

# Energy efficient refurbishment of existing housing



2003 EDITION



**HOUSING  
ENERGY EFFICIENCY**

**BEST PRACTICE  
PROGRAMME**

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## 1 INTRODUCTION

The aim of this Guide is to help landlords, private developers and others to refurbish and repair their existing housing in an energy efficient way. It gives advice on the full refurbishment of dwellings, as well as individual improvement measures during repair.

The guidance allows designers and developers to adapt dwellings to current efficient technology and improve the value of the property. The Guide provides answers to some common queries and concerns. This includes:

- how energy efficient?
- what is cost-effective?
- how can I avoid problems?
- what are the best options to use?
- where do I go for more information?

### DEFINING ENERGY EFFICIENCY

Energy efficiency in housing is defined as the minimisation of the energy cost necessary to provide the specified internal environment, subject to the criterion of cost-effectiveness used by the client. The internal environment can be specified in terms of temperatures, moisture levels, ventilation, hot water, lighting and appliance requirements.

A lot of information is available on energy efficient refurbishment and the most relevant sources are listed on page 35 and referred to within the text. This Guide makes general recommendations for designers and gives possible specifications for the energy efficient refurbishment of solid and cavity-walled housing.

Following refurbishment, all housing should be as energy efficient as cost-effectiveness allows, in order to:

- reduce occupants' and owners' fuel bills and provide affordable warmth
- minimise management and maintenance costs
- increase property value (and rent revenue)
- reduce global and local pollution
- conserve fossil fuel resources.

### COMMITMENT TO GLOBAL CLIMATE CONTROL

Under the Kyoto Protocol, the UK is obligated to reducing its greenhouse gas emissions, including carbon dioxide (CO<sub>2</sub>) emissions, to 12.5% below 1990 levels by the year 2012. The domestic sector contributes an estimated 25% to the total CO<sub>2</sub> emissions in the UK, or 60% of CO<sub>2</sub> related to buildings.

As the domestic sector accounts for about 32% of total UK electricity consumption, and mostly uses equipment that doesn't meet current standards of energy efficiency, scope exists for significant savings.

### ENERGY EFFICIENT REFURBISHMENT PACKAGES

It is impossible to prescribe a single package of measures that would be applicable to all existing dwellings. The most suitable and cost-effective insulation options depend, to a large degree, on the opportunities arising from the proposed general improvements and the form of construction.

Where an organisation sets out to provide affordable warmth for occupants, packages of measures that are identified in this Guide can be used to bring running costs within the range of low-income occupants.

### REGULATIONS

Building regulations vary between England and Wales, Scotland and Northern Ireland. Building control at the local authority should be consulted for individual national standards. Details on where to get copies of regulations are given on the back page.

## INTRODUCTION

### PACKAGE OF MEASURES TO ACHIEVE BEST PRACTICE

- Walls:
  - cavity: cavity wall insulation
  - solid: insulated dry lining to achieve a U-value of 0.45 W/m<sup>2</sup>K; external wall insulation to achieve a U-value of 0.35 W/m<sup>2</sup>K.
- Pitched roofs – 250 mm minimum insulation to achieve a U-value of 0.16 W/m<sup>2</sup>K.
- Ground floor – insulation to achieve a maximum U-value of 0.20-0.25 W/m<sup>2</sup>K.
- Windows – double or triple-glazed windows to achieve a maximum U-value of 2.0 W/m<sup>2</sup>K. See 'Requirements for Scotland', page 15)
- All doors and windows draughtstripped.
- Using gas where available (due to the significantly lower carbon impact of gas). Central Heating System Specifications (CHeSS) HR4 or HC4.
- Primary hot water pipework insulated.
- Controlled ventilation to prevent condensation.

### IMPROVING ENERGY EFFICIENCY DURING REPAIR AND IMPROVEMENT WORK

The energy efficiency of a dwelling can be improved without waiting for a full refurbishment package to be undertaken. Repair and improvement programmes provide many opportunities for incorporating individual energy efficiency measures, as illustrated below.

It is invariably cheaper to combine energy efficiency measures with repair and improvement work, rather than return in a few years time and install them separately.

Insulation and draughtstripping should ideally be upgraded before boilers and heating systems are replaced. This allows the heating plant to be matched to the reduced demand, so cutting capital costs and improving efficiency.

IMPROVEMENT OPPORTUNITY	Internal wall insulation	Double glazing	Cavity wall insulation	External wall insulation	Extract ventilation	Draught stripping	Trickle ventilation	Insulate loft	Insulate water pipes	Ventilate loft space	Insulate floors	Add porch or vestibule	Low-energy lighting	Insulate hot water cylinder	Improve Controls	Fit replacement combi boiler
Refitting kitchens and bathrooms																
Re-pointing of walls																
Repairing frost-damaged walls or render/upgrading external appearance																
Replastering																
Replace wall ties																
Rewiring																
Replacement windows																
Repairing cladding																
Re-roofing/roof repairs																
Replacing external doors																
Repairing ground floors																
Heating and plumbing repairs																
Increase security																

*Opportunities for including energy efficiency measures into repair and improvement work*

## INTRODUCTION

## SPECIFICATIONS AND TENDERS

The cost of energy efficient construction can be kept to a minimum by:

- ensuring an integrated package of energy efficiency measures (see section 2)
- including required energy efficiency measures in the 'standard' tender specification rather than having them priced as extras
- assessing the costs and benefits of different energy-saving features prior to tendering.

## ENVIRONMENTALLY FRIENDLY HOUSING AND ENERGY

The burning of fossil fuels produces CO<sub>2</sub>, which is a greenhouse gas and major contributor to global warming. Energy efficient refurbishment will lead to reduced fuel consumption and, as a consequence, will reduce CO<sub>2</sub> emissions.

The graphs below show the potential running cost and CO<sub>2</sub> savings for two types of dwelling with the improvements recommended in this Guide (based on the Standard Assessment Procedure, 2001).

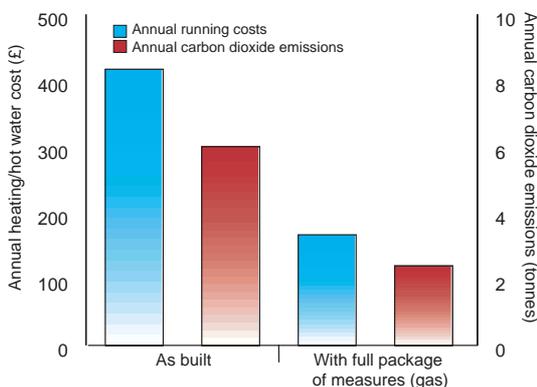
SAP rating	Typical annual heating and hot water costs
43 typical mid-terrace house basic gas central heating	£500
46 windows double glazed and draughtstripped	£470
85 fully insulated and double glazed	£210
102 fully insulated, double glazed and with gas condensing boiler	£160

## SAP RATINGS

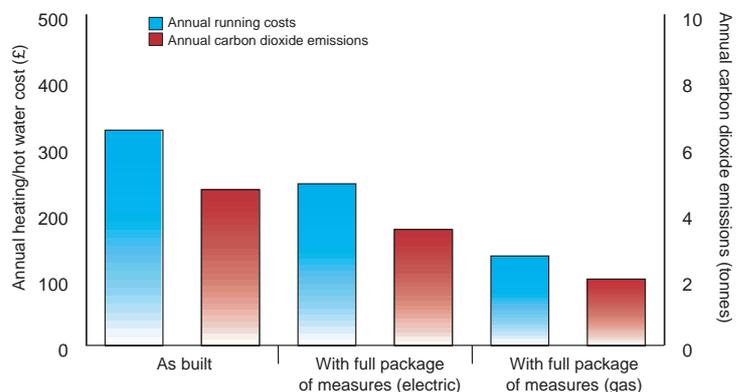
The Standard Assessment Procedure (SAP) is an energy rating which estimates the space and water heating costs (based on the size of the property and its heating and hot water system) and converts them into a rating on a scale from 1 to 120. The higher the number, the lower the energy consumption.

The SAP rating can be used to compare the relative benefits of different energy efficiency measures.

'The Government's Standard Assessment Procedure for the energy rating of dwellings. 2001 edition' is available from [www.bre.co.uk/sap2001](http://www.bre.co.uk/sap2001) or telephone 01923 664258.



**Annual running costs and CO<sub>2</sub> emissions for a 1930s three-bedroom semi-detached**



**Annual running costs and CO<sub>2</sub> emissions for a 1970s two-bedroom top floor flat**

## 2 INTEGRATED DESIGN

### DESIGN ADVICE SCHEME

The Design Advice scheme is a Government initiative aimed at improving the energy and environmental performance of building stock. Housing refurbishment projects with a floor area of 500 m<sup>2</sup> or more can benefit from subsidised energy design advice. Further details can be obtained from the Action Energy Helpline on 0800 585 794 or [www.designadvice.co.uk](http://www.designadvice.co.uk).

### WHAT IS INTEGRATED DESIGN?

Energy efficient refurbishment must be designed so that insulation, heating and ventilation work together. With adequate temperatures and ventilation levels, an integrated design maximises cost-effectiveness in construction and minimises fuel costs. For example, improving the insulation standard can influence the choice and capital cost of the heating system.

Within each of these areas the integrated approach should also be applied.

#### Insulation

Insulation should as far as practicable be distributed around all the exposed elements of the house to minimise overall heat loss and avoid thermal bridging, which can lead to condensation problems (see section 3).

#### Heating

Heating systems must be correctly sized for the actual heat loss from the dwelling (with allowance for warm-up). Oversizing is likely to waste energy. Undersizing will lead to substandard temperatures. Heating controls must be able to respond to incidental and solar gains and to provide adequate heating in all parts of the dwelling (see section 8).

#### Ventilation

Ventilation should be through purpose-designed openings that can be controlled by the occupant (such as trickle ventilators and extract fans) and not through uncontrollable ventilation paths (such as undraughtstripped windows and gaps around service pipes and cables). (See sections 4, 5, 6 and 7.)

### ENVIRONMENTAL EFFECTS

In addition to energy efficiency considerations, an assessment should be made, at an early stage in the refurbishment process, of the environmental impact of the project.

For example, choosing building products/processes that avoid the use of ozone-depleting gases, and selecting materials that come from sustainable or recycled sources, will help the environment at a global level.

### ENERGY RATINGS

The use of energy ratings should enable decision-makers to take energy efficiency into account on a rational basis when designing new dwellings or refurbishing existing ones. For building professionals, ratings can be used as a reliable design tool to optimise energy efficient design.

### BREDEM AND INTEGRATED DESIGN

The BRE Domestic Energy Model (BREDEM) can be used to calculate annual energy requirements of housing using different design criteria. The calculation can:

- estimate heat loss through each element of the fabric
- estimate ventilation heat loss
- apply incidental heat gains from occupants, lighting and appliances, solar gains, etc
- apply heating system efficiencies based on particular types of equipment and controls.

There are four principal benefits that arise from estimating the energy use and costs:

- fuel bill estimates can be compared with occupants' ability to pay
- energy efficiency measures can be considered according to the fuel savings they would make
- the fuel-saving potential of different measures and packages of measures can be compared to optimise a design
- reduced CO<sub>2</sub> emissions.

### THE SAP HOME ENERGY RATING

The Standard Assessment Procedure (SAP), an energy rating for housing, is based on BREDEM and takes into account space and water heating. It is expressed on a scale of 1 for a very inefficient home to 120 (100 before 2001) for one that is extremely energy efficient.

Although the SAP does not directly give fuel use estimates, it allows comparison of various energy efficiency packages. The Government is encouraging builders, local authorities, housing associations and those concerned with the UK housing stock to use SAP energy ratings as a means of assessing the energy performance of dwellings.

## INTEGRATED DESIGN

A number of home energy rating organisations provide SAP ratings. The current list of authorised organisations can be obtained from Housing Energy Efficiency Best Practice programme (HEEBPp) or [www.bre.co.uk/sap2001](http://www.bre.co.uk/sap2001). Some SAP calculation software also includes fuel use prediction.

### SETTING A TARGET

A target for refurbishment may be set using either an energy rating or a specification checklist, which takes account of the opportunity for improvement. Energy ratings also allow comparisons, based upon running costs, to be made between different dwellings and before and after refurbishment.

Setting a target for existing properties is less straightforward than for new housing. However, a SAP rating of 75 should be regarded as the minimum to be exceeded wherever technically and financially feasible.

Setting an energy rating standard allows the designer freedom to select the energy measures, or levels of energy efficiency, appropriate to a particular situation. At the same time occupants can be assured of an overall level of affordable warmth, if the target is high enough.

The affordability of heating and hot water depends on a number of factors, the main ones being:

- household income
- the energy efficiency of the dwelling
- the size of the dwelling.

'Affordable warmth' targets can be set based on the likely income of the occupants to ensure they can afford to heat their homes. Specifications can then be developed to ensure that fuel bills will not exceed this target.

### HEALTH AND SAFETY

It is the landlord's responsibility to ensure that the dwellings pose no risk of damage to the tenants' health. It is therefore important that the refurbishment of the dwellings takes into account the potential factors that may affect the occupants' health.

Typical examples include:

- insulation reduces cold surfaces, condensation and mould growth
- adequate ventilation removes moisture and prevents the build-up of other airborne substances
- hot pipes must be insulated to prevent burns
- hot water temperatures must not cause scalding
- windows and doors should be secure but escape must be possible in the event of a fire
- windows should have stays, which prevent small children falling from upper storeys
- rooms with fuel-burning appliances must be correctly ventilated for safe combustion.

The Gas Safety (Installation and Use) (Amendment) Regulations 1994 and 1996 introduce specific duties, with regard to gas fittings, on landlords who allow their premises to be occupied for residential purposes. In particular such gas fittings and associated flues, etc, must be maintained in a safe condition and safety checked every 12 months. Appropriate records must be kept and made available to the occupants on request. The landlord must also ensure that only Health and Safety Executive (HSE) approved gas fitters carry out any work on gas fittings on their premises.

### 3 INSULATION STANDARDS

This section shows typical solutions for insulating the most common forms of construction in existing dwellings.

Where possible, all exposed (and semi-exposed) elements of the dwelling should be insulated to produce an integrated insulation package. This will minimise heat loss in the most cost-effective way and avoid thermal bridges.

Where heating and insulation packages cannot be installed at the same time, the insulation package should ideally be installed first to reduce heating demand and improve comfort.

All proposals for improvement should be assessed using BREDEM-based software. This combines insulation with ventilation and heating to ensure a fully integrated design.

#### INSULATION VALUES

In this section minimum thermal resistance,  $R$  ( $\text{m}^2\text{K}/\text{W}$ ), is often shown to indicate the amount of insulation that must be provided for each form of construction.

Because the thermal properties of individual products vary, conductivity values should be checked with manufacturers. These values can then be used to calculate the minimum insulation thickness:

$$t[\text{mm}] = R \times \lambda \times 1000$$

where:

$R$  = the required thermal resistance of the insulation in  $\text{m}^2\text{K}/\text{W}$

$\lambda$  = the thermal conductivity of the insulation in  $\text{W}/\text{mK}$ .

Construction	Typical existing U-value ( $\text{W}/\text{m}^2\text{K}$ )	Improvement measure	Improved fabric U-value* ( $\text{W}/\text{m}^2\text{K}$ )
Cavity walls (brick/cavity/brick)	1.5	Fill cavity with mineral wool, polystyrene beads or urea formaldehyde foam	0.52
Solid 225 mm brickwork	2.1	Lined internally with 12.5 mm plasterboard with an insulation backing	<0.45
		Internal battened dry lining with 100 mm mineral wool batts	
		Insulated externally with rigid insulation or mineral wool with a protective render finish	<0.35
Pitched roof (uninsulated)	1.9	250 mm mineral wool quilt (first layer between joists, plus second layer across joists)	0.16
Flat roofs	1.0	Insulation added above structural deck (warm and inverted warm roof)	<0.25
Ground floor (mid- and end-terrace)	0.45–0.7	Insulation above or below concrete slab	<0.2–0.25
		Insulation between joists of timber ground floor	
Glazing (single, timber-framed)	4.7	Replace with windows achieving a whole window U-value of $2.0 \text{ W}/\text{m}^2\text{K}$ and integral draughtstripping	<2.0

\* Improved U-values are expressed as a target and will depend on the nature of the existing building

#### A summary table of recommended insulation standards

##### REQUIREMENTS FOR SCOTLAND

Interpretation of the Technical Standards can vary between different local building control departments. U-values which are worse than the minimum prescribed in Part J may not be acceptable unless a relaxation of the Standards is sought. The local authority building control department should be consulted if there is any doubt.

## INSULATION STANDARDS



## EXTERNAL WALLS

Existing walls can be insulated internally, externally or, if a cavity construction, by filling the cavity with insulation. Of these three alternatives, cavity wall insulation is the cheapest and most cost-effective.

For solid masonry walls, or where a cavity wall is unsuitable for filling with insulation, internal insulation is usually the most cost-effective option, although there is a marginal loss of internal space. This is, however, very disruptive to install if the dwelling is occupied. External wall insulation is the most expensive of the three alternatives, but can be a sensible solution where the external wall requires remedial action, for example to combat dampness due to driving rain or degradation of the surface.

## CAVITY WALLS

The great majority of masonry cavity walls, especially those built in the 1930s or later, are suitable for filling with cavity wall insulation.

While perceived technical risk is the main barrier to the uptake of cavity wall insulation, the failure rate of filled cavities is very low. In most cases, failures were attributed to existing building defects not identified in an individual survey.

Urea formaldehyde cavity wall insulation should not normally be used in particularly exposed areas. BR262 'Thermal insulation: avoiding risks' (see 'Further information' back page) gives further advice.

Regular users of cavity wall insulation are convinced of its benefits, and take a few simple precautions to ensure high quality:

- a survey of all existing properties in accordance with BS 8208:Part 1:1985 prior to cavity insulation being installed
- general cleaning of the cavities and other remedial work.

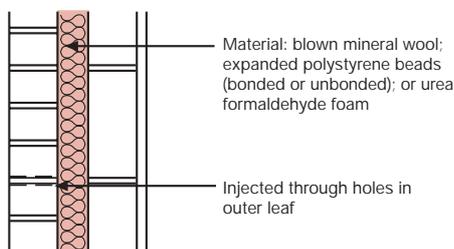
Mineral wool and polystyrene bead cavity wall insulation should have a current British Board of Agrément (BBA) certificate. Urea formaldehyde foam should conform to BS 5617:1985 and be installed in accordance with BS 5618:1985. Specify work to be carried out by reference to BS or an approvals certificate. A CIGA (Cavity Insulation Guarantee Agency) guarantee should also be provided (excludes non-traditional structures).

There are some concerns about the health effects of formaldehyde cavity wall insulation. Allergic skin reaction to formaldehyde is unlikely at the concentrations used for cavity fill. However, some individuals may suffer irritation to the eyes or upper respiratory tract. If in doubt seek medical advice.

Cavity walls that are not suitable for filling can be insulated using a solid-wall technique, subject to individual survey.

- GPG 26 'Cavity wall insulation in existing housing'
- GIL 23 'Cavity wall insulation: unlocking the potential in existing dwellings'

## INSULATION INJECTED INTO CAVITY



Typical U-values achieved: 0.5-0.6 W/m<sup>2</sup>K

- Timber-frame construction is already insulated. Advice on additional insulation should be sought from the Cavity Insulation Guarantee Agency (CIGA).
- Air bricks and balanced flues should be sleeved.
- Polystyrene should not be used if there are any unprotected PVC cables in the cavity, or if there are PVC cavity trays or dpcs.

## INSULATION STANDARDS



■ GPG 297 'Refurbishment site guidance for solid-walled houses – walls'

■ GPG 293 'External insulation systems for walls of dwellings'

## SOLID WALLS

## Advantages and disadvantages of internal and external insulation

## Internal insulation

Cheaper than external insulation.  
Can leave thermal bridges.  
Fixing of heavy items can be more difficult.  
Reduced room size can be critical in small rooms.  
Disruptive to tenants.  
Room surface warms up more quickly.

## External insulation

Can be applied without tenants having to move out.  
Thermal bridging avoided, except for projections, such as balconies.  
Not cost-effective on energy grounds alone.  
Can change external appearance dramatically.  
Not suitable for properties with fine architectural detailing or detailing will need replicating.  
May be vulnerable to impact damage.  
Vulnerable areas should be protected.  
May require alteration to rainwater goods and sills.

## Internal wall insulation

The cost-effectiveness of installing insulated dry-lining depends to a large extent on whether:

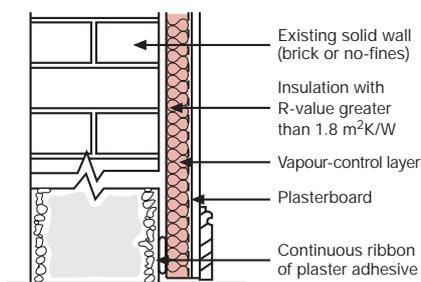
- the existing plaster is being renewed
- existing services (eg electrical cables, plumbing and central heating) and fittings (eg kitchen units and sanitary fittings) are being replaced.

In schemes where the existing plaster is being renewed, a wall U-value of 0.45 W/m<sup>2</sup>K or better should be specified. For a solid brick wall this equates to an insulation R-value of 2.2 m<sup>2</sup>K/W.

Where existing services and fittings are to be retained, the extra building work needed to remove and reattach electrical outlets, radiators, kitchen fittings, sanitary appliances and associated pipework extends the payback period significantly, to over 20 years.

These comparatively long payback periods highlight the importance of planning ahead. Where internal wall insulation is the most suitable method of insulating the wall, it is cheaper to include it as part of a full refurbishment or modernisation scheme than as a separate item at a later date. It is a false

## INTERNAL WALL INSULATION



U-value: 0.45 W/m<sup>2</sup>K

- Specify a vapour-control layer on the warm side of the insulation to prevent interstitial condensation.
- Specify a continuous ribbon of plaster adhesive (not dabs) at skirting and ceiling level, at perimeter walls and around any openings.
- Specify mechanical fixings as recommended by the manufacturer – they are needed for fire safety.
- Insulation should be returned into the reveals and soffits of window and door openings – a 25 mm thick board should be used where a thicker board would mask the window frame.
- PVC-sheathed electrical cables should not come into contact with polystyrene insulation as this can degrade the integrity of the cable insulation – cover cables with cover strips or place in ducts.
- It is advisable to return the insulated dry-lining a short distance (eg 500 mm) along separating walls, floors and ceilings in kitchens and bathrooms to avoid the risk of condensation at the thermal bridge.

Thickness of insulation required to achieve a U-value of 0.45 W/m<sup>2</sup>K

Conductivity (λ)	Minimum thickness (mm)
0.020	35
0.025	44
0.030	52
0.035	61
0.040	70

## INSULATION STANDARDS

economy to install central heating, new plumbing, wiring, etc, then to return and install internal wall insulation a few years later.

There is a wide variety of options for internal insulation and the final choice will be dependent on any restrictions on overall thickness, choice of insulant and cost factors.

### External wall insulation

The design and installation of external wall insulation systems is a specialist job. It is strongly recommended to use an insulation system with a current approvals certificate for all components of the system, eg fixings, render, insulant and panel, as appropriate.

It is generally the most expensive way to insulate an external wall. The high capital cost results in payback periods in excess of 20 years for the energy savings alone. However, for no-fines concrete and other constructions that require regular re-rendering, the extra cost of insulation is minimal. Also, where a solid brick wall requires

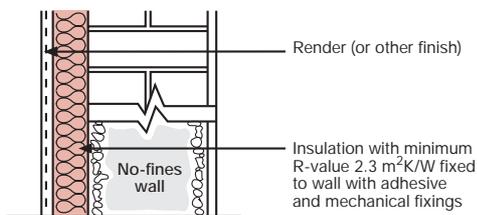
extensive remedial action (to combat rain penetration for example), the additional cost of incorporating insulation is worthwhile.

For best practice a wall U-value of 0.35 W/m<sup>2</sup>K or better should be specified.

### ENVIRONMENTAL NOTE

To reduce the environmental impact, specifiers should avoid foam insulation materials that use hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs) as blowing agents, unless there is no other environmental alternative available. These gases have powerful greenhouse and ozone-depleting properties that contribute to global warming. Where material strength is required, specify rigid foam products that use less-damaging blowing agents. For best overall environmental performance, look to cork, cellulose, rock-wool and low-density glass wool. (See Section 12, page 34).

### EXTERNAL WALL INSULATION



Recommended U-value: 0.35 W/m<sup>2</sup>K

- Confirm with the installer acceptable details at the junction of the wall insulation with roof eaves and verges, windows and door openings and other features.
- If a combustible insulant is being used, consult the approvals certificate for any precautions that may be necessary.
- Where the external appearance is changed check to see if planning permission is needed.

Thickness of insulation required to achieve a U-value of 0.35 W/m<sup>2</sup>K

Conductivity (λ)	Minimum thickness (mm)
0.020	48
0.025	60
0.030	72
0.035	82
0.040	95

## INSULATION STANDARDS

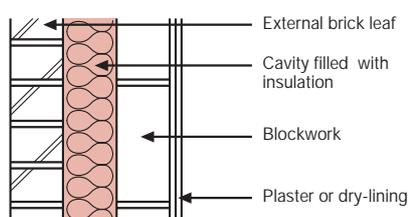


■ GPG 79 'Energy efficiency in new housing – a guide to achieving best practice'

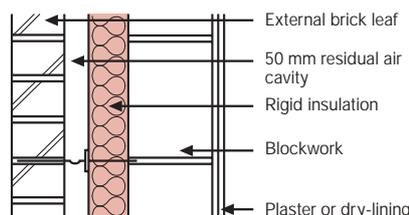
**New external walls**

Where a scheme includes new external walls, these should be constructed to energy efficient standards. The examples below all achieve U-values below 0.3 W/m<sup>2</sup>K.

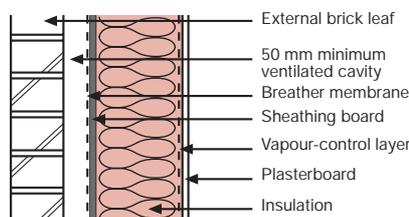
The thickness of insulation needed to achieve a particular U-value depends on the thermal properties of the structure and the insulation.

**FULL-FILL**

- Specify stop ends to all cavity trays.
- Specify weepholes over openings.

**PARTIAL-FILL**

- Specify a 50 mm minimum clear residual air cavity.
- Specify drips on wall tiles to be in the centre of the residual air cavity.
- Hold insulation boards against inner leaf with retaining clips; avoid gaps between the boards.

**TIMBER FRAME**

- Do not fill the ventilated cavity with insulation.
- Specify a vapour-control layer to be installed on the warm side of the insulation.
- Avoid services perforating the vapour-control layer or, if they do, fully seal all holes.
- Specify non-combustible insulation.
- Specify an insulation thickness no greater than actual timber dimensions to avoid compressing the insulation.

Construction to achieve U-value of 0.30 W/m<sup>2</sup>K

Block inner leaf	Lightweight
Block $\lambda$ value	0.16
Block thickness (mm)	100
$R_{req}$ of insulation	2.34
Insulation $\lambda$ value	Minimum thickness (mm)
0.035	82
0.040	94

Construction to achieve U-value of 0.30 W/m<sup>2</sup>K

Block inner leaf	Lightweight
Block $\lambda$ value	0.16
Block thickness (mm)	140
$R_{req}$ of insulation	1.93
Insulation $\lambda$ value	Minimum thickness (mm)
0.020	36
0.025	48
0.030	58
0.035	68
0.040	150

Construction to achieve U-value of 0.30 W/m<sup>2</sup>K

$R_{req}$ of insulation	3.50
Insulation $\lambda$ value	Minimum thickness (mm)
0.035-0.040	140 mm studs Frame cavity filled with insulation

**REQUIREMENTS FOR SCOTLAND**

The recommended U-value of 0.3 W/m<sup>2</sup>k is suitable for most situations but dwellings with inefficient heating systems, solid fuel or electric heating will require U-values of 0.27 W/m<sup>2</sup>k to be achieved. The local authority building control department should be consulted if there is any doubt.

## INSULATION STANDARDS



- GPG 296 'Refurbishment site guidance for solid-walled houses – roofs'

## PITCHED ROOFS

For all pitched roofs a U-value of 0.16 W/m<sup>2</sup>K or better should be specified. For sloping ceilings in attic rooms this may not always be practical, in which case a U-value of 0.2 W/m<sup>2</sup>K should be aimed for. For mineral wool quilt and blown cellulose fibre this equates to approximately 250 mm of insulation. For mineral wool quilt, insulation should be laid in two layers; one between the joists, and the second layer across the joists and butted-up to gable and separating walls.

Care is needed to ensure that the roof is adequately ventilated in order to disperse moisture and prevent condensation.

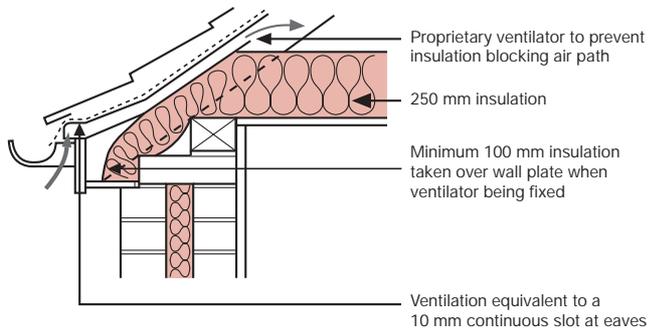
## SERVICES

- Seal any holes around services, especially those from kitchens, bathrooms and airing cupboards.
- Keep electrical cables above the insulation to avoid overheating.
- Avoid placing tanks and pipes in the roof if possible (low mains water pressure may not make this possible).
- Any pipes or tanks located in the roof space must be adequately insulated.

## General notes

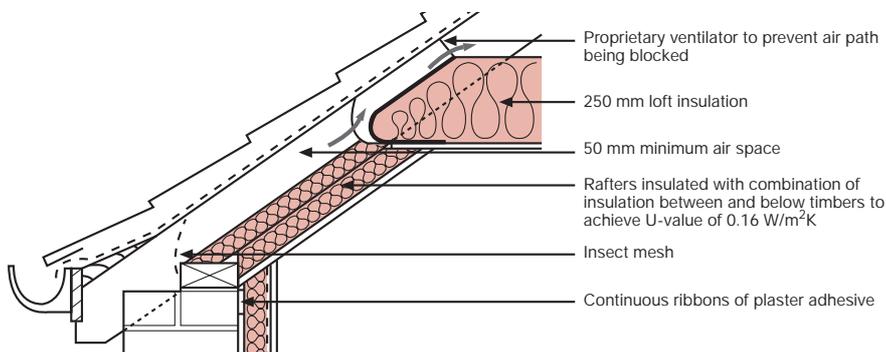
- Specify a 10 mm ventilation gap, for the length of the soffit, with a 3-4 mm mesh to prevent entry of insects.

## VENTILATED LOFT



- Complex or low pitched roofs may need extra ventilation.
- Include extra ventilation at the ridge of steeply pitched roofs.

## VENTILATED LOFT WITH SLOPING SOFFITS



## REQUIREMENTS FOR SCOTLAND

The recommended U-value of 0.2 W/m<sup>2</sup>k is suitable for most situations but dwellings with inefficient heating systems, solid fuel or electric heating will require U-values of 0.18 W/m<sup>2</sup>k to be achieved. The local authority building control department should be consulted if there is any doubt.

## INSULATION STANDARDS

- Use a proprietary cross-flow ventilator giving a minimum of 25 mm ventilation path or maintain a free air space of 50 mm minimum.
- Specify loft hatches with fixed insulation and draughtstripping.
- Avoid recessed light fittings in the ceiling below the roof space as they cannot be sealed.
- If necessary, specify battens to raise access walkways above the insulation. Walkways must be clearly identified.

### FLAT ROOFS

The preferred method of insulating a flat roof is to locate the insulation above the roof deck. The insulation can either be placed below the weatherproof membrane, in a warm deck (sandwich)

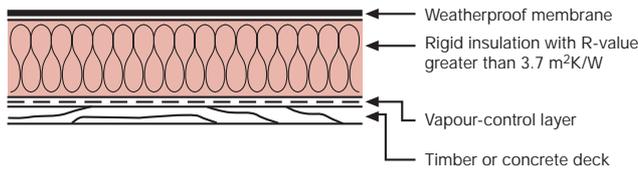
construction, or above the weatherproof membrane in an inverted warm deck construction. It is most economic to add insulation when work is to be carried out to replace the existing roof covering.

A U-value of 0.25 W/m<sup>2</sup>K should be specified to raise insulation values to best practice standards. However the design of the roof may limit the thickness of insulation that can be used. For the examples shown below a U-value of 0.25 W/m<sup>2</sup>K equates to R-values of 3.7 m<sup>2</sup>K/W (warm deck) and 4.4 m<sup>2</sup>K/W (inverted warm deck).

If conversion to a pitched roof is carried out these should be insulated to the same standard as conventional pitched roofs (value of 0.16 W/m<sup>2</sup>K).

### Insulation thickness required to achieve best practice

**WARM DECK**

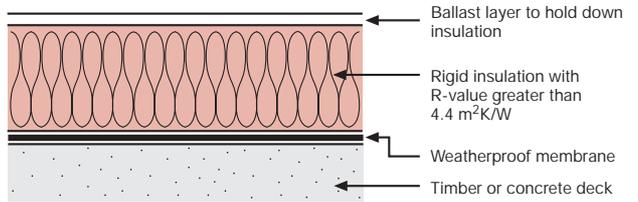


U-value: 0.25 W/m<sup>2</sup>K

- Insulation boards to be rigid.
- Insulation materials must be compatible with any bonding materials used for the weatherproof membrane.
- Voids in timber roof must not be ventilated to the outside.

Thickness of insulation required to achieve a U-value of 0.25 W/m <sup>2</sup> K	
Conductivity (λ)	Minimum thickness (mm)
0.020	74
0.025	93
0.030	111
0.035	130
0.040	148

**INVERTED WARM DECK**



U-value: 0.25 W/m<sup>2</sup>K

- The existing roof structure must be capable of supporting the extra weight, particularly of the ballast layer.

Thickness of insulation required to achieve a U-value of 0.25 W/m <sup>2</sup> K	
Conductivity (λ)	Minimum thickness (mm)
0.020	88
0.025	110
0.030	132
0.035	154
0.040	176

### REQUIREMENTS FOR SCOTLAND

The recommended U-value of 0.25 W/m<sup>2</sup>k is suitable for most situations but dwellings with inefficient heating systems, solid fuel or electric heating will require U-values of 0.22 W/m<sup>2</sup>k to be achieved. The local authority building control department should be consulted if there is any doubt.

## INSULATION STANDARDS

## WINDOWS

Where existing frames are replaced, windows with a whole window U-value of 2.0 W/m<sup>2</sup>K or better should be used to achieve best practice. As the specification of windows by U-value can be complicated it may be easier to specify windows by their frame and glazing combination rather than their thermal performance. There are many combinations of frame and glazing that will achieve the U-value of 2.0 W/m<sup>2</sup>K (see the table below for a selection).

Low-emissivity (low-e) coatings are of two principal types, known as 'hard' and 'soft'. The emissivity ( $\epsilon_n$ ) of low-e coatings varies between  $\epsilon_n = 0.15$  to 0.2 for hard coat and  $\epsilon_n = 0.05$  to 0.1 for soft coat. If the emissivity of the low-e coating is not known the higher number should be used in each case. If the type of coating is not known a hard coat should be assumed.

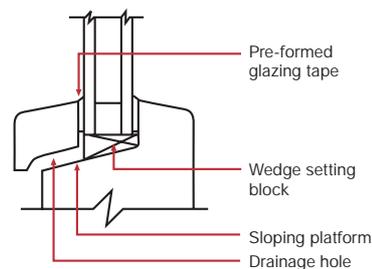
When available, manufacturers' certified U-values should be used in preference to the information given below. Where windows are being retained for architectural reasons, or because of their good state of repair, the thermal performance of single glazing can be improved by adding secondary glazing internally. In this case the outer frame should not be draughtstripped.

Although secondary glazing has a typical payback of over 20 years, it may be justified where there is a need for good sound insulation or for improved radiant comfort. An air gap of around 100 mm is recommended for optimum sound insulation.

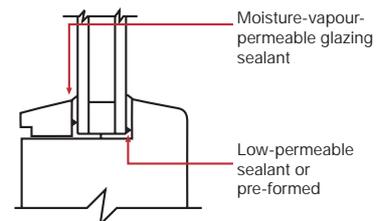
When selecting replacement windows:

- to achieve best practice specify a U-value of 2.0 W/m<sup>2</sup>K or better
- choose high-quality frames, designed for the chosen insulated glazing units
- specify glazing techniques that provide adequate drainage and ventilation – only use solid bedding in timber windows if factory glazed
- seal around window and door frames with compressible sealing strips or expanding foam, while not interfering with any drainage paths
- specify that units should be fitted to BS 6262 in accordance with the Glass and Glazing Federation manual ([www.ggf.org.uk](http://www.ggf.org.uk))
- specify dual-sealed glazing units that are Kitemarked to BS 5713:1979.

It should be noted that different types of low-e glass may have slightly different optical characteristics. Careful records may need to be kept to ensure that different types are not mixed within a dwelling.



**Drained and vented unit**



**Solid bedded unit**

Frame	Glazing	Coating	Gas fill	Gap	U-value
Timber/PVC-U	Double	Low-e, hard (0.15)	Air	16+	2.0
Timber/PVC-U	Double	Low-e, hard (0.15)	Argon	12	1.9
Timber/PVC-U	Double	Low-e, soft (0.1)	Air	16	1.9
Timber/PVC-U	Double	Low-e, soft (0.1)	Argon	12	1.9
Timber/PVC-U	Triple	None	Air	16+	2.0
Timber/PVC-U	Triple	Low-e, hard (0.15)	Air	12	1.7
Metal (4 mm break)	Triple	Low-e, hard (0.15)	Air	16+	2.0

**Combinations of frame and glazing to achieve a U-value of 2.0 W/m<sup>2</sup>K**

**REQUIREMENTS FOR SCOTLAND**

The recommended U-value of 2.0 is suitable for some situations but in other situations a U-value of 1.8 may be required. Specific guidance should be sought from building control at the local authority.

## INSULATION STANDARDS



- GPG 227 'Selecting energy efficient windows'
- GPG 295 'Refurbishment site guidance for solid-walled houses – windows and doors'

### EXTERNAL DOORS

Insulated doors that achieve a U-value of 1.0 W/m<sup>2</sup>K or better are readily available as replacements for solid timber doors (with a U-value of 3.0 W/m<sup>2</sup>K).

Glazing units within doors can be made to the same specification as for windows.

Insulated doors cost more than traditional timber entrance doors, but the cost difference can be small once decoration and fixing of ironmongery are taken into account, giving a payback period of around 10 years.

### PASSIVE SOLAR CONSIDERATIONS

There is limited scope in most refurbishment schemes to optimise passive solar gains.

The value of solar gains varies with:

- orientation
- obstructions of solar access from nearby buildings and trees
- the type of glazing
- window area facing toward the south.

Reducing the window area on north, east or west façades would reduce heating costs. However, where glazing is south-facing and solar access is not obstructed, it would be worth retaining large areas of glazing.



- GPG 294 'Refurbishment site guidance for solid-walled houses – ground floors'

### GROUND FLOORS

Heat loss through ground floors depends on the size and shape of the floor as well as the type of floor and conductivity of the ground below the

floor. Consequently, it may be easier to specify an R-value instead of a U-value. It is recommended that R-values of 2.5 m<sup>2</sup>K/W and 3.75 m<sup>2</sup>K/W should be stipulated for solid ground floors and timber suspended floors respectively.

These levels of insulation will generally result in U-values of approximately 0.2 W/m<sup>2</sup>K for mid-terrace properties and 0.25 W/m<sup>2</sup>K for end-of-terrace properties.

Some floor slabs extend beyond the external wall, eg into passages between buildings, and therefore form a thermal bridge. Even with wall insulation the floor slab may be sufficiently cold to produce condensation resulting in mould growth at the floor/wall boundary.

Because the damp-proof membrane may be fulfilling a number of functions, eg stopping the passage of ground water to the floor or stopping interstitial condensation, it may be placed in different positions. Common accepted practice is shown in this section.

With solid floors the replacement of screeds or ground floor slabs may present an opportunity to incorporate ground floor insulation.

With suspended timber ground floors, adding insulation is practical if ready access is available from below (eg a cellar) or if the floorboards are being removed and replaced. Mineral wool insulation should not be used in timber ground floors if above a cellar.

### General notes

- Lap the floor damp-proof membrane with the wall damp-proof course.
- Specify moisture-resistant flooring grade plywood or chipboard and allow for expansion at the floor edges.
- PVC cables must not come into contact with polystyrene insulation as this can degrade the integrity of the cable insulation. Use ducts or cover strips.

Conductivity (λ)	Solid concrete floors	Suspended timber floors
	Minimum thickness (mm) to meet R-value of 2.5 m <sup>2</sup> K/W	Minimum thickness (mm) to meet R-value of 3.75 m <sup>2</sup> K/W
0.020	50	75
0.030	75	115
0.040	100	150

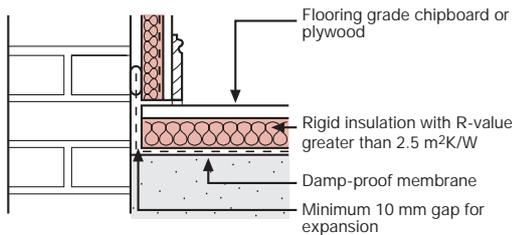
**Thickness of insulation required to achieve an R-value of 2.5 m<sup>2</sup>K/W and 3.75 m<sup>2</sup>K/W**

### REQUIREMENTS FOR SCOTLAND

The recommended ground floor U-value of 0.25 W/m<sup>2</sup>k is suitable for most situations but dwellings with inefficient heating systems, solid fuel or electric heating will require U-values of 0.22 W/m<sup>2</sup>k to be achieved. The local authority building control department should be consulted if there is any doubt.

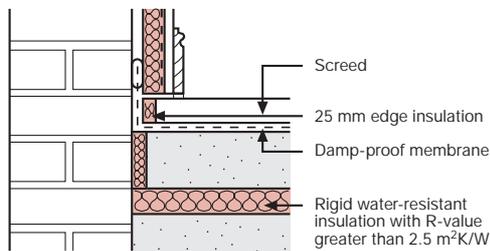
## INSULATION STANDARDS

## CONCRETE GROUND-BEARING SLAB WITH INSULATION ABOVE SLAB



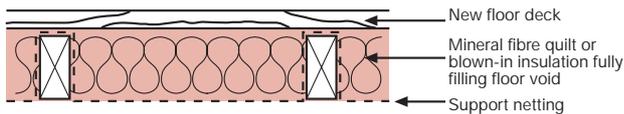
- The surface below the insulation should be both smooth and flat to a tolerance of 5 mm in 3 m (power-trowelled or levelled with screed).

## CONCRETE GROUND-BEARING SLAB WITH INSULATION BELOW SLAB



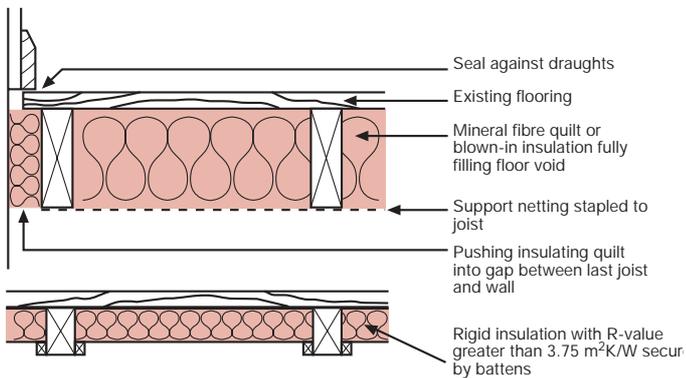
- This construction requires waterproof insulation with sufficient compressive strength.

## SUSPENDED TIMBER GROUND FLOORS, ACCESS FROM ABOVE



- Specify draughtstripping of floor at skirting.
- Do not specify a vapour-control layer, it can trap spilt water.
- Ensure the under-floor void is well ventilated.

## SUSPENDED TIMBER GROUND FLOORS, ACCESS FROM BELOW



- Floor may need a fire resistance of up to an hour if over the basement.
- Skirting draughtstripping of floor at skirting.
- Do not specify a vapour-control layer, it can trap spilt water.
- Ensure the under-floor void is well ventilated.

## INSULATION STANDARDS

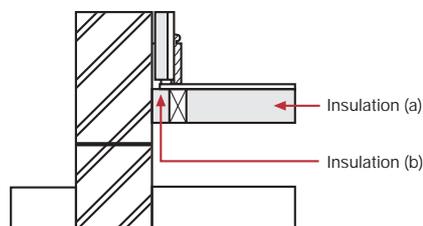
### THERMAL BRIDGING

Thermal bridging is common in older buildings and, even where there is a high standard of retrofitted insulation, cold spots can result on internal walls leading to discomfort and opportunities for condensation. The details below are examples of precautionary measures.

Particular care is needed where:

- internal insulation is being used
- a concrete frame, floor slabs or edge beams are exposed.

#### TIMBER GROUND FLOOR JUNCTION



Best practice

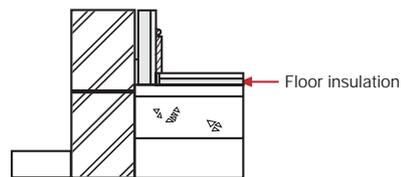
- Specify floor insulation as well as dry-lining to minimise thermal bridging (a).

AND

- Insulate between the last joist and the wall (b).

**Note:** Internal insulation should include vapour check on the warm side of the insulation.

#### CONCRETE GROUND FLOOR JUNCTION

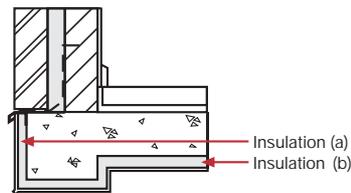


Best practice

- Butt the floor insulation up against the dry-lining to avoid thermal bridging.

**Note:** This detail may be impractical if height adjustments to doors and staircases cannot be made.

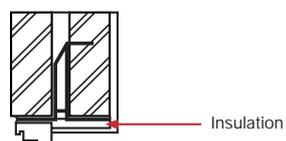
#### EXPOSED CONCRETE FLOOR



Minimum recommendations

- Insulate edge of ring beam (a).
- Insulate underside of exposed concrete (b).

#### STEEL LINTEL JUNCTION



Minimum recommendations

- Add insulation to soffit and reveals.

## 4 AIR INFILTRATION AND DRAUGHTSTRIPPING



■ GPG 224 'Improving airtightness in existing homes'

### AIR LEAKAGE

Air infiltrates into and out of dwellings via many routes. The rate of infiltration depends upon the airtightness of the dwelling and the driving forces of wind and temperature. Excessive infiltration wastes heat and causes draughts, which can be a major source of discomfort.

The ventilation required in a home is better provided by purpose-designed openings, over which occupants have some control, rather than by incidental leakage where there is no control. Full airtightening work should not be undertaken without providing controllable ventilation (see section 5).

Incidental leakage should be reduced as follows.

- Draughtstrip all windows and external doors with the exception of kitchens and bathrooms.
- Point joints between window and door frames and the surrounding wall with sealant.
- Draughtstrip the loft hatch.
- Provide a continuous perimeter seal adhesive behind new plasterboard dry-linings on external walls.
- Block up unused chimneys and provide an internal ventilator to the room, or alternatively vent to the outside.
- Seal around service pipes and cables where they enter the dwelling or pass through the ceiling into the loft space.

Don't block up air bricks and permanent ventilation that provide combustion air for heating appliances such as boilers, gas fires or solid-fuel fires, unless other provision is made for ventilation. Careful consideration should be given to the omission of draughtstripping in rooms with open-flued appliances. If there is any doubt draughtstripping should be omitted. It is not

considered acceptable to count trickle ventilators as permanent ventilation openings.

Where existing windows and doors are being retained, they should be draughtstripped. If trickle ventilators are not provided, at least 2 m of draughtstripping should be omitted per room. Draughtstrip should be omitted from kitchens and bathrooms to allow sufficient ventilation to remove moisture.

### ACHIEVING AIRTIGHTNESS

#### Timber ground floors

Suspended timber ground floors can be a serious cause of discomfort because of cold draughts that are drawn up from the ventilated space under the floor.

Where square-edged boards are being retained, lay hardboard or plywood over the whole floor. Hardboard must be room-conditioned before laying. If boarding is to be replaced, specify moisture-resistant chipboard with glued tongued and grooved joints.

If central heating is added for the first time, the wood will gradually dry out and shrink over the first one or two heating seasons. This will be particularly pronounced where new wood has been used – for skirtings and floorboards for example – creating new leakage paths to be sealed. Ensure that the space under the floor is well ventilated.

#### Windows and doors

Where existing windows and external doors are being retained, they should be draughtstripped. However, to ensure some ventilation in kitchens and bathrooms, windows in these rooms should not be draughtstripped unless extract ventilation is provided.

## AIR INFILTRATION AND DRAUGHTSTRIPPING

The most appropriate type of draught seal will depend on the type of window or door and the size and variability of the gaps, but should conform to BS 7386:1997. Many specialist insulation installers also supply and fix draught seals. It may be worth seeking their advice before specifying a particular type of seal. The diagrams below show examples of draughtstripping.

### Replacement windows and doors

Where new windows are specified they should:

- be factory-fitted with draught seals
- have trickle ventilation fitted (unless a mechanical ventilation system with heat recovery is used)
- have a bead of sealant applied at the frame/wall joint.

### Chimneys and fireplaces

To minimise air leakage disused fireplaces should be blocked up and provided with a small grille to ventilate the chimney. A ventilated weatherproof hood should be fitted on the chimney stack.

Suitable ventilation provision must be made for any new or retained fires.

### Other air-leakage paths

Further areas that need attention are as follows.

#### The loft access hatch

The loft hatch should be draughtstripped. Bolts or catches should be specified to ensure the seals are compressed.

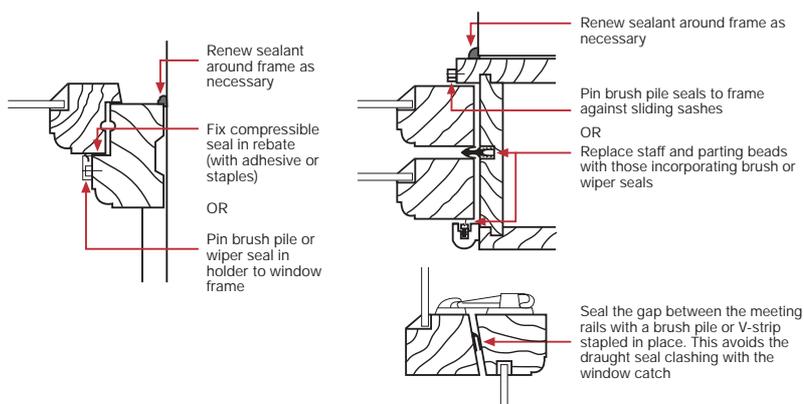
#### Gaps around pipes and cables

All gaps around pipes, cables and associated services should be sealed. This is especially important for gaps linking heated to unheated areas, eg from the airing cupboard to the loft. Sprayed expanded polyurethane foam is good for filling irregular holes. Sealant can be used for smaller gaps.

#### Letterboxes

Various types of draught excluders are available.

### EXAMPLES OF DRAUGHTSTRIPPING



**Timber or side-hung timber casement window**

**Timber sash window**

**Timber door**

**Timber door - extended and flush threshold**

- Both these methods are good at accommodating the seasonal movement of external timber frames

## AIR INFILTRATION AND DRAUGHTSTRIPPING

### Dry-lining junctions

Dry-lining can contribute to high levels of air infiltration and is especially difficult to seal, compared to a wet-plastered wall. Expanding polyurethane foam can be used around the perimeter of the walls and windows to seal the air space immediately behind the plasterboard. Where an insulated dry-lining is being used, use the detail shown (right). Otherwise, seal the gap between the skirting and the floor boards with sealant.

### Draught lobbies

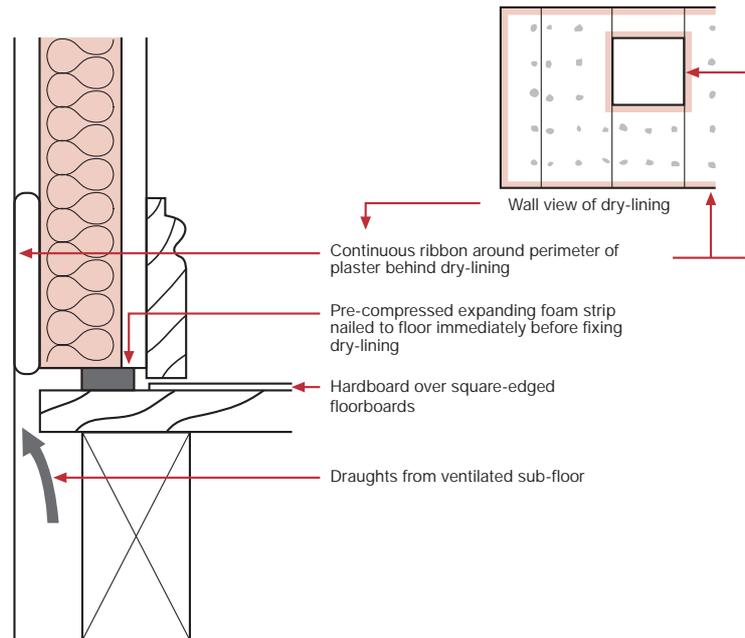
If feasible, the draught lobby should be added to external doors to act as a buffer space and reduce direct air leakage. Any existing porch or lobby should be retained.

External porches should not be heated. Avoid unheated lobbies within the heated envelope of a dwelling, unless the enclosing internal walls can be insulated.

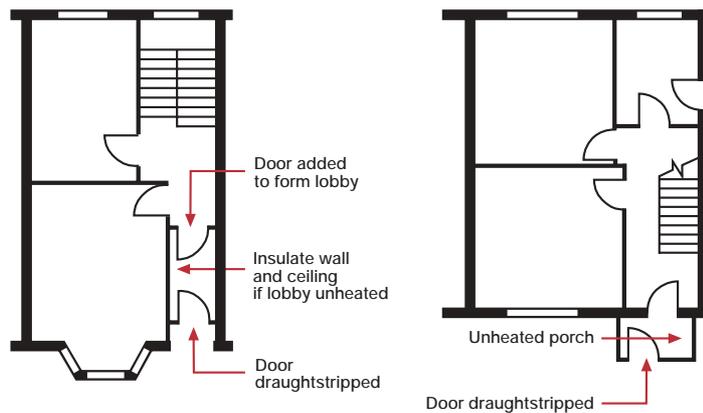
The outer door of a draught lobby should be draughtstripped.

External doors to common entrance areas serving flats should be draughtstripped and fitted with closers. These may be combined with door entry systems for security purposes.

The enclosure of open-access balconies can also act as a draught lobby and may be worth considering.



### Sealing at edge of dry-lining



### Alternative arrangements for draught lobbies

## 5 TYPES OF DRAUGHTSTRIP

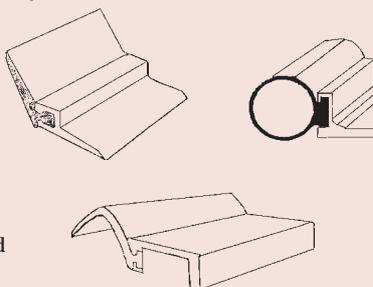
### DRAUGHTSTRIPS FOR DOORS

Note that these strips are intended to be typical of those currently available. Other types may be equally suitable and in all cases compliance with BS 7386 is strongly recommended.

#### Typical strips for external door sides and tops

Seals in good quality rubber (EPDM, silicone), sheathed foam or nylon brush, with rigid PVC-U or aluminium carriers nailed or screwed to frame of door.

Fitting with initial 3 mm compression allows for seasonal movement of door.



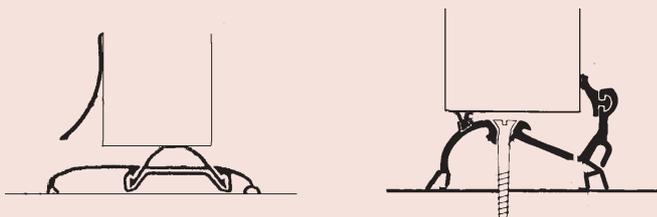
Care may be needed when painting to avoid damage to brush and some types of rubber.

#### Door bottom and threshold seals

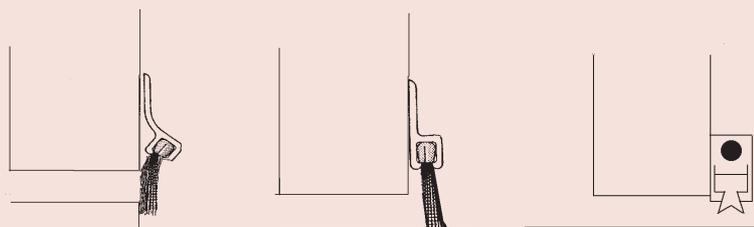
##### External doors

Threshold seals are normally made from aluminium and incorporate flexible draught and weather strips. Low profile sections are available for wheeled traffic and ease of access.

There are sections to cope with different exposures to driving rain.



##### Internal and external doors



Door bottom seals consist of a rigid carrier and flexible strips available in a variety of angles, sizes and finishes. Some types can be hidden in a groove cut into the bottom of the door. Seals which retract automatically when the door is opened are particularly useful where the floor is sloping. They can be fitted into a groove or fixed on the face of the door.

Letter box seals can be fitted to reduce draughts. Specialist products are available for fitting to keyholes.



The examples given on this page and page 23 show some of the types of draughtstripping available. New products are constantly emerging but try to ensure that they comply to BS 7386 1977.

### TYPES OF DRAUGHTSTRIP

Strips for sealing the gaps around windows and the sides and tops of doors can be divided into those fitted into the gap and those fitted outside the gap. Strips which are fitted into the gap between the frame and the opening part of the window or door are used on most new windows and doors. The design and fitting of a new window or door includes making allowance for the size of the strip, which is normally fixed into a groove in the rebate.

Fitting strips into the gaps in existing windows and doors is more of a problem because of the varying gap size around the perimeter of the frame. A careful choice of strip using the manufacturer's recommended gap size is essential as some strips are intended for use only on a limited gap range of 3-5 mm. Some low profile strips can compress to a lower gap size of 1-2 mm, making them suitable for the majority of windows.

Very small gaps over the length of a door or window can sometimes be tackled by creating a larger gap to take the strip or by using a strip fitted outside the gap (face fixed). A number of specialist companies deal with the windows in historic buildings by cutting grooves into the frame to take draughtstrips which are essentially the same as those used in new windows. Similarly, hidden brushes or seals which retract automatically when the door is opened can be fitted into the bottom sections of wooden doors.

Draughtstrips fitted outside the gap (face fixed seals) usually have two parts; a seal which moves against the door or window to close the gap, and a carrier (often made of rigid plastic or aluminium) which holds the seal firmly in place and is itself fitted to the frame. Carrier-based draughtstrips can easily cope with varying gaps around warped doors or small gaps, simply by adjusting the position of the carrier during the fitting. As the draughtstrip is exposed rather than hidden, a careful choice may need to be made to achieve an acceptable appearance.

## 6 DRAUGHTSTRIPS FOR WOOD AND INTERIOR DOORS

### DRAUGHTSTRIPS AND BS 7386

BS 7386: 1997 is a performance standard for draughtstrips which are to be fitted to existing doors and windows. Draughtstrips which comply with the standard are likely to operate successfully for many years and to recover their initial cost in fuel savings.

Durability in BS 7386 is assessed using a 20 000 cycle 'wear' test with a simulated door or window section. It is also essential that the draughtstrip recovers its shape after being compressed and that the elastic properties of the rubber or other draughtstrip material are maintained. This is tested by measuring the 'recovery' of the draughtstrip at low and high temperatures (to simulate ageing) as well as at room temperatures. There is also a 'peel' test for products which are glued into position, and a 'pullout' test for those which have a carrier.

### FITTING OF DRAUGHTSTRIPS

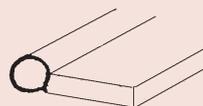
For exterior doors, draughtstrips with a range of 6 mm, with a compression allowance of 3 mm, are recommended. This will accommodate seasonal variation in gap size up to 3 mm. If the gap expands, the seal is maintained; if it shrinks, closing the door is not affected. For windows, both the seasonal movement and the opening length are likely to be less than for doors, and an initial compression of 3 mm is recommended.

General guidance on fitting draughtstrips and ventilation is covered in BS 7880 – 1997 and accompanies BS 7386. Guidance is currently available from manufacturers and the Draught Proofing Advisory Association.

### DRAUGHTSTRIPS FOR WOOD WINDOWS AND INTERIOR DOORS

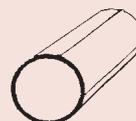
#### Typical strips fitted to the frames of wood windows and interior doors

Rubber tube fixed to carrier

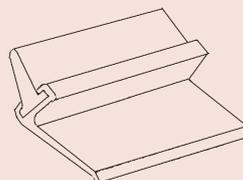


Good for interior doors and wood casement windows. Not suitable for sliding doors or windows.

Silicone 'O' tube (variety of sizes) glued with silicone adhesive. Several sizes available to cover gaps up to 10 mm

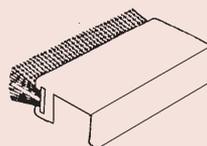


Angled blade seal



Good for wooden doors and casement windows. Some types suitable for sliding applications.

Brush pile (various heights) bonded to carrier

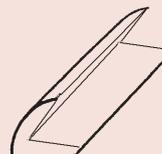


Suitable for most doors and window types. Especially good on sliding windows and doors but care needed when repainting to avoid damaging pile.

Brush pile, self-adhesive, available in several pile heights for different gaps

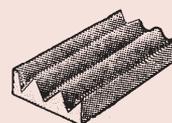


V-shaped seal in silicone, EPDM or sheathed foam. Glued (or stapled to wooden frames)



Covers gaps up to about 7 mm and some recent types down to less than 1.5 mm in one size. Can be used where other types are unsuitable.

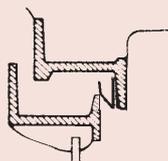
Expanded rubber, self-adhesive fixed



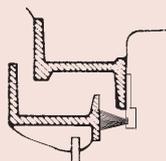
Only suitable for small range of gap sizes and not capable of being compressed down to fit small gaps; hence limited usefulness.

Steel windows often have very small gaps, especially on the hinge side, and specialist draughtstrips may be needed. These include:

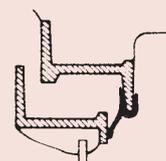
Tube and V-seals as used on wooden windows above



Face-fixed seals which are glued or screwed to the steel frame



'Clip on' seals where a carrier is simply fitted into position over the thin steel section of the frame.



Silicone or polyurethane mastic can be used as a gap filler. This does not allow for any seasonal movement, but may be the only solution if the gaps are very small.

## 7 VENTILATION AND THE AVOIDANCE OF CONDENSATION



- GPG 268 'Energy efficient ventilation in housing. A guide for specifiers on the requirements and options for ventilation'

Effective ventilation should be provided to maintain air quality and remove moist air without unnecessary loss of heat. High relative humidity levels can cause condensation and mould growth on cooler surfaces.

Average natural ventilation rates of between 0.5 and 1.0 air changes per hour are recommended for the whole dwelling. These air change rates can be achieved by:

- using trickle vents in all window frames with extract fans or passive ventilation systems in the kitchens and bathrooms
- whole-house mechanical ventilation systems with heat recovery.

Occupants should be made aware of the need for adequate ventilation. Information on condensation prevention should be included within an energy advice programme (see section 10). Likewise, for occupants to be comfortable with the use of new ventilation products such as trickle vents and extract fans, they should be consulted over refurbishment specifications.

### TRICKLE VENTS

All rooms should have sufficient background ventilation to meet the requirements of the building regulations. Building regulations vary between the nations. If in doubt consult the local building control at the local authority.

Trickle vents are unobtrusive openings in window frames that allow controllable background ventilation with little danger of draughts.

All types of new windows (including rooflights) can include trickle vents within or adjacent to the frame.

### EXTRACT FANS AND CONTROLS

Extract fans remove stale or polluted air from rooms while fresh air is drawn in from other rooms or from the outside via trickle ventilators and other openings.

Ideally all extract fans should have a humidistat controller to keep the humidity in the room to an acceptable level, normally below 70% relative humidity. However humidistats located close to cooking appliances may become coated in grease and fail to operate reliably. Fans in bathrooms without windows should operate automatically on the lightswitch and run for a preset period after the light is switched off, as well as operating on the humidistat controller to ensure that moisture levels are reduced sufficiently.

Occupants should be made aware of the importance and low running costs of extract fans, to prevent them being disabled.

For effective ventilation, extract fans should be located:

- as high as possible in the room
- close to the source of the pollution
- as far as possible from the source of fresh air
- in accordance with manufacturers' recommendations.

To ensure effective cross-room ventilation it is necessary to ensure that internal doors do not form an airtight barrier.

Extract fans can be fitted in external or internal walls or in a ceiling with a duct to outside the dwelling. In kitchens, a minimum extract ventilation fan rate of 60 litres per second is required, unless the extract grille is adjacent to (above in Scotland) a hob, when 30 litres per second is acceptable. In bathrooms, a minimum rate of 15 litres per second is required.

Ducting in unheated spaces such as lofts should be insulated to prevent condensation and moisture run-back.



### WARNING NOTE

It is vital to remember that rooms with open-flue appliances, such as gas fires, require a direct fresh air supply for the safe operation of the appliance. A separate provision for such a supply should be made, and a combustion product spillage test undertaken when airtightening work is being carried out.

## VENTILATION AND THE AVOIDANCE OF CONDENSATION

### PASSIVE STACK VENTILATION SYSTEMS

The layout of existing dwellings usually makes passive stack ventilation (PSV) difficult to accommodate. However, where the dwelling plan is suitable, adequate levels of ventilation can be achieved by this method.

PSV is a system of vertical or near-vertical ducts that run from the kitchen and bathroom to vents on the roof. The ducts extract moist air by the stack effect – the movement of air due to differences in temperature and therefore air density between the inside and outside of the dwelling – and by the effect of wind flows over the roof of the dwelling. Fresh air enters the dwelling via trickle ventilators and other openings.

Where PSV is provided, it is usually in place of extract fans. Humidity-controlled extract grilles, which vary the ventilation rate automatically, should be specified.

Further guidance can be found in BRE Information Paper IP13/94 (see 'Further reading' at the back of this document).

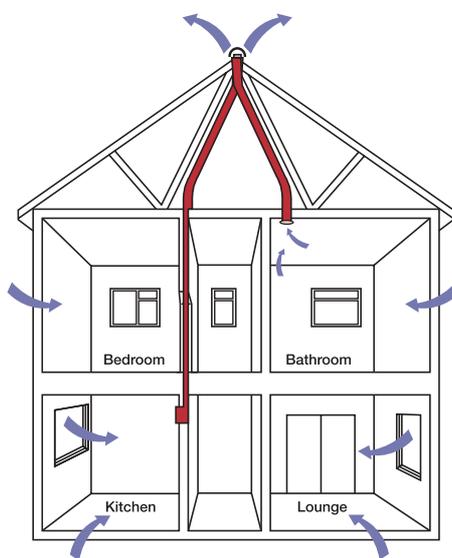
### WHOLE-HOUSE MECHANICAL VENTILATION SYSTEMS WITH HEAT RECOVERY

In whole-house mechanical ventilation systems with heat recovery (MVHR), fresh air is distributed via a duct system throughout the dwelling with air being extracted from kitchens, bathrooms and WCs. A heat exchanger warms the incoming air by recovering heat from the exhaust air. The success of the system relies on a well-sealed dwelling that should be tested for airtightness. Trickle vents are normally omitted. A sufficiently high degree of airtightness can be very difficult to achieve in existing homes. See section 4 for further information.

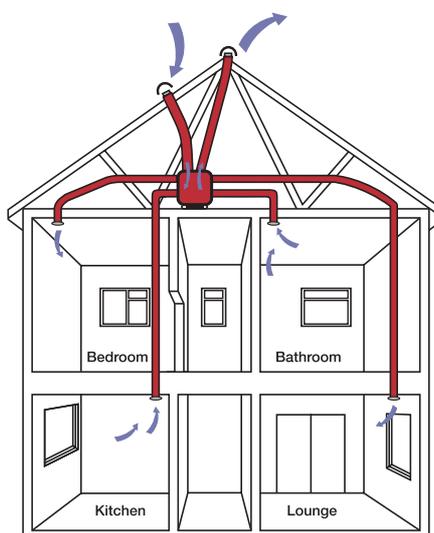
The running costs of MVHR systems can outweigh the energy savings and so they are not recommended as a standard energy efficiency feature. However, as part of an integrated energy efficient refurbishment such systems can significantly reduce the risk of condensation as well as providing health benefits for those suffering from asthma and particular allergies.

Other benefits can be improved home security, and reduced noise intrusion, where fanlight windows would otherwise be used for ventilation.

MVHR systems should be regularly cleaned and checked, and occupants should be aware of the need for alternative ventilation to remove moisture and maintain fresh air for human health should the system fail to operate.



*Passive stack ventilation*



*Mechanical ventilation with heat recovery*

## 8 SPACE HEATING AND HOT WATER



- GIL 59 'Central Heating System Specifications (CHeSS) – year 2002'
- GPG 284 'Domestic central heating and hot water: systems with gas and oil-fired boilers – guidance for installers and specifiers'
- GPG 301 'Domestic central heating and hot water – guidance for installers and specifiers'
- GPG 302 'Controls for domestic central heating and hot water'

### SYSTEM REQUIREMENTS

Space heating is needed to provide thermal comfort where and when required. Heat gains from the sun, occupants, the hot water system, cooking and electrical appliances supplement the main heating source.

The requirements of an energy efficient heating system are:

- to be correctly sized to warm up the dwelling from cold within a reasonable time (normally one hour)
- to use fuel as efficiently, and cheaply, as possible
- to be capable of control and thus provide heat only when and where needed
- to have controls that are easy to use and understand.

An efficient heating system will reduce running costs and can increase the value of a property.

Hot water can be heated as part of the space-heating system or by a separate source. If the hot water is stored, the cylinder must be well insulated.

A complete system replacement will provide most opportunity for improving energy efficiency. This will also allow a reassessment of fuel choice.

Partial upgrading of existing systems can also offer many of the same benefits, particularly when improving controls and insulation or replacing boilers.

### FUEL CHOICE

The choice of fuel depends on availability, running costs, capital costs and CO<sub>2</sub> emissions.

Due to the significantly lower carbon impact of gas, natural gas, where available, is preferred as the fuel for wet-heating systems.

Electric storage heating systems have typically the lowest capital cost but high running costs.

Liquefied petroleum gas (LPG) and oil can both be used where natural gas is unavailable. Oil will provide lower running costs than LPG. Both systems require storage tanks. Siting restrictions are more stringent for LPG, although the tank can be installed below ground. For oil, obligatory standards apply.

Coal-fired boilers with appropriate coal storage facilities can also be used where natural gas is unavailable. However they are less responsive and require regular maintenance (fuelling and de-ashing) by occupants.

The fuel prices and associated CO<sub>2</sub> emissions shown in the table below are averaged over the previous three years and across regions as used in the SAP 2001. Actual prices should be checked when selecting a fuel. Additional standing charges normally apply to fuels other than oil and solid fuel.

Fuel	Unit price* (p/kWh)	CO <sub>2</sub> emissions (kg/kWh)
Natural gas	1.3	0.19
Heating oil	1.6	0.27
Bulk LPG	3.0	0.25
Solid fuel (house coal)	1.7	0.29
Electricity (off-peak seven hour)	2.9	0.41
Electricity (on-peak seven hour)	7.1	0.41

### Comparison of fuels

\* Liable to fluctuation

## SPACE HEATING AND HOT WATER

### RECOMMENDED UPGRADE PACKAGE

The recommended heating upgrade packages are the 'best practice' standards HR4 and HC4, taken from CHeSS. More information on CHeSS and recommendations for other fuels is available in GIL 59 (2002).

### SYSTEM DESIGN

Heating systems must be large enough to meet reasonable maximum demand. However, oversizing will lead to inefficient operation as well as unnecessary capital cost. The following factors should be considered, particularly in the design of new systems for homes in which the fabric insulation has been upgraded.

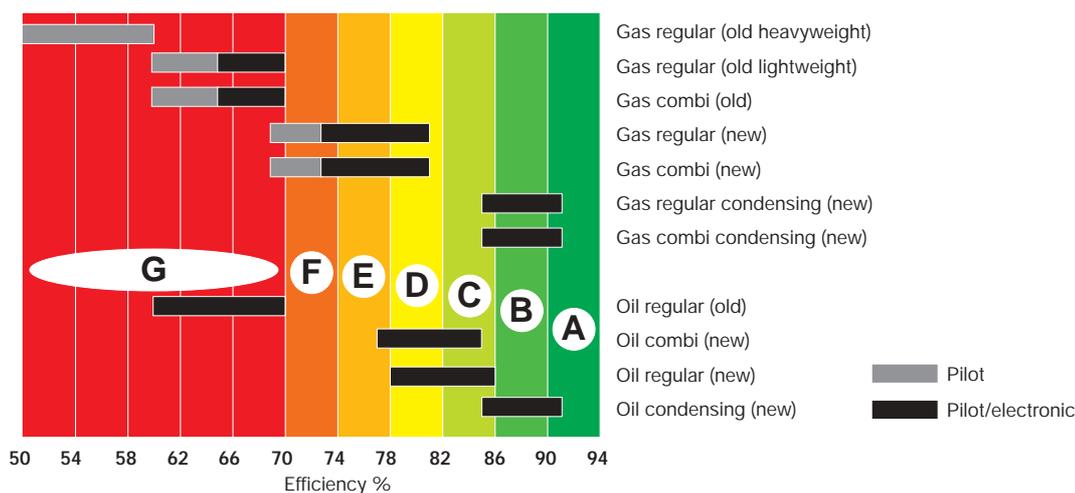
- Ventilation heat losses take up a greater percentage of the total heat loss and need to be well-controlled to maintain comfort conditions.
- The size of the boiler will be influenced by hot water requirements as well as space-heating demand.
- The required new boiler size should take into account any insulation improvements.
- The system should be designed accurately to the design temperatures in BS 5449.

Natural gas system	Regular system (CHeSS – HR4)	Combi system (CHeSS – HC4)
Description	Regular boiler and separate hot water store	Combination boiler or CPSU boiler
Boiler	SEDBUK efficiency of at least Bands A to C	
Hot water store	High-performance hot water cylinder	None – unless included within boiler
Controls	Programmable room thermostat with domestic hot water time control	Programmable thermostat
	Cylinder thermostat	N/A
	Boiler interlock	
	TRVs on all radiators except in rooms with room thermostat	
	Automatic bypass valve (where bypass circuit needed)	

### CHeSS HR4 and HC4 for gas systems

### SEASONAL BOILER EFFICIENCY

SEDBUK is a measure of the seasonal efficiency of a boiler installed in typical domestic conditions in the UK and is used in the Standard Assessment Procedure (SAP). The efficiency of most current and obsolete boilers can be found on the website [www.boilers.org.uk](http://www.boilers.org.uk).



Ranges of SEDBUK efficiencies

## SPACE HEATING AND HOT WATER

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### CONDENSING BOILERS

Condensing boilers are highly efficient boilers that use a larger heat exchanger area to extract more heat from the flue gases. They are always more efficient than non-condensing boilers even when they are not in 'condensing' mode. All gas condensing boilers are in the A to C bands.

### COMBINATION BOILERS

Combination ('combi') boilers provide space heating and 'instant' mains-pressure hot water, without a header tank or a hot water storage tank. Combis may be condensing or non-condensing and have typical seasonal efficiencies ranging from 78% to 90% (for condensing types). The power of combi boilers is usually governed by the hot water requirement, and often exceeds that needed for space heating. Consequently most combi boilers are designed with modulating burners which reduce the firing rate to match the output required for space heating. How to choose between a combi and an regular boiler with a separate hot water cylinder is discussed in detail in GPG 284.

### RADIATORS

Although the effectiveness of radiators located against uninsulated external walls can be improved by placing a reflectant-covered insulant on the walls behind them, improved wall insulation is a preferred option with greater benefit.

With improved fabric insulation or double-glazed windows, existing radiators might be oversized for the new duty. Improved controls will help to prevent overheating.

Temperature control of individual rooms can be accomplished by fitting thermostatic radiator valves (TRVs). When most or all radiators in any one zone have TRVs the system should also be fitted with an automatic bypass valve. This is necessary to ensure that a satisfactory minimum flow rate is maintained through the boiler. TRVs should not be used on radiators in the room where the room thermostat is sited.

### PIPEWORK

All pipework outside the heated envelope of the dwellings must be insulated (to save heat loss and avoid freezing), as well as the primary pipework. It is also recommended that heating pipework in all floor voids is insulated. Insulation of the hot water pipe from the source to the taps will help to ensure that hot water is more readily available, reducing excessive draw-off.

The boiler should preferably be positioned within the dwelling and the length of the primary pipework to the hot water cylinder minimised.

The hot water cylinder should be similarly positioned close to the kitchen and bathroom to minimise pipe runs.

### CONTROLS

The central heating boiler (and pump) should be wired to turn off automatically when there is no demand for space or water heating (with suitable pump over-run where required by some boilers). This is referred to as a 'boiler interlock'.

The heating in larger houses should be split into two or more zones, each with time and thermostatic controls. Generally these zones may be upstairs and downstairs but in a building with significant solar gain they may be north- and south-facing aspects.

Seven-day programmable thermostats are recommended for regular and combi systems, except where user needs dictate otherwise. These allow separate time and temperature settings for different heating times for each day of the week. Some programmable thermostats incorporate hot water control but a separate hot water programmer is also acceptable.

Time and temperature controls that are easy to understand and adjust by the user will be most effective.

## SPACE HEATING AND HOT WATER

### HIGH-RECOVERY HOT WATER CYLINDERS

Hot water cylinders fitted with rapid-recovery coils increase the rate of heat transfer from the boiler water to the domestic hot water. The principal advantages are:

- reduced heating times, reducing the operating times of the boiler
- lower average boiler return temperature, improving boiler efficiency
- a smaller hot water cylinder can be used, reducing standing losses
- additional insulation applied as standard, further reducing standing losses.

The installation is the same as for conventional cylinders.

### ELECTRIC STORAGE HEATING SYSTEMS

The CO<sub>2</sub> emissions from, and running costs of conventional electric heating systems will be higher than for gas systems.

#### Recommended electric heating package

- Fan-assisted off-peak storage heaters with top-up on-peak convectors in living rooms.
- Storage heaters in large bedrooms and large kitchens.
- On-peak fixed convector heaters with time switches and thermostats in small bedrooms.
- On-peak down-flow heaters in bathrooms and small kitchens.
- Automatic charge control and thermostatically controlled damper outlet on all storage heaters.
- Dual-immersion hot water cylinder with factory-applied insulation.
- Hot-water controller with one-hour on-peak boost facility.

Hot water cylinder capacities of between 110 litres (for small dwellings) and 245 litres (for large dwellings) are recommended.

### Storage heater controls

- Automatic storage heaters have a thermostat to govern heat output/storage during off-peak and on-peak times.
- A room temperature thermostat switches off the core extract fan when the room reaches the required temperature.
- The convector control is wired to the thermostat so that it will come on only when the stored heat has been largely used up.
- An external timer controls both the core extract fan and the convector.

Modern storage heaters with a fan are more responsive to control and take up less space than old, large-volume storage heaters.

### ALTERNATIVE HEATING SYSTEMS

#### Individual gas room heaters in conjunction with an instantaneous water heater

In dwellings that have been insulated to a good standard, two or three room heaters can often supply sufficient heat to the whole dwelling. Capital costs are low, but layout and design must ensure adequate heating throughout the dwelling.

#### Warm-air heating, stored hot water

For small well-insulated dwellings, warm-air heating (comprising heat generator, ducts, and fans) is a simple option. Careful design is needed for good heat distribution and a unit that supplies both space and water heating is required.

#### Alternative electric systems

On-peak electricity for space or water heating will always be costly, except where demand is extremely low and control is good. Consequently, it is not generally recommended. Central off-peak electric storage systems (water or brick) are costly to install and are unlikely to give low running costs. Electric heat pumps for space heating can provide low CO<sub>2</sub> emissions but running costs are likely to be higher than gas condensing boiler systems. Most domestic heat pump outputs are limited to approximately 5 kW. Additional output can be provided by electric heater elements, but these will increase running costs.



- GIR 72 'Heat pumps in the UK - a monitoring report'

## SPACE HEATING AND HOT WATER

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- GIR 88 'Solar hot water systems in new housing – a monitoring report'

### Communal systems

Group, district, community or combined heat and power (CHP) heating systems can be installed in suitable developments. However, consideration should be given to metering, maintenance and management arrangements.

A number of small-scale residential CHP schemes are already in operation in the UK. The environmental benefit of using small-scale CHP is that its high energy efficiency results in reduced CO<sub>2</sub> emissions. On smaller developments, consideration should be given to the location of CHP plant to avoid noise pollution for residents in its immediate vicinity.

### Solar systems

An active solar water system can supplement, but not replace, a conventional water-heating system. Payback periods are generally in excess of 20 years.

The development of photovoltaic cells has not yet reduced their cost to the level where they can be considered for producing electricity for heating purposes.

## 9 LOW-ENERGY LIGHTING AND APPLIANCES

Electricity consumption for lights and appliances (including cooking) in a dwelling can account for a significant proportion of total energy costs.

The landlord/developer can reduce this cost by:

- ensuring good daylighting to all areas (for example by window design)
- specifying energy efficient lamps where appropriate and switches at all room exits, (including two-way switching)
- encouraging cooking by gas, if gas is already available in the dwelling
- specifying or choosing low-energy appliances (where installed)
- providing information on the choice and use of lights and appliances.

### COMPACT FLUORESCENT LAMPS

Compact fluorescent lamps (CFLs) are available in a range of types and lighting outputs. They can provide the same levels of lighting as conventional tungsten filament bulbs but most are not suitable for use with conventional dimmer switches. CFLs are now available in a wide range of modern designs suitable for use as surface mounted and pendant fitting, standard, table and desk lamps.

A range of CFL designs is shown below.

Fittings designed specifically for CFLs should be specified where appropriate, thus ensuring that only CFLs are used as replacements and the life of the control gear is preserved. Replacement CFLs for this type of fitting are significantly cheaper than standard CFLs.

CFLs should be used in high-usage areas such as living rooms, study bedrooms, halls, landings and for communal and security lighting. They should not be used in conjunction with push-button delay switches or passive infrared (PIR) detectors.

Compact fluorescent lamps:

- can be fitted into existing bayonet fittings
- use as little as 20-25% of the energy of an equivalent tungsten incandescent lamp
- last five to eight times as long as a tungsten incandescent lamp; their longer life means that replacement labour costs in communal and landlord areas will be significantly lower.

### OTHER FLUORESCENT LAMPS

Fluorescent tube lighting is even more efficient than CFLs and can be successfully used in kitchens, communal corridors, workshops and garages. The modern 26 mm diameter (T8) high-efficiency tube gives energy savings of around 8-10% compared with the older 38 mm (T12) fluorescent tubes for the same colour rendering, and cost less to buy. High-frequency ballasts, although more expensive, avoid flicker and provide an additional energy saving of 5-10%. Dimmable high-frequency ballasts are also available. See the Energy Saving Trust (EST) website for details of products available (see back page for EST details).

CFLs for use with separate gear				CFLs with integral gear (plug-in lamps)			
Type 1 Two-finger tube 	Type 2 Four-finger tube 	Type 3 Triple loop/ triple two- finger tube 	Type 6 Enclosed with electromagnetic ballast 	Type 7 Enclosed with either electronic or electro- magnetic ballast 	Type 8 Four-finger tube with small electronic integrated ballast 		
Type 4 2D shape tube 	Type 5 Four-finger tube 	Type 9 Triple loop/triple two- finger with electronic integrated ballast 	Type 10 Four-finger tube with large electronic integrated ballast 	Type 11 Circular tube with integrated electronic ballast 			

## LOW-ENERGY LIGHTING AND APPLIANCES

### Notes

The EU energy labelling scheme is currently under review. Possible interim arrangements being considered are A+ and A++ ratings for products that exceed A rated performance. Similarly, technical criteria for EST's Energy Efficiency Recommended scheme is under continuous review.

Up to date information on labelling and products can be found at [www.mtprog.com](http://www.mtprog.com), [www.saveenergy.co.uk](http://www.saveenergy.co.uk), [www.ukepic.com](http://www.ukepic.com)

The energy labelling scheme will change by 2004. The current span of A – G scale will be applied to A – C and the lower grades will be eliminated.

A number of UK and EU searchable technical product information databases and buyers' guides are being developed for specifiers, including energy efficiency and wider environmental information. These will be accessible via [www.ukepic.com](http://www.ukepic.com)

### COMMUNAL LIGHTING

Estate and all communal lighting should be controlled by time switches, photoelectric units, push-button controls, or PIR detectors, as appropriate. Low-energy tubes or lamps should also be used (except where push-button time delay switches or PIR are to be used).

### EXTERNAL LIGHTING

Exterior lighting in estate and communal areas should be chosen for its duty and switching requirements.

In areas where lighting is required throughout the night but colour is not important, low-pressure sodium discharge lighting may be used. These offer the greatest efficiency (twice that of CFLs) and lowest maintenance costs (half that of CFLs), but their long start-up time makes them unsuitable for regular switching.

The use of high-pressure sodium discharge lamps will improve colour rendering but are not quite as efficient.

In communal areas where colour is important or where the lights can be switched, CFLs are used.

Tungsten lamps can be used where the use is very limited and where occupancy detection is used to switch single lamps.

External lighting control by time switch, and photoelectric (daylight) sensors is a minimum standard for permanent overnight illumination.

### HOUSEHOLD APPLIANCES

energy efficient domestic appliances use less electricity and are therefore less expensive to run and produce less atmospheric pollution. There is ample evidence that energy efficient appliances are often no more expensive to buy than equivalent appliances that are much less efficient. When buying an appliance, look for the energy label.

### Energy labelling

In 1995 the European Union introduced a compulsory energy labelling scheme for household appliances, covering refrigerators, freezers and fridge-freezers. This scheme has subsequently been extended to include washing machines, tumble dryers, washer-dryers, dishwashers and lamps. Energy labels are displayed on these products in shops and showrooms, in order to allow potential purchasers to compare their efficiencies.

The energy labels show estimated fuel consumption (based on standard test results) and an energy grading from A to G (where A is the most efficient). An A-rated appliance will use approximately half as much electricity as a G-rated appliance.

However, the actual amount of electricity used will depend upon how the appliance is used and where it is located. For example, a half-full fridge or freezer uses more energy than a full one; and a cold appliance which is placed next to a heater or oven will use more energy than one that is sited in a cooler place, so kitchen layout is an important consideration.

### Energy Efficiency Recommended



The Energy Saving Trust (EST) manages a labelling scheme for products of proven energy efficiency (eg most white goods, boilers, low-energy lamps, heating controls).

These products carry the Energy Efficiency Recommended label. Currently endorsed products can be found at [www.saveenergy.co.uk](http://www.saveenergy.co.uk)

### Ecolabels

There is also a voluntary Ecolabelling scheme that applies to washing machines and some other household goods. Products that display the Ecolabel have passed tests that check key environmental impacts, including energy efficiency.

Retailers should be able to provide details of the Energy Labelling and Ecolabelling rating schemes.

## 10 TENANT INVOLVEMENT

### OCCUPANT CONSULTATION

In addition to overall requirements on occupant participation, occupants staying in their homes following improvement work should be involved in the decisions that affect their homes. This is important to ensure occupants' confidence in using new heating and ventilation systems and can be done in a number of ways:

- meetings and discussions with groups of occupants
- surveys and questionnaires
- home visits
- general consultation policy (particularly where there are no allocated or existing occupants).

Where a scheme has a caretaker or estate management staff, they too should be involved in the decision-making process. Whatever form of consultation is used, it is important for the occupants to feel effectively involved. To help in this process, the housing association or private developer should:

- discuss proposals at an early stage and be open with occupants about the issues
- provide all available information to help occupants make an informed choice
- listen to occupants' views and act on them if possible
- allow enough time for the consultation period.

### HOW THE DESIGNER CAN HELP

Consideration should be given to heating system controls that are simple to understand and easy to adjust.

- Specify a heating time switch, which is easy to read and set, and has a default program (which fulfils normal heating requirements unless changed manually).
- Locate the time switch where it is easily visible and accessible.

- Specify room and cylinder thermostats with the 'usual' temperate range clearly marked.
- Provide heating controls, which can simply be set to low-limit protection should the occupant be away for more than a day.
- If an electric immersion heater is fitted to the hot water cylinder as a back-up, it must have an adjustable thermostatic control and a light outside the cupboard indicating when it is in use. (Poor control of immersion heaters can be very expensive.)
- Consideration should be given to simple, easy-to-understand controls, located in accessible areas, particularly for elderly or disabled occupants.

### ENERGY ADVICE

The following measures are helpful in establishing an energy advice programme, to enable occupants to make effective use of heating and ventilation systems.

- Following refurbishment, give occupants a purpose-designed leaflet on how to run their homes in an energy efficient way.
- Ensure face-to-face advice is given by a trained representative.
- Give special training to a resident who can act as a local energy advisor.
- Check the setting of all systems and give energy advice to occupants as part of the first year defects inspection.
- Monitor fuel bills (with resident agreement) and, if required, advise occupants on how they could reduce bills.
- Give advice on the benefits of energy efficient lighting (if installed) including the long-term value of investing in the more expensive CFLs.
- Specify or produce a durable information sheet, fixed in a convenient location where it will be read.

## 11 BENEFITS TO THE LANDLORD

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Providing warm, affordable homes is one of the primary aims for a landlord investing in upgrading the energy efficiency of its existing housing stock. The occupants benefit directly in reduced fuel bills and a warmer home. Less widely recognised are the benefits to the landlord.

### REPAIRS AND MAINTENANCE

It is more cost-effective to incorporate energy efficiency measures into planned improvement or repair work than to react with ad hoc measures

to combat individual problems. The insulation packages recommended in this Guide will reduce or eliminate the incidence of condensation and mould growth, often a significant source of both ad hoc repair work and overall maintenance costs.

### MANAGEMENT COSTS

energy efficient refurbishment has been demonstrated to reduce the management costs associated with complaints and repair work.

## 12 ENVIRONMENTAL CONSIDERATIONS

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There is growing global pressure to ensure that construction materials are sustainable. Whilst energy efficiency initiatives over the last 30 years have reduced the energy needed to heat a typical house considerably, initiatives to reduce the impact from construction materials have been comparatively slow.

The Green Guide to Housing Specification (Anderson and Howard, BRE, 2000) provides a useful reference for construction products, giving A,B,C environmental ratings for over 250 specifications. This definitive guide, developed over 20 years and supported in its current form by the National House-Building Council (NHBC), is predominantly based on life cycle assessment data from the DETR-supported BRE Environmental Profiles scheme. The Guide contains an extensive list of references to all of its sources of data.

The use of insulation in the building fabric will significantly reduce the operational environmental impact of the building over its lifetime. This benefit will outweigh the embodied environmental impact of the insulation materials. To minimise the embodied impact however, specifiers should avoid foam insulation materials that use blowing agents which cause ozone depletion or global warming, such as HCFCs or HFCs. Alternative blowing agents such as carbon dioxide or pentane are less environmentally damaging.

For best overall environmental performance, look to renewable or recycled materials such as cork, recycled cellulose, flax or sheep's wool, foams blown using pentane or CO<sub>2</sub> and low density mineral wool or glass wool, all of which have high ratings in the Green Guide to Housing Specification and have

similar insulation properties to mineral wool and expanded polystyrene. Lower density glass and mineral wools should be used in preference to denser ones where possible, as their environmental impact increases proportionally with their weight.

Despite their comparatively low mass, windows and doors typically contribute between 5 and 10% of the embodied environmental impact of a house. As rated by the Green Guide to Housing Specification, PVC-U has a poor environmental rating due to the high energy intensity of the materials' manufacture and the fact that they have no recycled input; however the industry is taking steps to encourage the recycling of PVC-U.

Primary aluminium manufacture is also very energy intensive though much less energy is needed to process recycled aluminium. But although aluminium extrusions contain around 30% recycled aluminium, and are also extensively recycled, the high impacts from primary and secondary aluminium manufacture still result in high overall environmental impact for aluminium windows.

Softwood timber windows, made from renewable material requiring low energy in manufacture, perform well. As with all timber products, specifiers should ensure that the timber is sustainably grown. This is particularly relevant for tropical hardwood windows, which also involve much longer transport distances. Locally grown hardwoods will have similar impacts to softwood. Information on sustainably sourced timber is available from the Forest Stewardship Council ([www.fsc-uk.demon.co.uk](http://www.fsc-uk.demon.co.uk) telephone 01686 413916).

## FURTHER INFORMATION

## HOUSING ENERGY EFFICIENCY BEST PRACTICE PROGRAMME DOCUMENTS

The following Housing Energy Efficiency Best Practice programme publications are available from the HEEBPP Helpline, telephone 01923 664258, or visit the website [www.housingenergy.org.uk](http://www.housingenergy.org.uk).

## Good Practice Guides (GPG)

- GPG 26: Cavity wall insulation in existing housing
- GPG 79: Energy efficiency in new housing – a guide to achieving best practice
- GPG 138: Internal wall insulation in existing housing – a guide for specifiers and contractors
- GPG 171: Energy efficiency primer
- GPG 183: Minimising thermal bridging when upgrading existing housing. A detailed guide for architects and building designers
- GPG 199: Energy efficient lighting – a guide for installers
- GPG 208: Providing energy advice to householders – a guide for local authorities and housing associations
- GPG 224: Improving airtightness in existing homes
- GPG 268: energy efficient ventilation in housing. A guide for specifiers on the requirements and options for ventilation
- GPG 284: Domestic central heating and hot water: systems with gas and oil-fired boilers – guidance for installers and specifiers
- GPG 293: External insulation systems for walls of dwellings
- GPG 294: Refurbishment site guidance for solid-walled houses – ground floors
- GPG 295: Refurbishment site guidance for solid-walled houses – windows and doors
- GPG 296: Refurbishment site guidance for solid-walled houses – roofs
- GPG 297: Refurbishment site guidance for solid-walled houses – walls
- GPG 301: Domestic heating and hot water – guidance for installers and specifiers (in preparation)
- GPG 302: Controls for domestic central heating and hot water

## General Information Leaflets (GIL)

- GIL 23: Cavity wall insulation: unlocking the potential in existing dwellings
- GIL 59: Central Heating System Specifications (CHeSS)
- GIL 70: The effect of Building Regulations (Part L1 2002) on existing dwellings
- GIL 72: Energy Efficiency Standards – for new and existing dwellings
- GIL 74: Domestic Condensing Boilers – the benefits and the myths

## General Information Reports (GIR)

- GIR 64: Post-construction testing – a professional's guide to testing housing for energy efficiency
- GIR 72: Heat pumps in the UK – a monitoring report
- GIR 88: Solar hot water systems in new housing – a monitoring report

## FURTHER INFORMATION

## BRE

Bucknalls Lane, Garston, Watford WD25 9XX  
 Tel: 01923 664000, web: [bre.co.uk](http://bre.co.uk)  
 The following are available from  
[www.bre.bookshop.com](http://www.bre.bookshop.com) Tel: 01923 664262.  
 Email: [brebookshop@emap.com](mailto:brebookshop@emap.com)

- BR 262: Thermal insulation: avoiding risks (2002 edition)
- BR 390: The Green Guide to Housing Specification
- BR 419: Defect Action Sheets: the complete set
- IP13/94: Passive stack ventilation systems: design and installation
- IP5/99: Humidistat controlled extract fans: performance in dwellings.

## BRITISH BOARD OF AGRÉMENT (BBA)

P0 Box 195, Bucknalls Lane, Garston, Watford WD25 9BA  
 Tel: 01923 665 300  
[www.bbacerts.co.uk](http://www.bbacerts.co.uk)

BBA publishes a monthly directory which includes a list of approved cavity insulation installers

## FURTHER INFORMATION

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### BRITISH STANDARDS INSTITUTION

389 Chiswick High Road, London W4 4AL.  
Tel: 020 8996 9000, web: [www.bsi.global.com](http://www.bsi.global.com)

#### British Standards (BSI)

To order BSI standards telephone 020 8996 9001.

- BS 8208: PE1:1988. Guide to assessment of suitability of external cavity walls for filling with thermal insulants. Existing traditional cavity construction.
- BS 7880: 1997. Code of practice for draught control of existing doors and windows in housing using draughtstrips.
- BS 7412: 2002. Plastic windows made from unplasticised polyvinyl chloride (PVC-u) extruded hollow profiles. Specification.
- BS 7386: 1997. Specification for draughtstrips for the draught control of existing doors and windows in housing (including test methods).
- BS 6262: 1982 Code of practice for glazing for buildings.
- BS 5713: 1979. Specification for hermetically sealed flat double glazing units.
- BS 5618: 1985. Code of practice for thermal insulation of cavity walls (with masonry or concrete liner and outer leaves) by filling with urea-formaldehyde (UF) foam systems.
- BS 5617: 1985. Specification for urea-formaldehyde (UF) foam systems suitable for insulation of cavity walls with masonry or concrete liner and outer leaves.
- BS 5449: 1990. Specification for forced circulation of hot water central heating systems for domestic premises.

### CAVITY INSULATION GUARANTEE AGENCY (CIGA)

3 Vimy Court, Vimy Road, Leighton Buzzard Bedfordshire LU7 1FG  
Tel: 01525 853 300, web: [www.ciga.co.uk](http://www.ciga.co.uk)  
CIGA runs the national 25 year guarantee scheme for cavity wall insulation.

### ENERGY SAVING TRUST (EST)

21 Dartmouth Street, London SW1H 9BP  
Tel: 0845 727 7200, web: [www.saveenergy.co.uk](http://www.saveenergy.co.uk)

### FOREST STEWARDSHIP COUNCIL (FSC)

Tel: 01686 413 916, web: [www.fsc-uk.demon.co.uk](http://www.fsc-uk.demon.co.uk)

### THE STATIONERY OFFICE

The Stationery Office, London  
Tel: 0870 600 5522, web: [www.tso.co.uk](http://www.tso.co.uk)

#### Regulations (National Details)

These documents can be obtained from The Stationery Office, London  
[www.tso.co.uk/bookshop](http://www.tso.co.uk/bookshop).

- The Building Regulations 2000 (England and Wales) Part L1 are set out in *The Building Regulations 2000, Approved Document L1 Conservation of Fuel and Power*
- The relevant Building Standards for Scotland are set out in *The Building Standards (Scotland) Regulations 1990, 6th amendment, Technical standards to Part J, Conservation of Fuel and Power*
- The relevant Building Standards for Northern Ireland are set out in *Building Regulations (Northern Ireland) Part F Conservation of Fuel and Power*

## The Government's Housing Energy Efficiency Best

**Practice programme** provides impartial, authoritative information on energy efficiency techniques and technologies in housing. This information is disseminated through publications, together with seminars, workshops and other events. Publications within the Best Practice programme are shown opposite.

Visit the website at [www.housingenergy.org.uk](http://www.housingenergy.org.uk)

Call the Housing Helpline on **01923 664258**

**Energy Consumption Guides:** compare energy use in specific building types.

**Good Practice:** promotes proven energy efficient techniques through Guides and Case Studies.

**New Practice:** monitors first commercial applications of new energy efficiency measures.

**Future Practice:** reports on joint R&D ventures into new energy efficiency measures.

**General Information:** describes concepts and approaches yet to be fully established as good practice.

The Housing Energy Efficiency Best Practice programme is managed by the Energy Saving Trust (EST).

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