U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy

BUILDING TECHNOLOGIES PROGRAM

Air Leakage GUIDE

Building Energy Codes

Meeting the Air Leakage Requirements of the

2012 IECC

The U.S. Department of Energy (DOE) recognizes the enormous potential that exists for improving the energy efficiency, safety and comfort of homes. The newest edition of the International Energy Conservation Code® (IECC) (2012) sets the bar higher for energy efficiency, and new air sealing requirements are one of the key new provisions.

This guide is a resource for understanding the new air leakage requirements in the 2012 IECC and suggestions on how these new measures can be met. It also provides information from Building America's Air Sealing Guide, Best Practices and case studies on homes that are currently meeting the provisions. The 2012 IECC and a few International Residential Code (IRC) requirements are referenced throughout the guide.

Building Energy Code Resource Guide:

Air Leakage Guide

PREPARED BY

Building Energy Codes

DOE's Building Energy Codes Program (BECP) is an information resource on national energy codes. BECP works with other government agencies, state and local jurisdictions, national code organizations, and industry to promote stronger building energy codes and help states adopt, implement, and enforce those codes.

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1 INTRODUCTION: Basics of Air Leakage

Air leakage control is an important but commonly misunderstood component of the energy efficient house. Tightening the structure with caulking and sealants has several positive impacts.

A tight house will:

- Have lower heating bills due to less heat loss
- Have fewer drafts and be more comfortable
- Reduce the chance of mold and rot because moisture is less likely to enter and become trapped in cavities
- Have a better performing ventilation system
- Potentially require smaller heating and cooling equipment capacities.

Air leakage is sometimes called infiltration, which is the unintentional or accidental introduction of outside air into a building, typically through cracks in the building envelope and through use of doors for passage. In the summer, infiltration can bring humid outdoor air into the building. Whenever there is infiltration, there is corresponding exfiltration elsewhere in the building. In the winter, this can result in warm, moist indoor air moving into cold envelope cavities. In either case, condensation can occur in the structure, resulting in mold or rot. Infiltration is caused by wind, stack effect, and mechanical equipment in the building (see Figure 1).

Wind creates a positive pressure on the windward face and negative pressure on the non-windward (leeward) facing walls, which pulls the air out of the building. Wind causes infiltration on one side of a building and exfiltration on the other. Wind effects can vary by surrounding terrain, shrubs, and trees.

The “stack effect” is when warm air moves upward in a building. This happens in summer and winter, but is most pronounced in the winter because indoor-outdoor temperature differences are the greatest. Warm air rises because it’s lighter than cold air. So when indoor air is warmer than the outdoor air, it escapes out of the upper levels of the building, through open windows, ventilation openings, or penetrations and cracks in the building envelope. The rising warm air reduces the pressure in the base of the building, forcing cold air to infiltrate through open doors, windows, or other openings. The stack effect basically causes air infiltration on the lower portion of a building and exfiltration on the upper part.

Mechanical equipment such as fans and blowers causes the movement of air within buildings and through enclosures, which can generate pressure differences. If more air is exhausted from a building than is supplied, a net negative pressure is generated, which can induce unwanted airflow through the building envelope.

Bathroom exhaust fans, clothes dryers, built-in vacuum cleaners, dust collection systems, and range hoods all exhaust air from a building. This creates a negative pressure inside the building. If the enclosure is airtight or the exhaust flow rate high, large negative pressures can be generated.

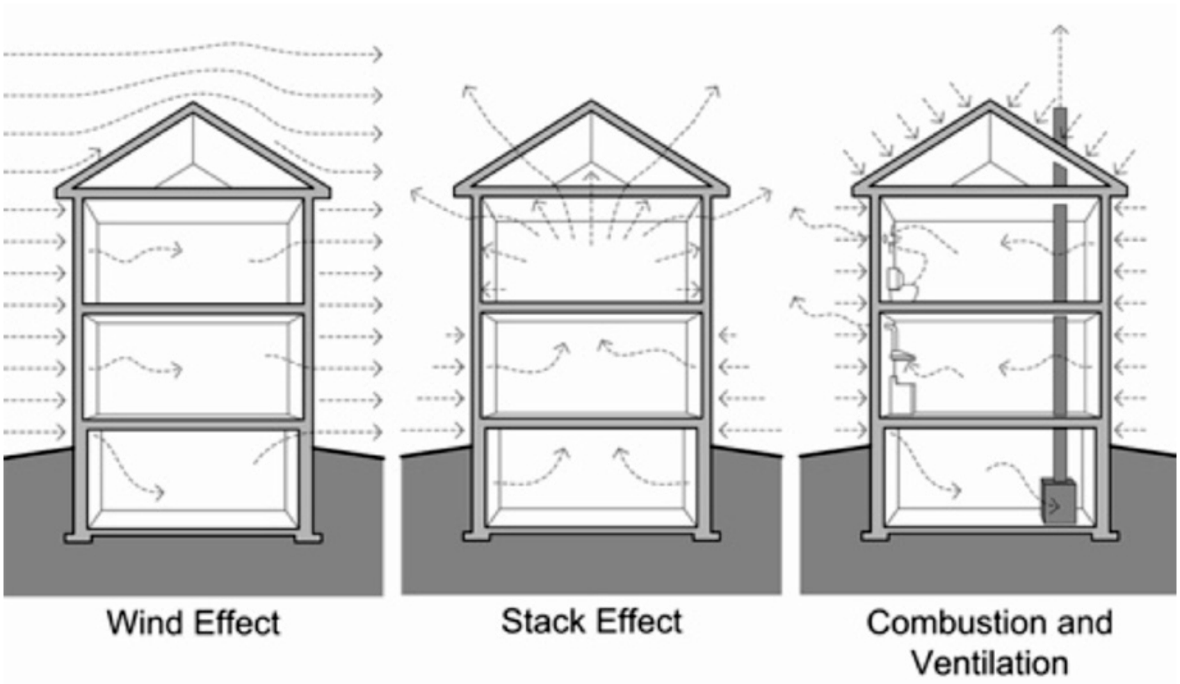


Figure 1: Examples of infiltration. Image courtesy: Building Science Corporation, www.buildingscience.com

2 CODES: New Code Air Leakage Requirements

The 2012 IECC has several new requirements for verification of air sealing in new construction and additions. **These new requirements apply to new construction, additions, and alterations where adopted by states and local jurisdictions.** Furthermore, additional language was added to clarify that where there are conflicts or differences between provisions of the IECC and referenced codes, the IECC provisions must apply (Section R106, 2012 IECC).

For more information on the status of state code adoption, visit **http://www.energycodes.gov/states/**

R106.1.2 Provisions in Referenced Codes and Standards

Where the extent of the reference to a referenced code or standard includes subject matter that is within the scope of this code, the provisions of this code, as applicable, shall take precedence over the provisions in the referenced code or standard.

Sealing the building thermal envelope has been required by the energy code for many years (editions of the IECC). However, in years past the provisions were somewhat vague and only required that areas of potential air leakage such as joints, seams, and utility penetrations be sealed with a durable material such as caulking, gasketing, or weather stripping. The 2009 IECC required verification of air sealing by either a visual inspection against a detailed checklist or a whole-house pressure test. The 2012 IECC ***NOW*** requires all new construction and additions be both visually inspected and pressure tested as mandatory requirements. There have been some slight changes to the visual inspection checklist and ratcheting down of the testing parameters, requiring houses to be much tighter than the previous edition of the code (see Figure 2 and Table 1).

DEFINITIONS

As defined according to 2012 IECC:

BUILDING

Any structure used or intended for supporting or sheltering any use or occupancy, including any mechanical systems, service water heating systems and electric power and lighting systems located on the building site and supporting the building.

BUILDING THERMAL ENVELOPE

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.

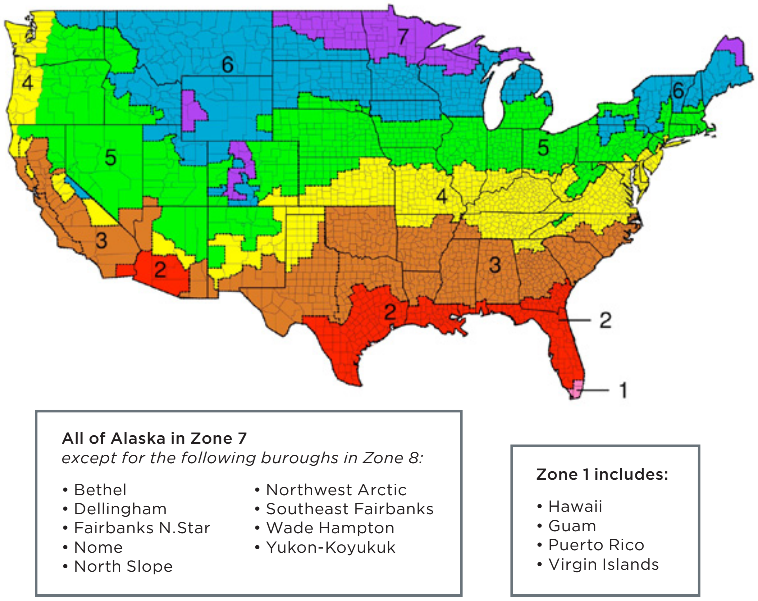


Figure 2: Climate zones (by county) for the 2012 IECC

Climate Zone	2009 IECC	2012 IECC
1 - 2	< 7 ACH	≤ 5 ACH @ 50 pascals
3 - 8	< 7 ACH @ 50 pascals	≤ 3 ACH @ 50 pascals

Table 1: 2009 vs. 2012 IECC Comparisons

R402.4 Air leakage (Mandatory)

The building thermal envelope shall be constructed to limit air leakage in accordance with the requirements of Sections R402.4.1 through R402.4.4.

3 PLANNING: Air Sealing Measures and Checklists

The 2012 IECC provides a comprehensive list of components that must be sealed and inspected. However, unless the components are installed properly, passing the inspection and meeting the tested air leakage rate requirements may not be achievable without rebuilding some construction assemblies (such as gypsum board) that were previously installed. A good example is the air barrier between the ceiling (unconditioned attic) and conditioned space (living area). Since air leakage paths are driven by the fact that warm air rises, the attic is the largest area (square footage) of potential heat loss. Areas in the ceiling that might not have been sealed properly could include recessed cans, wires, pipes, attic access panels, drop down stair or knee wall doors and more. Figure 3 is a picture taken with an infrared camera illustrating where the temperature difference is and potential heat loss. The reds and purples indicate higher heat loss areas.

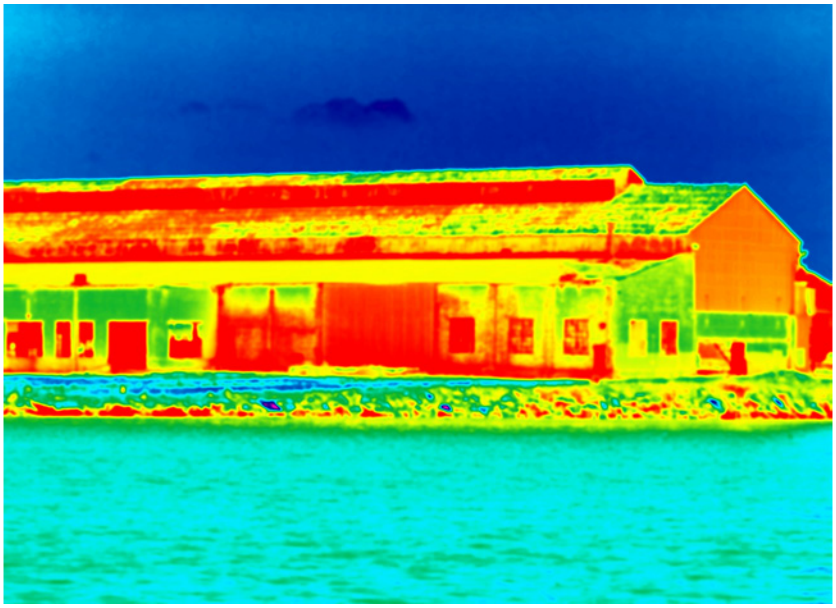
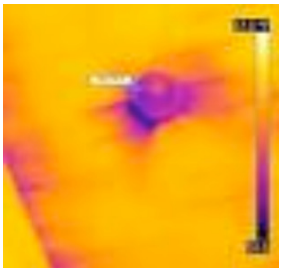
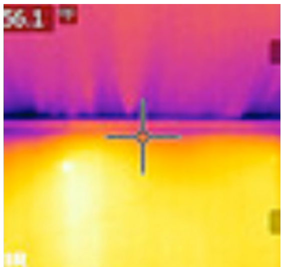


Figure 3: Air Leakage Test Results



Recessed Can



Ceiling Plane

DEFINITIONS
As defined according to 2012 IECC:

AIR BARRIER
Material(s) assembled and joined together to provide a barrier to air leakage through the building envelope. An air barrier may be a single material or combination of materials.

CONTINUOUS AIR BARRIER
A combination of materials and assemblies that restrict or prevent the passage of air through the building thermal envelope.

R402.4.1.1 Installation
The components of the building thermal envelope as listed in Table R402.4.1.1 shall be installed in accordance with the manufacturer's instructions and the criteria listed in Table R402.4.1.1, as applicable to the method of construction. Where required by the code official an approved third party shall inspect all components and verify compliance.

The IECC's checklist covers not only air barriers but proper installation of insulation and other elements. **In Table 402.4.1.1, items that are directly related to air leakage and proper air barriers are highlighted in yellow.**

Even though the IECC checklist lists 14 specific components that are directly related to air barriers, more attention must be focused on all areas that have potential for air leakage. A good understanding of building science can facilitate proper air sealing. For example, Building America research identifies 19 key areas where air sealing can improve a home's energy efficiency, comfort, and building durability.

Common air sealing trouble spots are shown in Figure 4 on page 8 and listed in the following table. Several of these trouble spots are described in more detail as highlighted in the Building America Air Sealing Checklist.

Additional information on other trouble spots and other building science information can be found in the Building America Best Practices guides and Air Leakage guide available for free download at **www.buildingamerica.gov**.

Builders, contractors, and/or designers should develop an air sealing strategy beginning with reviewing the building plans and identifying potential areas of air leakage. These checklists can be used to help identify the areas. The strategy also needs to include the types of materials that will be used to create an air barrier and seal the building envelope. The IECC does not identify specific products that must be used to create air barriers and seal the building envelope, but does require that the materials allow for expansion and contraction.

Table R402.4.1.1 (2012 IECC). Air Barrier and Insulation Installation*

COMPONENT	CRITERIA*
Air barrier and thermal barrier	A continuous air barrier shall be installed in the building envelope. Exterior thermal envelope contains a continuous air barrier. Breaks or joints in the air barrier shall be sealed. Air-permeable insulation shall not be used as a sealing material.
Ceiling/attic	The air barrier in any dropped ceiling/soffit shall be aligned with the insulation and any gaps in the air barrier sealed. Access openings, drop down stair or knee wall doors to unconditioned attic spaces shall be sealed.
Walls	Corners and headers shall be insulated and the junction of the foundation and sill plate shall be sealed. The junction of the top plate and top of exterior walls shall be sealed. Exterior thermal envelope insulation for framed walls shall be installed in substantial contact and continuous alignment with the air barrier. Knee walls shall be sealed.
Windows, skylights and doors	The space between window/door jambs and framing and skylights and framing shall be sealed.
Rim joists	Rim joists shall be insulated and include the air barrier.
Floors (including above-garage and cantilevered floors)	Insulation shall be installed to maintain permanent contact with underside of subfloor decking. The air barrier shall be installed at any exposed edge of insulation.
Crawl space walls	Where provided in lieu of floor insulation, insulation shall be permanently attached to the crawl space walls. Exposed earth in unvented crawl spaces shall be covered with a Class I vapor retarder with overlapping joints taped.
Shafts, penetration	Duct shafts, utility penetrations and flue shafts opening to exterior or unconditioned space shall be sealed.
Narrow cavities	Batts in narrow cavities shall be cut to fit, or narrow cavities shall be filled by insulation that on installation readily conforms to the available cavity space.
Garage separation	Air sealing shall be provided between the garage and conditioned spaces.
Recessed lighting	Recessed light fixtures installed in the building thermal envelope shall be air tight, IC rated, and sealed to the drywall.
Plumbing and wiring	Batt insulation shall be cut neatly to fit around wiring and plumbing in exterior walls, or insulation that on installation readily conforms to available space shall extend behind piping and wiring.
Shower/tub on exterior wall	Exterior walls adjacent to showers and tubs shall be insulated and the air barrier installed separating them from the showers and tubs.
Electrical/phone box on exterior walls	The air barrier shall be installed behind electrical or communication boxes or air sealed boxes shall be installed.
HVAC register boots	HVAC register boots that penetrate building thermal envelope shall be sealed to the subfloor or drywall.
Fireplace	An air barrier shall be installed on fireplace walls. Fireplaces shall have gasketed doors.

*In addition, inspection of log walls shall be in accordance with the provisions of ICC-400.

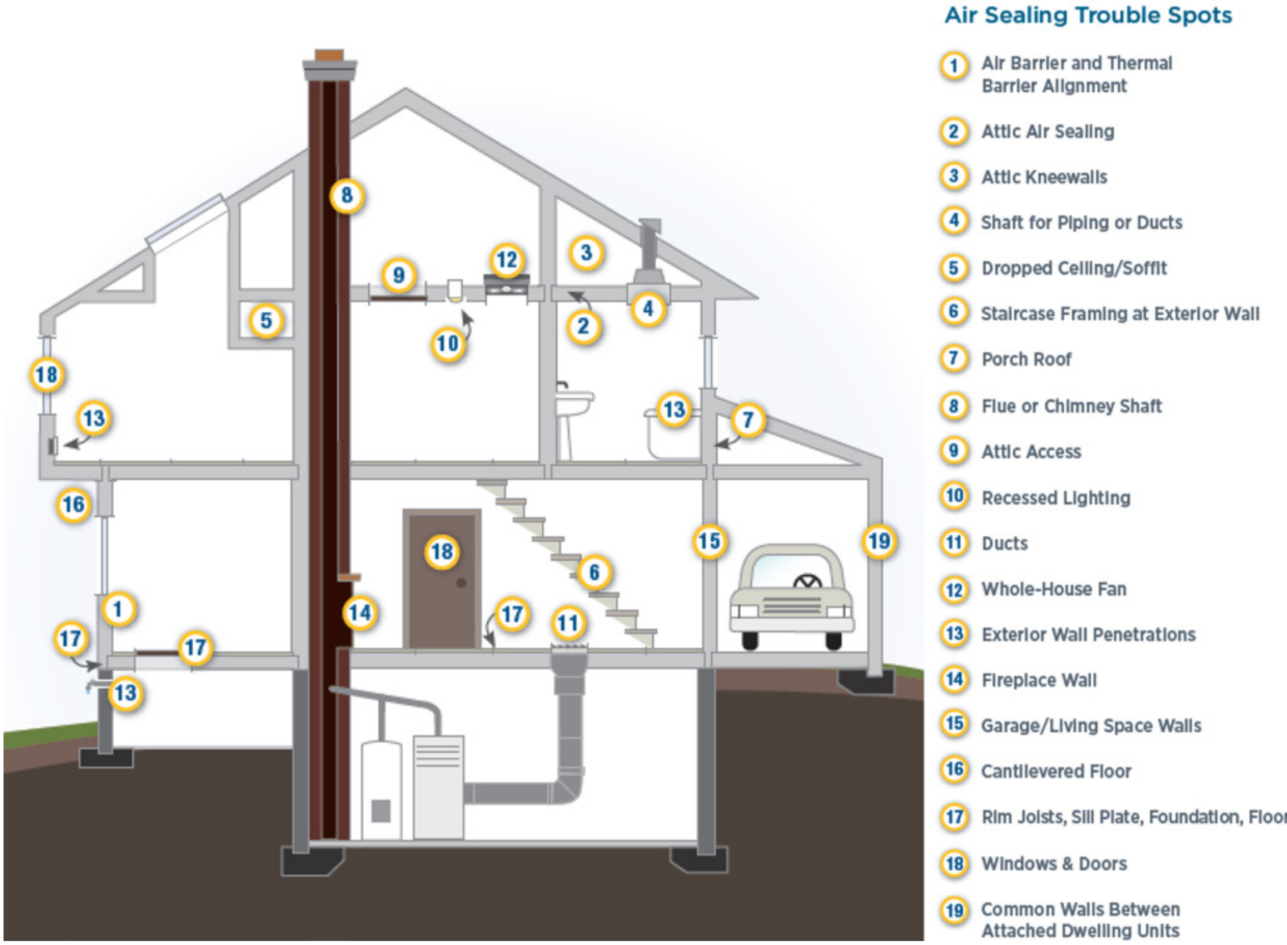


Figure 4: Building America—air sealing trouble spots

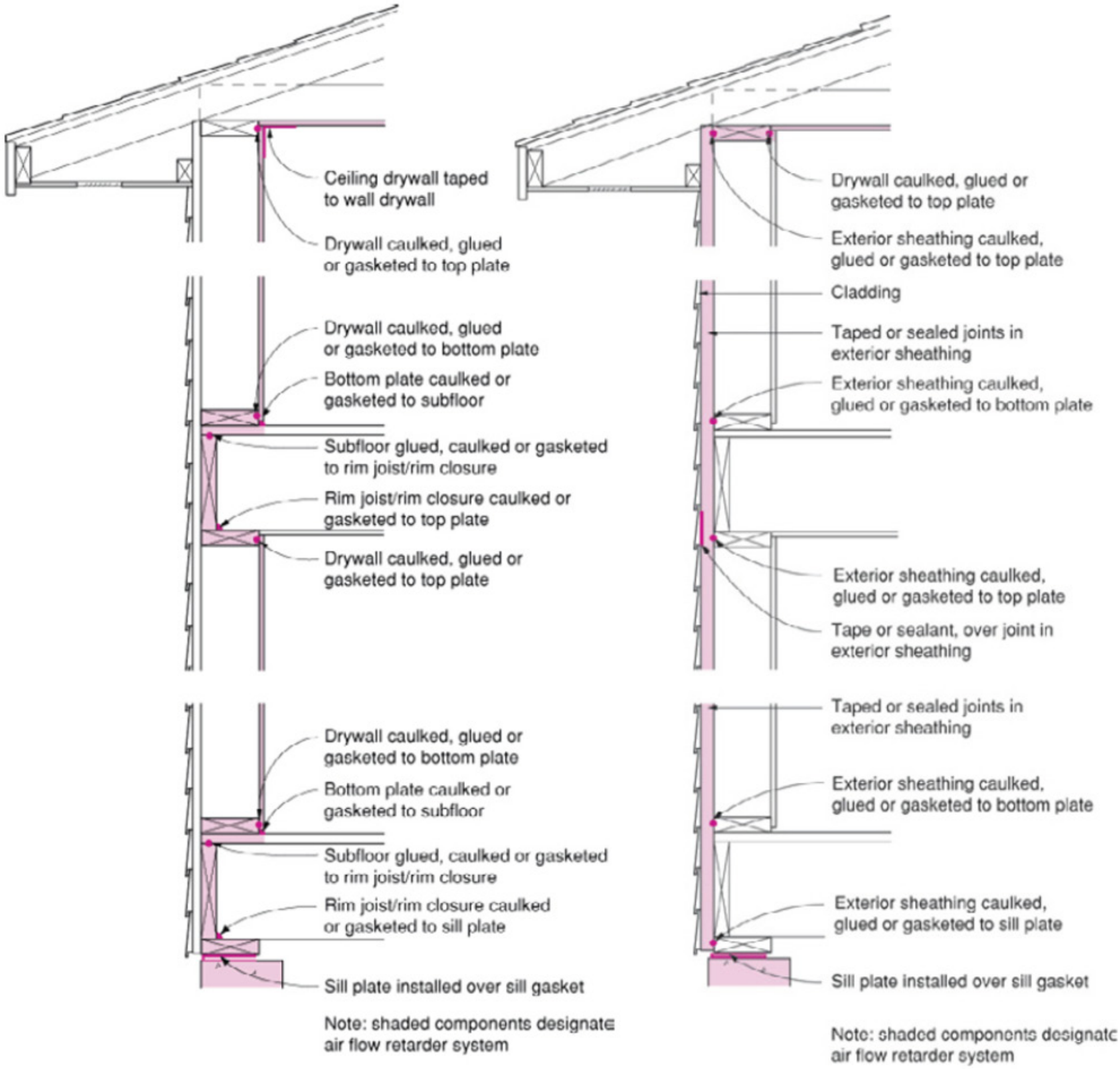
Table 2. Building America Air Sealing Checklist

Air Barrier	Completion Guidelines
1. Air Barrier and Thermal Barrier Alignment	Air Barrier is in alignment with the thermal barrier (insulation).
2. Attic Air Sealing	Top plates and wall-to-ceiling connections are sealed.
3. Attic Kneewalls	Air barrier is installed at the insulated boundary (kneewall transition or roof, as appropriate).
4. Duct Shaft/Piping Shaft and Penetrations	Openings from attic to conditioned space are sealed.
5. Dropped Ceiling/Soffit	Air barrier is fully aligned with insulation; all gaps are fully sealed.
6. Staircase Framing at Exterior Wall/Attic	Air barrier is fully aligned with insulation; all gaps are fully sealed.
7. Porch Roof	Air barrier is installed at the intersection of the porch roof and exterior wall.
8. Flue or Chimney Shaft	Opening around flue is closed with flashing, and any remaining gaps are sealed with fire-rated caulk or sealant.
9. Attic Access/Pull-Down Stair	Attic access panel or drop-down stair is fully gasketed for an air-tight fit.
10. Recessed Lighting	Fixtures are provided with air-tight assembly or covering.
11. Ducts	All ducts should be sealed, especially in attics, vented crawlspaces, and rim areas.
12. Whole-House Fan Penetration at Attic	An insulated cover is provided that is gasketed or sealed to the opening from either the attic side or ceiling side of the fan.
13. Exterior Walls	Service penetrations are sealed and air sealing is in place behind or around shower/tub enclosures, electrical boxes, switches, and outlets on exterior walls.
14. Fireplace Wall	Air sealing is completed in framed shaft behind the fireplace or at fireplace surround.
15. Garage/Living Space Walls	Air sealing is completed between garage and living space. Pass-through door is weather stripped.
16. Cantilevered Floor	Cantilevered floors are air sealed and insulated at perimeter or joist transition.
17. Rim Joists, Seal Plate, Foundation, and Floor	Rim joists are insulated and include an air barrier. Junction of foundation and sill plate is sealed. Penetrations through the bottom plate are sealed. All leaks at foundations, floor joists, and floor penetrations are sealed. Exposed earth in crawlspace is covered with Class I vapor retarder overlapped and taped at seams.
18. Windows and Doors	Space between window/door jambs and framing is sealed.
19. Common Walls Between Attached Dwelling Units	The gap between a gypsum shaft wall (i.e., common wall) and the structural framing between units is sealed.

Items highlighted in yellow will be discussed in more detail.

Air Barrier and Thermal Barrier Alignment

Envelope Air Sealing



Source: Building Science Corporation

Attic Kneewalls

Air barrier is installed at the insulated boundary (kneewall transition or roof, as appropriate)

Kneewalls, the sidewalls of finished rooms in attics, are often leaky and uninsulated. A contractor can insulate and air seal these walls in one step by covering them from the attic side with sealed rigid foam insulation. A contractor can plug the open cavities between joists beneath the kneewall with plastic bags filled with insulation or with pieces of rigid foam. Another option is to apply rigid foam to the underside of the rafters along the sloped roof line and air seal at the top of the kneewall and the top of the sidewall, which provides the benefit of both insulating the kneewall and providing insulated attic storage space.

Doors cut into kneewalls should also be insulated and air sealed by attaching rigid foam to the attic side of the door, and using a latch that pulls the door tightly to a weather-stripped frame.

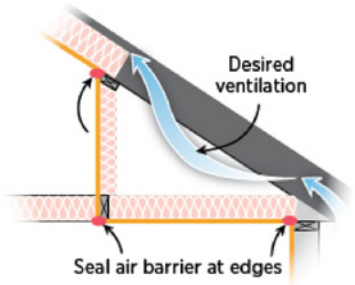


Figure 5. Insulate and air seal the kneewall itself, as shown, or along the roof line (Source: DOE 2000a).

Figure 6. Air seal floor joist cavities under kneewalls by filling cavities with fiberglass batts that are rolled and stuffed in plastic bags (as shown here) or use rigid foam, Oriented Strand Board (OSB), or other air barrier board cut to fit and sealed at the edges with caulk.

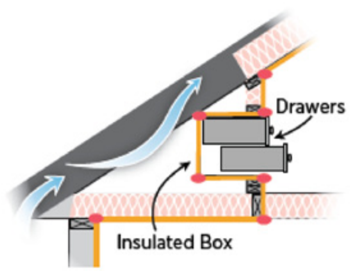


Figure 7. Build an airtight insulated box around any drawers or closets built into attic kneewalls that extend into uninsulated attic space. Insulate along air barrier (shown in yellow on drawing) or along roof line with rigid foam (Source: Iowa Energy Center 2008).

Dropped Ceiling/Soffit

Air barrier is fully aligned with insulation; all gaps are fully sealed

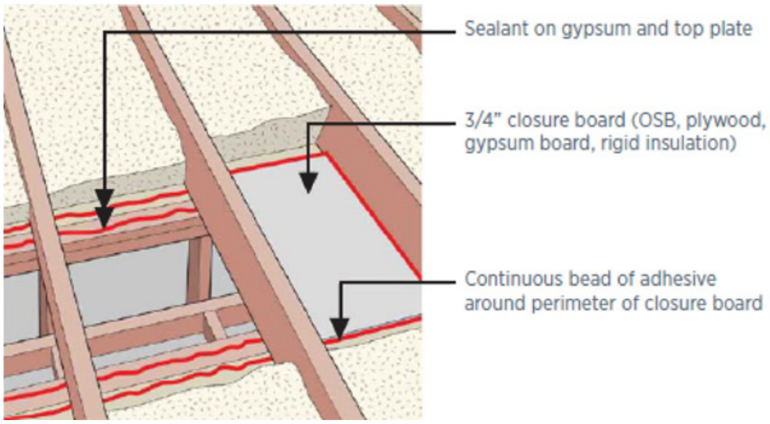
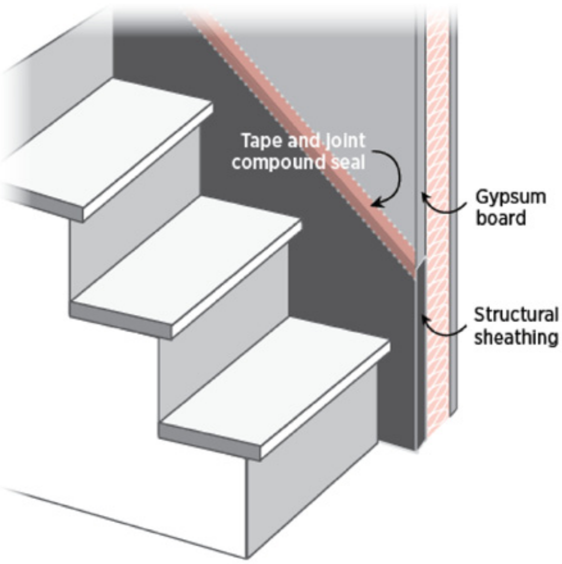


Figure 8. Place a solid air barrier over soffits as follows: pull back existing insulation; cover area with air barrier material (gypsum, plywood, OSB, rigid foam, etc.); seal edges with caulk; cover with insulation (Lstiburek 2010).

Soffits (dropped ceilings) found over kitchen cabinets or sometimes running along hallways or room ceilings as duct or piping chases are often culprits for air leakage. A contractor will push aside the attic insulation to see if an air barrier is in place over the dropped area. If none exists, the contractor will cover the area with a piece of rigid foam board, sheet goods, or reflective foil insulation that is glued in place and sealed along all edges with caulk or spray foam, then covered with attic insulation. If the soffit is on an exterior wall, sheet goods or rigid foam board should be sealed along the exterior wall as well. If the soffit contains recessed can lights, they should be rated for insulation contact and airtight or a dam should be built around them to prevent insulation contact.



Staircase Framing at Exterior Wall/Attic

Air barrier is fully aligned with insulation; all gaps are fully sealed

If the area under the stairs is accessible, look to see if the inside wall is finished. If not, have your contractor insulate it, if needed, and cover it with a solid sheet product like drywall, plywood, OSB, or rigid foam insulation. Then, your contractor can caulk the edges and tape the seams to form an air-tight barrier. Stairs should be caulked where they meet the wall.

Figure 9. Install an air barrier and air sealing on exterior walls behind stairs. If the area behind the stairs is inaccessible, caulk stairs where they meet the wall. Use caulk if the area is already painted; use tape and joint compound if area will be painted.

Porch Roof

Air barrier is installed at the intersection of the porch roof and exterior wall

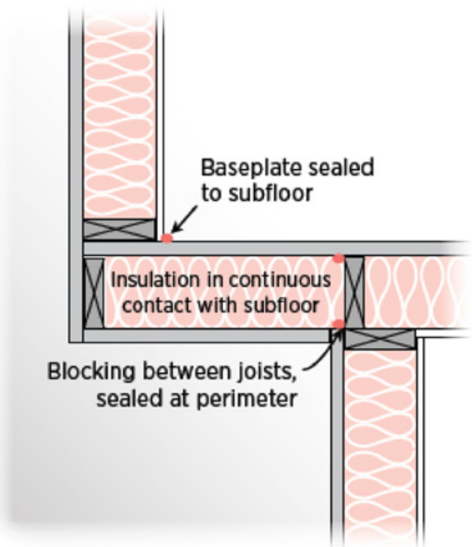
If a test-in inspection identifies air leakage at the wall separating the porch from the living space, the contractor will investigate to see if the wall board is missing or unsealed. If this is the case, the contractor will install some type of wall sheathing (oriented strand board, plywood, rigid foam board) cut to fit and sealed at the edges with spray foam. A contractor will also make sure this wall separating the attic from the porch is fully insulated.

Figure 10. When researchers pulled back the porch ceiling, they found the wall board was missing so nothing was covering the insulation on this exterior wall. An air barrier of rigid foam board was put in place with spray foam (Image: Moriarta 2008).

Studies Show

Steven Winter Associates, a Building America research team lead, used a blower door test and infrared cameras to investigate high-energy bill complaints at a 360-unit affordable housing development and found nearly twice the expected air leakage. Infrared scanning revealed an air leakage path on an exterior second-story wall above a front porch. Steven Winter Associates found that, while the wall between the porch and the attic had been insulated with unfaced fiberglass batts, wall board had never been installed. The insulation was dirty from years of windwashing as wind carried dust up through the perforated porch ceiling, through the insulation, into the attic and into the wall above. Crews used rigid foam cut to fit and glued in place with expandable spray foam to seal each area. Blower door tests showed the change reduced overall envelope leakage by 200 CFM_{50}. At a cost of $267 per unit, this fix resulted in savings of $200 per year per unit, for a payback of less than two years.

Cantilevered Floor



Cantilevered floors are air sealed and insulated at perimeter or joist transitions

Cantilevered floors, second-story bump-outs, and bay windows are another area in the home that often lacks proper air sealing. The floor cavity must be filled with insulation with good alignment (i.e., that is completely touching) the underside of the floor. The interior and exterior sheathing needs to be sealed at the framing edges. Blocking between floor joists should form a consistent air barrier between the cantilever and the rest of the house. Continuous sheathing, such as insulating foam sheathing, should cover the underside of the cantilever and be air sealed at the edges with caulk.

Figure 11. Block and air seal both the floor-to-upper wall junction and the floor-to-lower wall junction.

R402.4.1 Building thermal envelope

The building thermal envelope shall comply with Sections R402.4.1.1 and R402.4.1.2. The sealing methods between dissimilar materials shall allow for differential expansion and contraction.

The most common products for creating an airtight barrier are tapes, gaskets, caulks, and spray foam materials.

Tapes

To limit air leakage, builders use tapes to seal the seams of a variety of membranes and buildings products, including housewrap, polyethylene, OSB, and plywood. Tapes are also used to seal duct seams; seal leaks around penetrations through air barriers, for example, around plumbing vents, and sheet goods to a variety of materials, including concrete. No single tape works well in all of these applications, so builders, general contractors and trades need to familiarize themselves with the range of products and what will work best (time tested) and include these materials in the overall air barrier strategy.

Image: GreenBuildingAdvisor.com

Gaskets can be Better than Caulk

When builders first learn about air sealing, they often depend heavily on caulk. After inspecting a home for leaks during a blower-door test, however, they learn that caulk has a few downsides. That's when they usually graduate to gaskets.

Typical locations for gaskets include between the:

- Top of the foundation and the mudsill;
- Subfloor and the bottom plate;
- Window frame and the rough opening;
- Bottom plate and the drywall; and
- Top plate and the drywall.

Spray Foams

Spray foams are available in a variety of different forms, from small cans to larger industrial gallon sizes. Special care needs to be taken when using these products, as some expand more than others and some can exert significant pressure on the surrounding structure during expansion.

Image: Sprayfoam.com

Who is Responsible for Air Sealing?

The IECC does not specify who is responsible for air sealing; it states that the building envelope shall be sealed in accordance with manufacturers' instructions and the provisions (checklist) of the IECC. The construction documents for permitting to begin construction are typically submitted by the person in charge of the project and responsible for making sure all measures are installed properly and meet the provisions of the code. The inspector is responsible for making sure those measures meet code by verifying through on-site inspections.

Since so many different areas of the building envelope must be sealed, the responsibility will not always be on one person, installer, or trade. For example, the mechanical contractor who installs the heating and cooling equipment most likely will not be installing an air barrier between the attic and conditioned space, as that is usually the responsibility of the insulation contractor.

However, general contractors typically assume that the insulation and air sealing contractors seal and fill the holes, including filling any unintended holes that other subs leave behind. An air sealing strategy can include identifying who is responsible for sealing which building components, including unintended cracks or holes in the building thermal envelope.

The following table is an example of building components to be sealed and who might be responsible for sealing those components.

Table 3. Building components to be sealed and who might be responsible for sealing those components

Building Components	Contractor/Trade
Ceiling/attic, kneewalls, attic access, recessed lighting, walls, floors, garage separation, electrical and service penetrations in ceiling, floors, and walls	• Insulation/air sealing installers • Gypsum board contractors • Foundation contractors • Electricians • Roofers • Framers • General contractors
Service water piping, penetrations for water supply and demand	• Plumbers • Electricians
Rim joists, sill plates, windows, skylights, doors, porch roof, shower/tub on exterior wall, electrical box on exterior wall, fireplace	• Framers • Roofers • Plumbers • Electricians • Insulation/air sealing installers • Window and door installers • General contractors
Ducts, piping, shafts, penetrations, register boots	• HVAC installers
All of the above	• Inspectors • General contractors

4 TESTING: Requirements

The specific test requirements are based on the flow rate of air produced by a blower door at a specified pressure (50 pascals or 0.2 inches of water) when exterior doors are closed, dampers are closed but not otherwise sealed, exterior openings for continuous ventilation systems and heat recovery ventilators are closed but not sealed, HVAC systems are turned off, and duct supply and return registers are not covered or sealed.

The infiltration rate is the volumetric flow rate of outside air into a building, typically in cubic feet per minute (CFM) or liters per second (LPS). The air exchange rate, (I), is the number of interior volume air changes that occur per hour, and has units of 1/h. The air exchange rate is also known as air changes per hour (ACH).

ACH can be calculated by multiplying the building's CFM by 60, then dividing by the building volume in cubic feet. (CFM x 60)/volume. The requirement is expressed in ACH, which takes account of the overall size (volume) of the home:

Total air leakage < 3-5 ACH (air changes per hour)

What is a blower door? It is a powerful fan that attaches and seals to a door (typically the entrance door to the home) and blows air into or out of the house to pressurize or depressurize the home. The inside-outside pressure difference will cause air to force its way through any cracks in the building thermal envelope. Measuring the flow rate at the specified test pressure indicates the leakiness of the envelope.

Figure 12. Blower door

Who Performs the Test and is Certification Required?

The IECC does not specifically address who should perform the test. Builders, contractors, tradesmen, or code officials can perform the test. Code officials can also request the test be performed by an independent third party. The IECC does not require the person performing the test to be certified. However, it is recommended that the person be knowledgeable and have experience in using the equipment.

RESNET and BPI provide certifications for whole-house testing. For more information go to **www.resnet.org** or **www.bpi.org**.

R402.4.1.2 Testing

The building or dwelling unit shall be tested and verified as having an air leakage rate not exceeding 5 air changes per hour in Climate Zones 1 and 2, and 3 air changes per hour in Climate Zones 3 through 8. Testing shall be conducted with a blower door at a pressure of 0.2 inches 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.

During testing:

1. *Exterior windows and doors, fireplace and stove doors shall be closed, but not sealed, beyond the intended weatherstripping or other infiltration control measures;*
2. *Dampers including exhaust, intake, makeup air, backdraft and flue dampers shall be closed, but not sealed beyond intended infiltration control measures;*
3. *Interior doors, if installed at the time of the test, shall be open;*
4. *Exterior doors for continuous ventilation systems and heat recovery ventilators shall be closed and sealed;*
5. *Heating and cooling systems, if installed at the time of the test, shall be turned off; and*
6. *Supply and return registers, if installed at the time of the test, shall be fully open.*

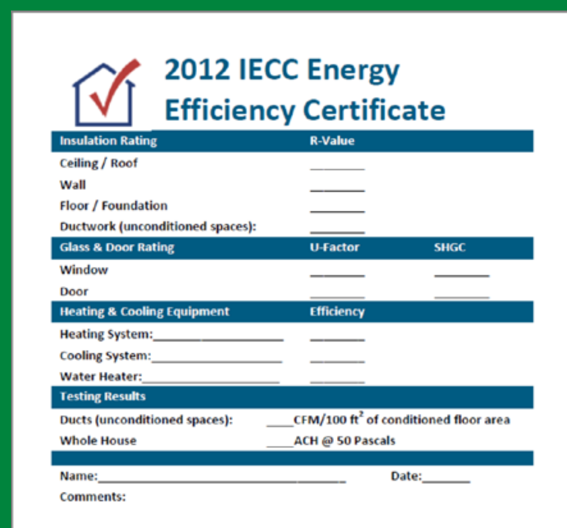
5 TESTING: Presenting Results

A permanently affixed certificate posted on or near the electrical panel is not a new requirement in the IECC. However, the information required on the certificate ***NOW*** includes results of duct and whole-house pressure tests in addition to the predominant R-values of insulation installed in or on ceiling/roof, walls, foundations, and ducts outside conditioned spaces; fenestration U-factors and solar heat gain coefficients (SHGCs); and efficiencies of heating, cooling, and service water heating equipment.

As a recommendation for verification of testing, whomever performs the testing should also submit the test results to the building official and/or general contractor, confirming the air leakage levels have been met.

R401.2 Certificate (Mandatory)

A permanent certificate shall be completed and posted on or in the electrical distribution panel by the builder or registered design professional. The certificate shall list the results from any required duct system and building envelope air leakage testing done on the building.



2012 IECC Energy Efficiency Certificate

Insulation Rating	R-Value	
Ceiling / Roof	_______	
Wall	_______	
Floor / Foundation	_______	
Ductwork (unconditioned spaces):	_______	
Glass & Door Rating	**U-Factor**	**SHGC**
Window	_______	_______
Door	_______	_______
Heating & Cooling Equipment	**Efficiency**	
Heating System:_______________	_______	
Cooling System:_______________	_______	
Water Heater:_______________	_______	
Testing Results		
Ducts (unconditioned spaces):	____CFM/100 ft² of conditioned floor area	
Whole House	____ACH @ 50 Pascals	

Name:_______________________________ Date:_______

Comments:

The illustration is an Energy Efficiency Certificate that can be created and printed using DOE's Building Energy Codes Program software called RES*check*™.

www.energycodes.gov

6 VENTILATION: Requirements

Many building scientists believed mechanical ventilation should have been part of the building design even prior to the 2012 IECC. However, there are disagreements as to the level of envelope tightness at which mechanical ventilation is necessary due to health and safety concerns. This is no longer a question given the new air leakage requirements of the 2012 IECC and other provisions in the International Residential Code (IRC) and International Mechanical Code (IMC). The 2012 IECC does not specifically address the requirements for whole-house mechanical ventilation, but it references the ventilation requirements of the IRC or IMC as a mandatory provision.

IECC, R403.5 Mechanical Ventilation (Mandatory)
*The building shall be provided with ventilation that meets the requirements of the **International Residential Code** or **International Mechanical Code**, as applicable, or with other approved means of ventilation. Outdoor air intakes and exhausts shall have automatic or gravity dampers that close when the ventilation system is not operating.*

Both the 2012 IRC and IMC require mechanical ventilation when the air infiltration rate of the dwelling unit is < 5 ACH when tested with a blower door in accordance with the 2012 IECC provisions.

IRC, Section R303.4 Mechanical Ventilation
Where the air infiltration rate of a dwelling unit is less than 5 air changes per hour when tested with a blower door at a pressure of 0.2 inch w.c. (50 Pa) in accordance with Section N1102.4.1.2, the dwelling unit shall be provided with whole-house ventilation in accordance with Section M1507.3.

Section N1102.4.1.2 is the extraction of the air leakage requirements in the IECC, Section R402.4. ICC duplicated the language from the IECC residential provisions in the IRC, Chapter 11, Energy Efficiency.

IMC, Section 401.2 Ventilation Required

Where the air infiltration rate in a dwelling unit is less than 5 air changes per hour when tested with blower door at a pressure of 0.2-inch water column (to Pa) in accordance with Section 402.4.1.2 of the International Energy Conservation Code, the dwelling unit shall be ventilated by mechanical means in according with Section 403.

IECC, Section R403.5.1 Whole-House Mechanical Ventilation System Fan Efficacy

Mechanical ventilation system fans shall meet the efficacy requirements of Table 403.5.1.

Exception: *Where mechanical ventilation system fans are integral to tested and listed HVAC equipment, they shall be powered by an electronically commutated motor.*

Table 4. 2012 IECC Table R403.5.1, Mechanical Ventilation System Fan Efficacy

Fan Location	Air Flow Rate Minimum (CFM)	Minimum Efficacy (CFM/watt)	Air Flow Rate Maximum (CFM)
Range Hoods	Any	2.8	Any
In-line Fan	Any	2.8	Any
Bathroom, Utility Room	10	1.4	< 90
Bathroom, Utility Room	90	2.8	Any

In addition, ASHRAE Standard 62.2 provides guidance on the appropriate ventilation for acceptable indoor air quality in low-rise residential buildings. The standard specifies that forced ventilation is required in houses with a natural infiltration rate less than 0.35 ACH. This is typically accomplished with heat recovery ventilation or exhaust fans running constantly or periodically. The standard offers guidance for incorporating whole-house systems into a home. This standard is not referenced in the IECC, though some jurisdictions and states adopt this standard as part of their requirements.

For more information on whole-house mechanical ventilation, refer to **Appendix B**.

Ventilation Systems

There are several options for mechanical ventilation systems. Spot ventilation, using exhaust-only fans in the kitchen and bathroom, removes water vapor and pollutants from specific locations in the home, but does not distribute fresh air. Balanced ventilation systems, such as air-to-air exchangers, heat-recovery ventilators, and energy recovery ventilators, both supply and exhaust air.

Table 5: Pros and Cons of Various Mechanical Ventilation Systems

Ventilation Type	Pros	Cons
Exhaust Only Air is exhausted from the house with a fan	• Easy to install • Simple method for spot ventilation • Inexpensive	• Negative pressure may cause backdrafting • Makeup air is from random sources • Removes heated or cooled air
Supply Only Air is supplied into the house with a fan	• Does not interfere with combustion appliances • Positive pressures inhibit pollutants from entering • Delivers to important locations	• Does not remove indoor air pollutants at their source • Brings in hot or cold air or moisture from the outside • Air circulation can feel drafty • Furnace fan runs more often unless fan has an ECM (variable-speed motor)
Balanced Air Exchange System Heat and energy recovery ventilators supply and exhaust air	• No combustion impact • No induced infiltration/exfiltration • Can be regulated to optimize performance • Provides equal supply and exhaust air • Recovers up to 80% of the energy in air exchanged	• More complicated design considerations • Over ventilation unless the building is tight • Cost

Heat and Energy Recovery Ventilation Systems

Heat recovery ventilators (HRVs) and energy recovery (or enthalpy recovery) ventilators (ERVs) both provide a controlled way of ventilating a home while minimizing energy loss by using conditioned exhaust air to warm or cool fresh incoming air. There are some small wall or window-mounted models, but the majority are central, whole-house ventilation systems that share the furnace duct system or have their own duct system. The main difference between an HRV and an ERV is the way the heat exchanger works. With an ERV, the heat exchanger transfers water vapor along with heat energy, while an HRV only transfers heat. The ERV helps keep indoor humidity more constant. However, in very humid conditions, the ERV should be turned off when the air conditioner is not running. Air-to-air heat exchangers or HRVs are recommended for cold climates and dry climates. ERVs are recommended for humid climates. Most ERV systems can recover about 70%–80% of the energy in the exiting air. They are most cost effective in climates with extreme winters or summers, and where fuel costs are high. ERV systems in cold climates must have devices to help prevent freezing and frost formation.

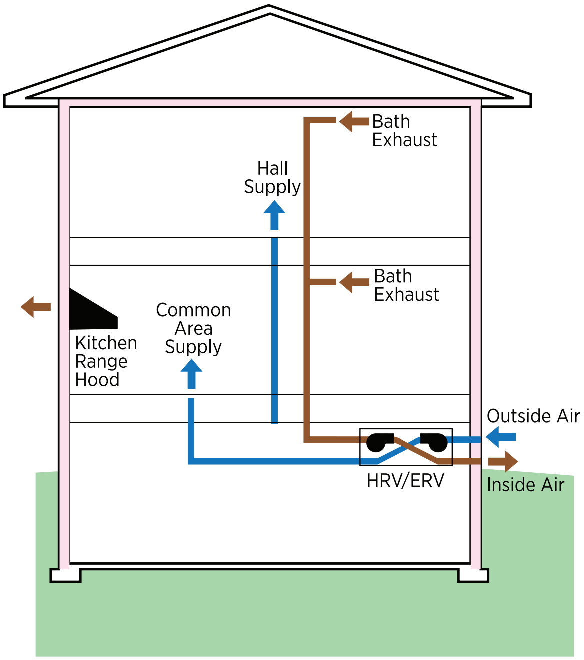


Figure 13. Heat and energy recovery ventilators bring in fresh air, exhaust stale air, and save energy by transferring heat into incoming air through a heat exchanger (Ruud 2011).

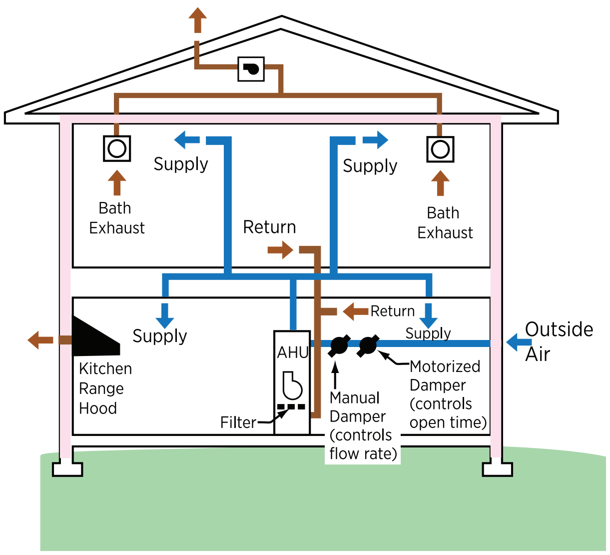


Figure 14. Semi-balanced ventilation systems provide fresh air and exhaust stale air but flow rates may not be balanced (Ruud 2011).

7 HVAC SIZING: Requirements

Reducing infiltration can reduce the loads on the building, which in turn can reduce the required sizes of the heating and cooling equipment. The 2012 IECC contains a mandatory requirement that equipment be sized according to Air Conditioning Contractors of America (ACCA) Manual S, based on loads calculated in accordance with ACCA Manual J (or other approved means of calculating the loads and equipment sizing). Many jurisdictions allow the use of other heating system sizing calculators. Builders/contractors should check with the governing jurisdiction to see what they accept. The builder or contractor will also need to make an assumption when calculating the loads based upon the tested air leakage rate (changes per hour at 50 pascals) of the home. Since the IECC requires $\leq$ 3 ACH for climate zones 3-8 or $\leq$ 5 ACH for climate zones 1-2, at a 50 pascals pressure test, the infiltration rate assumption will need to be at the applicable ACH when running the load calculations.

R403.6 Equipment Sizing (Mandatory)
Heating and cooling equipment shall be sized in accordance with ACCA Manual J or other approved heating and cooling calculation methodologies.

8 CASE STUDIES: Alternative Methods of Construction

Some builders are currently building energy efficient homes in the cold and very cold climates that achieve the low air leakage rates specified in the 2012 IECC ($\leq$ 3 ACH in climate zones 3-8). The following case studies showcase five cold climate builders who worked with Building America research teams. The builders used a variety of energy efficiency measures, including such things as insulated concrete forms (ICFs) and wood-framed walls with studs on 24-inch centers. The energy efficiency measures and testing results are summarized in Table 6 and the tested air leakage rates are highlighted in yellow.

Table 6. Summary of Energy Efficiency Measures Incorporated in Case Study Homes in the Cold Climate

	Devoted Builders Kennewick, WA	**Nelson Construction Farmington, CT**
Project	Mediterranean Villas Pasco, WA 230 duplex and triplex units 1,140 - 2,100 ft^2 Market rate	Hamilton Way Farmington, CT 10 single family homes 2,960 - 3,540 ft^2 Market rate
Tested Air Leakage and Sealing	**Tested at 0.8 to 2.0 ACH at 50 Pa; Spray foam ceiling deck**	**Tested at < 3.0 ACH at 50 Pa; Foam critical seal of rim and floor joists**
Walls	R-25 ICF	2x6 24-in. o.c.
Wall Insulation	R-25 ICF	2-inch foil-faced polyisocyanurate R-13 sheathing, plus R-19 cellulose in stud cavities
Attic Insulation	R-49 blown-in cellulose on ceiling	R-50 blown-in fiberglass on ceiling
Foundation Insulation	R-25 ICF perimeter foundation insulation with floating slab	2-inch/R-10 XPS below slab; 2-inch/R-10 XPS in thermomass basement walls
Ducts	In conditioned space or in attic covered with spray foam and blown cellulose	In conditioned space in dropped ceiling or between joists
Air Handler	In conditioned space	In conditioned basement
HERS	54 - 68	53 - 54
HVAC	8.5 HSPF/14 SEER heat pumps	94% AFUE gas furnace; SEER 14 air conditioner
Windows	U-0.29	U-0.32, SHGC-0.27, double-pane, low-e, vinyl framed
Water Heating	84% EF tankless gas water heater	82% EF tankless gas water heater
Ventilation	Energy recovery ventilator	Temperature- and timer-controlled fresh air intake; exhaust fan ducted to draw from main living space; transfer grilles
Green	3-star BuiltGreen certified homes	2008 "Best Energy Efficient Green Community" by CT Home Builders Association; 2010 NAHB Energy Value Housing gold award
Lighting and Appliances	70% hardwired CFL lighting; ENERGY STAR refrigerators, dishwashers, and clothes washers	100% CFLs; optional appliances
Solar	No	Optional 7-kW PV systems
Verification	100% are third party tested and inspected, all homes met federal tax credit criteria since 2007	All Builders Challenge certified

AC = air conditioner; ACH = air changes per hour; AFUE = annual fuel utilization efficiency; CFL = compact fluorescent lights; Ef = energy factor; HERS = Home Energy Rating System; HSPF = Heating Seasonal Performance Factor; ICF = insulated concrete form;

Table 6. Summary of Energy Efficiency Measures Incorporated in Case Study Homes in the Cold Climate (continued)

Rural Development, Inc. **Turner Falls, MA**	**S&A Homes** **Pittsburgh, PA**	**Shaw Construction** **Grand Junction, CO**
Wisdom Way Solar Village Greenfield, MA 20 duplex units 1,140 - 1,770 ft^2 Affordable housing	East Liberty Development, Inc. 6 single-family urban infill 3,100 ft^2 Above market rate	Burlingame Ranch Phase 1 Aspen, CO 84 units in 15 multi-family buildings 1,325 ft^2 Affordable
Tested at 1.1 to 1.5 ACH at 50 pa	**Tested at 3.0 ACH at 50 Pa; all penetrations and studs sealed**	**Tested at 2.5 in^2 leakage per 100 ft^2 of envelope**
Double walled (two 2x4 16-in. o.c. walls, 5 inches apart)	2x6 24-in. o.c.	2x6 24-in. o.c.
R-42 dense-pack, dry blown cellulose	R-24 blown fiberglass	R-24 of 3.5" high-density spray foam
R-50 blown-in cellulose on ceiling	R-49 blown-in fiberglass on ceiling	R-50 high-density foam at sloped roof, R-38 at flat roofs
Full uninsulated basement with R-40 blown cellulose under first floor	Precast concrete basement walls with steel-reinforced concrete studs at 2.5 in. XPS R-12.5	Slab with R-13 XPS edge; some basements with R-13 interior polyisocyanurate; R-28 of spray-foam insulation on ground under slab
No ducts	In conditioned space in open-web floor trusses	No ducts
None	In conditioned basement	None
8 - 18	51 - 55	54 - 62
Small sealed-combustion 83% AFUE gas-fired space heater on main floor; no AC	Two-stage 96%-AFUE gas furnace with multi-speed blower; SEER-14 AC	0.9 AFUE condensing gas boiler with baseboard hot water radiators
Triple-pane U-0.18 on north/east/west sides; double-pane U-0.26 on south side	U-0.33, SHGC-0.30, double-pane	U-0.37, SHGC-0.33 fiberglass-framed, double-pane
Solar thermal with tankless gas backup	82% EF tankless gas water heater	Solar thermal with gas boiler back-up
Continuous bathroom exhaust	Passive fresh air duct to return plenum; fan-cycler on 50% of time for fresh air circulation, bath exhausts	Heat-recovery ventilator
LEED Platinum	Meets LEED (not certified)	LEED Certified
100% CFLs; refrigerator, dishwasher	100% CFLs and ENERGY STAR refrigerator, dishwashers, and clothes washer	90% CFL; ENERGY STAR refrigerator, dishwashers, clothes washers, ceiling fans
2.8 to 3.4-kW PV; flat-plate collector solar thermal water heating	No	10-kW PV on one building; solar hot water heating on all buildings
All HERS rated	All Builders Challenge certified	All federal tax credit qualified

o.c. = on center wood framed walls; Pa = pascals; PV = photovoltaic; SEER = Seasonal Energy Efficiency Ratio; SHGC = solar heat gain coefficient; XPS = extruded polystyrene

CASE STUDIES/SUMMARY

Devoted Builders, LLC

http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/ba_bp_devoted_cold.pdf

Nelson Construction

http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/ba_bp_nelson_cold.pdf

Rural Development, Inc.

http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/ba_bp_ruraldevelopment_cold.pdf

S&A Home

http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/ba_bp_sahomes_cold.pdf

Shaw Construction

http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/ba_bp_shaw_cold.pdf

APPENDIX A: References and More Information on Air Sealing

2012 IECC. 2012 International Energy Conservation Code, Section 402.4 "Air Leakage," Section 403.5 "Mechanical Ventilation," International Code Council (ICC), Washington, DC. www.iccsafe.org/Store/Pages

2012 IRC. 2012 International Residential Code, Section M 1507.3, R303.4, R403.5

2010 ASHRAE, American Society of Heating, Refrigerating, and Air Conditioning Engineers, Atlanta, GA. ASHRAE Standard 62.2-2010

Air Sealing: A Guide for Contractors to Share with Homeonwners - Volume 10, Building America, Pacific Northwest National Laboratory, Oakridge National Laboratory, PNNL-19284

Builders Challenge Guide to 40% Whole-House Energy Savings in the Cold and Very Cold Climates, Volume 12, Building America Best Practices Series, February 2011, PNNL-20139

Building Science Corporation 2009a. *Air Barriers—Tub, Shower and Fireplace Enclosures.* Information Sheet 407 for All Climates 5/20/2009, prepared by BSC for DOE's Building America Program. http://www.buildingscience.com/documents/information-sheets/4-air-barriers/air-barriers2014tub- shower-and-fireplace-enclosures/?searchterm=building%20america

Building Science Corporation 2009b. *Air Sealing Windows.* Information Sheet 406 for All Climates 5/20/2009, prepared by BSC for DOE's Building America Program. http://www.buildingscience.com/documents/information-sheets/4-air-barriers/sealing-air-barrier-penetrations/?searchterm=building%20america

Building Science Corporation 2009c. *Critical Seal (Spray Foam at Rim Joist).* Information Sheet 408 for All Climates 09/18/2009, prepared by BSC for DOE's Building America Program. http://www.buildingscience.com/documents/information-sheets/4-air-barriers/info-408-critical-seal-spray-foam-at-rim-joist/?searchterm=building%20america

Building Science Corporation 2009e. *Sealing Air Barrier Penetrations*, Information Sheet 405 for All Climates 5/20/2009, prepared by BSC for DOE's Building America Program. http://www.buildingscience.com/documents/information-sheets/4-air-barriers/sealing-air-barrier-penetrations/?searchterm=building%20america

DOE – 2009a. *Attic Access Insulation and Air Sealing*. http://www.energysavers.gov/your_home/insulation_airsealing/index.cfm/mytopic=11400

DOE – 2009b. *Energy Savers: Sealing Air Leaks*. www1.eere.energy.gov/consumer/tips/air_leaks.html

DOE – 2009c. *Energy Savers: Your Home - Weather Stripping*. http://www.energysavers.gov/your_home/insulation_airsealing/index.cfm/mytopic=11280

EPA – 2008a. *A Do-It-Yourself Guide to Sealing and Insulating with ENERGY STAR*. EPA, May 2008. http://www.energystar.gov/index.cfm?c=diy.diy_index www.energystar.gov/index.cfm?c=diy.diy_index

EPA – 2008b. *ENERGY STAR Qualified Homes Thermal Bypass Checklist Guide*. http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/TBC_Guide_062507.pdf www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/TBC_Guide_062507.pdf

EPA – 2009c. *Sealing Air Leaks: Basement*. http://www.energystar.gov/index.cfm?c=diy.diy_sealing_basement www.energystar.gov/index.cfm?c=diy.diy_sealing_basement

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Lstiburek, Joseph. 2010. *Guide to Attic Air Sealing.* Prepared for U.S. Department of Energy by Building Science Corporation. www.buildingscience.com/documents/primers/guide-to-attic-air-sealing-with-details/?searchterm=air%20sealing

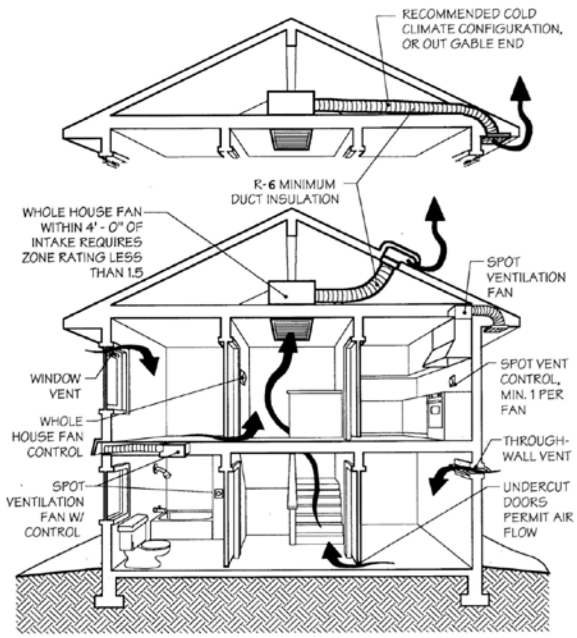
Moriarta, Courtney. 2008. "Fixing Air Leakage in Connecticut Town Houses," *Home Energy Magazine.* July/Aug 2008, p 28-30, www.swinter.com/news/documents/FixingAirLeakage.pdf&amp

Rudd, Armin. 2011. *Local Exhaust and Whole House Ventilation Strategies*, Prepared by Building Science Corporation for the U.S. Department of Energy, http://www.buildingamerica.gov

APPENDIX B: Code Note

Whole-House Mechanical Ventilation

[ASHRAE 62.2-2010, 2012 IECC, 2012 IRC]
PNNL-SA-83104



ASHRAE Standard 62.2, Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings, defines the roles of and minimum requirements for mechanical and natural ventilation systems to achieve acceptable indoor air quality. This material supplements requirements contained in the national model energy codes with respect to mechanical ventilation systems. At this time, the residential provisions of the IECC do not reference ASHRAE 62.2.

Ventilation
The process of supplying outdoor air to or removing indoor air from a dwelling by natural or mechanical means. Such air may or may not have been conditioned.

Mechanical Ventilation
The active process of supplying air to or removing air from an indoor space by powered equipment.

Natural Ventilation
Ventilation occurring as a result of only natural forces.

CFM
Cubic feet per minute, a standard measurement of airflow.

In the past, no specific requirements for ventilation were imposed for residential buildings because leakage in envelope components and natural ventilation were considered adequate to maintain indoor air quality. As envelope construction practices have improved, the need to provide fresh air to homes via mechanical means has increased.

ASHRAE Standard 62.2 provides guidelines for ventilation requirements. In addition to addressing whole-house ventilation, the standard also addresses local exhaust (kitchens and bathrooms) and criteria for mechanical air-moving equipment. Ventilation requirements for safety (including combustion appliances, adjacent space concerns, and location of outdoor air inlets) are also addressed.

To comply with the ASHRAE standard, residential buildings (including manufactured homes) are required to install a mechanical ventilation system. An override control for the occupants is also required.

Plan Review

1. Confirm that a mechanical ventilation system that provides the appropriate ventilation rate (CFM) is called out. See ASHRAE 62.2-2010, Table 4.1a, for details.
2. Check that the planned ventilation rate does not exceed 7.5 CFM per 100 ft^2 if located in a very cold climate or a hot, humid climate. See Tables 8.1 and 8.2 for details.
3. Check that local exhaust systems for kitchens and bathrooms have been planned for appropriately.

Field Inspection

1. Confirm that a mechanical ventilation system that provides the appropriate ventilation rate (CFM) is installed.
2. Confirm that occupant override control has been installed as required by ASHRAE 62.2-2010 section 4.4, and 2012 IRC, section M1507.3.

Code Citations*

ASHRAE 62.2-2010, Table 4.1a (I-P) Ventilation Air Requirements, CFM
[2012 IRC Table M1507.3.3(1) Continuous Whole-House Ventilation System Airflow Rate Requirements]

Floor Area (ft^2)	0-1 Bedrooms	2-3 Bedrooms	4-5 Bedrooms	6-7 Bedrooms	7+ Bedrooms
< 1,500	30	45	60	75	90
1,500 - 3,000	45	60	75	90	105
3,001 - 4,500	60	75	90	105	120
4,501 - 6,000	75	90	105	120	135
6,001 - 7,500	90	105	120	135	150
> 7,500	105	120	135	150	165

ASHRAE 62.2-2010, Table 8.1 Hot, Humid U.S. Climates

Mobile, AL	Savannah, GA	Wilmington, NC
Selma, AL	Valdosta, GA	Charleston, SC
Montgomery, AL	Hilo, HI	Myrtle Beach, SC
Texarkana, AR	Honolulu, HI	Austin, TX
Apalachicola, FL	Lihue, HI	Beaumont, TX
Daytona, FL	Kahului, HI	Brownsville, TX
Jacksonville, FL	Baton Rouge, LA	Corpus Christi, TX
Miami, FL	Lake Charles, LA	Dallas, TX
Orlando, FL	New Orleans, LA	Houston, TX
Pensacola, FL	Shreveport, LA	Galveston, TX
Tallahassee, FL	Biloxi, MS	San Antonio, TX
Tampa, FL	Gulfport, MS	Waco, TX
	Jackson, MS	

ASHRAE 62.2-2010, Table 8.2 Very Cold U.S. Climates

Anchorage, AK	Marquette, MI	Fargo, ND
Fairbanks, AK	Sault Ste. Marie, MI	Grand Forks, ND
Caribou, ME	Duluth, MN	Williston, ND
	International Falls, MN	

2012 IECC, Section R403.5 Mechanical ventilation (Mandatory)

The building shall be provided with ventilation that meets the requirements of the International Residential Code or International Mechanical Code, as applicable, or with other approved means of ventilation. Outdoor air intakes and exhausts shall have automatic or gravity dampers that close when the ventilation system is not operating.

2012 IRC, Section R303.4 Mechanical ventilation

Where the air infiltration rate of a dwelling unit is less than 5 air changes per hour when tested with a blower door at a pressure of 0.2 inch w.c. (50 Pa) in accordance with Section N1102.4.1.2, the dwelling unit shall be provided with whole-house ventilation in accordance with Section M1507.3.

2012 IRC, Section M1507.3 Whole-house mechanical ventilation system
Whole-house mechanical ventilation systems shall be designed in accordance with Sections M1507.3.1 through M1507.3.3.

M1507.3.1 System design
The whole-house ventilation system shall consist of one or more supply or exhaust fans, or a combination of such, and associated ducts and controls. Local exhaust or supply fans are permitted to serve as such a system. Outdoor air ducts connected to the return side of an air handler shall be considered to provide supply ventilation.

M1507.3.2 System controls
The whole-house mechanical ventilation system shall be provided with controls that enable manual override.

M1507.3.3 Mechanical ventilation rate
The whole-house mechanical ventilation system shall provide outdoor air at a continuous exchange rate of not less than that determined in accordance with Table M1507.3.3(1).

Exception: The whole-house mechanical ventilation system is permitted to operate intermittently where the system has controls that enable operation for not less than 25-percent of each 4-hour segment and the ventilation rate prescribed in Table M1507.3.3(1) is multiplied by the factor determined in accordance with Table M1507.3.3(2).2012.

Table 7.4. 2012 IRC Table M1507.3.3(2) Intermittent Whole-House Mechanical Ventilation Rate Factors

Run-Time Percentage in Each 4-Hour Segment	25%	33%	50%	66%	75%	100%
Factor	4.0	3.0	2.0	1.5	1.3	1.0

U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy

EERE Information Center
1-877-EERE-INFO (1-877-337-3463)
www.eere.energy.gov/informationcenter

PNNL-SA-82900 September 2011

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visit **www.energycodes.gov**

Building Energy Codes