# CE97-19

**IECC: C402.5, C402.5.1, C402.5.1.2, C402.5.1.2.3 (New)**

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## 2018 International Energy Conservation Code

**Revise as follows:**

**C402.5 Air leakage—thermal envelope (Mandatory).** The building thermal envelope ~~of buildings~~ shall comply with Sections C402.5.1 through C402.5.8, or the building thermal envelope shall be tested in accordance ~~with ASTM E 779 at a pressure differential of 0.3 inch water gauge (75 Pa) or an equivalent method approved by the code official and deemed to comply with the provisions of this section when the tested air leakage rate of the building thermal envelope is not greater than 0.40 cfm/ft$^2$ (2.0 L/s • m$^2$).~~ with Section C402.5.1.2.3. Where compliance is based on such testing, the building shall also comply with Sections C402.5.5, C402.5.6 and C402.5.7.

**C402.5.1 Air barriers.** A continuous air barrier shall be provided throughout the building thermal envelope. The air barriers shall be ~~permitted to be~~ located on the inside or outside of the building thermal envelope, located within the assemblies composing the building thermal envelope, or any combination thereof. The air barrier shall comply with Sections C402.5.1.1 and C402.5.1.2.

**Exception:** Air barriers are not required in buildings located in Climate Zone 2B.

**C402.5.1.2 Air barrier ~~compliance options~~. compliance.** A continuous air barrier for the opaque building envelope shall comply with the following:

1. Buildings or portions of buildings including group R and group I occupancy shall meet the provisions of Section C402.5.1.2.1 or C402.5.1.2.2.
2. Buildings or portions of buildings of other than group R and group I occupancy shall meet the provisions of Section C402.5.1.2.3.

   **Exceptions:**

   1. Buildings in Climate Zones 2B, 3B, 3C, and 5C.
   2. Buildings larger than 5000 square feet floor area in Climate Zones 0B, 1, 2A, 4B, and 4C.
   3. Buildings between 5000 and 50,000 square feet floor area in Climate Zones 0A, 3A and 5B.

3. Buildings or portions of buildings other than group R and group 1 occupancy that do not complete air barrier testing shall meet the provisions of Section C402.5.1.2.1 or C402.5.1.2.2.

**Add new text as follows:**

**C402.5.1.2.3 Non-residential building thermal envelope testing** The building thermal envelope shall be tested in accordance with ASTM E 779 or an equivalent method approved by the code official. The measured air leakage shall not exceed 0.40 cfm/ft$^2$ (2.0 L/s · m$^2$ ) of the building thermal envelope area at a pressure differential of 0.3 inch water gauge (75 Pa). Alternatively, portions of the building shall be tested and the measured air leakages shall be area-weighted by the surface areas of the building envelope in each portion. The weighted average test results shall not exceed the whole building leakage limit. In the alternative approach, the following portions of the building shall be tested:

1. The entire envelope area of all stories that have any spaces directly under a roof,
2. The entire envelope area of all stories that have a building entrance, exposed floor, or loading dock, or are below grade, and
3. Representative above-grade sections of the building totaling at least 25 percent of the wall area enclosing the remaining conditioned space.

**Exception:** Where the measured air leakage rate exceeds 0.40 cfm/ft$^2$ (2.0 L/s•m$^2$ ) but does not exceed 0.60 cfm/ft$^2$ (3.0 L/s•m2), a diagnostic evaluation using smoke tracer or infra-red imaging shall be conducted while the building is pressurized along with a visual inspection of the air barrier. Any leaks noted shall be sealed where such sealing can be made without destruction of existing building components. An additional report identifying the corrective actions taken to seal leaks shall be submitted to the code official and the building owner, and shall be deemed to comply with satisfy the requirements of this section.

**Reason:** Air leakage can be a significant source of energy waste in buildings, contributing to higher heating and cooling costs for building owners and occupants, and increasing risk related to comfort and durability. Air tightness testing can result in more attention to envelope assembly air barrier sealing and significantly reduced building leakage. Currently Section C402.5 Air Leakage – thermal envelope, allows air tightness testing as an alternative to meeting material or assembly selection and installation method requirements to ensure proper tightness and a controlled indoor environment. Adequate control over air leakage can provide many benefits, including reduced HVAC equipment sizing, better building pressurization, and energy savings due to reduced heating and cooling of infiltrated outside air. In moist climates, ensuring lower air leakage through whole-building testing can also result in better humidity control and reduced risk of durability issues.
While it is important that the materials and assemblies have limited leakage, that alone does not guarantee a low leakage building. Recent research (Wiss 2014) shows that 40% of buildings constructed *without* an envelope consultant have air leakage exceeding the currently optional test standard requirements, while buildings with envelope consultants all had leakage below 0.25 cfm/ft$^2$. Testing is the most reliable means of ensuring that the intent of this code section—limiting unintended energy waste in buildings due to air infiltration—will be achieved.

The measure retains the current IECC optional compliance path test limit of 0.40 cfm/ft$^2$ at 75 Pa. Since mandatory—rather than optional— testing would be a new requirement, it is appropriate to retain the current and higher limit of 0.4 cfm/ft$^2$ for improved building industry acceptance. Durston and Heron's review (2012) of the more stringent requirements by the U.S. Department of Defense (DOD) shows that without testing, the range of building leakage can exceed the requirement by more than double (0.9 cfm/ft$^2$). However, with testing included as part of the construction process, the average leakage of buildings was determined to be well below the 0.4 cfm/ft$^2$ limit. Therefore, based on the DOD findings, the test limit of 0.40 cfm/ft$^2$ is considered a realistic and achievable goal. In addition, the target is well established in the IECC, and aligns with similar optional requirements contained in Standard 90.1.

**Intent of the Code Change Proposal**

This code change proposal will require

· The leakage testing thresholds are the same as current optional testing thresholds.

· Proposed requirements for testing vary by climate zone and building size and are based on industry-accepted cost-effectiveness analysis methods.

· As outlined in the optional compliance path, portions of buildings could be tested on a sampling basis.

· Commercial buildings under 5000 square feet can be tested using residential methods, technicians, and

equipment with the maximum leakage rate set at 0.30 cfm/ft$^2$ (1.5 L/s · m$^2$) at 0.2 in. w.g. (50 Pa). This testing pressure differential is common for residential testing, and is equivalent to a leakage rate of 0.40 cfm/ft$^2$ (1.5 L/s · m$^2$) at 0.3 in. w.g. (75 Pa), the current alternative commercial test limit. Yet, implementing the residential procedure can dramatically reduce testing costs for these smaller buildings.

· Since this would be a new requirement, a backup exception is provided so that if a building fails the 0.40 cfm/ft$^2$ test, the building can still pass the requirement as long as the tested value is below 0.60 cfm/ft$^2$ and additional diagnostics are performed.

Climate Zones 0A and 0B are included in the code change proposal assuming that a code change proposal submitted by SEHPCAC to update the climate zones is submitted and approved. These climate zone designations can be removed from the proposal with no impact if the climate zones are not updated.

**What strategies are considered to minimize compliance burdens in the field?**

Three specific strategies are applied to minimize the impact of testing on building project costs:

· Testing is only required for certain building types and climate zones where analysis indicates it is cost-effective and the savings justifies the cost. Based on that analysis, size thresholds by climate zone are provided for non-residential buildings.

· It is also prudent to provide some flexibility in the test standard to allow for building industry acceptance and a transition to meeting a fixed testing requirement. Specifically, when the building envelope is complete and testing occurs, access to the air barrier for repairs is difficult. Thus, an exception is included that allows the tested leakage rate to be no more than 0.6 cfm/ft$^2$ as long as specific remediation efforts are made. This exception is meant to provide a modest relaxation of the requirement, but only if significant corrective actions are taken that may reduce the air leakage.

· As an additional strategy, the measure allows representative portions or a sample of spaces in the building to be tested instead of the whole building. This alternative supports more economical testing of large buildings, which can help reduce the compliance burden and is consistent with similar requirements in ASHRAE 90.1-2016.

**Existing Codes and Standards that Require Similar Testing Measures**

The measure is consistent with air leakage testing requirements and thresholds required by the State of Washington and City of Seattle commercial building energy codes (SDCI Community Engagement 2012), as well as procedures followed by the DOD for testing of commercial buildings referenced above. The City of Seattle requirements have been in place since 2009, and hundreds of commercial buildings have been tested under that code, including many large buildings. The proposed measure is less stringent than the current DOD requirements (0.25 cfm/ft$^2$), and case studies (Durston and Heron 2012) have shown that much lower leakage levels—in the range of 0.15 cfm/ft$^2$—can be achieved.

**Energy Savings**

An analysis of energy impact shows that annual energy savings from air barrier improvement resulting from testing due to the measure ranges from $5.07 to $71.88 per thousand square feet of floor area in offices in climate zones where testing is recommended. More details are found in the cost-effectiveness analysis referenced in the Appendix.

**Cost-effectiveness:** Pacific Northwest National Laboratory performed a cost-effectiveness analysis using the established DOE methodology (Hart and Liu 2015). Results of the analysis indicate that the average savings-to-investment ratio (SIR) and simple payback period (SPP) for commercial building testing with a limit of 0.40 cfm/ft$^2$ (1.5 L/s · m$^2$) at a pressure differential of 0.3 inch w.g. (50 Pa) in office buildings vary by size, as shown in the table below.

| Building size range, floor area square feet | <5000 | 5000 to 50,000 | >50,000 |
|---|---|---|---|
| Average SIR | 7.3 | 2.2 | 3.2 |
| Average SPP (years) | 7.1 | 13.1 | 10.2 |

A measure is cost-effective when the SIR is greater than 1.0, indicating that the present value of savings is greater than the incremental cost. Under ASHRAE 90.1 criteria, cost-effectiveness is proven when the simple payback is shorter than the scalar threshold of 22.2 years. Based on the cost-effectiveness analysis results, air barrier testing is specified for buildings that have both an SIR greater than 1 and a simple payback that is less than the 90.1 scalar threshold based on climate zone and building size.

As a result of breaks in cost assumptions, most climate zones qualify for testing for buildings below 5000 square feet, with fewer climate zones requiring testing for buildings larger than 50,000 square feet, and the fewest climate zones requiring testing for buildings between 5000 and 50,000 square feet.

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**Background References**

NEEC. 2011. *Air Barrier Management Fact Sheet*. https://neec.net/wp-content/uploads/2009/04/NREC-Air-Barrier-07-2011.pdf.

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**Cost Impact:** The code change proposal will increase the cost of construction
This measure will increase the cost of construction of new commercial buildings as whole building air leakage testing will be required except for primarily residential buildings (Group R and I building occupancies). Based on a survey of professional commercial building air barrier testing companies, it was determined that the cost of air

leakage testing fell into three ranges:

· $350 or $0.12 to $0.07 per square foot for buildings up to 5000 square feet

· $0.50 to $0.15 per square foot for buildings between 5000 and 50,000 square feet

· $0.15 to $0.09 per square foot for buildings between 50,000 and 100,000 square feet, with decreasing costs for larger buildings.

As demand for air leakage testing in commercial buildings increases, more companies will enter the market to provide these services. Therefore, a gradual decrease in cost is expected as more companies are available to do the testing.

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