Feature

Sealing the Deal: Avoid Getting Blown Away by the New IECC Air Leakage Requirements

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THE FIRST VERSION of the *International Energy Conservation Code* (IECC) was issued in 1998 and was preceded by ASHRAE Standard 90/90.1 and the *Model Energy Code* (MEC), dating back to 1975. The IECC is tasked with regulating the design and construction of buildings for the effective use and conservation of energy over the useful life of each building, while remaining flexible enough to allow innovation in the industry. Air leakage has become a priority for energy improvements for two reasons:

1. Air leakage has a large impact on the efficiency of mechanical equipment, which is the largest consumer of energy in buildings.
2. As the industry continues to improve the efficiency of mechanical systems, air leakage increasingly becomes the "low-hanging fruit" to improve overall building performance.

The U.S. Department of Energy conducted a study in 2014, which found that air leakage is responsible for 6% of the overall energy usage in commercial buildings.[1] Furthermore, EnergyStar estimates that 25–40% of overall energy usage in single-family homes can be attributed to air leakage.[2] Although this paper will focus on the commercial energy code requirements, the growing understanding of air leakage and its effects has resulted in a shift in how we design and build these assemblies across the construction industry.

WHAT IS AIR LEAKAGE AND WHY DO WE CARE?

Buildings are designed to intake outdoor air and exhaust interior air, primarily through heating, ventilation, and air conditioning (HVAC) systems. However, when the infiltration and exfiltration of air in a building is uncontrolled, there are a variety of issues that can arise. These issues include condensation, ingress of pollutants, high/low interior temperatures, elevated humidity levels, higher utility bills, and premature wear of HVAC equipment.

For air leakage to occur from one space to another, there needs to be a difference in air pressures and a path for air to travel between the spaces. Some of the factors that create these pressure differentials are wind, stack effect, and HVAC operation. Due to the variable and cumulative nature of these factors, building pressures can change seasonally, daily, or even second-by-second. There is typically an air pressure differential between the interior and exterior spaces. Depending on how the building is constructed and operated, there may also be an air pressure differential between interior spaces with different uses (e.g., server rooms, clean rooms, laboratories, natatoriums) or at different locations within the same building (e.g., stack effect).

AIR LEAKAGE IS TERRIBLE; HOW DO WE STOP IT?

With an increasing emphasis on energy efficiency in buildings, as well as rising energy costs, the ability to mitigate building pressurization issues solely through the use of mechanical systems is becoming less practical. Air barriers provide a means to passively (i.e., without external energy input) control the air leakage caused by pressurization, either between interior and exterior spaces or between interior spaces with different uses and mechanical setpoints.

Air barriers are one of four weather barriers used to control the natural elements, joining water, vapor, and thermal barriers. Historically, the construction industry has focused more

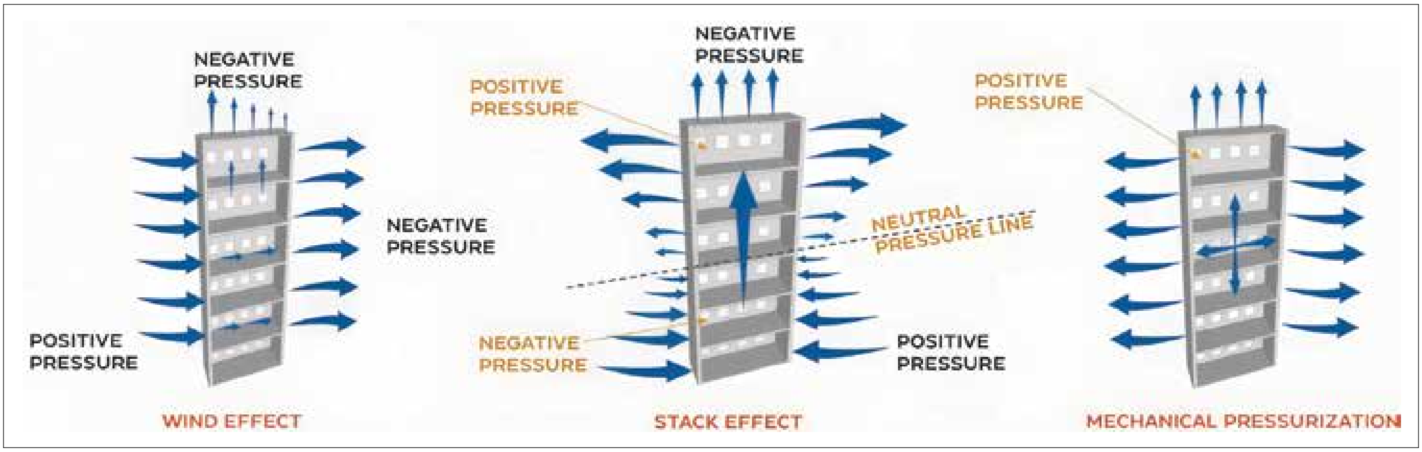

Figure 1.

on water barriers, primarily because of the prevalence of water leakage issues, the structural hazards they can cause, and their visibility to building occupants. Most water barriers can also serve as air barriers, however, the detailing required for water barriers is less arduous since water generally follows gravity downward. Air barriers, on the other hand, need to be detailed to stop air movement, which can travel in all directions. For example, sheets of building paper, if properly lapped to shed water, do not need to be sealed or taped at joints to serve as a water barrier but would to be considered an air barrier. Soffits on the underside of balconies will typically not be prone to water leakage but would need to be treated for air leakage.

The Environmental Protection Agency conducted a study of 100 buildings across various climate zones in the continental United States as part of their Building Assessment Survey and Evaluation (BASE) study and found that 85% had experienced water damage in the past and 45% were experiencing ongoing water leakage causing damage.[3] Due to the issues associated with water leakage, water-resistive barriers have been required since the first version of the *International Building Code* (IBC) was released in 2000 and for decades prior in the *Uniform Building Code* (UBC). Conversely, air barriers were not explicitly required in commercial buildings by model codes in the United States until the issuance of the 2012 IECC. The inclusion of air barrier requirements in the code is only the first step; as we have seen with water leakage, prescriptive code requirements do not prevent widespread issues in service. However, unlike requirements for water-resistive barriers, the IECC has implemented additional performance-based provisions as of the 2012 IECC, which include testing that quantifies air leakage, to ensure that new air barrier assemblies perform to a reasonable threshold.

IECC AIR LEAKAGE REQUIREMENTS

Starting in the 2012 IECC, the code has provided a performance-based compliance path for air leakage in the form of quantitative air leakage, or blower door, testing. Prior to 2012, air leakage requirements were entirely prescriptive and loosely enforced. As with other design disciplines, prescriptive requirements are often impractical for large and complex buildings. Allowing some elements of a building to be noncompliant, assuming that the overall performance of the building meets the required threshold, provides greater design flexibility and allows for more innovation, which aligns with the IECC's primary mission. Additionally, quantifying air leakage in buildings, and diagnosing problems when buildings do not meet the required threshold, allows the industry to learn and grow. The older, prescriptive requirements did not have the proper mechanisms in place to enforce them so, although well-meaning, they did not actually make appreciable improvements to the issue of air leakage.

Much of the language regarding air leakage in the IECC remains prescriptive and focuses on common sources of leakage, such as joints, penetrations, and fenestration assemblies. However, recent versions of the IECC (2021–2024) have implemented requirements for design reviews and site observations, which help to enforce the prescriptive requirements through third-party reviews during design and construction. In the following sections, we will summarize the compliance paths that are now available through these new provisions.

Thermal Envelope Verification

The IECC defines the "thermal envelope" as "Basement walls, exterior walls, floors, ceiling, roofs, and any other building element assemblies that enclose conditioned space and provide a boundary between conditioned space and exempt or unconditioned space". Thermal envelope "verification" is offered as a path for air leakage compliance starting with the 2021 IECC. The IECC requires that verification include a review of the air barrier during both design and construction. At the end of the project, the team must submit a final report summarizing any issues raised during these reviews and how each issue was resolved. This verification is prescriptive in nature and necessitates that project teams look at each air barrier requirement and explain how it was fulfilled. It also provides another level of quality assurance during the design phase and quality control during the construction phase, giving project teams additional opportunities to identify shortcomings that could result in future air leakage.

In addition to facilitating higher-performing air barrier assemblies, this process provides additional benefit because it requires a registered (or otherwise approved) professional to review the building enclosure. This process can identify other performance issues—especially with the water-resistive barrier, because the air and water barrier are typically the same material. For example, conducting site observations to review the air barrier installation can allow trained professionals to identify unique conditions that may not have been considered during the design phase and develop solutions before a performance issue arises.

The primary challenges with the implementation of this requirement are that it adds an upfront cost to the project and, if not properly coordinated in advance, could add time to the schedule. In our experience, the verification process is an asset to projects that properly coordinate it. However, to the extent that this requirement is overlooked early in the project, the value of verification decreases and the difficulty of implementing any resultant changes, in either the design or construction, increases. If a project team finds out about the verification requirement after they receive permit comments from the authority having jurisdiction (AHJ), it is unlikely that there will be extra design phase budget to cover the review and it would be challenging to implement any substantive design changes at that juncture in a project.

Thermal Envelope Testing

Thermal envelope testing became an air leakage compliance path for commercial buildings starting with the 2012 IECC, where the code provided an option that allowed teams to conduct an air leakage test in lieu of some prescriptive air leakage requirements (note: prescriptive requirements for air intakes/exhausts, stairways, shafts, loading docks, and vestibules are still required if the testing path is used). We note that the 2021 IECC allows the option for air leakage compliance through either verification or testing and the 2024 IECC generally requires testing but allows for verifications of areas that are not tested. Although the industry has historically embraced the idea of performance-based compliance, due to the design and programming flexibility it provides, air leakage testing may be challenging or undesirable to implement for the following reasons:

- Air leakage testing usually cannot be conducted until the end of the construction phase. In addition to roofing, fenestration assemblies, and wall weather barriers, all components impacting air leakage performance need to be installed, including door hardware, mechanical dampers, dryers, and other similar items. By the time the building enclosure is ready to be tested, there is often little room for failure because budgets are exhausted, the schedule does not have room to accommodate additional work, and access to any components allowing air leakage is likely limited.
- In the absence of "verification" (i.e., enclosure design review and site observations), the likelihood of passing the test will decrease. Under the 2021 IECC, project teams have the option of verification or testing. Due to the prescriptive nature of verification, as well as the inherent value it provides to a project, we generally recommend that project teams select verification over testing, assuming there are no prescriptive air leakage requirements that need to be avoided to accommodate the design.
- Air leakage testing for commercial buildings was not common in the United States prior to these code changes. The required air leakage targets are not unreasonable to meet but, in some instances, require a level of detailing that was not always common to an industry previously focused on water leakage. Failed tests will become less common as the industry becomes more familiar with these requirements, but this has caused some growing pains as we acclimate to this testing.

TABLE 1. IECC air leakage testing summary

IECC Code Year	Required?	Relevant Standards	Maximum Allowable Air Leakage Rate
2015	N	ASTM E779	0.40 CFM/ft² at 75 Pa
2018	N	ASTM E779	0.40 CFM/ft² at 75 Pa
2021	N	ASTM E779, ANSI/RESNET/ICC 380, ASTM E3158, or ASTM E1827 (whole-building) ASTM E779, ANSI/RESNET/ICC 380, ASTM E1827 (in-unit)	0.40 CFM/ft² at 75 Pa, but diagnostics (not retesting) allowed if rate is below 0.60 CFM/ft² (whole-building) 0.30 CFM/ft² at 50 Pa (in-unit)
2024	Y*	ASTM E3158 (whole-building)** ASTM E779, ANSI/RESNET/ICC 380, ASTM E1827 (in-unit) ASTM E1186 (diagnostics)	0.35 CFM/ft² at 75 Pa, but diagnostics (not retesting) allowed if rate is below 0.45 CFM/ft² (whole-building and in-unit)

* Testing is generally required but verification is allowed for areas that meet exceptions

** If test area is smaller than 10,000 ft^2, ASTM E779, ASTM E3158, or ASTM E1827 can be used

Since the initial inclusion of air leakage testing in the IECC, the following changes have been made to these requirements in subsequent versions of the code:

2021 IECC

- The air leakage testing requirements are identical in the 2012 to 2018 versions of the IECC and generally apply to "whole-building" air leakage testing. The 2021 IECC allows projects to test subsets of the building (areas under roofs, with public entrances, with loading docks, and 25% of the remaining above-grade areas), as well as "in-unit" air leakage testing. For the "in-unit" testing, only 20% of the dwelling units need to be tested (or seven units, minimum). However, for each failed test, an additional two units need to be tested.
- In addition to the ASTM E779 standard referenced in the 2012 to 2018 IECC, the 2021 IECC allows testing in accordance with ASNI/RESNET/ICC 380, ASTM E1827, and ASTM E3158. Although these standards are all similar to each other, their subtle differences can have a large impact on the testing and can often be the difference between a passing or a failing result. Some of these differences include the following:
  - Whether the testing needs to be conducted using positive pressure, negative pressure, or both
  - The number of data points that need to be collected
  - How, or whether, to provide temporary seals over building openings and penetrations (e.g., mechanical openings)
  - Allowable, or required, induced test pressures
- The allowable threshold for "whole-building" air leakage under the 2021 IECC is 0.40 cfm/ft^2, which is the same limit listed in the 2012 to 2018 IECC. However, this version of the code provides an allowance where the building does not need to be retested as long as the leakage result does not exceed 0.60 cfm/ft^2 and diagnostic methods (i.e., tracer smoke or infrared imaging) are conducted to identify leakage sources and, to the extent they're accessible, repair them.
  - "In-unit" testing does not provide any provisions or tolerance for air leakage rates above the 0.3 cfm/ft^2 at 0.2 inch water gauge threshold.

2024 IECC

- Allowable air leakage thresholds were reduced as follows:
  - Whole-building testing: 0.35 cfm/ft^2 at a pressure differential of 0.3 inch water gauge (75 Pa), with allowance for diagnostics (not retesting) if the leakage rate does not exceed 0.45 cfm/ft^2.
- Whole-building testing for projects larger than 10,000 ft^2 must comply with ASTM E3158. Previous versions of the code allowed testing

for commercial buildings of all sizes to comply with ASTM E779, ASNI/RESNET/ICC 380, ASTM E1827, or ASTM E3158, which provided for more flexibility in testing procedures.

- Building larger than 25,000 ft^2 in Climate Zones 0–4 do not need to conduct whole-building testing, except for Group I and R occupancies, which are still subject to "in-unit" testing.
- For each failed "in-unit" test, and additional three units need to be tested (increased from two additional units in the 2021 IECC).

CONCLUSION

The new IECC air leakage requirements, which include design reviews, site observations, and air leakage testing, are intended to confirm that prescriptive air leakage requirements in the energy code are properly implemented. While these provisions can add initial costs and, if not properly coordinated, time to projects, they serve to reduce long-term costs and resources associated with air leakage. In addition to their impact on air leakage, these provisions could serve to reduce the risk of other building-enclosure-related issues, such as water leakage, thermal bridging, condensation, material compatibility, and constructability. As the construction industry acclimates to these new requirements, their implementation onto projects will become more seamless and the performance of building enclosures across the industry will improve.

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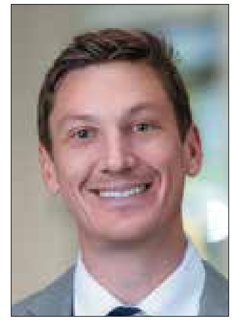
ABOUT THE AUTHOR



ALEX KOSIS

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