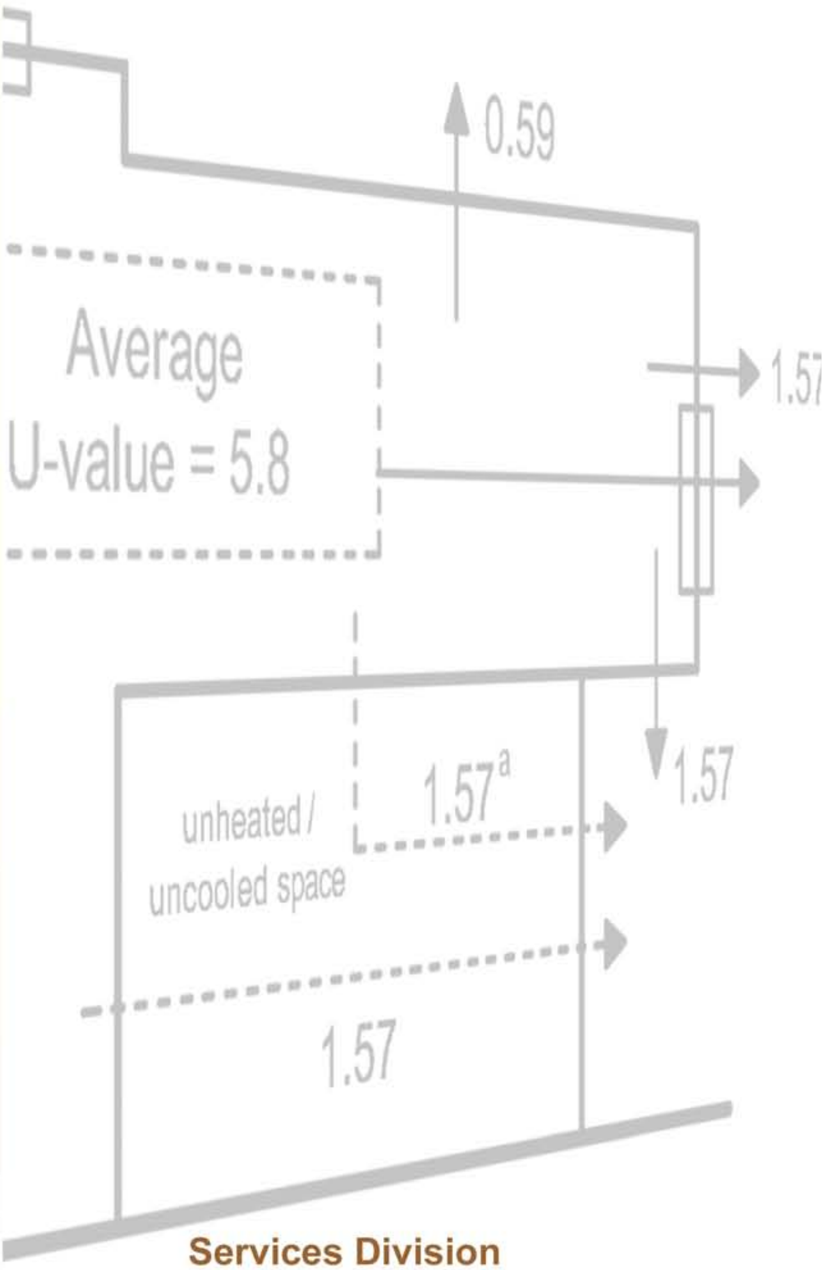
F

Technical Guidance

Conservation of Fuel, Energy and Natural Resources (minimum requirements on the energy performance of buildings regulations, 2006)



Services Division
Building Regulations Office
Malta

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The Requirement
Document F – Conservation of Fuel, Energy and Natural Resources (Minimum Requirements on the Energy Performance of Buildings Regulations, 2006)

Conservation of Fuel, energy and natural resources

(I) A building shall be so designed and constructed as to secure, insofar as is reasonably practicable, the conservation of fuel, energy and other natural resources.

Control of heat, power and lighting.

(II) Reasonable provision shall be made for the conservation of fuel and power in a building by:-

(A) limiting the heat loss in winter and the heat gain in summer through the fabric of the building;

(B) controlling the operation of the space heating, and hot water systems;

(C) controlling the operation of the space cooling systems;

(D) limiting the energy loss from water storage vessels and water service pipework;

(E) limiting the energy loss or gain from water pipes and air ducts used for space heating and cooling;

(F) installing artificial lighting systems that use no more fuel and power than is reasonable in the circumstances and making reasonable provisions for controlling such systems;

(G) providing sufficient information with the heating and cooling services so that building occupiers can operate and maintain the services in such a manner as to use no more energy than is reasonable in the circumstances.

Rain water collection.

(III) A building shall incorporate in its design and construction a cistern of adequate size and proportions for the storage of rainwater run-off.

Exploitation of climatic variables

(IV) A building shall incorporate measures to reduce adverse effects of solar radiation, wind and rain while exploiting the benefits of these climatic variables, according to the seasons.

Limits on applications

(V) (A) All building categories mentioned in *Legal Notice L.N. 238 of 2006.*

(B) Requirements (II) (A), (B), (C), (D), (E) and (III) apply only to dwellings and other buildings whose floor area exceeds fifty square metres. (II) (F) applies only to buildings and parts of buildings including their external areas where more than one hundred square metres of floor area is to be provided with artificial lighting and does not apply within dwellings.

Parameters of application

(VI) In the case of premises that fall under the category of terraced buildings, it should be assumed that adjacent buildings are already constructed when providing evidence satisfying the requirements of these guidelines.

In addition to the above, in those cases where different building heights result from impositions made by permits or other regulations and site conditions, the exposed walls, or parts thereof, are to be considered as exposed elements.

Provisions meeting the Requirement Document F – Conservation of Fuel, Energy and Natural Resources (Minimum Requirements on the Energy Performance of Buildings Regulations, 2006)

0. Definitions

0.01 Definitions of other words and phrases

Definitions of words and phrases in this Document that are not included in the following list of definitions shall have the meanings commonly assigned to them in the context in which they are used.

0.02 Definition of terms

In this Document,

Air-conditioning	This phrase is used to describe any system where refrigeration or heating is included to provide cooling or heating for the comfort of building occupants. Air-conditioning for cooling can be provided from stand-alone refrigeration equipment in the cooled space, from centralised or partly centralised equipment, and from systems that combine the cooling function with mechanical ventilation. Air-conditioning systems for heating can be provided from a similar equipment arrangement.
Basement	means a storey or storeys of a building located below the ground floor.
Boiler	the combined boiler body and burner-unit designed to transmit to water the heat released from combustion.
Building	means any structure used or intended for supporting or sheltering any use or occupancy and for which energy is used to condition the indoor climate; a building may refer to the building as a whole or parts thereof that have been designed or altered to be used separately.
CHP	combined heat and power: the simultaneous conversion of primary fuels into mechanical or electrical and thermal energy, meeting certain quality criteria of energy efficiency.
Dwelling	or dwelling unit means a suite operated as a house-keeping unit used, or intended to be used as a domicile and usually containing cooking, eating, living, sleeping and sanitary facilities.
Effective rated output	(expressed in kW): the maximum calorific output specified and guaranteed by the manufacturer as being deliverable during continuous operation while complying with the useful efficiency indicated by the manufacturer.
Exposed Element	means: • permanently exposed to the outside air, or • permanently separating a part of the building which is mechanically heated or cooled from a part which is not and which is exposed to the outside air.

Semi-exposed Element	means an element separating a heated or cooled space from one that is unheated or uncooled and which has exposed elements that do not meet the requirements of these guidelines.
Floor area	means the space or any storey of a building between exterior walls including the space occupied by interior walls.
Heat pump	a device or installation that extracts heat at low temperature from air, water or earth and supplies the heat to the building.
Industrial building	means a building which is used wholly or in part for the assembling, fabricating, manufacturing, processing, repairing or storing of goods and materials.
Mechanical Ventilation	This phrase is used to describe systems that use fans to supply outdoor air and/or extract indoor air to meet ventilation requirements. Systems may be extensive and can include air, filtration, air handling units and heat reclamation, but they do not provide any active cooling from refrigeration equipment. The definition would not apply to a naturally ventilated building, which makes use of individual wall or window mounted extract fans to improve the ventilation of a small number of rooms.
Other building	means any building which is not a dwelling, industrial or residential building and includes places of assembly, offices and shops.
Residential Building	means a building used for residential purposes which has sleeping accommodation and includes a hotel or institution.
Roof	means an external building element which is either horizontal or if sloping has a slope of less than 70º.
Solid parts	in relation to exposed elements means those parts which are not rooflights or other openings being glazed or unglazed.
Storey	means that part of a building which is situated between the top of a floor and the top of the next floor above it, or the ceiling if there is no floor above it.
Thermal Conductivity	Thermal conductivity (i.e. the lambda – value) of a material is a measure of the rate at which that material will pass heat per unit time and is expressed in units of watts per metre per degrees of temperature difference (W/mK).
U value	means the thermal transmittance coefficient, that is a measure of how much heat per unit time will pass through one square metre of a structure when the air temperatures on either side differ by one degree. U value is expressed in units of watts per square metre per degree of temperature difference (W/m^2K).
Wall	means a solid element of the building fabric which is either vertical or has a slope greater than 70º.
Window	means a glazed element or a door containing more than one square metre of glass.

1. Conservation of Fuel and Power

1.01 Design consideration

1.01.1 In designing a building the designer shall take into account all relevant factors that will make that building efficient in the consumption of heating, cooling, ventilation and the production of domestic hot and cold water, and creates an appropriate environment within the building.

1.01.2 In particular, the designer shall take account of the:

- External environment (climatic data): Buildings shall be designed to take account of the climate through the year, variations through the day, and any characteristics specific to the site.

- Orientation of the building: Careful siting of the building shall optimise the requirements for the conservation of energy with those of the use and function of the building. Special consideration is to be given to its shape and glazing ratio.

- Actual and probable adjacent properties: Consideration shall be given not only to the actual developments that may affect the design of a building, but also to potential adjacent developments.

- Internal environment: Consideration shall be given in the design of the building to the various cycles of use of the building over the full year.

    (i) Temporal variations in use: Variations in use through a variety of time cycles as indicated below, shall be considered in order to conserve energy;

    - twenty-four hour cycle
    - weekly cycle
    - other patterns of use through the full year

    (ii) Hygrothermal conditions in use: Consideration shall be given to the environmental characteristics which determine comfort:

    - ventilation energy loads, including specific ventilation and infiltration.
    - solar loading
    - lighting, including background, task, and other.
    - space heating and cooling, both seasonal and diurnal.
    - domestic hot and cold water production and distribution.
    - internal energy gain, including metabolic, mechanical and electrical.
    - humidity characteristics and control

1.02 Design of the work

1.02.1 Components and elements of the building shall be carefully considered in determining the design response required within the need to conserve energy.

1.02.2 Advantage shall be taken of design techniques to permit fenestration, openings and other elements of the design to respond to the comfort requirements within the building whilst complying with the relevant requirements of *Provisions meeting the Requirements of Safety in Case of Fire, Provisions meeting the Requirements of Accessibility and Safety in use, and Provisions meeting the Requirements of Environmental Aspects.*

1.02.3 In detailing buildings care shall be taken to avoid, as much as possible, heat or cold bridges across the construction.

1.02.4 Air-conditioned and Mechanically ventilated buildings (ACMV) should be designed and constructed such that:

- 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 external solar shading are an important way to limit cooling requirements.

- Components such as fans, pumps and refrigeration equipment are reasonable efficient and appropriately sized to have no more capacity for demand and standby than is necessary for the task.

- Suitable facilities are provided to manage, control and monitor the operation of the equipment and the systems.

1.03 Characteristics of building materials and components

1.03.1 The materials, components and systems from which the building is constructed shall be designed, selected, manufactured and assembled in such a way as to contribute to the energy efficiency of the building.

1.03.2 The following characteristics of building materials and components shall be considered in the selection of appropriate designs:

(i) transmittance or thermal resistance of building elements, such as:

- walls – including the effects of screening, shutters or blinds
- roofs – including the effects of screening, shutters or blinds
- ground floors

(ii) thermal conductivity and resistance of masonry,

(iii) moisture transfer,

(iv) driving rain resistance,

(v) air permeability,

(vi) thermal inertia characteristics,

(vii) solar energy transmission,

(viii) daylight transmission, and

(ix) effective areas and flow characteristics of openings for ventilation purposes

2. Resistance to the Passage of Heat

2.01 General

2.01.1 The envelope of all buildings shall be designed to resist heat loss or gain or, where appropriate, to encourage heat gain or loss.

2.01.2 Building extensions of 14sq.m or less, to existing dwellings may be assumed to fulfil the requirements of this section provided that this construction is similar to the un-extended building.

2.01.3 Care must be taken in insulating elements of buildings in order not to create difficulties such as interstitial condensation.

2.02 Window and rooflight openings

2.02.1 In calculating the measurement of windows and rooflights the following rules shall apply:

(i) the area of a wall used to calculate the area of openings shall include all openings in the wall, and exclude trickle vents,

(ii) any external door with more than 1.0sq.m of glazing will be treated as a window.

(iii) areas of walls, roofs and floors shall be measured to the inside faces of the building.

2.03 Exposed and semi-exposed elements

2.03.1 An exposed element is one that is directly exposed to the outside air.

2.03.2 A semi-exposed element means an element separating a heated or cooled space from one that is unheated or uncooled and which has exposed elements that do not meet the requirements of these guidelines.

2.04 Minimising heat loss through the building fabric

2.04.1 The calculated rate of heat loss per unit time through the solid parts of the exposed elements shall not be greater than those given in Table F.1

Limitation of the passage of heat through the building fabric — Table F.1

	Maximum U values in W/m^{2}K for all building categories
Exposed walls*	1.57
Exposed floors	1.57
Non-exposed floors	1.97
Roofs	0.59

***Note:**

Exposed walls of bathrooms, sanitary conveniences and utility rooms having an area of 5.6sq.m, or less, are excluded from this requirement

2.04.2 The calculated rate of heat loss per unit time through any windows and rooflights shall not be greater than what it would be if the conditions of Table F.2 are met.

2.04.3 - Design Flexibility - The designer can use his creativity to meet the requirements of these guidelines by taking the following trade-offs:

(i) Display windows in shops and showrooms with single-glazed panels protected by unheated or uncooled, enclosed draughtproof spaces may be assumed to have a U value of double-glazing for the purpose of these design guidelines.

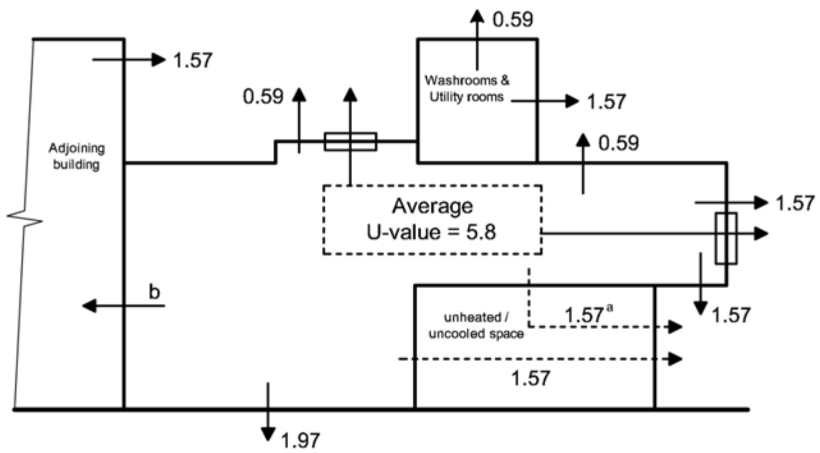
(ii) If in the proposed building, the U values of the exposed elements in Table F.1 are improved, the requirements stipulated in Table F.2 can be adjusted to reflect such values provided that the aggregate heat loss of the whole building shall be no greater than if the trade-off had not been applied.

2.04.4 In any building the maximum percentage of glazed area allowed in Table F.2 may be increased provided that windows and rooflights with better U values are provided and that the calculated heat loss through such windows and rooflights is not greater than what it would be if the conditions of Table F.2 are met.

Limitations for windows and rooflights — Table F.2

Building type	Windows and rooflights with the following U values in W/m^2K	Aggregate area as % of the area of the exposed walls bounding the building.	
		Windows & doors	Rooflights
Residential buildings*	5.8	20%	10% of roof area
Industrial and storage buildings	5.8	15%	
Offices, places of assembly	5.8	25%	
Showrooms, shops	5.8	50%	
***Note:** This category includes hotels and institutional buildings			

Standard U values for buildings — Diagram F.1



NOTE:

"a" - includes the effect of the unheated / uncooled space.
"b" - for calculation purposes only, in the case of adjoining buildings the U value of "would-be" unexposed party walls is to be taken as equal to the value of the exposed walls.

2.05 Calculation of U values

2.05.1 U values calculated using the methods in the standards and codes of practice given below will meet the requirement of provisions in these design guidelines;

For walls and roofs: *EN ISO 6946: 2000 Building components and building elements – Thermal resistance and thermal transmittance – Calculation method*.

For ground floors: *EN ISO 13370: 1998 Thermal performance of buildings – Heat transfer via the ground – Calculation methods.*

For windows and doors: *EN ISO 10077 – 1: 2000 Thermal performance of windows, doors and shutters – Calculation of thermal transmittance – Part 1; Simplified methods.*

Or

EN ISO 10077 – 2: 2003 Thermal performance of windows, doors and shutters – Calculation of thermal transmittance – Part 2: Numerical method for frames.

Or

EN ISO 12567 – 1 & 2: 2000 Thermal performance of windows and doors – Determination of thermal transmittance by hot box method – Part 1: Complete windows and doors and *Part 2: Roof windows and other projecting windows.*

For basements: *EN ISO 13370: 1998 Thermal performance of buildings – Heat transfer via the ground – Calculation methods.*

2.05.2 For building elements not covered by the above-mentioned documents, the following may be appropriate alternatives:

for curtain walling: *EN ISO 10211 – 1: 1996 Thermal bridges in building construction – Calculation of heat flows and surface temperatures – Part 1: General methods.*

EN ISO 10211 – 2: 2001 Thermal bridges in building construction – Calculation of heat flows and surface temperatures – Part 2: Linear thermal bridges.

2.05.3 U values for common building materials can be obtained from *EN 12524: 2000 Building materials and products - Hygrothermal properties – Tabulated design values*, but for ease of reference, *APPENDIX A – Tables of U values:* Table A.1, Table A.2 and Table A.3 give indicative U values for various types of windows, doors and rooflights. For specific insulation products, data should be obtained from the manufacturers.

2.05.4 When calculating U values, the thermal bridging effects of, for instance, structural and other framing, normal mortar bedding and window frames should generally be taken into account using the procedure given in *EN ISO 6946*. Thermal bridging can be disregarded however where the difference in thermal resistance between the bridging material and the bridged material is less than $0.1m^2K/W$. Where, walls contain in-built meter cupboards, and ceilings contain loft hatches, recessed light fittings, etc, area-weighted average U values should be calculated.

2.05.5 Thermal resistance of a component is obtained by:

- dividing the wall thickness in metres of a material by its thermal conductivity, and
- In the case of an air space, by using the standards given in Table F.3.

Thermal resistance of air spaces and surfaces Table F.3

Exposed walls	outside surface*	0.06m^{2}K/W
	air space (cavity)	0.18m^{2}K/W
	inside surface	0.10m^{2}K/W
Roofs	Roof space (pitched)	0.18m^{2}K/W
	Roof space (flat)	0.16m^{2}K/W
	outside surface	0.04m^{2}K/W
	inside surface	0.14m^{2}K/W
Exposed floors	inside surface	0.14m^{2}K/W
	outside surface	0.04m^{2}K/W

***Note:**

Outside surface resistance depends on the irradiative and convective heat transfer coefficient which is dependant on both the building orientation and its exposure.

2.05.6 A typical calculation can be seen in *APPENDIX B – Calculating U values*.

3. Solar Overheating

3.01 General

3.01.1 In designing a building the designer shall take into account all relevant factors so that:

- those occupied spaces or buildings that rely on natural ventilation do not overheat when these are subject to a moderate level of internal heat gain.
- those spaces or buildings that incorporate mechanical ventilation or cooling do not require excessive cooling plant capacity to maintain the desired space comfort conditions.

The requirements of 3.01.1 would be met through:

- the appropriate specification of the building envelope especially the areas and type of glazing and the surface finishes to be used,
- the incorporation of passive measures such as external shading,

and

- the use of high thermal capacity combined with day and night ventilation.

3.02 Compliance

3.02.1 Compliance to the requirement of 3.01.1 can be shown to be achieved by:

(i) Providing for a building fabric that meets the provisions of Table F.1 and in addition, in cases of spaces with glazing facing only one orientation, limiting the area of the glazed opening/s to the values given in Table F.4.

Alternatively,

(ii) showing by detailed calculation procedures such as those described in Section 5 of *"Environment Design, Guide A" 2006* published by the Chartered Institution of Building Services Engineers (CIBSE) or otherwise, that in the absence of mechanical cooling or mechanical ventilation and subject to an internal gain of $10W/m^2$, the space will not overheat more than if the requirements of clause 3.02.1(i) were applied.

Maximum allowable area of glazing — Table F.4

Orientation of opening	Maximum allowable area of opening (%) using a minimal correction factor of 0.95 for glazing/blind combination
N	25
S	20
NE	17
E/SE/SW/NW	12
W	9
Horizontal (rooflights)	7

Note:

The maximum allowable area of glazing for windows with an orientation falling in between the compass directions indicated in the table may be calculated by interpolating the values shown above.

4. Control of heating and cooling systems

4.01 General

4.01.1 Space heating, hot water, and cooling systems in buildings shall be provided with automatic controls capable of controlling the operation and output of the space heating and space cooling system and the temperature of the hot water.

4.01.2 Buildings that are fitted with space heating and or cooling systems should be provided with zone, timing and temperature controls such that energy is not wasted during long periods of un-occupancy of functional areas. Additional controls may be provided to allow heating/cooling during extended unusual occupation hours and to provide for sufficient heating/cooling to prevent condensation or other damage when the system would otherwise be switched off.

4.01.3 Hot water should be provided safely, making efficient use of energy and thereby minimising carbon emissions. Ways of achieving the requirement include:

- avoiding over-sizing of hot water storage systems.
- avoiding low-load and on/off operation of heat raising plant.
- avoiding the use of grid-supplied electric water heating except where hot water demand is low.
- providing solar water heating.
- minimising the length of circulation loops.
- minimising the length and diameter of dead legs

4.01.4 Where grid-supplied water heating is used, the off-peak heating of water is encouraged, hot water storage cylinders should:

- have a capacity which is slightly larger than standard
- be thoroughly insulated
- have a long element, operated trough a timer, for night/off-peak use
- short element for day use

4.02 Conventional hot water storage systems

- A way of satisfying the requirements for conventional hot water storage systems would be to provide controls that shut off or bypass heating when the required water temperature is achieved. The supply of heat should also be shut off during those periods when hot water is not required. *Legal Notice L.N. 62 of 2002* gives energy efficiency requirements for new hot-water boilers fired by liquid or gaseous fuels with a rated output of not less than 4kW and not more than 400kW.

4.03 Air conditioning units

- Where the work involves the provision of a fixed household air conditioner, reasonable provision would be to provide a unit having an energy efficiency classification equal to or better than class C in Schedule VIII of the labelling scheme adopted under *Legal Notice L.N. 27 of 2003.*

4.04 Solar powered systems

- The appropriate use of solar energy is encouraged in building development.

- When a built-in electric heater is incorporated in solar powered systems, such heater should be provided with a timer control.

- Any solar energy installation must be demonstrated by the designer to be adequate for the purpose for which it is intended, whether it is considered to be the main or an auxiliary supply for heating, cooling or power supply to any part of the building or site, and must additionally fulfil all requirements of the appropriate government authorities including regard to its visual effects.

4.05 Wind powered systems

- The appropriate use of wind energy is encouraged in building development.

- Any wind powered installation must be demonstrated by the designer to be adequate for the purpose for which it is intended, whether it is considered to be the main or an auxiliary supply for power to any part of the building, and must additionally fulfil all requirements of the appropriate government authorities/agencies with regard to its visual effects.

4.06 Insulation of heating and cooling services

4.06.1 Application

- These guidelines do not apply for Insulation of heating and cooling systems to industrial installations' pipework, ductwork and vessels for process use.

4.06.2 Insulation of hot or chilled water storage vessels

- Vessels which are used for the storage of hot or chilled water shall be adequately and appropriately insulated to minimise heat loss or gain.

- Where an insulated jacket is used to insulate a vessel, the jacket shall be held together in such a way as to provide a continuous cover for the vessel.

- These design guidelines will be deemed to be met with if the installation complies with *BS 1566 Part 1 2002 and BS 1566 Part 2 1984: Copper indirect cylinders for domestic purposes,* or *BS 3198 1981: Copper hot water storage combination units for domestic purposes* or *BS 5615 1985: Specification for insulated jackets for domestic hot water storage cylinders or other equivalent standards.*

4.06.3 Insulation of hot water or chilled pipes and cold or warm air ducts

- Hot water or chilled pipes and cold or warm air ducts shall be made of materials which are capable of successfully withstanding the effects of temperatures and pressures likely to be experienced within the system.

- Hot water or chilled pipes and cold or warm air ducts shall be detailed, fabricated and supported to take account of expansion, contraction and stresses caused by temperature and mechanical movement.

- Hot water or chilled pipes and cold or warm air ducts shall be adequately thermally insulated unless they are intended to contribute to the heating or cooling requirement of the building which is insulated, or do not give rise to significant un-useful heat loss

- Insulating material used to cover pipes and ducts shall be suitable for the design temperature and space conditions, and resist deterioration.

- Hot and cold water pipes shall not be located parallel and nearer than 200mm unless the hot water pipes are insulated to the standard of *Provisions meeting the Requirements – 4.06.2 Insulation of hot or chilled water storage vessels.*

- Where cold air ducts are run within buildings no heating pipes shall be run in the same duct unless the heating pipes are fully insulated to the standard of *Provisions meeting the Requirements – 4.06.2 Insulation of hot or chilled water storage vessels*, and are fixed no closer than 200mm

- Sufficient insulation is to be provided in cold air ducting to prevent condensation within or from the ducting.

4.07 Heating and cooling appliances

4.07.1 Where fuel burning heating appliances are installed within buildings, an adequate supply of air is to be provided for combustion and the efficient working of any flue or pipe.

4.07.2 Where heating appliances are installed there shall be no combustible material nearer than 200mm from any part of the appliance.

4.07.3 Any heating appliance is to be appropriately insulated and the room in which it is installed to be adequately ventilated.

4.07.4 Where required, a chimney or flue that transmits the products of combustion safely to the open air that will be neither a hazard nor a nuisance, is to be provided.

4.07.5 Any chimney or flue is to be appropriately insulated unless it is designed to contribute to the general heating of the building.

4.07.6 Where a radiator is fixed to a wall that is made of combustible material, the radiator is to be supplied with an incombustible lining.

4.07.7 Hot water storage vessels shall be adequately insulated to minimise heat loss.

4.08 Operating and Maintenance instructions for heating/cooling and hot water systems.

4.08.1 A way of meeting the requirements of these guidelines would be:

- For dwellings, a way of complying to the requirements of the design guidelines would be to provide the building owner and/or occupier a suitable set of operating and maintenance instructions in an accessible format in each new dwelling, and whenever the systems in an existing dwelling are substantially altered. The instructions should be directly related to the system(s) in the dwelling. Without prejudice to the need to comply with health and safety requirements, the instructions should explain to householders how to operate the systems so that they can perform efficiently, and what routine maintenance is advisable for the purposes of conservation of fuel and power.

- For all other types of buildings the owner and/or occupier of the building should be provided with a log-book giving details of the installed building services plant and controls, their method of operation and maintenance, and other details that collectively enable energy consumption to be monitored and controlled. The information should be provided in summary form, suitable for day-to-day use. This summary could draw on or refer to information available as part of other documentation, such as the Operation and Maintenance Manuals and the Health and Safety file.

- The details to be provided could include:

  (i) description of the whole building, its intended use and design philosophy and the intended purpose of the individual building services systems;

  (ii) a schedule of the floor areas of each of the building zones categorised by environmental servicing type (e.g. air-conditioned, naturally ventilated);

  (iii) the location of the relevant plant and equipment, including simplified schematic diagrams;

(iv) the installed capacities (input power and output rating) of the services plant;

(v) simple descriptions of the operational and control strategies of the energy consuming services in the building;

(vi) a copy of the report confirming that the building services equipment has been satisfactorily commissioned.

(vii) operating and maintenance instructions that include provisions enabling the specified performance to be sustained during occupation;

(viii) a schedule of the building's energy supply meters and sub- meters, indicating for each meter, the fuel type, its location, identification and description, and instructions on their use. The instructions should indicate how the energy performance of the building (or each separate tenancy in the building where appropriate) can be calculated from the individual metered energy readings to facilitate comparison with published benchmarks.

(ix) for systems serving an office floor area greater than 200sq.m, a design assessment of the building services systems' carbon emissions and the comparable performance benchmark.

(x) the measured air permeability of the building.

4.08.2 Installation of energy meters

- To enable owners or occupiers to measure their actual energy consumption, the building engineering services should be provided with sufficient energy meters and sub-meters. The owners or occupiers should also be provided with sufficient instructions, including an overall metering strategy, that show how to attribute energy consumptions to end uses and how the meter readings can be used to compare operating performance with published benchmarks.

- Reasonable provision would be to enable at least 90% of the estimated annual energy consumption of each fuel used in the building to be accounted for. Allocation of energy consumption to the various end uses can be achieved using the following techniques:-

  (i) direct metering;

  (ii) measuring the run-hours of a piece of equipment that operates at a constant known load;

  (iii) estimating the energy consumption, e.g. from metered water consumption for hot water systems (HWS), the known water supply and delivery temperatures and the known efficiency of the water heater;

  (iv) estimating consumption by difference, e.g. measuring the total consumption of gas, and estimating the gas used for catering by deducting the measured gas consumption for heating and hot water;

  (v) estimating non-constant small power loads using the procedure outlined in Chapter 12 of the *CIBSE Guide F: Energy efficiency in buildings*.

- Reasonable provisions of meters would be to install incoming meters in every building greater than 500sq.m gross floor area (including separate buildings on multi-building sites). This would include:

  (i) Individual meters to directly measure the total electricity, gas, oil and LPG consumed within the building;

  (ii) A heat meter capable of directly measuring the total heating and/or cooling energy supplied to the building by a district heating or cooling scheme where available.

- Reasonable provision of sub-metering would be to provide additional meters such that the following consumptions can be directly measured or reliably estimated. (See the second paragraph of clause 4.08.2)

(i) electricity, natural gas, oil and LPG provided to each separately tenanted area that is greater than 500sq.m.

(ii) energy consumed by plant items with input powers greater or equal to that shown in Table F.5.

(iii) any heating or cooling supplied to separately tenanted spaces. For larger tenancies, such as those greater than 2500sq.m, direct metering of the heating and cooling may be appropriate, but for smaller tenanted areas, the heating and cooling end uses can be apportioned on an area basis.

- any process load (see clause 4.08.3 below) that is to be discounted from the building's energy consumption when comparing measured consumption against published benchmarks.

4.08.3 For the purpose of this Document the following apply;

- Process requirements; in office buildings process requirements can be taken to include any significant area in which an activity takes place which is not typical of the office sector, and where the resulting need for heating, ventilation or air conditioning is significantly different to that of ordinary commercial offices. When assessing the performance of air conditioning or mechanical ventilation systems, areas which are treated because of process requirements should be excluded from the treated area, together with the plant capacity, or proportion of the plant capacity, that is provided to service those areas. Activities and areas in office buildings considered to represent process requirements would thus include:

  (i) Staff restaurants and kitchens;

  (ii) Large, dedicated, conference rooms;

  (iii) Sports facilities;

  (iv) Dedicated computer or communications rooms

- Treated areas; these are the floor areas of spaces that are served by the mechanical ventilation or air conditioning system in the context and should be established by measuring between the internal faces of the surrounding walls. Spaces that are not served by these systems such as plant rooms, service ducts, lift-wells etc. should be excluded.

Size of plant for which separate metering would be reasonable — Table F.5

Plant item	**Rated input power (kW)**
Boiler installations comprising one or more boilers or CHP plant feeding a common distribution circuit	50
Chiller installation comprising one or more chiller units feeding a common distribution circuit	20
Electric humidifiers	10
Motor control centres providing power to fans and pumps	10
Final electrical distribution boards	50

5. Artificial lighting systems

5.01 General

5.01.1 Lighting systems should be reasonably efficient and make effective use of daylight where appropriate.

5.01.2 Electric lighting systems installed in office, industrial and storage buildings should be provided with reasonably efficient lamp/luminaire combinations.

5.01.3 A way of meeting the requirements for the above-mentioned type of building would be to provide lighting with an initial efficacy averaged over the whole building of not less than 40 luminaire-lumens/circuit-watt.

5.02 Luminaire efficacy

The average luminaire-lumens/circuit-watt is calculated by using the formula:

$$\eta_{lum} = \frac{1}{P} \cdot \sum \frac{LOR \cdot \phi_{lamp}}{C_L}$$

Where η_{lum} = the luminaire efficacy (luminaire-lumens/circuit-watt)

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

φ_{lamp} = the sum of the average initial (100-hour) lumen output of all the lamp(s) in the luminaire;

P = the total circuit watts for all the luminaires;

C_L = the factor applicable when controls reduce the output of the luminaire when electric light is not required. The values of C_L are given in Table F.6 below.

Luminaire control factors — Table F.6

Control function	C_L
a. The luminaire is in a daylit space (see the second paragraph in clause 5.02.1), and its light output is controlled by • A photoelectric switching or dimming control, with or without manual override, or • Local manual switching (see the second paragraph in clause 5.05.1)	0.80
b. The luminaire is in a space that is likely to be unoccupied for a significant proportion of working hours and where a sensor switches off the luminaire in the absence of occupants but switching on is done manually.	0.80
c. Circumstances (a) and (b) above combined.	0.75
d. None of the above.	1.00

5.02.1 For the purposes of these design guidelines;

- circuit-watts means the power consumed in lighting circuits by lamps and their associated control gear and power factor correction equipment.

- a daylit space is defined as any space within 6m of a window wall, provided that the glazing area is at least 20% of the internal area of the window wall, or alternatively it can be roof-lit, with a glazing area at least 10% of the floor area.

- The normal light transmittance of the glazing should be at least 70% or, if the light transmittance is reduced below 70%, the glazing area could be increased proportionately, but subject to the considerations of Table F.2 and the provisions of Chapter 3, Solar Overheating.

5.02.2 This guidance need not be applied in respect of a maximum of 500 W of installed lighting in the building, thereby allowing flexibility for the use of feature lighting etc.

5.02.3 *APPENDIX C – Meeting the Lighting Standards* gives examples that show how the luminaire efficacy requirement can be met either by selection of appropriate lamps and luminaires or by calculation.

5.02.4 General lighting efficacy in all other building types.

For electric lighting systems serving other building types, it may be appropriate to provide luminaires for which photometric data is not available and/or are lower powered and use less efficient lamps. For such spaces, the requirements would be met if the installed lighting capacity has an initial (100 hour) lamp plus ballast efficacy of not less than 50 lamp-lumens per circuit-watt. A way of achieving this would be to provide at least 95% of the installed lighting capacity using lamps with circuit efficacies no worse than those in Table F.7.

Light sources meeting the criteria for general lighting — Table F.7

Light source	**Types and ratings**
High pressure Sodium	All types and ratings
Metal halide	All types and ratings
Induction lighting	All types and ratings
Tabular fluorescent	26mm diameter (T8) lamps, and 16mm diameter (T5**)** lamps, rating above 11W, provided with high efficiency control gear, 38mm diameter (T12) linear fluorescent lamps 2400mm in length
Compact fluorescent	All ratings above 11W
Other	Any type and rating with an efficacy greater than 50 lumens per circuit Watt.

Note:

For the purposes of these design guidelines, high efficiency control gear means low loss or high frequency control gear that has a power consumption (including the starter component) not exceeding that shown in Table F.8.

Maximum power consumption of high efficiency control gear — Table F.8

Nominal lamp rating (Watts)	Control gear power consumption (Watts)
Less than or equal to 15	6
Greater than 15, Not more than 50	8
Greater than 50 Not more than 70	9
Greater than 70 Not more than 100	12
Greater than 100	15
Note: The values in the table are in line with *European Directive 2000/55/EC 18 September 2000: On energy efficiency requirements for ballasts for fluorescent lighting*.	

5.03 Display lighting in buildings

- For the purposes of these design guidelines display lighting means lighting intended to highlight display of exhibits or merchandise, or lighting used in spaces for public entertainment such as dance halls, auditoria, conference halls and cinemas.

- Because of the special requirements of display lighting, it may be necessary to accept lower energy performance standards for display lighting. Reasonable provisions should nevertheless be made and a way of complying would be to demonstrate that the installed capacity of display lighting averaged over the building has an initial (100 hour) efficacy of not less than 15 lamp-lumens per circuit-watt. In calculating this efficacy, the power consumed by any transformers or ballasts should be taken into account.

- As an alternative, it would be acceptable if at least 95% of the installed display lighting capacity in circuit-Watts comprises lighting fittings incorporating lamps that have circuit efficacies no worse than those in Table F.9.

Light sources meeting the criteria for display lighting — Table F.9

Light source	Types and ratings
High pressure Sodium	All types and ratings
Metal halide	All types and ratings
Tungsten halogen	All types and ratings
Compact and tubular fluorescent	All types and ratings
Other	Any type and rating with an efficacy greater than 15 lumens per circuit Watt.

5.04 Emergency escape lighting and specialist process lighting

Emergency escape lighting and specialist process lighting are not subject to the requirements of these design guidelines. For the purposes of these design guidelines;

- *"Emergency Escape Lighting"* means that part of emergency lighting that provides illumination for the safety of people leaving an area or attempting to terminate a dangerous process before leaving an area, *and*

- *"Specialist Process Lighting"* means lighting intended to illuminate specialist tasks within a space, rather than the space itself. It could include theatre spotlights, projection equipment, lighting in TV and photographic studios, medical lighting in operating theatres and doctors' and dentists' surgeries, illuminated signs, coloured or stroboscopic lighting, and art objects with integral lighting such as sculptures, decorative fountains and chandeliers.

5.05 Lighting controls

- Where it is practical, the aim of lighting controls should be to encourage the maximum use of daylight and to avoid unnecessary lighting during the times when spaces are unoccupied. However, the operation of automatically switched lighting systems should not endanger the passage of building occupants. Guidance on the appropriate use of lighting controls can be obtained from the *British Research Establishment Publication, BRE IP 2/99.*

5.05.1 Meeting the Requirements for controls in offices and storage buildings

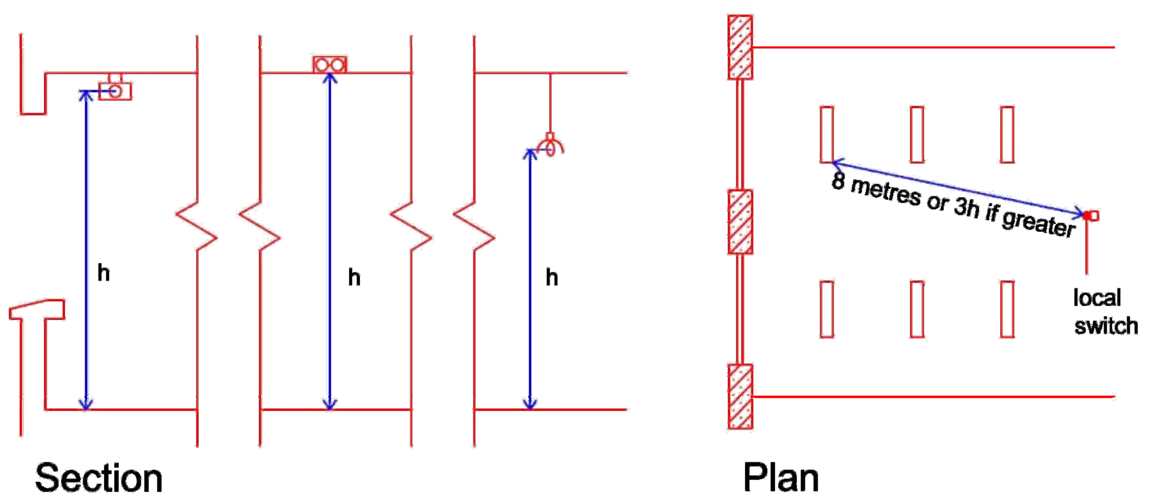
- A way of meeting the requirement would be the provision of local switches in easily accessible positions within each working area or at boundaries between working areas and general circulation routes. For the purposes of these design guidelines, reference to switch includes dimmer switches and switching includes dimming. As a general rule, dimming should be effected by reducing rather than diverting the energy supply.

- The distance on plan from any local switch to the luminaire it controls should generally be not more than eight metres, or three times the height of the light fitting above the floor if this is greater. Local switching can be supplemented by other controls such as time switching and photo- electric switches where appropriate. Local switches could include:

  (i) switches that are operated by the deliberate action of the occupants either manually or by remote control. Manual switches include rocker switches, push buttons and pull cords. Remote control switches include infra red transmitter, sonic ultrasonic and telephone handset controls.

  (ii) automatic switching systems which switch the lighting off when they sense the absence of occupants.

Local Lighting Controls	**Diagram F.2**



5.05.2 Meeting the Requirement for controls in buildings other than offices and storage buildings;

A way of meeting the requirement would be to provide one or more of the following types of control system arranged to maximise the beneficial use of daylight as appropriate:

- local switching as described in the second paragraph of clause 5.05.1,
- time switching, for example in major operational areas which have clear timetables of occupation;
- photo-electric switching.

5.05.3 Meeting the Requirement for control for display lighting (all building types);

A way of meeting the requirement would be to connect display lighting in dedicated circuits that can be switched off at times when people will not be inspecting exhibits or merchandise or being entertained. In a retail store, for example this could include timers that switch the display lighting off outside store opening hours, except for displays designed to be viewed from outside the building through display windows.

6. Conservation of Rain water

6.01 Rainwater that falls on roofs

Rainwater that falls on roofs shall not be allowed to drain into the public sewer or onto a public place or thoroughfare but shall be collected in suitable wells or cisterns within the site of the building. Such wells or cisterns shall have an overflow facility which will prevent the cistern from being filled more than its designed capacity and which drains to a public place, thoroughfare or underground public rain collection system where the latter is available.

6.02 Rainwater that falls on areas of a property other than roofs

Rainwater that falls on areas of a property other than roofs may be drained onto a public place or thoroughfare provided that appropriate provision is made to avoid nuisance and damage.

6.03 Rainwater drainage

6.03.1 The capacity of the system shall be adequate to carry the anticipated flows at each part of the system.

6.03.2 The system shall be of appropriate materials to conduct water from roofs or other areas to a cistern without contributing to dampness in any part of the building or adjoining buildings.

6.03.3 Roof falls shall be sufficient to prevent the build-up of water on roofs and shall direct the water to sufficient channels and outlets as appropriate. Falls of between 1:80 to 1:100 are recommended

6.03.4 Rainwater pipes may discharge onto another gutter or surface provided that the latter is also drained, and has the capacity to deal with the combined runoff.

6.03.5 Rainwater pipes and their fittings shall be appropriate to their purpose and shall be fixed to the external face of the walls of buildings.

6.03.6 Where it is necessary to introduce rainwater pipes within buildings they shall be completely accessible, and shall not be embedded within walls or passed through inaccessible wall cavities.

6.04 Wells and cisterns

6.04.1 All buildings shall incorporate a cistern or well for the storage of rainwater.

6.04.2 The size and number of cisterns, or wells shall conform to the requirements of Table F.10 or better.

Size of well or cistern — Table F.10

Building Type	Size of cistern (m^3)
1. Domestic dwellings (inc. Apartment blocks)	Total roof area (m^2) x 0.6m
2. Hotels, Schools, Offices, Factories, Industrial buildings and Hospitals	Total roof area (m^2) x 0.6m
3. Shops and showrooms, and places of public gathering and entertainment not integrated in 2 above	Total roof area (m^2) x 0.45m
4. External paved areas (inc. open terraces and balconies) *	Total paved area (m^2) x 0.6m
***Note:** This requirement applies only if the total open paved area is greater than 300sq.m	

6.04.3 The well or cistern shall be located within the site in such a position as to ensure its structural integrity and proper maintenance.

6.04.4 The cistern or well shall be designed and constructed to be watertight and meeting all requirements of structural stability.

6.04.5 The containing walls or wellhead shall:

- prevent surface water from draining directly into the well, and
- provide safety to users of the site

6.05 Interception traps

6.05.1 Rainwater shall be led into the well or cistern through an interception trap consisting of one or more chambers designed to settle out pollutants from the rainwater prior to its being stored within the cistern or well.

6.05.2 Where rainwater is taken from an area in which petrol or oil are prevalently located, then a petrol interceptor is to be installed as the collecting gully and the water led away to the public street.

6.06 Access

6.06.1 Safe access for inspection and cleaning the well or cistern is to be provided by means of suitable non-ferrous step irons, ladders or steps incorporated into the structure.

6.07 Use of rainwater collected in wells and cisterns

6.07.1 For every newly constructed building, a separate water circulation system together with associated draw off points for providing water for flushing of toilets and watering of planted areas should be provided.

6.07.2 In those buildings with multi-owner occupancies, the requirement of paragraph 6.07.1 should be provided to at least one of the occupancies.

APPENDIX A – Tables of U values

The following tables provide indicative U values for windows, doors and rooflights. Table A.1 applies to windows and rooflights with wood or PVC-U frames. Table A.2 applies to windows with metal frames, to which (if applicable) the adjustments for thermal breaks and rooflights in Table A.3 should be applied. The tables do not apply to curtain walling or to other structural glazing not fitted in a frame. For the purpose of these design guidelines a roof window may be considered as a rooflight. The U value of a window or rooflight containing low-E glazing is influenced by the emissivity, *En,* of the low-E coating.

Low-E coatings are of two principal types, known as 'hard' and 'soft'. Hard coatings generally have emissivities in the range 0.15 to 0.2, and the data for εn = 0.2 should be used for hard coating, or if the glazing is stated to be low-E but the type of coating is not specified. Soft coatings generally have emissivities in the range 0.05 to 0.1. The data for εn = 0.1 should be used for a soft coating if the emissivity is not specified.

When available, manufacturers' certified U values (by measurement or calculation according to the standards given in Section 2.05) should be used in preference to the data given in these tables.

Indicative U values (W/m^2K) for windows and rooflights with wood or PVC-U frames, and doors — Table A.1

	Gap between panes			
	6mm	**12mm**	**16mm or more**	**Adjustment for rooflights in dwellings[3]**
Single glazing	4.8			+0.3
Double glazing (air filled)	3.1	2.8	2.7	+0.2
Double glazing (low-E, εn = 0.2)[1]	2.7	2.3	2.1	
Double glazing (low-E, εn = 0.15)	2.7	2.2	2.0	
Double glazing (low-E, εn =0.1)	2.6	2.1	1.9	
Double glazing (low-E, εn = 0.05)	2.6	2.0	1.8	
Double glazing (argon filled)[2]	2.9	2.7	2.6	
Double glazing (low-E εn = 0.2, argon filled)	2.5	2.1	2.0	
Double glazing (low-E εn = *0.1, argon filled)*	2.3	1.9	1.8	
Double glazing (low-E εn = 0.05, argon filled)	2.3	1.8	1.7	
Triple glazing	2.4	2.1	2.0	
Triple glazing (low-E, εn = 0.2)	2.1	1.7	1.6	
Triple glazing (low-E, εn = 0.1)	2.0	1.6	1.5	
Triple glazing (low-E, εn = 0.05	1.9	1.5	1.4	
Triple glazing (argon filled)	2.2	2.0	1.9	
Triple glazing (low-E, εn = 0.2 argon filled)	1.9	1.6	1.5	
Triple glazing (low-E, εn = *0.1, argon filled)*	1.8	1.4	1.3	
Triple glazing (low-E εn = 0.05 argon filled)	1.7	1.4	1.3	
Solid wooden door[4]	3.0			------

Notes:

1. The emissivities quoted are normal emissivities. (Corrected emissivity is used in the calculation of glazing U values). Uncoated glass is assumed to have a normal emissivity of 0.89
2. The gas mixture is assumed to consist of 90% argon and 10% air.
3. No correction need be applied to rooflights in buildings other than dwellings.
4. For doors which are half-glazed the U value of the door is the average of the appropriate window U value and that of the non-glazed part of the door (e.g. 3.0W/m^2K for a wooden door)

Indicative U values (W/m²K) for windows with metal frames (4mm thermal break) — Table A.2

	Gap between panes		
	6mm	**12mm**	**16mm or more**
Single glazing	5.7		
Double glazing (air filled)	3.7	3.4	3.3
Double glazing (low-E, εn = 0.2)	3.3	2.8	2.6
Double glazing (low-E, εn = 0.1)	3.2	2.6	2.5
Double glazing (low-E, εn = 0.05)	3.1	2.5	2.3
Double glazing (argon filled)	3.5	3.3	3.2
Double glazing (low-E, εn = 0.2, argon filled)	3.1	2.6	2.5
Double glazing (low–E, εn = 0.1, argon filled)	2.9	2.4	2.3
Double glazing (low–E, εn =0.05, argon filled)	2.8	2.3	2.1
Triple glazing	2.9	2.6	2.5
Triple glazing (low–E, εn = 0.2)	2.6	2.2	2.0
Triple glazing (low–E, εn =0.1)	2.5	2.0	1.9
Triple glazing (low–E, εn = 0.05)	2.4	1.9	1.8
Triple glazing (argon filled)	2.8	2.5	2.4
Triple glazing (low-E, εn = 0.2, argon filled)	2.4	2.0	1.9
Triple glazing (low-E, εn = 0.1, argon filled)	2.2	1.8	1.7
Triple glazing (low-E, εn = 0.05, argon filled)	2.2	1.8	1.7

Note:

For windows and rooflights with metal frames incorporating a thermal break other than 4mm, the following adjustments should be made to the U values given in Table A.2.

Adjustments to U values for frames with thermal breaks — Table A.3

Thermal break (mm)	Adjustments to U value (W/m²K)	
	Window, or rooflight in building other than a dwelling	**Rooflight in dwellings**
0 (no break)	+0.3	+0.7
4	+0.0	+0.3
8	-0.1	+0.2
12	-0.2	+0.1
16	-0.2	+0.1

Note:

Where applicable adjustments for both thermal and rooflight should be made. For intermediate thicknesses of thermal breaks, linear interpolation may be used.

A1 Corrections to U values of roofs and floors

Annex D of *EN ISO 6946* provides corrections to U values to allow for the effects of:

- air gaps in insulation
- mechanical fasteners penetrating the insulation layer
- precipitation on inverted roofs

The corrected U value (U_c) is obtained by adding a correction term ΔU:

$$U_c = U + \Delta U$$

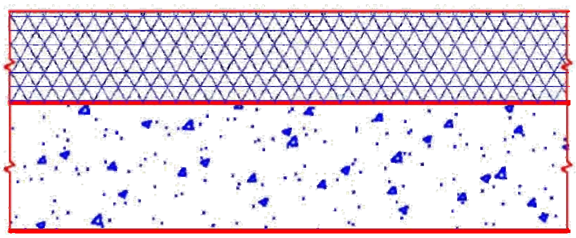
If the total ΔU is less than 3% of U then the corrections need not be applied and ΔU can be taken to be zero. However, where corrections are to be applied, before using the tables the following steps should be carried out:

(i) subtract ΔU from the desired U value.

(ii) use this adjusted U value in the tables when calculating the required thickness of insulation.

This thickness of insulation then meets the original desired U value, having allowed for the ΔU correction(s).

A2 Roofs



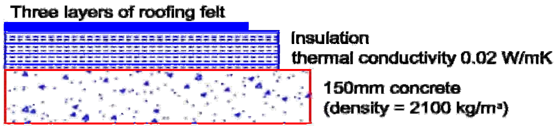
Base thickness for continuous insulation — **Table A.4**

	Design U value (W/m^2K)	Thermal conductivity of insulation (W/m.k) 0.020	0.025	0.030	0.035	0.040	0.045	0.050
		Base thickness of insulating material (mm)						
	A	B	C	D	E	F	G	H
1	0.15	131	163	196	228	261	294	326
2	0.20	97	122	146	170	194	219	243
3	0.25	77	97	116	135	154	174	193
4	0.30	64	80	96	112	128	144	160
5	0.35	54	68	82	95	109	122	136
6	0.40	47	59	71	83	94	106	118

Allowable reduction in thickness for common roof components — Table A.5

	Concrete slab density (kg/m^3)	Thermal conductivity of insulation (W/m.K) 0.020	0.025	0.030	0.035	0.040	0.045	0.050
		Reduction in base thickness of insulating material for each 100mm of concrete slab						
	A	B	C	D	E	F	G	H
1	600	10	13	15	18	20	23	25
2	800	7	9	11	13	14	16	18
3	1100	5	6	8	9	10	11	13
4	1300	4	5	6	7	8	9	10
5	1700	2	2	3	3	4	4	5
6	2100	1	2	2	2	3	3	3
	Other materials and components	**Reduction in base thickness of insulating material (mm)**						
7	10mm plasterboard	1	2	2	2	3	3	3
8	13mm plasterboard	2	2	2	3	3	4	4
9	13mm sarking board	2	2	3	3	4	4	5
10	12mm Calcium Silicate liner board	1	2	2	2	3	3	4
11	Roof space (pitched)	4	5	6	7	8	9	10
12	Roof space (flat)	3	4	5	6	6	7	8
13	19mm roof tiles	0	1	1	1	1	1	1
14	19mm asphalt (or 3 layers of felt)	1	1	1	1	2	2	2
15	50mm screed	2	3	4	4	5	5	6

Example: Concrete deck roof



Determine the thickness of the insulation layer required to achieve a U-value of 0.25 W/m^2K for the roof construction shown below.

Using Table A.4:

From column D, row 3 of the table, the base thickness of the insulation layer is 116mm.

The base thickness may be reduced by taking account of the other materials as follows:

From Table A.5:

3 layers of felt column D, row 14 = 1mm

150mm concrete deck column D, row 3 adjusted for 150mm thickness (1.5 x 8) = 12mm

Total reduction = 13mm

The minimum thickness of the insulation layer required to achieve a U-value of 0.25W/m^2K is therefore:

Base thickness less total reduction

i.e. 116 – 13 = **103mm**

A3 Building Materials

Thermal conductivity of some common building materials — Table A.6

	Density (kg/m^3)	Conductivity (W/m.K)
Walls		
Lightweight aggregate concrete block	1400	0.57
Autoclaved aerated concrete block	600	0.18
Concrete (medium density inner leaf)	1800	1.13
	2000	1.33
	2200	1.59
Concrete (high density)	2400	1.93
Mortar (protected)	1750	0.88
Mortar (exposed)	1750	0.94
Gypsum	600	0.18
	900	0.30
	1200	0.43
Gypsum plasterboard	900	0.25
Sandstone	2600	2.3
Limestone (soft)	1700	1.1
Limestone (hard)	2400	1.7
Fibreboard	400	0.1
Plasterboard	900	0.25
Tiles (ceramic)	2300	1.3
Timber (softwood), plywood, chipboard	500	0.13
Timber (hardwood)	700	0.18
Wall ties (stainless steel)	7900	17.0
Surface finishes		
External rendering	1300	0.57
Plaster (dense)	1300	0.57
Plaster (lightweight)	600	0.18
Roofs and roof finishes		
Reinforced concrete (1% steel)	2300	2.3
Reinforced concrete (2% steel)	2400	2.5
Aerated concrete slab	500	0.16
Asphalt	2100	0.70
Felt/bitumen layers	1100	0.23
Screed	1200	0.41
Stone chippings *(“hardstone”)*	2000	2.0
Limestone *(“torba”)*	1300	0.8
Tiles (clay)	2000	1.0
Tiles (concrete)	2100	1.5
Wood wool slab	500	0.10
Floors		
Cast concrete	2000	1.35
Metal tray (steel)	7800	50.0
Screed	1200	0.41
Timber (softwood), plywood, chipboard	500	0.13
Timber (hardwood)	700	0.18
Insulation		
Expanded polystyrene (EPS) board	15	0.040
Mineral wood quilt	12	0.042
Mineral wood batt	25	0.038
Phenolic foam board	30	0.025
Polyurethane board	30	0.025

Note:

If available, certified test values should be used in preference to those in the table.

APPENDIX B – Calculating U values

B1 Introduction

When calculating the U value, the effect of thermal bridges should be taken into consideration. Other factors, such as wall ties and air gaps around insulation should also be included where applicable. The calculation method, known as the *"Combined Method"*, is set out in *EN ISO 6946*. The following example illustrates the use of the method for a typical wall.

This example is offered as indicating ways of meeting the requirement but designers also have to ensure that their designs comply with all the other requirements of existing building regulations.

B2 Procedure

The U value is calculated by applying the following steps:

1). Calculate the upper resistance limit (R_{upper}) by combining in parallel the total resistance of all possible heat-flow paths (i.e. sections) through the plane building element.

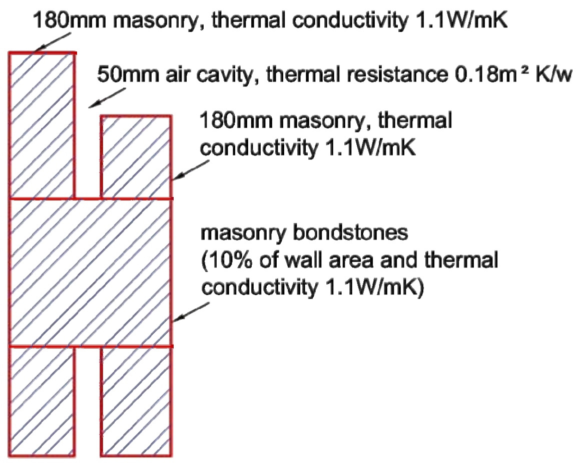
2). Calculate the lower resistance limit (R_{lower}) by combining in parallel the resistance of the heat flow paths of each layer separately and then summing the resistance of all layers of the plane building element.

3). Calculate the U value of the element from $U = \frac{1}{R_T}$

where $R_T = \frac{R_{upper} + R_{lower}}{2}$

4). Adjust the U value as appropriate to take account of metal fasteners, bond stones and air gaps.

B3 Example – U value calculation for a typical double leaf masonry wall



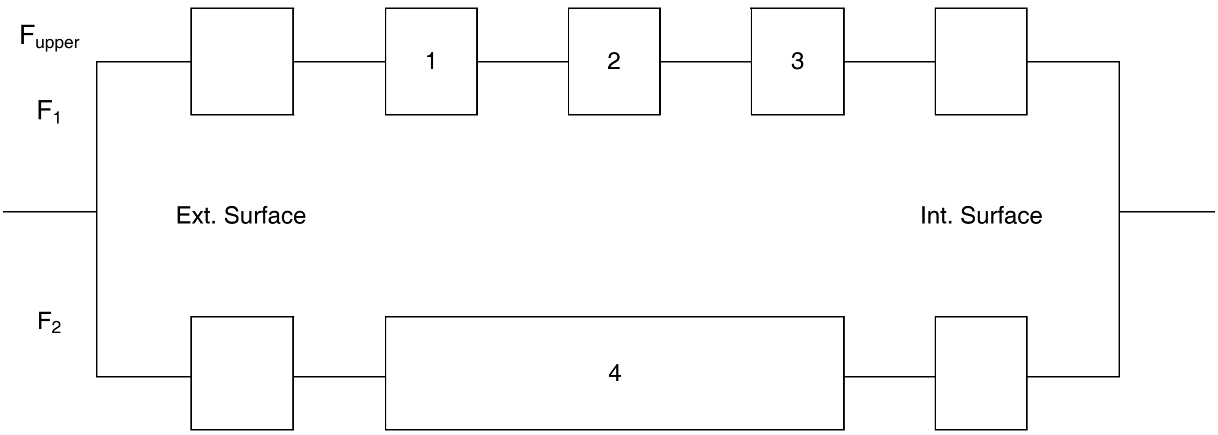
Layer	Material	Thickness *(mm)*	Thermal conductivity *(W/m.k)*	Thermal resistance *(m^2K/W)*
	External surface	----	----	0.060
1	Outer leaf masonry	180	1.1	0.164
2	Air cavity (unvented)	50	----	0.180
3	Internal leaf masonry	180	1.1	0.164
4	Bond stone 10%	410	1.1	0.373
	Internal surface	----	----	0.100

There are two possible paths through which heat can pass. The upper limit of resistance is therefore given by:

$$R_{upper} = \frac{1}{(\frac{F_1}{R_1} + \frac{F_2}{R_2})}$$

where F_m is the fractional area of section **m** and R_m is the total thermal resistance of section **m**. A conceptual illustration of the upper limit of resistance is shown in Diagram B.1 below.

Conceptual illustration of the upper limit of resistance — Diagram B.1



Resistance R_1 through section		
External surface resistance	=	0.060
Resistance of 180mm masonry	=	0.164
Resistance of air cavity	=	0.180
Resistance of 180mm masonry	=	0.164
Resistance of internal surface	=	0.100
Total thermal resistance R_1	**=**	**0.667m^{2}K/W**
Fractional area F_1 = 90%	**=**	**0.9**

Resistance R_2 through section containing bond stone		
External surface resistance	=	0.060
Resistance of 410mm masonry	=	0.373
Resistance of internal surface	=	0.100
Total thermal resistance R_2	**=**	**0.533m^{2}K/W**
Fractional area F_2 = 10%	**=**	**0.1**

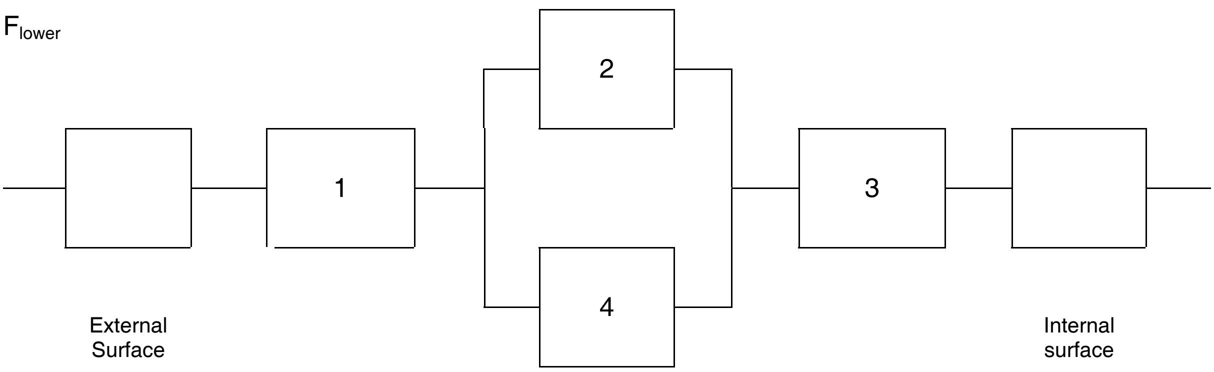
Combining these resistances, we obtain:

$$R_{upper} = \frac{1}{\frac{F_1}{R_1} + \frac{F_2}{R_2}} = \frac{1}{\frac{0.9}{0.667} + \frac{0.1}{0.533}} = \frac{1}{1.5365} = 0.651 m^2 K / W$$

B4 Lower Resistance Limit

A conceptual illustration of the lower limit of resistance is shown in Diagram B.2.

Conceptual illustration of the lower limit of resistance **Diagram B.2**



The resistance of the layers are added together to give the lower limit of resistance.

The resistance of the bridged layer consisting of the cavity and masonry bond stones is calculated using:

$$R = \frac{1}{\frac{F_{cavity}}{R_{cavity}} + \frac{F_{bondstones}}{R_{bondstones}}}$$

The lower limit of resistance is then obtained by adding together the resistance of the layers:

Resistance R_{lower} through section				
External surface resistance			=	0.060
Resistance of 180mm masonry			=	0.164
Resistance of bridged cavity	=	$\frac{1}{\frac{0.9}{0.18} + \frac{0.1}{0.045}}$	=	0.139
Resistance of 180mm masonry			=	0.164
Internal surface resistance			=	0.100
Total (R_{lower})			**=**	**0.626m²K/W**

B5 Total Resistance R_T of wall

The total resistance of the wall is the average of the upper and lower limits of resistance:

$$R_T = \frac{R_{upper} + R_{lower}}{2} = \frac{0.6508 + 0.6262}{2} = 0.638 m^2 K / W$$

B6 U value of the wall

$$U = \frac{1}{R_T} = \frac{1}{0.638} = 1.566 \text{W/m}^2\text{K}$$

APPENDIX C – Meeting the Lighting Standards

C1 General lighting in office, industrial and storage buildings

C1.1 By selection of lamp and luminaire types

The performance standard for the electric lighting system in these building types depends on the efficiencies of both the lamp/ballast combination and the luminaire. The recommendation in paragraph 5.01.2 is met if:

- the installed lighting capacity in circuit Watts comprises lighting fittings incorporating lamps of the type shown in Table F.6 and

- all the luminaires have a light output ratio of at least 0.6.

A maximum of 500W of installed lighting in the building is exempt from the above requirement (paragraph 5.02.2).

Otherwise, if the use of other types if lighting or less efficient luminaires is planned, a calculation of the average initial luminaire efficacy is required.

C1.2 Example - calculation of average luminaire efficacy

A small industrial unit is being constructed incorporating production, storage and office areas. Lighting in the production area (which is non-daylit) is to be controlled by staged time switching to coincide with shift patterns. The storage area is anticipated to be occasionally visited, and is to be controlled by local absence detection, where a sensor switches the lighting off if no one is present, but switching on is done manually. The office areas are daylit; the furthest luminaire is less than 6m from the window wall, which is 30% glazed with clear low emissivity double-glazing. Lighting control in this area is by localised infra red switch. Lighting in the non-daylit corridor, toilet and foyer areas is by full occupancy sensing with automatic on and off.

The lighting controls therefore meet the requirements of paragraph 5.05.1 (for the office and storage areas) and paragraph 5.05.2 (for the production and circulation areas).

Table C.2 below shows a schedule of the light sources proposed, together with a calculation of the overall average luminaire efficacy. It incorporates the luminaire control factor, which allows for the reduced energy use due to lighting in daylit and rarely occupied spaces. The storage areas are occasionally visited and incorporate absence detection, so have a luminaire control factor of 0.8.

The daylit office areas with local manual switching also have a luminaire control factor of 0.8. Note that if the office areas had tinted glazing, of transmittance of 0.33, the equivalent area of glazing of transmittance 0.7 would need to be calculated. This is 30% x 0.33/0.7 = 14% of the window wall area. As this area is less than 20% of the window wall, the office areas would not count as daylit if this type of glazing was used.

Schedule of the light sources proposed with a calculation of the overall average luminaire efficacy — Table C.1

Position	Number	Description	Circuit	Lamp lumen	Luminaire	Luminaire	Total corrected	Total
	N		*Watts (W) per fitting*	*output ϕ (lm) per fitting*	*light output ratio LOR*	*control factor C_L*	*luminaire output =* $N \times \phi \times \frac{LOR}{C_L}$ *(lm)*	*circuit Watts (W)*
Production	16	250W high bay metal halide	271	17000	0.8	1	217600	4336
Offices	12	4 x 18W fluorescent with aluminium Cat 2 louvre and high frequency control gear	73	4600	0.57	0.8	39330	876
Storage	16	58W fluorescent with aluminium louvres and mains frequency control gear	70	4600	0.6	0.8	55200	1120
Circulation toilets and foyer	30	24W compact fluorescent mains frequency down lights	32	1800	0.4	1	21600	960
						Totals	**333730**	**7292**

From Table C.1 *Schedule of the light sources proposed with a calculation of the overall average luminaire efficacy* the total corrected lumen output of all the lamps in the installation is 333730 lumens.

The total circuit Watts of the installation is 7292 Watts. Therefore the average luminaire efficacy is 333, 730/7292 = 45.8 lumens/Watt. As this is greater than 40 lumens/Watt, the proposed lighting scheme therefore meets the requirements of this guidance document. Note that up to 500W of any form of lighting, including lamps in luminaires for which light output ratios are unavailable, could also be installed in the building according to paragraph 5.02.2.

C2 General lighting in other building types

C2.1 Lighting calculation procedure to show average circuit efficacy is not less than 50 lumens/watt.

A lighting scheme is proposed for a new public house comprising a mixture of concealed perimeter lighting using high frequency fluorescent fittings and supplementary tungsten lamps in the dining area.

Lights in the dining and lounge areas are to be switched locally from behind the bar. Lighting to kitchens and toilets is to be switched locally.

Table C.2 shows a schedule of the light sources proposed together with the calculation of the overall average circuit efficacy.

Schedule of the light sources proposed with a calculation of the overall average circuit efficacy — Table C.2

Position	Number	Description	Circuit Watts (W) per lamp	Lumen output (lm)	Total circuit Watts (W)	Total Lamp lumen output (lm)
Over tables	20	60W tungsten	60	710	1,200	14,200
Concealed perimeter and bar lighting	24	32W T8 fluorescent high frequency ballast	36	3,300	864	79,200
Toilets and circulation	6	18W compact fluorescent mains frequency ballast	23	1,200	138	7,200
kitchen	6	50W T8 fluorescent high frequency ballast	56	6,200	336	31,200
				Totals	**2,538**	**131,800**

From Table C.2, the total lumen output of the lamps in the installation is 131,800 lumens.

The total circuit Watts of the installation is 2,538 Watts.

Therefore, the average circuit efficacy is:

$$\frac{131{,}800}{2538} = 51.9 \text{ lumens/Watt}$$

The proposed lighting scheme therefore meets the requirements of this guidance document.

If 100W tungsten lamps were used in the dining area instead of the 60W lamps actually proposed, the average circuit efficacy would drop to 43.4 lumens/W, which is unsatisfactory. If, however, 11W compact fluorescent lamps, which have similar light output to 60W tungsten lamps, were used in the dining area the average circuit efficacy would be 83.2 lumens/W.

C2.2 Lighting calculation procedure to show that 95% of installed circuit power is comprised of lamps listed in Table F.7 (paragraph 5.02.4)

A new hall and changing rooms are to be added to an existing community centre. The proposed lighting scheme incorporates lamps that are listed in Table F.7 except for some low voltage tungsten halogen downlighters that are to be installed in the entrance area with local controls. A check therefore has to be made to show that the low voltage tungsten halogen lamps comprise less than 5% of the overall installed capacity of the lighting installation.

C2.2.1 Main hall

Twenty wall mounted up-lighters with 250W high pressure Sodium lamps are to provide general lighting needs. The up-lighters are to be mounted 7m above the floor. On plan, the furthest light is 20.5m from its switch, which is less than three times the height of the light above the floor.

It is also proposed to provide twenty 18W compact fluorescent lights as an additional system enabling instant background lighting whenever needed.

C2.2.2 Changing rooms, corridors and entrance

Ten 58W, high frequency fluorescent light fittings are to be provided in the changing rooms and controlled by occupancy detectors. Six more 58W fluorescent light fittings are to be located in the corridors and the entrance areas and switched locally. Additionally, in the entrance area there are to be the six 50W tungsten halogen down-lighters noted above.

C2.2.3 Calculation

A schedule of light fittings is prepared as follows:

Position	Number	Description of light source	Circuit Watts per lamp	Total circuit Watts (W)
Main hall	20	250W SON	286W	5720
Main hall	20	18W compact fluorescent	23W	460
Entrance changing rooms and corridors	16	58W HF fluorescent	64W	1024
Entrance	6	50W low voltage tungsten halogen	55W	330
			Total	**7534W**

The percentage of circuit Watts consumed by lamps not listed in Table F.6 is

$$\frac{330 \times 100}{7534} = 4.4\%$$

Therefore, more than 95% of the installed lighting capacity, in circuit Watts, is from light sources listed in Table F.6. The switching arrangements comply with paragraph 5.05.2. The proposed lighting scheme therefore meets the requirements of these design guidelines.

Ministry for Resources and Infrastructure

SERVICES DIVISION

Building Regulations Office