



# **Conservation of Fuel and Energy - Buildings other than Dwellings**

## **Building Regulations 2017**

## **Technical Guidance Document**



**An Roinn Tithíochta, Pleanála  
agus Rialtais Áitiúil**

Department of Housing, Planning  
and Local Government





# Building Regulations 2017

## Technical Guidance Document L - Buildings other than Dwellings

### Conservation of Fuel and Energy

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# Buildings Regulations 2017

## Technical Guidance Document L – Conservation of Fuel and Energy for buildings other than Dwellings

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### Introduction

This document has been published by the Minister for the Housing, Planning and Local Government under article 7 of the Building Regulations 1997.

It provides guidance in relation to Part L of the Second Schedule to the Regulations as inserted by Building Regulations (Part L Amendment) Regulations (S.I. No. 538 of 2017). The guidance in this document applies to buildings other than dwellings.

The 2017 Part L Regulations (and this document) partly transpose the EU Energy Performance of Buildings Directive Recast (EPBD Recast) 2010/31/EU of 19th May 2010.

The 2017 amendment to Part L (Conservation of Fuel and Energy) of the Building Regulations and this Technical Guidance Document L, provide for the implementation of requirements of Articles 2,3 4, 6 (part of), 7, 8, 9(3,b) of the EU Energy Performance of Buildings Directive – EPBD (recast) (2010/31/EU of 19 May 2010).

These requirements include:

- application of a methodology for the calculation of the energy performance of buildings on the basis of a general framework set out in Annex I to the EPBD (recast).
- setting of minimum energy performance requirements for buildings and the application of these requirements to new buildings to achieve Nearly Zero Energy Buildings;
- ensuring where buildings undergo major renovation that the renovated systems- and components meet minimum thermal performance requirements in so far as this is technically, functionally and economically feasible.

- ensuring that when a building element that forms part of the building envelope and has a significant impact on the energy performance of the building envelope, is retrofitted or replaced, the energy performance of the building element meets minimum energy performance requirements in so far as this is technically, functionally and economically feasible.

The guidance in this document also gives due regard to the cost-optimal levels of minimum energy performance requirements submitted in Ireland's report to the Commission under Article 5 of the EPBD Recast Directive 2010/31/EU of 19th May 2010.

The 2017 Part L Regulations (and this document) set energy performance requirements to achieve Nearly Zero Energy Buildings performance as required by Article 4 (1) of the Directive for new buildings

The document should be read in conjunction with the Building Regulations 1997-2017 and other documents published under these Regulations.

In general, Building Regulations apply to the construction of new buildings and to extensions and material alterations to existing buildings. In addition, certain parts of the Regulations apply to existing buildings where a material change of use or a major renovation takes place. Otherwise, Building Regulations do not apply to buildings constructed prior to 1 June 1992.

### Transitional Arrangements

In general, this document applies to works, or buildings in which a material alteration or change of use or major renovation takes place, where the work, material alteration or the change of use commences or takes place, as the case may be, on or after 1st January 2019.

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edition) ceases to have effect from 31st December 2018.

However, these documents may continue to be used in the case of buildings:

- where the work, material alteration or the change of use commences or takes place, as the case may be, on or before 31<sup>st</sup> December 2018, or
- where planning approval or permission for buildings has been applied for on or before 31st December 2018, and substantial work has been completed by 1st January 2020

“Substantial work has been completed” means that the structure of the external walls has been erected.

## **The Guidance**

The materials, methods of construction, standards and other specifications (including technical specifications) which are referred to in this document are those which are likely to be suitable for the purposes of the Building Regulations (as amended). Where works are carried out in accordance with the guidance in this document, this will, *prima facie*, indicate compliance with Part L of the Second Schedule to the Building Regulations. However, the adoption of an approach other than that outlined in the guidance is not precluded provided that the relevant requirements of the Regulations are complied with. Those involved in the design and construction of a building may be required by the relevant building control authority to provide such evidence as is necessary to establish that the requirements of the Regulations are being complied with.

## **Technical Specifications**

Building Regulations are made for specific purposes, e.g. to provide, in relation to buildings, for the health, safety and welfare of persons, access for people with disabilities and the conservation of fuel and energy.

Technical specifications (including harmonised European Standards, European Technical Approvals, National Standards and Agrément Certificates) are relevant to the extent that they relate to these considerations.

Any reference to a technical specification is a reference to so much of the specification as is relevant in the context in which it arises. Technical specification may also address other aspects not covered by the Regulations.

A reference to a technical specification is to the latest edition (including any amendments, supplements or addenda) current at the date of publication of this Technical Guidance Document. However, if this version of the technical specification is subsequently revised or updated by the issuing body, the new version may be used as a source of guidance provided that it continues to address the relevant requirements of the Regulations.

## **Materials and Workmanship**

Under Part D of the Second Schedule to the Building Regulations, building work to which the regulations apply must be carried out with proper materials and in a workmanlike manner. Guidance in relation to compliance with Part D is contained in Technical Guidance Document D.

## **Interpretation**

In this document, a reference to a section, paragraph, appendix or diagram is, unless otherwise stated, a reference to a section, paragraph, appendix or diagram, as the case may be, of this document. A reference to another Technical Guidance Document is a reference to the latest edition of a document published by the Department of Housing, Planning, Community and Local Government under article 7 of the Building Regulations 1997. Diagrams are used in this document to illustrate particular aspects of construction - they may not show all the details of construction.

# Conservation of Fuel and Energy

## Buildings other than dwellings

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### Part L – The requirement

The requirements regarding conservation of fuel and energy are laid out in Part L of the Second Schedule to the Building Regulations 1997 (S.I. No.497 of 1997) as amended by the Building Regulations (Part L Amendment) Regulations 2017 (S.I. No 538 of 2017). The Second Schedule, insofar as it relates to works related to buildings other than dwellings is amended to read as:

#### Conservation of Fuel and Energy

L1 A building shall be designed and constructed so as to ensure that the energy performance of the building is such as to limit the amount of energy required for the operation of the building and the amount of Carbon Dioxide (CO<sub>2</sub>) emissions associated with this energy use insofar as is reasonably practicable.

L4 For existing buildings other than dwellings, the requirements of L1 shall be met by: –

- (a) limiting the heat loss and, where appropriate, availing of the heat gains through the fabric of the building;
- (b) providing energy efficient space heating and cooling systems, heating and cooling equipment, water heating systems, and ventilation systems, with effective controls;
- (c) ensuring that the building is appropriately designed to limit need for cooling and, where air-conditioning or mechanical ventilation is installed, that installed systems are energy efficient, appropriately sized and adequately controlled;
- (d) limiting the heat loss from pipes, ducts and vessels used for the transport or storage of heated water or air;
- (e) limiting the heat gains by chilled water and refrigerant vessels, and by pipes and ducts that serve air conditioning systems;
- (f) providing energy efficient artificial lighting systems and adequate control of these systems;
- (g) providing to the building owner or occupants sufficient information about the building fabric, the fixed building services, controls and their maintenance requirements when replaced so that the building can be operated in such a manner as to use no more fuel and energy than is reasonable; and
- (h) when a building undergoes major renovation, the minimum energy performance requirement of the building or the renovated part thereof is upgraded in order to meet the cost optimal level of energy performance in so far as this is technically, functionally and economically feasible.

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L5 For new buildings other than dwellings, the requirements of L1 shall be met by: –

- (a) providing that the energy performance of the building is such as to limit the calculated primary energy consumption and related Carbon Dioxide (CO<sub>2</sub>) emissions to a Nearly Zero Energy Building level insofar as is reasonably practicable, when both energy consumption and Carbon Dioxide emissions are calculated using the Non-domestic Energy Assessment Procedure (NEAP) published by Sustainable Energy Authority of Ireland;
- (b) providing that, the nearly zero or very low amount of energy required is covered to a very significant extent by energy from renewable sources produced on-site or nearby;
- (c) limiting the heat loss and, where appropriate, availing of the heat gains through the fabric of the building;
- (d) providing and commissioning energy efficient space heating and cooling systems, heating and cooling equipment, water heating systems, and ventilation systems, with effective controls;
- (e) ensuring that the building is appropriately designed to limit need for cooling and, where air-conditioning or mechanical ventilation is installed, that installed systems are energy efficient, appropriately sized and adequately controlled;
- (f) limiting the heat loss from pipes, ducts and vessels used for the transport or storage of heated water or air;
- (g) limiting the heat gains by chilled water and refrigerant vessels, and by pipes and ducts that serve air conditioning systems;
- (h) providing energy efficient artificial lighting systems and adequate control of these systems; and
- (i) providing to the building owner or occupants sufficient information about the building, the fixed building services, controls and their maintenance requirements so that the building can be operated in such a manner as to use no more fuel and energy than is reasonable.

# Section 0

## General Guidance

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### 0.1 Application of the Regulations

#### 0.1.1 General

**0.1.1.1** The aim of Part L of the Second Schedule to the Building Regulations is to limit the use of fossil fuel energy and related CO<sub>2</sub> emissions arising from the operation of buildings, while ensuring that occupants can achieve adequate levels of lighting and thermal comfort. Buildings should be designed and constructed to achieve this aim as far as is practicable.

**0.1.1.2** The guidance in this document applies to works to Buildings other than Dwellings only. Guidance for dwellings can be found in a separate Technical Guidance Document L-Dwellings.

**0.1.1.3** The guidance given in this Technical Guidance Document is generally applicable to all works associated with the construction of buildings other than dwellings.

**0.1.1.4** The guidance given in this Technical Guidance Document applies to buildings designed to be heated to temperatures appropriate for human occupancy. Less demanding standards could represent reasonable provision in those buildings or parts of buildings with a low level of heating or where heating provision is not intended. Low level of heating is considered to be where there is an installed heating capacity of less than 10W/m<sup>2</sup> and zones are not designed to be heated to temperatures appropriate for human occupancy. This includes buildings where heating and cooling systems are not provided, or are provided to only heat or cool a localized area rather than

the entire enclosed volume of the space concerned eg. localized radiant heaters at a workstation in a generally unheated space. A low level of heating can also be considered to apply where spaces are heated to a level substantially less than those normally provided for human comfort e.g. to protect a warehouse from condensation or frost. In these situations all fixed building services should meet the guidance for heating systems in section 1.4 or 2.2. Fabric should have a U value appropriate for the heating system provided and in no case greater than 0.7 W/(m<sup>2</sup>K) for opaque fabric. If a part of a building with low energy demand is partitioned off e.g. a heated office in an unheated warehouse then the fabric of the heated partitioned area should meet the guidance for fabric from sections 1.3 or 2.1. Where the occupancy level or level of heating required when in use cannot be established at construction stage, the building should be treated as fully heated and the provisions of Part L applied accordingly. It should be noted that the provisions of Part L apply where a material change of use occurs and such a change of use may require specific construction measures to comply with Part L. These measures may prove more costly than if carried out at the time of initial construction.

In all cases the energy consumption, Carbon Dioxide emissions and energy from renewable sources for new buildings should be modelled in NEAP.

**0.1.1.5** The guidance provided in this document for space heating, cooling, lighting and ventilation systems are appropriate for typical conditioned spaces intended for human occupancy.

Where a building has specialist processes, alternative operational procedures or ventilation requirements other than those

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required for human occupancy different performance specifications may be appropriate.

In the context of this section “specialist processes” can be taken to include any activity or operational profile where the resulting need for heating, hot water, ventilation or air conditioning is significantly different to that required for human occupancy.

The Energy Performance Coefficient (EPC), Carbon Performance Coefficient (CPC) and Renewable Energy Ratio (RER) calculations use the NEAP activities database for occupancy, heating, cooling, ventilation, air conditioning, lighting, equipment parameters and profiles.

The Renewable Energy Ratio calculation should exclude the heating, ventilation and air conditioning system demands determined by specialist process requirements, together with the plant capacity, or proportion of the plant capacity, provided to service specialist processes.

The NEAP methodology sets out the procedures to reflect specialist processes when calculating the Energy Performance Coefficient, Carbon Performance Coefficient and Renewable Energy Ratio.

**0.1.1.6** For shell and core buildings the specification used for the NEAP calculation should be compatible with the intended building end use and servicing strategy. The renewables required should be installed at an early stage in the construction process that ensures that the building will meet the renewables provision for the whole building when completed and prior to occupation of any part of the building. Where practical,

renewable systems should be installed on the shell and core building with the utility connections or with the primary heating and cooling services for the building.

**0.1.1.7** Where a shell has a fit out completed on all or part of the building through the provision or extension of any of the fixed services for heating, hot water, air-conditioning or mechanical ventilation then the Maximum Permitted Energy Performance Coefficient (MPEPC), Maximum Permitted Carbon Performance Coefficient (MPCPC) and Renewable Energy Ratio (RER) should be based on the building shell as constructed and the fixed building services as actually installed.

**0.1.1.8** In large complex buildings it may be sensible to consider the provisions for conservation of fuel and energy separately for the different parts of the building in order to establish the measures appropriate to each part.

## **0.1.2 New buildings other than dwellings**

**0.1.2.1** In accordance with the EU Energy Performance of Buildings Directive Recast (EPBD Recast) 2010/31/EU of 19th May 2010 definition for Nearly Zero Energy Buildings (NZEB) this revision of Part L provides for buildings with a very high energy performance as determined in accordance with Annex I of the Directive. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby.

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**0.1.2.2** The Nearly Zero Energy Building definition as defined in Article 9 of the EU Energy Performance of Buildings Directive Recast (EPBD Recast) 2010/31/EU of 19th May 2010 will be achieved by following the energy and related Carbon Dioxide emissions performance and energy contribution from renewable sources guidance set out in this document.

**0.1.2.3** For new buildings other than dwellings, reasonable provisions to be addressed to achieve Nearly Zero Energy Building performance are;

#### **Whole building performance**

- (a) Primary energy consumption and related CO<sub>2</sub> emissions: providing that the calculated primary energy consumption associated with the operation of the building and the related CO<sub>2</sub> emissions when calculated using the Non-domestic Energy Assessment Procedure (NEAP) published by the Sustainable Energy Authority of Ireland as described in Section 1.1 do not exceed a target value specified in this document;

#### **Individual minimum performance levels**

The performance levels specified for items (b) to (m) below are in the nature of backstop minimum performance levels so as to ensure reasonable levels of performance for all factors affecting energy use, irrespective of the measures incorporated to achieve compliance with Regulation L5(a).

Meeting the performance levels specified for items (b) to (m) will not necessarily mean that the level specified for primary energy consumption and related CO<sub>2</sub> emissions [item (a)] will be met.

One or more of the performance levels specified, for items (b) to (m), will need to be exceeded to achieve this.

- (b) Use of renewable energy sources: providing that the contribution of low or zero carbon energy sources to the calculated primary energy requirement meets the target for such contribution as set down in Section 1.2;
- (c) Fabric insulation: providing for fabric insulation, including the limitation of thermal bridging, which satisfies the guidance in this regard as set out in Section 1.3 (sub-sections 1.3.2 to 1.3.3);
- (d) Air tightness: limiting air infiltration as set out in sub-section 1.3.4;
- (e) Heat generator efficiency: providing an efficient heat generator as set out in sub-section 1.4.1;
- (f) Cooling plant efficiency: providing an efficient chiller or other cooling source as set out in sub-section 1.4.3;
- (g) Building Services Controls: controlling, as appropriate, the demand for, and output of, space heating and cooling and hot water services provided, as set out in subsections 1.4.2 and 1.4.4;
- (h) Mechanical Ventilation Systems: providing that, where a mechanical ventilation system is installed, the system meets reasonable performance levels, as set out in sub-section 1.4.3;
- (i) Air-conditioning and Mechanical Ventilation systems: to limit the need for

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space cooling and, where air-conditioning or mechanical ventilation is installed, provide energy efficient and appropriately sized appliances and equipment, and adequate control of these services; as set out in sub-sections 1.3.5 and 1.4.3

- (j) Limiting the heat loss from pipes, ducts and vessels used for the transport or storage of heated water or air, as set out in sub-section 1.4.5;
- (k) Insulation of pipes, ducts and vessels: to limit the heat gains by chilled water and refrigerant vessels, and by pipes and ducts that serve air-conditioning systems as set out in sub-section 1.4.5.
- (l) Lighting to provide energy efficient artificial lighting systems and adequate control of these systems as set out in 1.4.6; and
- (m) Commissioning: to ensure design and construction process are such that the completed building satisfies compliance targets and design intent. Guidance is given in Section 1.5.

#### **User information**

- (n) Ensure that adequate operating and maintenance instructions are available to facilitate operation in an energy efficient manner. Guidance is given in Section 1.6.

**0.1.2.4** Where a building contains dwellings TGD L Dwellings should be used for guidance for the individual dwellings. This TGD L for Buildings other than Dwellings should be used for guidance for those parts of the building which are not a dwelling such as common areas and in the case of mixed

use developments, the commercial or retail space.

Where a dwelling has an attached room or space that is to be used for commercial purposes (e.g. workshop, surgery, consulting room or office), such room or space should be treated as part of the dwelling if the commercial part could revert to domestic use on a change of ownership, e.g. where there is direct access between the commercial space and the living accommodation, both are contained within the same thermal envelope and the living accommodation occupies a substantial proportion of the total area of the building.

In the case of the Renewable Energy Ratio (RER) the renewables provision should be calculated separately for these common areas.

Where there are both common areas and individual units in a building, reasonable provision would be to show that the average contribution of renewable technologies to all areas meets the minimum level of renewable provision to the individual units and common areas combined. In this case a proportion of renewables should be provided to each area and individual unit in the building.

#### **0.1.3 Existing buildings other than dwellings**

**0.1.3.1** This amendment applies to all works to existing buildings other than dwellings that are covered by the requirements of the Building Regulations, including extensions, material alterations, material changes of use, major renovations and window and door replacement. In carrying out this work, the aim should be to limit energy requirements for



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the operation of the building and associated CO<sub>2</sub> emissions as far as practicable as required by Regulation L1. The key issues to be addressed are: -

- (a) Fabric insulation: providing for fabric insulation, including the limitation of thermal bridging, which satisfies the guidance in this regard as set out in Section 2.1
- (b) Air tightness: limiting air infiltration as set out in sub-section 2.1.4;
- (c) Heat generator efficiency: providing an efficient boiler or other heat source as set out in sub-section 2.2.2;
- (d) Cooling plant efficiency: providing an efficient chiller or other cooling source as set out in sub-section 2.2.4;
- (e) Building Services Controls: controlling, as appropriate, the demand for, and output of, space heating and cooling and hot water services provided, as set out in subsection 2.2.3 and 2.2.5;
- (f) Mechanical Ventilation Systems: providing that, where a mechanical ventilation system is installed the system meets reasonable performance levels, as set out in sub-section 2.2.4;
- (g) Air Conditioning and Mechanical Ventilation: to limit the need for space cooling and, where air-conditioning or mechanical ventilation is installed, provide energy efficient and appropriately

sized appliances and equipment and adequate control of these services as set out in subsection 2.2.4

- (h) limiting the heat loss from pipes, ducts and vessels used for the transport or storage of heated water or air, as set out in sub-section 2.2.6; Insulation of pipes, ducts and vessels: to limit the heat gains by chilled water and refrigerant vessels, and by pipes and ducts that serve air-conditioning systems as set out in subsection 2.2.6;
- (i) Lighting: Guidance is given in sub-section 2.2.7 to provide energy efficient artificial lighting systems and adequate control of these systems
- (j) Performance of completed building and services: providing that design and construction process are such that the completed building and services satisfies compliance targets and design intent as set out in section 2.4

### **User information**

- (k) Ensure that adequate operating and maintenance instructions are available to facilitate operation in an energy efficient manner. Guidance is given in section 2.5

### **Major Renovation**

- (l) providing that where more than 25% of the surface area of the building envelope undergoes renovation the energy performance of the whole building should be improved to Cost Optimal level in so far as this is technically, functionally and economically feasible. Guidance is given in section 2.3.

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## Technical risks and precautions

### General

**0.2.1** The incorporation of additional thickness of thermal insulation and other energy conservation measures can result in changes in traditional construction practice. Care should be taken in design and construction to ensure that these changes do not increase the risk of certain types of problems, such as rain penetration and condensation. Some guidance on avoiding such increased risk is given in Appendix B of this document. General guidance on avoiding risks that may arise is also contained in the publication “Thermal insulation: avoiding risks; Building Research Establishment (Ref BR 262)”.

Guidance in relation to particular issues and methods of construction will be found in relevant standards.

The guidance given in these documents is not exhaustive and designers and builders may have well-established details using other materials that are equally suitable.

### Fire Safety

**0.2.2** Part B of the Second Schedule to the Building Regulations prescribes fire safety requirements. In designing and constructing buildings to comply with Part L, these requirements must be met and the guidance in relation to fire safety in TGD B should be fully taken into account.

The design of ventilation systems should also take account of the guidance in TGD B and the standards referred to by that document.

### Ventilation

**0.2.3** Part F of the Second Schedule to the Building Regulations prescribes ventilation requirements both to meet the needs of the occupants of the building and to prevent excessive condensation in the building and in roofs and roof spaces. A key aim of the provisions in relation to ventilation of occupied spaces is to minimise the risk of condensation, mould growth or other indoor air quality problems. In addition to meeting the requirements of Part F of the Building Regulations, the avoidance of excessive condensation requires that appropriate heating and ventilation regimes be employed in occupied buildings.

Part J of the Second Schedule to the Building Regulations prescribes requirements in relation to the supply of air for combustion appliances, including open-flued appliances which draw air from the room or space in which they are situated. Technical Guidance Document J provides guidance in this regard.

### 0.3 Thermal Conductivity and Thermal Transmittance

**0.3.1** Thermal conductivity ( $\lambda$ -value) relates to a material or substance, and is a measure of the rate at which heat passes through a uniform slab of unit thickness of that material or substance, when unit temperature difference is maintained between its faces. It is expressed in units of Watts per metre per degree (W/mK).

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**0.3.2** For the purpose of showing compliance with this Part of the Building Regulations, design  $\lambda$ -values based on manufacturers declared values should be used. For thermally homogeneous materials declared and design values should be determined in accordance with I.S. EN ISO 10456: 2007. Design values for masonry materials should be determined in accordance with I.S. EN 1745: 2012. For insulation materials, values determined in accordance with the appropriate harmonized European standard should be used. Certified  $\lambda$ -values for foamed insulant materials should take account of the blowing agent actually used. The use of HCFC for this purpose is no longer permitted.

For products or components for which no appropriate standard exists, measured values, certified by an approved body or certified laboratory (see Technical Guidance Document D), should be used.

**0.3.3** Table A1 of Appendix A contains  $\lambda$  values for some common building materials. These are primarily based on data contained in I.S. EN 12524: 2000; I.S. EN ISO 10456:2007 or in CIBSE Guide A, Appendix 3, A7. These publications also include common values for insulation materials. The values provide a general indication of the thermal conductivity that may be expected for these materials. In the absence of declared values, design values or certified measured values as outlined in paragraph 0.3.2, values of thermal conductivity given in Table A1 may be used. However, values for specific products may differ from these illustrative values. Compliance should be verified for thermal insulation materials using thermal conductivity values for these materials derived as outlined in Paragraph 0.3.2 above.

**0.3.4** Thermal transmittance (U-value) relates to a building component or structure, and is a measure of the rate at which heat passes through that component or structure when unit temperature difference is maintained between the ambient air temperatures on each side. It is expressed in units of Watts per square metre per degree of air temperature difference ( $\text{W/m}^2\text{K}$ ).

**0.3.5** Thermal transmittance values (U-values) relevant to this Part of the Regulations are those relating to elements exposed directly or indirectly to the outside air. This includes floors directly in contact with the ground, suspended ground floors incorporating ventilated or unventilated voids, and elements exposed indirectly via unheated spaces e.g. plant rooms. The U-value takes account of the effect of the ground, voids and unheated spaces on the rate of heat loss, where appropriate. Heat loss through elements that separate buildings or other premises that can reasonably be assumed to be heated, is considered to be negligible. Such elements do not need to meet any particular U-value nor should they be taken into account in calculation of CO<sub>2</sub> emissions or overall transmission heat loss.

**0.3.6** A range of methods exists for calculating U-values of building elements. Methods of calculation are outlined in Appendix A, together with examples of their use. Alternatively U-values may be based on certified measured values. Measurements of thermal transmission properties of building components generally should be made in accordance with I.S. EN ISO 8990: 1997, or, in the case of windows and doors, I.S. EN ISO 12567-1:2010.

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**0.3.7** Any part of a roof that has a pitch of 70° or more may be treated as a wall for the purpose of assessing the appropriate level of thermal transmission. Elements separating the building from spaces that can reasonably be assumed to be heated should not be included.

**0.3.8** Appendix B contains guidance on the construction and installation for common forms of construction for roofs, walls and floors. It explains the condensation risk and gives guidance on the use of vapour control layers.

## 0.4 Dimensions

**0.4.1** Except where otherwise indicated linear measurements for the calculation of wall, roof and floor areas and building volumes should be taken between the finished internal faces of the appropriate external building elements and, in the case of roofs, in the plane of the insulation. Linear measurements for the calculation of the areas of external door, window and rooflight openings should be taken between internal faces of appropriate sills, lintels and reveals.

**0.4.2** "Volume" means the total volume enclosed by all enclosing elements and includes the volume of non-usable spaces such as ducts, stairwells and floor voids in intermediate floors

## 0.5 Definitions

For the purposes of this Technical Guidance Document the following definitions apply: -

*Biomass:* Biodegradable fraction of products waste and residues from agriculture (including vegetal and animal substances), forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste, used as a fuel or energy source. Fuels derived from biomass may be in solid, liquid or gas form. In this document, where the term "biomass" is used on its own, it should be taken to mean solid biomass (wood, wood chip, wood pellet, etc).

*Biofuel:* Liquid or gas fuel derived from biomass.

Note: Biomass (including biofuel) is generally included in Delivered Energy and thus, together with the energy used to produce and deliver it, included in Primary Energy

*Building Management System:* A building-wide network which allows communication with control of items of HVAC plant (and other building systems) from a single control centre, which may be local or remote. More advanced ("full") building management systems offer a wide range of functions including sequential control, zone control, weather compensation, frost protection and night set-back as well as energy use monitoring and targeting.

*Curtain Walling:* Part of the building envelope made of a framework usually consisting of horizontal and vertical profiles, connected together and anchored to the supporting structure of the building, and containing fixed and/or openable infills, which provides all the required functions of an internal or external wall or part thereof, but does not contribute to the load bearing or the stability of the structure of the building. Curtain walling is designed as a self-supporting construction which transmits dead-loads, imposed loads, environmental load (wind, snow, etc.) and seismic load to the main building structure.

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*Delivered Energy:* Energy supplied to the building and its systems to satisfy the relevant energy uses, e.g. space heating, water heating, cooling, ventilation, lighting. Delivered energy does not include renewable energy produced on-site. Delivered energy differs from energy use by the extent of on-site conversion and transformation losses, e.g. boiler efficiency losses.

*Energy Use:* (for a particular purpose, e.g. space heating, water heating, cooling, ventilation, lighting): Energy input to the relevant system to satisfy the relevant purpose.

*Free cooling* is generally accepted as the name for a cooling method where outside air at a low temperature is used to condition a building.

Free cooling is usually classified in two groups:

*Indirect* – During cold periods, the outside air is used to cool the cooling system, without the aid of a chiller. Outside air is isolated from the building and cools indirectly via a cooling liquid.

Humidity considerations and control will be the same as with traditional mechanical cooling.

*Direct* – The outside air is used to cool the room directly, and is not isolated from the room. Humidity considerations must be taken into consideration since the building is no longer isolated from the influence of the weather.

*Major Renovation:* means the renovation of a building where more than 25 % of the surface of the building envelope undergoes renovation.

The surface area of the building thermal envelope means the entire surface area of a building through which it can lose heat to the external environment or the ground, including all heat loss areas of walls, windows, floors and roof". The surface area should be calculated as outlined in section 0.4 using internal dimensions.

*Nearly Zero-Energy Building (NZEB):* means a building that has a very high energy performance, as determined in accordance with Annex I of the EU Energy Performance of Buildings Directive Recast (EPBD Recast) 2010/31/EU of 19th May 2010. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby;

*Primary Energy:* Energy that has not been subjected to any conversion or transformation process. For a building, it is the delivered energy plus the energy used to produce the energy delivered to the building. It is calculated from the delivered energy, with an allowance for any energy exported from the site, using conversion factors.

*Renewable Energy:* Energy from renewable non-fossil energy sources, e.g. solar energy (thermal and photovoltaic), wind, hydropower, biomass, aerothermal, geothermal, wave, tidal, landfill gas, sewage treatment plant gas and biogases.

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## **0.6 Application to Buildings of Architectural or Historical Interest**

**0.6.1** Part L does not apply to works (including extensions) to an existing building which is a “protected structure” or a ‘proposed protected structure’ within the meaning of the Planning and Development Act 2000 (No 30 of 2000).

Nevertheless, the application of this Part may pose particular difficulties for habitable buildings which, although not protected structures or proposed protected structures, may be of architectural or historical interest. Works such as the replacement of doors, windows and rooflights, the provision of insulated dry lining and damp-proofing to walls and basements, insulation to the underside of slating and provision of roof vents and ducting of pipework could all affect the character of the structure.

In general, the type of works described above should be carefully assessed for their material and visual impact on the structure.

Relaxation of the values proposed may be acceptable, to the local building control authority, if it can be shown to be necessary in order to preserve the architectural integrity of the particular building.

For more guidance on appropriate measures see “Planning Guidelines No. 9: Architectural Heritage Protection - Guidelines for Planning Authorities” and “Energy Efficiency in Traditional Buildings” published by the Department of the Environment, Heritage and Local Government.

Historic windows and doors should be repaired rather than replaced, and dry lining and damp-proofing should not disrupt or damage historic plasterwork or flagstones and should not introduce further moisture into the structure. Roof insulation should be achieved without damage to slating (either during the works or from erosion due to condensation) and obtrusive vents should not affect the character of the roof.

In specific cases, services and their controls can play a large part in improving energy efficiency. In most traditional buildings, building services such as heating systems, plumbing and electrical installations are not original to the building and there may therefore be some flexibility in altering them.

# Section 1

## New Buildings other than Dwellings

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L1 A building shall be designed and constructed so as to ensure that the energy performance of the building is such as to limit the amount of energy required for the operation of the building and the amount of Carbon Dioxide (CO<sub>2</sub>) emissions associated with this energy use insofar as is reasonably practicable.

L5 For new buildings other than dwellings, the requirements of L1 shall be met by –

- (a) providing that the energy performance of the building is such as to limit the calculated primary energy consumption and related Carbon Dioxide (CO<sub>2</sub>) emissions to a Nearly Zero Energy Building level insofar as is reasonably practicable, when both energy consumption and Carbon Dioxide emissions are calculated using the Non-domestic Energy Assessment Procedure (NEAP) published by Sustainable Energy Authority of Ireland;
- (b) providing that, for buildings a very significant proportion of the energy consumption to meet the energy performance of a the building is provided by renewable energy sources
- (c) limiting the heat loss and, where appropriate, availing of the heat gains through the fabric of the building;
- (d) providing and commissioning energy efficient space heating and cooling systems, heating and cooling equipment, water heating systems, and ventilation systems, with effective controls;
- (e) ensuring that the building is appropriately designed to limit need for cooling and, where air-conditioning or mechanical ventilation is installed, that installed systems are energy efficient, appropriately sized and adequately controlled;
- (f) limiting the heat loss from pipes, ducts and vessels used for the transport or storage of heated water or air;
- (g) limiting the heat gains by chilled water and refrigerant vessels, and by pipes and ducts that serve air conditioning systems;
- (h) providing energy efficient artificial lighting systems and adequate control of these systems.
- (i) providing to the building owner sufficient information about the building, the fixed building services, controls and their maintenance requirements so that the building can be operated in such a manner as to use no more fuel and energy than is reasonable.

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## 1.1 Limitation of Primary Energy Use and CO<sub>2</sub> emissions

**1.1.1** This Section provides guidance on how to show compliance with the requirements in relation to primary energy consumption and CO<sub>2</sub> emissions specified in Regulation L5(a). This framework enables the use of either a simplified building energy method or an approved alternative method. This framework is published by Sustainable Energy Authority of Ireland (SEAI) and calculates the energy consumption and CO<sub>2</sub> emissions associated with a standardised use of a building. The energy consumption is expressed in terms of kilowatt hours per square metre floor area per year (kWh/m<sup>2</sup>/yr) and the CO<sub>2</sub> emissions expressed in terms of kilograms of CO<sub>2</sub> per square metre floor area per year (kg CO<sub>2</sub>/m<sup>2</sup>/yr). Full details of the framework are available on the SEAI website at <http://www.seai.ie>

The NEAP modelling guide, also available on the SEAI website, describes the NEAP methodology. The calculation is based on the energy balance taking into account a range of factors that contribute to annual energy usage and associated CO<sub>2</sub> emissions for the provision of space heating, cooling, water heating, ventilation and lighting of buildings.

The NEAP framework is in accordance with Annex I of the Energy Performance of Buildings Directive (recast) and takes account of:

- Thermal characteristics of the building (shell and internal partitions, etc.); this includes air tightness
- Heating installation and hot water supply, including their thermal characteristics

- Air-conditioning installation
- Natural and mechanical ventilation
- Built-in lighting installation
- Position and orientation of buildings, including outdoor climate
- Passive solar systems and solar protection
- Indoor climatic conditions, including the designed indoor climate

The calculation also deals with the influence of the following aspects of energy performance, where relevant:

- Active solar systems, and other heating and electricity systems based on renewable energy sources
- Electricity produced by combined heat and power
- District or block heating or cooling systems
- Natural lighting

**1.1.2** The performance criteria are based on the relative values of the calculated primary energy consumption and CO<sub>2</sub> emissions of a building being assessed, and similar calculated values for a Reference Building. Details of the performance parameters for the Reference Building are given in Appendix C.



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The criteria are determined as follows:

- Primary energy consumption and CO<sub>2</sub> emissions for both the proposed building and the reference building are calculated using NEAP.
- The calculated primary energy consumption of the proposed building is divided by that of the reference building, the result being the energy performance coefficient (EPC) of the proposed building. To demonstrate that an acceptable Primary Energy consumption rate has been achieved, the calculated EPC of the building being assessed should be no greater than the Maximum Permitted Energy Performance Coefficient (MPEPC). The MPEPC is 1.0.
- The calculated CO<sub>2</sub> emission rate of the proposed building is divided by that of the reference building, the result being the carbon performance coefficient (CPC) of the proposed building. To demonstrate that an acceptable CO<sub>2</sub> emission rate has been achieved, the calculated CPC of the building being assessed should be no greater than the Maximum Permitted Carbon Performance Coefficient (MPCPC). The MPCPC is 1.15.

Each method within the NEAP framework will calculate the EPC and CPC of the building being assessed and clearly indicate whether compliance with the requirements of Regulation L5(a) has been achieved.

The MPEPC and MPCPC represent an improvement in the order of 60% over a similar Part L 2008 building with 20% of its energy provided from onsite or nearby renewables. and provide the numerical indicator for Nearly Zero Energy Buildings.

**1.1.3** The requirements that the calculated EPC and CPC do not exceed the MPEPC and MPCPC respectively, applies to the constructed building. It is considered good practice for designers to calculate the EPC and CPC at early design stage in order to assess alternative design approaches and to ensure that the EPC and CPC requirements can be achieved by the constructed building. It is also open to professional bodies or other industry interests to develop model building designs that can confidently be adopted without the need to calculate EPC and CPC at design stage. However, the use of constructions and service systems which have been assessed at design stage, or other model designs, does not preclude the need to verify compliance by calculating the EPC and CPC when all relevant details of the final construction are known. The use of design management programme and standards such as SEAI Excellence in Energy Efficient Design (EXEED) programme and Clause 8 of I.S. 399 Energy Efficient Design Management can also be used to support the design process for energy efficient buildings.

**1.1.4** The use of renewable and low carbon technologies, such as solar hot water, biomass (e.g. wood and wood pellets) and heat pumps, whether provided to meet the requirements of this Part of the Building Regulations (see Section 1.2) or provided as additional to meeting that requirement, can facilitate compliance with the requirements in relation to primary energy use and CO<sub>2</sub> emissions. As defined, primary energy for the calculation of the EPC and CPC does not include energy derived from on-site renewable energy technologies. In addition, as renewable energy technologies generally are characterised by zero, or greatly reduced, CO<sub>2</sub> emissions, the calculated EPC and/or CPC are reduced by the extent that they

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replace traditional fossil fuels. For certain types of buildings, use of renewables may prove the most practical approach to achieving compliance. The use of centralised renewable energy sources contributing to a heat distribution system serving all buildings in a development or campus may prove to be more practicable than providing separate renewable energy for each new building or new unit individually.

## 1.2 Renewable Energy Technologies

**1.2.1** This section gives guidance on the minimum level of renewable technologies to be provided to show compliance with Regulation L5 (b). Renewable Energy Ratio (RER) is the ratio of the primary energy from renewable energy sources to total primary energy as defined and calculated in NEAP.

The following represents a very significant level of energy provision from renewable energy technologies in order to satisfy Regulation L5 (b); -

- Where the MPEPC of 1.0 and MPCPC of 1.15 is achieved an RER of 0.20 represents a very significant level of energy provision from renewable energy technologies
- Where an EPC of 0.9 and a CPC of 1.04 is achieved an RER of 0.10 represents a very significant level of energy provision from renewable energy technologies

For the purposes of this Section, “renewable energy technologies” means technology products or equipment that supply energy derived from renewable energy sources, e.g. solar thermal systems, on-site solar

photovoltaic systems, biomass systems, systems using biofuels, heat pumps, combined heat and power, aerothermal, geothermal, hydrothermal, wind, biomass and biogases; and other on-site renewables.

**1.2.2** Where a building or campus contains more than one new building, reasonable provision would be to show that:

- every individual new building should meet the minimum provision from renewable energy technologies specified in paragraph 1.2.1 above; or
- the average contribution of renewable technologies to each new building other than a dwelling in the development or campus should meet that minimum level of provision.

**1.2.3** The calculation methodology as described in NEAP will calculate the minimum level of energy provision from renewable technologies.

All ancillary storage equipment and access provisions required to support and operate renewable energy technologies should be fully installed and commissioned.

In the case of systems based on biofuels or biomass, appliances must be designed to run on these fuels only, i.e. incapable of providing thermal energy from fossil fuels, to be accepted as renewable technology for the purposes of this Regulation. For example, a boiler which could operate on either fossil fuel oil or a biofuel mixture would not be considered to be a renewable technology. Similarly a boiler capable of utilising coal or

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peat, in addition to a biomass fuel would not be considered a renewable technology.

**1.2.4** The use of centralised renewable energy sources contributing to a heat distribution system serving all new building units other than dwellings on a campus or part of a development, may prove to be more practicable than providing separate renewable energy for each building individually.

**1.2.5** As an alternative to providing the RER (Renewable Energy Ratio) as outlined in sub-section 1.2.1 the use of a combined heat and power (CHP) system which contributes to the space and water heating energy use would be acceptable.

The primary energy savings due to the use of CHP should be equivalent to the RER of 0.20 or 0.10 as applicable contributing to the thermal energy use within the building. The calculation methodology for the primary energy saving contribution is provided in the NEAP calculation.

The design of the CHP system should take account of the output rating of the appliance and the design thermal profile for the development for which it is designed. It should be suitable for the building application (simultaneous electrical and thermal profile requirements) and not oversized.

Further guidance with regards to the design of CHP systems is available in CIBSE Manual AM 12 Combined Heat and Power in Buildings. Section 4.4 of CIBSE Manual AM 12 details an operating model for CHP sizing and recommends the use of an hour by hour model over a whole year with heat and electricity demand profiles representing an average year.

The optimum size of the CHP plant should maximise the running hours without requiring the shutdown of the unit or rejection of surplus heat as described in CIBSE Manual AM 12.

**1.2.6** Renewable energy technologies should be installed with the appropriate controls to optimize their sequencing and operation.

**1.2.7** Part D of the Building Regulations requires that all works be carried out with proper materials and in a workmanlike manner. "Materials" includes products, components and items of equipment, and guidance is provided on how products, components and items of equipment can be shown to be "proper materials".

Renewable technologies should satisfy the requirements of Part D in the same way as other construction products and materials. A range of standards applicable to renewable energy technologies are given in the "Standards and publications" Section in this document

**1.2.8** To ensure that works are carried out in a "workmanlike manner", the design and installation of renewable energy systems to comply with this guidance should be carried out by a person qualified, trained and with appropriate experience to carry out such work.

**1.2.9** Where appropriate the National Standards Authority of Ireland's SR 50-2: 2011 Code of practice for building services - Part 2: Solar panels may be used for guidance on the installation of solar thermal system.

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## 1.3 Building Fabric

### 1.3.1 General

**1.3.1.1** This section gives guidance on acceptable levels of provision to ensure that heat loss through the fabric of a building is limited insofar as reasonably practicable. Guidance is given on four main issues: -

- insulation levels to be achieved by the plane fabric elements (sub-section 1.3.2);
- thermal bridging (sub-section 1.3.3); and
- limitation of air permeability (sub-section 1.3.4).
- limiting the effects of solar gain and overheating (sub-sections 1.3.5 and 1.3.6).

**1.3.1.2** Unheated areas which are wholly or largely within the building structure and are not subject to excessive air-infiltration or ventilation, e.g. stairwells, corridors in buildings containing retail units, may be considered as within the insulated fabric. In that case, if the external fabric of these areas is insulated to the same level as that achieved by equivalent adjacent external elements, no particular requirement for insulation between a conditioned area and unconditioned areas would arise. It should be noted that heat losses to such unheated areas are taken into account by the NEAP methodology in the calculation of the unit EPC and CPC (see Section 1.1).

### 1.3.2 Fabric Insulation

**1.3.2.1** The derivation of U-values, including those applicable where heat loss is to an unheated space, is dealt with in Paragraphs 0.3.5 to 0.3.8 and Appendix A.

**1.3.2.2** In order to limit heat loss through the building fabric reasonable provision should be

made to limit transmission heat loss by plane elements of the building fabric. Acceptable levels of thermal insulation for each of the plane elements of the building to achieve this are specified in terms of average area-weighted U-value ( $U_m$ ) in Table 1 (Column 2) for each fabric element type. These values can be relaxed for individual elements or parts of elements where considered necessary for design or construction reasons. Maximum acceptable values for such elements or parts of elements are specified in Column 3 of Table 1. Where this relaxation is availed of, the average area weighted values given in Column 2 continue to apply and compensatory insulation measures may be necessary for other elements or parts of elements of that type to ensure that these are met. Where the source of space heating is underfloor heating, a floor U-value of  $0.15 \text{ W/m}^2\text{K}$  should generally be satisfactory.

**1.3.2.3** Reasonable provision would also be achieved if the total heat loss through the roof, wall and floor elements did not exceed that which would be the case if each of the area weighted average U-value ( $U_m$ ) set out in Table 1 were achieved for these elements individually. Where this approach is chosen, the values for individual elements or sections of elements given in Table 1 (Column 3) also apply. For ground floors or exposed floors incorporating underfloor heating, the guidance in paragraph 1.3.2.2 applies.

**1.3.2.4** The area of openings provided should take account of the level of daylight provision appropriate to the building. BS8206-2:2008 and CIBSE Lighting Guide (LG10),

give advice on adequate daylight provision. Natural daylight should be optimised where practical, taking into account the advice of LG10 and BS8206.

Care should be taken in the selection and installation of glazed systems to avoid the risk of condensation. Guidance can be obtained from BRE Report No 262. Thermal insulation: avoiding risks, published by BRE and Appendix D.

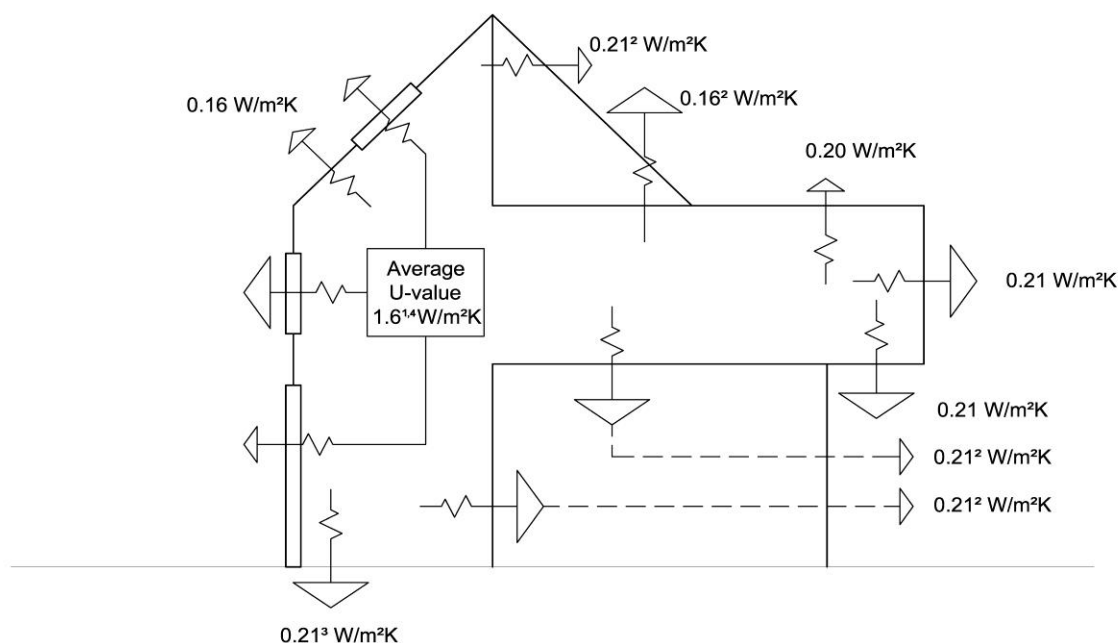
**1.3.2.5** Table 1 and Diagram 1 summarises the fabric insulation standards and allowances applicable in the Elemental Heat Loss method.

Table 1 Maximum elemental U-value <sup>1</sup> (W/m <sup>2</sup> K)		
Column 1 Fabric Elements	Column 2 Area – weighted Average Elemental U-Value (U <sub>m</sub> )	Column 3 Average Elemental U-value Individual element or section of element
Roofs <sup>2</sup>		
Pitched roof		
- Insulation at ceiling	0.16	
- Insulation on slope	0.16	0.3
Flat roof	0.20	
Walls <sup>2</sup>	0.21	0.6
Ground Floors <sup>2,3</sup>	0.21	0.6
Other exposed floors <sup>2</sup>	0.21	0.6
External personnel doors, windows <sup>4</sup> and rooflights <sup>6</sup>	1.6 <sup>5</sup>	3.0
Curtain Walling	1.8	3.0
Vehicle access and similar large doors	1.5	3.0
High usage entrance door <sup>7</sup>	3.0	3.0
Swimming Pool Basin <sup>8</sup>	0.25	0.6
<b>Notes:</b> 1. The U-value includes the effect of unheated voids or other spaces. 2. Reasonable provision would also be achieved if the total heat loss through the roof, wall and floor elements did not exceed that which would be the case if each of the area weighted average U-value (U <sub>m</sub> ) for these elements set out in Column 2 were achieved individually. 3. Where the source of space heating is underfloor heating, a floor U-value of 0.15 W/m <sup>2</sup> K should generally be satisfactory. 4. Excludes display windows and similar glazing but their impact on overall performance must be taken into account in EPC and CPC calculation. 5. In buildings with high internal heat gains a less demanding area-weighted average U-Value for the glazing may be an appropriate way of reducing overall primary energy and CO <sub>2</sub> emissions. Where this can be shown then the average U-value for windows can be relaxed from the values given above. However values should be no worse than 2.2 W/m <sup>2</sup> K. 6. This is the overall U-value including the frame and edge effects, and it relates to the performance of the unit in the vertical plane so, for roof-lights, it must be adjusted for the slope of the roof as described in Sect 11.1 of BR 443 7. High Usage Entrance door means a door to an entrance primarily for the use of people that is expected to experience larger volumes of traffic, and where robustness and/or powered operation is the main performance requirement. To qualify as a high-usage entrance door the door should be equipped with automatic closers and except where operational requirements preclude it, be protected by a lobby. 8. Where a swimming pool is constructed as part of a new building, reasonable provision should be made to limit heat loss from the pool basin by achieving a U Value no worse than 0.25 W/m <sup>2</sup> K as calculated according to BS EN 13370		

**1.3.2.6** A display window is an area of glazing, including glazed doors, intended for the display of products or services on sale within the building, positioned at the external perimeter of the building, at an access level and immediately adjacent to a pedestrian thoroughfare. Glazing that extends to a height of more than 4m above such an access level, or incorporates a fixed or opening light of less than 2m<sup>2</sup>, should not be considered part of a display window except:

- where the size of individual products on display require a greater height of glazing
- where changes to the façade requiring planning (including glazing) require a greater height of glazing, e.g. to fit in with surrounding buildings or to match the character of the existing façade.

**Diagram 1 Average Area Weighted Elemental U-values**



#### NOTES

Average U- values of all elements may vary as set out in Paragraph 1.3.2.3

1. The U-value of 1.6 W/m²K for windows and personnel doors applies
2. The U-values include the effect of unheated voids and other spaces.
3. Refer to Par. 1.3.2.2 for underfloor heating
4. For vehicle access doors and high usage entrance doors refer to Table 1-

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### 1.3.3 Thermal Bridging

**1.3.3.1** To avoid excessive heat losses and local condensation problems, reasonable care should be taken to ensure continuity of insulation and to limit local thermal bridging, e.g. around windows, doors and other wall openings, at junctions between elements and other locations. In general thermal bridges should not pose a risk of surface or interstitial condensation. Heat loss associated with thermal bridges is taken into account in calculating energy use and CO<sub>2</sub> emissions using the NEAP methodology. See Appendix D for further information in relation to thermal bridging and its effect on building heat loss and how this is taken account of in NEAP calculations.

**1.3.3.2** The following represents alternative approaches to making reasonable provision with regard to limitation of thermal bridging: -

- (i) adopt Acceptable Construction Details for wall constructions similar to those for dwellings where appropriate (see Appendix D, Table D1) and/or other certified details (as defined in (ii) below) for all key junctions
- (ii) use certified details which have been assessed in accordance, and comply with Appendix D, e.g. certified by a third party certification body such as Agrément or equivalent; or certified by a member of the NSAI approved thermal modellers scheme or equivalent; or certified thermal bridging details from an accredited database such as the BRE Certified Thermal Details and Products Scheme for all key junctions

- (iii) use alternative details which limit the risk of mould growth and surface condensation to an acceptable level as set out in paragraph D.2 of Appendix D for all key junctions.

Irrespective of which approach is used, appropriate provision for on-site inspection and related quality control procedures should be made (see sub-sections 1.5.2 and 1.5.3).

**1.3.3.3** The NEAP calculation of primary energy use and CO<sub>2</sub> emissions (see Section 1.1) takes account of thermal bridging effects. In general this is done by including an allowance for additional heat loss due to thermal bridging

Where provision for thermal bridging is made in accordance with option (i) of paragraph 1.3.3.2, the transmission heat loss coefficient ( $H_{TB}$ ) should be calculated using the psi values associated with the specific details adopted (i.e. Tables D1 to D6 of DHPLG Acceptable Construction Details or other certified psi values) or default linear thermal transmittances as provided in NEAP .

Where provision for thermal bridging is made in accordance with option (ii) of paragraph 1.3.3.2, the transmission heat loss coefficient ( $H_{TB}$ ) should be calculated using the psi values associated with the certified specific details adopted.

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Where provision for thermal bridging is made in accordance with option (iii) of paragraph 1.3.3.2, default linear thermal transmittances may be used to calculate the heat loss due to thermal bridges as provided for in NEAP.

The calculation of transmission heat loss ( $H_{TB}$ ) coefficient is explained in Appendix D paragraph D.3

The NEAP Modelling Guide also provides information for the inclusion of thermal bridges in NEAP.

#### **1.3.4 Building envelope air permeability**

**1.3.4.1** To avoid excessive heat losses, reasonable care should be taken to limit the air permeability of the envelope of each building. In this context, envelope is the total area of all floors, walls (including windows and doors), and ceilings bordering the building, including elements adjoining other heated or unheated spaces.

High levels of infiltration can contribute to uncontrolled ventilation. Infiltration is unlikely to provide adequate ventilation as required in the correct location. It is important as air permeability is reduced that purpose provided ventilation is maintained.

**1.3.4.2** The following represents a reasonable approach to the design and construction of buildings to ensure acceptable levels of air permeability: -

- (a) identify the primary air barrier elements, (e.g. sheathing, plaster, vapour control

layer, breather membrane) at early design stage;

- (b) develop appropriate details and performance specification to ensure continuity of the air barrier. Communicate these to all those involved in the construction process. Responsibility for construction of details should be established;
- (c) provide on-site inspection regime and related quality control procedures so as to ensure that the design intention is achieved in practice.

**1.3.4.3** Air pressure testing should be carried out on buildings on completion.

See sub-section 1.5.4 for details of the test procedure, extent of testing, use of test results in NEAP calculations and appropriate measures to be undertaken where the limit set is not achieved. When tested in accordance with the procedure referred to in sub-section 1.5.4, a performance level of  $5 \text{ m}^3/(\text{h.m}^2)$  represents a reasonable upper limit for air permeability.

**1.3.4.4** In order to achieve the required performance on completion it may be required to carry out testing both at completion of the shell and, again when the fit-out is completed depending on building complexity. In all cases testing should be performed on building completion.

Section 5 of ATTMA document Technical Standard L2 Measuring Air Permeability of Building Envelopes (Non-Dwellings) provides guidance for large complex buildings.



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In large complex buildings where there is a phased hand-over such as new district general hospitals, airport terminals, large city shopping centres over a significant time period may be part pressure tested to match the phasing of the development.

It is expected that many of these building types can be broken down by department or groups of retail outlets, for instance, which could facilitate part pressure testing.

For large complex buildings with an envelope area in excess of 160,000m<sup>2</sup> such as airport terminals, regional hospitals or large shopping centres where it is not practical to implement a phased pressure testing approach, the alternative approach outlined in Section 5.3 of ATTMA document Technical Standard L2 Measuring Air Permeability of Building Envelopes (Non-Dwellings) may be adopted. In this case the designer should be competent in air tightness design and should confirm that this building is a special case and that appropriate detailing and quality control procedures will be put in place on site to achieve an air permeability of 5 m<sup>3</sup>/(h.m<sup>2</sup>) @50Pa.

Where lower levels of air permeability are achieved it is important that purpose provided ventilation is maintained. It is recommended that ventilation systems are designed for lower levels of air permeability. TGD F and CIBSE Guidance B should be referenced for ventilation guidance when designing for buildings with lower air permeability.

### **1.3.5 Limiting the effects of solar gain in summer**

**1.3.5.1** Buildings should be designed and constructed so that:

- (a) those occupied spaces that rely on natural ventilation do not risk unacceptable levels of thermal discomfort due to overheating caused by solar gain, and
- (b) those spaces that incorporate mechanical ventilation or cooling do not require excessive plant capacity to maintain the desired space conditions.

**1.3.5.2** The following guidance applies to all buildings, irrespective of whether they are air-conditioned or not. The intention is to limit solar gains during the summer period to either:

- (a) reduce the need for air-conditioning; or
- (b) reduce the installed capacity of any air conditioning system that is installed.

**1.3.5.3** For the purposes of Part L , reasonable provision for limiting solar gain through the building fabric would be demonstrated by showing that for each space in the building that is either occupied or mechanically cooled, the solar gains through the glazing aggregated over the period from April to September inclusive are no greater than would occur through one of the following glazing systems with a defined total solar energy transmittance (g-value) calculated according to I.S. EN 410: 2011.

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- (a) For every space that is defined in NEAP database as being side lit, the reference case is an east-facing façade with full width glazing to a height of 1.0m. having a framing factor of 10 per cent and a normal solar energy transmittance (g-value) of 0.68. For every space that is defined in the NEAP as being top lit, and whose average zone height is not greater than 6m. the reference case is a horizontal roof of the same total area that is 10% glazed as viewed from the inside out and having roof lights that have a framing factor of 25% and a normal solar energy transmittance (g-value) of 0.68.
  - (b) For every space that is defined in the NEAP database as being top lit and whose average zone height is greater than 6m, the reference case is a horizontal roof of the same total area that is 20% glazed as viewed from the inside out and having
  - (c) roof-lights that have a framing factor of 15 % and a normal solar energy transmittance (g value) of 0.46.

Note: In double-height industrial type spaces, dirt on roof lights and internal absorption reduce solar gains. These effects combined with temperature stratification will reduce the impact of solar gains in the occupied space and so increased roof light area may be justified. In such situations, particular attention to the design assessments in Par 1.3.5.3 (b).

- (d) For the purpose of this specific guidance, an occupied space means a space that is intended to be occupied by the same person for a substantial part of the day.

This excludes circulation spaces and other areas of transient occupancy such as toilets and spaces not intended for occupation e.g. display windows.

### 1.3.6. Limiting Overheating

The assessment of solar gain in Section 1.3.5 is not an assessment of the internal comfort condition of the building as many other factors have a bearing on comfort e.g. room loads, thermal capacity, ventilation provisions. CIBSE TM 52 provide recommendations for new buildings and adaptation strategies. It is recommended that the designer should perform an overheating assessment in accordance CIBSE TM 52 to ensure overheating is avoided for normally occupied naturally ventilated spaces. Further guidance is provided in NEAP for carrying out the overheating assessment.

**1.3.6.1** CIBSE TM 37 provides the following recommendations and further guidance to reduce or avoid solar overheating:

- (a) *Layout*: planning the layout and orientation of buildings and rooms to maximise the benefits of sunlight and minimise the disadvantages.
- (b) *Solar shading*: this may include external, internal or mid-pane shading devices, or solar control glazing.
- (c) *Thermal mass*: an exposed heavyweight structure, with a long response time, will tend to absorb heat, resulting in lower peak temperatures on hot days. Night time venting and acoustic requirements should also be taken into account.

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- (d) *Good ventilation:* a reasonable level of ventilation will always be required in buildings to maintain indoor air quality. The ability to switch to a much higher air change rate can be a very effective way to control solar overheating. E.g. cross ventilation, stack ventilation or mechanical ventilation
  - (e) *Reducing internal gains:* e.g. energy efficient equipment, lamps and luminaires, and controls
  - (f) *Cooling:* free cooling, mechanical cooling or air conditioning.

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## 1.4: BUILDING SERVICES

### 1.4.1 Heat Generator Efficiency

Heat-generators should be designed and installed so that they operate efficiently over the range of loading likely to be encountered.

1.4.1.1 Energy efficiency standards for heat generator boiler systems are provided in Table 2.

1.4.1.2 The minimum energy performance requirements for heat pumps should meet eco-design Regulation 813/2013 implementing Directive 2009/125/EC with regards to eco-design requirements for space heaters and combination heaters. The methodology for calculating the seasonal coefficient of performance for heat pumps is provided in the NEAP guidance.

Table 2 Minimum energy efficiency standards for boiler systems <sup>1</sup>		
	Gas, oil and biomass-fired boilers	Seasonal efficiency (gross) <sup>2</sup>
Natural Gas	Single or Multiple boiler system > 70kW and ≤ 400kW output	93%
	Single or Multiple boiler system ≤ 70 kW and > 400kW output	86%
LPG	Single or Multiple boiler system > 70kW and ≤ 400kW output	93%
	Single or Multiple boiler system ≤ 70 kW and > 400kW output	86%
Oil	Single or Multiple boiler system > 70kW and ≤ 400kW output	93%
	Single or Multiple boiler system ≤ 70 kW and > 400kW output	86%
Biomass-independent, automatic, pellet/woodchip	Single or Multiple boiler system ≤ 20kW output	75%
	Single or Multiple boiler system > 20kW output	77%

Note 1. EU Regulations implementing the Eco-design Directive set minimum standards for the efficiency of energy using products that can be placed on the market. Products should also comply with these standards as they come into effect. Current regulations are listed at <https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficient-products>

Note 2. Efficiency is the heat output divided by the calorific output of the fuel. The net calorific value of a fuel excludes the latent heat of water vapour in the exhaust, and so is lower than the gross calorific value. Efficiency test results and European standards normally use net calorific values. The calculation methodology for the seasonal efficiency (gross) can be found in NEAP guidance.

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## **1.4.2 Controls for Space Heating and Hot Water Supply Systems**

**1.4.2.1** Space and water heating systems should be effectively controlled so as to limit energy use by these systems to that required to satisfy user requirements and, where appropriate, to protect the building and its contents from damage due to low temperatures. This section is not intended to apply to control systems for specialist or industrial processes.

**1.4.2.2** Buildings should be provided with zone, timing and temperature controls such that, for space heating, each functional area is maintained at the required temperature only during the period when it is occupied. Additional space heating controls may be provided to allow heating during extended unusual occupation hours and to provide for sufficient background heating to prevent condensation or frost damage when the heating system would otherwise be switched off.

**1.4.2.3** Hot water systems should be designed and provided with appropriate controls so that they can be operated efficiently. For efficient operation, hot water systems should not be over-sized and should be designed to avoid low-load operation of heating plant. The layout should minimize the length of circulation loops and minimize the length and diameter of dead legs. Designers should have particular regard to the need to limit the risk of promoting the growth of legionella bacteria. Local instantaneous heaters should be used, where appropriate.

**1.4.2.4** For buildings with a heat generator with an effective rated output for space heating purposes of more than 70kW a full

building management system (BMS) should be installed to control the heat generator(s). A full BMS linked to the heating plant will provide sequential controls of multiple heat generators, full zoned time control and weather compensation where applicable, frost protection or night set-back optimization and monitoring and targeting.

Minimum recommended controls for heat generator systems are specified in Tables 3, 4 and 5.

**1.4.2.5** For buildings with a heat generator with an effective rated output for space heating purposes with an effective rated output of over 70 kW a building automation and control system should be installed for the building with the following functions:

- (a) continuously monitoring, analysing and allowing for adjusting energy usage including that provided by renewable energy technologies;
- (b) benchmarking the building's energy efficiency, detecting losses in efficiency of technical building systems, and informing the person responsible for the facilities or technical building management about opportunities for energy efficiency improvement;
- (c) allowing communication with connected technical building systems and other appliances inside the building, and being interoperable with technical building systems across different types of proprietary technologies, devices and manufacturers, and
- (d) monitoring the energy provided by renewable energy technologies.

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A building automation and control system and a building management system may be integrated into a single system.

**1.4.2.6** Where controls and building management systems are installed they should be commissioned by competent persons and commissioning records kept for handover information. See section 1.5.

**Table 3 Minimum controls packages for new boilers and multiple boiler systems**

Effective rated Space Heating output	Package	Minimum Controls
<70kW	A	Timing and temperature demand control which should be zone specific where the building floor area is greater than 150m <sup>2</sup>  Weather compensation except where a constant temperature supply is required
70kW to 500kW	B	The BMS should include: (a) Controls package A above. (b) Optimum start/stop control with either night set-back or frost protection outside occupied periods. (c) Sequence control on multiple boilers to provide efficient part load performance. Note: The heat loss from non-firing boiler modules should be limited by design or application. For boilers that do not have low standing losses it may be necessary to install isolation valves or dampers
> 500kW individual boilers	C	Controls Package A and controls package B  For gas-fired boilers and multi-stage oil-fired boilers, fully modulating boiler controls

Table 4 Minimum controls packages for new heat pump systems			
Heat Source/sink	Technology	Minimum Controls package	
All types	All technologies	A	a. On/off zone controls. If the unit serves a single zone, and for buildings with a floor area of 150m <sup>2</sup> or less, the minimum requirements is achieved by default. b. Time control.
Air –to- air	Single package Split package Multi- split system  Variable refrigerant flow system	B	a. Controls package A above b. Heat pump unit controls for: (i) control of room air temperature (if not provided externally) (ii) control of outdoor fan operation (iii) defrost control of external airside heat exchanger (iv) control for secondary heating (if fitted) c. External room thermostat (if not provided in the heat pump unit) to regulate the space temperature and interlocked with heat pump unit operation.
Water –to-air	Single package energy transfer systems (matching heating/ cooling demanding buildings)	D	a. Controls package A above b. Heat pump unit controls for: (i) control of room air temperature (if not provided externally) (ii) control of outdoor fan operation for cooling tower or dry cooler (energy transfer systems) (iii) control for secondary heating (if fitted)on air-to-air systems (iv) control of external water pump operation c. External room thermostat (if not provided in the heat pump unit) to regulate the space temperature and interlocked with heat pump unit operation.
Air –to- water Water-to- water Ground-to- water	Single package Split package  Variable refrigerant flow system	E	a. Controls package A above b. Heat pump unit controls for: (i) control of room air temperature (internal and external as appropriate) (ii) control of water temperature for the distribution system (iii) control of outdoor fan operation for air-to-water units (iv) defrost control of external airside heat exchanger for air-to-water systems c. External room thermostat (if not provided in the heat pump unit) to regulate the space temperature and interlocked with heat pump unit operation.
Gas-engine-driven heat pumps are currently available only as variable refrigerant flow warm air systems	Multi-split  Variable refrigerant flow	F	a. Controls package A above b. Heat pump unit controls for: (i) control of room air temperature (if not provided externally) (ii) control of outdoor fan operation (iii) defrost control of external airside heat exchanger (iv) control for secondary heating (if fitted) c. External room thermostat (if not provided in the heat pump unit) to regulate the space temperature and interlocked with heat pump unit operation

<b>Table 5 Minimum controls packages for new primary and secondary electric heating systems other than electric boilers.</b>			
<b>Type of electric heating system</b>	<b>Type of control</b>	<b>Standard</b>	<b>Comments</b>
Warm air	Time and temperature control, either integral to the heater or external	A. A time switch /programmer and room thermostat, or B. A programmable room thermostat	
	Zone control	C. For buildings with a total usable floor area greater than 150m <sup>2</sup> , at least two space heating circuits with independent timing and temperature controls using either: i. Multiple heating zone programmers, or ii. A single multi-channel programmer	
Radiant heaters	Zone or occupancy control	A. Connection to a passive infra-red detector	Electric radiant heaters can provide zone heating or be used for a full heating scheme. Common electric radiant heaters include the quartz and ceramic types
Panel/skirting heaters	Local time and temperature control	A. control provided by: i. a programmable switch integrated into the appliance, or ii. a separate time switch. B. Individual temperature control provided by: i. integral thermostats ii. separate room thermostats	Panel heater systems provide instantaneous heat
Storage heaters	Charge control	A. Automatic control of input charge (based on an ability to detect the internal temperature and adjust the charging of the heater accordingly)	
	Temperature control	B. Manual controls for adjusting the rate of heat release from the appliance, such as adjustable damper or some other thermostatically controlled means	
Fan/ fan convactor heaters	Local fan control	A. A switch integrated into the appliance, or, B. A separate remote switch	
	Individual temperature control	C. Integral switches, or, D. Separate remote switches	



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### **1.4.3 Air Conditioning and Mechanical Ventilation (ACMV)**

**1.4.3.1** Buildings should be designed and constructed in such a way that:

- (a) the form and fabric of the building do not result in a requirement for excessive installed capacity of ACMV equipment for cooling purposes, and
- (b) the ventilating and cooling systems installed are energy efficient and are capable of being controlled to achieve optimum energy efficiency

**1.4.3.2** Natural ventilation strategies used should be considered appropriate for the building geometry.

Particular attention should be paid to limiting solar gains by ensuring that areas of the external building fabric which are susceptible to solar gain have appropriate areas of solar shading.

**1.4.3.3** A mixed-mode building integrates the use of air conditioning when and where it is necessary, with use of natural ventilation whenever it is feasible or desirable, to maximise occupant comfort whilst reducing energy use (compared to 'year round' use of air conditioning). CIBSE Guide AM 13 Mixed Mode Ventilation provides guidance on mixed mode design.

**1.4.3.4** Free cooling may be optimised in order to minimise the need for mechanical ventilation and air conditioning. When the external air temperature is higher than the space temperature the system design should allow the provision of a minimum level of

fresh air. Enthalpy control should also be considered to improve free cooling. The SEAI Guide to "Relative Humidity in Data Centres" explains how free cooling operates in the Irish Climate. BSRIA guide BG 8/2004 Free Cooling Systems also provides guidance on the design of free cooling systems. Where free cooling is used air-conditioning systems are still required to have heat recovery systems as required by Commission Regulation (EU) 1253/2014 with regard to eco-design requirements for ventilation units.

**1.4.3.5** Buildings that use mechanical ventilation or air conditioning systems should be designed and constructed such that:

- (a) the form and fabric of the building do not result in a requirement for excessive installed capacity of ACMV equipment. In particular, the suitable specification of glazing ratios and solar shading are an important way to limit cooling requirements (see Section 1.3.5 and 1.3.6);
- (b) components such as fans, pumps and refrigeration equipment are reasonably efficient and appropriately sized so as to have no more capacity for demand and standby than is necessary for the task;
- (c) suitable facilities are provided to manage, control and monitor the operation of the equipment and the systems.

**1.4.3.6** Specific fan power (SFP) of an air distribution system means the sum of the design circuit-watts of the system fans that supply air and exhaust it outdoors, including

losses through switchgear and controls such as inverters (i.e. the total circuit-watts for the supply and extract fans), divided by the design air flow rate through that system.

The specific fan power of an air distribution system should be calculated according to the procedure set out in I.S. EN 13779:2007 Annex D Calculation and application of Specific Fan Power.(See Appendix E)

**1.4.3.7** The specific fan power of air distribution systems at the design flow rate should be no worse than in Table-6. Specific fan power is a function of the system resistance that the fan has to overcome to provide the required flowrate. I.S. EN 13779:2007 Table A8 provides guidance on system pressure drop. To minimize specific

fan power it is recommended that the low range is used as a design target.

Where the primary air and cooling is provided by central plant and by an air distribution system that includes the additional components listed in Table 6a, the allowed specific fan powers may be increased by each of the values shown in Table 6a to account for the additional resistance.

Ventilation fans driven by electric motors should comply with European Commission Regulation No. 327/2011 implementing Directive 2009/125/EC with regard to ecodesign requirements for fans driven by motors with an electric input power between 125W and 500 kW.

**Table 6 Maximum specific fan power in air distribution systems**

System type	SFP (W/(l/s))
Central balanced mechanical ventilation system with heating and cooling	1.6
Central balanced mechanical ventilation system with heating only	1.5
All other central balanced mechanical ventilation systems	1.1
Zonal supply system where fan is remote from zone, such as ceiling void or roof-mounted units	1.1
Zonal extract system where fan is remote from zone	0.5
Zonal supply and extract ventilation units, such as ceiling void or roof units serving single area with heat recovery	1.9
Local balanced supply and extract ventilation system such as wall/roof units serving single area with heat recovery	1.6
Local supply or extract ventilation units such as window/wall/roof units serving single area (e.g. toilet extract)	0.3
Other local ventilation supply or extract units	0.5
Fan assisted terminal VAV unit	1.1
Fan coil unit (rating weighted average <sup>1,2</sup> )	0.5
Kitchen extract, fan remote from zone with grease filter	1.0

Note 1: The rating weighted average is calculated by the following formula:

$$\frac{P_{mains1} \times SFP1 + P_{mains2} \times SFP2 + P_{mains3} \times SFP3 + \dots}{P_{mains1} + P_{mains2} + P_{mains3}}$$

Where  $P_{mains}$  is useful power supplied from the mains

Note 2:NEAP allows for a value of SFP for system terminal units, so this figure should not be added to the SFP for the fan coil units when entering the data into NEAP

<b>Table-6a Extending specific fan power for additional components</b>	
Component	SFP(W/(l/s)
Additional return filter for heat recovery	+0.1
HEPA filter <sup>1</sup>	+1.0
Heat Recovery –Thermal Wheel system	+0.3
Heat Recovery-other systems	+0.3
Humidifier/Dehumidifier(air conditioning systems)	+0.1
Note 1 HEPA filtration is recognized as an option in NEAP. The pressure drop can be specified or NEAP will assume a default value from the NEAP activity database.	

**1.4.3.8** Air distribution in new buildings should meet the following recommended minimum standards:

- (a) Air handling systems should be capable of achieving a specific fan power at 25% of design flow rate no greater than that achieved at 100% design flow rate. This can be achieved by providing efficient variable flow control systems incorporating, for instance, variable speed drives or variable pitch axial fans. More detailed guidance is given in Action Energy General Information, Report 41 (GIR041) Variable flow control, General Information, published by BRECSU.
- (b) In order to aid commissioning and to provide flexibility for future changes of use, reasonable provision would be to equip with variable speed drives those fans that are rated at more than 1100W and which form part of the environmental control systems,

including smoke control fans used for control of overheating. The provision is not applicable to smoke control fans and similar ventilation systems only used in abnormal circumstances.

**1.4.3.9** In order to limit air leakage, ventilation ductwork should be made and assembled so as to be reasonably airtight. This may be achieved by following the guidance in EN Standards I.S. EN1507 2006, I.S. EN12237;2003 and I.S. EN 13403;2003

In order to limit air leakage air handling units should be made and assembled so as to be reasonably airtight. This may be demonstrated by achieving Class L2 air leakage as given in I.S. EN 1886 2007.

#### **1.4.3.10 Cooling System**

Cooling system means the complete system that is installed to provide comfort cooling to the space. It includes the cooling plant and the system by which the cooling medium effects cooling in the relevant zone and associated controls. This will in some cases be a complete packaged air conditioner.

Cooling plant means that part of a cooling system that produces the supply of cooling medium. It does not include means of distributing the cooling medium or the delivery of the cooling into the relevant zone. It may consist of a single chiller or series of chillers.

**1.4.3.11** The minimum seasonal space cooling energy efficiency of cooling products should be as provided for in the Eco-design Regulations.

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Seasonal energy efficiency ratio (*SEER*) as defined by Eco-design Regulations is the overall energy efficiency ratio of the air conditioner or comfort chiller, representative for the cooling season, calculated as the reference annual cooling demand divided by the annual energy consumption for cooling; - The relevant Eco-design Regulations are:-

- Commission Regulation (EU) 2016/2281 for the setting of eco-design requirements for energy-related products, with regard to eco-design requirements for air heating products, cooling products, high temperature process chillers and fan coil units
- Commission Regulation (EU) No 206/2012 with regard to eco-design requirements for air conditioners and comfort fans

#### **1.4.4 ACMV Controls**

1.4.4.1 Systems should be provided with appropriate controls to enable the achievement of reasonable standards of energy efficiency in use, in normal circumstances, the following features would be appropriate for air-conditioning and mechanical ventilation systems and controls

- (a) The systems should be divided into separate control zones to correspond to each area of the building that has a significantly different solar exposure or type of use; and
- (b) Each separate control zone should be capable of independent timing and temperature control and, where appropriate, ventilation and air recirculation rate; and

(c) The provision of the service should respond to the requirements of the space it serves. If both heating and cooling are provided they should be controlled so as not to operate simultaneously unless required for humidification control.

(d) Central plant should only operate as and when the zone systems require it. The default condition should be off.

(e) In addition to these general control provisions the systems should meet general control and efficiency standards as set out in Pars 1.4.4.2 and 1.4.4.3

**1.4.4.2** A minimum controls package should be provided as in Table 7 for air distribution-systems.

**1.4.4.3** Where the effective rated output of the air-conditioning systems is greater than 70kW a Building Management System should be installed which provides centralized control. A full BMS linked to the air conditioning systems will provide full zoned time control and weather compensation where applicable, frost protection or night set-back optimization. In larger or more complex buildings, the guidance contained in CIBSE Guide H: Building Control Systems may also be followed.

<b>Table 7 Minimum controls for air distribution systems from I.S. EN 15232:2012</b>		
System type		Controls package
Central mechanical ventilation with heating, cooling or heat recovery	Air flow control at air handler level	On/Off time control
	Heat exchanger defrosting control	Defrost control so that during cold periods ice does not form on the heat exchanger
	Heat exchanger-overheating control	Overheating control so that when the system is cooling and heat recovery is undesirable, the heat exchanger is stopped modulated ore bypassed
	Supply temperature control	Variable set point with outdoor temperature compensation
	Air flow control at air handler level	On/off time control
Central Mechanical ventilation with heating or heat recovery	Heat exchanger defrosting control	Defrost control so that during cold periods ice does not form on the heat exchanger
	Heat exchanger overheating control	Overheating control so that when the system is cooling and heat recovery is undesirable, the heat exchanger is stopped, modulated or bypassed
	Supply Temperature Control	Demand control
	Air flow control at room level	On/off time control
	Air flow control at handler level	No Control
Zonal	Supply temperature control	No control
	Air flow control at room level	On/off
	Air flow control at air handler level	No Control
Local	Supply temperature control	No Control

**1.4.4.4** For buildings with an effective rated output for air-conditioning systems of over 70 kW a building automation and control system should be installed for the building with the following functions:

- (a) continuously monitoring, analysing and allowing for adjusting energy usage;
- (b) benchmarking the building's energy efficiency, detecting losses in

efficiency of technical building systems, and informing the person responsible for the facilities or technical building management about opportunities for energy efficiency improvement;

- (c) allowing communication with connected technical building systems and other appliances inside the building, and being interoperable with

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technical building systems across different types of proprietary technologies, devices and manufacturers, and

- (d) monitoring the energy provided by renewable energy technologies.

A building automation and control system and a building management system may be integrated into a single system.

**1.4.4.5** Where controls and building management systems are installed they should be commissioned by competent persons and commissioning records kept for handover information.

#### **1.4.5 Insulation of storage vessels, pipes and ducts**

**1.4.5.1** This section only applies to pipes, ducts and vessels for the provision of space heating, space cooling (including chilled water and refrigerant pipework) and hot water supply for normal occupation. It does not apply to pipes, ducts and vessels associated with specialist or industrial processes.

**1.4.5.2** Hot water storage vessels, pipes and ducts associated with the provision of heating and hot water in a building should be insulated to limit heat loss, except where the heat flow through the wall of the pipe, duct or vessel is always useful in conditioning the surrounding space. Storage vessels for chilled water and refrigerant, and pipes and ducts that serve air-conditioning systems should be insulated to limit heat gain from the surrounding environment.

**1.4.5.3** Provision of insulation to pipes, ducts and storage vessels, in accordance with the standards specified in BS 5422: 2009, should adequately limit heat loss or heat gain, as appropriate. The appropriate insulation level for storage vessels should be taken as that given in BS 5422: 2009 for flat surfaces.

**1.4.5.4** It should be noted that water pipes and storage vessels in unheated areas will generally need to be insulated for the purpose of protection against freezing. Guidance on suitable protection measures is given in Technical Guidance Document G and BRE Report 262 Thermal insulation;- avoiding risks.

#### **1.4.6 Artificial Lighting**

**1.4.6.1** This Section provides guidance for the following types of lighting:

- general interior lighting
- display lighting

**1.4.6.2** For the purposes of this section the definitions for lighting are provided in Appendix F.

**1.4.6.3** General purpose artificial lighting systems shall be designed and controlled so as to ensure the efficient use of energy for this purpose.

**1.4.6.4** The aim of lighting controls should be to encourage the maximum use of daylight and to avoid unnecessary artificial lighting, particularly when spaces are unoccupied, having regard to the need to ensure that the operation of automatically switched lighting systems does not endanger occupants in a building. BS 8206: Part 2: 2008 Code of Practice for daylight and CIBSE Lighting

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Guide LG 10 gives advice on adequate daylight provision.

**1.4.6.5** Lighting controls in buildings should follow the guidance in BRE Digest 498 Selecting Lighting Controls. Display lighting where provided should be controlled on dedicated circuits that can be switched off when not required.

Adequate control depends on the nature and use pattern of the building. This may be achieved by one, or more, of the following means, used alone or in combination, as appropriate. Detailed guidance on the application of the following methods is provided in Table 2 of BRE Digest 498 Selecting Lighting Controls.

- (a) local manually operated switches in easily accessible positions within each working area or at boundaries between working areas and general circulation routes. The distance on plan from any local switch to the luminaires it controls should generally be not more than six metres, or twice the height of the light fitting above the floor if this is greater;
- (b) daylight-linked photo-electric switching or dimming for lighting adjacent to windows or other sources of natural light;
- (c) remote controlled switches operated by infrared transmitter, sonic, ultrasonic or telephone handset controls;
- (d) automatic switching systems which switch the lighting off when they sense the absence of occupants;
- (e) time-controlled switches.

All the above types of control can form part of a lighting or building energy management system. These enable a range of additional

functions including remote operation and management of lighting systems.

**1.4.6.6** Lighting in new buildings should meet the minimum standards for:

- (i) efficacy (averaged over the whole area of the applicable type of space in the building) and controls in column 3 of Table 8

OR

- (ii) maximum Lighting Energy Numeric Indicator (LENI) (kWh/m<sup>2</sup>/year) listed in Table 9. LENI is based on BS EN 15193:2007 Energy Performance of Buildings - Energy Requirements for Lighting. The LENI should be calculated using the procedure in Appendix F to meet the maximum values in Table 9.

<b>Table 8 Lighting Efficacy with controls in new buildings</b>		
<b>General lighting in office, industrial and storage spaces</b>		<b>Initial luminaire lumens/circuit watt</b>
		<b>60</b>
<b>Controls</b>	<b>Control Factor</b>	<b>Reduced luminaire lumens/circuit-watt<sup>1</sup></b>
<b>Column 1</b>	<b>Column 2</b>	<b>Column 3</b>
(a) daylight <sup>2</sup> space with photo-switching with or without override	0.90	54
(b) daylight <sup>2</sup> space with photo-switching and dimming with or without override	0.85	51
(c) unoccupied space with auto on and off	0.90	54
(d) unoccupied space with manual on and auto off	0.85	51
(e) space not daylight dimmed for constant illuminance	0.90	54
a + c	0.80	48
a + d	0.75	45
b + c	0.75	45
b + d	0.70	42
e + c	0.8	48
e + d	0.75	45
General lighting in other types of space		The average initial efficacy should be not less than 60 lamp lumens/circuit watt
Display lighting		The average initial efficacy should be not less than 22 lamp lumens/circuit watt
<sup>1</sup> In calculating the reduced luminaire lumens/circuit-watt for each luminaire the Initial luminaire lumens/circuit watt is multiplied by the appropriate control factor.		
<sup>2</sup> The zones for which daylighting controls can be applied are described in NEAP zoning rules		



**Table 9 Maximum LENI (kWh per square metre per year) in new buildings**

Hours			Illuminance (lux)								Display lighting	
Total	Day	Night	50	100	150	200	300	500	750	1000	Normal	Shop window
1000	821	179	1.11	1.92	2.73	3.54	5.17	8.41	12.47	16.52	10.00	
1500	1277	223	1.66	2.87	4.07	5.28	7.70	12.53	18.57	24.62	15.00	
2000	1726	274	2.21	3.81	5.42	7.03	10.24	16.67	24.70	32.73	20.00	
2500	2164	336	2.76	4.76	6.77	8.78	12.79	20.82	30.86	40.89	25.00	
3000	2585	415	3.31	5.72	8.13	10.54	15.37	25.01	37.06	49.12	30.00	
3700	3133	567	4.09	7.08	10.06	13.04	19.01	30.95	45.87	60.78	37.00	
4400	3621	779	4.89	8.46	12.02	15.59	22.73	37.00	54.84	72.68	44.00	96.80
5400	4184	1216	6.05	10.47	14.90	19.33	28.18	45.89	68.03	90.17	54.00	
6400	4547	1853	7.24	12.57	17.89	23.22	33.87	55.16	81.79	108.41	64.00	
8760	4380	4380	10.26	17.89	25.53	33.16	48.43	78.96	117.12	155.29	87.60	192.72

## 1.5 Construction quality and commissioning of services

### 1.5.1 General

**1.5.1.1** The requirements of Part L apply to the completed building. Reasonable measures should be taken during construction and appropriate checks and assessments carried out prior to completion to ensure that compliance with Part L is achieved. Sub-sections 1.5.2 to 1.5.5 give guidance on appropriate measures to satisfy this requirement.

### 1.5.2 Insulation continuity and air permeability

**1.5.2.1** The elements that comprise the external fabric of the building should be designed and constructed to ensure that the calculated performance of the building and of its components is achieved in practice. Changes made during design and construction should be assessed for their impact on insulation performance and on air permeability. Those not directly involved in the installation of insulation should be fully aware of the importance of not reducing the

effectiveness of the installed insulation through removal or damage. On-site quality control should include checks on the adequacy of insulation installation and of any barriers designed to limit air permeability, including an inspection of finished work to ensure that all work is properly constructed before covering over.

### 1.5.3 Thermal bridging

**1.5.3.1** There should be no reasonably avoidable thermal bridging, e.g. due to gaps between insulation layers and at joints, junctions and edges around openings. Where unavoidable thermal bridging is provided for in the design, care should be taken to ensure that the chosen design detail is accurately constructed on site.

### 1.5.4 Air permeability pressure tests

**1.5.4.1** Air permeability can be measured by means of pressure testing of a building prior to completion. The procedure for testing is specified in I.S. EN ISO 9972: 2015 "Thermal performance of buildings: determination of air

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permeability of buildings: fan pressurization method". Detailed guidance on testing procedure is given in ATTMA TSL2 publication "Measuring air permeability of Building Envelopes" and additional guidance is provided in CIBSE Technical Manual TM 23 "Testing Buildings for Air leakage". The preferred test method is that controllable ventilator grills should be temporarily sealed rather than just closed. When testing there should be an unobstructed route for the air to flow from the fans. All internal areas of the building should be connected by adequate openings at least the area of a fully opened single leaf door, to achieve even internal pressure distribution of the tested building.

Permeability is calculated by dividing the air leakage rate in  $\text{m}^3/\text{hr}$  by the envelope area in  $\text{m}^2$ . The performance is assessed at 50 Pascals pressure difference. Guidance on appropriate extent of testing is given in paragraphs 1.5.4.2 and 1.5.4.3.

**1.5.4.2** Subject to the guidance in paragraph 1.3.4.4, air pressure testing should be carried out on all buildings, as outlined in paragraphs 1.5.4.3 to 1.5.4.5 to show attainment of backstop value of  $5 \text{ m}^3/\text{hr}/\text{m}^2$ . The tests should be carried out by a person certified by an independent third party to carry out this work, e.g. Irish National Accreditation Body or National Standards Authority of Ireland certified or equivalent. The test report should contain at least the information specified in Section 7 of I.S. EN ISO 9972: 2015.

**1.5.4.3** If the measured air change rates are not worse than the criterion set out in paragraph 1.3.4.3, the test results should be taken as satisfactory evidence that the requirements of Part L5(c), insofar as it relates to air tightness, has been

demonstrated for this building. If satisfactory performance is not achieved in a particular test, then remedial measures should be carried out on the test building and a new test carried out. This should be repeated until the building achieves the criterion set out in paragraph 1.3.4.3.

**1.5.4.4** Where the air permeability assumed for the NEAP calculations is better than the value derived from pressure test results, a check calculation should be carried out to show that the calculated EPC and CPC using the measured air permeability (after any remedial works to satisfy paragraph 1.3.4.4, if such are necessary) are not worse than the MPEPC and MPCPC respectively. If necessary, additional remedial works or other measures should be carried out to ensure that this criterion is also met. Where further remedial works to reduce air permeability are undertaken, a further test would be necessary to verify revised air permeability figure to be used in revised NEAP calculations.

**1.5.4.5** Air pressurisation test reports should be retained by the developer of the building as proof of performance, and copies included in the user information referred to in Section 1.6.

## **1.5.5 Commissioning space and water heating systems, Air-Conditioning and Mechanical Ventilation systems and Renewable systems**

**1.5.5.1** The heating and hot water system(s), air conditioning and mechanical ventilation systems and renewable systems should be commissioned so that at completion, the system(s) and their controls are left in the

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intended working order and can operate efficiently for the purposes of the conservation of fuel and energy. The design should be reviewed to ensure systems, plant, equipment and components meet commissionability, maintainability, functionality, usability and operational performance requirements. The key elements of a commissioning plan, identifying the systems that need to be tested and the tests that will be carried out should be developed at the design stage. The BSRIA Job Book A project framework for engineering services BG1/2009 provides further useful information on commissioning of buildings.

**1.5.5.2** Ductwork leakage testing should be carried out on Class C and Class D ductwork where required by and in accordance with the procedures set out in B&ES DW/143 and B&ES DW/144 on systems served by fans with a design flow greater than 1m<sup>3</sup>/s.

If ductwork fails to meet the leakage standard, remedial work should be carried out as necessary to achieve satisfactory performance in retests and further ductwork sections should be tested as set out in DW/143

## **1.6 User information**

### **1.6.1 General**

The owner or occupants of the building should be provided with sufficient information about the building, the fixed building services and their maintenance requirements so that the building can be operated in such a manner as to use no more fuel and energy than is reasonable in the circumstances. A way of complying would be to provide a suitable set of operating and maintenance instructions aimed at achieving economy in

the use of fuel and energy in a way that the building owner or occupants can understand as applicable eg. manuals and/or digital media. The instructions should be directly related to the particular system(s) installed in the building. Without prejudice to the need to comply with health and safety requirements, the instructions should explain to the owner or occupier of the building how to operate the system(s) efficiently. This should include: -

- (a) drawings and manuals necessary to operate and maintain the energy using equipment in the buildings e.g. boilers, chillers, pumps and fans, lighting, building management systems
- (b) the monitoring of energy use and making of adjustments to the control settings for energy using equipment;
- (c) routine maintenance is needed to enable operating efficiency to be maintained at a reasonable level through the service life(lives) of the system(s).
- (d) details of the renewable systems installed and the optimal approach for operating, controlling and sequencing the renewable system(s).

## Section 2

# Existing Buildings other than Dwellings

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L4	For existing buildings other than dwellings, the requirements of L1 shall be met by –
(a)	limiting the heat loss and, where appropriate, availing of the heat gains through the fabric of the building;
(b)	providing energy efficient space heating and cooling systems, heating and cooling equipment, water heating systems, and ventilation systems, with effective controls;
(c)	ensuring that the building is appropriately designed to limit need for cooling and, where air-conditioning or mechanical ventilation is installed, that installed systems are energy efficient, appropriately sized and adequately controlled;
(d)	limiting the heat loss from pipes, ducts and vessels used for the transport or storage of heated water or air;
(e)	limiting the heat gains by chilled water and refrigerant vessels, and by pipes and ducts that serve air conditioning systems;
(f)	providing energy efficient artificial lighting systems and adequate control of these systems.
(g)	providing to the building owner sufficient information about the building fabric, the fixed building services, controls and their maintenance requirements when replaced so that the building can be operated in such a manner as to use no more fuel and energy than is reasonable.
(h)	when buildings undergo major renovation, the minimum energy performance requirement of the building or the renovated part thereof is upgraded in order to meet the cost optimal level of energy performance in so far as this is technically, functionally and economically feasible.

### 2.1 BUILDING FABRIC

#### 2.1.1 General

**2.1.1.1** This section gives guidance on acceptable levels of provision to ensure that heat loss through fabric elements provided by way of extension, material alteration, or material change of use to an existing building is limited insofar as reasonably practicable.

Guidance is given on three main issues: -

- insulation levels to be achieved by the plane fabric elements (sub-section 2.1.2);
- thermal bridging (sub-section 2.1.3); and
- limitation of air permeability (sub-section 2.1.4).

Where a material change of use of an existing building occurs, the performance of the fabric elements of the newly provided building should also meet the performance levels specified in this sub-section.

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**2.1.1.2** Where fabric upgrades result in changes to areas greater than 25% of the surface area of the building, major renovation requirements may apply, refer to Sect. 2.3.

**2.1.1.3** The derivation of U-values, including those applicable where heat loss is to an unheated space, is dealt with in paragraphs 0.3.4 to 0.3.7 and Appendix A.

**2.1.1.4** Unheated areas which are wholly or largely within the building structure, do not have permanent ventilation openings and are not otherwise subject to excessive air-infiltration or ventilation, e.g. common areas such as stairwells, corridors in buildings containing flats, may be considered as within the insulated fabric. In that case, if the external fabric of these areas is insulated to the same level as that achieved by equivalent adjacent external elements, no particular requirement for insulation between a heated area and unheated areas would arise.

## **2.1.2 Fabric Insulation**

### **Extensions**

**2.1.2.1** Acceptable levels of thermal insulation for each of the plane elements of the building for extensions, in terms of average area-weighted U-value ( $U_m$ ) are provided in Table 1.

**2.1.2.2** For extensions, reasonable provision would also be achieved if the total heat loss through all the roof, wall and floor elements did not exceed that which would be the case if each of the area-weighted average U-value ( $U_m$ ) set out in Table 1 were achieved individually. Where this approach is chosen,

the values for individual elements or sections of elements given in Table 1 Column 3 apply to each relevant element.

**2.1.2.3** For extensions, the maximum area-weighted average U-value for doors, windows and rooflights of  $1.60 \text{ W/m}^2\text{K}$  given in Table 1 applies. The area of openings should not be reduced below that required for the provision of adequate daylight. BS 8206: Part 2: 2008 Code of Practice and CIBSE Lighting Guide LG10 for daylight gives advice on adequate daylight provision.

### **Material Alterations**

**2.1.2.4** Acceptable levels of thermal insulation for each of the plane elements of the building for material alterations are specified in terms of average area-weighted U-value ( $U_m$ ) in Table 10 for each fabric element type.

### **Material Change of Use**

**2.1.2.5** Acceptable levels of thermal insulation for each of the plane elements of the building for material change of use are specified in terms of average area-weighted U-value ( $U_m$ ) in Table 11 for each fabric element type.

**2.1.2.6** In the case of material change of use where retained thermal elements exceed the values in Column 2 of Table 11, the elements should be upgraded to the U values in Column 3.

Reasonable provision would also be achieved if the total heat loss through all the floor, wall and roof elements did not exceed that which

would be the case if each of the area weighted average U-value (Um) set out in Column 3 were achieved individually. Where this approach is chosen, the values for individual elements or sections of elements given in Table 11 (Column 4) also apply.

<b>Table 10 Maximum elemental U value (W/m<sup>2</sup>K)<sup>1,2</sup> for Material Alterations</b>		
<b>Column 1 Fabric Elements</b>	<b>Column 2 Area-weighted Average Elemental U-Value (Um)</b>	<b>Column 3 Average Elemental U- value – individual element or section of element</b>
Roofs		
Pitched roof		
- Insulation at ceiling	0.16	0.35
- Insulation on slope	0.25	
Flat roof	0.25	
Walls		
Cavity Walls <sup>3</sup>	0.55	0.60
Other Walls	0.35	
Curtain Walls	1.8	0.60
Ground Floors	0.45 <sup>4,5</sup>	
Other Exposed Floors <sup>5</sup>	0.25	0.60
External doors, windows and rooflights	1.60	3.0
<b>Notes:</b> 1. The U-value includes the effect of unheated voids or other spaces. 2. For material alterations, the U-values relate to the new works. 3. This only applies in the case of a wall suitable for the installation of cavity insulation. Where this is not the case it should be treated as for "other walls". 4. This U value only applies where floors are being replaced. 5. For insulation of ground floors and exposed floors where the source of space heating is underfloor heating, a floor U-value of 0.15 W/m <sup>2</sup> K should generally be satisfactory where floors are being replaced.		

<b>Table 11 Maximum elemental U value (W/m<sup>2</sup>K)<sup>1</sup> for Material Change of Use for retained elements</b>			
<b>Column 1 Fabric Elements</b>	<b>Column 2 Area-weighted Threshold Elemental U-Value (U<sub>t</sub>)</b>	<b>Column 3 Area-weighted Average Elemental U-Value (U<sub>m</sub>)</b>	<b>Column 4 Average Elemental U-value – individual element or section of element</b>
Roofs			
Pitched roof			
- Insulation at ceiling	0.16	0.16	0.35
- Insulation on slope	0.35	0.25	
Flat roof	0.35	0.25	
Walls			
Cavity Wall <sup>3</sup>	0.55	0.55	0.60
Other Walls	0.55	0.35	
Curtain Walls (frame and centre panels)	3.6	1.8	3.0
Ground Floors	- 0.45	- 0.45 <sup>4,5</sup>	-
Other Exposed Floors	0.6	0.25	0.60
External doors, windows and rooflights	3.6	1.6 <sup>2</sup>	3.0
<b>Notes:</b> 1. The U-value includes the effect of unheated voids or other spaces. 2. For material change of use, windows, doors and rooflights should have a maximum U-value of 1.6 W/m <sup>2</sup> K 3. This only applies in the case of a wall suitable for the installation of cavity insulation. Where this is not the case it should be treated as for "other walls". 4. This U value only applies where floors are being replaced. 5. For insulation of ground floors and exposed floors where the source of space heating is underfloor heating, a floor U-value of 0.15 W/m <sup>2</sup> K should generally be satisfactory where floors are being replaced.			

**2.1.2.7** The values U<sub>m</sub> values in Tables 1, 10 or 11 can be relaxed for individual elements or parts of elements where considered necessary for design or construction reasons.

Maximum acceptable values for such elements or parts of elements are specified in Column 3 of the respective Tables 1 or 10, or Column 4 of Table 11. Where this relaxation is availed of, the average area-weighted values given in the Tables continue to apply and compensatory insulation measures may be necessary for other elements or parts of

elements of that type to ensure that these are met.

Where the source of space heating is underfloor heating, a floor U-value of 0.15 W/m<sup>2</sup>K should generally be satisfactory.

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### **2.1.3 Thermal bridging**

insulation should have minimum thermal resistance of  $0.7 \text{ m}^2\text{K/W}$  (25 mm of insulation with thermal conductivity of  $0.035 \text{ W/mK}$ , or equivalent).

**2.1.3.1** To avoid excessive heat losses and local condensation problems, reasonable care should be taken to ensure continuity of insulation and to limit local thermal bridging, e.g. around windows, doors and other wall openings, at junctions between elements and other locations. Any thermal bridge should not pose a risk of surface or interstitial condensation. See Appendix D for further information in relation to thermal bridging and its effect on building heat loss.

**2.1.3.2** Reasonable provision with regard to limitation of thermal bridging for extensions is to adopt Acceptable Construction Details for constructions similar to those for dwellings as shown in the document “Limiting Thermal Bridging and Air Infiltration – Acceptable Construction Details” where appropriate (see Appendix D, Table D1) or other details that are similar or have been assessed as limiting thermal bridging to an equivalent level.

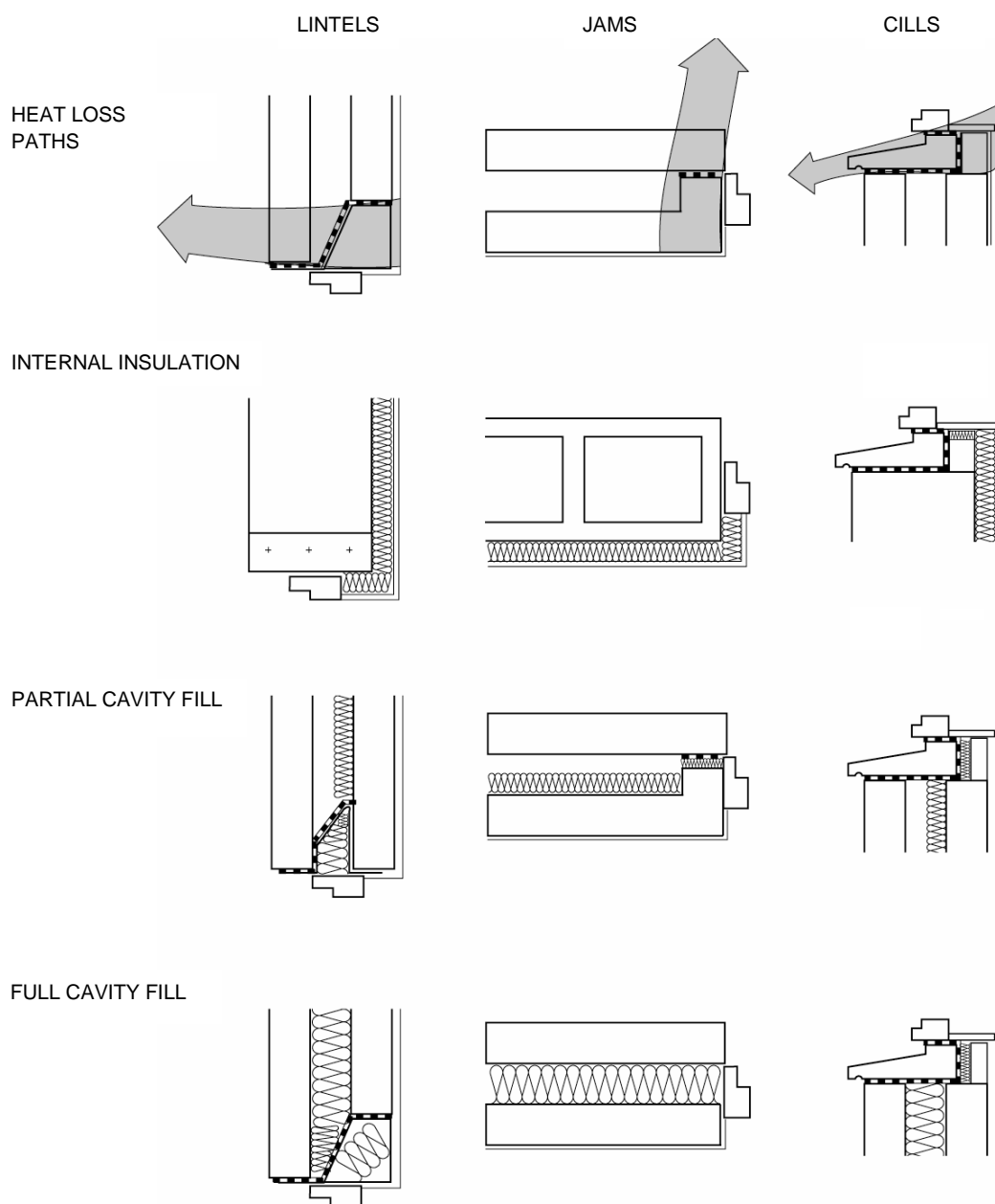
**2.1.3.3** For material alterations or material change of use lintel, jamb and cill designs similar to those shown in Diagram 2 would be satisfactory.

At lintel, jambs and cills generally a 15 mm thickness of insulation material having  $\lambda$ -value of  $0.033 \text{ W/mK}$  (or equivalent) will generally be adequate. Where advanced levels of insulation are applied a higher thermal resistance may be necessary.

**2.1.3.4** For material alterations or material change of use care should be taken to control the risk of thermal bridging at the edges of floors where the floor is being replaced. The



**Diagram 2 Lintel, jamb and cill designs**  
(Par. 2.1.3.3)



**Note:**

1. The internal faces of metal lintels should be covered with at least 15 mm of lightweight plaster; alternatively they can be dry-lined.
2. Where external insulation is used, thermal bridging details in accordance with third party certification should be used.
3. Further information on good practice details can be found in *Acceptable Construction Details* and may be applied to material alterations or material change of use in certain circumstances.

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## 2.1.4 Air permeability

constructions or voids.

**2.1.4.1** For extensions to existing buildings reasonable levels of air permeability can be facilitated by adopting the standard details referred to in paragraph 2.1.3.2 above, together with an appropriate performance specification and the on-site inspection regime and related quality control procedures, referred to in that paragraph. Alternative approaches to element design, details and quality control procedures may also be acceptable, provided it can be shown that these approaches are equivalent.

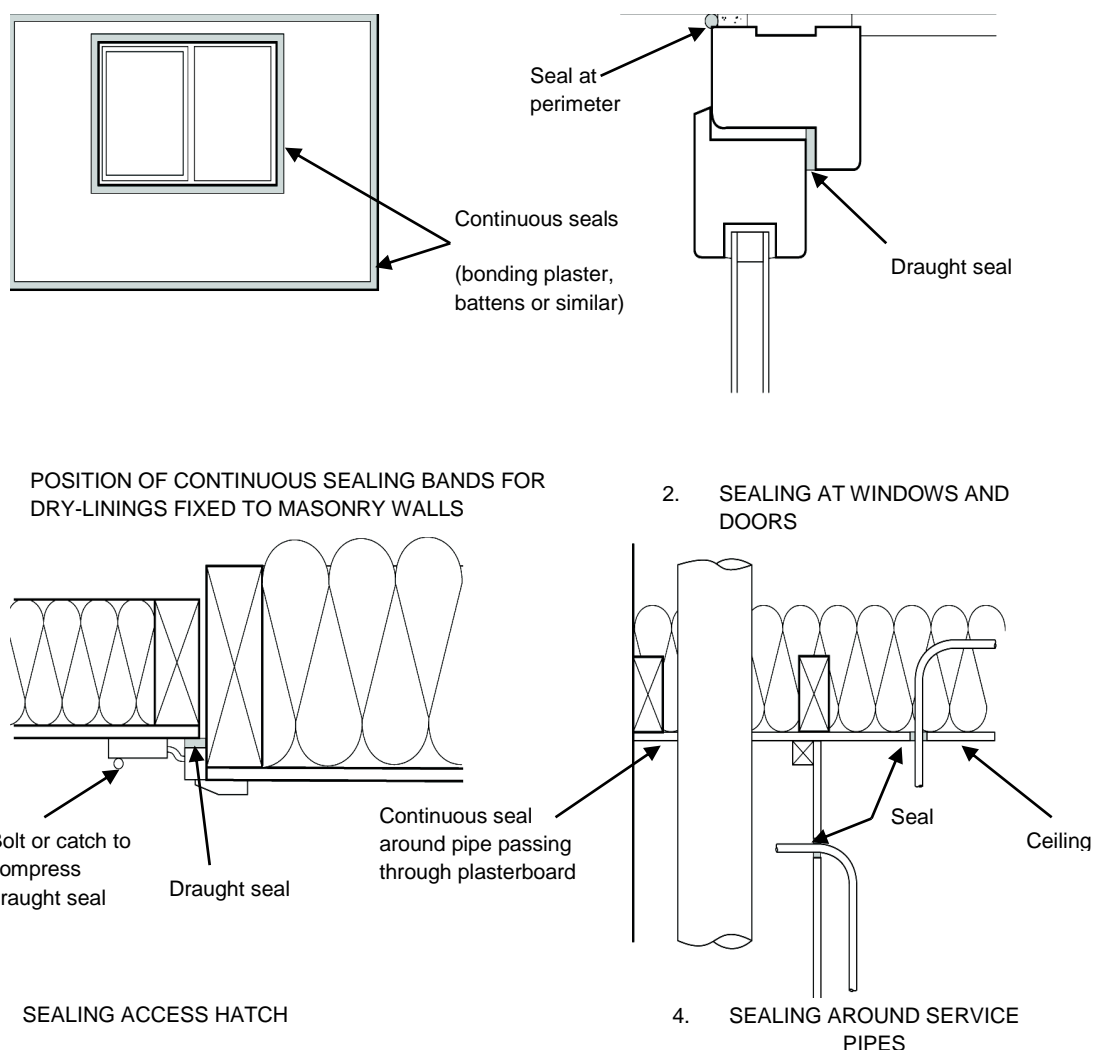
Diagram 3 illustrates some of these measures. Further information on sealing services penetrations can also be found in the Introduction Section of Acceptable Construction Details and BSRIA BG 47/2013 Designing and Constructing for Airtightness

Care should be taken to ensure compliance with the ventilation requirements of Part F and Part J.

**2.1.4.2** For material alterations or material change of use, infiltration of cold outside air should be limited by reducing unintentional air paths as far as is practicable. Measures to ensure this include: -

- (a) sealing the void between dry-lining and masonry walls at the edges of openings such as windows and doors, and at the junctions with walls, floors and ceilings (e.g. by the use of certified air tightness tapes and/or membranes);
- (b) sealing vapour control membranes in timber-frame constructions;
- (c) fitting draught-stripping in the frames of openable elements of windows, doors and rooflights;
- (d) sealing around loft hatches;
- (e) ensuring boxing for concealed services is sealed at floor and ceiling levels and sealing piped services where they penetrate or project into hollow

**Diagram 3 Air infiltration measures**  
(Par. 2.1.4.1)



## 2.2 BUILDING SERVICES

Guidance is provided for:

- (a) heating generator efficiency (sub-section 2.2.2);
- (b) space heating and hot water supply system controls (sub-section 2.2.3);
- (c) Air conditioning and mechanical ventilation (ACMV) (sub-section 2.2.4).

### 2.2.1 General

Where building services are being provided or extended to meet the requirements of Building Regulations by way of extension, material alteration, material change of use, replacement of services or major renovation to an existing building reasonable provision would be to meet the guidance in this section.

- 
- (d) Air conditioning and mechanical ventilation (ACMV) controls (sub-section 2.2.5);
  - (e) insulation of hot water storage vessels, pipes and ducts (sub-section 2.2.6);
  - (f) artificial lighting (sub-section 2.2.7).

## **2.2.2 Heat Generator Efficiency**

Heat generators should be designed and installed so that they operate efficiently over the range of loading likely to be encountered. Minimum energy efficiency standards for heat generators in existing buildings are provided in Table 2 for boilers and Par 1.4.1.2 for heat pumps.

## **2.2.3 Controls for space heating and hot water supply systems**

**2.2.3.1** Space and water heating systems should be effectively controlled so as to limit energy use by these systems to that required to satisfy user requirements and, where appropriate, to protect the building and its contents from damage due to low temperatures. This section is not intended to apply to control systems for specialist or industrial processes.

**2.2.3.2** Buildings should be provided with zone, timing and temperature controls such that, for space heating, each functional area is maintained at the required temperature only during the period when it is occupied. Additional space heating controls may be provided to allow heating during extended unusual occupation hours and to provide for sufficient background heating to prevent condensation or frost damage when the

heating system would otherwise be switched off.

**2.2.3.3** Hot water systems should be designed and provided with appropriate controls so that they can be operated efficiently. For efficient operation, hot water systems should not be over-sized and should be designed to avoid low-load operation of heat generators. The layout should minimize the length of circulation loops and minimize the length and diameter of dead legs. Designers should have particular regard to the need to limit the risk of promoting the growth of legionella bacteria. Local instantaneous heaters should be used, where appropriate.

**2.2.3.4** For buildings with a heat generator with an effective rated output for space heating purposes of more than 70kW a full building management system should be installed to control the heat generator(s). A full BMS linked to the heating plant will provide sequential controls of multiple heat generators, full zoned time control and weather compensation where applicable, frost protection or night set-back optimization and monitoring and targeting.

Minimum controls for heat generator systems are specified in Tables 3,4 & 5.

**2.2.3.5** For buildings with a heat generator with an effective rated output for space heating purposes with an effective rated output of over 70 kW a building automation and control system should be installed for the building with the following functions:

- (a) continuously monitoring, analysing and allowing for adjusting energy

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usage including that provided by renewable energy technologies;

- (b) benchmarking the building's energy efficiency, detecting losses in efficiency of technical building systems, and informing the person responsible for the facilities or technical building management about opportunities for energy efficiency improvement;
- (c) allowing communication with connected technical building systems and other appliances inside the building, and being interoperable with technical building systems across different types of proprietary technologies, devices and manufacturers, and
- (d) monitoring the energy provided by renewable energy technologies.

A building automation and control system and a building management system may be integrated into a single system.

**2.2.3.6** In larger or more complex buildings, control systems for boiler systems may follow the guidance contained in Chapter 5 CIBSE Guide H: Building Control Systems published by CIBSE.

**2.2.3.7** Where controls and building management systems are installed they should be commissioned by competent persons and commissioning records kept for handover information.

## **2.2.4 Air conditioning and mechanical ventilation (ACMV)**

**2.2.4.1** Buildings should be designed and constructed in such a way that:

- (a) the form and fabric of the building minimises the use of mechanical ventilation or cooling systems for cooling purposes, and
- (b) the ventilating and cooling systems installed are energy efficient and are capable of being controlled to achieve optimum energy efficiency.

**2.2.4.2** Natural ventilation strategies should be considered appropriate for the building geometry.

Particular attention should be paid to limiting solar gains by ensuring that areas of the external building fabric which are susceptible to solar gain have appropriate areas of solar shading.

**2.2.4.3** A mixed-mode building integrates the use of air conditioning when and where it is necessary, with use of natural ventilation whenever it is feasible or desirable, to maximise occupant comfort whilst reducing energy use (compared to 'year round' use of air conditioning). CIBSE Guide AM 13 Mixed Mode Ventilation provides guidance on mixed mode design.

**2.2.4.4** Free cooling may be optimised in order to minimise the need for mechanical ventilation and air conditioning. When the external air temperature is higher than the space temperature the system design should allow the provision of a minimum level of

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fresh air. Enthalpy control should also be considered to improve free cooling. The SEAI Guide to “Relative Humidity in Data Centres” explains how free cooling operates in the Irish Climate. BSRIA guide BG 8/2004 Free Cooling Systems also provides guidance on the design of free cooling systems. Where free cooling is used air-conditioning systems are still required to have heat recovery systems as required by Commission Regulation (EU) 1253/2014 with regard to eco-design requirements for ventilation units.

**2.2.4.5** Buildings that use ACMV systems should be designed and constructed such that:

- (a) the form and fabric of the building do not result in a requirement for excessive installed capacity of ACMV equipment. In particular, the suitable specification of glazing ratios and solar shading are an important way to limit cooling requirements;
- (b) components such as fans, pumps and refrigeration equipment are reasonably efficient and appropriately sized so as to have no more capacity for demand and standby than is necessary for the task;
- (c) suitable facilities are provided to manage, control and monitor the operation of the equipment and the systems.

**2.2.4.6** The specific fan power of air distribution systems at the design flow rate should be no worse than in Table 12. Specific fan power is a function of the system resistance that the fan has to overcome to provide the required flowrate. I.S. EN 13779 Table A8 provides guidance on system pressure drop. To minimize specific fan power it is recommended that the low range is used as a design target.

Where the primary air and cooling is provided by central plant and by an air distribution system that includes the additional components listed in Table 12a, the allowed specific fan powers may be increased by each of the values shown in Table 12a to account for the additional resistance.

**2.2.4.7** Ventilation fans driven by electric motors should comply with European Commission Regulation No. 327/2011 implementing Directive 2009/125/EC with regard to eco-design requirements for fans driven by motors with an electric input power between 125W and 500 kW.

Table 12 Maximum specific fan power in air distribution systems	
System type	SFP (W/(l/s))
Central balanced mechanical ventilation system with heating and cooling	2.2
Central balanced mechanical ventilation system with heating only	1.8
All other central balanced mechanical ventilation systems	1.6
Zonal supply system where fan is remote from zone, such as ceiling void or roof-mounted units	1.4
Zonal extract system where fan is remote from zone	0.5
Zonal supply and extract ventilation units, such as ceiling void or roof units serving single area with heat recovery	1.9
Local balanced supply and extract ventilation system such as wall/roof units serving single area with heat recovery	1.6
Local supply or extract ventilation units such as window/wall/roof units serving single area (e.g. toilet extract)	0.4
Other local ventilation supply or extract units	0.5
Fan assisted terminal VAV unit	1.1
Fan coil unit (rating weighted average <sup>1,2</sup> )	0.5
Kitchen extract, fan remote from zone with grease filter	1.0
<p>Note 1: The rating weighted average is calculated by the following formula:  <math>P_{\text{mains1}} \times \text{SFP1} + P_{\text{mains2}} \times \text{SFP2} + P_{\text{mains3}} \times \text{SFP3} + \dots</math>  <math>P_{\text{mains1}} + P_{\text{mains2}} + P_{\text{mains3}} + \dots</math></p> <p>Where <math>P_{\text{mains}}</math> is useful power supplied from the mains</p> <p>Note 2: NEAP includes a value of SFP for the fancoil system at zone level, so this figure should not be added to the SFP for the central system-when entering the data into NEAP</p>	

Table 12a Extending specific fan power for additional components	
Component	SFP (W/(l/s))
Additional return filter for heat recovery	+0.1
HEPA Filter <sup>1</sup>	+1.0
Heat Recovery –Thermal Wheel system	+0.3
Heat Recovery-other systems	+0.3
Humidifier/Dehumidifier(air conditioning systems)	+0.1
<p>Note 1: HEPA Filtration is recognized as an option in NEAP. The pressure drop can be specified or NEAP will assume a default value from the NEAP activity database</p>	

**2.2.4.8** New air distribution systems in buildings should meet the following recommended minimum standards:

- (a) Air handling systems should be capable of achieving a specific fan power at 25% of design flow rate no greater than that achieved at 100% design flow rate. This can be achieved by providing efficient variable flow control systems incorporating, for instance, variable speed drives or variable pitch axial fans. More detailed guidance is given in Action Energy General Information, Report 41 (GIR041) Variable flow control, General Information, published by BRECSU.
- (b) In order to aid commissioning and to provide flexibility for future changes of use, reasonable provision would be to equip with variable speed drives those fans that are rated at more than 1100W and which form part of the environmental control systems, including smoke control fans used for control of overheating. The provision is not applicable to smoke control fans and similar ventilations systems only used in abnormal

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circumstances.

**2.2.4.9** In order to limit air leakage, ventilation ductwork should be made and assembled so as to be reasonably airtight. This may be achieved by following the guidance in EN Standards I.S. EN1507:2006, I.S. EN12237:2003 and I.S. EN 13403:2003

In order to limit air leakage air handling units should be made and assembled so as to be reasonably airtight. This may be demonstrated by achieving Class L2 air leakage as given in I.S. EN 1886 2007.

**2.2.4.10** The minimum seasonal space cooling energy efficiency of cooling products should be as provided for in the Eco-design Regulations. The relevant Eco-design Regulations are:-

- Commission Regulation (EU) 2016/2281 for the setting of eco-design requirements for energy-related products, with regard to eco-design requirements for air heating products, cooling products, high temperature process chillers and fan coil units.
- Commission Regulation (EU) No 206/2012 with regard to eco-design requirements for air conditioners and comfort fans.

## **2.2.5 ACMV Controls**

**2.2.5.1** Systems should be provided with appropriate controls to enable the achievement of reasonable standards of energy efficiency in use, in normal circumstances, the following features would

be appropriate for heating, ventilation and air-conditioning systems and controls

- (a) The systems should be divided into separate control zones to correspond to each area of the building that has a significantly different solar exposure or type of use; and
- (b) Each separate control zone should be capable of independent timing and temperature control and, where appropriate, ventilation and air recirculation rate; and
- (c) The provision of the service should respond to the requirements of the space it serves. If both heating and cooling are provided they should be controlled so as not to operate simultaneously unless required for humidification control.
- (d) Central plant should only operate as and when the zone systems require it. The default condition should be off.
- (e) In addition to these general control provisions the systems should meet general control and efficiency standards as set out in Par 2.2.5.2

**2.2.5.2** A minimum controls package should be provided as in Table 7

**2.2.5.3** For buildings with a with an effective rated output for air-conditioning systems of over 70 kW a building automation and control system should be installed for the building with the following functions:



- 
- (a) continuously monitoring, analysing and allowing for adjusting energy usage;
  - (b) benchmarking the building's energy efficiency, detecting losses in efficiency of technical building systems, and informing the person responsible for the facilities or technical building management about opportunities for energy efficiency improvement;
  - (c) allowing communication with connected technical building systems and other appliances inside the building, and being interoperable with technical building systems across different types of proprietary technologies, devices and manufacturers and
  - (d) monitoring the energy provided by renewable energy technologies.

A building automation and control system and a building management system may be integrated into a single system.

**2.2.5.4** Where controls and building management systems are installed they should be commissioned by competent persons and commissioning records kept for handover information.

## **2.2.6 Insulation of storage vessels, pipes and ducts**

**2.2.6.1** This section only applies to pipes, ducts and vessels for the provision of space heating, space cooling (including chilled water and refrigerant pipe work) and hot

water supply for normal occupation. It does not apply to pipes, ducts and vessels associated with specialist or industrial processes.

**2.2.6.2** Hot water storage vessels, pipes and ducts associated with the provision of heating and hot water in a building should be insulated to limit heat loss, except where the heat flow through the wall of the pipe, duct or vessel is always useful in conditioning the surrounding space. Storage vessels for chilled water and refrigerant, and pipes and ducts that serve air-conditioning systems should be insulated to limit heat gain from the surrounding environment.

**2.2.6.3** Provision of insulation to pipes, ducts and storage vessels, in accordance with the standards specified in BS 5422: 2009, should adequately limit heat loss or heat gain, as appropriate. The appropriate insulation level for storage vessels should be taken as that given in BS 5422: 2009 for flat surfaces.

**2.2.6.4** It should be noted that water pipes and storage vessels in unheated areas will generally need to be insulated for the purpose of protection against freezing. Guidance on suitable protection measures is given in Technical Guidance Document G and BRE Report 262, Thermal insulation: avoiding risks published by BRE.

## **2.2.7 Artificial lighting**

**2.2.7.1** This Section provides guidance for the following types of lighting:

- general interior lighting

- 
- display lighting

**2.2.7.2** For the purposes of this section the definitions for lighting are provided in Appendix F.

**2.2.7.3** General purpose artificial lighting systems shall be designed and controlled so as to ensure the efficient use of energy for this purpose.

**2.2.7.4** The aim of lighting controls should be to encourage the maximum use of daylight and to avoid unnecessary artificial lighting, particularly when spaces are unoccupied, having regard to the need to ensure that the operation of automatically switched lighting systems does not endanger occupants in a building. BS 8206: Part 2: 2008 Code of Practice for daylight and CIBSE Lighting Guide LG 10 gives advice on adequate daylight provision.

**2.2.7.5** Lighting controls in buildings should follow the guidance in BRE Digest 498 Selecting Lighting Controls. Display lighting where provided should be controlled on dedicated circuits that can be switched off when not required.

Adequate control depends on the nature and use pattern of the building. This may be achieved by one, or more, of the following means, used alone or in combination, as appropriate. Detailed guidance on the application of the following methods is provided in Table 2 of BRE Digest 498 Selecting Lighting Controls.

- (a) local manually operated switches in easily accessible positions within each working area or at boundaries between working areas and general circulation routes. The distance on plan from any local switch to the luminaries it controls should generally be not more than 6m, or twice the height of the light fitting above the floor if this is greater;

- (b) daylight-linked photo-electric switching or dimming for lighting adjacent to windows or other sources of natural light;

- (c) remote controlled switches operated by infrared transmitter, sonic, ultrasonic or telephone handset controls;

- (d) automatic switching systems which switch the lighting off when they sense the absence of occupants;

- (e) time-controlled switches.

All the above types of control can form part of a lighting or building energy management system. These enable a range of additional functions including remote operation and management of lighting systems.

**2.2.7.6** Lighting in existing buildings should meet the minimum standards for:

- (i) efficacy (averaged over the whole area of the applicable type of space in the building) and controls in column 3 of Table 8

OR

- (ii) maximum Lighting Energy Numeric Indicator (LENI) (kWh/m<sup>2</sup>/year) listed in Table 9. LENI is based on BS EN 15193:2007 Energy Performance of Buildings - Energy Requirements for Lighting. The LENI should be calculated using the procedure in Appendix F to meet the maximum values in Table 9

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## 2.3 Major Renovation

**2.3.1** Where more than 25% of the surface area of the building envelope undergoes renovation the energy performance of the whole building should be improved to Cost Optimal level in so far as this is technically, functionally and economically feasible.

**2.3.2** When calculating the proportion of surface area undergoing renovation the area of the whole building external envelope should be taken into account including i.e. external walls, roofs, floors, windows, doors, and roof windows and lights

Works to the surface area of the building include the following:

- Cladding the external surface of the element
- Drylining the internal surface of an element
- Replacing windows
- Stripping down the element to expose the basic structural components (brickwork/blockwork, timberframe steelframe, joists, rafters, purlins etc.) and then rebuilding to achieve all the necessary performance requirements. Painting, replastering or rendering are not considered a major renovation for this part of the regulation.

**2.3.3** When undertaking on or in connection with a building that is of architectural or historical interest the aim should be to improve the building as far as is reasonably practical. The work should not prejudice the character of the building or increase the risk of long term deterioration of the building fabric or fittings. Refer to Par 0.5.

**2.3.4** The following improvements are normally considered to be cost optimal and

will typically be economically feasible when more than 25% of the surface area of a building is being upgraded:

- Upgrading oil, gas or biomass heating systems more than 15 years old and with an efficiency of less than that shown in Table 2;
- Upgrading controls for direct electric space heating systems to achieve the level of controls described in Table 5;
- Upgrading cooling and ventilation systems more than 15 years old and a cooling unit Seasonal Energy Efficiency Ratio less than that in the Eco-design Regulations referenced in par 1.4.3.11 and/or Specific Fan Power greater than that in Table 12 and by the provision of new plant; and
- Upgrading general lighting systems that are more than 15 years old or have an average lamp efficacy of less than 40 lamp-lumens per circuit-watt as defined in NEAP and that serves greater than 100m<sup>2</sup> to the guidance in section 2.2.7.

**2.3.5** As an alternative to the measures in paragraph 2.3.4 where the whole building performance achieves the primary energy performance levels as calculated in NEAP and specified in Table 13 where technically, functionally and economically feasible this can be considered the cost optimal level of performance. To allow flexibility in application the values in Table 13 can be increased by 15%.

Table 13 Whole Building Cost Optimal Level	
Building Type	Major Renovation - Cost Optimal Performance kWh/m <sup>2</sup> /yr primary energy
Retail Air Conditioned	338
Office Natural Ventilated offices and other Buildings	124
Office Air Conditioned	180
Hotel Air Conditioned	342
Schools	60
Other Air Conditioned Buildings	338
Other Naturally Ventilated Buildings	124

## 2.4 Construction quality and commissioning of services

### 2.4.1 General

**2.4.1.1** The requirements of Part L apply to the completed building. Reasonable measures should be taken during construction and appropriate checks and assessments carried out prior to completion to ensure that compliance with Part L is achieved. Sub-sections 2.4.2 to 2.4.4 give guidance on appropriate measures to satisfy this requirement.

### 2.4.2 Insulation continuity and air permeability

**2.4.2.1** The elements that comprise the external fabric of the building should be designed and constructed to ensure that the calculated performance of the building and of its components is achieved in practice. Changes made during design and construction should be assessed for their impact on insulation performance and on air permeability. Those not directly involved in the installation of insulation should be fully aware of the importance of not reducing the effectiveness of the installed insulation through removal or damage. On-site quality control should include checks on the adequacy of insulation installation and of any barriers designed to limit air permeability,

### 2.4.3 Commissioning space and water heating systems

**2.4.3.1** The heating and hot water system(s) should be commissioned so that at completion, the system(s) and their controls are left in the intended working order and can operate efficiently for the purposes of the conservation of fuel and energy. The design should be reviewed to ensure systems, plant, equipment and components meet commissionability, maintainability, functionality, usability and operational performance requirements. The key elements of a commissioning plan, identifying the systems that need to be tested and the tests that will be carried out should be developed at the design stage. The BSRIA Job Book A project framework for engineering services BG1/2009 provides further useful information on commissioning of buildings.

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## 2.4.4 Air Leakage Testing of Ductwork

**2.4.4.1** Where new systems are installed ductwork leakage testing should be carried out on Class C and Class D ductwork where required by and in accordance with the procedures set out in B&ES DW/143 and B&ES DW/144 on systems served by fans with a design flow greater than 1m<sup>3</sup>/s.

If ductwork fails to meet the leakage standard, remedial work should be carried out as necessary to achieve satisfactory performance in retests and further ductwork sections should be tested as set out in DW/143

- (a) Drawings and manuals necessary to operate and maintain the energy using equipment in the buildings e.g. boilers, chillers, pumps and fans, lighting, building management systems
- (b) the monitoring of energy use making of adjustments to the control settings for energy using equipment; and
- (c) what routine maintenance is needed to enable operating efficiency to be maintained at a reasonable level through the service life(lives) of the system(s).

## 2.5 User information

### 2.5.1 General

For replacement of services and major renovations the owner or occupants of the building should be provided with sufficient information about the building, the fixed building services and their maintenance requirements so that the building can be operated in such a manner as to use no more fuel and energy than is reasonable in the circumstances. A way of complying would be to provide a suitable set of operating and maintenance instructions aimed at achieving economy in the use of fuel and energy in a way that the building owner or occupants can understand. The instructions should be directly related to the particular system(s) installed in the building. Without prejudice to the need to comply with health and safety requirements, the instructions should explain to the building owner or occupier of the building how to operate the system(s) efficiently. This should include:-

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## ***APPENDICES***

# Appendix A

## Calculation of U-Values

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### GENERAL

**A1.1** General guidance on the calculation of U-values is contained in Report BR 443 “Conventions for the Calculation of U-values” 2006. For building elements and components generally, the method of calculating U-values is specified in I.S. EN ISO 6946: 2007. U-values of components involving heat transfer to the ground, e.g. ground floors with or without floor voids, basement walls, are calculated by the method specified in I.S. EN ISO 13370: 2007. A soil thermal conductivity of 2.0 W/mK should be used, unless otherwise verified. U-values for windows, doors and shutters may be calculated using I.S. EN ISO 10077-1: 2006 or I.S. EN ISO 10077-2: 2012. U Values for curtain walling should be calculated using I.S. EN 12631:2012. Information on U-values and guidance on calculation procedures contained in the 2015 8<sup>th</sup> edition of CIBSE Guide Section A3: Thermal Properties of Building Structures are based on these standards.

A method for assessing U-values of light steelframed constructions is given in Digest 465 “U-values for light steel construction”, published by BRE IP 10/02 “Metal cladding: assessing thermal performance of built-up systems which use ‘Z’ spacers” published by BRE.

Software packages to perform U-value calculations in accordance with the standards above are readily available.

**A1.2** U-values derived by calculation should be rounded to two significant figures and relevant information on input data should be provided. When calculating U-values the effects of timber joists, structural and other

framing, mortar bedding, window frames and other small areas where thermal bridging occurs must be taken into account. Similarly, account must be taken of the effect of small areas where the insulation level is reduced significantly relative to the general level for the component or structure element under consideration. Thermal bridging may be disregarded, however, where the general thermal resistance does not exceed that in the bridged area by more than 0.1 m<sup>2</sup>K/W. For example, normal mortar joints need not be taken into account in calculations for brickwork or concrete blockwork where the density of the brick or block material is in excess of 1500 kg/m<sup>3</sup>. A ventilation opening in a wall or roof (other than a window, rooflight or door opening), may be considered as having the same U-value as the element in which it occurs.

**A1.3** Examples of the application of the calculation method specified in I.S. EN 6946: 2007 are given below. An example of the calculation of ground floor U-values using I.S. EN ISO 13370: 2007 is also given.

**A1.4** Thermal conductivities of common building materials are given in Table A1. For the most part, these are taken from I.S. EN ISO 10456: 2007 or CIBSE Guide Section A3. Values for common insulation materials are also available in these documents. See paragraph 0.3.3 regarding application of these Tables.

### SIMPLE STRUCTURE WITHOUT THERMAL BRIDGING

**A2.1** To calculate the U-value of a building element (wall or roof) using I.S. EN ISO 6946:

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2007, the thermal resistance of each component is calculated, and these thermal resistances, together with surface resistances as appropriate, are then combined to yield the total thermal resistance and U-value. The result is corrected to account for mechanical fixings (e.g. wall ties) or air gaps if required. For an element consisting of homogenous layers with no thermal bridging, the total resistance is simply the sum of individual thermal resistances and surface resistances.



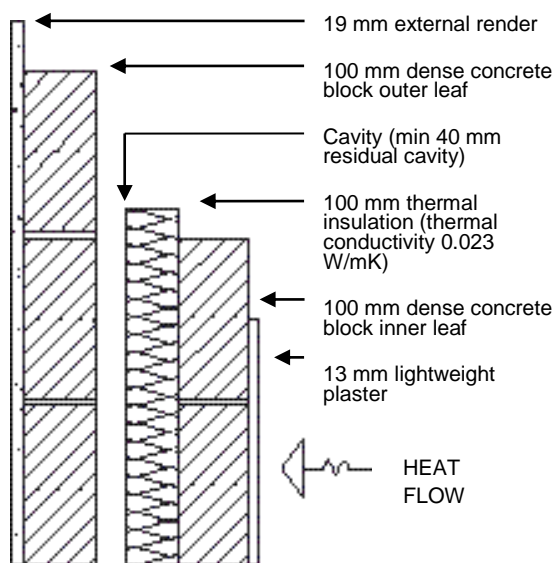
**Table A1 Thermal conductivity of some common building materials**

Material	Density (kg/m <sup>3</sup> )	Thermal Conductivity (W/mK)
<b>General Building Materials</b>		
Clay Brickwork (outer leaf)	1,700	0.77
Clay Brickwork (inner leaf)	1,700	0.56
Concrete block (heavyweight)	2,000	1.33
Concrete block (medium weight)	1,400	0.57
Concrete block (autoclaved aerated)	700	0.20
Concrete block (autoclaved aerated)	500	0.15
Concrete block (hollow)	1800	0.835
Cast concrete, high density	2,400	2.00
Cast concrete, medium density	1,800	1.15
Aerated concrete slab	500	0.16
Concrete screed	1,200	0.41
Reinforced concrete (1% steel)	2,300	2.30
Reinforced concrete (2% steel)	2,400	2.50
Wall ties, stainless steel	7,900	17.00
Wall ties, galvanised steel	7,800	50.00
Mortar (protected)	1,750	0.88
Mortar (exposed)	1,750	0.94
External rendering (cement sand)	1,800	1.00
Plaster (gypsum lightweight)	600	0.18
Plaster (gypsum)	1,200	0.43
Plasterboard	900	0.25
Natural Slate		
Concrete tiles	2,500	2.20
Clay tiles	2,100	1.50
Fibre cement slates	2,000	1.00
Ceramic/Porcelain tiles	1,800	0.45
Plastic tiles	2,300	1.30
Asphalt	1,000	0.20
Felt bitumen layers	2,100	0.70
	1,100	0.23
Timber, softwood		
Timber, hardwood	500	0.13
Wood wool slab	700	0.18
Wood-based panels (plywood, chipboard, etc.)	500	0.10
	500	0.13

Note:

The values in this table are indicative only. Certified values, should be used in preference, if available.

**Diagram A1 Masonry Cavity wall**  
(Par. A.2.1)



I.S. EN 6946: 2007 provides for corrections to the calculated U-value. In the case of example A1 (see Diagram A1), corrections for air gaps in the insulated layer and for mechanical fasteners may apply. However, if the total correction is less than 3% of the calculated value, the correction may be ignored.

In this case no correction for air gaps applies as it is assumed that the insulation boards meet the dimensional standards set out in I.S.

EN ISO 6946: 2007 and that they are installed without gaps greater than 5 mm.

The construction involves the use of wall ties that penetrate fully through the insulation layer.

Layer/ Surface	Thicknes s (m)	Conductivit y (w/mK)	Resistanc e (m <sup>2</sup> K/W)
External surface	-	-	0.040
External render	0.019	1.00	0.019
Concrete Block	0.100	1.33	0.075
Air cavity		-	0.180
Insulation	0.100	0.023	4.348
Concrete Block	0.100	1.33	0.075
Plaster (lightweight)	0.013	0.18	0.072
Internal surface	-	-	0.130
Total Resistance	-	-	4.939
<b>U-value of construction = 1 / 4.939 = 0.20 W/m<sup>2</sup>K</b>			

A potential correction factor applies which, assuming the use of 4 mm diameter stainless steel ties at 5 ties per m<sup>2</sup>, is calculated as 0.006 W/m<sup>2</sup>K. This is less than 3% of the calculated U-value and may be ignored. It should be noted that, if galvanised steel wall ties were used, a correction of 0.02 W/m<sup>2</sup>K would apply, and the corrected U-value for this construction would be 0.22 W/m<sup>2</sup>K.

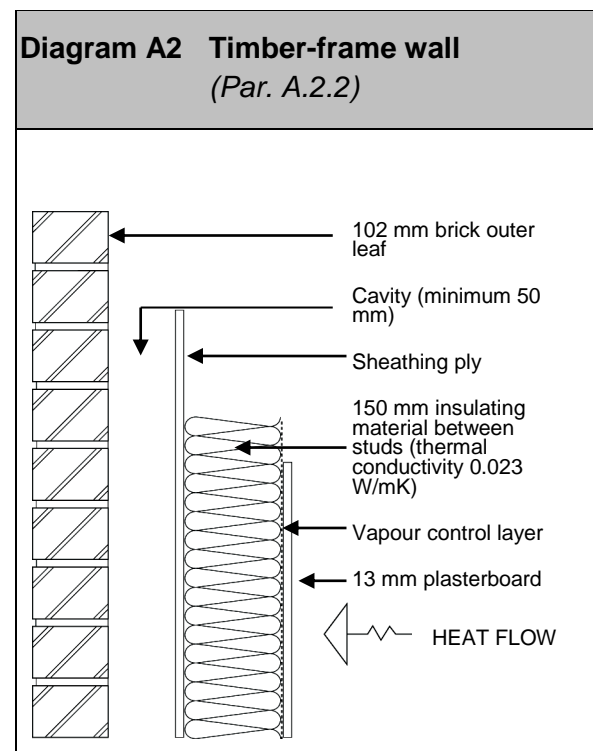
## STRUCTURE WITH BRIDGED LAYER(S)

**A2.2** For an element in which one or more layers are thermally bridged, the total thermal resistance is calculated in three steps as follows: -

- (a) The upper thermal resistance is based on the assumption that heat flows through the component in straight lines perpendicular to the element's surfaces. To calculate it, all possible heat flow paths are identified, for each path the resistance of all layers are combined in series to give the total resistance for the path, and the resistances of all paths are then combined in parallel to give the upper resistance of the element.
- (b) The lower thermal resistance is based on the assumption that all planes parallel to the surfaces of the component are isothermal surfaces. To calculate it, the resistances of all components of each thermally bridged layer are combined in parallel to give the effective resistance for the layer, and the resistances of all layers are then combined in series to give the lower resistance of the element.
- (c) The total thermal resistance is the mean of the upper and lower resistances.

The percentage of timber bridging the insulation layer as a repeating thermal bridge can be calculated when the size and frequency of the timber members is known. Alternatively, the figures given in Table A3 can be used.

### Example A2: Timber-frame wall (with one insulating layer bridged)



The thermal resistance of each component is calculated (or, in the case of surface resistances, entered) as follows: -

Layer/ Surface	Thickness (m)	Conductivity (W/mK)	Resistance (m <sup>2</sup> K/W)
External surface	-	-	0.040
Brick outer leaf	0.102	0.77	0.132
Air cavity	-	-	0.180
Sheathing ply	0.012	0.13	0.092
Polyisocyanurate (PIR)	0.150	0.023	6.522
Timber studs	0.150	0.12	1.25
Plasterboard	0.013	0.25	0.052
Internal surface	-	-	0.130

Table A3 Timber fractions for bridged layers					
Layer	Timber frame Walls	Ceiling flat/sloped		Drylined battened wall	Suspended Timber Floor
% Fraction	15	9	8	12	11

### Upper resistance

Assuming that heat flows in straight lines perpendicular to the wall surfaces, there are two heat flow paths - through the insulation and through the studs. The resistance of each of these paths is calculated as follows: -

Resistance through section containing insulation [m<sup>2</sup>K/W]: -

External surface resistance	0.040
Brick outer leaf	0.132
Air cavity	0.180
Sheathing ply	0.092
Polyisocyanurate (PIR)	6.522

Plasterboard	0.052
Internal surface resistance	0.130

**Total 7.148**

Resistance through section containing timber stud [m<sup>2</sup>K/W]: -

External surface resistance	0.040
Brick outer leaf	0.132
Air cavity	0.180
Sheathing ply	0.092
Timber studs	1.250
Plasterboard	0.052
Internal surface resistance	0.130

**Total 1.876**

The upper thermal resistance  $R_u$  is obtained from: -

$$R_u = 1 / (F_1 / R_1 + F_2 / R_2)$$

The thermal resistance of each component is calculated (or, in the case of surface resistances, entered) as follows: -

Layer/ Surface	Thickness (m)	Conductivity (W/mK)	Resistance (m <sup>2</sup> K/W)
External surface	-	-	0.040
Brick outer leaf	0.102	0.77	0.132
Air cavity	-	-	0.180
Sheathing ply	0.012	0.13	0.092
Polyisocyanurate (PIR)	0.150	0.023	6.522
Timber studs	0.150	0.12	1.25
Plasterboard	0.013	0.25	0.052
Internal surface	-	-	0.130

Table A3 Timber fractions for bridged layers					
Layer	Timber frame Walls	Ceiling flat/sloped		Drylined battened wall	Suspended Timber Floor
% Fraction	15	9	8	12	11

### Upper resistance

Assuming that heat flows in straight lines perpendicular to the wall surfaces, there are two heat flow paths - through the insulation and through the studs. The resistance of each of these paths is calculated as follows: -

Resistance through section containing insulation [m<sup>2</sup>K/W]: -

External surface resistance	0.040
Brick outer leaf	0.132
Air cavity	0.180
Sheathing ply	0.092
Polyisocyanurate (PIR)	6.522
Plasterboard	0.052
Internal surface resistance	0.130

**Total** **7.148**

Resistance through section containing timber stud [m<sup>2</sup>K/W]: -

External surface resistance	0.040
Brick outer leaf	0.132
Air cavity	0.180
Sheathing ply	0.092
Timber studs	1.250
Plasterboard	0.052
Internal surface resistance	0.130

**Total** **1.876**

The upper thermal resistance  $R_u$  is obtained from: -

$$R_u = 1 / (F_1 / R_1 + F_2 / R_2)$$

where  $F_1$  and  $F_2$  are the fractional areas of heat flow paths 1 and 2, and  $R_1$  and  $R_2$  are the resistances of these paths.

$$\text{Upper resistance } R_u = 1 / (0.85 / 7.148 + 0.15 / 1.876) = 5.028 \text{ m}^2\text{K/W}$$

### Lower resistance

Assuming an isothermal plane on each face of the layer of insulation which is bridged by timber studs, the thermal resistance of this bridged layer,  $R_b$ , is calculated from: -

$$R_b = 1 / (F_{ins} / R_{ins} + F_t / R_t)$$

where  $F_{ins}$  and  $F_t$  are the fractional areas of insulation and timber, and  $R_{ins}$  and  $R_t$  are their resistances.

$$R_b = 1 / (0.85 / 6.522 + 0.15 / 1.25) = 3.995 \text{ m}^2\text{K/W}$$

The resistances of all layers are then combined in series to give the lower resistance [ $\text{m}^2\text{K/W}$ ]: -

External surface resistance	0.040
Brick outer leaf	0.132
Air cavity	0.180
Bracing board	0.092
Bridged insulation layer	3.995
Plasterboard	0.05235
Internal surface resistance	0.130
<b>Lower resistance (RL)</b>	<b>4.621</b>

### Total resistance

The total resistance  $R_t$  is given by: -

$$R_t = (R_u + R_L) / 2 = (5.028 + 4.621) / 2 = 4.8245 \text{ m}^2\text{K/W}$$

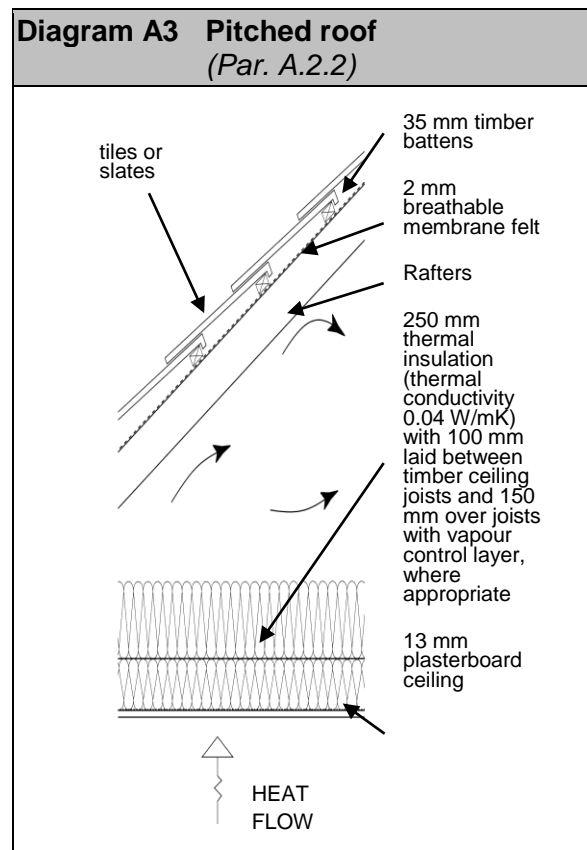
The U-value is the reciprocal of the total resistance: -

$$U\text{-value} = 1 / 4.8245 = 0.21 \text{ W/m}^2\text{K} \text{ (to 2 decimal places).}$$

There is a potential correction for air gaps in the insulation layer. I.S. EN ISO 6946: 2007 gives a U-value correction of  $0.0065 \text{ W/m}^2\text{K}$  for this construction. This is less than 3% of the calculated U-value and can be ignored.

Example A3: Pitched roof with insulation at ceiling level (between and over joists)

A pitched roof has 100 mm of mineral wool tightly fitted between 44 mm by 100 mm timber joists spaced 600 mm apart (centres to centres) and 150 mm of mineral wool over the joists. The roof is slated or tiled with breathable membrane felt under the slates or tiles. The ceiling consists of 13 mm of plasterboard. The fractional area of timber at ceiling level is taken as 9%.



Layer/ Surface	Thickness (m)	Conductivity (W/mK)	Resistance (m <sup>2</sup> K/W)
External surface	-	-	0.040
Roof space (including sloping construction and roof cavity)	-	-	0.200
Mineral wool (continuous layer)	0.150	0.04	3.750
Mineral wool (between joists)	0.100	0.04	2.500
Timber joists	0.100	0.13	0.769
Plasterboard	0.013	0.25	0.052
Internal surface	-	-	0.100

#### Upper resistance (R<sub>u</sub>)

Resistance through section containing both layers of insulation [m<sup>2</sup>K/W]: -

External surface resistance	0.040
Resistance of roof space	0.200
Resistance of mineral wool over joists	3.750
Resistance of mineral wool between joists	2.500
Resistance of plasterboard	0.052
Inside surface resistance	0.100
<b>Total</b>	<b>6.642</b>

Resistance through section containing timber joists: -

External surface resistance	0.040
Resistance of roof space	0.200
Resistance of mineral wool over joists	3.750

Resistance of timber joists	0.769
Resistance of plasterboard	0.052
Inside surface resistance	0.100

**Total 4.911**

The upper thermal resistance [R<sub>u</sub>] is obtained from: -

$$R_u = 1 / (F_1 / R_1 + F_2 / R_2)$$

where F<sub>1</sub> and F<sub>2</sub> are the fractional areas of heat flow paths 1 and 2, and R<sub>1</sub> and R<sub>2</sub> are the resistances of these paths.

$$\text{Upper resistance } R_u = 1 / (0.91 / 6.642 + 0.09 / 4.911) = 6.438 \text{ m}^2\text{K/W}$$

#### Lower resistance (R<sub>l</sub>)

Assuming an isothermal plane on each face of the layer of insulation which is bridged by timber studs, the thermal resistance of this bridged layer, R<sub>b</sub>, is calculated from: -

$$R_b = 1 / (F_{ins} / R_{ins} + F_t / R_t)$$

where F<sub>ins</sub> and F<sub>t</sub> are the fractional areas of insulation and timber, and R<sub>ins</sub> and R<sub>t</sub> are their resistances

$$R_b = 1 / (0.91 / 2.500 + 0.09 / 0.769) = 2.079 \text{ m}^2\text{K/W}$$

The resistances of all layers are then combined in series to give the lower resistance [m<sup>2</sup>K/W]: -

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External surface resistance	0.040
Resistance of roof space	0.200
Resistance of mineral wool over joists	3.750
Resistance of bridged layer	2.079
Resistance of plasterboard	0.052
Inside surface resistance	0.100
<b>Lower resistance (R<sub>L</sub>)</b>	<b>6.221</b>

### Total resistance

The total resistance R<sub>t</sub> is given by: -

$$R_t = (R_u + R_L) / 2 = (6.438 + 6.221) / 2 = 6.329 \text{ m}^2\text{K/W}$$

The U-value is the reciprocal of the total resistance: -

$$\text{U-value} = 1 / 6.329 = \mathbf{0.16 \text{ W/m}^2\text{K}} \text{ (to 2 decimal places).}$$

I.S. EN ISO 6946: 2007 does not specify any potential correction for this construction.

## GROUND FLOORS AND BASEMENTS

**A3.1** The U-value of an uninsulated ground floor depends on a number of factors including floor shape and area and the nature of the soil beneath the floor. I.S. EN ISO 13370: 2007 deals with the calculation of U-values of ground floors. Methods are specified for floors directly on the ground and for floors with vented and unvented sub-floor

spaces. I.S. EN ISO 13370: 2007 also covers heat loss from basement floors and walls.

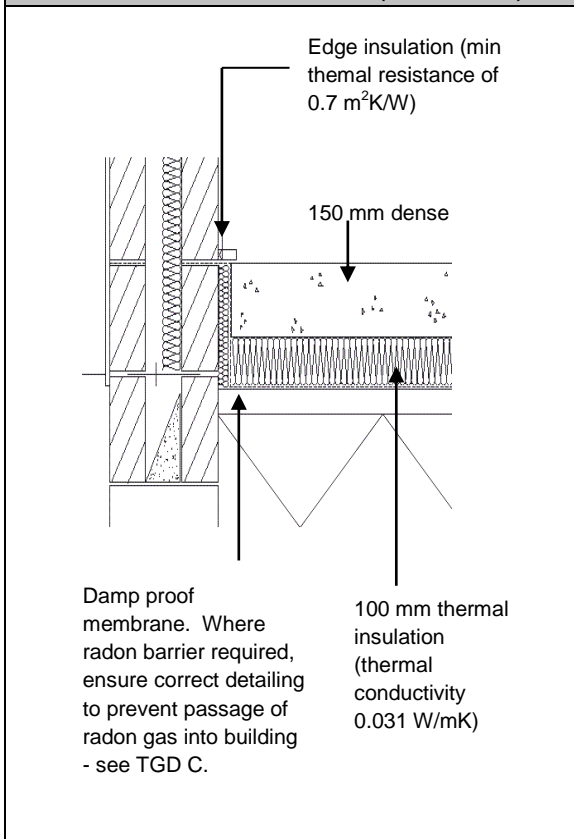
**A3.2** When calculating the U Value in the case of buildings with multiple premises, the floor dimensions can be taken as either those of the individual premises or those of the whole building. Unheated spaces outside the insulated fabric, such as warehouses, plant rooms or common areas, should be excluded when deriving floor dimensions but the length of the floor perimeter between the heated building and the unheated space should be included when determining the length of exposed perimeter. Where such ancillary areas have the potential to become part of the conditioned building, floors should be insulated to the same level as the conditioned building floors, unless it is envisaged that a new insulated floor will be provided when converted.

Example A4: Slab-on-ground floor – full floor insulation

The slab-on-ground floor consists of a 150 mm dense concrete ground floor slab on 100 mm insulation. The insulation has a thermal conductivity of 0.031 W/mK. The floor dimensions are 8750 mm by 7250 mm with three sides exposed. One 8750 mm side abuts the floor of an adjoining conditioned building.



**Diagram A4 Concrete slab-on-ground floor** (Par. A.3.1)



In accordance with I.S. EN ISO 13370: 2007, the following expression gives the U-value for well-insulated floors:

$$U = \frac{\lambda}{(0.457B' + d_t)}, \text{ where}$$

$$\lambda = \text{thermal conductivity of unfrozen ground (W/mK)}$$

$$B' = \frac{2A}{P} \text{ (m)}$$

$$d_t = w + \lambda(R_{si} + R_f + R_{se}) \text{ (m)}$$

$$A = \text{floor area (m}^2\text{)}$$

$$P = \text{heat loss perimeter (m)}$$

$$w = \text{wall thickness (m)}$$

$R_{si}$ ,  $R_f$  and  $R_{se}$  are internal surface resistance, floor construction (including insulation) resistance and external surface resistance

respectively. Standard values of  $R_{si}$  and  $R_{se}$  for floors are given as  $0.17 \text{ m}^2\text{K/W}$  and  $0.04 \text{ m}^2\text{K/W}$  respectively. The standard also states that the thermal resistance of dense concrete slabs and thin floor coverings may be ignored in the calculation and that the thermal conductivity of the ground should be taken as  $2.0 \text{ W/mK}$  unless otherwise known or specified.

Ignoring the thermal resistance of the dense concrete slab, the thermal resistance of the floor construction ( $R_f$ ) is equal to the thermal resistance of the insulation alone, i.e.  $0.1/0.031$  or  $3.226 \text{ m}^2\text{K/W}$ . Taking the wall thickness as  $350 \text{ mm}$ , this gives:

$$d_t = 0.35 + 2.0(0.17 + 3.226 + 0.04) = 7.222 \text{ m}$$

$$\text{Also } B' = \frac{2(8.75 \times 7.25)}{(8.75 + 7.25 + 7.25)} = 5.457 \text{ m}$$

$$\text{Therefore } U = \frac{2.0}{((0.457 \times 5.457) + 7.222)} = 0.21 \text{ W/m}^2\text{K}.$$

The edge insulation to the slab is provided to prevent thermal bridging at the edge of the slab. I.S. EN ISO 13370: 2007 does not consider this edge insulation as contributing to the overall floor insulation and thus reducing the floor U-value. However, edge insulation, which extends below the external ground level, is considered to contribute to a reduction in floor U-value and a method of taking this into account is included in the standard. Foundation walls of insulating lightweight concrete may be taken as edge insulation for this purpose.

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## ELEMENTS ADJACENT TO UNHEATED SPACES

**A4.1** As indicated in paragraph 0.3.5, the procedure for the calculation of U-values of elements adjacent to unheated spaces (previously referred to as semi-exposed elements) is given in I.S. EN ISO 6946: 2007 and I.S. EN ISO 13789: 2007.

### Other cases

In other cases  $R_{12}$  should be calculated using the following formula

$$R_u = \frac{A_i}{\Sigma[A_e \times U_e] + 0.33nV}$$

Where  $A_i$  and  $A_e$  are the areas of internal and external elements ( $m^2$ ),  
Excluding any ground floor;  $U_e$  is the U value of external elements ( $W/m^2 K$ ) and  $n$  is the air exchange rate (ach) of the unheated space ( $m^3$ ).

Typical values of the air exchange rate in unheated spaces are given in the Table A5. The default value of  $n = 3$ ach should be used if the airtightness of the unheated space is not known.

The following formulae may be used to derive elemental U-values (taking the unheated space into account) for typical building situations irrespective of the precise dimensions of the unheated space.

$$U_o = 1 / (1/U - R_u) \text{ or } U = 1 / (1/U_o + R_u)$$

Where:

$U =$  U-value of element adjacent to unheated space ( $W/m^2K$ ), taking the effect of the unheated space into account.

$U_o =$  U-value of the element between heated and unheated spaces ( $W/m^2K$ ) calculated as if there was no unheated space adjacent to the element.

$R_u =$  effective thermal resistance of unheated space inclusive of all external elements ( $m^2K/W$ ).

Table A 5 typical air change rates for unheated spaces	
Airtightness type	Air changes per hour
No doors or windows, all joints between components well-sealed, no ventilation openings provided	0.1
All joints between components well sealed, no ventilation openings provided	0.5
All joints well-sealed, small openings or permanent ventilation openings	1.0
Not airtight due to some localised open joints or permanent ventilation openings	3.0
Not airtight due to numerous open joints, or large or numerous permanent ventilation openings	10.0

# Appendix B

## Fabric Insulation : Additional Guidance for Common Constructions

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### GENERAL

**B.1** This Appendix provides some basic guidance in relation to typical roof, wall and floor constructions. Guidance is not exhaustive and designers and contractors should also have regard to other sources of relevant guidance, e.g. BR.262: 2001. Thermal Insulation; avoiding risks, relevant standards and good building practice.

In particular, diagrams in this Appendix are intended to be illustrative of the construction to which they refer. They do not purport to provide detailed guidance on the avoidance of thermal bridging. See sections 1.3.3, 2.1.3 and Limiting Thermal Bridging and Air Infiltration - Acceptable Construction Details (ACDs) for guidance on reasonable provision in this regard.

**B.2** For many typical roof, wall and floor constructions, the thickness of insulation required to achieve a particular U-value can vary depending on the thermal performance of the insulation material. Higher performing insulating materials, i.e. those with lower thermal conductivities, can achieve any given U-value with a lower thickness of insulating material.

**B.3** Condensation in buildings occurs whenever warm moist air meets surfaces that are at or below the dew point of that air. There are two main types, surface condensation and interstitial condensation.

Surface condensation occurs on the surface of walls, windows, ceilings and floors and may result in mould and mildew.

Interstitial condensation occurs within the construction of the building and can damage structural materials or make insulating materials less effective.

Full checks should be performed on the likelihood of surface and interstitial condensation of a construction detail in accordance with I.S. EN ISO 13788:2012.

This standard contains recommended procedures for the assessment of the risk of:

- surface condensation and mould growth;
- interstitial condensation.

The guidance in BRE document BR 497 Conventions for calculating linear thermal transmittance and temperature factors (2<sup>nd</sup> Edition) may be used to perform the checks in IS EN ISO 13788:2012.

IS EN 15026:2007 can also be used to assess the risk of surface condensation and mould growth. The transient models covered in this standard take account of heat and moisture storage, latent heat effects, and liquid and convective transport under realistic boundary and initial conditions.

**B.4** A vapour control layer (VCL) substantially reduces the water vapour transfer through any building component in which it is incorporated by limiting both vapour diffusion and air movement. The measures required to achieve a functional VCL must be carefully considered at the design stage.

A VCL should extend over the whole of the element into which it is incorporated and must

be integrated with and sealed to adjoining elements, such as masonry, upstands and glazing systems and to any VCL in those elements. VCLs may be formed with a membrane within the structure or with a lining board with an integral membrane. A VCL should be of appropriate vapour resistance and should be situated on the warm side of the insulation.

The performance of a VCL depends upon the vapour resistance of the material selected, the practicability of the design and the standard of workmanship involved in its installation. The integrity of the VCL should be ensured by effective sealing of all service penetrations, e.g. electrical wiring. Methods of avoiding such penetrations should be considered in the design stage.

Side and end joints in a flexible sheet VCL should be kept to a minimum. Joints should be made over a solid backing member or substrate, lapped not less than 50 mm and sealed with an appropriate sealant. Similarly, tears and splits should be repaired using the same material, jointed as above. If polyethylene sheeting is used, it should be protected from heat and sunlight to reduce the risk of degradation occurring.

Where a VCL is incorporated in a rigid board, joints between adjacent boards should be sealed to avoid mass transfer of water vapour due to air leakage. These seals should be designed to accommodate thermal or other movement which may occur during the design life of the building.

A VCL can also act as an air leakage barrier, which by reducing air movement has the added benefit of reducing the heat lost by convection.

## ROOF CONSTRUCTIONS

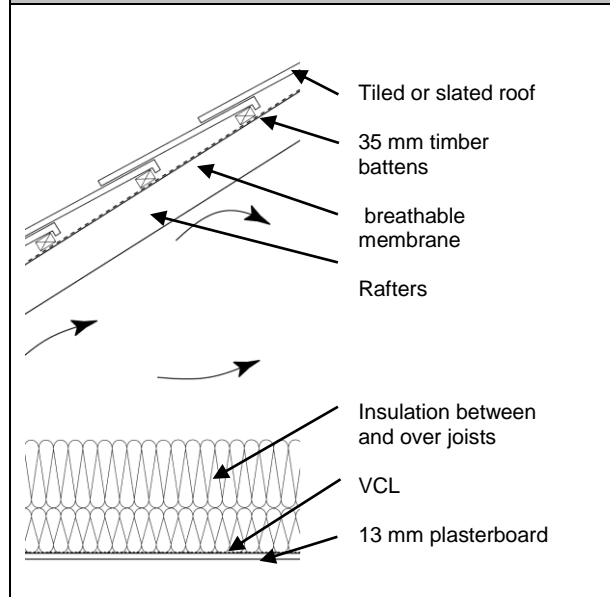
### B.5.1 Construction R1: Tiled or slated pitched roof, ventilated roof space, insulation at ceiling level

#### B.5.1.1R1 (a) Insulation between and over joists

#### Installation guidelines and precautions

Care is required in design and construction, particularly in regard to the following:

**Diagram B1 Insulation between and over joists**  
(Par. B.5.1.1)



#### Provision of adequate roofspace ventilation

Adequate ventilation is particularly important to ensure the prevention of excessive condensation in cold attic areas. See relevant guidance in Technical Guidance Document F.

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### **Minimising transfer of water vapour from occupied dwelling area to cold attic space**

In addition to ensuring adequate ventilation, measures should be taken to limit transfer of water vapour to the cold attic. Care should be taken to seal around all penetrations of pipes, ducts, wiring, etc. through the ceiling, including provision of an effective seal to the attic access hatch. Use of a VCL at ceiling level, on the warm side of the insulation, will assist in limiting vapour transfer and should therefore be used, but cannot be relied on as an alternative to ventilation. Where the roof pitch is less than 15°, or where the shape of the roof is such that there is difficulty in ensuring adequate ventilation, e.g. room-in-the-roof construction, the VCL is essential.

### **Minimising the extent of cold bridging**

Particular areas of potential cold bridging include junctions with external walls at eaves and gables, and junctions with solid party walls. Gaps in the insulation should be avoided and the insulation should fit tightly against joists, noggings, bracing etc. Insulation joints should be closely butted and joints in upper and lower layers of insulation should be staggered (see Acceptable Construction Details, details G01 - G04).

### **Protecting water tanks and pipework against the risk of freezing**

All pipework on the cold side of the insulation should be adequately insulated. Where the cold water cistern is located in the attic, as is normally the case, the top and sides of the cistern should be insulated. The area underneath the cistern should be left uninsulated and continuity of tank and ceiling insulation should be ensured, e.g. by overlapping the tank and ceiling insulation. Provision should be made to ensure

ventilation of the tank. Where raised tanks are used, (to aid head pressure), the ceiling should be insulated normally and the tank insulated separately.

### **Ensuring that there is no danger from overheating of electric cables or fittings**

Cables should be installed above the insulation. Cables which pass through or are enclosed in insulation should be adequately rated to ensure that they do not overheat. Recessed fittings and transformers should have adequate ventilation or other means to prevent overheating.

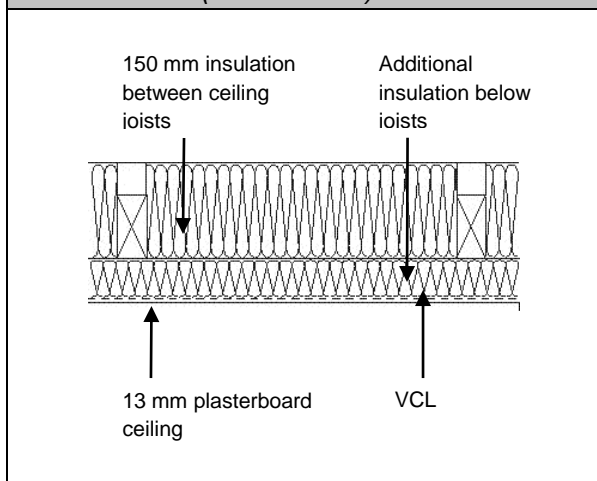
### **Providing for access to tanks, services and fittings in the roofspace**

Because the depth of insulation will obscure the location of ceiling joists, provision should be made for access from the access hatch to the cold water tank and to other fittings to which access for occasional maintenance and servicing may be required. This can be done by provision of walkways without compressing the installed insulation or by the use of high density insulation under the walkway or by installing composite attic boards.

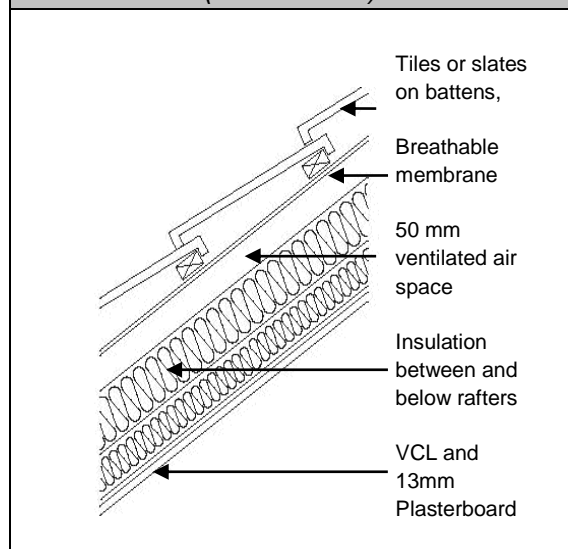
### **B.5.1.2 R1(b) Insulation between and below joists**

Insulation is laid in one layer between the joists, protruding above them where its depth is greater, and leaving air gaps above the joists. A composite board of plasterboard with insulation backing is used for the ceiling.

**Diagram B2 Insulation between and below joists**  
(Par. B.5.1.2)



**Diagram B3 Insulation between and below rafters**  
(Par. B.5.2.1)



### Installation guidelines and precautions

Similar guidelines and precautions apply as for R1(a) above. Where the thermal conductivity of insulation between and below the joists is different, the material on the warm side (i.e. below the joists) should have a vapour resistance no lower than that on the cold side (i.e. between the joists). It is preferable if the insulation on the cold side is more permeable than that on the warm side (e.g. mineral wool outside with expanded polystyrene inside).

### B.5.2 Construction R2: Tiled or slated pitched roof, occupied or unventilated roof space, insulation on roof slope

#### B.5.2.1R2(a) Insulation between and below rafters, 50 mm ventilated cavity between insulation and breathable membrane

### Installation guidelines and precautions

The insulation is installed in two layers, one between the rafters (and battens) and the second below and across them. To limit water vapour transfer and minimise condensation risks, a VCL is required on the warm side of the insulation. No material of high vapour resistance, e.g. facing layer attached to insulation to facilitate fixing, should be included within the overall thickness of insulation. Care must be taken to prevent roof timbers and access problems interfering with the continuity of insulation and VCL.

Provision should be made for ventilation top and bottom of the 50 mm ventilation gap on the cold side of the insulation.

An alternative construction using a breathable membrane may be used. In this case the membrane should be certified in accordance with Part D of the Building Regulations and

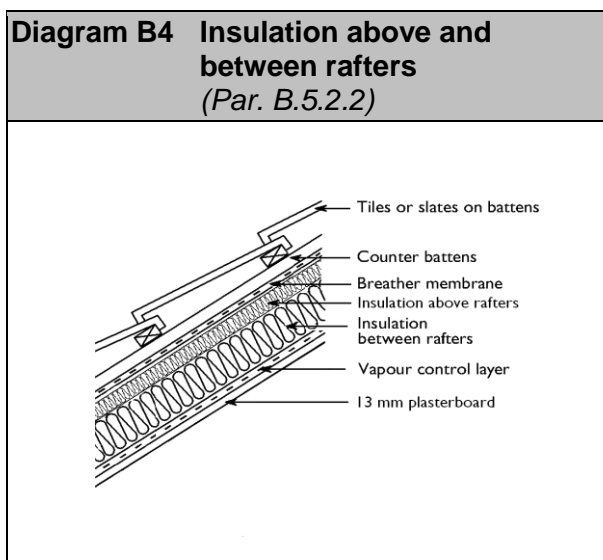
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installed in accordance with the guidance on the certificate.

Care should be taken to avoid thermal bridging at roof-wall junctions at eaves, gable walls and party walls (see Acceptable Construction Details, details 1.13 and 1.16).

Where the thermal conductivity of insulation between and below the rafters is different, the material on the warm side (i.e. below the rafters) should have a vapour resistance no lower than that on the cold side (i.e. between the rafters). It is preferable if the insulation on the cold side is more permeable than that on the warm side (e.g. mineral wool outside with expanded polystyrene inside).

#### **B.5.2.2R2 (b): Insulation above and between rafters, slate or tile underlay of breather membrane type**



#### **Installation guidelines and precautions**

The effective performance of this system is critically dependent on the prevention of air and water vapour movement between the warm and cold sides of the insulation. Only systems which are certified or shown by test and calculation as appropriate for this function, (see Technical Guidance Document D, paragraphs 1.1 (a) and (b) should be used.

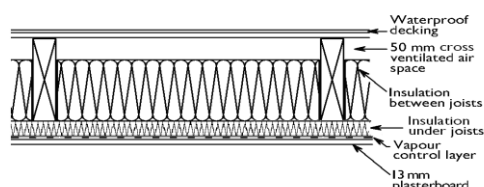
The precise details of construction are dependent on the insulation and roof underlay materials to be used. Installation should be carried out precisely in accordance with the procedures described in the relevant certificate.

Care should be taken to avoid thermal bridging at roof-wall junctions at eaves, gable walls and party walls (see Acceptable Construction Details, details 1.14 and 1.18)

#### **B.5.3 Construction R3: Flat roof, timber joists, insulation below deck (Cold Deck)**

##### **B.5.3 R3: Insulation between and below joists, 50 mm air gap between insulation and roof decking**

**Diagram B5 Timber flat roof, insulation between joists and below Joists (Par. B.5.3)**



joists) should have a vapour resistance no lower than that on the cold side (i.e. between the joists). It is preferable if the insulation on the cold side is more permeable than that on the warm side (e.g. mineral wool outside with expanded polystyrene inside).

#### **B.5.4 Construction R4: Sandwich warm deck flat roof**

The insulation is installed above the roof deck but below the weatherproof membrane. The structural deck may be of timber, concrete or metal.

#### **Installation guidelines and precautions**

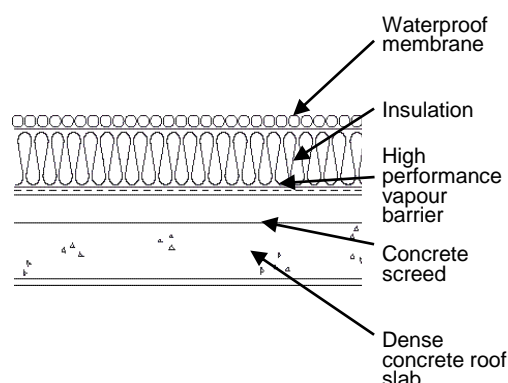
The insulation is installed in two layers, one between the joists, and the second below the joists. A ventilated air space as specified in Technical Guidance Document F should be provided above the insulation. Cross ventilation should be provided to each and every void. When installing the insulation, care is needed to ensure that it does not block the ventilation flow paths. The roof insulation should connect with the wall insulation so as to avoid a cold bridge at this point.

In general, the insulation material must be of low vapour permeability, there should be a tight fit between adjacent insulation boards, and between insulation boards and rafters. All gaps in the insulation (e.g. at eaves, ridge, gable ends, around rooflights and chimneys, etc.) should be sealed with flexible sealant or expanding foam with the procedures described in the relevant certificate.

The lower layer may be in the form of composite boards of plasterboard backed with insulation, with integral vapour barrier, fixed to the joists. The edges of boards should be sealed with vapour-resistant tape.

Where the thermal conductivity of insulation between and below the joists is different, the material on the warm side (i.e. below the

**Diagram B6 Sandwich warm deck flat roof above a concrete structure (Par. B.5.4)**



#### **Installation guidelines and precautions**

The insulation boards are laid over and normally fully bonded to a high performance vapour barrier complying with IS EN 13707: 2013 which is bonded to the roof deck. The insulation is overlaid with a waterproof membrane, which may consist of a single layer membrane, a fully-bonded built-up bitumen roofing system, or mastic asphalt on an isolating layer. At the perimeter, the vapour barrier is turned up and back over the insulation and bonded to it and the weatherproof membrane. Extreme care is

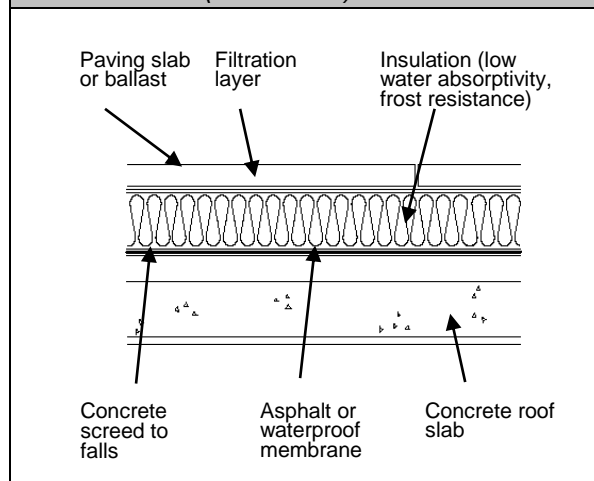


required to ensure that moisture can not penetrate the vapour barrier. The insulation should not be allowed to get wet during installation. There should be no insulation below the deck nor should this area be ventilated. This could give rise to a risk of condensation on the underside of the vapour barrier. Thermal bridging at a roof / wall junction should be avoided (see Acceptable Construction Details, details 1.19 and 1.20).

#### **B.5.5 Construction R5: Inverted warm deck flat roof: insulation to falls above both roof deck and weatherproof membrane**

Insulation materials should have low water absorption, be frost resistant and should maintain performance in damp conditions over the long term. To balance loss of performance due to the damp conditions and the intermittent cooling effect of water passing through and draining off from the warm side of the insulation, the insulation thickness calculated as necessary for dry conditions should be increased by 20%. Alternatively the extra heat loss can be calculated in accordance with Section D4 of Appendix D in IS EN ISO 6946

**Diagram B7 Inverted warm deck roof with concrete structure**  
(Par. B.5.5)



#### **Installation guidelines and precautions**

The insulation is laid on the waterproof membrane. A filtration layer is used to keep out grit, which could eventually damage the weatherproof membrane. The insulation must be restrained to prevent wind uplift and protected against ultraviolet degradation. This is usually achieved by use of gravel ballast, paving stones or equivalent restraint and protection. The insulation should have sufficient compressive strength to withstand the weight of the ballast and any other loads.

Rainwater will penetrate the insulation as far as the waterproof membrane. Drainage should be provided to remove this rainwater both at the upper surface and at the membrane level where practicable. To minimise the effect of rain on performance, insulation boards should be tightly jointed (rebated or tongued-and-grooved edges are preferred), and trimmed to give a close fit around upstands and service penetrations.

To avoid condensation problems, the thermal resistance of the construction between the

weatherproof membrane and the heated space is at least  $0.15 \text{ m}^2\text{K/W}$ . However, this thermal resistance should not exceed 25% of the thermal resistance of the whole construction.

Thermal bridging at roof / wall junctions should be avoided.

It should be noted that the details refer to cavity walls with a maximum overall cavity width of 150 mm which is the greatest cavity width for which details of construction are given in IS EN 1996. Eurocode 6; Design of Masonry Structures and associated national annexes. Where it proposed to use wider cavity widths, full structural and thermal design will be necessary

## WALL CONSTRUCTIONS

### B.6.1 W1: Cavity walls, insulation in cavity, cavity retained (partial fill)

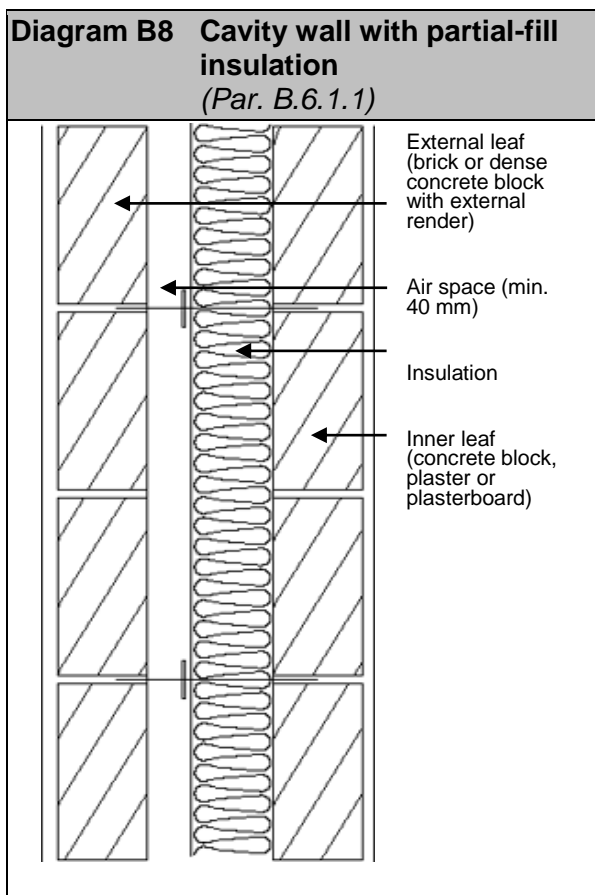
#### B.6.1.1W1(a): Brick or rendered dense concrete block external leaf, partial fill insulation, dense concrete block inner leaf, plaster or plasterboard internal finish.

The insulation thickness required to achieve a given U-value may be reduced by using lightweight concrete insulating blocks for the inner leaf. When calculating the U-value in accordance with Appendix A, the inner leaf is considered a bridged layer due to the mortar with a 7% fractional area.

Due to the sound attenuation properties of lightweight blocks this may limit their suitability for use in the inner leaves adjoining party walls due to flanking sound transmission.

### Installation guidelines and precautions

Insulation should be tight against the inner leaf. Any excess mortar should be cleaned off before fixing insulation. The insulation layer should be continuous and without gaps. Insulation batts should butt tightly against each other. Mortar droppings on batts should be avoided. Batts should be cut and trimmed to fit tightly around openings, cavity trays, lintels, sleeved vents and other components bridging the cavity, and should be adequately supported in position. BRE "Good Building Guide 68 Part 2 Installing thermal insulation: Good site practice" provides further guidance on installing insulation in cavity walls.



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Critical locations where care should be taken to limit thermal bridging include lintels, jambs, cills, roof-wall junctions and wall-floor junctions. The method of cavity closure used should not cause thermal bridge at the roof-wall junction (see Acceptable Construction Details, Group 1 details)

**B.6.1.2W1(b): As W1(a) except with insulation partly in cavity and partly as internal lining**

If composite boards of plasterboard backed with insulation (of similar conductivity to that used in the cavity) are used internally then the total insulation thickness (cavity plus internal) may be used to calculate the U-value. If internal insulation is placed between timber studs / battens, then the insulation must be treated as two separate layers with the bridging effect allowed for in the internal layer (similar to example A2 in Appendix A).

Where the thermal conductivity of the insulation is different, the material on the warm side (i.e. internally) should have a vapour resistance no lower than the insulation on the cold side (i.e. in the cavity).

Lower U-values, or reduced insulation thickness, can be achieved by using insulating concrete blockwork (rather than dense concrete) between the cavity and internal insulation.

Insulation partly in cavity and partly as internal lining helps minimise thermal bridging. Internal insulation limits thermal bridging at floor and roof junctions, whereas cavity insulation minimises thermal bridging at separating walls and internal fixtures.

**Installation guidelines and precautions**

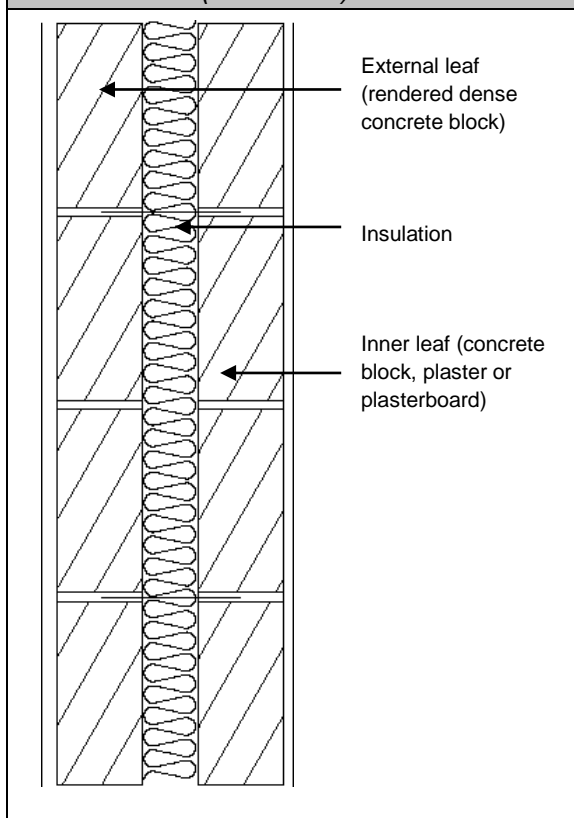
Installation of insulation in the cavity should follow the guidelines given above for construction W1(a) (partial-fill cavity insulation), and installation of the internal lining should follow the guidelines given below for construction W4 (hollow-block). BRE “Good Building Guide 68 Part 2 Installing thermal insulation: Good site practice” provides further guidance on installing insulation in cavity walls.

**B.6.2 Construction W2: Cavity walls, insulation in cavity, no residual cavity (full-fill)**

The insulation fully fills the cavity. Insulation may be in the form of semi-rigid batts installed as wall construction proceeds, or loose-fill material blown into the cavity after the wall is constructed; the former is considered here. Insulation material suitable for cavity fill should not absorb water by capillary action and should not transmit water from outer to inner leaf. Such insulation may extend below dpc level.

The insulation thickness required to achieve a given U-value may be reduced by using insulating concrete blocks for the inner leaf, as advised in W1(a) above.

**Diagram B9 Cavity wall with full-fill insulation**  
(Par. B.6.2)



### Installation guidelines and precautions

Only certified insulation products should be used, and the installation and other requirements specified in such certificates should be fully complied with. In particular, regard should be had to the exposure conditions under which use is certified and any limitations on external finish associated therewith.

Guidance on minimising air gaps and infiltration in partial-fill cavity insulation applies also to full-fill insulation. Similar issues regarding avoidance of thermal bridging as for partial-fill construction apply.

BRE “Good Building Guide 68 Part 2 Installing thermal insulation: Good site practice” provides further guidance on installing insulation in cavity walls.

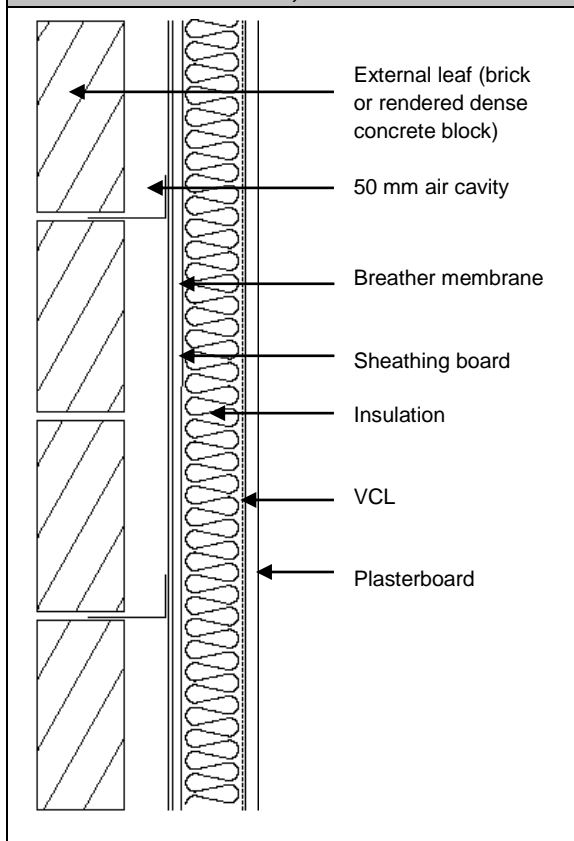
### B.6.3 Construction W3: Timber frame wall, brick or rendered concrete block external leaf

#### B.6.3.1W3(a): Insulation between studs

The insulation is installed between studs, whose depth equals or exceeds the thickness of insulation specified.

In calculating U-values, the fractional area of timber bridging the insulation should be checked. Account should be taken of all repeating timber elements which fully bridge the insulation. In Table A3, a fractional area of 15% is given as the default percentage and is used in Example A2 to calculate the upper and lower thermal resistance of the bridged construction.

**Diagram B10 Timber frame wall, insulation between framing timbers (Par. B.6.3.1)**



Care is required to minimise thermal bridging of the insulation by timber noggings and other inserts (see Acceptable Construction Details, Group 4 details).

#### **B.6.3.2W3(b): Insulation between and across studs**

Where the chosen stud depth is not sufficient to accommodate the required thickness of insulation, insulation can be installed to the full depth between the studs with additional insulation being provided as an internal lining. This additional insulation may be either in the form of plasterboard / insulation composite board or insulation between timber battens, to which the plasterboard is fixed.

The VCL should be on the warm side of the insulation. If different types of insulation are used between and inside the studs, the vapour resistance of the material between the studs should not exceed that of the material across them (see B4 regarding VCLs).

#### **Installation guidelines and precautions**

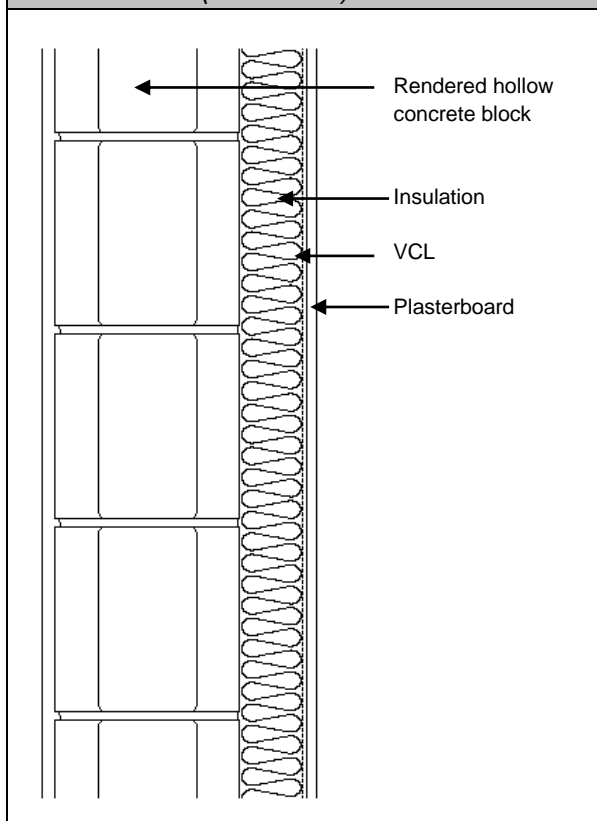
Air gaps in the insulation layer, and between it and the vapour barrier, should be avoided. Insulation batts should be friction fitted between studs to minimise gaps between insulation and joists. Adjacent insulation pieces should butt tightly together. Particular care is needed to fill gaps between closely-spaced studs at wall / wall and wall / floor junctions, and at corners of external walls.

A VCL should be installed on the warm side of the insulation. There should be no layers of high vapour resistance on the cold side of the insulation.

#### **B.6.4 Construction W4: Hollow concrete block wall, rendered externally, internal insulation lining with plasterboard finish**

The insulation is installed on the inner face of the masonry walls. It may be installed between preservative-treated timber studs fixed to the wall, or in the form of composite boards of plaster backed with insulation, or as a combination of these.

**Diagram B11 Hollow-block wall, internal insulation lining**  
(Par. B.6.4)



## Installation guidelines and precautions

### Air Movement

Air gaps in the insulation layer should be kept to a minimum. If using insulation between timber studs, there should be no gaps between insulation and studs, between insulation and the VCL, between butt joints in the insulation. If using composite boards, they should be tightly butted at edges, and should provide complete and continuous coverage of the external wall.

When mounting composite boards on plaster dabs or timber battens, there is a danger that air will be able to circulate behind the insulation, reducing its effectiveness. To minimise such air movement, the air gap

behind the boards should be sealed along top and bottom, at corners and around window and door openings, e.g. with continuous ribbon of plaster or timber studs. This also serves as a fire barrier.

### Condensation

A suitable VCL should be installed on the warm side of the insulation to minimise the risk of interstitial condensation on the cold masonry behind the insulation. Care should be taken to avoid gaps in the VCL at all joints, edges and service penetrations. The location of service runs in the air gap on the cold side of the insulation should be avoided. Refer to paragraph B4 for further guidance.

### Thermal Bridging

Care should be taken to minimise the impact of thermal bridging. Critical locations where care should be taken to limit thermal bridging include lintels, jambs, cills, roof-wall junctions and wall-floor junctions (see Acceptable Construction Details, Group 6 details).

Other areas where there is a risk of significant thermal bridging include: -

### Junctions with solid party walls and partitions

Internal partition or party walls of solid dense concrete blockwork can create significant thermal bridge effects at junctions with single leaf masonry external walls (see Acceptable Construction Details, details 6.05 and 6.06).

### Junctions with intermediate floors

The external walls in the floor space of intermediate floors should be insulated and

protected against vapour movement. Along the wall running parallel to the joists, insulation can be placed between the last joist and the wall. Where the joists are perpendicular to the wall, the insulation and VCL should be continuous through the intermediate floor space and should be carefully cut to fit around the joist ends (see Acceptable Construction Details, detail 6.04).

### **Stairs, cupboards and other fittings supported on or abutting the external wall**

Insulation should be carried through behind such fittings.

### **Ducts, e.g. Soil and vent pipe ducts, against external walls**

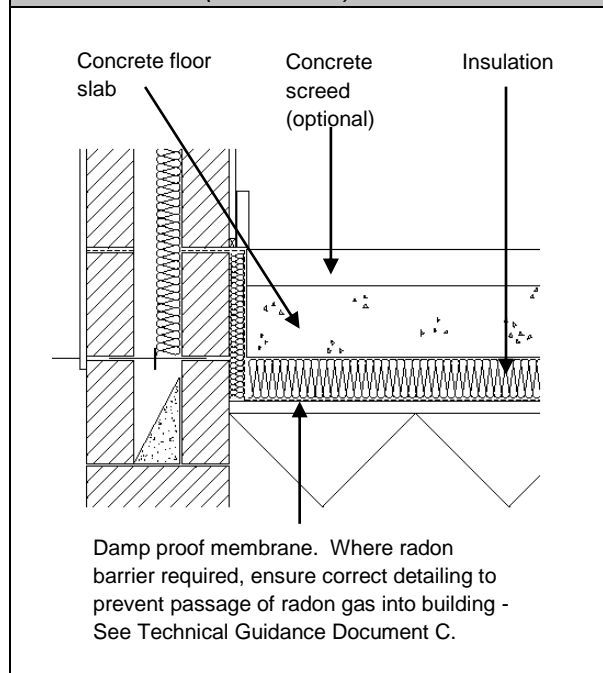
Insulation should be continuous at all such ducts, i.e. the insulation should be carried through on either the external or internal side of such ducts. Where the insulation is on the external side, particular care should be taken to prevent ingress of cold external air where ducts etc. penetrate the insulation.

## **FLOOR CONSTRUCTIONS**

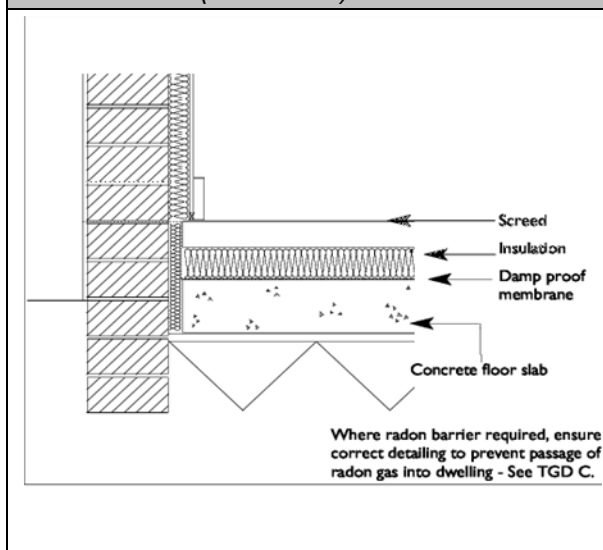
### **B.7.1 Construction F1: Ground floor: concrete slab-on-ground. Insulation under slab or under screed**

For continuous and uniform insulation under the full ground floor area, the insulation thickness required to achieve prescribed U-values for slab-on-ground floors varies depending on the floor area to exposed perimeter ratio as shown in Example A4 in Appendix A. When calculating the U value the ground conductivity should be taken as 2.0 W/mK and the full wall thickness as 350 mm

**Diagram B12 Concrete slab-on-ground floor, insulation under slab (Par. B.7.1)**



**Diagram B13 Concrete slab on ground floor, insulation under screed (Par. B.7.1)**



### Installation guidelines and precautions

The insulation may be placed above or below the dpm/radon barrier. The insulation should not absorb moisture and, where placed below the dpm / radon barrier, should perform well under prolonged damp conditions and should not be degraded by any waterborne contaminants in the soil or fill. The insulation should have sufficient load-bearing capacity to support the floor and its loading.

The insulation is laid horizontally over the whole area of the floor. Insulation boards should be tightly butted, and cut to fit tightly at edges and around service penetrations.

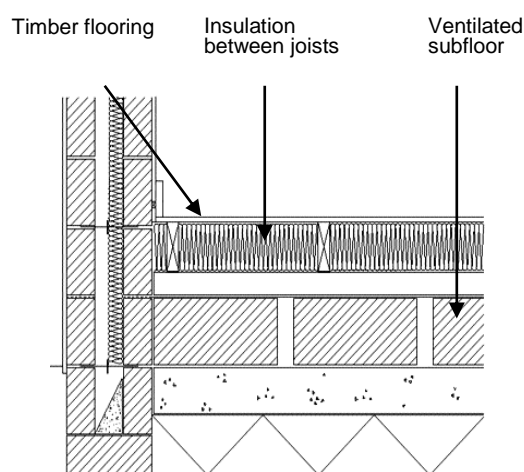
Care should be taken to prevent damage or dislodgement of insulation during floor laying. If the dpm is placed below the insulation, the joints between insulation boards should be taped to prevent wet screed from entering when being poured. If the slab / screed is power-floated, the exposed edges of perimeter insulation should be protected during power-floating, e.g. by boards, or the areas close to the edge of the floor should be hand trowelled.

Thermal bridging at floor-wall junctions should be minimised (see Acceptable Construction Details, details 1.01a and 6.02)

With cavity walls, thermal bridging via the inner leaf is difficult to avoid, but adequate provision to limit it should be made.

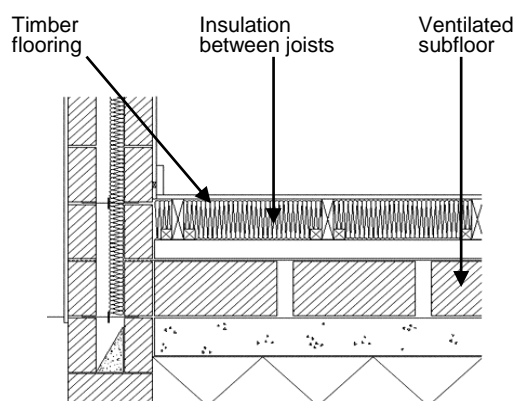
### B.7.2 Construction F2: Ground floor: suspended timber floor, insulation between joists

**Diagram B14 Suspended timber floor with quilt insulation (Par. B.7.2)**



Where radon barrier required, ensure correct detailing to prevent passage of radon gas into dwelling - See Technical Guidance Document C.

**Diagram B15 Suspended timber floor with rigid or semi-rigid board insulation (Par. B.7.2)**



Where radon barrier required, ensure correct detailing to prevent passage of radon gas into dwelling - See Technical Guidance Document C.



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### Installation guidelines and precautions

Where mineral wool quilt insulation is used, the insulation is supported on polypropylene netting or a breather membrane draped over the joists and held against their sides with staples or battens. The full thickness of insulation should extend for the full width between joists. Insulation should not be draped over joists, but cut to fit tightly between them.

Alternatively, rigid or semi-rigid insulation boards, supported on battens nailed to the sides of the joists, may be used.

When calculating the U-value for a timber floor the fractional area of timber thermal bridging can be calculated or assumed as 11% as per Table A3.

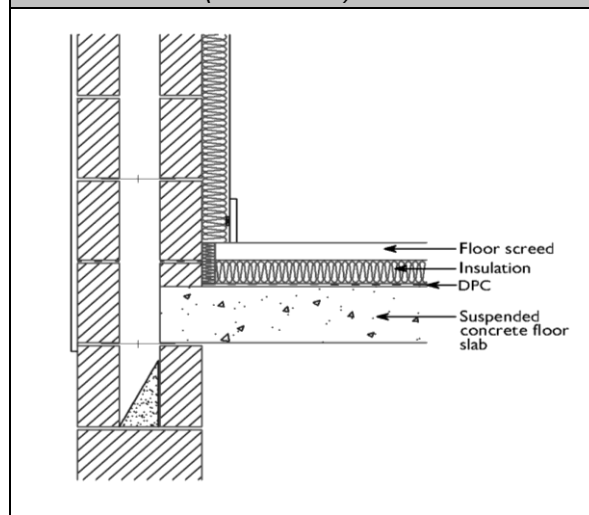
Thermal bridging, and air circulation around the insulation from the cold vented air space below, should be minimised. The insulation should fit tightly against the joists and the flooring above. Careful placement of supporting battens (or staples) is required to achieve this. At floor-wall junctions the insulation should extend to the walls. The space between the last joist and the wall should be packed with insulation to the full depth of the joist. Where internal wall insulation is used, the floor and wall insulation should meet. Where cavity insulation is used, the floor insulation should be turned down on the internal face and overlap the cavity insulation, or insulating blocks used in the wall at this level (see Acceptable Construction Details, details 1.03 and 6.03)

Cross-ventilation should be provided to the sub-floor space to remove moisture.

Water pipes in the sub-floor space should be insulated to prevent freezing.

### B.7.3 Construction F3: Ground floor: suspended concrete floor

**Diagram B16 Suspended reinforced concrete floor, internally insulated walls**  
(Par. B.7.3)



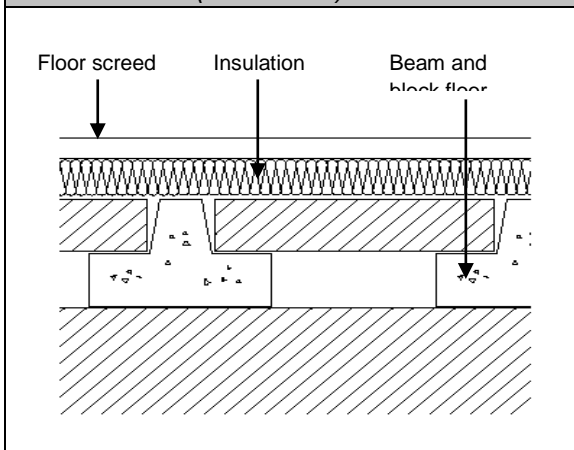
### Installation guidance and precautions

If the walls are internally insulated, it is recommended that the floor insulation be placed above the floor structure, since it can then connect with the wall insulation. Thermal bridging at the floor-wall junction is difficult to avoid when insulation is placed below the floor structure (see Acceptable Construction Details, details 6.01 and 6.02).

If the walls are cavity insulated, floor insulation cannot connect with wall insulation, so some thermal bridging is inevitable. It can be minimised by using insulating blocks for the inner leaf between overlapping floor and wall insulation. Insulation and insulating blocks may be either above or below the floor structure, but above is recommended. This will allow the use of less dense blocks (of

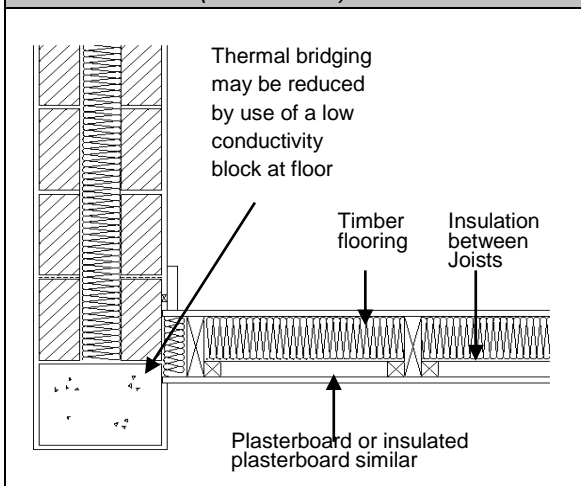
lower thermal conductivity), since they will not have to support the weight of the floor. Also, above the structure they will be above the dpc, where their lower moisture content will give a lower thermal conductivity than below the dpc. Heat loss from the floor can be further reduced by extending the cavity insulation down to, or below, the lower edge of the suspended floor.

**Diagram B17 Suspended beam and block floor**  
(Par. B.7.3)



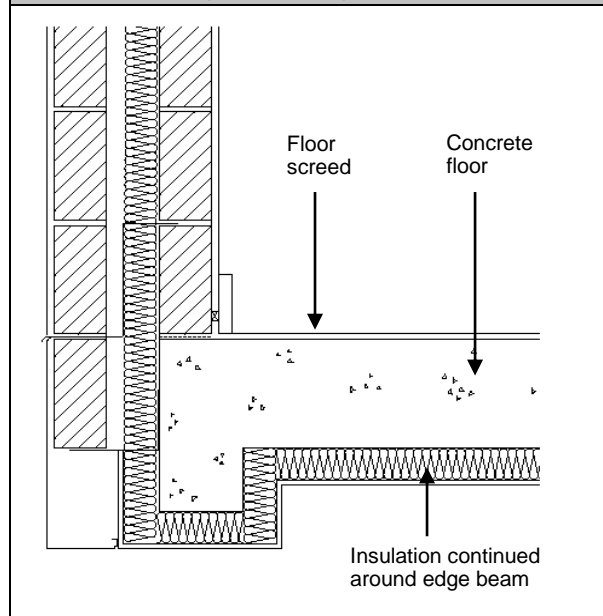
#### B.7.4 Construction F4: Exposed floor: timber joists, insulation between joists

**Diagram B18 Exposed timber floor. Insulation between joists**  
(Par. B.7.4)



#### B.7.5 Construction F5: Exposed floor: solid concrete, insulation external

**Diagram B19 Exposed concrete floor, external insulation**  
(Par. B.7.5)



#### Installation guidance and precautions

If the walls are internally insulated, this floor construction is not recommended. Floor insulation should instead be located internally in order to connect with the wall insulation.

With cavity wall insulation, thermal bridging may be minimised by supporting the external leaf independently, and continuing the external floor insulation around the edge beam to connect with the cavity insulation as shown in Diagram 19.

# Appendix C

## Reference Values for Calculation of MPEPC and MPCPC

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The following are parameters for the reference building which has the same size i.e. same floor area and volume as the building being assessed. These performance parameters represent an improvement in the order of 60% across all buildings with a 20% renewable energy contribution. This represents the Nearly Zero Energy Building performance.

The primary energy consumption and CO<sub>2</sub> Emissions per unit floor area calculated for this reference building are used to calculate the primary energy performance coefficient (EPC) and carbon performance coefficient (CPC) respectively for the building being assessed. These in turn are compared to the MPEPC and MPCPC in order to demonstrate compliance for the dwelling being assessed.

The MPEPC and MPCPC to be achieved should be 1 and 1.15 respectively.

Table C1 provides the performance specification for each performance parameter

Table C2 provides a set of linear thermal transmittance values for thermal bridges for use with Table C1

Alternative approaches to achieve the performance specification in Table C1 are permitted provided they give the same whole building energy performance when calculated in Non-domestic Energy Assessment Procedure (NEAP) as provided by SEAI.

Two different window specifications have been provided in Table C1 that vary depending on the dominant form of daylighting. The generic forms are:

- (a) sidelit through vertical windows (offices, halls of residence etc.). These have 40% glazing with 10% framing factor (FF);
- (b) toplit through rooflights (warehouses, industrial buildings etc). These are 12% glazed with 30% framing factor (FF);

The calculation methodology for Renewable Energy Ratio (RER) is provided in NEAP.

**Table C1: Reference Values**

Element	Performance value for reference building
Roof U Value (W/(m <sup>2</sup> K))	0.15
Wall U Value (W/(m <sup>2</sup> K))	0.18
Floor U Value (W/(m <sup>2</sup> K))	0.15
Thermal Bridging	Key TB length x psi value in Table C2
Window U Value (W/(m <sup>2</sup> K)) Side lit :Exposed facades will have windows with area that is the lesser of either: 1.5m high x full facade width OR 40% of exposed facade area Top Lit:12% of exposed roof area will be made up of roof-lights <sup>1</sup>	1.4 (10% FF) (for side lit or unlit buildings)  1.6 (30% FF) (for top lit buildings)
G-Value (%)	40
Light Transmittance (%)	71
Air Permeability (m <sup>3</sup> /(m <sup>2</sup> h)) Gross internal area less than 250 m <sup>2</sup>	5
Air Permeability (m <sup>3</sup> /(m <sup>2</sup> h)) Gross internal area greater than 250 m <sup>2</sup>	3
Lighting (luminaire lm/circuit watt)	65
Occupancy Control	Yes (Manual-On-Auto-Off)
Daylight Control	Yes (photo-electric dimming without back sensor control)
Maintenance Factor for lighting	0.8
Heating efficiency (heating and hot water)%	91
Central Ventilation SFP (W/(l/s)) <sup>2</sup>	1.8
Terminal unit SFP	0.3
Cooling-where applicable (air-conditioned) (SEER <sup>3</sup> /SSEER <sup>2</sup> )	4.5/3.6
Cooling where applicable (mixed mode) (SSEER)	2.7
SFP (W/(l/s)) for air distribution systems where applicable <sup>2</sup>	As per maximum values in Table 6 and Table 6a in Section 1.4.3
Variable speed control of fans and pumps controlled via multiple sensors	Yes
Demand Control (mechanical ventilation only) Variable speed control of fans via CO <sub>2</sub> sensors	Yes
Shading and Orientation	Same as actual building
Fuel	Auxiliary Energy= grid electricity <sup>4</sup> Cooling=grid electricity Space Heating=gas boiler Domestic hot water =gas boiler
Renewable Energy Ratio (RER) provided by photovoltaics	0.2

<sup>1</sup> The number of roof-lights per roof element is determined using the following equation: **Number of rooflights per roof element=roof element area/((1.68xzone height)/(cos(angle of slope)))**<sup>2</sup> The number of roof-lights should be rounded to the nearest integer and be greater than zero. Where the roof element is sloped, the zone height should be the height to the eaves or lowest point of the roof element.

<sup>2</sup> Guidance is provided in NEAP for specialist process.

<sup>3</sup> Seasonal energy efficiency ratio' (SEER) as defined by eco-design Regulations is the overall energy efficiency ratio of the air conditioner or comfort chiller, representative for the cooling season, calculated as the 'reference annual cooling demand' divided by the 'annual energy consumption for cooling';

<sup>4</sup> The methodology specified for Primary Energy Factor (PEF) in NEAP accounts for losses in the electrical generation and distribution systems and may be updated periodically by SEAI.

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**Table C2: Thermal Bridging Details (W/mK)**

Junction	W/mK	W/mK
Type of junction	Involving metal cladding	Not involving metal-cladding
Roof to wall	0.28	0.12
Wall to ground floor	1.0	0.16
Wall to wall (corner)	0.2	0.09
Wall to floor (not ground floor)	0.0	0.07
Lintel above window or door	1.0	0.30
Sill below window	0.95	0.04
Jamb at window or door	0.95	0.05

# Appendix D

## Thermal Bridging

### D.1 General

This Appendix deals with the assessment of discrete thermal bridging not taken account of in the calculation of the U-values of plane building elements, e.g. at junctions and around openings such as doors and windows. It gives guidance on: -

- avoidance of mould growth and surface condensation, and
- limiting factors governing additional heat losses.

The guidance is based primarily on “BRE IP 1/06: Assessing the effects of thermal bridging at junctions and around openings”.

### D.2 Mould Growth and Surface Condensation

The key factor used in assessing the risk of mould growth or surface condensation in the vicinity of thermal bridges is the temperature factor ( $f_{Rsi}$ ).

The temperature factor ( $f_{Rsi}$ ) is defined as follows: -

$$f_{Rsi} = (T_{si} - T_e) / (T_i - T_e)$$

where:

$T_{si}$  = minimum internal surface temperature,

$T_e$  = external temperature, and

$T_i$  = internal temperature.

To limit the risk of surface condensation or mould growth,  $f_{Rsi}$  should be greater than or equal to a critical value ( $f_{CRsi}$ ). This critical value depends upon the internal and external environments and applies generally to the whole of the internal surface. For buildings, other than dwellings critical temperature factors are provided in Tables 1 and 2 of IP 1/06. The critical temperature factor for avoiding mould growth in Institutional Residential and School buildings is 0.75 and for swimming pools is 0.9.

The indicative critical temperature factors for limiting the risk of surface condensation for different building types are provided in Table D1 below:

Table D1 : Critical Temperature factors for limiting risk of surface condensation

Table D1	
Building Type	$f_{CRsi}$
Storage Buildings	0.30
Offices, Retail Premises	0.50
Sports halls, Kitchens, canteens, buildings heated with unflued gas heaters	0.8
Buildings with high humidity, eg swimming pools, laundries, breweries	0.90

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### D.3 Linear Thermal Transmittance and Additional Heat Loss

The linear thermal transmittance ( $\psi$ ) describes the heat loss associated with a thermal bridge. This is a property of a thermal bridge and is the rate of heat flow per degree per unit length of bridge that is not accounted for in the U-values of the plane building elements containing the thermal bridge. The transmission heat loss coefficient associated with non-repeating thermal bridges is calculated as: -

$$H_{TB} = \sum(L \times \psi) \text{ (W/K)}$$

where L is the length of the thermal bridge over which  $\psi$  applies.

### D.4 Calculation procedures

The calculation procedure to establish both temperature factor ( $f_{Rsi}$ ) and the linear thermal transmittance ( $\psi$ ) is outlined in BRE IP 1/06. Details should be assessed in accordance with the methods described in IS EN ISO 10211:2007. These calculations of two dimensional or three dimensional heat flow require the use of numerical modelling software. To be acceptable, numerical modelling software should model the validation examples in IS EN ISO 10211:2007 with results that agree with the stated values of temperature and heat flow within the tolerance indicated in the standard for these examples. Several packages are available that meet this requirement.

Detailed guidance on decisions regarding specific input to the modelling software and the determination of certain quantities from the output of the software is contained in BRE Report BR 497 Conventions for calculating linear thermal transmittance and temperature

factors. This guidance should be followed in carrying out modelling work so that different users of the same software package and users of different software packages can obtain correct and consistent results.

### D.5 Treatment of Thermal Bridging in NEAP calculation

Heat loss through thermal bridging is taken account of in the NEAP calculation. The methods of accounting for heat Loss is described in 1.3.3. and the NEAP manual.

The following provides for the use of linear thermal transmission values for Acceptable Construction Details in NEAP.

Values of  $\psi$  can be determined from the results of numerical modeling, or they can be derived from measurement. . Values of  $\psi$  are given in Tables D1 to D5 of the Acceptable Construction Details available on Department of Housing Planning and Local Government Acceptable Construction Details have been assessed to provide a temperature factor  $f_{Rsi}$  of 0.75. The BRE Certified Thermal Details and Products Scheme provides temperature factor for the products/details listed.

# Appendix E

## Specific Fan Power

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### Introduction

This section gives guidance on specifying air distribution systems for new and existing buildings to meet relevant energy efficiency requirements in the Building Regulations.

### Scope of Guidance

This guidance applies to the following types of air distribution system:

- Central air conditioning systems
- Central mechanical ventilation systems with heating, cooling or heat recovery
- All central systems not covered by the above two types
- Zonal supply systems where the fan is remote from the zone, such as ceiling void or roof-mounted units
- Zonal extract systems where the fan is remote from the zone
- Local supply and extract ventilation units such as window, wall or roof units serving a single area (e.g. toilet extract)
- Other local ventilation units, e.g. fan coil units and fan assisted variable air volume (VAV) units
- Kitchen extract, fan remote from zone with grease filter
- Gas and oil-fired air heaters installed within the area to be heated are not within the scope of this section.

### Key Terms

*Air conditioning systems* means a combination of components required to provide a form of air treatment in which temperature is controlled or can be lowered, possibly in combination with the control of ventilation, humidity and air cleanliness.

*Ventilation system* means a combination of components required to provide air treatment in which temperature, ventilation and air cleanliness are controlled.

*Central system* means a supply and extract system which serves the whole or major zones of the building.

*Local unit* means an unducted ventilation unit serving a single area.

*Zonal system* means a system which serves a group of rooms forming part of a building, i.e. a zone where ducting is required.

*Demand control* is a type of control where the ventilation rate is controlled by air quality, moisture, occupancy or some other indicator of the need for ventilation.

*Specific fan power (SFP)* of an air distribution system means the sum of the design circuit-watts of the system fans that supply air and exhaust it back outdoors, including losses through switchgear and design air flow rate through that system.

For the purposes of this guide, the specific fan power of an air distribution system should be calculated according to the procedure set out in IS EN 13779:2007 Annex D

“Calculation and application of specific fan power. Calculating the SFP, SFP<sub>E</sub>, SFP<sub>V</sub>”

$$SFP = \frac{P_{sf} + P_{ef}}{q}$$

Where

SFP is the specific fan power demand of the air distribution system ( W/l/s)

P<sub>sf</sub> is the total fan power of all supply air fans at the design air flow rate, including power losses through switchgear and controls associated with powering and controlling the fans (W)



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$P_{ef}$  is the total fan power of all exhaust air fans at the design air flow rate including air flow losses through the switchgear and controls associated with powering and controlling the fans (W)

$q$  is the design air flow rate through the system, which should be the greater of either the supply or exhaust air flow (l/s). Note that for an air handling unit,  $q$  is the largest supply or extract air flow through the unit.

External system pressure drop means the total system pressure drop excluding the pressure drop across the air handling unit.

### **Air distribution systems in new and existing buildings**

Air distribution systems in new and existing buildings should meet the following recommended minimum standards:

- (a) air handling systems should be capable of achieving a specific fan power at 25% of the design flow rate no greater than that achieved at 100% design flow rate.
- (b) in order to aid commissioning and to provide flexibility for future changes of use, reasonable provision would be to equip with variable speed drives those fans that are rated at more than 1100W and which form part of the environmental control systems, including smoke control fans used for control of overheating. The provision is not applicable to smoke control fans and similar ventilation systems only used in abnormal circumstances.

- (c) in order to limit air leakage, ventilation ductwork should be made and assembled so as to be reasonable airtight. Ways of meeting this requirement would be to comply with the specifications given in:

EN Standards such as IS EN 1507:2006 , ISEN 12237:2003 and IS EN 13403: 2003.

- (d) in order to limit air leakage, air handling units should be made and assembled so as to be reasonably airtight. Ways of meeting this requirement would be to comply with Class L2 air leakage given in IS EN 1886:2007.

- (e) The specific fan power of air distribution systems at the design air flow rate should be no worse than in Table 4 for new and Table 12 for existing buildings. Specific fan power is a function of the system resistance that the fan has to overcome to provide the required flow rate. IS EN 13779:2007 Table A8 provides guidance on system pressure drop. To minimise specific fan power it is recommended that the 'low range' is used as a design target.

# Appendix F

## Lighting

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### Key Terms

The following definitions apply to lighting:

*Daylit space* means any space:

- (a) within 6 m of a window wall, provided that the glazing is at least 20% of the internal area of the window wall or
- (b) below rooflights, provided that the glazing area is at least 10% of the floor area

The normal light transmittance of the glazing should be at least 70%; if the light transmittance is below 70% the glazing should be increased proportionately for the space to be defined as daylit.

*Office area* means a space that involves predominantly desk-based tasks.

*Efficacy* is used to describe the energy efficiency of a lamp. It is described by the amount of light it produces in lumens with respect to the power it consumes in Watts.

Space classification for control purposes:

*Owned space* means a space such as a small room for one or two people who control the lighting-e.g. a cellular office or consulting room

*Shared space* means a multi-occupied area-e.g. an open-plan office or factory production area

*Temporarily owned space* means a space where people are expected to operate the

lighting controls while they are there-e.g. a hotel room or meeting room

*Occasionally visited space* means a space where people generally stay for a relatively short period of time when they visit the space-e.g. a storeroom or toilet

*Unowned space* means a space where individual users require lighting but are not expected to operate the lighting controls - e.g. a corridor or atrium

*Managed space* means a space where lighting is under the control of a responsible person-e.g. a hotel lounge, restaurant or shop

*Local manual switching* means that the distance on plan from any local switch to the luminaire it controls should generally be not more than 6 m, or twice the height of the light fitting above the floor if this is greater. Where the space is a daylit space served by side windows, the perimeter row of lighting should in general be separately switched.

*Photoelectric control* is a type of control which switches or dims lighting in response to the amount of incoming daylight. Presence detection is a type of control which switches the lighting off, or dims it down, after the space becomes unoccupied but where switching is done manually.

*Lamp lumens* means the sum of the average initial (100 hour) lumen output of all the lamps in the luminaire.

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*Circuit-watt* is the power consumed in lighting circuits by lamps and, where applicable, their associated control gear (including transformers and drivers) and power factor correction equipment

*Lamp lumens per circuit-watt* is the total lamp lumens summed for all luminaires in the relevant areas of the building, divided by the total circuit-watts for all the luminaires

*LOR* is the light output ratio of the luminaire, which means the ratio of the total light output of the luminaire under stated practical conditions to that of the lamp or lamps contained in the luminaire under reference conditions

*Luminaire lumens per circuit-watt* is the (lamp lumens x LOR) summed for all luminaires in the relevant areas of the building divided by the total circuit-watts for all the luminaires.

*LENI (Lighting Energy Numerical Indicator)* is a measure of the performance of lighting in terms of energy per square meter per year (kWh/m<sup>2</sup>/year) based on IS EN 15193:2007 Energy performance of buildings. Energy requirements for lighting.

An alternative to complying with the efficacy standards in Table 8 is to follow the Lighting Energy Numeric Indicator (LENI) method.

The LENI method calculates the performance of lighting in terms of energy per square metre per year. The approach described

below must be followed in calculating the LENI for a lighting scheme. The LENI should not exceed the lighting energy limit specified in Table 9 for the given illuminance and hours run.

### **Design the lighting**

The first step to energy efficient lighting is to design the lighting installation in a way that meets all of the users' needs for the space under consideration. Recommendations for appropriate illuminance values and other lighting requirements may be found in IS EN 12464-1:2011, and in the Society of Light and Lighting (SLL) *Code for Lighting*. The *SLL Lighting Handbook* provides practical advice on how to design lighting for a number of different applications.

### **Look up the lighting energy limit.**

In designing the lighting, a level of illuminance will have been selected as necessary for the tasks being done in a particular area. It is also necessary to determine how many hours per year the lighting will be needed. Once both the illuminance and the hours are known it is possible to look up the lighting energy limit in Table 9. For example, an office may be lit to 300 lux and used for 40 hours per week for 39 weeks of the year, giving a total of 1560 hours per year. Values of 1500 hours and 300 lux give a lighting energy limit of 7.70. Table 9 also gives a day-time ( $T_d$ ) and night-time ( $T_n$ ) hour values which are used in the calculation of energy consumption.

If display lighting is used, then the lighting energy limit may be increased by the value for normal display lighting for the area of the

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room where the display lighting is being used. For example, in an entrance area for a building there may be some display lighting in a small area around the reception desk but not in the rest of the area.

Shop windows use a lot of display lighting and may use up to 192.72 kWh/m<sup>2</sup>/year if the window faces a public road, and 96.8kWh/m<sup>2</sup>/year if the window is in a shopping centre that is closed during the night.

### **Calculate the parasitic energy use ( $E_p$ )**

If some form of lighting control system is used, then an allowance needs to be made for the energy used by the control system, and the fact that the luminaires take a little power even if they are dimmed down to give no light. An allowance of 0.3 W/m<sup>2</sup> should be made for power used in this way. If the whole lighting system is switched off when the room is not in use, then the power loss is only during the hours of use. If the system is left on all the time then the power loss occurs for 8760 hours per year.

### **Determine the total power of lighting ( $P_1$ )**

This is the total power in watts consumed by the luminaires within a space.

### **Determine the occupancy factor ( $F_o$ )**

$F_o$  allows for the fact that energy is saved if an automatic control system detects the presence or absence of people in a room and switches off the lights when there is nobody using the room. If no automatic control is

used then the occupancy factor,  $F_o = 1$ . If controls turn off the lights within 20 minutes of the room being empty, then  $F_o = 0.8$ .

### **Determine the factor for daylight ( $F_d$ )**

$F_d$  allows for the fact that if the lighting is dimmed down when there is daylight available, then less energy will be used. If no daylight linked dimming system is used, then  $F_d = 1$ . If the electric lighting dims in response to daylight being available, then in areas with adequate daylight  $F_d = 0.8$ . Adequate daylight may be found in areas that are within 6m of a window wall or in areas where 10% or more of the roof is translucent or made up of rooflights.

### **Determine the constant illuminance factor ( $F_c$ )**

When lighting is designed, a maintenance factor (MF) is used to allow for fact that as the lighting system ages it produces less light. This means that on day one the lighting system is providing more light than needed. Thus with a constant luminance system, it is possible to under-run the lighting on day one, and then slowly increase the power used by the lighting until the point is reached when maintenance needs to be carried out by changing the lamps or cleaning the luminaires. Systems that control the lighting in this way have an  $F_c = 0.9$ , and those that do not have an  $F_c = 1$ .

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**Calculate the daytime energy use ( $E_d$ )**

The daytime energy use is:

$$E_d = \frac{P_1 \times F_O \times F_d \times F_C \times T_d}{1000}$$

**Calculate the night-time energy use ( $E_n$ )**

The daytime energy use is:

$$E_n = \frac{P_1 \times F_O \times F_C \times T_n}{1000}$$

**Calculate total energy (kWh) per square metre per year (LENI)**

The total energy per square metre per year is the sum of the daytime, night-time and parasitic energy uses per year divided by the area (A) as set out in the formula below:

$$LENI = \frac{E_P + E_D + E_N}{A}$$

# Appendix G:

## Pipework and Ductwork Insulation

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### Introduction

This section gives guidance on insulating pipework and ducting serving space heating, hot water and cooling systems in new and existing buildings to meet the relevant energy efficiency requirements in the building regulations.

The insulation of pipework and ducting is essential to minimise heating system heat losses and cooling system heat gains. For cooling systems, it is also important to ensure that the risk of condensation is adequately controlled.

### Scope of guidance

The guidance in this section covers insulation for the following types of pipework and ductwork serving space heating, domestic hot water and cooling systems :

- pipe work : direct hot water, low, medium and high temperature heating, and cooled
- ductwork : heated, cooled and dual purpose heated and cooled.

### Insulation of pipes and ducts in new and existing buildings

Insulation of pipes and ducts serving heating and cooling systems should meet the following recommended minimum standards. The relevant standard for calculating insulation thickness is I.S. EN ISO 12241:2008 Thermal insulation for building equipment and industrial installations. Calculation rules.

### (a) Direct hot water and heating pipework

- (i) Pipework serving space heating and hot water systems should be insulated in all areas outside of the heated building envelope. In addition, pipes should be insulated in all voids within the building envelope and within spaces which will normally be heated, if there is a possibility that those spaces might be maintained at temperatures different to those maintained in other zones. The guiding principles are that control should be maximised and that heat loss from uninsulated pipes should only be permitted where the heat can be demonstrated as “always useful”.
- (ii) In order to demonstrate compliance, the heat losses shown in Table G.1 for different pipe sizes and temperatures should not be exceeded.

### (b) Cooling pipework

- (i) Cooling pipework should be insulated along its whole length in order to provide the necessary means of limiting heat gain. Control should be maximised and heat gain to uninsulated pipes should only be permitted where the proportion of the cooling load relating to distribution pipework is proven to be less than 1% of the total load.
- (ii) In order to demonstrate compliance, the heat gains in Table G.2 for different pipe sizes and temperatures should not be exceeded.

- (iii) Although unrelated to meeting relevant energy efficiency requirements in the Building Regulations, provisions should also be made for control of condensation by following TIMSA HVAC guidance for achieving compliance with Part L of the Building Regulations.

- (ii) The heat losses or gains per unit area should not exceed the values in Table G.3. Where ducting may be used for both heating and cooling, the limit for chilled ducting should be adopted since these are more onerous. (Heat gains are shown as negative values.)

### (c) Heating and cooling ductwork

- (i) Ducting should be insulated along its whole length in order to provide the necessary means of limiting heat gains or heat losses.

- (iii) As with pipework, additional insulation may be required to provide adequate condensation control, as detailed in TIMSA HVAC guidance for achieving compliance with Part L of the Building Regulations.

**Table G.1 Recommended maximum heat losses for direct hot water and heating pipes**  
Heat loss (w/m)

Outside pipe diameter (mm)	Hot water <sup>(1)</sup>	Low temperature heating <sup>(2)</sup>	Medium temperature heating <sup>(3)</sup>	High temperature heating <sup>(4)</sup>
		≤ 95°C	96°C TO 120°C	121°C TO 150°C
17.2	6.60	8.90	13.34	17.92
21.3	7.13	9.28	13.56	18.32
26.9	7.83	10.06	13.83	18.70
33.7	8.62	11.07	14.39	19.02
42.4	9.72	12.30	15.66	19.25
48.3	10.21	12.94	16.67	20.17
60.3	11.57	14.45	18.25	21.96
76.1	13.09	16.35	20.42	24.21
88.9	14.58	17.91	22.09	25.99
114.3	17.20	20.77	25.31	29.32
139.7	19.65	23.71	28.23	32.47
168.3	22.31	26.89	31.61	36.04
219.1	27.52	32.54	37.66	42.16
≥ 273.0	32.40	38.83	43.72	48.48

#### NOTE

To ensure compliance with the maximum heat loss criteria, insulation thicknesses should be calculated according to bs en iso 12241 using standardised assumptions:

[1] horizontal pipe at 60°C in still air at 15°C

[2] horizontal pipe at 75°C in still air at 15°C

[3] horizontal pipe at 100°C in still air at 15°C

[4] horizontal pipe at 125°C in still air at 15°C

<b>Table G.2 Recommended maximum heat gains for cooled water supply pipes</b>			
Outside diameter of steel pipe on which insulation has been based(mm)	Heat gain (W/m)		
	Temperature of contents (°C)		
	>10	4.9 to 10.0	0 to 4.9
17.2	2.48	2.97	3.47
21.3	2.72	3.27	3.81
26.9	3.05	3.58	4.18
33.7	3.41	4.01	4.60
42.4	3.86	4.53	5.11
48.3	4.11	4.82	5.45
60.3	4.78	5.48	6.17
76.1	5.51	6.30	6.70
88.9	6.17	6.90	7.77
114.3	7.28	8.31	9.15
139.7	8.52	9.49	10.45
168.3	9.89	10.97	11.86
219.1	12.27	13.57	14.67
> 273.0	14.71	16.28	17.48
<b>Note</b> To ensure compliance with the maximum heat gain criteria, insulation thicknesses should be calculated according to BS EN ISO 12241 using standardised assumptions: [1] Horizontal pipe at 10°C in still air at 25°C [2] Horizontal pipe at 5°C in still air at 25°C [3] Horizontal pipe at 0°C in still air at 25°C			

<b>Table G.3 recommended maximum heat losses and gains for insulated heating, cooling and dual- purpose ducts</b>			
	Heating duct	Dual-purpose duct	Cooling duct
Heat transfer (w/m <sup>2</sup> )	16.34	-6.45	-6.45
<b>Note</b> To ensure compliance with the maximum heat gain criteria, insulation thicknesses should be calculated according to bs en iso 12241 using standardised assumptions: [1] horizontal duct at 35°C with 600 mm vertical sidewall an still air at 15°C [2] horizontal duct at 13°C with 600 mm vertical sidewall an still air at 25°C [3] horizontal duct at 13°C with 600 mm vertical sidewall an still air at 25°C			



# Abbreviations

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ACDs	Acceptable Construction Details
ACMV	Air conditioning and mechanical ventilation
ATTMA	Air Tightness Testing & Measurement Association
BMS	Building Management System
BRE	Building Research Establishment
BRECSU	Building Research Energy Conservation Support Unit
BS	British Standards
BSRIA	The Building Services Research & Information Association
CHP	Combined Heat and Power
CIBSE	Chartered Institution of Building Services Engineers
CPC	Carbon Performance Coefficient
DHW	Domestic Hot Water
EER	Energy Efficiency Ratio
EN	European Norm
EPBD	Energy Performance of Buildings Directive
EPC	Energy Performance Coefficient
EU	European Union
EXEED	Excellence in Energy Efficient Design
HARP	Home-heating Appliance Register of Performance
HCFC	Hydrochlorofluorocarbons
HEPA	High efficiency particulate air
HTB	High Temperature Background
HVAC	Heating, Ventilation and Air Conditioning
ISO	International Organization for Standardization.
LENI	Lighting Energy Numerical Indicator
LOR	Light Output Ratio
MCRMA	Metal Cladding & Roofing Manufacturers Association
MPCPC	Maximum Permitted Carbon Performance Coefficient
MPEPC	Maximum Permitted Energy Performance Coefficient
NEAP	Non-domestic Energy Assessment
NZEB	Nearly Zero Energy Buildings
NSAI	National Standards Authority of Ireland
PIR	Polyisocyanurate (Insulation)
RER	Renewable Energy Ratio
S.I	Statutory Instrument
SBEM	Simplified Building Energy Model
SCOP	Seasonal Coefficient of Performance
SEAI	Sustainable Energy Authority of Ireland
SEER	Seasonal Energy Efficiency Ratio
SFP	Specific Fan Power
SLL	Society of Light and Lighting
TGD	Technical Guidance Document
TM	Technical Manual
VAV	Variable Air Volume
VCL	Vapour Control Layer

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