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Building Standards Domestic Technical Handbook (extract)

Consultation proposals – Standard 3.14 'Ventilation'

July 2021

The Building Standards Technical Handbooks provide guidance on achieving the standards set in the Building (Scotland) Regulations 2004.

Further information on the Scottish building standards system can be found at: www.gov.scot/policies/building-standards/.

This document sets out proposed changes to the guidance issued in support of **standard 3.14 'ventilation'** within the Building Standards **Domestic Technical Handbook**.

Where text is amended from the current, published 2015 edition of the handbook, this is shown by highlighting relevant passages in yellow.

The subjects matter of these changes is set out in more detail within section 4 of the consultation document 'Scottish Building Regulations – Proposed Changes to Energy Standards and associated topics', published online at: https://consult.gov.scot/local-government-and-communities/building-regulations-energy-standards-review/.

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Section 3: Environment (excerpt)

3.14 Ventilation

Mandatory Standard

Standard 3.14

Every building must be designed and constructed in such a way that:

a) **ventilation is provided so that the air quality inside the building is not a threat to the building or the health of the occupants; and**

b) **mechanical systems providing ventilation are commissioned to demonstrate effective operation; and**

c) **written information on the operation and maintenance of any installed ventilation system is provided.**

3.14.0 Introduction

Ventilation of a dwelling is required to maintain air quality and so contribute to the health and comfort of the occupants. Without ventilation it is possible that carbon dioxide, water vapour, organic impurities, smoking, fumes and gases could reduce the air quality by humidity, dust and odours and also reduce the percentage of oxygen in the air to make the building less comfortable to work or live in.

So that contaminants do not exceed acceptable levels and thereby endanger the health of the occupants, it is important that dwellings are adequately ventilated. Research has shown that occupants of dwellings are, for the most part, unaware of the standard of air quality within their homes. The lack of recognition of poor air quality has frequently resulted in occupants not being aware of the need to open ventilators or windows, particularly in bedrooms.

Well-designed ventilation has many benefits, not least financial and environmental, although it is also recognised that inside air quality can only be as good as outside air quality and in some cases filtration may be necessary. It is becoming more common, due in the main to improved insulation standards and reduced levels of fabric infiltration, to specify continuous mechanical systems to provide the ventilation solution for the building.

Conversely, ventilation can also have a significant effect on energy consumption and performance and so thorough assessment of provisions for both ventilation and energy performance, should be made, as uninformed choices may significantly affect both indoor air quality or the energy efficiency of the building (see Section 6, Energy).

Ventilation should not adversely affect comfort and, where necessary, designers might wish to consider security issues and protection against rain penetration prevalent in naturally ventilated buildings when windows are partially open to provide background ventilation.

The impact of reducing air infiltration - improved insulation and 'tighter' construction of buildings will reduce the infiltration and the level of natural air change. Unless ventilation is maintained, this can increase the risk of poorer indoor air quality and issues such as condensation and mould growth. Conversely, leaky buildings can be draughty and uncomfortable. Sealing up air leaks improves comfort and saves energy whilst proper ventilation keeps the indoor air pleasant and healthy. If poor attention to detail occurs air leakage can account for a substantial part of the heating costs. Energy savings from building 'tighter' could make significant savings on energy bills. There is a common perception that 'tight' construction promotes indoor air pollution. However both 'tight' and 'leaky' buildings can have air quality problems. Though air leaks can dilute indoor pollutants, there is no control over how much leakage occurs, when it occurs or where it comes from.

Occupants should have the opportunity to dry washing other than by a tumble dryer which uses a considerable amount of energy. Drying of washing internally can generate large quantities of moisture that should be removed at source to limit any adverse impact on the building or its occupants.

In addition to the clauses below, further guidance on aspects of ventilation installations, including controls, installation and commissioning of systems is provided with Annex 3.A – 'Domestic Ventilation Guide'.

Conversions - in the case of conversions, as specified in regulation 4,
the building as converted shall meet the requirement of this standard (regulation 12, schedule 6).

3.14.1 Ventilation generally

Ventilation is the process of supplying outdoor air to an enclosed space and removing stale air from the space. It can manage the indoor air quality by both diluting the indoor air with less contaminated outdoor air and removing the indoor contaminants with the exhaust air. Ventilation should have the capacity to:

- provide outside air to maintain indoor air quality sufficient for human respiration
- remove excess water vapour from areas where it is produced in sufficient quantities in order to reduce the likelihood of creating conditions that support the germination and growth of mould, harmful bacteria, pathogens and allergies
- remove pollutants that are a hazard to health from areas where they are produced in significant quantities
- rapidly dilute pollutant odours, where necessary.

Ventilation should be to the outside air. However, clauses 3.14.4. 3.14.5 and 3.14.11 explain where ventilators and background ventilators may be installed other than to the external air.

Additional ventilation provision

This guidance relates to the provision of air for human respiration and is in addition to, and should be kept separate from, any air supply needed for the smoke ventilation of escape routes in the case of fire (Section 2, Fire) and for the safe operation of combustion appliances (see Standards 3.21 and 3.22). Provision of ventilation will also assist in removing heat from a building in the summer months, reducing the risk of summertime overheating (see standard 3.28).

Small rooms

There is no need to ventilate a room with a floor area of not more than 4 m^2. This is not intended to include a domestic sized kitchen or utility room where ventilation should be in accordance with the recommendations in clause 3.14.2.

Calculation of volume

For ventilation purposes, a storey should be taken as the total floor area of all floors within that storey, including the floor area of any gallery or openwork floor. Where an air change rate is recommended, the volume of the space to be ventilated may be required. The volume of any space is the internal cubic capacity of the space. Any volume more than 3m above any floor level in that space may be disregarded.

3.14.2 Ventilation of dwellings

All buildings leak air to a greater or lesser extent. However the movement of uncontrolled infiltrating air through the fabric of a building can cause draughts and can have a significant adverse effect on the energy efficiency of the building as a whole. By improving building techniques it is possible to reduce this infiltrating air to lower levels that can improve energy efficiency (see Section 6 Energy).

Some building techniques may have little effect on air leakage and so allow the uncontrolled infiltrating air to be taken into account in the building's ventilation provision. By building with techniques designed to reduce air leakage there will need to be a reciprocal increase in the designed ventilation provision to make up for the lower levels of infiltrating air.

Ventilation is delivered via three components - supply air, extraction and purge ventilation. Under normal conditions, indoor air quality is provided for by the supply and extraction elements. Purge ventilation is essential for removal of higher levels of pollutants on an intermittent or occasional basis and can also assist in the cooling of the dwelling during the summer months.

Choice of ventilation solution

Infiltration (air movement through building fabric) is considered as a component of overall ventilation. Accordingly, the provision of intended ventilation should be made to reflect the level of fortuitous ventilation occurring through building fabric. Guidance to this standard sets out three forms of supply and extract ventilation:

1. Natural ventilation (with intermittent mechanical extract) – see clause 3.14.4.
2. Continuous mechanical extract – see clause 3.14.5.
3. Continuous mechanical supply and extract clause – see clause 3.14.6.

Provisions are recommended on the basis of the design and confirmed infiltration rate for the dwelling as follows:

Table 3.5a – Ventilation solutions for design infiltration levels.

Ventilation type	Suitable for infiltration rate:
Natural ventilation (with intermittent mechanical extract)	≥ 5 $m^3/(h.m^2)$@50Pa
Continuous mechanical extract ventilation	≥ 3 $m^3/(h.m^2)$@50Pa
Continuous mechanical supply & extract ventilation	Any

It is noted that the designer may choose to provide evidence of the suitability of another option for any of the above categories.

Supply air

Supply air for the dwelling should be delivered through either background ventilators (options 1 & 2 above) or continuous supply fans (option 3 above). The minimum whole dwelling ventilation rate for the supply of air to the habitable rooms in a dwelling should meet both of the criteria given in table 3.5b below for ventilation by number of apartments and by dwelling floor area.

Table 3.5b - Minimum whole dwelling ventilation rate

Number of apartments [1]	1	2	3	4	5
Minimum ventilation rate – litres/second [2]	13	19	25	31	37
Minimum ventilation rate – by floor area [3]: 0.3 l/s per m^2 of internal floor area					

Notes:

1. Where the dwelling has only one habitable room (principal apartment), a minimum ventilation rate of 19 litres per second is assigned to cover occupancy as both living and sleeping accommodation.
2. For each additional apartment, add 6 litres per second to the values above.
3. The minimum ventilation rate 0.3 litres per second per m_2 of internal floor area. (This includes all floors, e.g. for a two-storey building add the ground and first floor areas).

Background ventilator area

For the purpose of performance, the recommended areas for background ventilation (see clauses 3.14.4 & 3.14.5) should be achieved by the use of ventilators that are sized by the equivalent area, as determined using BS EN 13141-1:2019. When determining the equivalent area, the whole ventilator installation, including the external grille or canopy, should be considered as a single unit. Background ventilators should have the equivalent area marked where it will be easily visible from inside the dwelling when installed, to aid verification

Air flow within the dwelling

To enable effective air movement throughout the dwelling, ventilation should be provided between rooms and circulation spaces. This is commonly achieved at each internal door serving a ventilated space, providing a minimum free area equivalent to a 10 mm gap beneath each door (minimum door widths are set out in clause 4.2.6). The underside of the door leaf should be either:

- If the floor finish is fitted, 10 mm above the floor finish
- If the finish is not fitted, 20 mm above the floor surface.

Where the door is a fire door, this should not involve trimming of the door leaf, but raising the door set to provide the recommended gap. Alternatively, equivalent ventilation provision can be made through the wall dividing each space.

Open-flued appliances

Care should be taken when installing mechanical extract systems where there is an open-flued combustion appliance in the dwelling. Further guidance is provided in clause 3.17.8.

3.14.3 Provision for purge ventilation

Provision of purge ventilation enables occupants to remove higher concentrations of pollutants or water vapour from occasional activities that give rise to such increases. It can also assist in the cooling of a dwelling in the summer months.

A system for purge ventilation is required in each habitable room (apartment). The recommended opening areas in Table 3.6a below are set to give reasonable assurance that purge ventilation is capable of providing air change of at least of four air changes per hour per room directly to outside. This can be delivered through either openings (e.g. windows or doors) or by a mechanical extract system with a suitable high extract rate. The latter will be more common if there are environmental issues such as noise or pollution which make it more desirable to provide occasional higher levels of ventilation via an extract system.

Where purge ventilation in a habitable room is delivered through openings in that room, the minimum opening areas in Table 3.6a should be achieved. These are based on BS5925:1991, which assumes all of the following:

- single-sided ventilation
- an urban environment
- a wind speed of 2.1 metres per second
- a temperature difference of 3°C between the air inside and outside of the building.

Depending on the dwelling design or the external climate, it may be possible in other circumstances to achieve 4 air changes per hour with smaller openings. If smaller openings than Table 3.6a are specified, this should be supported by evidence from an appropriately qualified person competent in such matters.

Table 3.6a - Purge ventilation openings to apartments

Opening type	Minimum total area of openings
Hinged or pivot windows with an opening angle of 15 to 30 degrees.	1/10 of floor area of room
External doors; Opening sash windows; Hinged or pivot windows with an opening angle of greater than or equal to 30 degrees.	1/20 of floor area of room

Note: hinged or pivot windows with an opening angle of less than 15 degrees are not suitable for purge ventilation.

3.14.4 Natural ventilation (with intermittent mechanical extract)

It is recommended that natural ventilation with intermittent extract only be considered in dwellings where low or very low fabric infiltration is not present or planned. This would be where the infiltration rate is 5 $m^3/(h.m^2)$@50 Pa and above.

Note also that, for dwellings with a single aspect or an internal kitchen, the guidance below may not suffice to provide sufficient ventilation and further advice should be sought from the designers or an alternate solution proposed.

Purge ventilation is as set out in clause 3.14.3

Background ventilation

Natural ventilation relies upon a combination of fortuitous ventilation and background ventilation to drive air movement. This is assisted by the intermittent use of mechanical extract ventilation to remove air from rooms where activities will generate water vapour - kitchens, utility rooms, bathrooms and sanitary accommodation.

Table 3.7a - Minimum equivalent area of background ventilators for natural ventilation

Room	Area of background ventilation
Apartment	12,000 mm^2
Kitchen or Utility room	10,000 mm^2
Toilet, bathroom or shower room	10,000 mm^2

Additional information:

1. Where the background ventilator is ducted, the recommended areas in the table should be doubled to account for flow resistance within the ductwork.
2. The overall provision of background ventilation in a dwelling may be provided at an average of 11,000 mm^2 per room with a minimum of 11,000 mm^2 for each apartment.

3. To reduce the effects of stratification of the air in a room, some part of the background ventilator should be at least 1.75 m above floor level.

Extract ventilation

Intermittent mechanical extract fans should be fitted in each room where activities will generate water vapour - kitchens, utility rooms, spaces for drying washing, bathrooms and sanitary accommodation. Extract rates should be as set out below.

Table 3.7b - Minimum extract rates for intermittent extract ventilation systems

Room [1 2]	Intermittent extract rate [3]
Kitchen, extract above hob/cooker	30 litres per second
Kitchen, extract located elsewhere	60 litres per second
Utility room	30 litres per second
Bathroom or shower room	15 litres per second
Designated drying area (see 3.14.9)	15 litres per second
Sanitary accommodation (Toilet) [4]	6 litres per second

Additional information:

1. Where a room has both extract fan and background ventilators, these should be a minimum of 0.5 m apart (within and outside the dwelling) to reduce the risk of 'short circuiting' ventilation.
2. Refer to guidance to Standard 3.17 and OFTEC Technical Book 3 where an extract fan is fitted in a building containing an open-flued combustion appliance.
3. In design of a system, where exhaust air terminals are in a location exposed to prevailing winds, measures should be taken to minimise the adverse effect of wind on the extract rate. This may include relocation of extract terminals to another location or the use of constant volume flow rate units.
4. For a toilet (WC & WHB) provision of purge ventilation in accordance with clause 3.14.3 is an alternative to intermittent mechanical extract.

It is noted that passive stack ventilation (PSV) can be used as an alternative to intermittent mechanical extract in wet rooms. A passive stack ventilation system should be installed in accordance with the recommendations set out in BRE Information Paper BRE IP 13/94, noting that such systems are most suited for use in dwellings with a height of not more than 4 storeys as the stack effect will diminish as the air cools.

Work on existing buildings

Where infiltration rates in a dwelling exceed 10 $m^3/h/m^2$ @ 50 Pa, which may often be the case in existing buildings, the size of background ventilation may be reduced to 8000 mm^2 for apartments and 4000 mm^2 for all other rooms. Alternatively, the overall provision of background ventilation in a dwelling may be provided at an average of 6000 mm^2 per room, with a minimum provision of 4000 mm^2 in each apartment.

3.14.5 Continuous mechanical extract ventilation

For new dwellings with building fabric which has very low infiltration, ventilation by a continuous mechanical extract system (see below) or continuous mechanical supply and extract system (see clause 3.14.6) is recommended. 'Low infiltration' is defined as a design intent of not less than 3 $m^3/(h.m^2)$@ 50Pa and less than 5 $m^3/(h.m^2)$@50 Pa which is realised on construction.

A continuous mechanical extract ventilation system should provide for ventilation of the whole dwelling and may be delivered either by a central extract system, by individual extract fans or a combination of these.

Purge ventilation is as set out in clause 3.14.3

Background ventilation

Where continuous mechanical extract ventilation is used, background ventilators should provide a minimum equivalent area of 5,000 mm^2 for each apartment in the dwelling.

Background ventilators should not be installed in a room with continuous mechanical extract, to avoid short circuiting of ventilation pathways.

Where the background ventilator is ducted, the recommended area above should be doubled to account for flow resistance within the ductwork.

To reduce the effects of stratification of the air in a room, some part of the background ventilator should be at least 1.75 m above floor level.

Extract ventilation

Continuous mechanical extract fans should be fitted in each room where activities will generate water vapour ('wet rooms') - kitchens, utility rooms, spaces for drying washing, bathrooms, shower rooms and sanitary accommodation. Minimum room extract rates should be as set out below.

Table 3.7b - Minimum extract rates for continuous extract ventilation systems

Room [1 2]	High/boost rate [3]	Continuous extract rate [3]
Kitchen, extract above hob/cooker	30 litres per second	The total combined rate of continuous mechanical extract ventilation should not be less than the minimum whole dwelling ventilation rate for the dwelling as set out in Table 3.5b in Clause 3.14.2.
Kitchen, extract located elsewhere	60 litres per second	
Utility room	30 litres per second	
Bathroom or shower room	15 litres per second	
Designated drying area (see 3.14.9)[4]	15 litres per second	
Sanitary accommodation (Toilet)	6 litres per second	

Additional information:

1. Where a room has both extract fan and background ventilators, these should be a minimum of 0.5 m apart (within and outside the dwelling) to reduce the risk of 'short circuiting' ventilation.
2. Refer to guidance to Standard 3.17 and OFTEC Technical Book 3 where an extract fan is fitted in a building containing an open-flued combustion appliance.

3. In design of a system, where exhaust air terminals are in a location exposed to prevailing winds, measures should be taken to minimise the adverse effect of wind on the extract rate. This may include relocation of extract terminals to another location or the use of constant volume flow rate units.
4. Extract in a designated drying area which is not also another of the rooms described above may operate only on an intermittent basis, controlled by a humidistat – see clause 3.14.9. In such cases, it is excluded from the whole dwelling ventilation rate calculation.

3.14.6 Continuous mechanical supply and extract ventilation

For new dwellings with building fabric which has very low infiltration, ventilation by a continuous mechanical supply and extract system is recommended. Such systems can also be used for any level of building infiltration. 'Very low infiltration' is defined as a design intent of less than 3 $m^3/(h.m^2)$@50Pa which is realised on construction

To avoid unintended air pathways, background ventilators should not be installed with mechanical supply and extract ventilation systems.

Purge ventilation is as set out in clause 3.14.3

Supply ventilation

Each apartment should have mechanical supply ventilation. The total supply air flow should be distributed proportionately to the volume of each habitable room.

Extract ventilation

For dwellings using mechanical supply and extract ventilation, each wet room should have a minimum mechanical extract ventilation high rate as given in Table 3.7b in clause 3.14.5.

A continuous rate of mechanical supply and extract ventilation system should provide the minimum whole dwelling ventilation rate set out in Table 3.5b in Clause 3.14.2.

Combustion appliances

Note that specialist advice must be sought if considering installation of an open-flued appliance within a dwelling with continuous mechanical supply and extract ventilation to identify and provide assurance on supply of air for combustion.

3.14.7 Ventilation awareness in dwellings

Carbon dioxide (CO_2) is present in the external air we breathe at concentration levels of around 400 parts per million and is not harmful to health at low concentration levels. However, as people release CO_2 into the air when they exhale, increased levels of CO_2 in occupied buildings can occur. This is generally accepted as being a reasonable indication that ventilation action is necessary.

CO_2 monitoring equipment

A CO_2 monitor should be provided in the apartment expected to be the main or principal bedroom in a dwelling where infiltrating air rates are less than 15 $m^3/hr/m^2$ @ 50 Pa. This should raise occupant awareness of CO_2 levels (and therefore other pollutants) present in their homes and of the need for them to take proactive measures to increase the ventilation. Guidance on the operation of the monitoring equipment, including options for improving ventilation when indicated as necessary by the monitor, should be provided to the occupant. For more detailed information on the provision of guidance to occupants, reference should be made to sections 9 & 10 of Annex 3A – 'Domestic Ventilation Guide'.

The installed monitoring equipment for CO_2 should be mains operated and may take the form of a self-contained monitor/detector or a separate monitor and detector head. The monitor should have an easily understood visual indicator and be capable of logging data to allow the occupant to gain information on CO_2 levels for at least the preceding 24 hour period. If the detector/monitor has an audible alarm this should be capable of being permanently deactivated.

CO_2 monitoring equipment should be capable of recording and displaying readings within a range of at least 0 – 5,000 parts per million. The equipment should also be capable of logging data at no more than 15 minute intervals, over a 24 hour period.

Where carbon dioxide monitors/detectors are within the scope of either or both:

- European Directive 2014/35/EU – Low Voltage Directive (LVD), and/or
- European Directive 2014/53/EU – Radio Equipment

they should be constructed to fully comply with all applicable safety aspects of the Directive(s) as implemented through UK regulations.

A carbon dioxide detector head requires a flow of air over it to operate correctly, therefore, it should not be located in an area that is likely to restrict the free movement of air. Unless otherwise indicated by the manufacturer, a carbon dioxide detector head should not be sited:

- if ceiling mounted, within 300 mm of any wall
- if wall mounted, within 150 mm of the ceiling or a junction with another wall
- where it can be obstructed (for example by curtains, blinds or furniture)
- next to a door or window, or
- next to an air vent or similar ventilation opening.

Unless otherwise indicated by the manufacturer, a carbon dioxide monitor, with or without an integral detector, should be mounted between 1.4 m and 1.6 m above floor level. A carbon dioxide detector head (or monitor if integrated) should not be sited within 1 m of the expected location of a bed-head.

Where a separate detector head and monitor is installed, the monitor may be located other than in the room containing the detector head, for example, the hallway. This may be desirable if more than one detector head is installed.

3.14.8 Commissioning and written information.

Commissioning of mechanical elements of an installed ventilation system should be carried out as set out for the relevant system in sections 5 to 7 of Annex 3.A - 'Domestic Ventilation Guide'.

Correct use and maintenance of the ventilation systems will assist in delivering the designed ventilation to the dwelling whilst minimising energy use and environmental problems such as noise and thermal discomfort. To assist in this, the following information should be provided and made available to the occupant(s) of the dwelling, as relevant to the installed system.

- a design statement that sets out the key characteristics of the system along with non-technical information on how and when the system should be used;
- manufacturer's contact details;
- instructions on how to use background ventilators for background ventilation;
- location of and setting of automatic controls (humidity and timer controls);
- location and use of on/off and boost settings for mechanical ventilation systems;
- Instructions on how and when cleaning and maintenance should be carried out, including filter replacement;
- location of filters;
- if there are no filters on extract terminals, how ducts can be accessed for cleaning and recommendations on how and when cleaning should be under taken;
- instructions on how to recalibrate or check sensors and their location; and
- manufacturer's literature that may include information such as a spare parts list, means of obtaining spare parts, guarantees etc.
- A copy of the commissioning and testing report for the mechanical elements of the ventilation system.

3.14.9 Ventilation of conservatories

With large areas of glazing, conservatories attract large amounts of the sun's radiation that can create unacceptable heat build-up. Efficient ventilation therefore is very important to ensure a comfortable environment. A conservatory should have
a ventilator or ventilators with an opening area of at least 1/5th of the floor area it serves. Although this is the minimum recommended area, a greater area can provide more comfortable conditions particularly in sunny weather. Notwithstanding the recommended opening height of 1.75 m for ventilators, high level or roof vents are best placed to minimise the effects of heat build-up and reduce stratification.

3.14.10 Ventilation of areas designated for drying of washing

Where clothes are dried naturally indoors large quantities of moisture can be released and this will need to be removed before it can damage the building. Normally a utility room or bathroom is used and mechanical extract is the usual method of removing moisture. Where a space other than a utility room or bathroom is designated, that space should be provided with mechanical extraction capable of at least 15 l/s intermittent operation. The fan should be connected through a humidistat set to activate when the relative humidity is between 50 and 65%.

Guidance to Standard 3.11 gives information on the space recommended for the drying of washing.

3.14.11 Conservatories and extensions built over existing windows

Constructing a conservatory or extension over an existing window, or ventilator, will effectively result in the creation of an internal room, restricting air movement which could significantly reduce natural ventilation to that room. Reference should be made to clause 3.16.2 relating to natural lighting, and to the guidance to Standards 3.21 and 3.22 on the ventilation of combustion appliances, as this also may be relevant. There are other recommendations in Section 2: Fire relating to escape from inner rooms.

Conservatories

A conservatory may be constructed over a ventilator serving a room in a dwelling provided that the ventilation of the conservatory is to the outside air and has an opening area of at least 1/20th of the total combined floor area of the internal room so formed and the conservatory. The ventilator to the internal room should have an opening area of at least 1/20th of the floor area of the room. Background ventilators should also be provided relevant to the overall areas created.

Extensions

An extension may also be built over a ventilator but a new ventilator should be provided to the room. Where this is not practicable, e.g. where there is no external wall, the new extension should be treated as part of the existing room rather than the creation of a separate internal room because the extension will be more airtight than a conservatory and therefore the rate of air change will be compromised. The opening area between the 2 parts of the room should be not less than 1/10th of the total combined area of the existing room and the extension.

Moisture producing areas

If the conservatory or extension is constructed over an area that generates moisture, such as a kitchen, bathroom, shower room or utility room, mechanical extract, via a duct if necessary (or a passive stack ventilation) should be provided direct to the outside air. Any existing system disadvantaged by the work may require to be altered to ensure supply and extracted air is still to the outside air.

3.14.12 Control of legionellosis

An inlet to, and an outlet from, a mechanical ventilation system should be installed such that their positioning avoids the contamination of the air supply to the system. The system should be constructed and installed in accordance with the recommendations in Legionnaires' Disease: The control of legionella bacteria in water systems – approved code of practice and guidance - HSE L8, in order to ensure, as far as is reasonably practicable, the avoidance of contamination by legionella.

3.14.13 Ventilation of garages

The principal reason for ventilating garages is to protect the building users from the harmful effects of toxic emissions from vehicle exhausts. Where a garage is attached to a dwelling, the separating construction should be as air tight as possible. Where there is a communicating door airtight seals should be provided or a lobby arrangement may be appropriate.

Large garages - few domestic garages over 60 m^2 in area are constructed but guidance on such structures is provided in the non-domestic Technical Handbook.

Small garages - garages of less than 30 m^2 do not require the ventilation to be designed. It is expected that a degree of fortuitous ventilation is created by the imperfect fit of 'up and over' doors or pass doors. With such garages, it is inadvisable for designers to attempt to achieve an airtight construction.

Open-flued appliances - although not considered good practice, open-flued combustion appliances are installed in garages. Ventilation should be provided in accordance with the guidance to Standards 3.21 and 3.22.

A garage with a floor area of at least 30 m^2 but not more than 60 m^2 used for the parking of motor vehicles should have provision for natural or mechanical ventilation. Ventilation should be provided in accordance with the following guidance:

a. where the garage is naturally ventilated, by providing at least 2 permanent ventilators, each with an open area of at least 1/3000th of the floor area they serve, positioned to encourage through ventilation with one of the permanent ventilators being not more than 600 mm above floor level, or

b. where the garage is mechanically ventilated, by providing a system:

   - capable of continuous operation, designed to provide at least 2 air changes per hour, and
   - independent of any other ventilation system, and
   - constructed so that two-thirds of the exhaust air is extracted from outlets not more than 600 mm above floor level.

Annex 3A - Domestic Ventilation Guide

1 Purpose of This Document

1.1 The building standards system in Scotland is intended to ensure that building work on both new and existing buildings is compliant with the mandatory functional standards. Compliance with the standards can be met by following the guidance set out within the Scottish Building Standards Technical Handbooks. The system also has the flexibility of allowing compliance to be achieved by solutions other than those outlined in the technical handbook guidance. The purpose of this document is to complement existing guidance by providing supplementary information on ventilation for dwellings.

1.2 The quality of the air that people breathe in their homes can have a significant effect on their health and wellbeing. Good indoor air quality is therefore important as people spend a substantial amount of time in their homes. The air quality inside a building can also have an effect on the building itself, particularly when high levels of humidity exist.

1.3 The information provided in this document describes some of the ventilation systems that may be used to ventilate new and existing dwellings and outlines the performance requirements and practical installation guidance to assist in delivering an efficient system of ventilation. It also highlights key installation issues that can affect the performance of the systems.

1.4 A key purpose of this document is to raise awareness of, and requirements for, the commissioning of installed ventilation systems prior to operation to assist in meeting building standards. The mandatory building standards for energy require mechanical ventilation systems to be commissioned to achieve optimum energy efficiency. In addition, the Technical Handbook guidance to building standard 3.14 also recommends that a ventilation system is properly commissioned.

1.5 The information provided within this document only addresses matters relating to the air quality inside the dwelling. It is acknowledged that ventilation may fulfil other roles within a dwelling, such as the permanent provision of air for combustion appliances and as such may require to be considered separately. Additionally, the components of a ventilation system, if not installed correctly, may have a detrimental effect on the ability of elements within the dwelling to satisfy other building standards. An example of this would be incorrectly positioned fire dampers in a wall or floor that requires to be fire resisting. In these instances, the relevant sections elsewhere in the Technical Handbooks should be consulted.

1.6 The use of this document does not remove the need to obtain a building warrant where it is required by the building regulations. Furthermore, it is quite acceptable to use alternative methods of showing that compliance with the building standards has been or will be achieved.

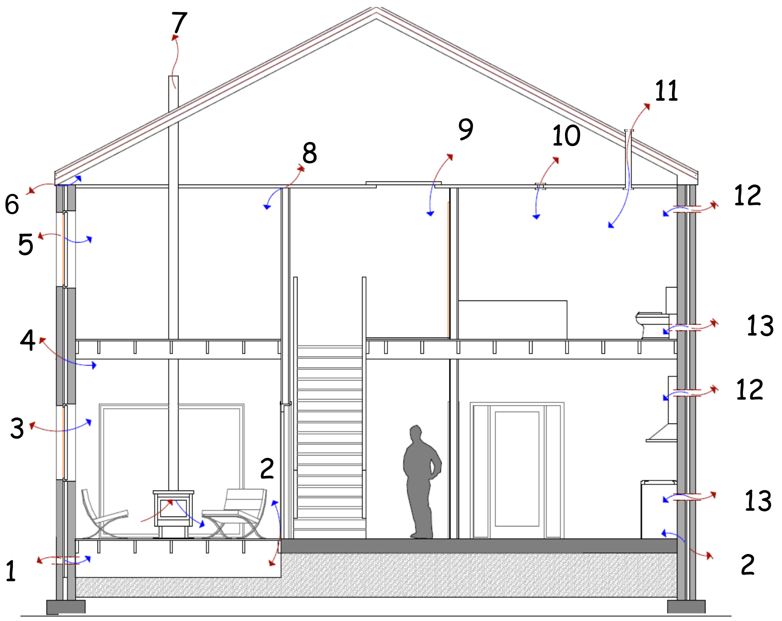
2 Ventilation in Buildings

2.1 All buildings require to be ventilated so that the air quality within the building is not a threat to the health of the occupants or the building itself. This is achieved by the process of changing air in an enclosed space. A proportion of the air in the space should be regularly withdrawn and replaced with external air. Dwellings are generally ventilated through a combination of both "purpose provided ventilation" and "fortuitous infiltration".

2.2 Purpose provided ventilation is the controllable air exchange between the inside and outside of a dwelling by means of a range of natural ventilating devices including windows and background (background) ventilators or mechanical devices such as extract and supply fans.

2.3 Fortuitous infiltration is the uncontrollable air exchange between the inside and outside of a dwelling due to pressure differences caused by wind and temperature variations. The air movement may occur through a wide range of air leakage paths through imperfections in the building structure such as cracks and gaps between building elements.

Infiltration Paths



1 under floor ventilators
2 floor to wall junctions
3 through poorly constructed windows/doors
4 through floor voids into the wall cavity
5 around poorly fitted windows/doors
6 ceiling to wall junctions
7 open flues
8 around services within hollow walls
9 around the loft hatch
10 service penetrations through ceiling
11 vents penetrating the ceiling and roof
12 around and through extract fans
13 around waste pipes

2.4 Reducing the amount of fortuitous infiltration that occurs within a dwelling can play a significant part in reducing carbon emissions by minimising both the amount of warm air leaking from the dwelling and the amount of cold air entering into the dwelling. However, this air movement has traditionally contributed to the ventilation strategy of dwellings. Reducing the overall fortuitous infiltration rate of a dwelling, for example below 5 $m^3/h/m^2$ @ 50 Pa, may necessitate the adoption of continuous mechanical extract ventilation to provide satisfactory air quality of the dwelling. A more airtight building also places a greater need for "purpose provided ventilation" to deliver satisfactory air quality within a dwelling.

2.5 In order to be satisfied that a new dwelling has an infiltration rate that meets the energy section of the technical standards, whilst not adversely affecting the method of ventilating the dwelling, it is now recommended within guidance to standard 6.2 that air tightness testing is carried out on each new dwelling. The results from the test will indicate if the dwelling has been constructed and performing as designed. Further information on the requirements for air tightness testing can be found within clause 6.2.5 of the domestic Technical Handbook.

2.6 Where air tightness testing indicates that a constructed dwelling has a level of air infiltration leakier or tighter than the design figure, the adequacy of the chosen ventilation strategy should be checked and re-evaluated. This may mean additional works are required so that adequate ventilation will be provided to all parts of the dwelling. Further information on approaches to take when the designed level of air-tightness is not achieved in the completed building can be found in section 3 and the accompanying flowcharts.

2.7 Although the guidance within this document is concerned with the ventilation of dwellings to assist in maintaining the quality of the indoor air, opening doors and windows may also be utilised to cool the dwelling in the summer.

3 Purpose Provided Ventilation

Natural Ventilation

3.1 Two natural air movement forces, wind pressure and the stack effect (thermal buoyancy), support the maintenance of air quality for the occupants of a dwelling. The effectiveness of both of these mechanisms in ventilating a dwelling is variable due to the air movement being influenced by the climatic conditions that occur throughout the year. Additionally, as no filtering occurs in natural ventilation, the indoor air quality can only ever be as good as the air outside.

3.2 The effectiveness of natural ventilation is very much dependent on the design of the dwelling, as well as external factors such as the geometry, orientation and geographic/topographic location of the building. For example, designing a natural ventilation system for a single aspect dwelling on the leeward side of a building will present a far greater challenge than one for a dual facing multi-storey house in an elevated location.

3.3 The building components that facilitate natural ventilation can include:

- Windows, doors and rooflights to apartments (livingrooms, bedrooms, etc)
- Background ventilators to all rooms
- Passive stack ventilator to wet rooms (kitchens, bathrooms, etc)

However, natural ventilation is commonly combined with intermittent mechanical extract.

Mechanical ventilation

3.4 A mechanical ventilation system normally relies on air movement generated by a powered fan. The effectiveness of a mechanical ventilation system relies on the design, appropriate product/component selection, installation, workmanship, commissioning, maintenance and the awareness of the correct operation of the system by the occupier of the dwelling. In systems where air is mechanically introduced into the building, treatment by filters may improve the quality of the indoor air but they must be cleaned/replaced at the correct intervals.

3.5 Mechanical ventilation systems commonly include:

- Localised intermittent mechanical extract ventilation with natural supply (e.g. kitchen/bathroom fans with background ventilator)
- Continuous mechanical extract ventilation with a natural supply providing "whole house" ventilation
- Continuous (balanced) mechanical supply and extract (with or without heat recovery) providing "whole house" ventilation

3.6 Even within dwellings with mechanical supply and extract, windows will still be used at certain times, for example, purge ventilation or cooling the building in summer.

4 Ventilation Design Pre and Post Construction.

Note: flow charts removed from revised document on the basis that guidance on choice of ventilation solution is now more explicit.

4.1 This section provides an outline of the processes that can be followed to determine the adequacy of a ventilation strategy adopted for a new dwelling in relation to, initially the designed, and ultimately the "as-constructed" air infiltration levels.

4.2 As noted in clause 3.14.2, guidance to the standard sets out three forms of supply and extract ventilation, with provision recommended on the basis of the design and confirmed infiltration rate for the dwelling as follows:

Ventilation type	Suitable for infiltration rate:
Natural ventilation (with intermittent mechanical extract)	$\geq$ 5 $m^3/(h.m^2)$@50Pa
Continuous mechanical extract ventilation	$\geq$ 3 $m^3/(h.m^2)$@50Pa
Continuous mechanical supply & extract ventilation	Any

It is essential that the basic ventilation strategy is determined at early design stage. There are three routes to follow, depending on the design intent for the fabric infiltration level of the proposed dwelling The intended design infiltration rate will therefore fall into one of three categories:

- 'very low infiltration' - 3 $m^3/(h.m^2)$@50Pa or tighter,
- 'low infiltration' - between 3 and 5 $m^3/(h.m^2)$@50Pa and
- 'higher infiltration' - 5 $m^3/(h.m^2)$@50Pa or more.

4.3 Once construction of the dwelling is complete, the air-tightness test results (see paragraph 2.5) should be compared with the declared design value used to determine the ventilation strategy. Where the test results differ from the design figure, the following actions are likely to be needed. Note that the following examples assume that the ventilation solution recommended in guidance is applied based upon the declared design infiltration rate. For other solutions, seek specialist advice.

4.4 Note that a tested infiltration rate poorer than the declared design intent or change of ventilation solution will result in a need to demonstrate that the dwelling still complies with standard 6.1 and the energy and emissions targets set under that standard.

4.5 **Declared design infiltration rate of 3 m³/(h.m²)@50Pa or below - 'very low infiltration' -** Continuous mechanical supply & extract ventilation

- If test reports below 3 m³/(h.m²)@50Pa – ventilation solution remains appropriate.
- If test reports above 3 m³/(h.m²)@50Pa – ventilation solution remains appropriate but seek advice from system designer to assess impact on overall dwelling ventilation rate due to any increased infiltration element.

4.6 **Declared design infiltration rate of between 3 and 5 m³/(h.m²)@50Pa or tighter - 'low infiltration'** - Continuous mechanical supply & extract ventilation

- If test reports below 3 m³/(h.m²)@50Pa – seek advice from system designer to assess impact on overall dwelling ventilation rate due to any reduced infiltration element. Evidence of adequacy of ventilation based upon the test infiltration value should be provided to the verifier.
- If test reports between 3 and 5 m³/(h.m²)@50Pa – ventilation solution remains appropriate
- If test reports above 5 m³/(h.m²)@50Pa –ventilation solution remains appropriate but seek advice from system designer to assess impact on overall dwelling ventilation rate due to any increased infiltration element.

4.7 **Declared design infiltration rate of 5 m³/(h.m²)@50Pa or higher - 'higher infiltration'** - Natural ventilation (with intermittent mechanical extract)

- If test reports below 5 m³/(h.m²)@50Pa – seek advice from system designer to assess impact on overall dwelling ventilation rate due to any reduced infiltration element. Evidence of adequacy of ventilation based upon the test infiltration value should be provided to the verifier. Depending upon the test result, altering the ventilation solution to a continuous mechanical extract ventilation solution may also be a consideration.
- If tested above 5 m³/(h.m²)@50Pa –ventilation solution remains appropriate.

4.8 Further advice on airtightness testing is available in the BSD document: 'Sound and Airtightness Testing'.

5 Natural Ventilation with Intermittent Mechanical Extract – Installation and Commissioning

5.1 Natural ventilation of a dwelling may be achieved by the operation of background ventilators and intermittent mechanical extract. As noted in clause 3.14.4, passive stack ventilation can be considered as an alternative to mechanical ventilation in some cased, subject to specialist advice.

5.2 An intermittent extract fan is a mechanical ventilator that does not run continuously, usually only running when there is a particular need to remove pollutants or water vapour (e.g. during cooking or bathing). Intermittent operation may be under either manual control or automatic control. Humidistat control should be used for areas that are designated for the drying of washing.

5.3 An installation consisting of background ventilators and intermittent extract fans is not recommended for a dwelling with an air-tightness level tighter than 5 $m^3/hr/m^2$@50Pa.

5.4 To reduce the effect of stratification and promote air movement, the location of background ventilators should be carefully considered. Although routinely installed in window heads this may not be the ideal location due to the potential for curtains, blinds, etc. to reduce air flows. Factors such as the size and shape of the room and the availability of external walls should be taken into account. For example, rather than one high level background ventilator it is often better to provide two smaller ventilators with the same combined equivalent area located at high and low levels on opposite walls.

5.5 Consideration should also be given to the accessibility and usability of ventilators by occupants and their location relative to heating components, such as radiators, to reduce the unwanted effects of draughts from incoming fresh air and to distribute air within the room.

5.6 Where a background ventilator is incorporated in an external wall a proprietary wind cowl or restrictor may be necessary to reduce wind noise and/or draughts and over provision of ventilation, which may prevent the occupier using it.

Installation

5.7 In all cases, the product manufacturer's installation instructions should be followed.

5.8 **Performance criteria – supply**. Supply of air to the dwelling is met by background ventilators. Provisions are set out in clause 3.14.4.

5.9 **Performance criteria – extract**. The provision of ventilation, in respect of intermittent extract rates are set out in clauses 3.14.4.

5.10 **Air Flow within dwelling**. To assist in good air transfer throughout the dwelling, provision should be made for air transfer between rooms and circulation space/other rooms as noted in clause 3.14.2.

5.11 **Duct runs.** The location of the fan unit should minimise overall duct run length, both from the internal terminals to the fan unit and from the fan unit to the external discharge terminal.

Where a duct breaches a vapour control layer, the continuity of the layer should be reinstated.

Refer to section 8 for ventilation ductwork.

5.12 **Fitting through external wall**. Where the fan is installed through a wall:

- the cored hole (and duct) should have a slight downward angle towards the outside to promote condensate drainage and avoid the risk of water ingress;

- the duct that connects the fan outlet to the terminal should be at least the diameter of the fan outlet; and

The duct should be rigid and be sealed to the external and internal wall leafs to maintain air tightness. However, flexible ducting may be used where rigid ducting is not possible, providing delivered ventilation rates are not compromised.

5.13 **Fitting through window**. Where a fan is installed through a window the window and glass should be assessed for its suitability to incorporate the fan unit. A mounting kit from the manufacturer of the fan unit should be used.

5.14 External discharge terminals – roof and wall mounted. Proprietary terminals should be used.

The free area of the terminal opening should be a minimum of 90% of the free area of the ducting being used. The terminals should prevent rain, birds and large insects from entering the system (however, fine fly-proof mesh should not be fitted).

The location of the external discharge terminal should minimise the potential for recirculation of extract air through ventilation air inlets.

A cored hole (and duct) through the external wall should have a slight downward angle towards the outside to promote condensate drainage and avoid the risk of water ingress.

To avoid noxious or dangerous gasses from entering the dwelling the external discharge terminal should be located remote from any flue or drainage vent pipe. Refer to Section 3, Environment, of the Technical Handbooks for guidance.

5.15 **Controls – operation**. If control of the fan speed is undertaken manually, the method of operating the fan in boost mode should be made obvious. Switching should be provided locally to the spaces being served, e.g. bathrooms, kitchen.

5.16 **Controls – isolation**. A local manual override control should be provided to an extract fan with automatic control to allow, amongst other things, for maintenance of the unit. This manual override control should be situated in a location that will not encourage its use as an "on-off switch" by the occupants.

5.17 **Controls – accessibility**. Manual switching controls for the fans should be accessible and positioned at least 350 mm from an internal corner and between 900 – 1100 mm above floor level.

5.18 **Noise – internal**. Extract fans should be capable of passing the required continuous air flow rate, at the available pressure drop, without generating excessive noise (maximum of 30 dB $_{LAeq.T}$ to bedrooms and livingrooms and 35 dB $_{LAeq.T}$ to less sensitive rooms, such as kitchens).

5.19 **Noise – external**. In situations where external noise is likely to be a nuisance to the occupants a sound attenuator may be fitted to the duct. It should be noted, however, that sound attenuators can reduce the air flow rate and a larger capacity fan may be necessary to achieve the minimum extraction rates needed.

Commissioning

5.20 **Written information**. A report containing the information gathered from the commissioning and testing of the ventilation systems should be prepared and submitted to the verifier.

A copy of the report, together with written information on the design and use of the system should be provided to the owner (see section 9 of this document).

5.21 **Initial visual inspection**. Verify that system is installed in accordance with the design criteria; Refer to information recorded during the construction process to confirm no issues identified and unresolved.

All temporary protection and packaging has been removed from all products.

All fans and terminals are in good condition with no obvious defects that will be hazardous or affect the system performance.

5.22 **Functional checks**. Check fan operates correctly when activated by manual control (e.g. light switch), or automatic control (e.g. humidistat activated at greater than 60% humidity); and

Check that the fan switches off after controls are de-activated and in the case of run-on timers, that these continue to operate for the period set by the designer.

5.23 **Airflow measurement**. All intended background ventilators or other air transfer devices should be open. All internal and external doors and windows should be closed, including the room in which measurement is being carried out.

Airflow measurements should be performed on each extract fan using suitable equipment, for example, a powered hood or a vane anemometer or similar airflow device with proprietary hood attachment and results recorded in litres per second (l/s). The airflow device should be capable of achieving an accuracy of ± 5% and have been calibrated within the last 12 months at a UKAS accredited calibration centre.

Reference should be made to design airflow rates. These and the measured airflow for each extract fan should be recorded on the commissioning sheet.

5.24 **Controls**. All local controls should be installed following the manufacturer's instructions and clearly labelled, indicating their function.

Where manual controls are provided clear and detailed written instructions should be made available to the occupier.

Where control of the fan is automated, the controls are configured to ensure that such operation, e.g. rapid changes in fan speed, are not disturbing to occupants.

As far as practical, the correct operation of each control function should be tested and the extent and result of this exercise recorded.

6 Continuous Mechanical Extract Ventilation – Installation and Commissioning

6.1 A continuously operating mechanical extract ventilation system comprises of a centrally located extract unit with multiple extract points, or separate extract fan units, both designed to provide whole dwelling ventilation via a continuous low level extract rate from each moisture producing area within the dwelling. The unit or fans have a manually operated or automated (with humidity control) boost facility. Replacement air is provided throughout the dwelling by infiltration and background ventilator provision.

6.2 A continuous mechanical extract ventilation system is not recommended for very low infiltration dwellings, with a designed or confirmed air-tightness level tighter than 3 $m^3/(h.m^2)$@50Pa.

6.3 To reduce the effect of stratification and promote air movement, the location of background ventilators should be carefully considered. Although routinely installed in window heads this may not be the ideal location due to the potential for curtains, blinds, etc. to reduce air flows. Factors such as the size and shape of the room and the availability of external walls should be taken into account. For example, rather than one high level background ventilator it is often better to provide two smaller ventilators with the same combined equivalent area located at high and low levels on opposite walls.

6.4 Consideration should also be given to the accessibility and usability of ventilators by occupants and their location relative to heating components, such as radiators, to reduce the unwanted effects of draughts from incoming fresh air and to distribute air within the room.

6.5 Where a background ventilator is incorporated in an external wall a proprietary wind cowl or restrictor may be necessary to reduce wind noise and/or draughts and over provision of ventilation, which may prevent the occupier using it.

Installation

6.6 The product manufacturer’s installation instructions should be followed.

6.7 **Performance criteria – supply**. Supply of air to the dwelling is met by background ventilators. Provisions are set out in clause 3.14.5.

6.8 **Performance criteria –** extract. The provision of ventilation, in respect of extract rates at continuous and high/boost level are set out in clauses 3.14.2 & 3.14.5.

6.9 **Air flow**. To assist in good air transfer throughout the dwelling, provision should be made for air transfer between rooms and circulation space/other rooms as noted in clause 3.14.2.

6.10 **Fan Unit (central)**. The fan unit should be:

- located as specified by the system designer.
- location to minimise overall duct run length from the internal extract terminals to the fan unit and from the fan unit to the external discharge terminal.

- located to allow safe access to undertake routine maintenance of the unit.
- installed to allow sufficient space for replacement at the end of its operational life of both the whole unit or of key mechanical/electrical components. This should be achievable without need to remove fixed structures or remove significant lengths of connected ductwork;
- installed on a suitable sound structure, which is stable and level;
- insulated to minimise the potential of condensation forming within or on the fan unit casing. This is not necessary if the unit is pre-insulated; and
- provided with a condensate drain that terminates in an appropriate location. The condensate pipe should be installed to have a minimum 5º fall from the fan unit. The drain should be adequately secured and where passing through an unheated space must be insulated to prevent freezing. The rate of condensate forming may be several litres per day and therefore the location of the drain and its final discharge should take account of this. Connections to a waste pipe or drain should be made through a trap. However, it is not recommended that a trap is installed on the condensate pipe as this could be subject to drying out.
- installed using the manufacturer's supplied or recommended fixing brackets. Anti-vibration isolation may be necessary for the extract unit and should be located and installed in accordance with the manufacturer's instructions.

6.11 **Room Extract Terminals & Grilles**. Room air extract terminals should be installed as detailed by the system designer.

Room air extract terminals should be positioned to clear as much air from as much of the room as possible and in a bathroom or shower room ideally over the bath or shower. They should be installed at high level and away from internal doors.

Where the extract terminals are fixed, there should be a means of achieving effective balancing of the system. If this is not provided within the fan unit then dampers should be installed within the duct system to allow balancing when the system is commissioned.

If the terminals are adjustable each terminal should be capable of being locked in its commissioned position once system balance has been achieved. It is vital for the correct operation of the system that the system remains balanced in its commissioned state.

The location and performance of extract terminals should be carefully considered to ensure they do not adversely affect the safe operation of an open-flued appliance, that is, cause the spillage of combustion products from the appliance. Refer to section 3 of the Domestic Building Standards Technical Handbook for guidance

6.12 **Fixed Terminals**. If the extract air terminals are fixed, ensure that effective balancing of the system can be achieved. If this is not provided within the fan unit then dampers should be installed within the duct system to allow balancing when the system is commissioned.

6.13 **Adjustable Terminals**. Ensure each terminal/grille can be locked in its commissioned position once system balance has been achieved. It is vital for the correct operation of the system that the system remains balanced in its commissioned state.

6.14 **Duct runs.** The location of the fan unit should minimise overall duct run length, both from the internal terminals to the fan unit and from the fan unit to the external discharge terminal.

Where a duct breaches a vapour control layer, the continuity of the layer should be reinstated.

Refer to section 8 for ventilation ductwork.

6.15 **Fitting through external wall**. Where the fan is installed through a wall:

- the cored hole (and duct) should have a slight downward angle towards the outside to promote condensate drainage and avoid the risk of water ingress;
- the duct that connects the fan outlet to the terminal should be at least the diameter of the fan outlet; and

The duct should be rigid and be sealed to the external and internal wall leafs to maintain air tightness. However, flexible ducting, whilst not recommended for central systems, may be used for individual fans where rigid ducting is not practicable, providing delivered ventilation rates are not compromised.

6.16 **Fitting through window**. Where a single fan is installed through a window the window and glass should be assessed for its suitability to incorporate the fan unit. A mounting kit from the manufacturer of the fan unit should be used.

6.17 **External discharge terminals – roof and wall mounted.** Proprietary terminals should be used.

The free area of the terminal opening should be a minimum of 90% of the free area of the ducting being used. The terminals should prevent rain, birds and large insects from entering the system (however, fine fly-proof mesh should not be fitted).

The location of the external discharge terminal should minimise the potential for recirculation of extract air through ventilation air inlets.

A cored hole (and duct) through the external wall should have a slight downward angle towards the outside to promote condensate drainage and avoid the risk of water ingress.

To avoid noxious or dangerous gasses from entering the dwelling the external discharge terminal should be located remote from any flue or drainage vent pipe. Refer to Section 3, Environment, of the Technical Handbooks for guidance.

6.18 **Common ducts – connection**. Where a mechanical ventilation system gathers individual extract ducts into a common duct for discharge to an outlet, no connections to the system should be made between any exhaust fan and the outlet. The use of non-return valves is not recommended.

6.19 **Controls – operation**. If control of the fan speed is undertaken manually, the method of operating the fan in boost mode should be made obvious. Switching should be provided locally to the spaces being served, e.g. bathrooms, kitchen.

Where sensors are not pre-installed within the fan unit, or additional optional sensors can be installed, only the sensors specified by the manufacturer of the fan unit should be installed.

If sensors are duct mounted, their location should be noted and provisions for access for maintenance or replacement made.

6.20 **Controls – isolation**. Continuous ventilation systems should not allow the occupier to turn off the fan other than at the local isolator for maintenance. Provision of an on/off function may result in the fans being operated intermittently and the required continuous air flow ventilation rates not being achieved.

6.21 **Controls – accessibility**. Manual switching controls for the fans should be accessible and positioned at least 350 mm from and internal corner and between 900 – 1100 mm above floor level.

6.22 **Noise – Internal**. Extract fans and extract terminals should be capable of passing the required continuous air flow rate, at the available pressure drop, without generating excessive noise (maximum of 30 dB LAeq.T to bedrooms and livingrooms and 35 dB LAeq.T to less sensitive rooms, such as kitchens).

6.23 **Noise – external**. In situations where external noise is likely to be a nuisance to the occupants a sound attenuator may be fitted to the duct. It should be noted, however, that sound attenuators can reduce the air flow rate and a larger capacity fan may be necessary to achieve the minimum extraction rates needed.

Commissioning

6.24 **Written information**. A report containing the information gathered from the commissioning and testing of the ventilation systems should be prepared and submitted to the verifier.

6.25 A copy of the report, together with written information on the design and use of the system should be provided to the owner (see section 9 of this document).

6.26 **Initial visual inspection**. Verify that system is installed in accordance with the design criteria; Refer to information recorded during the construction process to confirm no issues identified and unresolved.

All temporary protection and packaging has been removed from all products.

All ductwork and terminals are in good condition with no obvious defects that will be hazardous or affect the system performance.

On the initial start-up check that air flow direction is correct at each room terminal.

Check for any abnormal noises on start-up or when the system is running in normal background ventilation mode or when running at high rate (some units have a start-up diagnostic sequence that runs the fans at maximum speed before reverting to normal operation – refer to the manufacturer's instructions).

6.27 **Airflow balancing**. The system should be balanced to ensure that the designed air flow rates are achieved at each room. As there are several methods of control that may be used in domestic systems the system manufacturer's instructions should be followed to achieve balancing.

If specific details are not included the following steps should be adopted:

Adjustable terminals and a fixed (stepped) speed fan:

- The fan speed should be set to achieve the desired continuous flow rate;
- The index terminal flow rate is set to full open and all other terminals are adjusted to achieve the required flows at each terminal. (The index terminal can be assumed to be the furthest from the fan unit);
- If the total flow rate cannot be achieved through all the terminals then the fan speed should be increased; and
- If all the terminals have to be closed significantly to achieve the required air flow rate then reduce the fan speed and rebalance the terminals.

Adjustable terminals and a controllable speed fan:

- The fan speed should be set approximately to achieve the desired continuous flow rate;
- The index terminal flow rate should be set with the terminal fully open and all other terminals are adjusted to achieve the required flows at each terminal; and
- If the index terminal has to be closed to achieve the required air flow rate, then reduce the fan speed and rebalance the terminals;

Fixed terminals with flow adjustment by duct damper or similar device at the fan unit - as above depending on the type of fan speed control.

Adjustable terminals and a fixed volume flow fan:

- The fan speed should be set to achieve the desired continuous flow rate.
- The index terminal flow rate should be set with the terminal fully open and all other terminals are adjusted to achieve the required flows at each terminal.
- Adjustment of the terminals achieves balancing only; total flow rate is governed by the fan control setting. Great care should be taken not to close the terminals too far as the fan unit will always maintain a constant volumetric flow rate; closing the terminals will only require the fan to work harder to achieve a given air flow rate.

Fixed terminals with an automatic flow adjustment at the fan unit:

- The fan speed should be set to achieve the desired continuous flow rate; and
- The flows are balanced by automatic devices located within the fan unit and therefore no adjustment can be made.

6.28 **Airflow measurement**. All intended background ventilators or other air transfer devices should be open. All internal and external doors and windows should be closed, including the room in which measurement is being carried out.

Airflow measurements should be performed on each fan or terminal using suitable equipment, for example, a powered hood or a vane anemometer or similar airflow device with proprietary hood attachment and results recorded in litres per second (l/s). The airflow device should be capable of achieving an accuracy of ± 5% and have been calibrated within the last 12 months at a UKAS accredited calibration centre.

Reference should be made to design airflow rates. These and the measured airflow for each extract fan should be recorded on the commissioning sheet. Measurements should be taken at both maximum rate and minimum rate fan speeds

6.29 **Controls**. All local controls should be installed following the manufacturer's instructions and clearly labelled, indicating their function.

Where manual controls are provided clear and detailed written instructions should be made available to the occupier.

Where control of the fan is automated, the controls are configured to ensure that such operation, e.g. rapid changes in fan speed, are not disturbing to occupants.

If sensors have been installed separately from the fan unit, ensure installation follows the manufacturer's instructions.

Where control of the fan is automated, the controls should be configured to minimise the occurrence of 'hunting'. Hunting is where the fan speed continually increases and decreases. If this does occur, the occupants may seek to modify the control system or turn it off to remove the noise nuisance.

As far as practical, the correct operation of each control function should be tested and the extent and result of this exercise recorded.

7 Continuously Operating Balanced Supply and Extract Ventilation – Installation and Commissioning

7.1 A continuously operating balanced supply and extract ventilation system consists of centrally ducted supply and extract fans that operate continuously. The extract ducts serve the moisture producing areas of the dwelling with the supply ducts serving the habitable rooms. Free movement of air between these areas and rooms is therefore essential.

7.2 Systems with heat recovery operate by passing the warm extracted air through a heat exchanger prior to it being exhausted to external air. The recovered heat is then used to preheat the supply air before it is distributed to the habitable rooms. It is common in very low infiltration buildings for a balanced supply and extract system to be installed with heat recovery as the heat exchanger accounts for a relatively small proportion of the overall installation costs. A continuously operating balanced supply and extract system is suitable for dwellings regardless of the level of air-tightness.

7.3 Continuously operating balanced supply and extract systems (with or without heat recovery) are recommended for dwellings with very low infiltration, that being with an air-tightness level tighter than 3 $m^3/hr/m^2$@50Pa.

Installation

7.4 The product manufacturer's installation instructions should be followed.

7.5 **Performance criteria – supply**. Supply of air to the dwelling is met by continuous mechanical supply. Provisions are set out in clause 3.14.2 & 3.14.6.

7.6 **Performance criteria – extract**. The provision of ventilation, in respect of extract rates at continuous and high/boost level are set out in clauses 3.14.2 & 3.14.6.

7.7 **Air flow**. To assist in good air transfer throughout the dwelling, provision should be made for air transfer between rooms and circulation space/other rooms as noted in clause 3.14.2.

7.8 **Fan Unit (central).** The fan unit should be:

- located as specified by the system designer.
- location to minimise overall duct run length from the internal supply and extract terminals to the fan unit, from the fan unit to the external discharge terminal and from the external supply terminal to the fan unit;
- located to allow safe access to undertake routine maintenance of the unit, including changing or cleaning filters;
- installed to allow sufficient space for replacement at the end of its operational life of both the whole unit or of key mechanical/electrical components. This should be achievable without the need to remove fixed structures or remove significant lengths of connected ductwork;
- installed on a suitable sound structure, which is stable and level;
- insulated to minimise the potential of condensation forming within, or on, the fan unit casing. This is not necessary if the unit is pre-insulated;
- provided with a condensate drain that terminates in an appropriate location. The condensate pipe should be installed to have a minimum 5º fall from the fan unit. The drain should be adequately secured and where passing through an unheated space must be insulated to prevent freezing. The rate of condensate forming may be several litres per day and therefore the location of the drain and its final discharge should take account of this. Connections to a waste pipe or drain should be made through a trap; however, it is not recommended that a trap is installed on the condensate pipe as this could be subject to drying out.
- installed using the manufacturer's supplied or recommended fixing brackets. Anti-vibration isolation may be necessary for the extract unit and should be located and installed in accordance with the manufacturer's instructions.

7.9 **Room Extract Terminals & Grills**. Room air supply and extract terminals should be installed as detailed by the system designer;

Room supply terminals should be installed at high level, away from internal doors and directed across an area of unobstructed ceiling to provide good mixing without causing draughts.

Room extract terminals should be positioned to clear as much air from as much of the room as is practical and in a bathroom or shower room should ideally be positioned over the bath or shower. They should be installed at high level and away from internal doors.

In open plan areas where both supply and extract terminals may be installed, for example kitchen/dining rooms, consideration should be given to the proximity of the terminals to avoid short circuiting of the air. That is, to avoid the replacement air being extracted before it has mixed with or displaced stale air.

The number and location of terminals installed in a ventilated space should allow effective air distribution and minimise air noise when the system is operating at boosted air flow rates.

The location and performance of extract terminals should be carefully considered to ensure that they will not adversely affect the safe operation of an open flued appliance, that is, cause the spillage of combustion products for the appliance. Refer to Section 3 of the Technical Handbooks for guidance.

7.10 **Fixed Terminals**. If the supply and extract air terminals are fixed, ensure that effective balancing of the system can be achieved. If this is not provided within the fan unit then dampers should be installed within the duct system to allow balancing when the system is commissioned

7.11 **Adjustable Terminals**. Ensure each terminal/grille can be locked in its commissioned position once system balance has been achieved. It is vital for the correct operation of the system that the system remains balanced in its commissioned state.

7.12 **Duct runs**. The location of the fan unit should minimise overall duct run length, both from the internal terminals to the fan unit and from the fan unit to the external discharge terminal.

Where a duct breaches a vapour control layer, the continuity of the layer should be reinstated.

Refer to section 8 for ventilation ductwork.

7.13 **Common ducts - connection**. Where a mechanical ventilation system gathers individual extract ducts into a common duct for discharge to an outlet, no connections to the system should be made between any exhaust fan and the outlet. The use of non-return valves is not recommended.

7.14 **Fitting through external wall**. Where a duct is installed through a wall:

- the cored hole (and duct) should have a slight downward angle towards the outside to promote condensate drainage and avoid the risk of water ingress;
- the duct that connects the outlet to the terminal should be at least the diameter of the terminal; and

The duct should be rigid and be sealed to the external and internal wall leafs to maintain air tightness. Flexible ducting is not recommended for central systems except where rigid ducting is not practicable, providing delivered ventilation rates are not compromised.

7.15 **External discharge terminals – roof and wall mounted**. Proprietary terminals should be used.

The free area of the terminal opening should be a minimum of 90% of the free area of the ducting being used. The terminals should prevent rain, birds and large insects from entering the system (however, fine fly-proof mesh should not be fitted).

The location of the external discharge terminal should minimise the potential for recirculation of extract air through ventilation air inlets.

A cored hole (and duct) through the external wall should have a slight downward angle towards the outside to promote condensate drainage and avoid the risk of water ingress.

To avoid noxious or dangerous gasses from entering the dwelling the external discharge terminal should be located remote from any flue or drainage vent pipe. Refer to Section 3, Environment, of the Technical Handbooks for guidance.

7.16 **Controls – operation**. If control of the fan speed is undertaken manually, the method of operating the fan in boost mode should be made obvious. Switching should be provided locally to the spaces being served, e.g. bathrooms, kitchen.

A remote fault/status indicator should be provided in a circulation area, such as a hallway, to alert occupiers if the system is not functioning correctly.

Where sensors are not pre-installed within the fan unit, or additional optional sensors can be installed, only the sensors specified by the manufacturer of the fan unit should be installed.

7.17 If sensors are duct mounted, their location should be noted and provisions for access for maintenance or replacement made.

7.18 **Controls – isolation**. Continuous ventilation systems should not allow the occupier to turn off the fan other than at the local isolator for maintenance. Provision of an on/off function may result in the fans being operated intermittently and the required continuous air flow ventilation rates not being achieved

7.19 **Controls – accessibility**. Manual switching controls for the fans should be accessible and positioned at least 350 mm from and internal corner and between 900 – 1100 mm above floor level.

7.20 **Noise – Internal**. Fan unit, air supply and extract terminals should be capable of passing the required continuous air flow rate, at the available pressure drop, without generating excessive noise (maximum of 30 dB LAeq.T to bedrooms and livingrooms and 35 dB LAeq.T to less sensitive rooms, such as kitchens).

7.21 **Noise – external**. In situations where external noise is likely to be a nuisance to the occupants a sound attenuator may be fitted to the duct. It should be noted, however, that sound attenuators can reduce the air flow rate and a larger capacity fan may be necessary to achieve the minimum extraction rates needed

Commissioning

7.22 **Written information**. A report containing the information gathered from the commissioning and testing of the ventilation systems should be prepared and submitted to the verifier.

A copy of the report, together with written information on the design and use of the system should be provided to the owner (see section 9 of this document).

7.23 **Initial visual inspection**. Verify that system is installed in accordance with the design criteria; Refer to information recorded during the construction process to confirm no issues identified and unresolved.

All temporary protection and packaging has been removed from all products.

All ductwork and terminals are in good condition with no obvious defects that will be hazardous or affect the system performance.

On the initial start-up check that air flow direction is correct at each room terminal.

Check for any abnormal noises on start-up or when the system is running in normal background ventilation mode or when running at high rate (some units have a start-up diagnostic sequence that runs the fans at maximum speed before reverting to normal operation – refer to the manufacturer’s instructions).

7.24 **Airflow balancing**. The system should be balanced to ensure that the designed air flow rates are achieved at each room. As there are several methods of control that may be used in domestic systems the system manufacturer’s instructions should be followed to achieve balancing.

If specific details are not included the following steps should be adopted:

Adjustable terminals and a fixed (stepped) speed fan:

- the fan speed should be set to achieve the desired continuous flow rate;
- the index terminal flow rate is set to full open and all other terminals are adjusted to achieve the required flows at each terminal. (The index terminal can be assumed to be the furthest from the fan unit);
- if the total flow rate cannot be achieved through all the terminals then the fan speed should be increased; and
- if all the terminals have to be closed significantly to achieve the required air flow rate then reduce the fan speed and rebalance the terminals.

Adjustable terminals and a controllable speed fan:

- the fan speed should be set approximately to achieve the desired continuous flow rate;
- the index terminal flow rate should be set with the terminal fully open and all other terminals are adjusted to achieve the required flows at each terminal; and
- if the index terminal has to be closed to achieve the required air flow rate, then reduce the fan speed and rebalance the terminals;

Fixed terminals with flow adjustment by duct damper or similar device at the fan unit - as above depending on the type of fan speed control.

Adjustable terminals and a fixed volume flow fan:

- The fan speed should be set to achieve the desired continuous flow rate.
- The index terminal flow rate should be set with the terminal fully open and all other terminals are adjusted to achieve the required flows at each terminal.
- Adjustment of the terminals achieves balancing only; total flow rate is governed by the fan control setting. Great care should be taken not to close the terminals too far as the fan unit will always maintain a constant volumetric flow rate; closing the terminals will only require the fan to work harder to achieve a given air flow rate.

Fixed terminals with an automatic flow adjustment at the fan unit:

- The fan speed should be set to achieve the desired continuous flow rate; and

- The flows are balanced by automatic devices located within the fan unit and therefore no adjustment can be made.

7.25 **Airflow measurement**. All internal and external doors and windows should be closed, including the room in which measurement is being carried out.

Airflow measurements should be performed in each terminal using suitable equipment, for example, a powered hood or a vane anemometer or similar airflow device with proprietary hood attachment and results recorded in litres per second (l/s). The airflow device should be capable of achieving an accuracy of ± 5% and have been calibrated within the last 12 months at a UKAS accredited calibration centre.

7.26 Reference should be made to design airflow rates. These and the measured airflow for each extract fan should be recorded on the commissioning sheet. Measurements should be taken at both maximum rate and minimum rate fan speeds.

7.27 **Controls**. All local controls should be installed following the manufacturer's instructions and clearly labelled, indicating their function.

Where manual controls are provided clear and detailed written instructions should be made available to the occupier.

Where control of the fan is automated, the controls are configured to ensure that such operation, e.g. rapid changes in fan speed, are not disturbing to occupants.

If sensors have been installed separately from the fan unit, ensure installation follows the manufacturer's instructions.

Where control of the fan is automated, the controls should be configured to minimise the occurrence of 'hunting'. Hunting is where the fan speed continually increases and decreases. If this does occur, the occupants may seek to modify the control system or turn it off to remove the noise nuisance.

As far as practical, the correct operation of each control function should be tested and the extent and result of this exercise recorded.

8 Ventilation Ductwork

8.1 General Recommendations

Ducting should be:

- sized to minimise pressure loss and noise generation. This is achieved by sizing of the ducts and terminals to limit the air velocity. The main ducts should be the same size as the fan unit spigot; and
- routed in a manner which minimises overall duct length and the number of bends required. It is particularly important to minimise bends in main ducts operating at higher air velocities.
- installed where it cannot be easily damaged e.g. not across open loft areas where it may be stood on;
- installed to allow sufficient space to allow access for cleaning ducts where room extract terminal/grilles are not fitted with filters;

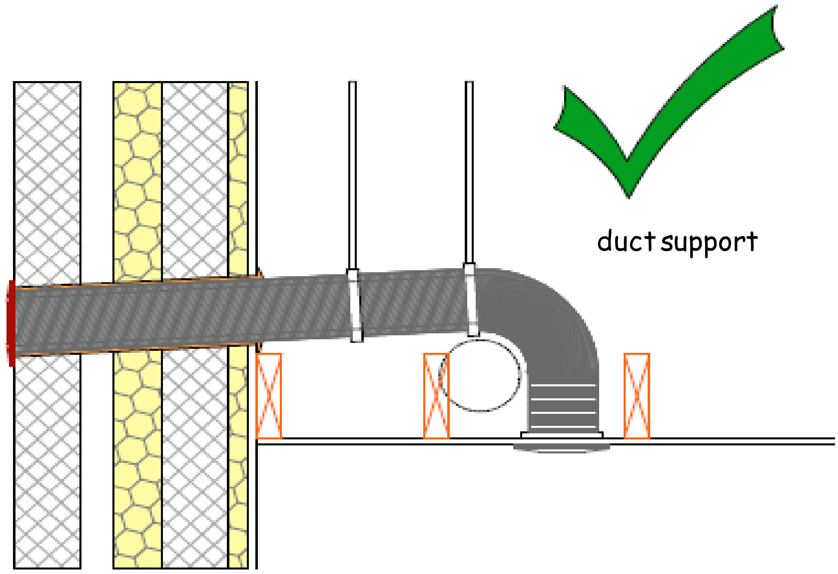
- insulated where it is passes through unheated areas with the equivalent of at least 25 mm of a material with a thermal conductivity of not more than 0.04 W/mK. This reduces the risk of condensation occurring within the duct;
- insulated or be fitted with a condensate trap where a duct extends above roof level. The condensate trap should be fitted just below roof level;
- insulated where carrying cold air between the external supply/discharge terminal(s) and a fan unit sited within the heated envelope. A vapour barrier should be wrapped outside the insulation to prevent condensation occurring within the insulation material, alternatively, rigid insulation of a type that is unaffected by moisture may be used;
- fitted with a condensate trap where it is installed vertically. The trap should prevent condensation flowing down the duct and potentially damaging a mechanical extract fan;
- arranged to slope slightly downwards away from the fan unit, to prevent backflow of any moisture into the unit, when installed horizontally;

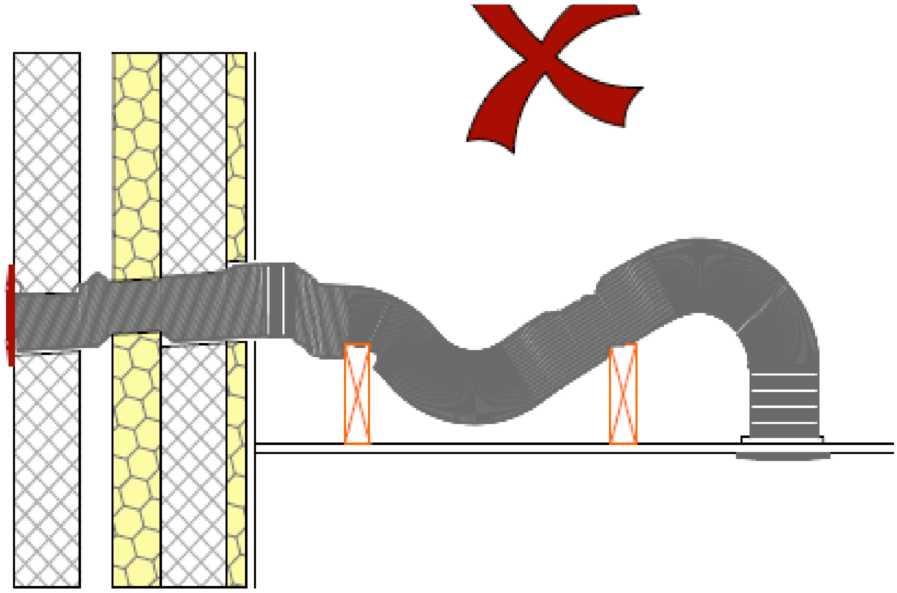
8.2 **Flexible ducting**

- Rigid ducts should be used wherever possible. Where flexible ductwork is installed this should only be used for final connections and duct lengths should be kept to a minimum. All flexible ductwork should meet the standards of BSRIA BG 43/2013.
- Flexible ducting is generally only suitable for single extract fan installations; refer to extract fan manufacturer's instructions.
- Ducting should be pulled taut to ensure that the full internal diameter is obtained and flow resistance minimised. This is considered to have been achieved if the duct is extended to 90% of its maximum length.
- Flexible ducting should be supported at suitable intervals to minimise sagging. Refer to manufacturer's information but generally it should be supported at no greater than 600 mm intervals;
- Bends in ducts should have a minimum inside radius equal to the diameter of the duct. If tighter bends are required, rigid bends should be used; and
- perforated insulated flexi duct, used to minimise airborne sound transmission, should not be used between the fan unit and the external discharge terminal to prevent condensation occurring within the insulation material.

Flexible Ducting Installation

Note: Insulation omitted to ceiling and over duct to aid clarity of duct arrangement.





8.3 Duct Connections/Terminals

- All duct connections require to be sealed. Where ducts are installed against a solid structure this can sometimes be difficult to achieve. In such locations pre-assembly of duct sections should be considered. This will require connections to be permanent to ensure the seal is maintained during installation;
- Connection of lengths of flexible duct must use a rigid connector and jubilee clips or similar to ensure a long term seal is achieved. Connections of lengths of flexible duct should not be taped only;
- Where access to ducts will not be possible after construction is complete, e.g. ductwork within floor and wall voids, consideration should be given to permanent connection and sealing with an appropriate non-hardening sealant. Using duct tape to achieve connections and seals is not recommended in these situations;

- Connection of components should not result in significant air flow resistance. Components should be proprietary and fit easily together without distortion
- Each air terminal should have a free area of at least 90% of the free area of its associated duct.

8.4 Where a duct breaches a vapour control layer the continuity of the layer should be reinstated after installation, for example, with suitable tapes or preformed sleeves.

8.5 Where an extract duct is installed this should not adversely affect the sound insulation of a separating wall or floor, internal wall or intermediate floor refer to Section 5, Noise, of the Domestic Building Standards Technical Handbook for guidance.

8.6 Where an extract duct penetrates cavity barriers or floors, ceilings and walls that require a fire resistance refer to Section 2, Fire, of the Domestic Building Standards Technical Handbook for guidance.

9 Carbon Dioxide Monitoring Equipment

9.1 This guidance supplements information provided under clause 3.14.7.

9.2 Air within a dwelling can contain an array of both naturally occurring and synthetic contaminants, particulates and gases. The majority of these contaminants are not easily identifiable to the occupants, even at relatively high levels. Research carried out recently for the Building Standards Division[1] (available here) indicated that over 90% of occupiers believe the indoor air quality within their main bedrooms is very good or fairly good. However, on-site monitoring of carbon dioxide (CO_2) levels found that 83% of properties tested had time weighted concentrations greater than 1,000 parts per million (ppm) within the main bedrooms.

9.3 Although in terms of health and safety, exposure to CO_2 levels of up to 5,000 ppm over an 8 hour period is generally not considered a risk[2], levels of over 1,000 ppm can be taken as an indicator of poor ventilation rates. High levels of CO_2 will, therefore, be associated with the presence of higher levels of other contaminants, such as volatile organic compounds, formaldehyde, particulates, bacteria, etc. The levels of these other contaminants are less easy to identify accurately without very sensitive testing equipment.

9.4 As dwellings become more air-tight the levels of uncontrolled “background ventilation” decreases. This results in a greater reliance on occupant interaction with controllable ventilators, such as windows and background ventilators, to maintain satisfactory levels of indoor air quality. However, as indicated above, occupants are frequently not aware of the need to ventilate. Therefore, to raise occupant awareness of poor ventilation, as evidenced by high levels of CO_2, the guidance to building standard 3.14 calls for a CO_2 monitor to be installed in the main or principal bedroom in a dwelling constructed to a level of air-tightness lower than 15 $m^3/hr/m^2$ at 50Pa. Dwellings with levels of air-tightness leakier than 15 $m^3/hr/m^2$ at 50Pa will have more

[1] Research Project to Investigate Occupier Influence on Indoor Air Quality in Dwellings - Mackintosh Environmental Architecture Research Unit

[2] HSE Publication EH40/2005 Workplace exposure limits - 8 hour time weighted average

uncontrolled ventilation, however, current building practices should be considered, as the completed building may be inadvertently constructed tighter than designed.

9.5 The main or principal bedroom was determined to be the best location for the CO_2 detection equipment as this is likely to be the room most frequently occupied for long periods of time. In addition, it is unlikely that the ventilation of the room will change during the period of occupation. That is to say, if windows, background ventilators or doors are closed when the residents go to bed it is unlikely that they will be opened before they rise the next day. It is reasonable to assume that if there are high levels of CO_2 indicated in the monitored bedroom, levels elsewhere in the property will also be high. The ventilation strategy adopted to reduce CO_2 should, therefore be replicated in other occupied rooms in the home.

9.6 It is not intended that the CO_2 monitoring equipment sounds an alarm if the concentration levels exceed 1,000 ppm as it is considered that this could lead to the permanent disabling of the monitor. Rather, it is intended that occupants can interrogate the equipment the next day and make informed decisions on how to ventilate their home. The Technical Handbook guidance also calls for information on the ventilation strategy and CO_2 monitoring to be provided to the householder. This information is expected to cover the operation of the specific CO_2 monitor installed (i.e. not generic guidance), an explanation of what the results the equipment is giving mean and suggested remedial action that can be taken to reduce subsequent overnight CO_2 levels.

9.7 The guidance allows the CO_2 monitoring equipment to be either a single unit with detector head and screen or separate detector and screen. In the case of a single unit this would be sited within the main or principal bedroom where the screen can be easily read. Where the detector is separate from the screen the detector should be sited in the main or principal bedroom but the monitor may be sited elsewhere, for example, in a hallway. The benefit of separate units is that additional detectors, sited in other rooms may be connected to the monitor for additional coverage.

9.8 A CO_2 monitor should be permanently fixed and is required to be mains operated. It should be capable of recording and displaying readings within a range of at least 0 – 5,000 parts per million CO_2 and logging and displaying data at no more than 15 minute intervals for at least a 24 hour period. A CO_2 monitor should be capable of measuring the actual level of carbon dioxide present in the room they are located in. Monitors that give an "equivalent" or "EQ" concentration of CO_2 are not suitable as they are not sensitive to CO_2 but are mixed gas sensors.

9.9 To allow free air movement over the detector head a CO_2 detector head should not be sited where air flow may be restricted. For example, close to corners of walls or ceiling/wall junctions, where curtains may be expected to be fitted. The average person exhales approximately 45,000 parts per million of CO_2 in every breath. Therefore to prevent potential false readings from exhaled breath the detector head should be sited away from where the head of the bed would be expected to be located.

9.10 When monitoring concentration levels of CO_2 within dwellings it should be remembered that CO_2 is present in outside air at concentration levels of between 350 and 575 ppm. As all the ventilation strategies within the Technical Handbooks rely on an exchange of air from outside the in-door concentration levels of CO_2 will be more or less the same as the external air in the proximity of the property. Although most whole house ventilation systems include some form of filtration on the incoming air ducts, even they do not prevent CO_2 entering the building.

9.11 The guidance in the Domestic Technical Handbook calls for occupiers of newly constructed dwellings to be provided with guidance on the operation of CO_2 monitoring equipment and their options for improving ventilation when indicated as necessary by the monitor.

9.12 Written information to be passed to the dwelling occupant should include:

a. The purpose of the carbon dioxide monitoring equipment is to inform occupants of CO_2 levels within their dwelling over the preceding 24 hour period. This information can then be used by the occupants to determine the quality of air within their homes and whether additional ventilation is required, for example, opening or increasing the opening of background ventilators. This section should advise that CO_2 is always present in the air we breathe at levels of around 400 ppm and that levels of CO_2 of up to 5,000 ppm are generally not considered to be a risk. However, concentration levels greater than 1,000 ppm can be indicative of poor ventilation and consequently, high levels of other contaminants.

b. Specific details of the CO_2 monitoring equipment, including manufacturer's operating instructions. Instructions on operation (manufacturer's or otherwise) should include:

- The location of the CO_2 sensor(s) and monitor
- Initial set up procedure
- How to switch between available modes, where available
- How to de-activate the audible alarm, where fitted
- How to adjust the time between data logging events, this should be set at a maximum of 15 minute intervals
- How to interrogate the monitor to determine CO_2 levels over the preceding 24 hour period
- Details and timeframe for re-calibrating the detector
- Advice on location of furniture near the detector head that may affect the operation of the unit, in particular the bedhead

c. Details of the ventilation strategy adopted in the dwelling, including but not limited to:

- Window operation, including where possible means of securing windows in a partially open position to prevent unauthorised entry
- Background ventilation location and operation
- Mechanical ventilation – intermittent operation
- Mechanical ventilation – continuous operation

d. Information on how occupants should ventilate their dwellings where the CO_2 monitor indicates concentration levels in excess of 1,000 ppm for periods of more than one hour. This information may be best presented in stages, for example:

- 800 – 999 ppm
- 1,000 – 1,199 ppm
- 1,200 – 1,499 ppm
- 1,500 – 1,999 ppm
- Over 2,000 ppm

9.13 Section 11 provides a template containing information that should be provided to occupiers of new dwellings. The text and layout within the template is intended only as a guide and should be taken as being indicative of the type of information to be provided. The generic information relating to the CO_2 monitor and ventilation options, that is, windows, background ventilators and mechanical extract fans (location and operation) should be replaced with building specific information.

10 Example format - information to the home occupier on use and interpretation of CO_2 monitoring equipment

Blank form

Address
Number and Street: Town: Postcode:
About your new home
Insert text
Ventilation Provisions
Insert text
Carbon Dioxide Monitor
Manufacturer: **Model Number:** **Frequency of re-calibration:** **Frequency of sensor replacement:** **Location:** **How to use the CO_2 monitor** Insert text **Note: CO_2 is present in internal and external air at concentration levels of around 400 parts per million (ppm). Levels of CO_2 of up to 5,000 ppm are not in themselves a danger to healthy occupants but can be indicative of the presence of high levels of other contaminants that may cause short or more long-term health issues.**
Action necessary to improve air quality
Insert text

Example of completed form

Address
20 Sunny Street Anytown XX9 1AA
About your new home
Your new home is designed and constructed so there are few leaks or draughts. However, it is important to ventilate it adequately to help maintain a healthy indoor environment for you and your family. As well as minor irritations, for example, a dry throat or headache, poor indoor air quality can also make existing conditions, such as asthma, worse. Extreme cases of poor indoor air quality may also be a causal factor of other respiratory and health conditions. It is sometimes difficult to identify when ventilation is required as it is not easy to tell when the quality of the air in your home is poor. To assist you in determining the quality of the air in your home it is fitted with a carbon dioxide (CO_2) monitor. The level of CO_2 present in your home is a good indicator of the overall quality of the air. The CO_2 monitor requires free air movement around it, therefore, do not place furniture or other objects in front of it that may impede its operation. This document provides you with information on the ventilation provisions within your home and, together with data from the CO_2 detector, how you should ventilate to maintain a healthy environment. Providing adequate ventilation will also reduce the levels of humidity within your home and therefore reduce the possibility of condensation forming.
Ventilation Provisions
Apartments Tilt and turn opening windows to all apartments with intruder resistant night latches to allow them to be locked in the partially open position. Background ventilators located in the following locations: • livingroom – one in the window head and one at low level in the east facing wall • dining room one in the window head and one at low level in the west facing wall • Bedroom 1 - one in the window head and one at low level in the west facing wall • Bedroom 2 - one in the window head and one at low level in the north facing wall • Bedroom 3 - high and low level in the north facing wall **Kitchen** Switchable two speed mechanical extract fan Background ventilator located at low level in the north facing wall **Utility room** Switchable single speed mechanical extract fan Background ventilator located at low level in the north facing wall **Bathroom** Switchable single speed mechanical extract fan Background ventilator located at low level in the east facing wall **En-suite** Switchable single speed mechanical extract fan Background ventilator located at low level in the west facing wall

Carbon Dioxide Monitor
Manufacturer: Badairre **Model Number:** 12345 **Frequency of re-calibration:** self-calibrating **Frequency of sensor replacement**: 10 years **Location:** The CO_2 monitor is located in bedroom 1 (the master bedroom) **How to use the CO_2 monitor** The manufacturer's literature accompanying this document will provide detailed advice on how to set up and operate the monitor. The CO_2 monitor will provide data on the levels of CO_2 within at least the previous 24 hours. This information will enable you to determine whether any action needs to be taken to improve the quality of the air in your home. The table below provides guidance on what action should be considered for various concentration levels. It is advisable to initially check the data daily and take whatever action is necessary to improve the indoor air quality in your home. Once the air quality has reached an acceptable level the frequency of the checks can be reduced. It should be remembered that air quality levels can vary due to many factors, so regular readings should be taken to make sure that it is still satisfactory. The CO_2 detector head is self-calibrating, the manufacturer's information on recalibration of the device should be consulted. **Note: CO_2 is present in internal and external air at concentration levels of around 400 parts per million (ppm). Levels of CO_2 of up to 5,000 ppm are not in themselves a danger to healthy occupants but can be indicative of the presence of high levels of other contaminants that may cause short or more long-term health issues.**
Action necessary to improve air quality
Your home has openable windows and controllable background ventilators to allow you to adjust the fresh air entering each room. Background ventilators are adjustable and positioned to encourage ventilation through each of the rooms. In rooms with more than one background ventilator, all ventilators should be opened similar amounts to encourage through ventilation.

CO2 level	Action
0 – 349 ppm	Check monitor is working correctly and recalibrate or replace sensor head if necessary
350 – 799 ppm	None
800 – 999 ppm	No immediate action but maintain daily monitoring
1,000 – 1,199 ppm	Partially open background ventilators or leave room door partially open
1,200 – 1,499 ppm	Fully open background ventilators or leave room door partially open
1,500 – 1,999 ppm	Partially open window
Over 2,000 ppm	Open window further and leave room door partially open
To achieve good air quality throughout your home, the ventilation actions identified above should be replicated in all occupied apartments in the dwelling.	