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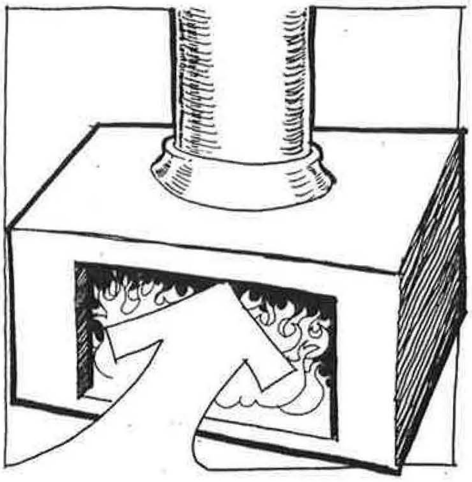
Fireplace Air Requirements



Research has shown that excessive house depressurization can cause combustion products from fuel-burning appliances to spill indoors. Fireplaces (especially open masonry ones) can be major sources of air exhaust from houses, enough to depressurize the house.

Fireplaces themselves can be a source of indoor air pollution when house depressurization causes them to spill. A CMHC sponsored study done by ORTECH looked at how much air is needed by factory-built fireplaces, their pressure limits and air supply strategies, as well as to suggest ways to separate house and fireplace air. The work was done in the ORTECH International laboratories.

Problems with fireplaces

These include:

* spillage of flue gasses from the fireplace into the house; this can be a nuisance when smoke spills into the room, but harmful if carbon monoxide and other gases spill into the house when the fire dies out.
* spillage of flue products from other combustion appliances when the fireplace depressurizes the house;
* fires resulting from overheating of combustible materials adjacent to the fireplace or fireplace chimney;
* reverse flow of flue products through air intakes connected directly to the firebox.

In an 11' x 11' x 8' high test room five factory-built fireplaces were taken through test burns to determine how resistant they were to spillage under various room depressurizations, their chimney flow rates, and the flow rates in their fresh air intakes. Separate tests were done to determine the airtightness of the glass doors and fireboxes, and the flow characteristics of the air intakes and chimneys.

Table 1 describes the fireplaces tested.

The results show that most of the factory-built fireplaces tested would not act as major house exhausts nor would they be likely to spill under normal operation. Chimney flow rates were low when the fireplaces were operated with closed doors, but much higher when doors were opened.

Combustion air intakes proved to be of variable utility, supplying close to all required air in some fireplaces and less than 25% in others. Air intakes connected to the circulation air plenums were not very effective. Those connected directly to the firebox could match air requirements but could be dangerous in reverse flow (when combustion products flow out through the intended intake). The frequency of such reversals has yet to be established.

All fireplaces would spill during fire diedown if a room depressurization of roughly 10 Pascals was maintained. This amount of depressurization does not happen often although it can in a reasonably tight house with good exhaust fans.

Five fireplaces were chosen for testing to represent the range of units found on the market (specific makes or model numbers were not identified in the report).

For units A, B and C the outdoor air supplies terminated in the plenum where indoor air circulated to remove heat from the fireplace. Unit A had no connection between the circulation air plenum and the firebox.

Units B and C took combustion air from the circulation air plenum. Unit B had two fans that pressurized this plenum to a certain extent to assist in the flow of combustion air. The fans were controlled by a thermostat on the fireplace. As well, dampers allowed the unit to draw all of the circulation and combustion air either from outdoors, or from the room in which the fireplace was located.

Unit D had combustion air directly ducted to the firebox. Air for the circulation plenum comes exclusively from inside the house. Unit E had combustion air ducted through the firebox wall, behind the refractory liner.

TABLE 1: DESCRIPTION OF FIREPLACES TESTED

Unit	Relative Tightness of Firebox	Outdoor Air Supply	Supply Air Duct Size	Firechamber Lining	Other
A	Loose	Circulation plenum	4" diameter	Refractory	
B	Medium	Circulation plenum	3 ¼" x 10"	Metal	Fan forced circulation & combustion air
C	Tight	Circulation plenum	4" diameter	Refractory	
D	Very Tight	Firebox	4" diameter	Metal	
E	Loose	Firebox	4" diamter	Refractory	Air-cooled chimney

TABLE 2. FLOWS THROUGH FLUES AND COMBUSTION AIR DUCTS

Fireplace	Pressure required to induce spillage (pascals)		Chimney flue air flow rate		Combustion air duct air flow
	high burn	low burn	high burn	low burn	(@ -5 Pa)
A doors open	14	11	98	84	16
A doors closed	25	20	61	33	16
A doors taped	27	20	48	38	16
B outside air fan off	25	16	92	90	42
B outside air fan on	25	16	84	73	75
B room air fan off			75	63	15
C	25	16	65	21	15
D	24		75	10	6
E			147	105	2

To create a 5 pascal negative pressure in the test room required an air flow of 85 cfm.

Pressures to induce spillage

Spillage is more likely to occur when the draft is lowest, as happens at the beginning and end of the burn cycles.

With doors open, at high burn rates, spillage could be induced in Fireplace A at a room pressure of -14 Pa (-11 Pa with a low burn rate). With the doors closed these values changed to 25 and -20 Pa respectively. As with the other units tested, how tight the doors were had little effect on the pressure at which spillage occurred.

Fireplaces C and D had fixed baffles above the fire which forced the flue gases towards the front of the firebox before they entered the chimney. When the fire was lit, there was a tendency for smoke to roll out the front of the fireplace when the doors were open. In fireplaces B, C, and D if the fireplace doors were closed tightly right after lighting the fire, it would go out as there was not enough draft to draw in enough air to sustain the fire.

The draft required for operation with doors closed tightly depends on the equivalent leakage (flow) area (ELA) of the combustion air intake. The smaller the ELA, the greater the draft required to induce adequate combustion air.

The connection of the outdoor combustion air supply directly to the firebox (fireplace D) did little to prevent spillage during start-up. The fireplace still had to rely on room air for combustion until enough draft had been created to allow closing the doors, and intake of combustion air through the direct connection. Fireplace B did have a fan assisted air supply, but the fan did not operate until the fireplace warmed up.

During die-down of the fire, spillage began at a room pressure of -10 Pa, (fireplaces A, B and C) when the temperature in the flue dropped below about 100°C. Backdrafting took place when the room pressure was 3 Pa less than the pressure at the base of the flue.

The range of airflow rates up the chimney was in the order of 20 to 105 cfm. The high flow rate would depressurize the test room by about 5 Pa.

Table 2 summarizes the results. It shows the combustion air flow (at a house depressurization of 5 Pascals) through 4 inch diameter supply ducts is not enough. They provide some protection against excessive depressurization in a tight house, but to supply 40 cfm at a 5 Pa differential pressure combustion air inlets would have to be roughly 2-3 times larger to match the fireplace exhaust rate at low burn.

Small short fires might be more likely to spill during diedown as there is less storage of heat in the fireplace and chimney to maintain a draft during diedown.

The results show that the fireplaces tested were more resistant to spillage than had previously been expected. However, it is difficult to start a fire without spillage when the room is under negative pressure, or if there is airflow down the flue. But if the pressure is reduced (by opening a window) a draft can be quickly established.

Room depressurizations of -10 Pa did result in spillage from the fireplaces towards the end of the fire when coals were burning. This is a dangerous situation, as the combustion gases are high in carbon monoxide concentration, which is odourless and does not contain any smoke particles. An ionization smoke detector will respond to spillage during startup of a fire, but it can't respond to spillage during diedown of a fire.

The 4 inch combustion air duct connected directly to the firechamber can supply the total air requirements for a low burn fire, after a draft pressure of 15 to 20 Pa has been established, and if the firebox can be sealed tightly from the room. The major problem with this type of intake is the potential for reverse flow of hot gases through the air intake when a large negative pressure is applied to the air intake. This could occur in a strong wind if the intake were in a leeward area.

"Fireplace Air Requirements" prepared for CMHC by ORTECH International, Scanada Consultants and Sheltair Scientific.