Install continuous rigid foam insulation or insulated siding to help reduce thermal bridging through wood- or metal-framed exterior walls.

- Install rigid foam over or in place of plywood, OSB, or other wall sheathing.
- Install over a water-resistant barrier. If rigid foam is rated for water resistance, no other water-resistant barrier is required, if seams in foam layer are sealed.
- Seal all seams in the rigid foam with a compatible tape; apply tape to clean, dry surfaces.
- ENERGY STAR requires that rigid foam or insulated siding be installed over walls if they are metal framed (ENERGY STAR 2015).
- ENERGY STAR requires that rigid foam sheathing or insulated siding or a combination of the two be installed to a thickness of \( R-3 \) in Climate Zones 1 to 4 or \( R-5 \) in Climate Zones 5 to 8 (ENERGY STAR 2015).

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

Continuous rigid insulation is a construction solution that provides a thermally efficient building enclosure. Rigid insulation sheathing is made of a rigid plastic foam that is typically sold in 4x8- or 4x10-foot boards. The boards are available in several thicknesses and R-values; 1-inch and 2-inch thicknesses are common. Rigid insulation provides thermal protection and it can also serve as an air and moisture barrier.

Continuous rigid insulation provides an effective solution to thermal bridging. Thermal bridging occurs wherever assembly components with low R-values (such as wood or steel) span from the interior to the exterior of the building. Steel framing has an R-value of 0.04 per inch and wood has an R-value of 1 per inch. In comparison, rigid insulation has an R-value 3.2 to 6.5 per inch, depending on whether it is low-density or high-density (BSC 2007). In traditional building construction, while the wall cavities are filled with insulation, there is no insulation at the window frames, door frames, studs, top plates and bottom plates; together this framing comprises nearly one-fourth of the wall area. Rigid insulation can be attached to the exterior side of the framing to provide a continuous insulating layer that reduces thermal losses through thermal bridging.

Rigid insulation can also function to mitigate moisture problems in building construction. Rigid insulation can act as an integral part of the wall’s wind-driven rain screen and vapor and condensation management systems (see climate-specific factors).

There are three primary types of rigid insulation: expanded polystyrene (EPS), extruded polystyrene (XPS), and polyisocyanurate (polyiso). EPS and XPS are theroplastics, which are non-cross-linked polymers so they are susceptible to deterioration in high temperatures (BSC 2007). Polyiso is a thermoset, which is made up of cross-linked polymers so it has a much higher melting temperature. While properties can vary among specific products, XPS and polyiso tend to be higher density, higher R-value, and lower permeance than EPS (see Table 1).

<table>
<thead>
<tr>
<th></th>
<th>R-value/inch@75°F</th>
<th>Density (pcf)</th>
<th>Permeance (perms)</th>
<th>Water Absorption (% by volume)</th>
<th>Compressive Strength (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expanded Polystyrene (EPS)</td>
<td>3.2</td>
<td>0.75</td>
<td>5.00</td>
<td>4.0</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>3.9</td>
<td>1.00</td>
<td>5.00</td>
<td>4.0</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>4.2</td>
<td>1.50</td>
<td>5.50</td>
<td>3.0</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>4.4</td>
<td>2.00</td>
<td>2.00</td>
<td>2.0</td>
<td>25</td>
</tr>
<tr>
<td>Extruded Polystyrene (XPS)</td>
<td>4.6</td>
<td>1.20</td>
<td>1.10</td>
<td>0.3</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>1.30</td>
<td>1.10</td>
<td>0.3</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>1.60</td>
<td>1.10</td>
<td>0.3</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>2.20</td>
<td>1.10</td>
<td>0.3</td>
<td>25</td>
</tr>
<tr>
<td>Polyiso-cyanurate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unfaced</td>
<td>6.0</td>
<td>1.60</td>
<td>2.77-4.49</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Faced</td>
<td>6.5</td>
<td>2.00</td>
<td>0.08</td>
<td>1.0</td>
<td>25</td>
</tr>
<tr>
<td>Glass fiber faced</td>
<td>6.5</td>
<td>2.00</td>
<td>&lt;1.0</td>
<td>1.0</td>
<td>25</td>
</tr>
</tbody>
</table>

Table 1. Insulated Sheathing R-Value, Density, Permeance, and other Properties

When using foam insulation, you'll need to decide whether you intend to use OSB in addition to the rigid foam to serve as the building sheathing or if the rigid foam layer will itself serve as the sheathing, and you'll need to determine what will serve as the drainage plane and where this layer will be. These decisions are determined somewhat by climate.

The wall sections in Figure 1 (BSC 2007) show four options for the drainage plane based on climate factors:

- Wall Section 1 - Insulating sheathing over house wrap over plywood or OSB – for regions with high winds and high rainfall. This strategy is the most durable assembly because the drainage plane (building paper or house wrap) is supported by the plywood sheathing and is protected against wind loading and other environmental factors by the insulating sheathing.
- Wall Section 2 - Insulation sheathing over house wrap over studs – for most rainfall zones but not best in high-wind regions.
- Wall Section 3 – House wrap installed over insulating sheathing over wood studs – ok for most rainfall zones but don’t use in high-wind regions. Fasteners used to install house wrap must reach through foam into studs.
- Wall Section 4 - Insulating sheathing as the drainage plane – ok in areas of limited rainfall and exposure. All vertical joints and penetrations must be sealed.
If rigid foam insulation will be used without OSB or plywood wall sheathing, determine what approach will be taken to meet local wind and earthquake code requirements. A common approach is to install exterior structural wood sheathing at the corners and at regular intervals as needed to meet code requirements for lateral load resistance. However, because the wood takes the place of the foam sheathing, it can create problems with drainage plane continuity and it leaves opportunities for thermal bridging.

Three recommended alternatives are allowed: metal cross bracing, inset shear panels, or structural insulated sheathing products. With metal cross bracing, the metal braces are thin straps that do not interfere with the installation of the insulating sheathing, for example, diagonal 1x4 let-in braces or diagonal T profile steel strapping. The capacity of the metal cross bracing, however, may not be adequate for areas with high-wind loads and/or seismic activity. In these locations, a more robust form of lateral load resistance may be needed. Inset shear panels can provide for high levels of lateral load resistance and can be used in all wind and seismic zones. Inset shear panels are wood-framed panels that fit within the stud spacing of the wall assembly, so the exterior face of the panel is flush with the exterior face of the wood studs. Another option is to use a structural insulated sheathing. It must be installed following the manufacturer’s installation recommendations and certified to meet structural requirements. When using any of these options, check the plans with local code officials before finalizing wall-sheathing layout.

Extruded polystyrene (XPS) and foil-faced polyisocyanurate (polyiso) are high-density rigid-foam insulations that can be used as exterior insulation and are generally approved to be used as a drainage plane if the joints are sealed. Insulation sheathing membranes rely on tape to complete the air barrier; the tapes should be applied on a clean, dry, warm surface. For the rigid insulation to be used as a water-resistant barrier, the vertical plane of the exterior face of the sheathing must be as smooth and continuous as possible.

One of the complications of foam plastic insulation is that it typically is less thermally stable and will expand and contract more than standard structural sheathing. This is why two layers of foam are often specified with joints offsetting, so if gaps open up they do not span the entire thickness of the foam insulation.

If you are using a structural insulated sheathing, then following the nail schedule provided by the manufacturer is very important to obtain the structural properties such as racking resistance that are mandated by codes. If a nonstructural insulated sheathing is used, nailing patterns become less important because the exterior cladding will be fastened through to the framing. Button cap nails are recommended by most sheathing manufacturers to maintain the holding strength and to avoid blow off during high winds before cladding installation.

Furring strips can adequately support the weight of the cladding and resist wind and seismic forces if the right fasteners and spacing are used. The following is recommended:

- **Furring** – wood 1x4s or 20-gauge steel
- **Fasteners** - long enough to penetrate studs by at least 1½ inch if wood, by three threads if steel.
- **Foam Density.** Use one of the following foams or foam with a greater density than these: Type II EPS or Type X XPS (per ASTM C578); Type 1 polyisocyanurate (per ASTM C1289) or Type IVB mineral fiber board (per ASTM C 612).
- **Fastener Schedule** – as specified by the foam manufacturer, see examples in Table 2 for walls with studs spaced 16 in. on center and Table 3 for walls with studs spaced 24 in. on center (Holladay 2012).
### Installing siding over rigid foam

Installing siding over rigid foam resembles standard installation, yet requires longer fasteners if fastening to the framing. With thicker insulating sheathing, longer and stronger fasteners will be needed to avoid cladding creep.

Stainless steel nails are the best choice, especially if the siding is to be finished with transparent or semitransparent stain. Use No. 304 stainless for general siding applications and No. 316 for seacoast exposures. Hot-dipped galvanized steel (per ASTM A 153), aluminum, and stainless steel fasteners are all corrosion-resistant and are acceptable. Electroplated and mechanically galvanized fasteners are not recommended. For best results, use “splitless” ring shank siding nails. These have thin shanks and blunt points to reduce splitting. Textured heads should be used to reduce the glossy appearance of the nail head. Hand nailing is preferred. The size of nails to use depends on the type and thickness of the siding. Use nails long enough to penetrate solid wood (sheathing and blocking or studs) a minimum of 1.5 inches. However if you use ring shank rather than smooth shank nails, ¾ in. penetration into solid wood should be adequate, unless you are building in high-coastal wind areas ([Holladay 2012](#)).

### Insulated Siding

Some brands of vinyl siding are manufactured with a layer of rigid foam adhered to the back. In order for insulated siding to qualify as home insulation, it must be installed directly over a water-resistive barrier and sheathing. When insulated siding is installed over furring strips, the space between the furring strips must be filled in with rigid insulation or another appropriate building material. Insulated siding installed over furring strips alone would not be considered home insulation.

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### Table 2. Fastener spacing for attaching furring strips if wall studs are 16 inch on center

<table>
<thead>
<tr>
<th>Foam thickness</th>
<th>Fastener spacing (vinyl siding)</th>
<th>Fastener spacing (fiber-cement siding)</th>
<th>Fastener spacing (stucco cladding)</th>
<th>Fastener spacing (adhered manufactured stone veneer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 in. or less</td>
<td>24 in.</td>
<td>24 in.</td>
<td>16 in.</td>
<td>8 in.</td>
</tr>
<tr>
<td>3 in. or less</td>
<td>24 in.</td>
<td>24 in.</td>
<td>24 in.</td>
<td>12 in.</td>
</tr>
<tr>
<td>2 in. or less</td>
<td>24 in.</td>
<td>24 in.</td>
<td>24 in.</td>
<td>16 in.</td>
</tr>
<tr>
<td>1 in. or less</td>
<td>24 in.</td>
<td>24 in.</td>
<td>24 in.</td>
<td>24 in.</td>
</tr>
</tbody>
</table>

**Table 2 notes:**
- Fasteners spaced 24 inches apart give you an allowable design wind pressure of 49 psf.
- Fasteners spaced 16 inches apart give you an allowable design wind pressure of 73 psf.
- Fasteners spaced 12 inches apart give you an allowable design wind pressure of 98 psf.
- Fasteners spaced 8 inches apart give you an allowable design wind pressure of 147 psf.

### Table 3. Fastener spacing for attaching furring strips if studs are 24 inch on center

<table>
<thead>
<tr>
<th>Foam thickness</th>
<th>Fastener spacing (vinyl siding)</th>
<th>Fastener spacing (fiber-cement siding)</th>
<th>Fastener spacing (stucco cladding)</th>
<th>Fastener spacing (adhered manufactured stone veneer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 in. or less</td>
<td>24 in.</td>
<td>24 in.</td>
<td>12 in.</td>
<td>Don’t do it</td>
</tr>
<tr>
<td>3 in. or less</td>
<td>24 in.</td>
<td>24 in.</td>
<td>16 in.</td>
<td>8 in.</td>
</tr>
<tr>
<td>2 in. or less</td>
<td>24 in.</td>
<td>24 in.</td>
<td>24 in.</td>
<td>12 in.</td>
</tr>
<tr>
<td>1 in. or less</td>
<td>24 in.</td>
<td>24 in.</td>
<td>24 in.</td>
<td>15 in.</td>
</tr>
</tbody>
</table>

**Table 3 notes:**
- Fasteners spaced 24 inches apart give you an allowable design wind pressure of 33 psf.
- Fasteners spaced 16 inches apart give you an allowable design wind pressure of 49 psf.
- Fasteners spaced 12 inches apart give you an allowable design wind pressure of 65 psf.
- Fasteners spaced 8 inches apart give you an allowable design wind pressure of 98 psf.
Climate Insulated Siding as Home Insulation: Guide for Users and Energy Raters

Wood Framing

Air barrier: Cladding attachment materials and specifications

Display Image: 0.75

2009 IECC Prescriptive Above-Grade Wall Insulation R-values

Wood frame R-value equivalent R-13+3

Per the 16 Minimum Penetration into Wall Framing (inches)

Building Science Corporation (minimum penetration of steel thickness + 3 threads)

Install adhesive-backed sill flashing in one piece if flexible or in two pieces as shown if not flexible. Install corner flashing patches at sill if not using flexible flashing.

DR Organization(s):

Fastening Furring Strips to a Foam-Sheathed Wall

1.5 Steel thickness + 3 threads

Guidance is needed for code-compliant installations of various cladding materials when installed over thicker foam ... to provide engineered prescriptive solutions for use by builders, designers, code officials, and siding manufacturers.

R-20 OR R-13+5

1 7 - 8 0.5 0.120" diameter nail

Standard requirements for DOE's Zero Energy Ready Home national program certification.

0.162" diameter nail

Weight

Attach siding to furring strip with nails spaced at a maximum of 24 inches on center.

Tennessee Valley Authority's Campbell Creek Energy Efficient Homes Project: 2010 First Year Performance Report

4 November, 2010

4 R-13

4 DR

Cladding/Furring Attachments:

c.i. R-value ? 2.5 over 2 x 4 wall

As the energy codes continue to become more stringent, the thickness of c.i. has increased prescriptively. Only recently ... or adhered masonry veneer, concern with rigidly supporting the weight of the cladding installed over thick c.i. grows.

Table R703.15.1

11 psf

Minimum Penetration into Wall Framing (inches)

Information sheet about what length screws should be used, and how closely to space the screws when fastening furring strips to a foam-sheathed wall.

DR 2 1.5 DOE

DR 2 12 2

R-20+5 OR R-13+10

TE441_rigidfoam_wrong12_JC2006.jpg

On the factory-cut ends of insulated siding panels, the foam is set back from both ends of the panel. This set-back is ... end, create the required foam set-back and siding panel notches following the siding manufacturer's instructions.

DR Figure 6

Where the required cladding fastener penetration into wood material is > ¾" and ? 1½", a minimum 2-inch nominal wood furring or an approved design shall be used.

Insulation:

4 Choose a siding pattern with narrower boards (8 inches or less) that are thicker. Thick, narrow siding is more stable than thinner, wider patterns and better able to resist dimensional changes. Use kiln-dried siding for more dimensional stability.

Foam sheathing must have a minimum compressive strength of 15 psi in accordance with ASTM C 578 or ASTM C 1289.

1.5 4

24" o.c. Furring

Weight

DR

Maximum Thickness of Foam Sheathing (inches)

25 psf

DR

Moisture

Thermal Enclosure System.

4 3.4 At above-grade walls separating conditioned from unconditioned space, one of the following options used (rim / band joists exempted):

1.5 4

Table R703.16.2

Furring or Minimum 1 x Wood Furring

Steel Frame Wall 16" o.c.

Weight

DR

Maximum Thickness of Foam Sheathing (inches)

1.5 4

R-13+5 OR R-15+4 OR R-21+3 OR R-0+10

R-13+11.5 OR R-15+10.9 OR R-19+10.1 OR R-21+9.7 OR R-25+9.1

Figure 2 - Lay out the rigid foam sheathing joints so they do not align with the window and door edges

Figure 2 - Lay out the rigid foam sheathing joints so they do not align with the window and door edges

f window and door openings

manufacturer's specifications.

wall and up to the underside of round the roof trusses) to act id of manufacturer-approved curer) to the top and bottom

nd layer to improve .ld be sealed with caulk,

on.