The Scottish Government

BUILDING STANDARDS

SUPPORTING GUIDANCE

DOMESTIC VENTILATION

2ND EDITION

Title: Building Standards Supporting Guidance Domestic Ventilation – 2nd Edition

Version	Date	Notes
1.0	01/10/10	First issue
2.0	02/12/15	Revised to reflect the changes in the Technical Handbooks introduced on 1 October 2015.
2.1	15/11/17	Revised to include flowcharts for pre and post construction design considerations

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 do*cument 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 of the Technical Handbooks should be consulted. The Technical Handbooks can be viewed here.

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.

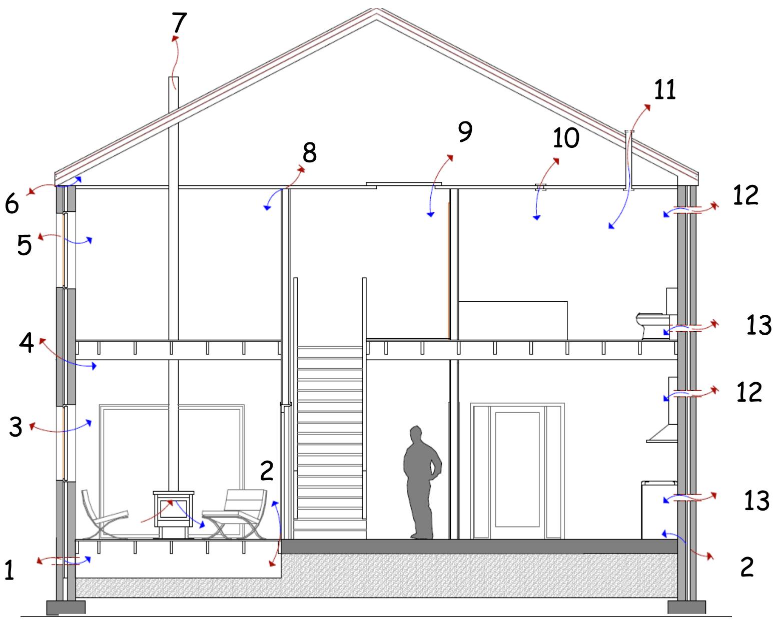
2 VENTILATION

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 trickle (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 $5m^3/h/m^2$ @ 50 Pa, may necessitate the adoption of an alternative ventilation strategy to achieve satisfactory ventilation of the dwelling. A more air tight 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 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 recommended within the guidance to building regulations that air tightness testing is carried out. The results from the test will indicate if the dwelling has been constructed 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 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 paragraph 3.4 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

3.1 Natural Ventilation

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.

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.

The building components that facilitate natural ventilation can include:

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

3.2 Mechanical ventilation

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.

Mechanical ventilation systems commonly include:

- Localised mechanical extract ventilation with natural supply (e.g. bathroom fan with trickle ventilator)
- Decentralised mechanical extract ventilation (dMEV) with a natural supply – individual continuously operating (low rate) extraction units with boost facility, usually within wet rooms (kitchens, bathrooms, etc)
- Centralised mechanical extract ventilation (MEV) with a natural supply – providing “whole house” ventilation
- Balanced mechanical supply and extract (e.g. Mechanical ventilation with heat recovery (MVHR)) – providing “whole house" ventilation

Even within dwellings with MVHR, windows may still be used at certain times, for example, cooling the building in summer.

3.3 Combined Natural and Mechanical Ventilation

It is usual for the ventilation strategy chosen for a dwelling to incorporate elements of both natural and mechanical systems (hybrid systems) to satisfy the building standards. For example, a dwelling designed where the apartments are ventilated by natural means and the moisture producing areas, such as a shower room, are mechanically ventilated.

3.4 Ventilation Design Pre and Post Construction Flowcharts

The flowcharts on the following pages provide 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. The levels of air infiltration are grouped into three categories aligning with the guidance both within this document and the Domestic Technical Handbook. The three categories of air-tightness levels used in the flowcharts are:

- 3 $m^3/hr/m^2$@50Pa or tighter,
- between 3 and 5 $m^3/hr/m^2$@50Pa and
- 5 $m^3/hr/m^2$@50Pa or leakier.

Flowchart 1 covers the basic ventilation strategy which is determined at early design stage. There are three routes to follow depending on the designed uncontrolled infiltration levels of the proposed dwelling. These routes align with the guidance within this document and the Domestic Technical Handbook relating to ventilation requirements for dwellings with infiltration rates of 3 $m^3/hr/m^2$@50Pa or tighter, between 3 and 5 $m^3/hr/m^2$@50Pa and 5 $m^3/hr/m^2$@50Pa or leakier.

Once construction of the dwelling is complete, the air-tightness test results (see paragraph 2.5) should be compared with the design figure used to determine the ventilation strategy. Where the test results differ from the design figure flowcharts 2 a, b or c should be consulted. Note that the results from a representative dwelling should be considered in relation to all dwellings forming part of that sample grouping.

Flowcharts 2 a, b & c – assist in determining the adequacy of the designed ventilation strategy post construction. Each of the flowcharts, one for each of the air-tightness categories noted above, provide routes for when the tested (or sampled) dwelling is tighter, leakier or the same as the designed level of air-tightness. Following the appropriate route will determine whether the “as designed” ventilation strategy is still fit for purpose or whether it will require to be re-evaluated.

Flowchart 1 may be re-consulted where the ventilation strategy has to be re-evaluated or an alternative way of complying is agreed with the verifier. Where an alternative ventilation strategy is required an amendment of warrant may require to be obtained prior to works commencing on site.

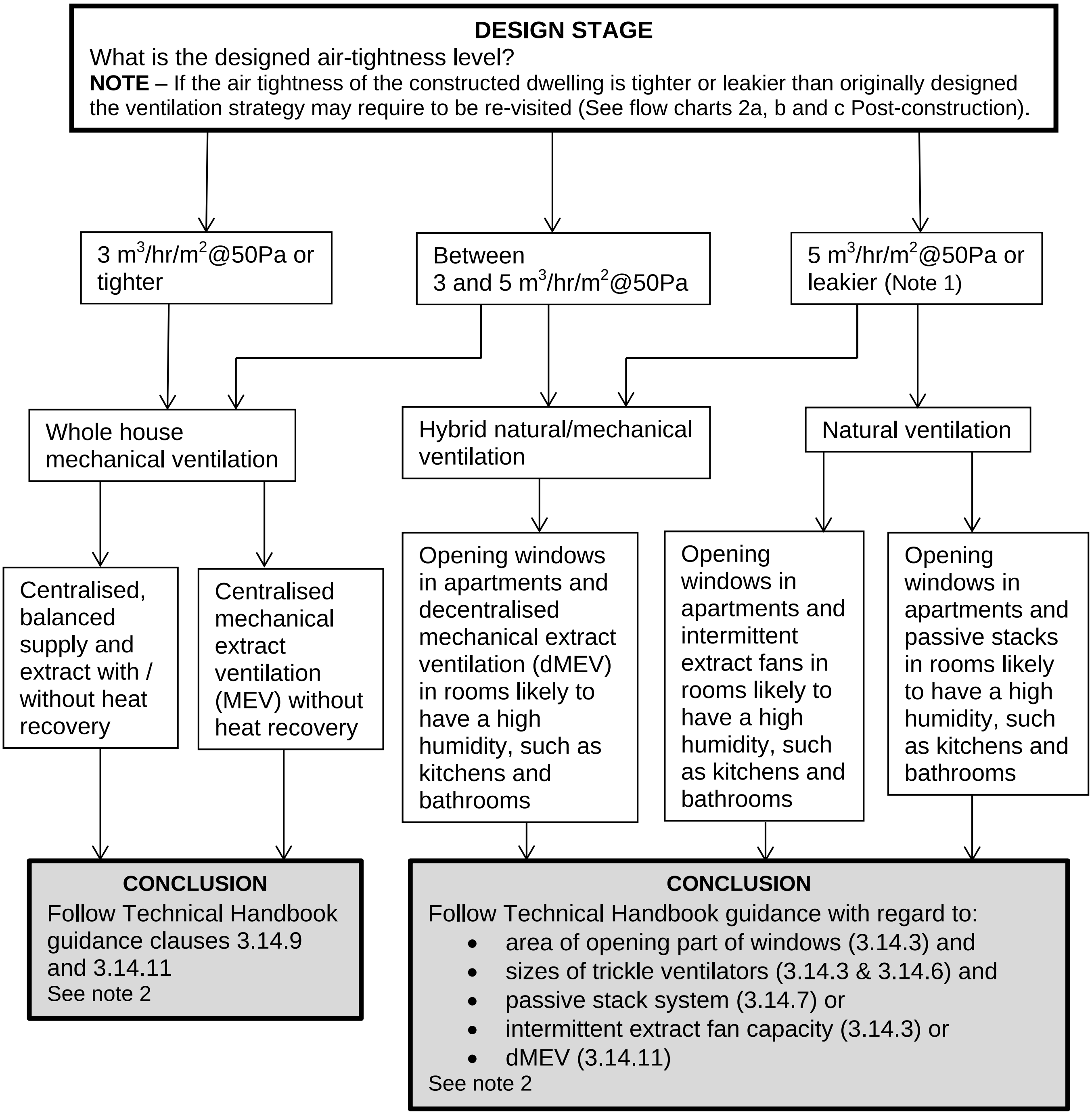
3.5 Example Ventilation Solutions

Chapter 13 provides simplified examples of combinations of ventilation solutions discussed in detail within chapters 4 to 9.

DOMESTIC VENTILATION FLOWCHART

STAGE 1 – PRE-CONSTRUCTION

DETERMINING VENTILATION STRATEGY IN A NEW DWELLING



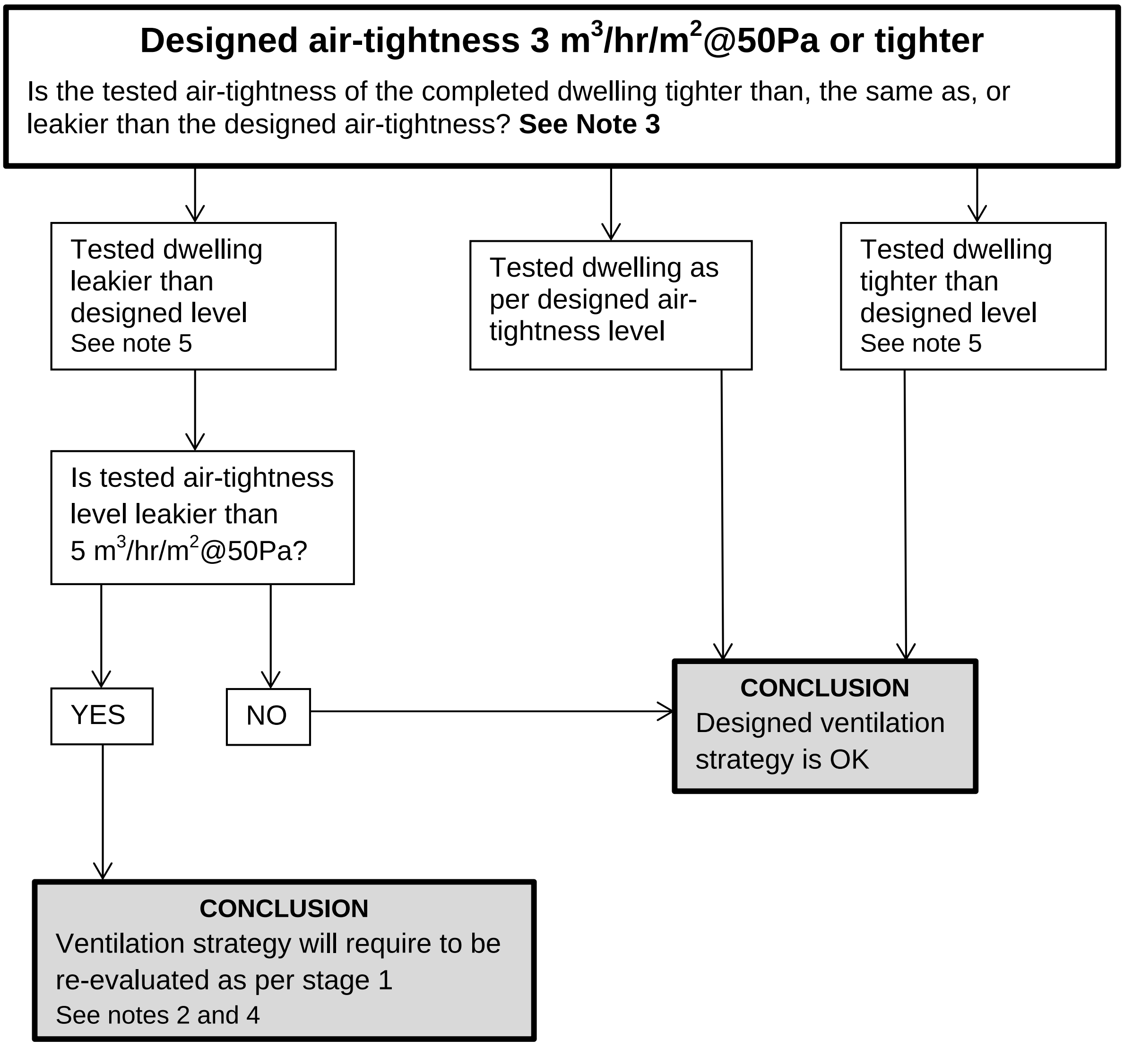
Note 1: Whole house mechanical ventilation is not generally suitable for dwellings with an air-tightness level leakier than 5 $m^3/hr/m^2$@50Pa.

Note 2: If the guidance contained within the Technical Handbook is not being followed full design information should be provided to the verifier in support of the building warrant application.

DOMESTIC VENTILATION FLOWCHART

STAGE 2a – POST-CONSTRUCTION

CONFIRMING ADEQUACY OF VENTILATION STRATEGY IN A NEW DWELLING FOLLOWING AIR-TIGHTNESS TESTING

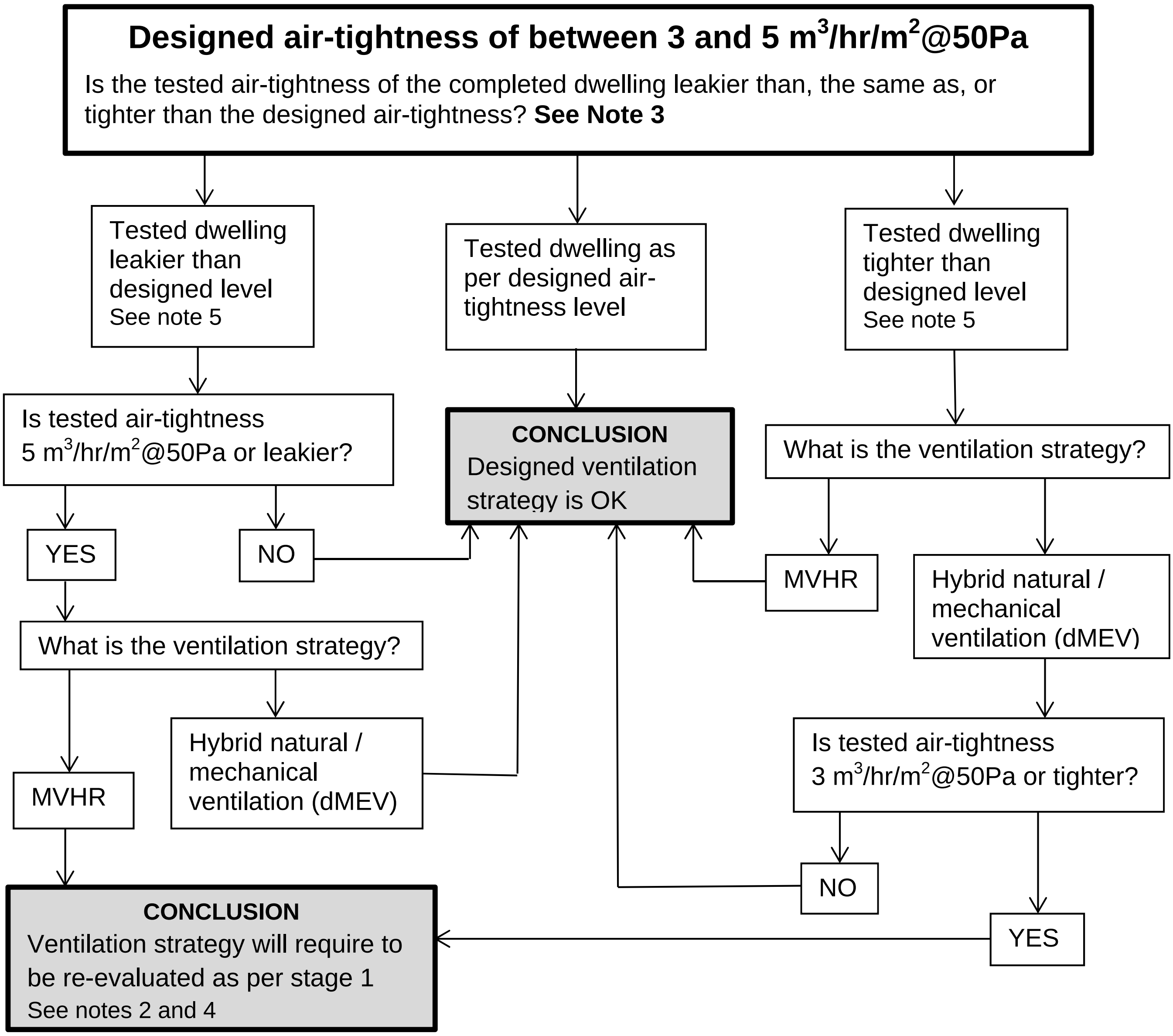


Note 2: If the guidance contained within the Technical Handbook is not being followed full design information will require to be provided to the verifier in support of the amendment of warrant application.
Note 3: The air-tightness of the completed dwelling may be the actual tested value or an indicative value from a sample group
Note 4: Where the ventilation strategy is changed an Amendment of Warrant application may be required.
Note 5: MVHR systems may require adjustments on site where the dwelling is tighter or leakier than the design assumptions

DOMESTIC VENTILATION FLOWCHART

STAGE 2b – POST-CONSTRUCTION

CONFIRMING ADEQUACY OF VENTILATION STRATEGY IN A NEW DWELLING FOLLOWING AIR-TIGHTNESS TESTING

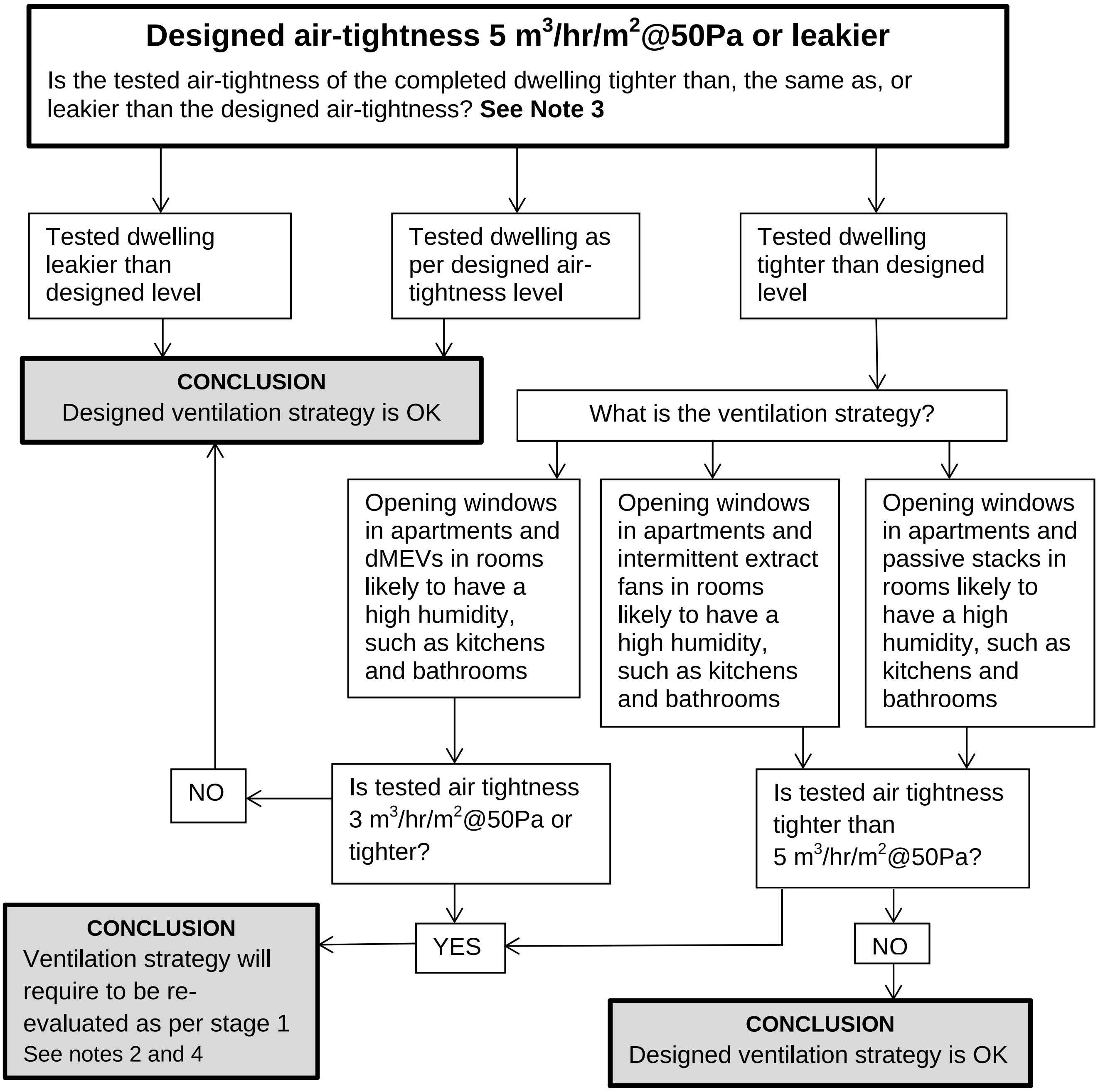


Note 2: If the guidance contained within the Technical Handbook is not being followed full design information will require to be provided to the verifier in support of the amendment of warrant application.
Note 3: The air-tightness of the completed dwelling may be the actual tested value or an indicative value from a sample group
Note 4: Where the ventilation strategy is changed an Amendment of Warrant application may be required.
Note 5: MVHR systems may require adjustments on site where the dwelling is tighter or leakier than the design assumptions

DOMESTIC VENTILATION FLOWCHART

STAGE 2c – POST-CONSTRUCTION

CONFIRMING ADEQUACY OF VENTILATION STRATEGY IN A NEW DWELLING FOLLOWING AIR-TIGHTNESS TESTING



Note 2: If the guidance contained within the Technical Handbook is not being followed full design information will require to be provided to the verifier in support of the amendment of warrant application.
Note 3: The air-tightness of the completed dwelling may be the actual tested value or an indicative value from a sample group
Note 4: Where the ventilation strategy is changed an Amendment of Warrant application may be required.

4 NATURAL VENTILATION – windows, doors and trickle ventilators

4.1 Natural ventilation of a dwelling may be achieved by the operation of ventilators such as trickle vents, windows, rooflights or doors. The trickle ventilators provide background ventilation and also replacement air for some mixed mode mechanical extract systems and passive stack ventilation systems. Windows, rooflights and external doors provide a means of rapidly ventilating a dwelling.

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

4.3 Ventilators with an opening area of at least that shown in the table below should be provided to rooms in a dwelling. The air flow performance of a trickle ventilator should be measured using the equivalent area methodology and this is usually indicated on the ventilator.

Room	**Window or External Door**	**Trickle ventilator provision [1]**
Apartment	1/30th of the floor area	12,000 mm^2
Kitchen	See note 2	10,000 mm^2
Utility Room	See note 2	10,000 mm^2
Bathroom or Shower room (with or without a WC)	See note 2	10,000 mm^2
Toilet	1/30th of the floor area	10,000 mm^2

Notes:
[1] The overall provision of trickle 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.
[2] A kitchen, utility room, bathroom or shower room should be ventilated with either a passive stack, intermittent extract fan or decentralised mechanical extract ventilator – see sections 5, 6 or 7 respectively for additional information on these.

4.4 A reduced trickle ventilator provision is acceptable in existing dwellings where infiltration rates exceed $10m^3/h/m^2$. Provision within apartments may reduce to 8000 mm^2 and 4000 mm^2 for all other rooms

4.5 To reduce the effect of stratification and promote air movement, the location of trickle 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 trickle 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.

4.6 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.

4.7 Where trickle ventilators are ducted, e.g. where serving an internal bathroom, the opening area of the ventilator stated in the table above should be doubled to compensate for the reduced air flow caused by the friction of the duct. Duct routes should be kept as straight and short as possible.

4.8 Where trickle ventilators are installed to provide replacement air for mechanical extract fans they should be located in a position that prevents short-circuiting of the air, i.e. to avoid the replacement air being extracted before it has mixed with or displaced stale air. To assist general air movement within a dwelling, consideration should be given to forming trickle ventilation to rooms containing mechanical extract fans by undercutting the room door to achieve an air space of at least 8,000 mm^2. This air space should be clear of any actual or notional floor coverings.

4.9 Where a trickle 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.

4.10 Trickle ventilators serving bath or shower rooms may open into an area that does not generate moisture provided that area is served by a trickle ventilator in accordance with the guidance in this document.

5 NATURAL VENTILATION – passive stack ventilators

5.1 Passive stack ventilators use ducts from terminals in the ceiling of rooms to terminals on the roof that extract air to outside by a combination of the natural stack effect and the pressure effects of wind passing over the roof of the dwelling. An installation consisting of passive stack ventilators is not suitable for a dwelling with an air-tightness level tighter than 5 $m^3/hr/m^2$@50Pa.

5.2 A passive stack ventilator may provide ventilation to a bathroom, shower room, kitchen, utility room or to a designated area within a dwelling for the drying of washing. They are suitable for use in domestic buildings up to 3 storeys in height (about 7.5m maximum length of stack).

5.3 Nearby buildings and local topography can have an adverse effect on the operation of passive stack ventilators. If a dwelling is to be sited near a significantly taller building or object (ie more than 50% taller) it should be positioned at least five times the difference in height away from the taller building. For example, if the difference in height is 10 m the dwelling should not be sited within 50 m of the taller building.

5.4 Each space to be ventilated should be served by separate ducts and be terminated individually. This reduces the risk of air from one room being routed to another.
as follows:

5.5 The circular ducts of the passive stack should be sized

Location	**Diameter**
Kitchen	125 mm
Utility room	100 mm
Bath / Shower room	100 mm
WC	80 mm

Note: Non-circular ducts of equivalent cross sectional area and flow resistance may be used.

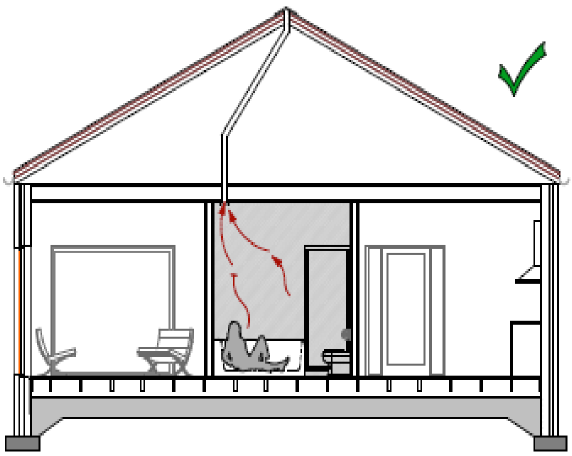
5.6 The outlet terminal of the stack should:

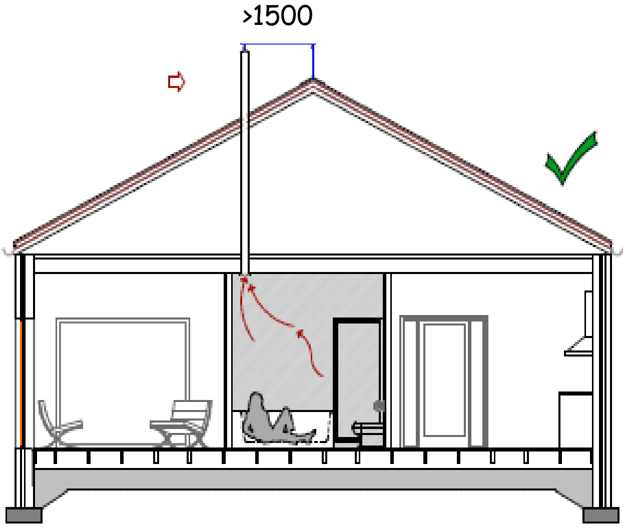
a. have a free area of not less than the cross sectional area of the duct;
b. be designed to inhibit rain from entering the duct;
c. not allow the ingress of insects or birds;
d. incorporate a condensation trap to allow run off of any condensation to the roof; and
e. be connected to the duct in a manner that does not restrict the cross sectional area of the duct. If a conversion fitting is required to connect the duct to the terminal then the duct cross sectional area must be maintained or exceeded throughout the conversion fitting so as not to restrict the flow.

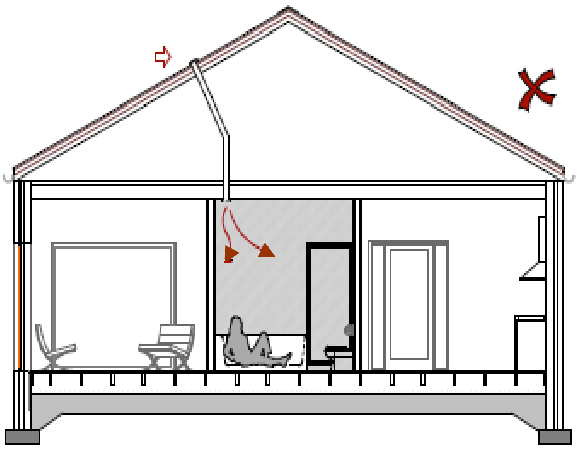
5.7 To reduce the adverse effects of wind gusts and certain wind directions the stack should terminate at:

a. the ridge of the roof, (being the preferred position); or
b. within 1.5 m of the ridge with the duct penetrating through the roof and terminating at least level with the ridge.

Passive Stack Terminal Locations

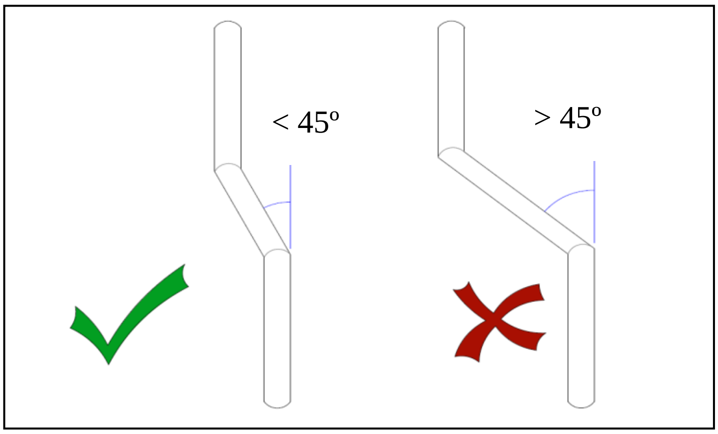






5.8 To minimise the resistance to air flow, ducts should consist of not more than one offset (i.e. not more than two bends) and these should be swept rather than sharp. Offsets should be no more than 45 degrees to the vertical.

Bends on passive stacks



5.9 Tests have indicated that correctly installed flexible and rigid ducts have similar resistance to air flow at the rates found in passive stack systems[1] and therefore either type may be used.

5.10 Flexible ducting should be:

a. fully extended but not taut;
b. securely fitted to both the extract grill and exhaust terminal;
c. installed in a manner such that where bends occur they are smooth, supported and do not restrict air flow;
d. terminated with rigid duct where it extends through the roof. The rigid pipe should project into the roof space sufficient to ensure the stability of the external duct. The connection between the flexible and rigid duct should be secure;
e. fully supported throughout its length to avoid sagging, distortion or kinks; and
f. sealed at the junction where the duct penetrates a ceiling or floor. Where a vapour control layer is breached by a duct the continuity of the barrier should be maintained.

5.11 Rigid ducting should be –

a. securely fitted to both the extract grill and exhaust terminal;
b. sealed at the junction where the duct penetrates a ceiling or floor. Where a vapour control layer is breached by a duct the continuity of the barrier should be maintained; and
c. adequately supported throughout its length.

5.12 Where a duct passes through a roof space, another unheated space, or a roof structure (e.g. a flat roof) to the external air, the duct should be insulated with at least 25 mm thick insulation having a thermal conductivity of 0.04 W/mK. This prevents the cooling of the duct, thus maintaining the stack effect and reducing the risk of condensation occurring within the duct.

5.13 Extract grilles should:

a. have a free area not less than the cross sectional area of the duct; and
b. be ceiling mounted and operate automatically with a humidity sensitive grill that operates when the relative humidity is between 50 & 65%.

5.14 Trickle ventilation with an equivalent area of at least 10,000 mm^2 should be provided to a room containing a passive stack ventilator.

5.15 Where a passive stack penetrates floors, walls, ceilings or cavity barriers that require a fire resistance refer to Section 2, Fire, of the Technical Handbooks for guidance.

5.16 Where a passive stack 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 technical handbooks for guidance.

5.17 To ensure good air transfer throughout the dwelling the bottom of internal doors, that are not required to be fire resistant, should be clear of the actual or notional floor

[1] Parkins LM. Experimental passive stack ventilation systems for controlled natural ventilation. *Proceedings CIBSE National Conference, Canterbury, April 1991*

finish by 5 to 8 mm. The fitment of a threshold plate is recommended as this prevents the gap being lost when floor coverings are laid.

6 MECHANICAL EXTRACT – intermittent extract fans

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

6.2 The extract fan should be selected to suit the location and performance criteria required. The table below identifies the minimum extraction rates that should be achieved.

Room	Minimum extraction rates
Kitchen	30 l/s (108 m^3/hr) if located above the hob 60 l/s (216 m^3/hr) if located elsewhere
Utility room	30 l/s (108 m^3/hr)
Bathroom or Shower room (with or without a WC)	15 l/s (54 m^3/hr)
Toilet	3 air changes/hour
Designated Drying Area	15 l/s (54 m^3/hr)

Note: The equivalent rates in m^3/hr are provided within brackets as extract fans are commonly specified in this manner

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

6.4 Consideration should be given to the planning and installation of the ductwork in co-ordination with other trade activities and installations, such that routes are designed without compromise to the required ventilation air flow rates.

6.5 Where the fan is installed through a wall:

a. 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;
b. the duct that connects the fan outlet to the terminal should be at least the diameter of the fan outlet; and
c. 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.

6.6 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.

6.7 Proprietary external discharge terminals should be used with a free area of at least 90% of the cross-sectional 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).

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

6.9 Trickle ventilators with an equivalent area of at least 10,000 mm^2 should be provided in an area fitted with a mechanical extract fan. These provide replacement air for the extract fan and should therefore be independent of the extract fan.

6.10 The location and performance of mechanical extract fans should be carefully considered so that they will 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 Technical Handbooks for guidance.

6.11 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.

6.12 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.

6.13 To limit the energy demand from the use of a mechanical extract fan the specific fan power should be no greater than 0.5 W/l/s.

6.14 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 noted in 6.2.

6.15 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.

6.16 Commissioning

The following points should be observed and recorded :

a. the installation(s) complies with the manufacturer’s installation instructions and clauses 6.1 to 6.15 above
b. the correct number of extract points and terminals been installed; and
c. all equipment is in good condition with no obvious defects that will be hazardous or affect the system performance.

Functional Checks

a. temporary protection and packaging has been removed from all products;
b. 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
c. 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.

Airflow Measurements

a. all intended trickle ventilators or other air transfer devices should be open;

b. all internal and external doors and windows should be closed, including the room in which measurement is being carried out;
c. airflow measurements should be performed 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 calibrated annually and be capable of achieving an accuracy of ± 5%. Reference should be made to design airflow rates; and
d. record the extract airflow for each extract fan on the commissioning sheet.

7 MECHANICAL VENTILATION – decentralised mechanical extract ventilation (dMEV)

7.1 A decentralised mechanical extract ventilation (dMEV) is a single room mechanical ventilator that operates continuously at a low extraction rate, with a humidity controlled, and/or manually operated, boost facility. A dMEV can be located in a wet room (i.e. bathroom, shower room, kitchen, utility room or a room containing an area designated for drying of washing) in place of a manually operated mechanical extract ventilator.

7.2 DMEVs are suitable for use in more air-tight dwellings, that is, those constructed to an infiltration rate of between 3 and 5 $m^3/hr/m^2$@50Pa. They may also be used as an alternative to switchable single room extract fans in less air tight dwellings. When installed in all the wet rooms (kitchens, bathrooms, etc) in a dwelling, they bring many of the advantages of a whole house ventilation system but at a much reduced capital and maintenance cost. However, there will be additional on-going running costs over switchable units.

7.3 The continuous and boost extract rates of dMEVs should be selected to suit the location, installation and performance criteria required. The table below identifies the minimum extraction rates that should be achieved.

	Minimum continuous extraction rates	**Minimum boost extraction rates**
Kitchen	6 l/s (22m^3/hr)	13 l/s (47 m3/hr)
Utility room	4 l/s (14 m^3/hr)	8 l/s (29 m3/hr)
Bathroom or Shower room (with or without a WC)	4 l/s (14 m^3/hr)	8 l/s (29 m3/hr)
Toilet	3 l/s (11 m^3/hr)	6 l/s (22 m3/hr)
Designated Drying Area	4 l/s (14 m^3/hr)	8 l/s (29 m3/hr)

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

7.5 Consideration should be given to the planning and installation of the ductwork in co-ordination with other trade activities and installations, such that routes are designed without compromise to the required ventilation air flow rates.

7.6 Where the fan is installed through a wall:

a. 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;
b. the duct that connects the fan outlet to the terminal should be at least the diameter of the fan outlet; and
c. 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 ventilation rates are not compromised.

7.7 Proprietary external discharge terminals should be used with a free area of at least 90% of the cross-sectional 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).

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

7.9 Trickle ventilators with an equivalent area of at least 10,000 mm^2 should be provided in an area fitted with a dMEV. These provide replacement air for the extract fan and should therefore be independent of the extract fan. As an alternative to a trickle ventilator to external air, the door to the wet room may be “undercut” to achieve an air space of at least 8,000 mm^2. This air space should be clear of the actual or notional floor covering. Ventilation via an undercut door can enhance background ventilation to the area that the wet room is accessed from, e.g. an en-suite off a bedroom. Doors that are required to have a period of fire resistance should not be subject to undercutting.

7.10 The location and performance of dMEVs 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.

7.11 A local manual override control should be provided to a dMEV to allow for maintenance of the unit. However, care should be taken to ensure, as far as is reasonably possible, that occupants do not view this as a routine manual control of the unit.

7.12 To limit the energy demand from the use of a mechanical extract fan the specific fan power should be no greater than 0.5 W/l/s.

7.13 In situations where noise is likely to be a nuisance to the occupants, for example, rooms adjacent to bedrooms, the noise generated by a dMEV on a continuous rate should not exceed 30 $dBl_{Aeq.T}$.

7.14 The use of communal ducting is not recommended for dMEV installations.

7.15 Commissioning

The following points should be observed and recorded :

a. the installation(s) complies with the manufacturer’s installation instructions and clauses 7.1 to 7.15 above
b. the correct number of extract points and terminals been installed; and
c. all equipment is in good condition with no obvious defects that will be hazardous or affect the system performance.

Functional Checks

a. check temporary protection and packaging has been removed from all products;
b. check fan operates correctly on continuous mode; and
c. check humidity control and/or manual operation of boost mode.

Airflow Measurements

a. both the continuous and boost extraction rates require to be measured;
b. all intended trickle ventilators or other air transfer devices should be open;
c. all internal and external doors and windows should be closed, including the room in which measurement is being carried out and adjoining room if trickle ventilation is provided by undercutting a door;

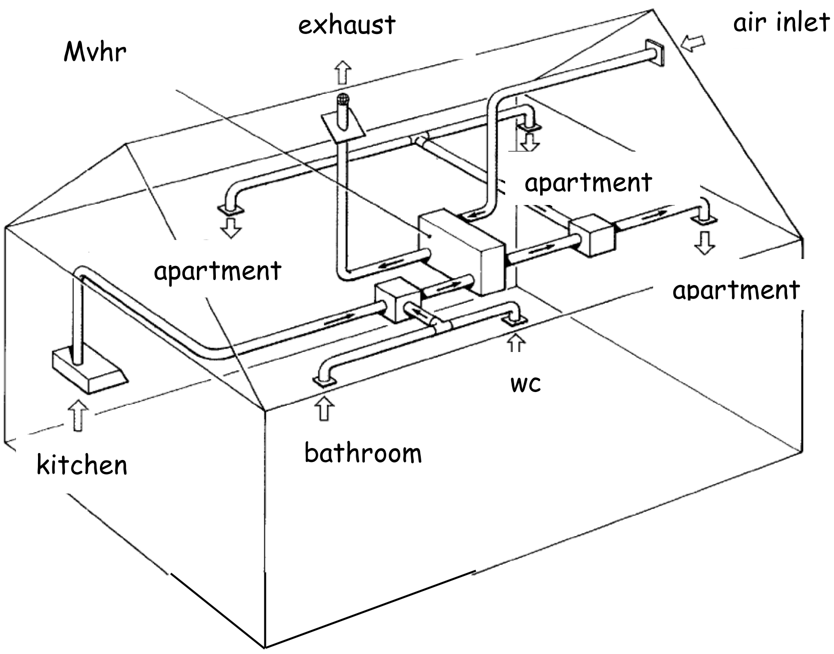
d. airflow measurements should be performed using suitable equipment, for example, a powered hood or a vane anemometer or similar airflow device with proprietary hood attachment and results recorded in litres per second (l/s). The airflow device should be calibrated annually and be capable of achieving an accuracy of ± 5%. Reference should be made to design airflow rates; and
e. record the continuous and boost extract airflow for each dMEV on the commissioning sheet.

8 MECHANICAL VENTILATION – continuously operating balanced supply and extract ventilation (with or without heat recovery)

8.1 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. Continuously operating balanced supply and extract systems (with or without heat recovery) are particularly suited to dwellings constructed to high levels of air-tightness.

8.2 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 usual 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.

Balanced supply and extract system (shown with heat recovery)



8.3 The total extract air flow rate during normal operation should be equivalent to at least 0.5 air changes per hour based on the volume of the whole dwelling. A facility to boost the air extract rate should be provided. It is preferable for a boost facility to target individual rooms rather than increase the overall extraction rate from the dwelling.

8.4 Opening windows should be provided where possible to assist with purge ventilation, for example, cooling the dwelling in hot weather and to provide ventilation provision should the system fail.

8.5 To ensure good air transfer throughout the dwelling the bottom of internal doors, that are not required to be fire resistant, should be clear of the actual or notional floor finish by 5 to 8 mm. The fitment of a threshold plate is recommended as this prevents the gap being lost when floor coverings are laid.

8.6 The product manufacturer's instructions should be followed.

8.7 The fan unit should be:

a. located as specified by the system designer. The location of the fan unit should 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;
b. located to allow safe access to undertake routine maintenance of the unit, including changing or cleaning filters;
c. 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;
d. installed on a suitable sound structure, which is stable and level;
e. 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;
f. 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; and
g. 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.

8.8 Room Supply and Extract Terminals

a. duct terminal fittings should be installed as detailed by the system designer;
b. duct terminal fittings should be capable of passing the required air flow rate, at the available pressure drop, without generating excessive noise (maximum of 30 dB $L_{Aeq.T}$ to bedrooms and livingrooms and 35 dB $L_{Aeq.T}$ to less sensitive rooms, such as kitchens);
c. air 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;
d. air 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;
e. in open plan areas where both supply and extract terminals may be installed, for example kitchen diners, 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;

f. 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; and
g. 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.

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.

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.

8.9 External Supply and discharge terminals – roof and wall mounted:

a. proprietary terminals should be used. The terminals should prevent rain, birds and large insects from entering the system, (however, fine fly-proof mesh should not be fitted);
b. the free area of the terminal opening should be a minimum of 90% of the free area of the ducting being used;
c. the location of the external discharge terminal should be positioned to minimise the potential for recirculation of extract air through the supply air terminal. It is recommended that the supply and extract air terminals are separated by a distance of 2 metres;
d. to avoid noxious or dangerous gasses from entering the dwelling the external terminals should be located remote from any flue or drainage vent pipe. Refer to Section 3, Environment, of the Technical Handbooks for guidance; and
e. a cored hole (and duct) through an external wall should have a slight downward angle towards the outside to promote condensate drainage and avoid the risk of water ingress.

8.10 Controls

a. continuous ventilation systems should not allow the occupier to turn off the fan other than at the local isolator. 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;
b. 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;
c. if sensors are duct mounted, their location should be noted and provisions for access for maintenance or replacement made;
d. if control of the fan speed is undertaken manually, the method of operating the fan in boost mode should be made obvious. This will minimise the likelihood of it being left on unnecessarily. Switching should be provided locally to the spaces being served, for example, bathrooms, kitchen; and

e. 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.
f. 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.

8.11 To limit the energy demand from the use of a mechanical extract system the specific fan power of the extract unit should be no greater than 1.5 W/l/s.

8.12 The heat recovery efficiency of a mechanical ventilation and heat recovery system should be 70% or more.

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

8.14 Commissioning

Visual Inspection

The following points should be observed and recorded:

a. the system complies with the installation clauses given above (8.1 to 8.13) ;
b. system is installed in accordance with the design criteria;
c. all ductwork and terminals are in good condition with no obvious defects that will be hazardous or affect the system performance;
d. on the initial start up check that air flow direction is correct at each room terminal, supply and extract; and
e. check for any abnormal noises on start-up or when the system is running in normal background ventilation mode (some units have a start up diagnostic sequence that runs the fans at maximum speed before reverting to normal operation – refer to the manufacturers instructions).

Air Flow 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 fan manufacturer's instructions should be followed to achieve balancing. If specific details are not included the following steps should be adopted:

a. 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.
b. 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;

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

d. 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 flow rate; and
  - 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.

e. 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.

Airflow Measurements

a. all internal and external doors and windows should be closed, including rooms in which measurements are being carried out;
b. air flow measurements should be performed using suitable equipment, for example, a powered hood or a vane anemometer or similar airflow device with a proprietary hood attachment and the results recorded in litres/ second (l/s). The airflow device should be calibrated annually and be capable of achieving an accuracy of ± 5%. Reference should be made to design airflow rates; and
c. record the airflow rate at each room terminal on the commissioning sheet, along with the design air flow rate for each terminal. Measurements should be taken at both maximum rate and minimum rate fan speeds.

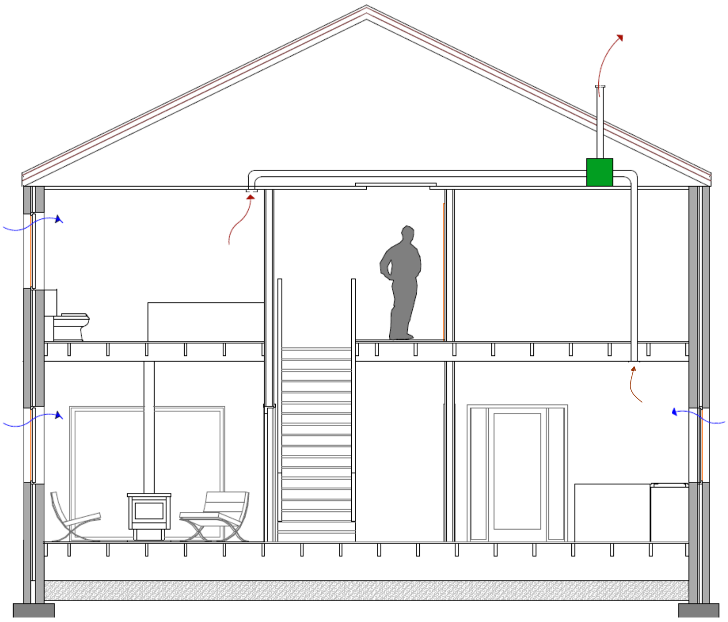
Controls

a. all local controls should be installed following the manufacturer’s instructions;
b. all local controls should be labelled, indicating their function;
c. if sensors have been installed separately from the fan unit ensure installation follows the manufacturer’s instructions;
d. 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;
e. where manual controls are provided clear and detailed instructions should be made available to the occupier; and
f. as far as practical the correct operation of each control function should be tested

9 MECHANICAL VENTILATION – centralised mechanical extract ventilation

9.1 A centralised mechanical extract ventilation (MEV) system essentially comprises of the extract components of an MVHR system (see chapter 8). The installation consists of a centrally located extract fan unit that continuously extracts air, via ductwork, from the moisture producing areas within the dwelling at a low extraction rate. The units have a manually operated or automated (with humidity control) boost facility. Replacement air is provided throughout the dwelling by infiltration and trickle ventilator provision. An MEV system is not suitable for a dwelling with an air-tightness level tighter than 3 $m^3/hr/m^2$@50Pa.

Continuously Operating Extract System



9.2 The total extract air flow rate during normal operation should be equivalent to at least 0.5 air changes per hour based on the volume of the whole dwelling. A facility to boost the air extract rate should be provided. It is preferable for a boost facility to target individual rooms rather than increase the overall extraction rate from the dwelling.

9.3 Trickle ventilators should be installed in accordance with clause 4.3 of this document. Opening windows should be provided to assist in cooling the dwelling in hot weather.

9.4 To ensure good air transfer throughout the dwelling the bottom of internal doors, that are not required to be fire resistant, should be clear of the actual or notional floor finish by 5 to 8 mm.

9.5 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.

9.6 The product manufacturer’s instructions should be followed.

9.7 The fan unit should be:

a. located as specified by the system designer;
b. located to allow safe access to undertake routine maintenance of the unit;
c. 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;
d. installed on a suitable sound structure, which is stable and level;
e. 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
f. 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; and
g. 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.

9.8 Room Extract Terminals & Grilles:

a. room air extract terminals should be installed as detailed by the system designer;
b. 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;
c. 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; and
d. 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.

9.9 External discharge terminals – roof and wall mounted:

a. proprietary terminals should be used;
b. 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);
c. the location of the external discharge terminal should minimise the potential for recirculation of extract air through ventilation air inlets;
d. 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; and
e. 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.

9.10 Controls:

a. continuous ventilation systems should not allow the occupier to turn off the fan other than at the local isolator. 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;
b. 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;
c. if sensors are duct mounted, their location should be noted and provisions for access for maintenance or replacement made;
d. 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; and
e. 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.

9.11 To limit the energy demand from the use of a mechanical extract system the specific fan power of the extract unit should be no greater than 0.7 W/l/s .

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

9.13 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

9.14 **Commissioning**

Visual Inspection

The following points should be observed and recorded:

a. system installation complies with the installation clauses given above (9.1 to 9.13);
b. system is installed in accordance with the design criteria;
c. all ductwork and terminals are in good condition with no obvious defects that will be hazardous or affect the system performance;
d. on the initial start up check that air flow direction is correct at each room terminal and;
e. check for any abnormal noises on start-up or when the system is running in normal background ventilation mode. (some units have a start up diagnostic sequence that runs the fans at maximum speed before reverting to normal operation – refer to the manufacturers instructions).

Air Flow 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 fan manufacturer's instructions should be followed to achieve balancing. If specific details are not included the following steps should be adopted:

a. 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;
- 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.

b. 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 flow rate;
   - if the index terminal has to be closed to achieve the required air
   - flow rate, then reduce the fan speed and rebalance the terminals.

c. Fixed terminals with flow adjustment by duct damper or similar device at the fan unit:
   - as a. or b. above depending on the type of fan speed control.
d. 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;
e. 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.

Airflow Measurements

a. all trickle ventilators or other air transfer devices should be open;
b. all internal and external doors and windows are closed, including rooms in which measurements are being carried out;
c. air flow measurements should be performed using suitable equipment, for example, a powered hood or a vane anemometer or similar airflow device with a proprietary hood attachment and the results recorded in litres/ second (l/s). The airflow device should be calibrated annually and be capable of achieving an accuracy of ± 5%. Reference should be made to design airflow rates; and
d. record the airflow rate at each room terminal onto the commissioning sheet, along with the design air flow rate for each terminal. Measurements should be taken at both maximum rate and minimum rate fan speeds;

Controls

a. all local controls should be labelled, indicating their function clearly;
b. all local controls should be installed following the manufacturer’s instructions;

c. if sensors have been installed separately from the fan unit ensure installation follows the manufacturer's instructions;

d. 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 hunting does occur the occupants may seek to modify the control system or turn it off to remove the noise nuisance;

e. where manual controls are provided clear and detailed instructions should be made available to the occupier;

f. as far as practical the correct operation of each control function should be tested.

10 MECHANICAL VENTILATION - ductwork

10.1 General Recommendations

Ducting should be:

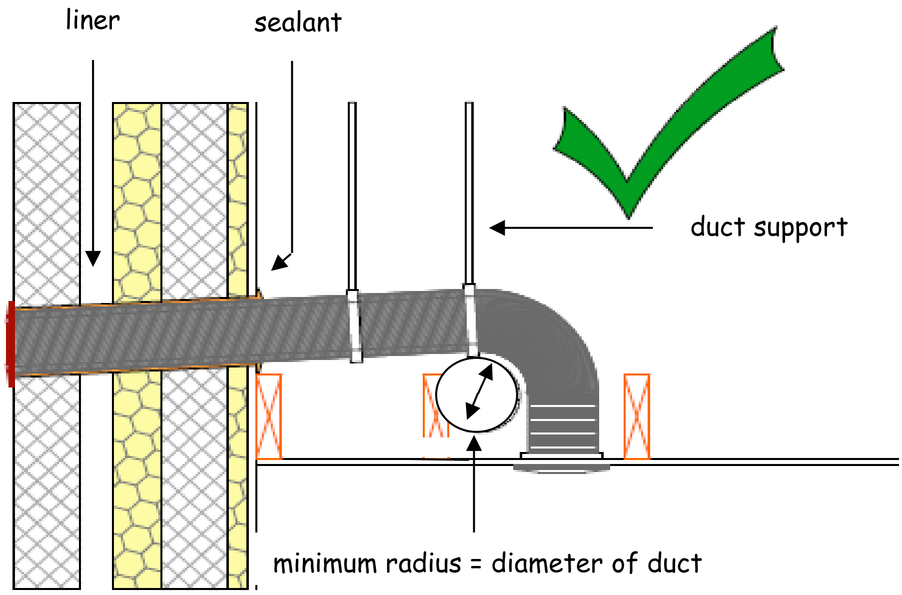
a. installed where it cannot be easily damaged e.g. not across open loft areas where it may be stood on;
b. installed to allow sufficient space to allow access for cleaning ducts where room extract terminal/grilles are not fitted with filters;
c. insulated where it is passes through unheated areas with 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;
d. 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;
e. 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;
f. 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;
g. arranged to slope slightly downwards away from the fan unit, to prevent backflow of any moisture into the unit, when installed horizontally;
h. 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
i. 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.

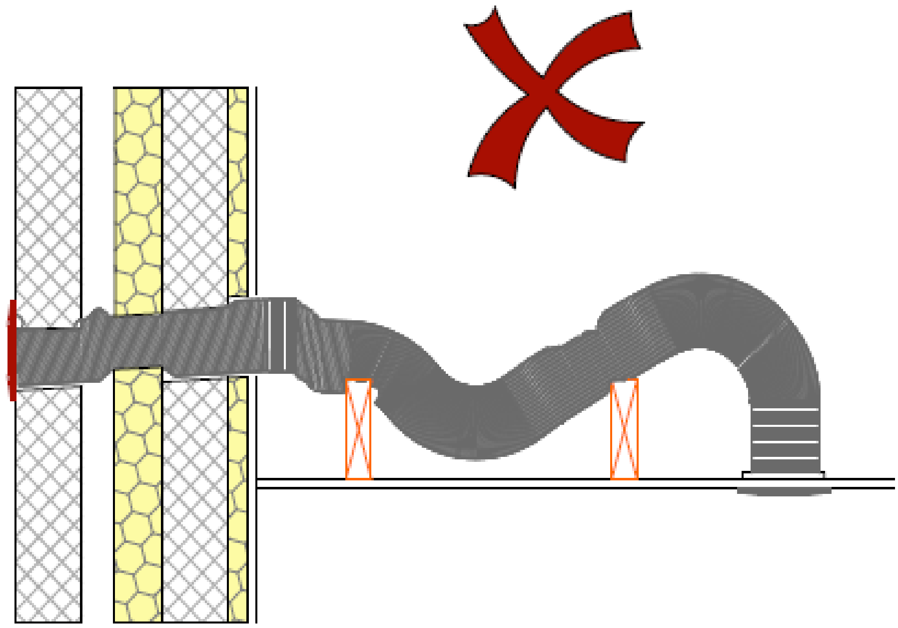
10.2 Flexible ducting

a. flexible ducting is generally only suitable for single extract fan installations – refer to extract fan manufacturer’s instructions.
b. 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;
c. 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;
d. 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
e. 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.





10.3 Duct Connections:

a. 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;
b. 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;
c. 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;
d. connection of components should not result in significant air flow resistance. Components should be proprietary and fit easily together without distortion

10.4 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.

10.5 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.

10.6 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.

11 CARBON DIOXIDE MONITORING EQUIPMENT

11.1 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[2] (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.

11.2 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[3], 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.

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

11.4 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, trickle 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.

11.5 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

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

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

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.

11.6 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.

11.7 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.

11.8 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.

11.9 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.

11.10 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.

11.11 **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 trickle 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
   - Trickle ventilation location and operation
   - Mechanical ventilation – manual 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

Annex A 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, trickle ventilators and mechanical extract fans (location and operation) should be replaced with building specific information.

12 WRITTEN INFORMATION FOR VENTILATION SYSTEMS

12.1 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, where relevant, to the occupant(s) of the dwelling.

a. 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;
b. manufacturer's contact details;
c. instructions on how to use trickle ventilators for background ventilation;
d. location of and setting of automatic controls (humidity and timer controls)
e. location and use of on/off and boost settings for mechanical ventilation systems;
f. Instructions on how and when cleaning and maintenance should be carried out, including filter replacement;
g. location of filters;
h. 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;
i. instructions on how to recalibrate or check sensors and their location; and
j. manufacturer's literature that may include information such as a spare parts list, means of obtaining spare parts, guarantees etc.

13 EXAMPLE VENTILATION SOLUTIONS

13.1 The following example solutions identify five alternative approaches to providing ventilation within a dwelling. Solutions 1 and 2 may be adopted for dwellings having an air infiltration rate between 5 and 10 $m^3/h/m^2$. Solutions 3, 4 and 5 may be adopted for dwellings with an air infiltration rate less than $5m^3/h/m^2$.

NEW DWELLING	INFILTRATION RATE: 5 — $15m^3/h/m^2$

Example Ventilation Solution 1: - Natural with Intermittent Mechanical Extract

	Apartment	Kitchen	Bathroom / Shower	Toilet	Utility Room
Openable Ventilator	1/30th floor area			1/30th floor area [2]	
Trickle Ventilator	12000 mm^2	10000 mm^2	10000 mm^2	10000 mm^2	10000 mm^2
Intermittent Mechanical Extract		60 l/sec (216 m^3/hr)[1] [3]	15 l/sec (54 m^3/hr) [3]		30 l/sec (108 m^3/hr) [3]

Note:
[1] May be reduced to 30 l/sec (108 m^3/hr) if located above a hob.
[2] May be substituted by mechanical extract capable of 3 air changes per hour.
[3] Humidistat control should be used if designated drying area for washing

Example Ventilation Solution 2: - Natural with Passive Stack

	Apartment	Kitchen	Bathroom / Shower	Toilet	Utility Room
Openable Ventilator	1/30th floor area			1/30th floor area	
Trickle Ventilator	12000 mm^2	10000 mm^2	10000 mm^2	10000 mm^2	10000 mm^2
Passive Stack System		125 mm stack [1]	100 mm stack [1]		100 mm stack [1]

Note:
[1] Incorporating a ceiling mounted automatic humidity sensitive extract grille.

NEW DWELLING	INFILTRATION RATE: ≥3m^3/h/m^2

Example Ventilation Solution 3: - Natural with Individual Continuously Operating Mechanical Extracts (dMEV)

	Apartment	**Kitchen**	**Bathroom / Shower**	**Toilet**	**Utility Room**
Openable Ventilator	1/30th floor area			1/30th floor area [1]	
Trickle Ventilator	12000 mm^2	10000 mm^2	10000 mm^2	10000 mm^2	10000 mm^2
Continuously Operating Mechanical Extract [2]		6 l/s min and 13 l/s boost	4 l/s min and 8 l/s boost	3 l/s min and 6 l/s boost [1]	4 l/s min and 8 l/s boost

Note:
[1] A toilet may be ventilated with either an openable window or an extract fan

NEW DWELLING	INFILTRATION RATE: ≥3m^3/h/m^2

Example Ventilation Solution 4: - Continuously Operating Mechanical Extract

	Apartment	**Kitchen**	**Bathroom / Shower**	**Toilet**	**Utility Room**
Openable Ventilator	1/30th floor area [1]			1/30th floor area [1]	
Trickle Ventilator	12000 mm^2	10000 mm^2	10000 mm^2	10000 mm^2	10000 mm^2
Continuously Operating Mechanical Extract [2]	0.5 ACPH minimum	0.5 ACPH minimum and 25 -50 % boost	0.5 ACPH minimum and 25 -50 % boost	0.5 ACPH minimum	0.5 ACPH minimum and 25-50% boost

Note:
[1] Openable ventilators (generally windows) provide summer cooling, rapid ventilation and for use when the mechanical system is switched off.
[2] Based on whole house ventilation rate.

Example Ventilation Solution 5: - Continuously Operating Balanced Supply and Extract (with or without Heat Recovery)

	Apartment	**Kitchen**	**Bathroom / Shower**	**Toilet**	**Utility Room**
Openable Ventilator	1/30th floor area [1]			1/30th floor area [1]	
Trickle Ventilator	N/A	N/A	N/A	N/A	N/A
Continuously Operating Mechanical Extract [2]	0.5 ACPH minimum	0.5 ACPH Minimum and 25 -50 % boost	0.5 ACPH minimum and 25 -50 % boost	0.5 ACPH minimum	0.5 ACPH minimum

Note:
[1] Openable ventilators (generally windows) provide summer cooling, rapid ventilation and for use when mechanical system switched off.
[2] Based on whole house ventilation rate.

ANNEX A

PROFORMA FOR INFORMATION TO BE PROVIDED TO THE HOME OCCUPIER ON USE AND INTERPRETATION OF CO_2 MONITORING EQUIPMENT

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 PROFORMA TO BE PROVIDED TO THE HOME OCCUPIER ON THE USE AND INTERPRETATION OF CO_2 MONITORING EQUIPMENT

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.

Trickle 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
Trickle ventilator located at low level in the north facing wall

Utility room

Switchable single speed mechanical extract fan
Trickle ventilator located at low level in the north facing wall

Bathroom

Switchable single speed mechanical extract fan
Trickle ventilator located at low level in the east facing wall

En-suite

Switchable single speed mechanical extract fan
Trickle 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 trickle ventilators to allow you to adjust the fresh air entering each room. trickle ventilators are adjustable and positioned to encourage ventilation through each of the rooms. In rooms with more than one trickle 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 trickle ventilators or leave room door partially open
1,200 – 1,499 ppm	Fully open trickle 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 actions identified above should be replicated in all occupied apartments in the dwelling.	