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Combustion Safety for Residential Equipment

Energy conservation, changes in building airtightness, appliance design and building materials, along with fuel switching, have all combined to potentially cause safety problems due to combustion equipment. The main concern is the level of pollutants in the indoor environment. Some of these may cause immediate, even life threatening problems; others longer term chronic health problems.

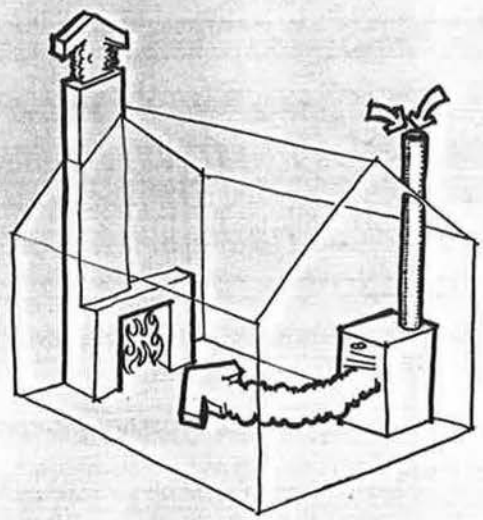
As homes become tighter, combustion equipment has a harder time getting enough air to operate properly. Spillage of incomplete combustion products or even chimney reversals can result in high levels of carbon monoxide and other combustion products being exhausted into the house.

Conventional flues are being called on to handle lower flows, temperatures and different fuels than they were designed for; the results are more condensation, corrosion, draft problems and generally unhealthy appliance performance. In the worst cases failures can result in life-threatening situations.

Combustion equipment requires air for the combustion process itself and for dilution. The dilution device (the draft hood on a gas system or the barometric damper on an oil system) is located downstream of the heat exchanger; it's there to separate the combustion from outside pressure fluctuations, but it needs 2 to 10 times the amount of air needed for combustion.

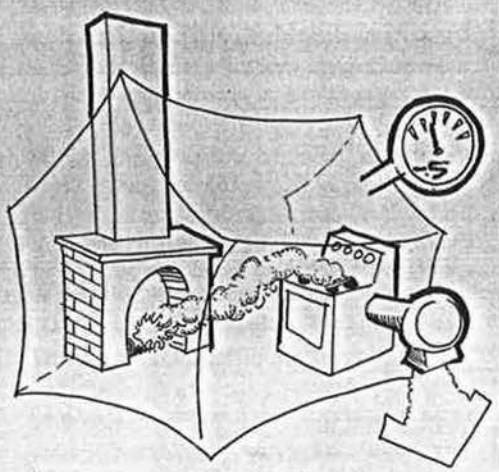
Conventional wood-burning fireplaces require the most air. While new houses may have an air change rate of ½ air changes per hour or less, fireplaces need 3 times this amount. The fireplace with a blazing fire, maximum draft and air needs can reverse the flow through the furnace flue; but when the fire is smouldering the reverse can happen, with the furnace pulling the incomplete combustion products from the fireplace into the living space.

New gas or oil-fired equipment eliminate the dilution by forcibly exhausting combustion products, either with a fan or



a series of powerful combustion pulses. These higher efficiency, low air demand appliances are well suited to the low energy homes of today, significantly reducing the chance for combustion spillage into the house.

Some household appliances such as down-draft cooktops have powerful exhaust fans. In a tighter house, or one with marginal draft due to poor chimney construction or maintenance they can cause combustion equipment to spill combustion gases into the house.



The only way to avoid this type of problem is to provide each with its own air supply.

Even the clothes dryer exhaust could create pressure imbalances high enough to cause problems. One way to overcome this is to duct outside air directly to the dryer. (At cold winter temperatures, the moisture content of the incoming air will be very low and should actually aid the drying process).

What Pollutants affect indoor air quality air?

Carbon Monoxide

Carbon Monoxide (CO) is a colourless, odourless, tasteless gas produced in any combustion process when there is incomplete combustion. High concentrations can quickly be fatal. Improving the combustion lowers the amount of CO produced.

On oil and gas furnaces, the poorest combustion is usually at start-up, where draft is marginal and mixing between fuel and air is not fully established. This can result in peaks of CO as much as ten times the "good tune".

Hydrocarbons

Hydrocarbons are generated during the instant of start-up or shut-down. If CO is dealt with, so are hydrocarbons.

Nitrogen Oxides

Nitrogen Oxides (NO_x) is a colourless, tasteless gas formed during combustion. NO_2 reduces the body's ability to absorb and distribute oxygen and can stress the cardiovascular system. It is one of the prime contributors to low level ozone and urban smog.

The hotter the flame and/or the more nitrogen in the fuel, the more NO_2 is formed. Modification of the flame pattern or mixing can reduce NO_x. Typical oil and gas furnaces produce about 80 ppm NO_x during average conditions. Some advanced combustion technologies are capable of producing NO_x levels 7 times lower.

Particulates and Polycyclic Organic Matter

Particulates and polycyclic organic matter are small pieces of solid matter that are incomplete combustion products usually produced during smouldering combustion, such as in cigarette smoke, fireplaces or damped-down wood stoves.

Sidestream smoke (smouldering cigarettes) can be more harmful because of the increased level of pollutants produced due to the even poor combustion.

Running wood stoves at high firing rates give better burning. Long slow overnight burns, using new, advanced technology stoves with properly vented combustion products to the outdoors should ensure minimal release of these pollutants inside the house.

Appliance Air Requirements

Over a typical Canadian heating season, a furnace will be on for only 15% to 25% of the time, depending on the degree of furnace oversize, but to calculate how much air is needed the unit must be treated as if it is on continuously.

Table 1 shows the air requirements of various combustion equipment for a typical Canadian house.

Gas Systems

Most conventional gas furnaces have naturally aspirating atmospheric burners, with no fan or blower to assist either in the fuel-air mixing, generation of flue drafts or exhausting the combustion products. A continuously-open draft hood has a large dilution air requirement.

In a tighter house or if the chimney is unsuitable, conventional gas furnaces can be subject to spillage of flue gasses, especially if other equipment with large air demands such as a fireplace are also operating. If the combustion is disrupted, incomplete combustion products, such as carbon monoxide, may be released into the indoor environment.

New higher efficiency gas furnaces/boilers and small, advanced combustion, clean burning wood stoves have no significant air demand and are ideal for lower energy consuming, tighter houses of today. They offer safer operation, making any spillage of combustion products unlikely, as well as improving the performance efficiency as well.

Wood Combustion Appliances

Fireplaces:

Fireplaces are very inefficient, supplying little, if any, energy to the house but they have massive air requirements. At high burning rates a typical fireplace may need 24,000 cu. ft./hr (680 m^3/h) of air. Fireplaces should be recognized as a major source of pollutants to the indoor environment.

The best way to ensure that fireplaces don't create problems is not to use one. If they are to be used, they should be isolated from the house with tight fitting glass doors and their own air supply. Artificial firelogs can lower the air needed, reduce emissions by 50-80% and significantly lessen the chances of combustion gas spillage into the house.

Airtight Wood Stoves

Wood can be used efficiently in a well-designed airtight wood stove. These can have an efficiency of up to 50-70%. Air requirements for such a stove are low: only about 600 cu. ft./hr (17 m^3/h). There is no dilution of flue gases need on an airtight wood stove; new designs are cleaner burning, producing 80% less pollutants, with even less potential to cause indoor air quality problems.

Unvented Kerosene Heaters

These appliances have been marketed widely; they may offer comfort and efficiency only if used carefully. Having no vent, they exhaust the combustion products into the living space so there is reason for concern if they are used for extended periods of time.

There may be long term health problems due to nitrogen oxides, particulates, carbon monoxide and even sulphur dioxide if the fuel is not good quality.

The air demand of an unvented kerosene heater is about 141 cu. ft./hr (4 m^3/h).

Gas-Fired Ranges

An appliance similar to the unvented heater is the gas range. Concern has been expressed about incomplete combustion products such as CO, as well as normal by-products of combustion, particularly nitrogen oxides (NO_x) venting into the house.

The range hood fan exhausted directly to the outside should be run continuously when the range is being used to ensure that all combustion products are removed from the living space. The energy penalty is slight (except, perhaps in the harshest of arctic climates).

Table 1: Air Demands for Residential Combustion Equipment

Appliance	Combustion Air	Dilution air	Total
Conventional Oil	2295 cu.ft./hr (65 m^3/hr)	6885 cu.ft./hr (195 m^3/hr)	9180 cu.ft./hr (260 m^3/hr)
High Efficiency Oil	1307 cu.ft./hr (37 m^3/hr)		1307 cu.ft./hr (37 m^3/hr)
Conventional Gas	1801 cu.ft./hr (51 m^3/hr)	5049 cu.ft./hr (143 m^3/hr)	6850 cu.ft./hr (194 m^3/hr)
Induced draft gas	1553 cu.ft./hr (44 m^3/hr)		1553 cu.ft./hr (44 m^3/hr)
Condensing Gas	1024 cu.ft./hr (29 m^3/hr)		1024 cu.ft./hr (29 m^3/hr)
Fireplace	24010 cu.ft./hr (680 m^3/hr)		24010 cu.ft./hr (680 m^3/hr)
Airtight Wood Stove	600 cu.ft./hr (17 m^3/hr)		600 cu.ft./hr (17 m^3/hr)

Poor Performance Due to Chimney Problems

Venting problems are increased by the fact that many masonry chimneys were not well built originally. These can include: lack of tile liner; incomplete tile liner; misaligned or cracked tiles; non-continuous connection of the flue pipe and chimney liner; defective chimney cap; changing fuel from oil to gas (gas has twice the moisture content in the flue gas, a higher dewpoint and lower flue gas temperatures. This promotes increased condensation and corrosion in the vent).

Simple indications of deterioration in masonry chimneys include deterioration of the exposed tile at the top of the chimney; cracking of the chimney cap; efflorescence (whitening) on the outside of the brick; spalling of the brick and mortar; tile segments at cleanout door; yellowish staining on the outside of the chimney; staining as evidence of water run-out at chimney clean-out door; staining or corrosion of the flue pipe connecting the appliance to the chimney.

Prefabricated metal chimneys are not immune to problems, so must be installed and maintained correctly.

Chimneys should be examined and defective chimneys repaired or relined whenever a combustion appliance is modified, changed or added to the system, to ensure good draft and proper combustion performance.

Chimney Location

In Canada most masonry flues are on the outside wall with three sides exposed to the cold air. The house often works better as a chimney than the flue itself, so that creating a draft is difficult. Chimneys should *always* be located inside the heated envelope.

Flue drafts are influenced by height, temperature and wind. It is often thought that the major factor affecting draft is height so if there is a problem nearly everyone will say, "increase the height of your chimney." However, this is not the case; proper design and location are the answer.

From "Combustion Safety For Residential Appliances" presented at the Affordable Comfort VI conference, Pittsburgh, March 1992 by A.C.S. Hayden; Combustion & Carbonization Research Laboratory (CCRL); ERL/CANMET Energy, Mines & Resources Canada. Ottawa, Canada K1A 0G1

The "Open" House

Canada Mortgage and Housing Corporation (CMHC) has designed an "Open" House, a barrier-free display house to promote accommodations suitable to a wide range of occupants. It was designed and assembled with advice from leading experts in the barrier-fee design field and from people with disabilities.

Design and products take into account users' needs in four main areas: mobility disabilities, sight impairments, hearing limitations and environmental sensitivities.

The needs of individual persons vary greatly, depending upon the type and extent of their disability. The 'Open' house does not advocate any one particular design or product but illustrates a number of possibilities for safer, more independent living. There are a number of common design elements. While they address special issues at the same time they can make any house pleasant and liveable.

Safety and accessibility are primary considerations for all aspects of the "Open" House. Some of the features of the house that make it more accessible are high lighted here. These include:

Wider hallways and doorways for easier movement of furniture and wheelchairs throughout the house. Swing clear door hinges on all doors.

Fresh air and natural lighting to every room of the house and an outdoor deck and garden.

Materials that reduce indoor air pollution. These include low vinyl content tile flooring with a transparent liquid beeswax finish that emits no harmful vapours, and an odourless, non-toxic, water-based adhesive for all floor finishes.

Light switches and electrical outlets that are at consistent locations and at heights accessible to everyone.

The entry

Features include: level floor area at the entrance covered by a large overhang; a bench by the doorway to set packages on while opening door; wide angle peep holes at both standing and sitting eye levels; seating while putting on boots, etc. A two door entry vestibule for better indoor climate control.

Child's Bedroom

Ease of access and the ability to care for a child are important in a child's bedroom, which is located on the ground floor. Features include colour contrasting to assist people with visual impairments distinguish between counter and wall edges; wheelchair accessible crib; desk lamp which has a touch activated base; closet organizer that provides height adjustments for clothes rods and shelves; window with a low sill height that allows a small child to see outside; carpet made of 100% unbleached cotton which does not release any harmful emissions.

The Bathroom

Safety and independence are two important objectives in the bathroom: reinforcement is built into the walls so grab bars may be easily added where and when required according to an individual's personal needs; the toilet incorporates a personal hygiene device with a heated seat