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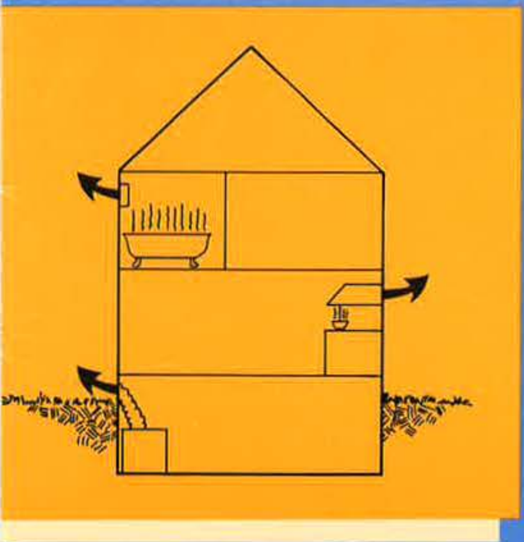
Ventilation: Health and Safety Issues



NHA 5888

Ventilation: Health and Safety Issues

The material for this publication was developed in consultation with the Canadian Home Builders' Association for a series of seminars held across the country.

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Contents

Introduction

As a result of recent changes in construction techniques, health and safety issues associated with house ventilation have become a new and evolving field for building research and an area of increasing public concern.

Prior to the energy conservation era of the mid-seventies, most houses had adequate ventilation because of unintentional leakage through the building envelope (except in the spring and fall when windows were closed and the furnace was off).

With the advent of intensified energy conservation practices, air leakage has been targeted as a major energy loss and construction practices have been directed toward producing "airtight" houses. The consequence, however, could be increased health and safety risks because of inadequate ventilation.

Media coverage has increased the public's level of awareness. Terms like "radon gas," "carbon monoxide poisoning," and "offgassing" have become commonplace.

Because of the recent concern over ventilation and also because of the increase in sophistication of heating and ventilation equipment, it has been proposed that heating, ventilating and air conditioning (HVAC) contractors be certified. At present there is no Canadian standard on residential ventilation.

This guide presents an overview of the issues, alerts builders to potential problems, and suggests some general solutions. This guide is limited to health and safety matters within the habitable portion of the house. Ventilation measures for attics, crawl spaces and wall cavities, while being very important for moisture control, are not included here.

It should be kept in mind that a considerable amount of research is still required — for example, in present installations there may be contradictions between solutions to control humidity and solutions to prevent combustion backdrafting. It should also be noted that great variability exists among houses.

Inevitably, many solutions will come from the experience of builders themselves in their efforts to resolve these problems.

To better understand the issues and terminology involved in this subject, see Terms and Definitions.

The purpose of ventilation is to:

- provide fresh air for occupants
- remove pollutants
- control humidity
- supply combustion and draft air for fuel-burning equipment.

Problem

High humidity levels

Symptoms

Homeowners may complain of excessive condensation on windows or wall surfaces. This is most readily apparent as fogged or frosted glazing and damage to finishes and window frames.

As a rough rule of thumb, condensation will occur when relative humidity (RH) levels exceed 30% for double glazing, and 45% for triple glazing, at an outdoor temperature of – 20°C (– 4°F) and a wind speed of 24 km/h (15 mph). See fig. 1.

More serious is concealed condensation in attics and wall cavities (also called interstitial condensation). This is caused by the exfiltration of moist house air through breaks in the vapour barrier. It can lead to deterioration of siding, sheathing and structure, and reduced thermal resistance of wet insulation. Wood rots at moisture contents over 22% if sufficiently warm (fig. 2).

Mould and mildew cause mustiness and odours, and may cause allergic reactions in humans. In theory, mould requires indoor ambient temperatures and humidity levels in excess of 50%, but can sustain itself at much lower RH levels once established.

Health studies suggest that occupants in homes with high humidity may show greater susceptibility to colds and flus because of the spread of microbes and dust mites which thrive in RH levels over 50%. It should be noted, however, that low humidity can also cause health problems. At RH levels below 30%, there may be a greater incidence of respiratory infection, asthma and allergies (fig. 3).

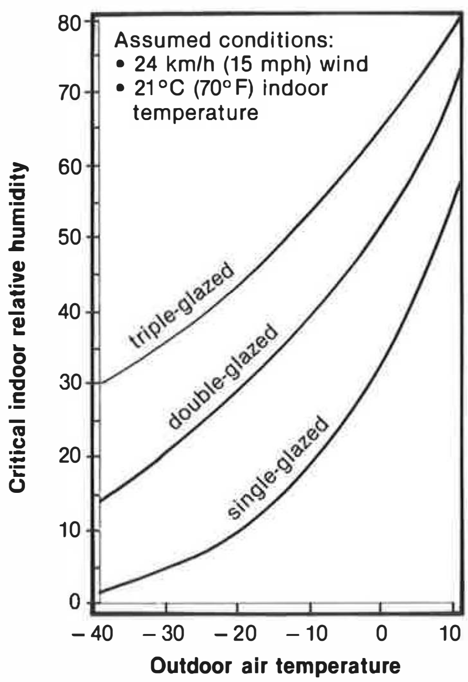

Fig. 1. Effect of glazing on condensation.

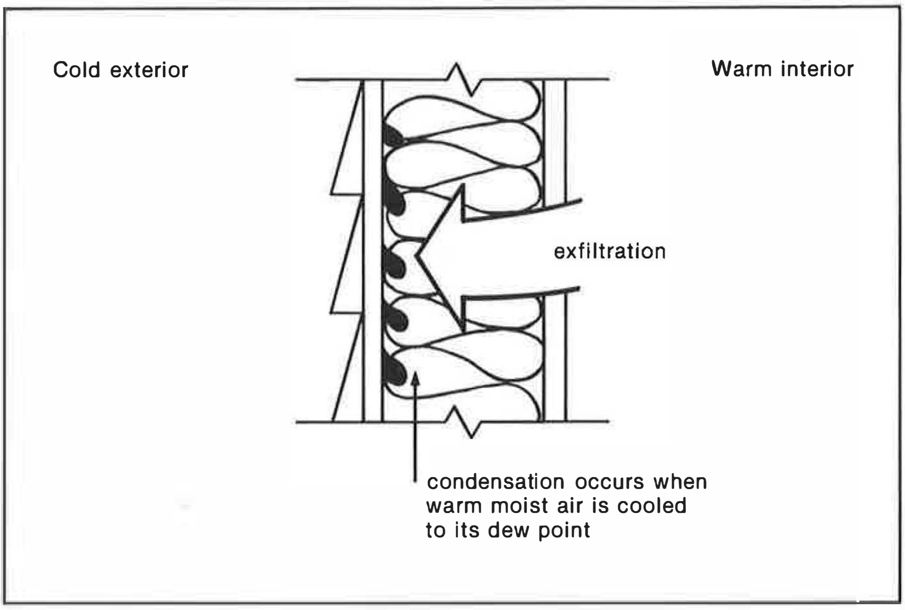

Fig. 2. Condensation in wall cavity.

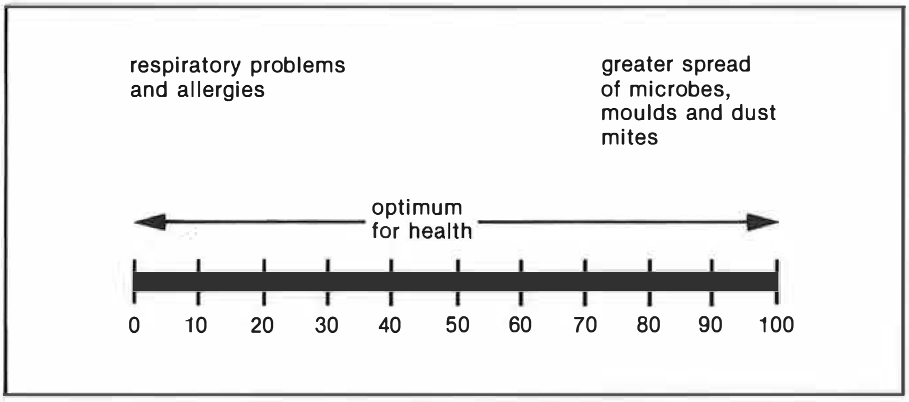

Fig. 3. RN effects on health.

Cause

Lack of general ventilation.
This is especially common in electrically heated houses with no active flue, and in airtight houses without controlled ventilation.

Solutions

- Provide increased mechanical ventilation. The 1985 National Building Code requires houses to have mechanical ventilation systems capable of providing at least half an air change per hour (fig. 4).*
- Install a forced fresh air supply, activated by a humidistat. Even saturated air can have considerable drying potential. As exterior air is heated to indoor temperatures, its relative humidity is lowered (fig. 5).
- Many recommend a manually controlled 2-speed ventilation system with a continuous exhaust rate of 35–50 L/s (70–100 cfm), and capacity for 70–75 L/s (140–150 cfm).
- Passive venting can be an effective ventilation technique if properly engineered. It may not be suited to cold climates or leaky houses. A "planned hole" approximately 100 mm (4″) in diameter placed high in the house, or a dummy chimney ("stack vent"), serves to raise the neutral pressure plane. This decreases the area subject to unwanted exfiltration of moist house air. Note that passive vents must be insulated above the ceiling (fig. 6).
- Don't rely on natural ventilation or uncontrolled leakage. This is unpredictable because of many factors: exterior temperature, wind speed and direction, building configuration, the number and location of flues, airtightness, and occupant behaviour. Note that ventilation for moisture reduction is effective only when fresh air is significantly drier than house air. In coastal regions with damp climates (Newfoundland and coastal B.C., for example), ventilation is of little value when exterior temperatures are above 5°C (41°F). In these conditions, dehumidification may be necessary.

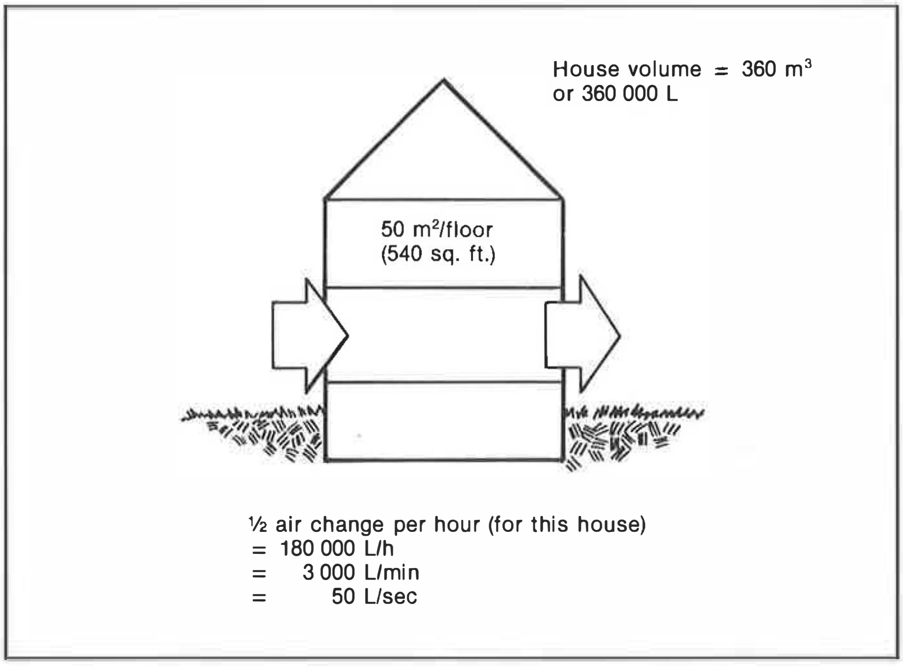

Fig. 4. *National Building Code* requirements.

* *National Building Code 1985*, 9.33.3.1 Dwelling units shall have a mechanical ventilation system capable of providing at least one-half an air change per hour during the heating season based on the interior finished volume of the dwelling unit. The system shall be controlled either manually by a switch or automatically.

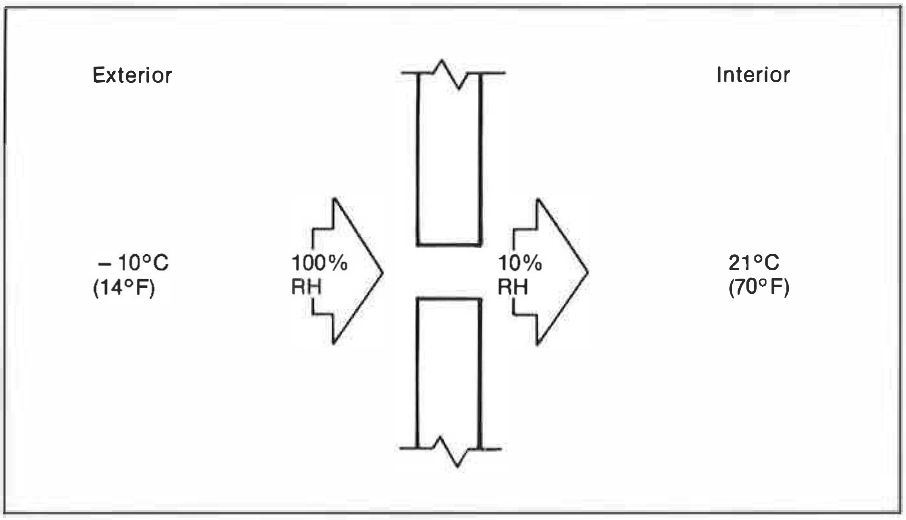

Fig. 5. Drying potential.

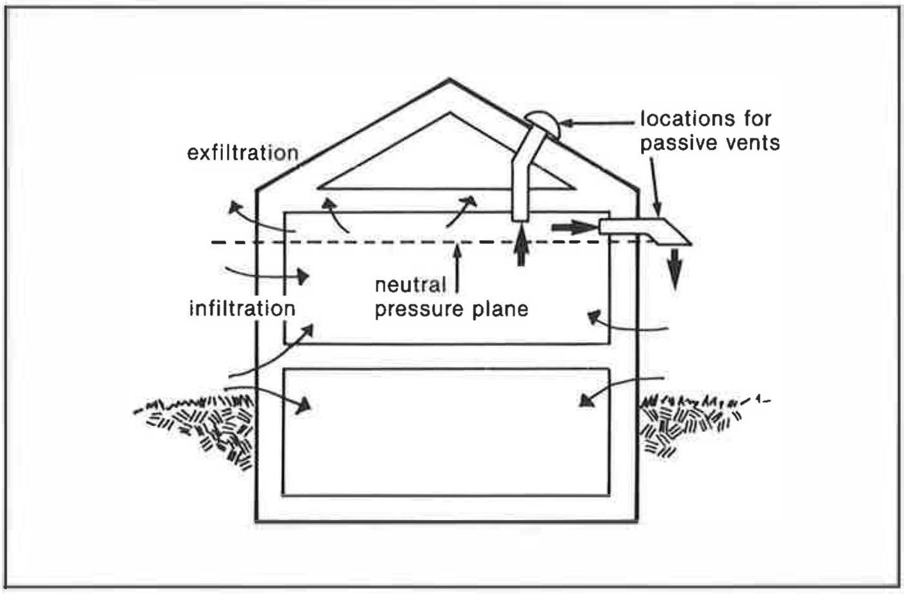

Fig. 6. Passive ventilation.

Cause

Lack of circulation.
In spite of adequate general ventilation, poor circulation to certain rooms, corners, or closets may cause localized problems.

Solutions

- Increase the number and distribution of return air grills. Ensure that return air ducts are properly sized and are not leaky.
- Where possible, supply fresh air to each bedroom and living area. The American Society of Heating and Refrigeration Engineers (ASHRAE) recommends a minimum of 5 L/s of outdoor air for each room. Design ductwork to supply and return specific quantities of air to each room in accordance with Heating, Refrigeration and Air Conditioning Institute (HRAI) recommendations.
- A central exhaust system works most effectively if every interior door is undercut at least 25 mm (1″). See fig. 7.
- Leave a gap at the top and bottom of closet doors, or use louvered or sliding doors. Keep closets away from exterior walls where possible.
- Install ceiling fans.
- Keep ductwork runs short and use as few elbows and bends as possible to improve efficiency.
- HRAI recommends high side wall registers for better mixing.
- Ensure good air flow past windows.

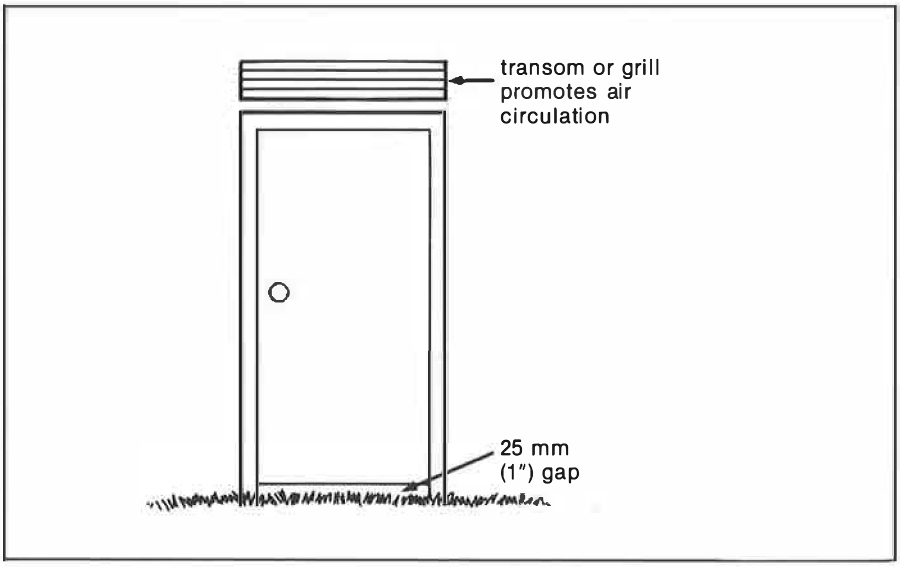

Fig. 7. Improvements to circulation.

Cause

Excessive moisture generation.
The elimination or reduction of moisture at its source is less costly than trying to remove it after it has been created.

Solutions

Some of the following solutions are within the builder's control — others are a matter of consumer education and should be part of an "owner's manual." Those intended for the builder's attention are marked (B), and those for occupants are marked (O).

Household activities such as cooking, washing and breathing, and the presence of pets and house plants produce 10-20 litres (2-4 gals.) of moisture per day for a typical family.

- Exhaust humid air from bathrooms, kitchen and laundry. Exhaust directly at source (fig. 8) or duct to basement to a central fan. Make sure ductwork that runs through unheated areas is insulated (B).
- Install additional exhaust systems for hot tubs, whirlpools and saunas. One of these units can produce as much as 10 litres (2 gals.) of moisture per day (B).
- Caution occupants to reduce or avoid certain moisture-producing activities, such as hanging clothes to dry indoors or running humidifiers (O).
- Caution occupants not to dry firewood indoors. Four cords of green firewood per heating season can release 5 to 10 litres (1 to 2 gals.) of moisture per day. See fig. 9 (O).
- Don't install humidifiers in heating systems, or lock out the upper part of the range above 50% RH (B).

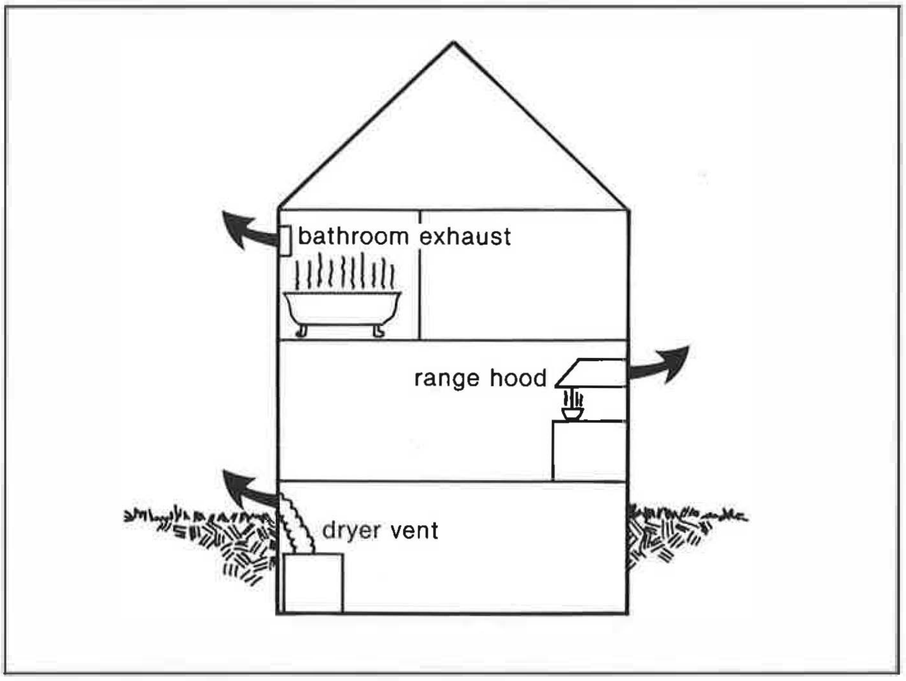

Fig. 8. Exhaust at moisture sources.

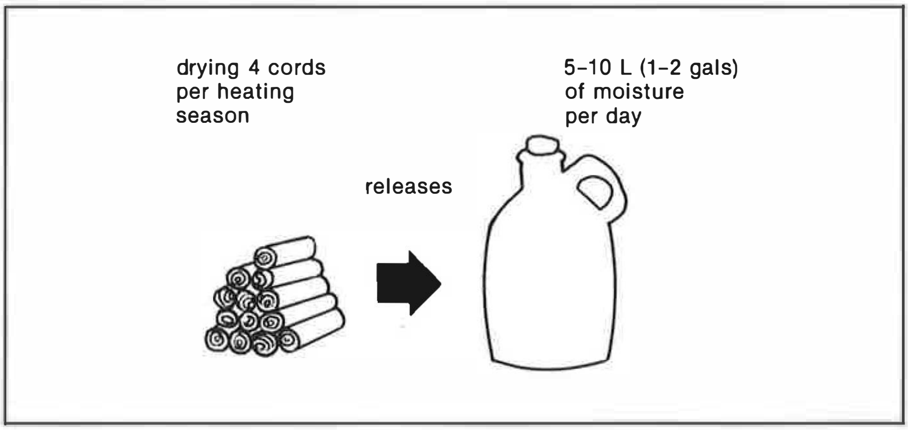

Fig. 9. Drying firewood.

Construction: drying of framing and other materials, and the curing of concrete can release an average of 5 to 15 litres (1 to 3½ gals.) of moisture per day for the first two years, decreasing over time.

- Ventilate and dehumidify the house during basement slab curing, painting, texture spraying, and other moisture-producing activities (B).
- Advise residents to provide as much natural and mechanical ventilation as possible during the first six months of occupancy (O).

Seasonal storage: moisture absorbed by concrete, framing and furnishings in summer can release from 3 to 8 litres (¾ to 1½ gals.) of moisture per day into house air in the fall when the house is first closed up.

- Encourage occupants to dehumidify the basement in summer, and continue to ventilate the house well into the fall (O).

Ground sources: basements have been described as "warm sponges on wet ground." Air leaking in from below-grade sources such as foundation cracks and weeping tile is often 100% saturated. This is also known as "soil gas." Subgrade infiltration and the wicking action of concrete walls and slabs can release 2 to 10 litres (½ to 2 gals.) of moisture a day into the house. Uncovered crawl spaces, if damp, can release 40 to 50 litres (9 to 10 gals.) of moisture a day (fig. 10).

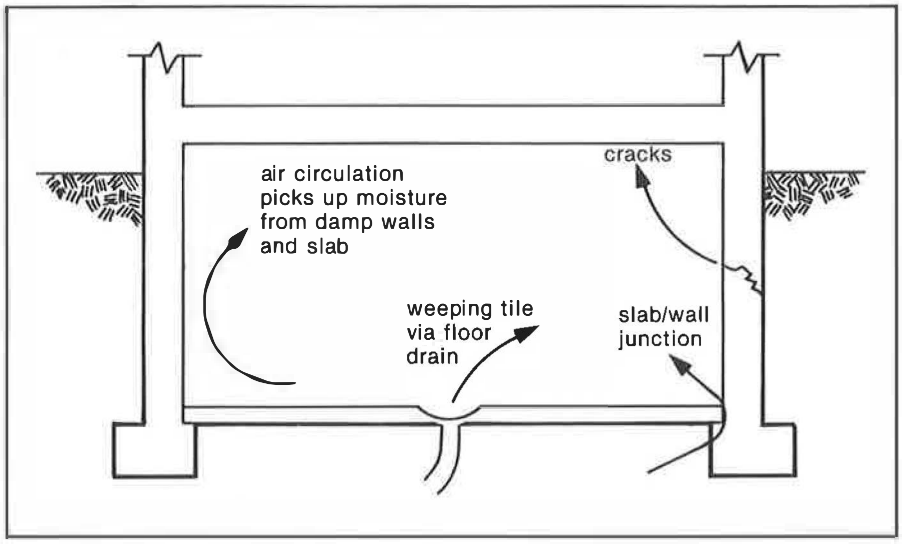

Fig. 10. Basement moisture sources.

- Provide proper weeping tile, granular backfill, and dampproofing to keep water away from basement walls and crawl spaces. See fig. 11 (B).
- Seal crawl space from ground and protect the moisture barrier from damage by covering with sand or concrete (B).
- Moisture seal the interior of walls and slab (O/B).
- Employ good construction practice, such as control joints, to reduce the frequency of concrete cracks. Refer to CMHC's Builders' Series booklet *Concrete Foundations*.

- Provide removable covers for floor drains and sump pits. Vent to outdoors. Provide trap primers to prevent the trap from drying out. See fig. 12 (B).
- Don't use the crawl space as a warm air plenum unless it is totally sealed from moisture sources (B).
- Finished basements, complete with insulation and continuous vapour barriers, may decrease the release of moisture into the air (O).

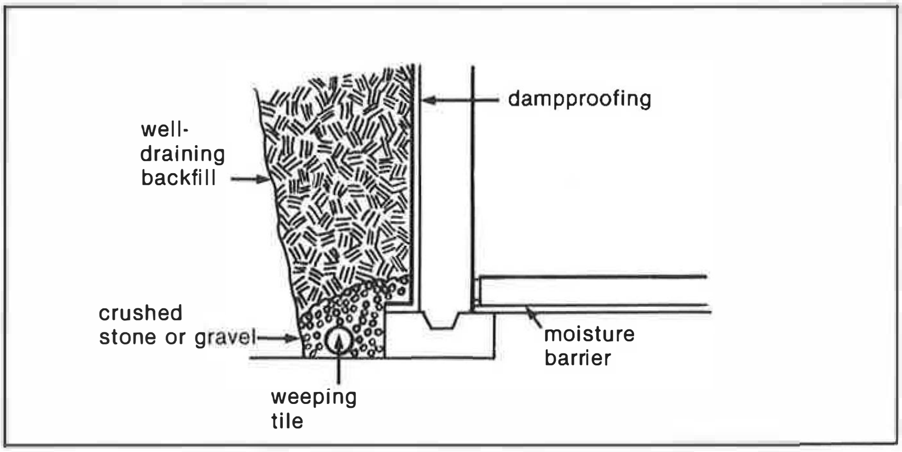

Fig. 11. Perimeter drainage.

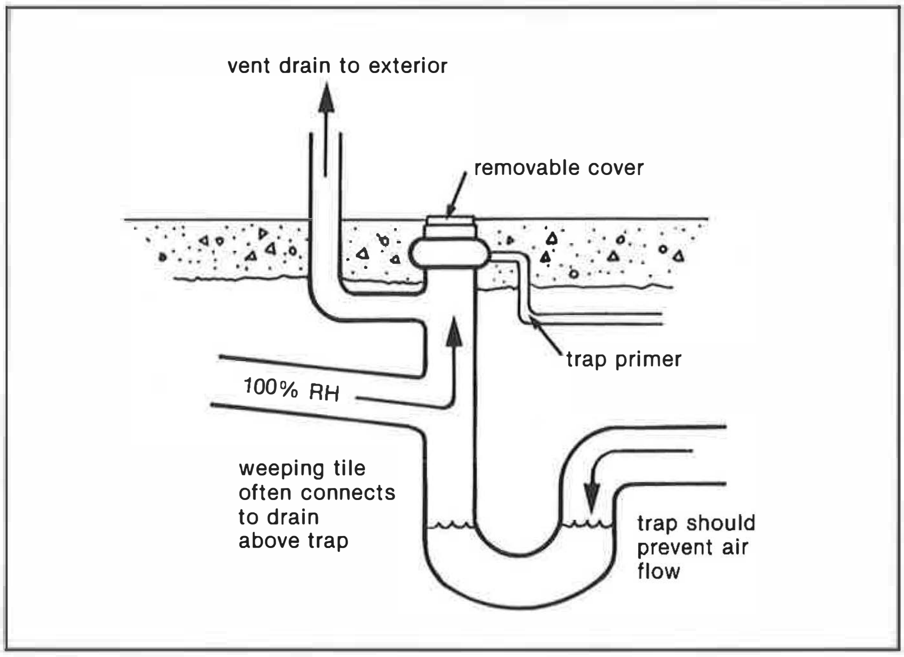

Fig. 12. Floor drain detail.

Problem

Poor air quality

Symptoms

Occupants may complain of odours and general lack of "fresh air." Increased concentrations of certain pollutants may result in health problems. Sensitive individuals may have adverse reactions to even low concentrations of pollutants.

Cause

Pollutants being generated faster than they are being removed. *This is especially critical in new houses because of offgassing.*

Major sources are as follows:
formaldehyde (HCHO) — adhesives, particleboard, interior plywood, some insulations, synthetic furnishings, glues, tobacco smoke
carbon monoxide (CO) — incomplete combustion, auto exhaust, tobacco smoke, kerosene space heaters
carbon dioxide (CO_2) — breathing, combustion
nitrogen oxides (NO, NO_2) — combustion, gas range, kerosene space heaters, auto exhaust, tobacco smoke
polycyclic aromatic hydrocarbons (PAH) — wood combustion
sulphur dioxide (SO_2) — combustion
various organics — household chemicals, cleaners, insecticides and herbicides, caulking and sealants, building materials, floor coverings
particulates — combustion, tobacco smoke, dust, pets, hobbies, moulds
pollen — from the exterior, indoor plants
odours — bodies, food preparation, tobacco smoke, household chemicals
radon — soil, rock, ground water, and possibly concrete and brick
methane — soil gas.

Solutions

- Increase the general ventilation rate. Sufficient ventilation to control humidity should be adequate, in typical houses, to control other pollutants, but will need to be higher for the first few months of occupancy.
- Provide additional spot ventilation at major pollutant sources, such as exhaust fans for dark rooms, range hoods for cooking, and sub-slab venting for radon gas control (fig. 13).
- Tobacco smoke is particularly difficult to control and remove. Homes with smokers will require much higher ventilation rates.
- Investigate various types of filtration systems. Typical throw-away furnace filters are only 5% efficient. Electronic air cleaners are highly effective in removing dust and even cigarette smoke, but are costly. Medium efficiency filters are just beginning to be used in residential applications and may prove to be cost-effective in improving indoor air quality. Note that greater resistance to flow may require higher fan speeds (fig. 14).

- Eliminate or seal off sources of pollutants where possible.
- For sensitive clients, substitute low-pollution alternative materials. For example, make greater use of exterior-grade plywood, plaster, ceramic tile, hardwood, enamelled steel, brick, mechanical fastening systems and so on.
- Provide seals at the garage interior door to prevent fumes from gas exhaust or hobby materials from entering the house.
- Seal all openings and cracks in the foundation to prevent entry of soil gas.
- Make sure that fresh air is provided to air-conditioned houses in the summer.
- Encourage homeowners to use spider plants (these have been found to absorb formaldehyde).

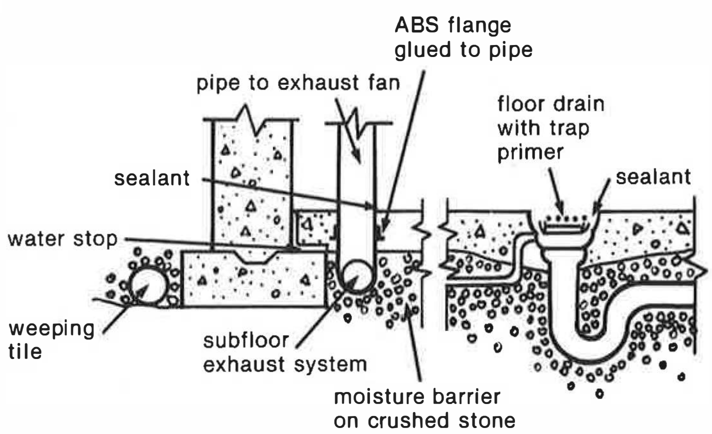

Fig. 13. Sub-slab venting for radon control.

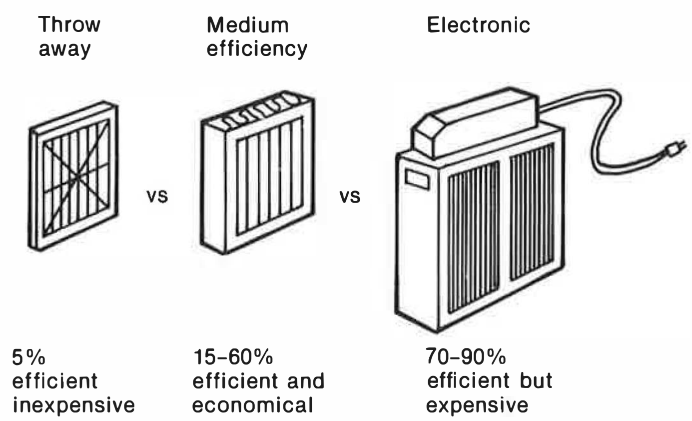

Fig. 14. Filter types.

Problem

Combustion backdrafting

Symptoms

Homeowners may complain of odours, increased humidity, back-puffing (oil furnaces), or minor health ailments. Unchecked, spillage of combustion gases such as nitrogen oxides, sulphur dioxide, and carbon dioxide can cause respiratory problems. Where there is insufficient combustion air or where combustion gases are being re-ingested by the furnace, carbon monoxide may be produced. At low concentration levels, CO can cause headaches, dizziness and nausea. At high levels it may result in more serious health problems.

Cause

Competition for air.
Exhaust fans always "win" against natural draft from a furnace, DHW heater or smouldering fireplace. This is particularly hazardous during spring and fall, when exterior temperatures are mild, the draft is weak, and the flue is cold from intermittent furnace cycling (fig. 15).

Solutions

- Provide combustion air to each room containing a fuel-burning appliance. The 1985 National Building Code requires that installations ensure complete venting of products of combustion to the exterior, thus compensating as necessary for other appliances and exhaust devices.*

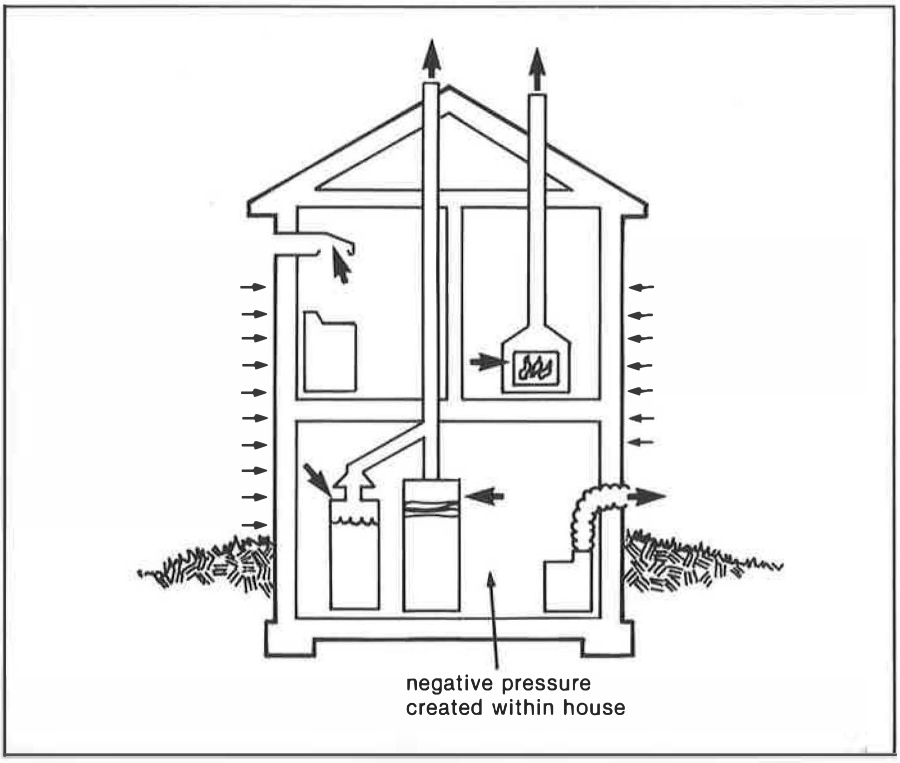

Fig. 15. Competition for air.

* *National Building Code* 1985. 9.34.2.3 Solid fuel-burning appliances shall be installed in a manner that ensures the complete venting of the products of combustion to the outside air. Compensation shall be made for air drawn by other appliances or exhaust equipment.

Typical Flows and Stall Pressures

Device	Free Flows (L/s)	Stall Pressure (Pa)
Furnace/chimney	25	25
Hot water heater/chimney	10	10
Fireplace — burning	110	40
— smouldering	varies	3
Kitchen range hood	70	50
Indoor barbecue fan	120	300
Bathroom exhaust fans	20	30
Clothes dryer	65	70

- Create a balance between exhaust air and supply air. Seal leaky ducts and plenums. Install additional supply air registers and cold air returns. Provide a fresh air duct to the return air plenum. Make sure that heat recovery ventilators are balanced, and are not designed to defrost by running in exhaust mode for extended periods. Placing the house under excessive negative pressure to prevent moisture problems in wall cavities and attics is not recommended when there are naturally aspirated combustion devices (fig. 16).

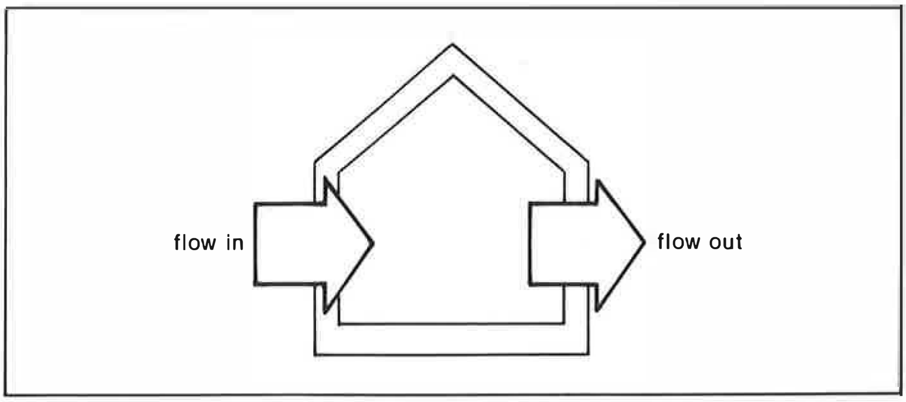

Fig. 16. Balanced exhaust and supply.

- Use a heating system which requires little or no combustion air; for example: electric baseboards, electric forced air, high-efficiency condensing gas furnaces. The additional costs of high-efficiency furnaces are largely offset by the savings in not having to construct a chimney (fig. 17).
  Note: the absence of an active flue may, however, lead to increased moisture problems, unless controlled ventilation is provided.
- A furnace with power venting is more resistant to backdrafting — an induced draft gas furnace, for example, or an oil furnace with a squirrel cage blower.
- Install a forced and tempered fresh air supply for combustion and dilution air. The supply fan can be controlled by exhaust fan operation, furnace operation, or indoor/outdoor pressure differences. A proportionally controlled duct heater with a thermostat will warm air to room temperature, but not higher.
- Install a delayed action solenoid valve. This stops the initial spillage in oil furnaces by preventing oil flow for a few seconds to ensure proper draft prior to ignition.
- Provide detection devices such as a temperature controller alarm at the dilution air inlet of a gas furnace, or install a carbon monoxide meter.
- Install a fail-safe device such as a thermodisc on hot water heaters to shut off the gas valve when spillage occurs.
- Treat each fuel-burning appliance as a closed system with a separate supply of combustion air from the exterior (fig. 18). The industry is in fact moving toward the use of sealed combustion devices. **Note:** Codes do not allow for exterior air to be supplied directly to a burner or to dilution air unless a furnace is specifically designed for this.
- Separate furnace rooms can be sealed, insulated and provided with an exterior air supply (fig. 19).
  Note: At present, controversies surround this practice. Potential dangers exist if the temperature falls below 10°C (50°F), and, in any case, it is virtually impossible to seal a room well enough.

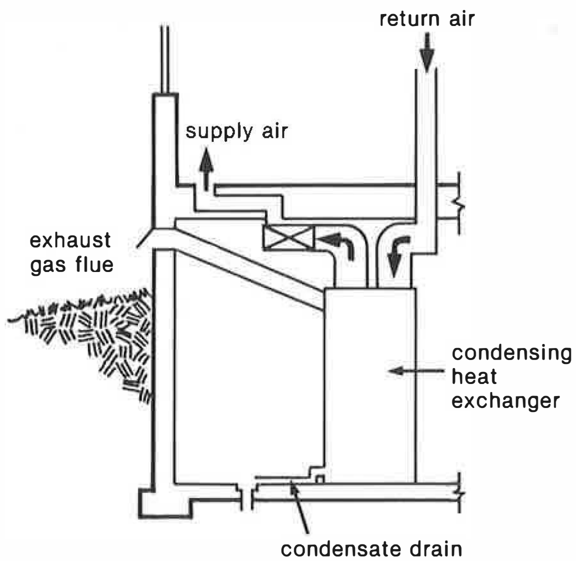

Fig. 17. High-efficiency furnace.

- Don't oversize the kitchen exhaust. Indoor barbecue fans are potentially risky, unless they have their own air supply.
- Provide a direct air supply for clothes dryers with flexible ducting and a two-way damper.
- Perform a "combustion safety test" (see Combustion Safety Checklist) on completion of construction and prior to occupancy. Make necessary adjustments to correct any lack of sufficient combustion air. It may be necessary to attach warning labels to exhaust fans or fireplace.

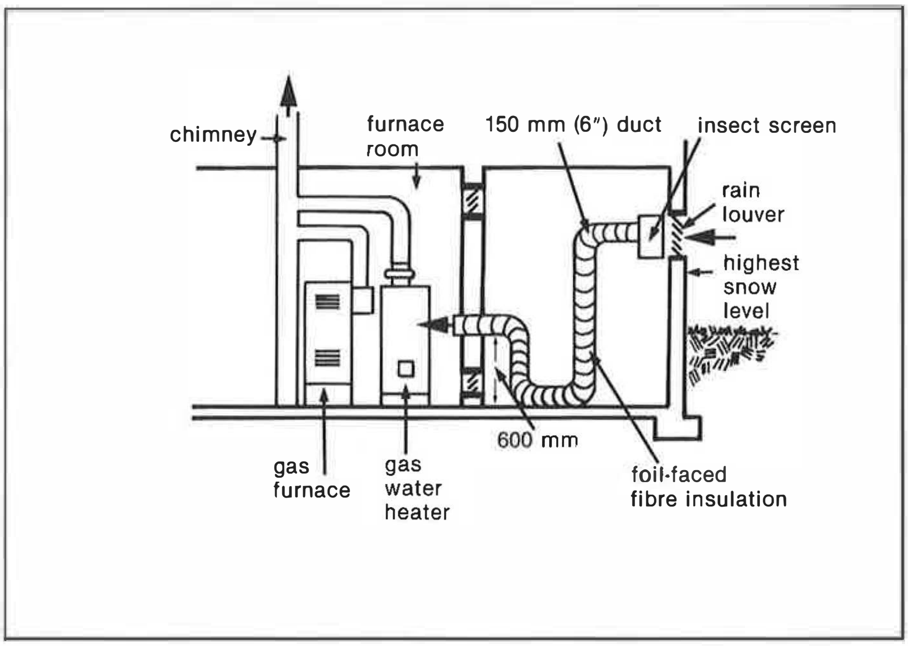

Fig. 18. Typical air supply for furnace and hot water heater.

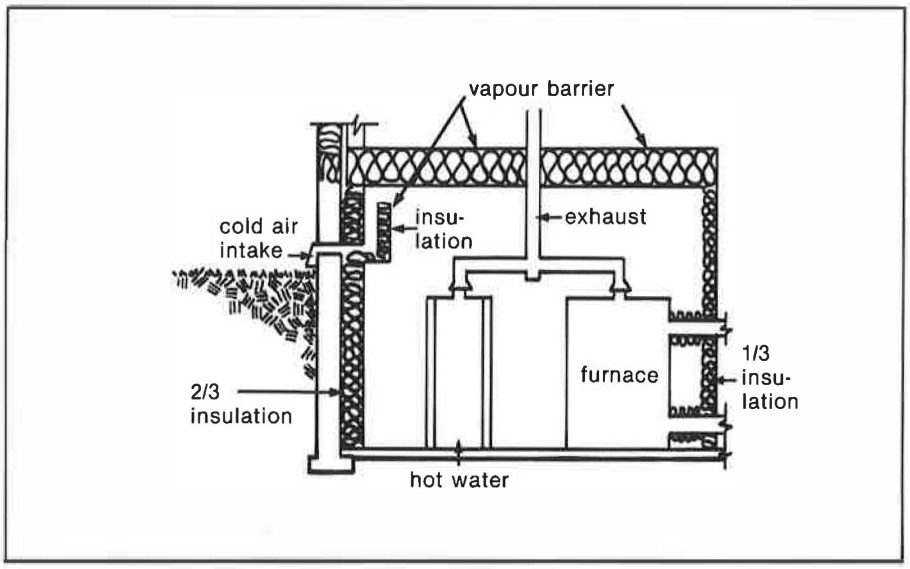

Fig. 19. Insulated furnace room.

Cause

Fireplaces

A roaring fireplace can backdraft other devices. During the furnace off-cycle, the fireplace may force the furnace flue to function as the air supply for the fireplace. When the furnace restarts, it may not be capable of reversing the downdraft (fig. 20).

A smouldering fire in the fireplace can be easily backdrafted by other devices and can produce high quantities of CO (fig. 21).

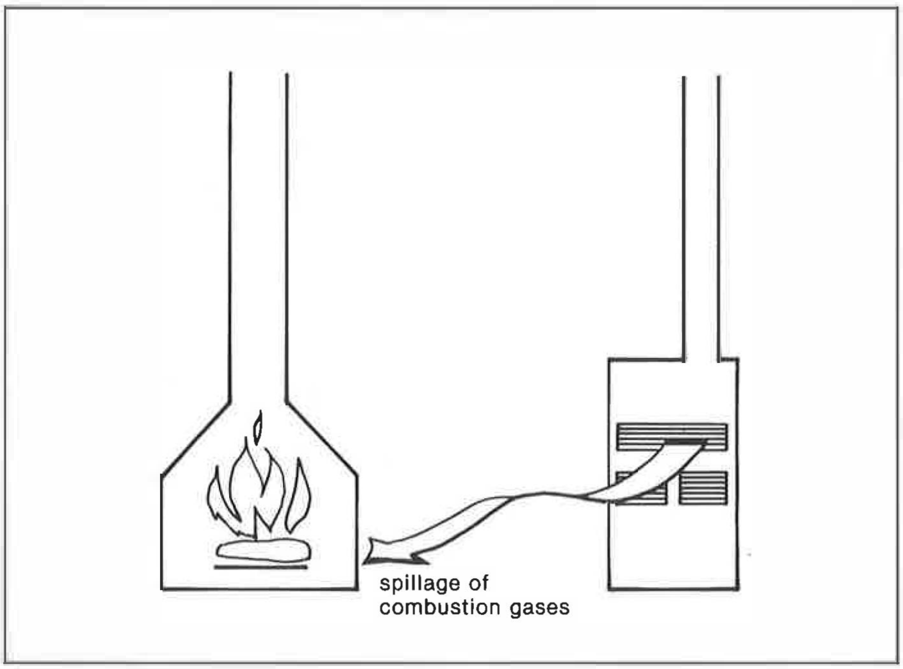

Fig. 20. Furnace backdrafted by roaring fire.

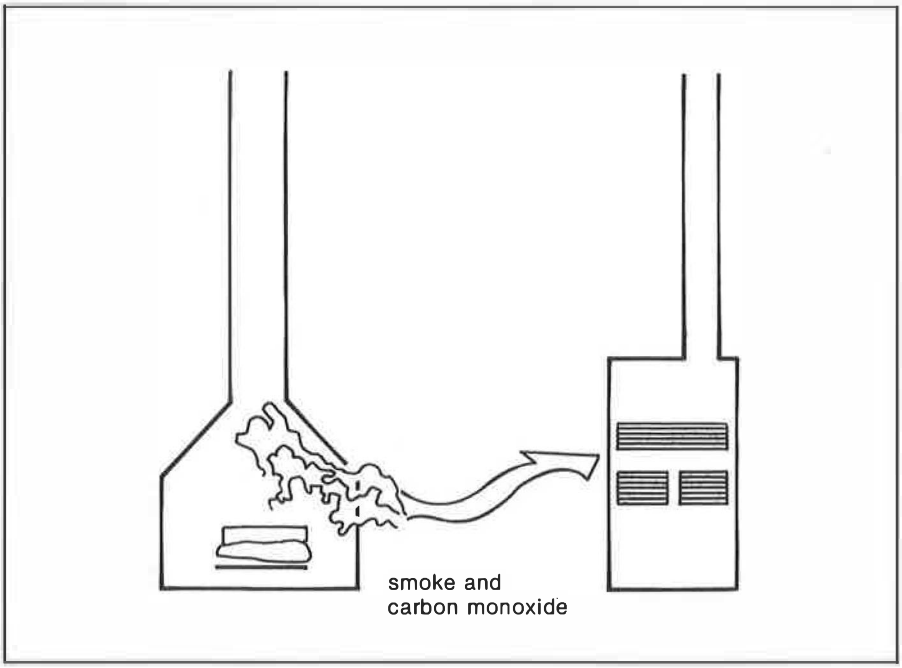

Fig. 21. Smouldering fire backdrafted by furnace.

Solutions

- Supply combustion air to appliances in accordance with National Building Code requirements.* It is no longer sufficient to advise owners to "open a window."
- Best solution: make the fireplace or wood stove a closed system. Draw little or no air from the house.
- Provide fresh air directly to the firebox. The recommended duct size is 200 mm (8″) or two 150 mm (6″), or half the area of the flue. It may be necessary to fireproof this duct. Locate the fresh air outlet at the front of the fire box (fig. 22).
- Connect the controls for the flue damper to the damper for the intake duct.
- Install tight fitting glass doors to reduce:
  - — excessive air flow up the chimney
  - — the possibility of air being drawn down the chimney into the house.

Note: With the exception of woodstove doors, current fireplace door designs are far from being airtight. Seal between the fireplace door frame and masonry with high temperature caulking. Note also that retrofitting glass doors on conventionally designed fireplaces may result in higher firebox temperatures than the design allows.

- Keep the size of the firebox small to promote efficient burning.
- Recent studies have demonstrated that it is extremely difficult to prevent accidental spillage with low-burning fires. The opinion has been expressed than a conventional fireplace does not belong in an energy efficient home.

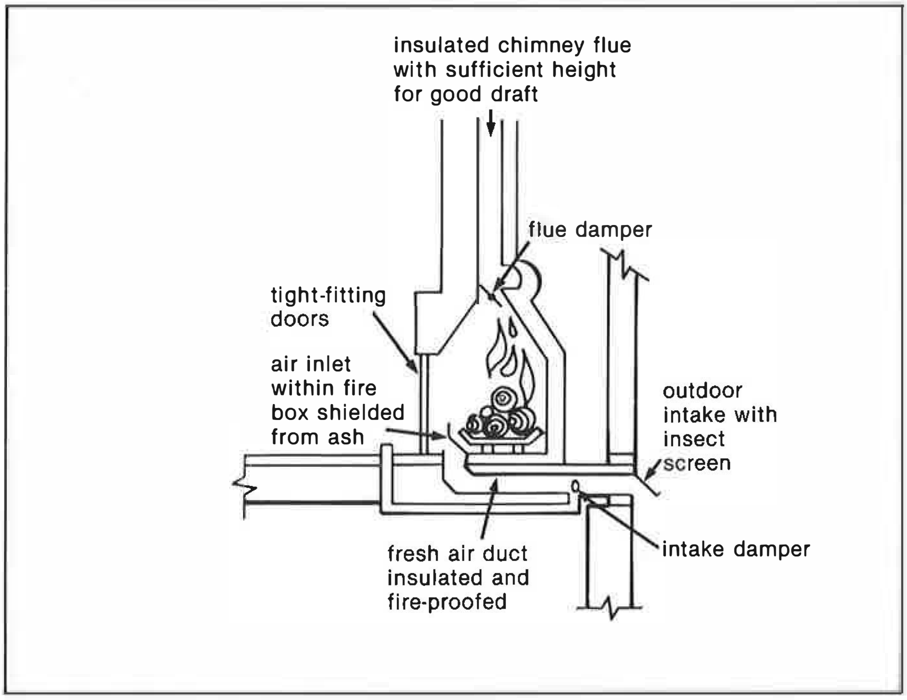

Fig. 22. Fresh air to fireplace.

* *National Building Code* 1985, 9.22.1.4 Fireplaces, including factory-built fireplaces, shall have a supply of combustion air in accordance with Article 9.34.2.3.

Cause

Poor chimney performance
A cold flue does not promote a good draft. Ice, soot, creosote or crumbling masonry may cause blockages.

Solutions

- Keep the chimney on an interior wall and insulate the chimney above the ceiling line to reduce cooling. A warmer flue will suffer less from acidic condensation and blockage caused by gradual icing of the chimney outlet (fig. 23).
- Avoid oversizing the flue area as this will lead to slower flue gas speed. The flue opening should be approximately 8–10% of the fireplace opening.
- A higher chimney draws better (only if insulated and properly sized).
- Stress the importance of chimney maintenance to owners.
- Provide adequate structural support for the chimney to prevent movement or deflection that could open flue joints and allow gases to escape.

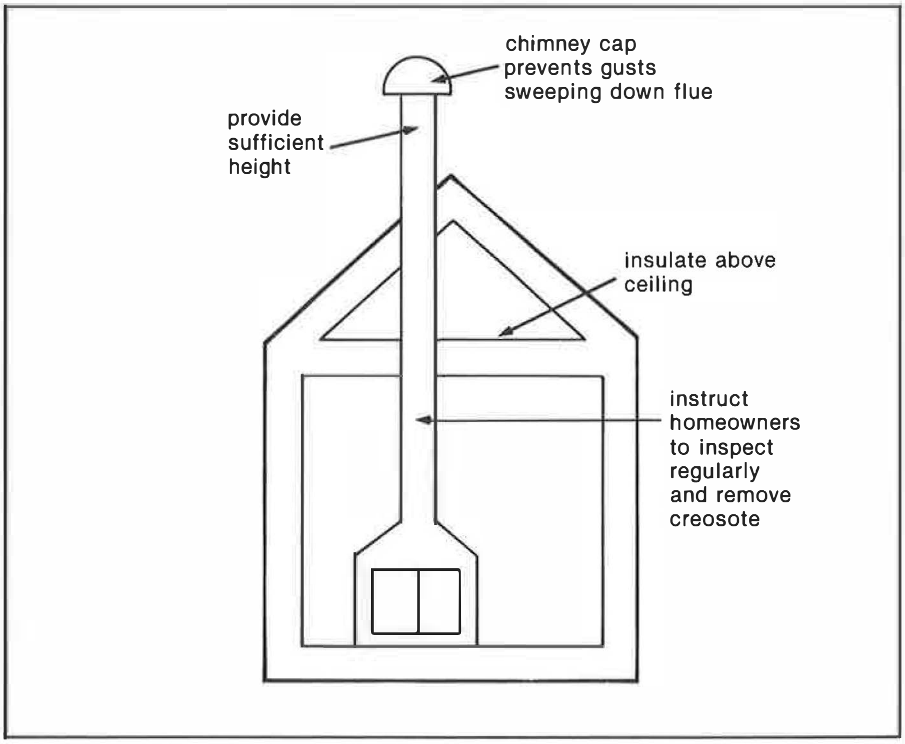

Fig. 23. Chimney construction.

Problem Occupants

Cause

Lack of awareness

Actions taken by occupants can impair the proper functioning of ventilation systems, and may lead to potentially hazardous situations.

Solutions

- Provide good quality silent exhaust fans. Noisy fans won't be used.
- Keep controls simple on heating/ventilation equipment; for example — "warmer-cooler."
- Provide "fail-safe" controls on combustion air supplies where possible. Occupants should not be able to shut off ventilation.
- Educate homeowners about:
  - — energy efficiency versus health and safety issues
  - — moisture generation and humidity levels
  - — the need for ventilation
  - — dangers of backdrafting.
- Have technical personnel "walk through" the house with new occupants.
- Provide an "owner's manual" with instructions for correct operation and maintenance of equipment, use of the fireplace, changing furnace filters, where to obtain advice, and so on.
- Provide warning labels on heating and ventilating equipment and their controls.
- Preheat fresh air to reduce occupants' discomfort and make it less likely that they will block outlets. Moving air at even a few degrees less than house air feels cool and is perceived as a "draft."

Methods of preheating air include:
— a proportional heating coil and thermostat in ducts
— a fan coil connected to a boiler or hot water heater to provide continuous heating of fresh air, regardless of furnace cycle (**Note:** Most codes do not allow a hot water heater to be used as the primary source of heat.)
— a packaged heating/ventilating system to avoid redundancy in ductwork and heating elements
— adequate mixing by supplying fresh air to less used spaces, at ceiling level or near the return air duct
— heat recovery ventilator (air-to-air heat exchanger) or heat pump. See fig. 24.

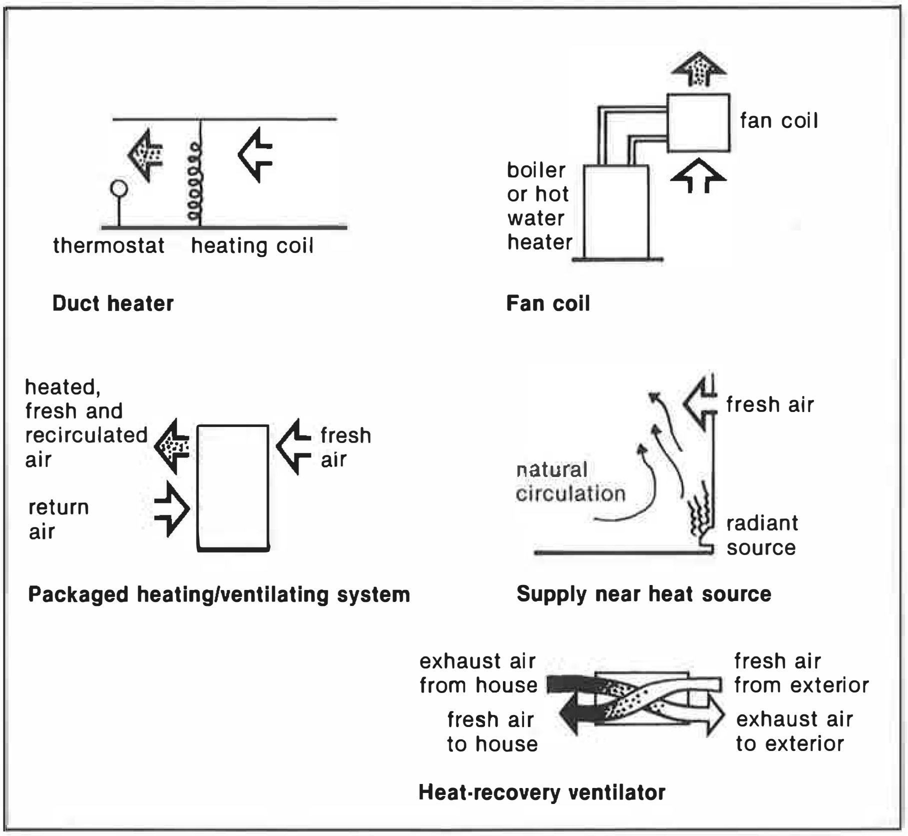

Fig. 24. Methods of preheating fresh air.

Terms and Definitions

Airtightness
A measure of the unintentional air leakage, as measured in a fan door depressurization test. Results are expressed as an "air change rate" or as an "equivalent leakage area." It is important to note that the results of a fan door test are expressed as the air change rate *at 50 Pa pressure* — a rule of thumb for typical house is to divide by a factor of 10–20 to obtain the annual average air change rate, but this varies with house configuration and location. Tracer gas sampling provides a better measure of actual air change rates.

Air change rate (ACR)
The rate at which the equivalent of the entire volume of air in a house is replaced by exterior air. This is expressed as the number of air changes per hour (acph for ac/h or sometimes incorrectly as ach). For example, if a house, including the basement, has a volume of 540 m^3 (19,200 cu ft.), and fresh air is brought in at the rate of 270 m^3 (9,600 cu ft.) per hour, the air change rate is ½ air changes per hour; for this house, an ACR of ½ corresponds to a flow of 75 L/s (150 cfm). See also fig. 4.

Equivalent leakage area (ELA)
The area of an opening equivalent to the sum of all air leakage paths through the envelope, calculated at a pressure difference of 10 Pa and expressed in cm^2.

Stack effect
The upward flow of heated air or gases within a chimney or enclosed space. Warm air is less dense than cool air, and will therefore tend to rise. Typical pressure differences in a three-storey house due to stack effect could be ± 7 Pa in midwinter and ± 2 Pa in spring or fall. Draft pressures for the chimney flue of a furnace or roaring fireplace on a cold day could be 25–50 Pa (250 Pa = 1″H_2O).

Neutral pressure plane (NPP)
The transition layer between the area of infiltration at the bottom or windward side of the house (negative pressure) and the area of exfiltration at the top or leeward side of the house (positive pressure) where there is neither infiltration nor exfiltration. It is also the layer having the same pressure as the outdoor air. The height of the NPP depends on the vertical distribution of leaks and can even be above or below the building envelope. Wind tilts the NPP and may also lift or depress it.

Relative humidity (RH)
The amount of water vapour in the air, expressed as a percentage of the maximum amount which could be held at the particular temperature and atmospheric pressure. Warm air is capable of holding more moisture than cool air. For example, outdoor air at 0°C (32°F) and 80% RH will drop to 20% RH when heated to an indoor temperature of 21°C (70°F). This can be determined by the use of a psychrometric chart. See also fig. 5.

Dewpoint
The temperature at which a given sample of air reaches 100% relative humidity. As air is cooled, the RH rises until the dewpoint is reached and condensation occurs. For example, house air at 21°C (70°F) and 50% RH will begin to condense when it is cooled to 10°C (50°F); the dewpoint temperature for that sample of air is therefore 10°C.

Air quality
A description of house air in terms of pollutant levels. See Poor Air Quality for a list of the most common pollutants.

Outgassing, offgassing, gas-off
The gradual release of volatile substances from construction materials and furnishings. The rate generally decreases with time.

Radon
A radioactive gas arising from the breakdown of radioactive trace elements naturally occurring in soil, rock and ground water (and possibly concrete and brick). Radon usually enters the house through cracks or openings in the basement. Radon breaks down further into radon "daughters."

Combustion backdrafting
A reversal of the natural upward flow (draft) in the flue of a fuel-burning device. If this occurs just before or during the operation of the device, spillage of combustion gases into the house can result.

Combustion Safety Checklist

The following checklist has been developed to assist homeowners in identifying combustion backdrafting hazards in their homes, and represents the current research available to CMHC. CMHC does not warrant that the use of these procedures will detect all possible hazards.

More sophisticated checklists, including the use of pressure gauges, CO detector tubes, and other simple instrumentation, are being developed for heating and ventilating contractors.

Backdrafting or spillage at any step indicates that the house has failed the test, and that remedial measures and warning labels are necessary. Proceed with subsequent steps only if backdrafting has not occurred. The test should take less than one hour to complete.

Step 1:
Choose a calm, cool day

This represents the most hazardous condition. Winds should be less than 10 km/h (6 mph). Outdoor temperatures should be lower than indoor temperatures, but well above freezing.

Step 2:
Inspect chimney and flue connector

Examine the following for proper installation and maintenance: chimney cap, masonry, metal lining, spark screens, ash cleanout, and flue connector. Check the flue for blockage, and for soot and creosote accumulations greater than 6 mm (¼″).

Step 3:
Prepare house for testing

Turn down thermostats on furnace and hot water heater to prevent their operation during test. Allow chimneys to cool (metal — 15 min; masonry — 30 min). Remove filters, grills and screens from all exhaust devices, including bathroom fans, range hood, clothes dryer and central vacuum system. Prepare fireplace or wood stove for a rapid, hot fire (but don't light yet); close metal or glass doors; close all dampers. Close exterior doors and windows. Close interior doors to rooms which do not contain exhaust devices (bedrooms, for example). Practice checking for an upward chimney draft by holding a flame (from a butane lighter or a candle) or a smoke pencil along the upper lip of the dilution air inlet of the furnace or next to the draft hood of the hot water heater. The flame will lean into the opening when the flue is exhausting; it will flutter during backdrafting.

Step 4:
Operate exhaust fans and check draft

Turn on all exhaust devices to their highest setting. Set heat recovery ventilators on defrost mode, and operate at high speed. Check draft at furnace and hot water heater.

Step 5:
Operate furnace blower and recheck draft
Turn on furnace blower to high speed (if the blower cannot be operated manually, proceed to the next step). Recheck draft.

Step 6:
Operate fireplace and check all chimneys
Open doors on fireplace or wood stove. Open chimney damper and any air supply inlets or fans to fireplace. Temporarily open a nearby window prior to lighting a fire. Light a fast fire with newspaper and kindling. When the fire is blazing, check for spillage by holding a flame along the top edge of the fireplace opening. Shut the window and recheck. Return to the furnace and hot water heater and recheck their draft.

Step 7:
Operate furnace and check for spillage
With exhaust devices and fireplace operating, start the furnace by turning up the thermostat. Once the furnace is fully operational, hold flame along dilution air inlet. Spillage for more than 15 seconds indicates failure. Also check flue connector joints, thimble, and water heater draft hood for spillage.

Warning: Continue only if no spillage has occurred in Step 7.

Step 8:
Operate gas hot water heater and recheck
Operate hot water heater by turning up its thermostat and turning on a hot water tap. Check for spillage at draft hood and along flue connector.

Step 9:
Check fireplace for spillage as fire dies down
With all systems (exhaust fans, furnace, hot water heater) still running, periodically check upper edge of fireplace opening or cracks around fireplace doors for spillage as fire dies down. If spillage occurs while fire is still burning, open a nearby window until spillage disappears.

Step 10:
Return house to normal operating conditions
Reset thermostats. Turn off exhaust devices. Open or close doors and windows as appropriate.

Additional Reading

Source	Publication
Canada Mortgage and Housing Corporation 700 Montreal Road Ottawa, Ontario K1A 0P7 (613) 748-2000	*Indoor Air Pollution and Housing Technology*, 1983 (Prepared by Bruce M. Small and Associates) *Ventilation for Humidity Control*, 1984 (Prepared by J.H. White, Research Division, CMHC) *Identifying Ventilation-Troubled Houses*, 1984 (Prepared by J.H. White, Research Division, CMHC) *Residential Combustion Safety Checklists*, 1984 (Prepared by Sheltair Scientific) *Exploring Low-Pollution Design*, 1985 (Prepared by Bruce M. Small and Associates)
Canadian Home Builders' Association 502–200 Elgin Street Ottawa, Ontario K2P 1L5 (613) 230-3060	*R-2000 Builders' Manual* (1985)
Ontario Marketing Productions Ltd. 69 Yorkville Avenue Toronto, Ontario M5R 1B7	*Insulation Aftermath* (1982) By Jon Eakes
Newfoundland and Labrador Housing Corporation and Canada Mortgage and Housing Corporation P.O. Box 12300, Station "A" St. John's, Newfoundland (709) 772-4365 or Zenith 07027	*Moisture and Air: Problems and Remedies — Householder's Guide* (1984)
National Research Council Institute for Research in Construction Publications Section Ottawa, Ontario K1A 0R6 (613) 993-2463	*Humidity Condensation and Ventilation in Houses* (NRCC 23293-1984) *Airtight Houses and Carbon Monoxide Poisoning* (CBD 222) *Moisture Problems in Houses* (CBD 231)

Canadian Gas Association 55 Scarsdale Road Don Mills, Ontario M3B 2R3	*Installation Code for Natural Gas Burning Appliances and Equipment* (B149-M85)
Heating, Refrigeration and Air Conditioning Institute of Canada 5468 Dundas Street West, Suite 226 Islington, Ontario M9B 6E3 (416) 239-8191	*Residential System Design Manual* (1982)