WAYS TO FIND THOSE MYSTERY LEAKS

By Marc Schwerzmann, PEng, CEM

Analyzing water and air leakage issues in effective and practical ways is something with which many building envelope professionals have struggled. Searching for the hidden deficiencies in the constructed condition to find the mystery leaks resulting in air and moisture infiltration can sometimes stump even the most experienced. Typically, the call comes to the building envelope consultant only after the owner has exhausted his or her patience with contractors, has applied many tubes of sealant to every visible crease and crack, and has resigned to the fact that scientific analysis may be required.

For many years, energy efficiency professionals in both Canada and the U.S. have tested building envelopes for air leakage and performed calculations on how much natural ventilation or air changes per hour (ACH) are present in a building envelope. This natural ventilation has typically been as a result of air leakage through the building envelope and has other uses in the energy efficiency arena that are not applicable here.

What is very applicable, however, is the method of detection of the air leakage through the building envelope—either via infiltration or exfiltration, helping us as building envelope professionals to solve leak diagnosis mysteries for building owners.

CREATING THE CONDITIONS

Intermittent leakage issues are usually due to various weather-related factors coming together to cause the problem, often a result of wind-driven rain. The goal, therefore, is to combine various known testing methods to recreate the circumstance(s) that caused the leakage to occur. One method used to detect hidden deficiencies in the building envelope is to create negative air pressure conditions on the inside of the building envelope (or a portion of it). This reduction in the interior pressures creates airflow through a building envelope, imitating wind pushing against the exterior of the building envelope. Typical induced pressure differential to provide sufficient airflow is over 50 Pa—theoretically equivalent to 50-km/h (30-mph) winds hitting the envelope from all sides simultaneously. Once these conditions are created inside the space, infrared cameras can be used to look at the building envelope as a whole and each detail and penetration. With as little as 5°C of temperature gradient from inside to outside temperature, it is possible to generate very visible results of where the building envelope is of concern and potentially leaking.

Similar test methods involve water spray while inducing negative pressures typical for testing window assemblies. Water spray testing is typically limited to warmer-weather conditions, lower elevations on high-rise buildings, easy-access buildings, etc. The test described in this article requires no exterior access and requires only a temperature differential from interior to exterior conditions and the ability to induce a pressure differential from the interior to the exterior of the building envelope.

THE RELEVANCE

Why is this method of testing beneficial? Where there is airflow that can be generated through an exterior wall system, there is also a path for water to infiltrate under the right weather conditions. We have all faced situations where we see the result of the leak (water stains, etc.), but water testing has proven nothing. The method of testing discussed herein provides the building envelope consultant with another opportunity to discover the mystery leak and pictorially demonstrate his or her findings to the client.

EXAMPLES OF FINDINGS

Site #1

The first site location is of a bank branch where the client was encountering performance and comfort issues with the office spaces around the perimeter of this ~465-m^2 (5,000-sq.-ft.) building, suspected to be from poor insulation and air barrier and vapor retarder continuity. Exterior walls

Figure 1 – Visual image of column and window interface at Site 1.

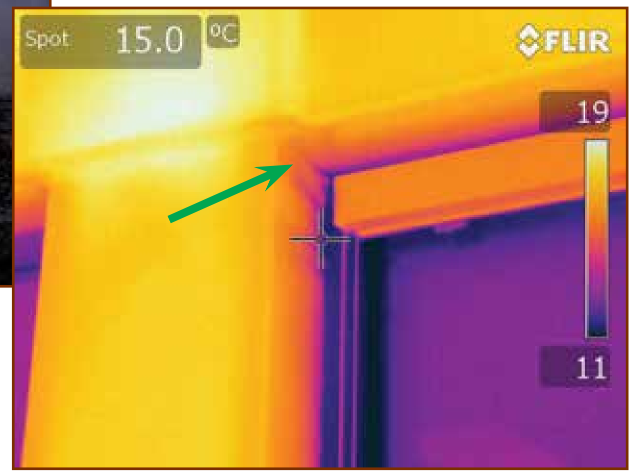

Figure 2 – Infared (IR) image of Figure 1. Note the streaks of dark color by the arrow showing air leakage.

felt "drafty" from air convection. Exterior conditions during the test were -14°C (7°F) with no precipitation.

The test involved depressurizing the entire building by 50 Pa, the equivalent of a 50-km/h (30-mph) wind hitting the building's exterior walls and roof. Thermographic images of the wall were taken with an infrared camera while the building was pressurized to identify conditions behind the gypsum finishes. *Figure 1* shows the location in question; no evidence of interior damage or deficiencies is visible. *Figure 2* is the thermographic image of the same column under depressurized conditions. The darker-colored streaks outline the path of air infiltration concentrated around the window frame; the bright yellow area is directly below a forced-air heating diffuser. *Figure 3* shows a typical exterior wall-to-floor junction in a corner of the building. *Figure 4* identifies the same corner under pressure, displaying significant amounts of heat transfer due to air infiltration and thermal bridging at the base of the walls and surrounding the exterior steel column.

As you can see from these images, it becomes very clear where the issues are. As building envelope consultants, you can effectively demonstrate to a building owner the deficiencies. If repair work is initiated by the owner, this testing can be a confirmation of the repair's effectiveness.

These images also serve to show that an experienced building envelope professional could have assisted in detailing the building design and reviewing the construction efforts of the contractor to construct a more efficient and reliable building.

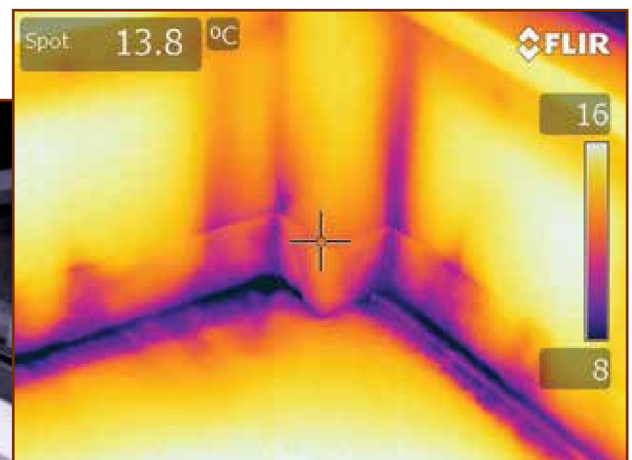

Figure 4 – IR image of Figure 3. Dark streaks on walls and floor indicate air leakage into building.

Figure 3 – Visual image of wall with floor interface in corner office at Site 1.

Site #2

Another situation tested with depressurization of the interior environment was utilized to detect exterior wall moisture infiltration in a ten-story masonry-clad apartment building. The leaks were reported to occur when there was a driving rainstorm condition, predominantly from easterly winds. Detection of these leaks is nearly impossible if not at the leak location during the rainstorm; without the specific conditions, the leakage will never be observed. The owner had employed contractors for over five years to repair exterior details, install through-wall metal and membrane flashings, and to install multiple layers of sealant, etc.

The test was performed on several units located on the seventh and eighth floors. Each individual unit was depressurized to 50 kPa (50 km/h or 30 mph) in an attempt to identify sources of air infiltration through the building exterior, the theory being the air infiltration would bring the moisture with it that was damaging the interior drywall and flooring finishes. The test was performed with an outside temperature of 7.5°C (45°F), zero wind, and no precipitation.

Figure 5 shows an infrared image of the inside face of the exterior fenestration-to-wall interface prior to pressurization, showing thermal transfer from the window frame to the gypsum finish, but no air infiltration. *Figures 6* and *7* are images taken during pressurization; each image demonstrates significant air infiltration occurring around the windows.

After these images were taken, a destructive test of the window detail revealed deficiencies in the original construction. Termination of the air barrier up to the window frame was allowing significant amounts of air to enter the building, bringing with it the moisture experienced through driving rain.

Visual probes with a borescope around this window were performed, and no other areas or evidence of moisture infiltration could be detected within the wall cavity.

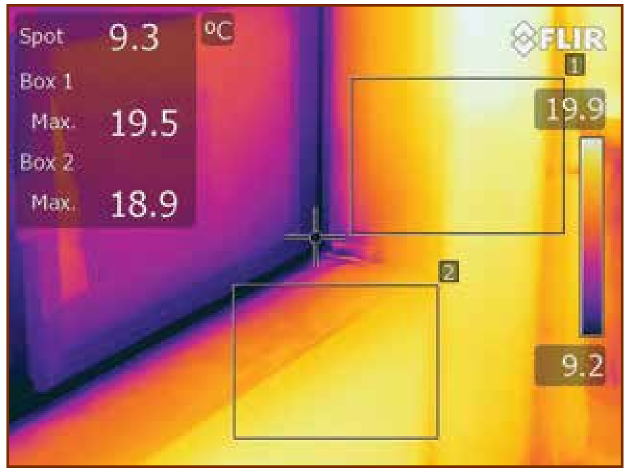

Figure 5 – IR image of fenestration. Wall interface prior to depressurization.

EQUIPMENT

The equipment varies from application to application, depending on how large the building or test area is. Generally, typical commercial-grade blower door equipment can be used. Segregation of areas within a building may be required to limit air leakage, utilizing polypropylene sheets and tape. Additionally, a high-resolution infrared camera that is capable of capturing small temperature differentials will allow the professional to capture minute deficiencies.

In the author's particular case, a Minneapolis Blower Door from The Energy Conservatory was used, equipped with a digital manometer and capabilities for multiple fans to generate airflow volumes of up to 14,000 cfm (~6,600 liters/second). The authors also use a FLIR T640 thermographic camera for this kind of testing work.

Utilization of this test procedure provides insight to building construction deficiencies and enables building envelope consultants to help clients discover the sources of many "mystery leaks."

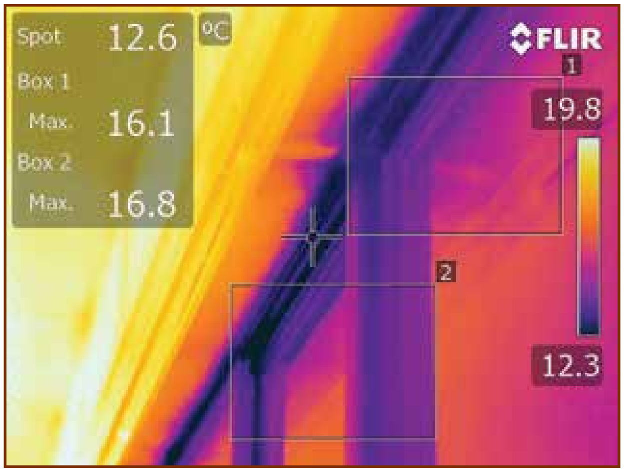

Figure 6 – IR image of fenestration system under depressurization. Note streaks indicating air leakage.

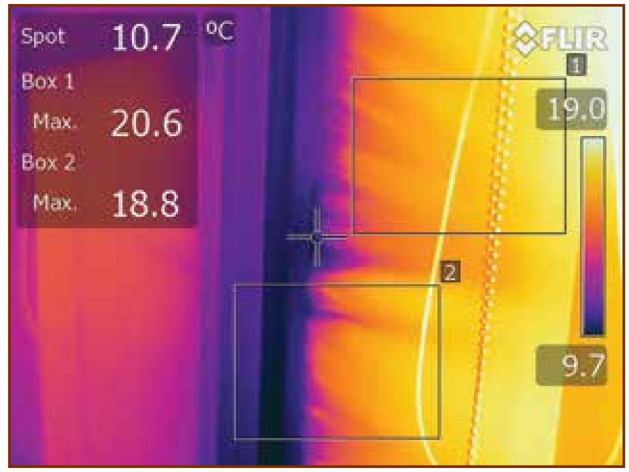

Figure 7 – IR image showing significant air leakage (streaking) between fenestration and wall system.

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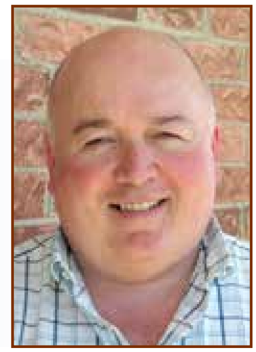

Marc Schwerzmann, PEng, CEM, is a professional engineer working with IRC Building Sciences Group Inc. He has 17 years of consulting experience and 29 years in the commercial construction field. Much of his career has been dedicated to retrofit work on existing building inventory with a focus on improving building performance and energy efficiency. He is a certified energy manager (CEM) with the Association of Energy Engineers.