

REVIEW MATERIALS

Course 10888

***SPS 322 Energy Conservation
and Commentary
6 Hour Continuing
Education Course***



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**This Course has been approved by the Wisconsin
Department of Safety and Professional Services for the
following Certifications, Registrations or License.**

Course: 10888 SPS 322 ENERGY CONSERVATION

This course is valid for these credentials:

Credential Description	Cred Code	Credit Hours
Dwelling Contractor Qualifier	DCQ	6.0
UDC-Construction Inspector	UCI	6.0

The course expiration date is: August 11, 2029

SPS 322 Energy Conservation
Wisconsin Department of Safety and Professional Services
Course Identification Number: 10888
Expiration Date: 8/11/2029
Credit Hours: 6 Hours

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Course Type: Continuing Education
Dwelling Contractor Qualifier
UDC Construction Inspector

SPS 322 – Energy Conservation

This course (6 hour continuing education) is designed to familiarize Contractors and Inspectors with information on the updated construction codes required for building a home, according to the Uniform Dwelling Code (UDC). SPS 322 and the commentary are used as reference materials.

This course is a distance learning or e-learning course, which allows the attendee to complete the course on their time schedule.

EXAM

360 questions related to the Reference Materials are used to test the attendee on their comprehension of the materials. A 70% score will need to be attained in order to pass this course.

Topics covered in this course include Scope, Application, Definitions, Insulation Materials and Installation, Dwelling Thermal Envelope, Systems and Simulated Performance Alternative are included in this course.

Subchapter I — Scope and Application

SPS 322.01 Scope.

SPS 322.02 Application.

Subchapter II — Definitions

SPS 322.10 Definitions.

Subchapter III — Insulation Materials and Installation

SPS 322.20 Basic requirements.

SPS 322.21 Protection of insulation.

Subchapter IV — Dwelling Thermal Envelope

SPS 322.30 General design requirements.

SPS 322.31 Prescriptive insulation and fenestration criteria.

SPS 322.32 Specific insulation requirements.

SPS 322.33 Slab floors.

SPS 322.34 Crawl spaces.

SPS 322.35 Thermally isolated sunrooms.

SPS 322.36 Fenestration.

SPS 322.37 Air leakage.

SPS 322.38 Vapor retarders.

SPS 322.39 Ventilation and moisture control.

Subchapter V — Systems

SPS 322.40 Indoor temperatures and equipment sizing.

SPS 322.41 Temperature control.

SPS 322.42 Duct systems.

SPS 322.43 Duct and plenum sealing.

SPS 322.44 Pipe insulation.

SPS 322.45 Air conditioner and heat pump efficiencies.

SPS 322.46 Replacement furnace and boiler efficiencies.

Subchapter VI — Simulated Performance Alternative

SPS 322.50 General.

SPS 322.51 Performance-based compliance.

SPS 322.52 Documentation.

SPS 322.53 Calculation procedure.

Chapter SPS 322

ENERGY CONSERVATION

Subchapter I — Scope and Application

- SPS 322.01 Scope.
SPS 322.02 Application.

Subchapter II — Definitions

- SPS 322.10 Definitions.

Subchapter III — Insulation Materials and Installation

- SPS 322.20 Basic requirements.
SPS 322.21 Protection of insulation.

Subchapter IV — Dwelling Thermal Envelope

- SPS 322.30 General design requirements.
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- SPS 322.40 Indoor temperatures and equipment sizing.
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SPS 322.44 Pipe insulation.
SPS 322.45 Air conditioner and heat pump efficiencies.
SPS 322.46 Replacement furnace and boiler efficiencies.
SPS 322.47 Equipment requirements.
SPS 322.48 Indoor Pools.
SPS 322.49 Lighting Equipment.

Subchapter VI — Simulated Performance Alternative

- SPS 322.50 General.
SPS 322.51 Performance-based compliance.
SPS 322.52 Documentation.
SPS 322.53 Calculation procedure.

Note: Chapter Ind 22 was renumbered to be chapter ILHR 22, *Register*, February, 1985, No. 350, eff. 3–1–85. Chapter ILHR 22 was repealed and recreated to be chapter Comm 22, *Register*, January, 1999, No. 517, eff. 2–1–99. Chapter Comm 22 as it existed on March 31, 2009, was repealed and a new chapter Comm 22 was created effective April 1, 2009. Chapter Comm 22 was renumbered chapter SPS 322 under s. 13.92 (4) (b) 1., Stats., *Register* December 2011 No. 672.

Subchapter I — Scope and Application

SPS 322.01 Scope. (1) This chapter applies to all one- and 2-family dwellings covered by this code that use any amount of non-renewable energy for heat generation.

Note: Non-renewable energy sources used for heat distribution only will not require compliance with this chapter.

Note: Although the actual source of heat delivered by a heat pump is renewable, a dwelling using a heat pump is not exempt from the requirements of this chapter due to the required input of electricity to run the pump and compressor.

(2) The equipment efficiency standards in this chapter apply to all one- and 2-family dwellings covered by this code that use the respective equipment.

(3) (a) The vapor retarder requirements under s. SPS 322.38 and the moisture control and ventilation requirements under s. SPS 322.39 apply to any dwelling with insulation installed, whether or not the insulation is required under this code.

(b) The vapor retarder requirements under s. SPS 322.38 do not apply to an unheated space, such as an attached, unheated garage.

History: CR 08-043: cr. *Register* March 2009 No. 639, eff. 4–1–09; correction in (3) made under s. 13.92 (4) (b) 7., Stats., *Register* December 2011 No. 672; CR 15-041: renum. (3) to (3) (a), cr. (3) (b) *Register* December 2015 No. 720, eff. 1–1–16.

SPS 322.02 Application. (1) This chapter is not intended to conflict with any safety or health requirements. Where a conflict occurs, the safety and health requirements shall govern.

(2) This chapter allows the designer the option of using various methods to demonstrate compliance with thermal performance requirements. The designer shall identify on the plan submittal form what method or subchapter is being used, and indicate the design criteria and how it is being applied. Unless specifically exempted, all requirements of this chapter apply regardless of the method used.

History: CR 08-043: cr. *Register* March 2009 No. 639, eff. 4–1–09.

Subchapter II — Definitions

SPS 322.10 Definitions. (1) “Air-impermeable” means having an air permeance less than or equal to 0.02 L/s-m² at a pressure differential of 75 pascals when tested according to ASTM E 2178 or ASTM E 283.

(2) “Conditioned floor area” means the sum of areas of all floors in conditioned space in the structure, including basements, cellars, and intermediate floored levels measured from the exterior faces of exterior walls or from the center line of interior walls, excluding covered walkways, open roofed-over areas, porches, exterior terraces or steps, chimneys, roof overhangs and similar features.

(3) “Conditioned space” means space within the dwelling thermal envelope which is provided with heated air or surfaces to provide a heated space capable of maintaining the temperature of the space to at least 50°F at design conditions.

(4) “Crawl space wall” means the opaque portion of a wall which encloses a crawl space and is partially or totally below grade.

(5) “Dwelling thermal envelope” means the elements of a dwelling with enclosed conditioned space through which thermal energy may be transferred to or from unconditioned space or the exterior.

(6) “Exterior wall area” means the normal projection of the dwelling envelope wall area bounding interior space which is conditioned by an energy-using system including opaque wall, window and door area. Any skylight shaft walls that are 12 inches or more in depth, measured from the ceiling plane to the roof deck, are considered in the area of exterior walls and are not considered part of the roof assembly.

(7) “Heated slab” means a floor slab in which an uninsulated heating element, uninsulated hydronic tubing or uninsulated hot air distribution system is in contact with the slab or placed within the slab or the subgrade.

(8) “HVAC” means heating, ventilating and air conditioning.

(9) “HVAC system” means the equipment, distribution network, and terminals that provide either collectively or individually the processes of heating, ventilating, or air conditioning to a building.

(10) “Infiltration” means the uncontrolled inward air leakage through cracks and interstices in any dwelling element and around windows and doors of a dwelling caused by the pressure effects of wind, and the effect of differences in the indoor and outdoor air density.

(11) “IC-rated” means an electrical fixture tested and listed by an independent testing laboratory as being suitable for installation in a cavity where the fixture may be in direct contact with thermal insulation or combustible materials.

(12) “Mass wall” means a wall of concrete block, concrete, insulated concrete forms, masonry cavity, brick other than brick veneer, earth and solid timber or logs.

(13) “Opaque areas” means all exposed areas of a dwelling envelope which enclose conditioned space except openings for windows, skylights, doors and dwelling service systems.

(14) “Proposed design” means a description of the proposed dwelling used to estimate annual energy use for determining compliance based on total building performance.

(15) “Renewable energy sources” means sources of energy, excluding minerals and petroleum products, derived from incoming solar radiation, trees and other plants, wind, waves and tides, lake or pond thermal differences and from the internal heat of the earth.

(16) “Roof assembly” means all components of the roof and ceiling envelope through which heat flows, thus creating a building transmission heat loss or gain, where such assembly is exposed to outdoor air and encloses a heated space. Any skylight shaft walls less than 12 inches in depth, as measured from the ceiling plane to the roof deck, are considered in the roof assembly and are not considered in the area of exterior walls.

(17) “Sun room” means a one-story structure attached to a dwelling with a glazing area in excess of 40% of the gross area of the structure’s exterior walls and roof and with any screened areas capable of being covered or replaced with glazing during the heating season.

Note: A thermally isolated sun room does not count in the calculation of amount of glazing.

(18) “System” means a combination of central or terminal equipment and their components, controls, accessories, interconnecting means, and terminal devices by which energy is transformed so as to perform a specific function, such as HVAC, water heating, or illumination.

(19) “Thermal resistance” or “R-value” means a measure of the ability to retard the flow of heat. The R-value is the reciprocal of thermal transmittance or U-factor expressed as $R = 1/U$.

Note: The higher the R-value of a material, the more difficult it is for heat to be transmitted through the material.

(20) “Thermal transmittance” or “U-factor” means the time rate of heat flow through a body or assembly which is located between 2 different environments, expressed in $\text{Btu/h} \cdot \text{ft}^2 \cdot ^\circ\text{F}$. The U-factor applies to combinations of different materials used in series along the heat flow path and also to single materials that comprise a dwelling section, including cavity air spaces and air films on both sides of a dwelling element.

Note: The lower the U-factor of a material, the more difficult it is for heat to be transmitted through the material.

Note: The thermal transmittance is also referred to as the coefficient of heat transfer or the coefficient of heat transmission.

(21) “Thermally isolated” means physically and thermally separated with separate zone or separate equipment controls for space heating.

(22) “Thermostat” means an automatic control device actuated by temperature and designed to be responsive to temperature.

(23) “Ventilation” means the process of supplying or removing air by natural or mechanical means to or from any space. The air may or may not have been conditioned.

(24) “Zone” means a space or group of spaces within a dwelling with heating requirements sufficiently similar so that comfort

conditions can be maintained throughout by a single controlling device.

History: CR 08–043: cr. Register March 2009 No. 639, eff. 4–1–09; CR 09–104: am. (17) Register December 2010 No. 660, eff. 1–1–11.

Subchapter III — Insulation Materials and Installation

SPS 322.20 Basic requirements. (1) GENERAL. When available, information and values on thermal properties, performance of building envelope sections and components, and heat transfer shall be obtained from the ASHRAE Handbook of Fundamentals.

(2) COMPUTATION OF R-VALUES. (a) Insulation material used in layers, such as framing cavity insulation and insulating sheathing, shall be summed to compute the component R-value.

(b) The manufacturer’s settled R-value shall be used for blown insulation.

(c) Computed R-values may not include values for air films or for building materials other than insulation materials.

Note: The REScheck program will automatically account for air films and other building materials.

(3) LABORATORY OR FIELD TEST MEASUREMENTS. (a) *General dwelling thermal envelope materials.* When information specified under sub. (1) is not available, or when a different value is claimed, supporting data shall be obtained using one of the following test methods:

1. ASTM C177, Standard test method for steady state heat flux measurements and thermal transmission properties by means of the guarded-hot-plate apparatus.

2. ASTM C335, Standard test method for steady state heat transfer properties of pipe insulation.

3. ASTM C518, Standard test method for steady state thermal transmission properties by means of the heat flow meter apparatus.

4. ASTM C1363, Standard test method for the thermal performance of building materials and envelope assemblies by means of a hot box apparatus.

(b) *Foam plastic insulation.* 1. When information specified under sub. (1) is not available, or when a different value is claimed, foam plastic insulation that uses a gas other than air as the insulating medium shall use laboratory or field tests conducted on representative samples that have been aged for the equivalent of 5 years or until the R-value has stabilized.

2. The tests shall be conducted by an independent third party using the standards listed under par. (a) and shall be submitted for department review and approval in accordance with s. SPS 320.18.

(c) *Concrete masonry units.* Systems using integrally-insulated concrete masonry units shall be evaluated for thermal performance in accordance with one of the following:

1. Default values as approved by the department with no extrapolations or interpolations.

2. Laboratory or field test measurements specified under par. (a).

3. The material approval process specified in s. SPS 320.18.

(4) GENERAL INSTALLATION. (a) Materials, equipment and systems shall be identified in a manner that will allow a determination of their compliance with the applicable provisions of this code.

(b) All insulation materials, caulking and weatherstripping, fenestration assemblies, mechanical equipment and systems components, and water-heating equipment and system components shall be installed in accordance with the manufacturer’s installation instructions.

(c) Manufacturer’s installation instructions shall be available on the job site at the time of inspection.

(d) Roof and ceiling, floor and wall cavity batt or board insulation shall be installed in a manner which will permit inspection of the manufacturer's R-value identification mark.

(5) IDENTIFICATION. (a) A thermal resistance identification mark shall be applied by the manufacturer to each piece of dwelling envelope insulation 12-inches or greater in width.

(b) 1. The thickness of blown-in roof and ceiling insulation shall be identified by thickness markings that are labeled in inches and installed at least one for every 300 square feet through the attic space.

2. The markers shall be affixed to trusses or joists marking the minimum initial installed thickness and minimum settled thickness with numbers a minimum of one-inch in height.

3. Each marker shall face the attic access.

4. The thickness of installed insulation shall meet or exceed the minimum initial installed thickness shown by the marker.

(6) CERTIFICATE. (a) A permanent certificate shall be posted on or immediately adjacent to the electrical distribution panel.

(b) The certificate shall be completed by the owner, builder or insulation installer.

(c) The certificate shall list at least the following information:

1. The predominant R-values of insulation installed in or on ceilings or roofs, walls, foundation walls, slabs and any heating ducts that are outside the thermal envelope.

2. The U-factors of all windows, skylights and doors.

(d) If using the REScheck or REM/Rate software programs, the certificate shall be printed from that program.

History: CR 08-043: cr. Register March 2009 No. 639, eff. 4-1-09; correction in (3) (a) made under s. 13.92 (4) (b) 1., Stats., Register March 2009 No. 639; correction in (3) (b) 2., (c) 3. made under s. 13.92 (4) (b) 7., Stats., Register December 2011 No. 672.

SPS 322.21 Protection of insulation. (1) BLANKET INSULATION. Insulating blankets or batts shall be held in place with a covering or other means of mechanical or adhesive fastening.

Note: If the insulation is on a below-grade wall, s. SPS 322.38 (4) may prohibit the use of vapor retarder material used as the covering.

(2) WIND WASH PROTECTION. (a) Except as provided under s. SPS 322.39 (4) for cathedral ceilings, all air-permeable insulation materials installed in any position other than horizontal, shall be covered on the cold-in-winter side with a permanently attached material of low air permeability to maintain the R-value of the insulation.

Note: Suitable materials for this purpose include house wrap permanently attached with batten strips, asphalt-impregnated felt or tar paper, plywood, oriented strand board or OSB, siding material, rigid insulation sheathing, etc.

(b) If non-rigid sheet material is used, it shall be water vapor permeable.

Note: Water vapor permeable materials for this purpose include house wrap permanently attached with batten strips and asphalt-impregnated felt or tar paper.

(3) FOAM PLASTIC INSULATION. (a) Exterior foam plastic insulation shall be protected from physical damage and damage from ultraviolet light with a permanent, opaque, weather-resistant covering or coating.

(b) The protective covering shall cover the exposed exterior insulation and extend a minimum of 2 inches below grade, except the covering is not required below a brick ledge.

Note: For interior applications, a thermal barrier may be required under s. SPS 321.11.

History: CR 08-043: cr. Register March 2009 No. 639, eff. 4-1-09; correction in (2) (a) made under s. 13.92 (4) (b) 7., Stats., Register December 2011 No. 672; CR 15-041: am. (3) (b) Register December 2015 No. 720, eff. 1-1-16.

Subchapter IV — Dwelling Thermal Envelope

SPS 322.30 General design requirements. (1) GENERAL. Dwelling thermal envelope insulation amounts and details shall be determined using one of the methods described in this subchapter.

(2) INFILTRATION. (a) Infiltration for heating design loads shall be calculated based on a maximum of 0.5 air change per hour in the heated space.

(b) 1. If the proposed design takes credit for a reduced air change per hour level, documentation of the measures providing the reduction or the results of a post-construction blower door test conducted in accordance ASTM E 779 shall be provided to the department.

2. The minimum air change per hour rate may not be less than 0.2, unless mechanical ventilation is provided.

(3) BASEMENTS AND CRAWL SPACES. Where basement and crawl space walls are part of the dwelling thermal envelope, their R-values and U-factors shall be based on the wall components. Adjacent soil may not be considered in the determination.

(4) GARAGES. (a) Except as provided under par. (b), a garage may not be provided with any supplemental heat unless all of the following conditions are met:

Note: Because of the scope of this chapter, the requirements under this subsection apply only to heat generated from non-renewable sources.

1. The dwelling shall be thermally isolated from the garage.

2. The garage floor, ceiling and walls shall be provided with a vapor retarder in accordance with s. SPS 322.38.

3. All building elements shall meet the requirements of s. SPS 322.31.

(b) The thermal envelope requirements under par. (a) are not required if all of the following conditions are met:

1. The thermostat is permanently limited to a maximum of 50°F.

2. Heating equipment is either separate from the dwelling unit equipment or installed as a separate zone.

3. Separate heating equipment shall be sized to provide a maximum indoor temperature of 50°F.

(5) MASONRY VENEER. When insulation is placed on the exterior of a foundation supporting a masonry veneer exterior, the horizontal foundation surface supporting the veneer is not required to be insulated to satisfy the foundation insulation requirement.

History: CR 08-043: cr. Register March 2009 No. 639, eff. 4-1-09; correction in (4) (a) 2., 3. made under s. 13.92 (4) (b) 7., Stats., Register December 2011 No. 672.

SPS 322.31 Prescriptive insulation and fenestration criteria. (1) REQUIREMENTS. (a) Except as specifically provided under this subchapter, dwellings using the prescriptive method shall meet the requirements of Table 322.31-1 or 322.31-2.

(b) In Tables 322.31-1 and 322.31-2, zone 2 consists of the following 15 northern counties: Ashland, Bayfield, Burnett, Douglas, Florence, Forest, Iron, Langlade, Lincoln, Oneida, Price, Sawyer, Taylor, Vilas and Washburn. Zone 1 consists of all other counties not included in zone 2.

(2) THERMAL ENVELOPE. (a) *General.* If the total dwelling thermal envelope UA is less than or equal to the total UA resulting from using the U-factors in Table 322.31-2 multiplied by the same assembly area as in the proposed building, the dwelling is in compliance with this chapter. The UA calculation shall be done using a method consistent with the ASHRAE Handbook of Fundamentals and shall include the thermal bridging effects of framing materials.

Note: UA is equal to the product of the U-factor times the assembly area.

Note: REScheck is an acceptable software program for determining compliance with this section.

(b) *Software version.* If a REScheck software program is used to show compliance with this section, a version approved by the department shall be used.

Note: The IECC 2009 version of REScheck meets the thermal envelope requirements of this code.

(3) APPLIANCE EFFICIENCY. (a) Except as allowed under par. (b) and s. SPS 322.46, oil-fired and gas-fired furnaces and boilers shall meet the minimum efficiency requirements in Table 322.31-3.

(b) In new construction, an oil-fired or gas-fired furnace or boiler meeting the federal efficiency standard but not the requirements of Table 322.31-3 may be installed if the dwelling thermal envelope requirements of Table 322.31-4 are met.

**TABLE 322.31-1
INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT^a**

Zone	Fenestration U-Factor	Skylight U-Factor	Ceiling R-Value	Wood Frame Wall R-Value	Mass Wall R-Value ⁱ	Floor R-Value	Basement Wall R-Value ^b	Crawl Space Wall R-Value ^b	Heated Slab R-Value ^c	Unheated Slab R-Value ^d
1	0.35	0.60	49 ^e	20 ^f or 13+5 ^g	15/19	30 ^h	15/19	10/13	10/15	10
2	0.35	0.60	49 ^e	21 ^f	19/21	38 ^h	15/19	10/13	10/15	10

^a R-values are minimums. U-factors are maximums.

^b "15/19" means R-15 continuous insulated sheathing on the interior or exterior of the home or R-19 cavity insulation at the interior of the basement wall. "15/19" shall be permitted to be met with R-13 cavity insulation on the interior of the basement wall plus R-5 continuous insulated sheathing on the interior or exterior of the home. "10/13" means R-10 continuous insulated sheathing on the interior or exterior of the home or R-13 cavity insulation at the interior of the basement wall.

^c The first R-value applies under the entire slab, regardless of depth below grade. The second R-value applies to the slab edge where the bottom of the slab is less than 12 inches below adjacent grade. Slab edge insulation shall extend downward from the top of the slab for a minimum of 48 inches or downward to at least the bottom of the slab and then horizontally to the interior or exterior for a minimum total distance of 48 inches. Also, see s. SPS 321.16 for protection against frost for slabs with supports less than 4 feet below grade.

^d The R-value applies to any slab, the bottom of which is less than 12 inches below adjacent grade. Also, see s. SPS 321.16 for protection against frost for slabs with supports less than 4 feet below grade.

^e See s. SPS 322.32 (1) for application and permitted reduced R-value.

^f R-20 and R-21 may be compressed into a 2X6 cavity.

^g "13+5" means R-13 cavity insulation plus R-5 insulated sheathing. If structural sheathing covers 25% or less of the exterior, insulating sheathing is not required where structural sheathing is used. If structural sheathing covers more than 25% of the exterior, structural sheathing shall be covered with insulated sheathing of at least R-2.

^h Or insulation sufficient to fill the framing cavity with a minimum of R-19.

ⁱ The second R-value applies when more than half of the insulation is on the interior of the mass wall.

**TABLE 322.31-2
EQUIVALENT U-FACTORS**

Zone	Fenestration U-Factor	Skylight U-Factor	Ceiling U-Factor	Wood Frame Wall U-Factor	Mass Wall U-Factor	Floor U-Factor	Basement Wall U-Factor	Crawl Space U-Factor	Unheated Slab U-Factor
1	0.35	0.60	0.026	0.057	0.060 ^a	0.033	0.050	0.065	10
2	0.35	0.60	0.026	0.057	0.057 ^a	0.028	0.050	0.065	10

^a When more than half the insulation is on the interior, the mass wall U-factors shall be the same as the frame wall U-factor.

TABLE 322.31-3

WARM AIR FURNACES AND BOILERS, MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type	Minimum Efficiency	Test Procedure
Natural gas and propane furnace	90% AFUE	DOE 10 CFR Part 430 or ANSI Z21.47
Natural gas and propane hot water boilers	90% AFUE	DOE 10 CFR Part 430
Oil-fired furnaces	83% AFUE	DOE 10 CFR Part 430 or UL 727
Oil-fired hot water boilers	84% AFUE	DOE 10 CFR Part 430

**TABLE 322.31-4
COMPONENT DWELLING THERMAL ENVELOPE REQUIREMENTS
FOR DWELLINGS USING LOWER EFFICIENCY APPLIANCES^a**

Fenestration U-Factor	Skylight U-Factor	Ceiling R-Value	Wood Frame Wall R-Value	Mass Wall R-Value	Floor R-Value	Basement or Crawl Space Wall R-Value ^b	Heated Slab R-Value ^c	Unheated Slab R-Value ^d
0.30	0.60	49 ^e	21 ^f or 19+5 ^g	19	30 ^h	15/19	10/20	15
Equivalent U-Factors								
0.30	0.60	0.026	0.057	0.057	0.033	0.045	0.033	0.047

^a R-values are minimums. U-factors are maximums.

^b The first R-value applies to continuous insulation. The second R-value applies to framing cavity insulation.

^c The first R-value applies under the entire slab, regardless of depth below grade. The second R-value applies to the slab edge. Slab edge insulation shall extend downward from the top of the slab for a minimum of 48 inches or downward to at least the bottom of the slab and then horizontally to the interior or exterior for a minimum total distance of 48 inches.

^d The R-value applies to the slab perimeter insulation, where the bottom of the slab is less than 12 inches below adjacent grade. Slab edge insulation shall extend downward from the top of the slab for a minimum of 48 inches or downward to at least the bottom of the slab and then horizontally to the interior or exterior for a minimum total distance of 48 inches. Also, see s. SPS 321.16 for protection against frost for slabs with supports less than 4 feet below grade.

^e See s. SPS 322.32 (1) for application and permitted reduced R-value.

^f R-21 may be compressed into a 2X6 cavity.

^g "19+5" means R-19 cavity insulation plus R-5 insulated sheathing. If structural sheathing covers 25% or less of the exterior, insulating sheathing is not required where structural sheathing is used. If structural sheathing covers more than 25% of the exterior, structural sheathing shall be covered with insulated sheathing of at least R-2.

^h Or insulation sufficient to fill the framing cavity with a minimum of R-19.

History: CR 08-043: cr. Register March 2009 No. 639, eff. 4-1-09; EmR0917: emerg. am. (2) (b), eff. 9-5-09; CR 09-072: am. (2) (b) Register March 2010 No. 651, eff. 4-1-10; CR 09-104: am. Tables 22.31-1 and 22.31-4 Register December 2010 No. 660, eff. 1-1-11; correction in (1) (a), (b), (2) (a), (b), (3) (a), (b), Table 322.31-1, Table 322.31-4 made under s. 13.92 (4) (b) 7., Stats., Register December 2011 No. 672; CR 15-041: am. Table 322.31-1, Table 322.31-2, Table 322.31-4 Register December 2015 No. 720, eff. 1-1-16.

SPS 322.32 Specific insulation requirements.

(1) CEILINGS WITH ATTIC SPACES. (a) R-38 will satisfy the ceiling R-value requirement for a dwelling where the full height of uncompressed R-38 insulation extends over the wall top plate at the eaves.

(b) An attic-access cover shall be weatherstripped and insulated to a level equivalent to the insulation on the surrounding surfaces when the attic is an unconditioned space. A wood framed or equivalent baffle or retainer is required to be provided when loose fill insulation is installed, the purpose of which is to prevent loose fill insulation from spilling into the living space when the attic access is opened, and to provide a permanent means of maintaining the installed R-value of the loose fill insulation.

(2) CEILINGS WITHOUT ATTIC SPACES. Where the design of the roof or ceiling assembly does not allow sufficient space for the required R-49 insulation, the minimum required insulation for the roof or ceiling assembly shall be R-30. This reduction of insulation shall be limited to 500 square feet of ceiling area.

(3) MASS WALLS. The requirements of Table 322.31-1 are applicable to mass walls.

(4) STEEL-FRAME CEILINGS, WALLS AND FLOORS. (a) Steel-frame ceilings, walls and floors shall meet the insulation requirements of Table 322.32 or shall meet the U-factor requirements in Table 322.31-2.

(b) The calculation of the U-factor for a steel-frame envelope assembly shall use a series-parallel path calculation method.

(5) FLOORS. Floor insulation shall be installed to maintain permanent contact with the underside of the subfloor decking.

(6) BASEMENT WALLS. (a) Walls associated with conditioned basements shall be insulated from the top of the basement wall down to the basement floor.

(b) Walls associated with unconditioned basements shall meet the requirement in par. (a) unless the floor overhead is insulated in accordance with Table 322.31-1.

(c) Where the total basement wall area is less than 50 percent below grade, the entire wall area, including the below-grade portion, is included as part of the area of exterior walls.

(7) BOX SILL AND RIM JOIST SPACES. Box sills and joist spaces at outside walls shall be insulated to the required wall R-value with air-impermeable insulation that is sealed on all sides to all framing members and the foundation, or with air-permeable insulation held in place as required under s. SPS 322.21 (1).

(8) OVERHANG JOIST SPACES. (a) Joist spaces that extend beyond exterior walls shall be insulated with an R-value of 30 or higher with insulation that completely fills the cavity including over the top of the exterior wall supporting the joists.

(b) The joist space insulation shall be air sealed either by using an air-impermeable insulation that is sealed to all framing members or by covering the insulation with a rigid material that is caulked or sealed to all framing members.

(c) If piping that is subject to freezing is located in the joist space, additional insulation shall be provided on the unconditioned side of the space.

(9) WALL INSULATION. (a) Except for closed-cell sprayed foam, wall insulation shall completely fill the wall cavity.

(b) The vertical and flared walls in a skylight shall meet the insulation requirements for walls. Tube skylights shall be insulated per the manufacturer's recommendations.

TABLE 322.32
STEEL-FRAME CEILING, WALL AND FLOOR INSULATION R-VALUES

Wood Frame R-Value Requirement	Cold-Formed Steel Equivalent R-Value ^a
Steel Truss Ceilings ^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
Steel Joist Ceilings ^b	
R-30	R-38 in 2X4 or 2X6 or 2X8 R-49 in any framing
R-38	R-49 in 2X4 or 2X6 or 2X8 or 2X10
Steel Framed Wall	
R-13	R-13 + 5 or R-15 + 4 or R-21 + 3
R-19	R-13 + 9 or R-19 + 8 or R-25 + 7
R-21	R-13 + 10 or R-19 + 9 or R-25 + 8
Steel Joist Floor	
R-13	R-19 in 2X6 R-19 + 6 in 2X8 or 2X10
R-19	R-19 + 6 in 2X6 R-19 + 12 in 2X8 or 2X10

^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.

History: CR 08-043: cr. Register March 2009 No. 639, eff. 4-1-09; correction in (3) (a), (b), (4) (a), (6) (b), (7) made under s. 13.92 (4) (b) 7., Stats., Register December 2011 No. 672; CR 15-041: renum. (1) to (1) (a), cr. (1) (b), renum. (3) (a) to (3) and am., r. (3) (b), renum. (9) to (9) (a), cr. (9) (b) Register December 2015 No. 720, eff. 1-1-16.

SPS 322.33 Slab floors. (1) HEATED OR UNHEATED SLABS. (a) Any heated or unheated slab floor, the bottom of which is less than 12 inches below adjacent grade, shall be provided with perimeter insulation in accordance with Table 322.31-1 or Table 322.31-4, except as provided in par. (b).

(b) At the threshold or the base of any door opening that leads directly to the exterior of the structure, the vertical perimeter insulation shall be at least R-5, excluding all garage doors.

(2) HEATED SLABS. In addition to meeting the requirement under sub. (1), if applicable, heated slab floors of any depth below grade shall meet the under-slab R-value requirement in accordance with Table 322.31-1 or Table 322.31-4.

(3) DETAILS. (a) The top edge of insulation installed between the exterior wall and the edge of the interior slab may be cut at a 45 degree angle away from the exterior wall.

(b) Horizontal insulation extending outside of the foundation shall be covered by soil a minimum of 10 inches thick or by pavement.

(c) Insulation on a foundation wall for a basement may be interrupted at the junction with a foundation wall.

Note: See Appendix for further explanatory materials.

History: CR 08-043: cr. Register March 2009 No. 639, eff. 4-1-09; CR 09-104: am. (1), (2) Register December 2010 No. 660, eff. 1-1-11; correction in (1), (2) made under s. 13.92 (4) (b) 7., Stats., Register December 2011 No. 672; CR 15-041: renum. (1) to (1) (a) and am., cr. (1) (b), (3) (c) Register December 2015 No. 720, eff. 1-1-16.

SPS 322.34 Crawl spaces. (1) FROST PROTECTION. If the bottom of the crawl space serving as the dwelling foundation is less than 48 inches below adjacent grade, the foundation shall

be frost protected in accordance with Table 322.31-1 for frost protected slabs.

(2) VAPOR RETARDER. Any exposed earth in crawl spaces shall be covered with a continuous vapor retarder.

(b) All decayable organic material, including topsoil, shall be removed from crawl space floors prior to placing the vapor retarder.

(c) All joints of the vapor retarder shall overlap by 6 inches and be sealed or taped.

(d) The edges of the vapor retarder shall extend at least 6 inches up the foundation wall and shall be attached and sealed to the foundation wall or insulation.

(3) CRAWL SPACES. (a) Crawl space walls shall be insulated in accordance with Table 322.31-1.

(b) Crawl space wall insulation shall be permanently fastened to the wall and shall extend the entire height of the wall.

History: CR 08-043: cr. Register March 2009 No. 639, eff. 4-1-09; correction in (1), (3) (c), (4) (a), (c) made under s. 13.92 (4) (b) 7., Stats., Register December 2011 No. 672; CR 15-041: am. (2) (d) Register December 2015 No. 720, eff. 1-1-16; CR 15-090: r. (3), (4) (c), renum. (4) to (3) and am. Register May 2016 No. 725, eff. 6-1-16.

SPS 322.35 Thermally isolated sunrooms. (1) The minimum opaque ceiling insulation R-value shall be R-24. The minimum opaque wall R-value shall be R-13.

(2) The maximum fenestration U-factor shall be 0.50 and the maximum skylight U-factor shall be 0.75.

(3) New walls, windows and doors separating a sunroom from conditioned space shall meet the building thermal envelope requirements.

(4) The temperature in the conditioned space shall be controlled as a separate zone or shall use separate heating equipment.

(5) Glazing in a thermally-isolated sunroom is not considered to be in the dwelling thermal envelope.

History: CR 08-043: cr. Register March 2009 No. 639, eff. 4-1-09.

SPS 322.36 Fenestration. (1) AVERAGE U-FACTORS. An area-weighted average of fenestration products may be used to satisfy the U-factor requirements.

(2) MAXIMUM FENESTRATION U-FACTOR. The area weighted average maximum fenestration U-factor permitted using trade offs from s. SPS 322.31 (2) or subchapter VI shall be 0.40 for vertical fenestration, and 0.75 for skylights.

(3) GLAZED FENESTRATION EXEMPTION. Up to 15 square feet of glazed fenestration per dwelling unit may be exempt from U-factor requirements of the chapter.

(4) OPAQUE DOOR EXEMPTION. One opaque door assembly is exempted from the U-factor requirements of this chapter.

(5) REPLACEMENT FENESTRATION. Where an existing fenestration unit is replaced with a new fenestration unit, including sash and glazing, the replacement unit shall meet the U-factor requirements of this chapter.

(6) CERTIFIED PRODUCTS. Except as provided in sub. (7), fenestration rating, certification and labeling of U-factors for windows, doors and skylights shall be in accordance with NFRC 100.

(7) DEFAULT VALUES. When a manufacturer has not determined product U-factor in accordance with NFRC 100, U-factors shall be determined by assigning a default value in accordance with Tables 322.36-1 and 322.36-2. Where a composite of materials of two different product types is used, the product shall be assigned the higher U-factor.

TABLE 322.36-1
U-FACTOR DEFAULT TABLE FOR WINDOWS, GLAZED DOORS AND SKYLIGHTS^a

Metal without Thermal Break	Single Glazed	Double Glazed
Operable	1.27	0.87

Fixed	1.13	0.69
Door	1.26	0.80
Skylight	1.98	1.31
Site-assembled Skylight	1.36	0.82
Metal with Thermal Break		
Operable	1.08	0.65
Fixed	1.07	0.63
Door	1.10	0.66
Skylight	1.89	1.11
Site-assembled Skylight	1.25	0.70
Vinyl or Metal-clad Wood		
Operable	0.90	0.57
Fixed	0.98	0.56
Door	0.99	0.57
Skylight	1.75	1.05
Wood or Fiberglass		
Operable	0.89	0.55
Fixed	0.98	0.56
Door	0.98	0.56
Skylight	1.47	0.84

^a Glass block assemblies shall have a default value of 0.60.

**TABLE 322.36-2
U-FACTOR DEFAULT TABLE FOR
NON-GLAZED DOORS**

Steel Doors (1¾ inches thick)	With Foam Core	Without Foam Core
	0.35	0.60
Wood Doors (1¾ inches thick)	Without Storm Door	With Storm Door
Panel with 7/16-inch panels	0.54	0.36
Hollowcore flush	0.46	0.32
Panel with 1½-inch panels	0.39	0.28
Solid core flush	0.40	0.26

History: CR 08-043: cr. Register March 2009 No. 639, eff. 4-1-09; correction in (2), (7) made under s. 13.92 (4) (b) 7., Stats., Register December 2011 No. 672.

SPS 322.37 Air leakage. (1) **GENERAL.** The requirements of this section apply to those components that separate interior conditioned space from a garage or an unconditioned space.

(2) **WINDOW AND DOOR ASSEMBLIES.** (a) *General.* Except as specified in par. (b), windows, skylights and sliding glass doors shall have an air infiltration rate of no more than 0.3 cfm per square foot, and swinging doors no more than 0.5 cfm per square foot, 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.

(b) *Exception.* Site-constructed doors and windows shall be sealed with gasketing or weatherstripping or shall be covered with a storm door or storm window.

(3) **JOINT AND PENETRATION SEALING.** (a) Exterior joints, seams or penetrations in the dwelling envelope, which are sources of air leakage, shall be sealed with durable caulking materials, closed with gasketing systems, taped, or covered with water-vapor-permeable house wrap. Joints to be treated include all of the following:

1. Openings, cracks and joints between wall cavities and window or door frames.

2. Between separate wall assemblies or their sill-plates and foundations.

3. Between walls, roof, ceilings or attic ceiling seals, and between separate wall panel assemblies, including between interior and exterior walls.

4. Penetrations of utility services through walls, floor and roof assemblies, and penetrations through top and bottom wall plates.

(b) Sealing shall be provided at the attic and crawl space panels, at recessed lights and around all plumbing and electrical penetrations, where these openings are located in the dwelling thermal envelope.

(c) The sealing methods between dissimilar materials shall allow for differential expansion and contraction.

(4) **RECESSED LIGHTING.** When installed in the dwelling envelope, recessed lighting fixtures shall be sealed to limit air leakage between conditioned and unconditioned spaces by one of the following means:

(a) The fixture shall be IC-rated and labeled with enclosures that are sealed or gasketed to prevent air leakage to the ceiling cavity or unconditioned space.

(b) The fixture shall be IC-rated and labeled as meeting ASTM E 283 when tested at 1.57 psi pressure differential with no more than 2.0 cfm of air movement from the conditioned space to the ceiling cavity.

(c) 1. The fixture shall be located inside an airtight sealed box with clearances of at least 0.5 inch from combustible material and 3 inches from insulation.

2. If the fixture is non-IC-rated, the box shall be constructed of noncombustible material that does not readily conduct heat.

Note: The department will accept cement board, drywall, and other materials that exhibit flame spread and smoke developed indices of 10 or less when tested in accordance with ASTM E-84.

(5) **FAN HOUSINGS.** Gaps between a fan housing and a ceiling or wall that could result in air leaks shall be gasketed, sealed or caulked.

(6) **COMPLIANCE DEMONSTRATION.** Building envelope air tightness and insulation installation shall be demonstrated to comply with one of the following options:

(a) *Testing option.* Building envelope tightness and insulation installation shall be considered acceptable when tested air leakage is less than seven air changes per hour (ACH) when tested with a blower door at a pressure of 33.5 psf (50 Pa). Testing shall occur after rough in and after installation of penetrations of the building envelope, including penetrations for utilities, plumbing, electrical, ventilation and combustion appliances. During testing all of the following shall be done:

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

2. Dampers shall be closed, but not sealed, including exhaust, intake, makeup air, backdraft and flue dampers.

3. Interior doors shall be open.

4. Exterior openings for continuous ventilation systems and heat recovery ventilators shall be closed and sealed.

5. Heating and cooling system(s) shall be turned off.

6. HVAC ducts shall not be sealed.

7. Supply and return registers shall not be sealed.

(b) *Visual inspection option.* Building envelope tightness and insulation installation shall be considered acceptable when the items listed in Table 332.37, applicable to the method of construction, are field verified. Where required by the code official, an approved party independent from the installer of the insulation shall inspect the air barrier and insulation.

**TABLE 332.37
AIR BARRIER AND INSULATION INSPECTION COMPONENT CRITERIA**

COMPONENT	CRITERIA
Air barrier and thermal barrier	Exterior thermal envelope insulation for framed walls is installed in substantial contact and continuous alignment with building envelope air barrier. Breaks or joints in the air barrier are filled or repaired. Air-permeable insulation is not used as a sealing material. Air-permeable insulation is inside of an air barrier.
Ceiling/attic	Air barrier in any dropped ceiling/soffit is substantially aligned with insulation and any gaps are sealed. Attic access (except unvented attic), knee wall door, or drop down stair is sealed.
Walls	Corners and headers are insulated. Junction of foundation and sill plate is sealed.
Windows and doors	Space between window/door jambs and framing is sealed.
Rim joists	Rim joists are insulated and include an air barrier.
Floors (including above-garage and cantilevered floors)	Insulation is installed to maintain permanent contact with underside of sub-floor decking. Air barrier is installed at any exposed edge of insulation.
Crawl space walls	Insulation is permanently attached to walls. Exposed earth in unvented crawl spaces is covered with Class I vapor retarder with overlapping joints taped.
Shafts, penetrations	Duct shafts, utility penetrations, knee walls and flue shafts opening to exterior or unconditioned space are sealed.
Narrow cavities	Batts in narrow cavities are cut to fit, or narrow cavities are filled by sprayed/blown insulation.
Garage separation	Air sealing is provided between the garage and conditioned spaces.
Recessed lighting	Recessed light fixtures are air tight, IC rated, and sealed to drywall. Exception—fixtures in conditioned space.
Plumbing and wiring	Insulation is placed between outside and pipes. Batt insulation is cut to fit around wiring and plumbing, or sprayed/blown insulation extends behind piping and wiring.
Shower/tub on exterior wall	Showers and tubs on exterior walls have insulation and an air barrier separating them from the exterior wall.
Electrical/phone box on exterior walls	Air barrier extends behind boxes or air sealed-type boxes are installed.
Common wall	Air barrier is installed in common wall between dwelling units.
HVAC register boots	HVAC register boots that penetrate building envelope are sealed to subfloor or drywall.
Fireplace	Fireplace walls include an air barrier.

History: CR 08-043: cr. Register March 2009 No. 639, eff. 4-1-09; CR 15-041: cr. (6), Table 322.37 Register December 2015 No. 720, eff. 1-1-16; correction in (6) (a) 6. made under s. 35.17, Stats., Register December 2015 No. 720.

SPS 322.38 Vapor retarders. (1) GENERAL. (a) *Definition.* Under this section, a vapor retarder is a material with no intrinsic thermal or structural properties that has a rating of 1.0 perm or less when tested in accordance with ASTM standard E 96, Procedure A.

(b) *Continuity.* 1. The vapor retarder shall be continuous. All joints in a vapor retarder consisting of sheet material shall be overlapped 6 inches and taped or sealed, except as provided in subd. 2. Rips, punctures, and voids in the vapor retarder shall be patched with vapor retarder materials and taped or sealed. Seams that are not over a framing member shall be taped or sealed.

2. Taping or sealing a vapor retarder is not required around doors and windows, behind bathtub enclosures, and at top and bottom wall plates, if the retarder is held to those materials in an airtight manner by other building components, such as gypsum wall-board.

(2) **FRAME ASSEMBLIES.** (a) *General.* Except as provided under par. (c), all frame walls, frame floors and frame ceilings that comprise the thermal envelope, shall have a vapor retarder installed on the warm-in-winter side of the thermal insulation.

(b) *Coverage.* The vapor retarder shall cover the exposed insulation and the interior face of the framing.

(c) *Exceptions.* 1. Where the vapor retarder is omitted, as allowed under subds. 2. to 4., all sources of air leakage, such as between double top or bottom plates or between double studs, shall be caulked or sealed.

2. No vapor retarder is required in the box sill.

3. No vapor retarder is required where batt insulation is provided with foil or kraft paper backing on the warm-in-winter side and the nailing tabs are tightly fastened to the warm-in-winter face of the framing members.

4. No vapor retarder is required over cavities that have at least 50% of the required R-value provided by spray-applied foam having a perm rating of 1.0 or less, unless required by the foam manufacturer.

5. A vapor retarder for a floor over an open, unheated area may consist of 5/8-inch tongue-and-groove oriented-strand board, or 3/4-inch tongue-and-groove CDX plywood, which is exposure-rated plywood.

(3) **CONCRETE FLOORS.** (a) Except as allowed under par. (d), a vapor retarder shall be installed directly under the concrete floor slab or under the base course of concrete floor slabs.

(b) Vapor retarder material shall be at least 6 mils in thickness or shall be a reinforced material.

(c) Joints in the vapor retarder shall be overlapped at least 6 inches and taped or sealed.

(d) A vapor retarder is not required under the slab of an unconditioned attached garage.

(4) **CONCRETE OR MASONRY BASEMENT WALLS.** A non-rigid sheet vapor retarder with a perm rating of 0.1 or less is prohibited in all of the following locations:

(a) On a concrete or masonry wall which is below grade to any extent.

(b) On an insulated frame wall constructed in front of a concrete or masonry wall which is below grade to any extent.

History: CR 08-043; cr. Register March 2009 No. 639, eff. 4-1-09; CR 09-104; r. (3) (d), renum. (3) (e) to be (3) (d) Register December 2010 No. 660, eff. 1-1-11; correction in (3) (a) made under s. 13.92 (4) (b) 7. Register December 2010 No. 660; CR 15-041; renum. (1) (b) to (1) (b) 1. and am., cr. (1) (b) 2., am. (2) (c) 4., cr. (2) (c) 5. Register December 2015 No. 720, eff. 1-1-16.

SPS 322.39 Ventilation and moisture control.

(1) GENERAL. Design and construction shall prevent deterioration from moisture condensation and ice damming.

(2) VENTED ATTICS. (a) 1. Except as allowed under subd. 6., where air-permeable ceiling or attic insulation is installed in a horizontal position, ventilation shall be provided above the insulation in accordance with this paragraph.

2. At least 50% of the net free ventilating area shall be distributed at the high sides of the roof.

3. The remainder of the net free ventilating area shall be distributed in the lower half of the roof or attic area.

4. If more than 50%, but less than 75% of the net free ventilating area is provided at the high sides of the roof, the total net free ventilating area shall be a minimum of 1/300 of the horizontal area of the ceiling.

5. If 75% or more of the net free ventilating area is provided at the upper sides of the roof, the total net free ventilating area shall be at least 1/150 of the horizontal area of the ceiling.

6. Ventilation is not required for separated roof areas, such as dormers, bump-outs or bays that cover a floor area of 40 ft² or less.

(b) Engineered systems that provide equivalent ventilation to that required under this subsection may be used.

(c) Insulation shall not block the free flow of air.

(3) CONDITIONED ATTICS. Attic spaces are not required to be vented where air-impermeable insulation is attached directly to the underside of the roof deck and all of the following conditions are met:

(a) No interior vapor retarders are installed between the living space and the conditioned attic.

(b) The temperature in the attic space is maintained high enough to prevent any moisture condensation on the insulation.

Note: Maintaining the interior surface temperature of the insulation at or above the dew point temperature of the interior air will minimize condensation. Maintaining at least 45°F on the surface of the insulation will minimize condensation on the surface when the interior air temperature is 70°F and the interior relative humidity is 45%.

(4) CATHEDRAL CEILINGS. Air-permeable insulation in a cathedral ceiling assembly shall fill the entire cavity space unless an air barrier separates the top of the insulation from the ventilation space.

(5) MECHANICAL VENTILATION. Outdoor air intakes and exhausts shall have automatic or gravity dampers that close when the ventilation system is not operating.

(6) CLOTHES DRYERS. Clothes dryers shall be vented to the outside of the structure.

Note: See s. SPS 323.14 for vent material requirements.

History: CR 08-043; cr. Register March 2009 No. 639, eff. 4-1-09.

Subchapter V — Systems

SPS 322.40 Indoor temperatures and equipment sizing. (1) GENERAL. The indoor temperatures listed under subd.

(2) shall be used to determine the total dwelling heat loss and to select the size of the heating equipment.

(2) INDOOR DESIGN TEMPERATURES. Unheated, non-habitable basement areas shall use a heating design temperature of less than 50°F. All other areas of a dwelling shall use a heating design temperature of 70°F.

(3) EQUIPMENT SIZING. Heating design loads including ventilation loads for the purpose of sizing systems shall be determined in accordance with the REScheck or REM/RATE software programs or one of the procedures described in Chapter 29 of ASHRAE Handbook of Fundamentals.

Note: Residential heat balance, residential load factor, Canadian F280 and ACCA Manuals J and S are among the methods recognized as equipment-sizing protocols under chapter 29.

History: CR 08-043; cr. Register March 2009 No. 639, eff. 4-1-09.

SPS 322.41 Temperature control. (1) GENERAL. Each system shall be provided with an adjustable thermostat for the regulation of temperature.

(2) CIRCULATING HOT WATER SYSTEMS. Circulating hot water systems shall include an automatic or readily accessible manual switch to turn off the circulating pump when the system is not in use.

(3) MERCURY THERMOSTATS. The installation of thermostats containing mercury is prohibited.

Note: This section does not require the replacement of existing mercury-containing thermostats.

(4) HEAT PUMP SUPPLEMENTARY HEAT. Heat pumps having supplementary electric-resistance heat shall have controls that, except during defrost, prevent supplemental heat operation when the heat pump compressor can meet the heating load.

History: CR 08-043; cr. Register March 2009 No. 639, eff. 4-1-09.

SPS 322.42 Duct systems. (1) Supply and return heating ducts, or portions thereof, that are not located completely within the thermal envelope, shall be provided with insulation with a thermal resistance of at least R-8.

(1m) Cooling supply ducts that pass through unconditioned spaces conducive to condensation, such as attics, shall be provided with insulation having a thermal resistance of at least R-8. The exterior of that insulation shall be covered with a vapor retarder that meets the requirements in s. SPS 322.38 (1)

(2) Building framing cavities may not be used as supply ducts.

History: CR 08-043; cr. Register March 2009 No. 639, eff. 4-1-09; CR 15-041; cr. (1m) Register December 2015 No. 720, eff. 1-1-16.

SPS 322.43 Duct and plenum sealing. (1) Duct systems with joints not located entirely within the conditioned space or with joints located on the unconditioned side of stud bays, joist cavities and similar spaces, shall be sealed in accordance with this section.

(2) Sealing shall be accomplished using welds, gaskets, mastics, mastic-plus-embedded-fabric systems or tapes installed in accordance with the manufacturer's instructions.

(3) Insulation that provides a continuous air barrier may be used in lieu of sealing metal ducts.

(4) Tapes and mastics used with rigid fibrous glass ducts shall be listed and labeled as complying with UL 181A.

(5) Tapes and mastics used with flexible air ducts shall be listed and labeled as complying with UL 181B.

(6) Tapes with rubber-based adhesives may not be used.

(7) Except where exempted as indicated in sub. (8), duct tightness shall be verified by either of the following:

(a) Postconstruction test: Leakage to outdoors shall be less than or equal to 8 cfm per 100 ft² of conditioned floor area or a total leakage less than or equal to 12 cfm per 100 ft² of conditioned floor area when tested at a pressure differential of 0.1 inches w.g. (25 Pa) across the entire system, including the manufacturer's air handler enclosure. All register boots shall be taped or otherwise sealed during the test.

(b) Rough-in test: Total leakage shall be less than or equal to 6 cfm per 100 ft² of conditioned floor area when tested at a pressure differential of 0.1 inches w.c. (25 Pa) across the roughed in system, including the manufacturer's air handler enclosure. All register boots shall be taped or otherwise sealed during the test. If the air handler is not installed at the time of the test, total leakage

shall be less than or equal to 4 cfm per 100 ft² of conditioned floor area.

(8) A duct tightness test is not required if the air handler and all ducts are located within conditioned space.

Note: Standard duct tape or “duck tape” has a rubber-based adhesive and does not comply with the requirements of this section.

History: CR 08-043: cr. Register March 2009 No. 639, eff. 4-1-09; CR 15-041: cr. (7), (8) Register December 2015 No. 720, eff. 1-1-16; numbering correction in (7) made under s. 13.92 (4) (b) 1., Stats., and correction in (7) (intro.), (b) made under s. 35.17, Stats., Register December 2015 No. 720, eff. 1-1-16.

SPS 322.44 Pipe insulation. (1) Mechanical system piping capable of carrying fluids above 105°F (41°C) or below 55°F (13°C) shall be insulated to a minimum of R-3.

(2) All circulating service hot water piping shall be insulated to at least R-2. Circulating hot water systems shall include an automatic or readily accessible manual switch that can turn off the hotwater circulating pump when the system is not in use.

(3) Heating pipes in unheated spaces shall be insulated with material providing a minimum thermal resistance of R-4 as measured on a flat surface in accordance with ASTM standard C 335

at a mean temperature of 75°F.

History: CR 08-043: cr. Register March 2009 No. 639, eff. 4-1-09; CR 15-041: renum. 322.44 to 322.44 (3), cr. (1), (2) Register December 2015 No. 720, eff. 1-1-16.

SPS 322.45 Air conditioner and heat pump efficiencies. (1) Heating and cooling equipment shall meet the minimum efficiency requirements in Table 322.45 when tested and rated in accordance with the applicable test procedure.

(2) The efficiency shall be verified through certification under an approved certification program or, if no certification program exists, the equipment efficiency ratings shall be supported by data furnished by the manufacturer.

(3) Where multiple rating conditions or performance requirements are provided, the equipment shall satisfy all efficiency requirements under this chapter.

(4) Where components, such as indoor or outdoor coils, from different manufacturers are used, calculations and supporting data shall be furnished by the designer that demonstrate that the combined efficiency of the specified components meets the requirements under this section.

**TABLE 322.45
UNITARY AIR CONDITIONERS AND CONDENSING UNITS AND UNITARY AND APPLIED HEAT PUMPS,
ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS**

Equipment Type	Minimum Efficiency	Minimum Efficiency	Test Procedure
Split system and single package air conditioner, air cooled	13.0 SEER		ARI 210/240
Space constrained product-air conditioner	12 SEER		ARI 210/240
Through-the-wall air conditioner, air cooled, split system	10.9 SEER (before Jan. 23, 2010) 12.0 SEER (as of Jan. 23, 2010)		ARI 210/240
Through-the-wall air conditioner, air cooled, single package	10.6 SEER (before Jan. 23, 2010) 12.0 SEER (as of Jan. 23, 2010)		ARI 210/240
Split system and single package air conditioner, water and evaporatively cooled	12.1 SEER		ARI 210/240
Split system and single package heat pump, air cooled	13.0 SEER	7.7 HSPF	ARI 210/240
Through-the-wall air conditioner and heat pump-split system	10.9 SEER (before Jan. 23, 2010) 12.0 SEER (as of Jan. 23, 2010)	7.1 HSPF (before Jan. 23, 2010) 7.4 HSPF (as of Jan. 23, 2010)	ARI 210/240
Through-the-wall air conditioners and heat pumps-single package	10.6 SEER (before Jan. 23, 2010) 12.0 SEER (as of Jan. 23, 2010)	7.0 HSPF (before Jan. 23, 2010) 7.4 HSPF (as of Jan. 23, 2010)	ARI 210/240
Space constrained products-heat pumps	12 SEER	7.4 HSPF	ARI 210/240
Water source, heating mode, 68°F entering water		4.2 COP	ARI/ASHRAE 13256-1
Groundwater source, heating mode, 50°F entering water		3.6 COP	ARI/ASHRAE 13256-1
Ground source, heating mode, 32°F entering water		3.1 COP	ARI/ASHRAE 13256-1

History: CR 08-043: cr. Register March 2009 No. 639, eff. 4-1-09; correction in (1) made under s. 13.92 (4) (b) 7., Stats., Register December 2011 No. 672.

SPS 322.46 Replacement furnace and boiler efficiencies. (1) A replacement furnace in existing construction may meet only the prevailing federal efficiency standard provided the duct distribution system is sealed and tested at 0.02 inches

water gage across the entire system, including the manufacturer's air handler enclosure, to have air leakage less than 10 percent of the furnace manufacturer's rated air flow across the blower at high speed.

Note: 0.02 inches water gage is equal to approximately 25 pascals.

(2) A replacement boiler in existing construction may meet only the prevailing federal standard provided there is no installed circulation pump larger than $\frac{1}{20}$ horsepower and no circulation pump runs continuously.

History: CR 08-043: cr. Register March 2009 No. 639, eff. 4-1-09.

SPS 322.47 Equipment requirements. (1) Mechanical ventilation outdoor air intakes and exhausts shall have automatic or gravity dampers that close when the ventilation system is not operating.

(2) Snow melt system controls. Snow- and ice-melting systems, supplied through energy service to the building, shall include automatic controls capable of shutting off the system when the pavement temperature is above 50°F, and no precipitation is falling and an automatic or manual control that will allow shutoff when the outdoor temperature is above 40°F.

History: CR 15-041: cr. Register December 2015 No. 720, eff. 1-1-16.

SPS 322.48 Indoor Pools. Indoor pools shall be provided with energy-conserving measures in accordance with all of the following:

(1) **POOL HEATERS.** All pool heaters shall be equipped with a readily accessible on-off switch to allow shutting off the heater without adjusting the thermostat setting. Pool heaters fired by natural gas shall not have continuously burning pilot lights.

(2) **TIME SWITCHES.** (a) Except where allowed in pars. (b) and (c), time switches that can automatically turn off and on heaters and pumps according to a preset schedule shall be installed on swimming pool heaters and pumps.

(b) Where public health standards require 24-hour pump operation, time switches are not required.

(c) Where pumps are required to operate solar- and waste-heat-recovery pool heating systems, time switches are not required.

History: CR 15-041: cr. Register December 2015 No. 720, eff. 1-1-16.

SPS 322.49 Lighting Equipment. A minimum of 50 percent of the lamps in permanently installed lighting fixtures shall be high-efficacy lamps.

History: CR 15-041: cr. Register December 2015 No. 720, eff. 1-1-16.

Subchapter VI — Simulated Performance Alternative

SPS 322.50 General. This subchapter establishes criteria for compliance using simulated energy performance analysis. The analysis shall include heating, cooling, and service water heating energy only.

History: CR 08-043: cr. Register March 2009 No. 639, eff. 4-1-09.

SPS 322.51 Performance-based compliance. Compliance based on simulated energy performance requires that a proposed dwelling be shown to have an annual energy cost that is less than or equal to the annual energy cost of the standard reference design.

History: CR 08-043: cr. Register March 2009 No. 639, eff. 4-1-09.

SPS 322.52 Documentation. (1) **COMPLIANCE SOFTWARE TOOLS.** Documentation verifying that the methods and accu-

racy of the compliance software tools conform to the provisions of this subchapter shall be provided to the inspector.

Note: REM/Rate is an acceptable software program for determining compliance with this section.

(2) **COMPLIANCE REPORT.** Compliance software tools shall generate a report that documents that the proposed design has annual energy costs less than or equal to the annual energy costs of the standard reference design. The compliance documentation shall include all of the following information:

(a) Address of the dwelling.

(b) 1. An inspection checklist documenting the building component characteristics of the proposed design as listed in Table 322.53-1.

2. The inspection checklist shall show the estimated annual energy cost for both the standard reference design and the proposed design.

(c) Name of individual completing the compliance report.

(d) Name and version of the compliance software tool.

(3) **ADDITIONAL DOCUMENTATION.** The inspector may require any of the following documents:

(a) Documentation of the building component characteristics of the standard reference design.

(b) A certification signed by the builder providing the building component characteristics of the proposed design as given in Table 322.53-1.

History: CR 08-043: cr. Register March 2009 No. 639, eff. 4-1-09; correction in (2) (b), (3) (b) made under s. 13.92 (4) (b) 7., Stats., Register December 2011 No. 672.

SPS 322.53 Calculation procedure. (1) **GENERAL.** Except as specifically allowed under this section, the standard reference design and proposed design shall be configured and analyzed using identical methods and techniques.

(2) **REFERENCE AND PROPOSED DESIGNS.** The standard reference design and proposed design shall be configured and analyzed as specified by Table 322.53-1. Table 322.53-1 shall include by reference all notes contained in Table 322.31-1.

(3) **CALCULATION SOFTWARE TOOLS.** Calculation procedures used to comply with this section shall be capable of calculating the annual energy consumption of all building elements that differ between the standard reference design and the proposed design and shall include the following capabilities:

(a) Computer generation of the standard reference design using only the input for the proposed design. The calculation procedure may not allow the user to directly modify the building component characteristics of the standard reference design.

(b) Calculation of whole-building sizing as a single zone for the heating and cooling equipment in the standard reference design residence in accordance with s. SPS 322.40 (3).

(c) Calculations that account for the effects of indoor and outdoor temperatures and part-load ratios on the performance of heating, ventilating and air conditioning equipment based on climate and equipment sizing.

(d) Printed code official inspection checklist listing each of the proposed design component characteristics from Table 322.53-1 determined by the analysis to provide compliance, along with their respective performance ratings.

TABLE 322.53-1
SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS

Building Component	Standard Reference Design	Proposed Design
Above-grade walls	Type: mass wall if proposed wall is mass; otherwise wood frame Gross area: same as proposed U-Factor: from Table 322.31-2 Solar absorptance = 0.75 Emittance = 0.90	As proposed As proposed As proposed As proposed As proposed
Basement and crawlspace walls	Type: same as proposed Gross area: same as proposed U-Factor: from Table 322.31-2 with insulation layer on interior side of walls	As proposed As proposed As proposed
Above-grade floors	Type: wood frame Gross area: same as proposed U-Factor: from Table 322.31-2	As proposed As proposed As proposed
Ceilings	Type: wood frame Gross area: same as proposed U-Factor: from Table 322.31-2	As proposed As proposed As proposed
Roofs	Type: composition shingle on wood sheathing Gross area: same as proposed Solar absorptance = 0.75 Emittance = 0.90	As proposed As proposed As proposed As proposed
Attics	Type: vented with aperture = 1 ft ² per 300 ft ² ceiling area	As proposed
Foundations	Type: same as proposed	As proposed
Doors	Area: 40 ft ² Orientation: North U-Factor: same as fenestration from Table 322.31-2	As proposed As proposed As proposed
Glazing ^a	Total area ^b = (a) The proposed glazing area; where the proposed glazing area is less than 18% of the conditioned floor area (b) 18% of the conditioned floor area; where the proposed glazing area is 18% or more of the conditioned floor area Orientation: equally distributed to four cardinal compass orientations U-Factor: from Table 322.31-2 SHGC = 0.40 Interior shade fraction: Summer (all hours when cooling is required) = 0.70 Winter (all hours when heating is required) = 0.85 External shading: none	As proposed As proposed As proposed As proposed Same as standard reference design ^c As proposed
Skylights	U-Factor: from Table 322.31-2	As proposed
Thermally isolated sunrooms	None	As proposed

TABLE 322.53–1 (Continued)
SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS

Building Component	Standard Reference Design	Proposed Design
Air exchange rate	Specific Leakage Area (SLA) ^d = 0.00036 assuming no energy recovery	For residences that are not tested, the same as the standard reference design; For residences without mechanical ventilation that are tested in accordance with ASHRAE 119, Section 5.1, the measured air exchange rate ^e but not less than 0.35 ACH; For residences with mechanical ventilation that are tested in accordance with ASHRAE 119, Section 5.1, the measured air exchange rate ^e combined with the mechanical ventilation rate ^f , which may not be less than 0.01 X CFA + 7.5 X (N br + 1) where: CFA = conditioned floor area N br = number of bedrooms
Mechanical ventilation	None, except where mechanical ventilation is specified by the proposed design, in which case: Annual vent fan energy use: kWh/yr = 0.03942 X CFA + 29.565 X (N br + 1) where: CFA = conditioned floor area N br = number of bedrooms	As proposed
Internal gains	IGain = 17,900 + 23.8 x CFA + 4,104 X N br (Btu/day per dwelling unit)	Same as standard reference design
Internal mass	An internal mass for furniture and contents of 8 pounds per square foot of floor area	Same as standard reference design, plus any additional mass specifically designed as a thermal storage element ^g but not integral to the building envelope or structure
Structural mass	For masonry floor slabs, 80% of floor area covered by R–2 carpet and pad, and 20% of floor directly exposed to room air; For masonry basement walls, as proposed, but with insulation required by Table 322.31–2 located on the interior side of the walls; For other walls, for ceilings, floors, and interior walls, wood frame construction	As proposed As proposed As proposed
Heating systems ^{h,i}	Fuel type: same as proposed design efficiencies: Electric: air–source heat pump with prevailing federal minimum efficiency; Nonelectric furnaces: natural gas furnace in accordance with Table 322.31–3; Nonelectric boilers: natural gas boiler in accordance with Table 322.31–3; Capacity: sized in accordance with section SPS 322.40 (3)	As proposed As proposed As proposed As proposed
Cooling systems ^{h,j}	Fuel type: electric Efficiency: in accordance with prevailing federal minimum standards Capacity: sized in accordance with section SPS 322.40 (3)	As proposed As proposed As proposed
Service Water Heating ^{h,k}	Fuel type: same as proposed design Efficiency: in accordance with prevailing federal minimum standards Use: gal/day = 30 + 10 X N br Tank temperature: 120°F	As proposed As proposed Same as standard reference Same as standard reference

TABLE 322.53–1 (Continued)
SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS

Building Component	Standard Reference Design	Proposed Design
Thermal distribution systems	A thermal distribution system efficiency (DSE) of 0.80 shall be applied to both the heating and cooling system efficiencies	Same as standard reference design, except as specified by Table 322.53–2
Thermostat	Type: manual, cooling temperature set point = 78°F; heating temperature set point = 68°F	Same as standard reference design

a Glazing shall be defined as sunlight–transmitting fenestration, including the area of sash, curbing or other framing elements, that enclose conditioned space. Glazing includes the area of sunlight–transmitting fenestration assemblies in walls bounding conditioned basements. For doors where the sunlight–transmitting opening is less than 50% of the door area, the glazing area is the sunlight transmitting opening area. For all other doors, the glazing area is the rough frame opening area for the door including the door and the frame.

b For residences with conditioned basements, R–2 and R–4 residences and townhouses, the following formula shall be used to determine glazing area: $AF = As \times FA \times F$ where:

1. AF = Total glazing area.
2. As = Standard reference design total glazing area.
3. FA = (Above–grade thermal boundary gross wall area)/(above–grade boundary wall area + 0.5 x below–grade boundary wall area).
4. F = (Above–grade thermal boundary wall area)/(above–grade thermal boundary wall area + common wall area) or 0.56, whichever is greater.

And where:

5. Thermal boundary wall is any wall that separates conditioned space from unconditioned space or ambient conditions.
6. Above–grade thermal boundary wall is any thermal boundary wall component not in contact with soil.
7. Below–grade boundary wall is any thermal boundary wall in soil contact.
8. Common wall area is the area of walls shared with an adjoining dwelling unit.

c For fenestrations facing within 15 degrees of true south that are directly coupled to thermal storage mass, the winter interior shade fraction may be increased to 0.95 in the proposed design.

d Where Leakage Area (L) is defined in accordance with Section 5.1 of ASHRAE 119 and where: $SLA = L/CFA$ where L and CFA are in the same units.

e Tested envelope leakage shall be determined and documented by an independent party approved by the code official. Hourly calculations as specified in the 2005 ASHRAE Handbook of Fundamentals, Chapter 27, page 27.21, Equation 40, Sherman–Grimsrud model, or the equivalent shall be used to determine the energy loads resulting from infiltration.

f The combined air exchange rate for infiltration and mechanical ventilation shall be determined in accordance with Equation 43 of 2005 ASHRAE Handbook of Fundamentals page 27.23 and the “Whole–house Ventilation” provisions of 2005 ASHRAE Handbook of Fundamentals, page 27.18 for intermittent mechanical ventilation.

g Thermal Storage Element means a component not part of the floors, walls or ceilings that is part of a passive solar system, and that provides thermal storage such as enclosed water columns, rock beds, or phase–change containers. A thermal storage element must be in the same room as fenestration that faces within 15 degrees of true south, or must be connected to a room with pipes or ducts that allow the element to be actively charged.

h For a proposed design with multiple heating, cooling or water heating systems using different fuel types, the applicable standard reference design system capacities and fuel types shall be weighted in accordance with their respective loads as calculated by accepted engineering practice for each equipment and fuel type present.

i For a proposed design without a proposed heating system, a heating system of 90% annual fuel utilization shall be assumed for both the standard reference design and proposed design. For electric heating systems, the prevailing federal minimum efficiency air–source heat pump shall be used for the standard reference design.

j For a proposed design home without a proposed cooling system, an electric air conditioner with the prevailing federal minimum efficiency shall be assumed for both the standard reference design and the proposed design.

k For a proposed design with a non–storage–type water heater, a 40–gallon storage–type water heater with the prevailing federal minimum energy factor for the same fuel as the predominant heating fuel type shall be assumed. For the case of a proposed design without a proposed water heater, a 40–gallon storage–type water heater with the prevailing federal minimum efficiency for the same fuel as the predominant heating fuel type shall be assumed for both the proposed design and standard reference design.

TABLE 322.53–2
DEFAULT DISTRIBUTION SYSTEM EFFICIENCIES FOR PROPOSED DESIGNS^a

Distribution System Configuration and Condition	Forced Air Systems	Hydronic Systems ^b
Distribution system components located in unconditioned space	0.80	0.95
Distribution systems entirely located in conditioned space ^c	0.88	1.00
Proposed “reduced leakage” with entire air distribution system located in the conditioned space ^d	0.96	—
Proposed “reduced leakage” air distribution system with components located in the unconditioned space	0.88	—
Ductless systems ^e	1.00	—

a Default values given by this table are for untested distribution systems, which must still meet minimum requirements for duct system insulation.

b Hydronic systems means those systems that distribute heating and cooling energy directly to individual spaces using liquids pumped through closed loop piping and that do not depend on ducted, forced air flows to maintain space temperatures.

c Entire system in conditioned space means that no component of the distribution system, including the air handler unit, is located outside of the conditioned space.

d Proposed “reduced leakage” means leakage to outdoors not greater than 3 cfm per 100 ft² of conditioned floor area and total leakage not greater than 9 cfm per 100 ft² of conditioned floor area at a pressure differential of 0.02 inches w.g. across the entire system, including the manufacturer’s air handler enclosure. Total leakage of not greater than 3 cfm per 100 ft² of conditioned floor area at a pressure difference of 0.02 inches w.g. across the entire system, including the manufacturer’s air handler enclosure, shall be deemed to meet this requirement without measurement of leakage to the outdoors. This performance shall be specified as required in the construction documents and confirmed through field–testing of installed systems as documented by an approved independent party.

e Ductless systems may have forced airflow across a coil but may not have any ducted airflows external to the manufacturer’s air handler enclosure.

History: CR 08–043; cr. Register March 2009 No. 639, eff. 4–1–09; correction in (2), (3) (b), (d), Table 322.53–1 made under s. 13.92 (4) (b) 7., Stats., Register December 2011 No. 672.



Chapter SPS 322

Introduction

This chapter of the UDC sets minimum standards for energy conservation for new one- and two-family dwellings. It sets requirements for insulation and moisture protection of the building envelope and capacity and efficiency requirements for heating, ventilating and air conditioning systems.

The standards attempt to satisfy the human comfort needs of proper temperature, air movement and humidity as well as economical and building-preserving construction and operation. To assist you in better understanding these standards, we've included the following energy basics section. Following that is the code section-by-section commentary.

Note that the effective date of the original energy conservation standards was December 1, 1978, differing from the June 1, 1980, effective date of the other chapters of the UDC.

Special electrically heated dwelling standards were removed by March 2008 Legislative action.

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The following information is offered as background material to the intent and proper application of the Ch. SPS 322 requirements.

Chapter SPS 322 requirements can be put into the four categories of heat loss control, moisture control, ventilation design, and heating equipment requirements with some overlap between the four.

I. Heat Loss

The heat loss control requirements of Ch. SPS 322 are meant to limit heat transfer. Heat transfer is the tendency of heat or energy to move from a warmer space to a cooler space until both spaces are the same temperature. Obviously, the greater the difference in temperatures, the greater will be the heat flow. There are three types of heat transfer:

- Radiation - transfer of heat through space. An example is your body heat radiating out a closed window on a winter night. The glass is cold so there is no radiation to you and it is a poor reflector of your own heat back to you. Another example is sunshine coming in through a window.

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- Conduction - transfer of heat through a material. An example is your warm hand held against the inside surface of a cold exterior wall. You will note that the code has a lower allowable R-value for what are called mass walls, versus frame walls. This reflects that capacity for such walls to maintain a certain temperature relatively longer because of its heat capacity.
- Convection - transfer of heat by moving masses of air. An example is heated air leaking out through door and window openings.

The code does not say much about radiative heat losses. It does say a lot about conductive and convective heat losses. Let's discuss these further.

A. Heat Loss By Conduction

1. C-Values and k-Values

A measure of a material's ability to Conduct heat is its "C"-value which is expressed in BTUs per (hour)(°F). A BTU is a British Thermal Unit which is the heat required to raise one pound (about a pint) of water by one degree Fahrenheit and is roughly equal to the heat given off by the burning of one kitchen match. A human body gives off about 400 BTUs per hour. Since a C-value is a flow rate of heat, it needs a per time unit similar to other rate measures such as speed, "55 miles per hour." An hourly rate is also used in the C-value. Finally, as you recall, heat flow is greater as the temperature difference increases. So the C-value needs to be expressed in terms of what the difference is. For simplicity, it is taken at 1 degree Fahrenheit difference.

Another term to be familiar with is a "k"-value which is merely the C-value for one inch of material.

Typically, building components such as walls or ceilings consist of a "series" or layers of different materials as you follow the heat flow path out. However, you cannot add C-values together because if you were to take two insulating materials with a C-value of .5 each and were to add them together, you get the result of a total C-value of 1.0. This would mean that the heat flow rate has increased with the addition of more insulating material. Obviously then you cannot add C-values to find the "series" value.

2. R-Values

Therefore, we now have to bring in the perhaps more familiar "R"-value which is a measure of a material's Resistance to heat flow and is the inverse or reciprocal of the material's C-value ($R=1/C$).

So if a material has a C-value of 0.5, it has an R-value of 2 (as $2 = 1/0.5$). If you have to add two materials in series or layers, say each with a C-value of 0.5, you take the inverse of both to get an R-value for each of 2. These can be added together to get a total R-value of 4. Usually materials are labeled or tables are

written so that the material's R-value is given [see SPS 322.20(5)(a)], which relieves you of finding the inverse of the material's C-value.

3. U-Values

For thermal heat loss calculations, we normally use "U"-values (U for Unrestrained heat flow or transmittance) which is a material's C-value but also includes the insulating effect of the air films on either side of the material. So it is, therefore, a smaller number (less heat flow).

A U-value can also refer to thermal transmittance of a series of materials in layers. To obtain a U-value for such an assembly, you add the individual R-values of the layers and the air films on either side of the assembly. Then you take the reciprocal of the total R-value to get the total U-value of the assembly ($U = 1/R$). (As with C-values discussed above, you can not add U-values for series calculations.)

4. Heat Loss Calculations

The purpose of these C-, k-, R- and U-values is to be able to calculate heat loss through a building component (wall, ceiling, floor). The basic equation is $U \times A \times TD = \text{Heat Loss}$ or

$$U \times \text{Area (ft}^2\text{)} \times \text{Temperature Difference (}^\circ\text{F)} = \text{Conduction Heat Loss (BTU/hr)}$$

So to find the heat loss per hour through a building section of wall, you:

- determine its U-value by finding the inverse of the sum of individual R-values for each layer of material;
- decide on the inside and outside temperatures (in the case of the UDC, the winter design temperatures are mandated – see SPS 322.40(c) and the UDC Appendix A 323.02(1));
- measure the surface area of the building section;
- multiply these numbers together and get a result in BTUs per hour.

If you did this for every different building section (solid wall, window, ceiling, etc.), you could obtain the total heat loss through the envelope at design temperatures, which is the worst case situation. Normally this maximum figure along with the heat loss by infiltration (see discussion later) is used to size the furnace or other heating source. It is referred to as the heating load.

If you wanted to know the total envelope loss for a heating season, you do a degree-day calculation. A degree-day is the difference between 65°F and the average temperature for a day if it was below 65°F. If this calculation is done for

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each day of the heating season, you can find the total heating degree-days for the year. This can be plugged into a modified version of the heat loss calculation as follows:

$$U \times \text{Surface Area} \times \text{Degree-days} \times 24 \text{ hours/day} = \text{Season Heat Loss}$$

5. U-Overall

One more term to know is U-overall or U_o which refers to the overall U-value of a building component such as a wall or ceiling. For example, a wall will have different individual U-values for the windows, stud cavities and stud locations. The UDC sets a minimum U_o for each overall component surface. If a designer has a large window area, more insulation will need to be placed in the wall cavities or sheathing areas so that the overall or "average" wall surface U-value is acceptable.

The U-overall value is calculated by taking the weighted average of the U-values (not R-values) of the different parallel paths through the same component (wall, ceiling or other) that you're dealing with.

6. System Design

As an alternative, the system design method can be used so that more insulation is put in the ceiling to make up for the extra windows. However, it is not a one-for-one tradeoff because of the thermal transfer properties and mathematics of reciprocals involved. Let's say you have an R-10 ($U = 0.1$) wall and R-10 ($U = 0.1$) ceiling of equal area. If you transfer half of the wall insulation, to the ceiling, the wall becomes R-5 ($U = 0.2$) and the ceiling becomes R-15 ($U = 0.07$).

However, you can see that the wall U-value increased by 0.1 and the ceiling U-value only decreased by 0.03. (Remember U-values are used to calculate heat losses.)

B. Heat Loss By Convection

As mentioned, the other mechanism of heat loss addressed by the UDC is convection, or heat loss by air movement. In homes, this is principally heat loss by exfiltration and infiltration. Exfiltration is the loss of heated air through building cracks and other openings. Infiltration is the introduction of outside cold air into the building. This air movement also causes discomfort (drafts) to occupants in addition to the heat loss itself.

The driving force for this exchange of air is the difference between indoor and outdoor air pressures. Air pressure differences are principally caused by wind pressures and the "stack" effect of warm inside air that tends to rise. Mechanically induced air pressure differences can also occur due to such things as exhaust fans and furnace venting.

To calculate the heat loss by convection, we go back to the general heat loss calculation and modify it to:

$$\text{Heat Loss} = \text{Air's Heat Capacity} \times \frac{\text{Air Volume Exchanged}}{\text{Hour}} \times \text{Temp. Difference}$$

The volume exchanged can be determined by measuring or judging how many air changes that a house goes through in an hour. To do this, you calculate the volume of the heated space and multiply by an air change rate. For a UDC home, you can assume a rate between 0.2 and 0.5 air changes per hour [see SPS 322.30(2)], usually with a lower rate for basements with little outside air exposure, and higher rates for living areas or exposed basements. If you have a 1500 square foot house on a crawl space with 8-foot ceilings, the calculation of the volume exchanged can be:

$$1500 \text{ sq. ft.} \times 8 \text{ ft.} \times 0.5 \text{ Air Changes/hr} = 6,000 \text{ cu. ft./hr}$$

The heat capacity of air is a physical constant and is 0.018 BTU per (°F)(cu. ft.). The temperature difference, which varies by site location, used is the same as for heat loss by conduction. So the whole equation for this example is:

$$\frac{0.018 \text{ BTU}}{(\text{°F})(\text{cu. ft.})} \times 6,000 \text{ cu. ft./hr.} \times 90^{\circ} = 9,720 \text{ BTUs/hr}$$

This figure is the design or maximum heat loss by convection. If you wanted to figure the total seasonal infiltration heat loss, you would perform a degree day calculation as for the seasonal conduction heat loss calculation. You substitute the seasonal degree days and the 24-hour multiplier for the temperature difference figure in the infiltration heat loss equation above.

Another method of determining heat loss by convection is the crack method. For this method you obtain the air leakage rates in cubic feet per minute for the doors and windows from their manufacturers and multiply by the lineal feet of sash crack or square feet of door area. (A more exact analysis would multiply the door infiltration rates by 1 or 2 due to open/close cycles and add 0.07 cfm per lineal feet of foundation sill crack.) This gives an air change rate per minute. This has to be converted to an hourly rate by multiplying by 60. Then you substitute this figure for the air change rate in the infiltration heat loss equation above.

C. Total Dwelling Heat Loss

If you add the heat losses by conduction and convection, you arrive at the total dwelling heat loss for purposes of the UDC. Of course this figure is approximate and ignores other means of heat loss. However, it also ignores the major heat gain from secondary sources such as electric lights, human bodies, cooking, etc. So the figure tends to overstate the heat loss but this ensures an adequately sized heating plant.

II. Moisture Control

The second area of concern addressed by the UDC is control of moisture. The occupancy of a dwelling produces a large amount of water vapor. As you may recall from weather

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forecasts, warmer air can hold more moisture than cold air. In the winter, the inside air is warmer than the outside, so if moisture moving outside by convection or dispersion (similar to conduction) reaches too cold of air, it will "condense out." This occurs at the dew point for that water vapor/air mixture. This condensation can be damaging to the building if it happens inside part of the wall or ceiling construction. It can promote structural member decay and lessening of the insulation's effective R-value.

There are three methods of reducing the possibility of condensation--vapor retarders and cold-side venting.

A. Vapor Retarders and Air Barriers

A vapor retarder (sometimes called a vapor barrier) acts to resist the movement of moisture through a section of the building envelope by water vapor diffusion and bulk movement of moist air. A vapor retarder's efficiency at reducing moisture movement by water vapor diffusion is measured by its permeability in "perms." A perm is one grain of water per (hour) (square foot) (inch of mercury vapor). The lower the number, the more resistant is the material to moisture flowing through it.

The required continuity of the vapor retarder over the warm-in-Winter surface provides the required barrier to bulk movement of moist air through the assembly. This means the retarder also needs to be continuous with seams and holes lapped or sealed. This bypass effect can be much greater than the movement of water vapor by diffusion. Note that the code also requires sealing of the building envelope against air infiltration from the exterior – typically the vapor retarder will satisfy the requirement for this "air barrier".

Vapor condenses when it comes in contact with material that is at a temperature lower than its dew point. This temperature typically occurs within the wall cavity and thus would condense out water vapor before it can escape from the dwelling. This moisture can cause decay of building materials and a reduction in insulating value.

Additional areas where condensation occurs are generally at corners of rooms at the exterior walls. This area is subject to condensation for a number of reasons. The temperature at the corners is generally cooler due to the fact that it is difficult to insulate at this location due to the method of construction. The insulation may be further reduced due to the roof system allowing less insulation to be placed above the corner. Condensation also occurs in areas with poor air circulation such as closets.

B. Cold-Side Venting

The other means of controlling moisture is cold-side venting. This is usually employed in attics and unheated crawlspaces. The venting removes excess moisture that bypassed the ceiling vapor retarders or comes out of the earth in the crawl space. This venting is usually done by natural means through the use of grills or louvers from the space to the outside. However, for that to work, there must be high and low venting in the case of the attic or cross ventilation in the case of the crawl space.

Cold-side attic venting also keeps the roof cooler so that there is less melting of snow and contributes to less creation of ice dams at the eaves in the winter. It also helps dissipate summertime attic heat, which increases comfort and reduces cooling costs.

C. Impervious Insulations

Thus use of closed-cell foam plastic insulation or similar non-absorbent insulating materials that are unaffected by moisture condensation is another effective method used for some designs of dwellings to deal with this issue.

D. Moisture Control During Construction

Unless proper construction techniques are utilized during construction, serious problems can occur as a result of water vapor that is trapped inside and then causes deterioration of gypsum wallboard.

Over the years we have seen many improvements in both materials and methods in home construction. Often times the use of a new material required the change in a technique or method of construction previously unheard of. Most building codes are only a reflection of our latest achievements in technology and engineering. The vapor retarder requirements in the Uniform Dwelling Code are a reflection of state of the art insulation techniques. Simply stated, the purpose of the vapor retarder is to prevent (as much as possible) water vapor from penetrating into the insulation and thereby reducing the effectiveness of the insulation. The problem is that builders who are not familiar with the use of vapor retarders, particularly during winter construction months, can inadvertently create problems for the homeowner if precautionary measures are not taken during construction. We offer the following suggestions to incorporate in construction procedures, especially during winter months:

1. Do not allow gypsum board to pick up excess moisture prior to installation.
2. Make sure attics are insulated prior to putting heat into the home for gypsum board taping and finishing. Many builders neglect to do this and create condensation problems when the water vapor condenses upon hitting the cold, attic air above the gypsum board. Gypsum board ceilings should be hung and insulated prior to putting heat into the home.
3. Make sure all heating appliances, i.e., furnaces, temporary heaters, salamanders, etc., are vented to the outside of the home. Builders who do not follow this warning are adding additional water vapor created by combustion of heating fuels.
4. Make sure all required attic ventilation is installed and operable to remove any water vapor trapped in the attic.
5. Provide a means for the water vapor in the home to escape; such as periodic opening of windows, doors, etc. Perhaps the installation of a humidistatically controlled exhaust fan is necessary, particularly where electric baseboard heat or heat pump systems are utilized.
6. Do not overload gypsum board ceilings with insulation beyond their capacity. See s. SPS 321.02 (1)(a) of this commentary.

Some Energy Basics

Incorporation of these techniques will avoid major problems with condensation. These methods are not new and have been proven successful by many hundreds of builders operating in climates such as ours.

E. Post-Construction" Moisture Control Problems

As discussed in the basics section of this commentary chapter, moisture must be dealt with in all homes. The following is a general discussion of typical symptoms, causes and prevention techniques regarding moisture problems in homes. It is intended as background information to help explain some UDC requirements. Additional recommendations above and beyond the UDC minimums are included for homeowners who may experience more severe moisture problems.

1. How can you determine if a home has a moisture problem?

You can get a good idea of whether your home has an excess moisture problem that may lead to damage by checking for the following symptoms.

- Extensive condensation on windows during the heating season. Some condensation is normal. Condensation that streams off the window and puddles on the frame and sill when outside temperatures are 10°F or above and inside temperatures are above 65°F indicates humidity levels are probably too high.
 - If condensation is limited to the inside surface of storm windows, then your primary windows may be allowing moist interior air to leak by them. Because of the "stack" pressure effect, this problem may be worse on second floor windows.
 - If condensation is limited to the inside surface of the primary windows, then your storm windows may be allowing cold air to leak by them which then cools the primary window.
- Staining and mold on window frames.
- Mold or water spots in numerous locations on the inside surface of outside walls. Common trouble spots include closets on outside walls; corners between two outside walls or between an outside wall and ceiling; and outside walls behind furniture; or other areas where air circulation is limited.
- Soft or buckling interior wall surfaces. Gypsum board is a common interior surface. When dampened it may pull away from studs or ceiling rafters. Additional moisture may cause the gypsum board to crumble.
- Staining or warping of exterior siding.
- Paint peeling from exterior siding, especially extensive peeling of paint down to the primer.

If you have not experienced any of these symptoms, the home probably does not have a moisture problem. However, it may be a good idea to consider some of the measures in the following Section III to assure that future problems do not develop.

2. What are typical causes of moisture problems in homes?

Through breathing and normal daily activities, each member of a household produces about seven pounds of water vapor. Naturally this number varies greatly depending on living habits. This water vapor becomes part of the air. However, air can hold only a limited amount of water vapor. This amount depends on temperature. The higher the temperature the more moisture the air can hold. When more moisture is introduced into the air than it can hold, some of the moisture will condense on surfaces. If cold surfaces sufficiently cool the surrounding air, condensation will occur on that surface even though the remaining room air is not saturated with moisture. The frosted cold beverage glass in summer is an example.

In most older homes there is enough movement of air into and out of the house that moisture does not build up and only small amounts of condensation occurs. However, when air leaks into and out of a house it not only takes moisture but heat as well. In order to make homes more energy efficient, builders have been trying to seal cracks and cut air leaks.

These efforts to tighten homes have meant that more moisture remains in the home. Unless controlled ventilation is added, moisture accumulates, and condensation occurs near the ceiling on outside walls or on outside walls of closets. These areas generally have cooler surfaces. If condensation persists on these surfaces, molds and mildews may develop. In addition, fungal growth and possible deterioration of material may occur when temperatures are at or above 50°F and the material remains wet. Such fungal growth could damage wood members in extreme circumstances.

3. Besides the UDC requirements, what measures can help prevent moisture problems?

- Reduce Moisture Production In The Home
 - One way to substantially reduce the chances that condensation will occur either on inside surfaces or within walls is to keep indoor moisture levels low. The first step is to reduce the amount of moisture produced in the home. Some major sources of moisture that can be controlled are listed below.
 - Prevent moisture from entering through basements. Many basements feel damp in the summer due to condensation of moisture from the air on cool basement surfaces. However, in some cases damp basements may be due to ground moisture entering the home through basement walls. Cracks or stains on basement walls and floors are signs of dampness entering through these surfaces.
 - You can check whether dampness is coming through walls by using a simple patch test. Tape a piece of plastic sheeting tightly against the basement wall where you suspect moisture penetration. After a couple of days pull the patch off and look for signs of moisture on the wall side of the patch. If you detect moisture, it means moisture is coming through the wall rather than condensing on the walls.
 - If you suspect a basement water problem, check the surface drainage around you home. Most basement water problems result from poor surface drainage. Make sure that the ground slopes away from the foundation. Consider installing gutters. If you have gutters, make sure they are clear of debris and functioning properly. Downspouts should direct water away from the foundation.

Some Energy Basics

- Do not store large amounts of firewood in the basement. Even seasoned wood can contain large amounts of moisture. It also may be a source for fungus.
 - Other ways you can reduce moisture generation:
 - Vent clothes dryers outdoors;
 - Don't line dry clothes indoors;
 - Limit the number of houseplants;
 - Cover kettles when cooking;
 - Limit the length of showers; and
 - Do not operate a humidifier in the wintertime unless your indoor relative humidity is below 25 percent.
 - Be sure any crawlspace floors have a vapor retarder covering.
 - If problems persist, you should also check for any blocked chimney flues that may be preventing moisture-laden flue gasses from exhausting out of the house.
 - Correct any plumbing and roof leaks. If ice dams are a problem, consider more attic ventilation and adding insulation.
- Add Mechanical Ventilation
 - A second way to reduce moisture levels is to add mechanical supply and exhaust ventilation. As an added benefit, ventilation will reduce concentrations of other possible air contaminants such as combustion by-products from heating, cooking and smoking.
 - A widely recommended ventilation rate for homes is one half air change per hour. In a 1,200-square-foot house with 8-foot high ceilings, there are about 9,600 cubic feet of air. To meet the ventilation standard, half of that amount or 4,800 cubic feet of air must be exchanged every hour. This roughly equals 100 cubic feet per minute (cfm) of air exchange. Even in a tight house some of this air exchange occurs naturally. A constantly running or humidstat-controlled bathroom fan would typically ensure adequate ventilation.
 - However, in a house that is experiencing severe moisture problems, it can be assumed you are getting less than one half air change per hour. A balanced ventilation system should be used to make up the remaining necessary air exchange. A balanced system is one that not only exhausts stale air but provides a source of fresh replacement air. Currently the UDC per SPS 323.02(3)(b)2. only mandates that 40% of exhaust ventilation be made up through another means. Without proper replacement air the home could have what is known as negative air pressure.
 - Negative pressure could cause exhaust gases from your furnace or water heater, which should be going up your chimney or out a vent, to be sucked into the living space.
 - Additional ventilation is needed only during the heating season. When you provide controlled ventilation for your home, the heat lost is relatively small. For a 1,200-square-foot home, the cost of this lost energy and the electricity to run the fan would amount to about a dollar a day assuming you heat with the most expensive heat source, electric baseboard. This cost should be much less if you heat with gas or other fuels. Also, some ventilation systems can reclaim a portion

of the heat (up to 80%) from the exhaust air by heat-recovery ventilators. This could help reduce energy costs.

- Stop Moisture At The Inside Wall Surface (In Addition To The Required Moisture Vapor Retarder)
 - In addition to reducing moisture levels of the interior air, carefully seal all openings in the inside surface of all exterior walls to prevent moist air penetration. This includes joints around window and door casings, baseboards, electrical outlets and switches and any other penetrations. Gaskets for electrical penetrations are now commonly available, be sure that they extend to the outside edge of the cover plate of electrical devices.

Relative Humidity

In winter, the ideal relative humidity range for comfort is 30 percent - 45 percent. A lower humidity may cause excessive skin evaporation which in turn will cause an undesired cooling effect. For the sake of protecting the structure from damage due to excessive moisture, an ideal relative humidity range of less than 45 percent is recommended. Therefore, to provide comfort and still protect the building, a relative humidity range between 30 percent to 45 percent is recommended.

In summer, the ideal comfort range is 30 percent to 50 percent. Higher humidity won't allow adequate skin evaporation and the resulting desired cooling effect.

III. Mechanical Ventilation

As the code has mandated tighter home construction, the UDC has had to provide increase of mechanical ventilation as an alternative to infiltration to maintain indoor air quality so excessive humidity or other pollutant levels are checked. This has taken the form of required exhaust ventilation for rooms with a toilet, tub or shower and for kitchen exhaust.

A designer may decide to use an air-to-air heat exchanger to satisfy the exhaust requirement, while at the same time recovering heat from the exhausted air. This is done by moving the exhausted air past the intake air with a heat exchanging barrier between the two air streams.

IV. Equipment Efficiency Requirements

The final area that Ch. SPS 322 regulates is heating and cooling equipment efficiencies.

Subchapter I — Scope and Application

322.01(3) Scope

Dwellings that use renewable sources of energy, such as wood or solar, for heat generation, including for what is used by any heat pumps, are exempt from the building envelope insulation requirements. Non-renewable sources of energy may be used to distribute heat by fans or pumps without affecting the dwelling exemption. Although homes that are heated with renewable sources of fuel, such as wood, are exempt from the insulation requirements, they are still subject

322.02(2)

to the moisture control requirements for vapor retarders and ventilation. These are needed to protect framing and keep insulation dry and protected from degradation.

322.02(2) Declaration of Method of Compliance

As there are more than one method, submitters of plans & calculations should clearly communicate which method of compliance is being provided for the dwelling.

Subchapter III — Materials and Equipment.

322.20(4) Material Installation

This section requires all insulation, mechanical equipment and systems to be installed per the manufacturer's installation instructions which are to be available at job sites during inspection.

322.20(6) Building Certification

This section requires that a permanent certificate of insulation R-values and fenestration U-factors be provided on or immediately adjacent to the electrical distribution panel. If REScheck or REM/Rate software program was used, that certificate print-out shall be provided. Otherwise, a copy of the following form may be used.

2016 Wisconsin/2009 IECC Energy Efficiency Certificate

(Post on or immediately adjacent to electrical distribution panel per SPS 322.20(6))

Insulation Rating **R-Value**
 Ceiling/roof _____
 Wall _____
 Floor/Foundation _____
 Ductwork (unconditioned spaces) _____
 Beneath Heated Slab _____
 Perimeter of Heated Slab _____

Glass & Door Rating **U-Factor**
 Window _____
 Skylight _____
 Door _____

Name _____ Date _____

Comments _____

These Efficiency and Compliance Certificates may be used in lieu of the REScheck Certificates



2016 Wisconsin/2009 IECC UDC Compliance Certificate (Submit with building plans)

Owner/Agent _____ Location _____

Heating Appliance Type & Efficiency _____ Insulation Zone (SPS 322.31(1)(b)) _____

Building Component	Code Min. Insulation Value (Table 322.31-1)		Code Min. Insulation Value For Lower Efficiency Appliances ¹ (Table 322.31-3)		Enter Actual Insulation Value & if Cavity or Continuous
	Zone 1	Zone 2	Zone 1	Zone 2	
Fenestration (U-Value)					
Window	0.35	0.35	0.30	0.30	
Door	0.35	0.35	0.30	0.30	
Skylight (U-Value)	0.60	0.60	0.60	0.60	
Ceiling					
Energy Heel					
Flat	R-38	R-38	R-38	R-38	
Flat	R-49	R-49	R-49	R-49	
Wood Framed Wall	R-20 or R-13 cav + R-5 cont	R-21 cav	R-21 cav or R-19 cav + R-5 cont	R-21 cav or R-19 cav + R-5 cont	
Mass Wall	R-15/19	R-19/21	R-19	R-19	
Floor	R-30	R-38	R-30	R-30	
Basement	R-15 cav or R-19 cont	R-15 cav or R-19 cont	R-15 cav/ R-19 cont	R-15 cav or R-20 cont	
Crawl Space	R-10 cav or R-13 cont	R-10 cav or R-13 cont	R-15 cav/ R-19 cont	R-15 cav or R-20 cont	
Heated Slab	R-10 / R-15	R-10 / R-15	R-10 / R-20	R-10 / R-20	
Unheated Slab	R-10	R-10	R-15	R-15	

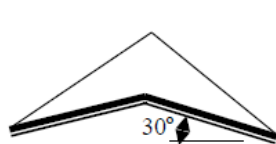
1. Includes less than 90% efficient natural gas and propane furnaces and hot water boilers, less than 83% efficient oil-fired furnaces and less than 84% oil-fired hot water heater boilers. (See Table 322.31-3)

322.21(1)&(2) Protection of Insulation

This section requires blanket insulation to be held in place by a covering or mechanical fastening. SPS 322.21(2) requires cold-in-Winter side windwash protection of air-permeable insulation, thus also keeping insulation in place and maintaining the R-value of that insulation. Normally the exterior sheathing would do this, but where that is not present, some other vapor-permeable material, such as housewrap would be required.

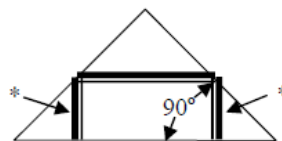
Question: If I have a sloped ceiling that is not a cathedral ceiling, such as that created by scissor trusses, that is insulated with an air-permeable insulation material, e.g. fiberglass or cellulose, do I need the wind wash protection required by this section?

Answer: No, if the ceiling is sloped less than 60 degrees from the horizontal and it is not a cathedral ceiling, wind wash protection is not required. A cathedral ceiling is a sloped ceiling, with closely-spaced, parallel ceiling and roof finishes. It is the intent of SPS 322.21(2)(a) to require the wind wash protection for walls or exposed vertical ends of air-permeable insulation at the perimeter of floor systems, open to attic space or other unconditioned space. The intent of incorporating the phrase “in a position other than horizontal” into this section is intended to exclude insulated ceilings, other than cathedral ceilings from the wind wash protection requirement. If that is the intent of that section, what is a wall? In model building codes and in Rescheck is the following guidance:



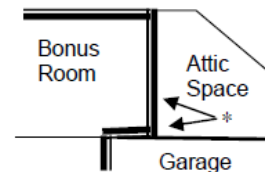
Bottom Chord Less Than 60° to Horizontal - Ceiling

* Wind Wash Protection Above Insulation Not Required.



Building Segment More Than 60° to Horizontal - Wall.

* Wind Wash Protection on Cold-in-Winter Side Required.



Building Segment More Than 60° to Horizontal - Wall.

* Wind Wash Protection on Cold-in-Winter Side Required, Including the End of the Floor Insulation.

In summary, a wall is defined as a building element that is sloped 60 degrees or more to the horizontal. Wind wash protection is not required for ceilings that are horizontal or tilted at less than 60 degrees to the horizontal.

Subchapter IV — Dwelling Thermal Envelope

322.31 Envelope Compliance

Envelope compliance may be by prescriptive method of SPS 322.31(1) by either complying with Table 322.31-1 or Table 322.31-4 or alternatively, per SPS 322.31(2) by showing the overall

envelope U-value multiplied by Area complies. The latter method may be done by hand calculation or more typically by the use of the free software program, Rescheck, available from the federal government at www.energycodes.gov. Rescheck version 4.3.0 or greater offers the required code of 2009 IECC. (Do **not** select "2009 Wisconsin".) Note that after selecting the 2009 IECC code, the previously available Loads tab in which to calculate your heating plant size will not be available. See SPS 323.02 of this commentary for methods of obtaining the heating load. See the last page of this chapter for an example of a Rescheck Compliance Report.

Note that if the permit applicant elects to install a heating appliance with efficiency lower than required by Table 322.31-3 and is therefore subject to the thermal envelope requirements of Table 322.31-4, Rescheck is **not** an acceptable method of showing code compliance.

The Rescheck program produces an inspection report based on the unamended 2009 IECC for use by builders and inspectors. Note that the following items in that report need to be modified per the amended Wisconsin adoption of the 2009 IECC:

- Duct tightness testing is only required per SPS 322.43 if any portion of the distribution system is outside the conditioned space.
- Thermostats are required per SPS 322.41 for all heating and cooling systems, but are not required to be programmable.
- The protective covering for exterior foundation insulation is only required to be installed 2" below grade per SPS 322.21(3).
- All ducts located outside conditioned spaces shall be insulated to R-8 per SPS 322.42.
- Only ducts located outside the conditioned space shall be sealed per SPS 322.43.

Finally, compliance may be shown per SPS 322.51 by calculations or software that models the whole house energy usage. Remrate is a type of acceptable software for that purpose if its version is 14.6.2.1 or greater. Contact the Wisconsin Focus on Energy program for more information.

With any of the envelope compliance methods, any authorized party to the design or construction process may complete the necessary calculations or form completion.

322.32 (1) Ceilings With Attic Spaces.

This section permits the use of R-38 in the attic space in lieu of R-49 specified in Table 321.23-1 as long as the R-38 insulation covers the entire attic area including over the exterior wall top plates. This could be accomplished with the use of "energy heel" trusses. The height of the heel would depend on the type of insulation used to attain the R-38 insulation value.

322.33 Slab Floors

Shallow slabs less than 12" below grade must meet Table 322.31-1 or 322.31-4 for Unheated Slab R-value with perimeter insulation. Heated slabs of any depth with embedded, uninsulated heating ducts or pipes require slab insulation throughout, with additional insulation at the perimeter. Horizontal slab insulation that projects away from the building shall be protected by either pavement or a minimum of 10 inches of soil. See UDC Appendix drawings showing

acceptable and unacceptable perimeter insulation in terms of ensuring the edge of the slab is properly insulated.

322.32(6) Discontinuities in Foundation Wall Insulation

See SPS 322.33(3)(c) for an exception that allows discontinuity in foundation insulation where interrupted by an intersecting foundation wall.

322.34 Crawl Spaces

This section requires a vapor retarder on the floor of a crawl space. Per Table 332.37, it shall be a Class I vapor retarder, which is defined by the IBC as having a perm rating of 0.1 or less. Note that requirement to run the vapor retarder 6" up the foundation wall is applicable when there is no floor present to maintain the vapor retarder in place.

322.35 Sunroom vs Screen Porch

This option for reduced insulation levels is only available to heated sunrooms with opaque walls and glazing. It is not available to heated screen rooms with only screens for a portion of the walls. Note that the requirement for a separate heating zone is not satisfied by dampers on the supply ducts.

322.36 Fenestration

Fenestration is an architectural term for windows and doors. The UDC generally requires them to be certified under the NFRC 100 standard for the values used, which is easily verified in the inspection of the window label on each unit. Where windows are not labeled, the conservative, default table values must be used for determining compliance. The code allows a single door and a single window to be exempt from door and window requirements which permits the installation of elements such as stained-glass windows

Different types of window operating hardware will produce different U-values for similar-sized windows. Therefore, a 3'-0" x 3'-0" double hung window would have a different U-value from a 3'-0" x 3'-0" fixed window sash. Similar size windows produced by two different manufacturers would most likely also have different U-values. Averaging of U-values is by area-weighting per SPS 322.36(1).

322.37 Air Leakage

Air leakage at fenestration and at other penetrations in the envelope are to be sealed properly per SPS 322.37(3), (4) & (6)(b) requirements or pass a blower door test per (6)(a).

SPS 322.37(4) provides specific guidance on recessed lighting installed at envelope areas, without leading to overheating fires.

322.37 Air Infiltration Barrier

The UDC does not define materials to be used as an infiltration barrier. It does require them to:

1. Be installed on the interior face, typically as part of the vapor retarder, or on the exterior face of the wall, typically as a house wrap or caulked building panels.
2. Form a continuous barrier over the walls of the building from the bearing points of the roof to the top of the foundation.
3. Have all seams, joints, tears, and punctures sealed.

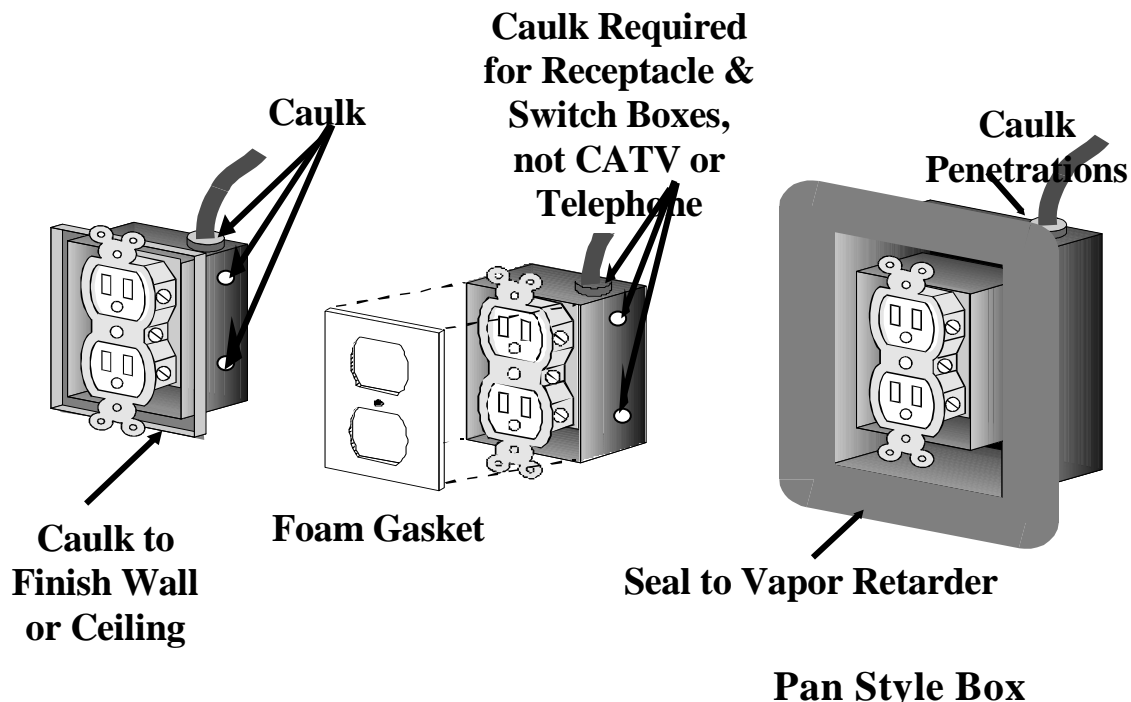
Additionally, the department has determined such infiltration barrier construction:

1. Be water vapor permeable to prevent moisture problems within the wall if installed on the cold side of the wall. The perm rating must be significantly higher than the interior vapor retarder. Alternatively, it is acceptable to have an exterior infiltration barrier that is vapor impermeable, but provides insulation to keep the dew point out of the wall.
2. Restrict infiltration to an appreciable extent.

These materials include:

- Spun bond polyolefin sheets, with taped joints.
- Micro-perforated polyethylene film sheets, with taped joints.
- Building panel sheets such as foam sheathing or plywood sheathing with taped joints, regardless if the panels have butt or tongue and groove edges

322.37(3)(b) Air Sealing of Electrical Switch and Receptacle Boxes



322.37(6)(b) Air Barrier & Insulation Inspection Component Criteria Table

322.38(1)

Note that some of the items on this list need to be verified at the insulation inspection and others at the final inspection. Also the Table has several additional requirements that are not applicable if the Blower Door Test option is chosen. To highlight several items the list:

- Corners and headers of walls are required to be insulated.
- The reference to a Class I vapor retarder on the floor of a crawl space means a vapor retarder with a perm rating of 0.1 or less.
- Non-IC rated recessed ceiling light fixtures may be used in insulated ceilings if installed per SPS 322.37(4)(c)2., since this is a more specific treatment of the topic than the Table.
- The requirement to place insulation in the building envelope to the exterior of plumbing piping is based on SPS 382.40(8)(a)1. that requires piping to be protected against freezing.
- Common walls of duplexes require an air barrier, and exterior wall insulation, only if the two units are separately owned and therefore may not necessarily both be heated.

322.38(1) Paint as a Vapor Retarder

Certain paints have been tested per ASTM E-96 to provide a vapor retarder with a perm of 1 or lower or labeled as Class II (Class I would also be acceptable) when applied at specified rates and coats for certain surfaces. Regardless of the type of vapor retarder used, per SPS 322.38(1)(b), it shall be continuous. So in the case of vapor retarder paint, any discontinuities in the surface being painted, must caulked, gasketed or otherwise sealed.

In order to assure building officials and owners that vapor retarder paint has in fact been installed and the intent of SPS 322.38 met, a certificate of compliance (see following sample certificate) may be filled out and submitted to the building official with a copy to the owner. In addition to the certificate, the contractor should provide the inspection agency with the labels from the paint cans that were used by the applicator.

The following is the recommended procedure to be followed by building inspection agencies to assure compliance with the vapor retarder requirement:

1. At the time of plan submittal, the builder should state or have shown on the plans what type of vapor retarder is to be used in the dwelling.
2. At the time the plan is approved, the inspector should provide a blank Certificate of Application if one will be locally required.
3. At the time the insulation/rough energy inspection is made, the inspector will be able to determine where the standard vapor retarder was applied in the dwelling.
4. At the final inspection, the contractor should supply to the building inspector the completed certificate as well as the labels from the paint cans.
5. The inspector may then destroy the labels and the Certificate of Application can be filed with the building file.

VAPOR RETARDER PAINT
CERTIFICATE OF APPLICATION

THIS CERTIFIES THAT A VAPOR RETARDER PAINT HAVING A PERM RATING
BELOW 1.0 WAS APPLIED TO THE FOLLOWING STRUCTURE:

PAINT MANUFACTURER: _____

SUPPLIER: _____

GALLONS USED: _____ LABELS SUBMITTED: YES NO

CEILINGS - TOTAL SQUARE FEET COVERED: _____

WALLS - TOTAL SQUARE FEET COVERED: _____

NUMBER OF GALLONS USED ON: 1st COAT _____ 2nd COAT _____

APPLICATION MADE BY NAME: _____

ADDRESS: _____

SIGNATURE: _____

322.38(1)(b)

322.38(1)(b) Vapor Retarder Continuity

Vapor retarder continuity is important for purposes of preventing bulk movement of warm, moist air into building assemblies, which is a more significant source of moisture than diffusion through the vapor retarder.

322.38(2)(a) Vapor Retarders Not on In-Winter Warm Side

Occasionally it occurs that a wall will have two materials or layers that may act as vapor retarders. It is important in this situation that the better vapor retarder (lower perm rating) be placed closer to the warm side. Also, extreme care should be taken to make the interior vapor retarder continuous with good joint and penetration sealing. This will help avoid condensation of moisture in the wall.

In some dwelling designs, double walls are constructed with insulation in both walls. Often this is to avoid making electrical box and other penetrations in the vapor retarder. A single vapor retarder is placed between the two walls. This conflicts with the requirements that vapor retarders be placed on the warm side of all insulation. However it may be acceptable depending on the distribution of the insulation between the two walls. If there is enough insulation on the exterior side of the vapor retarder, the air temperature in the insulation at the interior face of the vapor retarder may still be warm enough to prevent condensation.

A DEW POINT CALCULATION estimates expected temperatures throughout the thickness of the wall. Interior temperature, exterior temperature, and wall component R-values must be known. Additionally, a "design" interior air relative humidity must be assumed. Since typical wintertime reported indoor humidities range from 40 percent to 60 percent, the department will accept 50 percent as an average indoor relative humidity (RH) design value for such a calculation.

In order to do such a calculation, a person must have access to a psychrometric chart or table to determine dew points throughout the wall section given specific design temperatures, RH, and wall component R-values.

Example: Fictional Wall

R = 10, uniformly distributed across thickness of 4 inches

RH = 50% (interior)

Temp = 70°F interior and -10°F exterior

This would result in condensation if interior air was lowered in temperature or exposed to a surface temperature of approximately 50°F. In this wall, the 50°F dew point occurs at 1 inch from the interior surface. Therefore, a recessed vapor retarder must be to the inside of this 1-inch limit.

Detailed calculations shall be submitted for each specific project where a designer wishes to recess a vapor retarder into the wall cavity, other than as permitted by SPS 322.38(2)(c)4. for spray-applied foam insulation, that is relatively air impermeable. For air

permeable insulation such as fiberglass and cellulose, a rule of thumb is that no more than one-third of the insulation should be on the warm side of the vapor retarder.

322.38(2)(c)1. Exceptions to Vapor Retarder

If the exceptions in this section to a continuous vapor retarder at boxsills or over spray-applied foam are used, you are also required to stop air leakage at those locations that would have been otherwise provided by a continuous vapor retarder.

322.38(3) Omission of Taping of Vapor Retarder Joints Under Concrete Slabs

Similar to the exception in (1)(b) for taping of vapor retarder seams that are compressed between framing and finish materials, properly lapped seams that are under a poured floor are considered effectively sealed and will not require taping. Note that the negative impact from the small amount water vapor that may diffuse through any gaps into the dwelling is much less of a problem than gaps in wall and ceiling vapor retarders that allow bulk moisture laded-air from the interior into the building construction.

322.38(4) Vapor Retarders Prohibited on Concrete or Masonry Walls

The code prohibits installing a non-rigid vapor retarder of a 0.1 perm or less rating, such as roll polyethylene sheeting ("Visqueen"), on or in front of masonry or concrete below grade foundation walls. This is avoiding the potential for moisture from adjoining earth being trapped between an interior vapor retarder and the wall and possibly causing degradation and mold.

322.39 Attic Ventilation

Attic ventilation is generally required where air-permeable insulation is installed. This means that attic ventilation is not required above closed-cell foam insulation. Note that insulation shall not block the ventilation route, so attic vent chutes may be required at the eaves.

The code requirements of these sections for venting areas are based on effective venting area. Louvers and screening greatly decrease the effective venting of attic vents. Usually the effective venting area of a vent is indicated on it. Otherwise the following is a guide:

Obstruction in Ventilator (Louvers and Screens)	To Determine Total Free Area of Ventilator Multiply Gross Area by:
1/4 inch mesh hardware cloth	1
1/8 inch mesh screen	0.8
No. 16 mesh insect screen (with or without plain metal louvers)	0.5
Wood louvers and 1/4 inch mesh hardware cloth	0.5
Wood louvers and 1/8 inch mesh screen	0.44
Wood louvers and No. 16 mesh insect screen	0.33

Regarding turbine vents, the effective area is equal to the bottom opening area.

Regarding power vents, manufacturer's requirements should be followed. Otherwise an installed mechanical ventilation capacity of 0.25 cfm per square foot of attic floor area is acceptable.

Additionally, adequate air intakes must be provided. Control of the fan must be provided by a humidistat or combination humidistat/thermostat. A humidistat setting of 90 percent is acceptable.

322.39(4) Cathedral Ceiling Venting Exception

A cathedral ceiling is a sloped ceiling, with closely-spaced, parallel ceiling and roof finishes.

Subchapter V — Systems

322.40 Outdoor Design Temperatures

The design of heating equipment to satisfy the heating load is regulated by ss. SPS 323.02 and 323.03. Those sections refer to the UDC Appendix table for determining outdoor design temperatures. See the commentary for SPS for SPS 323.02 for methods of calculating heating load now that the more recent versions of Rescheck do not offer that option anymore.

322.42 Ducts in Unconditioned Spaces

Ducts located outside conditioned space, including those in attics, unheated garages, and vented crawl spaces and under slabs, shall be insulated to at least R-8. Per SPS 322.10(3), conditioned is defined as being heated to 50 degrees or more at design conditions. Burying the ducts in attic insulation that provides the minimum R-8 value is acceptable, except if the ducts are used for cooling purposes. Per (1m) of this section, cooling supply ducts require at least R-8 duct insulation with an exterior vapor retarder to reduce surface condensation. Note that any ducts outside the conditioned space, which per SPS 322.37 includes the required air barrier, would generally trigger duct sealing and testing of the complete duct system per SPS 322.44.

Also note SPS 323.08(3) that requires exterior ducts that are susceptible to damage to be metal.

Ducts in underslab locations may be insulated per either of the following methods:

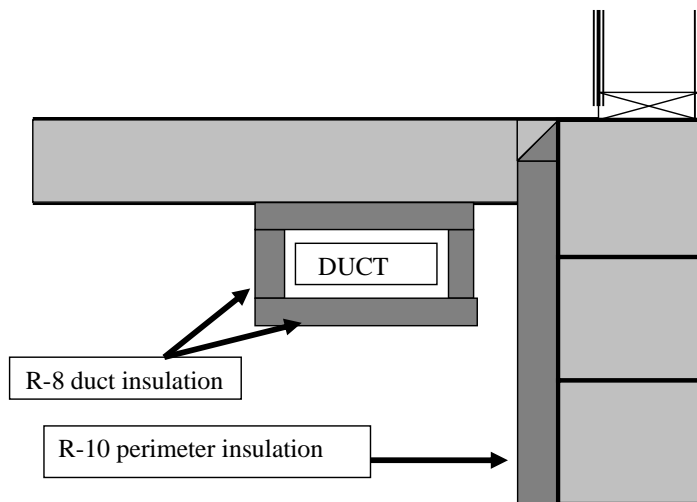


Fig. 1 - Acceptable design for insulated duct outside building thermal envelope of an unheated slab on grade design

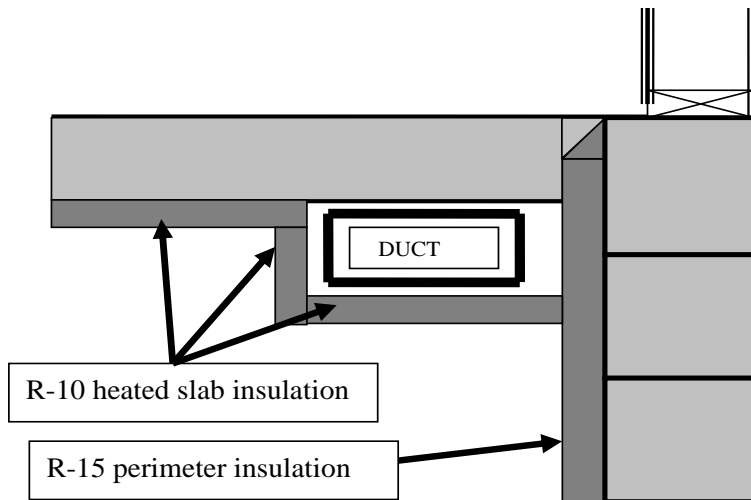


Fig. 2 - Acceptable design for heated slab-on-grade design as duct is within building thermal envelope

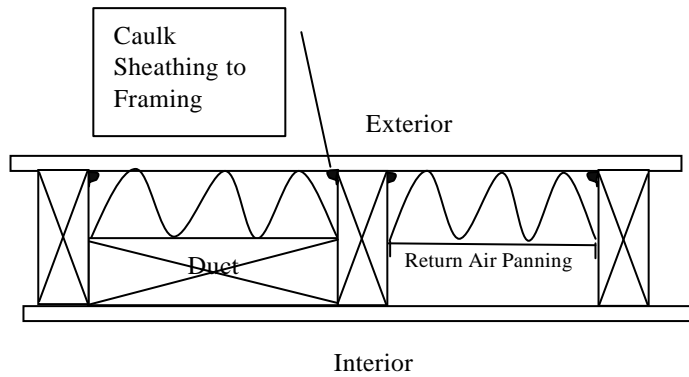
322.43 Duct Sealing and Testing

Any part of the supply and return duct system that is outside the conditioned space, including those in unconditioned attics, unheated garages, insulated floors, exterior stud spaces and vented crawl spaces and under slabs, shall be sealed per this section. Additionally, the whole duct system, including the air handler and both supply and return ducts, shall be tested for air tightness at either the rough-in or post-construction testing. Note that the post-construction test measures just the leakage to the outdoors, whereas the rough-in test measures the total system leakage, including leakage from the duct system to the conditioned space. The latter rough-in test would typically require that all of the ductwork of the dwelling be sealed in order to pass the test.

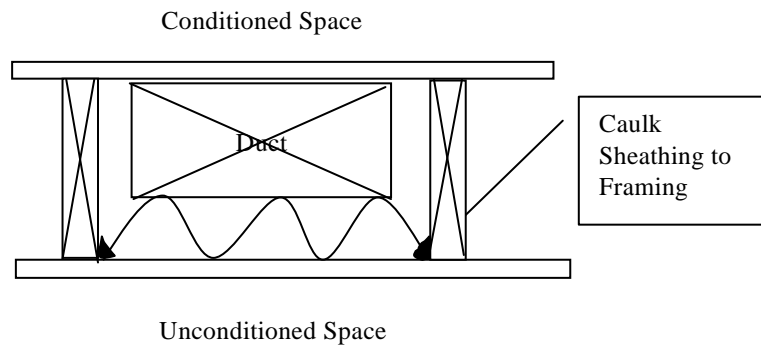
Duct tightness, especially relative to the outdoors, is important in that any air lost to the outdoors causes negative dwelling pressure as the result of the air handler drawing in outside air to replace the leaked duct air. Negative dwelling pressure potentially causes backdrafting of any open combustion appliances and infiltration of unconditioned air into the dwelling.

There are several exceptions to these general sealing and testing requirements:

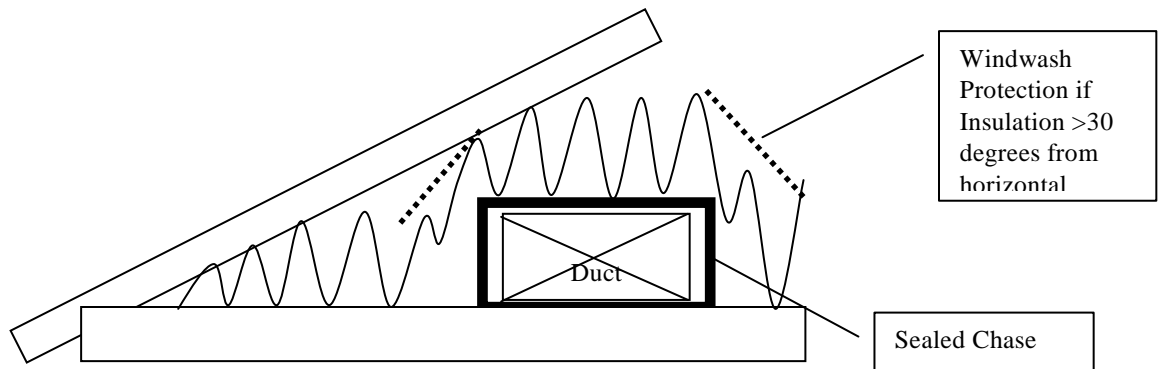
- Ducts that are in insulated ceilings, floors or walls that are insulated on the unconditioned side the same as the rest of the component (unless a different R-value of at least R-8 for the duct area has been entered into Rescheck) and there is a continuous air barrier separating the duct from the outdoors, are considered to be in the conditioned space and are exempt from the insulating, sealing and testing provisions. Additionally:
 - In exterior walls, this air barrier may be achieved with appropriate caulking and taping.



- An insulated floor, as below a bonus room over an unheated garage, would require sealing of the ceiling finish as well as the required windwash protection, per SPS 322.21(2), at any exposed, non-horizontal insulation.



- In attics, a sealed chase would be accepted as keeping the ducts within the conditioned space. If the sides of the chase are insulated with air permeable insulation exposed to the attic at more than 30 degrees from horizontal, then that insulation requires windwash protection per SPS 322.21(2).



- Just the ductwork in the unconditioned space may be tested at rough-in stage, meaning the remaining ductwork would not need to be sealed and tested. The "conditioned floor area" for calculation purposes would be the area served by the tested ducts.
- Ductwork located under a slab that is insulated per above Fig. 2 for underground ducts, will be considered within the conditioned space if the foam insulation joints are taped or otherwise sealed
- Ductwork located under a slab may be tested for leakage per the post-construction or rough-in methods required by the code, or alternatively, rigid plastic ductwork may be tested with a static air pressure of at least 5 psi, that holds for at least 15 minutes. Note that SPS 323.08(4) also requires underground duct to be moisture-proof.

If the rough-in testing option is chosen, then any stud or joist spaces used for return air purposes would need to be panned by the time of testing, rather than being panned with drywall at a later time.

322.44(1) Pipe Insulation

Subsection (1) requires hydronic heating pipes in **all** areas to have at least R-3 insulation and subsection (3) requires hydronic spaces in unheated spaces to have at least R-4 insulation. Generally basements are not considered unheated spaces, even without radiators installed.

The requirement for insulating circulating service hot water piping is applicable to systems mechanically circulated with pumps, not to thermosiphon systems that use convection to circulate the water.

322.46 Replacement Furnace & Boiler Efficiencies

Normally replacement equipment may meet the code at the time of their original installation per s. SPS 320.07(61) definition of repair, as opposed to alterations that need to meet the current code. (Note that the federal government has evolving minimum heating appliance efficiencies that apply to all residential installations, new or replacement.) However, this section requires that replacement furnaces also comply with specified duct sealing criteria and that replacement boilers comply with circulating motor limits. Alternatively, the replacement equipment may instead just comply with the more stringent Wisconsin heating equipment efficiency requirements of Table 322.31-3 (as for new construction that is permitted reduced thermal envelope insulation levels) without duct sealing or circulating motor limits.

Subchapter VI — Simulated Performance Alternative

322.51 Documentation of Simulated Performance Alternative

Compliance by SPS 322.52 is typically shown by REMrate software that models the whole house energy usage. REM/Rate software is proprietary to certain providers. The version 12.6.2.1 or greater is acceptable to show compliance with the current code.



REScheck Software Version 4.6.2

Compliance Certificate

Project North Meadows Development

Energy Code: **2009 IECC**
Location: **Abbotsford, Wisconsin**
Construction Type: **Single-family**
Project Type: **New Construction**
Conditioned Floor Area: **2,000 ft²**
Glazing Area: **15%**
Climate Zone: **6 (9125 HDD)**
Permit Date: **3/17/00**
Permit Number:

Construction Site:

Owner/Agent:

Designer/Contractor:

Compliance: Fails using UA trade-off

Compliance: **6.7% Worse Than Code** Maximum UA: **326** Your UA: **348**

The % Better or Worse Than Code Index reflects how close to compliance the house is based on code trade-off rules. It DOES NOT provide an estimate of energy use or cost relative to a minimum-code home.

Envelope Assemblies

Assembly	Gross Area or Perimeter	Cavity R-Value	Cont. R-Value	U-Factor	UA
Ceiling 1: Flat Ceiling or Scissor Truss	729	38.0	0.0	0.030	22
Ceiling 2: Flat Ceiling or Scissor Truss	592	30.0	0.0	0.035	21
Wall 1: Wood Frame, 16" o.c.	1,647	13.0	6.0	0.053	71
Door 1: Glass	84			0.310	26
Window 1: Vinyl Frame, Double Pane with Low-E	204			0.320	65
Door 2: Solid	20			0.350	7
Wall 2: Wood Frame, 16" o.c.	276	13.0	0.0	0.082	21
Door 3: Solid	18			0.350	6
Floor 1: All-Wood Joist/Truss, Over Unconditioned Space	938	19.0	0.0	0.047	44
Floor 2: All-Wood Joist/Truss, Over Outside Air	32	30.0	0.0	0.033	1
Floor 3: Slab-On-Grade:Unheated Insulation depth: 2.0'	82		8.0	0.779	64

Project Notes:

Previously saved project information:
1010 Construction Ave.

Project Title: North Meadows Development
Data filename: C:\Users\Kaspctg\Documents\REScheck\example.rck

Report date: 05/02/16
Page 1 of 8

Optional Uniform Dwelling Code (UDC) Makeup and Combustion Air Worksheet

Project Address _____ **Completed by:** _____ **Tel.** _____

Background: The UDC applies to all one and two family dwellings built since June 1, 1980. SPS 323.02 of the UDC requires that outside **makeup air** be supplied to balance mechanical exhaust ventilation, including required bathroom fans, so that adequate air change occurs, without backdrafting of open combustion heating appliances. SPS 323.06 of the UDC requires that adequate **combustion air** be supplied to heating appliances for complete fuel combustion and flue gas venting purposes, which should minimize carbon monoxide hazards. This worksheet demonstrates compliance with both requirements.

If your dwelling does not have any open combustion appliances, then you do not have any **combustion air** requirements and, by code, can rely upon infiltration through building cracks for **makeup air**. Open combustion appliances are those which use air from within the dwelling for combustion.

Notes: Typical appliance values are given in the tables; however use actual values if known. **Round pipe** has the following areas: 3" dia. pipe - 7 sq in, 4" - 12 sq in, 5" - 20 sq in, 6" - 28 sq in, 8" - 50 sq in, 10" - 79 sq in, 12" - 113 sq in. **Opening Restrictions:** If louvers or screening is provided on an opening, then multiply its area by the following factors: 1.0 for 1/4" hardware cloth, 0.8 for 1/8" screen, 0.75 for metal louvers, 0.5 for metal louvers and 1/8" screen, and 0.25 for wood louvers.

A. Makeup Air - Complete the following table for exhaust fans, but not recirculating, whole house fans, attic fans or inlets of balanced ventilation systems.

Intermittent Exhaust Fans	Typical Exhaust CFM	OR Actual CFM	Number	Total (cfm)
Bathroom fan (min. 50 cfm)	75		x	
Residential Kitchen range hood	180		x	
Downdraft range exhaust	400		x	
Electric clothes dryer	175		x	
Gas clothes dryer	150		x	
Sub Total				
Intermittency Adjustment Factor				X .40
Adjusted Total				
Any constant exhaust fans without dedicated makeup air				+
Grand Total				

You can provide makeup air via the following methods (check appropriate boxes). Note that openings or ducts shall be provided between the source of the makeup air and the exhaust fans.

- **Intake fans with a capacity equal to the Grand Total above.** If ducts are connected to the fan, the fan capacity shall be appropriately adjusted.
- **Openings to the outside, ducted to the return plenum of the furnace** to provide tempering and distribution. Multiply the Grand Total by the appropriate factor for louvers or screening to obtain the gross makeup air required:

_____ (Net Grand Total Makeup Air Required) ÷ _____ (Opg Restr. Factor) = _____ (Adjusted Makeup Air Req'd).
 The calculated capacity for round intake duct is: 3" - 38 cfm; 4" - 69 cfm; 6" - 157 cfm; 8" - 279 cfm (Circle planned size).

SPS 323.02(3) requires outside makeup air openings to have automatic or gravity dampers for periods when no makeup air is required. Because of this damper requirement, you may not use makeup air openings for combustion air openings, which are prohibited to have dampers.

B. Combustion Air (Note that appliance manufacturer requirements may be more restrictive.)

There are several methods of providing combustion air, of which you will choose one for each group of appliances in a common space. First, complete the table for **open combustion appliances** on the next page to determine if you can comply with method 1, below, which allows the air to be drawn from inside the dwelling. Otherwise, choose another method from the next page.

1. Inside Air (Discontinuous Vapor Barrier): Allows combustion air to be drawn from an inside space if the building has a discontinuous vapor barrier, as is permitted at box sills by SPS 322.38. The space shall provide a room volume of at least 50 cubic feet per 1000 btu/hr combined input rating of all open combustion appliances in that space. **Room Interconnection:** An inside space may include several rooms if connected with **high and low openings**, with each opening providing one square inch of clear opening per 1,000 btu/hr input rating, but not less than 100 square inches each. Remember to apply the above Opening Restriction Factors for louvers on the openings.

sq in required at Input/1,000: _____ (Min. 100 sq in) ÷ _____ (Opg. Restr. Factor) = _____ sq in **each opg;**

Appliance	Appl. Group Number	Typical BTU/hr Input	Actual BTU/hr	Total BTU/hr in Each Numbered Group of Appliances That Share a Space	Room or Interconnected Space Volume	Room Volume Divide by [Total BTU/hr in Room ÷ 1,000]*
Furnace <input type="checkbox"/> Gas <input type="checkbox"/> Other		100,000		Appl. Group 1		
Water Heater <input type="checkbox"/> Gas <input type="checkbox"/> Oil		50,000		Appl. Group 2		
Gas clothes dryer		35,000				
Gas fireplace		50,000				
Gas range		65,000		Appl. Group 3		
Wood stove or fireplace (Input per Cu Ft of firebox capacity)		100,000				

*If any room, or interconnected group of rooms, provides less than 50 cu ft per 1,000 BTU/hr of all appliances within, per the last column of the table, or the dwelling has a continuous vapor barrier, then choose one of the appropriate methods below. Enter the appliance group number in front of the applicable method. You can skip to Method 3 or 5 if the room is small and isolated.

Appl. Group# _____ **2. Inside & Outdoor Air (Continuous Vapor Barrier):** If dwelling has a continuous vapor barrier, and therefore cannot use method 1 of taking all air from inside, but per the above table has a room volume of at least 50 cubic feet per 1000 btu/hr combined appliance input rating, then provide supplemental outside air via a single, direct or ducted, exterior, high opening, sized at one square inch per 5,000 btu/hr combined input rating.

Exterior Opening:

sq in required at Input/5,000: _____ ÷ _____ (Opg. Restr. Factor) = _____ sq in; Planned Opg. Dim. _____

Room Interconnection:

sq in required at Input/1,000: _____ (Min. 100 sq. in.) ÷ _____ (Opg. Restr. Factor) = _____ sq in each opg;

3. Single Outdoor Opening (Gas Appliances Only): If serving only gas appliances, then provide outdoor air via a single, direct or ducted, exterior, high opening sized at one square inch per 3,000 btu/hr combined input rating, but not smaller than the combined cross sectional areas of the appliance flue outlets in that space.

Appl. Group# _____ a. Sizes & areas of flue outlets: _____ Total flue area: _____ sq in

_____ b. Net sq in required at Input/3,000: _____ sq in

Greater of a. or b.: _____ ÷ _____ (Opg. Restr. Factor) = _____ sq in; Planned Opg. Dim. _____

Appl. Group# _____ **4. Prorated Inside Air Credit Plus Outdoor Air:** Calculate the pro-rated credit for an inside space that partially meets method 1, and then make up the difference by pro-rating the outside combustion air otherwise required by method 5. Example: If the inside space provides only 25 cubic feet per 1,000 btu (per last column of table above), or half of the size required by method 1, then the additional direct or ducted outside combustion air, as calculated by method 5 can be reduced by one half. Pro-rating credit: 100% - [_____ (Actual room vol. per 1000 BTU/hr) x 2] = _____

5. Two Outdoor Openings: Provide outdoor air via high and low, direct or vertically ducted, exterior openings, each sized at one square inch per 4,000 btu/hr combined input rating; or via horizontally ducted openings, each sized at one square inch per 2,000 btu/hr combined input rating.

Appl. Group# _____ Direct or Vertical Ducts: sq in required at Input/4,000: _____ sq in x _____ (Credit from 4.) = _____ sq in

_____ Horizontal Ducts: sq in required at Input/2,000: _____ sq in x _____ (Credit from 4.) = _____ sq in

Net sq in required: _____ ÷ _____ (Opg. Restr. Factor) = _____ sq in; Planned Opg. Dim. _____