Sealing and Insulating Existing Floors above Unconditioned Spaces - Code Compliance Brief

Overview:

The intent of this brief is to provide code-related information about sealing and insulating existing floors above unconditioned spaces in existing residential buildings to help ensure that the measures will be accepted as being in compliance with the code. Providing notes for code officials on how to conduct plan reviews and field inspections can provide jurisdictional officials with information for acceptance. Providing the same information to builders, contractors, designers, and others is expected to result in increased compliance and fewer innovations being questioned at the time of plan review and/or field inspection.

Floors can account for up to one-fourth of the surface area of a building. When defects in the air barrier and insulation system exist, heat flow through floors over unconditioned basements or vented crawlspaces can significantly impact thermal comfort and space conditioning costs.

From a model code perspective, submittal of construction documentation, permitting, plan review, and field inspection may be required depending upon the specific details of renovating the floor above an unconditioned space (e.g., floor over a vented crawl space). Several different approaches can be taken to seal and insulate existing floors during a renovation project.

Code versions before the 2015 International Energy Conservation Code (IECC) and 2015 International Residential Code (IRC) required floor insulation to be in direct contact with the underside of subfloor decking. However, another option is now defined in the 2015 IECC/IRC allowing airspace between the floor sheathing and the top of the cavity insulation. In this application, the cavity insulation must be in direct contact with the topside of the sheathing or continuous insulation installed on the underside of the floor framing and must be combined with perimeter insulation that meets or exceeds the R-value requirements for walls. This newer option leads to fewer cold spots (the airspace makes for a warmer floor) but does not change the heat loss as long as the cavity insulation is in direct contact with sheathing or continuous insulation below it. Filling the airspace completely reduces heat flow and saves energy but does not make the floor warmer. So the best way to construct a warm floor is continuous rigid insulation coupled with an airspace above the cavity insulation (see figure below). It also facilitates services to be enclosed within the building thermal envelope.¹

The following section entitled Plan Review provides code sections applicable to alterations. Then, the Field Inspection section provides details regarding inspections of alterations involving sealing and insulating existing exterior floors. Refer to the Technical Validation/Reference Materials section for resources on technical validation, best practices, and measure guidelines on the proper techniques that can ensure that an improved sealed and insulated floor will increase the home’s overall energy efficiency.

¹The 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.

Plan Review:
This section lists the applicable code requirements followed by details helpful for plan reviews regarding provisions associated with sealing and insulating existing floors.

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

Construction Documentation. Review the construction documents for details describing the renovation of the floors, insulation and sealing materials, installation, and construction techniques.

- **2015 IECC/IRC, Section R103.2/N1101.5 Information on construction documents.** Construction documents should include:
  - Details associated with the floor(s) renovation (e.g., water/moisture damage, water control layer, and drainage)
  - Insulation material(s) and their R-values with the floor(s) and any openings in the floor(s) such as air returns, ducts, crawl space access, etc.
  - Details indicating how the insulation is to be installed to the existing floor(s)
  - Air sealing details.

- **2015 IECC/IRC, Section R501.1.1/N1107.1.1 Alterations – General.** Alterations to an existing building or portion thereof should comply with Sections R502/N1108, R503/N1109 or R504/N1110. Unaltered portions of the existing building are not required to comply.

- **R503.1/N1109.1 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.

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

- **R503.1.1/N1109.1.1 Building Envelope.** Building envelope assemblies that are part of the alteration must comply with Sections R402.1.2/N1102.1.2 (Insulation and Fenestration Table) or R402.1.4/N1102.1.4 (U-factor Alternative), and Sections R402.2.1/N1102.2.1 through R402.12/N1102.12, R402.3.1/N1102.3.1, R402.3.2/N1102.3.2, R402.4.3/N1102.4.3 and R402.4.4/N1102.4.4
  - Construction where the existing floor cavity is not exposed.

- **2012 IECC/IRC, Section R101.4.3/N1101.3 and 2009 IECC/IRC, Section 101.4.3/N1101.4.3 Alterations – General.** Alterations to an existing building or portion thereof should comply to the provisions of the code as they relate to new construction without requiring unaltered portion(s) of the existing building to comply with this code.
  - Existing floor cavities exposed during construction, provided that the cavities are filled with insulation
  - Construction where the existing floor cavity is not exposed.

- **2015 IECC/IRC, Section R402.1.2/N1102.1.2 Insulation Criteria.** The *building thermal envelope* must meet the requirements of Table R402.1.2/N1102.1.2, based on the climate zone specified in Chapter 3 of the code and the building assemblies associated with the floor(s) that are considered part of the *building thermal envelope*.

- **2015 IECC/IRC, Section R402.1.3/N1102.1.3 or 2012 IECC/IRC, Section R402.1.2/N1102.1.2 R-Value Computation.** Insulation material used in layers, such as framing cavity insulation, or continuous insulation should be summed to compute the corresponding component R-value. The manufacturer’s settled R-value should be used for blown insulation. Computed R-values should not include an R-value for other building materials or air films.
An excerpt from the *Insulation and Fenestration Requirements by Component Tables* follows:

2015 IECC/IRC, Table R402.1.2/N1102.1.2 or 2012 IECC/IRC, Table R402.1.1/N1102.1.1

(R-values and footnote are the same for both code versions)

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4 Except Marine</th>
<th>5 and Marine 4</th>
<th>6</th>
<th>7, 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor R-value</td>
<td>13</td>
<td>13</td>
<td>19</td>
<td>19</td>
<td>30(^a)</td>
<td>30(^a)</td>
<td>38(^a)</td>
</tr>
</tbody>
</table>

\(^a\)Or insulation sufficient to fill the framing cavity, R-19 minimum.

- 2015 IECC/IRC, Section R402.1.4/N1102.1.4 or 2012 IECC/IRC Section R402.1.3/N1102.1.3 U-Factor Alternative. An assembly with a U-factor equal to or less than that specified in Equivalent U-factor Tables should be permitted as an alternative to the R-value in Insulation and Fenestration Requirements by Component Tables of the IECC/IRC.

An excerpt from the *Equivalent U-factor Tables* follows:

2015 IECC/IRC, Table R402.1.4/N1102.1.4 or 2012 IECC/IRC, Table R402.1.3/N1102.1.3

(U-factors are the same for both code versions)

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>1</th>
<th>2</th>
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<th>4 Except Marine</th>
<th>5 and Marine 4</th>
<th>6</th>
<th>7, 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor U-factor</td>
<td>0.064</td>
<td>0.064</td>
<td>0.047</td>
<td>0.047</td>
<td>0.033</td>
<td>0.033</td>
<td>0.028</td>
</tr>
</tbody>
</table>

An excerpt from the *2009 IECC/IRC Insulation and Fenestration Requirements by Component Table 402.1.1/N1102.1.1* follows:

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>1</th>
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<td>30(^a)</td>
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<td>38(^a)</td>
</tr>
</tbody>
</table>

\(^a\)Or insulation sufficient to fill the framing cavity, R-19 minimum.

Air Sealing/Air Leakage Control

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

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

- R402.4.1.1/N1102.4.1.1 Installation. The components listed in the Air Barrier and Insulation Installation Table should be installed in accordance with the manufacturer’s instructions and criteria listed as the applicable method of construction. Below are the General Requirement and components from the table that are applicable to sealing and insulating floors.

- 2015 IRC/IECC, Air Barrier and Insulation Installation Table R402.4.1.1/N1102.4.1.1

- Continuous air barrier\(^2\) – Confirm that construction documents specify a continuous air barrier for the building components associated with the insulation of the exterior floor(s). Breaks or joints in the air barrier should be sealed. Air-permeable insulation should not be used as a sealing material.

- 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.

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

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

- 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.
• Heating, ventilating, and air conditioning (HVAC) register boots – HVAC register boots that penetrate the ceiling (vented attic) are sealed to the subfloor or drywall.

• 2012 IECC/IRC, R402.4/N1102.4 Air Leakage. The building thermal envelope should be constructed to limit air leakage.  
  o R402.4.1/N1102.4.1 Building Thermal Envelope. Methods used for sealing between dissimilar materials should allow for differential expansion and contraction.
  o R402.4.1.1/N1102.4.1.1 Installation. 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 and insulating floors.
  o R402.4.1.1/N1102.4.1.1 Air Barrier and Insulation Installation Table
    ■ Air barrier and thermal barrier – A continuous air barrier should be installed in the building envelope (floor). Breaks or joints in the air barrier should be sealed. Air-permeable insulation should not be used as a sealing method.
    ■ 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 IECC/IRC.

• 2009 IECC/IRC, 402.4.1/N1102.4.1 Air leakage, Building Thermal Envelope
  o The building thermal envelope should be constructed to limit air leakage. Methods used to seal between dissimilar materials should allow for differential expansion and contraction. Sources of infiltration (see listing below) should be caulked, gasketed, weather-stripped, or otherwise sealed with an air-barrier material, suitable film, or solid material:
    o All joints, seams, and penetrations
    o Utility penetrations
    o Rim joist junction
    o Other sources of infiltration

2The term “continuous air barrier” is defined in the 2015 IRC/IECC as a combination of materials and assemblies that restrict or prevent the passage of air through the building thermal envelope.

Field Inspection:

Per the 2015 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 footing and foundation, framing and rough-in work, plumbing rough-in, mechanical rough-in, and final inspection.

Per the 2015 IRC, Section R109, Inspections, the wording is somewhat different in the IRC versus the IECC in that for onsite construction, 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 foundation, plumbing, mechanical, gas and electrical, floodplain, frame and masonry, and final inspection. Any additional inspections are at the discretion of the building official.

This section provides details for inspecting to the specific provisions for sealing and insulation of existing floors where one or more specific type of inspection per the IECC or IRC may be necessary to confirm compliance. To confirm code compliance, framing and rough-in would be the typical type of inspection performed for new construction. In existing residential floors where framing already exists, the framing inspection would also involve ensuring floor(s) that have any sources of air leakage are sealed and the existing framing is acceptable (e.g., no water damage or deterioration).

• Joints, seams, holes, and penetrations in the floor are caulked, gasketed, weather-stripped, or otherwise sealed.
• Ensure that the appearance of the floor insulation, as appropriate, in the field matches what is on the approved construction documents.
• If the R-value or U-factor approach for compliance was used in the documentation, ensure that the insulation installed meets the minimum R-value or maximum U-factor required for the type of assembly and climate zone per the approved construction documents.
• Confirm that an air barrier is installed properly at all exposed edges of insulation.
Confirm that framing cavity insulation is installed to maintain permanent contact with the underside of subfloor decking per approved construction documentation or that floor framing cavity insulation is in contact with the topside of sheathing or continuous insulation installed on the bottom side of the floor framing and extends from the bottom to the top of all perimeter floor framing members.
Technical Validation(s):

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

  Author(s): ICC
  Organization(s): ICC
  Publication Date: May 2014
  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.

- **2015 IRC—International Residential Code for One- and Two-Family Dwellings** [2]
  Author(s): ICC
  Organization(s): ICC
  Publication Date: May 2014
  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: January 2012
  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.

  Author(s): ICC
  Organization(s): ICC
  Publication Date: January 2012
  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: January 2009
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  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.


Related Building America Solution Center Guides:

- Floor Above Unconditioned Basement or Vented Crawlspace, [https://basc.pnnl.gov/resource-guides/floor-above-unconditioned-basement-or-vented-crawlspace][8]
- Floor Above Garage, [https://basc.pnnl.gov/resource-guides/floor-above-garage][9]