### Code Amendment Proposal Form

For public amendments proposed to the 2018 editions of the International Codes

**Instructions:** Upload this form and all accompanying documentation at [www.denvergov.org/BuildingCode](http://www.denvergov.org/BuildingCode). If you are submitting your proposal on a separate sheet, make sure it includes all information requested below.

All proposals must be received by **April 26, 2019**.

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**CONTACT INFORMATION**

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Signature: [Signature]

**Co-proposed by:** Amber Wood, Denver Department of Public Health and Environment  
Jim Meyers, Southwest Energy Efficiency Project

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**AMENDMENT PROPOSAL**

Please use a separate form for each proposal.

1) Code(s) associated with this proposal. Please use acronym: **IECC**

2) Please check here if a separate graphic file is provided: ☐

3) Use this template to submit your proposal or attach a separate file, but please include all items requested below in your proposal. The only formatting needed is **BOLDING, STRIKEOUT AND UNDERLINING**. Please do not provide additional formatting such as tabs, columns, etc., as this will be done by CPD.

#### Code Sections/Tables/Figures Proposed for Revision:

**IECC C402.5**

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Code Name</th>
<th>Acronym</th>
<th>Code Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>DBC-xxxx</td>
<td>Denver Building Code–xxxx (code) amendments (e.g., DBC-IBC, DBC-IEBC)</td>
<td>IFGC</td>
<td>International Fuel Gas Code</td>
</tr>
<tr>
<td>IEBC</td>
<td>International Existing Building Code</td>
<td>IMC</td>
<td>International Mechanical Code</td>
</tr>
<tr>
<td>IECC</td>
<td>International Energy Conservation Code</td>
<td>IPC</td>
<td>International Plumbing Code</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IRC</td>
<td>International Residential Code</td>
</tr>
</tbody>
</table>

**Proposal:**

Modify Sections C402.5, and C402.5.1 as follows and add table C402.5.1 and section C402.5.1.3:
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/ft² (2.0 L/s · m²). 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 continuous air barrier 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.

No changes to sections C402.5.1.1

C402.5.1.2 Air barrier compliance options. 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 occupancies shall meet the provisions of Section C402.5.1.2.1, C402.5.1.2.2, or C402.5.1.2.3.
2. Buildings or portions of buildings other than Group R and Group I occupancy shall meet the provisions of Section C402.5.1.2.3.

No changes to sections C402.5.1.2.1 & C402.5.1.2.2

C402.5.1.2.3 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/ft² (2.0 L/s · m²) 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.
4. For R-2 Occupancies, 25% of the dwelling units.

Exception: Where the measured air leakage rate exceeds 0.40 cfm/ft² (2.0 L/s · m²) but does not exceed 0.60 cfm/ft² (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 satisfy the requirements of this section.

Supporting Information:

Purpose:
The purpose of this proposal is to improve the air leakage rates of commercial buildings through requiring air leakage testing in most cases.

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/ft². 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. According to a study by the Pacific Northwest National Lab (Achieving the 30% Goal: Energy and Cost Savings Analysis of ASHRAE Standard 90.1-2010), the prescriptive requirements used in the IECC and Standard 90.1 only deliver 1.0 CFM/sf, not the 0.4 cfm/sf that is required by testing. Due to the cost of testing, few projects choose the testing path unless testing is already being done as a...
part of an above-code program. This makes 1.0 cfm/sf the effective code requirement in the commercial section even though a more stringent testing path is available.

The measure retains the current IECC optional compliance path test limit of 0.40 cfm/ft² 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/ft² 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/ft²). 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/ft² limit. Therefore, based on the DOD findings, the test limit of 0.40 cfm/ft² 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.

This code change proposal will require:

- The leakage testing thresholds are the same as current optional testing thresholds.
- As outlined in the optional compliance path, portions of buildings could be tested on a sampling basis.
- Since this would be a new requirement, a backup exception is provided so that if a building fails the 0.40 cfm/ft² test, the building can still pass the requirement as long as the tested value is below 0.60 cfm/ft² and additional diagnostics are performed.

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/ft² 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.

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/ft²), and case studies (Durston and Heron 2012) have shown that much lower leakage levels—in the range of 0.15 cfm/ft²—can be achieved. This proposal is based on a proposal that has been submitted for the 2021 IECC.

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. When applied to the mid-rise and high-rise prototype models developed by the Pacific Northwest National Lab for energy code determinations studies, this measure saved 6-9% total energy use over the IECC-2015 in Denver’s climate zone.

Bibliography:


Referenced Standards:

NA

Note: List any new referenced standards that are proposed to be referenced in the code.

Impact:

The effect of the proposal on the cost of construction: ☒ Increase ☐ Reduce ☐ No Effect

- This measure will increase the cost of construction of new commercial buildings as whole building air leakage testing will be required in most cases. 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.

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/ft² (1.5 L/s · m²) at a pressure differential of 0.3 inch w.g. (50 Pa) in office buildings vary by size, as shown in the table below.

<table>
<thead>
<tr>
<th>Building size range, floor area square feet</th>
<th>&lt;5000</th>
<th>5000 to 50,000</th>
<th>&gt;50,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average SIR</td>
<td>7.3</td>
<td>2.2</td>
<td>3.2</td>
</tr>
<tr>
<td>Average SPP (years)</td>
<td>7.1</td>
<td>13.1</td>
<td>10.2</td>
</tr>
</tbody>
</table>

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.

The effect of the proposal on the cost of design: ☐ Increase ☒ Reduce ☐ No Effect

- There may be a minor increase in the cost of design due to the fact that a higher quality of detailing will be required in order to ensure that the building meets the requirement.

Is the proposal more or less restrictive than the I-codes: ☒ More ☐ Less ☐ Same

- Since the prescriptive path delivers significantly poorer infiltration than the testing compliance path, this proposal will increase stringency.

Departmental Impact: (To be filled out by CPD staff)

Note: CITY STAFF ONLY. Discuss the impact of this proposal in this section AND indicate the impact of this amendment proposal for each of the following:

- The effect of the proposal on the cost of review: ☐ Increase ☐ Reduce ☐ No Effect
- The effect of the proposal on the cost of enforcement/inspection: ☐ Increase ☐ Reduce ☐ No Effect