CHAPTER 8

AIR MOVEMENT

This chapter is about the control of air movement and how it can save energy. The contents of the chapter outline measures that can be taken to reduce air leakage and provide guidelines for designing controllable ventilation and maintaining acceptable air quality.

Control of air movement can save energy

The control of air movement—the reduction of uncontrolled air leakage and the inclusion of controllable ventilation—is essential to minimise the need for supplementary heating and cooling. This can save up to 20% on heating and cooling costs and improve comfort.

Air leakage has a significant impact on thermal performance. This should be minimised by draught proofing new and existing homes. This can prevent heat loss in winter, thereby saving on the cost of heating, and prevent the entry of warm air in summer, reducing the need for cooling.

A typical home with a wall vent in each room will have approximately one air change per hour (one air change per hour occurs when the volume of inside air is replaced totally by outside air in a period of an hour). Sealing the vents reduces the air change rate to 0.5 per hour, which reduces overall energy requirements by up to 15% and still allows for adequate ventilation.

Many older homes have significant air leakage, which can average up to three air changes per hour. Some typical sources of air leakage are shown in figure 8.1. Limiting air leakage in older homes can save up to 25% of heating energy costs.

Ventilation should be planned to cool the home and its occupants in summer, and reduce or eliminate the need for mechanical air conditioning.

Controllable ventilation can be simply and inexpensively incorporated into the house design, allowing fresh air in when necessary. Units with appropriate seals or louvres can also prevent heated air from escaping and cold air from entering the home. Forced ventilation systems such as exhaust fans and rangehoods can be used to avoid problems of odour and condensation.

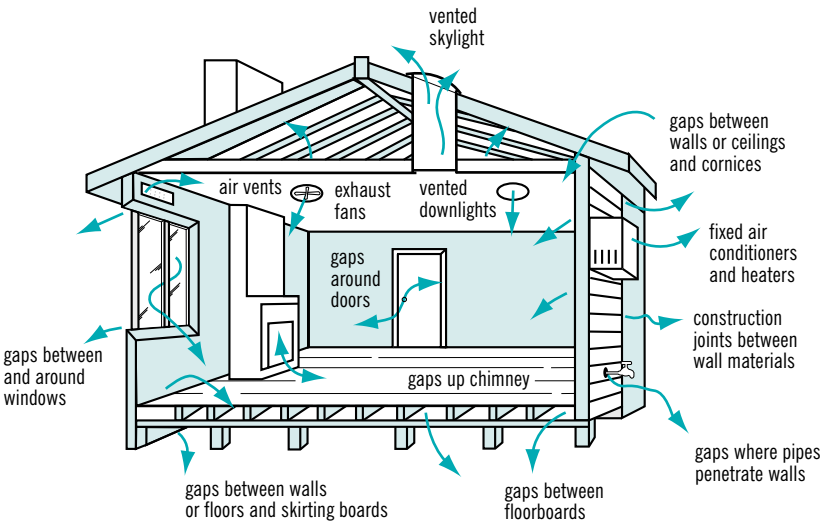


Figure 8.1: Major sources of heat leaks and draughts

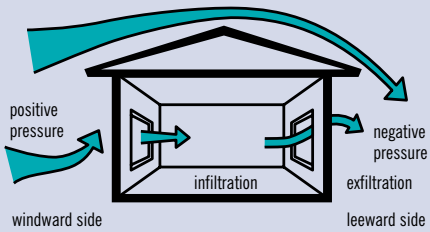


Figure 8.2: Infiltration and exfiltration

Air leakage

Air leakage is made up of:

- infiltration—the uncontrolled entry of outside air through structural gaps, window and door openings, exhaust fans, vented downlights and fixed wall vents; and
- exfiltration—the loss of air from indoors by the same means.

Most buildings leak air around windows and doors and through construction gaps. When the wind blows, a pressure difference is created between inside and outside. This causes some outside air to be forced into the home on the windward side (infiltration) and some inside air to be sucked out on the leeward side through gaps in the structure (exfiltration) as shown in figure 8.2.

Air leakage can be minimised by careful attention to design, detailing, specification and construction. Typical sources of heat loss are:

- fixed wall vents (required by regulation in houses built before 1984);
- poorly-fitting windows and external doors (increase energy costs by up to 15%);
- gaps between external walls and window and door frames and around construction joints and pipes;
- open fireplaces (five or more air changes per hour increase energy requirements by up to 120%);
- vented skylights which allow warm air near the ceiling to escape;
- non-sealable exhaust fans;
- unsealed duct outlets; and
- downlights or recessed light fittings which require fixed ventilation to cool the luminaire (adding up to 10% to heating costs).

Checking for draughts

The following methods can be used to locate or identify draughts:

- look for obvious gaps—visible light under and around doors and windows;
- listen for 'rattles' or 'whistling' around doors and windows, especially during strong winds;
- feel for moving air (or use a lighted candle) around doors, windows, fireplaces, air outlets, vents, stairways, architraves and skirting boards; and
- look for moving curtains.

Some typical sources of air leakage, with recommendations for improvement are shown in table 8.1.

Table 8.1: Air leakage source and recommended solutions

SOURCE OF AIR LEAKAGE	SOLUTION
Fixed vents in walls, ceiling or windows	▸ New housing does not require fixed ventilation, close off fixed ventilation in existing homes where regulations permit or replace with closeable type ▸ Provide controllable ventilation such as windows positioned for cross-ventilation and sealed exhaust fans
Door and window openings	▸ Seal gaps around doors and openable windows with lightweight self-adhesive weatherstripping products (foam, flexible plastic, polypropylene pile strips). Some standard doors and windows are available with weatherstrips already fitted ▸ Fit draught excluders to the bottom of all external doors and to internal doors leading to unheated and vented areas (figure 8.3) ▸ Fit automatic door closers to external doors and doors leading to unheated areas ▸ Avoid the use of cavity sliding doors which are hard to seal
Construction joints	▸ Use silicone or latex-based foams to seal cracks and gaps between building components, such as the junction of window and door frames, walls, floors and ceilings, skirting boards, plumbing pipes, exposed rafters and beams, in-built heaters and air conditioners, and between masonry walls and timber framing (see figure 8.4)

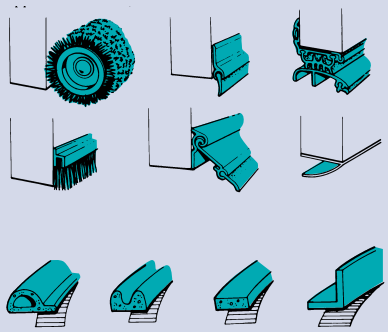


Figure 8.3: Draught excluders

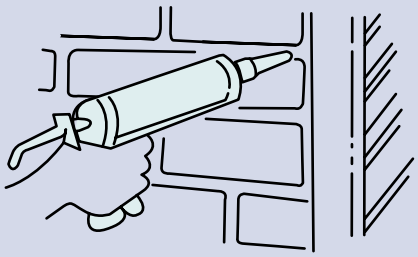
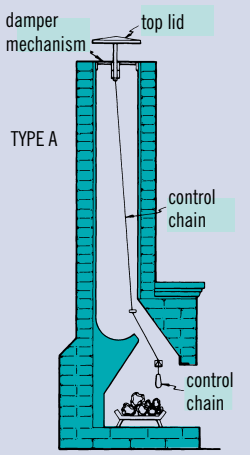


Figure 8.4: Seal around construction joints



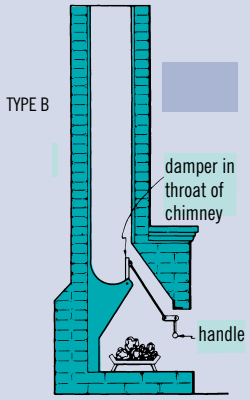


Figure 8.5: Chimney dampers

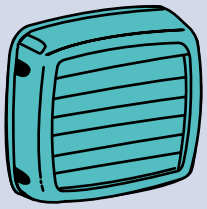


Figure 8.6: Self-closing exhaust fan

Table 8.1 continued

SOURCE OF AIR LEAKAGE	SOLUTION
Open fireplaces	▸ Victorian insulation regulations require dampers to all new fireplaces which should be closed when the fireplace is not in use. There are two basic types—both prevent entry of rain and insects (see figure 8.5) ▹ Type A fits on top of the chimney and is controlled from inside with a chain and handle ▹ Type B sits in the throat of the chimney, giving more control, and reducing heat wastage up the chimney, but is more difficult to install in existing fireplaces
Vented skylights	▸ Unless ventilation is required by regulation, block off vents in existing skylights or install a clear plastic sheet under the skylight ▸ Do not use permanently vented skylights in new construction or in heated areas
Exhaust fans	▸ Select self-closing models (automatic shutters or dampers) to stop air leaks, always vent exhaust fans and rangehoods to the outside, not into the roof space or wall cavity where moisture may condense and damage wall or ceiling linings (see figure 8.6) ▸ For existing fans, fit a lid over the outlet. The lid blows open when the fan is switched on and falls shut when the fan stops
Vented recessed light fittings	▸ In existing buildings, the only solution is replacement with surface-mounted light fittings ▸ Avoid use in new construction
Duct outlets	▸ Provide dampers or covers to outlets when not in use ▸ Roof-mounted evaporative coolers should be sealed or covered when not in use

Ventilation

Ventilation is the deliberate replacement of warm inside air with cooler outside air by utilising naturally-occurring air temperature and pressure differences, or by mechanical means such as exhaust fans.

Ventilation, at air speeds greater than that provided by natural air leakage, has a cooling effect on the human body. At air speeds of between 0.5 to 1.0 m per second the body will feel 2–3° cooler in 25°C air.

The greater the extent of air-tightness to eliminate draughts and reduce energy costs, the more important it is to provide controlled ventilation to maintain adequate air quality, particularly in service areas such as kitchens and bathrooms. Controllable ventilation, such as exhaust fans that close off when not in use, provide ventilation when required without contributing to overall air leakage.

More recently, specialised mechanical heat recovery ventilation systems have become available. These work in conjunction with central heating/cooling units, and provide control of ventilation and humidity levels.

Openable windows and doors, and the interior layout, can be planned to take advantage of natural breezes and convection flow. Fans can be used where natural ventilation is inadequate, or where rapid removal of air contaminants is required.

Principles of cooling by ventilation

CONVECTION FLOW (STACK EFFECT)

Low to high window openings across a space can be positioned to set up a convection flow. When the outside air is cooler, windows can be opened, and warm, less dense air rises and passes out through the high opening. The warm inside air is replaced with cooler air from outside drawn in through a relatively low opening. This cool air absorbs the heat of the building and carries it outside (see figure 8.7).

CROSS-VENTILATION

Cross-ventilation utilises differential wind pressure. When the air outside is cooler, windows on opposite sides of the home can be opened. Cool air enters on the windward side and passes out on the other side, replacing warm inside air with cool outside air.

EXHAUST FANS

Ceiling and roof-mounted exhaust fans can be used to extract warm air, creating a pressure imbalance that will draw cool air from outside via open windows or doors to replace the warm inside air (see figure 8.8). Powerful 'whole-house' fans, which can move large volumes of air quickly, are also available. Only fans with dampers, auto-closing louvres or vent covers should be used. Such fans use very small amounts of electricity.

CEILING FANS

Ceiling fans can provide additional air movement in summer if ceiling height is adequate (see figure 8.9). Overhead fans circulate large volumes of air and assist evaporative heat loss from the body. They are an economical and efficient way of creating cool breezes. In hot summer conditions, increased air movement can raise the body's tolerance threshold for high temperatures by about 3°C.

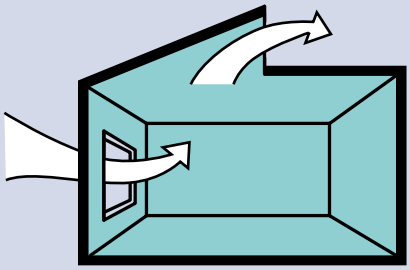


Figure 8.7: Cooling by convection flow

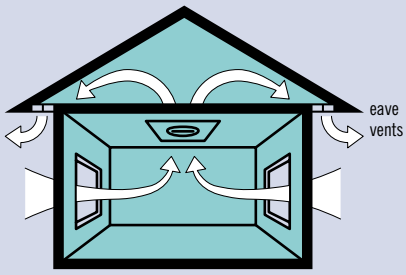


Figure 8.8: Cooling with ceiling exhaust fan

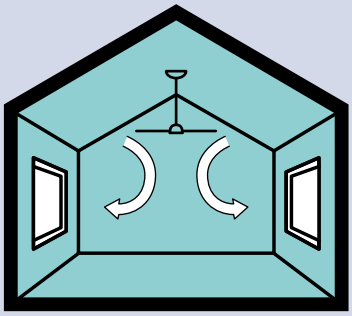


Figure 8.9: Cooling with ceiling fan

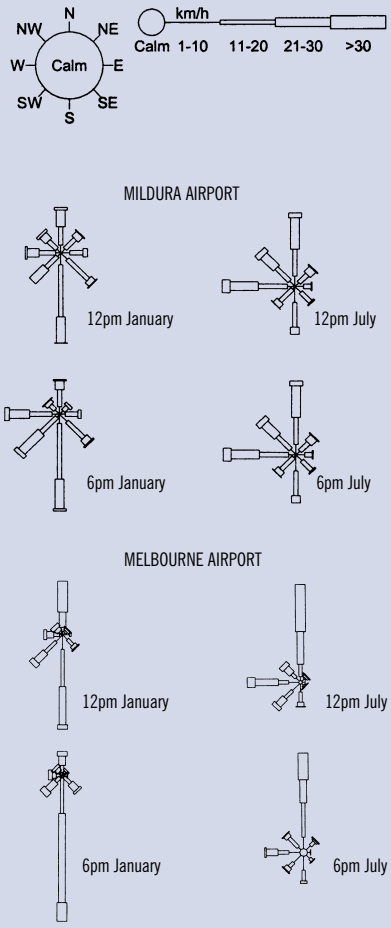


Figure 8.10: Wind roses for Mildura and Melbourne

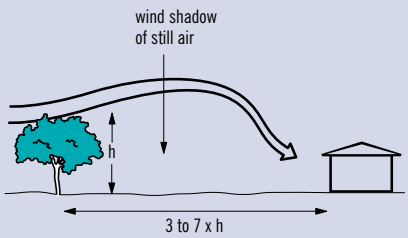


Figure 8.11: Wind shadow

Designing good ventilation

DETERMINE WHERE THE NATURAL BREEZES COME FROM

The direction of prevailing winds for each month can be sourced from the Bureau of Meteorology (see figure 8.10). In and around Melbourne, the cooling summer breezes tend to come from the south.

DETERMINE HOW LOCAL CONDITIONS MODIFY THE DIRECTION OF THE BREEZE

Valleys and large land masses can direct or deflect wind away from prevailing paths. Buildings, tree belts or other tall features can cause wind shadows, which cause pockets of fairly still air. Such obstruction can impede ventilation and should be taken into account in house design. Wind shadows between the obstruction and the immediately adjacent building are created for a distance of about three to seven times the height of obstruction (see figure 8.11).

LOCATE AND DETERMINE THE SIZE OF OPENINGS THAT WILL ADMIT COOLING BREEZES

Allow for both an inlet and outlet opening on opposite sides of the home and a short unrestricted path. With an inlet only opened, the air speed inside the building will be only 4% of that on the outside (see figure 8.12).

With both an inlet and outlet opening of the same size, the inside air speed will be around 35% of the prevailing wind space outside. The opening on the leeward side should be equal to, or bigger than, the inlet on the windward side. Increasing the size of the outlet should result in an air speed inside that is approximately 44% of the outside, enhancing its cooling effect (see figure 8.13).

PLAN THE INTERIOR SO THAT AIR CAN FLOW FREELY

The more direct the path for air to move through a building, the greater its speed and effect to cool. The planning of partitions and openings should ensure that pockets of still air are not created (see figure 8.14). Passages that have openings to the outside can create paths for air movement to adjoining rooms.

INSTALL FANS IF THE NATURAL VENTILATION IS NOT ADEQUATE

Roof-mounted exhaust fans can extract hot air from the roof space at night and replace it with cool air. Their effectiveness is largely dependent on the level of ceiling insulation installed. They can be activated by wind or operate on a thermostat. Outlets should have covers or dampers to prevent winter heat loss.

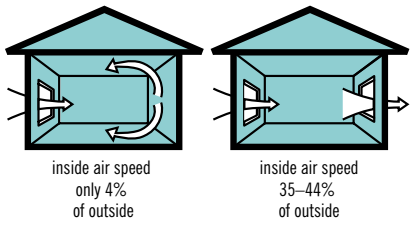


Figure 8.12: Inside air speed with cross-ventilation

Air quality

A completely airtight home without controllable ventilation is not desirable as a minimum level of ventilation is necessary to replace used internal air that contains odours, carbon dioxide, water vapour and contaminants.

Indoor air quality depends on the activities, furnishings and building materials in the home which may produce air contaminants and the degree to which these contaminants can escape. Many building materials and household goods can emit chemicals which dissipate over time. The recommended minimum air exchange of 0.5 air changes per hour is, however, not adequate to completely remove contaminants in all situations, and should be supplemented with controllable ventilation such as openable windows and exhaust fans. High levels of fixed ventilation are wasteful of energy and should be avoided.

Heaters which burn internal air (e.g. solid fuel and some gas heaters) can be provided with a separate external air supply to avoid draughts and maintain indoor air quality. These require a damper to be closed off when not in use (see figure 8.15). Ventilation is essential when using unflued LPG gas heaters.

For situations where additional ventilation at a higher air change rate is required at some times:

- provide openable windows which increase ventilation only when needed.
- use self-closing wall or ceiling exhaust fans, vented externally, for rapid removal of cooking fumes, odours or steam from laundry, kitchen or bathroom.
- locate fans near the source of the contaminant, e.g. an exhaust fan near the shower.

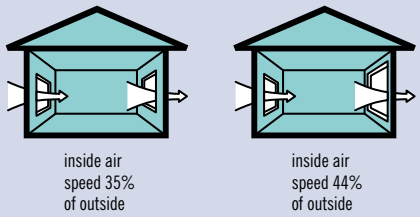


Figure 8.13: Relative window opening sizes

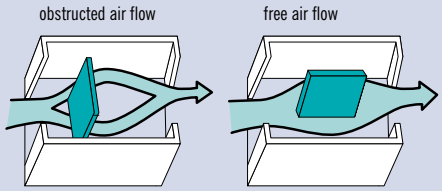


Figure 8.14: Air flow

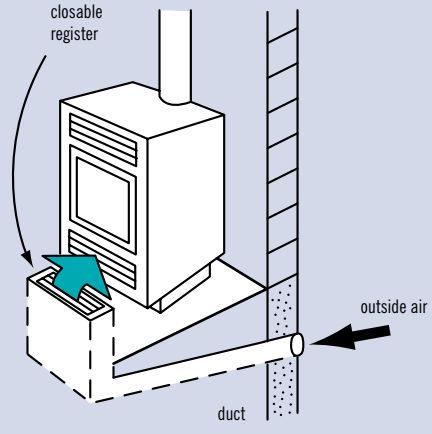


Figure 8.15: Separate air supply for some heaters

