GPG268

Energy efficient ventilation in dwellings – a guide for specifiers

energy saving trust™

Contents

This publication has been revised with the assistance of the technical committees of the Residential Ventilation Association and The Electrical Heating and Ventilation Association.

1 Introduction

All dwellings need a supply of fresh air, not just for the health and comfort of the occupants, but also to control condensation, remove pollutants, and to ensure the safe and efficient operation of some combustion appliances. The amount of fresh air should match the needs of the dwelling and the people living within it. To achieve an energy efficient standard of ventilation requires consideration of both the building fabric and the efficiency of the ventilation system. Whether designs for new or existing buildings are under consideration, ventilation should be thought of as part of an integrated design approach for achieving energy efficiency. Thermal insulation, heating systems and controls, and householder advice are some other important aspects to consider during the design process.

Home energy use is responsible for 27 per cent of UK carbon dioxide (CO_2) emissions. (CO_2 is one of the main gases that contribute to climate change.) By following the Energy Saving Trust's best practice standards, new build and refurbished housing will be more energy efficient – reducing these emissions, and saving energy and money, as well as safeguarding the environment.

Traditionally, many UK dwellings have relied on natural air infiltration to provide ventilation. This can result in excessive ventilation rates that increase energy consumption for space heating, and cause discomfort to occupants because of cold draughts.

Energy loss due to ventilation accounts for approximately a fifth of space-heating energy demand in an older poorly insulated dwelling. In a new energy efficient house the high insulation levels mean that the proportion of space-heating demand due to ventilation increases to around a third. Equally, natural air infiltration alone can result, at times, in too little ventilation. This leads to poor indoor air quality and other, more readily visible impacts such as condensation and mould on indoor surfaces. The objective of a good ventilation strategy is, therefore, to provide a balance between energy efficiency and indoor air quality.

About this guide

This guide has been prepared to help architects, surveyors and specifiers understand the issues associated with energy efficient ventilation and the types of systems that are available to provide satisfactory ventilation in dwellings.

The guide explains why ventilation is important, the impact that good ventilation has on achieving the efficient use of energy, and the importance of airtightness. It also describes the advantages and disadvantages of a range of ventilation systems. The guidance is presented in two parts:

- General issues and theory relating to ventilation.
- Ventilation options.

References to sources of more detailed information relating to specific design issues are also provided.

Building regulations and ventilation

There are specific requirements for the ventilation of dwellings laid down in building regulations. The relevant documents are:

England and Wales
Approved Document F: Means of ventilation.

Scotland
Section 3: Environment, of the Domestic Technical Handbook on possible ways of complying with the Building (Scotland) Regulations.

Northern Ireland
Technical Booklet K: Ventilation.

Approved Document F provides substantial information on many aspects of ventilation that is relevant across the UK. For this reason it has been referred to throughout this document.

2 Why ventilate?

Definition
Ventilation rate is the rate at which air within a building is replaced by fresh air. It may be expressed as:

- Number of times the volume of air within a space is changed in one hour (air changes per hour or ach).
- Rate of air change in volume and time, e.g. litres per second (l/s).

Ventilation is necessary to provide a healthy and comfortable internal environment for the building's occupants. The main task of ventilation is to remove polluted indoor air from a building and replace it with 'fresh' outside air.

Ventilation can also serve other roles – for instance, to provide an air supply to open-flued combustion appliances (see box, right) and to form part of an integrated strategy to provide thermal comfort and control summertime over-heating. These issues are not covered in this guide.

There are different types and sources of pollution within the home, for example:

- Moisture e.g. from washing, cooking.
- Carbon monoxide (CO) and oxides of nitrogen e.g. from combustion alliances, smoking.
- Volatile organic compounds (VOCs), e.g. from aerosols and formaldehyde found in some furniture.
- Allergens e.g. from house dust mites.
- CO_2 e.g. from humans and also combustion appliances.
- Environmental tobacco smoke (ETS).
- Odours e.g. from cooking, bodies and pets.

Moisture is probably the most significant of these because of the high rates generated by activities such as cooking and bathing, and because of the problems associated with condensation and mould growth.

Research has shown that if relative humidity levels exceed 70 per cent for prolonged periods, there is a high probability that the condensation occurring on cold surfaces will lead to mould growth[1]. A ventilation rate of between 0.5 and 1.5 air changes per hour (ach) for the whole dwelling will usually be sufficient to control condensation[2].

These levels of ventilation are generally sufficient to control many other indoor pollutants e.g. combustion products generated by gas cooking, VOCs from building and consumer products, body odours. Although research is still on-going on the most effective strategies to control house dust mites and allergen production, again the reduction of indoor humidity levels is a key factor.

Air supply to combustion appliances
Guidance is given in the following building regulations across the UK:

- **England and Wales:**
  Approved Document J: Combustion appliances and fuel storage systems.
- **Scotland**:
  Section 3: Environment, of the Domestic Technical Handbook on possible ways of complying with the Building (Scotland) Regulations.
- **Northern Ireland**:
  Technical Booklet L: Heat producing appliances and liquefied petroleum gas installations.

However, ventilation is not seen as an adequate means to protect the health of non-smokers in the vicinity of tobacco smoke, because environmental tobacco smoke is a carcinogen and there is no known safe level.

As an example, the typical requirements for fresh air for a four-person semi-detached dwelling are illustrated in Figure 1. Note that these values should not be simply summed because, as discussed above, the level of ventilation to control moisture will also help control the many other indoor pollutants.

In recent years, the airtightness of buildings has become an issue, as part of a drive to provide thermal comfort and reduced energy consumption (see section 3). However, as dwellings are made more airtight, internal pollutant sources can have a greater impact on indoor air quality and occupants may experience adverse health effects unless ventilation is effective. This emphasises the need for good ventilation design.

In addition, the emission of pollutants from increased activities (most notably from increases in traffic) in urban areas, have led to the outdoor air quality deteriorating. It is therefore important to minimise the levels of pollutants entering the building by effective design and operation. Furthermore, in noisy areas it may be appropriate to use either sound attenuating background ventilators or mechanical ventilation solutions.

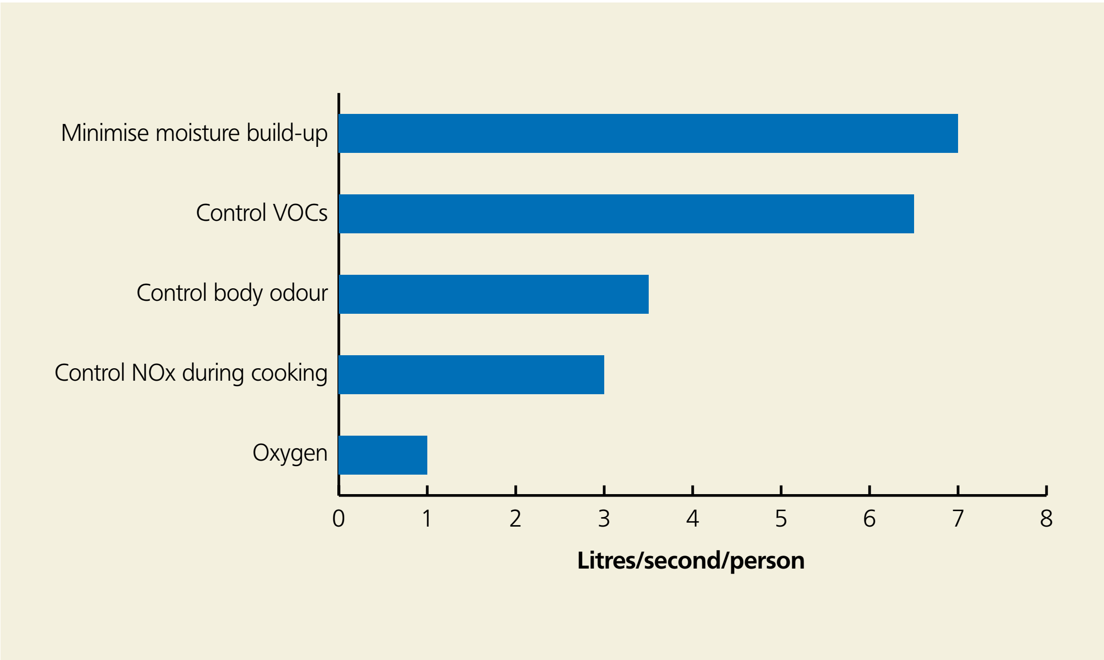


Figure 1 Ventilation rates to control pollutants (Source: derived from Approved Document F (2006))

3 The principles of ventilation

Ventilation can be defined as: 'The replacement of stale indoor air with 'fresh' outdoor air through purpose-provided openings, and through cracks and gaps in the building envelope'.

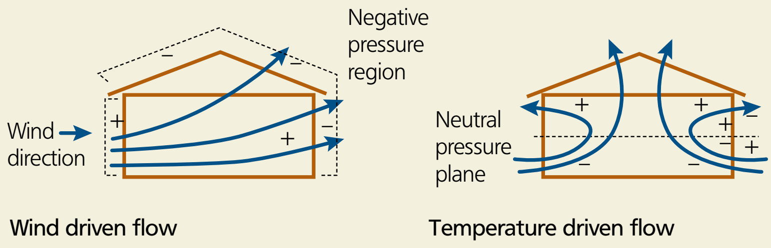


Figure 2 Schematic showing wind and temperature driven ventilation

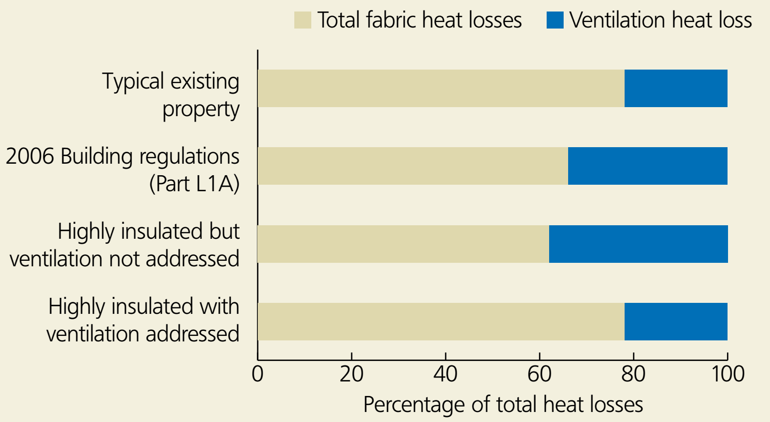


Figure 3 Comparison of ventilation and fabric heat losses for a semi-detached house.

The uncontrollable component of ventilation is referred to as 'air infiltration' or 'air leakage'.

There are two natural mechanisms that drive ventilation:

- The effect of wind pressure on the building causes air to enter on the windward façade and pass through the dwelling.
- The 'stack' effect, resulting from the temperature difference between the indoor and outdoor air, causes air to enter at the lower part of the dwelling and then rise up through the dwelling and exit towards the top of the dwelling. This effect increases with the height of the dwelling (i.e. greater number of storeys). The flow direction can reverse during warmer months, when the outside air temperature can be greater than that inside.

In addition, these natural mechanisms can be supplemented by the use of mechanical systems. Before the building regulations set a requirement for purpose-provided provisions for ventilation, UK dwellings mainly relied on these natural forces to provide ventilation via the numerous air leakage routes (cracks and gaps) in the building envelope.

This type of ventilation is uncontrolled and can result in significant energy wastage. Furthermore, it cannot ensure the higher ventilation rates necessary during times of greatest moisture production and is a key cause of high levels of condensation in dwellings.

Figure 3 shows that as insulation standards have improved, ventilation heat losses have increased as a percentage of total heat loss. In well-insulated dwellings, the ventilation losses can be responsible for around one third of the total heat loss.

The objective of a good ventilation strategy is, therefore, to provide a balance between energy efficiency and indoor air quality. This has led to the concept of 'build tight – ventilate right'. In other words – minimise the amount of uncontrolled air leakage through the building envelope, then install a controllable ventilation system to provide the necessary level of ventilation both where and when it is needed.

The following three-pronged strategy for ventilation is recommended.

- Extract ventilation in 'wet' rooms where most water vapour and/or pollutants are released e.g. kitchens, bathrooms, utility rooms and WCs. This is to remove these pollutants directly to outside and minimise their spread into the rest of the building.
- Whole building ventilation to provide a continuous supply of fresh air from outside, and to dilute and disperse water vapour and pollutants that are either not removed by extract ventilation or are generated in other rooms in the home.
- Purge ventilation throughout the building to aid removal of high concentrations of pollutants and water vapour released from occasional activities such as painting and decorating. Typically windows are opened, where necessary, to purge a room.

4 Energy efficiency savings

There are two main ways in which ventilation 'uses up' energy. The major one is the continual need to heat up the incoming air (during the heating season) and its subsequent loss as it leaves the building via the purpose-provided openings and air leakage. In addition, any form of mechanical ventilation requires electrical power to operate. This section of the guide is intended to highlight some of the ways these energy uses can be minimised through consideration of the dwelling fabric and good design of ventilation systems.

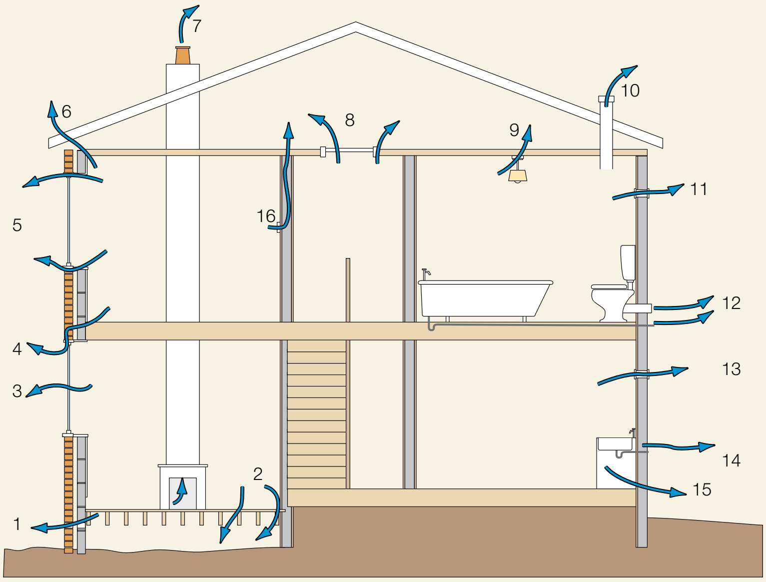
Improving airtightness

Air leakage is the uncontrolled movement of air, both into and out of the building, through the cracks and gaps in the building envelope. Figure 4 shows the most common air leakage paths.

Although air leakage can be a direct leak, for example around an opening casement in a window, most leakage follows a more complicated path through a series of routes, as illustrated in Figure 5. Consequently, air leakage paths can be difficult to trace and seal effectively once construction is completed. Improving airtightness in dwellings, GPG224 (see 'Further information') explains how a high level of airtightness can be achieved with careful design and construction.

The standard of airtightness achieved within a dwelling will have a significant impact on the ventilation rates achieved. In 2004, a study of 100 new dwellings of all types in England and Wales found that the air permeability values range from 4 to 17m^3/h/m^2. These values correspond to air infiltration rates of approximately 0.2 – 0.9ach under average weather conditions. More information on the results of this study can be found on the website: www.est.org.uk/partnership.

This means that the uncontrolled air leakage in many dwellings is already achieving an average ventilation rate within the target zone of between 0.5 and 1.5ach for the whole dwelling. (However, because it is uncontrolled, it is unlikely to provide sufficient air flow at the right time and in the right locations.) The uncontrolled nature of this infiltration means that in windy conditions the infiltration rate alone will exceed the target rate. Any further provisions, such as extract fans, will increase ventilation losses. To achieve the energy efficient ventilation rate of between 0.5 and 1.0ach suggested earlier (i.e. controllable ventilation to match demand), the rate of air leakage needs to be reduced significantly.



Most common air leakage paths

1 Underfloor ventilator grilles.

2 Gaps in and around suspended timber floors.

3 Leaky windows or doors.

4 Pathways through floor/ceiling voids into cavity walls and then to the outside.

5 Gaps around windows.

6 Gaps at the ceiling-to-wall joint at the eaves.

7 Open chimneys.

8 Gaps around loft hatches.

9 Service penetrations through ceilings.

10 Vents penetrating the ceiling/roof.

11 Bathroom wall vent or extract fan.

12 Gaps around bathroom waste pipes.

13 Kitchen wall vent or extractor fan.

14 Gaps around kitchen waste pipes.

15 Gaps around floor-to-wall joints (particularly with timber frame).

16 Gaps in and around electrical fittings in hollow walls.

Figure 4 Common air leakage paths

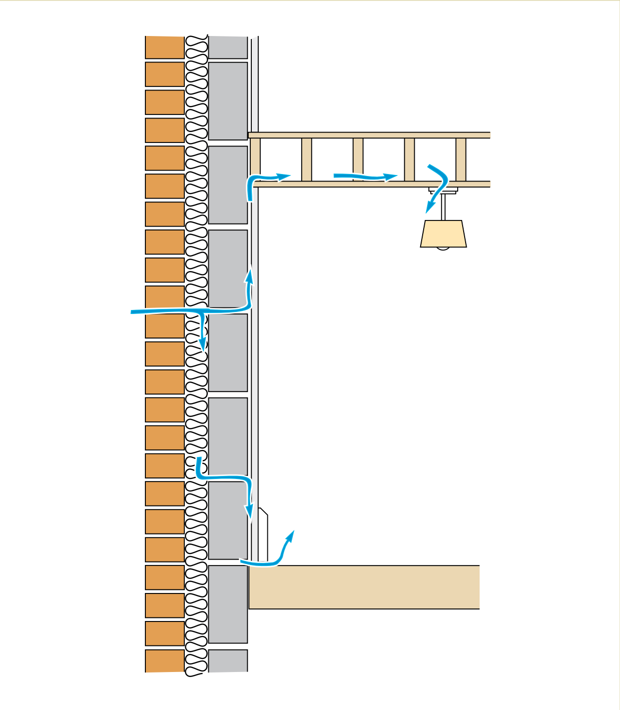


Figure 5 Indirect air leakage paths

In England and Wales, Approved Document L1A[3] specifies a maximum air permeability limit of 10m^3/h/m^2 (a third of the homes tested in the study above, failed to meet this target.) To check that an acceptable level of air leakage is achieved in practice, Approved Document L1A requires that a representative sample of new dwellings be tested after construction to demonstrate that this level has been achieved.

The Energy Saving Trust sets standards in excess of building regulations. The air permeability levels of the standards covered by this publication are given in Table 1. Further information on the standards is given in section 5.

Table 1 Good and best practice standard air permeability rates for dwellings

	Maximum air permeabilty, m^3/h/m^2
Good practice	5
Best practice	3

Measuring airtightness

Airtightness of the building envelope is measured using the fan-pressurisation test. The test uses a fan mounted into a temporary screen door to induce both positive and negative pressure differences across the building envelope while measuring the air flow through the fan.

The air leakage rate can then be calculated and quoted for a standard 50Pa pressure difference. The air leakage is quantified as 'air permeability'. This is the rate of leakage (m^3/h/m^2) in or out of the dwelling.

A recommended procedure for measuring the airtightness of dwellings is contained in CIBSE TM23[4] (to be replaced by ATTMA TS1 'Measuring Air Permeability of Building Envelopes'). This allows the results to be used for:

- Comparing the airtightness of the dwelling with recognised standards.
- Identifying air leakage paths and the rate of air leakage.
- Assessing the potential for reducing air leakage within a dwelling.
- Measuring the improvement following airtightness work.

The measurement usually does not include the effects of chimneys and flues because they are normally sealed during the pressurisation test.

When installing new windows, the airtightness of the existing dwelling is likely to improve. Unless the room is ventilated adequately by other installed ventilation methods, it is recommended that all replacement windows include trickle ventilators. These allow a controlled amount of ventilation to take place.

Ventilation system design

The energy efficiency of the ventilation system can be improved, where applicable, by employing heat recovery devices, efficient types of fan motor and/or energy saving control devices in the ventilation system.

Specific fan power

Mechanical systems require electrical power to operate, including power to the fans, any compressor(s) and transformer(s) and control and safety devices. The term 'specific fan power' is used to compare the electrical energy use for different ventilation systems as installed (i.e. allowing for system resistance).

Specific fan power is defined as:
The power consumption, in Watts, of the fan (plus any other electrical system components) divided by the air flow through the system, in Watts per litre per second (W/l/s).

A well-designed ventilation system should minimise this energy usage, and the later sections of this guide include criteria for mechanical systems. In addition, during installation it is important to minimise unwanted pressure losses in the ventilation system. Flexible ducting increases flow resistance, so minimising the length used, pulling it fairly taut and keeping duct runs straight, with as few bends and kinks as possible, are all important.

Heat recovery units

Most heat recovery units for dwellings are 'air-to-air' types. These recover heat from the exhaust air stream and use it to pre-condition the incoming air from outside. The effectiveness of these units is given by its 'heat exchange efficiency' i.e. the proportion of waste heat that is usefully recovered by the process (typically expressed as a percentage).

A heat recovery unit will reduce the amount of energy needed to heat up the incoming air to room temperature. This benefit must always be balanced against the electrical power requirements needed to drive the process. Such systems work best in more airtight homes, where almost all ventilation takes place via the heat exchanger.

Sections 8 and 10 discuss single room and whole house heat recovery systems respectively. Heat exchange efficiency criteria are provided for each system type.

Energy saving control devices

The amount of ventilation needed in a room depends on the pollution level in that room (and, in some cases, whether anyone is present). Automatic controls can be included with all types of ventilation system (e.g. humidity sensor, occupancy/usage sensor, detection of moisture/pollutant release). These reduce the level of ventilation if the source of pollution and/or the pollution level is low, and thus save energy.

However, the supplier of the system needs to take care when designing the system to ensure that reducing the ventilation rate in response to a low level of one pollutant does not result in a high level of another pollutant.

Installation issues

Poor workmanship and a lack of understanding by installers can substantially affect the correct operation of ventilation systems. Many manufacturers operate registered installers' schemes to help train and monitor contractors in the correct installation of their systems and this should reduce any problems.

The installation issues vary with each system type and some key issues are highlighted in the sections that describe the individual system types. In addition, it is important to size the system correctly to ensure the correct airflow is provided when installed (i.e. allowing for all resistance in the system). Manufacturers' installation and commissioning instructions should be followed carefully.

5 Ventilation systems in dwellings

The following sections of the guide describe various systems that are typically used for providing ventilation to dwellings. A short summary of each system is given, along with a number of advantages and disadvantages, and typical applications. Energy penalties as a result of the use of ventilation need to be factored into the design. The systems considered are:

- Passive stack ventilation (PSV).
- Intermittent extract fans and background ventilators.
- Single room heat recovery ventilation (SRHRV).
- Mechanical extract ventilation (MEV).
- Whole house mechanical ventilation with heat recovery (MVHR).

Other systems could be used as long as they provide equivalent performance and meet the relevant building regulations, for example:

- Positive input ventilation (PIV).

For all systems, manufacturers' instructions should be following during installation.

Energy Saving Trust standards for new housing

There are three Energy Saving Trust performance standards for new housing:

Good practice

Represents an improvement on building regulations in specific energy efficiency areas – principally insulation, heating and airtightness. Any ventilation system can be used so long as compliance with building regulations can be demonstrated.

Best practice

Represents a readily achievable higher standard and is suitable for all general housing. High standards of airtightness limit the ventilation options; specific performance criteria are set.

Advanced

Suitable for extremely energy efficient exemplar housing requiring specialist design and construction input. It is based on the European PassivHaus standard (www.passivhaus.de).

In this guide, we focus on whether systems are suitable to meet good and best practice standards in new housing and their necessary performance.

The good and best practice standards use a 'whole house' Dwelling Emissions Rate (DER) approach to consider the overall carbon dioxide emissions in a very similar way to the 2006 building regulations in England and Wales (Part L1A) and Northern Ireland (Technical Booklet F). This allows specifiers to 'trade off' the performance of one construction element against others. Limits, or 'lowest acceptable standards' are set for the performance of both the building fabric and services, and in many cases better performance will be required to meet the whole house requirements.

Full details of these standards can be found on the Energy Saving Trust website at: www.est.org.uk/housingbuildings/standards

Application for refurbishment

In this guide, we also discuss whether the systems are appropriate for minor and major refurbishment projects. An energy efficient system should meet any requirements for the good practice standard for new housing.

6 Passive stack ventilation (PSV)

Applications	Advantages	Disadvantages
• New build: good practice ✓ • New build: best practice ✗ (unless 'assisted') • Major refurbishment ✓ • Minor refurbishment ✗	• No direct running costs associated with the system. • No electrical connection required. • Silent in operation. • Provides continuous extract ventilation.	• Existing house layouts can make it difficult to accommodate vertical ducting from ground floors. • As low pressure differences are involved, systems are more sensitive to proper installation and must be installed correctly to ensure that design performance is achieved. • The air flow through a passive stack is weather dependant. In particular, additional ventilation may be required (e.g. opening of windows) during warmer weather.

Description
A PSV system comprises vents located in 'wet' rooms, connected via near-vertical ducts to ridge or other roof terminals. Warm, moist air is drawn up the ducts by a combination of the stack effect and wind effect. Replacement dry air is drawn into the property via background ventilators (e.g. trickle ventilators) located in the habitable rooms, and by air leakage. Providing a gap at the bottom of the internal doors will allow the free passage of air through the property.

Guidance on design and site installation is given in Appendix D of Approved Document F (2006). Ducting is available in circular and rectangular sections for flexibility of layout.

Control
Standard PSV systems have a simple inlet grille to the duct, usually fitted into the ceiling. In addition, humidity-sensitive inlets are available that provide increased flows when humidity is high (e.g. during periods of moisture production). These give enhanced energy performance because air extraction is minimised when moisture production is low, and are necessary if the good practice standard is to be achieved.

Acoustic treatment of the systems to reduce external noise ingress is possible where external noise levels are likely to be a problem.

Fire dampers are available for ducts that pass through a fire separating floor.

Installation
This system's performance is highly dependant on good installation because it is reliant on lower pressure natural driving forces:

- Care should be taken to ensure that ducts are installed as near vertically as possible.
- Ducting should be cut to length and there should be no more than two bends which should be of the 'swept' type to minimise flow resistance.
- Offsets at an angle of no more than 45° to the vertical are preferred.
- Ducting should be properly supported along its length to ensure that the duct can run straight and that there are no kinks at any bends or the connections to ceiling grilles and outlet terminals.
- Ducting should be fixed securely to the inlet and outlet terminals to avoid them becoming disconnected.
- A single duct should run to each terminal.
- Ducts should be insulated where they pass through unheated spaces to prevent the formation of condensation.

Placing the outlet terminal at the ridge of the roof is the preferred option for reducing the adverse effects of wind gusts and certain wind directions. A tile ventilator may be used close to the roof ridge, otherwise the duct must extend above the roof slope to at least ridge height. Further guidance is given in Appendix D of Approved Document F.

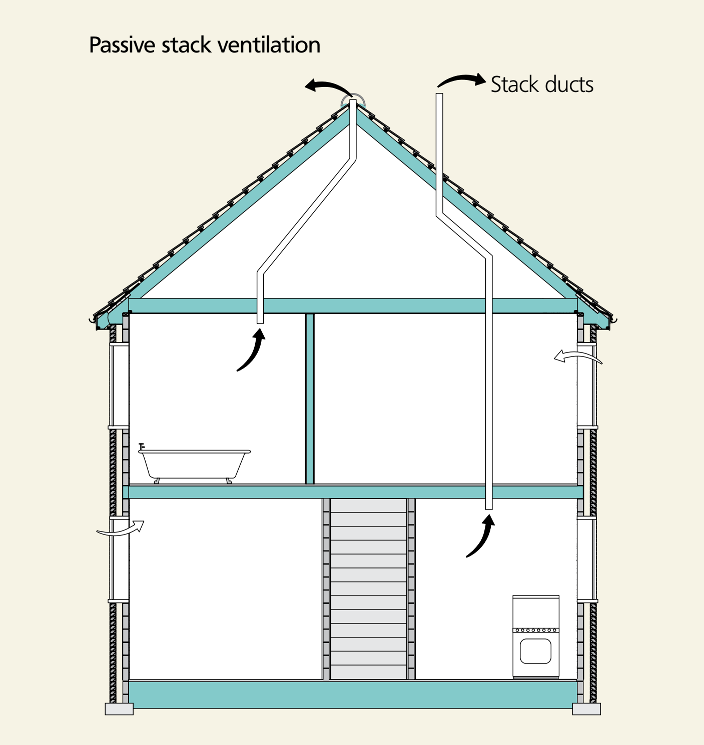


Figure 6 Passive stack ventilation

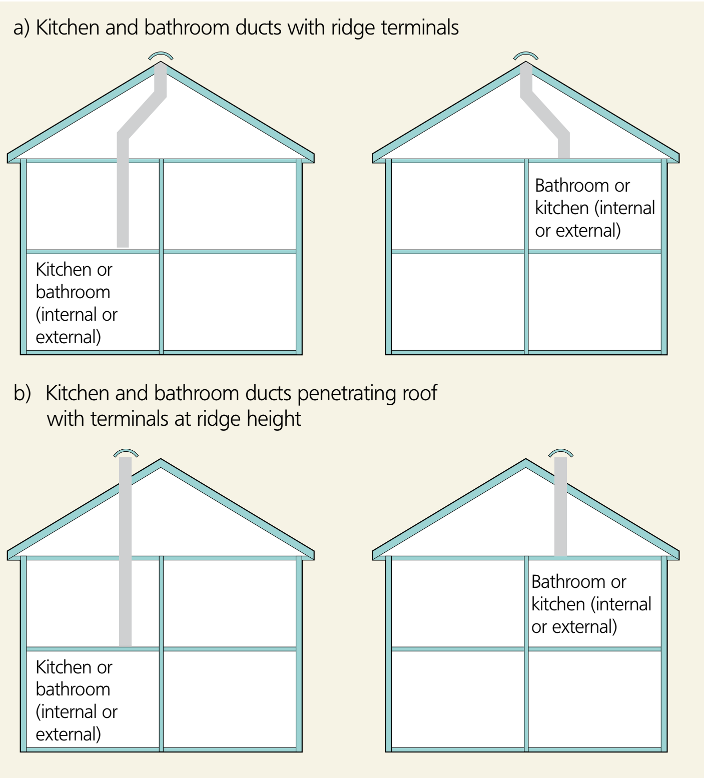


Figure 7 Suitable layouts for passive stack systems

Maintenance and cleaning

Under normal circumstances, a PSV system requires very little maintenance. A periodic check of the roof terminal and of any ducting that is accessible should be enough to maintain the structure of the system.

Cleaning the grilles – especially the one in the kitchen – is essential to ensure that there are no restrictions to air flow up each stack. The primary causes of blockage are built-up dust and grease in the tines of the grille.

Criteria for establishing energy efficiency of passive stack ventilation

PSV systems are intrinsically energy saving, in that they simply work on the wind and stack effects and consume no electricity. However, none of the heat loss through ventilation is recovered.

The good practice standard is met by following the relevant national standards and regulations. In addition, to minimise heat loss, a good practice standard PSV system should have humidity-sensitive duct inlet grilles.

To ensure a good balance between indoor air quality and energy use, the controls should be set such that they always meet the minimum air flow requirements under building regulations and guidance (e.g. Approved Document F in England and Wales) and are fully open when the humidity in the room is greater than 65 per cent.

A simple PSV system is not recommended for best practice standard. This is because the system is reliant on weather conditions (e.g. can under-ventilate in warmer weather), and the high level of airtightness required to achieve this standard (as given in Table 1).

The term 'assisted passive stack' can be applied to two types of system, both of which are acceptable for best practice standard. These are:

- The system is set up such that flow in the duct is automatically augmented by an extract fan only when required.
- The system is set up such that an extract fan is constantly running in the duct. (Note that this system is similar to mechanical extract ventilation and should comply with the requirements – see section 9)

7 Intermittent extract fans and background ventilators

Applications	Advantages	Disadvantages
• New build: good practice ✓ • New build: best practice ✗ • Major refurbishment ✓ • Minor refurbishment ✓	• Easy to install. • Provide rapid extraction of pollutants. • Operation is easy to understand.	• Noise. • If occupant controlled, may not be used. • Prone to occupant tampering.

Description

Local extract fans are installed in 'wet' rooms and provide rapid extraction of moisture and other pollutants. They operate intermittently under either occupant or automatic control. The fans can be either mounted in a window, ceiling or external wall. When ceiling-mounted, the extract should be ducted to outside. Replacement dry air is provided via background ventilators (e.g. trickle ventilators) and air leakage. In addition, as these fans do not run continuously, the background ventilators should be sized to provide adequate continuous whole house ventilation. Providing a gap at the bottom of the internal doors will allow the free passage of air through the property.

Care should be exercised when choosing a location for extract fans to ensure that draughts are not produced, and that combustion gases are not drawn into a room from open-flue appliances (see section 2 for sources of further guidance on this).

Control

The simplest fans are manually controlled via a switch, or wired into the light switch. Fans can be used with a humidistat sensor and a manual override facility. However, depending on the type, some sensors may operate the fan when not required, for example in warm, humid summertime conditions, or at night time when temperatures drop sharply[5]. The humidity sensors should be sited with consideration to where the main source of moisture generation is within the room. Other automatic controls include passive infra red detectors and usage sensors (which turn on extract systems when a specific appliance is used, for example a shower).

Installation

For fans discharging via ducting, the ducting should be installed to minimise flow resistance (e.g. cutting the duct to length and minimising kinks etc). Ducting should be adequately clamped to the inlet and outlet terminals to avoid detachment resulting in warm, moist air being discharged into the surrounding space. Further guidance on these issues is provided in Appendix E of Approved Document F.

Any automatic sensor should be correctly located, wired and commissioned on site. Experience has shown that when isolating switches had been installed close to fans, occupants may turn them off. This problem may be reduced by not locating isolating switches in the same room as the fan, although they should be readily accessible for isolating purposes.

Maintenance and cleaning

Occasional cleaning is required to remove deposits of grease and dust is required to maintain fan performance.

Criteria for establishing energy efficiency of intermittent extract fans

The good practice standard is met by following the relevant national standards and regulations.

This system is not recommended for the best practice standard. At the high level of airtightness (Table 1), it will be difficult to achieve sufficient ventilation because, with the fans switched off, the system is reliant on natural ventilation through background ventilators only.

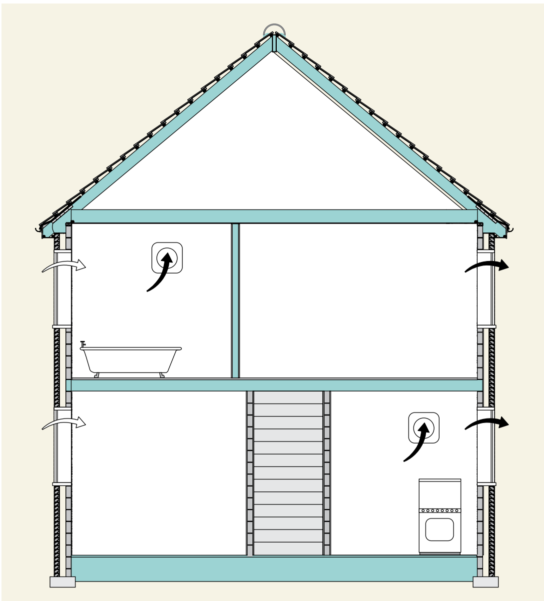


Figure 8 Intermittent extract fans

8 Single room heat recovery ventilators (SRHRVs)

Applications	Advantages	Disadvantages
• New build: good practice ✓ • New build: best practice ✗ • Major refurbishment ✓ • Minor refurbishment ✓	• Easy to install. • Provides continuous 'low-level' background ventilation. • Heat recovery from extracted air. • Almost silent in operation at trickle speed.	• Some recirculation possible due to close proximity of supply and extract grilles.

Description

Single room heat recovery ventilators are a development of the extract fan. They provide a balanced flow of supply and extract air into 'wet' rooms. A heat exchanger recovers heat from the outgoing air and pre-heats the incoming air. The unit is typically dual speed, providing low-speed continuous 'trickle' ventilation, and high-speed 'boost' flow. As the units are typically only used in wet rooms, appropriately size background ventilators (e.g. trickle ventilators) are required to ventilate the habitable rooms.

Unfortunately, there is the potential for the incoming and outgoing airstreams to mix, which reduces the ventilation effectiveness. The main sources of this mixing are the close proximity of both the supply and extract grilles inside of the dwelling and the intake and exhaust grilles on the outside. The effect can be mitigated by good design and a European performance standard (BSEN 13141-8 [6]) is in preparation to provide tests for its assessment. Approved Document F recommends that these ventilators should meet a minimum rating of Class U4 in this standard.

Performance monitoring of these fans has demonstrated that they are successful at lowering the overall relative humidity, when compared with conventional extract fans with humidity control and with properties relying on natural ventilation. The design considerations for locating these fans are similar to those for extract fans.

Control

The unit's boost setting can be automatic (e.g. using a humidistat sensor) or via manual switching.

Installation

Any automatic sensor should be correctly located, wired and commission on site. If isolating switches are installed close to fans, occupants may be tempted to turn them off. This problem may be reduced by not locating isolating switches in the same room as the fan, although they should be readily accessible for isolating purposes.

Maintenance and cleaning

Regular maintenance is required to remove dust and grease from the fan, heat exchanger, grilles and filters.

Criteria for establishing energy efficiency of single room heat recovery ventilators

The good practice standard is met by following the relevant national standards and regulations.

This system is not recommended for the best practice standard. The (balanced) units only ventilate the rooms within which they are located and not the rest of the property. At the high level of airtightness (Table 1), it will be difficult to achieve sufficient ventilation in these other rooms as they are reliant on natural ventilation through background ventilators only.

9 Mechanical extract ventilation (MEV)

Applications	Advantages	Disadvantages
• New build: good practice ✓ • New build: best practice ✓ • Major refurbishment ✓ • Minor refurbishment ✓ (individual room continuous fans only)	• Easy to install. • Provides continuous 'low-level' background ventilation. • Operation is easy to understand.	• Requires ducting from wet rooms. • Requires commissioning.

Description

A mechanical extract ventilation (MEV) system continually extracts air from 'wet' rooms. It usually consists of a central ventilation unit positioned in a cupboard or loft space ducted throughout the dwelling to extract air from the wet rooms. (Other configurations do exist, including the use of continuously running individual room fans, although with latter, care must be taken to minimise the effects of wind pressure on the flow.)

The system is typically dual speed, providing low-speed continuous 'trickle' ventilation, and high-speed 'boost' flow. Replacement dry air is drawn into the property via background ventilators (e.g. trickle ventilators) located in the habitable rooms, and by air leakage. Providing a gap at the bottom of the internal doors will allow the free passage of air through the property.

Controls

The system's boost setting can be operated automatically (e.g. using a humidistat sensor), or via manual switching.

Installation

The ducting should be installed to minimise flow resistance (e.g. cutting the duct to length and minimising kinks etc). Ducting should be adequately clamped to the inlet and outlet terminals to avoid detachment resulting in warm, moist air being discharged into the surrounding space.

It is important that the air flows from wet rooms are correctly set. Any automatic sensor should be correctly located, wired and commissioned on site.

Maintenance and cleaning

The system will require regular maintenance to remove dust and grease from the fans, grilles and filters.

Criteria for establishing energy efficiency of mechanical extract ventilation (MEV)

The good practice standard is met by following the relevant national standards and regulations.

To qualify as best practice standard, the whole system must have a specific fan power of 0.6W/l/s or less when running at each of its settings.

Guidance on the relevant European testing standards is being prepared by the Energy Saving Trust in conjunction with The Electric Heating and Ventilation Association (TEHVA) and the Residential Ventilation Association (RVA) entitled "Performance testing of products for residential ventilation". For more information see www.est.org.uk/housingbuildings/standards

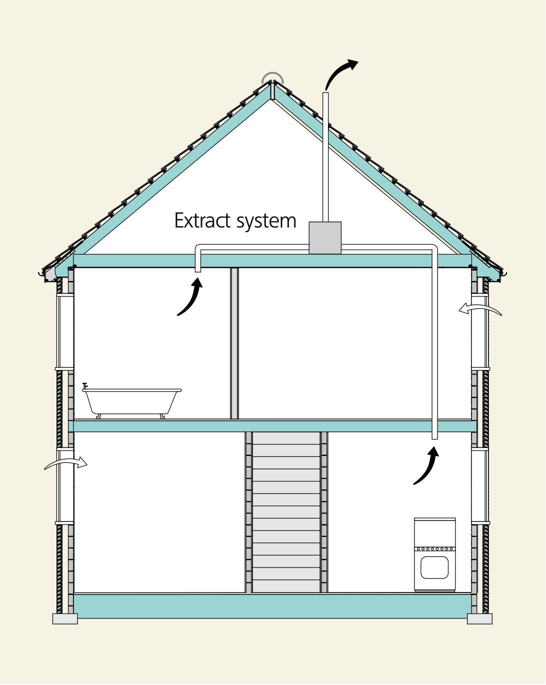


Figure 9 Mechanical extract ventilation (MEV)

10 Whole house mechanical ventilation with heat recovery (MVHR)

Applications	Advantages	Disadvantages
• New build: good practice ✓ • New build: best practice ✓ • Major refurbishment ✓ • Minor refurbishment ✗	• Controlled, preheated fresh air is provided throughout the house. • Heat exchanger reduces heating demand. • Offers air filtration of the incoming air from outside.	• Initial costs are high. • For optimum performance, an adequate level of airtightness must be achieved, which can be difficult in existing dwellings. • Complexity of installation and commissioning.

Description

A whole house mechanical ventilation (MVHR) system usually combines supply and extract ventilation in one system. Systems considered here incorporate a heat exchanger.

Typically, warm, moist air is extracted from 'wet' rooms via a system of ducting and is passed through a heat exchanger before being exhausted to outside. Fresh incoming air is preheated via the exchanger and ducted to the living room and other habitable rooms.

These systems can be effective at meeting part of the heating load in energy efficient dwellings, and helping to adequately distribute the heat. The system is typically dual speed, providing low-speed continuous 'trickle' ventilation, and high-speed 'boost' extract flow.

These systems can provide the ideal ventilation system, delivering the required ventilation rate almost independently of the weather conditions. However, the energy saving benefits are only realised for airtight properties ($<5m^3/hr/m^2$ at 50Pa) when almost all ventilation air passes through the heat exchanger.

There are a number of non-energy benefits claimed for the systems. They are particularly effective at reducing the risk of condensation, and as a consequence of the airtight structure and controlled ventilation rate, reducing cold air draughts. They are normally supplied with air filters which can be useful, particularly in more polluted areas, although the most effective filters do result in a need for greater energy use for the fans to overcome the increased resistance.

There is the potential for internal mixing between the exhaust and supply air streams in the MVHR unit. This effect can be mitigated by good design of the unit. A European performance standard (BS EN 13141-7[7]) provides tests for its assessment. Approved Document F recommends that these ventilators should meet a minimum rating of Class 2 in this standard.

Control

A boost in extract rates can be provided from bathrooms and kitchens during times of high moisture production.

The systems can be acoustically treated to reduce the ingress of external noise if required, and should be provided with fire dampers where ducts pass through separating walls or floors.

Installation

The ducting should be installed to minimise flow resistance (e.g. cutting the duct to length and minimising kinks, etc). Ducting should be adequately clamped to the inlet and outlet terminals to avoid detachment resulting in warm, moist air being discharged into the surrounding space.

The total supply and extract air that flows through the system should be balanced when installed. To operate efficiently and to help prevent interstitial condensation, the systems normally give a slight under-pressure in the house by setting the extract flow 5 to 10 per cent greater than the supply flow. It is equally important that the air flows to and from individual rooms are correctly set.

Any automatic sensor should be correctly located, wired and commissioned on site.

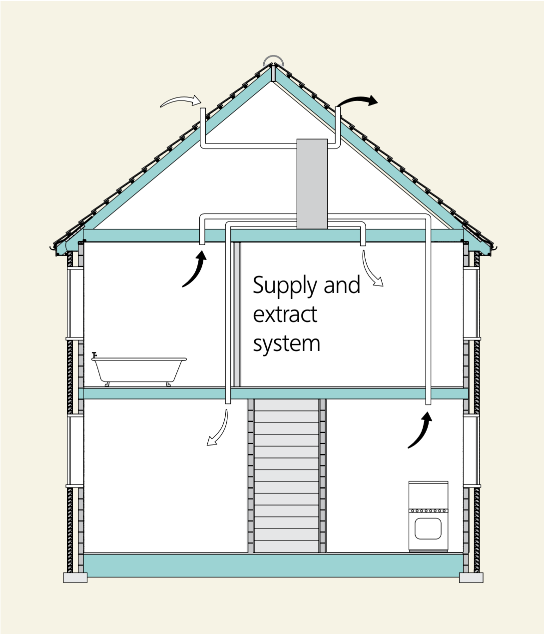


Figure 10 Whole house mechanical ventilation with heat recovery (MVHR)

Maintenance and cleaning

Regular maintenance should be carried out to ensure the system is still in balance, that filters and grilles are clean, and that the system is functioning correctly. Fans and heat exchangers will also need to be cleaned regularly.

Criteria for establishing energy efficiency of whole house mechanical ventilation with heat recovery

The good practice standard is met by following the relevant national standards and regulations.

To qualify as best practice standard, the whole system must have:

- A specific fan power of 1W/l/s or less when running at each of its settings.
- A heat recovery efficiency of 85 per cent.

Guidance on the relevant European testing standards is being prepared by the Energy Saving Trust in conjunction with The Electric Heating and Ventilation Association (TEHVA) and the Residential Ventilation Association (RVA) entitled "Performance testing of products for residential ventilation. This guidance may result in changes to the requirements of the best practice standard. For the latest information see www.est.org.uk/housingbuildings/standards

11 Other systems – positive input ventilation (PIV)

Applications	Advantages	Disadvantages
• New build: good practice – depending on the individual system's compliance with building regulations. • New build: best practice ✗ • Major refurbishment ✓ • Minor refurbishment ✓	• Easy to install. • Operation is easy to understand. • Heat gain to loft space is utilised.	• Limited research into their use. • Some additional enhancement measures may be needed, dependent on building shape and layout.

Description

A fan, typically mounted in the roof space, supplies air into the dwelling via central hallway or landing. This creates a slight positive pressure in the dwelling. With these systems, excess water vapour is not directly extracted from kitchens or bathrooms, etc. but has to find its way out by means of either background ventilator openings or air leakage routes. Fans typically run continuously at low speeds with a manual or humidity controlled boost option. These systems are often recommended for dealing with radon problems[8].

A study by BRE[9] showed that installing a low-energy PIV system may give an energy saving compared with a conventional extract system, providing the same level of ventilation air exchange. This is because input ventilation takes its air from the roof space where temperatures were found to be about 3°C higher on average than outside.

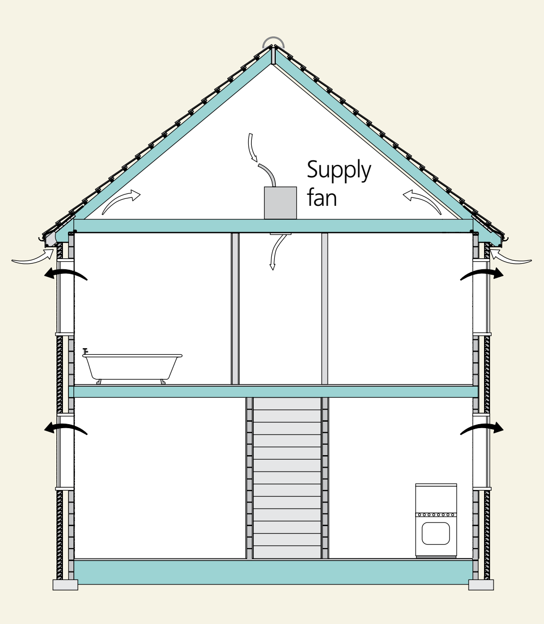


Figure 11 Positive input ventilation (PIV)

Energy performance proved difficult to quantify in the project, but the relative saving is estimated to be a maximum of about 150 Watts in an average modern family house (equivalent to about 550kWh over a heating season, or 10 per cent of annual space heating cost). Actual relative savings will be less than this (possibly even halved) because of recirculation of room air via the roof space.

Control

The systems deliver a continuous flow of air to the dwelling. Fan speed can be increased by occupant, or automatic switching.

Installation

If the fan draws air directly from the roof space, it will depressurise the roof space relative to the rest of the house, and can cause significant recirculation of air from the dwelling to the roof space and then back into the dwelling again. This needs to be minimised by ensuring the upstairs ceiling is as airtight as reasonably practical.

Furthermore, the roof space needs to be adequately ventilated from outside. In addition, air taken from the roof space should be filtered.

The units should be designed and located so as to minimise any cold draughts from the airflow into the landing. Furthermore, the airflow should not pass directly over a smoke detector, as it may reduce the detector's speed of response.

Any automatic sensor should be correctly located, wired and commission on site.

Maintenance

As with other fan systems, occasional cleaning is necessary. Intake filters (fitted to most units) will need occasional cleaning/replacement.

References

1 Surface condensation and mould growth in traditionally-built dwellings. BRE Digest 297.

2 British Standards Institution. BS5250. Control of condensation in buildings, BSI, London, 2002.

3 Building Regulations 2000, Conservation of fuel and power, Approved Document L1A - Work in new dwellings (2006 Edition). www.odpm.gov.uk/buildingregs

4 CIBSE, Technical Manual 23 Testing Buildings for Air Leakage, 2000.

5 Stephen RK, Humidistat-controlled extract fans: performance in dwellings, IP 5/99, BRE, 1999.

6 BSEN 13141-8. Ventilation for buildings – Performance testing of components/products for residential ventilation – Part 8: Performance testing of unducted mechanical supply and exhaust ventilation units (including heat recovery) for mechanical ventilation systems intended for a single room (to be published).

7 BS EN 13141-7: 2004. Ventilation for buildings – Performance testing of components/products for residential ventilation – Part 7: Performance testing of a mechanical supply and exhaust ventilation units (including heat recovery) for mechanical ventilation systems intended for single family dwellings.

8 Stephen RK, Positive pressurisation: a BRE guide to radon remedial measures in existing dwellings, BR 281, BRE, 1995.

9 Stephen RK, Positive Input Ventilation in Dwellings, IP12/00, BRE, 2000.

Further information

The Energy Saving Trust sets energy efficiency standards that go beyond building regulations, for use in the design, construction and refurbishment of homes. These standards provide an integrated package of measures covering fabric, ventilation, heating, lighting and hot water systems for all aspects of new build and renovation. Free resources including best practice guides, training seminars, technical advice and online tools are available to help meet these standards.

The following publications may also be of interest:

- Improving airtightness in dwellings (CE137/GPG224)
- Post-construction testing – a professional's guide to testing housing for energy efficiency (CE128/GIR64)

To obtain these publications or for more information, call 0845 120 7799, email bestpractice@est.org.uk or visit www.est.org.uk/housingbuildings

energy saving trust™

Energy Saving Trust, 21 Dartmouth Street, London SW1H 9BP Tel 0845 120 7799 Fax 0845 120 7789
bestpractice@est.org.uk www.est.org.uk/housingbuildings