Photo 3: Sheathing and top of rafters mouldy.

Photo 2: 7Pa of pressure in the dog house driving the moist air into the attic

How to Get your Ducts in a Row: Air Leakage, Moisture, and Attics

By Greg Labbé

Over the past 12 years I've been called to many homes, both new and old, where clients experience one (or sometimes a combination of all) of the following problems: serious ice damming on the roof, comfort problems in parts of the home, or mould growth in the attic. More often than not, the places with the most significant problems have ductwork running through the attic.

Both the Energy Star for New Homes and R2000 programs prohibit ductwork running outside of the thermal envelope and it's well established that the attic is a less-than-ideal place to run ductwork, yet it still happens with some frequency on retrofits. In fact, it's somewhat common to find retrofit air-conditioning systems and the associated ductwork in the attics of older homes. I want to make the case for banishing ductwork from Ontario attics - or at least severely curtailing their installation.

First, a bit of perspective. The reality is that ductwork in attics isn't that common, at least not in the GTA. Fewer than 25 per cent of homes have significant amounts of ductwork in their attics, but that 25% keeps us busy in the retrofit department.

So, what's the problem? The attic is a place where pot-light cans are rarely or poorly sealed, where drop-ceiling air barriers often have breaches, where coffered ceilings around skylights often leak air, and where chimneys are rarely sealed well to the surrounding wood framing. In short - most of the air leakage in a home occurs in the attic.

Attics are typically vented to the outdoors, to help carry moisture out of the attic. This also serves to allegedly extend the shingle life by apparently lowering the air temperature inside the attic. The theory goes that eaves or soffit vents bring outdoor air into the unconditioned attic, and mushroom vents on the roof peak let air escape back outside. Yet the research on attics shows that cold winter air cannot carry much moisture and, therefore, the air has a very low drying potential. Research also shows that the temperatures of well- ventilated attics are very similar to those of sealed, unvented attics. The bottom line is, even well-ventilated attics cannot cope with large amounts of moisture.

Let's look at moisture. High attic humidity as a result of excessive air leakage from the living space is generally not a problem in the summertime; however, in winter it's another story. An attic's coldest points are - in order - the shingle nail tips, the sheathing, and the underside of the rafters. When the warm, moist air from the conditioned living area hits these cold surfaces the water vapour condenses into a liquid and then forms a frost and stays there until the seasonal warmth comes back. So if you only see condensation/frost on nail tips it's a minor problem. But, if you see condensation/frost on the sheathing, it's a big problem. And if you see it on the rafters it's a really big problem. I often see frost on the rafters in home with ducts in the attic.

Putting ductwork in attics, cold crawl spaces, or in floor cavities above cold garages is problematic for four reasons: these ducts move moist air, this air is pressurised, these ducts have many joints that allow air leakage, and these ducts are rarely well-insulated. Ducts forcefully carry moist air through leaky lengths of poorly insulated ductwork, and the pressure drives moist air into the attic. So, attics that are already at risk of being overburdened with air-leakage moisture from living space (from conditioned air driven by stack effect) will reach their tipping point when compounded with air leakage from attic duct work.

Admittedly, the first priority is to air seal ductwork, then insulate it and Ontario Building Code (OBC) does require that '[duct] pass-

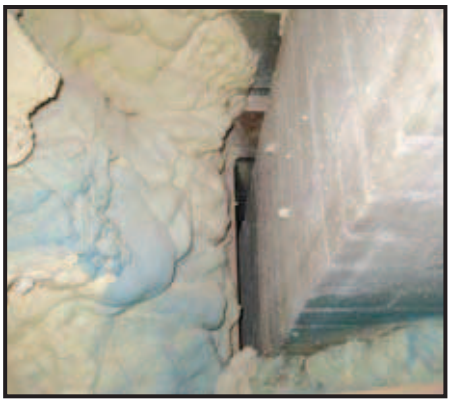

Photo 1: No seal around masonry chimney

Photo 4: No foam on duct and large area of delaminating ½ lbs foam

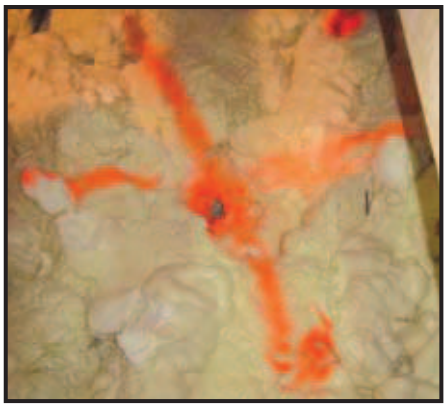

Photo 5: one of a few dozen blisters in the foam on the attic floor.

ing through unconditioned spaces shall have all joints taped or otherwise sealed' but let's be frank, who's going to check and how do you effectively seal the under belly joints on ducts that rest on the attic floor? As for attic duct insulation, the OBC's minimum is R12. Remember the speed of heat loss is a function of the difference of temperature between inside/outside (or Delta T) and because ducts often contain air that , a good argument should be made to increase those levels of insulation to at least current attic insulation levels or higher.

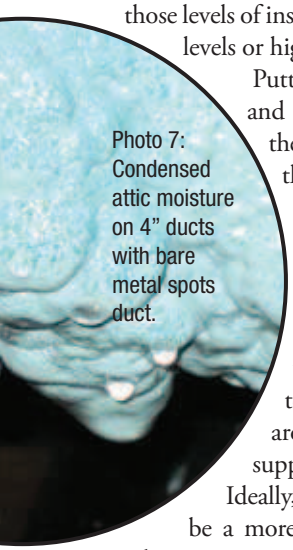

Photo 7: Condensed attic moisture on 4" ducts with bare metal spots duct.

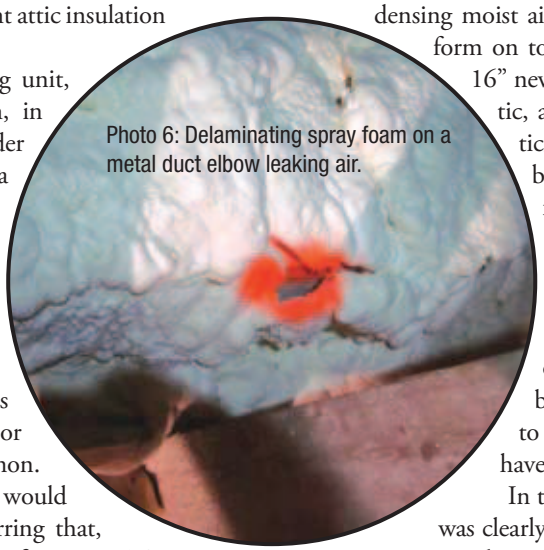

Photo 6: Delaminating spray foam on a metal duct elbow leaking air.

Putting an air conditioning unit, and its distribution system, in the hottest place i.e. under the roof is clearly not a "best practice." In summertime, the system has to run overtime to compensate for the heat it's absorbed in the attic, and in winter condensation issues around the return grill or supply outlets are common. Ideally, multi-head mini-splits would be a more effective solution. Barring that, the way to mitigate the negative effects of attic HVAC systems is to air seal ducts, mound R40 of insulation on the ductwork. It should be noted that the AC's "fan only" option to circulate air should not be used during the winter months, and the homeowner should seasonally decommission the system in the fall by air sealing all register and return openings to prevent moist air from the living space getting up into the system and causing condensation to drip back down.

I know many who think spray foam insulation will solve these problems, as it both insulates and air seals, but I was recently called to a home where the attic floor was foamed expecting the product would seal and insulate the myriad ductwork for the air conditioner/steam humidifiers, ERV, in-line exhaust fans, and skylight tubes all running in an unconditioned attic, but much the client's chagrin, there was evidence of severe air/moisture leakage and the rafters were wet to the touch (see photo 3).

The cause of this excessive moisture was both the driving mechanical pressure (see photo 2)and the poor installation of spray foam. My suspicion is that the attic floor must have been filthy, and the sprayers covered over a very rough substrate, which resulted in many blisters (see photo 5) in the foam where conditioned air leaked into the attic. Additionally, the spray foam wasn't applied to the masonry chimney for fear of breaching code (see photo 1). This resulted in massive air leakage up the chase, along the masonry chimney.

Other problems in the attic resulted from the fact that it's particularly difficult to air seal a round duct, especially a four-inch duct, without using (read: wasting) a lot of foam. In this home there were many bare spots on the small round ducts, where the metal was condensing moist air in the attic and causing small pools to form on top of the duct (see photo7). Large 16" x 16" new metal ducts were also installed in the attic, and the seams were not sealed with mastic/silicone, but they were then foamed. But, because the new ductwork is oil filmed, foam easily delaminated from the duct fissures in the foam were evident and air leaks were detected (see photo 6). Had the ducts been cleaned of the oil film perhaps the delaminating would not have occurred, or had the metal seams in the duct been sealed with mastic or silicone, prior to spray foaming, the ducts would likely not have leaked as severely.

In this home, and in others I have seen, there was clearly an issue with the foam sprayers not having enough access to do a thorough installation. Typically they need least four feet of clearance around the object to be foamed. The result was that large areas of dust near eaves were missed and weren't insulated (see photo 4). So, while, in theory, foaming ducts may seem like a sound solution, in practice they almost never live up to their purported performance.

I would urge all contractors to do their utmost to design new or retrofit HVAC systems so that all ductwork remains within the heated envelope of the home (i.e. on the warm side of the vapour barrier). If it simply cannot be avoided, consider a "hot roof" insulation solution, so all the mechanicals are brought into the heated volume of the home, leaving you an attic that's conditioned and cleaner for service personnel.

For rooms above the garage the ducts need to be on the warm side of the vapour barrier. As a last resort, if the client insists on running the ductwork in the attic and his/her budget will not allow you to insulate the roof line, you can limit your liability by pressure testing the house, to make sure the attic floor is very well sealed, and then pressure test your duct sealing in the attic with a duct blaster fan. Ideally the perfectly air-sealed ductwork should run low to the floor, so it can be mounded withR60 of less expensive loose-fill insulation.