Air Leakage Testing

New Research Is on the Way

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Changes to building codes are a fact of life for architects and designers and air leakage testing is currently a hot topic. Energy standard and code writers are currently looking at lowering air leakage limits while also requiring testing to ensure compliance. Both ASHRAE 90.1 and the International Energy Conservation Code (IECC) are spearheading such efforts. In most areas, whole-building air leakage testing is now an alternative compliance

How Testing Works

Air leakage testing is undertaken according to the ASTM E 779 *Standard Test Method for Determining Air Leakage Rate by Fan Pressurization* with modifications from the U.S. Army Corps of Engineers Air Leakage Test Protocol for Building Envelopes. This USACE Protocol requires that both a pressurization and depressurization test meet a specified air leakage rate target.

The current versions of ASHRAE 90.1 and the IECC specify that air leakage must not exceed 0.40 cubic feet per minute of leakage per square foot of envelope area at 75 Pascals of pressure across the building envelope (or using a shorthand: 0.4 CFM/sf@75Pa). The USACE, the ASHRAE standard 189.1 and Washington state currently specify a tighter building with a leakage target of 0.25 CFM/sf @ 75 Pascals. It is expected that, in time, these limits will become more stringent.

There is a more recent standard being specified by designers: the ASTM E 3158 S*tandard Test Method for Measuring the Air Leakage Rate of a Large or Multizone Building*. It was developed based on the USACE Protocol and research from other studies. The ASTM E 3158 describes two different air leakage tests: the "building envelope only" and the "operational envelope." The building envelope only test procedure requires taping all mechanical openings to exclude any leakage from the mechanical system. The operational envelope test does not allow taping of any mechanical openings as this test procedure measures the leakage rate of the envelope plus any leakage from the mechanical system enclosure including leakage around any normally closing dampers.

The testing itself is fairly straightforward, and typically for metal buildings takes no more than a few hours, including preparation. Tests will take longer for larger and more complex buildings; for example, our research was conducted first with the overhead doors sealed with tape and then with them not taped to differentiate the leakage of the overhead doors from leakage through the walls and roof.

Preparation includes opening interior doors, sealing plumbing traps, lifting a few ceiling tiles, turning off the HVAC system, setting up the testing equipment and, for a building envelope only air leakage test, sealing all mechanical penetrations in the building envelope. The purpose of the preparation is to ensure that the testing is conducted in a prescribed way to assure accurate and repeatable test results.

Calibrated fans are positioned in exterior door openings. The number of fans required to create a pressure of 75 Pascals depends on the building envelope area and the expected leakage rate. The fans blow into the building for one part of the test (pressurization) and blow out of the building for the second part (depressurization) while digital gauges measure the pressure across the building envelope and the calibrated fans to calculate the amount of air moving in or out of the building (air leakage rate). Leakage rates are based on the pressures recorded and the correlation coefficients which indicate whether the test data is accurate and repeatable.

Meghan McDermott of High Performance Building Systems in Charlotte, North Carolina, has overseen metal building air leakage testing on a number of buildings. She notes that "The testing process for completing a whole building air leakage test, whether in a 5,000-square-foot building or a 500,000-square-foot building, can be completed in a day. The key is to hire a competent testing agent who has an extensive background in testing large and complex buildings and understands the preparation, equipment and staffing required to meet the testing goals of the individual project," she says.

path, while it is required in only a few specific areas such as the state of Washington. With the coming updates, more states will require on-site testing of new buildings to meet the code.

This means that there's more for architects, designers and contractors to think about to ensure compliance; but that doesn't mean they should be concerned, particularly when specifying metal buildings. When the right materials are specified and correctly installed, metal buildings indeed pass the new air leakage tests with flying colors.

Current Code Considerations

The two primary documents addressing energy conservation in use today are ASHRAE 90.1 and the IECC. In previous editions, whole-building air leakage testing had been optional. In the newest editions, ASHRAE 90.1-2019 and IECC 2021, the test is required in most areas. For ASHRAE 90.1, semi-heated buildings in climate zones 1 through 6 are exempt because an air barrier is not required, and there is an installation verification program option. For the IECC, zones 2B, 3B, 3C and 5C are exempt. Additionally, buildings greater than 5,000 square feet in zones 1, 2A, 4B and 4C are exempt, as are buildings with a square footage between 5,000 and 50,000 in zones 3A and 5B.

Other energy codes are applicable in particular U.S. states and in some government agencies. For example, Washington state and the U.S. Army Corps of Engineers require all new buildings to pass an air leakage test regardless of location or size. The Metal Building Manufacturers Association (MBMA) has created a document that lays out the codes and the differences, with a climate zone map for reference. It is available here http://blog.mbma.com/uploads/pdfs/MBMA_Comparison-of-Air-Leakage-Testing-Requirements.pdf.

The LEED Connection

When designing for energy efficiency, architects need to be aware that, in addition to enabling a building to meet the applicable energy code requirements, air leakage testing can also contribute to earning LEED 4.1 credits. These may be awarded for buildings in both the Building Design and Construction (BD+C) and the Residential BD+C Multifamily Homes programs. This would include new construction for a range of low-rise, nonresidential structures that are often metal buildings, such as: warehouses and distribution centers, schools and retail buildings, and multifamily residential buildings. "While the air leakage testing is not directly cited in LEED 4.1," notes Jonathan Humble, FAIA, NCARB, LEED AP BD+C, "it contributes indirectly through compliance with ASHRAE standard 90.1-2016."

LEED credits may be earned under the EA Prerequisite: Minimum Energy Performance category by complying with ASHRAE standard 90.1-2016, when using either the prescriptive provisions contained in Chapter 5 “Envelope,” or the performance provisions in Appendix G “Performance Rating Method” (e.g., Table G3.1, subpart 5 building envelope). Additionally, credits may be earned from the category EA Credit: Enhanced Commissioning. Air infiltration testing is part of the path that can earn up to four LEED credits.

Research on the Rise

With new testing requirements in the works, architects can rest assured that proactive testing is underway. In fact, the MBMA, in collaboration with the North American Insulation Manufacturers Association (NAIMA) and the Metal Building Contractors and Erectors Association (MBCEA), is testing metal buildings to see how well they comply with the air leakage requirements of the energy code and what specific elements may cause buildings to pass or fail. Having completed several tests, and with more on the way, the researchers confirmed that metal buildings do typically pass the test. However, they caution that architects, specifiers and installers need to pay attention to overhead doors, fenestrations, transition areas (such as the base of the walls and around windows and doors) and intersections in a building’s insulation system (such as wall corners and where the roof meets the exterior walls).

To date, the MBMA/NAIMA/MBCEA collaboration has tested metal buildings in the southeast United States, but additional tests in other climate zones and states are on the way. Robert Tiffin, of insulation manufacturer Silvercote and a member of the MBMA Task Group managing this project, emphasizes what has been learned thus far and what can be improved. “The Air Leakage Task Group has identified critical leakage paths in the building envelope, such as transition points between floor to wall, and the wall to roof,” he says. The image above shows synthetic smoke coming out at the base of the building where the walls meet the foundation and each other.

This testing image shows synthetic smoke coming out at the base of the building where the walls meet the foundation.

Whole-building air leakage testing can typically be completed in a day; and when the right materials are specified and correctly installed, metal buildings should indeed pass air leakage tests with flying colors.

One completed test was done on a warehouse in North Carolina that had a loading dock with four overhead doors on one side, plus two overhead doors on an adjacent side. First, pressurization and depressurization tests were administered with the overhead doors sealed. This resulted in an average of 0.13 cfm/sf. Then, a pressurization test with the doors unsealed was completed, with a result of 0.21 cfm/sf. Under the coming IECC and ASHRAE 90.1 requirements, the allowable leakage is 0.40 cfm/sf, meaning the building would pass with or without its overhead doors. If a building does not pass, the areas of leakage need to be addressed. Diagnostic tools to locate leakage paths include synthetic smoke and thermography.

Comparing the two tests with the doors sealed and unsealed showed that there can be a significant amount of leakage associated with the overhead doors, though it was not determined specifically how this leakage occurred. This has been shown to be true in other situations as well, including one where the difference was 0.37 cfm/sf between having the doors sealed and unsealed. To ensure that these doors do not significantly contribute to the building failing a test, it is particularly important that architects and designers specify doors that meet the standards with appropriate perimeter seals. It is just as vital that the building contractors follow the manufacturer's directions for installation. Improper installation, by itself, can lead to significant leakage and possibly test failure.

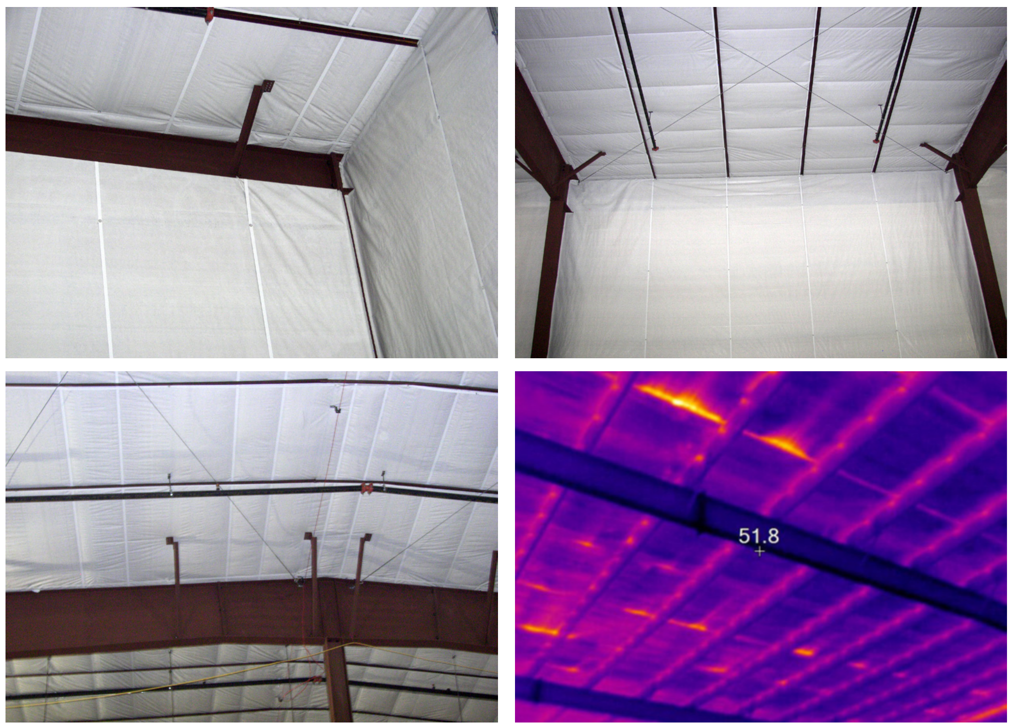
Other places of concern are any exterior opening—not just the overhead doors—such as windows and regular doorways. Seams in the building envelope and the insulation system, as well as the floor slab, can provide areas where air may escape, as identified with a thermal camera. Metal building contractors need to pay particular attention to the seams and joints to prevent them from becoming a source of air leakage.

Insulation, with its air barrier, is also a major factor in determining air leakage and can make or break any test. Again, transitional areas are important, such as where the walls meet other walls, the roof and the foundation. In addition to specifying the appropriate insulation system, installing it correctly is key. It is also notable that the more complicated the insulation systems are, the more places there are that could lead to problems with leakage.

When there are questions, the insulation manufacturer is always a good resource, as Tiffin notes: "It is important to follow the manufacturer's installation and product guidelines to understand how to best achieve the optimum performance. These instructions should be included with the shipment of the order and are typically also found on the manufacturer's web or social media sites. If and when you still have questions, contact the manufacturer's (local) rep directly."

Research Resources

Where can professionals go to find resources that help them navigate air leakage issues? Currently, MBMA is developing a best-practice guide on air leakage testing for architects, designers and contractors. It will describe proactive practices to mitigate potential problem areas and will alleviate concerns that metal buildings might have trouble meeting energy codes. This guide will complement several other resources available through MBMA, including *Energy Code Compliance: A Guide for Metal Building Contractors*, a free download, and the *Energy Design Guide for Metal Building Systems,* available in print or PDF through TechStreet at www.techstreet.com/mbma.



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