Aerosol Sealing Building Enclosures, Single and Multifamily Dwellings - Code Compliance Brief

Overview:

Intent:

The intent of this brief is to provide code-related information for aerosol sealing building enclosures to achieve durable air tightness levels that will be accepted as being in compliance with the code. This brief provides consistent information on documenting compliance with codes and standards for all relevant parties responsible for verifying compliance with those codes and standards (e.g., code officials, builders, contractors, designers, etc.) to assist in increased compliance and timely, less challenging, and more uniform plan reviews and field inspections.

Overview:

When a developer or builder is striving to meet a tighter envelope leakage specification to meet building code requirements or striving to build a higher-performance home, this technology could greatly reduce the cost to achieve that goal by providing a simple and relatively low-cost method for reducing the air leakage of a building envelope using an innovative approach that results in little to no change in overall building practices. (Harrington and Modera 2014).

Aerosol sealing of dwelling enclosures is a new approach to sealing that promises to address many of the shortcomings of traditional approaches. This technology originated with the use of aerosol sealants to seal ductwork, most notably through the Aeroseal® brand name and network of contractors. The process has been refined and modified to simultaneously measure and seal envelope leakage. A fan is used to pressurize the dwelling enclosure, then a sealant is released into the space by atomizing nozzles that disperse particles small enough to be carried by air currents. The resulting fog of sealant particles are drawn to envelope air leaks, where they catch on the edges and accumulate. Eventually, enough particles build up that they seal the leaks entirely. Initial evaluations of the process indicate the potential for large reductions in building air leakage.

A team of technicians can achieve a required level of airtightness in a precalculated amount of time and verify infiltration rates as the process unfolds. This approach compares to traditional methods in which the air leakage test is one of the last stages of construction, when remediation is difficult and expensive. Therefore, aerosol sealing has the potential to dramatically reduce the labor and expense associated with achieving air sealing. (Harrington and Modera 2014).

Requirements for addressing air leakage have increased over the last couple of versions of the International Energy Conservation Code (IECC) and International Residential Code (IRC). The 2012 IECC/IRC set the stage by requiring mandatory air leakage testing for the first time (the previous version, 2009 IECC/IRC, required a visual inspection). The air leakage rates have also become more stringent from requiring 7 air changes per hour at 50 Pa (ACH) in all climate zones in the 2009 IECC to requiring 5 ACH in climate zones 1-2 and requiring 3 ACH in climate zones 3-8 in the 2012/2015/2018 IECC/IRC. The latest requirement applies to all residential buildings, which includes detached one- and two-family dwellings and multiple single-family dwellings (townhouses), as well as Group R-2 (apartment dwellings), R-3, and R-4 buildings three stories or less in height above-grade plane (see code brief on Air Sealing and Insulating Common Walls in Multifamily Buildings[1]). Air leakage rates at these new levels cannot be achieved unless planning and careful attention to detail is taken into account with each phase of construction (e.g., footing and foundation and framing and plumbing rough-in, etc.). The code also expanded upon the components of the thermal building envelope, air barriers, and insulation installation criteria listing the different components where air leakage can occur (e.g., ceiling, exterior walls, windows/diors, foundation, plumbing and electrical etc.). The code does not specify specific air barrier material(s) or sealants for each of the components, which are described in the table, Air Barrier and Insulation Installation[1], except for stating that sealing methods between dissimilar materials shall allow for differential expansion and contraction and must be installed in accordance with the manufacturer’s instructions as well as the criteria listed in the code. Failure of compliance in meeting the air leakage rate can be costly, especially if air leakage testing is done post-construction (i.e., when the building envelope construction has been completed). Finding the area(s) that have not been properly sealed and resealing them could take many -hours and could delay the final certificate of occupancy.

The U.S. Department of Energy Building America research team, Center for Energy and Environment, continues to do research on aerosol sealing in new construction. The project developed guides and case studies for optimal integration of aerosol envelope sealing for new home construction. The team worked with builders in MN and CA to identify options for when to seal and what current sealing can be eliminated. The sealing guides will enable builders to reduce infiltration space conditioning energy use by over 50% which can reduce space conditioning energy use by over 10%. Project was completed July 31, 2019 (see report on Auto-Sealing New Home Leaks with Aerosols[2]). A new project, however, has just begun to continue aerosol sealing research.

Since this technology is not addressed in the code, the next section of this Code Compliance Brief lists applicable code requirements and details helpful for Plan Review. The Field Inspection section provides details regarding the inspection of the air barrier.
Plan Review:

**How do builders, designers, and building/code officials comply with the new technology if it is not addressed in code?** States and local jurisdictions can have unique adoption processes with their own legislative and regulatory adoption language and code adopting bodies that adopt different building codes and code versions (e.g., 2009, 2012, 2015, or newly published 2018 IRC/IECC). States and local jurisdictions that have not adopted the 2018 IRC and/or IECC could reference the most recent version of the IRC/IECC for guidance. The building code (IRC/IECC) allows for alternative materials, design, and methods of construction and equipment not specifically prescribed by code and this would include consideration of new guidance published in more recent versions of model codes. Consequently, the building official/code official[1] has the authority and responsibility to review and approve the proposed design as satisfactory and compliant with the intent of the provisions of the code (per Section R104.11/IRC and Section R102.1/IECC) as a means of achieving code compliance. The alternative materials, design, and methods provision has been a long-standing allowance and this important tradition has been continued in every version of the IRC/IECC. The alternative methods section in the IRC is below:

**2018 IRC, Section R104.11 Alternative Materials, Design and Method of Construction and Equipment.** The provisions of this code are not intended to prevent the installation of any material or to prohibit any design or method of construction not specifically prescribed by this code. The building official shall have the authority to approve an alternative material, design, or method of construction upon application of the owner or the owner’s authorized agent. The building official shall first find that the proposed design is satisfactory and complies with the intent of the provisions of this code, and the material, method, or work offered is for the purpose intended, not less than equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability and safety. Compliance with the specific performance-based provisions of the International Codes shall be an alternative to the specific requirements of this code. When the alternative materials, design or method of construction is not approved, the building official shall respond in writing, stating the reasons why the alternative was not approved (2018 IECC, Section R102.1 has similar language).

**2018 IRC, Section R104.11.1, Tests.** Whenever there is insufficient evidence of compliance with the provisions of this code, or evidence that a material or method does not conform to the requirements of this code, or in order to substantiate claims for alternative materials or methods, the building official shall have authority to require tests as evidence of compliance to be made at no expense to the jurisdiction. Test methods shall be as specified in this code or by other recognized test standards. In the absence of recognized and accepted test methods, the building official shall approve the testing procedures. Tests shall be performed by an approved agency. Reports of such tests shall be retained by the building official for the period required for retention of public records.

The lists and provisions provided in each section below are intended to target the main code sections and provisions. Words and terms that are italicized, appear in code text and the Chapter 2 definition applies. Other references, code sections, standards, testing methods, etc., that affect the technology or other assemblies or functions of the building may exist.

**Plan Review:**

This section provides applicable code sections and provisions in the 2018, 2015, 2012, and 2009 IRC and IECC in regard to air sealing the building thermal envelope.

**2015/2018 IRC, Section R104.1 General.** The building official has authority to render interpretations of this code and to adopt policies and procedures in order to clarify the application of its provisions. Such interpretations, policies and procedures shall be in conformance with the intent and purpose of this code.

**2015/2018 IECC, Section 103.1 General.** Construction documents, technical reports or other supporting data shall be submitted in one or more sets with each application for a permit. The documents shall be prepared by a registered design professional here required by the statutes of the jurisdiction in which the project is to be constructed. Where special conditions exist, the code official is authorized to require necessary construction documents to be prepared by a registered design professional.

**Construction Documentation.** Review the construction documents for details describing air sealing and construction techniques.

**2015/2018 IRC/IECC, Section R106.3/R103.3 Examination of Documents.** The code official must examine or cause to be examined construction documents for code compliance.

**2015/2018 IRC/IECC, Section N1101.5/R103.2 Information on construction documents.** Construction documents should include:

- Air sealing details (copy of building plans specifying where air sealing will be completed, type(s) of sealant)
- Confirm that the continuous air barrier is specified

and air sealing components. Refer to the last section of this brief for resources on technical validation, case studies, best practices, and measure guidelines.
Air Sealing/Air Leakage Control. Confirm all areas required to be sealed have been identified and components and materials used to seal such areas are acceptable. Confirm air leakage testing meets provisions of the code.

2015/2018 IRC/IECC, Section N1102.4/R402.4 Air Leakage. The building thermal envelope should be constructed to limit air leakage.

- **Section N1102.4.1/R402.4.1 Building Thermal Envelope.** The sealing methods between dissimilar materials should allow for differential expansion and contraction.

- **Section N1102.4.1.1/R402.4.1.1 Installation.** The components listed in the Air Barrier and Insulation Installation Table should be installed in accordance with the manufacturer’s instructions and the criteria listed as the applicable method of construction. Where required by the building/code official, an approved third party shall inspect all components and verify compliance.

Below are the General Requirements and components that are applicable to sealing building thermal envelope assemblies.

**Air Barrier and Insulation Installation Table N1102.4.1.1/R402.4.1.1**

- **Continuous air barrier[2]** – Confirm that construction documents specify a continuous air barrier for the building components associated with the insulation. Air-permeable insulation should not be used as a sealing material.

- **Ceiling/attic** – The air barrier in any dropped ceiling/soffit should be aligned with the insulation and any gaps in the air barrier sealed. Access openings, drop-down stairs, or knee wall doors to unconditioned attic spaces should be sealed.

- **Walls** – Cavities within corners and headers of frame walls should be insulated by completely filling the cavity with a material having a thermal resistance of R-3 per inch minimum. Exterior thermal envelope insulation for framed walls should be in substantial contact and continuous alignment with the air barrier.

- **Floors (including above-garage and cantilevered floors)** – The air barrier should be installed at any exposed edge of insulation. Floor framing cavity insulation should be installed to maintain permanent contact with the underside of subfloor decking, or floor framing cavity insulation should be permitted to be in contact with the top side of sheathing, or continuous insulation installed on the underside of floor framing and extends from the bottom to the top of all perimeter floor framing members.

- **Crawl space walls** – Exposed earth in unvented crawl spaces should be covered with a Class 1 vapor retarder with overlapping joints taped.

- **Crawl space insulation installation** – Where provided instead of floor insulation, insulation should be permanently attached to the crawlspace walls.

- **Rim joists** – Rim joists should include the air barrier and be insulated.

- **Shafts/penetrations** – Duct shafts, utility penetrations, and flue shaft openings to the exterior or unconditioned space are sealed.

- **Recessed lighting** – Recessed lighting fixtures installed in the ceiling (vented attic) are sealed to the drywall, and the fixtures installed are air tight and IC rated.

- **HVAC register boots** – HVAC register boots that penetrate the ceiling (vented attic) are sealed to the subfloor or drywall.

- **Plumbing and wiring** – Batt insulation should be cut neatly to fit around wiring, and plumbing or insulation that on installation readily conforms to available space should extend behind piping and wiring.

- **Concealed sprinklers** – Concealed fire sprinklers should only be sealed in a manner that is recommended by the manufacturer. Caulking or other adhesive sealants should not be used to fill voids between fire sprinkler cover plates and ceiling.

**Section N1102.4.1.2/R402.4.1.2 Testing.** The building or dwelling unit shall be tested and verified as having an air leakage rate not exceeding five air changes per hour in Climate Zones 1 and 2, and three air changes per hour in Climate Zones 3 through 8. Testing shall be conducted in accordance with ASTM E 779 or ASTM E 1827 (testing standards referenced are new in the 2015 IRC/IECC and RESNET/ICC 380 is new to 2018 IECC) and reported at a pressure of 0.2 inch w.g. (50 Pascals). Where required by the code official, testing shall be conducted by an approved third party. A written report of the results of the test shall be signed by the party conducting the test and provided to the code official. Testing shall be performed at any time after creation of all penetrations of the building thermal envelope[3] (this code section has additional details on testing).

2012 IRC/IECC, N1102.4/R402.4 Air Leakage. The building thermal envelope should be constructed to limit air leakage.

- **Section N1102.4.1/R402.4.1 Building Thermal Envelope.** The sealing methods used between dissimilar materials should allow for differential expansion and contraction.
**Section N1102.4.1.1/R402.4.1.1 Installation.** The components listed in the Air Barrier and Insulation Installation Table should be installed in accordance with the manufacturer’s instructions and the criteria listed as the applicable method of construction. Below are the components from the table that are applicable to sealing the building thermal envelope assemblies.

**Section N1102.4.1.1/R402.4.1.1 Air Barrier and Insulation Installation Table**

- **Air barrier and thermal barrier** – A continuous air barrier should be installed in the building envelope (ceiling). Breaks or joints in the air barrier should be sealed. Air-permeable insulation should not be used as a sealing method.

- **Ceiling/attic** – The air barrier in any dropped ceiling/soffit should be aligned with the insulation and any gaps in the air barrier should be sealed. Access openings, drop-down stair or knee wall doors to unconditioned attic spaces should be sealed.

- **Walls** – The junction of the top plate and top of exterior walls should be sealed. Exterior thermal envelope insulation for framed walls should be installed in substantial contact and continuous alignment with the air barrier.

- **Floors (including above-garage and cantilevered floors)** – Insulation should be installed to maintain permanent contact with underside of subfloor decking. The air barrier should be installed at any exposed edge of insulation.

- **Rim joists, shafts/penetrations, plumbing and wiring, and HVAC register boots** – Similar language as the 2015 IRC/IECC.

- **Crawl space walls** – Where provided instead of floor insulation, insulation should be permanently attached to the crawlspace walls. Exposed earth in unvented crawl spaces should be covered with a Class 1 vapor retarder with overlapping joints taped.

- **Shafts/penetrations, recessed lighting, and HVAC register boots** – Similar language as the 2015 IRC/IECC.

**Section N1102.4.1.2/R402.4.1.2 Testing.** Similar language as the 2015 IRC/IECC, except testing shall be done with a blower door instead of referencing testing standards.

**2009 IRC/IECC, N1102.4.1/402.4.1 Air leakage, Building Thermal Envelope**

The building thermal envelope should be constructed to limit air leakage. Sealing methods used between dissimilar materials should allow for differential expansion and contraction. Sources of infiltration that should be caulked, gasketed, weather-stripped, or otherwise sealed with an air-barrier material, suitable film, or solid material include:

- All joints, seams, and penetrations
- Utility penetrations
- Dropped ceilings or chases adjacent to the thermal envelope
- Attic access openings
- Rim joist junction
- Other sources of infiltration.

**EXISTING BUILDINGS**

Review the construction documents and confirm whether compliance is required based on the scope of work proposed on the existing building:

- Work proposed is exempt (not required) to meet the provisions of the code
- Work proposed is not exempt and proper documentation has been submitted that specifies compliance will be met.

If only air sealing will be completed to an existing building, the code does not specifically address that compliance would be required. It could be considered an energy upgrade. Re-air sealing the existing building thermal envelope does not typically alter any of the building thermal envelope assemblies, therefore, it would not be considered an alteration and the measure does not add newly conditioned floor area to the existing building, therefore it would not be considered an addition. Re-air sealing the thermal building envelope could be considered “maintenance or repair” and if confirmed with the building/code official, compliance would be exempt.

**2015/2018 IRC/IECC, Section N1107.1.1/R501.1.1 Additions, alterations, or repairs: - General.** Alterations to an existing building or portion thereof should comply with Section N1108/R502, N1109/R503 or N1110/R504. Unaltered portions of the existing building or building supply system are not required to comply.
2015/2018 IRC/IECC, Section N1108.1/R502.1 General. Additions to existing buildings should conform to code as they relate to new construction without requiring the unaltered portion of the existing building or building system to comply.

- **Section N1108.1.1/R502.1.1 Building Envelope.** New building envelope assemblies that are part of the addition should comply with Sections N1102.1/R402.1, N1102.2/R402.2, N1102.3.1/R402.3.1 through N1102.3.5/R402.3.5 and N1102.4/R402.4.
  - Exception: where non-conditioned space is changed to conditioned space, the building envelope of the addition must comply where the UA (U-factor x Area), as determined in Section N1102.1.4/R402.1.4 (U-factor Alternative[4]), of the existing building and the addition, and any alterations that are part of the project is less than or equal to UA generated for the existing building.

**Alterations**

- **2015/2018 IRC/IECC, Section N1109.1/R503.1 General.** Alterations to any building or structure should comply with the requirements of the code for new construction. Alterations should be such that the existing building or structure is no less conforming to the provisions of this code than the existing building or structure was prior to the alteration. Alterations should not create an unsafe or hazardous condition or overload existing building systems. Alterations should be such that the existing building or structure uses no more energy than the existing building or structure prior to the alteration.

- **Section N1103.2/R503.2 Change in space conditioning.** Any non-conditioned or low-energy space that is altered to become conditioned space should be required to be in full compliance with this code. (This means not only the altered assembly is brought into compliance but the entire space or building also would need to be brought into compliance.)

- **Section N1109.1.1/R503.1.1 Building Envelope.** Building envelope assemblies that are part of the alteration must comply with Sections N1102.1.2/R402.1.2 (Insulation and Fenestration Table) or N1102.1.4/R402.1.4 (U-Factor Alternative), and Sections N1102.2.1/R402.2.1 through N1102.2.12/R402.2.12, N1102.3.1/R402.3.1, N1102.3.2/R402.3.2, N1102.4.3/R402.4.3 and N1102.4.4/R402.4.4.

Exception: The following alterations need not comply with the requirements for new construction provided the energy use of the building is not increased:

- Existing ceiling cavities exposed during construction, provided that the cavities are filled with insulation
- Construction where the existing roof cavity is not exposed
- Roof recover
- Roofs without insulation in the cavity and where the sheathing or insulation is exposed during reroofing should be insulated either above or below the sheathing.

[1] Building official/code official are both defined as the officer or other designated authority charged with the administration and enforcement of the code or duly authorized representative. IRC references the building official and IECC refers to the Code official.

1. The term “continuous air barrier” is defined as a combination of materials and assemblies that restrict or prevent the passage of air through the building thermal envelope.

[3] The term “building thermal envelope” is defined as the basement walls, exterior walls, floor, roof, and any other building elements that enclose conditioned space or provide a boundary between conditioned space and exempt or unconditioned space.

[4] “U-factor Alternative” An assembly with a U-factor equal to or less than that specified in Table N1102.1.4/R402.1.4 should be permitted as an alternative to the R-value in Table N1102.1.2/R402.1.2.

**Field Inspection:**

This section provides details for inspecting to the specific provisions for air leakage where one or more specific types of inspection called for by the IRC or IECC may be necessary to confirm compliance. To confirm code compliance, all phases of construction should be taken into consideration.

Per the 2015/2018 IRC, Section R109 Inspections, for onsite construction, from time to time the building official, upon
notification from the permit holder or his agent, can make or cause to be made any necessary inspections. Further details are provided for inspections regarding the foundation, plumbing, mechanical, gas and electrical, floodplain, frame and masonry, and the final inspection. Any additional inspections are at the discretion of the code official.

Per the 2015/2018 IECC, Section R104 Inspections, construction or work for which a permit is required is subject to inspection. Construction or work is to remain accessible and exposed for inspection purposes until approved. Required inspections include footings and the foundation, framing and rough-in work, plumbing rough-in, mechanical rough-in, and final inspection.

Inspections should provide verification in the following areas:

- Joints, seams, holes, shafts and penetrations caulked, gasketed, weather-stripped, or otherwise sealed (building thermal envelope assemblies).
- Ceiling/attic – access openings, drop down stairs or knee wall doors, dropped ceiling soffits aligned with insulation and any gaps in air barrier sealed
- Walls – junction of the foundation and sill plate sealed, junction of top plate and top of exterior walls, knee walls sealed, corners, and headers sealed
- Windows/skylights/doors – space between framing sealed
- Floors – air barrier installed at any exposed edge
- Crawl space walls – unvented, Class I vapor retarder
- Garage separation – air sealing between garage and living space (conditioned space)
- Recessed lighting – sealed to drywall
- Plumbing and wiring – holes, gaps, penetrations sealed
- HVAC register boots – sealed where penetration is at drywall
- Concealed sprinklers - sealed in a manner that is recommended by manufacturer.

Technical Validation(s):

This section provides additional related information and references to materials applicable to the provision.

  
  Author(s): ICC
  
  Organization(s): ICC
  
  Publication Date: May 2014/October 2017

  This code for residential buildings creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy, and electrical provisions for one- and two-family residences.

  
  Author(s): ICC
  
  Organization(s): ICC
  
  Publication Date: May 2014/October 2017

  This code establishes a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems, and service water heating systems in homes and commercial businesses.


The Western Cooling Efficiency Center at the University of California-Davis has performed controlled testing on lab-constructed enclosures as well as limited field testing on single-family new construction and existing homes to demonstrate the concept of aerosol sealing. Preliminary data from those tests have been very promising, yielding at least a 50% reduction in enclosure leakage in test homes (Harrington and Modera 2014). In single-family homes, the benefit of air sealing is well documented and understood. In multifamily buildings, reducing enclosure leakage is equally important, but because the buildings can be taller, controlling stack effect becomes an important priority as well. One strategy to reduce stack effect is compartmentalization.

Related BASC Guides/Code Compliance Briefs:


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