Scope

Insulate a new foundation wall or an existing foundation wall by adding rigid insulation to the exterior side as follows:

- Locate underground utilities.
- Excavate the foundation perimeter.
- Install a footing perimeter drain pipe to provide adequate exterior drainage.
- Install damp proofing or a waterproofing membrane on the exterior side of the foundation wall and footing.
- Install rigid board insulation (XPS or rigid mineral fiber) on the exterior wall from the top of the footing to the bottom of the cladding to at least the minimum R-value specified in the local building code.
- Install an aluminum coil stock or sheet metal protective cover for the rigid insulating sheathing.
- Back-fill excavation to within 8 inches of the finished grade with free-draining backfill.
- Install closed-cell sprayed polyurethane foam (SPF) insulation on the interior side of the rim joist.

Note that this assembly is appropriate only for flat foundation walls. Due to the cost and logistical difficulties, this measure is typically more suitable for new construction rather than a retrofit project.

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.
Rigid board insulation (XPS or rigid mineral fiber) can be installed on the exterior side of homes with smooth foundation walls such as those made of cast concrete or concrete block. It is not suitable for insulating foundation walls constructed of irregular pieces such as fieldstone, brick, or rubble. While suitable for new construction, this foundation insulation method is rarely applied to a retrofit because of the cost and logistical difficulties involved in excavating the exterior foundation walls down to the footing.

The rim joist can be insulated on the interior with sprayed polyurethane foam (SPF) insulation applied from inside the basement or crawlspace. The spray foam should cover the sill plate and extend from the top of the foundation wall to the underside of the subfloor to provide continuity of the thermal control layer at the transition between the rigid insulation below grade and the cavity insulation above grade.

In retrofit cases, an assessment should be made of the condition of the sill prior to beginning the retrofit. (See the Success tab.) If there is no capillary break under the sill and/or if the sill is within 12 inches of the ground, it is possible that it has suffered water damage. If so, the damaged pieces should be replaced and at the same time, a capillary break should be installed under the new pieces. If there is no capillary break under the sill and/or the sill is within 12 inches of the ground but there is no indication of damage, then it is likely that the sill has been able to dry. Depending on the properties of the exterior rigid insulation and waterproofing, the new assembly may have limited drying potential to the exterior, and if so, care must be taken to preserve the drying potential of the assembly to the interior.

Even though foundation wall materials are water tolerant, measures should be taken to protect the walls from bulk water and a number of strategies can be implemented to this end (see Figure 1). If the grade around the perimeter does not slope away from the house, for example, grading adjustments should be made so that it slopes away at 5% grade for at least the first 3 feet and if possible, 10 feet. If gutters are installed, the downspouts should direct water away from the perimeter of the house and the gutter system must be regularly maintained to prevent overflowing, leaks, or breaks in the system as these can concentrate water at the building's foundation. A trench of gravel around the perimeter that extends out at least as far as the roof drip edge may also be provided to further mitigate bulk water problems. The gravel trench helps disperse bulk water that comes from the roof so that the top of the foundation wall is not continually splashed. These ground water control strategies should be implemented at the discretion of the practitioner based on project goals and site conditions.

The foundation walls themselves should also be protected from water with damp-proofing or a waterproofing membrane (at the discretion of the practitioner) applied directly to the concrete before installing the rigid foam. A drainage mat of high-density polyethylene dimple mat should be installed over the rigid foam, unless the insulation itself is free draining. The damp-proofing or the waterproofing membrane should be integrated to the water control layer of the sheathing above with a transition strip of self-adhered membrane. This membrane also provides termite protection.

A protective cover of aluminum coil stock or sheet metal should be installed over the top portion of the rigid insulation to provide damage protection and serve as a closure piece. The top edge of this flashing should extend up under the rigid foam sheathing or house wrap and under the cladding. A strip of self-adhered membrane should cover the top edge of this flashing.
How to Install Rigid Board Insulation at Exterior of the Foundation Wall

1. Evaluate the existing foundation wall’s structural integrity and ability to tolerate excavation from grade to footing. NOTE: Rubble wall foundations typically are relatively flush and planar to the interior but highly variable and non-planar on the exterior. For rubble wall foundations, proceed with great care when excavating and/or conduct a small-scale excavation test to assess the rubble wall’s exterior.

2. Locate underground utilities serving the building or passing near the foundation. Implement measures to ensure the protection of these throughout the project. STOP! Do not proceed if underground utilities are not located.

3. Excavate the foundation perimeter down to the footing and 4 feet out from the foundation wall to provide room to work and to accommodate free-draining back-fill material.

4. Install a perforated perimeter drain pipe at the footing if none exists. Place the pipe in coarse gravel bed, no fines, with filter fabric wrapping around the gravel bed. Slope the drain pipe to a storm water collection system or to a daylight outlet.

5. Install damp-proofing or a waterproofing membrane per manufacturer’s recommendations (refer to ENERGY STAR Water Management System Builder Checklist Section 1.5 cited above) extending from grade to the base of the foundation wall and over the top of the footing. Note that primer may be required.

6. Provide a transition strip of fully adhered membrane between the wall sheathing and the foundation wall damp-proofing or a waterproofing membrane as a termite protection and to provide continuity of the water control layers above and below grade.

7. Install XPS or semi-rigid mineral fiber insulation board applied to the outside of the foundation wall. Typically the boards are sufficiently rigid and the spans are small enough to permit the insulation to be loose laid at installation and then held in place by the backfill. The use of adhesives, tape, or temporary supports may be required to hold the insulation in place prior to backfill.
8. Install an aluminum coil stock or sheet metal protective cover over the top of the rigid foam; extend it up the wall approximately 4 inches with the top edge extending behind the house wrap or rigid foam drainage plane of the above grade wall. The flashing should extend down over the front face of the rigid foam to approximately 6 inches below grade.

9. Install a fully adhered bituminous membrane across the top edge of the metal flashing protective cover to complete the termite protection.

10. When work is complete, back-fill the excavation to within no more than 8 inches of the finished grade with free-draining material. Separate the free-draining material from the top soil with filter fabric. Provide a minimum 5% grade slope away from the foundation wall.

11. From the interior, apply 3 inches of closed-cell spray foam insulation to the interior side of the rim joist extending from the top of the foundation wall to the underside of the subfloor. Concrete block or brick foundation walls will require an interior air control layer such as a parge coat applied over the interior face of the wall with a continuous transition to the spray foam at the top of the wall.
Ensuring Success

Locate the underground gas and electric utilities in the vicinity of the excavation.

Provide a fully adhered membrane extending from the existing sheathing down onto the foundation wall to protect the wood framing from termites.

Provide flashing across the top of the exterior insulation and seal it at the top with the membrane to protect the insulation from UV rays and physical damage.

Install a 4-inch perforated perimeter drain pipe in a gravel bed wrapped in filter fabric to allow for proper drainage.
Climate

The basement wall assembly should be designed for the specific hygrothermal region, rain exposure zone, and interior climate. The climate zones are shown on the map below, which is taken from Figure C301.1 of the 2012 IECC.

Local building code practices with respect to termite resistance should be followed. The insulation levels should be based on the minimum requirements for vapor control in the current adopted building code and the minimum requirements for thermal control in the current energy code. Additional insulation can be added above these minimums to create high R-Value basement wall assemblies. The table below provides the minimum thermal resistance (R-value) requirements for basement walls specified in the 2009 IECC (ICC 2009b) and the 2012 IECC (ICC 2012b), based on climate zone.

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>2009 IECC</th>
<th>2012 IECC</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
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<td>6</td>
<td>15/19</td>
<td>15/19</td>
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<tr>
<td>7 and 8</td>
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* First value is cavity insulation, second 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.

Table 1. Minimum R-Value Requirements for Basement Wall Insulation in the 2009 and 2012 IECC
Training

Right and Wrong Images
None Available
CAD
None Available
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).

National Rater Field Checklist

4. Air Sealing (Unless otherwise noted below, “sealed” indicates the use of caulk, foam, or equivalent material).
4.3 Above-grade sill plates adjacent to conditioned space sealed to foundation or sub-floor. Gasket also placed beneath above-grade sill plate if resting atop concrete / masonry & adjacent to conditioned space.26,27

Footnote 26) Existing sill plates (e.g., in a home undergoing a gut rehabilitation) on the interior side of structural masonry or monolithic walls are exempt from this Item. In addition, other existing sill plates resting atop concrete or masonry and adjacent to conditioned space are permitted, in lieu of using a gasket, to be sealed with caulk, foam, or equivalent material at both the interior seam between the sill plate and the subfloor and the seam between the top of the sill plate and the sheathing.

Footnote 27) In Climate Zones 1 through 3, a continuous stucco cladding system adjacent to sill and bottom plates is permitted to be used in lieu of sealing plates to foundation or sub-floor with caulk, foam, or equivalent material.

Water Management System Builder Requirements

1. Water-Managed Site and Foundation.
1.5 Exterior surface of below-grade walls of basements & unvented crawlspaces finished as follows:
a) For poured concrete, masonry, & insulated concrete forms, finish with damp-proofing coating.6
b) For wood framed walls, finish with polyethylene and adhesive or other equivalent waterproofing.
1.8 Drain tile installed at basement and crawlspace walls, with the top of the drain tile pipe below the bottom of the concrete slab or crawlspace floor. Drain tile surrounded with ? 6 in. of ½ to ¾ in. washed or clean gravel and with gravel layer fully wrapped with fabric cloth. Drain tile level or sloped to discharge to outside grade (daylight) or to a sump pump. If drain tile is on interior side of footing, then channel provided through footing to exterior side.8

Footnote 6) Interior surface of an existing below-grade wall (e.g., in a home undergoing a gut rehab.) listed in Item 1.5a is permitted to be finished by:

- Installing a continuous and sealed drainage plane, capillary break, Class I Vapor Retarder (per Footnote 7) and air barrier that terminates into a foundation drainage system as specified in Item 1.8; OR
- If a drain tile is not required as specified in Footnote 8, adhering a capillary break and Class I Vapor Retarder (per Footnote 7) directly to the wall with the edges taped/sealed to make it continuous.

Footnote 8) Alternatively, either a drain tile that is pre-wrapped with a fabric filter or a Composite Foundation Drainage System (CFDS) that has been evaluated by ICC-ES per AC 243 are permitted to be used. Note that the CFDS must include a soil strip drain or another ICC-ES evaluated perimeter drainage system to be eligible for use. In an existing home (e.g., in a home undergoing a gut rehab.) a drain tile installed only on the interior side of the footing without a channel is permitted. Additionally, a drain tile is not required when a certified hydrologist, soil scientist, or engineer has determined that a crawlspace foundation, or an existing basement foundation (e.g., in a home undergoing a gut rehab.), is installed in Group I Soils (i.e. well-drained ground or sand-gravel mixtures), as defined by 2009 IRC Table R405.1.

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

The DOE Zero Energy Ready Home Program is a voluntary high-performance home labeling program for new homes operated by the U.S. Department of Energy. Builders and remodelers who are performing retrofits on existing homes are welcome to seek certification for those homes through this voluntary program.

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 6) Certified under EPA Indoor airPLUS.

Exhibit 2 DOE Zero Energy Ready Home Target Home.
The U.S. Department of Energy’s Zero Energy Ready Home program allows builders to choose a prescriptive or performance
path. The DOE Zero Energy Ready Home prescriptive path requires builders to meet or exceed the minimum HVAC efficiencies listed in Exhibit 2 of the National Program Requirements (Rev 07), as shown below. The DOE Zero Energy Ready Home performance path allows builders to select a custom combination of measures for each home that is equivalent in performance to the minimum HERS index of a modeled target home that meets the requirements of Exhibit 2 as well as the mandatory requirements of Zero Energy Ready Home Exhibit 1.

Exhibit 2, 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 International Energy Conservation Code (IECC) Code Level Insulation – DOE Zero Energy Ready Home Requirements for more details.

EPA Indoor airPLUS (Revision 04)

1.4 Basement and Crawlspace Insulation and Conditioned Air. Item 1.4 under moisture control requires that basements/crawlspace are insulated, sealed and conditioned.

2009 - 2018 International Energy Conservation Code (IECC) and International Residential Code (IRC) Minimum Insulation Requirements: The minimum insulation requirements for ceilings, walls, floors, and foundations in new homes, as listed in the 2009, 2012, 2015, and 2018 IECC and IRC, can be found in this table.

2009 and 2012 IECC

Section 303.2.1 Protection of exposed foundation insulation
Section 401.3 Certificate
Section 402.1.1 Insulation and fenestration criteria
Table 402.1.1 Insulation and Fenestration Requirements by Component
Table 402.1.3 Equivalent U-factors
Section 402.2.7 (R402.2.8 in 2012 IECC) Basement walls
Table 402.4.2 (R402.4.1.1 in 2012 IECC) Air barrier and insulation inspection component criteria

2015 and 2018 IECC

Section 303.2.1 Protection of exposed foundation insulation
Section 401.3 Certificate
Section 402.1.2 Insulation and fenestration criteria
Table 402.1.2 Insulation and Fenestration Requirements by Component
Table 402.1.4 Equivalent U-factors
Section R402.2.9 Basement walls
Table 402.4.1.1 Air barrier and insulation inspection component criteria


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

Section R401.3 Drainage
Section R403.1.4.1 Frost protection
Section R403.1.6 Foundation anchorage
Section R403.3 Frost protected shallow foundations
Section R403.3.4 Termite damage
Section R404.1.4.2 Concrete foundation walls
Section R405 Foundation drainage
Section R406 Foundation waterproofing and dampproofing
Section N1101.4 Building thermal envelope insulation
Section N1101.7.1 Protection of exposed foundation insulation
Section N1101.9 Certificate
Section N1102.1 Insulation and fenestration criteria
Table N1102.1 Insulation and fenestration requirements by component
Table N1102.1.2 Equivalent U-factors
Section N1102.2.7 Basement walls
Table N1102.4.2 Air barrier and insulation inspection

2012 IRC
Section R401.3 Drainage
Section R403.1.4.1 Frost protection
Section R403.1.6 Foundation anchorage
Section R403.3 Frost protected shallow foundations
Section R403.3.4 Termite damage
Section R404.1.4.2 Concrete foundation walls
Section R405 Foundation drainage
Section R406 Foundation waterproofing and dampproofing
Section N1101.12.1 (R303.1.1) Building thermal envelope insulation
Section N1101.13.1 (R303.2.1) Protection of exposed foundation insulation
Section N1101.16 (R401.3) Certificate (Mandatory)
Section N1102.1.1 (R402.1.1) Insulation and fenestration criteria
Table N1102.1.1 (R402.1.1) Insulation and fenestration requirements by component
Table N1102.1.3 (R402.1.3) Equivalent U-factors
Section N1102.2.8 (R402.2.8) Basement walls
Table N1102.4.2.1 (402.4.1.1) Air barrier and insulation inspection

2015 and 2018 IRC
Section R401.3 Drainage
Section R403.1.4.1 Frost protection
Section R403.1.6 Foundation anchorage
Section R403.3 Frost protected shallow foundations
Section R403.3.4 Termite damage
Section R404.1.4.2 Concrete foundation walls
Section R405 Foundation drainage
Section R406 Foundation waterproofing and dampproofing
Section N1101.12.1 (R303.1.1) Building thermal envelope insulation
Section N1101.13.1 (R303.2.1) Protection of exposed foundation insulation
Section N1101.14 (R401.3) Certificate (Mandatory)
Section N1102.1.2 (R402.1.2) Insulation and fenestration criteria
Table N1102.1.2 (R402.1.2) Insulation and fenestration requirements by component
Table N1102.1.4 (R402.1.4) Equivalent U-factors
Section N1102.2.9 (R402.2.9) Basement walls
Table N1102.4.1.1 (402.4.1.1) Air barrier and insulation inspection

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.
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*

   Author(s): Pettit, Neuhauser, Gates
   Organization(s): Building Science Corporation
   Publication Date: July, 2013
   Guidebook providing useful examples of high performance retrofit techniques for the building enclosure of wood frame residential construction in a cold and somewhat wet climate.

*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.

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