IT'S NOT THE VOLUME; IT'S THE PRESSURE!

(Why passive make-up air openings do not ensure proper operation of fuel-fired appliances)

For more than 20 years, Canada Mortgage and Housing Corporation has been conducting research on combustion and combustion venting issues. This note is a brief summary of the findings of that research as they pertain to the issue of make-up air.

1. Air for combustion: In all Canadian houses tested by CMHC and other agencies, there is adequate air in the house to provide for combustion air for any residential space heating or domestic water-heating appliance. In some houses, compartmentalization of the house has created spaces with too limited an air supply, but this is answered by ensuring interconnection with the air of the rest of the house (e.g. through transfer grills). Indeed, it is extremely difficult to build a furnace or utility room that would not be adequately connected to the rest of the house by leakage.

   In other words, we have never encountered a house where the lack of air caused or even threatened to cause incomplete combustion. The burner always gets the air it needs.

   As long as the house has some means of exchanging air with the outdoors, such as an exhaust fan or a chimney, air will continue to be drawn into the house to replace the air used in combustion. There is no way that the oxygen of the house will be "used up". This is not true if the appliance is unvented. A charcoal burner or a kitchen stove consuming large quantities of oxygen inside a small, sealed dwelling with no active chimney or exhaust device may reduce the indoor oxygen to unsafe levels.

2. Air for Dilution: Naturally aspirated appliances require air for dilution but the only mechanism to drive that air into the dilution port (e.g. vent hood or barometric damper) is the chimney "draft." This mysterious term refers to the pressure difference between the venting system and the space where the appliance is installed. If that space is at a lower pressure than the venting system, the dilution air, even if available if copious quantities will not enter the dilution port. Thus the issue is not one of lack of air but lack of pressure with the right polarity.

3. Depressurization issues: This brings us to the nub of the issue. Excessive house depressurization will cause the combustion appliance venting system to malfunction, through "puffing," spillage, or backdrafting. Venting of an appliance is dependent upon the pressures found in the venting systems, the house, and the ambient air surrounding the house. The level of house depressurization that naturally aspirated venting systems can tolerate is of the order of 5 Pa for most appliances with a chimney, and somewhat higher if there is a fan assisting venting into a sealed flue or flue pipe. Average new Canadian houses can easily be depressurized to this level by commonly available range hoods or downdraft cooktops.

4. Will a passive make-up air opening solve the depressurization problem? No. Certainly outdoor air will flow into the house through a make-up air opening. But what drives that air flow? Air pressure. And the smaller the opening, the more pressure it takes to drive a given amount of air through it. It would take a very large opening to bring the level of depressurization down below 5 Pa.. This has been tested many times. In a typical house with big exhaust fans, the venting system might have to work against, say, 8 Pa of house depressurization with no make-up air inlet or with the make-up air inlet sealed shut; it will experience a depressurization of 6-7 Pa with an

open, standard-complying make-up air inlet. In other words, these openings through the envelope will only make a small difference in house pressures if they are open or closed. For most houses, even R2000 houses, the area of an intake air duct is very small compared to the total house envelope leakage area.

A passive-make-up air inlet may actually exacerbate the problem since, under certain wind conditions, such air inlets run backwards, exhausting air outside and further depressurizing the space around the appliance. This has been observed frequently in field surveys. Where the inlet duct lead directly to the fire chamber, the hot gases going out the inlet can cause dangerous temperatures on nearby combustible surfaces.

5. Why passive combustion air devices have gone on so long: Basically, passive air openings are the cheapest apparent fix to a problem and they are presumed to absolve the utility or installer of liability for a spillage problem. This has been explained in times past as "I put in an opening for the air my appliance needs. If the house is using that hole as a supply for another appliance, this is not my fault." Essentially this excuse ignores two basic aspects of building science: the house acts as system and air is stupid. The air cannot tell that it was designated for use by the furnace only and will respond just as readily to pressures caused by other appliances such as the clothes dryer. All flows and pressures in the house are connected. The combustion appliance installer or vendor cannot escape liability if he or she makes no attempt to be aware of the pressure regime likely to be found in a house and installs an appliance inappropriate for that regime.

6. Does a direct outdoor air connection decouple the appliance from the house pressure? Yes, if the appliance itself and its venting system are well sealed. However, it does not work as a field-applied fix to appliances and venting systems not designed for this approach. This was tried in CMHC fireplace/woodstove research in the early 1990's. The appliances were hooked up to a fresh air duct directly to the combustion chamber of the appliance. Still, at fire diedown, there was spillage as smoky fireplace air exited the appliance around the doors.

Summary

The combustion appliance manufacturing and installation communities and the standards they use have put all their eggs in the make-up air basket and assumed that someone else will worry about the pressure issue. Similarly the manufacturers of ventilation equipment assume that houses and the heating appliances in them will somehow be able to accommodate massive exhaust flows. In fact, no one discipline has overall responsibility for the pressure regime in a house, with the possible exception of the homebuilder, in the context of new housing.

Imagine the following scenario:

- A builder who prides himself on his building envelope construction practices builds a new, well-sealed, energy-efficient, custom house and asks his heating contractor to supply a gas furnace and water heater.
- The customer has ordered a number of custom "pizzazz" touches, such as a 150 L/s downdraft cooktop stove, and so wants to save money on the heating system.
- The heating contractor therefore supplies a normal draft-hood-equipped furnace and a similar water heater.
- The heating installer makes no attempt to learn about what exhaust equipment might be installed in the house. He just goes ahead and installs the furnace and water heater and puts a hole in the wall according to CSA B149. However, the furnace has been jostled in bringing it down the

basement stairs. The installer has inspected it but found no damage. Nevertheless, one of the burners has been damaged to the point that it produces carbon monoxide instead of carbon dioxide.

- The electrical contractor makes no attempt to learn what type of heating equipment is in the house and just goes ahead and installs the downdraft cooktop according to the manufacturer's instructions, which make no mention of make-up air or depressurization.
- The next winter, the homeowner happens to use the downdraft cooktop at the same time the furnace is operating
- Outdoor air flows in the make-up air opening but this just results in the depressurization in the house being 10 Pa instead of 12 Pa.
- One of two things happen –
  - The carbon monoxide detectors go off, triggering an investigation that leads to the discovery that the heating system is incompatible with the cooktop. Much finger pointing follows.
  - Someone is made ill or dies from carbon monoxide poisoning. Lawyers do the finger pointing.

Who is responsible?

- the builder?
- the heating contractor?
- the heating installer?
- the B149 committee?
- the cooktop manufacturer?
- the electrical contractor?

Imagine the following changes in the scenario:

- The heating installer, following a revised B149, investigates the ventilation equipment to be installed in the house and concludes that the combination of the tight building envelope and large downdraft cooktop is likely to result in high levels of depressurization in the house. He advises the homebuilder that, subject to a CGSB 51.71 spillage test, the naturally aspirated furnace and water heater probably cannot be installed in this house unless measures are taken to avoid this depressurization.
- The homebuilder seeks the advice of his HRAI-trained heating contractor and, following that advice, he convinces the customer to accept a smaller capacity downdraft fan in the cooktop and instructs the electrical contractor to interlock the control of the cooktop fan with a make-up air fan of equal capacity blowing outdoor air into an unfinished portion of the basement.
- No problems ensue.

Which is the preferable scenario?

This is why the standards for combustion appliances and their installation need to be revised to address depressurization rather than make-up air. If these can be made compatible with other standards such as CSA F326, "Residential Mechanical Ventilation Requirements" and CGSB 51.71, "The Spillage Test," it will enhance the chances of cooperation among the many facets of the construction industry that have influence on indoor air quality and combustion venting.

References

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