

IT'S TIME TO SOUND THE ALARM REGARDING HIGH CAPACITY EXHAUST DEVICES

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ABSTRACT

There are more high capacity exhaust appliances coming on the market. These appliances, unless installed with provision for fan-supplied make-up air, can severely depressurize modern houses. This can lead to problems with venting of combustion products, soil gas infiltration and infiltration of carbon monoxide attached garages. Where these appliances are installed in a new building, the industry may find it difficult to comply with code requirements for fan-supplied make-up air if the appliances have not been designed with provision for inter-connection. Of more serious concern is the situation where the owner of an existing house simply purchases and installs one of these appliances and is unaware of the potential problems such appliances can create. The appliance industry does not seem very aware of the problems these devices can create in even a moderately tight house. This paper reviews the technical issues involved and discusses possible means of addressing them.

INDEX TERMS

Depressurization, Combustion Spillage, Soil Gas Infiltration, Carbon Monoxide Infiltration

INTRODUCTION

There are more and more high capacity exhaust appliances – 150+ L/s down-draft cooktops, 200+ L/s range hoods, 200+ L/s clothes dryers, etc. – coming on the market. These appliances, unless installed with provision for fan-supplied make-up air, can severely depressurize modern Canadian houses. This, in turn, can lead to very high potential for problems with –

- venting of the products of combustion from fuel-fired heating appliances
- infiltration of soil gas into basements
- infiltration of carbon monoxide and other pollutants from attached garages

Where these appliances are installed in a new building, the local building officials can apply the requirements of the building code, which may mandate the provision of fan-supplied make-up air. However, as indicated above, the industry may find it difficult to comply with the code's requirements if the appliances have not been designed with provision for inter-connection with supply fans.

Of more serious concern is the situation where the owner of an existing house simply purchases and installs one of these appliances. It would be rare that the local building department would be aware of such cases and even rarer that the homeowner would be aware of the potential problems such appliances can create.

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The indications are that the appliance industry is also not very aware of the problems these devices can create in even a moderately tight house. Otherwise, why would they ignore the issue in their installation instructions and why would they sell products that cannot easily be interconnected with supply fans.

Nor is the issue dealt with in product standards – current appliance standards tend to only deal with energy efficiency or electrical safety.

THE EFFECT OF EXHAUST DEVICES ON TIGHT HOUSES

When an exhaust device extracts air from a house (Figure 1) and there are no supply fans operating simultaneously, that air will automatically be replaced by inward leakage of outside air through the house's building envelope. The rate of inward leakage will automatically equal the rate of outward extraction. It cannot be otherwise; otherwise the house would eventually implode. The instant the exhaust device is turned on, the house pressure is lowered and the inside/outside pressure difference drives outside air in through any leaks it can find.

Even if the house is tightened up (Figure 2), this situation will still be true; i.e. the inward leakage will equal the outward fan flow. However, because there are now fewer and/or smaller leakage sites available, it will take a larger inside/outside pressure difference to drive the same amount of air through the remaining leakage sites.

It is possible that the exhaust device will no longer be able to achieve its rated flow when operating against a very high inside/outside pressure difference. However, in this case, the inward flows will also reduce and the two will still be in equilibrium, but now at a higher inside/outside pressure difference than in the leakier house.

An exhaust device not operated in conjunction with a supply fan will always depressurize a house to some extent – even a leaky house. But a given exhaust device will depressurize a tight house more than a leaky house. And, of course, an exhaust device with a higher capacity will depressurize a given house more than a device with a smaller capacity.

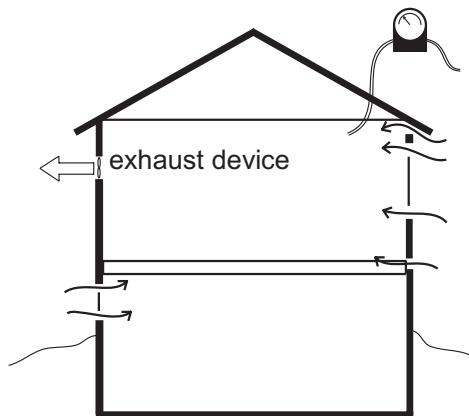


Figure 1

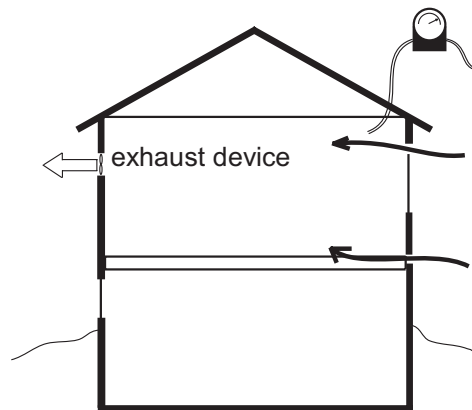


Figure 2

In recent research conducted for Canada Mortgage and Housing Corporation (Phillips, 2000), 36 out of 49 randomly selected new houses in various parts of Canada were found to be tight enough that simultaneous operation of their ventilation fans, clothes dryers and rangehoods (totaling less than 200 L/s of exhaust capacity in all but one case) would result in depressurization of more than 5 Pa, the level that is generally regarded as the threshold at

which problems of the type described in the next section are more likely to occur. 13 of these houses would be depressurized to 10 Pa or more and 2 of these would be depressurized to more than 100 Pa if their exhaust devices were actually capable of achieving full flow at such high pressures! Eighteen of these houses would be depressurized to more than 5 Pa by operation of the clothes dryer alone.

Similar research by the University of Minnesota (Huelman and Seavey, 1995) indicated that Minnesota houses, while perhaps not as tight as some of the Canadian extremes, are nevertheless tight enough that significant levels of depressurization can be achieved with only modestly sized exhaust appliances.

If, on the other hand, an exhaust device is coupled to a supply fan of equal capacity so that every time the exhaust device operates the supply fan operates to bring in outdoor air at the same rate as the exhaust device extracts it, the house pressure will be unaffected. This is referred to as a “balanced system.” (Figure 3)

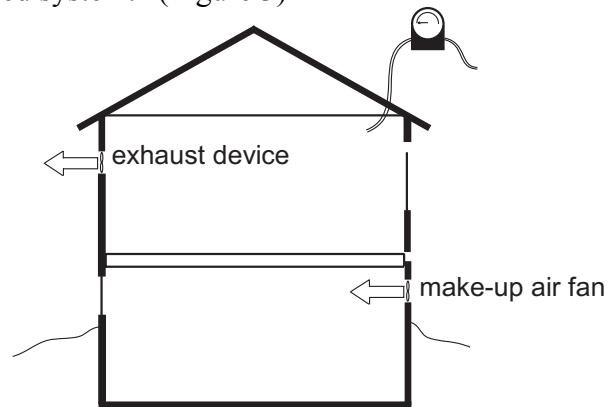


Figure 3

THE EFFECT OF DEPRESSURIZATION IN HOUSES

In many houses, depressurization does not create any problems. However the potential for depressurization to cause problems exists in the following common situations:

- when the house contains any form of combustion equipment
- when the house is located in an area where soil gas drawn into the basement by depressurization may contain radon or other potentially harmful pollutants or high levels of water vapour
- when the house has an attached garage

Spillage of Products of Combustion

In most jurisdictions, all combustion appliances used within houses, such as furnaces, water heaters and clothes dryers, must have their products of combustion vented to the outdoors. However, some of the venting systems used will fail under very modest depressurization of the house; i.e. some portion or all of the products of combustion from the appliance will fail to go out the vent and will spill into the house. In the case where all of the products of combustion spill into the house, it is sometimes referred to as “backdrafting,” which is just a special case of the general phenomenon of “spillage.” (Figure 4)

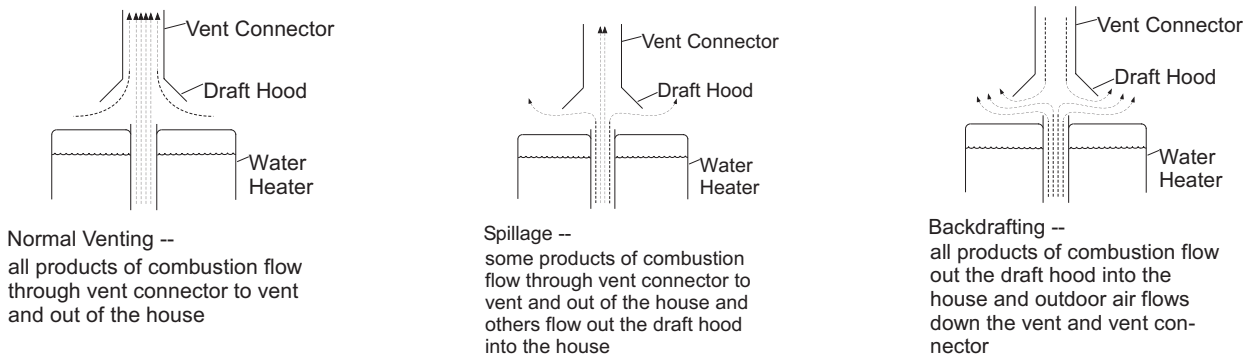


Figure 4

The combustion appliances most prone to depressurization-induced combustion products spillage are open fireplaces. Next are “naturally aspirating” gas and oil furnaces and water heaters; i.e. those with draft hoods (gas) or barometric dampers (oil). More modern appliances, such as “induced draft,” “direct vented,” “high efficiency,” etc. are generally perceived to be more resistant to depressurization-induced combustion products spillage, but the appliance standards include no method of rating appliances for the highest level of depressurization they can tolerate.

Infiltration of Soil Gas

The interstices of the soil surrounding basements can hold a wide variety of vapours and particles that can be harmful if they enter the house, either to the house itself or to the occupants – radon gas, volatile organic compounds, bacteria, moulds, water vapour, etc. In the winter, even in the best of circumstances, basements tend to be at a lower pressure than the surrounding soil due to stack effect. Thus, even in the absence of depressurization caused by the operation of exhaust devices, there is a need for basements to have some minimum level of resistance to soil gas infiltration. Many building codes specify simple, basic provisions to address this, such as the incorporation of polyethylene film beneath basement slabs. However, if the pressure difference between the soil and the basement is increased significantly by the operation of high capacity exhaust devices, these simple provisions may not prove sufficient. And the potential for hazardous levels of infiltration is even greater when high capacity exhaust devices are retrofitted in existing houses that do not incorporate even the simplest measures to make them more resistant to soil gas infiltration.

Infiltration of Carbon Monoxide

Most building codes incorporate provisions intended to make the separation between an attached garage and a house resistant to the passage of air since air infiltrating into the house from the garage may bring with it carbon monoxide (CO) and other pollutants. Anecdotal evidence suggests that these measures are not very effective even in normal circumstances and are likely to be no match for high pressure differences created by depressurization of the house by high capacity exhaust devices. One might be tempted to suggest that having codes require CO detectors in houses with attached garages would take care of this problem. However the reliability of CO detectors is subject to some doubt, as is their longevity. Then there is also the question of cases of high capacity exhaust devices being retrofitted in existing houses where code requirements are unlikely to have been applied.

THE PROBLEMS

Thus we see that there are two problems:

1. High capacity exhaust devices are readily available and can be retrofitted in houses where they can create hazards that are health- and even life-threatening (in the case of CO). In most cases, there is no mechanism in place to warn the occupants of the hazards being created and the measures that can be taken to avoid the hazards.
2. Even where there are such mechanisms in place (e.g. in the case of new houses where the building code compliance/enforcement process creates awareness of the hazards and the avoidance measures), implementing the avoidance measures can be problematic if the exhaust devices are not designed to facilitate them.

It seems that both of these problems stem from the fact that neither the industry that manufactures these high capacity exhaust devices nor the retail network that distributes them is aware of the hazards they can create. One sees increasingly large draft hoods advertised in home improvement store flyers with not a word about depressurization or the need for make-up air.

One might ask why these problems have not become more apparent as, for example, death statistics. There are a number of possible explanations. For one thing, the spillage from most gas appliances is usually a fairly benign mixture of carbon dioxide and water vapour. It is only when the appliance is somehow out of tune that significant carbon monoxide appears. Thus an unfortunate coincidence (out of tune appliance plus depressurization occurring when it is operating) is needed to cause a serious problem. Another factor is that, unless the house is fairly tight, although a large exhaust appliance may depressurize it and cause spillage, it also brings in so much outdoor air that the spillage products are diluted to safe levels. However, as houses get tighter and exhaust appliances get bigger, we cannot continue to rely on this lucky combination.

WHO IS AFFECTED BY THESE PROBLEMS

Although they are generally not aware of it, the occupants of the houses where these high capacity exhaust devices are installed are obviously affected because they are exposed to hazards.

Builders of new homes are affected because, when they are unable to directly interconnect the exhaust devices with make-up air fans, they must find “work-around” solutions such as the use of current detecting devices.

Building officials are affected in those rare cases when they become involved in a retrofit situation and try to explain the hazards and building code requirements to homeowners and are regarded as having come from some other planet.

Another group of people who seem to be unaware that they are affected by these problems are the manufacturers and distributors of the exhaust devices. Every time one of these devices is installed without proper provision for make-up air, a potential liability to the manufacturer and/or distributor is created. Hopefully it will take something less than a law suit by the family of someone killed by carbon monoxide drawn into a house by a down-draft cook top to make the manufacturers and distributors aware of this liability.

POSSIBLE SOLUTIONS

Regulation

Building codes already address this issue, but, as noted, have almost no effect in the retrofit area. Also, codes cannot make it mandatory that exhaust devices include interconnection features to address the new construction problem unless such a requirement were incorporated in referenced product standards.

As also noted, appliance standards for this type of product do not address this issue, being limited to electrical safety and energy efficiency. However, standards could possibly address the interconnection issue by requiring the incorporation of interconnection features. Conceivably too, standards could include criteria for installation instructions and certification of the products to the standards could include certification of the installation instructions. The criteria for the installation instructions could address measures to limit the risk of depressurization.

One “last resort” measure that could be considered if other avenues fail would be to cover these devices under hazardous products regulations, which would presumably insist that depressurization avoidance be covered in installation instructions as a condition for being permitted to sell the product.

Public Information Campaigns

There are any number of conduits that could be used to inform the public of this issue – press releases to the popular press, consumer protection TV shows, do-it-yourself TV shows, Web sites, etc. The difficulty with this approach is that such campaigns have a finite life and, even if very successful during this life, don’t reach people contemplating the purchase of the devices after the campaign is forgotten.

Manufacturers’ Instructions

If the instructions that come with every high capacity exhaust device were to contain warnings about the hazards created by depressurization and the measures that can be taken to avoid those hazards, the information would be in the right place at the right time. As indicated earlier, it is in the best interests of the manufacturers that their instructions include this information.

CONCLUSION

The combination of increasingly large exhaust devices installed without make-up air provisions and increasingly airtight houses is bound to lead to health- and life-threatening problems. Among the parties that will be affected by these problems, the appliance industry is in the best position to forestall these problems by including in its installation instructions for exhaust devices directions on the balancing of exhaust with fan-supplied make-up air. It would be in its own best self-interests to do so. If the appliance industry does not take the initiative in this area, it will be incumbent on regulatory agencies to force it to take action.

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