Floor Above Unconditioned Basement or Vented Crawlspace

Last Updated: 03/14/2016

Scope

Air seal the floor above an unconditioned basement or crawlspace and make sure floor insulation is in full contact with the underside of the subfloor.

Air seal the floor above an unconditioned basement or crawlspace and make sure floor insulation is in full contact with this subfloor air barrier.

- Seal all seams, gaps, and holes in the subfloor air barrier with caulk or foam.
- Air seal rim joists.
- Install insulation in floor joist bays without misalignments, compressions, gaps, or voids.
- Install supports to keep insulation in permanent contact with the air barrier above, for example, metal staves for batt insulation or netting for blown insulation.
- If spray foam insulation is used for the floor cavity insulation, the spray foam can serve as the air barrier if it is at least 5.5 inches thick if open-cell or at least 1.5 inches thick if closed-cell spray foam insulation.

See the **Compliance Tab** for related codes and standards requirements, and criteria to meet national programs such as DOE's Zero Energy Ready Home program, ENERGY STAR Certified Homes, and Indoor airPLUS.

Description

Floors can account for one-fourth to one-third of the building enclosure's surface area. When defects in the air barrier and insulation system exist, heat loss through floors over unconditioned basements or vented crawlspaces can cause uncomfortably cold floors and increases in space conditioning costs as well. Heat loss in floors can be caused by

- Conduction losses, also known as thermal bridging, when heat transfers through framing members dues to a lack of insulation
- Air leakage, due to the lack of an effective air barrier or unsealed holes in the air barrier
- Misalignment of the air barrier and thermal barrier, which allows gaps to exist, for example between batt insulation and the drywall, which allow air to flow in wall cavities due to convective currents or holes in the air barrier, which rob the insulation of its effectiveness (**EPA 2011**).

To prevent these heat losses, the insulation layer in the floor should be continuous and consistent and should be completely aligned with (in continual contact with) the air barrier separating the house from the unconditioned space below. When basements or crawlspaces are uninsulated the air barrier is typically the subfloor, which consists of plywood or OSB. Any holes around plumbing wiring, etc., in the subfloor must be sealed.

Note, if HVAC equipment and plumbing pipes will be located in the crawlspace (especially in cold climates) or if the basement may be used for living space, the crawlspace or basement should be insulated along the walls rather than in the ceiling to include these areas within the thermal envelope of the home. The thermal envelope consists of the continuous air barrier and thermal barrier/insulation which surround the home's walls, ceilings, and foundation. (See the guide **Continuous Air Barrier in Exterior Walls** for more information.) However, if HVAC equipment is not located in the basement and plumbing lines can be protected, it might be reasonable to establish the thermal and pressure boundary in the floor above the basement, rather than along the foundation walls.

How to Insulate and Airseal the Floor above an Unconditioned Basement or Crawlspace

1. Install a subfloor that can serve as a continuous air barrier between the crawlspace or basement and the house above. In most cases, this air barrier will be plywood or OSB floor sheathing. Install the subfloor sheathing panels according to APA Sturd-I-Floor recommendations, which includes the following (**APA 2011**):

- Install subfloor in panel widths that align with the framing (typically 16-, 20-, or 24-inches on-center).
- Stagger subfloor panel end joints.
- Use tongue-and-groove subfloor panels or install blocking beneath panel joints.
- Apply construction adhesive or caulk at panel seams and between subfloor panel and framing members.

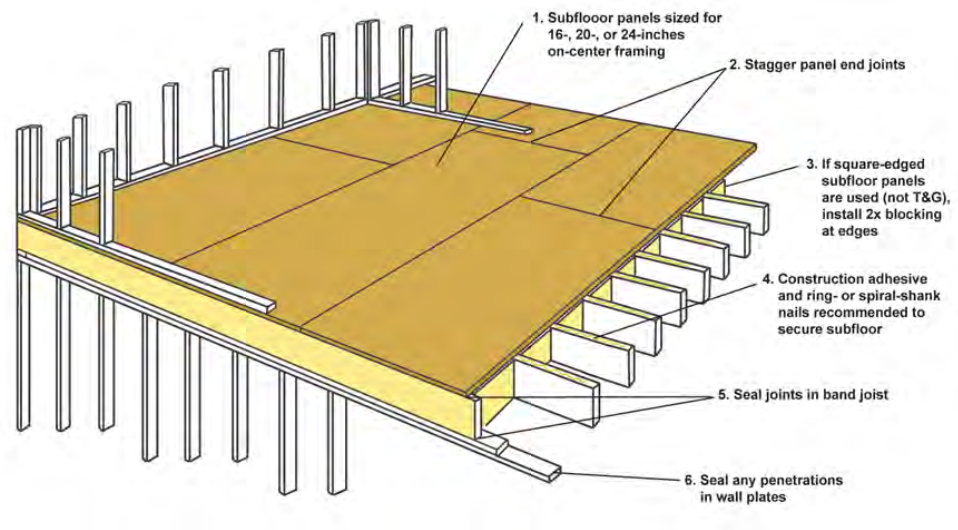


Figure 1 - Seams in the subfloor are sealed with construction adhesive so that the subfloor can serve as an air barrier separating the garage from the living space above.

2. Air seal the band and rim joists and any penetrations.

- Block off any open floor joists running from the crawlspace to under other conditioned parts of the home. Use a rigid air barrier material and seal the edges with spray foam. Batt insulation is not a good air barrier. See the guide **Garage Rim/Band Joist Adjoining Conditioned Space** for more information.

- Seal around any mechanical penetrations such as piping, wiring, or ducts. Use rigid foam or plywood plus spray foam for large holes, as shown in Figure 2 (**EPA 2011**).
- Seal the rim joists with rigid foam cut to fit and caulked or spray foamed at edges to seal in place (Figure 5). Rim joists can also be air sealed and insulated in one step using spray foam insulation. To qualify as an air barrier, open-cell or closed-cell foam must have a finished thickness greater than or equal to 5.5 inches or 1.5 inches, respectively (**EPA 2011**). Batt insulation can be added over spray foam or rigid foam but should not be installed alone as it is not an air barrier (Figure 4).

Figure 2 - All mechanical and plumbing penetrations through the subfloor need to be air sealed.

Figure 3 - Seal and insulate rim joists with rigid foam board cut to fit and sealed with foam or caulk.

Figure 4 - Batt insulation is not an effective air barrier.

3. Install insulation in the floor joists.

- Insulation should be fully "aligned" with the air barrier, i.e., in full contact with the subfloor above. There should be no gaps between the insulation and the sheathing above it like those seen in Figure 5.(**EPA 2011**).
- Batt insulation should fit tightly between the floor joists but avoid gaps, compressions, or voids. Batts should be fully lofted (not crammed or compressed into the space, see Figure 6). Batts should be cut lengthwise to fit narrow joist bays, and split to fit neatly around electrical wiring running across joist bays. See the guide **Insulation Installation Achieves RESNET Grade 1** for more on quality installation.
- Spray foam insulation can be used to insulate the floor above a crawlspace or basement as well as the band joist. Spray foam provides high R-value and a continuous air barrier in one labor-saving application. To qualify as an air barrier, open-cell spray foam must have a finished thickness **?** 5.5 inches and closed-cell spray foam must have a finished thickness **?** 1.5 inches (**EPA 2011**).

Figure 5 - Without wire stays or metal support rods, this batt insulation will not stay fully aligned with the subfloor air barrier.

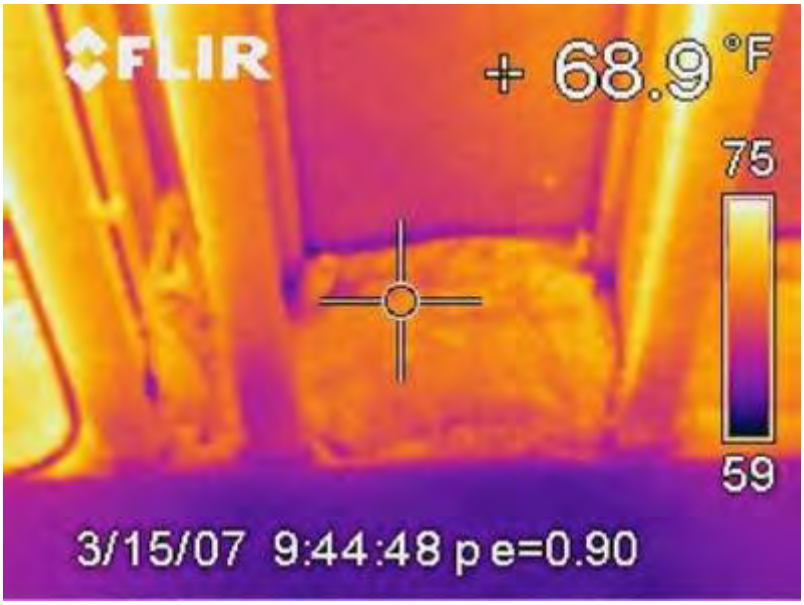
4. Support the insulation. Install metal staves or mechanically fastened wire to keep batts in continuous contact with the subfloor above.

Ensuring Success

Blower door testing, conducted as part of whole-house energy performance testing, may help indicate whether air leakage at through the floor has been successfully sealed.

Infrared imaging. An infrared camera may also be used to determine air leakage through the floor over a garage if a sufficient temperature difference exists between the outdoors and the conditioned space above the garage. For best results, scan twice – first under static conditions before blower door testing has been conducted. This will allow the technician to evaluate the integrity of insulation behind the drywall, if the garage ceiling has been finished. Conduct a second scan with the blower door running in depressurization mode and the door between the house and the garage open. This will demonstrate the integrity of the air barrier, showing where air leakage has infiltrated the framing and seeped through insulation.

The infrared image below shows the rim joist area. Typically the darker areas indicate the areas that are the coldest, and represent the greatest amount of heat loss. Here, where the insulation meets the subfloor and the I-joists, you can see dark purple spots. These spots indicate heat loss or air leakage. These areas are where you want to be sure you air seal *before* you insulate.



Through this thermograph from an infrared camera, heat loss or air leakage is visible as dark purple spots, which clearly display a lack of air sealing

Diagnostic smoke. With the blower door pressurizing, the garage door closed, and the door to the house open, check for air leaks in the floor and near the rim joist with a smoke pencil. A smoke trail moving away from the smoke pencil indicates a leak to the outdoors that should be sealed.

Climate

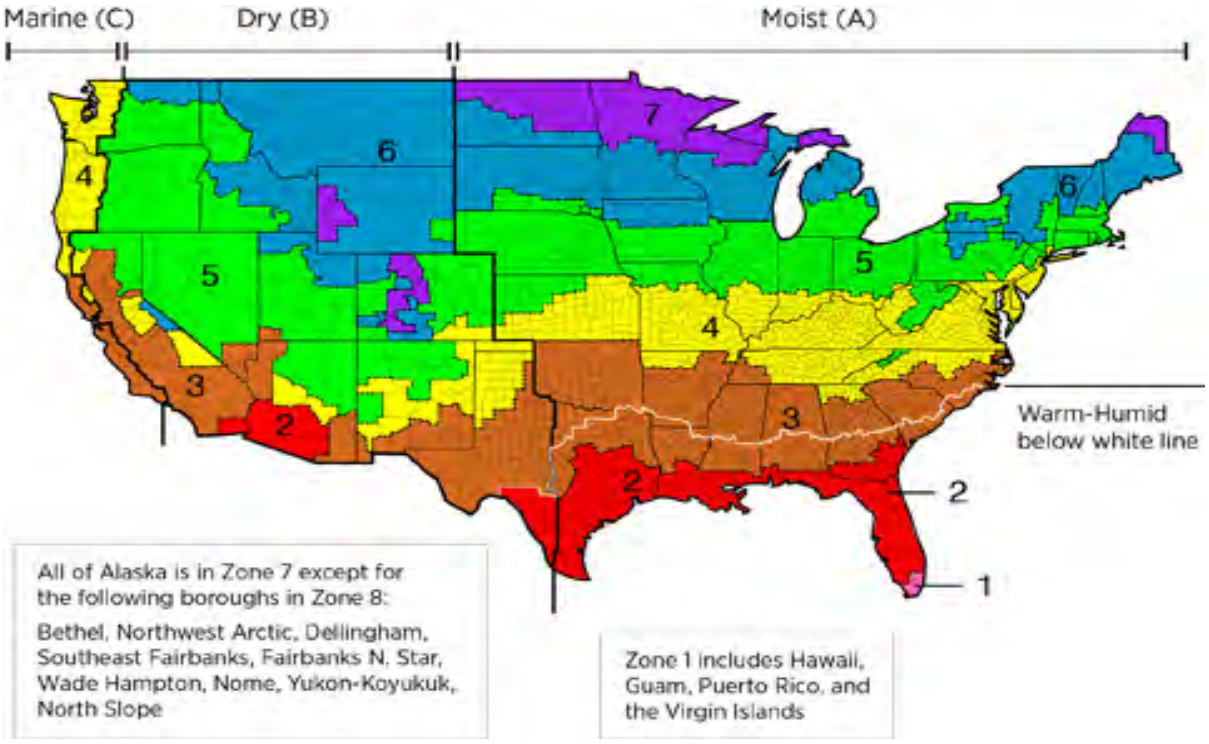
Install insulation in amounts that meet or exceed code-required levels for your climate zone. See for example Table R402.1.1 in the 2009 or 2012 International Energy Conservation Code (**2009 IECC**, **2012 IECC)** or Table R402.1.2 in the **2015 IECC**)

ENERGY STAR Certified Homes

ENERGY STAR Certified Homes (Ver. 3/3.1 Ver 08) Rater Field Checklist, a complete air barrier that is fully aligned with insulation is installed at the exterior vertical surface of floor insulation in all climate zones and, if over unconditioned space, also at the interior horizontal surface.

DOE Zero Energy Ready Home

DOE Zero Energy Ready Home (Rev 05) Exhibit 2: Infiltration: Climate Zones 1-2: 3 ACH 50; Zones 3-4: 2.5 ACH50; Zones 5-7: 2 ACH50; Zone 8: 1.5 ACH50. Building envelope leakage shall be determined by an approved verifier using a RESNET-approved testing protocol.



International Energy Conservation Code (IECC) Climate Regions

Training

Right and Wrong Images

Display Image: ES_TESRC_3.2.3_PG78_124b_102811_0.jpg

Display Image: [ES_TESRC_3.2.3_PG78_125c_102811_0.jpg]

Display Image: [ES_TESRC_3.2.3_PG78_126d_102811_0.jpg]

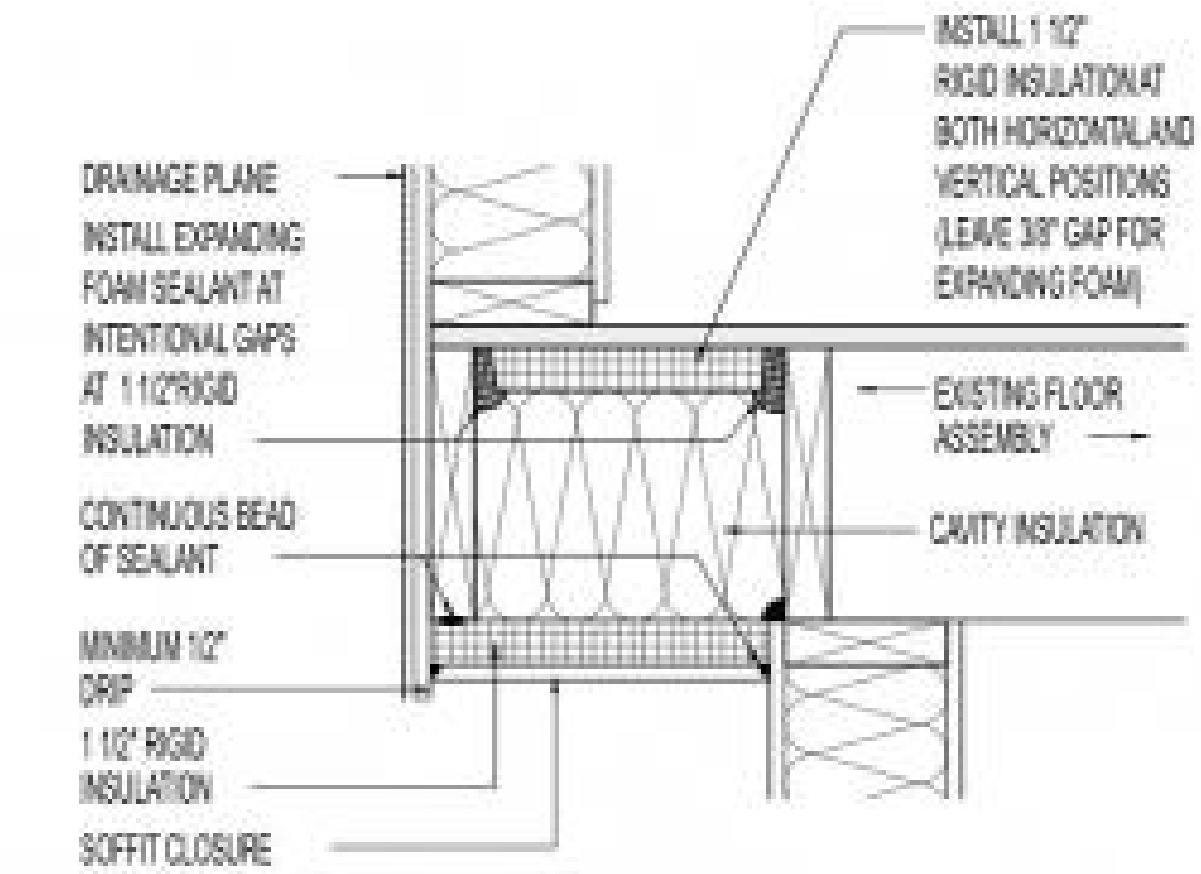
Display Image: ES_TESRC_3.2.3_PG78_127e_102811_0.jpg

Display Image: [ES_TESRC_3.2.3_PG78_128f_102811_0.jpg]

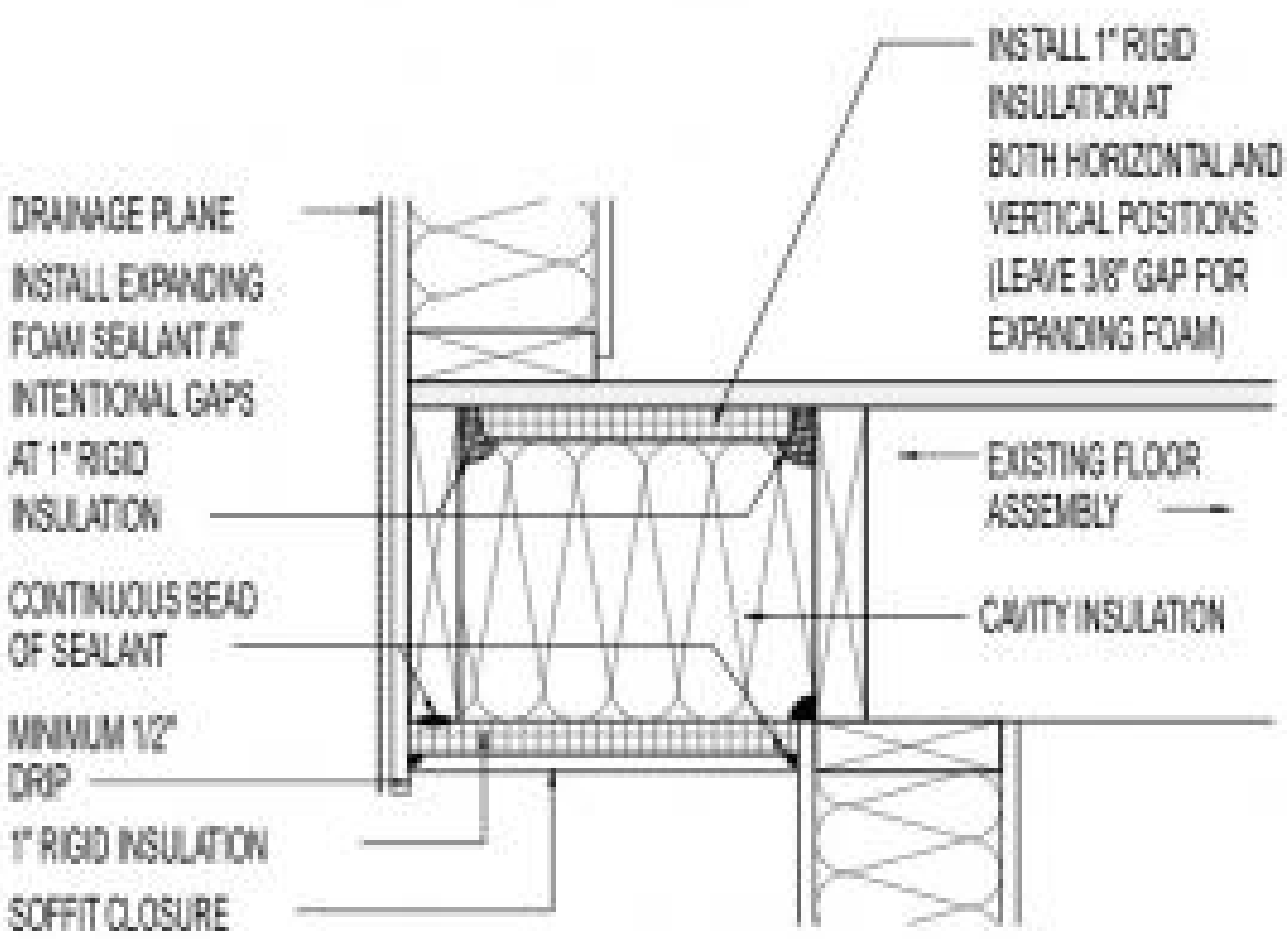
Display Image: [ES_TESRC_3.2.3_PG78_129g_102811_0.jpg]

Display Image: [ES_TESRC_3.2.3_PG78_130h_102811_0.jpg]

CAD



CAD FILE: 322_CAD_3-2_cantilever_floor_1_5_in_rigid_foam_5-01020_GBA_1-31-12.dwg
PDF: 322_CAD_3-2_cantilever_floor_1_5_in_rigid_foam_5-01020_GBA_1-31-12.pdf



CAD FILE: 322_CAD_3-2_cantilever_floor_1_in_rigid_foam_5-01019_GBA_1-31-12.dwg
PDF: 322_CAD_3-2_cantilever_floor_1_in_rigid_foam_5-01019_GBA_1-31-12.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

ENERGY STAR Certified Homes (Version 3/3.1, Revision 08), Rater Field Checklist, Thermal Enclosure System

2. Fully-Aligned Air Barriers[5], At each insulated location below, a complete air barrier is provided that is fully aligned as follows:

2.6 Floors above garages, floors above unconditioned basements or crawlspaces, and cantilevered floors

Floors: At exterior vertical surface of floor insulation in all climate zones and, if over unconditioned space, also at interior horizontal surface including supports to ensure alignment. See Footnotes 10 & 11 for alternatives.[9, 10, 11]

Footnotes:

(5) For purposes of this Checklist, an air barrier is defined as any durable solid material that blocks air flow between conditioned space and unconditioned space, including necessary sealing to block excessive air flow at edges and seams and adequate support to resist positive and negative pressures without displacement or damage. EPA recommends, but does not require, rigid air barriers. Open-cell or closed-cell foam shall have a finished thickness ? 5.5 in. or 1.5 in., respectively, to qualify as an air barrier unless the manufacturer indicates otherwise. If flexible air barriers such as house wrap are used, they shall be fully sealed at all seams and edges and supported using fasteners with caps or heads ? 1 in. diameter unless otherwise indicated by the manufacturer. Flexible air barriers shall not be made of kraft paper, paper-based products, or other materials that are easily torn. If polyethylene is used, its thickness shall be ? 6 mil.

(9) EPA highly recommends, but does not require, an air barrier at the interior vertical surface of floor insulation in Climate Zones 4-8.

(10) Examples of supports necessary for permanent contact include staves for batt insulation or netting for blown-in insulation. Alternatively, supports are not required if batts fill the full depth of the floor cavity, even when compression occurs due to excess insulation, as long as the R-value of the batts has been appropriately assessed based on manufacturer guidance and the only defect preventing the insulation from achieving the required installation grade is the compression caused by the excess insulation.

(11) Alternatively, an air barrier is permitted to be installed at the exterior horizontal surface of the floor insulation if the insulation is installed in contact with this air barrier, the exterior vertical surfaces of the floor cavity are also insulated, and air barriers are included at the exterior vertical surfaces of this insulation.

ENERGY STAR Revision 08 requirements are required for homes permitted starting 07/01/2016.

DOE Zero Energy Ready Home

Exhibit 1: Mandatory Requirements. Certified under ENERGY STAR Qualified Homes Version 3. Exhibit 2: DOE Zero Energy Ready Home Target Home. Insulation levels shall meet or exceed the 2012 IECC (Table R402.1.1) and achieve Grade 1 installation, per RESNET standards. Infiltration (ACH50): Zones 1-2: 3; Zones 3-4: 2.5; Zones 5-7: 2; Zone 8: 1.5. Envelope leakage shall be determined by an approved verifier using a RESNET-approved testing protocol. Steel-frame ceilings, walls, and floors shall meet the insulation requirements of the 2012 IECC – Table 402.2.6.

2009, 2012, and 2015 IECC

Table R402.4.1.1 Air Barrier and Insulation Installation, Floors: Insulation in floors (including above garage and cantilevered floors) is installed to maintain permanent contact with underside of subfloor decking. A continuous air barrier is installed in the building envelope including rim joists and exposed edges of insulation. Breaks or joints in the air barrier are sealed. Air permeable insulation is not used as a sealing material. Junction of foundation and wall sill plates, wall top plate and top of wall, sill plate and rim-band, and rim band and subfloor are sealed. Corners, headers, and rim joists making up the thermal envelope are insulated.*
Table R402.1.1 (Table R402.1.2 in 2015 IECC) Insulation and Fenestration Requirements – meet or exceed the insulation levels listed in this table.

2009, 2012, and 2015 IRC

Table N1102.4.2 Air Barrier and Insulation Installation, Floors: Insulation in floors (including above garage and cantilevered floors) is installed to maintain permanent contact with underside of subfloor decking. A continuous air barrier is installed in the building envelope including rim joists and exposed edges of insulation. Breaks or joints in the air barrier are sealed. Air permeable insulation is not used as a sealing material. Junction of foundation and wall sill plates, wall top plate and top of wall, sill plate and rim-band, and rim band and subfloor are sealed. Corners, headers, and rim joists making up the thermal envelope are insulated.*
Table R402.1.1 (Table R402.1.2 in 2015 IECC) Insulation and Fenestration Requirements – meet or exceed the insulation levels listed in this table.

*Due to copyright restrictions, exact code text is not provided. For specific code text, refer to the applicable code.

Floors: Above Unconditioned Basement, Vented Crawlspace, Cantilevered Floors, and Floors above Garage, Code Compliance Brief

Overview:

Previous codes (prior to the 2015 IECC/IRC) only addressed one option for insulating floors, requiring insulation in floors to be in direct contact with the underside of subfloor decking. However, another option that is now defined in the 2015 IECC/IRC, is to have an airspace between the floor sheathing and the top of the cavity insulation where the cavity insulation is in direct contact with the topside of sheathing or continuous insulation installed on the underside of the floor framing and is combined with perimeter insulation that meets or exceeds the R-value requirements for walls. This second option leads to fewer cold spots yet does not change the heat loss as long as the cavity insulation is in direct contact with sheathing below it or continuous insulation below it. It also facilitates services to be enclosed within the thermal envelope.

If an older version of the code is being enforced in your location, the approach to overcome this barrier is to reference this version of the code as documentation for acceptance for compliance.

Plan Review:

- Ensure the drawings and construction specifications detail the layering of insulating materials – the individual and total R-values of insulating materials comprising the building envelope assembly.
- Confirm insulation placement and an air barrier is specified at exposed edges of insulation on drawings.
- Refer to code citations on insulation and air barrier placement: reference 2015 IECC/IRC, Section R402.2.8/N1102.2.8, Table 402.4.1.1 (N1102.4.1.1). An excerpt from the Table R402.4.1.1 is below.

Component	Insulation Installation	Air Barrier
Floors (including above garage and cantilevered floors)	Floor framing cavity insulation installed to maintain permanent contact with the underside of subfloor decking, or floor framing cavity insulation 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.	Air barrier installed at any exposed edge of insulation

Field Inspection:

Depending on proposed insulation installation verify proper installation of the following:

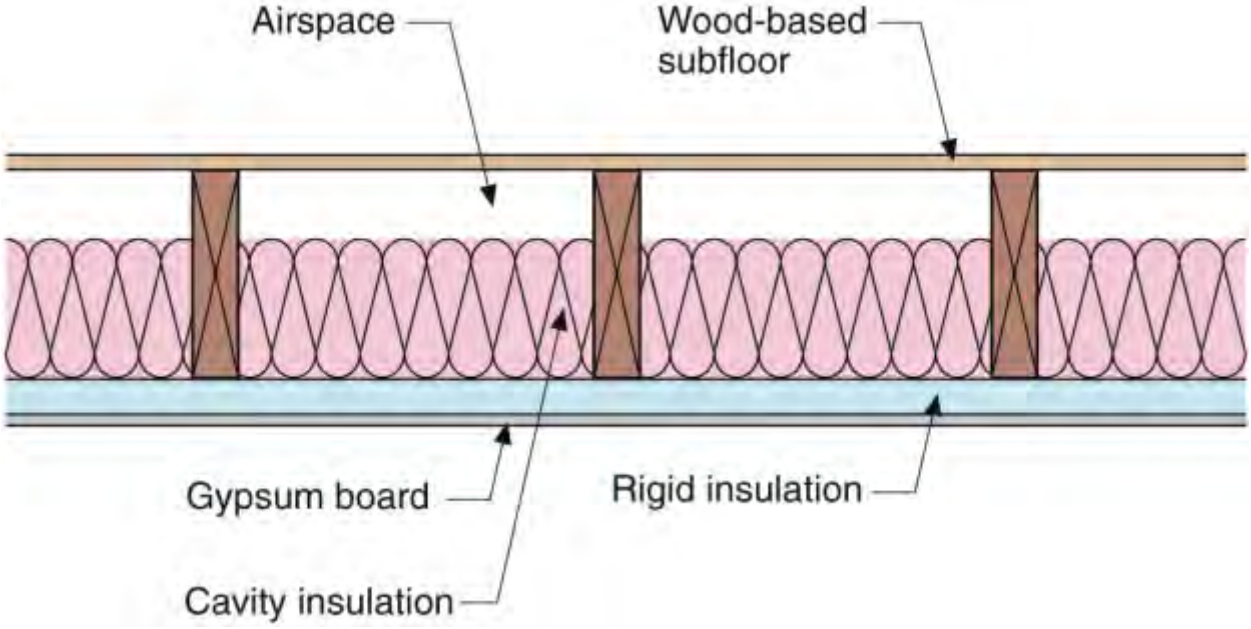
- Floor framing cavity insulation – installed to maintain permanent contact with underside of subfloor decking
- Sheathing or continuous insulation installed – confirm floor framing cavity insulation is in contact with the top side of sheathing or continuous insulation installed on the underside of the floor framing and extends from the bottom to the top of all perimeter floor framing members
- Confirm an air barrier is installed at all exposed edges of insulation

Technical Validation(s):

Building Science Corporation
http://www.buildingscience.com/documents/insights/bsi-064-bobby-darin-thermal-performance?topic=doctypes/insights

Figure 1 – Air space between the cavity insulation and subfloor, the top side of cavity insulation is in direct contact with the

rigid insulation (continuous insulation) and air barrier (gypsum board)



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

None Available

References and Resources*

1. **Crawlspace Insulation**
   Author(s): BSC
   Organization(s): BSC
   Publication Date: May, 2009
   Information sheet about crawlspace insulation, including installation details.
2. **DOE Zero Energy Ready Home National Program Requirements**
   Author(s): DOE
   Organization(s): DOE
   Publication Date: April, 2017
   Standard requirements for DOE's Zero Energy Ready Home national program certification.
3. **ENERGY STAR Certified Homes Building Science Introduction**
   Author(s): EPA
   Organization(s): EPA
   Publication Date: January, 2011
   Document outlining building science principles about air flow, heat flow and moisture flow in homes.
4. **ENERGY STAR Certified Homes, Version 3 (Rev. 08) National Program Requirements**
   Author(s): EPA
   Organization(s): EPA
   Publication Date: December, 2015
   Document outlining the program requirements for ENERGY STAR Certified Homes, Version 3 (Rev. 08).
5. **Engineered Wood Construction Guide**
   Author(s): APA - The Engineered Wood Association
   Organization(s): APA - The Engineered Wood Association
   Resource library with information on engineered wood products.
6. **Thermal Enclosure System Rater Checklist Guidebook**
   Author(s): EPA
   Organization(s): EPA
   Publication Date: October, 2011
   Guide describing details that serve as a visual reference for each of the line items in the Thermal Enclosure System Rater Checklist.

*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.

Pacific Northwest National Laboratory