RESIDENTIAL MECHANICAL VENTILATION—GETTING IT RIGHT

Robert Marshall

THE ISSUES

In recent decades, home builders have tightened and "improved" building envelopes with new construction techniques and materials. Tighter windows, large areas of drywall, glued/sealed air barrier assemblies, and exterior wall air barrier materials have all contributed to tighter homes. Government- or utility-sponsored new construction programs result in tighter construction that requires mechanical ventilation (Marshall and Gregerson 1993). Voluntary ventilation standards have been published by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and the Canadian Standards Association (CSA).

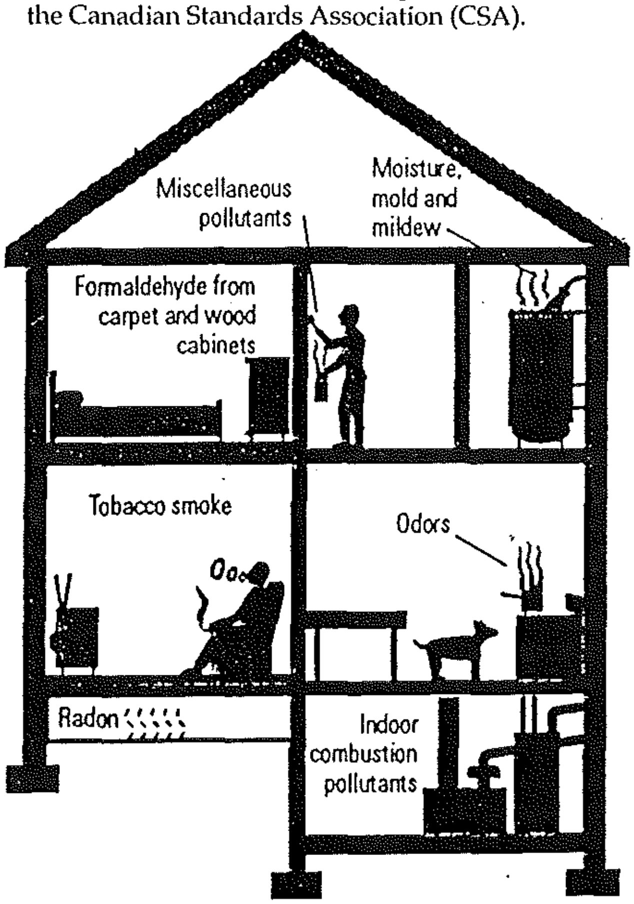

Figure 1 Sources of indoor pollutants—pollutants in homes range from the annoying to the toxic. (Excerpt from Space Heating Technology Atlas—E SOURCE, INC.)

Since 1990, residential mechanical ventilation and a continuous air barrier have been required in all new homes in Ontario. These are needed to provide outdoor air to occupants, reduce interior moisture levels, and minimize the risk of damage to the building envelope. In 1993, substantial amendments were made to the Ontario Building Code to eliminate the "hole in the wall" option, as it was not popular. As well, revised prescriptive ventilation alternatives were developed to give builders a choice between part 6, design, and part 9, specific requirements.

Mechanical ventilation dilutes and removes indoor pollutants that can make people uncomfortable or sick or damage building materials. It also supplies fresh air for people to breathe. The historic practice of relying on random leaks to provide air is simply not sufficient, especially in new homes, which are built much tighter than older structures (Marshall and Gregerson 1993).

All homes have indoor sources of air pollutants (Figure 1). Some can be controlled at the source. These avoidable pollutants include

- toxic building materials (for example, carpet and cabinetry with formaldehyde-containing glue);
- toxic household cleaning products, pesticides, and paint;
- spilled combustion gases from unsealed or natural draft (atmospheric) combustion appliances (use sealed combustion or direct vent furnaces); and
- radon.

If soil gas (radon) is deemed to be a problem, measures must be taken to control its entry into the habitable space. Exhaust-type mechanical ventilation systems should not be used.

Other sources of pollutants cannot be avoided, because they are generated by the occupants, but they can be controlled. These include

- bacteria, molds, and mildew (linked to high levels of humidity from people, plants, and animals);
- dust mites and pet dander;
- tobacco smoke; and
- odors from many sources.

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Tobacco, which can be addicting, may be difficult to control, as it depends completely on the occupant(s). Also, there is no law against smoking and even if there was, it would not be enforceable.

To reduce health risks, mechanical ventilation systems have been mandated in all provinces in Canada. To reduce structural damage to building envelopes, air barrier systems also are required in all provincial jurisdictions.

What have we learned to date?

SYSTEM DEFECTS

While many new homes are well built with few problems, in all too many instances homes are constructed with built-in defects. These are a concern to consumers, builders, designers, inspectors, and warranty programs. Of great concern are the common built-in deficiencies and improper use of the equipment by homeowners who lack the knowledge of the need to use their systems. The *1993 Ontario Building Code Mechanical Ventilation Assessment* research study (Duffy 1994) reached the following conclusions:

— Exhaust-only, heat-recovery-ventilation-based, and design ventilation systems were effective in terms of installed capacity, and all homes studied were provided with sufficient ventilation capacity (see Figure 2).

— Inspectors needed to be trained to check for specific installation deficiencies. By using a total quality management process that focuses on actual serious defects, problems can be systematically prevented.

— Tighter quality control is needed to eliminate deficiencies (see Figure 3).

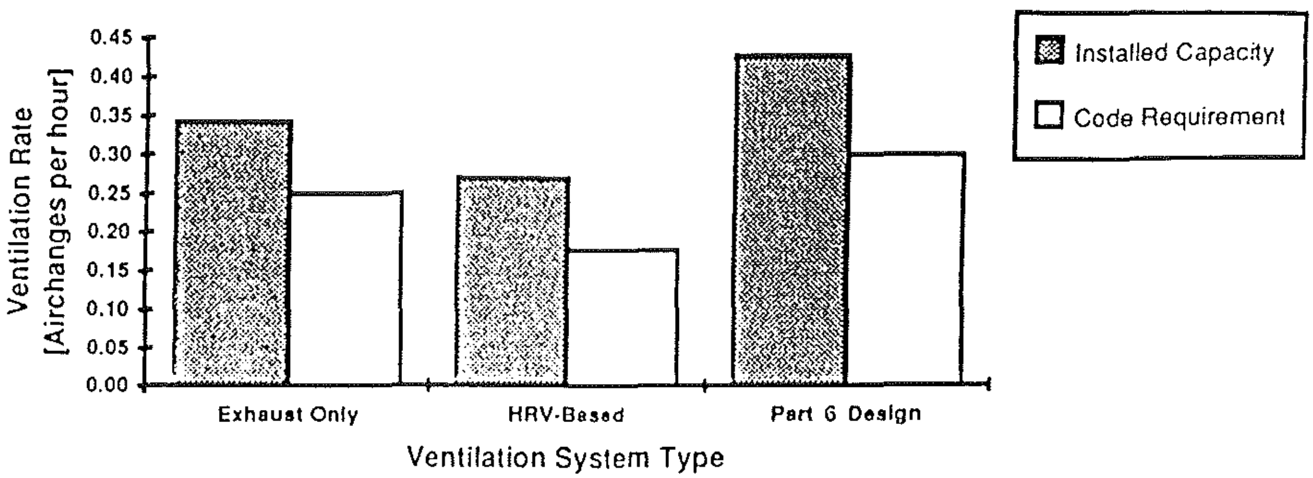


Figure 2 *Average code prescribed vs. installed capacity by ventilation system type.*

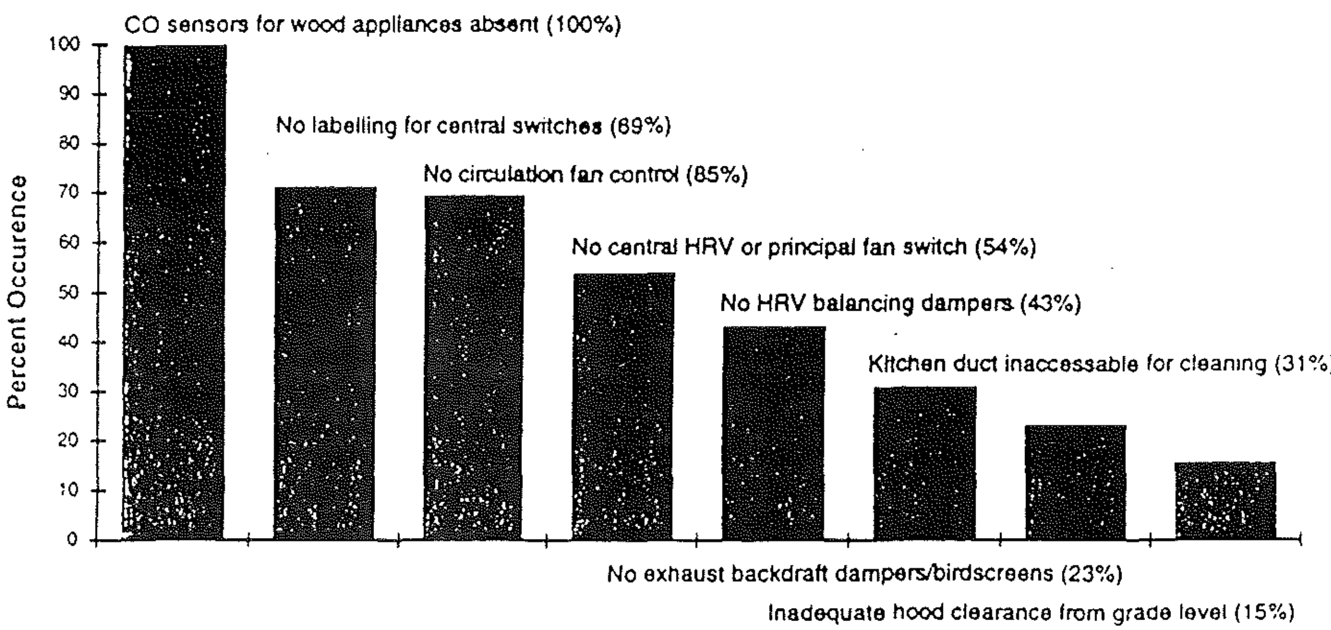


Figure 3 *Frequency distribution of code deficiencies.*

— Consideration needs to be given to amending the code to provide upper limits on heat recovery ventilation (HRV) capacity and balancing requirements for HRVs.
— Due to the airtightness of houses, the measures to prevent combustion spillage were effective.
— Home purchasers are clearly satisfied with the air quality and general comfort level of their homes. However, more customer education is needed, especially for exhaust-only types of ventilation systems where improper operation resulted in poor indoor air quality.

It also is essential to prevent costly air barrier/insulation building envelope defects. According to another study, insulation/air barrier defects were the most frequent Ontario Building Code defect (Martin and Marshall 1993).

The types of defects that were most common were missing air barriers. As a result, moist air exfiltration caused damage around windows and patio doors, as well as wall and roof deterioration. Penetrations of the air barrier system by electrical boxes, access hatches, and unsealed chases led to costly roof replacement in some cases.

A systems approach is needed to resolve these problems. If the air barrier defects are addressed, then *more* attention is needed to ensure that a mechanical ventilation system is properly installed and appropriately operated.

THE CONSEQUENCES

The consequences of improperly installed systems are potential lawsuits that invariably ensue when serious health hazards and structural safety concerns are present. Typical damage claims can be hundreds of thousands of dollars for each building.

Expensive service costs to handle complaints can destroy a company's profits and ruin a reputation. It is in everyone's interest to ensure the mechanical ventilation system is "installed right the first time" and that owners know how to use the system.

PRACTICAL APPROACHES

From extensive research of possible options and a comprehensive analysis of the deficiencies from the field, practical guidelines were developed. A learning-oriented environment and a team approach were used. Technical solutions were developed from working meetings with key government and industry stakeholders.

Building codes are an appropriate vehicle by which to mandate ventilation requirements. The ventilation experts today say that a ventilation rate based on house volume (such as .3 air changes per hour [ACH]) or total number of rooms leads to *overventilation*. Instead, the rates should be based on the number of occupants. The master bedroom is assumed to have two occupants and all others are assumed to have one occupant.

Experts agree that low levels of continuous ventilation should be supplemented with higher levels of intermittent ventilation to remove moisture and odors at the source (Lio 1992). For principal ventilation (continuous), Table 1 can be used.

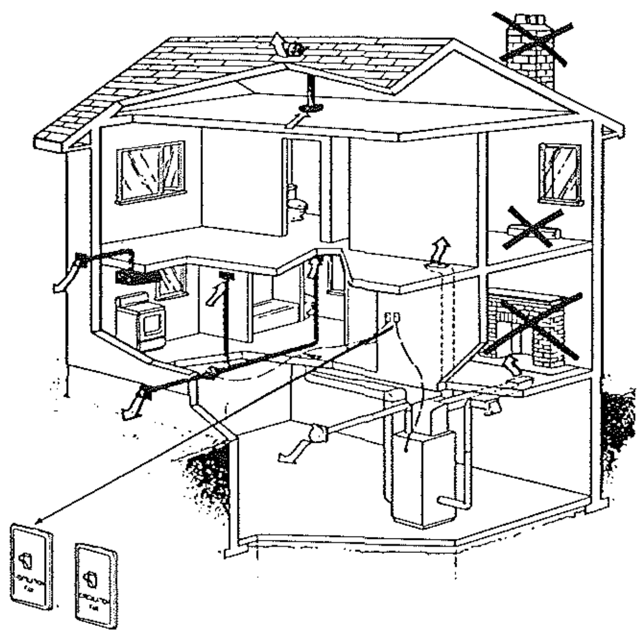
TABLE 1 **Minimum Principal Fan Capacity**

1 bedroom 32 cfm (15L/s)	2 bedrooms 48 cfm (22.5L/s)
3 bedrooms 64 cfm (30L/s)	4 bedrooms 80 cfm (37.5L/s)
More than 4 bedrooms Design	

The total ventilation capacity is based on the sum of individual room capacities. For example, the total ventilation capacity for a typical three-bedroom house is 138 cfm (65 L/s). The master bedroom has 21.2 cfm (10 L/s) + two other bedrooms, kitchen, dining room, living room, family room, laundry room, and two bathrooms at 10.6 cfm (5 L/s) each and an unfinished basement area of 21.2 cfm (10 L/s). The principal exhaust fan capacity is 64 cfm (30 L/s). The capacity of supplementary exhaust fan(s) is 74 cfm (35 L/s). The supplementary exhaust capacity is the total ventilation capacity minus the principal exhaust fan capacity. Supplementary capacity would be point exhaust fans in bathrooms and/or the kitchen. ("Complying with residential ventilation requirements of the 1993 Ontario Building Code" by Ontario New Home Warranty [1993]).

There are numerous types of ventilation systems with different impacts on house pressure, as well as spillage-susceptible appliances. In Ontario, both prescriptive and specially designed systems are permitted. As occupant safety is paramount and in the absence of a responsible designer, safety features are prescribed with the prescriptive systems to minimize risks. Figure 4 is an exhaust-fans-only system, which is popular in gas-heated homes in subdivision housing. Figure 5 is a heat recovery ventilation system, which is required in electrically heated homes. Specially designed systems (Figure 6), such as a central-supply-only system that uses ducted outside fresh air inlets into the return air plenum with an automatic damper, should have site testing and verification procedures to ensure that systems are safe and that pressure imbalance problems, which may affect the building envelope, are avoided.

Regardless of whether a jurisdiction uses mechanical ventilation guidelines or mandates requirements, it is critical that field demonstrations be done to verify that approaches are understood in the local area or culture and that they perform effectively and meet the needs of the customer. Defects can be prevented by measuring the results and making continuous improvements on an ongoing basis.

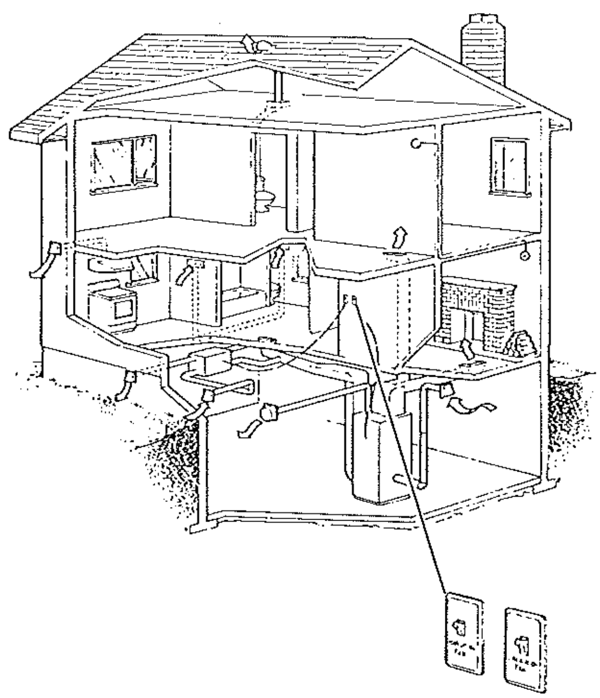


Exhaust fans expel air from the house, which draws outside air in through the building envelope. No additional supply air required. Forced air heating system circulation fan distribution air.

Note: May not be suitable for areas where radon is a problem.

For full system details, see "Complying With Ventilation Requirements of the Ontario Building Code" (2nd ed.)

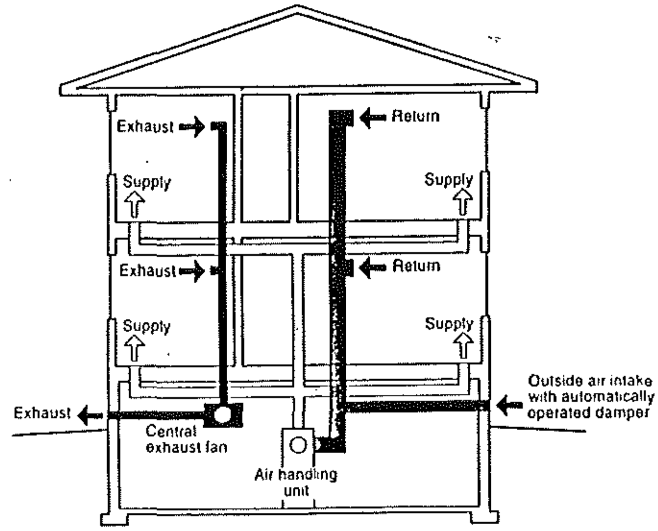
Figure 4 *Type A—Exhaust fans only (prescriptive).*



Heat recovery ventilator ductwork takes exhaust air from kitchen, bathrooms and/or other central location, and supplies pre-heated outside air directly to return air plenum of forced-air furnace.

For full system details, see "Complying With Ventilation Requirements of the Ontario Building Code" (2nd ed.)

Figure 5 *Type B—HRV: Extended exhaust (prescriptive).*



An effective controlled ventilation system in a heating climate should have the following characteristics:

- Stale air is removed through a central exhaust system. Exhaust vents are located in the kitchen and bathrooms.
- The central exhaust system operates continuously—at least 15 minutes per hour whenever occupants are present.
- The outside air supply is connected to the return side of the air handling unit. An automatically operated damper covers the outside air intake.
- The forced-air system provides effective distribution of fresh air throughout the house.
- The control system is designed so that the central exhaust system only operates when the outside air damper is open and the air handling unit is running.
- The overall system must be designed, balanced, and commissioned so that the pressure relationships recommended for heating climate buildings are maintained.
- The outside air damper need not be open when only the air handler is operating.

Figure 6 *Type C—Central supply (special designed systems). Controlled ventilation system for a house in a heating climate.*

(Excerpt From Moisture Control practices for heating climates (Lstiburek and Carmody))

VENTILATION SYSTEM CHECKLIST

"Getting it right" requires a focus on key problem areas. At the design stage, choose materials that remove pollutants at the source.

An effective ventilation system must do all of the following:

- Use proven systems that can be accomplished by developing your own pre-engineered systems or selecting a professional with the prerequisite knowledge. (Ensure important safety equipment is specified or depressurization tests are done to confirm combustion spillage will not be a problem.)
- Provide automatic controls.
- Use cost-effective heating of ventilation air.

- Have a site quality control program to eliminate installation defects.
- For HRV systems, check for balancing dampers and only accept balanced systems.
- Ventilation equipment must be accessible for servicing and must be properly maintained.
- Commit to continuous learning by taking training programs and obtaining technical information manuals.

Finally, do not forget to educate homeowners on the use of their ventilation systems. If they have an exhaust-only system, let them know they need to run the ventilation fans longer, especially in cold weather. By using these tools, defects can be prevented, homeowner health is ensured, and significant cost savings are achievable for industry and government.

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