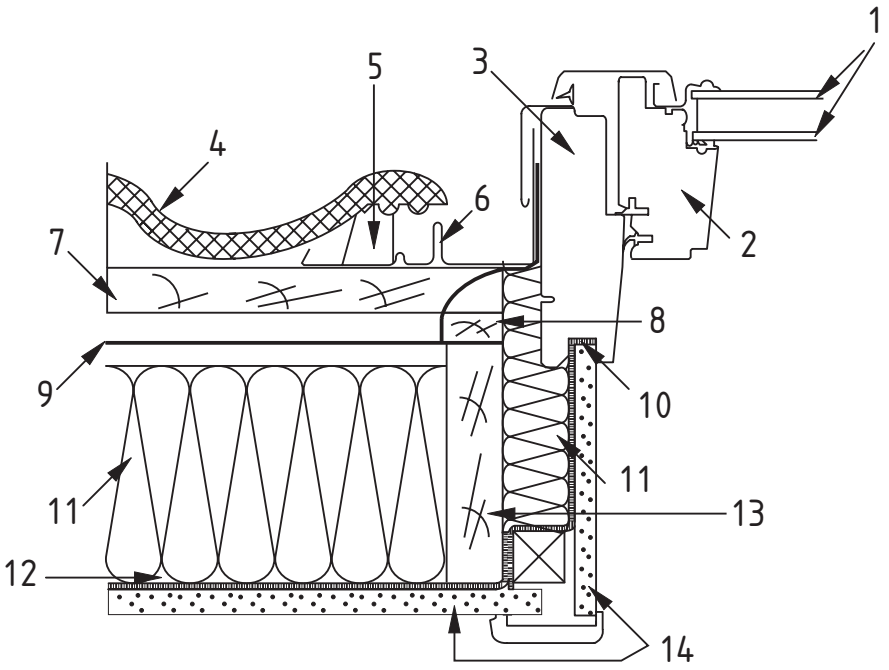


6.4.7 Roof windows

NOTE Without good attention to detail, windows in a warm roof can be significant sources of air leakage into the roof construction. Figure 28 shows a good practice detail around a typical warm roof window.

Airtightness should be maintained at the corners of the windows, where necessary using sealing tapes.

Figure 28 **Illustrative detail of a window in a warm roof**



Key

1 Glass
2 Casement
3 Window frame
4 Tile
5 Foam
6 Flashing
7 Tile batten
8 Counterbatten
9 Vapour permeable underlay
10 Gasket/sealant
11 Insulation
12 AVCL
13 Rafter
14 Plasterboard

Annex A (informative) Requirements for airtightness and control of condensation in the Building Regulations

A.1 Introduction

The following Building Regulations (2000) Approved Documents for England and Wales refer to, or are related to, the airtightness of buildings or the control of condensation:

- Part C, Site preparation and resistance to contaminants and moisture;
- Part F, Ventilation;
- Part L, Conservation of fuel and power; and
- Part P, Electrical safety – Dwellings.

The four Approved Documents are interrelated and the method chosen to meet the requirements of one approved document will directly influence the options available to fulfil the requirements of the other regulations.

The following Building (Scotland) Regulations 2004 Technical Handbook [6] Sections contain the equivalent guidance to the noted Approved Document subjects:

- Section 3, Environment (site preparation and resistance to contaminant and moisture, and ventilation);
- Section 6, Energy (conservation of fuel and power); and
- Section 4, Safety (electrical safety).

The following Building Regulations (Northern Ireland) [5] Parts contain the equivalent guidance to the noted Approved Document subjects

- Part C, Preparation of site and resistance to moisture (site preparation and resistance to contaminant and moisture);
- Part K, Ventilation (ventilation); and
- Part F, Conservation of fuel and power (conservation of fuel and power).

A.2 Approved Document C – Site preparation and resistance to contaminants and moisture

Approved Document C [9] is published with two parts:

- C1, Site preparation and resistance to contaminants; and
- C2, Resistance to moisture

Part C2, Resistance to moisture, refers to BS 5250 as the means to demonstrate compliance with the regulations. BS 5250 recognizes that where a building is constructed to be more airtight, less moisture will transfer into the fabric of the building or into the unconditioned spaces of the building such as lofts. BS 5250 allows a lower level of ventilation of the loft space where a well-sealed ceiling has been installed. A well-sealed ceiling is defined in BS 5250 and is included in this standard. This standard was prepared to provide guidance on how to achieve the necessary details and seals required for a well-sealed ceiling.

A.3 Approved Document F – Ventilation

Approved Document F [4] has been revised to take into consideration the revised airtightness of buildings.

Where the airtightness of the building is low (airtight) the ventilation of the occupied spaces needs to be higher to ensure that a healthy environment is provided and that moisture is removed to avoid the risk of harmful condensation. With naturally ventilated buildings the amount of ventilation needed will vary with the building type, e.g., for dwellings the number of bedrooms and the height of the building can affect the requirement. For buildings that do not have opposing elevations, high and low level ventilators might be required to ensure adequate air movement.

A.4 Approved Document L – Conservation of fuel and power

Approved Document L is published in four parts:

- L1A, Conservation of fuel and power in new dwellings [10];
- L1B, Conservation of fuel and power in existing dwellings [10];
- L2A, Conservation of fuel and power in new buildings other than dwellings [7]; and,
- L2B, Conservation of fuel and power in existing buildings other than dwellings [7].

To show compliance with the regulations the energy performance of the building have to be calculated in accordance with a prescribed method and the value has to be below a target figure for the type of building. The calculation method allows a balance to be made between insulation levels, airtightness and the efficiency of the heating and cooling equipment.

The airtightness is measured as the volume of air that leaks from the building per hour per square metre of the surface area of the internal surface of the exterior walls, floor and ceiling ($m^3/hr \cdot m^2$).

Bibliography

[1] *Airtightness in commercial and public buildings.* B.C. Webb and R. Barton. Garston: BRE. 2002.

[2] BRE IP 4/06. *Airtightness of ceilings – Energy loss and condensation risk*. Garston: BRE. March 2006.

[3] BRE IP 5/06. *Modelling condensation and air flow in pitched roofs.* Garston: BRE. April 2006.

[4] GREAT BRITAIN. Approved Document F – Ventilation, 2003. London: The Stationery Office. (http://www.planningportal.gov.uk)

[5] GREAT BRITAIN. Building Regulations (Northern Ireland) 2000. (Amended 2005 and twice in 2006.) London: The Stationery Office. (http://www.planningportal.gov.uk)

[6] SCOTLAND. *Technical Handbooks 2007.* Livingston: Scottish Building Standards Agency. (http://www.sbsa.gov.uk)

[7] GREAT BRITAIN. Approved Document L2 – Air permeability requirements for buildings, 2006. London: The Stationery Office. (http://www.planningportal.gov.uk)

[8] GREAT BRITAIN. Approved Document P – Electrical safety – Dwellings, 2006. London: The Stationery Office. (http://www.planningportal.gov.uk)

[9] GREAT BRITAIN. Approved Document C – Site preparation and resistance to contaminants and moisture, 2006. London: The Stationery Office. (http://www.planningportal.gov.uk)

[10] GREAT BRITAIN. Approved Document L1 – Conservation of fuel and power in dwellings, 2006. London: The Stationery Office. (http://www.planningportal.gov.uk)

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