BRANZ

ISSUE 581 BULLETIN

RESIDENTIAL MECHANICAL VENTILATION SYSTEMS

February 2015

- Ventilation is required to introduce fresh air from outside to replace indoor air that has accumulated pollutants that can cause discomfort, health problems or damage to building materials.
- Residential mechanical ventilation systems include supply, extract and heat recovery ventilation systems.
- This bulletin combines and updates Bulletin 484 *Mechanical home ventilation systems* and Bulletin 508 *Heat/energy recovery ventilation systems*.

1.0 INTRODUCTION

1.0.1 Ventilation plays a major role in indoor air quality and moisture management in houses, removing and diluting contaminants, including water vapour.

1.0.2 Ventilation comes from three sources:
- The uncontrolled airflow through the building envelope (infiltration), which depends mainly on the airtightness of the building and exposure to wind.
- The actions of the occupants, such as how often they open windows that control natural ventilation.
- The use of mechanical ventilation systems.

1.0.3 New Zealand Building Code clause G4 *Ventilation* requires that spaces within buildings shall have a means of ventilation with outdoor air that will provide an adequate number of air changes to maintain air purity.

1.0.4 For a house, the ventilation rate can be given as the number of air changes per hour (ach). This is how many times a volume of air equal to the house volume has entered and left the house in 1 hour. It is recommended that the number of air changes per hour be between 0.35 and 0.5. Lower than this risks not effectively removing contaminants, while higher ventilation rates may compromise energy efficiency.

1.0.5 Opening windows can be used to provide sufficient ventilation (acceptable under G4), but heat can be lost, it is a potential security risk and it relies on the occupants to use them. Mechanical ventilation can provide more controlled ventilation rates but requires equipment and energy to operate. Not all mechanical ventilation systems will meet the requirements of G4.

1.0.6 This bulletin combines and updates Bulletin 484 *Mechanical home ventilation systems* and Bulletin 508 *Heat/energy recovery ventilation systems*.

2.0 INFILTRATION AND AIRTIGHTNESS

2.0.1 Over time, New Zealand homes have become more airtight (Figure 1). Pre-1960s homes had a low level of airtightness. Houses were typically uninsulated, made from strip materials and had timber windows that lacked tight air sealing. Since then, there has been a greater uptake of particleboard flooring, sheet linings and aluminium joinery, and insulation is now mandatory.

2.0.2 Since the 1970s, the use of concrete slabs and square stopping or bonded coving have significantly reduced air leakage opportunities at these junctions.

2.0.3 The requirement of Acceptable Solution to NZBC clause E2 *External moisture* (E2/AS1) for air sealing around the rough opening of windows for weathertightness reasons has also had an impact, along with a general industry trend towards energy efficiency, resulting in more attention to closing up air leakage paths.

2.0.4 Many homes constructed since the 1990s have infiltration rates that are too low to provide for the minimum ventilation needs for that building, and additional ventilation, either passive or mechanical, is required.

3.0 NEED FOR VENTILATION

3.0.1 Ventilation introduces fresh air from outside to replace indoor air that has accumulated pollutants such as:
- carbon dioxide and water vapour from people breathing
- formaldehyde from furniture and finishes
- dust and other airborne particles
- micro-organisms such as spores, pollens, viruses, bacteria and mould

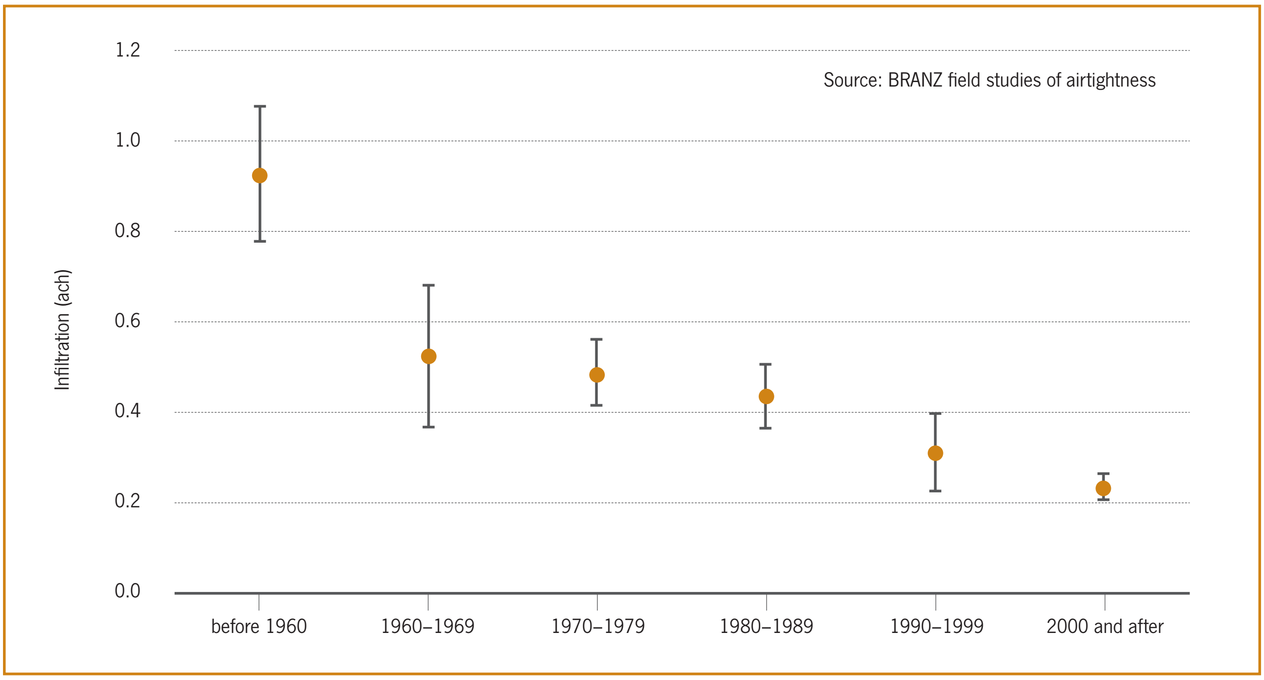

Figure 1. The average New Zealand home infiltration rate broken down by year of construction.

- odours from kitchens, bathrooms, waste storage and people
- cigarette smoke
- combustion products (e.g. from gas heaters and cooktops)
- fats and oils (e.g. from cooking)
- water vapour (e.g. from showers, cooktops, kettles)
- off gassing from finishes and other materials.

3.0.2 These pollutants need to be moved out of the building to prevent potential discomfort, health problems or damage to building materials.

3.0.3 A key concern in houses is moist air, which is commonly associated with kitchens, bathrooms, laundries and bedrooms. This can cause dampness and condensation on cold surfaces such as external walls and windows.

3.0.4 Rather than relying on a ventilation solution, the management of moisture problems should follow a hierarchy that eliminates or controls moisture sources before attempting to modify large general volumes of air:

1. Elimination of unnecessary moisture sources.
2. Control (removal) of moisture at source.
3. Insulation.
4. Heating, ventilation.
5. Dehumidification.

3.0.5 In particular, moisture problems may be made worse by:

- occupants not opening windows
- use of unflued gas heating
- lack of a ground vapour barrier under the house with a suspended timber floor
- water leaks
- rainwater flowing under the house
- indoor drying of clothes
- unvented clothes dryers
- no or poor use of extractor fans in wet areas such as bathrooms and kitchens
- inadequate heating
- insufficient insulation.

4.0 VENTILATION RATES

4.0.1 The ALF (Annual Loss Factor) tool on the BRANZ website (under Toolbox) is used to estimate the energy use for particular house designs but can also provide an estimate of the base ventilation. Information on factors such as the number of flued heaters, the number of window vents and the wind exposure of the house are combined with an estimation of the base infiltration of the house to estimate the base ventilation rates for that particular design. For more information on ALF, see BRANZ Bulletin 555 *A guide to ALF 3.2*.

4.0.2 While overall ventilation rates for a house are expressed as the number of air changes per hour, mechanical ventilation systems move particular volumes of air per unit time, usually expressed as the number of litres per second (L/s). Alternatively, m^3/hour may also be used.

4.0.3 The requirements of Acceptable Solution to clause G4 *Ventilation* (G4/AS1) can be met by:

- having a net openable area (e.g. windows) that is a minimum of 5% of the floor area, or
- a mechanical ventilation system supplying outdoor air to occupied spaces at the flow rates given in Table 2 of NZS 4303:1990 *Ventilation for acceptable indoor air quality* (Table 1).

TABLE 1. FRESH AIR REQUIREMENTS
(ADAPTED FROM NZS 4303:1990 TABLE 2.3, WITH PERMISSION PROVIDED BY STANDARDS NEW ZEALAND UNDER LICENCE 001125)

	Fresh air requirements (L/s)		
Space	per person (pp)	continuous	intermittent
Living areas	7.5 (or 0.35 ach)	na	na
Bathroom/toilet	na	10	25
Kitchen	na	12	50

4.0.4 For extract systems, Table B1 of AS 1668.2:2002 *The use of mechanical ventilation and air-conditioning in buildings Part 2: Ventilation design for indoor-air contaminant control* states that the general exhaust ventilation rates for residential spaces are:

- bathrooms and toilets – 25 L/s
- laundries – 20 L/s (can be intermittent)
- spa pools – 5 L/s per m^2 of floor area.

4.0.5 Improved ventilation performance will be achieved with higher local extraction near activities such as cooking, showering, bathing or clothes drying.

5.0 MECHANICAL VENTILATION

5.0.1 Mechanical ventilation systems control airflow between the air inside the building and the air surrounding it or from the roof space. Supply systems introduce air from outside or from the roof space into the living spaces, while extract systems remove indoor air and discharge it to the outside. Balanced systems will include both supply and extract.

5.0.2 Mechanical ventilation has a number of advantages, including:

- it provides air movement in hard-to-reach spaces (e.g. in apartment buildings)
- air can be supplied or removed at specific flow rates and for set periods of time (automated control)
- polluted or moist air can be extracted directly from where it is produced
- the removal of polluted indoor air to the outside is guaranteed
- excess ventilation can be minimised, lowering the amount of extra space heating required
- rooms can be pressurised relative to the surrounding spaces so that passive airflow into the room is reduced (with supply systems) or encouraged (with extract systems)
- airflow into and out of the house is less affected by outside air temperature, wind velocity and direction
- it offers higher building security than opening windows
- it can provide ventilation of rooms/spaces without outside windows.

5.0.3 Mechanical ventilation also has disadvantages. It uses energy, produces noise, requires extra penetrations of the building envelope, can be expensive to buy and install and needs ongoing maintenance.

5.0.4 Heat pumps are sometimes confused with mechanical ventilation systems. A split-cycle heat pump is a heating and cooling system that heats (or cools) the indoor air directly. A heat pump does not remove indoor air or bring outdoor air indoors and is therefore not a ventilation system.

5.0.5 Mechanical ventilation systems generally comprise some or all of the following components:
- a supply inlet
- supply ductwork
- supply outlets, diffusers and louvres
- fans
- an air-to-air heat exchanger
- an extract inlet
- extract ductwork
- extract outlets
- sensors
- control systems.

6.0 SUPPLY SYSTEMS

6.1 OPERATION

6.1.1 Most mechanical ventilation supply-only positive pressure ventilation systems (Figure 2) and roof space air-supplied positive pressure systems tend to run continuously over long periods with low fresh airflow rates. Occasionally, larger volumes are supplied as replacement air for an associated mechanical ventilation extract system (e.g. from a spa room).

6.2 COMPONENTS

6.2.1 Supply-only systems normally include an air intake, an air filter, a fan, ductwork and room diffusers. The system must be set up to ensure:
- the intake position and air filter produce ventilation air that is better quality than the air being replaced
- supply diffusers are sized and positioned to provide the desired air velocity, flow rate and direction for the room location – the air flow should be away from positions where it may cause discomfort for the room occupants.

6.3 SUPPLY AIR

6.3.1 In winter, the outdoor supply air, or roof space-sourced air, is likely to be cold. This will cool down the indoor air, requiring heating.

6.3.2 Some systems include an air-tempering device, or air heater within the supply ductwork. These heaters are not particularly efficient as they lose heat into the roof space and through the ductwork. It is more efficient to position the heater within the room. However, if the system is delivering too much cool air into the room, this may cause some discomfort. Additional heating or air-tempering requirements may be better managed if the system has the ability to reduce airflow rates when the supply air is cooler than the room temperature.

6.3.3 Systems may also provide multiple air sources that allow air to be drawn from different locations (from the roof space or from outside) depending on the temperature and relative humidity of these sources.

6.3.4 Outdoor air can be preheated by using a solar heated ventilation system. In these systems, air runs past special solar panels that warm the outdoor air before it is brought into the building.

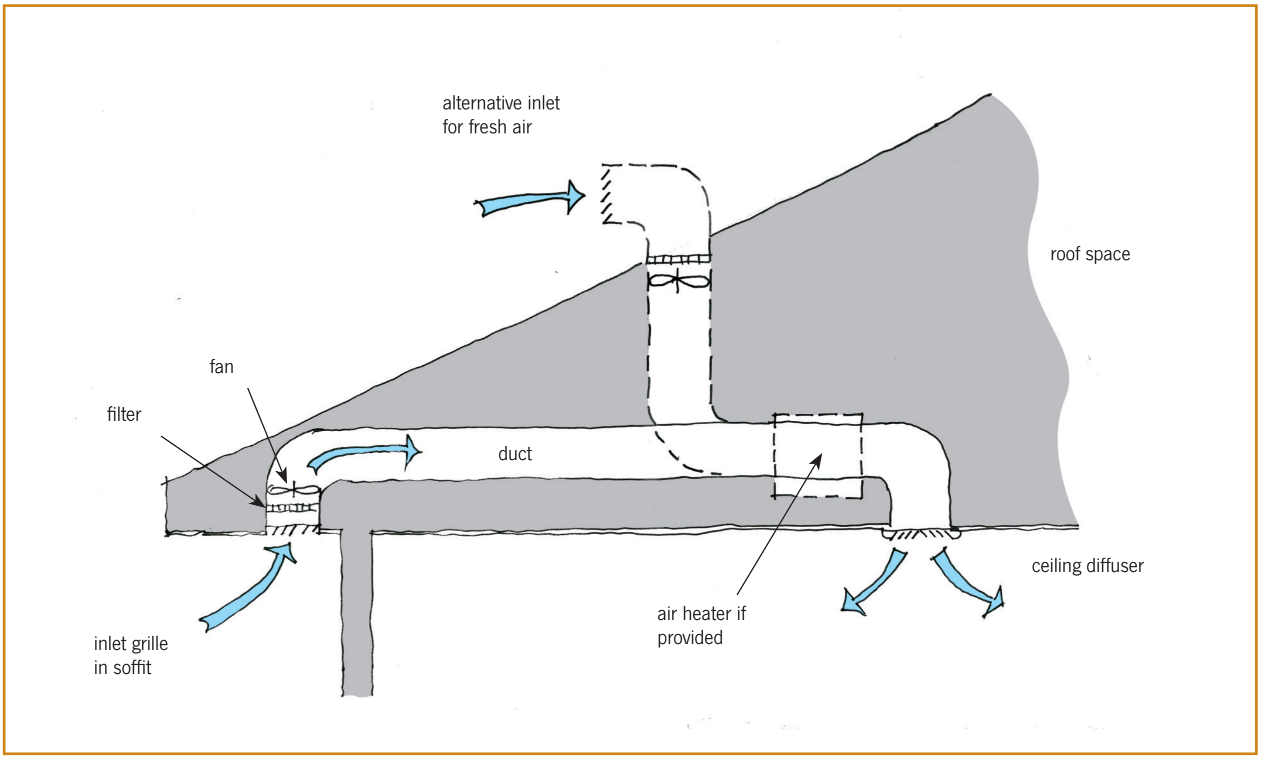

Figure 2. Mechanical ventilation supply-only system (also known as external air-sourced positive pressure ventilation system).

6.4 ROOF SPACE AIR-SOURCED POSITIVE PRESSURE SYSTEMS

6.4.1 A roof space air-sourced positive pressure system uses the air in the roof space as its supply source. The roof space air is an intermediate space between indoors and outdoors. For these systems to work:

- there needs to be sufficient roof space that is adequately ventilated to the outside to meet the air change rate needed in the occupied space
- the roof space needs to be free from moisture sources or moisture transported from other areas (such as from kitchens or bathrooms or from the sub floorspace via the walls)
- there needs to be limited moisture penetration from the spaces below, such as open downlights, otherwise the system will just recirculate moisture around the building.

6.4.2 These systems do not meet the requirements of clause G4 *Ventilation* because G4 specifically requires outside air, but they are frequently used in retrofit situations where moisture or condensation is of concern.

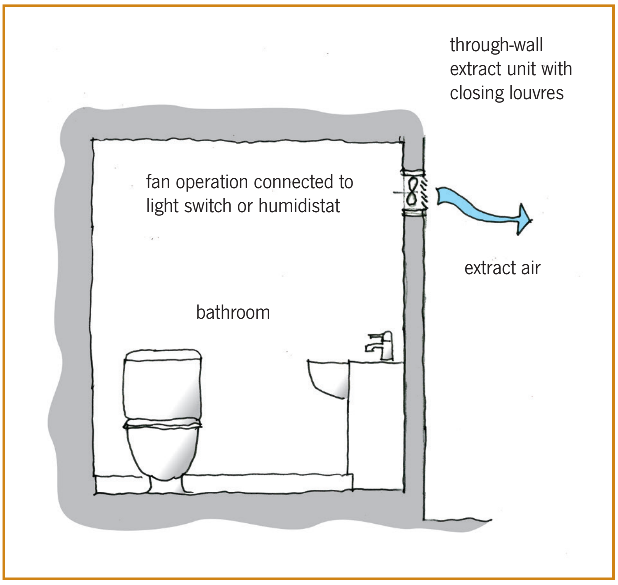

Figure 3. High flow rate localised extract system.

6.4.3 The ductwork inlet should be located so that the air supply does not pick up particles from the roof space. An air filter is important to remove these particulates. The higher the filter grading, the fewer particulates that will be transmitted through the filter. Filters commonly require replacing every 12 or 24 months.

7.0 EXTRACT SYSTEMS

7.0.1 Mechanical ventilation extract systems remove air from a building and discharge it to the outside. Extract systems can be considered as one of two types:

- High flow rate localised extraction in wet areas, such as a rangehood in a kitchen or an extractor fan in a bathroom (Figure 3). These systems tend to be operated on demand or via a timer system or humidistat.
- General extract system (Figure 4) that operates at a lower flow rate but for longer time periods. These general extract systems are able to be used with supply systems to provide a greater balance of supply and extract air.

7.0.2 An extract system may also be required to remove:

- stale air from toilet areas that have no passive ventilation
- moist air from bathrooms, particularly where there is no opening window
- moist air from laundries located in a closet-type space
- moist air from spa or sauna facilities.

7.0.3 Extract systems can create negative pressure in a building space. This means that passive air movement will generally be directed inward through the building (or room) envelope. The aim is to limit the movement of moist or polluted air out to other building spaces and to encourage fresher, cleaner, drier air to enter from outside the building or from a neighbouring room. Good practice for short extraction events (such as cooking or showering) is to open a window within the same room, located away from the fan outlet to avoid recirculation.

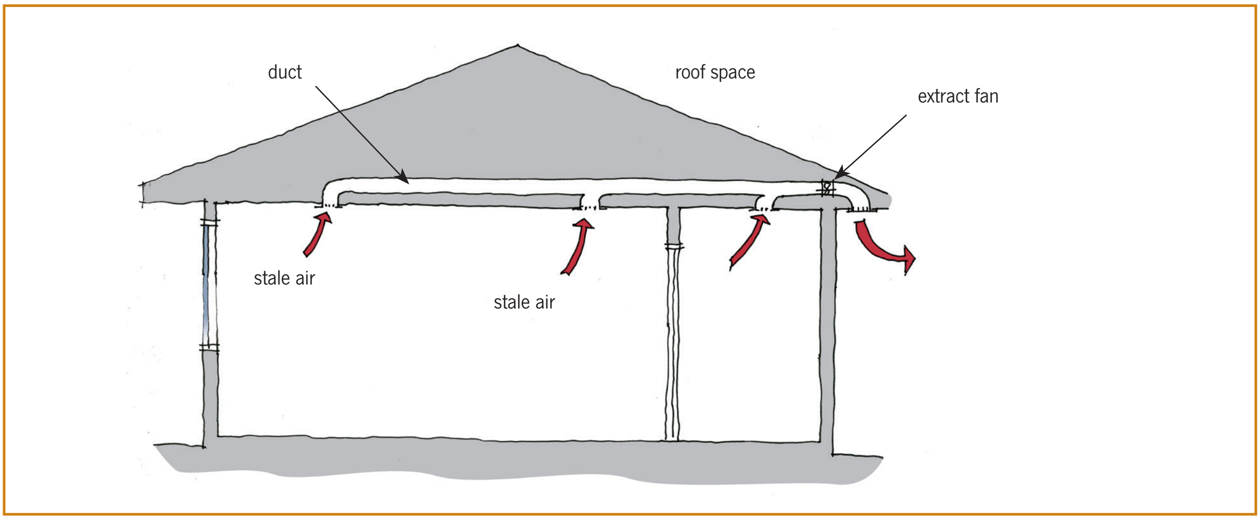

Figure 4. Mechanical ventilation general extract system.

7.1 FANS

7.1.1 To minimise energy use, extract fans should be sized and controlled to move only the amount of air needed for the time required.

7.1.2 For rooms used infrequently or intermittently, an extract fan can be connected to the light switch with a timer delay for switching off. Another option is to connect a humidity sensor to switch the extract fan on and off automatically.

7.1.3 In many house installations, an extract fan is part of a compact unit mounted in the external wall.

7.1.4 Fans can be noisy and increase noise output as more air is moved. However, the fan can be positioned away from the room when ducting is used.

7.1.5 Fans should last at least 7 years and may remain serviceable for up to 20 years. Fan motors come in both AC and DC types and have a rateable life of around 50,000 hours when operated at full speed, but systems generally do not operate at maximum speed. Breakdowns may occur because of:
- motor bearing failure
- internal corrosion
- heat exchange core deterioration
- atmospheric corrosion from damp air being drawn into the system
- control system failure
- damage to ducting
- dirt build-up in the system.

7.2 DUCTED EXTRACT SYSTEMS

7.2.1 Extract system ductwork may be required where the discharge air is:
- coming from an internal room
- going out through the roof or soffit via the ceiling
- extracted via a grille in a light or heat lamp fitting.

7.3 EXTRACT AIR LOCATION

7.3.1 Extract air locations should be:
- as high as possible
- as close as possible to the source of the steam or polluted air
- opposite the point in the room where make-up replacement air enters – to create a pathway through the room so fresh air can pick up the maximum amount of contaminated air before being extracted.

7.4 DISCHARGE AIR LOCATION

7.4.1 Stale, moist or polluted air must be discharged to the outside and not into another building space including the roof space.

7.4.2 Locate the outlet grille to ensure the discharge air does not:
- re-enter the fresh air supply system
- immediately have a passive ventilation route back into the building (e.g. through a window)
- get directed into another building
- get directed to where people commonly gather or pass by (e.g. a footpath).

7.4.3 To prevent water entry or air leakage, the outlet penetration should have a cover plate with either a seal or flashing and grille blades angled to deflect rain. Further protection can be provided by:
- automatic shutters that open only when the fan is switched on
- louvres – although some rattle in the wind, and airflow is reduced by around 30% for fixed louvres and 50% for gravity louvres
- backflow flaps – with inline ducted fans.

8.0 MECHANICAL VENTILATION HEAT RECOVERY SYSTEMS

8.0.1 Mechanical ventilation heat recovery (MVHR) systems (Figure 5) are designed to remove stale polluted air and provide a continuous supply of air drawn from outside the building. Colder outdoor air is warmed from heat or energy recovered from the exhaust air before being brought into the internal spaces of the building.

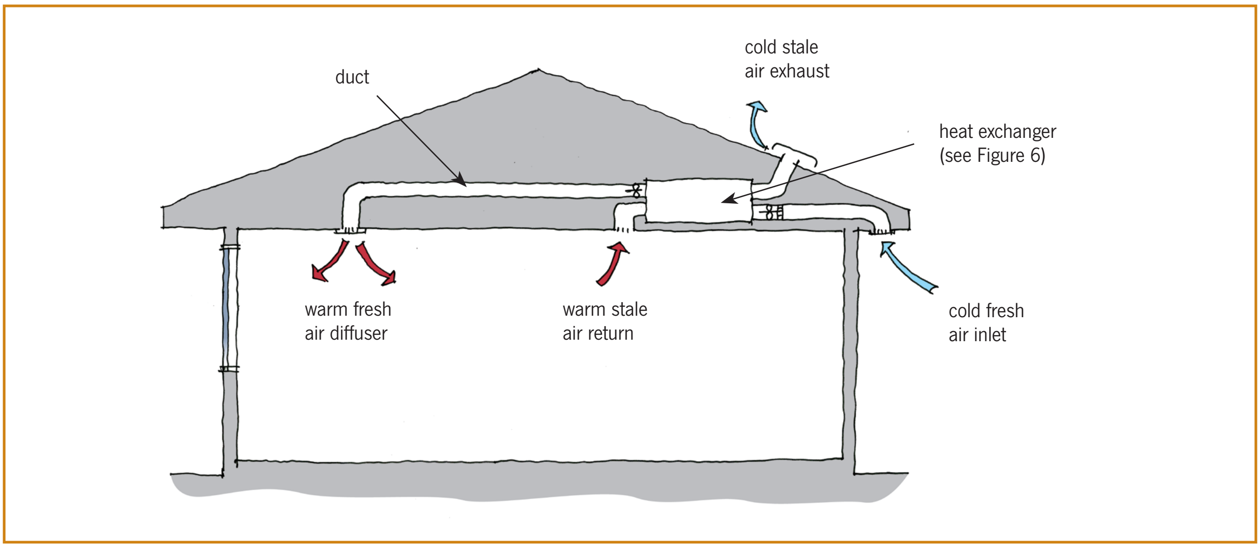

Figure 5. Mechanical ventilation heat recovery (MVHR) system.

8.0.2 An MVHR system generally comprises:
- supply air ducting
- exhaust air ducting
- a heat exchange unit
- an electronic control
- fan units for the extract and supply air streams
- condensate drain to the exterior (if necessary).

8.0.3 The key to the system is the heat exchange unit. Outdoor air is drawn into a ducting system and passed through the heat exchanger where heat from the outgoing exhaust air stream is transferred to the incoming air.

8.0.4 The heat exchange unit is made up of narrow passages through which the two air streams (supply and exhaust) flow but cannot mix. As long as there is a difference in temperature, heat from one air stream will pass into the other.

8.0.5 The air streams of the heat exchanger may flow at 90° to each other (cross-flow, Figure 6) or in parallel, opposite directions (counter-flow, Figure 7). Counter-flow systems are generally more efficient than cross-flow systems. Other systems may use a combination or alternate flow paths within the heat exchanger.

8.1 LOCATION

8.1.1 The heat exchange unit and ducting should be located where:
- there is access for installation and maintenance
- noise is not likely to be a problem – do not locate the heat exchange unit over a bedroom
- duct runs are as short and straight as possible.

8.1.2 The best location is usually the roof space. If this is not an option, other locations include:
- a ceiling bulkhead
- a cupboard
- a service area (where minimal noise is acceptable and access is available)
- garage roof space
- underfloor.

8.1.3 A variation to heat recovery ventilation is energy recovery ventilation, where the heat exchanger is made of a specially treated, permeable material that allows both moisture and heat to be transferred between the two air streams. Given New Zealand's naturally high humidity, energy recovery systems are not generally recommended for most North Island conditions but are suitable for Central Otago and other parts of New Zealand with low relative humidity.

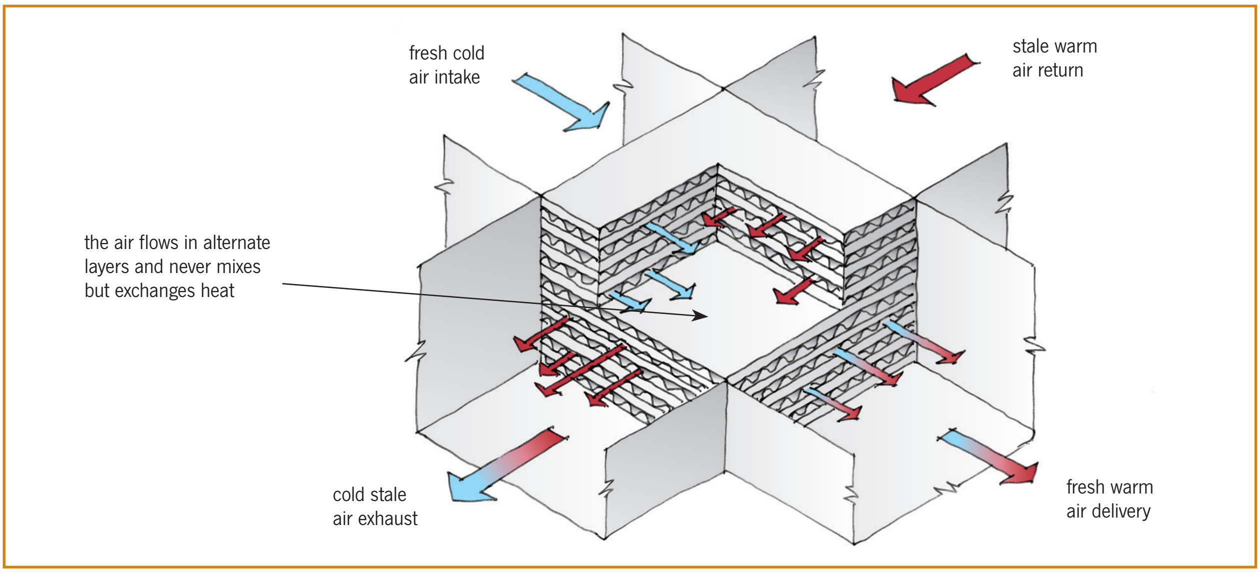

Figure 6. Principle of a cross-flow system.

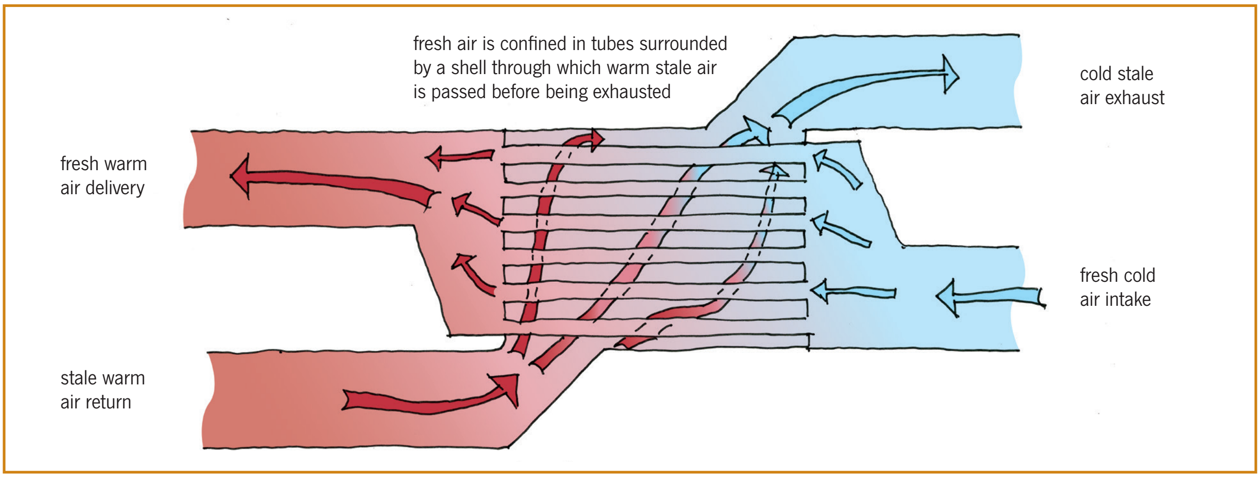

Figure 7. Principle of a counter-flow system.

8.1.4 Heat recovery systems are usually good for moisture removal where moist indoor air is replaced with warmed drier outdoor air.

8.1.5 Heat/energy recovery ventilation systems are primarily ventilation systems. The ability to raise or lower the temperature of the incoming air is a secondary benefit so they must not be considered as a heating system. They are typically designed to operate as a balanced system, where the same amount of air goes in and out, maintaining a balanced pressure in the house.

8.1.6 These systems can be combined with ducted heating systems.

8.1.7 A heat/energy recovery system is not designed to remove combustion byproducts or supply the combustion air requirements of fuel-burning appliances. These appliances must have an independent source of oxygen and be vented to the outside.

8.2 SINGLE-ROOM MVHR SYSTEMS

8.2.1 An alternative configuration to a roof space-mounted whole house ducted MVHR system is a single room-based system. These systems are mounted on an external wall and allow single rooms to be ventilated with outdoor air while reducing heat loss from the room. They provide an easier to install yet highly energy efficient retrofit option for existing houses.

8.3 BENEFITS OF MVHR SYSTEMS

8.3.1 Winter heat recovery: Because these systems recover heat/energy from the exhaust air, less heat is required to maintain a comfortable indoor environment. For example, if the outdoor temperature is 5°C and the indoor temperature is to be maintained at 18°C, outdoor air introduced by passive or supply-only ventilation (i.e. an open window or a positive pressure system) requires a temperature increase of 13°C to match the internal air temperature. If the temperature of the incoming air is raised by 7°C via heat recovered from the exhaust air, the space heating is only required to raise the temperature by 6°C. The amount of heat/energy recovered depends on the surface area of the heat exchanger, air temperature difference, airflow rates and the relative humidity level at the time of recovery.

8.3.2 Moisture reduction: When outdoor air is warmed before being drawn inside, its relative humidity decreases and, as the moisture-laden indoor air is expelled, the relative humidity indoors is reduced.

9.0 DUCTING

9.0.1 Some considerations around ducting design include:

- air distribution
- airflow rate
- air velocity
- airflow resistance through the ducting (a factor of duct length and type, the number of bends and other fittings and also the cross-sectional area)
- fan performance
- duct insulation level (heat loss)
- noise.

9.0.2 Ducting should be well sealed and not allow air to leak into other spaces. Ideally, it should be pressure tested.

9.0.3 Ducting should be well insulated. Where the ducting is transporting warm air through a cooler space, this will reduce heat loss. This is especially important for MVHR systems.

9.0.4 The larger the diameter of ducting, the better and quieter the airflow. Where possible, the diameter should be 150–250 mm, reducing to 100–150 mm diameter at ceiling vents or grilles. Smaller ducting is not recommended as airflows need to be higher, creating greater noise and energy use for fans.

9.0.5 Where bends in ducts are unavoidable, they should have as large a bend radius as possible.

9.0.6 MVHR systems must have a condensation drain (draining to the outside) installed from the heat exchanger to the exterior to remove moisture that has condensed as a result of the heat exchange between the two air streams.

10.0 CHOOSING A VENTILATION SYSTEM

10.0.1 Before a ventilation system is installed, it is important to consider the airtightness of the house and how this will affect the ventilation system. For example, if an MVHR system is installed within a house that is not particularly airtight, the energy losses through natural ventilation can be equal or even higher than the energy recovered by the system, resulting in a net energy loss when taking the energy demand of the MVHR system into account.

10.0.2 One of the important considerations in the overall ventilation system is how well the supply airflow is matched with the extract airflow. This is especially important in an airtight house where an unbalanced system may result in pressurised or depressurised areas within the house. Balancing of systems can be undertaken in a number of different ways and can include both passive and mechanical ventilation solutions.

10.0.3 As houses become better insulated, the relative importance of heat loss due to ventilation increases. A higher flow rate through a ventilation system will increase the system's ability to remove pollutants, but during winter, the colder outdoor temperatures will influence the indoor temperatures requiring additional heating. It is therefore important to not over-ventilate, as this will require additional heating.

11.0 MAINTENANCE

11.0.1 An annual service of the system is recommended.

11.0.2 In addition, the homeowner should be informed of the regular maintenance requirements specified by the manufacturer such as (not all items will be present):

- replacing air filters – either 6 or 12 monthly
- cleaning outside hoods and screens – typically 12 monthly
- cleaning the heat exchange unit – either 12 or 24 monthly
- cleaning the condensate drain and pans to remove mould, bacteria and fungi –12 monthly
- servicing and lubricating the fans (most are factory sealed and do not require lubrication).

12.0 CODES, STANDARDS, REFERENCES

Ministry of Business, Innovation and Employment
New Zealand Building Code clause G4 *Ventilation*

Standards New Zealand
AS/NZS 3666.1:2011 *Air handling and water systems of buildings – Microbial control – Part 1: Design, installation and commissioning*
AS/NZS 3666.2:2011 *Air handling and water systems of buildings –Microbial control – Part 2: Operation and maintenance*
NZS 4303:1990 *Ventilation for acceptable indoor air quality*

Standards Australia
AS 1668.2:2002 *The use of mechanical ventilation and air-conditioning in buildings Part 2: Ventilation design for indoor-air contaminant control*

BRANZ
Good Repair Guide *Dealing with Mould*
Good Repair Guide *Improving Internal Ventilation*

Bulletin 555 *A guide to ALF 3.2*
ALF 3.2 online http://alf.branz.co.nz/

Other
Natural Resources Canada, 2012. *Heat Recovery Ventilators* www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/pdf/energystar/HRV_EN.pdf

BRANZ

THE CORE PURPOSE OF BRANZ IS TO IMPROVE PEOPLE'S LIVES THROUGH OUR RESEARCH AND OUR DRIVE TO INFORM, EDUCATE AND MOTIVATE THOSE WHO SHAPE THE BUILT ENVIRONMENT.

BRANZ ADVISORY HELP LINES

FOR THE BULDING INDUSTRY
0800 80 80 85

FOR THE HOME OWNER AND PUBLIC ENQUIRIES
0900 5 90 90

Calls cost $1.99 per minute plus GST. Children please ask your parents first.

HEAD OFFICE AND RESEARCH STATION
Moonshine Road, Judgeford
Postal Address – Private Bag 50 908, Porirua 5240, New Zealand
Telephone – (04) 237 1170, Fax – (04) 237 1171
www.branz.co.nz

Standards referred to in this publication can be purchased from Standards New Zealand by phone 0800 782 632 or by visiting the website: www.standards.co.nz.

Please note, BRANZ books or bulletins mentioned in this publication may be withdrawn at any time. For more information and an up-to-date list, visit BRANZ Shop online: www.branz.co.nz or phone BRANZ 0800 80 80 85, press 2.

ISSN 1170-8395