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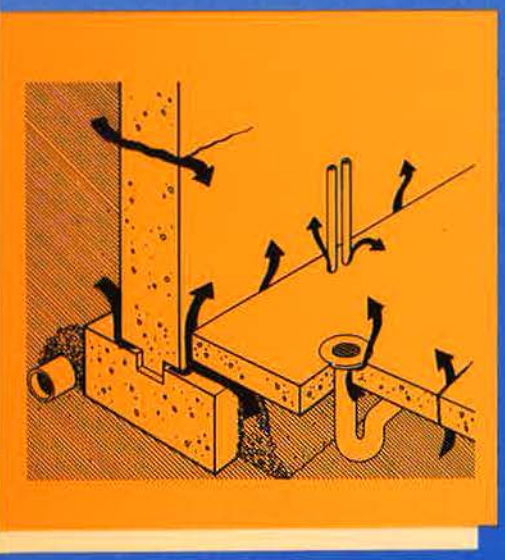
BUILDERS' SERIES

Indoor Air Quality



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Indoor Air Quality

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Contents

Indoor Air Quality: Opportunities and Problems

The purpose of this book is to make builders aware of the opportunities and problems that indoor air quality presents and to provide them with practical advice on:

- how to build for good indoor air quality;
- how to operate a house for high indoor air quality; and
- how to solve indoor air quality problems if they occur.

Good indoor air quality can be defined as the absence from the air of a building of any substance that is a health hazard or a source of discomfort to the occupants, or a threat to the building structure. What represents a health hazard or a source of discomfort will, naturally, vary. This book covers information applicable to the general public. Hypersensitive people — the approximately 20 percent of Canada's population unusually sensitive to allergens or chemicals — may require special types of housing not covered in this guide. For information on their special needs, refer to the publications listed at the back of this booklet.

Every builder can benefit from up-to-date information on indoor air quality. The reasons are many.

- There is a much greater awareness now about the need for a healthy indoor environment. Home buyers want to be reassured, or even sold, on the health and safety aspects of your homes.
- By applying the principles outlined in this book, you can produce a more durable house, less prone to moisture and rot problems, thus reducing callbacks.
- The use of panelized construction materials, better sealants and tighter doors and windows is leading to the construction of tighter houses. New building codes may require additional air sealing. Without adequate attention to ventilation and pollution control, indoor air quality can suffer.
- The use of large-capacity exhaust fans in tighter houses without adequate make-up air can cause indoor air quality problems by inducing combustion appliances to backdraft or by drawing radon and other soil gases into the house.
- The use of synthetic construction materials introduces large amounts of chemicals into houses, especially over the first year or two. Exposed particle board, for example, can lead to high formaldehyde gas levels. Caulking and sealants can generate toxic compounds.

The Opportunities

For the knowledgeable builder, good indoor air quality provides a wide range of opportunities.

- More features to sell:
  - cleaner air
  - lower dust levels
  - controlled humidity levels
  - elimination of condensation
  - better ventilation
- Increased buyer confidence in the builder's product through:
  - factual answers to indoor air quality questions
  - builder-generated solutions to indoor air quality problems
- Reduced callbacks and liability:
  - more durable construction because humidity and moisture problems are eliminated
  - greater comfort
  - a safer home environment

Specialized Markets

For builders willing to learn more about indoor air quality, there is a small but growing market for housing for individuals who are chemically sensitive or hyperallergenic. Generally speaking, building for these people requires measures beyond those covered in this book. If you are interested in these special markets, you should refer to other publications on this topic and consider consulting allergists and indoor air quality specialists.

How the Builder and Homeowner Affect Indoor Air Quality

Maintaining good indoor air quality requires your involvement and the homeowner's. The builder largely influences the choice and assembly of construction materials and combustion and ventilation equipment. Homeowners must know how to operate and maintain ventilation equipment and combustion appliances. Homeowners also affect indoor air quality through their choice of furniture, carpeting and other finishes, as well as by the way they clean their house and store cleaning products and other chemicals.

Building for Good Indoor Air Quality

The quantity of air pollutants in household air is affected by two factors:

1. The release rate of pollutants by the contents of the house, building materials, incoming outside air and seepage from the soil surrounding the house.
2. The removal rate of pollutants by filtration, absorption and ventilation.

As a general rule **it is more effective to eliminate the source of a pollutant than to try to remove the pollutant once it has entered the air.**

Follow these guiding principles when building for indoor air quality:

- Choose materials that do not contain pollutants, or seal pollutants away from the house air:
- Provide continuous air and vapour barriers on the interior of the building.
- Use appropriate sealers to reduce the escape of pollutants.
- Provide an effective ventilation system:
- Ventilate all habitable rooms in the house and provide both automatic and manual controls.
- Provide continuous "background" ventilation, as well as spot ventilation in kitchens and bathrooms.
- Install combustion appliances that will not spill flue gases into the house.
- Follow good housekeeping practices during construction to reduce indoor air pollution when the house is completed:
- Don't bury wood or other biodegradable materials around the foundation — they can be a source of methane gas and moulds.
- Avoid spilling volatile solvents in the house.
- Clean ductwork of all dust and debris.

See table 1 for a summary of common indoor air pollutants.

Table 1.
Summary of Common Indoor Air Pollutants, Their Health Effects, Sources and Methods of Control

Pollutant	Sources in the Home	Health Effects	Methods of Pollutant Control
Formaldehyde Colourless gas with strong odour.	Various construction materials, including particle board, interior paneling and drapes.	Nose, throat and eye irritation.	Substitute waferboard and exterior-grade plywoods for particle boards. Seal particle board with vapour-proof sealer, paint or varnish in cabinets and closets and on subflooring. Increase ventilation rates.
Radon Odourless, colourless radioactive gas.	Soil beneath and around the house foundation.	Believed to be cause of 5 to 10 percent of all lung cancer.	Seal floor drains, sumps, and all cracks, joints and penetrations through basement walls and slab. Ventilate crawl space and tightly seal subfloor joints and penetrations. Depressurize gravel bed beneath slab or isolate basement from rest of house and pressurize with air drawn from floors above.
Carbon Monoxide Colourless, odourless gas.	Kerosene heaters, wood-burning appliances, unvented gas appliances, and attached garages.	Nausea, headaches, and blue finger nails. Severe poisoning can cause brain damage in fetuses and can be fatal.	Provide outside combustion air feed to firebox of all wood-burning appliances. Install tight-fitting doors on fireplaces and wood stoves. Vent gas ranges directly to outside. Provide adequately sized, tempered make-up air for exhaust fans. Use induced draft or sealed draft hot water heaters and furnaces or place outside building envelope.
Nitrogen Dioxide Has odour when present in large quantities.	Kerosene heaters and unvented gas appliances.	Lung damage and increased potential for lung disease after long exposure.	Same as above

Table 1. (cont'd)

Pollutant	Sources In the Home	Health Effects	Methods of Pollutant Control
Respirable Suspended Particulates Particles suspended in the air that can be inhaled.	Tobacco smoke, wood smoke, unvented gas appliances, kerosene heaters, asbestos construction materials, dust.	Nose, throat, and eye irritation, lung cancer, emphysema, heart disease, bronchitis, respiratory infections.	Avoid smoking inside. Ensure wood-burning appliances and flues do not leak. Vent combustion appliances outside. Provide outside combustion air feed to firebox of all wood-burning appliances. Install tight-fitting doors on fireplaces and wood stoves. Increase ventilation rates. Use medium efficiency pleated fabric filters or HEPA filters in furnace and change regularly.
Moisture High humidity.	Ground water entering through the foundation. Cleaning, bathing, washing, and respiration.	Causes growth of micro-organisms. Increases release of formaldehyde.	Place drainage pad of crushed stone beneath foundation and provide drainage at foundation perimeter. Seal beneath foundation with polyethylene barrier. Provide dehumidistat-controlled central exhaust fan. Vent dryer directly to the outside.
Organic Solvents	Household cleaners, solvents in paints and caulkings.	Irritation of eye, nose and throat. Can affect central nervous system.	Use solvent-based materials in well-ventilated areas. Substitute latex-based paints and caulks for solvent-based products.

Soil Gases and Radon

Various gases can enter a house through the foundation *(fig. 1)*. These range from the most commonly found problem of water vapour to the more difficult problem of radon (a radioactive gas), methane and pesticides. Moulds, while not gases, also enter through the foundation; moulds aggravate allergies and, in some cases, cause more serious health problems. The entry of soil gases also leads to high humidity levels and the growth of mould and mildews. It can also lead to potentially serious health effects.

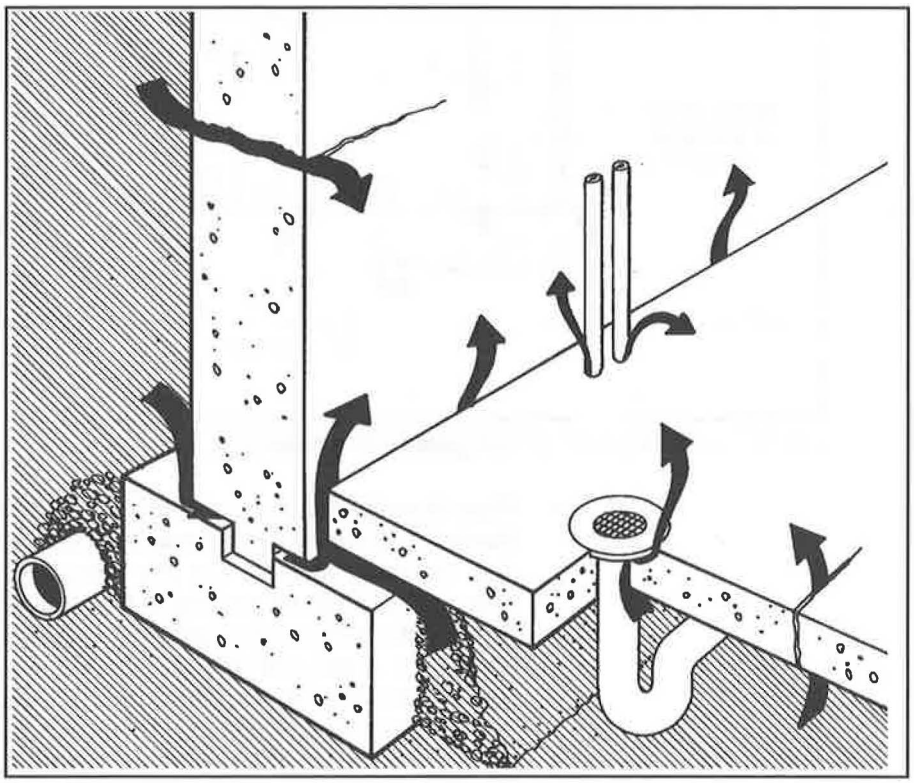

Fig. 1. Soil gas entry points in a basement foundation

Some problems can be avoided before construction if builders avoid wet sites or sites on or near old sanitary landfills. Radon varies a great deal from site to site and its presence cannot be reliable detected before construction. Even in parts of the country where radon is not recognized to be a problem, builders should take note of the radon control techniques outlined in CMHC's publication *Radon Control in New Houses* to reduce the entry of soil gas. The 1990 National Building Code also incorporates radon and soil gas control techniques.

Problems and Related Symptoms

- Mould and mildew growth on floor joists in crawlspaces
- Mould and mildew growth in basement areas
- Rotten egg smell in basement
- High radon readings in the house
- High humidity levels in the house

Causes

Movement of soil gases through cracks and openings in the foundation slab and walls, and movement of water by capillary action through the concrete slab and foundation walls.

Solutions

- Eliminate the entry of soil gases by sealing the foundation *(fig. 2)*.
- Minimize cracking of the concrete slab by using a dry mix and plasticizers.

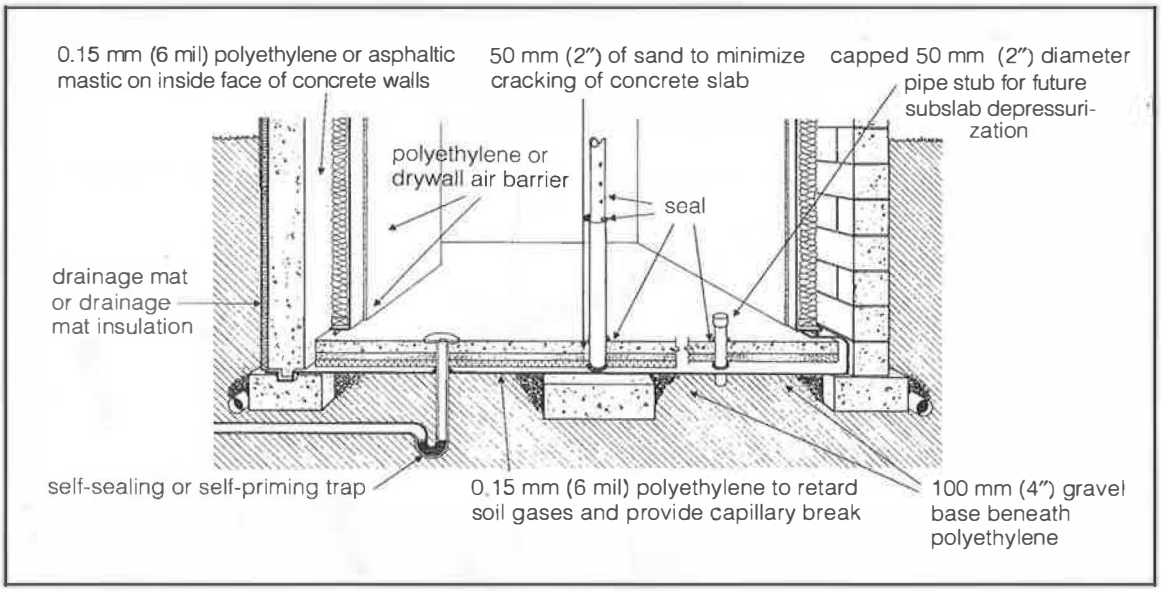

Fig. 2. Controlling entry of soil gases into a basement foundation

- Provide a capillary break and soil gas retarder by placing a continuous layer of 0.15 mm (6 mil) or cross-laminated polyethylene beneath the slab. Separate concrete and poly with a 50 mm (2") layer of dry sand to reduce cracking during curing of the slab.
- Seal cracks and gaps in floors and walls, and seal plumbing, electrical conduit and steel post penetrations through the concrete with appropriate sealants, such as one part urethane caulking, after the concrete has cured.
- When placing a wood subfloor, seal the concrete slab with 0.15 mm (6 mil) polyethylene sheeting beneath the sleepers.
- Seal the interior face of concrete walls with waterproof coating such as polyethylene sheeting or an asphalt emulsion.
- Build a continuous air barrier at the interior finish. Refer to CMHC's Builders' Series publication *Moisture Problems* (see page 35).
- Depressurize beneath the slab when radon levels are known or expected to be high, or slightly pressurize the basement.

Cause

Soil gas entry through floor drains, sumps, and the weeping tile system.

Solutions

- Use self-priming floor traps.
- Use self-sealing floor traps *(fig. 3)*. This is especially important if the weeping tile connects to the floor drain above the trap.
- Seal sump covers to reduce water vapour and radon entry. Install submersible pumps which can operate in an enclosed environment.

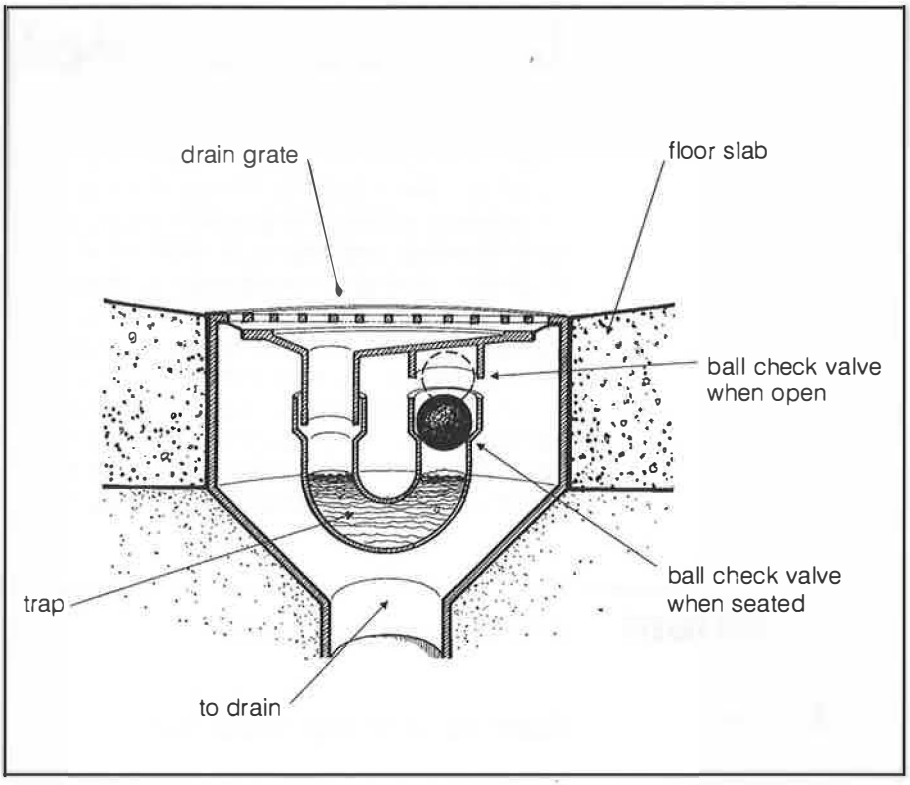

Fig. 3. Self-sealing floor drain

Cause

High water table beneath slab and adjacent to walls.

Solutions

- Place floor slab on a drainage pad of crushed rock 100 to 150 mm (4" to 6") thick and connect to storm sewer.
- Run perimeter drainage around footings and tie into storm sewers or run to daylight.
- Backfill with porous material, or use a drainage mat or drainage-type rigid fibreglass insulation connected to the drain tile.

Cause

Soil gases drawn in by negative pressure in house.

Solutions

- Ensure adequate volume of make-up air, particularly for powerful exhaust devices.
- Use a balanced ventilation system.
- Slightly pressurize the basement by providing additional warm air registers, installing a continuously operating furnace fan, sealing all penetrations and air passages between the basement and upper floors, and weatherstripping doors between the basement and upper floors.

Note: For more detailed information on radon, refer to CMHC's publication *Radon Control in New Houses.*

Outdoor Air Pollution

Outdoor air in certain locations carries with it pollutants that affect both the house and the occupants. Pollutants resulting from human activity, such as car exhaust, industrial air pollution and wood smoke, may cause headaches and poisoning, and aggravate chemical sensitivities. Natural pollutants such as pollens, dust and moulds may cause allergic reactions.

The house location has a significant effect on the entry of outdoor air pollutants. Outdoor air around sites adjacent to busy streets has a higher car exhaust content, especially when the site is close to stop signs, traffic lights or bus stops. Sites near industrial facilities are more likely to suffer from industrial pollutants. Areas in which temperature inversions occur are likely to have higher levels of all pollutants. In rural locations, outdoor air may contain higher amounts of wood smoke and pesticides.

Problem

Entry of outdoor air pollutants.

Cause

Outdoor air pollution generated locally.

Solutions

- Avoid busy streets.
- Avoid industrial facilities.
- Avoid areas where crop spraying occurs.
- Avoid sites exposed to strong winds.
- Avoid areas where temperature inversions occur.
- Landscape to provide windbreaks, using hedges (cedar, for example), or slat fencing.

Cause

Uncontrolled entry of outdoor air through cracks and openings in exterior walls, floors and ceilings.

Solutions

- Construct the house with a continuous air barrier *(fig. 4)*. Air barriers are described in detail in CMHC's Builders' Series publication *Moisture Problems*.

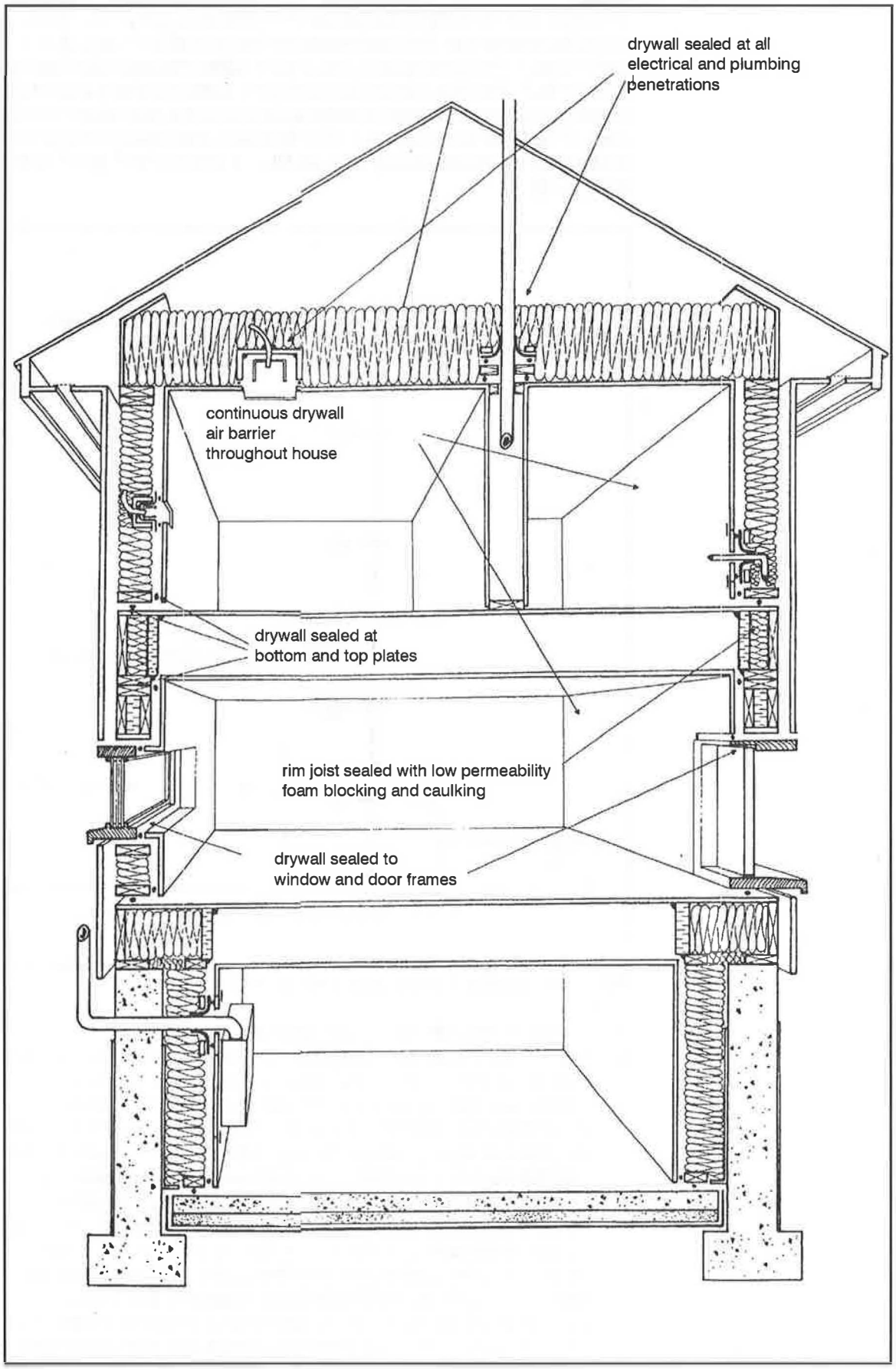

Fig. 4. Continuous drywall air barrier

To ensure that the continuous air barrier is effective, carry out a house depressurization test. This test measures the sum of the areas of all holes and cracks in the building skin; this area is called the equivalent leakage area, or ELA. The ELA can be divided by the outside surface area of the building to give the average leakage area (called the normalized leakage area, or NLA) for every square metre. To ensure that the continuous air barrier is effective, the house should have an NLA of 155 mm^2/m^2 (2 $in.^2$ /100 $ft.^2$) or less *(fig. 5)*.

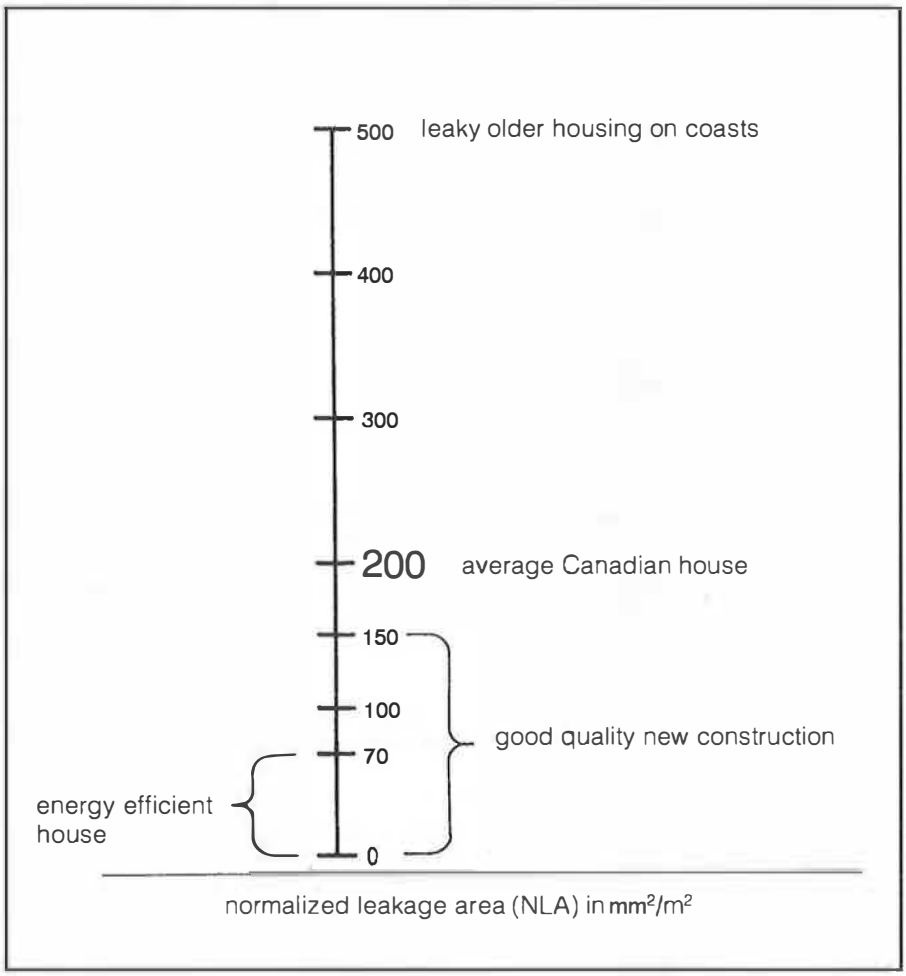

Fig. 5. Interpreting the results of a fan door test

- Use doors and openable windows that seal tightly.
- Use a continuously operating mechanical ventilation system that draws outside air from clean locations away from streets, driveways, gas meters, and garbage containers. The intake system should be at least 450 mm (18") above the ground and, at a minimum, above the highest winter snow level (generally the higher the intake is located the better).
- Install a mechanical ventilation system which filters incoming air. Note that most filters remove only particulates, not gases or odours. Various kinds of filters or combinations of filters may be required, such as:
- fibreglass filters (rock catchers) for filtering out large items like insects;
- medium efficiency pleated fabric filters rated at 40 to 60 percent;
- high efficiency filters (HEPA) for filtering out dust and pollen;
- electrostatic filters for removing smoke and smaller particles; and
- activated carbon filters for removing odours and many other gases (not effective for carbon monoxide).

- Incorporate higher-efficiency filtration into forced air furnaces. Use of HEPA, electrostatic and activated charcoal filters may require the fabrication of specially sized filter slots in the furnace ductwork. They are most easily installed when the ductwork is put in. As a minimum, consider using medium efficiency (60 percent) pleated fabric filters, 50 mm (2") thick. The thicker the filter, the greater the filtering area and the less often the homeowner will need to replace the filter. Homeowners should be advised where to find replacements.

Cause

House operating under a large negative pressure (for example, more than 5 Pa of depressurization).

Solutions

- Size the make-up air capacity to adequately supply replacement air for air removed by exhaust devices like bathroom exhaust fans, range hoods, downdraft cooktops, dryers and central exhaust systems (*see Table 2*). It is important to temper the make-up air entering the house so that occupants are not uncomfortable enough to seal the make-up air supply. One tempering option currently available for ventilation air is a heat-recovery ventilator. Other options include a CSA-approved fan and duct heater interlocked with the largest exhaust appliance in the house. In milder climates, such as Canada's west coast, make-up air could be supplied through wall diffusers located near the ceiling.
- Provide an outside combustion air supply, as required by the building code, for every combustion appliance. Refer to CMHC's Builders' Series publication *Ventilation: Health and Safety Issues*.
- Consider using a two-speed furnace, which helps temper incoming air by mixing it with house air and provides constant filtration. Note that two-speed furnaces require higher quality motors for the blower and can increase trade costs.

Table 2
Sizing Passive Make-Up Air for Exhaust Appliances in Houses with Natural Draft Chimneys

Rated Exhaust Fan (Largest single exhaust fan in the house*)			
Capacity		Make-Up Air Duct Diameter	
L/s	cfm	mm	inches
45	90	100	4
50	100	125	5
55	110	150	6
60	120	175	7
70	140	200	8
90	180	250	10

Note: Assumed house depressurization limit of 5 Pa. Assumed existing house leakage area of 350 cm^2. Assumed free duct area 60 percent of duct size. Assumed duct length approximately 3 m (10′) with one or two elbows.

* Where the exhaust fan capacity exceeds those noted in Table 2, fan-forced make-up air should be used. The make-up air fan should be interlocked with the largest exhaust fan in the house; provision should be made for tempering air as required.

Formaldehyde Gas

Formaldehyde gas can be released by formaldehyde-based glues. Urea formaldehyde glues are widely used in construction products such as particle boards, insulation binders, interior panelling, furniture, carpeting and drapery. Formaldehyde gas is colourless, with a strong pungent odour at elevated levels. It can cause headaches, stinging eyes and strong allergic reactions in some individuals.

Problem

Offgassing of formaldehyde.

Causes

Incomplete mixing of urea formaldehyde glue components, and release of formaldehyde caused by high indoor humidity levels.

Solutions

- Use exterior-grade panel materials, which use the more stable phenol formaldehyde glues, instead of interior-grade particle boards and panelling. Use waferboard.
- Seal the urea formaldehyde into particle boards by covering with water- and vapour-proof coatings such as polyurethane, varnishes, lacquers, oil-based paints or low-permeability latex paints (semi-gloss and vapour-barrier paints). Typically, the key locations that need to be sealed in a new house include the undersides of kitchen and bathroom counters, the interiors of cupboards, closet shelving, and particle board subflooring. It is especially important to thoroughly seal the edges of boards.
- Construct the house with a continuous interior air barrier such as gasketed drywall. This will block formaldehyde gases generated in insulation and framing materials from entering the house.
- Advise homeowners how to control humidity levels in the house through a mechanical ventilation system controlled by a dehumidistat. A dehumidifier can be used if relative humidity levels are above 60 percent.

Wood Smoke from Fireplaces and Wood Stoves

Wood smoke contains many pollutants. Of most concern are carbon monoxide, which can cause poisoning and death; combustion particles, like soot, which can cause odours and bronchial irritation; and complex hydrocarbons like benzene, which can cause cancer.

Cause

Inadequate combustion air to wood-burning appliance.

Solutions

- Provide a dedicated outside combustion air supply and tight-fitting doors for each wood-burning appliance. The best method for doing this is to supply combustion air directly to the fire box *(see fig. 6)*.

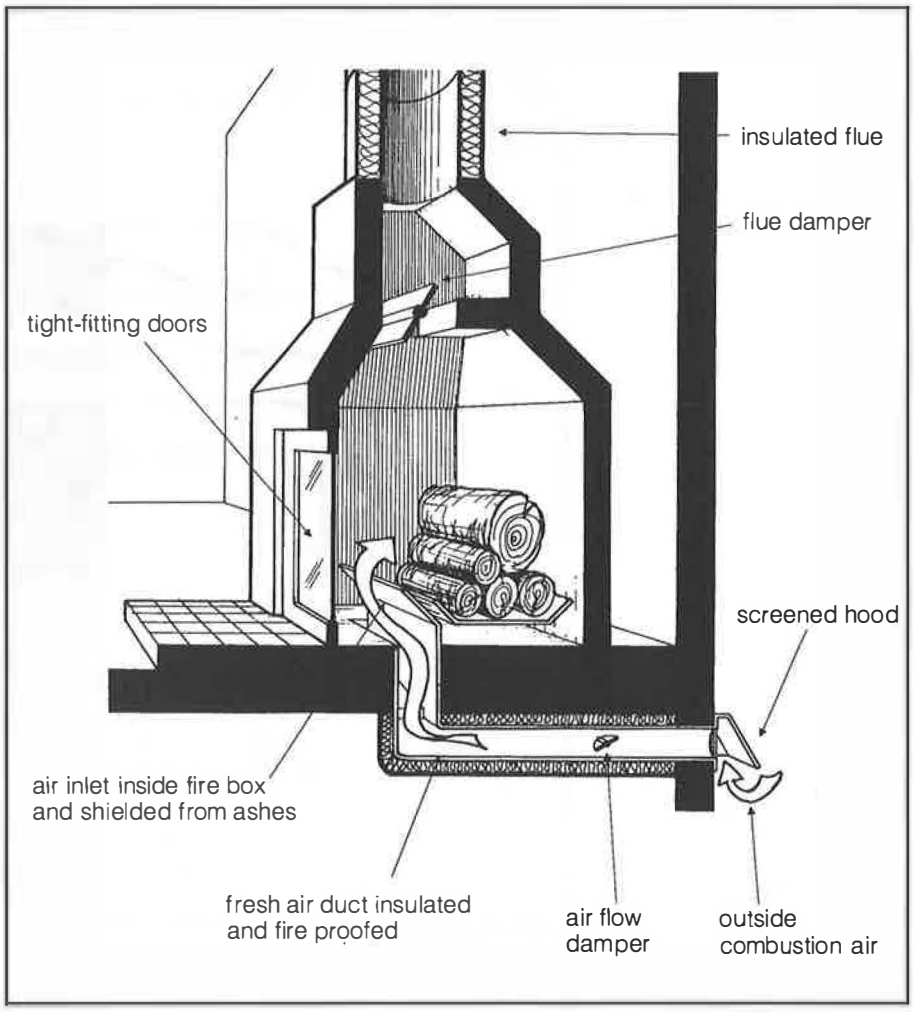

Fig. 6. Zero-clearance fireplace with outside combustion air feed

Note: There are only a few fireplaces that meet this requirement, although all fireplaces used in mobile homes must be built this way and must meet ULC S610, Part B.

- Be careful when selecting fireplaces. Truly airtight fireplaces cost more because of their better quality construction and use of glass parts that can withstand high temperatures. Doors should be gasketed, and combustion air should be drawn exclusively from outdoors.
  In some zero-clearance fireplaces, outside air is supplied to the room and for combustion purposes through the same ductwork. While this provides combustion air, it also provides a path for flue gases to enter a room. This is also true for fireplaces which draw combustion air from a combustion air supply grille in the hearth in front of the fireplace.

Cause

Local wind conditions and temperatures causing the chimney not to draw.

Solutions

- Install a draft-inducing chimney cap *(figs. 7 and 8)*.
- Remove trees near chimney.
- Locate the chimney inside the house so that all four sides of it are in a heated space. This helps prevent the chimney from becoming cold as the fire dies down.
- Build a well-insulated chimney, especially if it is located on an exterior wall.
- Increase chimney height.

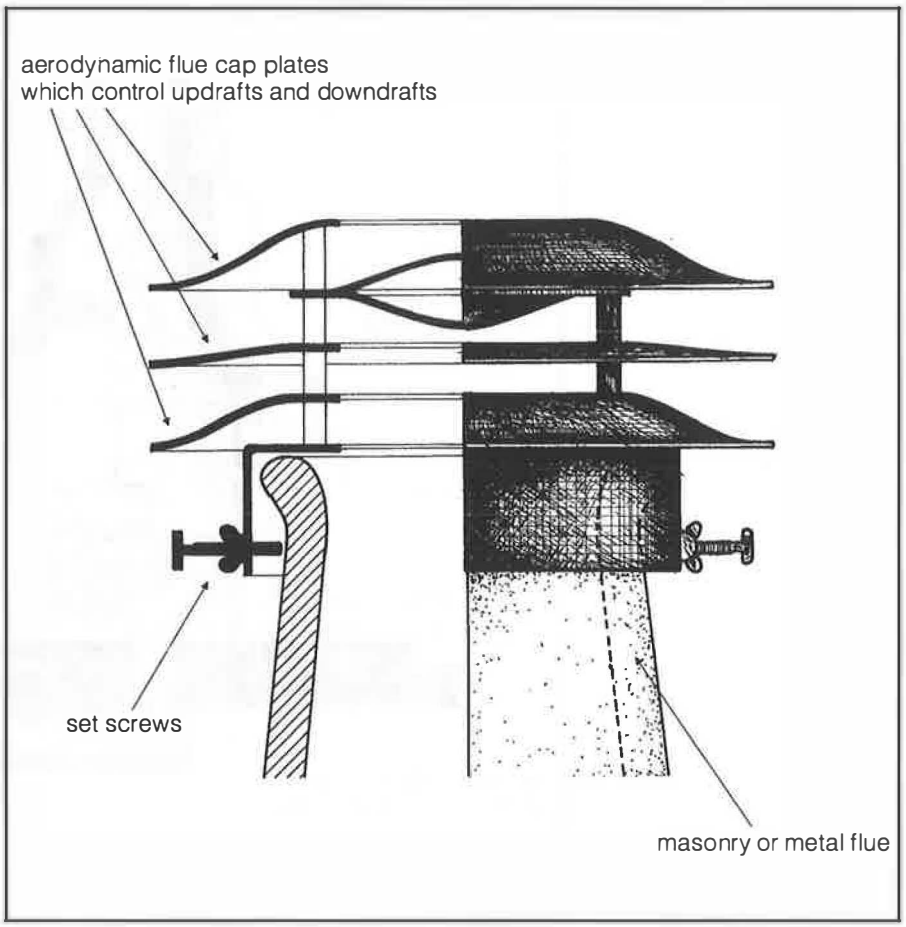

Fig. 7. Draft-inducing flue cap

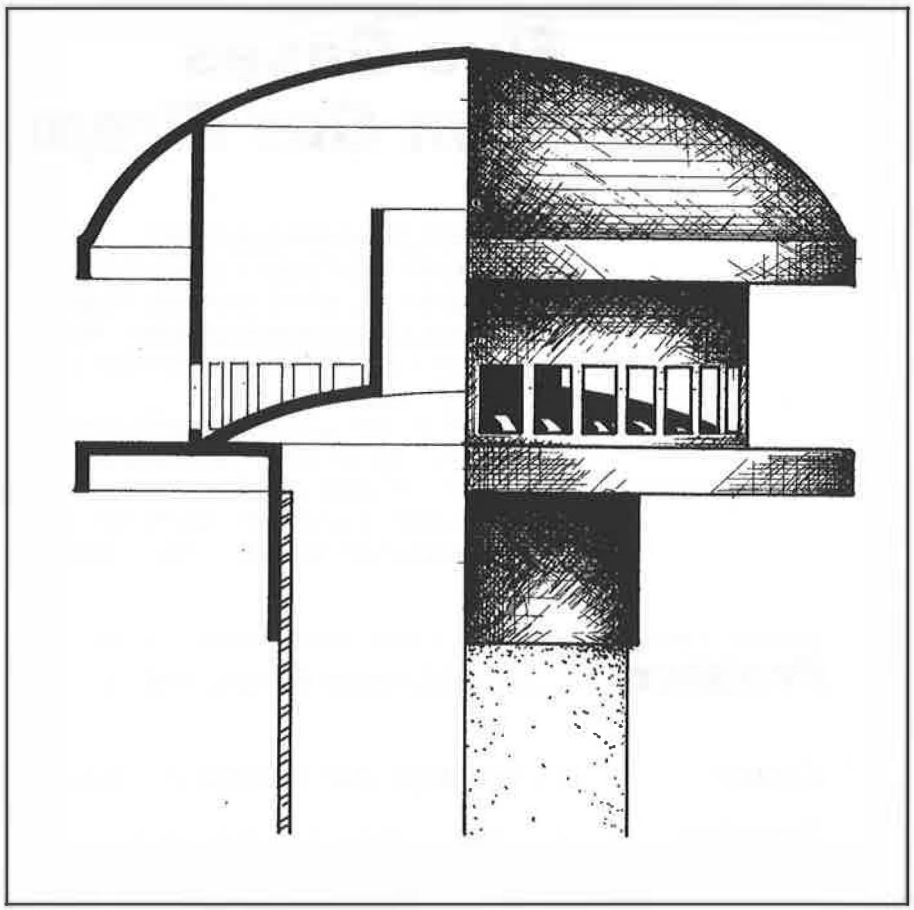

Fig. 8. "B" vent draft-inducing flue cap

Cause

House operating under negative pressure.

Solutions

- Provide adequate make-up air for exhaust appliances or use a balanced ventilation system.
- Provide forced air from the upper storey of the home into the room with the fireplace.

Flue Gases from Gas Fireplaces

Metal gas fireplaces and gas log sets in masonry fireplaces are becoming more common in Canadian housing. Despite safety measures taken by manufacturers and testing agencies, the potential for flue gas spillage still exists. Houses are becoming progressively more airtight, and larger exhaust fans without adequate make-up air create negative pressures and induce spillage from gas fireplaces.

When flue gases spill they typically produce excessively high levels of the gas nitrogen dioxide, which can cause damage to lungs and increase susceptibility to colds and other respiratory problems. Carbon monoxide may also be present; it can lead to headaches, nausea and death. Large amounts of water vapour are dumped into the house when flues spill.

Problem

Spillage of flue gases from gas fireplaces.

Cause

Combustion process not sealed from house.

Solution

- Install a sealed-combustion gas fireplace *(fig. 9)*. This unit draws combustion air directly from the outside through a concentric flue, completely isolating the combustion process from the house. These units can be located only on an outside wall.

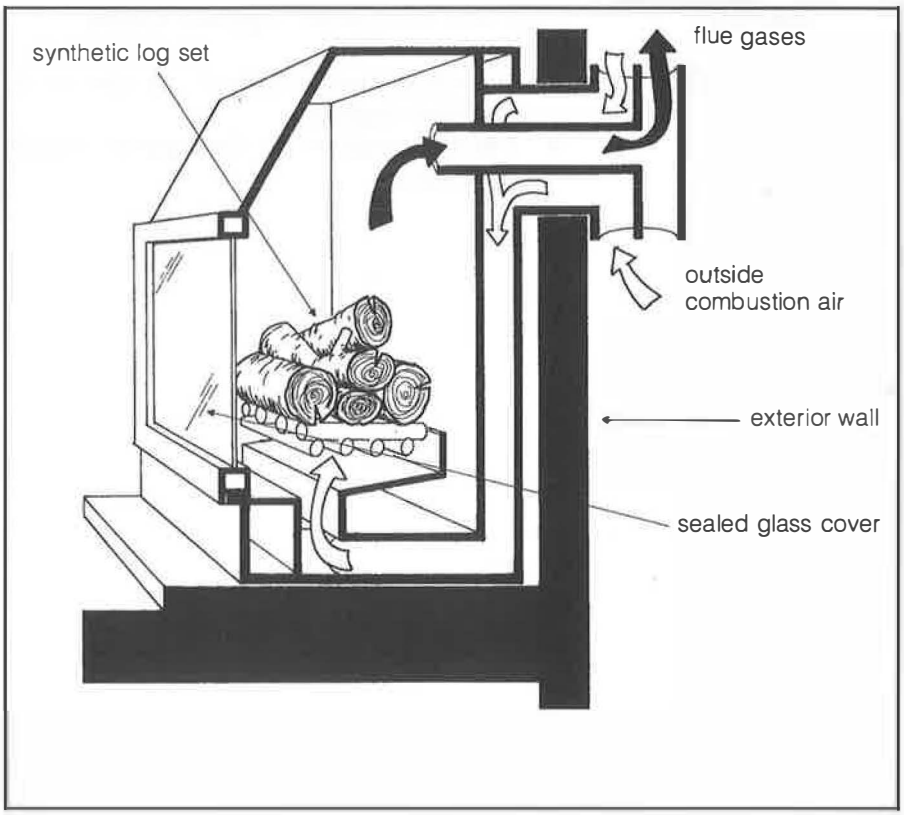

Fig. 9. Sealed-combustion gas fireplace

Cause

Inadequate combustion air supply.

Solution

- Install combustion air feed to fireplace using manufacturer-supplied kit. This will help reduce spillage but will probably not eliminate the problem. It is essential that the house not be allowed to operate under more than 5 Pa negative pressure as measured at the appliance. To achieve this, provision must be made for adequate make-up air, or a balanced ventilation system must be used.

Gas Ranges

Gas ranges produce large amounts of combustion products which, unless adequately vented, can have adverse effects on the occupants. Gas ranges produce nitrogen dioxide, carbon monoxide, and combustion particles. These cause headaches and allergic reactions in some individuals.

Problem The range hood does not have adequate capacity to ventilate the gas stove.

Cause Too much air flow resistance in the exhaust fan ductwork.

Solution

- Use a larger-diameter smooth sheet-metal duct and minimize the bends in the duct run. Avoid flexible ductwork.

Cause Inadequately sized range hood or poor design.

Solutions

- Increase the size and exhaust capacity of the hood.
- Build vertical surfaces around the range to direct the gas plume to the hood.

Cause Kitchen range hood too noisy or inconvenient and therefore not used by occupants.

Solutions

- Select a range hood based on fan sound ratings (rated for noise), where available. Unfortunately, most common range hood fans are considered noisy by occupants. The most effective way to eliminate noise is to use a remotely mounted exhaust fan. The fan should ideally be located in the attic. It should be mounted with vibration-isolating mounts and have a "soft" vibration-absorbing connection to the range hood.
- Educate homeowners about the importance of using the range hood when burners are operating.

Flue Gas from Furnaces, Boilers and Hot Water Heaters

Flue gases from gas- or oil-burning appliances can spill into the home when the chimney is restricted or blocked or is made to backdraft. The results of flue gas spillage can be odours, stuffiness, high humidity and increased concentrations of hazardous pollutants. Frequent spillage of flue gases can lead to chronic health complaints, such as headaches or respiratory problems. If large amounts of carbon monoxide are produced (for example, by an appliance with a poorly tuned burner or dirty air intakes), the health hazard is much more severe.

Problem

Backdrafting or spillage of flue gases from naturally aspirated gas-fired appliances.

Cause

More than 5 Pa of house depressurization.

Solutions

- Provide an adequately sized outside combustion air supply, as called for by building codes, to each fuel-burning appliance in the house.

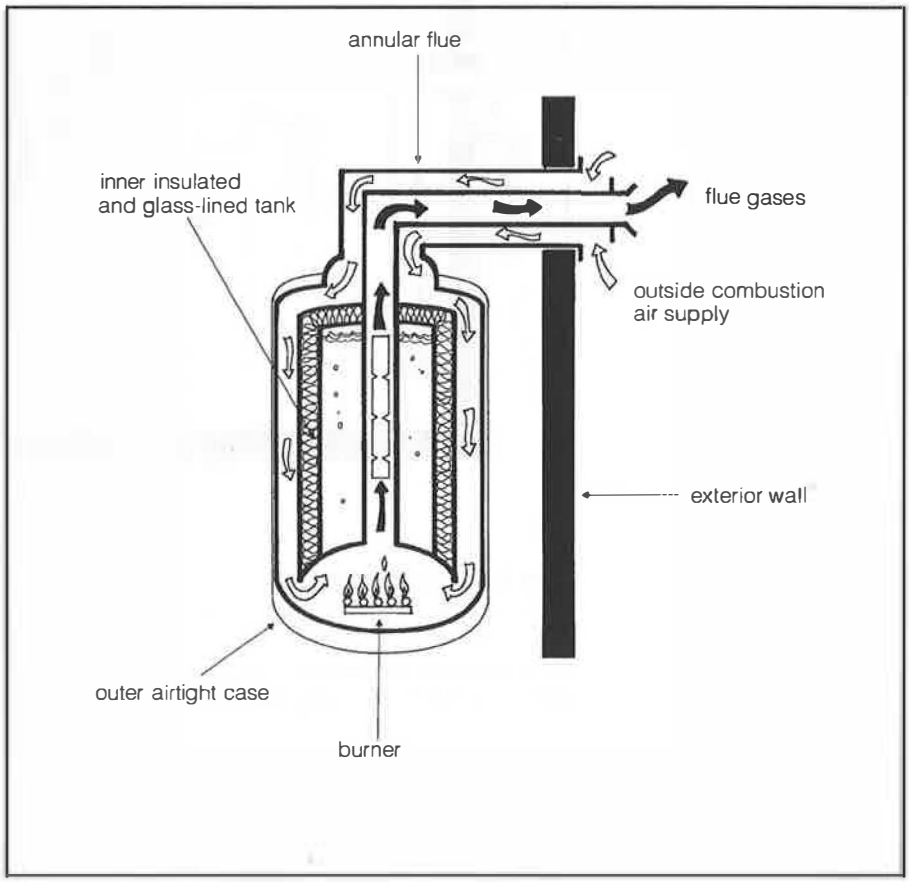

Fig. 10. Direct-vent gas hot water tank

- Ensure adequately sized and tempered make-up air for all powerful exhaust fans in the house, particularly those rated at 75 L/s (150 cfm) or more. This can be done by providing make-up air with CSA-approved fan and duct heater assemblies.
- Replace all exhaust fans with a balanced ventilation system.
- Use a sealed combustion gas-fired water heater or boiler *(fig. 10)*. This type of device isolates the combustion venting system from the interior of the house. The water heater or boiler is side-vented and must be located next to an outside wall. If a side vented appliance is used in conjunction with an induced-draft furnace, the B-vent going through the roof can be eliminated.
- Use an induced-draft furnace in combination with a sealed-draft or induced-draft domestic hot water heater. Ensure that all B-vent joints are sealed.
- Exterior power vent kits are available for ensuring that conventional, naturally aspirating domestic hot water heaters are positively vented to the outside.
- Place conventional, naturally aspirating gas furnaces and domestic water heaters outside the house envelope. This is typically done by placing them in an attached insulated garage or isolated furnace room *(fig. 11)*.

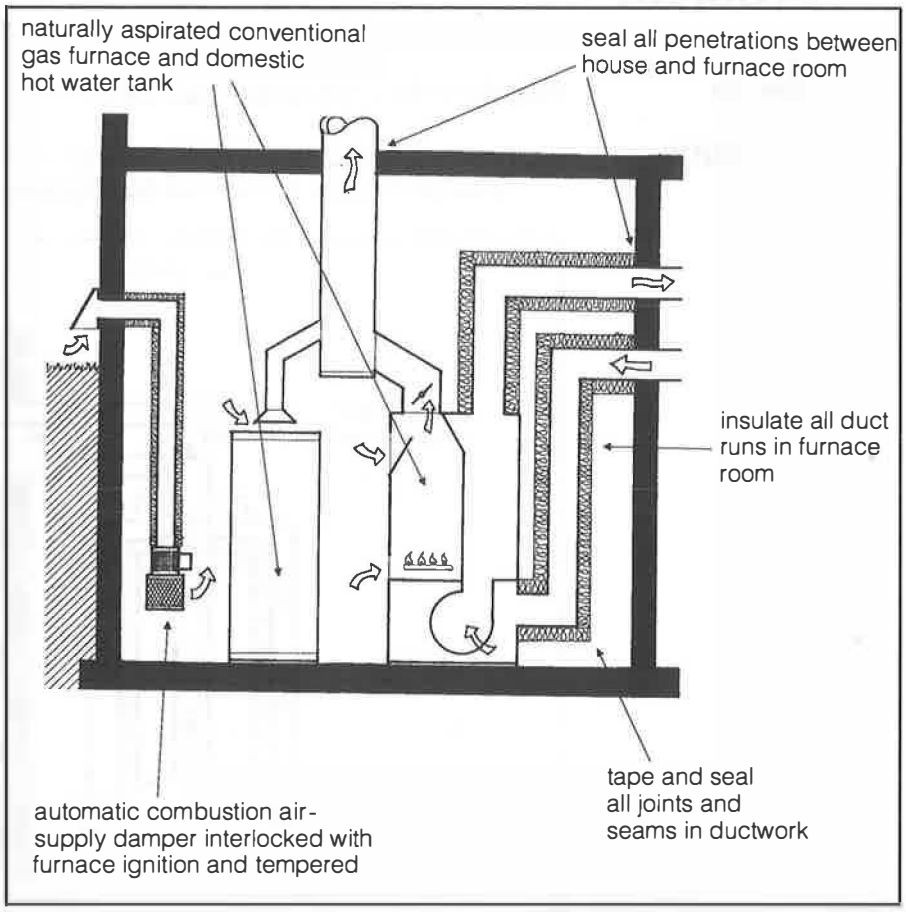

Fig. 11. Isolated furnace room

Extra care must be taken to build a tight air barrier between the furnace room and the house. Return-air ductwork located in this space must be taped or otherwise sealed to prevent the entry of cold outside air and to prevent depressurization. All return-air and supply-air ductwork should be insulated with a minimum of RSI 1.2 (R7). The combustion air supply should be tempered and the furnace room should not drop below 10°C (50° F). Because of the time required to build such a tight room and insulate all ducts, some experienced builders argue that it is more cost-effective to use an induced-draft furnace and a sealed- or induced-draft water heater, and so also obtain the benefits of increased energy efficiency.

Cause

Slow response time of thermally activated flue vent dampers creating large spillage at start up.

Solution

- Substitute an electromechanical vent damper in place of a thermally activated unit.

Problem

Frequent or prolonged start-up spillage from oil-fired appliances.

Cause

House operating under negative pressure between furnace cycles.

Solutions

- Ensure that the oil burner has a purge cycle of at least 10 seconds before ignition.
- Seal joints and connections in the flue pipes to eliminate leakage.
- Install a high quality, properly balanced barometric damper.
- Install a sealed and insulated venting system with a high-pressure oil burner (without a barometric damper).

Cause

Chimney with inadequate draft.

Solutions

- Avoid twisted or long runs for chimney vent connectors.
- Seal joints on vent connectors to prevent entry of cold air into the chimney.
- Prevent the entry of outdoor air into the chimney chase — cold air will cool the B-vent liner and reduce draft.
  For a more detailed discussion of this topic, refer to the CMHC publication *Ventilation: Health and Safety Issues*.

Cause

Wind-induced downdraft.

Solution

- Use a draft-inducing flue cap *(see figs. 7 and 8)*.
- Remove trees near chimney.
- Increase chimney height.

Mould and Mildew Growth

As well as causing odours and staining, mould and mildew on interior finishes can also cause allergic reactions in some people. In addition, there is increasing evidence that certain types of moulds release mycotoxins which can cause very serious health problems. Moulds and mildews are naturally occurring fungi that need a very damp surface above 10°C (50°F) to grow. Fungi are best controlled by the elimination of wet surfaces. For more detailed information on controlling moisture, read CMHC's publication *Moisture Problems*.

Problem

Mould and mildew growth.

Cause

Poor insulation at exterior wall corners and wall and ceiling junctions. Moisture condenses on these cold surfaces, providing an environment suitable for the growth of mould and mildew.

Solutions

- Raise the surface temperature of the drywall by providing better insulation in corners and where ceiling framing members or trusses rest on outside walls. This can be done by insulating the stud "gutter" at outside corners during framing *(fig. 12)*, or by using two-stud framing with drywall clips,

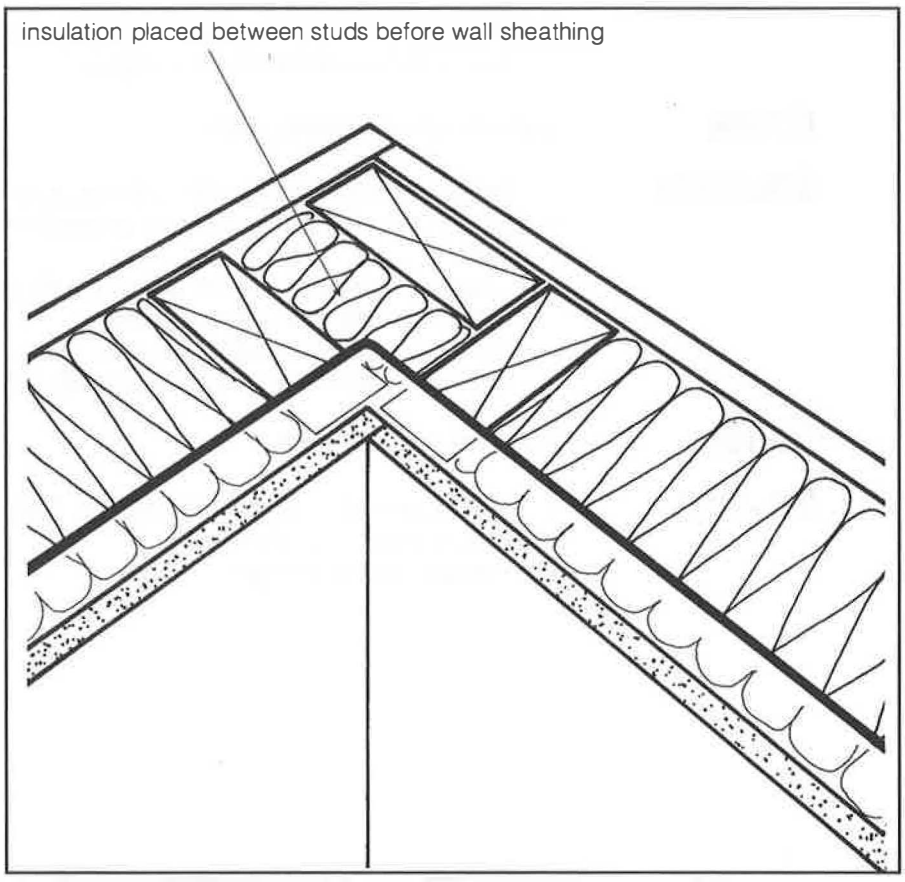

Fig. 12. Insulated stud gutter

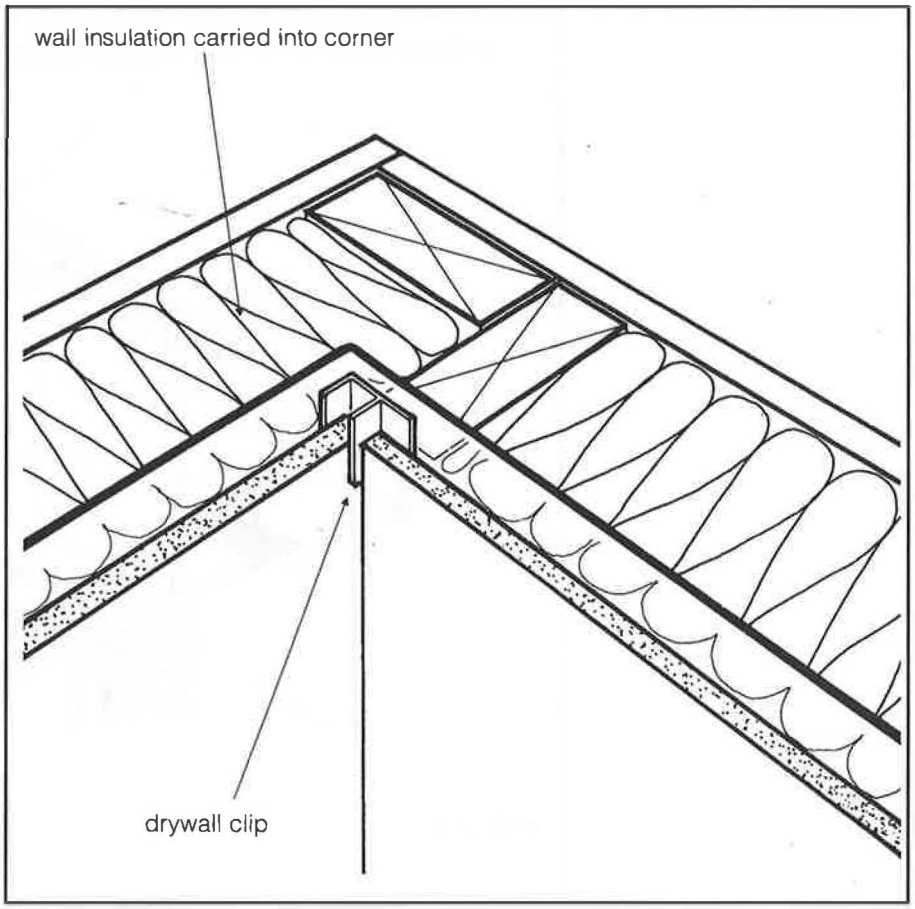

Fig. 13. Two-stud corner

which can be insulated with the rest of the wall *(fig. 13)*. The use of insulating sheathing also reduces thermal bridges at corners.

- Ensure that the ceiling or wall joint is insulated but that it can still provide adequate attic ventilation. This can be done with baffles and a raised heel truss *(fig. 14)*.

Cause

High indoor humidity levels, which can be caused by the following moisture sources: drying of construction materials, damp basements, infiltration of air from below grade, seasonal storage of moisture in the building and its contents, and the activities of occupants.

Solutions

- Reduce moisture sources. Refer to CMHC's publication *Moisture Problems.*
- Educate homeowners about moisture-generating activities and proper use of humidifiers and exhaust fans.
- Provide dehumidification through more ventilation and by controlling the operation of bathroom exhaust fans with a dehumidistat set at between 40% and 60% RH. Ensure that the fan is capable of continuous mechanical operation and has a low noise rating. Provide tempering for make-up air.

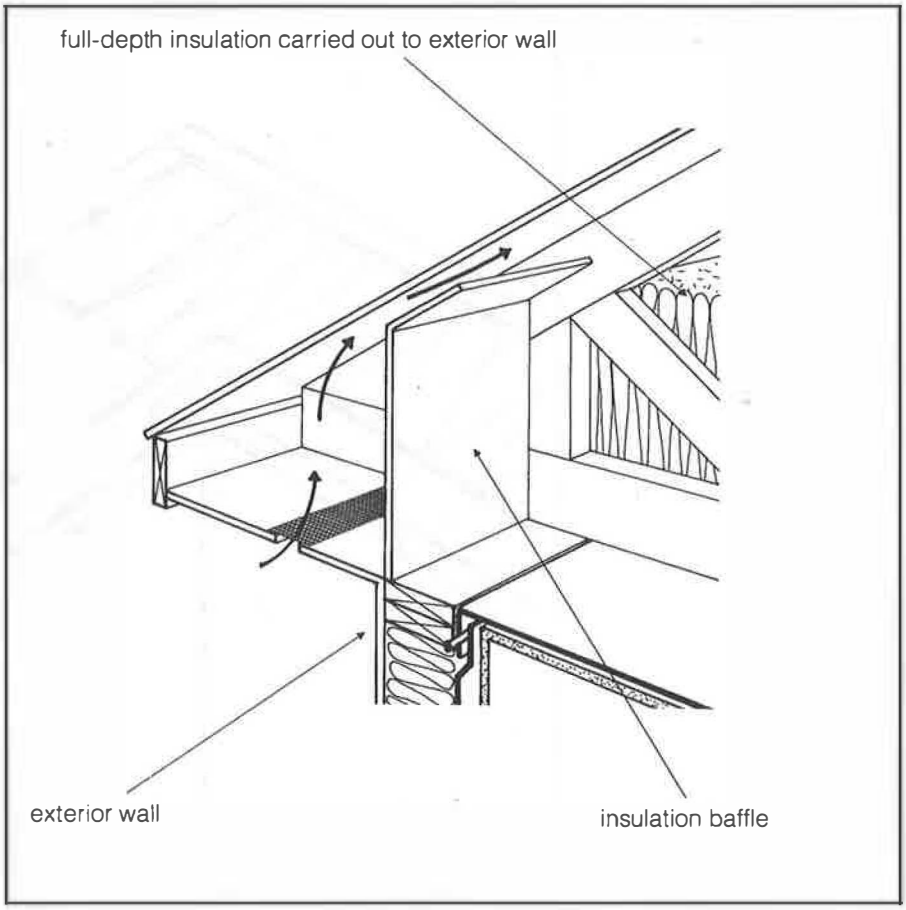

Fig. 14. Raised heel truss

Cause

Insufficient delivery of warm dry air to windows and corners.

Solutions

- Increase fan speed in furnace.
- Advise homeowners to avoid excessive thermostat set-backs.
- Direct warm air registers at problem areas.
- Undercut doors at least 10 mm (3/8") (above carpet).
- Use triple glazing on windows that tend to have excessive condensation.
- Mount windows closer to the interior face of walls.
- Provide interior storms.

Cause

Minor plumbing leaks or condensation on piping in cupboards under sinks.

Solutions

- Insulate cold water lines.
- Improve circulation by providing louvered cupboard doors or by under-cutting doors.

Cause

Poorly maintained mechanical equipment. Humidifiers, dehumidifiers, air conditioning units and heat-recovery ventilators can become breeding grounds for moulds.

Solution

- Educate homeowners on the need for proper cleaning and regular maintenance of all equipment that contains water.

Off-Gassing of Organic Vapours from Interior Finishes

Many building materials such as paints, caulks and glues release organic solvents when curing. This process can last many months, during which the organic vapours may cause odours, headaches, allergic reactions, bronchial irritation and permanent respiratory damage.

Problem

Release of organic solvents from building materials within the house.

Cause

Curing of new materials.

Solutions

- Ventilate the house continuously at a high rate before occupancy.
- Overheat the rooms to 25°-35° C (77°-95° F) to accelerate the release of organic vapours during this breaking-in period.
- Test the sealants and finishing materials before use or discuss choices with the manufacturers.
- Avoid indoor use of exterior-grade sealants.

Problem

Release of organic vapours from cleaning agents, paints, and solvents.

Cause

Storage and use inside the house.

Solutions

- Increase ventilation rates when using cleaning agents by opening windows or operating exhaust fans.
- Never use paint strippers indoors.
- Educate homeowners about the need to ventilate when using cleaning agents, paints, and solvents.
- Provide cupboards with weatherstripped doors that are vented to the outside for the storage of volatile chemicals. Ensure that the cupboard vents will not act as intakes.

Suspended Particulates

The term "particulates" refers to small particles which are suspended in the air and which can be inhaled. High levels of particulates can cause respiratory problems. Dust, pollen, fungal spores and mites aggravate allergies. Bacteria and viruses thrive at either low or high humidity. Mineral fibres cause irritation to the skin, eyes and lungs. Cigarette smoke is particularly harmful in that the smoke particles are quite small and therefore penetrate deep into the lungs.

Problem

Excessive particulates in the indoor air.

Cause

Primarily related to occupant lifestyle: for example, smoking, furnishings, pets, sickness and combustion.

Solutions

- Install higher-efficiency filtration systems (see page 11).
- Provide vents for clothes dryer to exhaust lint to the outdoors.
- Provide for continuous ventilation. Increased air circulation promotes "plating out" of suspended particles onto floors and furnishings, making removal easier through cleaning and vacuuming.
- Install central vacuum systems which exhaust to the outdoors. Conventional vacuums tend to recycle fine particles.
- Provide improved control over humidity with humidistats, furnace humidifiers, dehumidistats, exhaust fans and so on. Educate homeowners regarding the optimum range of humidity levels (30 to 55 percent) to reduce bacteria, viruses and mites.
- Provide outside combustion air to wood-burning appliances, and install tightly fitting glass doors (see page 13).

Operating Houses for Good Indoor Air Quality

Educating Homeowners about Indoor Air Quality

Homeowners will benefit from your efforts to improve air quality only if they know how to operate and maintain ventilation equipment and combustion appliances. Your role as builder is to teach the homeowner the purpose of each device and the best methods for control and maintenance. If this is done properly, you will gain credibility while transferring responsibility to the homeowner. Provide an owner's maintenance manual. High customer satisfaction and confidence often lead to future sales through word-of-mouth recommendations. Homeowner education also has the added benefit of reducing callbacks. Cover the following items:

Ventilation System

- Describe the ventilation system and its operation:
- spot ventilation provided
- rate of continuous ventilation
- location of exhaust and supply points
- location and operation of ventilation controls
- Make the homeowner aware of the need to:
- clean and replace filters frequently (provide additional filters or a list of suppliers), and
- lubricate exhaust fans, furnace fans and fans in HRVs every three to six months.
- Show the homeowner the make-up air and tempering system. Explain the need for make-up air in preventing the house from operating under negative pressure and causing back-drafting of combustion appliances.
- Show the location of grease traps and filters and indicate how often they need to be cleaned.
- Point out where heat recovery ventilator filters are located, and show how they are removed and cleaned. Inform the homeowner of the need to clean HRV filters to maintain flow rates and flow balances.
- Explain that over-ventilation can lead to dryness in the house and high fuel consumption. Dehumidistats should be set at between 40% and 60% RH. In the coldest winter weather, the dehumidistat setting may need to be reduced to 30 percent to avoid condensation and icing on windows.
- Describe the particular benefits of the ventilation system in the house.

Heating System

- Describe the type of heating system used in the house and explain why it was chosen.
- If using sealed draft or induced-draft natural gas appliances, describe the benefits of high efficiency and combustion safety.
- Explain the annual maintenance required.

Wood-Burning Appliances

- Demonstrate the safe operation of wood-burning appliances and explain the functions of tight-fitting doors and outside combustion air supply.
- Discuss the purpose and operation of the outside combustion air supply and damper, and how to prevent backdrafting.
- Explain the importance of leaving the doors shut when the fireplace is left unattended and overnight.
- Demonstrate ways of controlling rates of burn by use of the combustion air supply dampers.

Gas Fireplaces

- Explain the general operation of a gas fireplace.
- Describe the benefits of a sealed-draft fireplace:
  - higher efficiency
  - elimination of flue-gas spillage
- Describe the benefits of fireplaces with outside combustion air kit:
  - higher efficiency because of burning of outside air
  - spillage switch (show how to reset)

Some builders have homebuyers sign a waiver indicating that they have been informed about and understand the importance of safe operation and maintenance of ventilation and heating equipment.

Solving Indoor Air Quality Problems After Occupancy

A range of complaints related to indoor air quality is common in new housing. To maintain customer satisfaction it is important for you to quickly analyze the problem, explain its cause and, when necessary, solve it or show the occupant how to solve it.

Complaint

High humidity causing condensation on windows, mould and mildew, and similar problems.

Cause

House structure and interior finishes drying out. In the first year up to 2250 litres (500 gallons) of water can be released as the house dries.

Solution

- Increase the ventilation rate and leave the basement unfinished for six months or more.

Cause

Ventilation system operating infrequently or inadequately.

Solutions

- Ensure that the dehumidistat is set below 50 percent relative humidity.
- Clear the exhaust fan ductwork and screens of restrictions or blockage.

Cause

Excessive moisture generated by occupants.

Solution

- Instruct homeowners to avoid drying firewood indoors, venting clothes dryers to the inside, running humidifiers continuously, and other moisture-generating activities.

Complaint

Dryness of house air, particularly in winter.

Cause

Ventilation system moving too much air.

Solutions

- Ensure that the dehumidistat is not set too low. Reset to between 40 and 60 percent relative humidity.
- If using a heat-recovery ventilator, check the continuous ventilation rate and ensure that it complies with the manufacturer's recommendations. Reduce the continuous air-flow rates if required.

Cause

Humidifier not operating. In some cases, even when the house is ventilated at recommended levels, the house air will become too dry.

Solution

- To compensate for dryness install a humidifier.

Complaint

Generalized health complaints, headaches, eyes stinging. These types of complaints are often caused by pollutants such as formaldehyde, organic solvents or flue gases.

Cause

Inadequate ventilation.

Solutions

- Ensure that the ventilation system is supplying fresh air or exhausting air from all supply and exhaust grilles. Bedroom ventilation is particularly critical. In rooms without return air grilles, ensure that all undercut doors are free from blockage by carpets or rugs.
- Clean the grilles and filters to increase air flows.

Cause

Flue gas spillage.

Solutions

- Ensure that all combustion air supplies are free from blockage.
- Ensure that ventilation make-up air openings are free from blockage.
- Ensure that ventilation make-up air openings are large enough.
- Run a spillage test by following the steps outlined in the combustion safety checklist in CMHC's publication *Ventilation: Health and Safety Issues*.
- If using a heat recovery ventilator, ensure that fresh and stale air flows are balanced. Clean filters and adjust balancing dampers.
- Ensure that all combustion appliance flues are clean and free of blockages.

Testing for Common Indoor Air Pollutants

Testing indoor air quality in a home can be useful for the following reasons:

- Determining the specific cause of a customer's complaint so that it can be properly corrected.
- Establishing whether the building is the cause of the indoor air quality problem.
- Determining the magnitude of the problem and confirming whether a major expense to improve indoor air quality is justified.
- Reassuring homeowners of the high indoor air quality in their house.
- Checking that the indoor air quality measures taken by the builder are really effective.

Types of Testing

There is a wide range of methods used in indoor air quality testing. Most methods fall within three basic categories.

Time-averaged testing. This is a testing method that involves taking a continuous series of readings and averaging the results. This type of testing gives the average levels of a pollutant. Typical time-average testing includes the use of track-etch detectors for radon, and formaldehyde "badge" detectors.

Spot testing. This approach to testing is valuable for determining the peak levels of a household pollutant. The testing is usually performed when the house is operated in a way that produces the maximum pollutant levels; that is, the ventilation system is shut off and the humidity and air temperatures are raised.

Continuous monitoring. In this method, a simple strip-chart recording device, such as a hygrothermograph for measuring temperature and humidity, can be used to monitor levels over a period of time.

Note that if the source of the problem is not readily apparent, testing can be a very complicated and expensive task. Observation, common sense and experience are often more appropriate guides.

Sources of Information

- Health Canada, through publications and local offices across the country, can provide information on indoor air quality standards for various pollutants.
- Provincial Workers' Compensation Boards usually have staff members who are familiar with indoor air quality standards. You should be aware, however, that industrial air quality standards are often different from those standards set for long-term exposure in housing. These agencies are probably also familiar with local air quality testing firms.
- CMHC research personnel located at the Corporation's national office in Ottawa.
- Canadian Centre for Occupational Health and Safety.

Using Indoor Air Quality Testing

Air pollution measuring services are being offered by testing firms in all major Canadian cities. They are usually listed under "Air Pollution Measuring Services." Some air pollution measurements can be carried out by householders by means of mail order kits. This type of testing is usually used for radon (track-etch detectors) and formaldehyde (badges).

Understanding Health and Welfare Canada Guidelines

Health and Welfare Canada, in conjunction with the provinces, has developed a set of guidelines for exposure to indoor air pollutants in housing. These guidelines are for both short-term exposure (acceptable short-term exposure range, or ASTER) and long-term exposure (acceptable long-term exposure range, or ALTER). ASTER guidelines are for a specified period of time, typically one to 24 hours. ALTER guidelines are considered safe for continuous exposure over a lifetime. See table 3 for ALTER and ASTER guidelines for common indoor air pollutants. See fig. 15 for formaldehyde standards compared to common exposure levels.

Table 3
Health and Welfare Canada Guidelines for Exposure to Indoor Air Pollutants In Housing

Pollutant	**Acceptable Long-Term Exposure (ALTER)**	**Acceptable Short-Term Exposure (ASTER)**
Formaldehyde *	0.05 ppm (parts per million)	Less than 0.1 ppm (parts per million)
Carbon Dioxide	3500 ppm	Less than 7000 ppm
Carbon Monoxide	None	Less than 11 ppm averaged over 8 hours Less than 25 ppm 1 hour average
Nitrogen Dioxide	Less than .052 ppm	Less than 0.25 ppm 1 hour average
Moisture (water vapour)	30% to 80% relative humidity in the summer 30% to 55% relative humidity in the winter	100%
Sulphur Dioxide	Less than 0.019 ppm	Less than 0.38 ppm 5 minute average

* For formaldehyde, the guidelines specify a long-term "target level" rather than an ALTER, and a short-term "action level" rather than an ASTER.

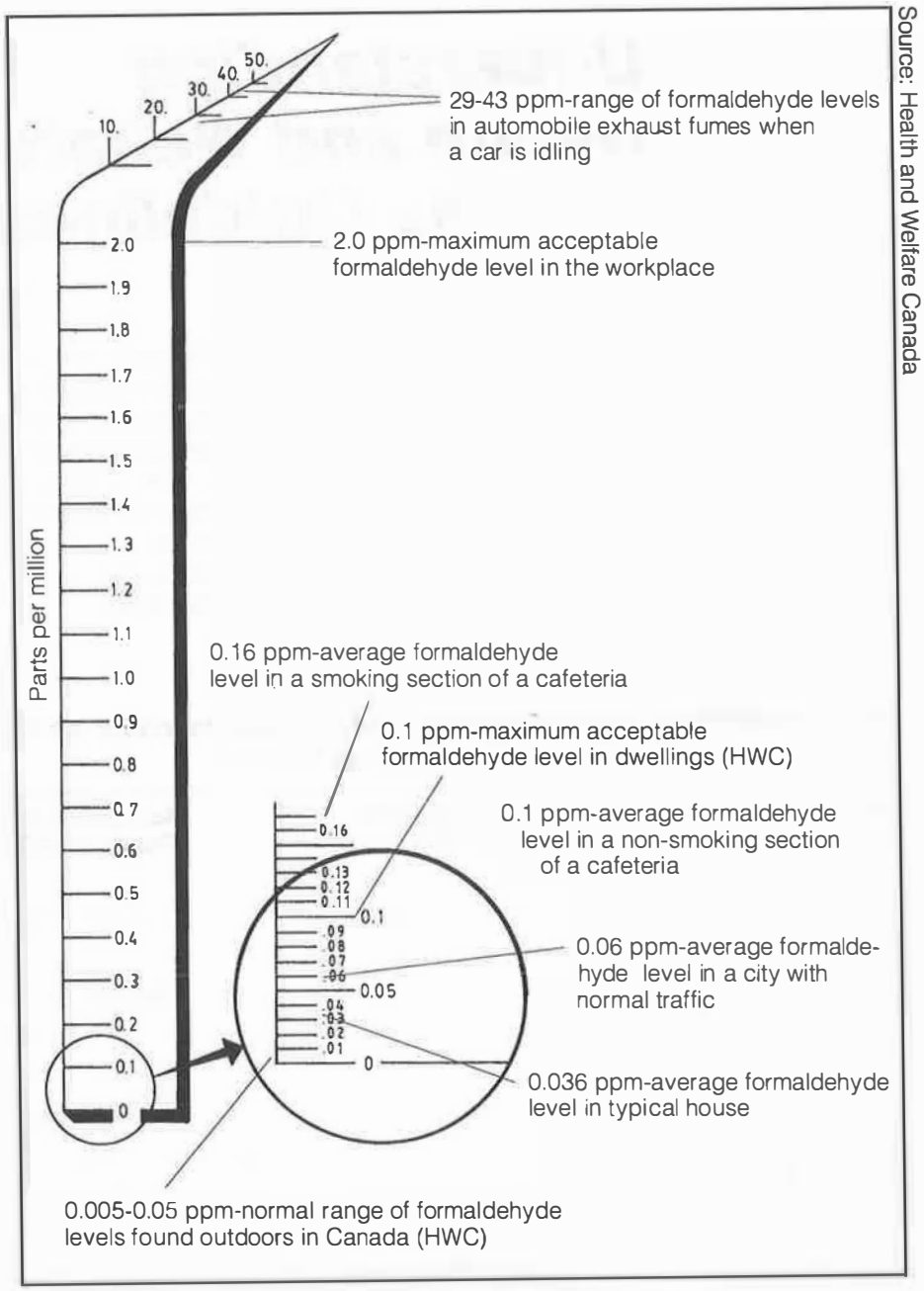

Fig. 15. Formaldehyde levels

Additional Reading

Source	Publication
Canada Mortgage and Housing Corporation 700 Montreal Road Ottawa, Ontario KIA 0P7 (613) 748-2000	*Indoor Air Quality and Housing Technology,* 1983; *Studies on Indoor Air Quality in Canadian Homes,* 1985; and *Exploring Low-Pollution Design,* 1985, by Bruce M. Small and Associates *Ventilation: Health and Safety Issues* (NHA 5888) *Moisture Problems* (NHA 6010) *Radon Control in New Houses* (NHA 6067) *Chimney Safety Tests User's Manual,* by Scanada Sheltair Consortium
Federal-Provincial Advisory Committee on Environmental and Occupational Health Health and Welfare Canada Brooke Claxton Building, 5th Floor Ottawa, Ontario KIA 0K9	*Exposure Guidelines for Residential Indoor Air Quality,* April 1987

For copies of the booklets listed below, send your order with cheque or money order made out to Canada Mortgage and Housing Corporation:

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