Air Sealed, Insulated Basements

Scope

Foil-faced rigid foam and spray foam can be used to insulate a basement on the interior; use good moisture management techniques to keep the basement dry.

Insulate a basement to improve the overall thermal performance of the building and provide more dry, usable conditioned space for home occupants and for HVAC equipment.

- Address site drainage and plan for water/moisture management.
- Assess risks posed by insects and other pests. (See the International Code Council’s guide, Pest Prevention by Design.)
- Assess and address Radon issues. (See the EPA’s guide Building Radon Out: A Step-by-Step Guide on How to Build Radon-Resistant Homes. Also see Building Science Corporation’s information sheet on Soil Gas Control.)
- Design and install safe combustion systems in the home. (See the pre-retrofit assessment guide on combustion appliances.)
  - Sealed combustion equipment is strongly recommended.
  - Include carbon monoxide detectors.
- Determine code, program, and/or other goals and requirements for basement insulation.
- Consider insulating the foundation walls using exterior rigid insulation, insulated concrete forms, or prefabricated panels. If these are impractical (due to pest issues or because it’s an existing building), consider interior insulation systems.
- Install systems per code requirements and manufacturer specifications.
- Verify systems are installed properly and other systems (such as drainage systems, combustion appliances, etc.) are operating safely.

See the Compliance Tab for related codes and standards requirements and criteria to meet national program such as DOE’s Zero Energy Ready Home program, ENERGY STAR Certified Homes, and Indoor airPLUS.
Description
Because basements are largely below grade and because winter ground temperatures are often warmer than winter air temperatures, the potential for heat loss from a basement is smaller than from the above-grade portions of a home’s envelope. While insulation levels below grade need not be as high as those of above-grade walls, insulating basements is critical in order to achieve the energy and comfort goals of high-performance homes.

This guide describes good practices for insulating basements in new and existing homes. This is by no means an exhaustive list; rather, it is a short list of systems that can work well, can comply with current codes, and can be practically implemented by builders and contractors.

Before insulating a basement, be sure to assess (and address if necessary) key health, safety and durability issues. These include:

- Site/building drainage and water management
- Combustion safety
- Radon (See the EPA’s guide Building Radon Out: A Step-by-Step Guide on How to Build Radon-Resistant Homes, Also see Building Science Corporation’s information sheet on Soil Gas Control.
- Insect/pest concerns (See the International Code Council’s guide, Pest Prevention by Design.)

Where to Insulate?

Foundation Walls or First Floor?
One of the first questions to answer when determining a basement insulation strategy is: Where to install the insulation on the basement walls or on the underside of the first floor?

Insulating at the Walls
In most cases insulating the basement walls—and possibly the slab—results in better performance. Insulating the basement walls, rather than under the first floor, brings the basement within the thermal envelope or conditioned space of the home and connects the basement thermally to the rest of the house. This will keep the basement warmer during the winter. In the summer, a conditioned basement will usually be dryer than the alternative. A warmer, dryer basement can have much more value as a functional, usable space. It also provides better conditions for HVAC equipment.

In extremely cold climates, insulating the basement walls may be critical to keep temperatures in the basement above freezing (which is important if there are any mechanicals or plumbing in the basement). If heating equipment is located in the basement (e.g., a boiler or furnace, water heater, ducts, etc.), the heat losses from this equipment may provide all the heat needed to keep an insulated basement comfortable and usable.

During the summer months, because the ground is generally cooler than the air within the home, connecting the basement to the conditioned space will reduce the cooling load. It’s true that good basement wall insulation will limit this cooling effect, but even a home with a well-insulated basement will generally require less air conditioning energy than the same home with insulation beneath the first floor.

Insulating Under the First Floor
Insulating under the first floor, rather than along the walls will result in an uninsulated basement that is disconnected from the rest of the house from a thermal standpoint. While insulating beneath the first floor may result in lower performance overall, there are some scenarios where this strategy is still chosen. Reasons for this include:

- Water management. If moisture management strategies do not keep the basement consistently dry (e.g., if the area is prone to seasonal flooding), insulating at the first floor may be the best option to avoid repeated damage to water-susceptible materials.

- Combustion safety. It is strongly recommended that air-tight buildings not include natural-draft combustion appliances within the insulated enclosure. If natural-draft appliances are located in the basement and are not likely to be replaced with noncombustion or sealed-combustion direct-vent appliances in the near future, air sealing and insulating at the first floor may be a safer option than air sealing and insulating the basement walls and floor. For information on assessing combustion safety see these guides:
  - Combustion appliance zone testing
  - Pre-Retrofit Assessment of Combustion Appliances

- Cost. While insulating the basement walls generally results in better performance, this strategy is often more expensive. Some choose to insulate at the floor purely for cost reasons.

Inside or Outside of Foundation Walls?
Basement walls can be insulated along either the inside surface or the outside surface of the exterior walls. Insulating on the outside of a foundation wall is usually only a practical option in new construction due to the excavation costs associated with an
exterior installation. Most retrofit strategies involve installing insulation on the inside of the foundation walls unless major excavation is already necessary for foundation repair or site water management.

In most cases, insulating on the outside can result in better moisture management of the foundation assembly, but there are challenges with protecting the insulation at and above grade. These challenges lead many designers and builders of new homes to choose interior basement insulation. Examples of both strategies—as well as challenges and limitations of each—are discussed in the Description section.

**Systems Described**
While there are many viable basement insulation strategies, a few common systems are described in this guide:

- Exterior rigid insulation on concrete walls
- Insulated Concrete Forms (ICFs)
- Precast foundations.
- Interior insulation
  - foil-faced rigid foam left exposed
  - rigid foam covered with drywall
  - spray foam covered with drywall.

**Exterior, Rigid Insulation on Block or Poured Concrete Walls**
Extruded polystyrene (XPS) foam, rigid fiberglass, and mineral wool boards are the most common materials for insulating the exterior of foundation walls. None of these materials retains water, so long-term thermal properties should not be significantly affected by moisture.

Rigid fiberglass and mineral wool boards have thermal resistance of approximately R-4 per inch (ft²hr°F/Btu-in). To achieve the same R-value as XPS insulation, the thickness of these insulations must be approximately 25% greater than XPS (which is R-5 per inch).

In most cases, insulation on the exterior of basement walls can result in drier foundation assemblies and basement conditions. Because of the difficulty of accessing the foundation exterior in existing buildings, exterior foundation insulation is usually only practical for new construction. Other key challenges for exterior insulation systems are:

- protecting the insulation at and above grade
- insect and pest management
- transitions between foundation insulation and above-grade walls
- achieving higher R-values can be more difficult than with interior insulation (although a combination of both interior and exterior insulation is possible).

One common—though unacceptable—solution to protecting insulation at and above grade is simply to not insulate above-grade sections of the foundation wall (Figure 1). In this scenario, the un-insulated portion of the foundation wall (at grade and above) is exposed to the coldest temperatures. (Figure 2 shows an inside view of the wall shown in Figure 1; condensation and ice have formed on the inside surface of the wall.). Research has shown that insulating the top portion of the wall is by far the most critical for thermal performance; insulating only below-grade portions of the wall is ineffective in stopping heat transfer.

Insulation must be extended to the top of the foundation wall to provide a seamless thermal barrier in conjunction with the above-grade walls (Figure 3). This above-ground insulation must be protected with a durable material that can withstand weather, sunlight, impacts, etc. (Figure 4). Protective materials can include stucco, fiber-cement boards, fiberglass panels, vinyl sheets, aluminum coil stock, or even pressure-treated plywood. (For more options see this article, [How to Finish Exterior Foundation Insulation](#)).

Another potentially tricky detail is integrating the extra dimension of the foundation insulation into the above-grade walls. There are many solutions to this; two are presented here. In Figure 5, above-grade walls also incorporate rigid exterior insulation. In this case, there is usually not much difference between the two planes. If the above-grade walls do not have exterior insulation, there must be a curb, flashing, or transition that protects the insulation, manages drainage well, and is aesthetically acceptable. One possible solution is presented in Figure 6.

When considering any external foundation insulation strategy, it is critical to consider insects and pest management. While termites and other pests do not eat foam, they can easily tunnel through foam to reach wooden building components. Many insect management strategies incorporate a “vision strip,” typically a 3-inch gap in the insulation extending across the top of the foundation wall that exposes the concrete, so termite activity is visible. Another strategy is a termite “shield,” typically a piece of metal flashing that extends over the top of the foundation wall and extends from the sill or insulation transition. These strategies do not necessarily stop termites, but the devices will force bugs out of the insulation where their presence can be noticed. See more information in the “Insect and Pest Management” section in the Ensuring Success tab.
Figure 1. Exterior fiberglass insulation on this new home was (incorrectly) cut to terminate below-grade after backfill, which will expose the above-grade portions of the foundation wall to cold temperatures. (Source: Measure Guideline: Basement Insulation Basics)

Figure 2. Because the above-grade portions of the wall lack exterior insulation, condensation and even ice form during cold winter conditions. (Source: Measure Guideline: Basement Insulation Basics)
Figure 3. Exterior XPS basement insulation is correctly installed to completely cover the foundation wall. (Source: Measure Guideline: Basement Insulation Basics).

Figure 4. Rolled fiberglass sheets are installed to protect exterior XPS at and above grade. (Source: Measure Guideline: Basement Insulation Basics).
Insulated Concrete Forms (ICFs)

When making poured concrete foundation walls, builders typically use wood or metal forms to hold the concrete in place until it hardens. Another option is to use insulated concrete forms (ICFs) where the forms consist of rigid foam that stays in place after the concrete is poured to form a lasting layer of insulation on the inside and outside surface of the concrete wall. The rigid polystyrene foam (either EPS or XPS) is connected with polymer spacers to form large (e.g., 9”x18”) hollow blocks that are stacked in courses like bricks to form a hollow wall (Figure 7). The wall is reinforced with steel rebar that is run horizontally and vertically through the spacers then the hollow space is filled with concrete (Figure 8). Many ICF systems include vertical plastic or metal nailing strips to which interior and exterior finishings can be attached. See the guide, Insulated Concrete Forms for more information.
Instead of “sandwiching” concrete between the foam layers, another system sandwiches the rigid foam insulation between two layers of concrete. This approach can solve concerns about thermal barriers, some moisture issues, and possibly pest management concerns.

**Pre-Cast Foundation Walls**

Precast concrete foundations have a significant presence in several regional markets, in particular in the Northeast and Midwest. Not surprisingly, both of these regions are dominated by full basement foundations in residential construction, and they have robust pre-cast concrete industries. Very simply, pre-cast foundations are factory-produced concrete panels designed for a
specific project, shipped to a job site, and set by a crane and set crew. A very simple foundation could consist of as few as four panels; larger, more complicated foundations require more. The simplest panels are monolithic reinforced concrete slabs, while more sophisticated panels can be pre-insulated “sandwich” panels (with a layer of rigid insulation sandwiched between two layers of concrete). Another version is a thin-shelled rib system that includes thin (2-inch thick) panels with monolithically poured top bond-beams, bottom footers, and evenly spaced concrete ribs. Some of these thin-shelled rib systems have insulation adhered to the interior side of the shell and wrapped around the ribs; these systems come in various R-values. The ribs are usually faced with sheet metal which is placed over the rigid foam to serve as a nailing surface for the ribs, which act like walls studs. The cavities between the ribs can be filled with additional blown or batt insulation.

Pre-cast panels are typically set on a compacted crushed stone base with no additional footing needed (Figure 9). The crushed stone base is placed and compacted uniformly over the entire foundation area (including under the slab). The first panel is meticulously located to pre-surveyed points, and the remaining panels are positioned in reference to it. Joints between panels are typically treated with two large beads of poly-butyl caulk with come-along bolt connections used to draw the panels together, then the below-grade surface is treated with one of a variety of damp-proofing or moisture-proofing techniques.

Pre-cast foundations can be set in a single day. Panel bracing is critical prior to backfilling, so the floor deck will have to be installed with limited at-grade access. The time savings are also labor savings, but material costs for pre-cast foundations are generally higher. Total installed costs are similar to those of poured concrete foundations (especially near precast plants) and are dependent on local market conditions.

Insulation on Interior of Foundation Walls

In existing homes, interior basement insulation is often the only practical option. Even in new construction, challenges with protecting insulation at grade and above, as well as integrating the extra dimensions of exterior insulation, lead some builders to install interior insulation. Building America researchers have found that the best interior basement wall insulation strategies have several key features:

- Insulation is directly in contact with the basement wall and there is no channel for air movement between the insulation and the concrete.
- The assembly is air sealed so that basement air (and the moisture in it) cannot move into the insulation assembly.
- No moisture-sensitive materials are in contact with the concrete walls or floor (this is often addressed by building codes).

Exposed, Foil-Faced, Polyisocyanurate Board

Most residential building codes require foam insulation to be covered with a thermal barrier (2015 IRC, Section R316.4). The most common type of barrier is drywall. Attaching drywall over foam can be costly; however, it is often already factored into project costs if the basement will be finished for living space. At least one manufacturer of foil-faced, polyisocyanurate board insulation has a product that is allowed to remain exposed per an International Code Council Evaluation Services report (ICC 2006, NER-681). In many jurisdictions, this product can be left exposed against basement walls without drywall or an additional thermal barrier.
Insulation may be fastened with either construction adhesive or with mechanical fasteners into the concrete. (Figure 10 shows insulation attached using 1x strapping as a base for the fasteners.) Polyisocyanurate has an R-value of approximately R-6 per inch (ft²hr°F/Btu-in). Typically one inch is installed to meet R-5 requirements, two inches are installed to reach R-10, and three inches are installed to reach R-15.

The polyiso boards should be completely sealed to each other and to the concrete wall (Figure 11). There should be no avenue for air movement between the foam and the foundation wall. Insulation seams can be sealed with caulk, foam, foil tape, or polypropylene tape. Caulk or foam should be used at the edges of the insulation (near the sill, the slab, around windows or doors, etc.).

As with most systems described here, spray foam can be a good option to seal and insulate the sill and band joist areas. Many codes allow for this small area of foam to be left exposed in these locations (2015 IRC, Section R316.5.11).

![Figure 10](image-url) Foil-faced polyiso foam is held in place along the interior of a basement wall with nails or screws through the furring strips. Seams are sealed with foil tape and all edges are sealed with caulk or foam. (Source: Measure Guideline: Basement Insulation Basics).
Polystyrene Board with Drywall

Both unfaced expanded polystyrene (EPS) and extruded polystyrene (XPS) rigid foam are common basement insulation materials, but they cannot be left exposed without a thermal barrier (2015 IRC Section R316.4). The most common such barrier is ½-in. drywall.

Of these two foams (EPS and XPS), XPS is more commonly used, simply because it has a higher R-value (R-5 per in. rather than R-4). To meet R-5, R-10, and R-15 code requirements, one, two, and three inches of foam are required respectively. One commonly cited drawback of XPS is that its blowing agent is a potent greenhouse gas, although manufacturers are exploring alternatives with lower global warming potential.

As with the polyisocyanurate foam insulation systems, XPS foam can be attached to the wall with construction adhesive or with mechanical fasteners. Seams in the foam should be sealed, and the top and bottom edges should be sealed to the concrete with caulk or foam. In one method of mechanical attachment, fasteners are attached through 1x furring strips. This furring then serves as a base for attaching drywall with screws. Using these furring strips against irregular walls can be more challenging. As concrete surfaces are not always smooth, the drywall may follow any irregularities in the furring or wall shape. While wires can be run in the gap between the drywall and the foam, electrical boxes (when installed) must be recessed and cut into the foam.

To overcome these challenges, some builders choose to install a more conventional framed wall to the inside of the rigid foam (Figure 12). Framing cavities can be filled with batts or other appropriate cavity insulation. With the addition of frame cavity insulation, less rigid foam may be required to meet target R-values. For example, one inch of XPS in conjunction with a 2x4 wood-framed wall (20% framing factor) and R-13 fiberglass batts results in an effective R-value of approximately 15 ft²hr°F/Btu.
Spray Foam with Framing and Drywall

Sprayed polyurethane foam can provide excellent air sealing and thermal resistance in many envelope systems. The chief drawback to the product is cost; it is usually more expensive to install than rigid foam boards. Like unfaced foam boards, spray foam must be covered with a thermal barrier. While spray foam can be effective in many types of foundation walls, with very irregular walls (such as stone foundations), spray foam is one of the only options for excellent thermal and moisture performance. As open-cell spray foam can absorb and retain water (up to 40% by volume), closed-cell foam is recommended for most foundation wall applications.

A recommended spray-foam system for a poured-concrete or block wall is shown in Figure 13. Framing is installed at least one or two inches away from the interior surface of the foundation wall to allow for a continuous layer of foam to be blown behind the framing. Drywall (which provides the required thermal barrier) is attached to 2x4 framing in this detail. As with the XPS system discussed above, it’s possible to use a hybrid system with spray foam directly against the foundation wall and cavity insulation within the framing. It may also be practical to use 2x3 framing or steel framing in some applications.

It bears repeating that proper moisture management is critical for basements. The figures in these sections show examples of moisture control strategies that may or may not be appropriate for a specific home. Proper water management should be assessed on a case-by-case basis.

Figure 12. XPS is installed along basement walls before constructing a framed wall. (Source: Measure Guideline: Basement Insulation Basics).
Figure 13. Closed-cell spray foam insulates the inside surface of a foundation wall and provides a thermal break between the concrete and a 2x4 framed wall. The remaining cavity space can be filled with fiberglass or mineral wool insulation; the stud wall must be covered with drywall to provide the code-required thermal barrier. (Image courtesy of Steven Winter Associates).
Ensuring Success

Moisture Management
Basements are essentially holes in the ground. As such, they are susceptible to filling with water. Water management is critical in providing for overall durability and healthy basement conditions. Water issues can be related to rain or storm water run-off, ground water intrusion, movement of moist air, water vapor movement, or bulk water leaks from inside the basement (e.g., plumbing leaks). Insulating basement walls without adequately addressing moisture management can simply mask problems down the road. In some cases, insulation can trap water in assemblies and cause more severe problems.

Moisture management MUST be addressed before insulating a basement. There is a great deal of information in the Solution Center on this topic.

Insect and Pest Management
Insect problems vary tremendously from region to region and even locally within regions. Termites eat wood, and precautions should be taken for any wood assemblies located near grade. Termites do not eat most insulation products (such as foams and fiberglass), but they can tunnel through these materials to reach food sources in the building.

When termites tunnel through insulation, they are generally not visible. Some codes require a “vision strip,” which is basically a gap in the insulation that force pests to come out into the open. Vision strips do not stop insects, but they make them more noticeable. In areas with a high likelihood of termites, regular inspections should be conducted. If termites are present, their mud tunnels will likely be visible where they cross the vision strip in search of food. When pests are identified, other pest control measures must be taken.

Vision strips have a significant drawback: they require gaps in the insulation. These gaps are generally near grade where insulation is most important thermally (because of the larger temperature differentials). Where possible, the authors recommend the use of termite shields rather than gaps in insulation. A termite shield usually consists of a strip of metal flashing that is laid over the top of the foundation wall and below the sill plate. The metal extends out over the top of the rigid insulation installed on the interior or exterior surface of the foundation wall. It won’t necessarily stop termites from getting up into the wood framing but, because they can’t chew through the metal, they will have to come out of the insulation to go around it. The mud tunnels they leave on the metal shield will be a visible indicator that they are present. Once detected other pest treatment steps can be taken.

A termite shield extends over the top of the foundation wall and the exterior rigid foundation insulation. The shield separates the insulation on the foundation wall from the exterior rigid insulation on the above-grade frame walls.

There are also insulation products available (including some XPS foam boards) with pesticides incorporated into them. Manufacturers of these products often recommend termite shields or similar barriers be used as well.

Termites can represent a substantial durability risk in some areas. Where termites are present, termite shields or other measures should be included in the insulation strategies presented in this guide. If effective pest management cannot be incorporated effectively into the foundation insulation systems, other strategies should be considered (such as insulating beneath the first floor). Some more rigorous resources for pest management are presented elsewhere in the Solution Center.

Combustion Safety
Basements are often home to combustion appliances (boilers, furnaces, water heaters, etc.). Atmospherically vented appliances—where exhaust gases are drawn up a flue by natural convection—require substantial amounts of air in the room in which the atmospherically vented appliance is located (referred to as the combustion appliance zone or CAZ). When the appliance is located in an uninsulated basement, that air is often drawn through cracks and air leaks around windows and at rim...
joists. If the basement is later insulated and air sealed, those air sources will be sealed off, which can cause problems with proper combustion of atmospherically vented appliances and can potentially lead to dangerous conditions such as back drafting.

The insulation details presented here emphasize air sealing. While poured concrete walls do not leak air, the sills and rim joists are notorious air leakage areas. Before and after sealing and insulating a basement, ensure that combustion appliances are operating appropriately and safely. The best way to avoid combustion problems is to install non-combustion equipment or sealed-combustion equipment. Sealed-combustion, direct-vented appliances draw air directly from outside through their own dedicated air inlet pipes and they exhaust air directly outside through sealed flues so they do not draw air from the CAZ. If combustion equipment other than sealed-combustion equipment is present in a home, have a qualified contractor assess combustion safety before and after retrofitting, as described in the guides *Combustion Appliance Zone Testing* and *Pre-Retrofit Assessment of Combustion Appliances*.

**Radon**

Radon is a radioactive gas that occurs naturally in some soils and rocks and can cause health problems at higher concentrations. For more information on radon testing and mitigation, see this Solution Center guide on radon mitigation and the EPA website *Radon-Resistant New Construction Builder/Contractor Resources*. 


Climate

During warm seasons in humid climates, humid air can leak into an air-sealed basement through cracks, such as around windows and rim joists. This humid air can condense on cooler surfaces such as floor joists or below-grade wall surfaces, causing moisture issues in the basement. In cold climates an uninsulated basement can expose HVAC equipment and plumbing located therein to excessively cold temperatures. See the Compliance tab for prescriptive requirements for insulation levels in the International Energy Conservation Code and International Residential Code.

Consult with local code authorities regarding foundation inspection requirements for termites and requirements for radon mitigation. Also see the Ensuring Success tab for more information and resources on these topics.

IECC Climate Zones
Training

Right and Wrong Images

Display Image: 2019-Lifestyle-8-Foundation Insulation Board 4.jpg

Display Image: 2019-SDJessup-7-Basement Wall Set.JPG
CAD FILE:  Termite Shield.dwg
PDF:  Termite Shield.pdf
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)

ENERGY STAR Certified Homes requires that ceiling, wall, floor, and slab insulation levels meet or exceed those specified in the 2009 International Energy Conservation Code (IECC) with some alternatives and exceptions, and achieve Grade 1 installation per RESNET Standards (see 2009 and 2012 IECC Code Level Insulation – ENERGY STAR Requirements and Insulation Installation (RESNET Grade 1)).

Please see the ENERGY STAR Certified Homes Implementation Timeline for the program version and revision currently applicable in your state.

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 2) Ceiling, wall, floor, and slab insulation shall meet or exceed 2015 IECC levels and achieve Grade 1 installation, per RESNET standards. See the guide 2015 IECC Code Level Insulation – DOE Zero Energy Ready Home Requirements for more details.

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.

EPA Indoor airPLUS (Revision 04)

1.4 Basement and Crawlspace Insulation and Conditioned Air.

- Seal crawlspace and basement perimeter walls to prevent outside air infiltration.

- Insulate crawlspace and basement perimeter walls according to the prescriptive values determined by local code or R-5, whichever is greater.

- Provide conditioned air at a rate not less than 1 cfm per 50 sq. ft. of horizontal floor area. This can be achieved by a dedicated supply (2015 IRC section R408.3.2.2) or through crawl-space exhaust (2015 IRC section R408.3.2.1). However, if radon-resistant features are required (see Specification 2.1), do not use the crawlspace exhaust method.

See Indoor airPLUS Specifications for exceptions.
Building codes vary by region, state, and even locally, but most regions in the United States use some version of the International Residential Code (IRC) and/or the International Energy Conservation Code (IECC). Basement insulation requirements from these codes are shown in Table 1. Check energycodes.gov for codes used in your state.

Section R402.2.7 (R402.2.8 in 2012 IECC and R402.2.9 in 2015 and 2018 IECC). Basement walls. Walls associated with conditioned basements shall be insulated from the top of the basement wall down to 10 feet below grade or to the basement floor, whichever is less. Walls associated with unconditioned basements shall meet this requirement unless the floor overhead is insulated in accordance with Sections R402.1.1 (R402.1.2 in 2015 and 2018 IECC) and R402.2.6 (R402.2.7 in 2012 IECC, R402.2.8 in 2015 and 2018 IECC).

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For Si: 1 foot = 304.8 mm.

*The IRC code requirement differs from the IECC code requirement, as noted.

a. Table adapted from Table R402.1.1 in the 2009 and 2012 IECC and Table R402.1.2 in the 2015 and 2018 IECC (Table N1102.1 in 2009 IRC, Table N1102.1 in 2012 IRC, and Table N1102.1 in 2015 and 2018 IRC).

b. 2012, 2015, and 2018 IECC; R-values are minimums. When insulation is installed in a cavity which is less than the label or design thickness of the insulation, the installed R-value of the insulation shall not be less than the R-value specified in the table.

c. 2009 IECC: R-values are minimums. R-19 batts compressed into a nominal 2x6 framing cavity such that the R-value is reduced by R-1 or more shall be marked with the compressed R-value in addition to the full thickness R-value.

d. Refers to fenestration requirements not shown on this excerpted table.

e. 2009-2018 IECC: “10/13” means R-10 continuous insulation (called “insulated sheathing” in 2009 IECC) on the interior or exterior of the home or R-13 cavity insulation at the interior of the basement wall. “15/19” means R-15 continuous insulation on the interior or exterior of the home or R-19 cavity insulation at the interior of the basement wall. Alternatively, compliance with “15/19” shall be R-13 cavity insulation on the interior of the basement wall plus R-5 continuous insulation on the interior or exterior of the home.

f. 2009 IECC Only: The first R-value applies to continuous insulation, the second to framing cavity insulation; either insulation meets the requirement.

g. 2018 IECC: R-5 insulation shall be provided under the full slab area of a heated slab in addition to the required slab edge insulation R-value for slabs, as indicated in the table. The slab edge insulation for heated slabs shall not be required to extend below the slab.

h. 2009, 2012, and 2015 IECC: R-5 shall be added to the required slab edge R-values for heated slabs. Insulation depth shall be the depth of the footing or 2 feet, whichever is less in Climate Zones 1 through 3 for heated slabs.

i. 2009-2018 IECC: Basemat wall insulation is not required in warm-humid locations as defined by Figure R301.1 and Table R301.1 (Figure/Table N1101.2 in 2009 IRC and Figure/Table N1101.10 in 2012, 2015, and 2018 IRC).

j. 2009-2018 IECC: Alternatively, insulation sufficient to fill the framing cavity and providing not less than an R-value of R-10.

k. 2015 and 2018 IECC: Cavity insulation is continuous insulation. Therefore, as an example, “13+5” means R-13 cavity insulation plus R-5 continuous insulation.

l. 2012 IECC: First value is cavity insulation, second value is continuous insulation or insulated siding, so “13+5” means R-13 cavity insulation plus R-5 continuous insulation or insulated siding. If structural sheathing covers 40 percent or less of the exterior, continuous insulation R-value shall be permitted to be reduced by no more than R-3 in the locations where structural sheathing is used – to maintain a consistent total sheathing thickness.

m. 2009 IECC: “13+5” means R-13 cavity insulation plus R-5 insulated sheathing. If structural sheathing covers 25 percent or less of the exterior, insulating sheathing is not required where structural sheathing is used. If structural sheathing covers more than 25 percent of exterior, structural sheathing shall be supplemented with insulated sheathing of at least R-2.

n. 2018 IECC: Mass walls shall be in accordance with Section R402.2.5 (N1102.2.5 in 2018 IRC). The second R-value applies where more than half of the insulation is on the interior of the mass wall.

o. 2009, 2012, and 2015 IECC: The second R-value applies where more than half of the insulation is on the interior of the mass wall.

(p. 2009 IRC, footnote “k” addresses mass wall insulation while footnote “i” and “j” address fenestration.)

q. 2009 IECC Only: Refers to fenestration requirements not shown on this excerpted table.

Typical R-values for common insulation materials discussed here are summarized in Table 2.
Table 2. Typical R-values for common basement insulation materials.

<table>
<thead>
<tr>
<th>Insulation Type</th>
<th>R-value per inch (ft²°F/Btu-in)</th>
<th>Air barrier?</th>
<th>Vapor Barrier?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiberglass</td>
<td>2.5 – 4</td>
<td>No</td>
<td>No, depends on facing</td>
</tr>
<tr>
<td>Mineral wool (Mineral fiber)</td>
<td>3 – 4</td>
<td>No</td>
<td>No, depends on facing</td>
</tr>
<tr>
<td>Expanded polystyrene (EPS)</td>
<td>3.8 – 4.4</td>
<td>Yes</td>
<td>Typically Class III (2.6 Perm-inch)</td>
</tr>
<tr>
<td>Extruded Polystyrene (XPS)</td>
<td>5</td>
<td>Yes</td>
<td>Typically Class II (1.2 Perm-inch)</td>
</tr>
<tr>
<td>Polyisocyanurate (Polyiso)</td>
<td>Approx. .6</td>
<td>Yes</td>
<td>Depends on facing, typically Class I</td>
</tr>
<tr>
<td>Polyurethane Spray Foam (high-density)</td>
<td>Approx. .6</td>
<td>Yes</td>
<td>Typically Class II (1 Perm-inch)</td>
</tr>
</tbody>
</table>


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 IRC, 2012 IRC, 2015 IRC, and 2018 IRC

For IRC 2009-18 insulation requirements, see Table 1 above. Insulation requirements are described in Chapter 11 Energy Efficiency. Water management details are described in R405 Foundation Drainage and R406 Foundation Waterproofing and Dampproofing.


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.

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 Aeroset® 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[11] 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 statues 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 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, N1102.4.1/402.4.1Air 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 N1108.1.1/R502.1.1General. 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 N1108.1.1.1/R502.1.1.1 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 N1103.2/R503.2 Change in space conditioning.** Any non-conditioned or low-energy space that is altered to become conditioned space should be required to be in full compliance with this code. (This means not only the altered assembly is brought into compliance but the entire space or building also would need to be brought into compliance.)

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

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

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

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

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

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

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

Field Inspection:

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

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

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

Inspections should provide verification in the following areas:

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

Technical Validation(s):

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

- **2015/2018 IRC—International Residential Code for One- and Two-Family Dwellings**
  
  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
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

1. **Interior Foundation Insulation Upgrade - Madison Residence Madison, WI**
   - Author(s): ORNL
   - Organization(s): ORNL
   - Publication Date: October, 2013
   
   Case study of a basement retrofit of a 1916 home in Madison, Wisconsin, home that involved installing dimple drain mat and closed-cell spray foam on interior of basement wall and an interior footing drain to manage moisture before finishing an existing basement.

2. **New Whole-House Solutions Case Study: Exterior Rigid Foam Insulation at the Edge of a Slab Foundation, Fresno, California**
   - Author(s): IBACOS
   - Organization(s): IBACOS
   - Publication Date: October, 2013
   
   Case study describing application of exterior rigid foam insulation on a foundation system.

3. **Technology Solutions Case Study: Exterior Rigid Foam Insulation at the Edge of a Slab Foundation, Fresno, California**
   - Author(s): IBACOS
   - Organization(s): IBACOS
   - Publication Date: October, 2013
   
   Case study describing installation of exterior rigid foam insulation on a slab foundation.

4. **Technology Solutions Case Study: Innovative Retrofit Foundation Insulation Strategies, Minneapolis, Minnesota**
   - Publication Date: August, 2015
   
   Case study describing methods to retrofit foundations and basements in climate zones 6 and 7.

References and Resources*

1. **2009 IECC - International Energy Conservation Code**
   - Author(s): International Code Council
   - Organization(s): ICC
   - Publication Date: January, 2009
   
   Code establishing 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.

2. **2009 IRC - International Residential Code for One and Two Family Dwellings**
   - Author(s): International Code Council
   - Organization(s): ICC
   - Publication Date: January, 2009
   
   Code for residential buildings that 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): International Code Council
   - Organization(s): ICC
   - Publication Date: January, 2012
   
   Code establishing 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.

4.
2012 IRC - International Residential Code for One and Two Family Dwellings
Author(s): International Code Council
Organization(s): ICC
Publication Date: January, 2012
Code for residential buildings that 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.

5. 2015 IECC - International Energy Conservation Code
Author(s): International Code Council
Organization(s): ICC
Publication Date: May, 2014
Code establishing 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.

6. 2015 IRC - International Residential Code for One and Two Family Dwellings
Author(s): International Code Council
Organization(s): ICC
Publication Date: May, 2014
Code for residential buildings that 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): International Code Council
Organization(s): ICC
Publication Date: November, 2017
Code establishing 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.

Author(s): International Code Council
Organization(s): ICC
Publication Date: November, 2017
Code establishing 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.

9. 2018 IRC - International Residential Code for One and Two Family Dwellings
Author(s): International Code Council
Organization(s): ICC
Publication Date: August, 2017
Code for residential buildings that 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.

10. 2018 IRC - International Residential Code for One and Two Family Dwellings
Author(s): International Code Council
Organization(s): ICC
Publication Date: August, 2017
Code for residential buildings that 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.

11. Building America Special Research Project - High-R Foundations Case Study Analysis
Author(s): Smegal, Straube
Organization(s): Building Science Corporation
Publication Date: August, 2013
Research study describing a number of promising foundation and basement insulation strategies that can meet the requirement for better thermal control in colder climates while enhancing moisture control, health, and comfort.

12.
13. **Critical Seal (Spray Foam at Rim Joist)**
   - **Author(s):** Building Science Corporation
   - **Organization(s):** Building Science Corporation
   - **Publication Date:** September, 2009
     
     Information sheet about air sealing.

14. **Measure Guideline: Basement Insulation Basics**
    - **Author(s):** Aldrich, Mantha, Puttagunta
    - **Organization(s):** CARB, National Renewable Energy Laboratory, Steven Winter Associates, SWA
    - **Publication Date:** October, 2012
      
      Document describing good practices for insulating basements in new and existing homes.

15. **Pest Prevention by Design: Authoritative Guidelines for Designing Pests out of Structures**
    - **Author(s):** SF Environment
    - **Organization(s):** SF Environment, International Code Council
    - **Publication Date:** November, 2012
      
      Report providing strategies for designing structures to prevent pest entry.

*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.

Steven Winter Associates, Inc. [www.swinter.com](http://www.swinter.com)