Tighter Specs for Energy Efficiency

By Tony Woods and Steven Tratt, Canam Building Envelope Specialists Inc.

A whistling in the front foyer, thermal comfort complaints, a boiler system running for longer and longer periods of time. The evidence is clear, but the guilty party fails to reveal itself.

Fortunately, good building science detectives have seen this before. They call it a classic failed relationship. The building envelope is leaking and the mechanical systems are paying the price.

Building professionals are well aware of the broad benefits of a tighter building envelope. But the relationship between the envelope and a building's HVAC system is often a little hazier. A 2005 study by the National Institute of Science and Technology (NIST), Investigation of the Impact of Commercial Building Envelope Airtightness on HVAC Energy Use, indicates the benefits of specifying a high-quality building envelope are worth investigating. The authors of the study note that the general understanding of the effects of air infiltration in high-rise buildings is not widespread and that it can have a greater impact than commonly thought:

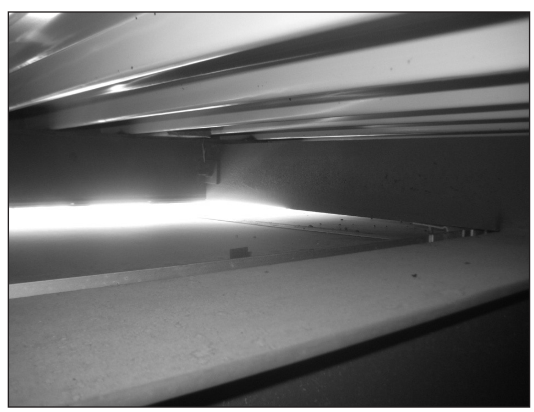
Infiltration in commercial buildings can have many negative consequences including reduced thermal comfort, interference with the proper operation of mechanical ventilation systems, degraded indoor air quality, moisture damage of building envelope components and increased energy consumption.

What does "interference with the proper operation of mechanical ventilation systems" mean to building durability, energy efficiency and occupant comfort, health and safety? It means that a leaky building envelope without a continuous air barrier system may affect the heart of a building's operation: its HVAC system. The study looked at that phenomenon and evaluated the potential energy savings of an effective air barrier requirement for non-residential buildings in five different climate zones in the United States, including Miami, Phoenix, St. Louis, Bismarck, and Minneapolis. The methodology included blended national average heating and cooling energy prices and cost effectiveness calculations matching the scalar ratio employed by ASHRAE SSPC 90.1. The air barrier systems selected for the study included components that met material air tightness levels of 0.02L/m2 at 75Pa (0.004 cfm/ft2 at 0.3 in H2O) and were judged to be consistent with the whole building target used in the energy modeling.

In relation to the building envelope and HVAC system, the study concluded that a building's energy consumption and operating costs were impacted by the relationship. The inclusion of an air barrier system in the four sampled types and sizes of buildings reduced air leakage by up to 83 percent. The reduction indicated potential gas savings of greater than 40 percent and electrical savings of greater than 25 percent.

The Path of Least Resistance

Air leaks directly through roofs and exterior walls, but most often it travels through the joints of assemblies



such as roof/wall junctions, parapets, low level soffits, the intersections of different cladding systems, and through numerous internal vertical and horizontal pathways.

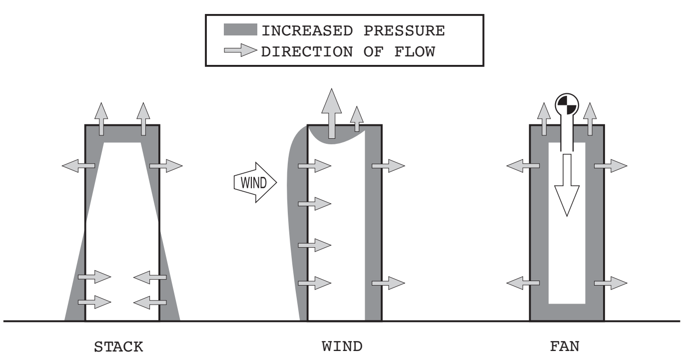
Two conditions are needed for air to leak. First there must be a hole, gap, crack or leak from one side of the envelope to the other. Second, there must be an air pressure difference.

There are three principal causes of air pressure difference: wind, stack effect and the HVAC system.

Wind pressurizes the windward side of the building and depressurizes the back, sides and roof. It can account for up to 25 percent of total leakage . . . and it cannot be controlled, only reduced by plugging the holes in the envelope.

Stack or chimney effect is a buoyancy phenomenon where warm inside air rises through the building and exerts continuous pressure against the roof and upper parts of the exterior walls. The resulting lower pressure at the bottom of the building sucks in air.

The third pressure comes from the mechanical system itself. Mechanical engineers, and on-site managers, often choose to bring in makeup air to increase pressure and overcome this infiltration at the base of the building. Unfortunately, this increases pressure at the top, causing more exfiltration problems in that area. This over-pressurization at the top of the building cannot be controlled at the same time as controlling infiltration at the base of the building. The only solution is to seal air leaks at the top and the bottom of the building.



Air leakage causes discomfort to a building's inhabitants and, in relation to our conversation here, causes undue pressure on a building's HVAC system. A building suffering from stack effect has to crank up the heat to compensate for the colder lower floors, while the building's uppermost inhabitants sweat it out. A drafty building has to make up for incoming cold air forcing warm, conditioned air leaking out through holes. In short, the HVAC system struggles to compete with incoming and outgoing air for which it shouldn't be compensating.

Experience in the Field

As Andy Taylor, a mechanical and electrical engineer and partner in Weinstein Taylor & Associates consulting firm notes, building envelope upgrades aren't often at the top of the list in energy efficiency retrofit projects.

"People think in terms of replacing windows; they don't really think of sealing them or replacing weatherstripping, which is much less expensive and a much better payback," he says. "It doesn't break like a boiler plant, so it doesn't come up as an emergency."

Taylor recently performed several computer simulations to research how air infiltration affects an existing building's HVAC system. Taylor used E20-II HAP software to compute building data with weather information. The simulation produced hard data on the effects of air infiltration.

"Essentially, air infiltration through windows and doors and other holes in the wall accounts for 25 percent of heat load," Taylor reports. "So if you handle the air infiltration via the envelope — not reducing it to zero but bringing it up to very modern standards — then you can reduce the heating plant by 25 percent."

He suggests that reduced air infiltration appears to reduce total energy use by about 20 to 25 percent. How those numbers are used is up to the building owner and the manner in which they choose to execute their energy efficiency strategy.

Neil Smith, president of Arvin Air Systems, a company based in Stoney Creek, Ontario that specializes in HVAC systems, sees the influence a building's air barrier has on its HVAC system every day. Stack effect and its impact on the HVAC system is a problem he often encounters.

"With all high-rise buildings, whatever water you supply to the bottom, you have to supply to the top," he says. "That's a big, big issue with us. We can't solve it unless we do something with the building envelope. The solution is not to put in more heating capacity, obviously. We find that when we solve the building envelope problem, we can reduce water temperatures and increase comfort on all floors, whether it's the lower or upper floors. Of course, that's a win-win."

One of Smith's more dramatic experiences with an air barrier/HVAC relationship occurred four years ago when Arvin Air was hired to help reduce an industrial building's million-dollar annual energy consumption.

Arvin Air engineers attacked the problem using three major initiatives. First, they reduced the amount of mechanical exhaust in the building, to building code and ASHRAE standards. The building was exhausting more air than needed to ensure negative pressure was not created in the building. Correspondingly, the heated makeup air was reduced because less exhaust meant less air had to be replaced. Finally, the building envelope was sealed, including roof openings, window insulation, weather-stripping, and new mechanization of some frequently used doors to reduce the amount of time they stayed open. Smith says the entire project cost $300,000, which was returned through energy savings in one year. The project reduced the annual energy bill to $750,000, which is a marked difference from the building's prior consumption.

"That's very fast—you don't normally get that," says Smith of the quick payback on the company's investment. "But when we first went into that building, there's no way they thought we would focus on the building envelope."

Ed Porasz, owner of M&E Engineering near Toronto, Ontario, says his firm finds their clients' building envelope projects return the investment via energy savings in as little as three and a half years, but most often his estimates are in the four and a half to five year range. The real threat to a building envelope's ability to function well, he says, is time. If he's called into a newer building to do an energy feasibility study, he says there's often not a lot to be done, because they're often built to higher energy efficiency standards. A building that was built in the '80s, however, quite often has a leaky building envelope in need of an upgrade. The effect of a leaky envelope to a building's HVAC system varies, he says, but it definitely plays a role.

"There are multiple things that save energy," he says, referring to the need for a comprehensive energy strategy. "But the building envelope is definitely a measure that should be looked at. Restoring its integrity is definitely a measure that does save energy, and it's definitely a measure that most old buildings need to have done."

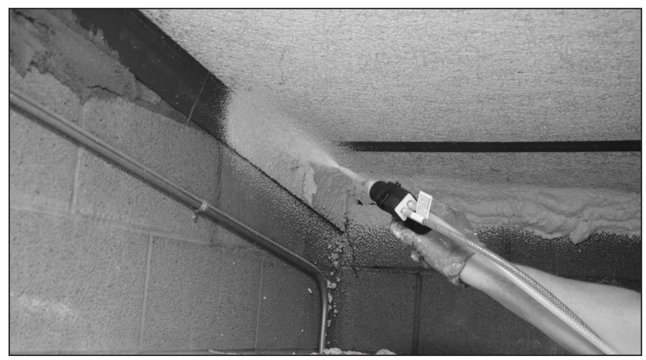
How do you improve the building envelope?
Sealing air leaks in any kind of building has to start with an assessment. Cracks, gaps, leaks and holes are easily made visible with an air leakage detector or smoke pencil. Sometimes a large-scale depressurization fan is used to create negative pressure in the building and increase the visibility of leaks. In some instances, infrared thermography

from outside the building can show patterns of air leakage. Energy saving potential is analyzed using EC 128/ALCAP software.

Once the air leakage pathways have been identified throughout the building, including their exit and entry points, the building envelope specialist can prepare the air barrier continuity plan. This addresses air sealing in five critical areas. First, the top of the building; second, the bottom; third, the vertical shafts; fourth, the outside walls and openings; and finally compartmentalizing by sealing internal horizontal air leaks.

Examples of typical pathways that need to be sealed include:

Top of the building:
- Roof/wall intersections
- Mechanical penthouse doors and walls
- HVAC equipment
- Various roof penetrations



Bottom of the building:
- Underground parking access doors
- Exhaust and air intake vents
- Soffits and ground floor access doors
- Pipe, duct, cable and other service penetrations into core of the building
- Sprinkler hanger penetrations, inspection hatches and other holes
- Core wall to floor slab

Vertical shafts:
- Stairwell fire doors
- Fire hose cabinets
- Plumbing, electrical, cable and other penetrations within service rooms
- Elevator rooms, cable holes, door controller cable holes, bus bar openings
- Garbage chute perimeter and access hatches
- Hallway pressurization grille perimeters
- Elevator shaft smoke control grille
- Service shafts

Outside walls and openings:

- Weatherstripping on windows, doors, balcony and patio doors
- Window trim
- Exhaust fans and ducting
- All service penetrations
- Baseboard heaters
- Electrical receptacles
- Baseboards

Compartmentalization:

- Vented mechanical rooms
- Garbage compactor room
- Emergency generator room
- High voltage rooms
- Shipping docks
- Elevator rooms
- Workshops

Once The Envelope Is Tight… Then What?

People that don't take care of their building envelope baffle Neil Smith. He thinks the general awareness of building envelope benefits is there, but maintenance is an entirely different matter.

In order for a nicely sealed building to continue to allow the HVAC system to work to its specifications, the envelope has to function at the level to which it was originally installed. It's a nice idea, says Smith, but it has to be acted upon. The building envelope needs to stay sealed and doing its job, with an out for on new holes in the building, the condition of the weatherstripping, and the building's shape as it settles and changes.

"The energy savings originate with good design," Smith explains. "You put the proper size equipment in and you do the building envelope, but that's just the beginning."

Ed Porasz agrees, saying that it's important for building owners or property managers to be aware that the initial investment has to be maintained or it will lose its value. Something as simple as a roof door that's constantly opened and closed needs to be monitored on a regular basis for deterioration of the weatherstripping or caulking, he says. And the implications of non-maintenance can be severe. He says an uncared-for, unsealed window frame can lose its integrity, not only allowing air in, but increasing the risk that a brisk wind might take that window right out.

Looking forward

A high performance, functioning building envelope contributes to an effective, efficient operation of an HVAC system. The combination of the two creates a healthy, comfortable and safe building for its occupants.

Currently, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.1 Envelope Subcommittee is looking to update the building air leakage requirements under Addendum z to the 90.1-2004 version of the standard to include a continuous air barrier system. The NIST report was prepared in part to show that committee the potential energy savings and cost effectiveness of an air barrier requirement. Building science experts believe that because the United States Federal Government mandates 90.1 as the minimum requirement for the individual states, the inclusion of air barriers in 90.1-2004 will lead to a similar requirement in the International Energy Conservation Code.

About Canam Building Envelope Specialists, Inc.

Canam Building Envelope Specialists Inc. is an affiliate of the Tremco Roofing & Building Maintenance Division of Tremco Incorporated. Canam offers a comprehensive range of environment and energy related services in all types of buildings. These include insulation, ventilation, air leakage control, air tightness and window testing, auditing and total tune-ups.

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