Air Seal HVAC Cabinet Seams

Last Updated: 04/19/2016

Scope

Seal seams and holes in the air handler or furnace cabinet of central forced air HVAC systems to prevent the loss of conditioned air.

- Select an air handler with a manufacturer’s designation showing that air leakage is ≤2% of the design air flow rate.
- Use mastic, mastic plus embedded fiberglass mesh fabric, or UL 181A or B tape to seal all cabinet seams and junctures between the air handler or furnace cabinet and the evaporator coil cabinet, the supply plenum and the return plenum.
- Use putty around all conduit and wiring holes.
- Use UL-approved gaskets to seal cabinet doors and access panels.
- Seal all unused conduit knockouts with UL-listed tape or mastic.
- Seal all fixed seams in the cabinets and all seams between the cabinet and the supply or return plenums with mastic or mastic and fiberglass mesh fabric.
- Use a sealing putty to seal the inside of the high-voltage wire conduit termination point in the air handler after the wiring has been installed.
- Check the insulation inside the air handler where the conduit enters. If the insulation has been compromised, repair it with approved spray glue and additional insulation.
- Use a duct blower tester to test the airtightness of the air handler/furnace cabinet and ducts. Verify that the duct system meets code or program airtightness requirements.

See the Compliance Tab for related codes and standards, and criteria to meet national programs such as ENERGY STAR, DOE’s Zero Energy Ready Home program, and EPA’s Indoor airPLUS.
Many homes are equipped with central forced air systems that rely on ducts to transport heated or cooled air from a furnace or heat pump to the rest of the home. If the ducts are leaky, they can be a source of energy loss through loss of heated or cooled air, poor HVAC performance through loss of air pressure in the ducts, and comfort problems. Air leakage problems can be worst at the HVAC furnace or air handler cabinet, where air pressures are highest. Cabinet seams, holes, and junctions should be sealed to prevent air leakage. The only place air should be able to leave the supply duct system and the furnace or air handling unit is at the supply registers. The only place air should be able to enter the return duct system and the furnace or air handling unit is at the return grilles (Building Science Corporation 2011).

In high-performance homes, all HVAC equipment, including the furnace or heat pump air handler and any ducts, should be located within the thermal envelope of the home. When the air handler is located within the conditioned space, it is tempting to think that sealing the cabinet is not that important because conditioned air will leak into the home rather than being lost to an attic or crawlspace. However, sealing cabinet air leaks is still very important for maximizing the performance of the HVAC equipment because it helps to ensure maximum air flow to the ducts. In a central forced air system, the highest air pressures are experienced at the air handler, with pressures increasing the closer one gets to the air handler fan. It is common for air pressures in the supply and return plenum at the air handler to equal or exceed 0.5-inches water column (125 Pascals). Therefore, it is critical to seal up the knockouts, seams, and slots in the air handler cabinet.

Gas- or oil-fired furnaces are often equipped with an add-on refrigerant coil (called the evaporator coil) to provide cooling during the summer months (Figure 1). The connection between the evaporator coil cabinet and the furnace cabinet is likely the highest point of pressure in the system and can be a large source of leakage if care is not taken to properly seal this juncture during installation. Refrigerant coil cabinets do not always fit directly on top of the furnace; many coil cabinets have a larger footprint than the furnace so the seam between the two boxes is uneven. The coil cabinet should be sealed to the furnace using mastic or an Underwriters Laboratories (UL) 181 approved foil tape. For larger gaps (greater than 3/8 inch) mastic and fiberglass mesh tape should be used.

Air handlers (Figure 2), furnaces, and evaporator coil cabinets come from the factory with holes in the form of knockouts, penetrations, and slots for installing piping and wiring. These holes are there for ease of installation and service. However, when installation is completed, any unused holes should be sealed, along with gaps around wiring and piping. Holes where the condensate line and refrigerant lines penetrate the evaporator coil cabinet will be the next highest pressure point, and depending on the model may be a point of negative pressure. Seal around these lines with non-hardening putty. Use non-hardening putty to seal around pipes, tubing, and conduit penetrations in the air handler cabinet as well. This putty comes in strips, slugs, and cords (see Figure 3) and does not dry out, but remains pliable so it can be removed and reapplied. Seal unused electrical and piping knockouts with mastic.

The third point of high (negative) pressure is the area of the cabinet that houses the indoor blower fan. With respect to indoor air quality, this may be considered the most concerning area for air leakage, especially if the furnace is located in a garage or any other area where chemicals are stored or where there is exposure to carbon monoxide. Any seams or unused holes should be sealed with mastic.

The connections with the supply and return plenums are additional areas that experience high pressures. These seams and other cabinet seams should be sealed with mastic, mastic and fiberglass mesh tape, or UL-approved tape.

There are some penetrations in a furnace cabinet that are not considered leakage points. The furnace in Figure 1 is a condensing
gas furnace. The penetrations for the condensate line for the condensing gas furnace, vent pipes, gas line, and high voltage wiring (not shown) are not connected to the conditioned air stream and therefore are not areas of concern for leakage.

Regarding cabinet panels that must be periodically removed for routine maintenance of the HVAC equipment, some HVAC technicians suggest using cloth-backed duct tape to seal the panel seams because it is easy to remove or cut through.

Figure 2. Air seal a heat pump or air conditioner air handler cabinet at all seams, holes, and junctions.

Figure 3. Non-hardening removable putty can be used to seal around wiring holes in the HVAC cabinet.

How to Air Seal the HVAC Cabinet

1. Install the furnace or air handler and all associated ducting within the conditioned space of the home. Select an air handler with a manufacturer’s designation showing that air leakage is no more than 2% of the design air flow rate when tested in accordance with ASHRAE 193 (per 2012 IECC R403.2.2.1).

2. Use Underwriters Laboratory (UL) approved gaskets, mastic, mastic plus embedded fiberglass mesh fabric, or UL 181A or B tape to seal all cabinet seams and junctures between the air handler or furnace cabinet and the evaporator coil cabinet, the supply plenum and the return plenum.

3. Use putty around all conduit and wiring holes.

4. Seal all unused conduit knockouts with UL-listed tape or mastic. Seal all fixed seams in the cabinets and all seams between the cabinet and the supply or return plenums with mastic or mastic and fiberglass mesh fabric.

5. Use a sealing putty to seal the inside of the high-voltage wire conduit termination point in the air handler after the wiring has been installed.

6. Check the insulation inside the air handler where the conduit enters. If the insulation has been compromised, repair it with approved spray glue and additional insulation.

7. Use a duct blower tester to test the airtightness of the air handler/furnace cabinet and ducts. Verify that the duct system meets code or program airtightness requirements.
Ensuring Success

Install the air handler within the conditioned space of the home.

Seal all seams and holes in the air handler cabinet.

Test the airtightness of the cabinets and ducts with a duct blower test. Verify that the duct system meets code or program airtightness requirements.
Climate

No climate specific information applies.
Training

Right and Wrong Images

Display Image: 2019-Amaris-X-Utility Room 2.jpg
GASKET ON PANEL OR ITS CONTACT SURFACE

MERV 8 FILTER (OR HIGHER RATING)

WITH COMPLETE CONTACT WITH FILTER RACK, ACCESS PANEL IS GASKETED.
- HIGH-EFFICIENCY FILTER UNITS CAN BE SUBSTITUTED FOR MERV 8 PANEL FILTER.
- GOOD FIT OF FILTER IN RACK PREVENTS AIR FROM PASSING AROUND FILTER, SIGNIFICANTLY LOWERING EFFICIENCY.
CAD
None Available
Compliance

The Compliance tab contains both program and code information. Code language is excerpted and summarized below. For exact code language, refer to the applicable code, which may require purchase from the publisher. While we continually update our database, links may have changed since posting. Please contact our webmaster if you find broken links.

ENERGY STAR Certified Homes, Version 3.3.1 (Rev. 09)

National Rater Field Checklist

HVAC System.
6.4 Rater-measured total duct leakage meets one of the following two options. Alternative in Footnote 37, 36, 37, 38
6.4.1 Rough-in: The greater of 4 CFM25 per 100 sq. ft. of CFA or 40 CFM25, with air handler & all ducts, building cavities used as ducts, & duct boots installed. In addition, all duct boots sealed to finished surface, Rater-verified at final. 39
6.4.2 Final: The greater of 8 CFM25 per 100 sq. ft. of CFA or 80 CFM25, with the air handler & all ducts, bldg. cavities used as ducts, duct boots, & register grilles atop the finished surface (e.g., drywall, floor) installed. 40
6.5 Rater-measured duct leakage to outdoors the greater of 4 CFM25 per 100 sq. ft. of CFA or 40 CFM25. 36, 38, 41

Footnote 36) Items 6.4 and 6.5 only apply to heating, cooling, and balanced ventilation ducts. Duct leakage shall be determined and documented by a Rater using the same version of ANSI / RESNET / ICC Std. 380 that is utilized by RESNET for HERS ratings. Leakage limits shall be assessed on a per-system, rather than per-home, basis. For balanced ventilation ducts that are not connected to space heating or cooling systems, a Rater is permitted to visually verify, in lieu of duct leakage testing, that all seams and connections are sealed with mastic or metal tape and all duct boots are sealed to floor, wall, or ceiling using caulk, foam, or mastic tape.

Many states have adopted state- or region-specific ENERGY STAR Certified Homes criteria - Please see the ENERGY STAR Certified Homes website for regional specifications.

DOE Zero Energy Ready Home (Revision 07)

Exhibit 1 Mandatory Requirements.
Exhibit 1, Item 1) Certified under the ENERGY STAR Qualified Homes Program or the ENERGY STAR Multifamily New Construction Program.
Exhibit 1, Item 3) Duct distribution systems located within the home’s thermal and air barrier boundary or an optimized location to achieve comparable performance.
Exhibit 1, Item 6) Certified under EPA Indoor airPLUS.

Footnote 14) Exceptions and alternative compliance paths to locating 100% of forced-air ducts in home’s thermal and air barrier boundary are:

a. Up to 10’ of total duct length is permitted to be outside of the home’s thermal and air barrier boundary.

b. Ducts are located in an unvented attic, regardless of whether this space is conditioned with a supply register.

c. Ducts are located in a vented attic with all of the following characteristics: [Note that in either of these designs the HVAC equipment must still be located within the home’s thermal and air barrier boundary.

1. In Moist climates (Zones 1A, 2A, 3A, 4A, 5A, 6A and 7A per 2015 IECC Figure R301.1) and Marine climates (all “C” Zones per 2015 IECC Figure R301.1), minimum R-8 duct insulation with an additional minimum 1.5” of closed-cell spray foam insulation encapsulating the ducts; duct leakage to outdoors ≤ 3 CFM25 per 100 ft2 of conditioned floor area (in addition to meeting total duct leakage requirements from Section 4.1 of the ENERGY STAR HVAC Rater checklist); and ductwork buried under at least 2” of blown-in insulation.

2. In Dry climates (all “B” Zones per 2015 IECC Figure R301.1), minimum R-8 duct insulation; duct leakage to outdoors ≤ 3 CFM25 per 100 ft2 of conditioned floor area (in addition to meeting total duct leakage requirements from Section 4.1 of the ENERGY STAR HVAC Rater checklist); and ductwork buried under at least 3.5” of blown-in insulation.

d. Systems which meet the criteria for “Ducts Located in Conditioned Space” as defined by the 2018 IECC Section R403.3.7

e. Jump ducts which do not directly deliver conditioned air from the HVAC unit may be located in attics if all joints, including boot-to-drywall, are fully air sealed with mastic or foam, and the jump duct is fully buried under the attic insulation.

f. Ducts are located within an unvented crawl space.

g. Ducts are located in a basement which is within the home’s thermal boundary.

h. Ductless HVAC system is used.

Please see the DOE Zero Energy Ready Home website for state-specific requirements.

EPA Indoor airPLUS (Revision 04)
4.2 Duct System Design and Installation. Indoor airPLUS requires that homes meet ENERGY STAR for Homes criteria including the requirement that all duct systems are installed to be substantially airtight. Indoor airPLUS advises that seams in the HVAC cabinet, plenum and adjacent ductwork should be sealed with mastic systems, tape that meets the applicable requirements of UL 181a or UL 181b, or gasket systems.

2009 International Energy Conservation Code (IECC)

403.2.2 Ducts. Sealing (Mandatory). All ducts, air handlers, filter boxes, and building cavities used as ducts should be sealed. Duct tightness should be verified by duct leakage testing (testing is not required if the air handler and all ducts are in conditioned space.) Testing can be done at rough-in or when construction is complete.

If testing is done at rough in, total leakage must be < 6 cfm/100 sq. ft. of conditioned floor area when tested at a pressure difference of 25 Pascals (Pa) across the roughed in system, including the manufacturer's air handler enclosure, with all register boots sealed. If the air handler is not installed at the time of the test, total air leakage must be < 4 cfm/100 sq. ft. of conditioned floor area.

If testing is done post construction, leakage to outdoors must be < 8 cfm/100 sq. ft. of conditioned floor area or total leakage must be < 12 cfm/100 sq. ft. of conditioned floor area at 25 Pa across the system including the air handler enclosure.

2012, 2015, and 2018 IECC

R403.2.2 (R403.3.2 in 2015 and 2018 IECC) Ducts. Sealing (Mandatory). All ducts, air handlers, and filter boxes should be sealed. Duct tightness should be verified by duct leakage testing (testing is not required if the air handler and all ducts are in conditioned space). Testing can be done at rough-in or when construction is complete.

If testing is done at rough-in, total leakage must be < 4 cfm/100 sq. ft. of conditioned floor area when tested at a pressure difference of 25 Pa across the roughed in system including the manufacturer's air handler enclosure, with all register boots sealed. If the air handler is not installed at the time of the test, total air leakage must be < 3 cfm/100 sq. ft. of conditioned floor area.

If testing is done post construction, leakage to outdoors must be < 4 cfm/100 sq. ft. of conditioned floor area at 25 Pa across the system including the air handler enclosure.

R403.2.2.1 (R403.3.2.1 in 2015 and 2018 IECC) Sealed air handler. The air handler should have a manufacturer's designation showing that air leakage is no more than 2% of the design air flow rate when tested in accordance with ASHRAE 193.


Section R101.4.3 (Section R501.1.1 in 2015 and 2018 IECC). Additions, alterations, renovations, or repairs shall conform to the provisions of this code, without requiring the unaltered portions of the existing building to comply with this code. (See code for additional requirements and exceptions.)

2009 International Residential Code (IRC)

M1601.4.1 Duct Installation: Joints and Seams. The joints of duct systems shall be made airtight by means of tapes, mastics, liquid sealants, gasketing, or other approved closure systems.

2012, 2015, and 2018 IRC

M1601.4.1 Duct Installation: Joints, Seams, and Connections. The joints of duct systems should be sealed with welds, gaskets, mastics, mastic plus embedded fabric, or tape.


Section N1101.3 (Section N1107.1.1 in 2015 and 2018 IRC). Additions, alterations, renovations, or repairs shall conform to the provisions of this code, without requiring the unaltered portions of the existing building to comply with this code. (See code for additional requirements and exceptions.)

Appendix J regulates the repair, renovation, alteration, and reconstruction of existing buildings and is intended to encourage their continued safe use.


603.9 Joints, seams and connections. Securely fasten all joints, seams, and connections with welds, gaskets, mastics, mastic plus embedded fabric, liquid sealants, or tapes that are listed and in accordance with Underwriters Laboratory: For connecting rigid duct use UL 181A products marked “181A-P” for pressure-sensitive tape, “181 A-M” for mastic, or “181 A-H” for heat-sensitive tape. For flexible ducts use UL 181B sealants marked “181B-FX” for pressure-sensitive tape or “181B-M” for mastic. The connections of ducts to the flanges of air distribution system equipment should be sealed and mechanically fastened.

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 Springer 2015).

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). 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/doors, 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). 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 and air sealing components. Refer to the last section of this brief for resources on technical validation, case studies, best practices, and measure guidelines.

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 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
- Air leakage testing results (pre and post results)
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/R402.4.1 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.

### ADDITIONS

**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/R402.3.3.5 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 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.

[^4]: 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.
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.

“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:**


More Info.

Access to some references may require purchase from the publisher. While we continually update our database, links may have changed since posting. Please contact our webmaster if you find broken links.

Case Studies

   Author(s): PNNL
   Organization(s): PNNL, FSEC, BA-PIRC
   Publication Date: January, 2013
   Case study about a DOE Building America 2012 Top Innovation on ventilation strategies in hot and humid climates developed and assessed by Florida Solar Energy Center.

2. Technology Solutions Case Study: Sealed Air-Return Plenum Retrofit (780KB)
   Author(s): PNNL
   Organization(s): PNNL
   Publication Date: August, 2012
   Case study about retrofitting a leaky air handler.

References and Resources*

1. ACCA Manual D - Residential Duct Systems
   Author(s): Air Conditioning Contractors of America
   Organization(s): Air Conditioning Contractors of America
   Publication Date: December, 2013
   Standard outlining industry procedure for sizing residential duct systems.

2. ACCA Standard 5: HVAC Quality Installation Specification
   Author(s): Air Conditioning Contractors of America
   Organization(s): Air Conditioning Contractors of America
   Publication Date: January, 2015
   Standard providing a universally accepted definition for quality installation for residential and commercial heating, ventilating, and air conditioning applications.

3. ACCA Standard 9: HVAC Quality Installation Verification Protocols
   Publication Date: January, 2016
   Document detailing the requirements, roles, and obligations for participants in an organized effort, ensuring that HVAC installations comply with the ANSI/ACCA 5 QI – 2010 (HVAC Quality Installation Specification) QI Standard.

4. Duct Sealing
   Author(s): Building Science Corporation
   Organization(s): Building Science Corporation
   Publication Date: May, 2009
   Brochure with details on HVAC duct air sealing.

5. Indoor airPLUS Construction Specifications Version 1 (Rev. 03)
   Author(s): U.S. Environmental Protection Agency
   Organization(s): EPA
   Publication Date: October, 2015
   Document outlining specifications that were developed by the U.S. Environmental Protection Agency (EPA) to recognize new homes equipped with a comprehensive set of indoor air quality (IAQ) features.

   Author(s): Beal, McIlvaine, Fonrow, Martin
   Organization(s): BA-PIRC, National Renewable Energy Laboratory, Florida Solar Energy Center, FSEC
   Publication Date: November, 2011
   Document illustrating guidelines for efficient installation of interior duct systems in new housing.

7.
8. **Vent Right and Then? Mechanical Ventilation, Dehumidification, and Energy Use in Humid Climates**

   **Author(s):** Fairey, Parker, Vieira, Martin  
   **Organization(s):** FSEC  
   **Publication Date:** September, 2014

   Preliminary results of two monitored lab homes constructed to represent the thermal characteristics of typical existing Florida homes are presented.

*Publication dates are shown for formal documents. Dates are not shown for non-dated media. Access dates for referenced, non-dated media, such as web sites, are shown in the measure guide text.

**Contributors to this Guide**

The following authors and organizations contributed to the content in this Guide.

- Calcs-Plus  
- Pacific Northwest National Laboratory