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Make-up Air Supply

The development of new materials and building practices has led the construction of tighter, draft-free houses. The trend to using more high capacity exhaust fans in the tighter house can create high pressure differences between indoors and outdoors.

Where pressure imbalances are likely to happen, make-up air provision must be made. Technically, make-up air provides an "easy passage" for the entrance of air into a house to replace air exhausted from a house. Restricting the inlet flow will increase the indoor/outdoor pressure difference required to create the replacement flow.

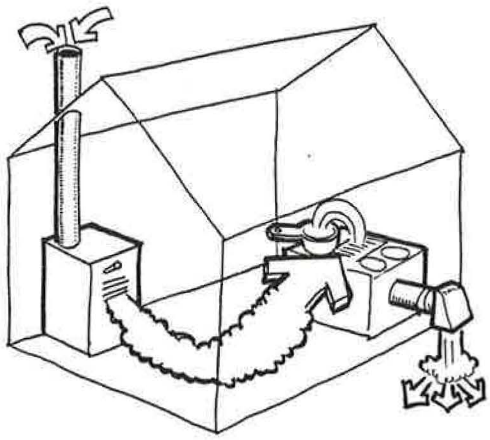
Why be concerned about these pressure differences? Hazards that can be associated with these higher pressure differences include:

1) Negative pressures can overcome the venting forces used to expel exhaust products from fuel-fired equipment. Spillage or backdrafting of combustion appliances (furnaces, hot water tanks, and fireplaces) is much more common than previously thought.

2) If there is no easy entry path for uncontaminated air (from the outside), replacement air may enter through contaminated areas. For example, soil gases (including radon) can be sucked into the house.

3) If ventilation in the house relies only on the exhaust devices, the rate of air change could be reduced as negative pressures restrict fan flow.

Historically, it has been assumed that make-up air would enter through the leaks and cracks naturally occurring in the building envelope. However, with the construction of tighter houses in recent years the quality of leakage paths have been restricted. As a result, there are high indoor/outdoor pressure differences are happening.



Codes for fuel-burning equipment (gas, oil or solid fuel) require the provision of, or at least the consideration of, combustion air supplies. However, these are sized to only supply the air needs of the appliance. These are always treated as stand alone units and do not consider the effect of any other exhausting appliance that may be present in the home.

There is a growing recognition, if not regulated as yet, that it is necessary to limit the suction forces in houses especially when there are likely to be exterior contaminants such as radon.

The CSA standard for residential ventilation systems (CSA F326.1 - Solplan Review No. 26) identifies a concern for balanced conditions. Unfortunately, ventilation in houses is not yet well addressed by current building codes.

The National Building Code of Canada requires that a house must have a mechanical venting system capable of providing 0.5 air changes per hour. It does not require that the system actually be used. Nor is it very clear what sort of pressure limits should be maintained.

A make-up air system must be sized to suit the house. A packaged system must be suitable to cover a significant portion of the housing market. Anything less than 80 or 100 cfm would restrict itself to a small segment of new housing. A make-up air system that could deal with 250 cfm would cover all but the most unusual housing configurations.

The ideal make-up air system would allow, or force, air to enter the structure at a rate that would maintain the house indoor/outdoor pressure differential at a predetermined level generally as close to neutral as practical. The fresh air entering the house should be distributed where most needed, to avoid pockets of pressure imbalances (a closed, reasonably airtight furnace room could develop some rather unhealthy pressure imbalances relative to the remainder of the house). The system should operate as desired under all weather conditions.

Requirements for an effective make-up air system.

Pressure control capacity.

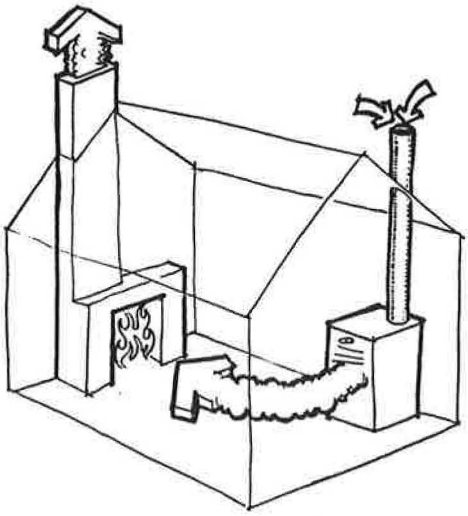
There is much evidence that the venting performance of naturally aspirating combustion appliances is affected by small negative pressures in the house. Negative pressure differences as small as 5 pascals can lead to some exposure to combustion spillage hazards, (especially when starting against a cold flue).

Appliances that use a fan to provide a forced or induced draft should, theoretically, have a higher pressure tolerance. However, it is now becoming clear that even for these a significant level of spillage occurs at negative pressures as low as 10 or 15 pascals.

Open fireplaces are of special concern. They are susceptible to

TABLE 1: TYPICAL AIRFLOW REQUIREMENTS (cfm)

	Operating at -5 Pa		Operating at -10 Pa	
	Small House (8800 ft^3)	Large House (26500 ft^3)	Small House (8800 ft^3)	Large House (26500 ft^3)
EXHAUST DEVICES				
Fans @0.5 ACH/HR	148	222	148	222
Largest common exhaust *(Downdraft cook top)*	265	265	265	265
FURNACES				
Natural Aspirating Gas	64	106	64	106
Induced Draft Gas	25	25	25	25
Condensing Gas	17	17	17	17
Conventional Oil	159	159	159	159
Condensing Oil	21	21	21	21
DOMESTIC HOT WATER HEATER				
Conventional Gas	21	21	21	21
Induced Draft Gas	21	21	21	21
Oil	159	159	159	159
WOOD BURNING APPLIANCES				
Open Fireplace	318	318	318	318
(Fireplace With Doors and No Combustion Air)				
(Fireplace With Doors And Combustion Air)				
Non-Air Tight Wood Stove	106	106	106	106
Air Tight Wood Stove	36	36	36	36
MAKE-UP AIR FLOW THROUGH THE ENVELOPE				
Tight House (1.0 ACH)	- 21	- 74	- 42	-127
Conventional House (2.5 ACH)	- 74	-201	-106	-328
AIR FLOW REQUIRED THROUGH MAKE-UP AIR SUPPLY				
Very Tight Houses				
gas heating, no fireplace	127	148	191	222
gas heating, no fireplace, grill fan	244	191	307	265
gas heating, open fireplace	445	466	508	540
- from the fireplace perspective	212	275	508	540
gas heating, fireplace, grill fan	561	517	625	582
oil heating & DHW, no fireplace	127	148	424	413
oil heating, open fireplace	445	466	582	572
electric heat, open fireplace	127	148	424	413
TIGHT CONVENTIONAL HOUSES				
gas heating, no fireplace	74	21	127	21
gas heating, no fireplace, grill fan	191	64	244	64
gas heating, open fireplace	392	339	445	339
- from the fireplace perspective	159	148	445	339
gas heating, fireplace, grill fan	508	381	561	381
oil heating & DHW, no fireplace	74	21	360	212
oil heating, open fireplace	392	339	519	371
electric heat, open fireplace	74	21	360	212



combustion product spillage at low firing rates and, when operating at high firing rates, can become major exhausting devices creating negative pressures that can influence other appliances in the house. Even fireplaces that are approved for mobile home use (the most stringent standard) are only tested at a pressure of 17.5 pascals and a significant level of spillage is allowed under the certification test. There are few fireplaces of any sort which operate with no spillage when negative pressures are much above 15 pascals.

Minor spillage on an occasional basis many not be a reason to panic, but sustained exposure to combustion products, especially if undetected, is not too healthy.

What is a "tolerable" level of spillage? Two factors must be taken into account:

1) The total amount and type of contaminants contained in the exhaust products and
2) is the spillage likely to happen when it may not be noticed (i.e. when occupants are sleeping?) Spillage from automatically operating appliances is of concern because this can happen when occupants are asleep.

It could be argued that spillage that may happen as a result of voluntary activities requiring the active participation of the homeowners (i.e. when they are awake) may be considered to be less of an issue.

Open fireplaces, must also be treated with a similarly stringent standard because of the relatively hazardous nature of their combustion products and the relative ease with which they can spill in an unattended dying fire situation. 0 to 5 pascal pressure standards should be applied to these devices.

Make up Air Capacity

The make-up air system must be sized to balance any exhaust flows from the house and must account for whatever can be supplied through the house envelope at the "tolerable" pressure. The stack effect will create a certain level of negative pressure during the winter but the mechanisms which create stack effect also improve chimney performance.

It is interesting to note how little flow actually penetrates the house envelope at very low pressures. Table 1 shows the calculated estimates of inward flow of air leakage through the building envelope.

Tight houses are not unusual in Canada. Houses with airtightness test results of less than 2.5 air changes per hour are not unusual. Depending on the volume of the house, a 5 pascal pressure difference would only create a 60 to 200 cfm air flow. In a very tight house, such as an R-2000 house, this could be reduced to 20 to 80 cfm. This is much less than the exhaust capacity in most houses.

Tempering Incoming Air

By its very nature, make-up air is cold outdoor air being brought into the house. Minimum distribution temperatures to occupied rooms should be at least 17°C if delivered through floor gills and 13°C if delivered through wall or ceiling grills. If comfort issues are not dealt with, the occupants will shut off all openings to restrict airflows causing drafts, and thus defeat the objective of the make-up air.

All Weather Performance

Aside from comfort issues, weather protection can be evaluated on two bases:

1) how does weather affect the normal operation of the device;
2) how likely is the device to fail due to weather effects?

Make-up Air Components

The key components of a make-up air system are:

- *an air passage through the building envelope*
- *a driving force for air movement*
- *a flow controller*
- *a control activator*
- *a temperature control element*

Sizing inlets for the required flow obviously depends on the driving force that is available to bring air into the house. This is especially relevant for passive duct systems, as the only driving force is the pressure difference (that we are trying to minimize).

Table 2 shows calculated flow rates for passive make-up air ducts assuming an equivalent length of 66 ft. (duct hood, a limited amount of ducting and one or two 90° elbows). Even an 8" duct can only provide 100 to 120 cfm at a 5 pascal pressure difference. This flow is at the very low end of the range that we would consider appropriate for broadly applicable make-up air systems.

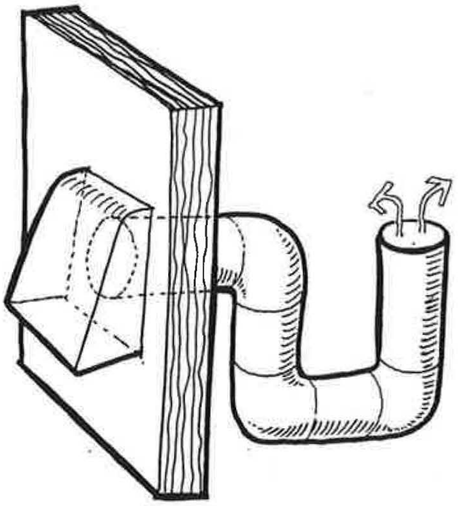


TABLE 2: PASSIVE AIRFLOW THROUGH DUCT (66 ft. equivalent length) (CFM)

Duct Size (inches)	*Pressure Difference (pascals)*					
	5	*10*	*15*	*20*	*25*	*50*
3	<10	10	15	19	21	29
4	16	23	29	38	42	63
5	31	46	59	67	80	106
6	53	74	95	114	127	180
7	85	106	148	169	191	275
8	116	159	212	254	286	381
9	169	233	296	318	381	529
10	212	296	381	445	487	699

These are calculated flow rates for passive make-up air ducts assuming an equivalent length of 66 feet (a duct hood, a limited amount of duct and one or two 90° elbows).

It is obvious that a tight house with a large exhaust appliance such as a downdraft cook top is going to require a very large opening. If a mechanical force is not applied to drive the make-up air, then a very large opening will be needed. Any guess what's going to happen when the first cold spell comes along?

Many of the devices that are being marketed as make-up air inlets are clearly undersized and most of them don't show any advantage over a standard exterior duct hood in any case.

Obviously, some kind of driving force must be provided for make-up air entry. This could be done by a separate fan designed to ensure adequate flow at whatever pressure regime you need.

An independent supply fan gives you higher driving forces and smaller envelope penetrations but one is still confronted with the same control problems. How do you detect when you need make-up air and when you don't? A number of manufacturers have flow control devices including barometric damper, dampers which are controlled by furnace temperature, and electric dampers which require some kind of outside signal to tell them when to activate.

Some of the barometric dampers have been tested. The results indicated they don't work at the very low pressure levels that we are concerned with. The lowest pressure that activates dampers is about 20 pascals.

Electric dampers need signals to tell them when make-up air is required. Most commonly, they are interlocked with furnace operation so that the damper opens anytime the furnace is required. That is fine if all you are worried about is the furnace. But when you consider the domestic hot water heater, fireplaces or any other fan in the house, a fully integrated system would require a series of parallel controls and associated wiring running throughout the house. This could get expensive! There seems to be a real need for a single controller which can sense the need for make-up air and react accordingly.

This article is excerpted from a paper presented at the EEBA 'Excellence in Housing '89 conference' Winnipeg, Man. written by Mark Lawton, a principal of Buchan, Lawton, Parent Ltd.

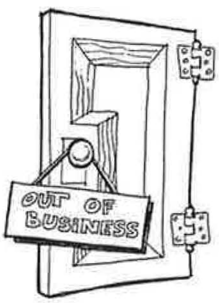
What are the properties of a good make-up air system?

** peak flow capacity should be 200 - 250 cfm.*
** a fan to drive the air.*
** the flow rate must be controlled (continuous operation at peak capacity would not be tolerable).*

Control strategies would include:

** interconnect with operation of combustion appliances*
** interconnect with large exhaust appliances*
** direct indoor/outdoor pressure control*
** make-up air pre-heating must be considered for most areas*
** heating control will be required.*

EBA Closes



The Board of Directors of the Energy Business Association in Seattle, has curtailed operations. EBA was a non-profit trade association focusing on energy conscious design and construction products and services.

The highest profile activity of the group were the *Housing for the 90's* conferences. Although qualitatively successful, the 1988 conference was a financial disaster. The resulting debt, with no prospects for offseting income meant the group had to close its doors.

The Board members also perceive that the public market has little current interest in energy conservation and the electric utilities in the US Pacific Northwest are unable to make the necessary decisions to effectively market their product vis-a-vis conservation.

(This organization should not be confused with EEBA or Energy Efficent Building Association which is still very much in business).