

**CHAPTER 4 [RE]  
RESIDENTIAL ENERGY EFFICIENCY**

**SECTION R401  
GENERAL**

**R401.1 Scope.** This chapter applies to residential buildings.

**R401.2 Compliance.** Projects shall comply with Sections identified as “mandatory” and with either sections identified as “prescriptive” or the performance approach in Section R405.

**R401.3 Certificate (mandatory).** A building certificate shall be completed and posted on or in the electrical distribution panel by the builder or registered design professional. The certificate shall not cover or obstruct the visibility of the circuit directory label, service disconnect label, or other required labels. The certificate shall list: the date the certificate is installed; the dwelling address; residential contractor name and contractor license number, or homeowner name, if acting as the general contractor; the predominant installed R-values, their location, and type of insulation installed in or on ceiling/roof, walls, rim/band joist, foundation, slab, basement wall, crawl space wall or floor, and ducts outside conditioned spaces; U-factors for fenestration and the solar heat gain coefficient (SHGC) of fenestration; and the results of any required duct system and building envelope air leakage testing done on the building. Where there is more than one value for each component, the certificate shall list the value covering the largest area. The certificate shall list the types, input ratings, manufacturers, model numbers and efficiencies of heating, cooling, and service water heating equipment. The certificate shall also list the structure's calculated heat loss, calculated cooling load, and calculated heat gain. Where an

electric furnace or baseboard electric heater is installed in the residence, the certificate shall list “electric furnace” or “baseboard electric heater,” as appropriate. An efficiency shall not be listed for electric furnaces or electric baseboard heaters. The certificate shall list the mechanical ventilation system type, location, and capacity, and the building's designated continuous and total ventilation rates. The certificate shall also list the type, size, and location of any make-up air system installed and the location or future location of the radon fan.

**SECTION R402  
BUILDING THERMAL ENVELOPE**

**R402.1 General (Prescriptive).** The *building thermal envelope* shall meet the requirements of Sections R402.1.1 through R402.1.4.

**R402.1.1 Insulation, waterproofing, and fenestration criteria.** The building thermal envelope shall meet the requirements of Table R402.1.1 based on the climate zone specified in Chapter 3, and the requirements contained in Section R402.2. Cast-in-place concrete and masonry block foundation walls shall be waterproofed according to IRC Section R406 and the following requirements:

1. The waterproofing shall extend from the top interior wall edge, across the top of the wall, and down the exterior wall face to the top of the footing. If a full width, closed-cell material is installed to create a seal between the sill plate and the top of the foundation wall, the installation is deemed to meet the requirements for the top of the wall waterproofing.
2. If the walls are exposed to the exterior environment, the waterproofing system shall have a rigid, opaque,

**TABLE R402.1.1  
INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT<sup>a</sup>**

CLIMATE ZONE	FENESTRATION U-FACTOR <sup>b</sup>	SKYLIGHT <sup>b</sup> U-FACTOR	GLAZED FENESTRATION SHGC <sup>b,e</sup>	CEILING <sup>l</sup> R-VALUE	WOOD FRAME WALL R-VALUE <sup>f</sup>	MASS WALL R-VALUE <sup>e,g,h</sup>	FLOOR R-VALUE	BASEMENT <sup>c,i</sup> WALL R-VALUE	SLAB <sup>d</sup> R-VALUE & DEPTH	CRAWL SPACE <sup>e,i</sup> WALL R-VALUE
6	0.32	0.55	NR	49	20, 13+5	15/20	30°	15	10, 3.5 ft	15
7	0.32	0.55	NR	49	21	19/21	38°	15	10, 5 ft	15

For SI: 1 foot = 304.8 mm.

- a. R-values are minimums. U-factors and SHGC are maximums. When insulation is installed in a cavity that 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.
- b. The fenestration U-factor column excludes skylights. The SHGC column applies to all glazed fenestration.
- c. See Section R402.2.8.
- d. Insulation R-values for heated slabs shall be installed to the depth indicated or to the top of the footing, whichever is less.
- e. Or insulation sufficient to fill the framing cavity, R-19 minimum.
- f. 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.
- g. The second R-value applies when more than half the insulation is on the interior of the mass wall.
- h. When using log-type construction for thermal mass walls the following applies:
  - (1) a minimum of a 7-inch diameter log shall be used; and
  - (2) the U-value of fenestration products shall be 0.29 overall on average or better.
- i. See Section 402.2.8. A minimum R-19 cavity insulation is required in wood foundation walls.
- j. Roof/ceiling assemblies shall have a minimum 6-inch energy heel.

and weather-resistant protective covering to prevent degradation of the waterproofing system. The protective covering shall cover the exposed waterproofing and extend a minimum of 6 inches (152 mm) below grade. The protective covering system shall be flashed in accordance with IRC Section R703.8.

**R402.1.1.1 Integral foundation insulation requirements.** Any insulation assembly installed integral to the foundation walls shall be manufactured for that intended use and installed according to the manufacturer’s installation instructions.

**R402.1.1.2 Exterior draining foundation insulation requirements.** Any insulation assembly installed on the exterior of the foundation walls and on the perimeter of slabs-on-grade that permits water drainage shall:

1. be made of water-resistant materials manufactured for that intended use;
2. be installed according to the manufacturer’s installation instructions;
3. comply with either ASTM C 578, C 612, or C 1029, as applicable; and
4. have a rigid, opaque, and weather-resistant protective covering to prevent the degradation of the insulation’s thermal performance. The protective covering shall cover the exposed exterior insulation and extend a minimum of 6 inches (152 mm) below grade. The insulation and protective covering system shall be flashed in accordance with IRC Section R703.8.

**R402.1.1.3 Exterior nondraining foundation insulation requirements.** Any insulation assembly installed on the exterior of the foundation walls or on the perimeter of slabs-on-grade that does not permit bulk water drainage shall:

1. be made of water-resistant materials manufactured for that intended use;
2. be installed according to the manufacturer’s installation instructions;
3. comply with either ASTM C 578 or C 1029, as applicable;
4. be covered with a 6-mil polyethylene slip sheet over the entire exterior surface; and
5. have a rigid, opaque, and weather-resistant protective covering to prevent degradation of the insulation’s thermal performance. The protective covering shall cover the exposed exterior insulation and extend a minimum of 6 inches (152 mm) below grade. The insulation and protective covering system shall be flashed in accordance with IRC Section R703.8.

**R402.1.1.4 Interior foundation insulation requirements.** Any insulation assembly installed on the interior of foundation walls shall meet the following requirements:

1. Masonry foundation walls shall be drained through each masonry block core to an approved interior drainage system.
2. If a frame wall is installed, it shall not be in direct contact with the foundation wall.
3. The insulation assembly shall comply with the interior air barrier requirements of Section R402.4.
4. The insulation assembly shall comply with Section R402.1.1.5, R402.1.1.6, or R402.1.1.7, as applicable.

**R402.1.1.5 Rigid interior insulation.** Rigid interior insulation shall comply with ASTM C 578 or ASTM C 1289 and the following requirements:

1. For installation:
  - a. the insulation shall be in contact with the foundation wall surface;
  - b. vertical edges shall be sealed with acoustic sealant;
  - c. all interior joints, edges, and penetrations shall be sealed against air and water vapor penetration;
  - d. continuous acoustic sealant shall be applied horizontally between the foundation wall and the insulation at the top of the foundation wall; and
  - e. continuous acoustic sealant shall be applied horizontally between the basement floor and the bottom insulation edge.
2. The insulation shall not be penetrated by the placement of utilities, fasteners, or connectors used to install a frame wall, with the exception of through penetrations.
3. Through penetrations shall be sealed around the penetrating products.

**R402.1.1.6 Spray-applied interior foam insulation.** Spray-applied interior foam insulation shall comply with the following:

1. Closed-cell foam:
  - a. the foam shall comply with ASTM C 1029 and have a permeance not greater than 0.8, in accordance with ASTM E 96 procedure A, and a permeance of not less than 0.3, in accordance with ASTM E 96 procedure B.
  - b. the foam shall be sprayed directly onto the foundation wall surface. There shall be a 1-inch (25.4 mm) minimum gap between the foundation wall surface and any framing.
  - c. the insulation surface shall not be penetrated by the placement of utilities, fasteners, or connectors used to install a frame wall, with the exception of through penetrations.
  - d. through penetrations shall be sealed around the penetrating products.

2. Open-cell foam:
  - a. The foam shall be sprayed directly onto the foundation wall surface. There shall be a 1-inch (25.4 mm) minimum gap between the foundation wall surface and any framing.
  - b. The insulation surface shall not be penetrated by the placement of utilities, fasteners, or connectors used to install a frame wall, with the exception of through penetrations.
  - c. Through penetrations shall be sealed around the penetrating product.
  - d. A vapor retarder and air barrier shall be applied to the warm-in-winter side of the assembly with a permeance not greater than 1.0, in accordance with ASTM E 96 procedure A, and a permeance not less than 0.3, in accordance with ASTM E 96 procedure B.

**R402.1.1.7 Fiberglass batt interior insulation.** Fiberglass batt insulation shall comply with the following:

1. The above-grade exposed foundation wall height shall not exceed 1.5 feet (457 mm).
2. The top and bottom plates shall be air sealed to the foundation wall surface and the basement floor.
3. A vapor retarder and air barrier shall be applied to the warm in winter side of the wall with a permeance not greater than 1.0 in accordance with ASTM E 96 procedure A and a permeance not less than 0.3 in accordance with ASTM E 96 procedure B meeting the following requirements:
  - a. the vapor and air barrier shall be sealed to the framing with construction adhesive or equivalent at the top and bottom plates and where the adjacent wall is insulated;
  - b. the vapor and air barrier shall be sealed around utility boxes and other penetrations; and
  - c. all seams in the vapor and air barrier shall be overlapped at least 6 inches (152 mm) and sealed with compatible sealing tape or equivalent.

**R402.1.1.8 Foundation wall insulation performance option.** Insulated foundation systems designed and installed under the performance option shall meet the requirements of this section and the foundation, basement, or crawl space wall equivalent U-factor from Table 402.1.3.

1. **Water separation plane.** The foundation shall be designed and built to have a continuous water separation plane between the interior and exterior. The interior side of the water separation plane shall:
  - a. have a stable annual wetting and drying cycle whereby foundation wall system water (solid, liquid, and vapor) transport processes produce no net accumulation of ice or water over a full calendar year and the foundation wall system

is free of absorbed water for at least 4 months over a full calendar year;

- b. prevent conditions of moisture and temperature to prevail for a time period favorable to mold growth for the material used; and
- c. prevent liquid water from the foundation wall system from reaching the foundation floor system at any time during a full calendar year.

2. **Documentation.** The foundation insulation system designer shall provide documentation certified by a professional engineer licensed in Minnesota demonstrating how the requirements of this section are fulfilled. The foundation insulation system designer shall also specify the design conditions for the wall and the design conditions for the interior space for which the water separation plane will meet the requirements of this section. The foundation insulation system designer shall provide a label disclosing these design conditions. The label shall be posted according to Section R401.3.

3. **Installation.** The water separation plane shall be designed and installed to prevent external liquid or capillary water flow across it after the foundation is backfilled.

4. **Foundation air barrier.** The foundation insulation system shall be designed and installed to have a foundation air barrier system between the interior and the exterior. The foundation air barrier system shall be a material or combination of materials that is continuous with all joints sealed and is durable for the intended application. Material used for the foundation air barrier system shall have an air permeability not to exceed 0.004 ft<sup>3</sup>/min.ft<sup>2</sup> under a pressure differential of 0.3 inches water (1.57 psf) (0.02 L/s.m<sup>2</sup> at 75 Pa) as determined by either commonly accepted engineering tables or by being labeled by the manufacturer as having these values when tested according to ASTM E 2178.

**R402.1.2 R-value computation.** Insulation material used in layers, such as framing cavity insulation and insulating sheathing, shall be summed to compute the component R-value. The manufacturer's settled R-value shall be used for blown insulation. Computed R-values shall not include an R-value for other building materials or air films.

**R402.1.3 U-factor alternative.** An assembly with a U-factor equal to or less than that specified in Table R402.1.3 shall be permitted as an alternative to the R-value in Table R402.1.1.

**R402.1.4 Total UA alternative.** If the total *building thermal envelope* UA (sum of U-factor times assembly area) is less than or equal to the total UA resulting from using the U-factors in Table R402.1.3 (multiplied by the same assembly area as in the proposed building), the building shall be considered in compliance with Table R402.1.1. The UA calculation shall be done using a method consist-



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exceed 2.6 air changes per hour and the total square feet between the finished grade and the top of each foundation wall does not exceed 1.5 multiplied by the total lineal feet of each foundation wall that encloses conditioned space. Interior insulation, other than closed cell spray foam, shall not exceed R-11. See footnote c to Table R402.2.1.

- b. Minimum R-19 cavity insulation is required in wood foundation walls. See footnote 1 to Table R402.2.1.

**R402.2.9 Slab-on-grade floors.** Slab-on-grade floors with a floor surface less than 12 inches (305 mm) below grade shall be insulated in accordance with Table R402.1.1. The insulation shall extend downward from the top of the slab on the outside or inside of the foundation wall. Insulation located below grade shall be extended the distance provided in Table R402.1.1 by any combination of vertical insulation, insulation extending under the slab or insulation extending out from the building. Insulation extending

**TABLE R402.2.6  
STEEL-FRAME CEILING, WALL AND FLOOR INSULATION  
(R-VALUE)**

WOOD FRAME R-VALUE REQUIREMENT	COLD-FORMED STEEL EQUIVALENT R-VALUE <sup>a</sup>
<b>Steel Truss Ceilings<sup>b</sup></b>	
R-30	R-38 or R-30 + 3 or R-26 + 5
R-38	R-49 or R-38 + 3
R-49	R-38 + 5
<b>Steel Joist Ceilings<sup>b</sup></b>	
R-30	R-38 in 2 × 4 or 2 × 6 or 2 × 8 R-49 in any framing
R-38	R-49 in 2 × 4 or 2 × 6 or 2 × 8 or 2 × 10
<b>Steel-Framed Wall 16" O.C.</b>	
R-13	R-13 + 4.2 or R-19 + 2.1 or R-21 + 2.8 or R-0 + 9.3 or R-15 + 3.8 or R-21 + 3.1
R-13 + 3	R-0 + 11.2 or R-13 + 6.1 or R-15 + 5.7 or R-19 + 5.0 or R-21 + 4.7
R-20	R-0 + 14.0 or R-13 + 8.9 or R-15 + 8.5 or R-19 + 7.8 or R-19 + 6.2 or R-21 + 7.5
R-20 + 5	R-13 + 12.7 or R-15 + 12.3 or R-19 + 11.6 or R-21 + 11.3 or R-25 + 10.9
R-21	R-0 + 14.6 or R-13 + 9.5 or R-15 + 9.1 or R-19 + 8.4 or R-21 + 8.1 or R-25 + 7.7
<b>Steel Framed Wall, 24" O.C</b>	
R-13	R-0 + 9.3 or R-13 + 3.0 or R-15 + 2.4
R-13 + 3	R-0 + 11.2 or R-13 + 4.9 or R-15 + 4.3 or R-19 + 3.5 or R-21 + 3.1
R-20	R-0 + 14.0 or R-13 + 7.7 or R-15 + 7.1 or R-19 + 6.3 or R-21 + 5.9
R-20 + 5	R-13 + 11.5 or R-15 + 10.9 or R-19 + 10.1 or R-21 + 9.7 or R-25 + 9.1
R-21	R-0 + 14.6 or R-13 + 8.3 or R-15 + 7.7 or R-19 + 6.9 or R-21 + 6.5 or R-25 + 5.9
<b>Steel Joist Floor</b>	
R-13	R-19 in 2 × 6, or R-19 + 6 in 2 × 8 or 2 × 10
R-19	R-19 + 6 in 2 × 6, or R-19 + 12 in 2 × 8 or 2 × 10

a. Cavity insulation R-value is listed first, followed by continuous insulation R-value.

b. Insulation exceeding the height of the framing shall cover the framing.

away from the building shall be protected by pavement or by a minimum of 10 inches (254 mm) of soil. The top edge of the insulation installed between the exterior wall and the edge of the interior slab shall be permitted to be cut at a 45-degree (0.79 rad) angle away from the exterior wall. Slab-edge insulation is not required in jurisdictions designated by the code official as having a very heavy termite infestation.

**R402.2.10 Crawl space walls.** As an alternative to insulating floors over crawl spaces, crawl space walls shall be permitted to be insulated when the crawl space is not vented to the outside. Crawl space wall insulation shall be permanently fastened to the wall and extend downward from the floor to the finished grade level and then vertically and/or horizontally for at least an additional 24 inches (610 mm). Exposed earth in unvented crawl space foundations shall be covered with a continuous Class I vapor retarder in accordance with the *International Building Code* or *International Residential Code*, as applicable. All joints of the vapor retarder shall overlap by 6 inches (153 mm) and be sealed or taped. The edges of the vapor retarder shall extend at least 6 inches (153 mm) up the stem wall and shall be attached to the stem wall.

**R402.2.11 Masonry veneer.** Insulation shall not be required on the horizontal portion of the foundation that supports a masonry veneer.

**R402.2.12 Sunroom insulation.** All sunrooms enclosing conditioned space shall meet the insulation requirements of this code.

**Exception:** For sunrooms with thermal isolation, and enclosing conditioned space, the following exceptions to the insulation requirements of this code shall apply:

1. The minimum ceiling insulation R-values shall be R-19 in Climate Zones 1 through 4 and R-24 in Climate Zones 5 through 8; and
2. The minimum wall R-value shall be R-13 in all climate zones. Wall(s) separating a sunroom with a thermal isolation from conditioned space shall meet the building thermal envelope requirements of this code.

**R402.3 Fenestration (Prescriptive).** In addition to the requirements of Section R402, fenestration shall comply with Sections R402.3.1 through R402.3.6.

**R402.3.1 U-factor.** An area-weighted average of fenestration products shall be permitted to satisfy the U-factor requirements.

**R402.3.2 Glazed fenestration SHGC.** An area-weighted average of fenestration products more than 50-percent glazed shall be permitted to satisfy the SHGC requirements.

**R402.3.3 Glazed fenestration exemption.** Up to 15 square feet (1.4 m<sup>2</sup>) of glazed fenestration per dwelling unit shall be permitted to be exempt from U-factor and SHGC requirements in Section R402.1.1. This exemption shall not apply to the U-factor alternative approach in Section R402.1.3 and the Total UA alternative in Section R402.1.4.

**R402.3.4 Opaque door exemption.** One side-hinged opaque door assembly up to 24 square feet (2.22 m<sup>2</sup>) in area is exempted from the U-factor requirement in Section R402.1.1. This exemption shall not apply to the U-factor alternative approach in Section R402.1.3 and the total UA alternative in Section R402.1.4.

**R402.3.5 Sunroom U-factor.** All *sunrooms* enclosing conditioned space shall meet the fenestration requirements of this code.

**Exception:** For *sunrooms* with *thermal isolation* and enclosing conditioned space, in Climate Zones 4 through 8, the following exceptions to the fenestration requirements of this code shall apply:

1. The maximum fenestration U-factor shall be 0.45; and
2. The maximum skylight U-factor shall be 0.70. New fenestration separating the *sunroom* with *thermal isolation* from *conditioned space* shall meet the *building thermal envelope* requirements of this code.

**R402.3.6 Replacement fenestration.** Where some or all of an existing fenestration unit is replaced with a new fenestration product, including sash and glazing, the replacement fenestration unit shall meet the applicable requirements for U-factor and SHGC in Table R402.1.1.

**R402.4 Air leakage (Mandatory).** The building thermal envelope shall be constructed to limit air leakage in accordance with the requirements of Sections R402.4.1 through R402.4.4.

**R402.4.1 Building thermal envelope.** The *building thermal envelope* shall comply with Sections R402.4.1.1 and R402.4.1.2. The sealing methods between dissimilar materials shall allow for differential expansion and contraction.

**R402.4.1.1 Installation.** The components of the *building thermal envelope* as listed in Table R402.4.1.1 shall be installed in accordance with the manufacturer's instructions and the criteria listed in Table R402.4.1.1, as applicable to the method of construction. Where required by the *code official*, an *approved* third party shall inspect all components and verify compliance.

**R402.4.1.2 Testing.** The building or dwelling unit shall be tested and verified as having an air leakage rate of not exceeding 5 air changes per hour in Climate Zones 1 and 2, and 3 air changes per hour in Climate Zones 3 through 8. Testing shall be conducted with a blower door at a pressure of 0.2 inches 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*.

During testing:

1. Exterior windows and doors, fireplace and stove doors shall be closed, but not sealed, beyond the

intended weatherstripping or other infiltration control measures;

2. Dampers including exhaust, intake, makeup air, backdraft and flue dampers shall be closed, but not sealed beyond intended infiltration control measures;
3. Interior doors, if installed at the time of the test, shall be open;
4. Exterior doors for continuous ventilation systems and heat recovery ventilators shall be closed and sealed;
5. Heating and cooling systems, if installed at the time of the test, shall be turned off; and
6. Supply and return registers, if installed at the time of the test, shall be fully open.

**R402.4.2 Fireplaces.** New wood-burning fireplaces shall have tight-fitting flue dampers and outdoor combustion air.

**R402.4.3 Fenestration air leakage.** Windows, skylights and sliding glass doors shall have an air infiltration rate of no more than 0.3 cfm per square foot (1.5 L/s/m<sup>2</sup>), and swinging doors no more than 0.5 cfm per square foot (2.6 L/s/m<sup>2</sup>), when tested according to NFRC 400 or AAMA/WDMA/CSA 101/I.S.2/A440 by an accredited, independent laboratory and *listed* and *labeled* by the manufacturer.

**Exception:** Site-built windows, skylights and doors.

**R402.4.4 Recessed lighting.** Recessed luminaires installed in the *building thermal envelope* shall be sealed to limit air leakage between conditioned and unconditioned spaces. All recessed luminaires shall be IC-rated and *labeled* as having an air leakage rate not more than 2.0 cfm (0.944 L/s) when tested in accordance with ASTM E 283 at a 1.57 psf (75 Pa) pressure differential. All recessed luminaires shall be sealed with a gasket or caulk between the housing and the interior wall or ceiling covering.

**R402.5 Maximum fenestration U-factor and SHGC (Mandatory).** The area-weighted average maximum fenestration U-factor permitted using tradeoffs from Section R402.1.4 or R405 shall be 0.48 in Climate Zones 4 and 5 and 0.40 in Climate Zones 6 through 8 for vertical fenestration, and 0.75 in Climate Zones 4 through 8 for skylights. The area-weighted average maximum fenestration SHGC permitted using tradeoffs from Section R405 in Climate Zones 1 through 3 shall be 0.50.

## SECTION R403 SYSTEMS

**R403.1 Controls (Mandatory).** At least one thermostat shall be provided for each separate heating and cooling system.

**R403.1.1 Programmable thermostat.** Where the primary heating system is a forced-air furnace, at least one thermostat per dwelling unit shall be capable of controlling the heating and cooling system on a daily schedule to maintain different temperature set points at different times of