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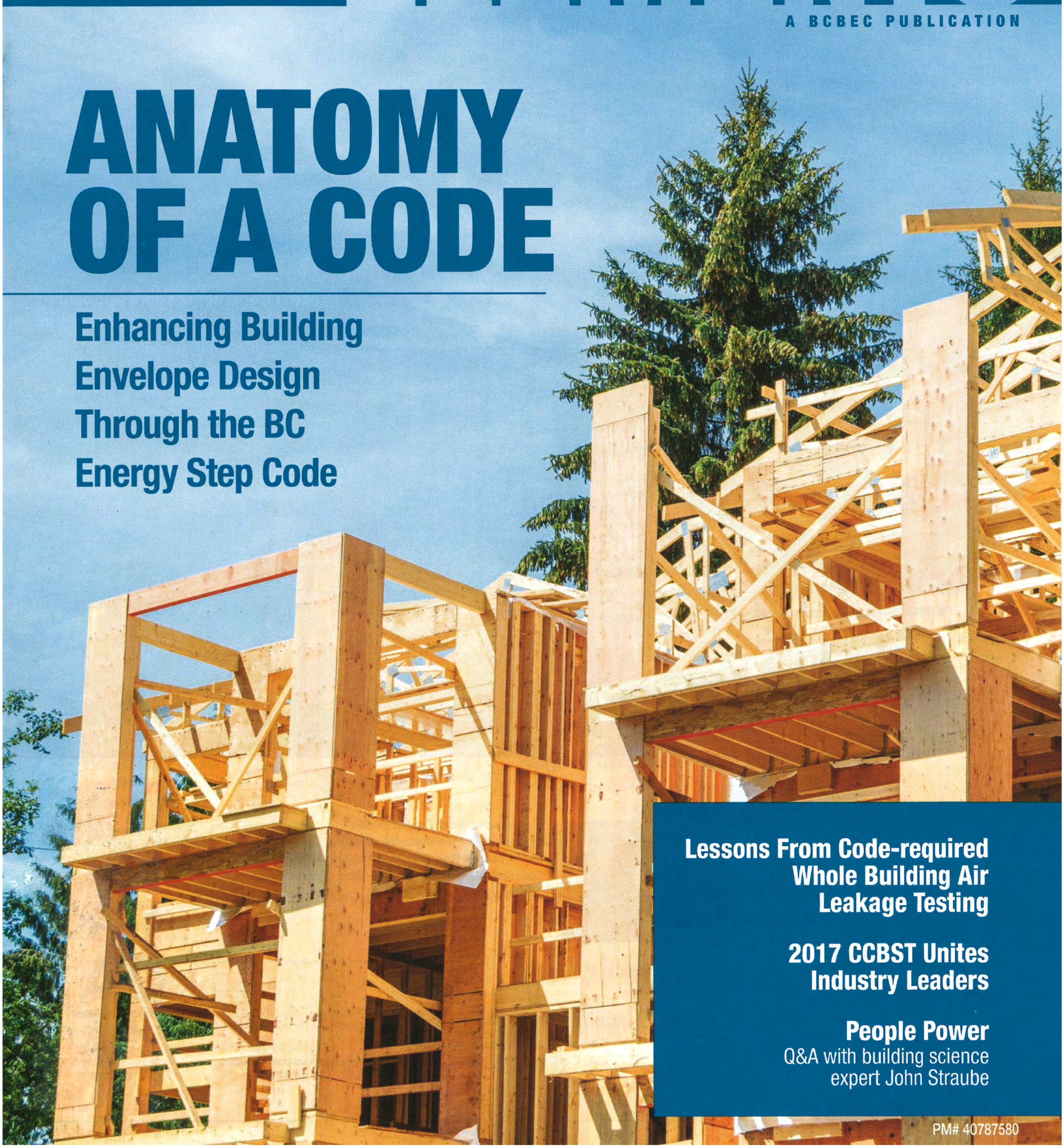

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Enhancing Building Envelope Design Through the BC Energy Step Code

Lessons From Code-required Whole Building Air Leakage Testing

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THIS IS A TEST

Lessons from code-required whole building air leakage testing

By Jeff Speert, AIA, LEED®AP, JRS Engineering

As British Columbia embarks on code-required whole building air leakage testing (WBALT), there are lessons to be learned from our neighbours to the south in Washington State – one of the first North American jurisdictions to require such testing. Now in their third code cycle, the Washington State and Seattle energy codes require WBALT on a considerable number of large commercial, institutional and residential buildings. This article gives guidance on WBALT and touches on design and construction issues.

WHAT IS WHOLE BUILDING AIR LEAKAGE TESTING?

WBALT is a procedure that quantifiably demonstrates the performance of a building's air barrier system. This testing commonly uses a fan (or series of special calibrated fans) to induce a pressure difference between the interior and exterior of a completed air barrier. To isolate the air barrier components, intentional openings in the tested area (such as doors, windows and mechanical ventilation openings) need to be temporarily closed or sealed. In addition, all interior doors are typically opened, creating a continuous volume of air so the tested area can be treated as one zone. The air flow required to maintain the specified pressure difference equates to the air leakage rate through unintentional openings or breaches in the air barrier. Care needs to be taken to create an induced pressure within the structure that is relatively consistent – typically no greater than +/- 10 per cent in any one given spot.

These tested leakage rates can be compared to other buildings, to quantify the relative success of an air barrier system's design and implementation. Because there are several test standards, including ASTM E-779 and U.S. Army Corps of Engineers (USACE), requirements for preparing and testing a building tend to vary and as a result, leakage results also vary.

HOW ARE LEAKAGE RATES EXPRESSED AND WHAT IS THE DIFFERENCE?

Two metrics for reporting air leakage results are commonly adopted throughout the industry. The air flow required to induce pressure differences may be described in terms of volume (air changes per hour) or surface area (square foot of enclosure area), and leakage rates are reported at specific pressure differentials – typically 50 or 75 Pascals. Leakage rates for single-family homes and smaller spaces have been historically expressed at air changes per hour at 50 Pascals (ACH50). USACE testing and larger buildings generally tend to use cubic feet per square foot at 75 Pascals (CFM/SF@75). Other units of expressing air leakage exist, such as equivalent leakage area, but are less commonly used.

Because the ratio of volume to surface area changes based on a building's size and configuration, there is no simple conversion between these two metrics. CFM/SF is more easily compared between a range of buildings, because it is framed to

TEMPORARY RANGE HOOD SEALING

the air barrier's location. ACH target values become easier to achieve as buildings get larger and more compact.

WHAT NEEDS TO HAPPEN BEFORE THE TEST?

For successful results, the team must be prepared to handle testing logistics. Assistance from general contractors and subcontractors is also required, for completing all air barrier components and providing temporary sealing at agreed-upon locations.

The testing team needs to calculate or verify the areas and volumes to be tested. Because air flow rates are divided by these quantities, these numbers are very important in determining leakage rates. These numbers are also used to calculate how much fan capacity is needed to achieve the required pressure. Each building needs to be analyzed for efficient placement of fans, and for which doors need to be opened or closed during the test. Also, there may be some spaces that cannot be linked into the building's single testing zone. A strategy for handling this must be determined, and often means using additional fans so these spaces can be tested at the same time as the larger volume.

For the general contractor, it is critical to have all air barrier components or a suitable temporary mock-up in place at the time of testing. Depending on testing protocol, some other elements may need to be temporarily sealed. This could include exhaust fans, range hoods, and fresh air supply.

As mentioned earlier, interior doors need to be held open and all exterior doors and windows closed. Plumbing drains should also be charged with water so air does not make it past P-traps. Depending on the building configuration and height, it is common to need elevator doors open at various floors so the elevator shaft can be used for vertical passage of air. General contractors are well suited to complete these preparatory tasks, but testing agencies can also complete them.

WHAT SHOULD HAPPEN DURING THE TEST?

Before the actual test is attempted, pressure should be induced to make sure the building setup is correct, the target pressure differential can be achieved, and the pressure difference is equivalent throughout the building. The building needs to stay secured, with exterior doors

FOR THE GENERAL CONTRACTOR, IT IS CRITICAL TO HAVE ALL AIR BARRIER COMPONENTS OR A SUITABLE TEMPORARY MOCK-UP IN PLACE AT THE TIME OF TESTING. DEPENDING ON TESTING PROTOCOL, SOME OTHER ELEMENTS MAY NEED TO BE TEMPORARILY SEALED. THIS COULD INCLUDE EXHAUST FANS, RANGE HOODS, AND FRESH AIR SUPPLY.

FANS SET UP WITH OPERATOR OUTSIDE OF THE BUILDING

and windows closed during the test. Although workers and inhabitants can be in the building during testing, problems can be avoided if it is completed during evenings or weekends when there is less activity on site.

For larger buildings, the test should be conducted at a range of pressures and data recorded. Various test protocols have different requirements for the quantity of data points, the range of pressures that should be achieved, and whether the test is conducted by pressurizing, depressurizing, or both. Experienced testers have generally found that leakage rates are marginally lower when a depressurization test is conducted, because depressurized buildings tend to pull gravity dampers shut. This results in a tighter enclosure whereas pressurized buildings tend to push these dampers open, resulting in more leakage through intentional openings.

WHAT THINGS MAKE A TEST MORE CHALLENGING?

Challenges encountered during a test generally fall into two categories. The first relates to testing equipment and building setup. Other issues relate to building configuration and preparation.

Because large building tests require multiple fans working together, setting up equipment in an organized fashion is critical. Software is available to control all equipment simultaneously, but bugs and quirks sometimes need to be negotiated.

Because most fans have a large power draw that will trip ground fault outlets and electrical breakers, it is important to plug fans into outlets that will have uninterrupted power. In residential buildings this can be done at locations for dedicated high-power appliances (clothes dryers, dishwashers, microwaves). In commercial buildings it is typically easier to find power sources, but because each fan should be on a different circuit it is sometimes difficult to find multiple circuits near the intended door. Fan equipment can be placed in a variety of standard-size door openings but if openings are larger or smaller than standard, a custom-built door block-out may be necessary.

In buildings with many smaller internal spaces, such as stratas, it is more difficult to achieve balanced air pressures than for buildings with open interior spaces such as museums, offices and schools. This sometimes requires fan placement strategies, or extra measures for opening elements in the building. As discussed earlier, temporary sealing and closing of operable elements is critical. Sometimes doors or roof hatches that look to be closed are not latched, and are pulled or pushed open by the induced air pressure. Self-adhered plastic sheeting is commonly used to temporarily seal mechanical registers and grilles. This material sometimes gets forced off by the pressure or simply falls off.

WHAT ARE THE RESULTS AND WHY THE VARIATION?

For most newly constructed buildings where a continuous air barrier is designed and installed, JRS Engineering has generally seen projects achieving their leakage rate goals. In Washington State, these have generally been 0.40 CFM/SF@75 and changed to 0.30 CFM/SF@75 in Seattle for the 2015 Code. Many factors influence the tested leakage rate. Small influencers

AUTHOR WITH EQUIPMENT AT LARGE OFFICE BUILDING TEST

EXTERIOR SEALED LOUVERS

generally include small holes in a limited number of locations. Large influencers are listed below. These are generally larger holes or systemic smaller holes.

Large Influencers:

- **Roof assemblies:** Vented roof assemblies are much harder to construct airtight, as opposed to non-vented assemblies.

- **Air barrier components on walls:** Nearly all projects JRS Engineering has tested have used the weather-resistive barrier membrane as the air barrier. Mechanically attached sheets allow for more leakage than fully adhered or liquid products. Sealed sheathing is also a good option for improved airtightness.

- **Quantity of wall penetrations for mechanical exhaust and supply:** The more these penetrations occur, the leakier the test results. This is due in part to small inconsistencies adding up, but is also linked to the next item in this list.

- **Method and approach to temporary sealing:** It seems to make a difference if range exhaust or other appliances are sealed at the range fan or at the exterior louver. When sealed at the interior, the duct and all its joints become part of the tested area. Often, this does not get sealed as tight as the rest of the air barrier.

- **Incomplete air barrier components not temporarily mocked up to finished condition:** This can include missing glass and sealant joints, among others.

- **Elevators within the enclosure on some levels, but open directly to the exterior at one or more levels:** Elevator doors do not seal in an airtight manner, so vestibules are important.

In testing building additions, sealing across the joint between existing structures and additions has been very problematic. Although this joint has little impact on an operating building's energy performance, this issue could be considered during design and construction so that valid leakage results are provided.

WBALT can be complicated and problems that crop up during testing can be challenging, so it is important to have appropriately trained staff, use calibrated equipment, and use an experienced tester that can help coordinate the mechanics of testing and also help contractors and owners through the process so goals are achieved.