

Smoke safety, energy efficiency and occupant comfort. What's the connection?

Air movement, says Jim Bunting. Control it, and you can reduce the danger of smoke spread during a fire, reduce energy bills, reduce complaints about occupant comfort and get help paying for the work.

These three important building management issues are rarely discussed in the same meeting, let alone in the same sentence. Why, you ask? Probably because most peoples' understanding of how air (and that includes smoke-laden air) moves within, into and out of a building is limited. So let's explore the three issues, look at how each is affected by air movement, and then tackle the big question of how to finance the required building improvements.

Smoke spread during a fire

If you take a look at the Ontario Association of Architects and CMHC joint publication Fire Safety in High-Rise Apartment Buildings¹, written by Ken Richardson of Ken Richardson Fire Technologies Inc., you'll see some alarming statistics on what really causes deaths. It's nearly always smoke and it's usually in the higher floors. Why? Because once a fire starts smoke travels unbelievably quickly upwards through a high-rise.

In 1993, a terrorist bomb exploded in the underground parking garage of the World Trade Center, New York. Smoke spread from three floors below ground all the way up to the 84th floor in just 12 minutes.

¹ Any building six storeys or more in height.

Richardson writes that a study of representative Canadian high-rise fires illustrates a number of points that designers should consider. Among them are:

- Unsuppressed fires in high-rise buildings generate large quantities of smoke that can spread vertically or horizontally through the building even if the fire is contained to only one room or apartment.
- Vertical smoke spread is exacerbated by wind and by stack effect, which occurs when the building's inside temperature is greater than the outside.
- In multiple death fires in residential high-rise buildings many fatalities occur in the egress routes (stairways and corridors) due to smoke from a fire elsewhere in the building.
- In apartment fires with doors left open or burned-through, smoke will spread to the corridors, shafts and upper levels.

Two examples of fatal fires:

In 1992, a fire began in a 9th floor apartment of 250 Davenport Road, a 25-storey unsprinklered apartment building in Toronto. The occupants escaped, but left the door open. The fire was contained to the apartment of origin. Within ten minutes of the alarm, smoke spread to all floors above the ninth and to the exit stairwells causing one fatality².

In 1995 a fire began on the 6th floor of 2 Forest Laneway, a 30-storey reinforced concrete apartment building in Toronto. The occupants escaped, but left the door open. The fire was essentially contained to the unit of origin.

² Goodyear, D. and Harper, R., Fire Investigation Report – High-rise Buildings, National Fire Protection Association, Quincy, MA, 1994.

Smoke spread rapidly throughout the building causing six fatalities near the top of the two stairwells³⁴.

Richardson says that although these and other examples address buildings not built to current code requirements, simply complying with a building code does not necessarily provide optimum life safety.

A complex series of pipes, ducts, cables and conduit, including fire protection water supplies, run vertically and horizontally through these buildings. Smoke travels rapidly through any penetration in floors or walls created for these services but left unsealed...even though these penetrations are required by Code to be fire-stopped. Most importantly, it travels through all rooms that have open vents and are therefore not separated into 'fire and smoke compartments'.

One strategy to control the fire and smoke spread process, according to Richardson, is known as *Control by Construction*. This includes the stability of structural elements against fire attack and fire 'compartmentation' with rated walls and floors. But these same construction elements may not be effective in controlling the spread of smoke if there are cracks and openings in them such as for doors and windows, penetrations for ducts, cables and piping. Often, he says, these openings have a significant effect on fire and smoke spread, so architects must exercise special care in their design.

Michele Farley, President of FCS Fire Consulting Services Ltd., of Innisfil, Ontario, feels that building owners and managers face difficult responsibility and liability issues around this subject. If complying with building and fire

³ Proulx, G., et al, Study of the occupants' Behaviour During the 2 Forest Laneway Fire in North York, ON, January 6, 1995, Internal Report No. 705, Institute for Research in Construction, National Research Council of Canada, 1995.

⁴ Fire Investigation Report, Residential High-Rise, Six Fatalities, North York, ON, January 6, 1995, National Fire Protection Association, Quincy, MA, 1995.

codes is not enough, what is a property manager or condominium board to do?

Farley has a concern that although Building Codes call for fire sealing of penetrations and smoke stop measures to be implemented at time of construction, there's too little enforcement of continued compliance under the Fire Code.

Owners and managers would like to be able to say: "we have done everything we can do", but the definition of 'everything we can do' is unclear. Reducing smoke spread in high buildings is shown to be the most critical aspect of fire protection, so at the very least, we should do as much as we can, in addition to mechanical means, to control the flow of air within, into and out of the building and contribute to better control of smoke spread.

Farley reminds property managers and condominium boards that it is essential for all buildings, particularly older ones, to have a fire separation review every few years. Service alterations, building aging effects, or even residents performing their own plumbing work can damage fire separations. Although regular maintenance can address these areas, significant or numerous breaches will compromise smoke containment during a fire emergency, she says.

Lower energy bills

Controlling air leakage has been proven to improve energy efficiency. Examples include 10% reductions in demand and consumption in Ottawa and Toronto high-rise apartment buildings following perimeter air sealing.

After the fatal fire at 2 Forest Laneway, the 30-storey high-rise described in the example above, property managers hired the author's company to air

seal the building to achieve dual objectives of smoke control and improving occupant comfort. To everyone's surprise except the author, energy cost savings were achieved considerably beyond forecast (*see sidebar story*).

'Payment by results' energy efficiency projects performed by energy service companies (ESCOs) have regularly included air sealing upgrades to allow them to better control HVAC systems. The results include downsized mechanical equipment and lower operating costs.

In two multi-unit towers in West Toronto, an air leakage control retrofit program consisting of weatherstripping doors and windows, using polyurethane foam behind baseboards, air sealing the doors on the mechanical penthouses and reducing the size of the openings for elevator cables added up to a considerable reduction in both energy use and energy demand. For electricity users, reduced demand charges are often a major factor in reduced costs.

What does a smoke control/energy efficiency retrofit entail? After a thorough air leakage assessment, involving depressurization, infrared and leak detection procedures, potential energy savings are calculated and air-sealing measures prioritized according to cost benefit.

A typical plan to control air movement will address air sealing in five critical areas of the building: the top, the bottom, the vertical shafts, the outside walls and, finally, horizontal openings that create permanent connections to the outside from rooms and other areas. (Sealing these latter openings is known as 'compartmentalization' in the building science profession).

The pathways that are sealed to create barriers to smoke and improve energy efficiency include:

- Roof/wall intersections

- Mechanical penthouse doors and walls
- HVAC equipment
- Roof penetrations
- Underground parking access doors
- Exhaust and air intake vents
- Soffits and ground floor access doors
- Service penetrations
- Sprinkler hanger penetrations
- Inspection hatches
- Slab/wall intersections
- Stairwell fire doors
- Fire hose cabinets
- Elevator cable holes
- Elevator room doors
- Garbage chute perimeters and access hatches
- Hallway pressurization grille perimeters
- Elevator shaft smoke control grilles
- Fire exit signs
- Vented mechanical rooms
- Garbage compactor rooms
- Emergency generator rooms
- High voltage rooms
- Shipping docks
- Workshops
- Door and window trim and weatherstripping
- Baseboards
- Baseboard heaters
- Electrical receptacles

Improving occupant comfort

Controlling air movement has many side benefits. Improving comfort for people who live or work in a building not only makes for happy occupants; it reduces stress for building managers who have fewer complaints to deal with.

Problems around thermal discomfort are most common; typically they are about drafts and cold spots. Reducing irritants such as noise, cigarette smoke, pests, flies, dust and dirt will get gratitude from the majority. A good air leakage control strategy will solve all of these.

Get help paying for it

Lower energy costs resulting from a major air leakage control retrofit will certainly help pay for the project over time. Simple paybacks range from three to seven years. But your return on investment can be accelerated with the help of financial incentives available from utilities and/or government.

Gas utilities offer incentives based on the number and type of measures and savings forecasts verified by independent consultants. The Ontario Energy Board is expected to soon approve similar incentives through local distribution companies (formerly municipal utilities). Natural Resources Canada offers a similar set of incentives.

Add these together, and you have the real prospect of improving life safety, energy efficiency and occupant comfort in your building and getting a solid financial return on your investment.

SIDEBAR STORY:

Air sealing retrofit improves smoke control, energy efficiency and tenant comfort

The owners of Forest Laneway, a three-tower, 1000-plus unit apartment complex in Toronto, faced steadily escalating energy costs, 27-year-old heating and air conditioning systems that had reached the end of their useful life, and spiralling maintenance requirements.

Fortunately, their consulting team recognized the need to review building envelope performance and brought in Canam Building Envelope Specialists Inc.

Stack effect in these buildings was found to be extreme and it was causing comfort problems, particularly with lower units. Canam informed the building owners that controlling air movement caused by stack pressures would improve smoke and odour control, energy efficiency and occupant comfort.

At the top of the building, the Canam team isolated and compartmentalized mechanical rooms by weatherstripping doors, fire stopping appropriate penetrations through rated walls, reducing the size of cable holes in the elevator shafts and door controller cable penetrations, as well as busbar and other electrical penetrations through the floor of the elevator rooms.

At the bottom of the building, the team effectively sealed the many penetrations found in the underground parking areas. Doors were weatherstripped and a large number of unsealed cable conduit duct and pipe penetrations and gaps between the block infill and slabs were sealed.

Vertical shafts, where doors with two-inch gaps underneath were prevalent, were weatherstripped. This decoupled floor-to-floor and reduced air

movement. This activity had to be balanced with the need of people on upper floors to open doors.

Other areas sealed included fire cabinets, garbage disposal rooms, electrical rooms and other service shafts. The highest quality, durable Zerodraft brand weatherstripping, together with appropriate one- and two-component polyurethane foam and fire stopping sealants were used throughout the project.

The combined efforts of Canam and a major HVAC upgrade resulted in big savings.

“Our goal was \$200,000 a year,” says Evelyn Visconti, Vice President, Residential Division for the Tandem Group, property managers for Forest Laneway. “We did much better in our first year and considerably surpassed projections. In fact, we might very well reduce our estimated payback target.”

About the author:

Jim Bunting, a senior client advisor with Canam Building Envelope Specialists Inc., Mississauga, has worked on building envelope upgrades for the condominium sector for many years. He also works with the fire protection industry to implement smoke control strategies that improve life safety in high-rise buildings. He can be reached at 1-800-27CANAM or jbunting@canambuildingenvelope.com.