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Management of moisture in buildings — Code of practice

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Summary of pages

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Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 July 2021. It was prepared by Subcommittee B/540/2, *Building performance – Moisture*, under the authority of Technical Committee B/540, *Energy performance of materials, components and buildings*. A list of organizations represented on these committees can be obtained on request to the committee manager.

Supersession

This British Standard supersedes BS 5250:2011+A1:2016, which is withdrawn.

Information about this document

This is a full revision of the standard, and introduces the following principal changes:

- guidance on moisture risk concerning problems other than just condensation has been added;
- a whole-building approach to moisture safe design, introduced in the BSI White Paper *Moisture in buildings* [1] is adopted, including prescriptive, modelling and principles based;
- approaches considering building context, coherence of design and detailing and interactions, capacity and in-service conditions have been added;
- a major revision of the content relating to floors ([Clause 10](#)), walls ([Clause 11](#)) and roofs ([Clause 12](#)) with particular emphasis on managing moisture risks in buildings undergoing energy saving measures; and
- a general update of other parts of the standard.

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It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The provisions of 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.

The word “should” is used to express recommendations of this standard. The word “may” is used in the text to express permissibility, e.g. as an alternative to the primary recommendation of the clause. The word “can” is used to express possibility, e.g. a consequence of an action or an event.

Notes and commentaries are provided throughout the text of this standard. Notes give references and additional information that are important but do not form part of the recommendations. Commentaries give background information.

Where words have alternative spellings, the preferred spelling of The Shorter Oxford English Dictionary is used (e.g. “organization” rather than “organisation”).

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Introduction

Moisture in buildings is considered to be a significant cause of many building failures, including some building-related occupant health problems. Some problems are decreasing (due mainly to the increased availability of central heating in buildings), while others could be increasing due to increased airtightness and insulation, fuel poverty, overcrowding and changing use of buildings. This British Standard contains recommendations for the management of moisture in buildings.

NOTE See UKCMB report for further information on moisture in buildings [2].

The understanding of moisture risk in buildings has developed considerably in the past few years. Not only have the mechanisms of moisture movement been explored more fully, but the types of buildings and applications being studied have widened (in particular, to include existing, retrofitted buildings). At the same time there is a growing acknowledgement of the key role of moisture in the health of occupants as well as in the condition of the building fabric. The air permeability of buildings is being reduced and traditional walls are being insulated, with the purpose of achieving the targets of greenhouse gases emission reduction, reducing fuel poverty and improving the comfort of occupants. Building use is also changing, with more sedentary lifestyles and greater moisture production from appliances such as showers and the drying of clothes inside. Predicted changes due to climate change over the next century, including milder, more humid winters and larger volumes of driving rain, are also likely to increase the number and severity of moisture problems.

In view of changing conditions and greater understanding, it is apparent that the established approach to moisture issues in standards, regulations and certification needs review and revision. The current approach is based predominantly upon the idea of a building as composed of discrete building elements in perfect conditions, not affected by their interactions with other elements or by their context or use. In reality, however, most building elements interact in multiple and sometimes complex ways with one another, the occupants and the external environment. Building materials are also affected by changes to their condition over time. A new approach is therefore required, which takes these into account and is more closely related to real world moisture problems and risks. This is the reason for this major revision to BS 5250.

The publication of the BSI White Paper *Moisture in buildings* [1] in 2017 stimulated new ways of diagnosing moisture problems, and developing remedial measures for problems in existing buildings and more robust solutions for the design and construction of new buildings. In both new and existing buildings, the gap between design and as built is now clearly understood. There are very few buildings without “in service” effects of residual moisture from construction, moisture generated in usual use or, where more serious, moisture due to building faults. The following three conditions occur:

- as designed on the drawing board;
- as built in practice; and
- in service after several years of occupancy.

The assessment of moisture risk in buildings or building elements varies according to these different conditions, requiring a different approach according to the type of building and the quality of work.

For the purpose of analysis and guidance in this British Standard, only two conditions are dealt with, combining “as built” with “in service” to represent a real world as opposed to a theoretical situation.

To summarize, there is:

- as designed in theory (ADT), which refers to buildings as though built as designed, without construction faults or degradation in use; and
- as built/in service (ABIS), referring to conditions resulting from commonly occurring problems or failures which arise either during construction or as buildings age, are altered and the materials used in their construction degrade.

Despite the recognition of possible differences between ADT and ABIS, it is important that all building materials used are durable, all designs follow best practice and all workmanship is to a high standard.

Previous methods of moisture risk assessment have dealt mainly with individual building elements and not the interactions between them or the effects on the whole building as a system. The previous focus on new buildings where design of connections was to some extent controllable meant that this approach was acceptable. Furthermore, until this century the comparatively low standards of airtightness and insulation, even in new buildings, meant that the moisture risks and consequences of high internal humidity were relatively low, making it less important to consider the issue of whole-building effects. The significant increase in airtightness and insulation in new building regulations, along with an awareness that there are often significant gaps between design and actual construction, mean that these effects now require consideration in any moisture risk assessment.

This means that alongside analysis of individual elements, there needs to be an assessment of the moisture risk of interactions with other elements and an awareness of the moisture risk to the whole structure more generally including the indoor environment.

However, because the assessment of these connective and systemic effects is still in a relatively early stage of development, moisture risk assessment still continues to be based on individual elements, but with an awareness of these more complex interactions.

This British Standard suggests three main ways to assess and manage moisture risk (see [4.2](#)).

- By prescriptive guidance, based on commonly used applications.
- By modelling as specified in standards such as BS EN ISO 13788, BS EN 15026 or BS EN ISO 10211 for thermal bridge analysis, where appropriate.
- By understanding and applying the principles of moisture safety in buildings, as laid out in [Annex A](#).

Another reason why a new approach is required is the lack of integration between guidance that treats different moisture problems, such as condensation, rain penetration and rising damp. This British Standard treats all these as different aspects of the same problem, which need to be considered to obtain an understanding as to how best to manage moisture risk as a whole. This holistic approach is seen in the treatment of internally insulated solid walls. In focusing on condensation alone, previous editions of BS 5250 (up to the 2011 edition) recommended that a vapour barrier be present on the warm side of the insulation. However, when rain penetration and solar driven moisture are considered, it is clear that this vapour barrier can actually prevent drying of the wall and create rot and mould in joist ends.

In this case, the best approach is to allow moisture to move through the structure and evaporate from the internal and external surfaces.

In other cases, flat roofs for example, it is necessary to prevent moisture movement into and through the structure as far as possible. A good understanding of the materials present and their interactions with moisture is a key part of the design of building to reduce the risks of moisture damage.

It is essential that conflicts between moisture risk management and other issues such as fire safety, conservation of energy, acoustic protection, access, etc. are understood and taken into account.

A standard on the management of moisture in buildings needs to take into account these many different factors and provide an integrated approach which minimizes moisture risk to the greatest degree possible. For this reason, this British Standard takes a "whole-building approach", which addresses moisture in buildings through a combination of principles, prescriptive guidance and modelling. It does this within the framework of a joined-up process of assessment, design, construction and use. The lack of integration between these stages is the other major way in which interfaces can create moisture risks.

A whole-building approach ensures that physical interfaces (known as junctions) and the systemic effects of the whole, as well as the physical and historical context and the as built and in service conditions, are all addressed and integrated. The joined-up process ensures that the whole-building approach is integrated throughout each stage of design and construction and that feedback is given where challenges appear and changes occur.

Section 1: General

1 Scope

This British Standard gives recommendations for the management of moisture in buildings using an integrated and pragmatic approach. This includes the management of moisture risk from interstitial and surface condensation, from too high or too low internal relative humidity, and from rain penetration or high levels of ground water. It covers all states of water as gas, liquid and solid, and the interactions between these states. It describes the principal sources of moisture in buildings, its transportation and deposition and provides recommendations and guidance on how to manage those risks during the assessment, design, construction and operation of buildings.

This British Standard does not cover measures specifically dealing with flooding and escape of water. These are dealt with in [BS 85500](#).

This British Standard is intended for use by designers, builders and users of any class of building. This standard gives guidance on risks of all sorts from high moisture levels, whether in the building fabric or in indoor air, which can endanger the health and well-being of building occupants and the integrity of the building fabric.

This British Standard is relevant to buildings of all types, whatever their form, construction and occupancy, both new and existing, and both domestic and non-domestic, except for buildings used for storage at sub-zero temperatures.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes provisions of this document.¹⁾ For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

[BS 3533](#), *Glossary of thermal insulation terms*

BS 5427, *Code of practice for the use of profiled sheet for roof and wall cladding on buildings*

BS 5534:2014+A2:2018, *Slating and tiling for pitched roofs and vertical cladding – Code of practice*

[BS 5864](#), *Installation and maintenance of gas-fired ducted air heaters of rated heat input not exceeding 70 kW net (2nd and 3rd family gases) – Specification*

[BS 5925](#), *Code of practice for ventilation principles and designing for natural ventilation*

BS 6229:2018, *Flat roofs with continuously supported flexible waterproof coverings – Code of practice*

[BS 6915](#), *Design and construction of fully supported lead sheet roof and wall coverings – Code of practice*

[BS 8102](#), *Code of practice for protection of below ground structures against water from the ground*

[BS 8215](#), *Code of practice for design and installation of damp-proof courses in masonry construction*

[BS 8219](#), *Installation of sheet roof and wall coverings – Profiled fibre cement – Code of practice*

[BS 9250](#), *Code of practice for design of the airtightness of ceilings in pitched roofs*

BS EN 1279 (all parts), *Glass in building – Insulating glass units*

¹⁾ Documents that are referred to solely in an informative manner are listed in the Bibliography.

[BS EN 13141-1:2019](#), *Ventilation for buildings – Performance testing of components/products for residential ventilation – Part 1: Externally and internally mounted air transfer devices*

BS EN 13859-2, *Flexible sheets for waterproofing – Definitions and characteristics of underlays – Part 2: Underlays for walls*

BS EN 15026, *Hygrothermal performance of building components and building elements – Assessment of moisture transfer by numerical simulation*

BS EN 60529, *Degrees of protection provided by enclosures (IP code)*

BS EN ISO 10211, *Thermal bridges in building construction – Heat flows and surface temperatures – Detailed calculations*

BS EN ISO 12572, *Hygrothermal performance of building materials and products – Determination of water vapour transmission properties – Cup method*

BS EN ISO 13788, *Hygrothermal performance of building components and building elements – Internal surface temperature to avoid critical surface humidity and interstitial condensation – Calculation methods*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this British Standard, the terms and definitions given in [BS 3533](#) and the following apply.

3.1.1 ABIS conditions

effects of use, alterations, faults and general degradation of materials and services through the life of a building

NOTE ABIS stands for “as built and in service”.

3.1.2 ADT conditions

design as it is intended to be applied in perfect practice, not allowing for ABIS conditions

NOTE ADT stands for “as designed, theoretical”.

3.1.3 air and vapour control layer (AVCL)

continuous layer to restrict the movement of air and water vapour

3.1.4 ceiling

3.1.4.1 ceiling, normal

ceiling with a typical air permeability of $300 \text{ mm}^2/\text{m}^2$ (0.3%)

3.1.4.2 ceiling, well-sealed

ceiling with a typical air permeability of not more than $30 \text{ mm}^2/\text{m}^2$ ($\leq 0.03\%$)

NOTE The measures generally required to achieve a well-sealed ceiling are given in [12.4.2](#) and [BS 9250](#).

3.1.5 condensation

process whereby water condenses from water vapour to liquid water when the temperature of air containing the water vapour drops to, or below, dewpoint

3.1.6 conditioned space

occupied space in which the temperature and humidity are controlled

3.1.7 connective effects

effects of changing conditions at junctions between different building elements (such as floors, walls and roofs) and between parts of elements (such as junctions at openings, chimneys, balconies, gas and electric meters)

3.1.8 damp-proof membrane (DPM)

membrane intended to resist the passage of moisture from the ground to a floor

NOTE Damp-proof membrane also constitutes an AVCL.

3.1.9 dewpoint

temperature at which air becomes saturated with water vapour and condensation occurs

NOTE Temperature can be expressed in °C or K.

3.1.10 dry bulb temperature

temperature of the air as measured by a dry thermometer

NOTE Temperature can be expressed in °C or K.

3.1.11 emissivity

ratio of radiant energy emitted by a surface to that emitted by a black body at a given temperature

NOTE Emissivity is expressed as a dimensionless ratio.

3.1.12 HR underlay

membrane with water vapour resistance, s_d , greater than 0.05 m (0.25 MN·s/g)

NOTE For underlay, HR stands for high vapour resistance.

3.1.13 hygroscopic

able to absorb and desorb water vapour

3.1.14 hygrothermal

simultaneous movement of moisture and heat

3.1.15 interstitial condensation

condensation which occurs within or between layers of a construction

3.1.16 LR underlay

membrane with water vapour resistance, s_d , not exceeding 0.05 m (0.25 MN·s/g)

NOTE For underlay, LR stands for low vapour resistance.

3.1.17 membrane

thin layer of material

3.1.18 minimum free area

area of all unobstructed openings measured in the plane of maximum restriction

3.1.19 relative humidity (RH)

amount of water vapour contained within a given volume compared with the maximum amount at the given temperature

NOTE Relative humidity is usually expressed as %.

3.1.20 rising damp

capillary movement of water in masonry from below to above ground level

3.1.21 saturation vapour pressure (SVP)

maximum vapour pressure over a plane water surface, at any given temperature

NOTE Saturation vapour pressure is expressed in kPa or Pa.

3.1.22 stack effect

tendency of air in a building to rise as a result of differential temperatures and air density

3.1.23 surface condensation

condensation which occurs on an internal surface within a building

3.1.24 systemic effects

effects of an action on the whole of the building, or parts not directly connected, due to changes in the hygrothermal condition of the inside of the building

3.1.25 thermal bridge

part of a construction with thermal resistance significantly lower than that of the surrounding construction

3.1.26 vapour permeable membrane

membrane with water vapour resistance, s_d , less than 0.12 m (0.6 MN·s/g) but greater than 0.05 m (0.6 – 0.25 MN·s/g) used in walls, metal sheeted roofs and flat roof constructions

NOTE 1 Also known as breather membrane.

NOTE 2 When used in exposed locations, e.g. open rainscreen cladding, the membrane is expected to be UV-resistant (see [11.6.6](#)).

NOTE 3 Membranes for use in walls, metal sheeted roofs and flat roof construction are different from those vapour permeable membranes termed LR underlays used in slated and tiled pitched roofs (see [3.1.16](#)) where the water vapour resistance, s_d , of the membrane is no greater than 0.05 m (0.25 MN·s/g).

NOTE 4 Breather membrane requirements are different from those for LR underlays used in pitched roofs (see [3.1.16](#)).

3.1.27 vapour resistance

resistance of a material to the diffusion of water vapour

NOTE Vapour resistance is expressed in MN·s/g.

3.1.28 vapour resistivity

resistance of unit thickness of material to the diffusion of water vapour at unit vapour pressure difference

NOTE Vapour resistivity is expressed in MN·s/g·m.

3.1.29 ventilated cavity

volume of air with openings to the outside air so placed as to promote the through passage of air

NOTE The effect of different degrees of ventilation to cavities is given in [Annex B, B.3](#).

3.1.30 wet bulb temperature

temperature of the air as measured by a thermometer cooled by evaporation of water

NOTE Temperature can be expressed in °C or K.

3.2 Abbreviated terms

For the purposes of this British Standard, the following abbreviated terms apply.

ABIS	as built and in service
ADT	as designed, theoretical
AVCL	air and vapour control layer
CLT	cross-laminated timber
CMU	concrete masonry unit
dMEV	decentralized mechanical ventilator
DPC	damp-proof course
DPM	damp-proof membrane
EPS	expanded polystyrene insulation
GRP	Glass reinforced plastic
HR (underlay)	high vapour resistance
ICF	insulating concrete formwork
IGU	insulated glass unit
IWI	internal wall insulation
LPG	liquid petroleum gas
LR (underlay)	low vapour resistance
MEV	mechanical extract ventilation systems
MVHR	mechanical ventilation with heat recovery
PIV	positive input ventilation
PSV	passive stack ventilation
RH	relative humidity
SIPS	structural insulated panel systems
SRHRV	single room heat recovery ventilator
SVP	saturation vapour pressure
WFRL	water flow reducing layer

Section 2: Design and guidance to avoid moisture related problems

4 Design to avoid moisture related problems

COMMENTARY ON CLAUSE 4

The whole-building approach takes into account the interactions between fabric, services and occupants in the context of the geographical location, the type of occupancy, the past history and possible future changes of the building. This approach is based upon the principles outlined below and is supplemented by the use of prescriptive guidance and modelling where these are appropriate and useful.

Moisture safe design cannot be separated from other design issues and regulatory requirements. It needs to be balanced against other key design aims and be part of an ongoing discussion and feedback process throughout a building project.

It is therefore essential to establish the correct process for moisture risk assessment, design and management.

The whole-building approach to moisture risk can be broken down into four key principles.

- a) Understand the context of the building and the building project and ensure compatibility of the design with this context.*
- b) Ensure coherence in approach and detailing.*
- c) Build in extra capacity in the design and construction phase for uncertainties in the build process and future challenges.*
- d) Ensure that caution is taken in the use, maintenance and after-care phase where there are ongoing requirements of care and uncertainty of outcomes.*

The principles identified above are described in detail in [Annex A](#).

[Annex C](#) contains guidance on methods of diagnosing the causes of dampness problems.

4.1 Assessing the likelihood of condensation

COMMENTARY ON 4.1

Once excess moisture from the construction phase has been removed, the rate at which humidity is generated within a building is determined by the occupants and their activities: for example, swimming pools, some industrial processes, laundries, canteens and food factories generate very large amounts of moisture.

In order to avoid the occurrence of condensation and/or sustained excessive humidity, which can result in mould growth and damage to the building fabric and/or contents, designers should assess the amount of water vapour likely to be generated within the building and determine the resultant increase in internal vapour pressure above that of external air. They should then aim to ensure that the physical properties of the construction separating inside from outside do not lead to problems of surface or interstitial condensation.

Designers should take into account the effects of the external climate, which, being site related, is beyond direct control but might be moderated by the building's form and orientation in relation to topography, prevailing winds, sunlight and over-shadowing.

Designers should also take into account that the rate at which water vapour is generated can change over time as buildings are adapted to different functions or levels of occupancy; furthermore, the cost

of energy might deter occupants from maintaining an adequate heating regime. Therefore, designs should allow for the worst-case scenario.

4.2 Methods of assessment

COMMENTARY ON 4.2

In this British Standard, there are three main ways that moisture risk can be assessed and managed.

- *By prescriptive guidance. This is based on the experience of commonly used applications where there is good evidence of success over many years; for example, the guidance given for ventilation of cold pitched roofs. This guidance is used where there is certainty of experience and sufficient data and empirical testing to provide guidelines for practice and design to prevent moisture risk. Prescriptive guidance is provided as recommendations which form the provisions of this standard.*
- *By modelling where appropriate in accordance with standards such as BS EN ISO 13788 or BS EN 15026; also BS EN ISO 10211 for thermal bridging risk. This form of guidance is used where there is uncertainty with regard to experience or context, but sufficient certainty of data, moisture mechanisms and safety parameters.*
- *By understanding and applying the principles of moisture safety in buildings. This approach is used where there is uncertainty with regard to experience and also uncertainty in data and/or parameters or modelling methods and protocols. The principles are given in [Annex A](#).*

For the assessment of designs for which calculations are required, designers should assess the risk of surface condensation, mould growth and interstitial condensation using the methods described in BS EN ISO 13788 or BS EN 15026 and/or BS EN ISO 10211 (according to context, with reference to [Clause 13](#)).

BS EN ISO 13788 determines three criteria for assessment.

- a) The design of the structure and the heating system should be such that, over the coldest month, the average relative humidity at internal surfaces of the rooms does not exceed the critical relative humidity.

The critical relative humidity for mould growth should be taken as 80% unless more specific information is available from national regulations or elsewhere. A lower critical relative humidity of 60% can be used to avoid corrosion, if appropriate.
- b) Any interstitial condensation which might occur in winter expected evaporate during the following summer, preventing an accumulation of moisture year on year.
- c) The risk of degradation of materials should be assessed in terms of the level of moisture content and temperature.

NOTE 1 Software programs are available to perform calculations in accordance with BS EN ISO 13788, BS EN 15026 and BS EN ISO 10211.

If an assessment indicates condensation is likely to occur, then the designer should assess the likelihood of it causing damage to the materials used and, if necessary, modify the design.

NOTE 2 Some materials can degrade due to prolonged exposure to high moisture levels (e.g. some organic materials or some metals).

NOTE 3 BS EN ISO 13788 considers only the risks arising from the diffusion of water vapour through the building fabric; it does not take account of the much greater risk of condensation occurring as a result of air leakage, which transports water vapour through gaps, joints and cracks in the building fabric.

Whilst external climate data from an average year should be used for the calculation of long-term energy demand, its use for condensation risk analysis might not be appropriate since years worse than average are likely to occur and might result in damaging condensation. For most buildings, a

once-in-ten-year climate year should be used. For particularly sensitive constructions or buildings with vulnerable contents, a once-in-twenty or once-in-fifty-year climate year may be used instead.

NOTE 4 Guidance is given on the selection of more severe years in [13.2.2](#).

4.3 Internal climate

4.3.1 General

The most suitable operational conditions of a building should first be determined by reference to user requirements and then maintained by controlling the internal temperature, relative humidity, excess water vapour and air movement.

The internal climate of a building should be controlled in order to maintain the health, well-being and comfort of its occupants and the proper functioning of equipment such as boilers, fires and cookers. Air which is contaminated by combustion products, bacteria, mould, smoke, smells, high levels of CO₂, excess water vapour and heat should be removed and replaced by fresh air. The temperature and distribution of that incoming fresh air should be taken into account in order to avoid it being perceived as an unwanted draught.

NOTE 1 Such an exchange of air removes not only the contaminants but also heat, which can be beneficial in summer, but undesirable in winter.

NOTE 2 Example threshold values for various contaminant levels and durations, for dwellings, can be found in Appendix A of Approved Document F for England [\[3\]](#) and Appendix A of Approved Document F for Wales [\[4\]](#).

If, at the designed operational temperature, relative humidity is likely to exceed 70% (see [Annex D, D.5](#)), water vapour should be extracted from the air; this may be achieved by ventilation or by dehumidification.

NOTE 3 Historically, sufficient fresh air for the building occupants and their activities was available as a result of air leakage through the gaps, cracks and openings in the building envelope; such unintentional air movement is no longer acceptable in buildings which require a heated interior because it is wasteful of energy. The ventilation rate to avoid excessive humidity in a dwelling usually provides sufficient fresh air for healthy indoor conditions.

NOTE 4 Dehumidification is not appropriate for domestic environments when considering a long-term solution to moisture control.

4.3.2 Ventilation

The external envelope of the building should be as airtight as practicably possible and then provision made for the required level of ventilation. Ventilation systems should be designed to extract moist air as close as possible to the point of generation and to discharge it to the outside, preferably away from the prevailing wind.

NOTE 1 Designers can specify natural or mechanical ventilation systems, which rely on the uncontained movement of air from one space to another or on ducts to transport air.

Natural ventilation systems, including passive stack systems, should be designed in accordance with [BS 5925](#).

NOTE 2 Natural systems allow air to move through a building in response to pressure differential across the building envelope, which is generated by internal/external temperature differences, together with wind forces; such systems use no electrical energy.

NOTE 3 Most ventilation systems require the provision of vents, which may be manually controlled or regulated by thermostatic or hygrostatic means.

The provision of the required level of ventilation may utilize mechanical or other systems, and combinations thereof, to:

- a) extract air from a building, allowing replacement air to be drawn in through vents located in rooms other than those where air is being extracted; or
- b) force external air into a building, to pass out through vents; or
- c) move balanced volumes of air in and out of a building.

Where a domestic heated drying cupboard is provided it should be ventilated to discharge moisture directly to outside air, but where that is not practicable it may be vented to a room which is provided with an extractor fan with a humidity sensor.

NOTE 4 Detailed guidance on ventilation can be found in [Clause 8](#).

4.3.3 Dehumidification

COMMENTARY ON 4.3.3

Electrically powered dehumidification units, running on a closed cycle, draw air from a given space, heat and dry it, and then return it to the same space, the moisture being discharged to drain. Dehumidification units are more effective where excess moisture is caused by high vapour pressure in well heated buildings; they are less effective at low temperature. Dehumidification is not appropriate for domestic environments when considering a long-term solution to moisture control.

The process of mechanical dehumidification can be beneficial in the short term, for example to remove entrapped construction moisture or moisture introduced by flooding or broken pipework, but it should not be used to remove contaminants such as CO₂ and smells.

4.3.4 Heating

COMMENTARY ON 4.3.4

Less heat is required to prevent moisture-related problems in a building which is well-designed and well-insulated: a well-insulated building is more energy efficient, more economical to run and, when not heated as intended, less prone to condensation. If the heating system maintains comfort conditions in the whole building at all times, condensation problems are minimized. If all or part of a building is used and heated infrequently the construction remains cold, increasing the risk of severe condensation: that risk is greatest if the construction has high thermal mass and heating is purely convective. If some rooms are unheated then water vapour which moves from other heated rooms can raise the relative humidity high enough to cause condensation or mould growth in the unheated rooms.

Heating should maintain air and surface temperatures sufficient to prevent problems associated with excessive humidity. To be effective, the heating regime should be matched to the construction (see [4.5.2](#)).

4.4 External climate (condensation risk)

Designers should assess and document the factors likely to affect the formation and persistence of condensation in buildings, including exposure to sunlight, clear night skies, wind and driving rain, the potential effects of which are as follows.

- a) Solar gain. The external surface temperature of roofs and walls can be increased several degrees above the external air temperature, even in winter, by direct sunlight. This can promote rapid drying of any condensation which has occurred within the structure. It can also drive moisture towards the interior of the building where it might condense on any AVCL. The degree of exposure to direct sunlight can be affected by neighbouring buildings and/or trees.

- b) Night sky radiation. On clear still nights at any time of year the radiative temperature of the sky is much less than the external air temperature; the external surfaces of roofs cool rapidly overnight, which means interstitial condensation can occur on the underside of an external weatherproof layer. Although this might evaporate rapidly the next day, there can be sufficient accumulation of condensate to cause running or dripping overnight.
- c) Exposed positions. High wind speeds, especially when accompanied by precipitation, chill the external surface of the building, thereby significantly increasing the risk of interstitial condensation within the structure.

4.5 The external envelope

4.5.1 General

COMMENTARY ON 4.5.1

In the UK climate the essential functional requirement of the external envelope is to provide protection to the occupants by excluding rain and wind whilst moderating the flow of heat.

Good design is needed to avoid moisture problems from a number of causes, including rain penetration and rising damp, in walls; in particular, minimization of surface and interstitial condensation can require careful choice of materials.

Most elements of construction (floors, walls and roofs) consist of several layers, each chosen to perform specific functions, be it external appearance, loadbearing, fire protection, airtightness, energy conservation, sound attenuation or internal appearance; some materials have a single function, others might perform several functions. The rate at which heat, air and moisture are transferred through the building envelope and the risk of interstitial condensation are determined by the properties of the various layers of construction and their position relative one to another.

The risk of condensation occurring at any point in a construction is determined by the differences between the internal and external temperature and vapour pressure, the materials which make up the building envelope (including any cavities) and the relative positions of those materials.

Lightweight constructions (those with low thermal mass inside the insulated envelope) have a rapid thermal response rate and they heat up and cool down quickly. Massive constructions (those with high thermal mass inside the insulated envelope) have a slow thermal response rate and they heat up and cool down slowly.

Depending upon their nature, the durability and performance of all building materials can be adversely affected by moisture to some degree; notably, the rate of heat flow through any material is greater in the presence of moisture. Hygroscopic materials such as plaster, masonry and timber absorb moisture, but might release it without suffering structural damage, although timber might rot if exposed to prolonged high moisture levels; non-hygroscopic materials such as metals, glass and plastics are impervious but might suffer damage from prolonged exposure to moisture.

Heat is transferred through materials and constructions by conduction, by convection and by radiation. Water vapour is transferred through materials by diffusion, but much more significant water vapour transfer occurs as a result of air movement; therefore, when designing to avoid the risk of damaging condensation, air filtration into and air leakage through the construction are the most important mechanisms to be considered. Consideration also has to be given to the fact that different materials offer different degrees of resistance to the various forms of transfer of both heat and moisture.

All elements of building construction should meet their functional requirements, which include the avoidance of damaging surface and interstitial condensation. The choice of materials used to form the external envelope of a building should be determined by considerations of appearance, construction requirements and cost. When selecting and positioning materials within an element, designers

should assess the heat, air and water vapour transport properties of those materials in relation to the risks of surface or interstitial condensation.

4.5.2 Arrangement of materials in constructions (condensation risk)

In order to minimize the risk of interstitial condensation in any element, materials with the highest vapour resistance should be located on the warm side, and those with lower vapour resistance on the cold side, of any thermal insulation. Constructions which incorporate an impervious external weathering layer (such as sheet metal or glass) contravene those basic recommendations; in such constructions, provision should be made for ventilation behind/beneath the impervious layer to allow any moisture to disperse to atmosphere.

The position of thermal insulation in relation to the thermal mass of a building determines whether or not that mass is warmed by the heating system; designers should assess the relative position of structural layers, thermal insulation layers and AVCLs in order to avoid damage by condensation.

In a building which is occupied and heated only intermittently, thermal insulation applied as close as possible to the internal surface and protected by an AVCL reduces the risk of condensation and mould growth. Designers should, however, take into account that in such constructions any layers outside the insulation are isolated from the heating systems and therefore present a greater risk of interstitial condensation occurring.

The effect of the thermal mass of building elements bounding the occupied space should be taken into account for the heating system.

NOTE Whilst a high thermal mass is beneficial to reduce fluctuations in internal temperature and minimize the risk of surface condensation in buildings with constant, slow response heating systems, buildings with intermittent heating systems and high thermal mass are likely to experience low internal surface temperatures leading to a greater risk of mould growth and of surface condensation.

With all forms of construction, the effects of thermal bridges at junctions between building elements (wall/floor, wall/wall, wall/roof) and those between building elements and components (wall/window, wall/door, roof/rooflight) should be minimized; at such junctions there is a higher rate of heat loss which results in lower surface temperatures and an increased risk of mould growth and surface condensation (see the recommendations in [Clause 9](#)).

The air permeability of the external envelope should be as low as practicable to minimize heat loss from the building by air leakage and to facilitate control of the internal climate. An airtight layer on the warm side of the envelope minimizes the penetration of warm moist air into the construction and so reduces the risk of interstitial condensation. Air movement from a heated building into a cold cavity greatly increases the risk of condensation and should be avoided.

4.5.3 Cavities

COMMENTARY ON 4.5.3

Water vapour can be transferred across any cavity by air movement. Air movement from inside a heated building into a cold cavity not only increases the rate of heat loss from the building, but also greatly increases the risk of interstitial condensation. Calculations suggest that even minimal air movement can have a significant effect on the risk of condensation occurring.

Even in sealed cavities, water vapour and heat are transferred by convection currents generated by temperature differences between the two surfaces of the cavity. Any surface facing a cavity radiates heat across that cavity, the rate of transfer being dependent upon the emissivity of the surface. A low emissivity surface reduces the rate of heat transfer by radiation.

Designers should take into account that most conventional forms of construction, including suspended floors, masonry walls and pitched roofs, contain cavities which are likely to have a significant effect on the risk of condensation occurring.

Air movement from within the building into any cavity should be controlled to minimize the risk of interstitial condensation.

4.5.4 Thermal insulants

Thermal insulants should be selected by matching their performance characteristics to the specific requirements of their application, with particular regard to their hygrothermal characteristics. (See [Annex A, A.2.3.2](#) for the coherence of moisture approach.) Designers should take into account that different insulants offer different degrees of resistance to the transfer of both heat and moisture. When thermal insulation is provided in more than one layer, their relative physical characteristics should be carefully evaluated and the risk of interstitial condensation assessed.

NOTE Gaps in the thermal insulation and between that insulation and adjacent materials, such as rafters, joists and studs, can give rise to localized condensation.

4.5.5 Low emissivity materials

COMMENTARY ON 4.5.5

Low emissivity materials, such as aluminium foil or metalized plastics, have a highly reflective surface which can reduce the rate of heat transfer by radiation when installed facing a cavity: preferably one not less than 25 mm wide. The vapour resistance of such materials can be very high, as in the case of aluminium foil, or low, as in the case of metalized non-bonded polyolefin membranes.

In terms of transfer of heat, air and moisture, the overall performance of low emissivity materials when installed in the building depends upon the treatment of laps and joints. When wrongly placed, or not properly sealed at joints, low emissivity materials can greatly increase the risk of interstitial condensation occurring.

When considering the use of low emissivity materials, designers should carefully assess the risk of condensation occurring, using the method described in [Clause 13](#), with performance data.

NOTE Designers are advised to consider using performance data which has been evaluated and certified by an accredited third party.

In order to obtain the stated level of performance of any low emissivity material, the material should be installed facing a cavity; designers should pay particular attention to the practicability of forming and maintaining those conditions throughout the life of the building.

4.5.6 Air and vapour control layers

For each element of construction (floors, walls and roofs) the designer should determine the vapour control plane upon which the movement of water vapour is to be controlled: those planes should be continuous over the whole of the element and they should be joined to the vapour control planes of adjoining elements. Any AVCL should be located on the warm side of the insulation layers.

NOTE 1 Impervious materials of construction, such as glass, metal or plastics sheet floor covering, may of themselves constitute all or part of a vapour control plane.

NOTE 2 Depending upon the materials forming an element and their disposition in relation one to another, it might be necessary to provide a layer of material specifically to control the movement of water vapour and air; such a layer constitutes an AVCL, forming a barrier to both water vapour and air.

The selection of vapour control materials should be determined by:

- a) the degree of vapour resistance required (determined by assessing the likelihood of interstitial condensation using the method and guidance in [Clause 13](#) and the vapour resistance values of various materials given in [Annex B](#));
- b) the practicability of installation, including the formation of sealed laps and joints; and
- c) the anticipated life to renewal.

NOTE 3 An AVCL may consist of:

- a) materials of construction with an inherently high vapour resistance, such as glass, plastics sheet floor covering or steel liner in insulated twin skinned panel; or
- b) an applied surface coating; or
- c) an integral barrier, such as a board with an applied film or foil; or
- d) an air and vapour impermeable membrane.

Designers should determine the performance standard required in any given situation and establish that the specified AVCL meets that standard over the life of the building.

NOTE 4 Some membranes offer high resistance to the passage of water vapour and air, whilst others offer high resistance to air leakage but low resistance to the passage of water vapour.

In order to form an effective AVCL, side and end joints should be kept to a minimum, joints in flexible membranes should be formed over solid backing members or a rigid substrate, be lapped at least 50 mm and be sealed. Any damage should be repaired using matching material and jointing techniques. Unstabilized plastics-based sheeting should be protected from heat and sunlight to prevent degradation.

Penetrations through an AVCL by pipes and services compromise its performance; they should preferably be eliminated at the design stage. If that is not possible, they should be sealed by means of proprietary seals and collars, or liquid-applied sealants, which are expected to be able to accommodate thermal and other movements, likely to occur during the life of the building.

A void should be formed behind the internal surface finish to enable services to be installed without compromising the AVCL (see [4.1](#)).

Building owners/occupants should be made aware of the importance of maintaining AVCLs throughout the life of the building, particularly when repairs, alterations and extensions are made.

4.6 Alterations and extensions to buildings

Where a building is to be altered or extended, it should be determined what precautions to prevent condensation were included in the original building; those precautions should be retained, adapted and, if necessary, improved. The new work should be carried out in accordance with this British Standard. If the building is merely to be repaired, then a diagnosis of its existing condensation problems should be made and remedial action should be taken in accordance with [Clause 6](#).

5 Guidance for builders and owners

Building owners and occupiers should be given information that can help them minimize the risk of developing problems associated with condensation and other forms of moisture.

Information should be provided in a way that is understandable and achievable to the layperson.

NOTE [Annex E](#) contains draft guidance which could be modified for inclusion in sitework instructions. [Annex F](#) contains suggested text for inclusion in an owner's manual.

6 Remedial works

6.1 Actions to manage moisture risk

NOTE [Annex C](#) contains guidance on methods of diagnosing the causes of dampness problems.

Any actions to manage moisture risk should take account of the intended use of the building and involve comprehensive consideration of heating, ventilation and thermal insulation.

Any additional insulation should be located in accordance with [4.5.4](#).

6.2 Heating

COMMENTARY ON 6.2

All surface condensation problems can, in principle, be solved by the application of heat to raise temperatures above the dewpoint, coupled with adequate levels of ventilation.

A common cause of harmful condensation in existing buildings is lack of adequate heating; if the existing system is inadequate, a heating system designed in accordance with the recommendations given in [Clause 7](#) should be installed.

Heating and insulation should always be evaluated together as the provision of adequate insulation can ensure both capital and running costs are kept to a minimum.

6.3 Ventilation

In order to keep the internal relative humidity low enough to prevent a build-up of harmful condensation, adequate ventilation should be provided (see [Clause 8](#)).

Section 3: Design principles – Building services

7 Application of design principles – Heating

7.1 General

COMMENTARY ON 7.1

Surface condensation is unlikely to be a problem in regularly heated buildings with a low vapour load, such as office buildings, and is most commonly found in dwellings that are insufficiently heated and in other buildings that are used, and consequently heated, intermittently, such as churches.

Surface condensation is likely in buildings such as swimming pools and laundries where large amounts of moist air are generated on a regular basis. These types of buildings are beyond the scope of this British Standard but the design principles of [Annex A](#) would apply to their design.

Further guidance on heating provision is given in CIBSE Guide B [\[5\]](#) and in CIBSE Domestic heating – design guide [\[6\]](#).

Many condensation problems arise because the majority of buildings are not used 24 hours a day for every day of the year and are, therefore, not heated continuously.

In new buildings, the building fabric should be insulated to the optimal level so that any necessary heating can be provided as economically as possible. In existing buildings, the building fabric insulation should preferably be upgraded so that any necessary heating can be provided in a cost-effective manner.

To minimize surface condensation, the duration and amount of heating should be regulated to maintain the internal surface temperatures above dewpoint; ideally, this involves matching the heating system to the thermal mass of the building fabric and to the way that the heating system is likely to be used by the building occupants.

Ignoring the comfort of the occupants, an air temperature above 10 °C should be maintained in all parts of the building that are heated.

NOTE *In well insulated buildings, it is possible to maintain these temperatures without any heating other than that given off by lighting and equipment such as computers.*

To achieve a balance of internal temperatures, detailed calculations should be made, taking account of solar gains, internal gains, ventilation rates and local climatic conditions as well as the thermal response of the building fabric.

7.2 Warm air heating

COMMENTARY ON 7.2

Wholly convective heat from forced warm air systems heats room air very rapidly and is liable to be operated intermittently to provide heat only when required for the comfort of the occupants.

Modern forced warm air heating systems are used in a similar fashion to water-based central heating systems, where by use of a time clock the warm air system is used to preheat buildings before occupation, usually with a reduced preheat time when compared to water-based systems. Current warm air heaters have electronic controls, which proportionally vary heat output to avoid large temperature swings and maintain preset temperatures. This allows warm air systems to be used in both low thermal mass buildings and high thermal mass buildings.

Hot water radiators produce natural convective heating and, as they do not respond as quickly as warm air systems, are more suited to high mass buildings. They are normally heated before building occupation and give off residual heat after the system is switched off, thus prolonging the heating period. Hot water radiators are also suitable for low mass buildings but surface temperatures in these types of buildings fall more rapidly after the heating is switched off as there is little thermal storage in the structure.

High temperature radiant heaters include radiant gas and electric fires, and produce easily controlled and almost immediately felt local warmth. However, both are unlikely to be used for sufficiently long to warm the structure and they can also leave some parts of a room relatively unheated.

Gas fires need a suitable air supply for combustion and this, plus the warm flue, creates some ventilation to the room in which they are sited.

Underfloor heating in a high mass floor is slow to warm up and is therefore best suited to a continuous heating regime that gives out heat for long periods, which is advantageous in controlling condensation.

Open fires and solid fuel burning stoves require considerable air supplies for combustion and can result in much heat loss via the flue. The effect of the heated flue is to draw air from other parts of the building including the moisture generating areas. However, the high air change rate in the room usually negates any increased risk of condensation in that room that would have resulted from moist air being pulled in.

Warm air systems should be installed in accordance with [BS 5864](#).

NOTE 1 The British System Design Manual (Gas fired warm air heating) [Z] also provides useful guidance.

NOTE 2 A percentage of outdoor air make-up may be incorporated into a warm air system. This provides a definite air change for the building, a positive air pressure to moisture producing areas and thus a flow of moisture to outside.

7.3 Electric storage heaters

COMMENTARY ON 7.3

Storage heaters without fans emit heat almost continually to provide background heating; however, they can be difficult to control. Storage heaters with fans have some characteristics similar to forced warm air heating. Some storage heaters incorporate a radiant heating element to provide rapid local warmth when required. Because of their characteristics, storage heaters are particularly suited to buildings that are occupied for long periods, and/or for buildings of high thermal mass.

Electric storage heaters generally have a low rate of heat output; the charging period should be related both to the needs of the occupants and to the need for a sufficient reserve for heating the building fabric.

7.4 Unflued oil and gas heaters

Unflued oil and gas heaters are usually used as supplementary or temporary heating; their use should be avoided as they release large quantities of water vapour into the room. To avoid the need for such supplementary heating, the building should be designed such that it can be heated in an economical manner.

7.5 Heating controls

Two factors control the output of a heating system: the length of time that the system is operative and the output power of the system. Heating systems that are capable of being automated should have time controls to regulate the duration of heat output and temperature controls such that the heating is switched off in rooms or zones (where the heating system is zoned) when the demand temperature is met.

NOTE 1 Some set-back control to maintain lower-than-comfort temperatures when the building is not in use are particularly beneficial in avoiding large fluctuations in temperatures which would exacerbate the risk of condensation.

NOTE 2 Further advice is given in the Good Practice Guide 302 [8].

8 Application of design principles – Occupied space ventilation

8.1 General

COMMENTARY ON 8.1

GPG 268 [9] provides an overview of the issues relating to domestic ventilation. Older properties might only have openable windows as a ventilation provision but might be able to adopt one of the following systems (see the Building Regulations guidance on ventilation [3, 4, 10, 11]).

New buildings are progressively being constructed in a tighter form (reduced air permeability) and existing buildings are constantly being adapted to reduce the amount of uncontrolled air infiltration. This therefore requires more consideration to be given to the ventilation system(s) to ensure that any build-up of condensation is reduced to a minimum.

As fabric energy efficiency standards progressively improve, limiting heat loss through ventilation (either intended or unintended) becomes increasingly important. Clearly there is a balance to be struck between restricting unnecessary ventilation and the subsequent heat loss and the control of condensation.

Correct system design and installation is a vital part of an efficient system. Efficient ventilation contributes greatly to the health not only of the occupant but also of the building.

Increased use of ventilation controls can minimize energy consumption, either:

- a) controlled ventilation – providing some form of regulation to the system, usually by user intervention; or*
- b) demand controlled ventilation – providing regulation to the system dependent upon the local environmental conditions, without user intervention.*

Examples of types of control include, but are not limited to:

- 1) humidity controlled fan (stand-alone controller or integral with fan);*
- 2) humidity or automatically controlled trickle ventilator;*
- 3) timer;*
- 4) passive infra-red sensor (presence sensor); and*
- 5) air quality sensor (i.e. CO₂).*

Continuous mechanical ventilation systems operate at low levels but have the facility to boost to reduce the threat of condensation.

Background ventilation differs depending on construction details and the Building Regulation guidance on ventilation [3, 4, 10, 11].

Forced ventilation is more reliable than natural ventilation because air change rates and flow directions can be better controlled. Natural or passive ventilation methodologies have the advantage of not needing an energy using fan. Forced ventilation can also be used for short periods to assist natural ventilation.

The performance of ventilation systems should be assessed, including consideration of the specific fan power (SFP) and heat exchanger efficiency, if appropriate.

Many fans used within the ventilation industry now use high efficiency motors and therefore consume less electrical energy than previously; fans selected should meet the required air flow rates when installed. The manufacturer's data should be checked.

NOTE Performance standards for products that may be included in more than one system include: BS EN 13141-1, BS EN 13141-2, BS EN 13141-9 and BS EN 13141-10.

8.2 Natural ventilation

8.2.1 General

In naturally ventilated buildings, background ventilation should be provided to dilute pollutants; however, it is unlikely to be able to cope with high amounts of water vapour production on its own. Background ventilation should therefore be supplemented by mechanical extract or passive stack ventilation (PSV) in the moisture producing areas to remove the water vapour to the outside of the building.

NOTE In many existing buildings, the only method that the occupier has of controlling the ventilation is openable windows. In winter, this method is unlikely to be used unless the window incorporates provision for controllable background ventilation. Controllable background ventilation can be installed in windows or walls.

8.2.2 Background ventilators and intermittent extract fans

Background ventilators should be located in all rooms with an outside wall, including kitchens, bathrooms, sanitary and utility rooms (wet rooms).

NOTE 1 Background ventilators are air transfer devices that exchange air between the internal and external environment. Guidance on sizing is given in the Building Regulations guidance on ventilation [3, 4, 10, 11], CIBSE Guide B [5] and their equivalents.

Intermittent fans should be provided in rooms/areas where moisture or other pollutants to the air are generated. Extract fans should be located in kitchens, wet rooms, bathrooms and sanitary rooms.

NOTE 2 Guidance on locations is given in the Building Regulations guidance on ventilation [3, 4, 10, 11], CIBSE Guide B [5] and their equivalents.

Background ventilators should not be located within 500 mm of an extract fan to avoid short circuiting of the extracted air. These ventilators should be installed in the top section of the window, or in a wall, typically 1 700 mm above floor level, as this minimizes the possibility of draughts.

NOTE 3 BS EN 13141-4 specifies requirements for the performance testing of fans.

8.2.3 Passive stack ventilation

NOTE 1 Passive stack ventilation (PSV) is a ventilation system using ducts from the ceiling or walls of a room to terminals on the roof which operate by a combination of the natural stack effect, i.e. the movement of air due to the difference in temperature between inside and outside and the effect of wind passing over the roof of the building.

In order to maximize the stack effect, ducts should be mounted as near vertical as possible, and should not be at an angle of more than 45° to the vertical. Ducts should be insulated to prevent any condensation within the duct, where they pass through unheated spaces such as lofts.

NOTE 2 The free space within the duct determines the air flow and is specified in the Building Regulations guidance [3, 4, 10, 11]. Humidity sensitive extract grilles are available that provide reduced air flows and heat loss when water vapour is not being generated.

Background ventilators should be located in all rooms with an outside wall, including kitchens, bathrooms, sanitary and utility rooms (wet rooms).

NOTE 3 Background ventilators are air transfer devices that exchange air between the internal and external environment. Guidance on sizing is given in the Building Regulations [3, 4, 10, 11], CIBSE Guide B [5] and their equivalents.

Background ventilators should be installed in the top section of the window, or in a wall, typically 1 700 mm above floor level, as this minimizes the possibility of draughts.

NOTE 4 These ventilators, which can be installed in windows or walls, can be controlled by the ambient humidity.

NOTE 5 Humidity sensitive inlet grilles are available that provide reduced air flows when water vapour is not being generated. Further information on these systems is given in the Building Regulations guidance on ventilation [3, 4, 10, 11], CIBSE Guide B [5], BRE IP 13/94 [12] and their equivalents.

8.3 Continuous mechanical ventilation

8.3.1 Mechanical extract ventilation systems

NOTE 1 Mechanical extract ventilation systems (MEVs) consist of a continuously running fan, usually mounted in a central location to extract air from the wet rooms.

MEVs should be capable of extracting air at a slow continuous rate, and of increasing the flow rate as required. For airtight buildings [air permeability less than 5 m³/(h.m²) at 50 Pa], background ventilators (trickle ventilators) should be provided in all dry rooms to provide make up air (see Approved Document F [3] and applicable regional variants [4, 10, 11]).

NOTE 2 Decentralized mechanical extract ventilators (dMEV) that run continuously may also be used (these are also sometimes known as single room MEVs).

NOTE 3 Further information and performance requirements for these systems are given in the Building Regulations guidance on ventilation [3, 4, 10, 11] and CIBSE Guide B [5].

NOTE 4 BS EN 13141-6 specifies requirements for the performance testing of MEVs.

8.3.2 Mechanical supply ventilation systems

COMMENTARY ON 8.3.2

Supply ventilation systems (sometimes referred to as positive input ventilation – PIV) are fans that are often mounted in the roof space, which supply air continuously to the centre of the house, usually through the ceiling of the landing. Besides providing a continuous supply of outside air, these systems can benefit from some degree of solar gain in the roof, supplying air that is warmer than outside.

Systems that draw air from the roof are not suitable for unventilated roof spaces.

BS EN 13141-11 specifies requirements for the performance testing of PIVs.

Background ventilators (trickle ventilators) should be provided in all rooms to allow for air to disperse to the outside.

PIV fans should be positioned such that they are as quiet as possible and should not be mounted in a way that might cause resonance. The inlet air supply terminal should be installed so that the effect of cold draughts is minimized.

8.3.3 Continuous mechanical supply and extract with heat recovery

COMMENTARY ON 8.3.3

Whole house, mechanical ventilation with heat recovery (MVHR) is a balanced ventilation system that combines supply and extract ventilation in one system. Whole dwelling units comprising two fans and a heat exchanger may be installed as loft mounted, ceiling mounted, wall mounted or floor standing. The supply fan continuously provides outdoor air to all habitable rooms (dry rooms) using a system of ductwork. The extract fan removes the moist air from kitchens, bathrooms and utility rooms (wet rooms) via a system of ductwork and passes it across the heat exchanger before it is passed to the outside. The recovered heat preheats the incoming outdoor air.

Single room heat recovery ventilators (SRHRV) are also available. These are mounted in the external wall and consist of two fan impellers with one or two motors and a heat exchanger. Warm air is

extracted from the room and is passed across a heat exchanger. The recovered heat is transferred to the incoming outdoor air.

Units usually have multiple speed settings permitting continuous background ventilation with a provision to increase the flow rate.

Further information and performance requirements on these systems is given in the Building Regulations guidance on ventilation [3, 4, 10, 11] and CIBSE Guide B [5].

BS EN 13141-7 specifies requirements for the performance testing of whole house heat recovery ventilators. BS EN 13141-8 specifies requirements for the performance testing of single room heat recovery ventilators.

MVHR units and associated duct work should be located within the thermal envelope (heated space) of the building where possible. All ducts within the unheated space (loft) and all ducts carrying cold air should be insulated to minimize condensation on or within the ducts. There might also be a need to provide for the removal of any condensate that might accumulate within the unit; instructions should be obtained from the manufacturer of the MVHR unit. Fans should be positioned such that they are as quiet as possible and should not be mounted in a way that could cause resonance.

NOTE See BS 5422 and NHBC Standards 2020 [13] for further information on condensation control and other performance requirements for ducts.

Background ventilators (trickle ventilators) should not be provided as these units provide balanced ventilation; MVHR requires that fabric air permeability is reduced to a minimum for it to operate near its ideal efficiency.

8.3.4 Exhaust air heat pump (combined unit)

COMMENTARY ON 8.3.4

Exhaust air heat pumps require a minimum air flow to operate satisfactorily and this can have limitations for smaller properties where the required minimum airflow could provide too much ventilation for the floor area of the dwelling

These units have an airflow adjustment to increase the airflow where necessary, but they do not allow it to be lower than the minimum requirement for optimum operation of the heat output.

A typical exhaust air heat pump should have a required minimum airflow of not less than 110 m³/h (31 L/s). The area in which the unit is installed should also be ventilated; typically, this would be 36 m³/h (10 L/s).

8.4 Cooker hood (range hood)

COMMENTARY ON 8.4

BS EN 13141-3 specifies requirements for the performance testing of cooker hoods. Some cooker hood performance requirements are specified by regulations.

Cooker hoods should be installed directly above a cooking area, span at least the full width of the hob and installed at a height between 650 mm and 750 mm above the cooking area.

NOTE Cooker hoods are generally regarded as intermittent extract fans, if they capture the moisture generated by the cooking process and exhaust it directly to the outside. Recirculating cooker hoods are not considered as extract fans, as they do not meet any ventilation requirement and do not remove moisture from the room.

8.5 Purge ventilation

COMMENTARY ON 8.5

Purge ventilation is referenced within Building Regulations guidance [3, 4, 10, 11] and it is intended to introduce rapid ventilation throughout the building to aid removal of high concentrations of pollutants and water vapour released from occasional activities such as painting and decorating or accidental releases such as smoke from burnt food or spillage of water. Purge ventilation is intermittent, i.e. only required when such occasional activities occur.

Purge ventilation provisions may also be used to improve thermal comfort and/or over-heating of buildings in summer, especially the overnight cooling of buildings with high thermal mass as part of an overall cooling strategy. This is considered further in the appropriate Building Regulation guidance on ventilation [3, 4, 10, 11].

The means to provide rapid ventilation of a building, purge ventilation, should be provided with openable windows or, if that is not possible, a mechanical fan system which is capable of the high extract rate.

8.6 Drying rooms/cupboards

Where a heated drying cupboard/room is provided it should be ventilated to disperse moisture directly to the outside. Alternatively, where the drying area is located within another room, e.g. bathroom, the ventilation should be controlled by a fan with a humidity sensor that responds to increased moisture levels.

Humidity sensors may be incorporated into some fans or may be mounted separately. They should be mounted in the most practicable location such that they operate at their peak efficiency and prevent the spread of moisture. The manufacturer's instructions/recommendations should be followed.

8.7 Dehumidifiers

COMMENTARY ON 8.7

Electric dehumidifiers that work on a closed refrigeration cycle both dry and heat the air. As some latent heat is released when the water that is extracted from the air condenses within the unit, the heat output can be 10% to 30% greater than the electricity consumed. An essential feature of all dehumidifiers is that the volume of water that they extract is dependent on the temperature and vapour pressure of the air. They are more effective in warmer dwellings where condensation problems might be caused by high vapour pressures, than in more typical condensation prone dwellings where the problems are caused by low temperature. These units can be fairly obtrusive and can be noisy to run overnight in bedrooms; they might not therefore be acceptable to all occupiers.

Dehumidifiers should not be employed in continuous use, but they may be used to assist in reduction of water content within the air.

NOTE The portability of dehumidifiers means that they can be used as circumstances demand and moved elsewhere if needed.

Section 4: Design principles – fabric details

9 Application of design principles – junctions

9.1 Heat loss and surface temperatures

COMMENTARY ON 9.1

The severity of a thermal bridge, in terms of its effect on internal surface temperatures can be expressed by the surface temperature factor, f , defined under steady state conditions by:

$$f = \frac{T_{sl} - T_o}{T_i - T_o} \quad (1)$$

where:

T_{sl} is the internal surface temperature;

T_i is the internal air temperature;

T_o is the external air temperature;

This is close to 1.0 for a well-insulated structure, but falls towards 0.5 or below at severe thermal bridges.

As it depends on the properties of the construction detail alone and is independent of the environmental conditions, once the temperature factor has been found for a thermal bridge, it can be used to calculate the internal surface temperature, T_{sl} , from any set of temperatures:

$$T_{sl} = T_o + f(T_i - T_o) \quad (2)$$

This can then be used to calculate the internal surface relative humidity and risk of mould growth, if the internal humidity is known.

A surface temperature factor of not less than 0.75 is considered to be sufficient to avoid mould growth, given the range of conditions in UK buildings and the UK climate. Further guidance on this is given in BS EN ISO 13788 and BRE IP 1/06 [14].

The surface temperature factor of a thermal bridge can be found from thermal bridge catalogues or by calculation. A wide range of software packages (which conform to BS EN ISO 10211) are also available and may be used to carry out the appropriate calculations with a two- or three-dimension thermal model. However, thermal bridge calculation software is complex and is currently used only by specialist consultants. Guidance for calculation is given in BRE BR 497 [15].

Thermal bridge catalogues have been produced that contain a representative sample of building details, identify possible problems and give recommended solutions. These catalogues have the advantage of simplicity and ease of use and cover most common constructions. The most comprehensive examples in the UK are the Energy Efficiency Office Good Practice Guides 174 and 183 [16, 17], which cover new and existing housing respectively, and the DEFRA/DETR report on thermal bridging [18], published in association with the Building Regulations [19, 20, 21, 22, 23].

Sets of Accredited Construction Details are available for England and Scotland [24, 25], which are designed to minimize problems of heat loss, condensation risk and air infiltration. A list of enhanced details for low-thermal-bridge parameters are given in the Energy Saving Trust Enhanced Construction Details [26]. Specific guidance for sheeted metal constructions is given in MCRMA TP 18 [27].

In terms of energy and moisture performance, the fabric of a building consists of a series of planes and the junctions between them.

The junctions contain a number of features that make their heat, air and moisture performance significantly different from the plane areas:

- a) the geometry is complex so that heat and moisture flow is two or three dimensional and not a simple path from inside to out;*
- b) at junctions such as corners, where two external walls meet or the eaves of a roof, the area of the external surface is greater than the internal surface, giving greater potential for heat loss; and*
- c) some junctions (e.g. window or door lintels) can contain structural elements like steel or concrete, which have higher thermal conductivity than surrounding materials.*

If the heat flow through a junction is higher than the surrounding areas, the internal surface temperature is lower, leading to an increased risk of localized surface condensation and mould growth.

Because of the increased heat flows, these junctions have been commonly called “thermal bridges” or even “cold bridges”. Besides these junctions, many fabric elements contain features such as timber joists, mortar joints or mullions in curtain walling. These are known as “repeating thermal bridges” and have a significant effect on heat loss. They are, however, rarely severe enough to cause surface temperatures to fall low enough to cause surface condensation or mould growth.

The effects of thermal bridging at junctions on the risk of surface condensation or mould growth should be assessed, especially in buildings where the internal humidity is likely to be high.

9.2 Principles for reducing the effects of thermal bridging

Measures should be taken to limit the effect of thermal bridging on heat loss and condensation risk. There are various strategies that can be used to help mitigate losses and, therefore, the reduced surface temperatures that can occur internally of the building envelope in proximity to them. These include the following.

- a) Isolate the thermal bridge through insulation: use a layer of insulation to minimize direct contact of the thermal bridge with either the inside or outside temperature.
- b) Change the thermal bridge geometry: move, remove or reduce the size of the thermal bridge component.
- c) Increase the thermal bridge path: increase the length of the heat flow path in the thermal bridge or strategically place insulation in order to make the heat travel further to escape.
- d) Change the thermal bridge materials: change the conductivity of the material causing the thermal bridge to a less conductive one.

10 Application of design principles – Floors

10.1 General

The designer should take account of and document the following sources of moisture in floors:

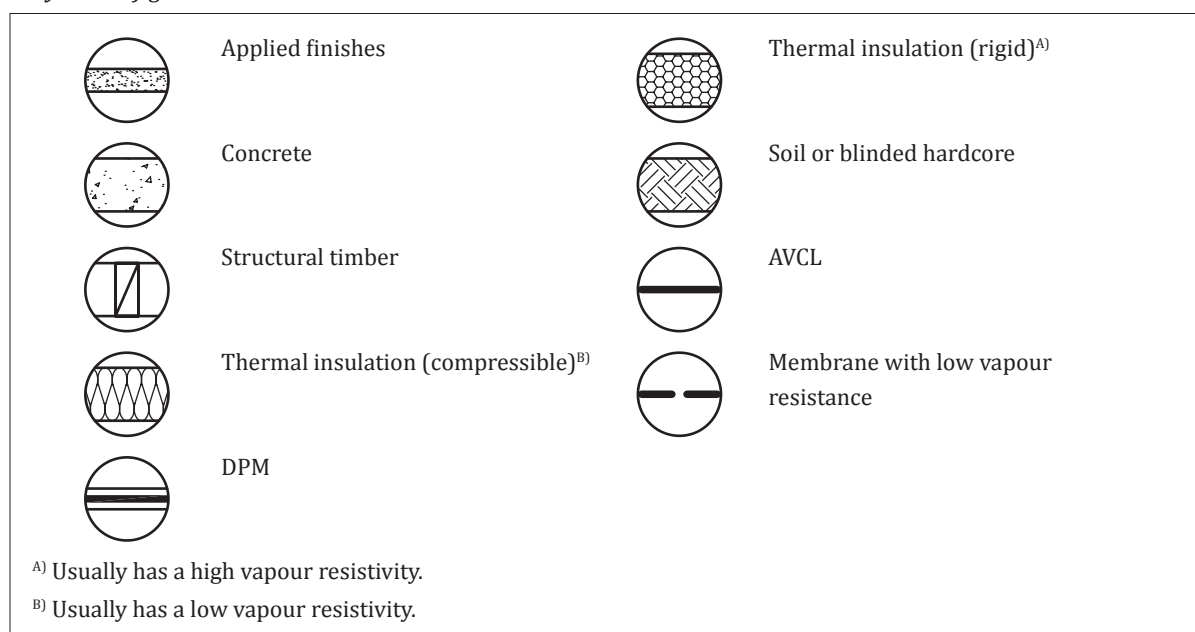
- a) ground moisture (where there is a suspended floor or one without a damp-proof course [DPC], or where the floor is below external ground level);
- b) construction moisture: water incorporated in screeds, pre-cast units and concrete slabs is released as the constructions dry out and can cause degradation of floor finishes as well as high humidity levels in the indoor environment. Time should be allowed for drying out, particularly where a concrete slab is formed above a DPM (refer to [BS 8204](#) [all parts] and, for floor coverings, [BS 8201](#));

- c) moisture generated by the occupants and their activities, which are liable to change during the life of the building;
- d) ABIS conditions: leaks resulting from defects in the external envelope or in piped services and spillage within the building which might cause damage to the structure or finishes if retained on impervious layers; and
- e) due to climate change, greater volumes of rainwater causing pressure on drains and culverts and overflows impacting on adjacent buildings.

NOTE 1 The figures in this clause use the graphic conventions shown in [Figure 1](#). Small gaps are shown between layers in the figures to distinguish one layer from another but, in reality, the layers would be in contact. Cavities are labelled as such.

NOTE 2 Where investigations are needed in order to establish the nature, implications and extent of moisture in an existing floor or walls, guidance is given in [Clause 13](#).

Figure 1 — Key to the figures



10.2 Categories of floors

Floors of buildings should be categorized as one of the following:

- a) groundbearing floors of concrete which are cast on and supported by a prepared base with DPM; a cast in-situ concrete floor should be treated as a groundbearing slab for the detail of DPMs/ DPCs and insulation;
- b) groundbearing floors of tiles, stone, rammed earth or lime-based concrete, laid on prepared base, without DPM;
- c) suspended floors of structural concrete or timber with a void beneath them; such floors might separate a conditioned space from an unconditioned space, such as a loading bay, parking space, garage or void; or
- d) floors below external ground level/basements.

NOTE [Table 1](#) gives a summary of floor constructions in this clause.

Table 1 — Summary of floor constructions

Clause	Detail
10.3	Groundbearing floors with DPM
10.4	Groundbearing floor without DPM, with or without insulation either above or below the floor slab/tiles
10.5.6	Suspended concrete floors
10.5.7	Suspended timber floors
10.6	Basements

10.3 Groundbearing floors with DPM

COMMENTARY ON 10.3

Groundbearing solid floors are usually constructed with a concrete slab; because of their thermal mass they respond slowly to changes in air temperature and, being hygroscopic, they absorb moisture to some degree. The thermal performance of most floor insulation materials is affected by moisture, and such materials ought to only be used above a DPM. Insulation materials whose thermal performance is not affected by moisture can be used above or below a DPM. If in doubt, the product's suitability can be checked with the manufacturer.

10.3.1 New and existing buildings

New groundbearing floors are not problematic if they are designed and constructed correctly. However, if they are part of extensions to traditional buildings without DPCs, then either a DPC should be inserted into the existing wall (if possible) or other measures should be taken such that moisture pressure from below the new floor does not create moisture problems for the adjoining wall and building (including floors).

All joints and junctions between DPMs, wall DPCs or tanking in substructure walls should be undamaged, especially while the concrete for the ground slab is being poured, as well as during the construction of formwork and striking of formwork at construction joints.

Existing groundbearing floors can be of variable quality and strength. New work (such as extensions) or alterations to existing floors (such as new finishes) should take into account possible DPM failure and other ABIS conditions (see [10.3.3](#)).

The addition of a groundbearing floor in a traditionally built structure (e.g. older solid masonry walls) should be approached with caution, as concentration of moisture in the wall footings can result where a new DPC is introduced to an existing wall.

Where practicable, a new DPC and DPM measure should be installed, whilst at the same time addressing external drainage and ground levels, as this would represent the most robust approach (see [10.3.2.4](#)).

10.3.2 Moisture risks – ADT issues

10.3.2.1 Surface mould growth

Groundbearing floors with DPMs and edging insulation should be designed and constructed such that they are not subject to surface condensation or mould growth.

NOTE See [Figure 2](#) for typical connective/systemic considerations for groundbearing floors, and also general principles outlined in [10.2](#).

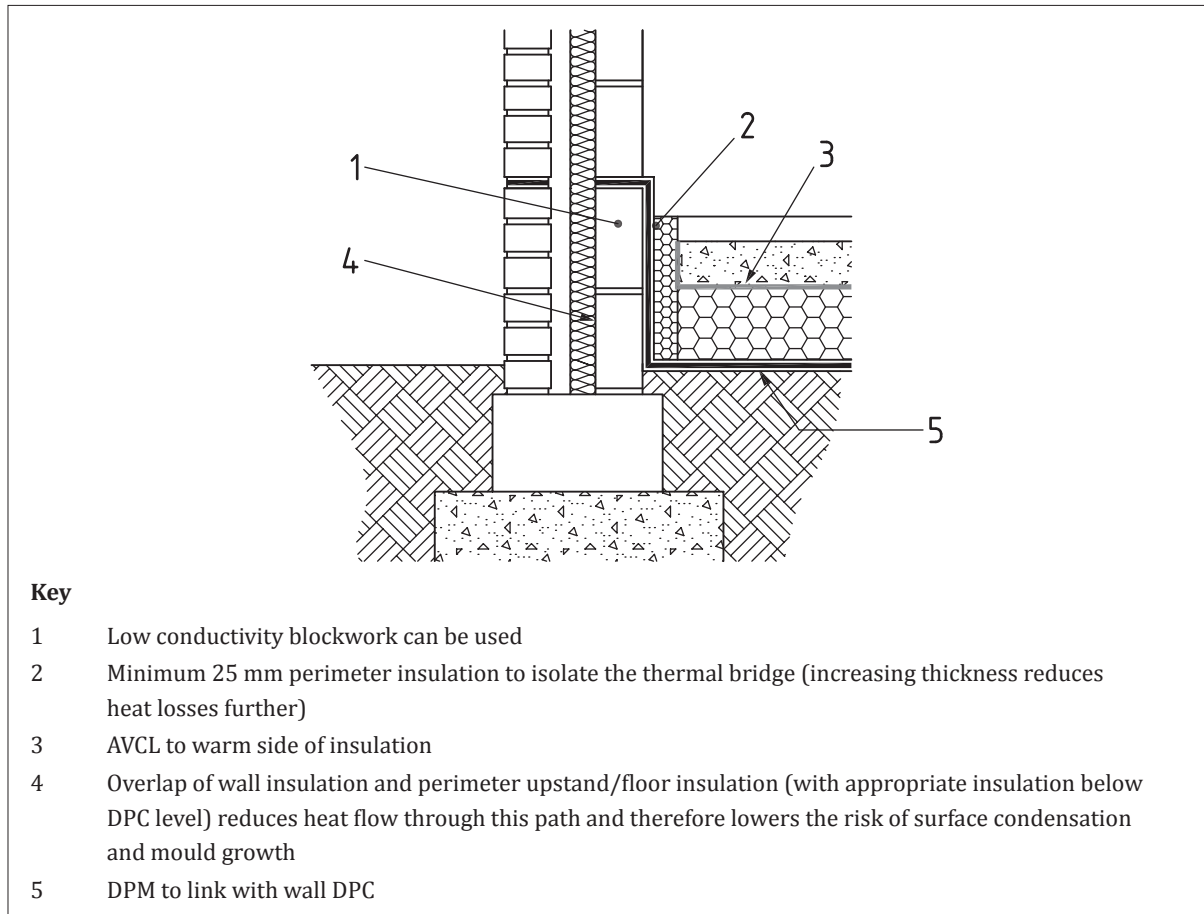
10.3.2.2 Interstitial condensation

Groundbearing floors with DPMs and edging insulation should be designed and constructed such that they are not subject to interstitial condensation or mould growth.

NOTE 1 See Figure 2 for guidance on design, construction and use.

NOTE 2 Recommendations for the selection of appropriate external temperatures for calculations of interstitial condensation in groundbearing and suspended ground floors are given in 13.2.2.3 and 13.2.2.4 respectively.

Figure 2 — Connective/systemic effects for groundbearing floors



10.3.2.3 Driving rain

There is no moisture risk from driving rain, but the recommendations for ABIS conditions in 10.3.3 should be followed.

10.3.2.4 Moisture from the ground

A complete DPC and DPM should be installed to prevent rising damp from affecting the base of the wall or floor in all new work.

The addition of a groundbearing floor in a traditionally built structure (e.g. older solid masonry walls) should be approached with caution, as a concentration of moisture in the wall footings can result where a new DPM is introduced to an existing floor. In this case, an effective DPC should be installed to protect the walls.

NOTE When dealing with such a floor, using a water vapour permeable base (such as lime or concrete) increases the moisture vapour load and thereby adds to condensation risk.

10.3.3 ABIS conditions

COMMENTARY ON 10.3.3

For new groundbearing floors in new buildings, the main as built concern relates to the moisture of the construction process and any additional moisture through exposure to rain.

For in service conditions, groundbearing floors with DPMs can be affected by leaks from penetrations such as water mains, drains and other plumbing. It is also possible that condensation can form at the edge of floors due to lack of edging insulation.

Spills of water should be removed and major flooding of floors from appliance failure or external flooding events are likely to require considerable dehumidification and ventilation of the building in order to remove moisture risks.

NOTE Where there is a damp problem, an assessment by a moisture expert might be required to identify the nature of the problem and the solution.

10.3.4 Connective and systemic effects

COMMENTARY ON 10.3.4

On groundbearing floors there is a risk of surface condensation forming, particularly at the junction with external walls and at external corners; that risk can be reduced both by installing edging insulation and furthermore by providing sufficient heating and ventilation of the occupied space. In order to help minimize the moisture risks from higher humidity levels, management of the internal environment over the long term needs careful consideration.

Where new groundbearing floors are part of extensions to existing buildings, or abut any existing building, the new floor DPM should be linked to the existing building DPM or DPC (if in a wall). Where the existing building does not have a DPM or DPC, either a complete DPC/DPM system should be inserted into the whole of the existing building (if possible without undue cost or damage) or capacity and caution should be built into the design, construction and use of the building to reduce risks and manage any moisture effects.

The DPM should be positioned depending on the moisture absorption properties of the insulant used.

Where the DPM is on the warm side of the insulation, it should be assumed to form an AVCL.

Where the DPM is on the cold side of the insulation, a separate AVCL should be placed on the warm side of the insulation. If the insulation is applied beneath the slab (see [Figure 4](#)) the floor should be regarded as a massive construction best suited to a continuous heating regime (see [7.1](#)).

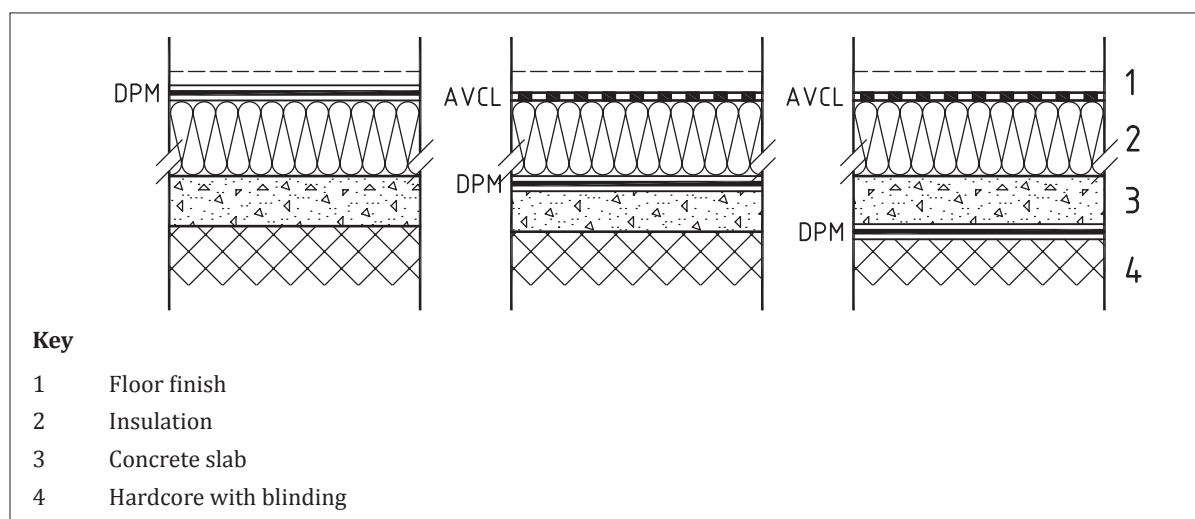
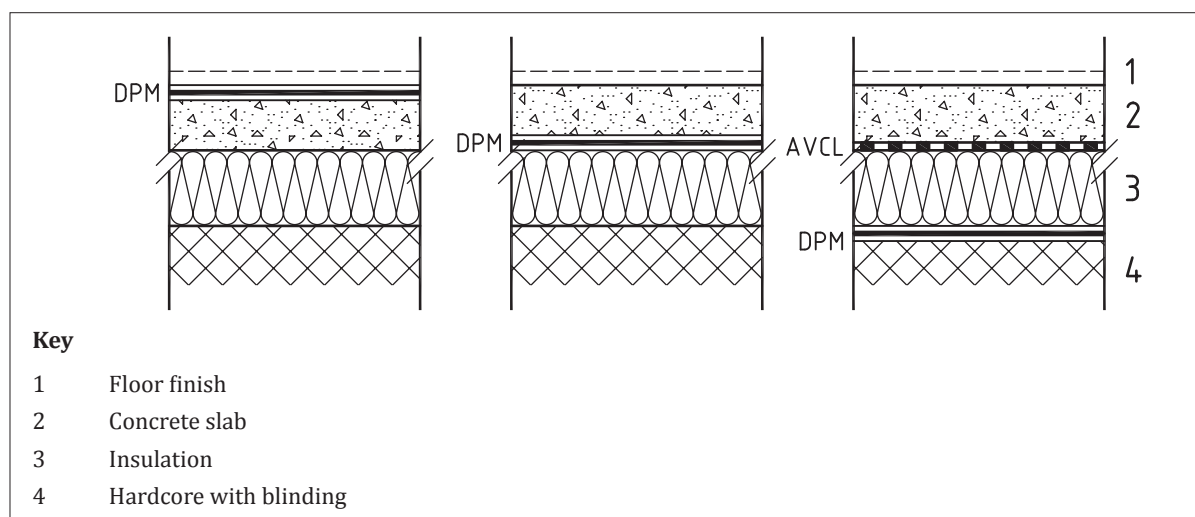
NOTE 1 These moisture risks and effects are very much context dependent and might require expert advice, especially when considering historic structures with vapour open principles of construction.

A DPM under the slab and turned up around the edges might retain rainwater during construction; this water should be allowed to dry out before any impervious toppings are applied.

The building should be adequately heated and ventilated, and moisture production limited to keep internal humidity relatively low especially if there is residual moisture in the slab.

If thermal insulation is installed above the floor slab (see [Figure 3](#)) there is a moisture risk of interstitial condensation occurring on the upper surface of the floor slab; to prevent that, an AVCL with a vapour resistance equivalent to that of the DPM should be laid over the thermal insulation. Such a floor should be regarded as suitable for intermittent heating regime (see [7.1](#)).

NOTE 2 DPM may be above or below the insulation or the concrete slab. Where the DPM is on the warm side of the insulation, it acts as an AVCL and minimizes the moisture risk of interstitial condensation forming on any of the layers on the cold side of the insulation.

Figure 3 — *Insulation above concrete slab***Figure 4** — *Insulation below concrete slab*

10.4 Groundbearing floor without DPM, with or without insulation either above or below the floor slab/tiles

COMMENTARY ON 10.4

Solid groundbearing floors prior to the advent of plastic membranes were constructed without DPMs. In order to protect against moisture from the ground, care was taken to ensure that the building was not subject to high water tables or flooding, and often capillary closed finishes such as vitrified tiles or other low porosity materials were used. In older buildings where flagstones were laid, it was important that lime mortar joints were used in order to allow moisture to evaporate through these joints. In most pre-1940s buildings, solid floors were laid down only in small areas and the rest of the ground floor had predominantly suspended timber floors. This meant that moisture pressure from the ground was reduced and so did not push up into the solid floors or the bottom of walls, or concentrations of moisture were able to disperse via other routes.

10.4.1 Existing buildings

New groundbearing floors without DPMs have been used in some historic buildings such as churches, particularly where insulation is required or where extensions are added. Insulation tends to be

loadbearing minerals which act as both insulation and hardcore. Finishes are sometimes hydraulic lime screeds, rather than tiles or stones.

Existing groundbearing floors without DPMs can be of variable quality and strength. Such floors do not have insulation (see information on ABIS conditions in [10.4.3](#)).

10.4.2 Moisture risks – ADT issues

10.4.2.1 Surface mould growth

Groundbearing floors without DPMs but with insulation should be designed and constructed such that they are not subject to surface condensation or mould growth.

NOTE See guidance from Historic England [28] on design and construction.

10.4.2.2 Interstitial condensation

Groundbearing floors without DPMs but with insulation should be designed and constructed such that they are not subject to surface condensation or mould growth.

NOTE See guidance from Historic England [28] on design and construction. Even without a DPM, a dense concrete floor, or even a solid floor made of a thick layer of high strength hydraulic lime, allows very little moisture movement and also effectively functions as a damp-proof construction in itself.

Floor insulation should be added where a DPM is an integral part of the system, and where there has been no membrane used in the floor in the past.

10.4.2.3 Driving rain

There is no moisture risk from driving rain, but the recommendations for ABIS conditions in [10.4.3](#) should be followed.

10.4.2.4 Moisture from the ground

All of these floors are at risk where there are high water tables or a likelihood of flooding. Ground water should be drained away from buildings which contain floors without DPMs. If ground water cannot be prevented from affecting the building, then such floors should be avoided.

NOTE Any decoration or surface coating that acts as a vapour check increases the risk of interstitial condensation and hence possible damage; the use of vapour open finishes is more appropriate to manage the likely levels of moisture movement where a DPM cannot safely be incorporated into the construction.

10.4.3 ABIS conditions

COMMENTARY ON 10.4.3

For new groundbearing floors without DPMs, the main as built concern relates to the moisture of the construction process and any additional moisture through exposure to rain. See [10.1](#) for drying times for slabs, once the floors are enclosed in the building.

For in service conditions, older groundbearing floors without DPMs usually do not have any insulation under them and can therefore suffer from surface condensation, particularly where there is insufficient heating and ventilation. As with all groundbearing floors, they can be affected by leaks from penetrations such as water mains, drains and other plumbing.

Spills of water should be removed; major flooding of floors from appliance failure or external flooding events are likely to require considerable dehumidification and ventilation of the building in order to remove moisture risks.

NOTE Where there is a damp problem, an assessment by a moisture expert might be required to identify the nature of the problem and the solution.

10.4.4 Connective and systemic effects

COMMENTARY ON 10.4.4

On groundbearing floors without DPMs, there is a risk of surface condensation forming, particularly at the junction with external walls and at external corners (although this also depends on the construction, thickness and condition of the wall); that risk can be reduced by providing sufficient heating and ventilation of the occupied space; in order to help minimize the moisture risks from higher humidity levels, management of the internal environment over the long term needs careful consideration.

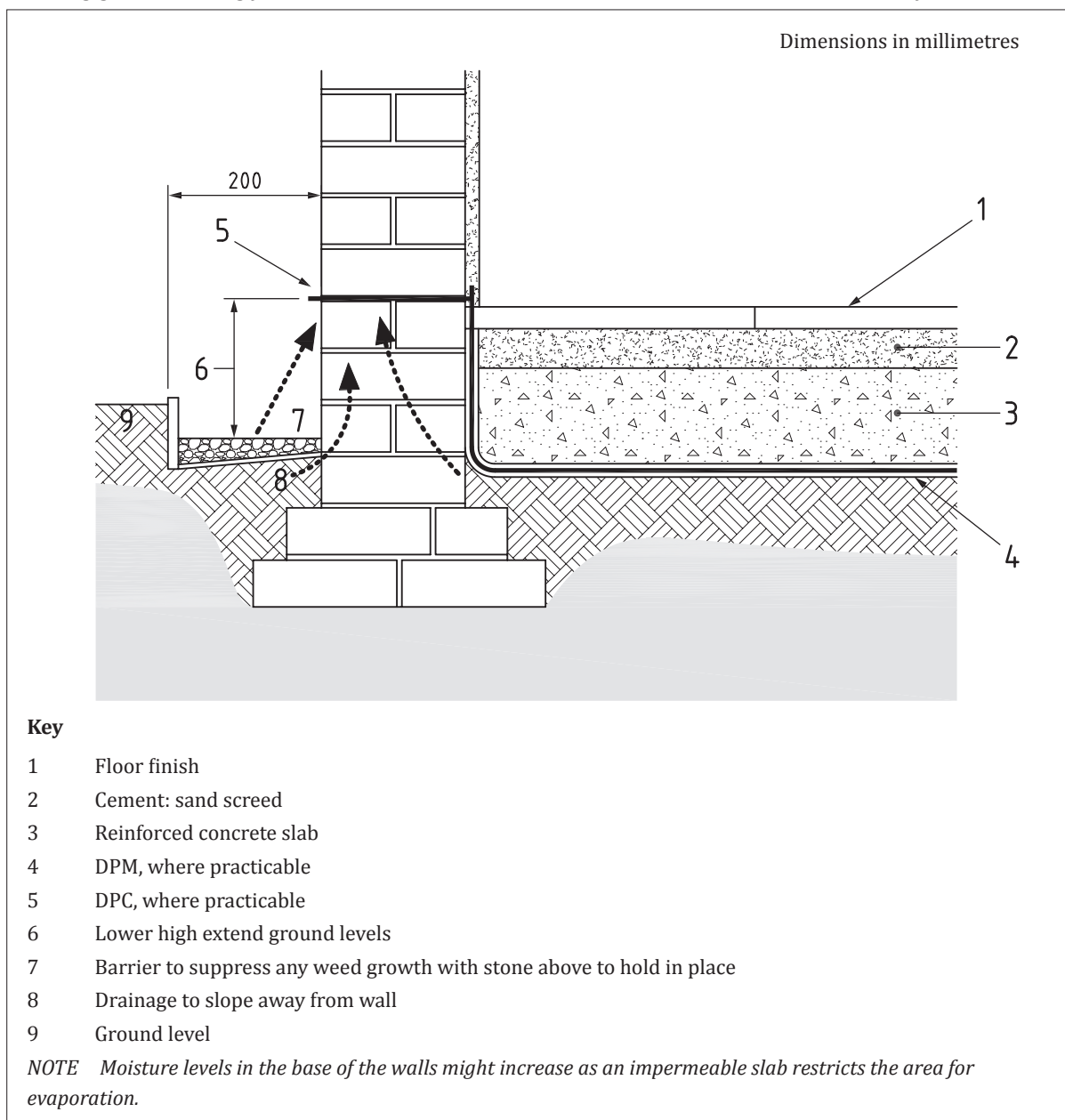
The building should be adequately ventilated and heated, and moisture production limited to keep internal humidity reasonably low.

NOTE 1 Principles regarding addressing internal surface condensation and mould growth risks at junctions as outlined in [Figure 5](#) might also still be applicable where there is no DPM, but opportunities to act on these are more limited for existing dwellings.

The addition of a groundbearing floor in a traditionally-built structure (e.g. older solid masonry walls) should be approached with caution, as a concentration of moisture in the wall footings can result where a new DPC is introduced to an existing wall, or where a DPM measure is introduced to a replacement floor.

Where practicable, a new DPC and linked DPM measure might be installed, whilst addressing external drainage and ground levels; however, this might not always be practicable or desirable for an existing building. In such circumstances, the advice of an appropriately qualified retrofit specialist should be sought.

NOTE 2 Further guidance can be found in the Historic England document [\[28\]](#).

Figure 5 — Existing groundbearing floors either without DPM or without insulation above or below the floor

10.5 Suspended floors

10.5.1 General

COMMENTARY ON 10.5.1

A suspended floor can be formed of concrete cast in situ, or consist of pre-cast slabs or pre-cast beams with infill blocks or insulation, or be formed with timber joists and boarding, or in older properties, even just timber. A suspended floor which separates similarly conditioned spaces does not usually incorporate thermal insulation; in such floors there is no risk of surface or interstitial condensation.

A suspended floor which separates a conditioned space from an unconditioned space or void should incorporate thermal insulation.

NOTE As the soffit of the floor is at or near external air temperature, there might be a risk of surface and/or interstitial condensation: such risk can be eliminated by providing sufficient heating and ventilation of the conditioned space.

10.5.2 New and existing buildings

New suspended floors should be designed and constructed so as to avoid risks of interstitial or surface condensation following the recommendations in this clause.

NOTE 1 New suspended floors can typically be constructed as extensions to existing buildings that do not have existing DPCs/DPMs, without incorporating additional measures of capacity and caution.

NOTE 2 Existing suspended floors can be of variable quality and strength. Older suspended floors might not incorporate insulation and might not be airtight, leading to draughts. In some cases, these draughts might be an important source of ventilation, particularly where open fires or stoves require oxygen for combustion; where proposing any changes to such constructions, additional ventilation measures to fulfil these combustion needs might need to be considered.

10.5.3 Moisture risks – ADT issues

10.5.3.1 Surface mould growth

New suspended floors should be designed and constructed such that they are not subject to surface condensation or mould growth.

NOTE See [Figure 6](#) for guidance on design and construction.

10.5.3.2 Interstitial condensation

Suspended floors should be designed, constructed and used such that they are not subject to interstitial condensation or mould growth.

NOTE See [Figure 6](#) for guidance on design, construction and use.

10.5.3.3 Driving rain

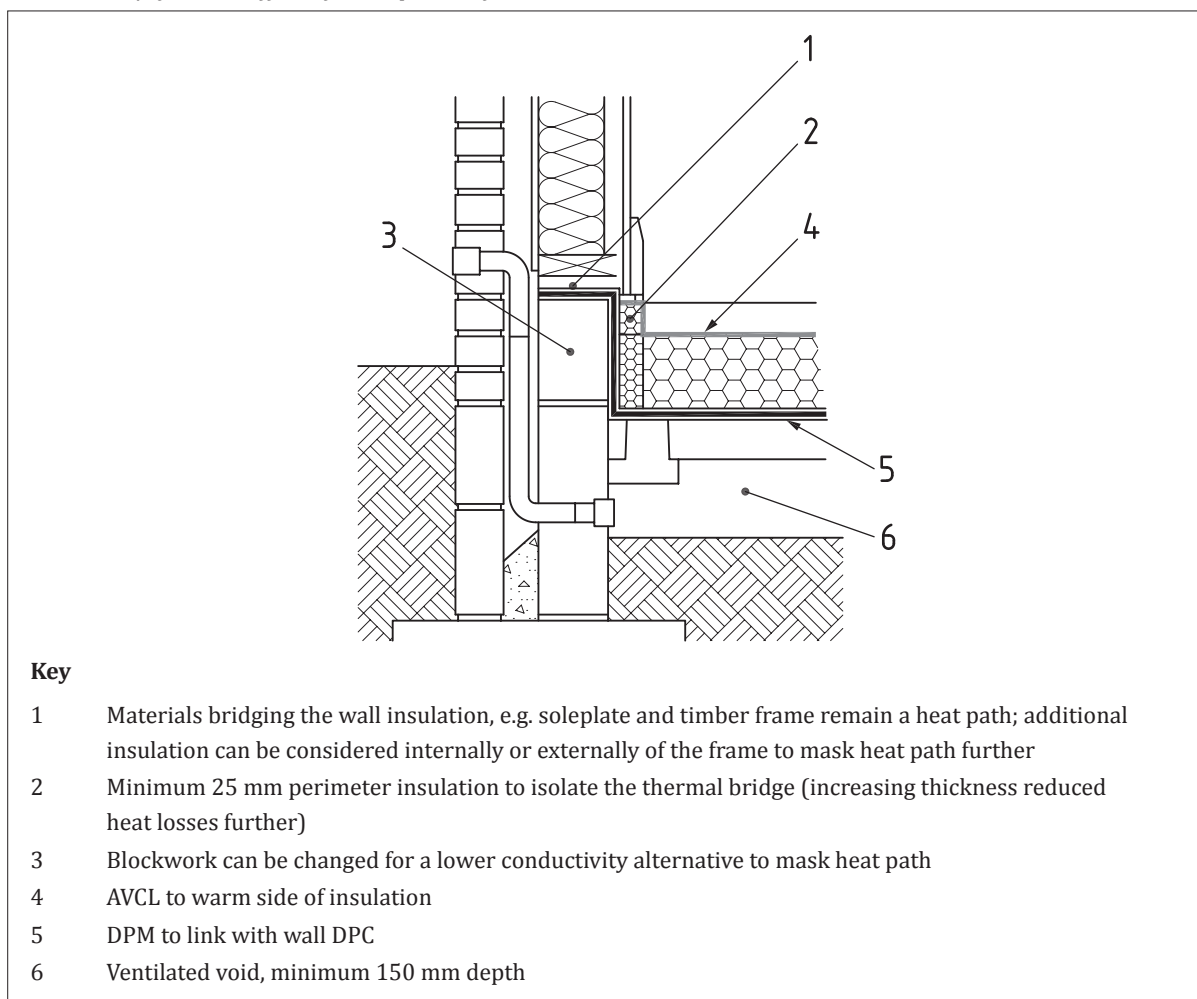
There is no moisture risk from driving rain, but the recommendations for ABIS conditions in [10.5.4](#) should be followed.

10.5.3.4 Moisture from the ground

DPCs should be inserted under sleeper walls in timber floors and concrete suspended floors should be linked to DPCs in walls.

Voids below suspended ground floors should be ventilated.

NOTE In the case of dwellings, ventilation can be achieved by means of vents having a free area of not less than 1 500 mm²/m run of external wall or 500 mm²/m of floor area, whichever is the greater.

Figure 6 — *Connective/systemic effects for suspended floors*

10.5.4 ABIS conditions

For new suspended floors, the main as built concern relates to the moisture of the construction process and any additional moisture through exposure to rain if suspended floors are inserted prior to covering in the building. Timber floors should be very carefully protected against rain such that boards do not warp, expand or rot. The subfloor voids should also be kept clear and clean, so that ventilation is unimpeded.

NOTE 1 As built moisture risks also relate to the coherence and position of the AVCL within the construction (see [Figure 6](#)).

For timber suspended floors (see [10.5.7.1](#), [Figure 9](#) and [Figure 10](#)), there is also an as built moisture risk of interstitial condensation if insulation is not fitted tightly between joists. Sufficient ventilation should be allowed around the end of the floor joists such that the ends do not absorb moisture from walls, particularly if the walls are part of an existing building without DPCs.

NOTE 2 In solid walled buildings, floor joists might penetrate the walls without damage if the moisture risks above are addressed. Timber can also be in direct contact with masonry if it is dry.

Where extensions are added to existing buildings with suspended floors, the existing building subfloor ventilation should not be inhibited but be fully incorporated into effective subfloor ventilation for the whole building.

Spills of water should be removed and major flooding of floors from appliance failure or external flooding events might require dehumidification and ventilation of the building in order to remove moisture risks.

NOTE 3 For in service conditions, all suspended floors can be affected by moisture and air leakage from penetrations such as water mains, drains and other plumbing. Air leakage can have systemic effects on the building as well as leading to localized condensation. In timber floors, boards or finishes might have to be removed and replaced as part of this drying process.

NOTE 4 Existing timber floors might not be insulated, or might be incorrectly or only partially insulated. Incorrect insulation (such as insulation between joists without an airtightness membrane or with a high resistance membrane below the insulation) can cause interstitial condensation and eventually rot; well-fitted insulation of a vapour open type does not need membranes or AVCLs. See HES Short Guide 1 [29].

In existing floors there might also be gaps between floorboards, allowing air movement in both directions. This should be taken into account when renovating or retrofitting the building. If these are addressed through re-laying, then ventilation of the solum void below is sufficient.

10.5.5 Connective and systemic effects

COMMENTARY ON 10.5.5

There is a risk of surface condensation forming in all suspended floors at the junction with external walls and at external corners if the insulation in the wall is not in the same plane or lower than the floor insulation. If this is not possible (for example, if the floor abuts an existing solid wall), the risk can be reduced by providing adequate heating and ventilation of the occupied space; in order to help minimize the moisture risks from higher humidity levels, management of the internal environment over the long term needs careful consideration.

The building should be adequately heated and ventilated, and moisture production limited to keep internal humidity reasonably low, especially if there are unavoidable ABIS conditions.

10.5.6 Suspended concrete floors

COMMENTARY ON 10.5.6

A suspended concrete floor might be insulated either above or beneath the concrete slab. When insulation is applied above the slab there is no risk of surface condensation but interstitial condensation is likely to occur on the upper surface of the slab.

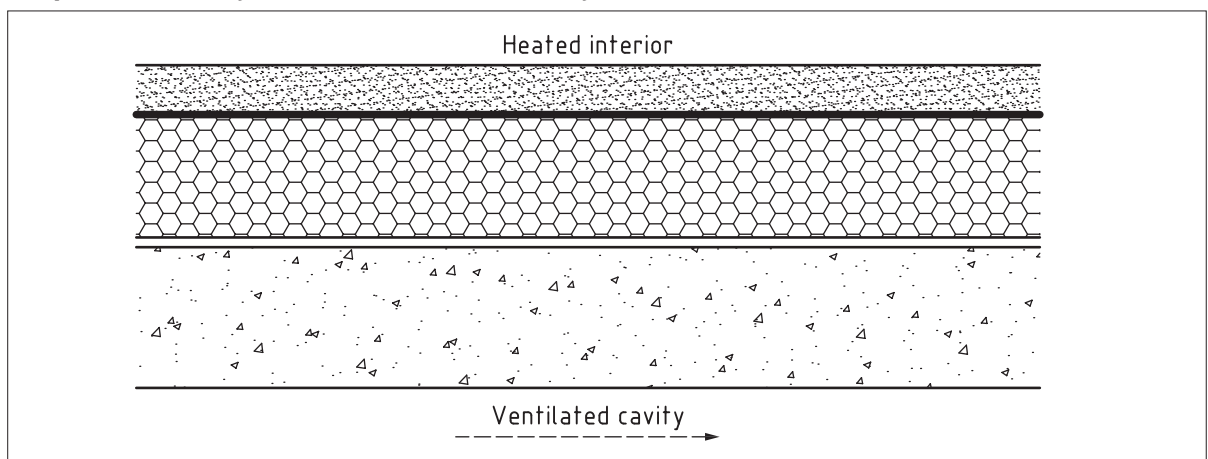
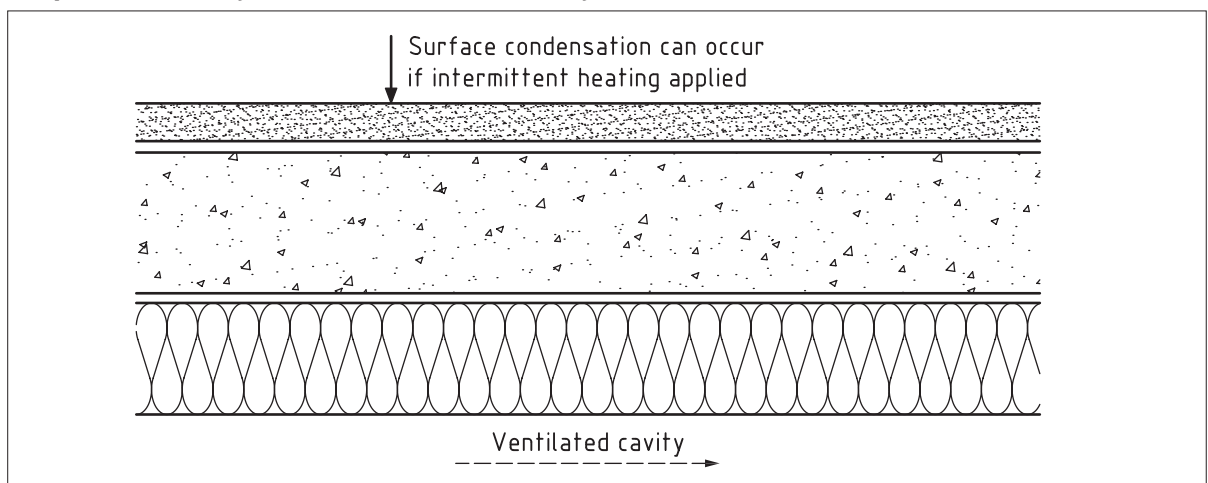
To avoid the risk of interstitial condensation, an AVCL should be laid between the thermal insulation and the floor finish (see [Figure 7](#)) and the space beneath the floor should be ventilated. In the case of new dwellings, subfloor ventilation should be provided by evenly spaced vents having a free area of not less than 1 500 mm²/m run of external wall or 500 mm²/m² of floor area, whichever is the greater. Vents should be placed on at least two opposing elevations at no more than 2 m centres and no more than 450 mm from the corner of the building.

NOTE 1 For existing buildings, alternative approaches to achieving equivalent ventilation might be required.

NOTE 2 Such a floor can be regarded as suitable for an intermittent heating regime (see [7.1](#)).

NOTE 3 When thermal insulation is applied beneath the slab (see [Figure 8](#)) the floor can be regarded as suitable for use in continuously heated buildings; in such cases, there is no likelihood of interstitial condensation; however, surface condensation can occur if continuous heating is not provided (see [7.1](#)).

If an external soffit of high vapour resistance is provided, an AVCL should be installed on the warm side of the insulation and a ventilated void not less than 50 mm deep should be provided between the thermal insulation and the soffit finish.

Figure 7 — *Suspended concrete floor with insulation above the floor slab***Figure 8** — *Suspended concrete floor with insulation below the floor slab*

10.5.7 Suspended timber floors

10.5.7.1 General

NOTE A suspended timber floor might be insulated by applying insulation above, between or beneath the joists, separately or in any combination of these three locations.

Voids below suspended timber ground floors should be ventilated. In the case of dwellings, ventilation should be provided by vents having a free area of not less than 1 500 mm²/m run of external wall or 500 mm²/m² of floor area whichever is the greater.

When thermal insulation is applied above the joists, there is no risk of surface condensation, but interstitial condensation can occur on the timber; to avoid such condensation, an AVCL should be laid between the thermal insulation and the floor finish (see [Figure 9](#)).

When thermal insulation is applied between the joists (see [Figure 10](#)), it should not be supported on a material which offers a vapour resistance higher than that of the thermal insulation.

If an external soffit of high vapour resistance is provided, an AVCL should be installed on the warm side of the insulation and a ventilated void not less than 50 mm deep should be provided between the thermal insulation and the soffit (see [Figure 11](#)).

The solum (prepared area within the containing walls of a building) should be treated to prevent vegetable growth and reduce the evaporation of moisture from the ground to the inner surface of any part of a dwelling that it could damage.

The solum should be brought to an even surface; any up filling should be of hard, inert material, with either a DPM or concrete 50 mm thick laid on 0.25 mm (1 000 gauge) polyethylene sheet; or concrete 100 mm thick; so that the top surface is not below that of the adjacent ground (see [Figure 9](#) and [Figure 10](#)). On sloping sites, drainage should be provided on the upslope side of the building.

Figure 9 — *Suspended timber floor with insulation above the joists*

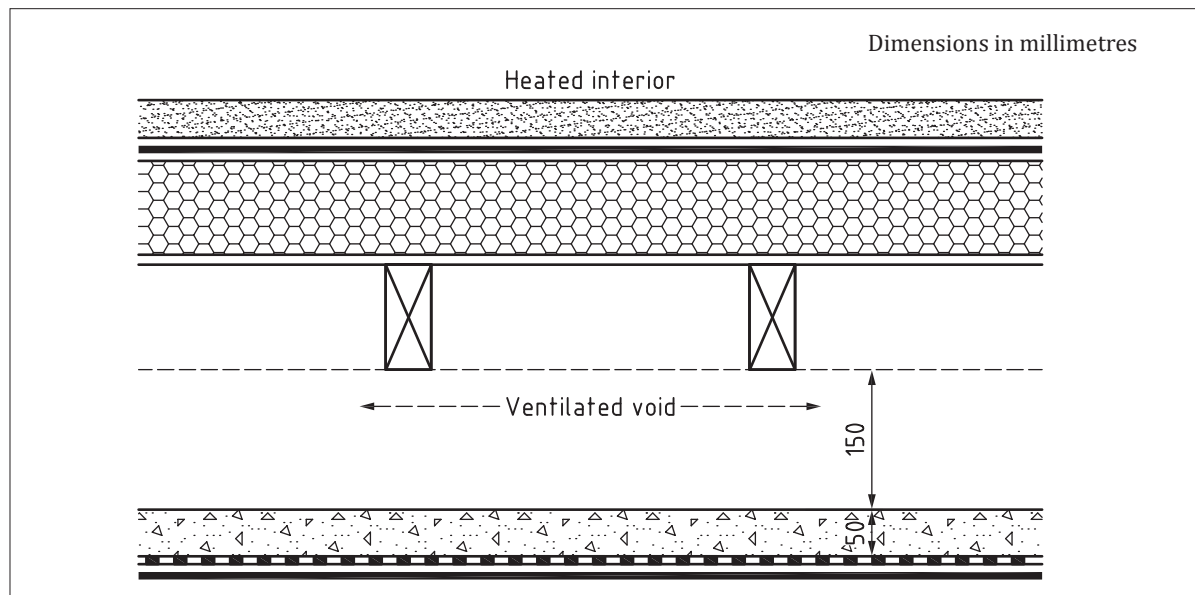


Figure 10 — *Suspended timber floor with insulation between the joists*

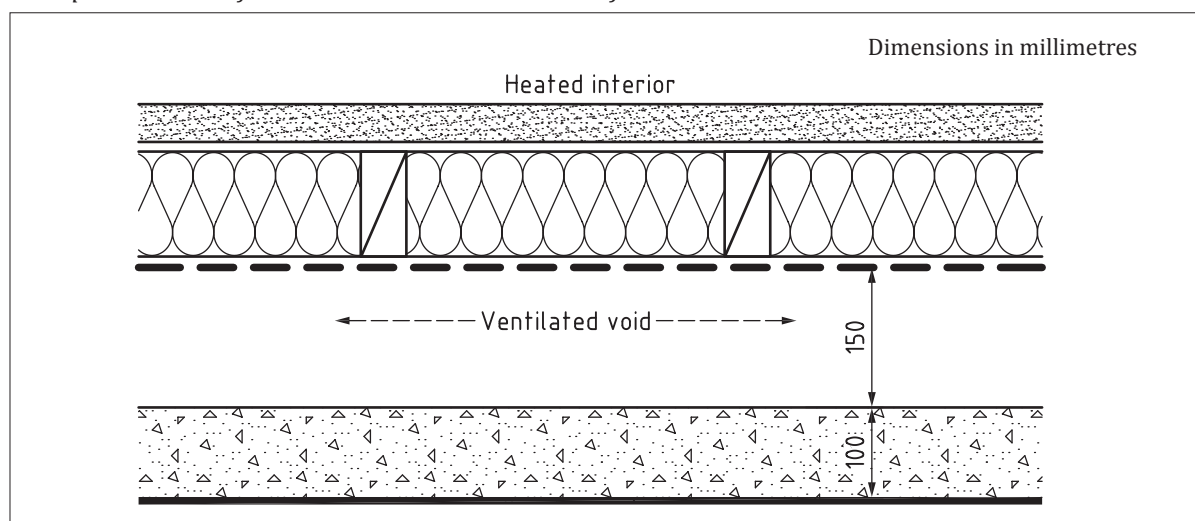
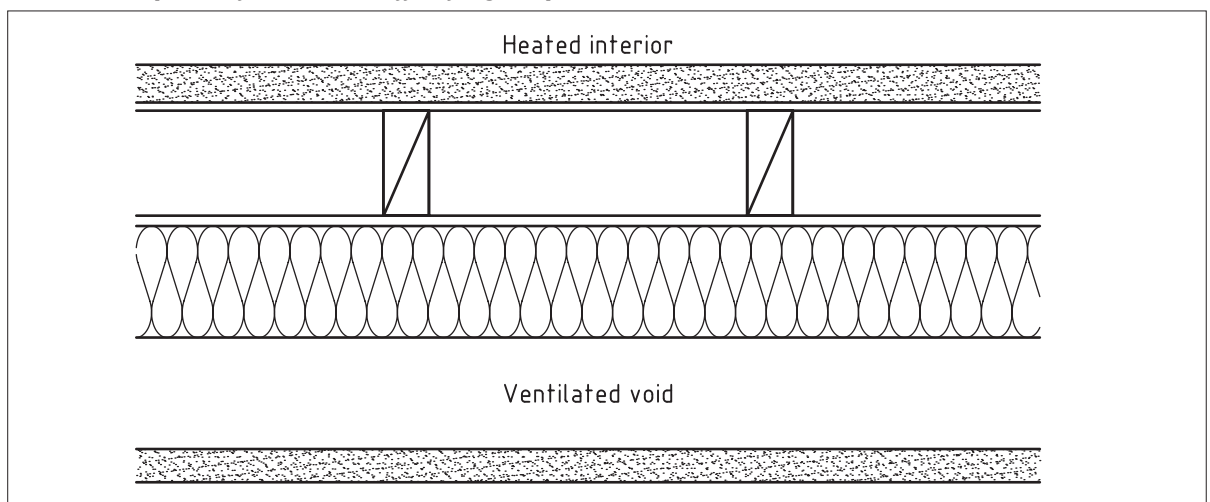


Figure 11 — Timber suspended floor with a soffit of high vapour resistance**10.5.7.2 Embedded joists****COMMENTARY ON 10.5.7.2**

Timber floor joists which are embedded in exterior walls can be vulnerable to moisture arriving from:

- a) *capillary rise from the ground;*
- b) *rain penetration through the exterior wall; or*
- c) *condensation.*

The retrofit installation of wall insulation and incorrect use of vapour control layers can increase the condensation risk on the embedded joist.

The inaccessibility of embedded joists can make protection difficult.

The possible use of treatment or retrofit should be assessed to provide a moisture barrier on the surface of the timber or reducing the propensity to wood rots by precautionary biocide treatments.

10.6 Basements**10.6.1 General****COMMENTARY ON 10.6.1**

For the purposes of this document, a basement is a storey(s) of a building constructed either entirely or partially below ground level. This subclause considers moisture risk to both walls and floors of a basement structure.

Before considering what is an acceptable level of moisture within a basement, it is essential to establish the intended use of the space. [BS 8102](#) can be used to help identify acceptable levels of moisture control for various uses of underground structures.

Many basements are built for storages purposes; when used in this capacity then an adequate provision of ventilation to minimize moisture risk might be acceptable.

Measures to control the moisture conditions in basements should be appropriate to the risk.

10.6.2 Moisture risks – ADT issues

10.6.2.1 Moisture from the ground

COMMENTARY ON 10.6.2.1

Detailed guidance on controlling water from the ground in below ground structures can be found in [BS 8102](#).

Moisture from the ground can derive from a range of sources and these can change during the life of the structure. A site investigation is important as its results have a bearing not only on the waterproofing options considered, but also how the structure is designed. Although the findings of a site investigation can be seen as conclusive, it is often a snap shot in time and conditions on or around the site might change in the future, for example, due to the effects of climate change, burst water mains and sewers.

The risk of hydrostatic pressure coming to bear at some stage in the structure's life should be taken into account and determined, especially in the absence of a full site investigation. Appropriate measures to mitigate this risk should be implemented dependent on the use of the basement.

New basement walls and floors should use one of the three forms of protection outlined in [BS 8102](#): a barrier approach (type A), structural integral approach (type B), or a drained cavity approach (type C), or a combination of approaches.

These protection measures should be designed by someone with the appropriate skill set and experience. They should have understanding of the different forms of protection and how continuity between the different building elements can be achieved. All elements of the underground structure should be taken into account, including floor, walls and where applicable buried roofs or podium decks. The interface between these building elements should also be determined.

10.6.2.2 Existing structures

COMMENTARY ON 10.6.2.2

Controlling ground water in existing basements has its own unique considerations and options for systems for protection of ground water are dependent on many factors including the end use and the condition of the existing structure. Unlike in new basements construction (where a waterproofing designer needs to be engaged at the earliest design stages), many existing structures have been built with little regard for future waterproofing.

The designer should determine what is possible within the confines of the structure. This limits the waterproofing options and results in the reliance on a single waterproofing system applied to the internal face of the structure.

10.6.2.3 Moisture generated by the occupants

COMMENTARY ON 10.6.2.3

Basements wholly or partially below ground means that the same opportunities to promote air exchange through doors and windows to the outside can be restricted. In addition, natural "incidental" air exchange through discontinuities, cracks and other openings in the fabric of the building are all but eliminated if the waterproofing system has been designed and installed correctly.

Ventilation systems in basements are often critical in the control of both heat and moisture. Air management systems should be designed and commissioned by specialist practitioners such that the systems work, are safe and perform as intended. Ventilation systems should also be cleaned and serviced regularly to ensure safety and reliability.

10.6.2.4 Moisture generated from the outside air

COMMENTARY ON 10.6.2.4

In the summertime particularly, cellar or basement windows or light wells might be opened for fresh air. If the outside air is warm and humid, it can condense on cooler basement walls and floor surfaces. This can be mistaken for a failure of the waterproofing system, when in fact the accumulated moisture is from condensation.

Ventilation provision should be used to reduce condensation risk.

Ventilation and air management systems should be designed and commissioned by specialist practitioners such that systems work and perform as intended.

10.6.2.5 Surface mould growth

Basement floors and walls should be designed and constructed such that they are not subject to surface condensation or mould growth.

10.6.2.6 Interstitial condensation

Basement floors and walls should be designed and constructed such that they are not subject to interstitial condensation.

Insulation and vapour control layers should be continuous and unbroken.

NOTE Failure to maintain continuity allows vapour movement and cold bridging that can result in localized condensation.

Insulation applied beneath floor slabs, above buried roofs or behind earth retaining walls should also be continuous as discontinuity could result in cold bridging and variable performance that can lead to differences in finished wall temperatures with colder surfaces becoming susceptible to mould growth and condensation.

Insulation applied in below ground settings should be compatible with any waterproofing system.

10.6.3 ABIS conditions

COMMENTARY ON 10.6.3

For new basement construction, consideration needs to be given to the moisture of the construction process especially when considering the potential for restricted ventilation in subterranean structures.

Two types of defects might occur in any waterproofing system, where a structure is subjected to water pressure, and could mean that the required level of moisture control is not achieved. These defects are either due to poor workmanship and the use of inappropriate materials or defects owing to the specific properties of the material being used.

The system designer should evaluate the possibility of defects and take repairability into account.

10.6.4 Connective and systemic effects

COMMENTARY ON 10.6.4

Good design and workmanship are primary factors in achieving waterproof construction of below ground constructions as well as an appreciation of wider area factors in the adjacent environment. Key considerations are compatibility of waterproofing systems, sealing around joints and junctions of the waterproof membrane and, for integral structural waterproofing systems, attention to the construction joints.

Any waterproofing measure should be continued to a minimum of 150 mm above external ground height and should be compatible and continuous with the above ground measure to control moisture.